

# Echinoderms from Middle and Upper Ordovician Rocks of Kentucky

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 1066-K

*Prepared in cooperation with the  
Commonwealth of Kentucky,  
University of Kentucky,  
Kentucky Geological Survey*





# Echinoderms from Middle and Upper Ordovician Rocks of Kentucky

By RONALD L. PARSLEY

CONTRIBUTIONS TO THE ORDOVICIAN PALEONTOLOGY OF  
KENTUCKY AND NEARBY STATES

*Edited by* JOHN POJETA, JR.

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Commonwealth of Kentucky,  
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*Descriptions and illustrations of  
nine species of Stylophora,  
Paracrinoidea, Inadunata, Cyclocystoidea,  
and Rhombifera*



UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

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## SYSTEM OF MEASUREMENT UNITS

The investigations underlying this series of reports were made over a period of years, and distances and stratigraphic measurements appear fairly uniformly in English units. Measurements of fossil specimens, on the other hand, follow the long-standing convention of appearing in metric units. Because of the dates of the investigations and the amount of resulting data, the English measurements have been retained. Conversions to metric units may be made by using the following conversion table:

To convert English unit:	To metric unit:	Multiply by:
Mile (mi)	Kilometer (km)	1.61
Foot (ft)	Meter (m)	.305
Inch (in.)	Centimeter (cm)	.394



## ECHINODERMS FROM MIDDLE AND UPPER ORDOVICIAN ROCKS OF KENTUCKY

By RONALD L. PARSLEY<sup>1</sup>

### ABSTRACT

The Middle and Upper Ordovician limestones of Kentucky, especially the Lexington Limestone, have yielded a diverse silicified echinoderm fauna, including: Stylophora—*Enoploura* cf. *E. punctata*; Paracrinoidea—*Amygdalocystites*; Crinoidea, Inadunata—*Hybocrinus tumidus*, *Hybocystites problematicus*, *Carabocrinus* sp., *Cupulocrinus* sp., *Heterocrinus* sp.; Cyclocystoidea—*Cyclocystoides* sp. A rhombiferan cystoid, *Amecystis laevis*, from the Edinburg Formation, Virginia, is also discussed. No new taxa are introduced.

### INTRODUCTION

The Lexington Limestone and adjacent Middle to Upper Ordovician formations of Kentucky have yielded a rich and varied silicified fauna. Most of the echinoderm material has come from the Curdsville Limestone Member of the lowermost part of the Lexington Limestone, although some is from stratigraphically higher Middle and Upper Ordovician formations. Echinoderm specimens are usually poorly preserved because of the coarseness of the silicification, and they are generally damaged by the etching process.

Despite the limited number of identifiable (articulated) specimens, the diversity of higher taxa is considerable, which is typical for Middle Ordovician rocks. Mitrata stylophorans, paracrinoids, inadunate crinoids, and cyclocystoids are discussed herein. A rhombiferan cystoid from the Edinburg Formation, Tumbling Run, Va., is also included. Ordovician edrioasteroids and asteroids from Kentucky have been discussed by Bell (1979) and Branstrator (1979), respectively.

A few of the collections contain many disarticulated crinoid columnals and various types of disarticulated thecal plates. The former are generally unidentifiable and are here recorded by formation and collection number at the end of the paper.

In spite of the rather high diversity of echinoderms, especially in the lower part of the Lexington Limestone, the actual number of echinodermal remains seems to be rather low. Of the 1,086 collections made, only 84, or slightly less than 8 percent, yielded echinoderm remains. Although there is a collecting bias for silicified mollusks and brachiopods (John Pojeta, Jr., oral commun., 1975), it is puzzling why presumed shallow-water,

normal marine echinoderms are not more commonly found with brachiopods, mollusks, bryozoans, etc., in these collections. Preservation alone does not seem to be an adequate explanation for the paucity of echinoderms, nor does the fact that many Ordovician echinoderms, e.g., edrioasteroids and crinoids, had a definite tendency to form small colonies on the sea bottom (see Springer, 1911, p. 13, concerning the crinoid *Hybocystis*). Most echinoderms partly or entirely disarticulate after death and are spread over the sea floor by currents. The question of their poor representation at this time is unresolved.

Although no new taxa are recognized in this study, several specimens have enhanced our knowledge of known genera, notably the specimens of the mitrate *Enoploura* and the rhombiferan *Amecystis*.

Many of the genera and species of Echinodermata found in the Lexington Limestone also occur in the Kirkfield Limestone of Kirkfield, Ontario, Canada, and in the Hull Beds (and in lesser numbers in the Sherman Fall Beds) of the Ottawa, Ontario, area. These units seem not only to span essentially the same time period but also to have a similar paleoenvironmental setting.

### ACKNOWLEDGMENTS

I wish to thank John Pojeta, Jr., U.S. Geological Survey, Washington, D.C., for selecting me to work on this material. James C. Brower, Dept. of Geology, Syracuse University, Syracuse, N.Y., identified some of the crinoids. The text figure was drawn by Susan Foster, Newcomb College, Tulane University, New Orleans, La. Dennis Greig of Chevron, U.S.A., New Orleans, La., took the SEM photographs with his company's instrument.

### SYSTEMATIC PALEONTOLOGY

- Phylum ECHINODERMATA
- Subphylum HOMALOOZOA Whitehouse, 1941
- Class STYLOPHORA Gill and Caster, 1960
- Order MITRATA Jaekel, 1918
- Suborder ANOMALOCYSTITIDA Caster, 1952
- Family ANOMALOCYSTITIDAE Bassler, 1938
- Genus ENOPLOURA Wetherby, 1879
- Enoploura* cf. *E. punctata* Bassler, 1932

Plate 1, figures 14-19

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*Enopleura* [sic] *punctata* Bassler, 1932, p. 218, pl. 18, fig. 9:  
*Enopleura punctata* Bassler, Bassler and Moodey, 1943, p. 157: Parsley  
 1969, p. 69-75, pl. 2, figs. 1-7.

**Diagnosis.**—Carapace prosopon scaly punctate; oral lip thick and evenly rounded, distal spines thick, unbowed, terete. Styloid blades not greatly expanded.

**Description.**—*Enopleura punctata* has a subrectangular, convexo-concave theca which thickens proximally towards the subvective aulacophore. Articulated spines are attached at the distal corners of the theca; they are terete (typical of this Middle Ordovician species), rather than compressed and slightly curved (typical of Late Ordovician species). Along the distal margin, a heavy, evenly curved unornamented lip projects from the lower (plastron) surface. (Late Ordovician species of *Enopleura* have a thin, often distally denticulate lip, which is commonly ornamented with veinlike depressions on its upper surface.)

The aulacophore is divided into three sections: (1) a proximal tetramerous part consisting of 10 to 11 segments, usually having several of the proximal segments inserted into the theca; (2) a distal trimerous part, composed of a keel-shaped basal ossicle and paired covering plates over the food groove, which is on the upper surface of the basal ossicle; and (3) an intermediate section, the styloid, which is made up of highly modified distal aulacophore segments, the basal ossicles (three) being projected laterally and ventrally into broad flat blades. These blades serve as a base for the distal aulacophore, which was held above the animal for subvection (Ubaghs, 1967, p. 532-535; Parsley, 1967, p. 172-173; Parsley and Caster, 1975, p. 1225-1226).

**Discussion.**—The material studied for this report consists of seven incomplete specimens, among which is a single nearly complete individual (pl. 1, fig. 17). These specimens, which can only be tentatively assigned to the species *E. punctata*, are generally poorly preserved. Plate outlines are blurred because of silicification, and only gross external and some internal features are observable.

The position of the gut is suggested by what appears to be mud infilling; this mud probably was emplaced soon after the death of the animal. The gut seems to have extended from the aulacophore opening in a diagonal direction along the septum on the plastron floor to the distal right corner of the theca, where presumably the anus opened into the central (cloacal cavity?) opening. Almost all internal detail has been obliterated because of the coarseness of silicification.

Perhaps the most interesting aspect of this material is that several specimens (pl. 1, figs. 17, 18) on file seem to have taken refuge under *Rafinesquina* shells, which were lying convex-side upward on the substrate. The theca and most of the proximal aulacophore of each specimen are under the respective shells, and the styloid and distal aulacophore of one specimen extend upwards

over the top of the animal and the brachiopod shell in what appears to be close to the habitus feeding position. The positions of the specimens seem to be deliberate, rather than being the result of fortuitous preservation.

**Localities and materials.**—Curdsville Limestone Member, Lexington Limestone: USNM 245193-245195 (pl. 1, figs. 14-16), USGS loc. 6134-CO; USNM 247881 (pl. 1, fig. 17), USGS loc. 6134-CO; USNM 247883 (pl. 1, fig. 19), USGS loc. 7785-CO. Clays Ferry Formation: USNM 247882 (pl. 1, fig. 18), USGS loc. 6143-CO.

Subphylum CRINOZOA Matsumoto, 1929

Class CYSTOIDIA von Buch, 1846

Order RHOMBIFERA Zittel, 1879

Superfamily GLYPTOCYSTITIDA Bather, 1899

Family PLEUROCYSTITIDAE Neumayr, 1899

Genus AMECYSTIS Ulrich and Kirk, 1921

*Amecystis laevis* (Raymond), 1921

Plate 1, figure 1

*Pleurocystites laevis* Raymond, 1921, p. 2-3, pl. 2, figs. 1-3.

*Amecystis laevis* Ulrich and Kirk, 1921, p. 147-148: Parsley, 1970, p. 192-194, pl. 29, figs. 1-5, pl. 30, figs. 5, 6: Broadhead, 1974, p. 670-673; Broadhead and Strimple, 1975, p. 318.

**Diagnosis.**—*Amecystis* with flattened, evenly sagittate theca; thecal plates thin, smooth, or with pustulose prosopon.

**Discussion.**—This species is represented herein by a single specimen that shows the ventral (anal) surface of the theca and part of the column (pl. 1, fig. 1; text-fig. 1). Except for a few proximal plates, the brachioles are missing. The specimen is significant in that it clearly shows the entire polyplated periproctal area and the ventral thecal plates adjacent to the brachioles. The number and geometry of the distal ventral thecal plates have been subject to controversy (Parsley, 1970, p. 189; Broadhead, 1974, p. 671, text-fig. 1; Broadhead and Strimple, 1975, p. 313, fig. 1, p. 318).

The problem primarily concerns the presence or absence of oral plate 06 and its relationships to 01 and 07, which are identifiable in all pleurocystitids. In *Amecystis*, plate 01 underrides 07, so that 07 is quite thin and is seemingly susceptible to postmortem fracture. The ease of fracture probably is enhanced by the additional thinning of 07 where the conduits for the hydro-pore and gonopore traverse its undersurface. Apparently, fracturing accounts for the presence of an "06" plate in this genus. In some specimens, 06 may indeed split from 01 early in ontogeny, and the presence of 06 would then be an example of intrageneric variation (see Sinclair, 1948, p. 311; Kesling, 1961, p. 66; Paul, 1967, p. 107; Parsley, 1970, p. 154).

Plates L1 and L4 are considerably attenuated towards the sagittal axis. In most specimens the thinned parts of these plates fracture, and these breaks can resemble sutures, resulting in the identification of spurious plates.

The ornamentation on the marginal plates is unique to this specimen, but to establish a new species on this



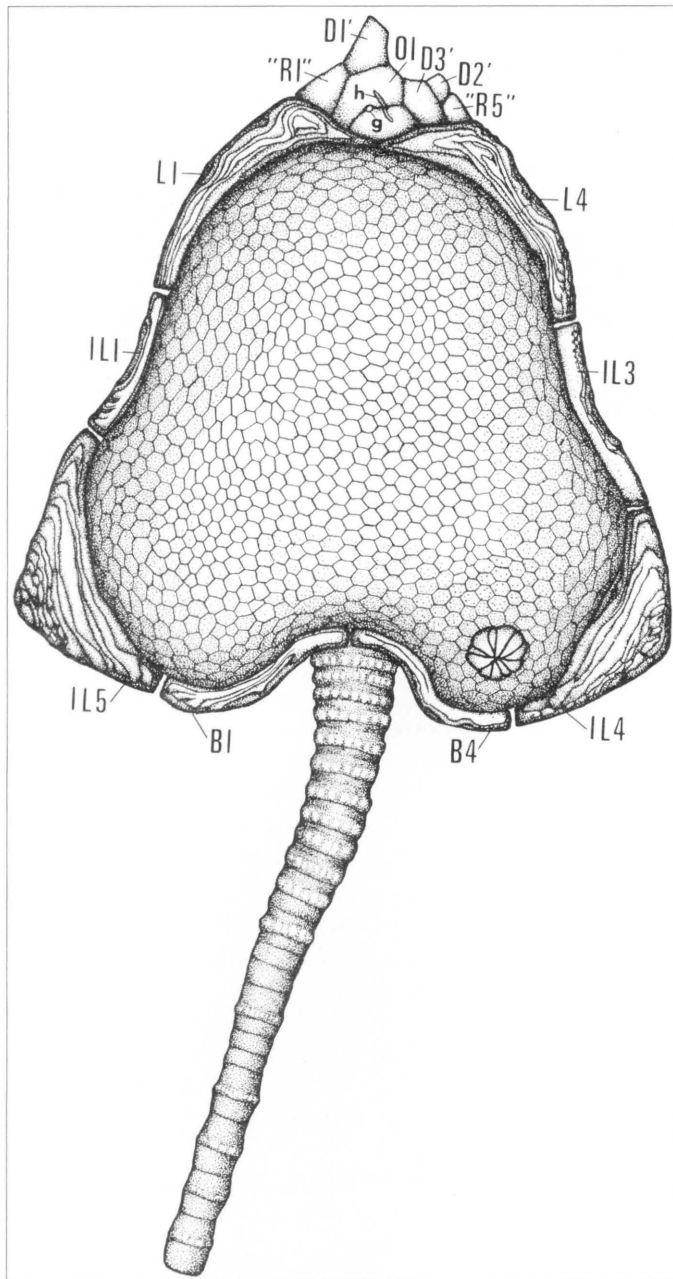


Figure 1.—Partial reconstruction of the ventral (anal) face of *Amecystis laevis*. Plate terminology is that used for glyptocystitid rhombiferans: B, basals; IL, infralaterals; L, laterals; R, radials; O, orals; D, distals (see Parsley 1970, p. 140); h, hydropore slit; g, gonopore. The plate that shares the hydropore and gonopore with O1 is O7. The large tessellated surface is the greatly expanded periproct, the anal pyramid being just above the suture between B4 and IL4.

feature alone, with no knowledge of the opposite face, seems unwise.

*Locality and materials.*—Edinburg Formation, Tumbling Run, near Strasburg, Va.; cobbly limestone facies nearest to junction of road paralleling creek with State Route 11: USNM 245181.

Subphylum PARACRINOZOA Parsley and Mintz, 1975  
Class PARACRINOIDEA Regnéll, 1945  
Order COMAROCYSTITIDA Parsley and Mintz, 1975  
Family AMYGDALOCYSTITIDAE Jaekel, 1900  
Genus AMYGDALOCYSTITES Billings, 1854

*Amygdalocystites florealis* Billings, 1854

Plate 1, figures 2, 3

*Amygdalocystites florealis* Billings, 1854, p. 270–271, figs. 4–6; Billings, 1857, p. 289; Billings, 1858, p. 63–64, pl. 6, figs. 1a–e; Billings, W. R., 1883, p. 51–52; Wilson, 1946, p. 9–10, pl. 1, figs. 1–2; Parsley and Mintz, 1975, p. 49–51, pl. 4, figs. 1–7, pl. 5, figs. 1–7, text-fig. 1.

*Amygdalocystis* [sic] *florealis* Billings, Haeckel, 1896, p. 106–107, fig. 15; Bather, 1900, p. 57, fig. 19.

*Amygdalocystites tenuistriatus* Billings, 1854, p. 271, fig. 9; Billings, 1857, p. 289–290; Billings, 1858, p. 64–65, pl. 6, figs. 2a–f.

*Amygdalocystites huntingtoni* Wetherby, 1881, p. 177, pl. 5, fig. 3.

*Ottawacystites laevis* (Billings, W. R.) Wilson, 1946, p. 14, pl. 3, figs. 1a–b.

*Diagnosis.*—Amygdaloid theca with two recumbent arms; thecal plates with expending rays expanding from rounded central boss to plate corners; smaller rays extending from boss to bisect plate facets.

*Discussion.*—*Amygdalocystites* was first reported in the Lexington Limestone by Wetherby (1881) as *A. huntingtoni* Wetherby; Parsley and Mintz (1975, p. 50) placed Wetherby's species in synonymy with *A. florealis* Billings. Two specimens of *A. florealis* are included in this report. Both have the offset and bent proximal column, theca, and the recumbent arms. One specimen, USNM 245183 (pl. 1, fig. 3), has poorly preserved exothecal pinnules lying over the theca. Species-level identification of these poor specimens is possible because of the radial ornament on a few of the thecal plates.

These specimens clearly show the proximally reflexed column, which in life canted the theca at an angle to its longitudinal axis and resulted in the offset peristome being in an uppermost and horizontal position or very close to it.

*Locality and materials.*—Curdsville Limestone Member, Lexington Limestone, USGS loc. 6134-CO: USNM 245182, 245183.

Class CRINOIDEA J. S. Miller, 1821

Subclass INADUNATA Wachsmuth and Springer, 1885

Order HYBOCRINIDA Jaekel, 1918

Family HYBOCRINIDAE Zittel, 1879

Genus HYBOCRINUS Billings, 1857

*Hybocrinus tumidus* Billings, 1857

Plate 1, figures 6, 9

*Hybocrinus tumidus* Billings, 1857, p. 275; Billings, 1858, p. 28, pl. 2, figs. 1a–c; Springer, 1911, p. 24, pl. 5, figs. 1–5; Wilson, 1946, p. 31.

*Discussion.*—The new material available is a single partly preserved theca that has the proximal parts of the arms attached. The crenulated anal (X) plate is visible, although it is somewhat worn. Identification of this specimen is based on the nature of the anal plate (see

Springer 1911, p. 24) and the rather globular outline of the theca. No new morphological features have been observed on the specimen.

*Locality and material.*—The single specimen USNM 245186 is from USGS loc. 5083-CO, Curdsville Limestone Member, Lexington Limestone.

Genus *HYBOCYSTITES* Wetherby, 1880  
*Hybocystites problematicus* Wetherby, 1880

Plate 1, figures 7, 8, 10

*Hybocystites problematicus* Wetherby, 1880, p. 150-152, pl. 5, figs. 1, 1a-c; Carpenter, 1882, p. 307-312, pl. 9, figs. 6-24.

*Hybocystis* [sic] *problimaticus* Wetherby emend. Parks, 1908, p. 232-234, pl. 2, figs. 1-3, 5.

*Hybocystis* [sic] *eldonensis* Parks, 1908, p. 234-235, pl. 2, fig. 4; Springer 1911, p. 13, 19-20, pl. 2, figs. 1-10.

*Discussion.*—This species is represented by two incomplete thecae and some disarticulated plates. In neither specimen is there any evidence of a column of the distal ends of the arms. Identification is based on the presence of recumbent arms over the radials and the distinctive crenulate ornament of the thecal plates. Among the disarticulated plates, the radials are especially identifiable (pl. 1, fig. 8).

This species has the tendency to form colonies that are very closely spaced so that 100 or more individuals may have lived in an area of several square feet (Springer, 1911, p. 13). Within one such colony, Springer (1911) described specimens attributed to *H. problematicus* and *H. eldonensis*. Springer (1911, p. 19-20) correctly pointed out that the identification as two species was probably due to differences in size and growth between the two specimens and that both specimens should be placed under a single species. Although he declined to synonymize the two species, it is done herein.

*Hybocystites* is one of the most unusual of the crinoids in that three of the arms are short (five or six segments long), whereas the two anterior lateral arms are recumbent and fit into grooves that extend across the radials and sometimes even onto the basals and column in mature specimens.

*Localities and materials.*—Specimens USNM 245187 (pl. 1, fig. 7) and USNM 245189, (pl. 1, fig. 10) are from USGS loc. 5083-CO, which is at the base of the Curdsville Limestone Member, of the Lexington Limestone. Disarticulated plates such as USNM 245188 (pl. 1, fig. 8), USGS loc. 7785-CO, Curdsville Limestone Member, Lexington Limestone, are also found in localities 5084-CO, 5101-CO, and 7784-CO of the same stratigraphic unit.

The same species of *Hybocystites* and *Hybocrinus* are found in the Hull Beds of Ontario. Many other Trentonian echinoderms are common to the Curdsville Limestone Member and Hull Beds, clearly indicating their similarity in paleoenvironment and probable time equivalence.

Suborder *CYATHOCRINOIDEA* Bather, 1899

Family *CARABOCRINIDAE* Bather, 1899

Genus *CARABOCRINUS* Billings, 1857

*Carabocrinus* sp.

Plate 1, figures 11, 12

*Discussion.*—Disarticulated plates can be assigned to *Carabocrinus* because of characteristic raised radiating ridges on their outer surfaces. Radial and basal plates are present. Identification of these plates to the species level is not possible; however, *C. vancortlandi* Billings, *C. radiatus* Billings, and *C. ovalis* Miller and Gurley have all been previously reported in the Curdsville Limestone Member of the Lexington Limestone (see Bassler and Moodey, 1943, p. 306). The three named species may be synonyms of a single species, at least in the Curdsville. However, the material at hand is of no value in determining this.

*Locality and materials.*—USGS loc. 7785-CO, Curdsville Limestone Member, Lexington Limestone: USNM 245190 (pl. 1, fig. 11); USNM 245191 (pl. 1, fig. 12).

Order *CLADIDA* Moore and Laudon, 1943

Suborder *DENDROCRININA* Bather, 1899

Family *DENDROCRINIDAE* Miller, 1889

Genus *CUPULOCRINUS* d'Orbigny, 1849

*Cupulocrinus* sp.

Plate 1, figures 4, 13

*Discussion.*—Species-level identification of the two figured specimens is uncertain, as the diagnostic features of the anal sac are not preserved. The specimens probably are either *C. humulis* (Billings) or *C. jewetti* (Billings), both of which were previously reported from the Curdsville Limestone Member of the Lexington Limestone (Springer, 1911). The short wide primibrachs are typical of *Cupulocrinus*, and this feature serves to distinguish it from the closely related coeval genus *Dendrocrinus*.

*Locality and materials.*—Curdsville Limestone Member of the Lexington Limestone, USGS loc. 5072-CO: USNM 245184 (pl. 1, fig. 4) and USNM 245192 (pl. 1, fig. 13).

Order *DISPARIDA* Moore and Laudon, 1943

Family *HETEROCRINIDAE* Zittel, 1879

Genus *HETEROCRINUS* Hall, 1872

*Heterocrinus* sp.

Plate 1, figure 5

*Discussion.*—This form is known from a single incompletely preserved specimen, which shows part of the monocyclic theca, part of the proximal column, and the proximal parts of several arms (primibrachs), one arm with the primary axillary. Although several Middle Ordovician species of *Heterocrinus* are known, *Heterocrinus tenuis* Billings, reported from Quebec and Ontario (by Billings, 1857, and Wilson, 1946), is the most likely species name for this specimen.

*Locality and materials.*—Grier Limestone Member, Lexington Limestone, USGS loc. 4946-CO: USNM 245185 (pl. 1, fig. 5).

Subphylum ECHINOZOA Matsumoto, 1929  
 Class CYCLOCYSTOIDEA Miller and Gurley, 1895  
 Family CYCLOCYSTOIDIDAE Miller, 1892  
 Genus CYCLOCYSTOIDES Salter and Billings, 1858

*Cyclocystoides* sp.  
 Plate 1, figure 20

*Discussion.*—At several localities, distinctive, disarticulated submarginal plates of *Cyclocystoides* have been found in considerable numbers. Plates having two, and, less commonly, three radial ducts are present. At least five species of Middle Ordovician cyclocystoids (all genus *Cyclocystoides*) are known in North America, but this is their first reported occurrence from Kentucky. The rather poor preservation of the plates precludes specific identification.

*Localities and materials.*—Salvisa Bed, Perryville Limestone Member, Lexington Limestone, USGS loc. 5015-CO: USNM 247884 (pl. 1, fig. 20). Other USGS localities where cyclocystoid plates have been found: 6409-CO, Calloway Creek Limestone; 6410-CO, 6411-CO, Ash-lock Formation; and 6416-CO, Grant Lake Limestone.

#### OCCURRENCES OF DISARTICULATED ECHINODERM PLATES IDENTIFIABLE ONLY TO A HIGH TAXONOMIC LEVEL

The following list gives USGS locality numbers arranged by the formations that contain echinoderm remains. Most of the remains are short segments of crinoid columnals or individual columnals. A locality number indicates the occurrence of crinoid columnals or short column lengths, unless otherwise stated.

Camp Nelson Limestone: 5079-CO, 7835-CO, 7863-CO, 7875-CO.

Tyrone Limestone: 6035-CO, 6036-CO, 6037-CO, 6039-CO, 6041-CO, 6042-CO, 6133-CO, 7795-CO, 7886-CO.

Lexington Limestone:

Curdsville Limestone Member: 4073-CO, 4940-CO (*Cupulocrinus*), 5022-CO, 5069-CO, 5072-CO (*Cupulocrinus*), 5084-CO, 5101-CO (crinoid thecal plates, *Hybocrinus*, *Carabocrinus*), 6131-CO (crinoid thecal plates, *Carabocrinus?* plate), 6134-CO (crinoid thecal plates, mitrate), 6135-CO (crinoid thecal plates), 6751-CO, 7782-CO (*Carabocrinus* plates), 7784-CO, 7785-CO (mitrates, crinoid thecal plates, *Carabocrinus*, *Hybocrinus* plates, small *Cupulocrinus*), 7817-CO.

Logana Member: 7791-CO.

Grier Limestone Member: 4073-CO, 4852-CO, 4874-CO, 4928-CO, 4959-CO, 5074-CO, 5093-CO, 7792-CO.

Perryville Limestone Member: 5015-CO (partly preserved circlet of cyclocystoid plates, disarticulated cyclocystoid plates), 6136-CO, 6138-CO, 6715-CO (cyclocystoid plates), 7842-CO.

Tanglewood Limestone Member: D-1200-CO, D-1202-CO, D-1206-CO, 7783-CO, 7787-CO, 7793-CO, 7796-CO, 7809-CO, 7811-CO, 7821-CO, 7823-CO.

Millersburg Member: 6144-CO, 7079-CO (crinoid thecal plates), 7353-CO, 7790-CO.

Clays Ferry Formation: D-1172-CO, D-1173-CO, 6128-CO, 6142-CO, 6143-CO (mitrate), 7044-CO, 7348-CO, 7349-CO, 7350-CO, 7458-CO, 7812-CO.

Point Pleasant Tongue: 6699-CO (crinoid hold-fasts), 7824-CO (crinoid thecal plates), 7825-CO, 7830-CO.

Kope Formation: 7834-CO.

Grant Lake Limestone: 6416-CO (crinoid thecal plates, cyclocystoid plates).

Ashlock Formation: 6043-CO, 6410-CO (cyclocystoid plates), 7794-CO, 7843-CO;

Gilbert Member: 6411-CO (cyclocystoid plates), 6412-CO (cyclocystoid plates, crinoid thecal plate).

Whitewater Formation: 7802-CO.

Dillsboro Formation: 6140-CO.

#### LOCALITY REGISTER

This locality register supplements that published by Pojeta (1979) in chapter A of this series, which contains the details of the numbering and the methods of notation. Only localities not mentioned in chapter A are included here; therefore, refer to chapter A for any locality numbers used in this paper that are not in this register.

Collection number .....	4928-CO*.
Geographic location .....	The same as for 4929-CO.
Coordinates .....	Do.
Formation .....	Grier Limestone Member, Lexington Limestone.
Stratigraphic position ...	22 ft below the base of the Brannon Member, Lexington Limestone.
Silicified .....	Yes (40 lbs).
Quadrangle name .....	Salvisa, Ky.
Section name .....	Salvisa A.
Section number .....	175.
Collection number .....	4946-CO.
Geographic location .....	The same as for 4940-CO.
Coordinates .....	Do.
Formation .....	Float in lower part of the Grier Limestone Member, Lexington Limestone.
Silicified .....	Yes (3 lbs).
Quadrangle name .....	Salvisa, Ky.
Section name .....	Salvisa B.
Section number .....	176.

Collection number ..... 5074-CO\*.  
 Geographic location ..... Small quarry on west side of Tates Creek  
 Pike, north of Gainesway, Ky., and 2 mi  
 south of intersection with Cooper Rd.  
 Coordinates ..... 15.5 mm east, 545 mm north.  
 Formation ..... Grier Limestone Member, Lexington  
 Limestone.  
 Silicified ..... Yes (15 lbs).  
 Section name ..... Tates Creek Rd. quarry.

Collection number ..... 5079-CO\*.  
 Geographic location ..... The same as for 7875-CO.  
 Coordinates ..... Do.  
 Formation ..... Camp Nelson Limestone.  
 Silicified ..... Yes (10 lbs).  
 Quadrangle name ..... Wilmore, Ky.  
 Section name ..... High Bridge.

Collection number ..... 5083-CO.  
 Geographic location ..... The same as for 5081-CO.  
 Coordinates ..... Do.  
 Formation ..... Curdsville Limestone Member, Lexington  
 Limestone.  
 Stratigraphic position ... 1 ft above the Tyrone Limestone—Lexing-  
 ton Limestone contact.  
 Silicified ..... Yes (35 lbs).  
 Section name ..... Tyrone C.  
 Section number ..... 174.

Collection number ..... 6035-CO\*.  
 Geographic location ..... Roadcut on New Watts Mill Rd., 0.1 mi SW.  
 of intersection with State Route 39.  
 Coordinates ..... Base of section at 260 mm east, 346 mm  
 north.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 89-94 ft above base of section.  
 Silicified ..... Yes (335 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6036-CO\*.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 80-84 ft above base of section.  
 Silicified ..... Yes (418 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6037-CO\*.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 70-74 ft above base of section.  
 Silicified ..... Yes (178 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6039-CO\*.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 65 ft above base of section.  
 Silicified ..... Yes (32 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6041-CO.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 38 ft above base of section.  
 Silicified ..... Yes (6 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6042-CO.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 35 ft above base of section.  
 Silicified ..... Yes (6 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6043-CO\*.  
 Geographic location ..... The same as for 6035-CO.  
 Coordinates ..... Do.  
 Formation ..... Oregon Formation.  
 Stratigraphic position ... 25 ft above base of section.  
 Silicified ..... Yes (17 lbs).  
 Quadrangle name ..... Little Hickman, Ky.  
 Section name ..... Little Hickman A.

Collection number ..... 6133-CO.  
 Geographic location ..... The same as for 6134-CO.  
 Coordinates ..... Do.  
 Formation ..... Tyrone Limestone.  
 Stratigraphic position ... 6 in. below Tyrone Limestone—Lexington  
 Limestone contact.  
 Silicified ..... Yes (38 lbs).  
 Quadrangle name ..... Bryantsville, Ky.  
 Section name ..... Bryantsville D.

Collection number ..... 6715-CO.  
 Geographic location ..... The same as for D-1169-CO.  
 Coordinates ..... Do.  
 Formation ..... Clays Ferry Formation.  
 Stratigraphic position ... 19 ft above base of formation.  
 Quadrangle name ..... Ford, Ky.  
 Section name ..... Clays Ferry; Ford A.  
 Section number ..... 22.

Collection number ..... 6751-CO.  
 Geographic location ..... The same as for 5072-CO.  
 Coordinates ..... Do.  
 Formation ..... Upper part of the Curdsville Limestone  
 Member, Lexington Limestone.  
 Silicified ..... Yes (301 lbs).  
 Quadrangle name ..... Frankfort East, Ky.  
 Section name ..... Frankfort East B.  
 Section number ..... 87.

Collection number ..... 7783-CO.  
 Geographic location ..... The same as for 5095-CO.  
 Coordinates ..... Do.  
 Formation ..... Topbed of the uppermost part of the Tangle-  
 wood Limestone Member (Tongue), Lex-  
 ington Limestone.  
 Stratigraphic position ... Just below Devils Hollow Member, Lexing-  
 ton Limestone.  
 Silicified ..... Yes (141 lbs).  
 Quadrangle name ..... Frankfort East, Ky.  
 Section name ..... Frankfort East A.  
 Section number ..... 86.

- Collection number ----- 7787-CO.  
Note: Recollection of 7783-CO.
- Collection number ----- 7794-CO.  
Geographic location ----- Roadcut on U.S. Route 227, just northeast of bridge crossing of Kentucky River.  
Coordinates ----- 397 mm east, 154 mm north.  
Formation ----- Oregon Formation.  
Stratigraphic position --- 112 ft below base Tyrone Limestone, 8 ft above base Oregon Formation.  
Quadrangle name ----- Ford, Ky.  
Section name ----- Daniel Boone Inn.
- Collection number ----- 7795-CO.  
Geographic location ----- The same as for 7794-CO.  
Coordinates ----- Do.  
Formation ----- Tyrone Limestone.  
Stratigraphic position --- 65 ft below top of Tyrone Limestone, 15 ft above top of Oregon Formation.  
Quadrangle name ----- Ford, Ky.  
Section name ----- Daniel Boone Inn.
- Collection number ----- 7796-CO.  
Geographic location ----- Interstate Route 75, 1.3 mi south of exit to State Route 418.  
Coordinates ----- 434 mm east, 313 mm north.  
Formation ----- Lowermost part of the Tanglewood Limestone Member (Tongue), Lexington Limestone.  
Stratigraphic position --- 3-9 ft above base Cane Run Bed of the Grier Limestone Member, Lexington Limestone.  
Silicified ----- Yes (175 lbs).  
Quadrangle name ----- Coletown, Ky.
- Collection number ----- 7802-CO.  
Geographic location ----- Roadcut 1.3 mi south of junction of U.S. Route 27 and State Route 227, south of Richmond, Ind.  
Coordinates ----- 347 mm east, 168 mm north.  
Formation ----- Whitewater Formation.  
Stratigraphic position --- 8-12-in. limestone ledge at top of roadcut.  
Quadrangle name ----- Richmond, Ind.
- Collection number ----- 7811-CO.  
Geographic location ----- The same as for 6945-CO.  
Coordinates ----- Do.  
Formation ----- Tanglewood Limestone Member, Lexington Limestone.  
Stratigraphic position --- 32 ft above Brannon Member—Tanglewood Limestone Member contact, Lexington Limestone.  
Silicified ----- Yes (117 lbs).  
Quadrangle name ----- Ford, Ky.  
Section name ----- Ford-Boonesboro Rd.
- Collection number ----- 7817-CO.  
Geographic location ----- Roadcut on State Route 39, 0.3 mi southeast of Black Bridge crossing of Hickman Creek.  
Coordinates ----- 269 mm east, 280 mm north.  
Formation ----- Curdsville Limestone Member, Lexington Limestone.  
Stratigraphic position --- 6 in. above Tyrone Limestone—Curdsville Limestone Member contact.  
Silicified ----- Yes (17 lbs).
- Quadrangle name ----- Little Hickman, Ky.  
Section name ----- Little Hickman A.
- Collection number ----- 7821-CO.  
Geographic location ----- Roadcut on U.S. Route 27, 0.5 mi northeast of junction with State Route 152.  
Coordinates ----- 433 mm east, 518 mm north.  
Formation ----- Tanglewood Limestone Member, Lexington Limestone.  
Silicified ----- Yes (29 lbs).  
Quadrangle name ----- Bryantsville, Ky.
- Collection number ----- 7823-CO.  
Geographic location ----- Roadcut on State Route 35, 0.6 mi northeast of junction with State Route 355.  
Coordinates ----- 16 mm east, 273 mm north.  
Formation ----- Lower part of the Tanglewood Limestone Member, Lexington Limestone.  
Silicified ----- Yes (68 lbs).  
Quadrangle name ----- Monterey, Ky.
- Collection number ----- 7824-CO.  
Geographic location ----- Roadcut on U.S. Route 42, 0.5 mi west of mouth of Sugar Creek to 0.5 mi east of mouth of Creek.  
Coordinates ----- 203 mm east, 139 mm north.  
Formation ----- Point Pleasant Tongue, Clays Ferry Formation.  
Stratigraphic position --- 3 ft above base of exposure, 20-25 ft below Point Pleasant Tongue—Kope Formation contact.  
Silicified ----- Yes (154 lbs).  
Quadrangle name ----- Patriot, Ky.-Ind.
- Collection number ----- 7825-CO.  
Geographic location ----- The same as for 7824-CO.  
Coordinates ----- Do.  
Formation ----- Point Pleasant Tongue, Clays Ferry Formation.  
Stratigraphic position --- 3 ft below Point Pleasant Tongue—Kope Formation contact.  
Silicified ----- Yes (231 lbs).  
Quadrangle name ----- Patriot, Ky.-Ind.
- Collection number ----- 7830-CO.  
Geographic location ----- The same as for 6211-CO.  
Coordinates ----- Do.  
Formation ----- Point Pleasant Tongue, Clays Ferry Formation.  
Stratigraphic position --- Float in lower 10 ft of gully on east wall.  
Silicified ----- Yes (22 lbs).  
Quadrangle name ----- Moscow, Ohio-Ky.  
Section name ----- Bear Creek.
- Collection number ----- 7835-CO.  
Geographic location ----- The same as for 7836-CO.  
Coordinates ----- Do.  
Formation ----- Camp Nelson Limestone.  
Stratigraphic position --- Float at base of section.  
Silicified ----- Yes (15 lbs).  
Quadrangle name ----- Little Hickman, Ky.  
Section name ----- Type section Camp Nelson Limestone.
- Collection number ----- 7842-CO.  
Geographic location ----- Quarry on U.S. Route 150 about 2.4 mi southeast of Danville.

- Coordinates ..... 18.5 mm east, 9.5 mm north.  
 Formation..... Cornishville Bed, Perryville Limestone Member, Lexington Limestone.  
 Quadrangle name..... Bryantsville, Ky.  
 Section name..... Caldwell Stone Quarry.
- Collection number ..... 7843-CO.  
 Geographic location ..... Roadcut on U.S. Route 127 (State Route 35) about 2.5 mi north of Moreland.  
 Coordinates ..... 260 mm east, 173.5 mm north.  
 Formation..... Ashlock Formation.  
 Silicified ..... Yes (450 lbs).  
 Quadrangle name..... Junction City, Ky.
- Collection number ..... 7863-CO.  
 Geographic location ..... The same as for 5079-CO.  
 Coordinates ..... Do.  
 Formation..... Camp Nelson Limestone.  
 Stratigraphic position... 5.1 ft above base of section.  
 Quadrangle name..... Wilmore, Ky.  
 Section name..... High Bridge.
- Collection number ..... 7885-CO.  
 Geographic location ..... The same as for 7875-CO.  
 Coordinates ..... Do.  
 Formation..... Camp Nelson Limestone.  
 Stratigraphic position... 102 ft above base of section.  
 Quadrangle name..... Wilmore, Ky.  
 Section name..... High Bridge.
- Collection number ..... 7886-CO.  
 Geographic location ..... The same as for 7875-CO.  
 Coordinates ..... Do.  
 Formation..... Tyrone Limestone.  
 Stratigraphic position... 210 ft above base of section.  
 Quadrangle name..... Wilmore, Ky.  
 Section name..... High Bridge.
- Collection number ..... D-1202-CO\*.  
 Geographic location ..... The same as for D-1200-CO.  
 Coordinates ..... Do.  
 Formation..... Brannon Member, Lexington Limestone.  
 Stratigraphic position... 215 ft above base of section.  
 Quadrangle name..... Frankfort East, Ky.  
 Section name..... Frankfort East A.  
 Section number ..... 86.
- Collection number ..... D-1206-CO\*.  
 Geographic location ..... The same as for D-1200-CO.  
 Coordinates ..... Do.  
 Formation..... Tanglewood Limestone Member, Lexington Limestone.  
 Stratigraphic position... 247 ft above base of section.  
 Quadrangle name..... Frankfort East, Ky.  
 Section name..... Frankfort East A.  
 Section number ..... 86.

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## **PLATE 1**

Contact photograph of this plate in this report is available at cost, from  
U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225.

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PLATE 1

FIGURE 1. *Amecystis laevis* (Raymond), 1921 (p. K2).

Ventral (anal) face of the theca and part of the column. Note the sculpture of the marginal plates and the tessellated periproct. Edinburg Formation, Tumbling Run, near Strasburg, Va. USNM 245181; (X 1.75).

2,3. *Amygdalocystites florealis* Billings, 1854 (p. K3).

Both specimens are from USGS locality 6134-CO, Curdsville Limestone Member, Lexington Limestone.

2. Anterior face of the theca with the recumbent arms and curved proximal part of the column attached. The actual plate ornamentation is not preserved. USNM 245182; (X 1.5).

3. Posterior face of the theca with the curved proximal part of the column and recumbent arms attached. The pinnules on the left arm are preserved lying on the theca. USNM 245183; (X 2).

4,13. *Cupulocrinus* sp. (p. K4).

Both specimens are from USGS locality 5072-CO, Curdsville Limestone Member, Lexington Limestone.

4. The dorsal cup and proximal parts of the arms (two pieces). USNM 245184; (X 2).

13. Poorly preserved theca and proximal parts of the arms. USNM 245192; (X 1.5).

5. *Heterocrinus* sp. (p. K4).

Thecal cup with part of the column and the proximal parts of the arms attached. USGS locality 4946-CO, Grier Limestone Member, Lexington Limestone. USNM 245185; (X 3).

6, 9. *Hybocrinus tumidus* Billings, 1857 (p. K3).

Two views of a poorly preserved theca. Note the crenulated anal (X) plate in fig. 9. USGS locality 5083-CO, Curdsville Limestone Member, Lexington Limestone. USNM 245186; (X 2).

7, 8, 10. *Hybocystites problematicus* Wetherby, 1880 (p. K4).

Specimens for figs. 7 and 10 from USGS locality 5083-CO, Curdsville Limestone Member, Lexington Limestone. Specimen for fig. 8 from USGS locality 7785-CO, Curdsville Limestone Member, Lexington Limestone.

7. Incomplete theca with a prominent radial plate. USNM 245187; (X 2).

8. Disarticulated radial plate. USNM 245188; (X 2).

10. Poorly preserved but essentially complete theca; note the radial plate with the arm base. USNM 245189; (X 2).

11, 12. *Carabocrinus* sp. (p. K4).

Both specimens from USGS locality 7785-CO, Curdsville Limestone Member, Lexington Limestone.

11. Radial plate. USNM 245190; (X 2).

12. Basal plate. USNM 245191; (X 2).

14-19. *Enoploura* cf. *E. punctata* Bassler, 1932 (p. K2).

Specimens shown in figs. 14-17 are from USGS locality 6134-CO, Curdsville Limestone Member, Lexington Limestone.

14. Poorly preserved incomplete carapace surface of the theca. USNM 245193; (X 3).

15. Incomplete carapace surface of the theca. USNM 245194; (X 2.5).

16. Incomplete theca with poorly preserved internal surface of the plastron face exposed. USNM 245195; (X 3).

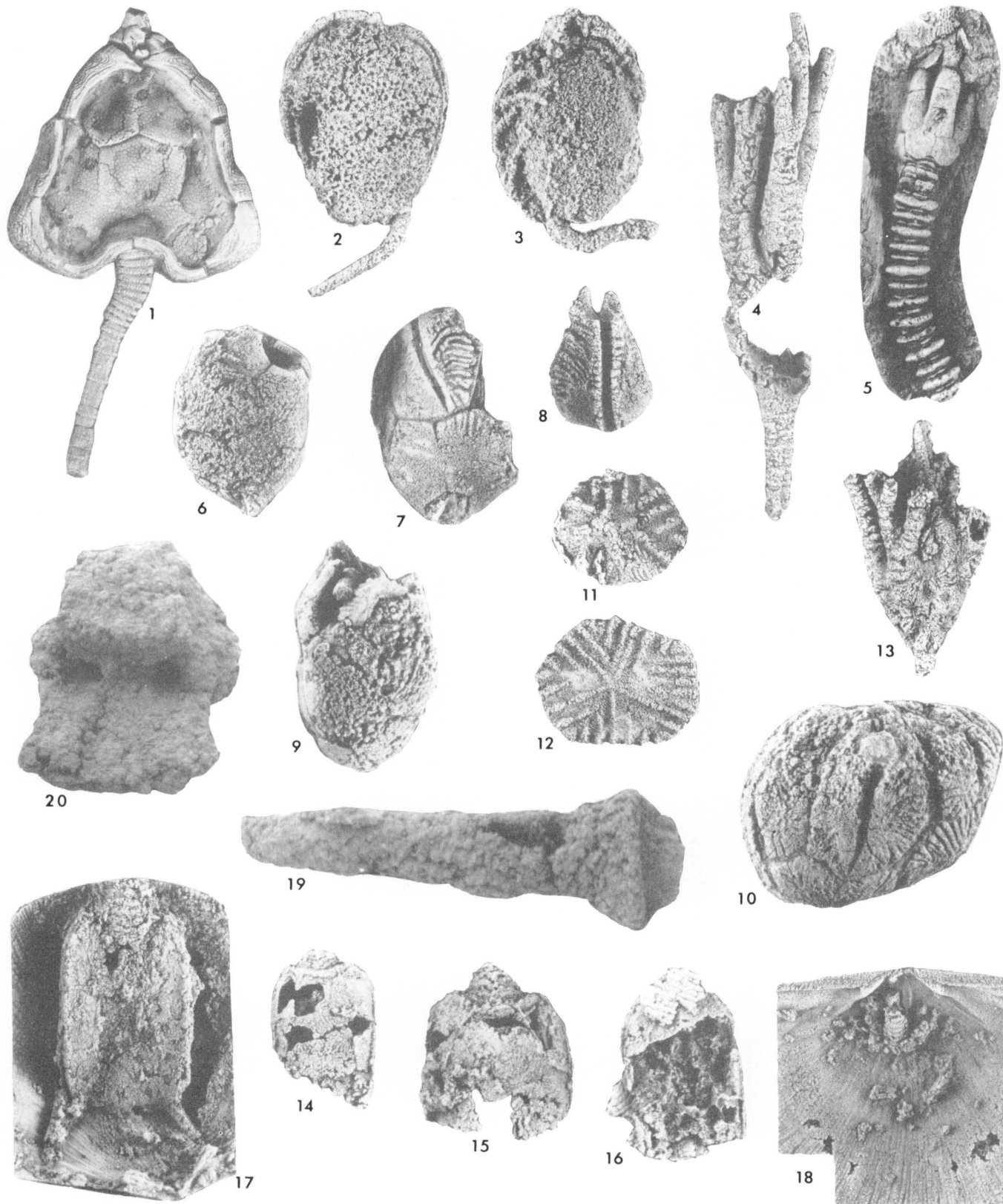
17. Theca with plastron surface exposed, articulating spines and proximal aulacophore attached. The animal is on the inner surface of a shell of the brachiopod *Rafinesquina*. USNM 247881; (X 2.5).

18. Fragmentary remains of a theca and proximal aulacophore on the undersurface of a shell of the brachiopod *Rafinesquina*. USGS locality 6143-CO, Clays Ferry Formation. USNM 247882; (X 2).

19. Articulating spine, lateral view. SEM photo. USGS locality 7785-CO, Curdsville Limestone Member, Lexington Limestone. USNM 247883; (X 18).

20. *Cyclocystoides* sp. (p. K5).

Distal view of a single submarginal plate with two radial ducts. SEM photo. USGS locality 5015-CO, Salvisa Bed, Perryville Limestone Member, Lexington Limestone. USNM 247884; (X 23).



*AMECYSTIS, AMYGDALOCYSTITES, CUPULOCRINUS, HETEROCRINUS, HYBOCRINUS, HYBOCYSTITES, CARABOCRINUS, ENOPLOURA, AND CYCLOCYSTOIDES*

