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# CRINOIDS FROM THE OOLOGAH FORMATION (PENNSYLVANIAN) TULSA COUNTY, OKLAHOMA

by

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# Crinoids from the Ologah Formation (Pennsylvanian) Tulsa County, Oklahoma

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## ABSTRACT

The Ologah Formation, in and near Tulsa, has yielded more than 1,000 crinoid calices, most of which are erisocrinids. The fauna comprises 45 species representing 33 genera and 16 families. A new genus, *Bathronocrinus,* is based upon *B. turioformis,* new species, and *Hydreionocrinus deweyensis* Strimple is assigned to the genus. New species are: *Graphiocrinus deflectus, Erisocrinus terminalis, E. mediator, Graffhamicrinus tulsaensis, G. variabilis, Tholiacrinus rimulatus, Glaukosocrinus naturalis, Perimestocrinus? bulbosus, P. papillatus, Athlocrinus clarus, Metaperimestocrinus trapezoidalis, Bathronocrinus turioformis, Metacromyocrinus minutus, Stellarocrinus minimus, Haeretocrinus depressus,* and *Euonychocrinus magnus.* The fauna also includes two columnal forms, one of which, *Columnal nodosus,* is a new section. More than a dozen of the calices collected have aberrant or unusually developed features.

## INTRODUCTION

The primary material used in this study of crinoids from the Ologah Formation is a collection of 662 crinoid specimens collected several years ago from Garnett quarry in SW¼ sec. 28, T. 20 N., R. 14 E., in Tulsa County, Oklahoma. The material is in the Springer Collection, U. S. National Museum, Washington, D. C. At the southern edge of the quarry the procedure for quarry operations was to strip back the upper few feet of shale and limestone prior to drilling into the main limestone beds, which are 30 to 40 feet thick in this area. Often the exposed bed was a crinoidal shale, and after a few rains the calices were plentiful. Present-day

operations move too fast to allow time for weathering. In the winter of 1959, I measured an exposure above the blue-gray main limestone. Immediately above the limestone is more than four feet of black fissile shale containing phosphatic nodules and capped by a cherty limestone from 1 to 1.5 feet thick. Next above is a 4-foot-thick section containing four limestone layers from 4 to 12 inches thick with intervening beds of clay shale and/or thin limestone lentils. At the top is a deeply weathered cherty limestone layer, approximately 1 foot thick. Some of the zones are richly fossiliferous.

In the winter of 1959 - 1960, a ditch, approximately one-quarter mile long, was dug along the south side of State Highway 33 in NW¼ sec. 4, T. 19 N., R. 14 E., Tulsa County. Rainy weather delayed the completion of the project for several weeks and the shale weathered. I have collected as many as 100 calices from the exposure. Unfortunately the shale was returned to the excavation and the entire exposure is now under weeds.

A small collection has been obtained in the abandoned quarry in SE¼ SW¼ sec. 18, T. 20 N., R. 14 E., Tulsa County. The best exposure was covered by concrete in 1960 for some business enterprise which was there for a few months. Small biohermal structures in the upper part of the formation are exposed, and many of the specimens are larger and appear more rugged than those normally found in the formation.

The excellent exposure on the eastward extension of 31st Street, NE¼ sec. 21, T. 19 N., R. 14 E., Tulsa County, is ruined by modern progress and weeds. Years ago this was a dirt road and the road bed was the crinoidal shale zone. Specimens were in the fill to the west of the hill, in the ditches, in the road, and in the cuts. The road was graveled and later covered with asphalt. Weeds have obliterated about everything that is not otherwise covered.

Several interesting specimens have been found in the road cut on 51st Street, SE¼ SE¼ sec. 27, T. 19 N., R. 14 E., Tulsa County. Oakes (1952) considered the cherty limestone exposed here to be the lower part of the Oologah Limestone Formation. The crinoids came from the shale about three feet below the cherty limestones.

A few specimens have been found in the road cuts on Interstate Highway 44 in NE¼ sec. 5, T. 19 N., R. 14 E., Tulsa County.

All specimens described herein, except where noted otherwise

in the sections on occurrence, have come from the Oologah Formation, Marmaton Group, Des Moines Supergroup, Pennsylvanian. Because nearly all occurrences are in Tulsa County, Oklahoma, at the localities described above, most locations are referred to by name only as follows:

| *Name* | *Location* |
|---|---|
| Garnett quarry locality | SW¼ sec. 28, T. 20 N., R. 14 E. |
| State Highway 33 locality | NW¼ sec. 4, T. 19 N., R. 14 E. |
| 31st Street locality | NE¼ sec. 21, T. 19 N., R. 14 E. |
| 51st Street locality | SE¼ SE¼ sec. 27, T. 19 N., R. 14 E. |
| Interstate Highway 44 locality | NE¼ sec. 5, T. 19 N., R. 14 E. |

More than 1,000 crinoid calices from the Oologah Limestone Formation have been studied. Three-fourths of the specimens are of erisocrinids. A total of 45 crinoid species is now known from this formation, representing 33 genera and 16 families. Sixteen new species and one new genus are presented herein. In addition, two columnals are described under a section for fragmentary remains.

## Descriptive Terms and Abbreviations

Descriptive terms relative to the articular facets of the radial plates follow those of Moore and Plummer (1940, text-fig. 4). Abbreviations for crinoid parts are not commonly used, but when so used are those recommended by Moore and Laudon (1941).

## Acknowledgments

Acknowledgment for assistance in making this study possible is here made to Carl C. Branson, Director, Oklahoma Geological Survey, and to G. A. Cooper and Porter Kier, U. S. National Museum, Washington, D. C. Specimens were contributed by John Kerns, Joe Welch, and Jack Hood of Tulsa, Oklahoma.

## Aberrant or Unusually Developed Specimens

*Paradelocrinus subplanus,* OU 3993

The left anterior infrabasal is enlarged and has an extra facet, with the area normally developed as a point truncated to support a small extra basal plate in true anterior position. Most of the

increased size of the left anterior infrabasal is compensated for by reduction of the anterior infrabasal. The extra plate is shorter and narrower than a normal basal plate.

*Paradelocrinus subplanus,* OU 3992

The cup is composed of four infrabasals, four basals, and five radials. The general outline of the cup is not disturbed by the reduced number of plates. The right posterior and right anterior basals are fused. In this pattern the right anterior radial loses its pointed lower extremity and is quadrangular. In the infrabasal circlet the right anterior infrabasal plate is missing.

*Paradelocrinus subplanus,* various specimens

Certain infrabasals tend to be larger than others and the radials tend to meet the infrabasals. The shape of the basals changes when contact is made between a radial and an infrabasal.

*Sciadiocrinus harrisae* (Moore and Plummer),
Springer Collection (01-1)

The left anterior and anterior infrabasals are fused so that the suture is entirely obscured. There is no inequality or distortion caused by this anchylosis.

*Sciadiocrinus harrisae* (Moore and Plummer), OU 4567

This specimen has only four basals, the right anterior basal having been eliminated. Another advanced condition is that the left posterior radial has contact with the left posterior infrabasal. The radianal is small and is directly above the posterior basal in the narrow, sharply impressed posterior interradius. Anal X is large and rests obliquely upon the RA and extends well above the summit of the calyx. RX is a large plate to the right above and it does not contact the RA. The specimen appears granulose under low magnification, especially in the basal area.

*Erisocrinus mediator* Strimple

Several young specimens of this species have been observed wherein the anal plate is visible in side view of the cup as a narrow, pointed sliver. Because the anal plate has not been observed in mature specimens within the outer walls of the cup, the condition is considered to be unusual. Radial plates tend to contact infrabasal plates, and infrabasals tend to be unequal.

*Apographiocrinus rotundus* Strimple, OU 4568

The anal plate has completely lost contact with the posterior basal. The occurrence is not indicative of a transitional series because only one specimen of the species has been found showing the condition.

*Apographiocrinus quietus* Strimple, Springer Collection

The single anal plate has facets for the reception of three plates rather than for two plates. It is the only specimen of the genus in the present group that has been observed with this feature.

*Apographiocrinus obtusus* Strimple, Springer Collection

The single anal plate has lost contact with the posterior basal. This condition has been observed in only one specimen of the species.

*Laudonocrinus catillus*? Moore and Plummer, OU 4594

The three basal plates in posterior position and the radianal plate are missing in this specimen. Anal X and RX are almost entirely out of the cup. The specimen is figured as plate 4, figures 9-11.

*Bathronocrinus turioformis* Strimple, OU 4582

The lower end of the left anterior radial is truncated, and a small quadrangular supernumerary plate is directly below it. No pronounced distortion nor inequality in the shape of the cup is caused by the insertion of this extra plate. A normal basal is 3.3 mm wide, but the supernumerary is only 1.4 mm wide.

## DESCRIPTION OF SPECIES

Subclass INADUNATA Wachsmuth and Springer
Order DISPARATA Moore and Laudon, 1943
Family ALLAGECRINIDAE Carpenter and Etheridge, 1881
Subfamily ALLAGECRININAE Moore, 1940
Genus *Allagecrinus* Carpenter and Etheridge, 1881

### *Allagecrinus dignatus* Moore, 1940

*Allagecrinus dignatus* is reportedly devoid of ornamentation and *A. constellatus* Moore, from the same horizon, reportedly has a granulose surface. All presently considered specimens of *A. dignatus* (five topotypes) have granular surfaces. This fact requires a re-evaluation of the original specific concept. Comparison of Moore's illustrated paratype of *A. constellatus* (1940, specimen 458912C, plate 2, fig. 1) and the holotype of *A. dignatus* (specimen 458911A, plate 2, fig. 6) discloses a remarkable similarity aside from the ornate condition of specimen 458912C. It is not necessary to abandon the species *A. dignatus,* but certainly the concept must be modified to accept ornamentation, and Moore's specimen 458912C should be referred to *A. dignatus* rather than to *A. constellatus.* The largest specimen in the present group even has a few nodes on the protruded mid-portion of the radial plates. The pear-shaped radial plates serve readily to distinguish the species from other described forms.

*Types.*—Five topotypes considered herein are deposited in the Springer Collection, U. S. National Museum. Plesiotype OU 4556 is in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Topotypes from Garnett quarry; plesiotype from Interstate Highway 44 locality.

### *Allagecrinus constellatus* Moore, 1940

Five specimens of *Allagecrinus constellatus* are available in the present study; topotypes from Garnett quarry. Some discussion of the species has been given under *A. dignatus.* All of the present

specimens have granular surfaces but the ornamentation is not so pronounced as in the type specimens.

*Topotypes.*—Five specimens are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

Subfamily CATILLOCRININAE Moore, 1940

Genus *Metacatillocrinus* Moore and Strimple, 1942

*Metacatillocrinus bulbosus* Moore and Strimple, 1942

Only one specimen of the unique crinoid *Metacatillocrinus bulbosus* has been found. I collected it in the road fill just to the west of the excavation in the hill on the eastward extension of 31st Street. The exact exposure has long since been covered by weeds and grass.

*Occurrence.*—Thirty-first Street locality.

Order CLADOIDEA Moore and Laudon, 1943
Suborder DENDROCRINOIDEA Bather, 1899

Family ERISOCRINIDAE S. A. Miller, 1889

Genus *Graphiocrinus* de Koninck and LeHon, 1854

*Graphiocrinus deflectus,* new species
Plate 7, figures 8-10

The dorsal cup of *Graphiocrinus deflectus* is low and truncate bowl-shaped, with horizontal infrabasal plates. The basal area is smooth except for the sharply impressed columnar scar, which occupies the median portion of the infrabasal circlet. The posterior side of the cup slopes less steeply than the others. Five infrabasal plates are present, extending slightly beyond the perimeter of the columnar scar. Five basal plates form a confluent plane with the infrabasals but curve strongly upward to form part of the lateral walls of the cup. Five radials are wide, pentagonal plates, with subhorizontal articular facets. The outer ligament area is rather long and almost fills the width of the plate. A ligament pit is

well defined and the transverse ridge is prominent. The lateral furrows extend the width of the plate to the intermuscular furrow. Lateral lobes are slightly elevated so that muscle areas toward the inner edge of the facets slope slightly outward. The single anal plate is in contact with the posterior basal and extends above the summit of the cup. Of the six facets, only one is for the reception of a single tube plate. A few irregular denticles are on the upper facet. Three primibrachs, preserved in one of the paratypes, are wide, mildly convex in mid-section, and axillary. The two posterior primibrachs are of equal length and are slightly longer than the right anterior primibrach. A toothlike projection is between the upper facets of the primibrachs. The entire surfaces of the calyx and brachials are highly ornate and have rather long thin intertwining ridges. The name of the species is a coined adjective from the Latin *flecto,* meaning to bend.

The thin proximal columnal is in place in the holotype. Its outer surface is confluent with the basal plane. There are 20 crenellae, the lumen is of medium size and round, and the columnal is round.

| Measurements in millimeters: | *Holotype USNM* |
|---|---|
| Height of calyx | 2.9 |
| Width of calyx (maximum) | 8.2 |
| Width of calyx (posterior to anterior) | 8.0 |
| Width of infrabasal circlet | 2.8 |
| Width of proximal columnal | 1.8 |
| Length of left anterior basal | 2.5* |
| Width of left anterior basal | 2.5* |
| Length of left anterior radial | 2.8* |
| Width of left anterior radial | 5.0* |

*Measurement taken along surface curvature.

*Types.*—Holotype and one paratype are from the 31st Street locality. Two paratypes are from the lower part of the Oologah Limestone at Garnett quarry. All are in the Springer Collection, U. S. National Museum.

*Occurrence.*—The holotype and one paratype were collected in the road cut on the line between sections 16 and 21 at the 31st Street locality. Most specimens are from the south side of the road at the 31st Street locality. Two paratypes were collected about seven feet above the base of the massive limestone at the Garnett quarry locality.

## Genus *Erisocrinus* Meek and Worthen, 1865

The generic concept established by Moore and Plummer (1940) is used herein. Presently described species have calices lower than typical for the genus.

*Genotype.—Erisocrinus typus* Meek and Worthen, 1865.

*Occurrence.*—Des Moines Supergroup, Pennsylvanian to Lower Permian; North America, Sicily, Timor, Brazil, Transcaucasia. Mississippian? (Lower Carboniferous); Scotland.

### *Erisocrinus terminalis,* new species
Plate 9, figures 1-4

The dorsal cup of *Erisocrinus terminalis* is shallow and is truncate conical with subhorizontal infrabasals. The outline is strongly pentagonal as viewed from above or below. Five infrabasals are confined to the mid-portion of the fairly broad, mildly concave basal area. They form a star-shaped disk with the mid-portion sharply depressed for reception of the proximal columnal. Lower portions of the basal plates participate in the basal area. The basal plates curve out of the basal plane to a low angle. The lateral walls of the cup are sloped outward, especially the posterior side, which appears slightly more extended than do the other sides, although there is no increase in length. There may be some inequality in size among the infrabasal plates, and in some specimens the radials tend to join with the infrabasals, and thus to make a short interbasal suture. In extreme cases the suture between two basals is eliminated. Five wide, pentagonal radial plates are present. The outer surface ends with the sharp ridge of the outer ligament area. Division of the outer area is effected by a median ridge that extends most of the width of the area and is marked by fine denticles. The outer ligament pit is well defined and is adjoined by the transverse ridge. The ridge extends the full width of the plate but is interrupted in mid-section by the central pit. Long, well-defined lateral furrows are backed by prominent oblique ridges. The intermuscular furrow is rather deep, and muscle areas are restricted. The facets are relatively short and are almost subhorizontal except for the outward slope produced by the areas adjacent to the facets for reception of the single anal plate. The columnar

scar is round, is marked by about 28 crenellae, and has a mildly pentalobate lumen.

| Measurements in millimeters: | *Holotype OU 3994* |
|---|---|
| Height of cup | 4.0 |
| Width of cup (maximum and minimum) | 17.7 |
| Width of infrabasal circlet | 5.8 |
| Width of columnar scar | 2.8 |
| Width of left posterior basal | 4.7* |
| Length of left posterior basal | 2.7* |
| Width of left anterior radial | 10.5* |
| Length of left anterior radial | 5.9* |
| Length of interbasal suture | 0.4 - 1.0 |
| Length of interradial suture | 5.1* |

*Measurement taken along surface curvature.

*Remarks.*—The wide, low nature of the dorsal cup (holotype, H/W ratio=0.23) and short sutures between basal plates serve readily to distinguish *E. terminalis* from all other described species. The associated *E. mediator* has a lower cup than have other species of the genus, except *E. terminalis.* The H/W ratio is 0.36. The sutures between basal plates tend to be short; however, the cup shape is different in that the lateral sides are more or less vertically directed in *E. mediator.* The specific name *terminalis* is the Latin term, meaning boundaries.

*Types.*—Holotype, OU 3994, and paratypes, OU 3995 and 4565, are in the paleontological collections, The University of Oklahoma. Three paratypes are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Holotype, OU 3994, and paratype, OU 4565, are from the Highway 33 locality; paratype, OU 3995, and the three paratypes in the Springer Collection are from the Garnett quarry.

*Erisocrinus mediator,* new species
Plate 8, figures 4-7

The dorsal cup of *Erisocrinus mediator* is low and truncate conical, with subhorizontal infrabasals. The outline is mildly pentagonal as viewed from above or below. Normally this species has a shallow, broad basal concavity. Five infrabasals are confined to the median portion of the basal area. The center portion of the infrabasal disk is sharply impressed for the columnar attachment. In many specimens the infrabasals are of unequal size and the

radials tend to reach or actually to make contact with the infrabasal circlet. Five basals are normally six-sided; however, in instances where facets between basals are eliminated, there are of course fewer sides. In advanced specimens the basals may have triangular outlines, although there are really four facets. The lower facets, for contact with infrabasals, have a broad angle of contact. Proximal edges of the basals are in the basal area, the basal plane being formed at about their midportion, and their upper edges participate in the lateral sides of the cup. Five radials are broad, and their proximal tips do not closely approach the basal plane. In upper portions the outer surface of the plate reaches the outer ligament area without longitudinal curvature. Articular facets are sloped slightly outward. The outer marginal ridge is thin but sharply defined. A median ridge carries fine denticles and borders the ligament pit. The inner side of the transverse ridge and the outer side of the oblique ridges carry denticles. The intermuscular furrow is well defined and the muscle areas are shallow and triangular. Lateral ridges are rather low, with low adsutural slopes. The single anal plate is rudimentary, a small triangular piece placed toward the inner edge of the radial articular facets. In a few young specimens the anal plate is to the fore of the facets and enters into the side walls of the calyx. Even then it is a small, narrow, and obviously decadent element.

| Measurements in millimeters: | *Holotype OU 4566* |
|---|---|
| Height of cup | 5.9 |
| Width of cup | 16.0 |
| Width of infrabasal circlet | 6.4 |
| Width of columnar scar | 3.0 |
| Length of left posterior basal | 4.9* |
| Width of left posterior basal | 5.6* |
| Length of left anterior radial | 6.7* |
| Width of left anterior radial | 10.3* |
| Length of interbasal suture | 0.3 - 1.4* |
| Length of interradial suture | 4.0* |

*Measurement taken along surface curvature.

*Remarks.—E. mediator* typically has a lower dorsal cup than have previously described species ascribed to the genus, with the exception of *E. terminalis*. It is more comparable to *E. typus* than to most forms. When viewed from the side, that species typically has a mildly outward flare to the dorsal cup, caused by the upper

portions of the radials, which curve slightly outward. *E. mediator* typically has shorter sutures between basal plates than has *E. typus*. The species *E. elevatus* Moore and Plummer, *E. erectus* Moore and Plummer, and *E. propinquus* Weller have proportionately higher dorsal cups, with relatively broader bases than has *E. mediator*. The specific name is the Latin term *mediator,* meaning go-between.

*Types.*—Holotype, OU 4566, and paratype, OU 4552, are in the paleontological collections, The University of Oklahoma. Three paratypes are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Holotype, OU 4566, and the three paratypes in the Springer Collection are from the Garnett quarry locality; paratype, OU 4552, is from the Interstate Highway 44 locality.

## Genus *Graffhamicrinus* Strimple, 1961

Little is added to our knowledge or concept of the genus *Graffhamicrinus* by the two new species in the Oologah Limestone Formation. Relatively few (about ten) specimens are in this large crinoidal fauna. The species *Graffhamicrinus variabilis* demonstrates the trend toward elimination of surface ornamentation which produces the genus *Delocrinus,* the later becoming a dominant form in the Missouri Group.

*Genotype.—Graffhamicrinus acutus* Strimple, 1961.

*Occurrence.* — Pennsylvanian and Lower Permian; North America.

### *Graffhamicrinus tulsaensis,* new species
Plate 4, figures 1-4

The dorsal cup of *Graffhamicrinus tulsaensis* is a low, basally impressed globe, with downflaring infrabasals. Five infrabasals are confined to the rather pronounced basal invagination. Five basals also participate in the concave base but curve sharply out of the basal region so that their upper extremities form a portion of the lateral walls of the cup. Five radials are pentagonal, considerably wider than long, and only slightly curved longitudinally into the outer articular area. Articular facets slope slightly outward. A median ridge divides the outer ligament furrow into two parts and is marked with fine crenulations. The outer ligament pit is narrow but well defined. The transverse ridges are marked by a few den-

ticles at their outer edges. Lateral furrows are pronounced and join those of adjacent facets. The intermuscular furrow is well defined, with the central pit more or less triangular. Muscle areas are large and shallowly depressed. The lateral lobes are broken in each instance in the holotype. It is certain that a thin segment extends inward at each lobe. The single anal plate is hexagonal, elongate, rests solidly upon the posterior basal, and is somewhat larger above the summit of the cup than is the portion within the cup. Ornamentation consists of numerous nodes and granules. A confluence of granules forms thin, short ridges that pass from basal to radial plates at right angles to the plate sutures. The column, as represented by the columnar scar, is small, round, and pierced by a pentalobate lumen. The arms are unknown.

| Measurements in millimeters: | *Holotype OU 3983* |
|---|---|
| Width of cup (maximum) | 19.7 |
| Width of cup (posterior to anterior) | 19.0 |
| Height of cup | 5.7 |
| Length of left anterior basal | 8.8* |
| Width of left anterior basal | 7.7* |
| Length of left anterior radial, to transverse ridge | 6.8* |
| Width of left anterior radial | 11.8* |
| Depth of basal cavity | 3.2 |

*Measurement taken along surface curvature.

*Remarks.*—The nodes of *Graffhamicrinus tulsaensis* are more numerous and more closely spaced than are those in typical *G. granulosus.* No swellings border the sutures between radial and basal plates, and the dorsal cup is broader and lower than in *G. granulosus. G. somersi* (Whitfield) may be closely related to *G. tulsaensis,* but the type specimens are not available for close comparison.

*Types.*—Holotype, OU 3983, and paratype, 3985, are in the paleontological collections, The University of Oklahoma. Two paratypes are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

### *Graffhamicrinus variabilis,* new species
Plate 4, figures 5-8

The dorsal cup of *Graffhamicrinus variabilis* is a low, basally

impressed globe having downflaring infrabasals. The five infrabasals are confined to the basal concavity and form a small bowl-shaped disk. Five basals participate strongly in the basal concavity but curve upward to participate in the lateral walls of the cup. Five large radials are wide, pentagonal, and have a strong curvature in their upper portion toward the articular surfaces. The outer ligamental areas are poorly defined in the holotype except for the outer ligament pit. The inner articular facets are subhorizontal except for the rise of the lateral sides. A decided transverse ridge carries fine denticles. The intermuscular furrow is narrow, with the intermuscular notch well defined, but there is no central pit to the fore. Oblique ridges are prominent and there are some fine denticles to the fore, at their lateral ends. The lateral furrows are deep and meet those of adjacent facets, but do not form a confluent trough. A depression and laterally directed furrow are on each side of the intermuscular furrow a short distance from the intermuscular notch. These furrows break up the muscle areas. Adsutural slopes are narrow at the front but widen rapidly and then gradually narrow again, giving an outline somewhat like that of an arrow point. The anal plate is long, hexagonal, and about half in and half above the calyx. The upper portion curves inward. A semicircular depressed area is on the upper facet, and reception of a single tube plate is provided. The column is small and round, and the lumen is pentalobate. The surface of the calyx is smooth except for sporadic nodes and for the festoon of nodes across the upper portion of the radials. The sutures between plates are not impressed.

| Measurements in millimeters: | *Holotype OU 3990* |
|---|---|
| Width of cup (maximum) | 13.2 |
| Width of cup (posterior to anterior) | 12.5 |
| Height of cup | 4.7 |
| Length of left posterior basal | 6.6* |
| Width of left posterior basal | 5.0* |
| Width of left anterior radial | 7.8* |
| Length of left anterior radial | 5.0* |
| Depth of basal cavity | 1.6 |

*Measurement taken along surface curvature.

*Remarks.*—The absence of granulations on the surface of the calyx, paucity of nodes, and absence of impressions at the sutures

serve to distinguish *G. variabilis* from *G. granulosus* and from most other species of the genus. The variety *G. granulous moniliformis* Moore and Plummer is somewhat comparable, but it has little, if any, inward slope of the upper portions of the radial plates into the articular areas. *G. tulsaensis* has the most comparable cup shape, but it carries granules as well as nodes and has a deeper and wider basal concavity. The specific name *variabilis* is the Latin term meaning changeable.

*Types.*—Holotype, OU 3990, and paratypes, OU 4591 and OU 3984 (2), are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—State Highway 33 locality.

Genus *Tholiacrinus* Strimple, 1962

*Tholiacrinus rimulatus,* new species
Plate 7, figures 11-14

The dorsal cup is in the form of a flat, basally impressed globe, with downflaring infrabasals. The five infrabasals are confined to the narrow, sharply impressed basal invagination, and the proximal portions of the basals also participate in the depression. The five basals are six-sided except for the posterior, which is truncated for the reception of the single anal plate. They are tumid and their upper portions curve upward from the basal area to participate in the lateral walls of the cup. Five radials are pentagonal, wide, and tumid. There is a strong longitudinal curvature of the plate into the relatively large outer ligamental area. Preservation of the articular facets is not satisfactory. The inner facets are subhorizontal and of medium length. A transverse ridge and low, shallowly depressed muscle areas, separated by an intermuscular furrow, are discernable. The intermuscular notch is well developed but is only slightly larger than the notches formed at the sutures. The single anal plate is elongate, hexagonal, and is longer than is apparent because of the sharp curvature in the upper portion. It has a subcircular depression for reception of a single tube plate. At the lower apex of each radial and at the upper apex of each basal, is a sharp depression. Ornamentation consists of rather sporadic, nodelike proturberances on the basals and radials, especially well developed across the upper portion of the radials. A

slightly raised area is adjacent to the sutures between radials and basals. The columnal scar is round and small, with a small pentalobate lumen. Arms are unknown.

| Measurements in millimeters: | *Holotype OU 3989* |
|---|---|
| Height of cup | 2.3 |
| Width of cup (maximum) | 8.0 |
| Width of cup (posterior to anterior) | 7.8 |
| Width of infrabasal circlet | 1.5 |
| Length of left anterior basal | 2.8* |
| Width of left anterior basal | 2.5* |
| Length of left anterior radial | 4.6* |
| Length of anal plate | 2.1* |
| Width of anal plate (maximum) | 0.8 |

*Measurement taken along surface curvature.

*Remarks.—Tholiacrinus rimulatus* is most readily distinguished from other species of the genus by the relatively low nature of the dorsal cup. The name of the species is from the Latin *rimula,* the diminutive of *rima,* meaning cleft or fissure.

*Types.*—Holotype, OU 3989, and paratype, OU 3967, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Holotype, OU 3989, is from the State Highway 33 locality; paratype, OU 3967, is from the Garnett quarry locality.

## Genus *Paradelocrinus* Moore and Plummer, 1938

The generic concept used herein is that of Moore and Plummer (1940). The only species involved in the present study is *Paradelocrinus subplanus* Moore and Plummer (1940), which is atypical of the genus. Several hundred specimens have been observed and considerable variety has been found. For quite some time I thought of establishing several species based upon the extreme varieties, but there is so much gradual transition that my only change was to place those forms having a decidedly pentagonal outline and absence of curvature of the radials into the outer ligamental areas into *Erisocrinus.*

*Genotype.—Paradelocrinus aequabilis* Moore and Plummer, 1938.

*Occurrence.*—Morrow to Virgil Groups, Pennsylvanian; North America.

*Paradelocrinus subplanus* Moore and Plummer, 1940
Plate 3, figures 16-17; plate 6, figures 1, 2; plate 8, figure 1

As noted above, *Paradelocrinus subplanus* is atypical for the genus, mainly in the absence of a basal concavity. Typical representatives have strongly downflared infrabasals confined to a basal concavity, as in *Delocrinus*. Moore and Plummer (1940) cited 21 specimens as paratypes from Garnett quarry, and so there is no question as to the identification of the present specimens. The calices of the figured types from Texas have circular outlines as viewed from above or below, and some curvature of the radial plates into the outer ligamental areas. On this basis, I have removed all specimens having a decided pentagonal outline and lack of an inward curvature in the upper radial areas to *Erisocrinus*. This assignment is more or less arbitrary, and certain specimens are certainly transitional between the two genera.

Although they are relatively rare, a few specimens have a decided basal concavity and downflared infrabasal plates. The radial plates tend to reach the infrabasal plates and thus eliminate the suture between the basal plates. Some specimens also show an inequality in the size of infrabasal plates so that the larger ones are closer to the radial plates. The condition appears to be more prevalent in the anterior and right and left posterior than in other rays. The size and shape of the basal plates are affected by such developments so that some basal plates may even be triangular.

Specimens are rather small at all exposures except at the old abandoned quarry in the SW¼ SW¼ sec. 18, T. 20 N., R. 14 E., in the road cut in SE¼ sec. 34, T. 20 N., R. 14 E., Rogers County, and the road cut at the 51st Street locality. At the exposure in section 18, small bioherms are present near the top of the formation, and specimens of the species are quite large and thick walled. Within the past year (1960-1961) the best exposures have been covered by a cement floor, apparently for use in some commercial enterprise. A cup, OU 4574, with a width of 28.6 mm was found in the abandoned quarry. In section 34, the lowermost bed of the Oologah Formation is exposed and only three poorly preserved crinoid calices have been collected, although corals and brachiopods, as well as crinoid stems, are common. One specimen of the species, OU 4563, has a diameter of 22.2 mm. At the 51st Street

locality the exposed shales are crinoidal but the plates of the specimens are normally poorly cemented and fall apart easily. One specimen, OU 4564, with a width of 24.6 mm, has been found at this exposure. One complete crown, OU 4554, of the species has been found at the exposure at the Interstate Highway 44 locality, although it is a fairly small specimen, and several partial crowns have been collected from the exposure on 51st Street. These specimens confirm that the arms, at least of this atypical species, are essentially the same as those of *Erisocrinus;* that is, the ten arms are long, gently tapering, biserial, and they bifurcate with the first primibrach in each ray.

*Plesiotypes.*—Numerous plesiotypes from Garnett quarry are in the Springer Collection, U. S. National Museum. The following figured or specifically mentioned specimens are in the paleontological collections, The University of Oklahoma: OU 4553 and OU 4554 from Interstate Highway 44; OU 4562 and OU 4564 from 51st Street; OU 4563 from sec. 34; OU 3993 (aberrant) and OU 4574 from sec. 18; OU 3992 (aberrant) from Garnett quarry.

*Occurrence.*—Road cut SE¼ sec. 34, T. 20 N., R. 14 E., Rogers County; Garnett quarry locality; State Highway 33 locality; and the following locations in Tulsa County: road cut on north side of State Highway 33, SW¼ sec. 33, T. 20 N., R. 14 E.; road cut on south side of Interstate Highway 44, SW¼ sec. 33, T. 20 N., R. 14 E; road cuts on north and south sides of Interstate Highway 44, NE¼ sec. 5, T. 19 N., R. 14 E.; abandoned quarry in SE¼ SW¼ sec. 18, T. 20 N., R. 14 E.; road cut on line between sections 16 and 21 at 31st Streeet locality; road cut on north side of 51st Street locality.

## Family Anobasicrinidae Strimple, 1961

### Genus *Anobasicrinus* Strimple, 1961

### *Anobasicrinus erectus* (Strimple), 1951

As no other specimen of *Anobasicrinus erectus* has been found, it remains a monotype. A new concept of the species has been given by Strimple (1961), wherein the presence of three anal plates is assumed. The type locality is Garnett quarry.

*Anobasicrinus praecursor* (Moore and Plummer), 1940
Plate 9, figures 7-10

*Anobasicrinus praecursor* was originally described under the genus *Neozeacrinus* Wanner. The type locality is three miles southwest of Brock, Texas; Brannon Bridge Limestone Member, Millsap Lake Formation, Desmoinesian. Strimple (1961) reassigned the species to *Anobasicrinus*. On the basis of the appearance of paratype H-22 figured by Moore and Plummer (1940, pl. 5, fig. 5), two specimens from the Oologah Limestone Formation are assigned to the species as plesiotypes. The specific characteristic that is distinctive for this comparison is the nature of the infrabasal circlets. In median portion, the circlet is sharply impressed by processes for the attachment of the column. Portions of the circlet that extend beyond the columnar attachment have an upflared attitude, even though the over-all basal area of the calyx is concave.

The form is distinct from associated *Sciadiocrinus harrisae*. The latter has a deep basal concavity accentuated by bulbous radial plates.

*Plesiotypes.*—OU 3957 is figured and is in the paleontological collections, The University of Oklahoma. One plesiotype is in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

Genus *Glaukosocrinus* Strimple, 1951

*Glaukosocrinus parviusculus* (Moore and Plummer), 1940

Seven paratypes of *Glaukosocrinus parviusculus* were reported by Moore and Plummer from the Oologah Limestone at Garnett quarry, but the holotype is from the Millsap Lake Formation, Strawn Group, Desmoinesian, one-fourth mile below Kickapoo Falls, on Kickapoo Creek, Hood County, Texas. In addition to the one specimen figured by Strimple (1951), six other specimens from Garnett quarry are in the Springer Collection. Two subsequently collected specimens from Garnett quarry are in the paleontological collections, The University of Oklahoma, OU 4576 and 4576a.

The characteristics of the genus remain consistent. Specimens from the Oologah Limestone are remarkably constant in their characters. One characteristic is the nature of the summit of anal

X, which does not project appreciably above the summit of the calyx. The short articular facets of the radials, which do not fill the upper face, are also characteristic.

*Occurrence.*—Garnett quarry locality.

*Glaukosocrinus naturalis,* new species
Plate 3, figures 12-15

The dorsal cup of *Glaukosocrinus naturalis* is a basally impressed flattened bowl, with flat-bottomed basal depression. The flattened basal area is composed of the five infrabasals, and the center portion is sharply impressed for the columnar attachment. Five basals form the sides of the basal concavity and curve upward to participate slightly in the lateral walls of the cup. The five radials are slightly wider than long. A pronounced gap is between radials at the summit of the cup. Most of the cup height is provided by the nearly vertical, flattened, arcuate area below the outer ligament facets of the radials. A strong outer ridge and a well-developed ligament pit are present on the facets. The transverse ridge is interrupted in midportion by the rather large central pit. The intermuscular furrow is deep and is accentuated by bordering ridges. Muscle facets are deep and triangular. The outer surface of the cup continues into the adsutural area between radials, but these surfaces are not ornate. There is provision for three anal plates in normal or "primitive" arrangement. RX is not preserved, but the facet shows that its lower portion was in contact with the pentagonal RA, which rests obliquely on the upper right shoulder of the posterior basal and is in contact with the right posterior basal. Anal X is hexagonal, extends slightly above the summit of the cup, and rests evenly upon the posterior basal. All sutures, except those between infrabasals, are deeply impressed; and the surface of the cup is covered by a peculiar type of ornamentation, consisting mainly of heavy ridges that have the appearance of corrugations.

| Measurements in millimeters: | *Holotype OU 3987* |
|---|---|
| Width of cup | 8.8 |
| Height of cup to transverse ridge | 2.3 |
| Width of infrabasal circlet | 2.4 |
| Width of columnar scar | 1.4 |
| Width of left posterior basal | 3.1* |

| | |
|---|---|
| Length of left posterior basal | 3.0* |
| Width of left anterior radial | 5.2* |
| Length of left anterior radial | 3.8* |

*Measurement taken along surface curvature.

*Remarks.*—Affinities of this unique little crinoid are not readily apparent. Assignment to *Glaukosocrinus* is made primarily upon the basis of the unusual articular facets. The rugose ornamentation and deeply impressed sutures of *G. naturalis* are distinctive of the species. The name of the species is the Latin *naturalis,* meaning innate, not artificial.

*Holotype.*—The holotype, a monotype of the species, is in the paleontological collections, The University of Oklahoma, OU 3987.

*Occurrence.*—Garnett quarry locality.

Family PIRASOCRINIDAE Moore and Laudon, 1943

Genus *Laudonocrinus* Moore and Plummer, 1940

*Laudonocrinus catillus* Moore and Plummer, 1940
Plate 1, figures 13, 14; plate 4, figures 9-11

The holotype of *Laudonocrinus catillus* is from the Millsap Lake Formation, Strawn Group, Desmoinesian; Potato Knob, on tar road to Gold Ranch, east of old Santo-Patillo road, Palo Pinto County, Texas (University of Texas locality 181-T-93); Plummer Collection, University of Texas, P-10640. Nine paratypes are from the upper portion of the Oologah Limestone, Marmaton Group, Desmoinesian; at Garnett quarry, about seven miles northeast of Tulsa, Oklahoma (University of Kansas locality 4589); Stevens Collection, University of Kansas, 45893, 45893a-g.

About 32 specimens from the Garnett quarry exposure have been studied by me, and four of these closely follow the characters ascribed to *Laudonocrinus catillus.* In a large (fully mature) stage it resembles some species of *Plaxocrinus.*

An unusual aberration is discussed under the section dealing with aberrant forms (specimen OU 4594) and is illustrated on plate 4, figures 9-11.

*Plesiotypes.*—Four specimens of *L. catillus* are in the Springer Collection, U. S. National Museum. Plesiotypes, OU 3951, OU

3955 (young), and OU 4557, and aberrant specimen, OU 4594, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Plesiotypes in the Springer Collection and specimens, OU 3951, 3955, and 4594, are from Garnett quarry locality; OU 4557 is from Interstate Highway 44 locality.

## Genus *Perimestocrinus* Moore and Plummer, 1938

The genus *Perimestocrinus* has been restricted by Strimple (1961) to forms having characteristics of the genotype species. No effort has been made to separate species for which the arms are not known.

*Genotype.—Hydreionocrinus noduliferus* Miller and Gurley.

*Occurrence.*—Pennsylvanian, Permian; North America.

### *Perimestocrinus? bulbosus,* new species
Plate 2, figures 1-4

*Perimestocrinus? bulbosus* is assigned to *Perimestocrinus* with considerable hesitation. The extraordinary bulbosity in the median portion of the basal plates may well represent an undescribed generic characteristic. I have observed similar development in some undescribed species from the Morrowan. *Utharocrinus pentanodus* (Mather) has downward-projected points on the basals, but they are only superficially comparable to the knoblike projections of the present species. The Permian genus *Calceolispongia* Etheridge Jr. has even more pronounced downward projection of the basal plates, but the genus is more advanced in having a single anal plate retained in the posterior interradius of the calyx. Some Upper Pennsylvanian and Lower Permian species, formerly assigned to *Utharocrinus* or *Triceracrinus* have mildly projected basals and have articular facets with an extremely high angle and long surface, as in the present species (e. g., *Utharocrinus quinquacutus* Moore, 1939). Such forms are at present assigned to the genus *Perimestocrinus* after Strimple (1961).

The dorsal cup *P.? bulbosus* is of medium height and is in the form of a truncated globe with subhorizontal infrabasals and a flat-bottomed basal depression. Five infrabasals form a disk that extends appreciably beyond the sharply impressed columnar scar. Five basals are tumid and project downward as knobs. Proximal edges join with the infrabasals and form the walls of the basal

concavity, but the upper extremities form part of the lateral walls of the calyx. The radials are wide, pentagonal, tumid plates. An arcuate subvertical area is below the outer ligamental area. An outer marginal ridge, a thin outer ligament furrow, and a sharp outer ligament ridge are present. The ridges are irregular but do not appear to be crenellate. The ligament pit is large and the ligament pit furrow is well developed. The transverse ridge is strongly developed and extends inward for quite a distance. Lateral furrows are deep and extend from the lateral ridges to the short intermuscular furrow. There is a fairly large central pit. There are no special oblique ridges, and the muscle areas pass into the lateral furrows. The lateral lobes are sharp and form the straight edges of the intermuscular notch. Adsutural slopes are pronounced. The entire inner articular facet slopes outward. The three anal plates are in normal or "primitive" arrangement. The radianal is long, oblique, and has a small node in its upper portion. The radianal is in contact with the right posterior basal to the right below and supports the RX above and the anal X to the left above. Anal X is elongate, rests solidly upon the posterior basal, and extends well above the summit of the cup. The columnar scar is round, marked by 25 crenellae, and has a small pentalobate lumen. The arms are unknown. The entire outer surface of the calyx is marked by fine pimplelike granulations, rather prolific on the outer edges of the infrabasal plates. Strong depressions are at all angles of the plates.

| Measurements in millimeters: | *Holotype OU 3964* |
|---|---|
| Width of cup (maximum) | 10.8 |
| Height of cup (to transverse ridge) | 4.0 |
| Width of infrabasal disk | 3.1 |
| Width of columnar scar | 2.3 |
| Length of left anterior basal | 4.2* |
| Width of left anterior basal | 3.7* |
| Length of right anterior radial (to transverse ridge) | 4.6* |
| Width of right anterior radial | 6.3* |

*Measurement taken along surface curvature.

*Remarks.*—The extraordinary bulbosity of the basal and radial plates of *P.? bulbosus* serve to distinguish it from other described forms. The name *bulbosus* is a Latin term meaning swollen.

*Types.*—Holotype, OU 3964, and paratype, OU 4590, are in the paleontological collections, The University of Oklahoma. Five paratypes are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

*Perimestocrinus papillatus,* new species
Plate 2, figures 5-8

The dorsal cup of *Perimestocrinus papillatus* is shallow, is broadly expanded, and has a deeply convex base. Strong notches at the juncture between radial articular facets give the cup a distinctive appearance when it is viewed from below. Five infrabasals form a subhorizontal platform at the bottom of the depressed basal area, and its mid-portion is sharply impressed by the columnar scar. Proximal edges of the five basals form almost vertical sides to the concavity and curve outward to participate in the sides of the dorsal cup. Five radials are wide and have strong protrusion in mid-section that creates an arcuate area below the outer ligamental area. An outer marginal ridge is almost confluent with a sharp outer ligament ridge. The intervening furrow is almost obliterated. The ligament pit is wide but rather short. The transverse ridge is thin, and no evidence of denticles has been observed. A mildly uplifted area is behind the transverse ridge, that is most prominent on each side of the shallow intermuscular furrow. Lateral furrows are rather well developed and extend to the intermuscular area. Oblique ridges are absent or are rudimentary. The muscle areas are more or less triangular and slope upward. Lateral ridges are sharp and adsutural slopes rather broad. The intermuscular notch is a sharply defined large V-shaped element. The central pit is fairly broad. Four anal plates are in the posterior interradius of the holotype; three of them are calyx plates in normal or "primitive" arrangement. The interradius is not depressed but the extensions of the radial plates give it a depressed appearance when the cup is viewed from below. In the holotype, anal X is directly upon the truncated upper edge of the posterior basal and is bordered to the right below by the long RA, to the right above by the RX, and directly above by $X_2$. The radianal is in contact with the right posterior basal. In a paratype, OU 4589, RA is a large plate that has contacted the left posterior radial and supports anal X above. The columnar scar is round and is marked

by 22 well-defined crenellae. The surface of the dorsal cup is marked by sharp granules that are rather widely spaced. The arms are unknown.

| Measurements in millimeters: | *Holotype OU 3965* |
|---|---|
| Width of dorsal cup (maximum) | 14.5 |
| Width of dorsal cup (posterior to anterior) | 13.3 |
| Height of dorsal cup (to transverse ridge) | 3.2 |
| Width of infrabasal circlet | 3.7 |
| Width of columnar scar | 2.3 |
| Width of left anterior basal | 3.3* |
| Length of left anterior basal | 4.6* |
| Width of left anterior radial | 7.8* |
| Length of left anterior radial (to transverse ridge) | 4.3* |

*Measurement taken along surface curvature.

*Remarks.*—The surface ornamentation of *P. papillatus* and the strong bulge across the radial plates are somewhat like those found in *P. formosus* Moore and Plummer (1940). However, the granules or nodes of *P. papillatus* are much less numerous than those in *P. formosus,* and the basal invagination is more pronounced in the latter species. The specific name is the Latin adjective *papillatus,* meaning budlike.

*Types.*—Holotype, OU 3965, and paratype, OU 4589, are in the paleontological collections, The University of Oklahoma. Two paratypes are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

### *Perimestocrinus impressus* Moore and Plummer, 1940
Plate 2, figures 9-12

The present specimens of *Perimestocrinus impressus* do not agree in all respects with the characteristics of the holotype of the species, but apparently Moore and Plummer intended to leave considerable latitude. The figured holotype is a rather compact calyx with erect lateral sides. The figured paratype is a rather broad, low specimen with a shape much like that of *Perimestocrinus hexagonus* Strimple. Specimens from the Oologah Limestone ascribed to the species *P. impressus* are not quite as compact at the holotype, nor are the lateral sides as erect, yet they are not so low as the

figured paratype and are not so angular appearing as viewed from above or below. The Ologah specimens are covered with small granules that are somewhat coarser than normal for the species, but not so coarse as those in *P. formosus* or *P. papillatus*. The slight overhang of the infrabasals by the basals is not so pronounced as in the holotype of *P. impressus*.

It is of some interest that the holotype of *P. impressus* is reportedly of Missourian age and the paratype of Desmoinesian age, both from Texas.

*Plesiotypes*.—OU 3966 and OU 4578 are in the paleontological collections, The University of Oklahoma. Three plesiotypes are in the Springer Collection, U. S. National Museum.

*Occurrence*.—Garnett quarry locality.

## Genus *Sciadiocrinus* Moore and Plummer, 1938

The generic concept used herein is that originally proposed by Moore and Plummer. The original concept is strengthened by the determinations given by Strimple (1961).

*Genotype. — Zeacrinus (Hydreionocrinus?) acanthophorus* Meek and Worthen, 1870.

*Occurrence*.—Pennsylvanian; North America.

### *Sciadiocrinus harrisae* Moore and Plummer, 1940
Plate 9, figures 5, 6

Such a wide variance exists between specimens of *Sciadocrinus harrisae* that one is led to to suspect the existence of several species but gradation from one form to another has forced me to conclude that no purpose would be served by separation.

The species is characterized by bulbous radials that provide the entire height of the cup and curve strongly into the basal concavity. The bulbosity is not so pronounced in the holotype as in the figured paratype. Specimens found in the Ologah Limestone are more like the paratype figured by Moore and Plummer (specimen K. U. 6026C). The body cavity is so shallow that one must presume that some of the visceral parts extended into the area above the calyx. This thesis is substantiated by the relatively large anal plates that extend well above the summit of the calyx. Instead of tapering distad, the anal plates widen in many specimens. Pre-

sumably it has a large sac, probably somewhat like the anal sac of *Schedexocrinus* Strimple (1961). Unfortunately of *S. harrisae* only the calyx is known. Moore and Plummer (1940) reported the exterior of the cup plates to be smooth; in most specimens from the Oologah Limestone this is the case, but there are a few specimens that have pronounced granular ornamentation. One plesiotype, OU 3963, broke almost exactly in half during preparation and affords a natural cross section of the dorsal cup. It is figured at plate 9, figure 5. The extraordinary thickness of the radial plates is disclosed by the illustration.

*Types.*—Plesiotypes, OU 3963, and aberrant specimen, OU 4567, from the Garnett quarry locality, and OU 4559, from Interstate Highway 44 locality, are in the paleontological collections, The University of Oklahoma. Several plesiotypes, as well as aberrant specimen (01-1), are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality and Interstate Highway 44 locality.

## Genus *Schistocrinus* Moore and Plummer, 1940

### *Schistocrinus ovalis* Strimple, 1951

The monotype of *Schistocrinus ovalis* was found at Garnett quarry and is deposited in the Springer Collection, U. S. National Museum. I have found no other representative. It may well be that the specimens figured herein as *Sciadocrinus praecursor* are related to, or conspecific with, *Schistocrinus ovalis*. The form of the junction of radial plates with infrabasal plates may not be of generic or even of specific significance among these forms.

*Occurrence.*—Garnett quarry locality.

## Genus *Plaxocrinus* Moore and Plummer, 1938

The generic concept used here is that originally proposed by Moore and Plummer (1938) as interpreted by Strimple (1961). The genus is represented in the Oologah Formation by a form assigned to *Plaxocrinus aplatus* and a form tentatively ascribed to *P. obesus*.

*Genotype.—Hydreionocrinus crassidiscus* Miller and Gurley, 1894.

*Occurrence.*—Pennsylvanian; North America.

### *Plaxocrinus? obesus* Moore and Plummer, 1940
Plate 7, figure 19

The form of *Plaxocrinus? obesus* presented here is probably not a true representative of the species. The species itself is not a true representative of the genus (Moore and Plummer, 1940). There is some indication of close relationship between specimens from the Oologah Limestone and the highly variable species *Sciadiocrinus harrisae* (Moore and Plummer). However, a complete series of variants linking the two forms has not been observed. The dorsal cup of the figured plesiotype is 21.5 mm wide by 5.4 mm high.

*Plesiotype.*—OU 3996 is figured herein and is in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality.

### *Plaxocrinus aplatus* Moore and Plummer, 1940
Plate 1, figure 5-8; plate 2, figures 13-16

Specimens found in the Oologah Limestone have characteristics so close to those ascribed to *Plaxocrinus aplatus* that assignment is possible with only slight hesitation. One specimen broke during preparation and afforded a natural cross section (pl. 1, fig. 6). A young specimen with slight notches between radials is figured on plate 2, figures 13-16. It is designated as a plesiotype, OU 3968, and demonstrates a possible affinity with *Laudonocrinus catillus.* The impressed sutures and decided basal concavity distinguish the species from *Laudonocrinus.*

The holotype and paratype of the species are from the Mineral Wells Shale Formation, Strawn Group, Desmoinesian, of Palo Pinto County, Texas.

*Plesiotypes.*—OU 3952 from Garnett quarry and OU 3968 from State Highway 33 locality are in the paleontological collections, The University of Oklahoma. Five plesiotypes from Garnett quarry are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality; State Highway 33 locality.

## Genus *Athlocrinus* Moore and Plummer, 1940

The generic concept used herein is that proposed by Moore and Plummer (1940) without modification. The arms and tegmen of the genus *Athlocrinus* are not known. One species from the Oologah Formation is described as *Athlocrinus clarus,* new species.

*Genotype.—Athlocrinus placidus* Moore and Plummer, 1940.

*Occurrence.*—Pennsylvanian; North America.

### *Athlocrinus clarus,* new species
Plate 1, figures 1-4

The dorsal cup of *Athlocrinus clarus* is a shallow bowl with an almost flat basal area except for the sharply impressed columnar scar. Five infrabasals form a pentagonal disk, with the outer edges mildly upflared. The five basals form the remainder of the broad base and curve upward so that their upper extremities are visible in side view of the cup. Five radials are bulbous, are considerably wider than long, and form almost all of the subvertical walls of the cup. Weak notches are at the summit plane between the radials. In the outer ligamental area, the outer marginal ridge is well defined and is backed by a furrow in front of a pronounced ligament pit. The transverse ridge is ill defined. Small triangular oblique furrows are at the lateral corners of the facets, with fine denticles marking the adjoining sloped areas. Diagonally placed ligament furrows are directed inward, but, being blocked by a mild rise, they do not join those at the lateral extremities. The ligament furrows terminate at the intermuscular furrow between the triangular central pit and the intermuscular notch. Muscle areas are large and flattened. In the forepart of the adsutural area there is normally a raised ridge, a continuation of the surface from the exterior surface of the cup. The sutures appear to be marked by fine crenellations. The posterior interradius is moderately wide and may be slightly less protruded than the normal perimeter of the cup, or may be mildly convex. Three anal plates are in normal or "primitive" arrangement in the calyx. The radianal is a small, elongate, pentagonal plate, in contact with the right posterior basal. Anal X and RX are large, elongate plates. X is somewhat narrower and longer than RX so that the latter plate extends only a slight distance above the summit of X. The two plates support $X_2$. In addition RX has a facet directly above for the reception of another

plate, and toward the interior on the right side is a small facet for the reception of a tube plate. Anal X normally has a small facet on the left inner side for the reception of a small tube plate. Under low magnification the entire surface of the cup is seen to be covered by fine, closely spaced granules. The arms are unknown. The columnar scar is round, marked by 26 fairly short crenellae and is pierced by a small, pentagonal lumen.

| Measurements in millimeters: | *Holotype OU 3954* |
|---|---|
| Width of cup (maximum) | 13.7 |
| Width of cup (posterior to anterior) | 12.2 |
| Height of cup | 4.3 |
| Length of left posterior basal | 2.5* |
| Width of left posterior basal | 3.7* |
| Length of left anterior radial | 5.0* |
| Width of left anterior radial | 8.2* |
| Width of infrabasal circlet | 4.0 |
| Width of columnar scar | 2.2 |

*Measurement taken along the surface curvature.

*Remarks.*—The species is rather close to *Athlocrinus clypeiformis* Moore and Plummer, from the Graford Formation, Missourian of Texas. *A. clarus* has a deeper cup with a narrower posterior interradius and the raised rim about the columnar scar is more pronounced than that in *A. clypeiformis.* The specific name is the Latin *clarus,* meaning clear.

*Types.*—Holotype, OU 3954, from the Garnett quarry locality, and paratype, OU 4558, from Interstate Highway 44 locality, are in the paleontological collections, The University of Oklahoma. One paratype from the State Highway 33 locality is in the Springer Collection, U. S. National Museum.

*Occurrence.* — Garnett quarry locality; State Highway 33 locality; Interstate Highway 44 locality.

## Genus *Lasanocrinus* Moore and Plummer, 1940

The generic concept proposed by Moore and Plummer (1940) is followed here; however, I do not agree with the conspecific concept that embraces specimens from the Brentwood Limestone Member with those of the Wapanucka Formation.

*Genotype.—Hydreionocrinus daileyi* Strimple, 1940.

*Occurrence.* — Morrowan and Desmoinesian, Pennsylvanian; North America.

### *Lasanocrinus altamontensis* Strimple, 1950

*Lasanocrinus altamontensis* was assigned to the genus *Lasanocrinus* by Strimple (1950). It is indeed closer to that genus than to other known genera. The shallow, broad basal area indicates possible relationship with *Metaperimestocrinus* Strimple (1961), but some knowledge of the arms is desirable before close comparison is made. The holotype is from an exposure that is no longer productive, and I have found no specimen other than the monotype. One specimen, OU 4588, from the State Highway 33 locality, is assigned to the species with hesitation. It has the exaggerated protrusion of the radial plates, but the basal plates are more bulbous than are those in the holotype, and there is a decided basal concavity partly due to the protrusion. The species *Perimestocrinus? bulbosus* is somewhat comparable but has a deep basal concavity, longer articular facets on the radials, and radials that are not produced downward so noticeably as in *L. altamontensis.* I suspect that the two are closely related.

*Holotype.*—The holotype was found in the road cut at the 31st Street locality and is in the Springer Collection, U. S. National Museum.

*Occurrence.*—State Highway 33 locality; 31st Street locality.

### Genus *Metaperimestocrinus* Strimple, 1961

It is not desirable to use the genus *Metaperimestocrinus* without knowledge of the arms and/or tegminal termination. However the absence of a decided basal concavity is characteristic of the genus. This, together with other characteristics that are normally ascribed to *Perimestocrinus* and/or *Stenopecrinus,* serves to distinguish the genus.

*Genotype.—Metaperimestocrinus spiniferus* Strimple, 1961.

*Occurrence.*—Pennsylvanian; North America.

### *Metaperimestocrinus trapezoidalis,* new species
Plate 7, figures 15-18

The dorsal cup of *Metaperimestocrinus trapezoidalis* is a medium-truncate bowl having subhorizontal infrabasals. Five infra-

basals form a flattened base with a sharply impressed columnar scar. The basal concavity is shallow but in other respects the calyx is much like that of *Perimestocrinus* or *Stenopecrinus*. The proximal edges of the five basals are curved to provide a mild basal depression; thence they curve upward to form a basal plane and continue on into the lateral walls of the cup. Five large radials are somewhat wider than long and have a flat arcuate area below the outer articular facets. An outer marginal ridge and a well-defined pit are in the outer ligament area. In the inner articular area, a transverse ridge and well-defined lateral furrows continue to the intermuscular furrow just in front of the intermuscular notch. Muscle areas are flat and triangular. The articular facets have a mild outward slope. On the holotype, five anal plates in the anal pyramid and one tube plate are preserved. Three anal plates enter into the dorsal cup and are in normal or "primitive" arrangement. The entire anal area is moderately narrow and slightly protruded. RA is in contact with the right posterior basal, with X to the left above, and with RX directly above. X is in contact with the posterior basal and supports $X_2$ above. RX supports $RX_2$ directly above and, on the inner side, supports a tube plate that is about the same size as $RX_2$ but appears to be much thinner. In paratype OU 4579, the posterior interradius is narrow. RA completely dominates the area and supports the elongate X above. RX is entirely eliminated. The outer surface of the cup appears granular under low magnification. The granules are normally sharply pointed and are not closely spaced. Sutures between plates are mildly impressed and all plates except the infrabasals are slightly tumid. The columnar scar is round and has 18 crenellae in the holotype and a small, circular lumen.

| Measurements in millimeters: | *Holotype OU 3981* |
|---|---|
| Height of cup | 3.7 |
| Width of cup (maximum) | 10.2 |
| Width of cup (posterior to anterior) | 9.3 |
| Width of infrabasal circlet | 3.2 |
| Width of columnar scar | 1.9 |
| Length of left anterior basal | 3.6* |
| Width of left anterior basal | 3.2* |
| Length of left anterior radial | 3.2* |

| | |
|---|---|
| Width of left anterior radial | 5.2* |

*Measurement taken along surface curvature.

*Remarks.*—The small size, compact and erect calyx, and narrow posterior interradius serve to distinguish *M. trapezoidalis* from other described forms.

*Types.*—Holotype, OU 3981, from State Highway 33 locality; paratype, OU 4560, from Interstate Highway 44 locality; and advanced paratype, OU 4579, from the Garnett quarry locality are all in the paleontological collections, The University of Oklahoma.

*Occurrence.*—State Highway 33 locality; Garnett quarry locality; Interstate Highway 44 locality.

## Genus *Bathronocrinus,* new genus

*Bathronocrinus* is distinctive in having gently upflared infrabasals with the entire cup shallowly conical. Viewed from below the cup shows well-defined notches between the radials at the summit of the cup. The name is derived from the Greek *bathron,* meaning base.

Five infrabasals project beyond the impressed columnar scar and are slightly upflared and visible in side view of the cup. The five basals are moderately large and are six-sided except where affected by contact with the anal plates. Five radials are the dominant plates of the cup. Articular facets slope mildly outward. Three anal plates are partly or entirely within the cup and are in normal or "primitive" arrangement. The column is round; the arms are unknown.

*Remarks.*—This is a small form. It has some of the characters of *Laudonocrinus* Moore and Plummer. That genus is characterized by the absence of a decided basal concavity and by the smoothness of the surfaces of the calyx. Actually there is normally a mild basal concavity. The lateral sides of the cup are more or less erect and give a bowl shape to the cup. *Bathronocrinus* has an even expansion starting at the columnar scar, and little curvature is in the upper extremities of the radials other than to produce the pronounced notches at the summit of the cup between radial plates. Close affinity with *Athlocrinus* Moore and Plummer seems more likely. The form described as *Hydreionocrinus deweyensis* Strimple is assigned to *Bathronocrinus.*

*Genotype.—Bathronocrinus turioformis,* new species.
*Occurrence.*—Pennsylvanian; North America.

*Bathronocrinus turioformis,* new species
Plate 1, figures 15-18

The generic description is also applicable to *Bathronocrinus turioformis,* which is the genotype. The outer ligament area of the radial plate is rather limited and the outer marginal ridge is sharp. A median ridge divides the area into two parts. The ligament pit is well defined and the inner ligamental area slopes outward. The species has a transverse ridge, a large central pit, and a short intermuscular furrow. Pronounced ligamental furrows start at the lateral corners and extend to the fore of the intermuscular notch. Resultant muscle areas are flat and triangular. The outer surface tends to continue into the adsutural areas between articulating areas. The sides of the columnar scar slope rather evenly from the perimeter to the small pentagonal lumen. About 20 crenellae are present. The entire surface of the cup appears finely frosted under low magnification.

The specific name is derived from the Latin *turio,* meaning shoot or sprout.

| Measurements in millimeters: | *Holotype OU 3956* |
|---|---|
| Height of dorsal cup (to transverse ridge) | 2.7 |
| Width of dorsal cup (maximum) | 11.8 |
| Width of cup (posterior to anterior) | 10.7 |
| Width of infrabasal disk | 3.7 |
| Width of columnar scar | 2.0 |
| Length of left anterior basal | 2.2* |
| Width of left anterior basal | 3.4* |
| Length of left anterior radial | 2.8* |
| Width of left anterior radial | 6.0* |

*Measurement taken along surface curvature.

*Types.*—Holotype, OU 3956, and paratype, OU 4577, are from the State Highway 33 locality. OU 4582 is aberrant and is from the Garnett quarry locality. All are in the paleontological collections The University of Oklahoma. One paratype from the Garnett quarry locality is in the Springer Collection, U. S. National Museum.

*Occurrence.*—State Highway 33 locality; Garnett quarry locality.

## Genus *Galateacrinus* Moore, 1940

### *Galateacrinus stevensi* Moore, 1940

Of fourteen observed topotypes of *Galateacrinus stevensi,* only seven have three anal plates in perfectly normal (primitive) arrangement. There are several variants. In one the anal X is unusually expanded and suppresses RX. In some instances, the rudimentary RX is not even visible in side view of the cup but is visible from above as a small triangular element. In two specimens, RA is in contact with the left posterior radial, placing it between the posterior basal and anal X.

Several minor variants differ in cup shape and/or ornamentation, but in general the topotypes agree remarkably well with those characteristics ascribed to the species. One immature specimen has been found, in addition to the above-discussed topotypes, in which part of the cup (including the posterior interradius) is missing. It is approximately 5.5 mm wide. One of the larger topotypes is 13.4 mm wide. In the small specimen, the left anterior, anterior, and right anterior infrabasals have rounded outer terminations, whereas the left posterior and right posterior infrabasals have pointed terminations.

*Types.*—Ten of the topotypes studied are in the Springer Collection, U. S. National Museum. Four topotypes, OU 4571, and two specimens, OU 4551, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Topotypes are from Garnett quarry locality; specimens OU 4551 are from the Interstate Highway 44 locality.

## Family Cromyocrinidae Jaekel, 1918

## Genus *Metacromyocrinus* Strimple, 1961

### *Metacromyocrinus minutus,* new species
Plate 4, figures 12-15

The dorsal cup of *Metacromyocrinus minutus* is of medium height and is a truncate bowl with subhorizontal infrabasals. The five infrabasals have an upflared appearance, but there is a mild over-all basal concavity that prevents the plates from being visible in side view of the cup, except in the impressed interbasal areas. The columnar scar is sharply impressed. Five basals are rather

large and are six-sided except where contact is made with anal plates. Five radials are wide plates with their greatest width slightly below the summit of the plate. The articular facets are poorly preserved. The facets slope inward and the outer ligament area is deeply impressed. Two anal plates are present. The RA is quadrangular, elongate, and narrow. Anal X is fundamentally five-sided and rests evenly upon the posterior basal, with a right shoulder on RA. It does not extend far above the summit of the cup. The columnar scar is round, is marked by about 30 crenellae, and has a small pentalobate lumen.

| Measurements in millimeters: | *Holotype USNM* |
|---|---|
| Height of cup | 8.7 |
| Width of cup | 14.5 |
| Width of infrabasal circlet | 6.0 |
| Width of columnar scar | 2.5 |
| Length of left anterior basal | 7.1* |
| Width of left anterior basal | 7.3* |
| Length of left anterior radial | 5.5* |
| Width of left anterior radial | 8.9* |

*Measurement taken along surface curvature.

Ornamentation is obscured on the holotype, but there are faint remnants of three tuberclelike ridges on each infrabasal and of irregular nodes and ridges on the remainder of the cup. Sutures are strongly impressed, and there is indication of nodes and depressions along the edges of the sutures between plates. Strong nodes and tubercles are found on plates of a disarticulated cup from the State Highway 33 locality. The articulated infrabasal circlet and disarticulated basal and radial plates are designated as a paratype, OU 4580.

*Remarks.*—The infrabasals are slightly more prominently upflared than is typical for the genus; this feature serves to distinguish it from other described species. The name of the species is the Latin adjective *minutus,* meaning small.

*Types.*—The holotype is in the Springer Collection, U. S. National Museum. Paratype, OU 4580, is in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Holotype is from 31st Street locality; paratype is from State Highway 33 locality.

## Family Stellarocrinidae Strimple, 1961

### Genus *Stellarocrinus* Strimple, 1940

*Synonymy.—Whiteocrinus* Strimple, 1939 (not Jaekel), *Apollocrinus* Moore and Plummer, 1940, *Brychiocrinus* Moore and Plummer, 1940.

There have been no appreciable changes in the generic concept of these forms since the original description. Comprehensive consideration of the forms was given by Moore and Plummer (1940). The latest comprehensive usage is by Strimple (1961).

*Genotype.—Cyathocrinus stillativus* White, 1879.

*Occurrence.* — Pennsylvanian and Lower Permian; North America.

### *Stellarocrinus angulatus* (Miller and Gurley), 1894
Plate 3, figures 2-4

The distinguishing feature of *Stellarocrinus angulatus* is the complete absence of ridges or granules on the surface of the cup. The holotype has a broad low cup, comparable to the presently considered specimen. Although the type is from the Missourian (probably Lane Shale) at Kansas City, Missouri, I have considered this Desmoinesian specimen to be conspecific. It may well be that more complete specimens from either or both localities will provide information disclosing differences.

The plesiotype from the Oologah Limestone discloses a feature that has escaped my attention to this time. This feature is a small plate on the left shoulder of the left posterior radial. It is the same as an interbrachial plate of a camerate or a flexible crinoid. Close examination shows that small shelflike grooves are provided for the reception of two such plates in each interradius except the posterior, where anal plates are present.

Plesiotype, OU 4570, has a maximum width of 17.8 mm and a height to the transverse ridge of 3.2 mm. The arms are not known for the species.

*Plesiotype.*—OU 4570 is in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality.

*Stellarocrinus minimus,* new species
Plate 3, figures 5-7

The dorsal cup of *Stellarocrinus minimus* is of medium height and has a truncate bowl shape. The base is mildly depressed, or slightly above the basal plane, but is subhorizontal except for the sharply impressed columnar attachment. Ridges on the basal plates form the basal plane. Five infrabasals form a pentagonal disk. Five basals form part of the flattened base and curve sharply upward to participate in the cup walls. Five radials are wide pentagonal plates. The articular facets of the holotype are not well preserved but a paratype provides the following data. The outer marginal ridge is well defined and is backed by a flat, crenellated area that is rather long and continues to the poorly defined ligament furrow and sharply defined ligament pit. The transverse ridge is not prominent. A small central pit and a well-defined intermuscular furrow are present. Broad muscle areas are interrupted by a transverse, shallow depression toward the inner side of each area. Adsutural areas are wide and represent a continuation of the outer cup surface for about half their total length, at which a slight rim is formed. (In *S. planoconvexus* an interbrachial plate has been found at this point.) One primibrach has been observed in a paratype. It is axillary, not quite so long as high, has short lateral sides, and is highly ornate. The suture between it and the radial is gaping. It has a keellike ridge along its length and a transverse ridge along the lower portion. Although it does not extend the full width of the plate, a short transverse ridge crosses the plate at the height of the lateral sides. Only one anal plate is preserved in the holotype; it is pentagonal and rests evenly upon the posterior basal. There is provision above for two anal plates of about equal size. The higher plates would have their lower extremities below the summit of the cup. Ornamentation of the radial plate consists mainly of a pair of longitudinal ridges that pass onto the two basal plates below. The ridges do not meet. A transverse ray is present on each upper section and joins with similar rays on adjoining radials. These rays do not join with the longitudinal rays. On the basal plates, a pair of main longitudinal rays joins with those from the radials. They meet on the basal plates at a point well above the transverse ridges that form the lowest point of the calyx. The transverse basal

ridge is confluent and forms a pentalobate outline, which is also the basal plane. The columnar scar is round and is marked by 21 crenellae.

| Measurements in millimeters: | *Holotype USNM* |
|---|---|
| Width of cup (maximum) | 11.0 |
| Width of cup (posterior to anterior) | 10.0 |
| Height of cup (to transverse ridge) | 4.0 |
| Height of cup to summit of adsutural areas | 5.0 |
| Length of left anterior basal | 3.8* |
| Width of left anterior basal | 4.4* |
| Length of left anterior radial (to transverse ridge) | 3.7* |
| Width of left anterior radial | 6.6* |
| Width of infrabasal circlet | 3.0 |
| Width of columnar scar | 2.1 |
| Height of first primibrach** | 3.5 |
| Height of lateral sides of first primibrach | 1.0 |
| Width of first primibrach** | 4.6 |

*Measurement taken along surface curvature.
**Paratype.

*Remarks.*—*S. minimus* is closer to *Stellarocrinus distinctus* Strimple than to any other described species. In *S. minimus* the pointed development in mid-portion of the basal plate, where the ridges converge, is not so pronounced nor so protuberant as in *S. distinctus.* The latter species also has more pronounced depressions in the areas between ridges, which in turn give it a more angulate appearance. The name of the species is the Latin *minimus,* meaning least.

*Types.*—Holotype and one paratype (partial cup) are in the Springer Collection, U. S. National Museum. Two paratypes, OU 4572, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality.

## Genus *Exocrinus* Strimple, 1949

### *Exocrinus desmoinesensis* Strimple, 1949

The holotype of *Exocrinus desmoinesensis,* which is also a monotype, was collected at the old exposure of the Oologah Limestone at the 31st Street locality. The specimen is in the Springer Collection, U. S. National Museum. No other specimen of the species has been found.

## Family Texacrinidae Strimple, 1961

## Genus *Haeretocrinus* Moore and Plummer, 1940

### *Haeretocrinus depressus,* new species
Plate 1, figures 9-12; plate 7, figures 5-7

The dorsal cup of *Haeretocrinus depressus* is of medium height and is conical, with upflared infrabasals. It is asymmetrical, with the posterior side being protuberant. The five infrabasals flare evenly upward from the columnar attachment. Five large basals have six sides except for extra facets in the posterior interradius. Five radials are rather large and are pentagonal. Because the articular facets are poorly preserved in the holotype, the description is taken from the young paratype in which the facets are short and slope slightly inward. The outer ligament ridge is strongly developed and is bordered on the inner side by fine denticles. The ligament pit is shallow and well defined. The transverse ridge is not especially prominent. No intermuscular notch is present, but the intermuscular furrow is well developed. It is outlined by raised edges. Two furrows to the right and left form prominent lateral furrows in what would normally be a portion of the muscle area behind the regular lateral furrows which are adjacent to the transverse ridge. The regular lateral furrows are weakly defined in this species. Muscle areas are small. Lateral ridges and adsutural slopes are poorly defined. The posterior interradius is wide and somewhat convex. Three large plates are in normal, or "primitive," arrangement. In the holotype, the right shoulder of the left posterior radial is even with the left shoulder of anal X, and the upper surface of X is diagonal, rising from left to right. The young paratype has a complex of facets for the reception of anal tube plates on the upper surfaces of X and RX. Anal has a strong curvature, especially in the upper left portion. There are two small facets for reception of plates and a half-facet in conjunction with another on the RX. Besides the half-facet, three smaller facets are on the RX. In the holotype, depressions are present at the corners of each plate. The column is round, the lumen is pentalobate, and in the holotype, the columnar scar has about 35 crenellae. The arms are unknown.

| Measurements in millimeters: | *Holotype OU 3997* | *Young Paratype OU 3953* |
|---|---|---|
| Width of cup (maximum, posterior to anterior) | 13.7 | 10.5** |
| Width of cup (minimum) | 13.0 | — |
| Height of cup | 7.0 | 4.1** |
| Width of infrabasal circlet | 4.9 | 2.8 |
| Width of columnar scar | 2.0 | 1.4 |
| Length of left anterior basal | 5.2* | 4.1* |
| Width of left anterior basal | 5.0* | 3.7* |
| Length of left anterior radial | 4.5* | 2.9* |
| Width of left anterior radial | 7.0* | 5.0* |

*Measurement taken along surface curvature.
**Distorted.

*Remarks.*—In *Haeretocrinus missouriensis,* the genotype, the radianal plate reaches the left posterior radial, with X above. This is a considerably more advanced condition than that in *H. depressus,* wherein X rests evenly upon the posterior basal. *H. turbinatus* has an unusual arrangement in which the upper surfaces of X and RX form an even plane. The specific name *depressus* is the Latin term meaning pressed down, low.

*Types.*—Holotype, OU 3997; paratype (young), OU 3953; and paratype, OU 4592, are in the paleontological collections, The University of Oklahoma. One paratype is in the Springer Collection, U. S. National Museum.

*Occurrence.*—Holotype, OU 3997, and paratype (young), OU 3953, were collected in the fall of 1959 from the Garnett quarry locality. Paratype, OU 4592, was collected by Jack Hood (obtained from Leon Gilmore) in the fill just west of Mayo Road, NE¼ NE¼ sec. 5, T. 19 N., R. 14 E. One paratype collected at the abandoned quarry in the SE¼ SW¼ sec. 18, T. 20 N., R. 14 E., is in the Springer Collection, U. S. National Museum.

## Genus *Texacrinus* Moore and Plummer, 1940

### *Texacrinus associatus* Strimple, 1952

I have not found another specimen of *Texacrinus associatus* and the holotype remains a monotype. It is from the Garnett quarry locality and is in the Springer Collection, U. S. National Museum.

## Family APOGRAPHIOCRINIDAE Moore and Laudon, 1943

### Genus *Apographiocrinus* Moore and Plummer, 1940

The utter simplicity of the genus *Apographiocrinus,* yet the ease with which it may be distinguished from other genera on the basis of apparently minor characteristics, demonstrates the practicability of such media for determinations. The genus does not appear to differ appreciably from some species of *Graphiocrinus* or *Endelocrinus.* All three forms are rather small and are comparable in the general contour of cup, number and distribution of cup plates, including the single anal plate, and the number and type of arms (exception is that many species of *Endelocrinus* develop biserial arms in their upper portions). *Apographiocrinus* is readily separable because the arm-articulating facets of the radial plates do not fill the upper face of the plates and are in fact separated by low partitionlike extensions between the facets. One other characteristic is the anal plate, which in *Apographiocrinus* normally widens above the summit of the cup and has two thin facets for the reception of two tube plates. As a matter of interest, Pennsylvanian species of *Graphiocrinus* have an anal plate succeeded by a single tube plate. The anal plate is rather thin and may be marked on the upper surface by crenellations. In *Endelocrinus,* the anal plate is also succeeded by a single tube plate, but the facet is thick and is marked by a subcircular, depressed muscle scar.

Representatives of the genus are fairly common in some exposures of the Oologah Limestone. *Apographiocrinus quietus* Strimple, *A. angulatus* Strimple, *A. obtusus* Strimple, and *A. rotundus* Strimple were fairly common at the 31st Street exposure, which is the type locality for each of these species. Several years ago, in one exposure at Garnett quarry, they were abundant. Some 98 specimens from the Garnett quarry exposures are in the Springer Collection, U. S. National Museum, and are divided into species as follows:

| | *Number of specimens* |
|---|---|
| *Apographiocrinus angulatus* | 7 |
| *Apographiocrinus quietus* | 52* |
| *Apographiocrinus obtusus* | 25* |
| *Apographiocrinus rotundus* | 16 |

*One specimen aberrant.

Some question exists as to the practicability or validity of having more than one species of the same genus from the same exposure and time. My observation has been that little intergradation occurs in this group. At least I had no difficulty in separating the specimens into the previously established species. The forms are quite different from each other. For example, from a casual observation, *A. rotundus* does not even appear to be congeneric with *A. angulatus*. Surprisingly few mutants or atypical specimens occur, with only the single anal plate being involved.

Typically the anal plate is in solid contact with the posterior basal. In one specimen of *A. obtusus* the anal plate is not in contact with the posterior basal. One specimen of *A. rotundus,* OU 4568, in the paleontological collections of The University of Oklahoma, has this same development. One specimen of *A. quietus* has an extra facet for reception of a third tube plate.

*Genotype.—Apographiocrinus typicalis* Moore and Plummer, 1940.

*Occurrence.*—Pennsylvanian; North America.

Family ETHELOCRINIDAE Strimple, 1961

Genus *Parethelocrinus* Strimple, 1961

*Parethelocrinus* sp.

Although all of the fundamental features of the dorsal cup of *Parethelocrinus* sp. are preserved, excessive weathering of the basal and summit portions has prevented my making a definite specific identification at this time. The dorsal cup has a maximum width (posterior to anterior) of 35.4 mm and an approximate height of 14.7 mm. The specimen, OU 3991, is in the paleontological collections, The University of Oklahoma. It was collected in the fill just west of Mayo Road at the intersection with State Highway 33. This material was taken from the excavation of Interstate Highway 44 about one block to the east of the fill.

Family AMPELOCRINIDAE Kirk, 1942

Genus *Aesiocrinus* Miller and Gurley, 1890

*Aesiocrinus basilicus* Miller and Gurley, 1890

Plate 3, figures 8-11

The simplicity of the dorsal cup of this type of crinoid makes it most difficult to establish diagnostic characteristics without

knowledge of arm or anal-tube structures. Tentative assignment is made to *A. basilicus* because of the wide nature of the cup, absence of basal concavity, and the erect sides of the cup, which are all characteristics of that species. *A. barydactylus* (Keyes), except for a slight but distinct basal concavity, has a comparable dorsal cup.

Ages of the Lane Shale (Missourian) and the Oologah Limestone (Desmoinesian) are quite different. It is probable that differences will be found if a crown of the Oologah form is discovered. Only one specimen of the species has been found; this was in the spring of 1960. The articular facets are poorly preserved but are adequate for some observation as to size and attitude. The facets are relatively long, are subhorizontal, and completely fill the upper extremities of the radials.

*Plesiotype.*—OU 3986, paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality.

Suborder CYATHOCRINOIDEA Bather, 1899

Family CODIACRINIDAE Bather, 1899

Genus *Lecythiocrinus* White, 1879

*Lecythiocrinus optimus* Strimple, 1951

The holotype of *Lecythiocrinus optimus* came from the 31st Street exposure of the Oologah Limestone and is in the U. S. National Museum. One poorly preserved specimen has been subsequently collected there and is designated as a metatype, OU 4593. In addition to the holotype, three specimens from the Garnett quarry locality are in the Springer Collection, U. S. National Museum.

Subclass CAMERATA Wachsmuth and Springer
Order MONOBATHRA Moore and Laudon, 1943

Family ACROCRINIDAE Wachsmuth and Springer, 1885

Genus *Acrocrinus* Yandell, 1846

*Acrocrinus expansus* Strimple, 1951

The holotype of *Acrocrinus expansus* came from Garnett quarry. One other specimen has subsequently been found and is

here designated as a metatype. Both specimens are in the Springer Collection, U. S. National Museum.

*Occurrence.*—Garnett quarry locality.

## Subclass FLEXIBILIA Zittel
## Order SAGENOCRINOIDEA Springer, 1913

### Family LECANOCRINIDAE Springer, 1913

### Genus *Cibolocrinus* Moore and Plummer, 1938

### *Cibolocrinus detrusus* Strimple, 1951

One complete cup of *Cibolocrinus detrusus* has been found at Garnett quarry, but it is poorly preserved. A cup from the Interstate Highway 44 locality has been partly restored to show the large size attained by the species.

Measurements in millimeters:

| | *OU 3982* | *OU 4573* |
|---|---|---|
| Width of cup | 28.1 | 40.0** |
| Height of cup | 10.4 | 11.4 |
| Width of left anterior basal | 16.0* | |
| Length of left anterior basal | 14.2* | |
| Width of left anterior radial | 19.6* | |
| Length of left anterior radial | 10.4* | |
| Width of anal plate | 11.0* | |
| Length of anal plate | 8.2* | |
| Width of infrabasal circlet | 11.6 | 10.6 |

*Measurement taken along surface curvature.
**Estimated.

The cup affords little additional data of specific importance. The anal plate is relatively large, the calyx is broad and rather low, and the base is slightly concave. Several disarticulated cup plates and arm segments representing one specimen have been found in soft shales. A tendency for granules to become confluent and form rays has been observed on many radial and basal plates.

*Specimens.*—OU 3982 is from Garnett quarry; partially restored specimens, OU 4555 and OU 4573, are from Interstate Highway 44 locality. They are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality; Interstate Highway 44 locality.

## Family Synerocrinidae Jaekel, 1918
## Genus *Amphicrinus* Springer, 1906
## *Amphicrinus carbonarius* Springer, 1906
Plate 5, figures 3-5

*Amphicrinus carbonarius* was established on the basis of an imperfectly preserved crown. The upper arms of the specimen are rather well preserved but the dorsal cup is not preserved. Laudon (1937) figured a specimen from the Oologah Limestone at Garnett quarry and assigned it to *A. carbonarius*. Unfortunately the outermost portions of the arms are not preserved in Laudon's specimen nor in any of the specimens subsequently collected. Exact comparison and identification is therefore not possible at this time.

None of the presently studied specimens agrees too closely in all respects with the specimens described by Laudon. Primarily, the major differences are in the interrays. The current specimens exhibit diversity among themselves. The figured specimen of Laudon has a long posterior basal plate, extending well out of the depressed area occupied by the proximal columnal. Anal X is succeeded by $X_1$, $X_2$, and LX and $X_3$. Expressed in another way, the single anal plate is followed by one anal plate, which is in turn followed by one anal plate, but there are two plates in the next position.

In specimen 1—Springer Collection—the posterior basal extends only slightly beyond the impressed columnar scar, and anal plates are X, $X_1$, LX and $X_2$, $LX_1$ and $X_3$, $LX_2$ and $X_4$, with the probability that other small plates succeeded these but have not been preserved.

In specimen 2—Springer Collection—the posterior basal extends only slightly beyond the impressed columnar scar and the plates are X, $X_1$, $X_2$, $X_3$, LX and $X_4$, with the probability that one or more small plates may have been above but have not been preserved.

In specimen OU 4575—The University of Oklahoma—the posterior basal extends only slightly beyond the columnar scar, and anal plates are X, $X_1$, LX and $X_2$, $LX_1$ and $X_3$, $LX_2$ and $X_4$. Other unpreserved plates were probably present. LX and $LX_1$ are not in contact, the former being a small element.

In the other lower interrays of Laudon's figured specimen, a large $IBr_1$ is followed by a long series that is normally in double rows, the entire series expressed as 1, 2, 2, 2, 2. Two of the specimens in the Springer Collection follow this pattern, although the area is more restricted in specimen 1 than in Laudon's specimen. Specimen 2 has a restricted area with an IBr pattern of 1, 1, 1, 2 or 1, 2, 1, 2.

The intersecundibrachs of Laudon's specimens commence at $SBR_1$, which is followed by a double series of plates, reportedly as many as seven. The areas are more restricted in all of the present specimens and the pattern in specimen 1 is ISBr 1, 2, ?. Specimen 2 is ISBr 1, or 1, 2 (small). OU 4575 is 1, 2 (small). The lower edge of the intersecundibrachs of specimen 2 is in the second secundibrach position instead of with the first secundibrach.

Another specimen (OU 4581) is a dorsal cup in which the radial plates are preserved in all rays, and the radianal and anal plates are also preserved. The base of anal X actually extends into the area covered by the proximal columnal.

Externally the lumen in the basal circlet is pentalobate, but internally it is trilobate. Probably this is caused by the retention of the effects of the three absorbed infrabasals, although the plates are absorbed into the five basals.

Another interesting internal feature is the development of an anal tube, starting with a projection of the right side of anal X (left side from external posterior view of the calyx). Three circular plates, free from the calyx, are present in specimen 1, Springer, Collection.

*Types.*—Two plesiotypes (specimens 1 and 2) are in the Springer Collection, U. S. National Museum. Plesiotype OU 4575 and specimen OU 4581 are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Garnett quarry locality.

Genus *Synerocrinus* Jaekel, 1897

*Synerocrinus formosus* Moore and Plummer, 1940
Plate 3, figure 1; plate 8, figures 2, 3

Knowledge of *Synerocrinus formosus* has been restricted to specimens from the type locality in Texas, which is in the Bran-

non Bridge Limestone Member, Millsap Lake Formation, Strawn Group, Desmoinesian, three miles southwest of Brock, Parker County, Texas. Two specimens have been found in the Oologah Formation in two quarries northeast of Tulsa, Oklahoma. Description of the Oklahoma plesiotypes is as follows:

Three infrabasal plates are entirely covered by the columnar scar. Five basals are also partly covered by the columnar scar but project beyond its perimeter. The posterior basal does not extend much beyond the other basals, but is more prominent and is truncated for the reception of a single anal plate. The radial plates are wide, low, and pentagonal. The anal plate of specimen OU 4569 is seven-sided and has two plates above it. In specimen OU 3988, the anal plate is six-sided and apparently had only one plate above it. The first primibrach is wide, low, and non-axillary and the second primibrach is wide, low, and axillary. A single first interbrachial is between the first primibrachials, which, so far as is known, are followed by two interbrachials between the second first primibrachs. In two rays an interbrachial plate rests between the second secundibrachs, and it is apparently followed by a smaller plate.

| Measurements in millimeters: | *Plesiotype OU 4569* |
|---|---|
| Width of dorsal cup | 17.5 |
| Height of cup (exclusive of anal plate) | 4.0 |
| Width of columnar scar | 7.2 |
| Width of basal circlet (minimum) | 10.7 |
| Width of basal circlet (posterior to anterior) | 12.2 |

*Plesiotypes.*—Partial crown, OU 4569, and calyx, OU 3988, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—OU 4569 is from the abandoned quarry in SE¼ SW¼ sec. 18, T. 20 N., R. 14 E., and OU 3988 is from Garnett quarry locality.

## Family Sagenocrinitidae Bassler, 1938

### Genus *Euonychocrinus* Strimple, 1940

The most distinctive feature of the genus *Euonychocrinus* is the unusual arrangement of the anal plates. The dominant anal plate is in the position of a radianal (to the right shoulder of pos-

terior basal) but is faceted for reception of a plate above. Another plate is now known to be in the posterior position (facet for its reception was previously known), and it therefore should be the true anal X. In the holotype of *Euonychocrinus dubius,* the genotype species, the anal X is preserved in place. It is pentagonal and lacks upper facets for reception of plates. It does not, therefore, participate in the formation of an anal tube. It is of some interest to note that the anal plate, or the plate at the base of the tube structure, in Missourian species is smaller than in Desmoinesian species. All currently known species have a distinctive granulose surface with the ornamentation readily visible to the naked eye. The presently known species are:

| | *Series* | *State* |
|---|---|---|
| *Euonychocrinus dubius* Strimple, 1940 | Missourian | Kansas |
| *Euonychocrinus subservire* Strimple, 1951 | Missourian | Texas |
| *Euonychocrinus magnus,* new species | Desmoinesian | Oklahoma |

*Euonychocrinus magnus,* new species
Plate 5, figures 1, 2; plate 6, figures 3-5

In *Euonychocrinus magnus* the crown is broad and slightly elongate, and the dorsal cup is low and truncate bowl-shaped. Infrabasals and most of the basals are covered externally by the columnar scar. The posterior basal is elongate and is followed by an anal plate to the right in a position normally occupied by a radianal with an anal plate directly above. The anal plate in true posterior position curves inward and has no facet for contact with plates above. The anal plate to the right has a facet above for the reception of a tube plate. Radial plates are low, wide, and mildly tumid. Two low, wide first primibrachials are present, the second being axillary. A single interbrachial is present between them and is found in three of the preserved rays. The right posterior interbrachial is large and has two facets above. The right anterior interbrachial is large and has three facets above. The left anterior interbrachial is large and has three facets above. In the paratype from the Oologah Limestone, three interbrachials are also preserved; these are the left posterior, left anterior, and anterior. The interbrachials curve strongly inward and form a tumid projection. The facets for two succeeding interbrachials are at midlength of the first interbrachial. The upper plates do not fill the upper surface of the first interbrachial, and those preserved do not have

facets above for succeeding plates. Second bifurcation of the arms takes place with the third secundibrach in some rays. The column is wide at the point of junction with the cup and tapers rapidly distad. The proximal columnals are thin but apparently start to thicken a short distance from the cup.

| Measurements in millimeters | *Holotype OU 4351* | *Paratype OU3999* |
|---|---|---|
| Width of crown | 35.0 | |
| Width of calyx | 16.7 | 15.8 |
| Height of calyx (excluding anal plate) | 3.1 | 4.1 |
| Width of columnar scar | 5.0 | 6.2 |

*Remarks.—E. magnus* is larger than the Missourian species of the genus. The anal plate that supports the anal tube is larger and more prominent in this than in other described species. The name is the Latin *magnus,* meaning large.

*Types.*—Holotype, OU 4351 (Wewoka Formation), collected by Allen Graffham, and paratype, OU 3999 (Oologah Formation), collected by John Kerns, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Holotype, OU 4351, is reportedly from 12 feet above the base of the exposure, sec. 5, T. 6 N., R. 9 E., south of Holdenville, Oklahoma (Girty's location no. 2006); Wewoka Formation, Marmaton Group, Desmoinesian, Pennsylvanian. Paratype, OU 3999, is from the shale about three feet below the cherty limestone (Oologah Formation) at the 51st Street locality.

## FRAGMENTARY CRINOIDAL REMAINS

Many fragmentary crinoidal remains are unquestionably distinctive and readily identifiable, and therefore they are potentially useful as stratigraphic markers. There are two possible approaches to this study of the fragments: (1) through association with known genera and species in articulated condition and (2) through a classification based strictly on disarticulated parts. Both approaches eventually should prove useful. Several attempts have been made to establish a suitable classification for fragmentary remains that will not be in conflict with existing taxonomic units properly established as genera and species under the *International Rules of Zoölogical Nomenclature*. The latest of such proposals is that of Moore and Laudon (1944), which will be followed herein in so far as the crinoid columnals are concerned. Two of the more prolific and outstanding types of columnals are figured. Several other distinctive types of columnals are present in the Oologah Formation but are not considered at this time.

### Group *Columnals* Moore and Laudon, 1944

#### *Columnal nodosus* Strimple, new section

Plate 7, figures 1, 2

In *Columnal nodosus* every eighth columnal is a nodal and has at least five knoblike projections that may or may not bear cirri. The intervening columnals are alternately expanded both in width and in thickness. The central area around the lumen is normally depressed and granulose. It is surmised that part of the depressed central area is due to a collapse of the surface because in some specimens the surface is nearly flat right up to the lumen. The lumen itself is poorly preserved in most instances, but when preserved, it is large and pentalobate. The area immediately adjacent to the lumen is not strongly granulose, but, as the crenellae are approached, the granules become profuse and continue onto the crenellae. Fine ridges at right angles to the crenellae are visible under magnification. In the figured specimen are 54 crenellae, with a length of 2.0 mm. The nodal is 16.8 mm wide and 3.2 mm long. The internodal is 13.2 mm wide and 1.0 mm long.

*Remarks.*—This form is somewhat like *Columnal granulosus* Moore if the internodal plates alone are considered, but I doubt that they are closely related. The columnals of *C. granulosus* apparently are not alternately expanded. The specific name *nodosus* is the Latin term meaning full of knots.

*Types.*—Figured type, OU 4583, and six "paratypes," OU 4584, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Interstate Highway 44 locality.

*Columnal excentricus* (Moore), 1939
Plate 7, figures 3, 4

Although few of the presently considered specimens exhibit an eccentric placement of the lumen, the form is so close to *Columnal excentricus* in most respects that it is considered to be conspecific. Moore reported one stem segment with 21 columnals, none of which was nodal. The outer surface is unusually smooth with the sutures slightly impressed. The articular surface is divided into two areas. A circular, shallow, sharply depressed area surrounds the lumen. A few sporadic granules are present in some instances. The lumen is large, round-lobed, and pentapetaloid. In the figured specimen 56 crenellae are at the inner margin, 17 crenellae are added by implantation, and 14 crenellae are added by bifurcation. The primary crenellae are 5.7 mm long; the columnal is 1.4 mm long and 19.3 mm wide.

*Types.*—Figured type, OU 4585, and two specimens, OU 4586, are in the paleontological collections, The University of Oklahoma.

*Occurrence.*—Interstate Highway 44 locality.

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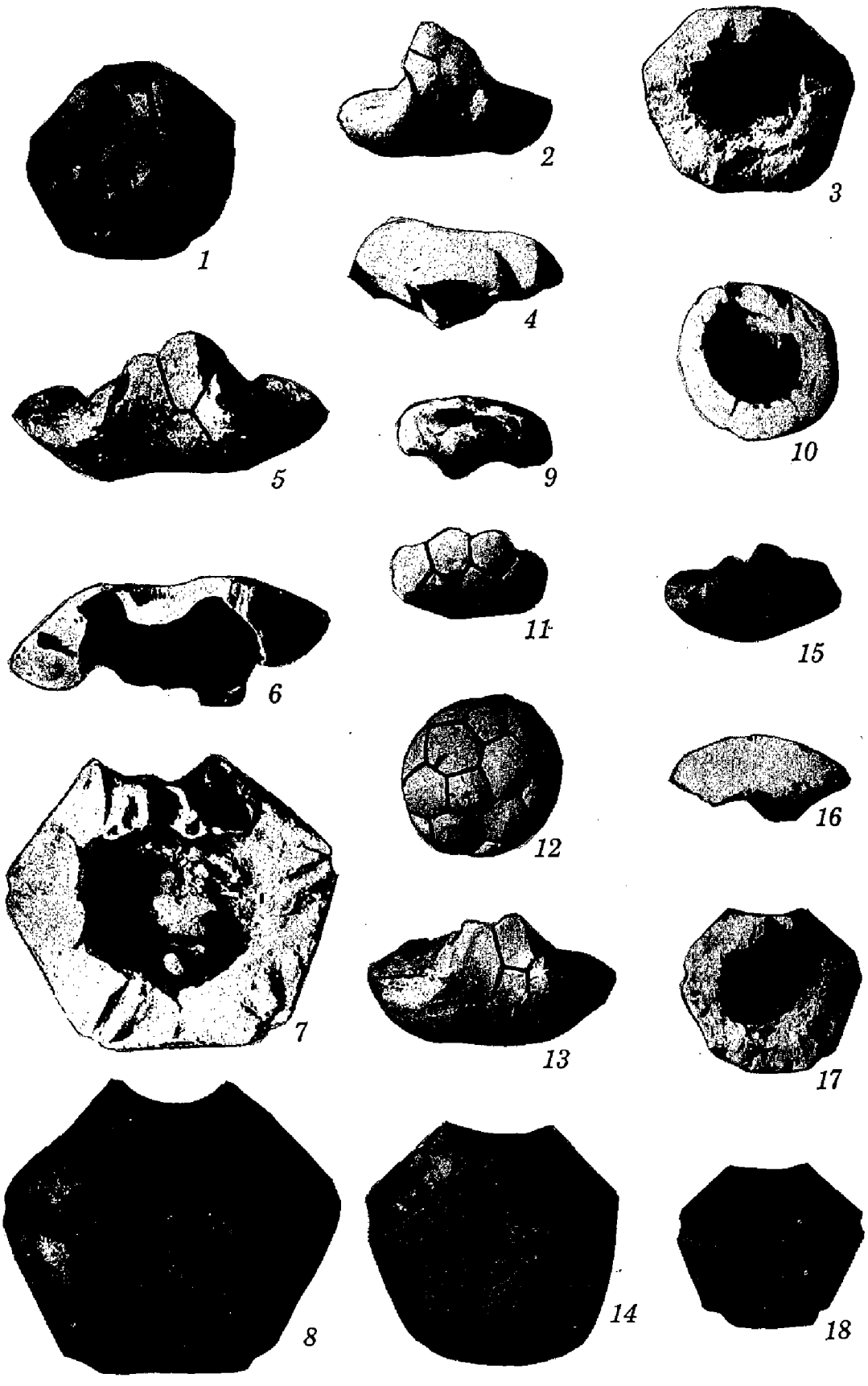
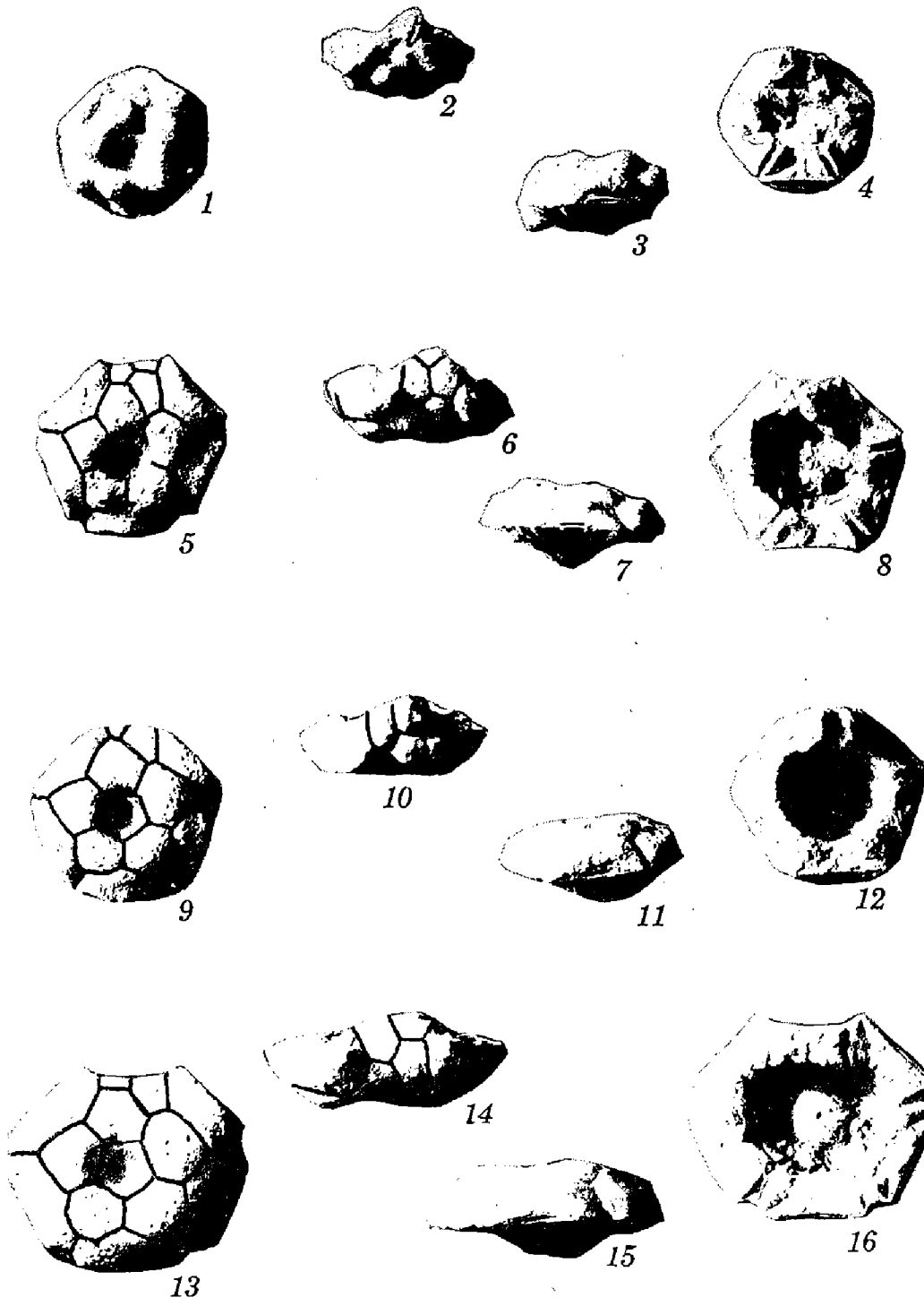
## PLATE 1

PLATE 1



## PLATE 2

PLATE 2



## PLATE 3

| FIGURE | | PAGE |
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| 2- 4. | *Stellarocrinus angulatus* Miller and Gurley. Plesiotype, OU 4570, x2.<br>2. Posterior view.<br>3. Basal view.<br>4. Anterior view. | 41 |
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| 16-17. | *Paradelocrinus subplanus* Moore and Plummer. Plesiotype, OU 4562, x2.<br>16. Basal view.<br>17. Side view. | 21 |

PLATE 3

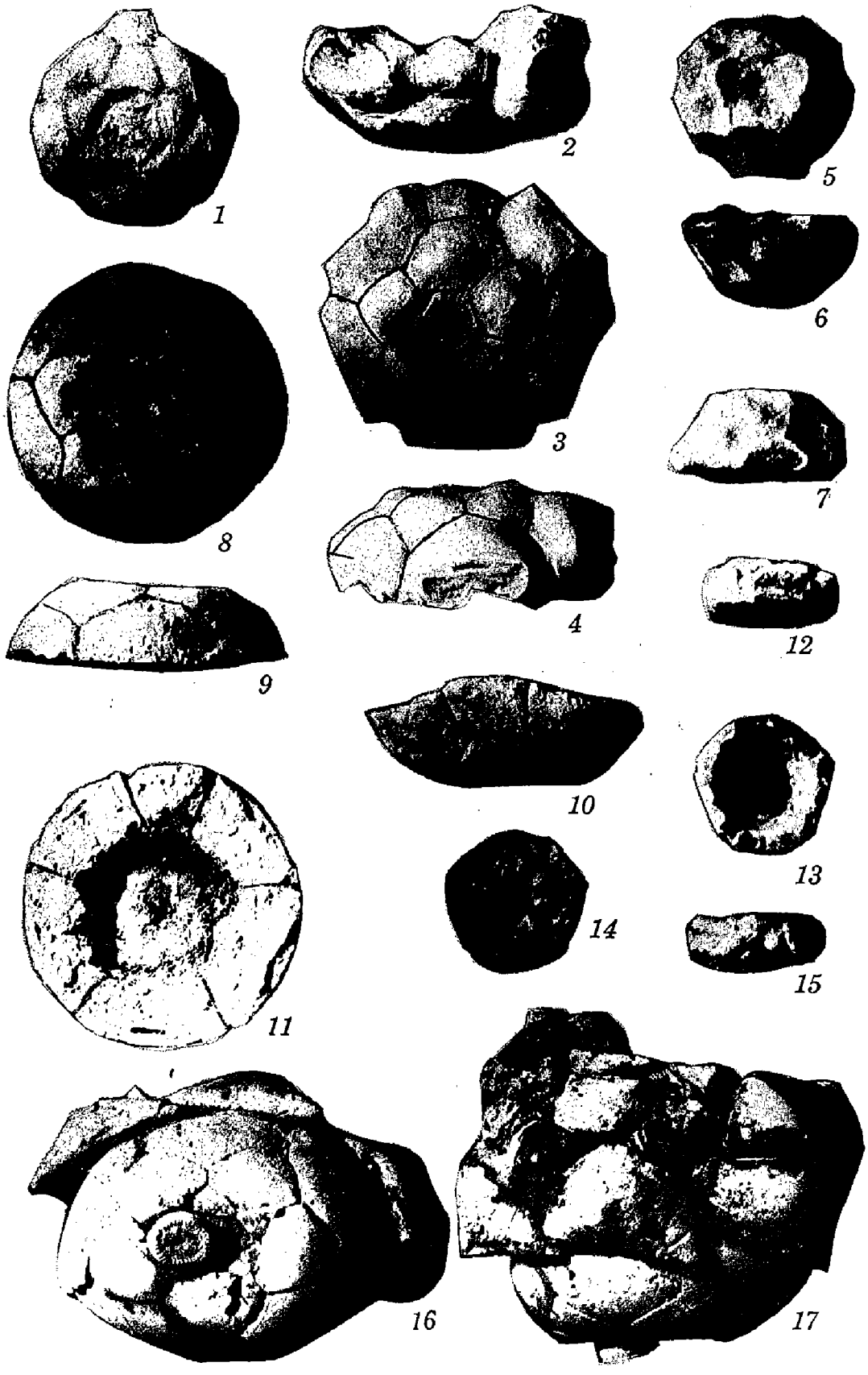

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PLATE 4

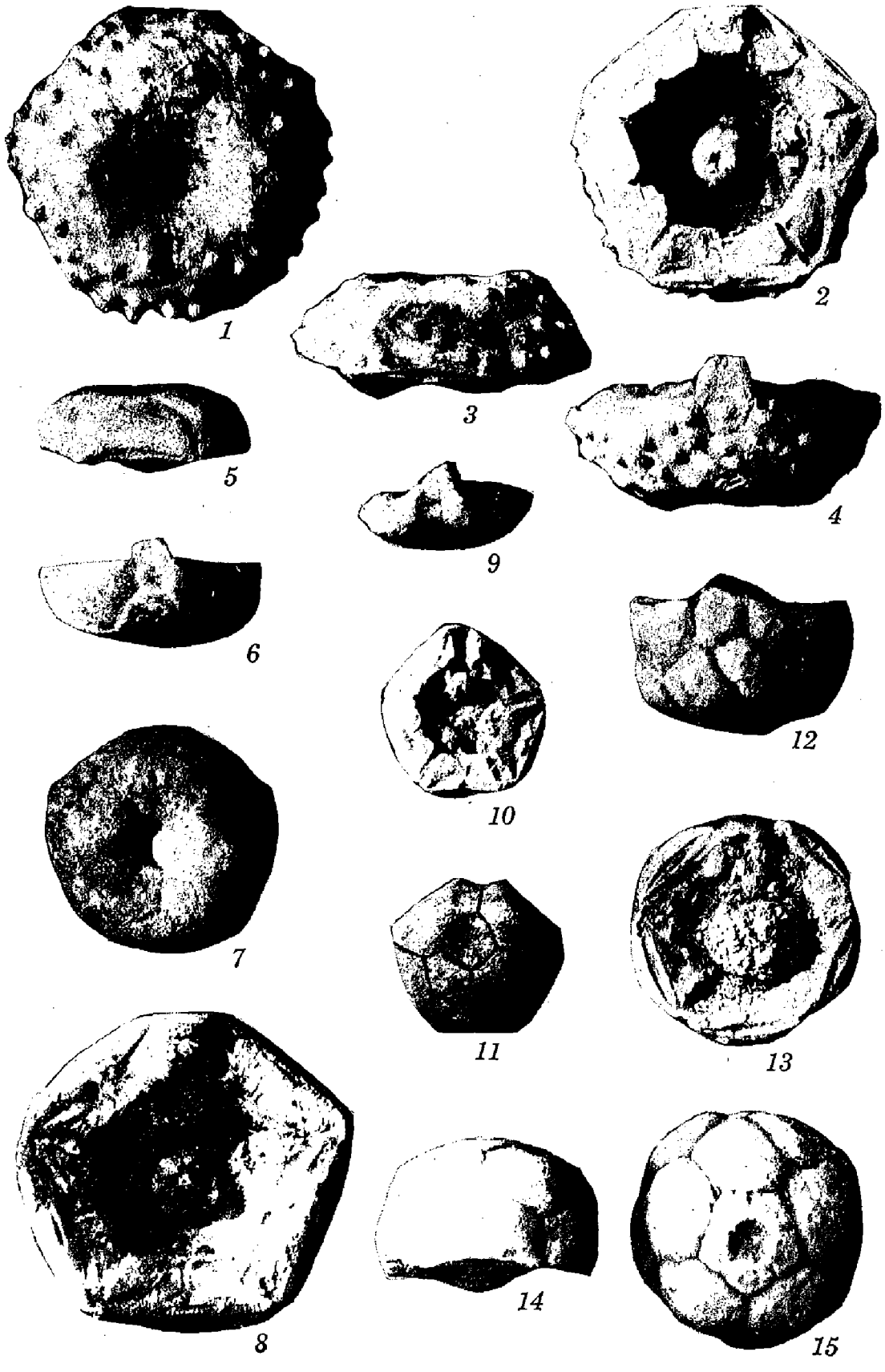

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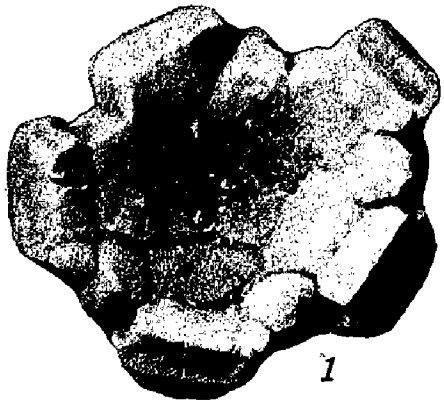
PLATE 5



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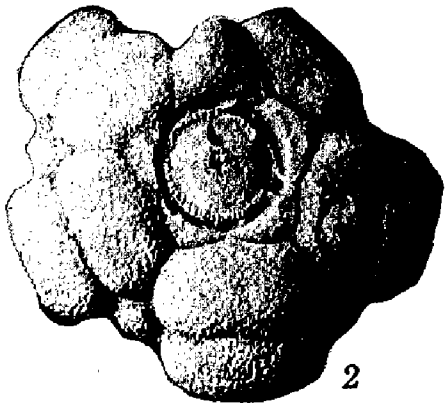

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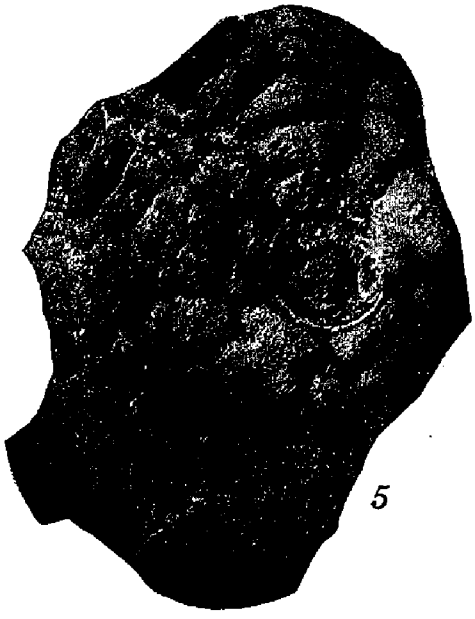

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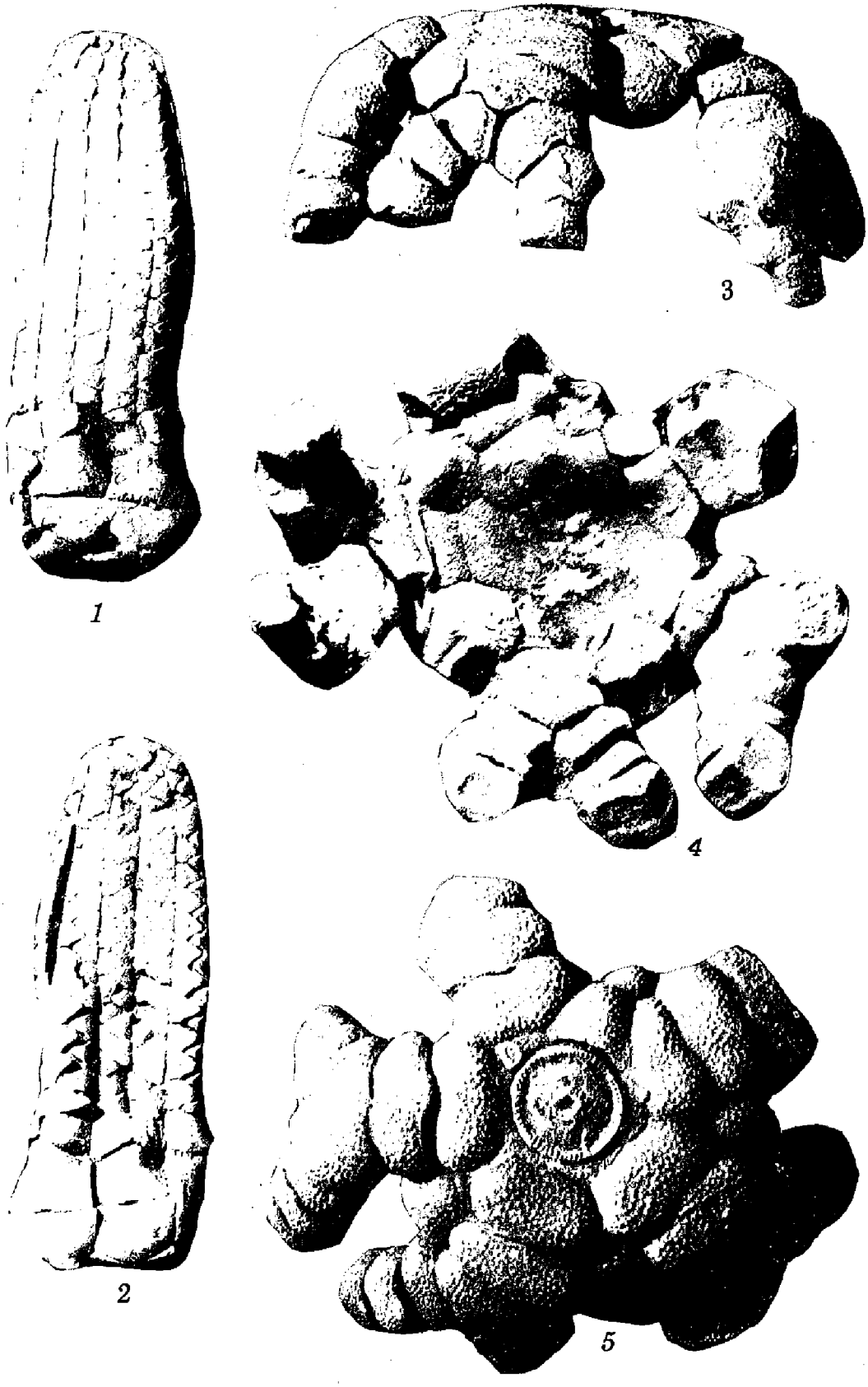

## PLATE 7

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| 11-14. | *Tholiacrinus rimulatus*, new species, Holotype, OU 3989, x1.5.<br>11. Basal view.<br>12. Summit view.<br>13. Posterior view.<br>14. Anterior view. | 19 |
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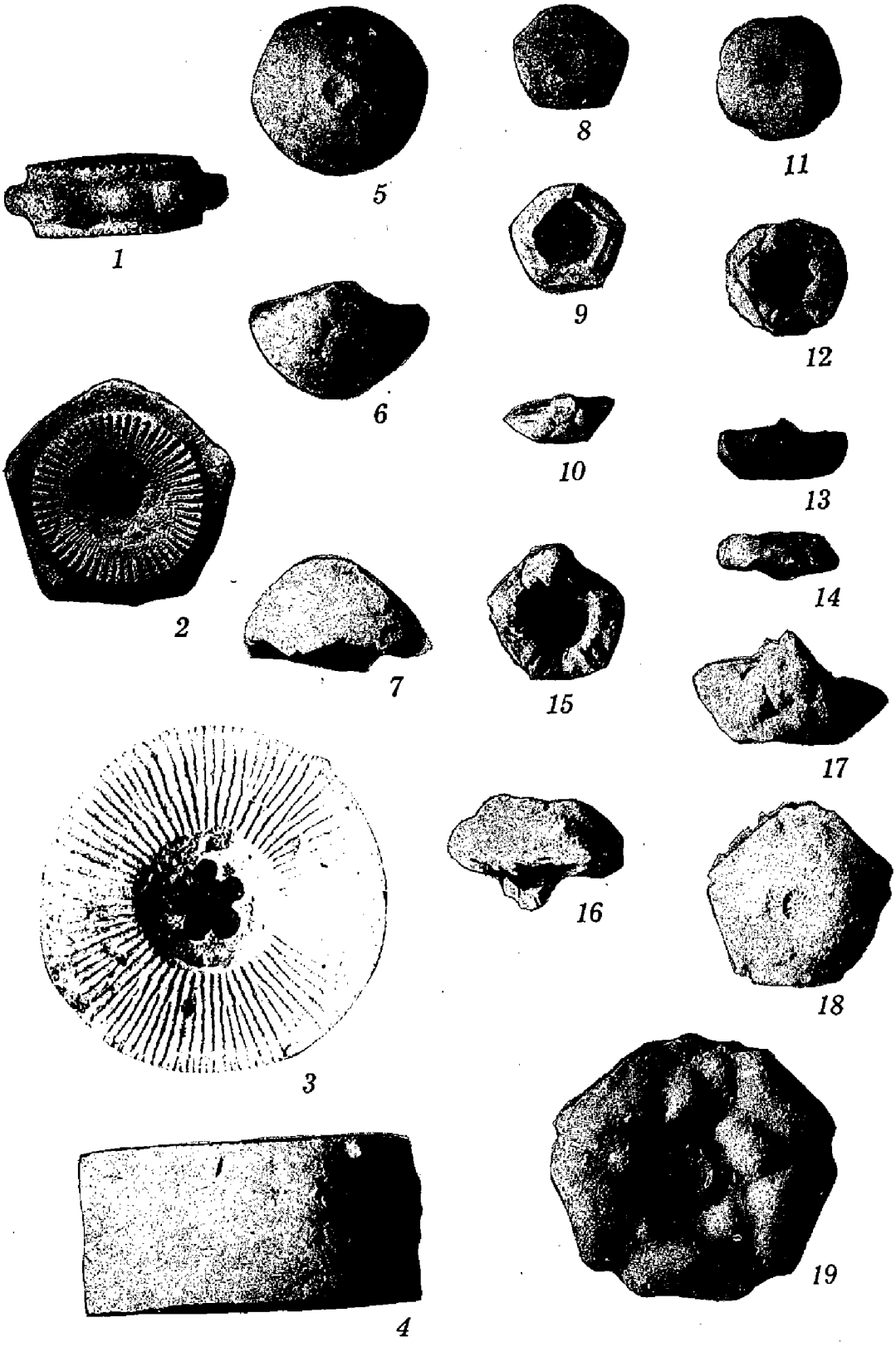
PLATE 7



## PLATE 8

FIGURE — PAGE

1. *Paradelocrinus subplanus* Moore and Plummer. OU 4587, x1.5. Basal view of highly specialized individual having radials in full contact with infrabasals in three rays. — 21

2- 3. *Synerocrinus formosus* Moore and Plummer. Plesiotype, OU 4569, x2. — 51
   2. Crown viewed from posterior.
   3. Basal view.

4- 7. *Erisocrinus mediotor*, new species. Holotype, OU 4566, x2. — 14
   4. Posterior view.
   5. Anterior view.
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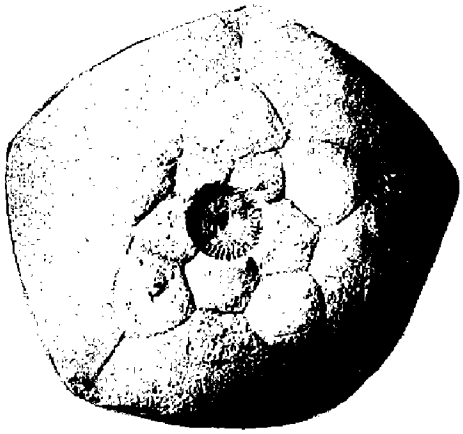
PLATE 8



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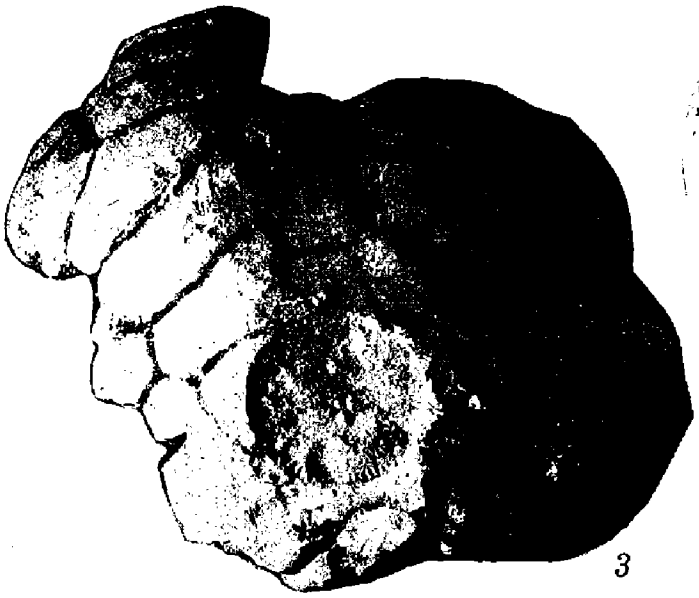

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PLATE 9