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NEW *BOTRYOCRINUS* AND *GLOSSOCRINUS* FROM THE MIDDLE DEVONIAN BELL SHALE OF MICHIGAN

BY

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NEW *BOTRYOCRINUS* AND *GLOSSOCRINUS* FROM THE MIDDLE DEVONIAN BELL SHALE OF MICHIGAN

ROBERT V. KESLING

ABSTRACT—From the Middle Devonian Bell Shale exposed in Alpena County, Michigan, two new crinoids have been found, each represented by several specimens collected over the last quarter century. *Botryocrinus bellensis* is a small inadunate characterized by a cup of slightly convex plates, long arms, and an unusually ornate long anal sac featuring a rectilinear series of strong supporting plates, lateral spines, and pores at the middle of each suture of the smaller plates. Its rays each divide once on PBr_3, producing ten zigzag arms which, starting at SBr_2 or SBr_3, bear a stout pinnule on every other plate; the pinnules are directed alternately away from and toward the midplane of the ray. *Glossocrinus bellitubatus* also has a cup of slightly convex plates and an unusually constructed anal sac supported by a rectilinear series of strong plates; the bordering anal plates in this species, however, are wide and deeply pleated, concealing the sutures. Both new crinoids have pentastellate columns.

INTRODUCTION

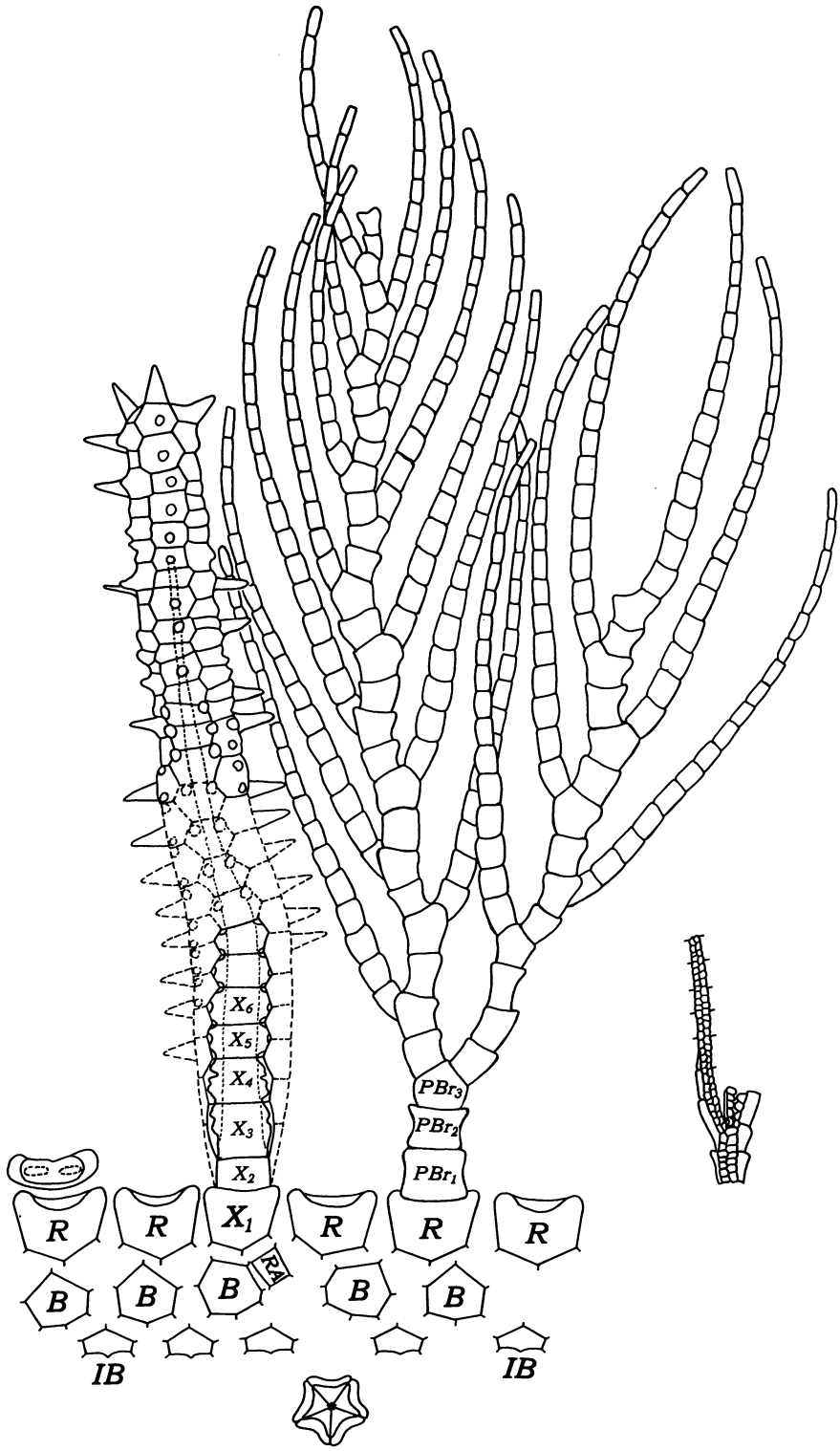
MANY YEARS have passed since the first specimens were discovered of the two crinoids described here. In the early 1940's, Mr. Irving G. Reimann picked up some small slabs bearing *Botryocrinus* from dump piles in the abandoned Kelley's Island Lime & Transport Quarry in northeastern Alpena County, Michigan. Since he was then connected with the Buffalo Museum of Science, he deposited his collection in that museum. In 1947 Reimann moved to the staff of the University Museums at The University of Michigan, and two years later I joined the Museum of Paleontology there. Shortly thereafter, with Professor (now Emeritus) George M. Ehlers and the late Professor Erwin C. Stumm, Reimann and I went on collecting trips to Devonian outcrops. Somehow, our itineraries did not include Alpena County. In discussion of Middle Devonian fossils and their occurrences, however, Reimann mentioned the fossiliferous slabs and the productive blue clay of the upper Bell Shale. From time to time in the years that followed, Ehlers, our students, and I searched the area of the Kelley's Island Quarry and gradually accumulated the *Botryocrinus* specimens described herein.

In searching the nearby exposure of soft clay shale for *Gennaeocrinus* and numerous other excellently preserved invertebrates, a specimen of *Glossocrinus* was found. It was not clean like the *Gennaeocrinus* with which it was associated, but encrusted with hard iron oxide, probably the weathering product of some marcasite in the replacement. Because the soft shale readily broke down as a matrix and yielded an outstanding microfauna, considerable quantities of the upper Bell Shale were processed from year to year. The residues contained other small invertebrates as well as the ostracods. A few of these washings had *Glossocrinus*, although it remains about as rare as *Logocrinus conicus* Kesling. In all, we now have only six specimens of the new *Glossocrinus*.

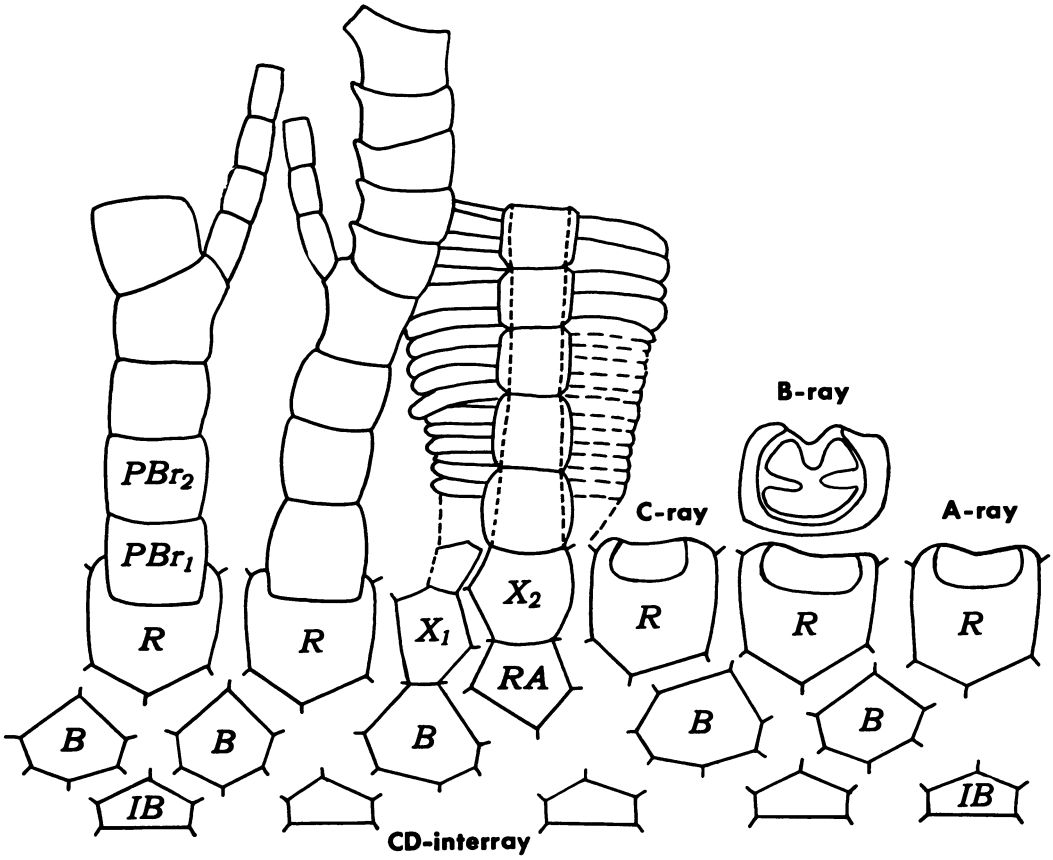
The supply of soft shale is plentiful, and processing on an expanded scale should produce many more *Glossocrinus*. This is not true of the *Botryocrinus*-bearing limy slabs. The productivity of the dump piles has declined in recent years. Small fossiliferous slabs can still be obtained but practically all of them have been inspected more than once for crinoids. No good reason exists for delaying the description of the crinoids any longer.

None of the hard slabs and pieces are in place, which makes stratigraphic placement difficult. These hard fossiliferous pieces probably came from a unit near the top of the Bell which crops out just below water level in the ditch from which the dump piles were derived. It is hard to decide, because chunks of the limestone unit freshly broken from the underwater ditch outcrop do not show clearly the kinds of fossils they contain. Prolonged weathering of the spoil slabs is necessary to bring the fossils into relief; the undersides of many slabs, lying on and protected by the soft shale with which they are admixed, expose very little of the fossil content. A few cups of *Botryocrinus* evidently weather completely from the hard limy matrix, and two have been found free on the Kelley's Island Quarry dump piles.

The same unit apparently once occurred in the Rogers City area. There, in the Calcite Quarry of Michigan Limestone Operations of



TEXT-FIG. *1*—*Botryocrinus bellensis* n. sp. Composite plate diagram based on camera lucida sketches of several specimens. Also shown are articular surfaces of one R and the ambulacral covering plates of a section of arm. Drawing by George C. McIntosh.



TEXT-FIG. 2—*Glossocrinus bellitubatus* n. sp. Plate diagram based primarily on holotype. Drawing by George C. McIntosh.

United States Steel Corporation, sinkholes in the highly soluble Rogers City Limestone were filled with collapsed debris from many levels in the overlying Bell Shale. At least one sink filling included rocks stratigraphically as high as the Ferron Point Formation. These sink fillings of shale contaminate the quarried limestone to such an extent that they must be completely eliminated by small operations and transported to dump piles in abandoned areas of the quarry. In 1958 Dr. Orval Pines, Chief Chemist for Michigan Limestone Operations, presented Professor Ehlers with a cup of *Botryocrinus* which he found in material removed from sink fillings in the quarry. This occurrence is unusual, for the crinoid *Gennaeocrinus variabilis* Kesling & Smith, rather common at the Kelley's Island Quarry, has never been recorded from Calcite Quarry. Nevertheless, the *Botryocrinus* found by Pines is obviously the same species as that found in the Kelley's Island Quarry dump piles of the upper Bell Shale; it is illustrated in plate 5, figures 6–8.

I am grateful to Irving G. Reimann for calling attention to his discovery, to Professor Ehlers for his long and patient field collecting, to Doctor Pines for his generous gift, and to the several students who assisted through the years, especially Porter M. Kier, Martin Weiss, Robert M. Linsley, and Rex M. Peterson. George C. McIntosh drew the text-figures from camera lucida sketches. This paper was helped by the excellent talents of Helen Mysyk in typing, Karoly Kutasi in photography, and Gladys Newton in proofreading.

All types are catalogued in our Museum of Paleontology.

LOCALITY

All specimens are from the upper part of the Bell Shale. With one exception, all are from the Kelley's Island Lime & Transport Company Quarry, near Rockport, in the northeast corner of Alpena County; this site lies about one-fourth mile west-northwest of the foundations of the old quarry buildings, in the NW¼ sec. 6, T 32 N, R 9 E. The exception is a *Botryocrinus* from a sink filling in the Calcite Quarry of Michigan Limestone Operations of United States Steel Corporation, near Rogers City,

Presque Isle County. This material was dumped and spread alongside the railroad leading from Calcite Quarry to Adam's Point Quarry and includes fossils from both Bell Shale and the Ferron Point Formation. Orval Pines picked up the crinoid just east of Swan River in the NE¼ sec. 32, T 35 N, R 6 E.

The *Botryocrinus* specimens from Alpena County occur on small slabs and fragments of hard argillaceous limestone, most about an inch thick and some much thinner. On both sides of a drainage ditch, which extends down into the Bell Shale, the ridges of spoil thrown up and dumped by the dredging contain scattered slabs admixed with the soft gray clay. Never numerous, these slabs are now very scarce. They probably came from a unit which crops out underwater in the ditch.

The *Glossocrinus* occur in the same quarry about 100 yards south-southeast of the dump piles, in an outcrop which has yielded *Gennaeocrinus variabilis* Kesling & Smith and *Logocrinus conicus* Kesling. The same fauna occurs at about the same topographic level in the northeast corner of the quarry, in a roadside ditch near the exit from the quarry, although no *Glossocrinus* have been found there. The local strike, therefore, is nearly due north, although the general strike is northwest. From its location, I think the *Botryocrinus* bed is stratigraphically a little higher than the *Glossocrinus*-bearing unit and only a little below the base of the Rockport Quarry Limestone.

SYSTEMATIC DESCRIPTIONS

Class CRINOIDEA
Subclass INADUNATA
Order CLADOIDEA
Suborder DENDROCRINOIDEA

Family BOTRYOCRINIDAE Bather 1899
Genus BOTRYOCRINUS Angelin 1878

BOTRYOCRINUS BELLENSIS n. sp.

Text-fig. 1; pls. 1–4; pl. 5, figs. 1–3, 6–10; pl. 6; pl. 7, figs. 1, 2, 10–12

Description.—Crown with low cup and long arms (pl. 2, fig. 1; pl. 3, fig. 3; pl. 6, figs. 1, 3). Anal sac forming tube about 5 times the height of the dorsal cup; arms distinctly longer than anal tube, their fragile tips seldom preserved.

Dorsal cup subconical, its sides making an angle of about 60 degrees with the base. RR-X_1 circlet slightly flared and indented at the sutures (pl. 2, figs. 2–4; pl. 4, fig. 5; pl. 5, figs. 6–10); IBB circlet subpentagonal with sutures protuberant (pl. 2, fig. 2; pl. 3, fig. 2; pl. 4, fig. 5; pl. 7, figs. 11, 12); and BB circlet nearly conical and smooth, confluent with other circlets. Plates thick, with RA nearly forming a cube (pl. 5, fig. 3), sutural surfaces large (pl. 3, fig. 1); many cups, therefore, well preserved and not distorted.

IBB about equal, varying somewhat from specimen to specimen but with height rarely exceeding half the width. Base of IBB circlet strongly reflecting the stellate shape of the column (pl. 5, figs. 6–8). Each IB with its sides protuberant and its center slightly concave, especially the lower half.

BB intermediate in size between IBB and RR, each plate very slightly convex (pl. 2, fig. 2). Posterior BB modified in shape to accommodate RA and X_1 (as in other species of the genus), but not appreciably larger than other BB (text-fig. 1; pl. 5, figs. 6–8).

RA small, its outer face nearly square (pl. 3, fig. 3; pl. 4, fig. 2; pl. 5, fig. 2) and its inner face nearly the same size and shape (pl. 5, fig. 3). Each side of RA about equal to thickness of the dorsal cup; hence, total plate approximately a cube. Height of RA (along diagonal of the square) considerably less than height of adjacent BB, in most specimens about two-thirds.

RR and X_1 forming circlet of six nearly equal plates with depressed sutures. Each R wider than high, subcylindrical. Arm facet occupying only about half the ventral border of R, its articular surface broad. Inner ventral margin with a median indentation for ambulacral groove (pl. 3, fig. 1; pl. 5, fig. 3). Shoulders of R on either side of arm facet clearly defined. X_1 the same size and shape as adjacent RR, its resemblance heightened by the armlike rectilinear series of stout supporting anal plates rising from its ventral articular surface (pl. 5, fig. 10; pl. 6, fig. 1).

Each ray dividing on PBr_3 to produce ten long zigzag arms. Each PBr wider than high, its sides concave and its distal end widened

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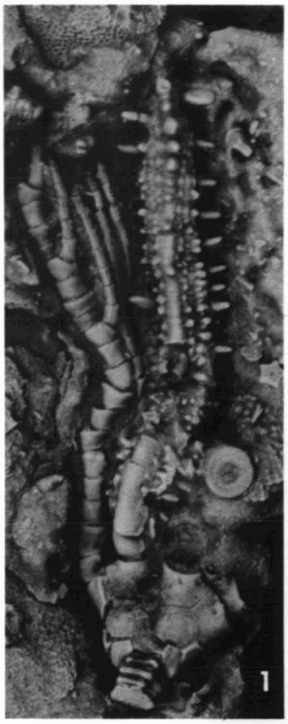
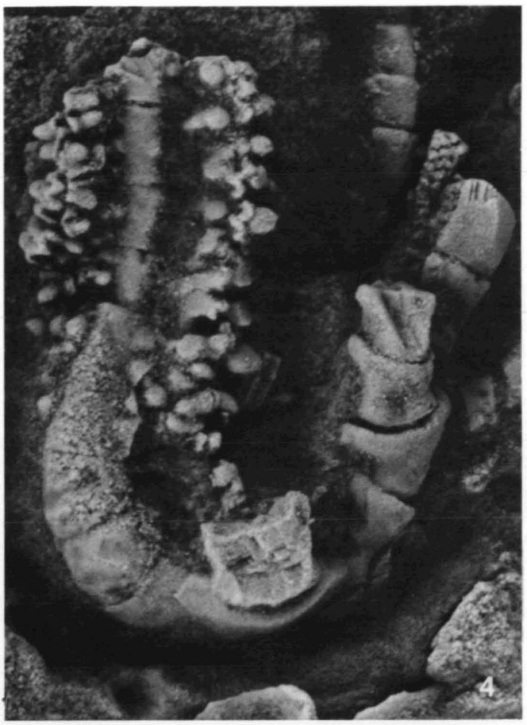
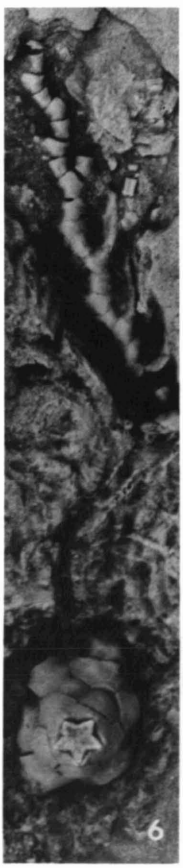
EXPLANATION OF PLATE 1
Figures × 4 except as noted

FIGS. *1–6—Botryocrinus bellensis* n. sp. *1, 2,* holotype UMMP 57966, cup with posterior side uppermost on slab; *2,* anal tube and arm of D ray, × 10. *3, 4,* paratype UMMP 57977, two cups mostly embedded in matrix with parts of arms and anal tubes exposed; *4,* base of anal tube of lower cup showing median row of large plates and lateral small plates with convoluted edges, × 10. *5,* paratype UMMP 57970, cup and attached arms partly exposed on small slab. *6,* paratype UMMP 57984, cup with ventral end down and partly exposed arm of C ray; one columnal still attached to base.







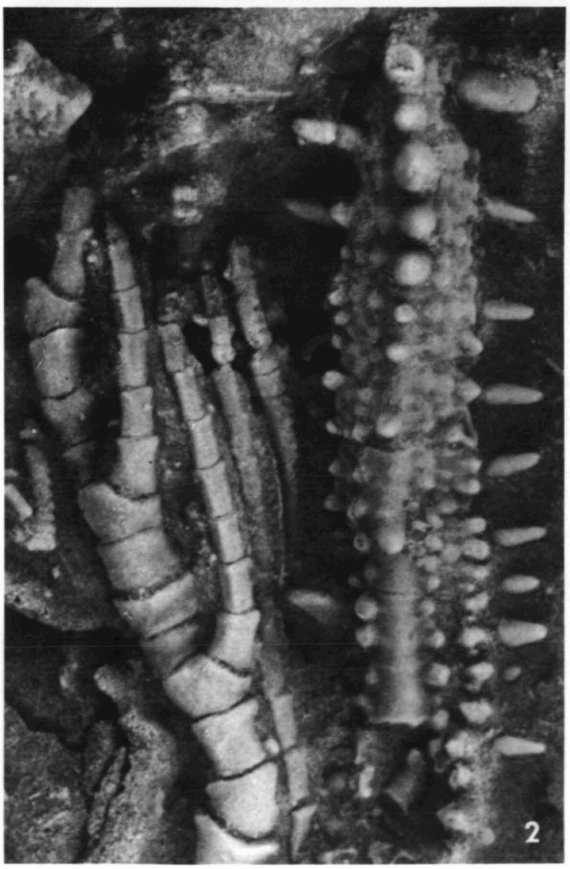


PLATE 1

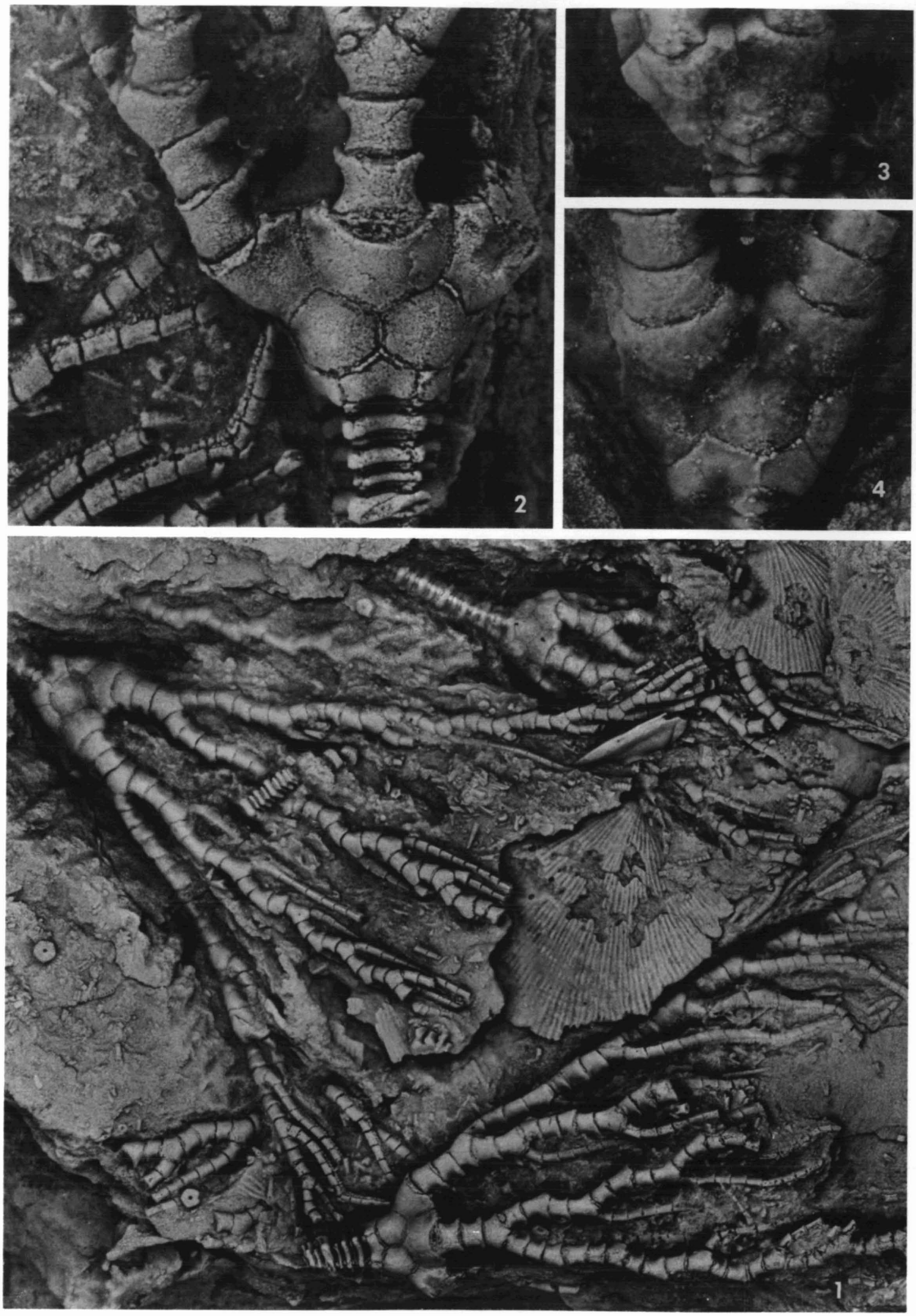


PLATE 2

laterally to form smoothly confluent flanges (pl. 2, fig. 2). PBr_1 about half as wide as the R at its articulation, constricting to become only a little wider than high at midheight, and flaring to greatest width at the distal flanges. PBr_2 the same shape as PBr_1 but slightly smaller. PBr_3 axillary, about as large as PBr_1, distally bearing two equal arms. One ray found with PBr_2 axillary (right ray, pl. 4, fig. 5).

Arms long, composed of as many as 33 SBrBr each (left specimen in pl. 2, fig. 1) but delicate tips seldom preserved. Starting with SBr_2 or SBr_3, every other SBr bearing a stout pinnule; the first pinnule directed away from the midplane of the ray, the second directed toward the midplane, and alternating regularly thereafter to the end of the arm. Two arms of the same ray may bear the first pinnule on a different PBr (central ray in bottom specimen, pl. 2, fig. 1), or arms of one ray may start pinnules on $PBrBr_2$ and arms of an adjacent ray may start pinnules on $PBrBr_3$ (middle and right rays, pl. 4, fig. 5). More arms bearing first pinnule on SBr_3 than on SBr_2. Each pinnule-bearing SBr pentagonal (resembling an axillary Br), distally acuminate with the pinnule arising from the shorter slanting end surface and the next (pinnule-free) SBr arising from the longer slanting end surface; arm sharply changing direction, therefore, at end of each pinnule-bearing SBr, veering away from side bearing the pinnule. With at least 33 SBrBr in each arm, crinoid possibly possessed 16 or more pinnules per arm (eight on each side) and 160 or more pinnules per individual.

SBrBr very gradually decreasing in size distally. Each pinnule-free SBr nearly square in outer view, bearing small lateral projections or flanges at its distal end. Each pinnule-bearing SBr wider and higher than the preceding SBr but also bearing small lateral projections. Except for lateral projections, each SBr subcylindrical, without median ridge or ornamentation. Inner surface of PBrBr and SBrBr deeply incised for ambulacral groove (pl. 3, fig. 1).

Pinnules stout and long, tapering very gradually, bearing a median angulation or crest. Proximal pinnular at least half as wide as the opposing SBr; pinnulars averaging the same length as the corresponding SBrBr equidistant from the pinnule-bearing SBr, hence each about twice as high as wide. At least 14 pinnulars in each pinnule (pl. 7, fig. 2); the average pinnule, therefore, nearly half as long as the SBrBr series in the arm. Ambulacral groove in both BrBr and pinnules covered by series of alternating narrow cover plates, about four on each side of each plate (pl. 2, fig. 2; pl. 3, fig. 1). Each crown possessed about 15 PBrBr, at least 330 SBrBr, at least 2240 pinnulars, and at least 20,680 ambulacral cover plates; a perfect specimen might show even more plates.

Anal sac forming a long tube, its base apparently covering much of the tegminal area (pl. 1, fig. 1). Tube supported mainly by a rectilinear series of large quadrate plates above X_1, tapering very gradually with height in width and thickness. Each side of tube provided with a vertical row of stout rather blunt spines (pl. 1, fig. 2). Proximal plates of rectilinear series about the same size as the PBrBr of arms (pl. 5, fig. 10; pl. 6, fig. 1); distal plates of series bearing nodes or blunt spines (pl. 1, fig. 2). Each plate of rectilinear series bordered on each side by two or three smaller subhexagonal plates arranged in vertical series (pl. 1, figs. 3, 4; pl. 4, fig. 6; pl. 6, fig. 5). Smaller plates indented at middle of each side by a large circular pore, giving them stellate shapes; most smaller plates bearing central nodes, certain of those at sides of tube bearing stout spines. Distal plates of anal tube becoming irregular in outline (pl. 6, fig. 4), some provided with two or three nodes or short spines each (pl. 5, fig. 1).

Column pentastellate, heteromorphic. Noditaxes normally consisting of nodal, priminternodal, and two secundinternodals (pl. 4, fig. 2), but with intercalations, omissions, or substitutions at some places (pl. 3, fig. 2). Nodal with rounded epifacet, priminternodal and secundinternodal similar to nodal but smaller. An occasional nodal with very large inflated epifacet. Articulum sharply pentastellate (pl. 5, fig. 8), its wide crenularium containing about 7 crenulae per side. Selected indices in the system of Moore, Jeffords, & Miller (1968): columnal height index of nodal (KH/KD × 100) about 19; nodal index (NH/NTH × 100) about 31; internodal index (INH/NTH × 100) about 69; epifacetal index of nodal (2ER/KD × 100) about 22.

Remarks.—The new species differs from

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EXPLANATION OF PLATE 2
Figures × 10 except as noted

FIGS. *1–4—Botryocrinus bellensis* n. sp. Paratype UMMP 57968. *1*, small slab with three cups and extensive parts of arms exposed, × 4. *2–4*, three cups, the first naturally weathered and preserving fine details of cup and proximal section of column.

EXPLANATION OF PLATE 3
Figures × 10 except as noted

FIGS. *1–3—Botryocrinus bellensis* n. sp. *1*, paratype UMMP 57973, weathered part of cup and attached arms, showing interior surface of cup plates and ambulacral grooves of arms, the latter partly retaining ambulacral cover plates. *2*, paratype UMMP 57974, partly crushed cup and attached column, showing pentagonal circlet of IBB plates and heteromorphic columnals. *3*, paratype UMMP 57967, small slab with two crowns, the lower poorly replaced in fossilization (enlargement of the upper cup shown in plate 5, figure 9); × 4.

EXPLANATION OF PLATE 4
Figures × 4 except as noted

FIGS. *1–6—Botryocrinus bellensis* n. sp. *1*, *3*, paratype UMMP 57969, two cups on the same small slab; *1*, cup with anal series crushed inward but continuous with anal tube; *3*, broken cup and inner surface of two arms showing ambulacral cover plates. *2*, paratype UMMP 57976, cup partly embedded with C ray uppermost; enlargement of cup shown in plate 5, figure 2, and another specimen on the same slab shown in plate 5, figure 1. *4–6*, paratype UMMP 57982, slab with three specimens embedded; *4*, *5*, crown with a few columnals attached; figure 5, × 10; *6*, broken section of anal tube showing crenulate edges of plates, × 10 (another specimen on this slab shown in plate 6, figure 5).

EXPLANATION OF PLATE 5
All figures × 10

FIGS. *1–3*, *6–10—Botryocrinus bellensis* n. sp. *1*, *2*, paratype UMMP 57976, two specimens on small slab; *1*, partly disarticulated anal tube showing spinose crenulate-edged plates; *2*, cup with C ray uppermost showing diamond-shaped RA (another view of cup shown in plate 4, figure 2). *3*, paratype UMMP 57985, broken cup showing interior surface, oriented with X lowermost on slab. *6–8*, paratype UMMP 38204, cup weathered free of matrix and retaining a few columnals; *6*, lateral view centered on E ray; *7*, lateral view centered on C ray; *8*, dorsal (basal) view with C ray uppermost, showing articular facet of columnal. *9*, paratype UMMP 57967, one of two cups on slab, with RA uppermost; see also plate 3, figure 3. *10*, paratype UMMP 57972, cup on small slab with X uppermost, showing expansion of anal series leading into anal tube.

4, *5—Botryocrinus* sp. UMMP 57987. *4*, lateral view of compressed cup centered on B ray. *5*, lateral view centered on RA.

EXPLANATION OF PLATE 6
Figures × 4 except as noted

FIGS. *1–5—Botryocrinus bellensis* n. sp. *1–3*, paratype UMMP 57983, slab with three crowns exposed; cleaning did not expose pinnulars well; *1*, crown with X uppermost; *2*, crown in very hard matrix, incompletely exposed; *3*, crown with BC interray uppermost. *4*, paratype UMMP 57975, part of anal tube flattened and recurved, with the main anal series at the right, × 10. *5*, paratype UMMP 57982, part of arm and inner surface of some plates of broken anal sac, showing pore at middle of each side of each small anal plate, × 10 (other specimens on this slab shown in plate 4, figures 4–6).

EXPLANATION OF PLATE 7

FIGS. *1*, *2*, *10–12—Botryocrinus bellensis* n. sp. All figures × 10. *1*, paratype UMMP 57971, cup and part of column on small slab, C ray uppermost. *2*, paratype UMMP 57979, slab bearing part of arm, showing length and size of pinnules. *10–12*, paratype UMMP 57986, cup weathered free of matrix; *10*, lateral view centered on A ray; *11*, lateral view centered on X_1; *12*, dorsal (basal) view with X uppermost, showing articular facet for column on base of IBB circlet.

3–9—Glossocrinus bellitubatus n. sp. Figures × 5 except as noted. *3–5*, holotype UMMP 57989, cup with parts of column and arms, preserving proximal section of anal sac; *3*, lateral view centered on AE interray; *4*, *5*, lateral views centered on CD interray, showing deeply pleated anal plates alongside rectilinear series of stout supporting plates; *5*, × 10. *6–9*, paratype UMMP 57988, cup with two large anal plates attached to tegmen; views centered on CD interray, tegmen (venter), D ray, and columnar facet of the IBB circlet (enlargement of posterior region shown in plate 8, figure 11).

EXPLANATION OF PLATE 8
Figures × 5 except as noted

FIGS. *1–14—Glossocrinus bellitubatus* n. sp. *1–6*, paratype UMMP 57990, cup with proximal sections of arms, anal sac broken up and most plates dislodged; *1–4*, views centered on A ray, CD interray, DE interray, and column; *5*, plates of anal sac showing deep pleats, × 10; *6*, articular facets of column, × 10. *7–10*, paratype UMMP 57991, cup with proximal sections of some arms, anal plates in disarray except for rectilinear series; *7–9*, views centered on AE interray, CD interray, and base (dorsum); *10*, RA and basal XX plates, × 10. *11*, paratype UMMP 57988, RA and adjacent plates, × 10 (other views of specimen in plate 7, figures 6–9). *12*, paratype UMMP 56519, view centered on D ray, with 8 BrBr; reverse side (not shown) preserves some pleated anal plates. *13*, *14*, paratype UMMP 57524, views centered on CD and AB interrays, anal plates disarranged.

15, *16—Logocrinus conicus* Kesling. UMMP 57992, specimen associated with *Poteriocrinites bellitubatus*.

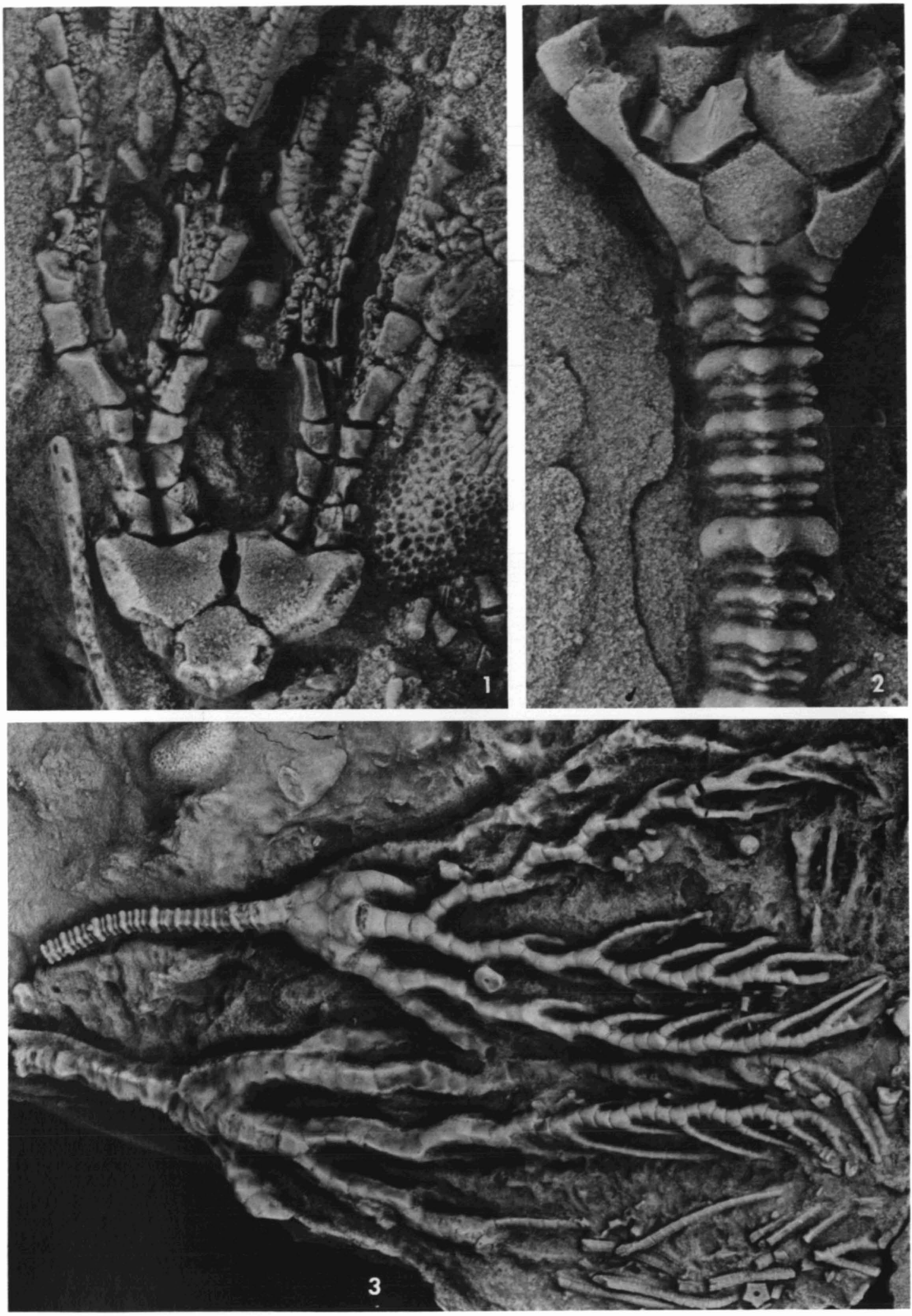


PLATE 3

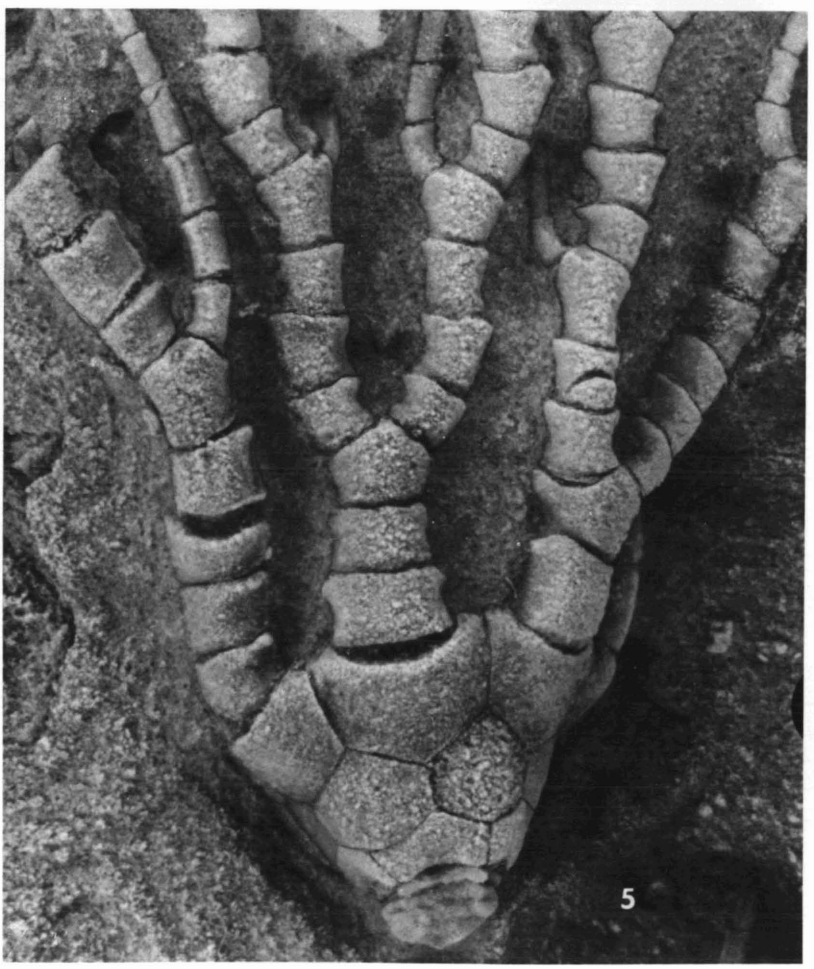


PLATE 4

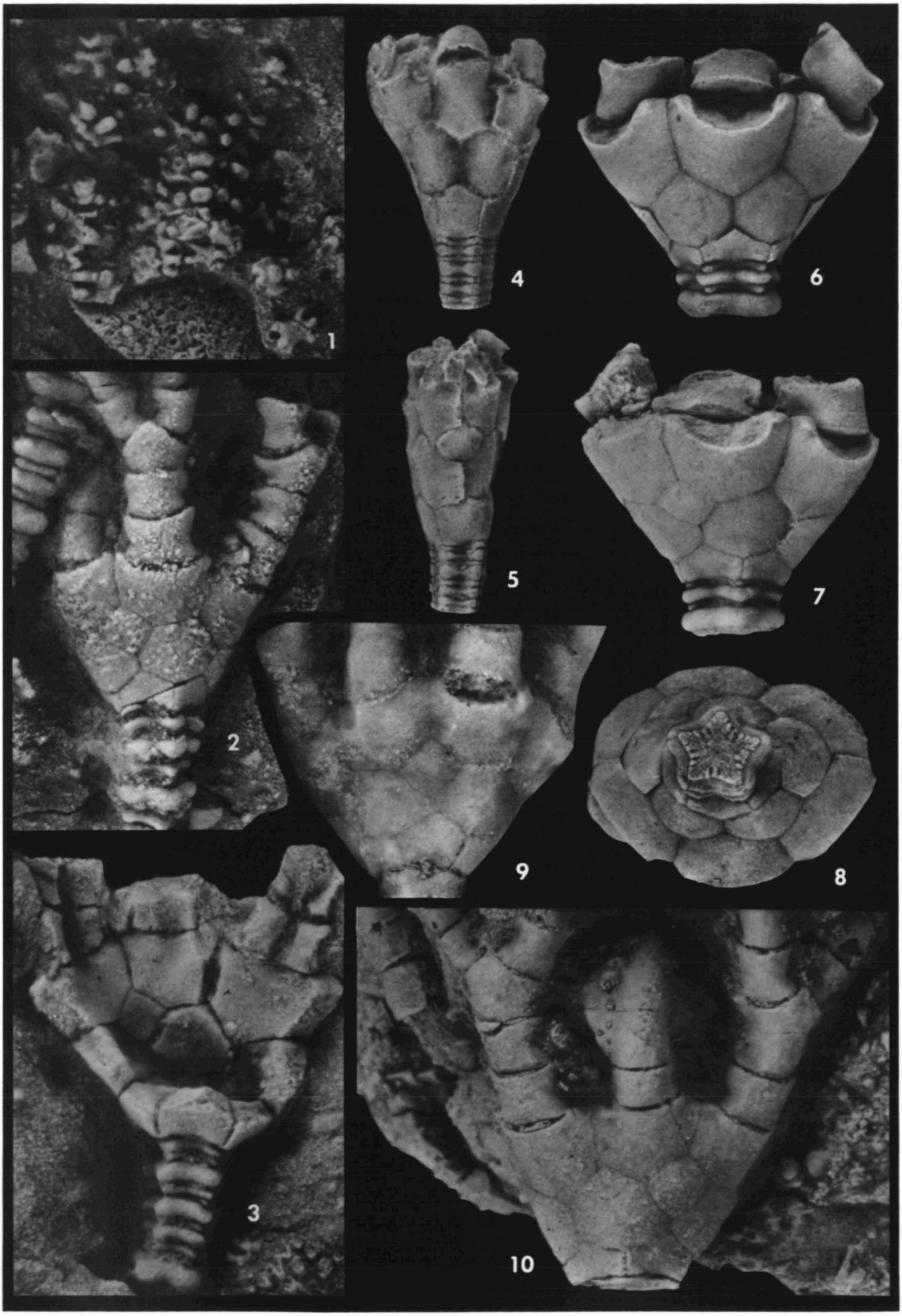
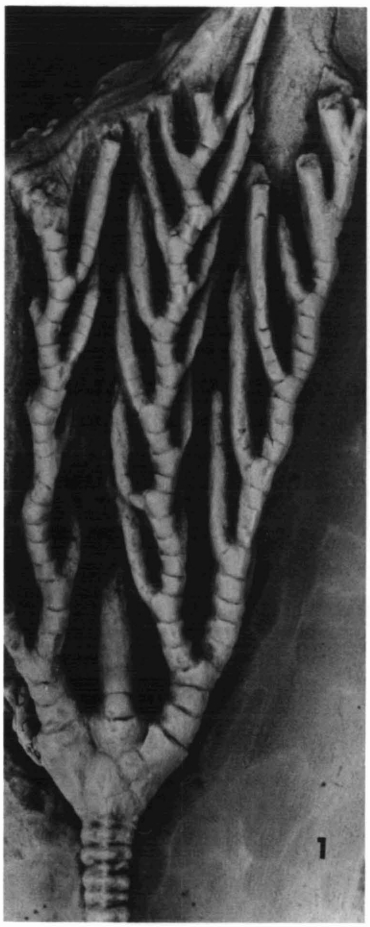
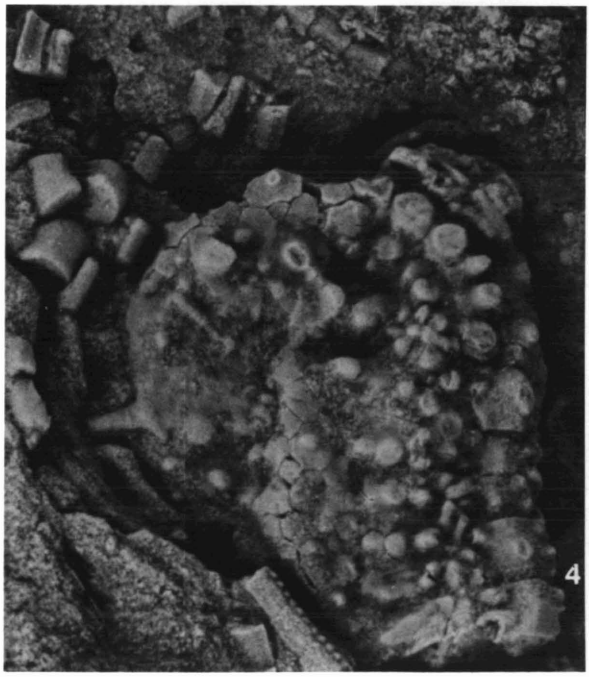


PLATE 5





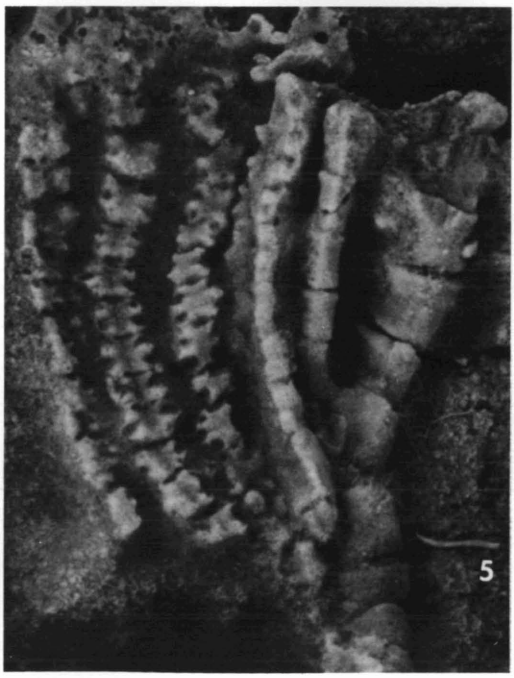


PLATE 6

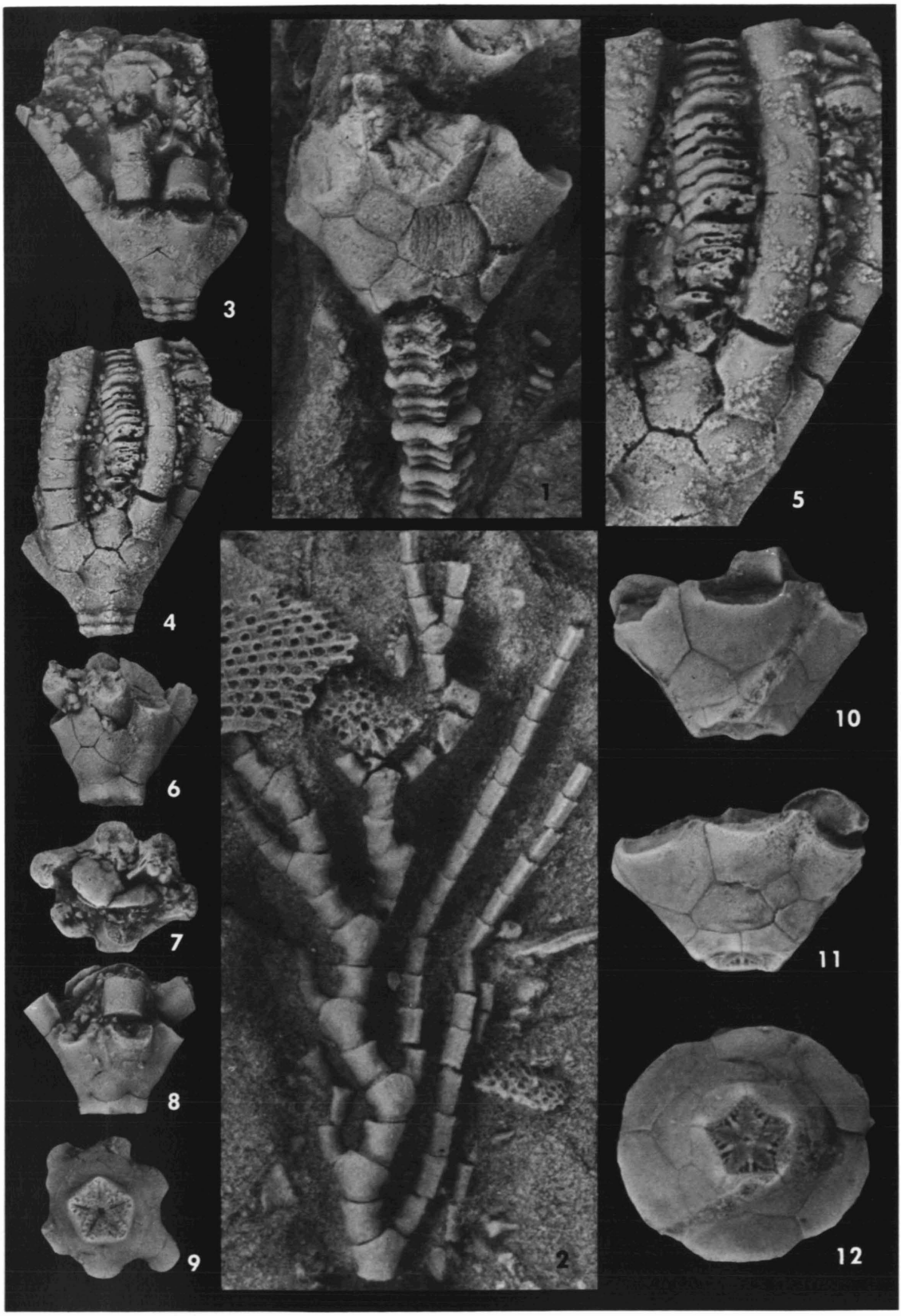


PLATE 7

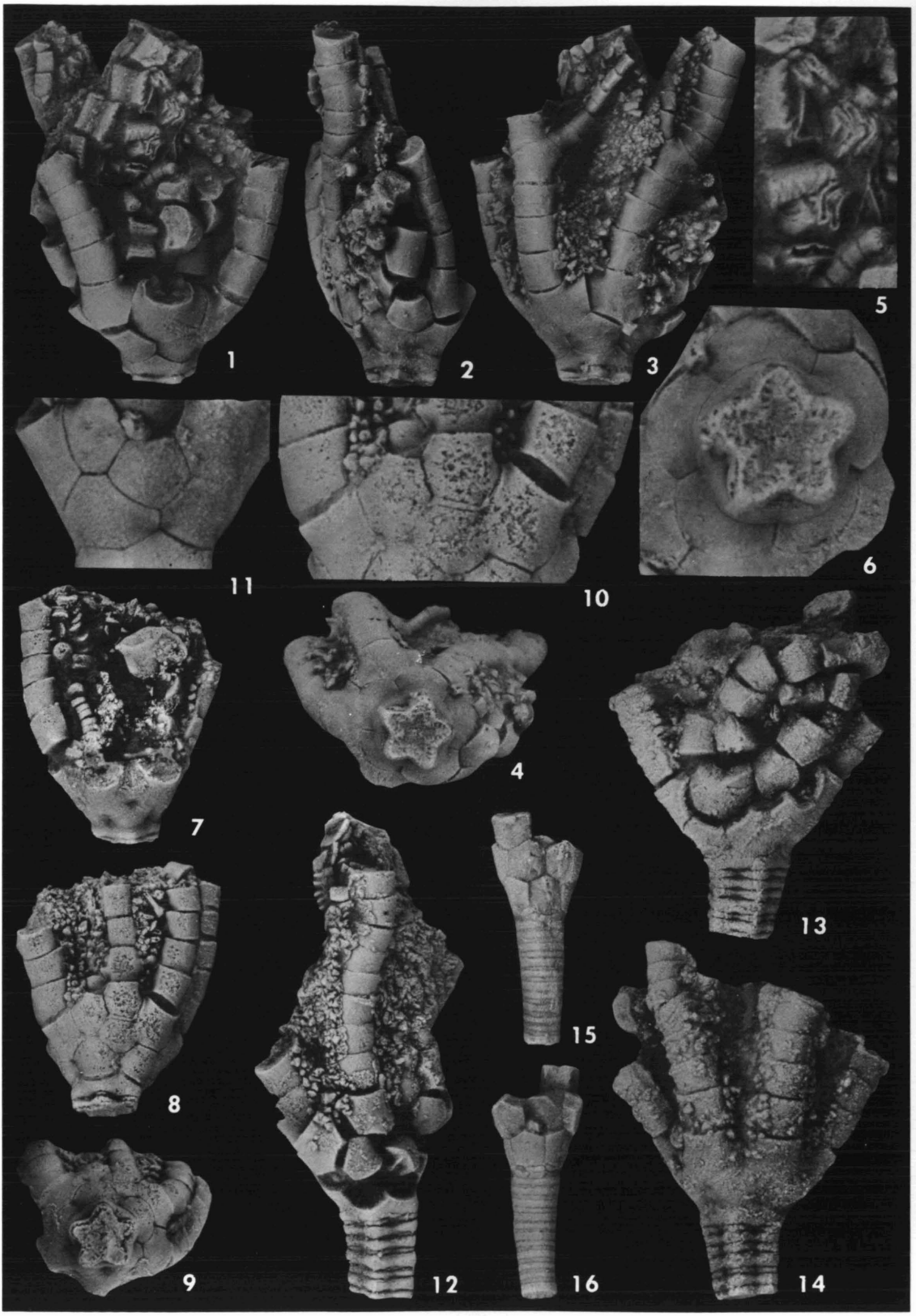


PLATE 8

the several species described by Goldring (1923, 1935, 1954). It is distinguished from *Botryocrinus costatus* Goldring, *B. crassus* (Whiteaves), *B. ornatus* Goldring, and *B. angularis* Goldring by its lack of ornamentation on plates of the cup. Its radial facets do not protrude like those of *B. bethaniensis* Goldring and they are much wider than those of *B. nycteus* (Hall). The preservation of the anal tube and most of the arms, as well as the proximal section of the column, make this one of the best known species of the genus.

Type specimens.—Holotype UMMP 57966 (pl. 1, figs. 1, 2). Paratypes UMMP 38204 (pl. 5, figs. 6–8), 57967 (pl. 3, fig. 3; pl. 5, fig. 9), 57968 (pl. 2, figs. 1–4), 57969 (pl. 4, figs. 1, 3), 57970 (pl. 1, fig. 5), 57971 (pl. 7, fig. 1), 57972 (pl. 5, fig. 10), 57973 (pl. 3, fig. 1), 57974 (pl. 3, fig. 2), 57975 (pl. 6, fig. 4), 57976 (pl. 4, fig. 2; pl. 5, figs. 1, 2), 57977 (pl. 1, figs. 3, 4), 57979 (pl. 7, fig. 2), 57982 (pl. 4, figs. 4–6; pl. 6, fig. 5), 57983 (pl. 6, figs. 1–3), 57984 (pl. 1, fig. 6), 57985 (pl. 5, fig. 3), and 57986 (pl. 7, figs. 10–12).

BOTRYOCRINUS sp.
Pl. 5, figs. 4, 5

Remarks.—A small cup with a few millimeters of column attached is rather crushed, but enough is preserved to indicate that it is different from *Botryocrinus bellensis* n. sp. and apparently from other species of the genus. The cup is about the same height as that of the new species, but it is much narrower at the level of the RR-X_1 circlet. The IBB are higher than wide, the BB are a little higher than wide, and the RR and X_1 are relatively narrow and only slightly flared. The RR facets are narrow and semicircular, protruding from the rest of the ventral borders of the RR plates. The column is pentastellate, containing alternating colmnals of two sizes.

The general shape of the cup and the rather high IBB suggest that the species might be assigned to *Bactrocrinites*. Its cup is not nearly as narrow as those in crinoids assigned to *Bactrocrinites* by Goldring (1954), and its BB are much smaller. Until better specimens are discovered, it is perhaps best to leave the species unnamed.

Specimen.—UMMP 57987.

Family POTERIOCRINITIDAE Bassler 1938
Genus GLOSSOCRINUS Goldring 1923

GLOSSOCRINUS BELLITUBATUS n. sp.
Text-fig. 2; pl. 7, figs. 3–9; pl. 8, figs. 1–14

Description.—Cup low, wider than high. In lateral view, cup with parallel (vertical) sides in IBB circlet, flared in BB and RR-XX circlets with sides there making an angle of about 60 degrees with the base. Cup distinctly indented along IB-IB sutures, shallowly indented at corners of other plates (pl. 8, figs. 7, 8). Plates unornamented.

IBB circlet pentagonal at columnar facet (pl. 7, fig. 9), its sides nearly vertical (pl. 7, figs. 6, 8; pl. 8, figs. 1–3, 7, 8). Each IB about 2½ times as wide as high, with very short sides. BB circlet flaring, set at distinct angle to IBB circlet (pl. 7, figs. 3, 4, 6, 8). Each B with nearly equal width and height. RR forming a circlet with X_1 and X_2, irregularly offset above RA, continuing the flare of the BB circlet. RR somewhat larger than BB. Each R with protruding semicircular facet occupying nearly two-thirds of its upper (ventral) edge. R of C ray with nearly equal sides adjoining X_2, RA, B of BC interray, and R of B ray.

Arms unbranched as far as PBr_9 (pl. 8, fig. 3) but some bearing stout pinnules at PBr_4 (pl. 8, figs. 1, 3). PBrBr tapering very little in preserved sections of arms; each plate nearly square in lateral view, its distal end expanded into small flanges, sharp and projecting laterally. Pinnules with large bases, tapering rapidly and changing cross section from U- to V-shaped. Pinnulars longer than wide, except perhaps the proximal one.

RA, X_1, and X_2 about the same size (pl. 8, fig. 10). RA pentagonal, its sides about equal. X_1 hexagonal, with longest side adjoining R of D ray. X_2 pentagonal, with longest side adjoining R of C ray.

Anal sac forming an upright tube, supported mainly by a vertical rectilinear series of stout subrectangular XX atop X_2 (pl. 7, figs. 4, 5; pl. 8, fig. 8). X_3 a small polygonal plate above X_1. Anal plates alongside main rectilinear series wide but very thin, deeply pleated in horizontal folds, having the appearance of stacked coins or poker chips. Pleats (pl. 8, fig. 5) very deep, obscuring the sutures between these plates. Three to four pleats beside each supporting plate, suggesting this number of pleats per bordering plate; the latter probably offset from the supporting plates but sutures not seen. Isolated pieces adhering to tegmen in some specimens, probably broken sections of bordering plates (pl. 7, figs. 7, 8; pl. 8, fig. 7), with large parallel upper and lower surfaces. Other plates of anal sac not known with certainty, apparently small and possibly irregular.

Column pentastellate, heteromorphic, consisting of alternating nodals and internodals. Columnar facet on base of IBB circlet pentagonal (pl. 7, fig. 9), its crenularium penta-

stellate. Epifacets of nodals and internodals small, rounded. Crenularium of columnals divided into outer and inner zones of crenulae (pl. 8, fig. 6), forming concentric pentagrams.

Remarks.—*Glossocrinus* is a rare crinoid; only one other species is known in addition to the type species. Its cup plates are like those of *Poteriocrinites*, but it can be easily identified by the unusual anal sac. This was described by Goldring (1923, p. 389, 390) as follows:

> Anal tube long and slender, almost as long as the arms; supported on the dorsal (posterior) side by a median line of quadrangular plates, the first of which rests upon the radianal and touches on the anal *x* on the left, the right posterior radial on the right. Median row of plates flanked on each side by a row of plates provided with comparatively high thin folds, four or five to a plate, which gives the tube a plicated appearance. Ventral (anterior) side the same, except that the median row of quadrangular ossicles is replaced by a median row of small interlocking plates.

Goldring presented a clear account of the structure in the type species, *Glossocrinus naplesensis* (1923, p. 392):

> Anal tube very striking and characteristic; long and slender. . . A median line of quadrangular, supporting ossicles extends up the dorsal (posterior) side of the anal tube, giving the appearance of a simple uniserial arm. . . On each side of the median line of plates is a row of wide plates, each of the height of the neighboring plate of the axial row, each provided with folds, usually four or five, which give a plicated, accordion-pleated appearance to the tube. Along the margin of the tube on each side these plates are thickened and strengthened.

Several features separate the new species from the two described by Goldring. *Glossocrinus bellitubatus* lacks radial ridges on the cup plates, differentiating it from *G. naplesensis* Goldring in which such ridges are strongly developed; in this respect, it resembles *G. cornellianus* (Williams). It differs from both species in the arrangement of pinnules, which are apparently irregularly distributed on the proximal PBrBr and not, as Goldring found them in *G. naplesensis* (1923, p. 392) and in *G. cornellianus* (1923, p. 396), "alternately on each side." The new species has a cup flaring much more than that of *G. cornellianus*. All three species are nearly the same size.

The thinness and great surface area of the pleated anal plates suggests that respiration was accomplished directly through the plate material. The sac does not show any pores like those present in *Botryocrinus bellensis*.

Types.—Holotype UMMP 57989 (pl. 7, figs. 3–5). Paratypes UMMP 56519 (pl. 8, fig. 12), 57524 (pl. 8, figs. 13, 14), 57988 (pl. 7, figs. 6–9; pl. 8, fig. 11), 57990 (pl. 8, figs. 1–6), and 57991 (pl. 8, figs. 7–10).

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