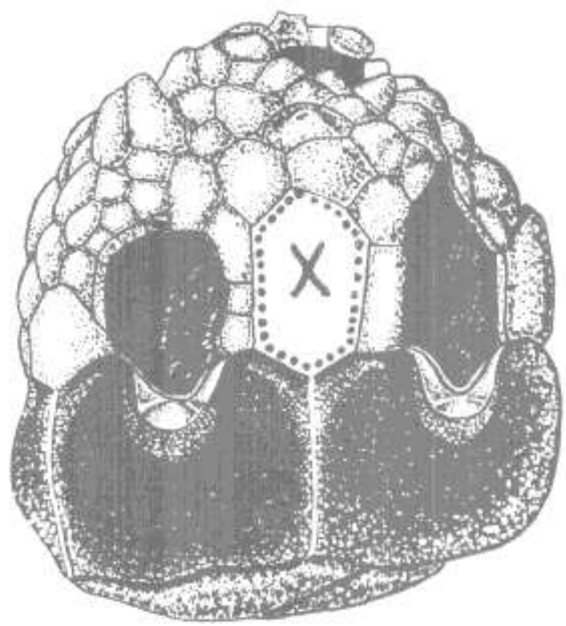
Platycrinites and associated crinoids from Pennsylvanian rocks of the Sacramento Mountains, New Mexico

by Arthur L. Bowsher and Harrell L. Strimple



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COVER—*Platycrinites nactus* n.sp., see Fig. 48f for further explanation.

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by Arthur L. Bowsher[1] and Harrell L. Strimple[+]

'Yates Petroleum Corporation, Artesia, New Mexico 88201

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Abstract

Platycrinites and other genera in the family Platycrinitidae are abundant in the Early Carboniferous worldwide. Numerous platycrinitids are known from the Permian of East Indies. By contrast, very few occurrences are reported of Late Carboniferous platycrinitids, whose record consists chiefly of columnals questionably referred to this family. Doubt that platycrinitids existed during Late Carboniferous was allayed when in 1969 Strimple and Watkins for the first time reported a platycrinitid calyx from the Pennsylvanian of Texas. The two genera and species of platycrinitids, *Platycrinites nactus* n.sp. and *Exsulacrinus alleni* n.gen. et sp., found in the collections described in this report, further confirm the existence of platycrinitids in the Late Carboniferous. Similar types occur in the Early Carboniferous and in the Permian.

The collection from the Sacramento Mountains also includes numerous other typically Late Carboniferous crinoids: *Lecythiocrinus sacculus* n.sp., *Laudonocrinus subsinuatus* (Miller and Gurley, 1894), *Aglaocrinus* aff. *marquisi* (Moore and Plummer, 1940), *Parulocrinus globatus* n.sp., *Erisocrinus typus* Meek and Worthen, 1865, *Erisocrinus* aff. *erectus* Moore and Plummer, 1940, *Endelocrinus bifidus* Moore and Plummer, 1940, *Endelocrinus perasper n.sp., Sciadiocrinus* aff. *harrisae* Moore and Plummer, 1940, *Stenopecrinus glaber* n.sp., and an indeterminate synerocrinid.

Crinoid workers have long recognized the enigma of absence of platycrinitid calyces in Late Carboniferous strata, although they are common in the Early Carboniferous and are known from the Permian strata of Timor, East Indies. It is exciting to find platycrinitid calyces in the Pennsylvanian rocks of the Sacramento Mountains. The occurrence of the platycrinitids in Grapevine Canyon, Sacramento Mountains, is believed to be a function of the reef-type strata of the Gobbler Formation present at the locality, a rock type of the Pennsylvanian not commonly exposed on the surface for examination. The incompleteness of the local geologic record is obvious.

Introduction

General

The holotype of *Platycrinites remotus* Strimple and Watkins, 1969, is the only platycrinitid calyx reported from the Late Carboniferous anywhere in the world. It is therefore exciting to find *Platycrinites nactus* n.sp. and *Exsulacrinus alleni* n.gen. et sp. in the Pennsylvanian of the Sacramento Mountains, New Mexico. *Platycrinites* and forms similar to *Exsulacrinus* are common in the Early Carboniferous and are known also in the Permian of Timor, East Indies. The New Mexico occurrences dispel the opinion of long standing that platycrinitids are absent from Upper Carboniferous strata.

In late 1949, Dr. Edwin Kirk and the senior author were examining material collected from Grapevine Canyon, Sacramento Mountains, New Mexico, by Drs. I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928, during a study of the base of the Permian. The collection had been turned over to Dr. G. H. Girty of the U.S. Geological Survey (USGS) for study. We were surprised to find platycrinitid calyces in a collection of typically Pennsylvanian crinoids such as *Lecythiocrinus* White, 1879, *Laudonocrinus* Moore and Plummer, 1940, *Stenopecrinus* Strimple, 1961, and *Erisocrinus* Meek and Worthen, 1865. The crinoids were silicified and we thought it might be possible to etch the calyces out of the matrix. The senior author began the slow process of dissolving the matrix with dilute hydrochloric acid. The fragile nature of the calyces required their frequent removal from the acid bath for inspection and coating of the exposed skeletal elements with wax dripped from a candle to control the etching. Ultimately, some very fine specimens were freed from the matrix. Two fine calyces of a species of *Platycrinites* Miller, 1821, were present in the material. It was decided to delay reporting on the find until the locality could be revisited and, hopefully, additional material obtained. Data concerning the collection and the locality from which it came were meager. We knew only that the locality was supposed to be a short distance northwest of a ranch house in Grapevine Canyon, 23 miles south of Alamogordo, New Mexico. The senior author was familiar with the area, having studied the Devonian and Mississippian strata there earlier in the company of L. R. Laudon, L. Pray, and Frank V. Stevenson on several occasions. The senior author and W. T. Allen, at the time both members of the staff of the U.S. National Museum (USNM), made an unsuccessful search of the area during a three-day period in the summer of 1950. W. T. Allen and Dr. G. Arthur Cooper visited the canyon again with the senior author in the summer of 1951 to search for the crinoids and to obtain additional silicified brachiopods (Cooper, 1957) from near the Old Juniper Tank (Fig. 1, USNM loc. 3302), an occurrence discovered the previous summer by Allen and Bowsher. What appeared to be the bed containing the silicified crinoids was located during the later trip. This location, USNM loc. 3353 (Fig. 1), appears to be about one-half mile to the east of the probable original locality collected by Keyte, Blanchard, and Baldwin. Blocks of limestone from this newly discovered locality, when dissolved in acid, yielded silicified columnals and calyces of platycrinitids. However, these calyces were not a species of *Platycrinites* as in the original collection. They more closely resembled the platycrinitid genus *Pleurocrinus* Austin and Austin, 1843, but are here referred to a new genus, *Exsulacrinus,* because they differ from *Pleurocrinus* in the construction of the tegmen. *Exsulacrinus* is placed in the Platycrinitidae. Other crinoids in the silicified residue were similar to some of those in the original collection. Eleven genera and at least 13 species of crinoids are now known from the localities. Though work was begun in 1953 on describing the collections, the course of events long delayed the writing of the report. Recently the authors agreed to complete the manuscript on these exciting collections. However, it has required a considerable amount of time to update

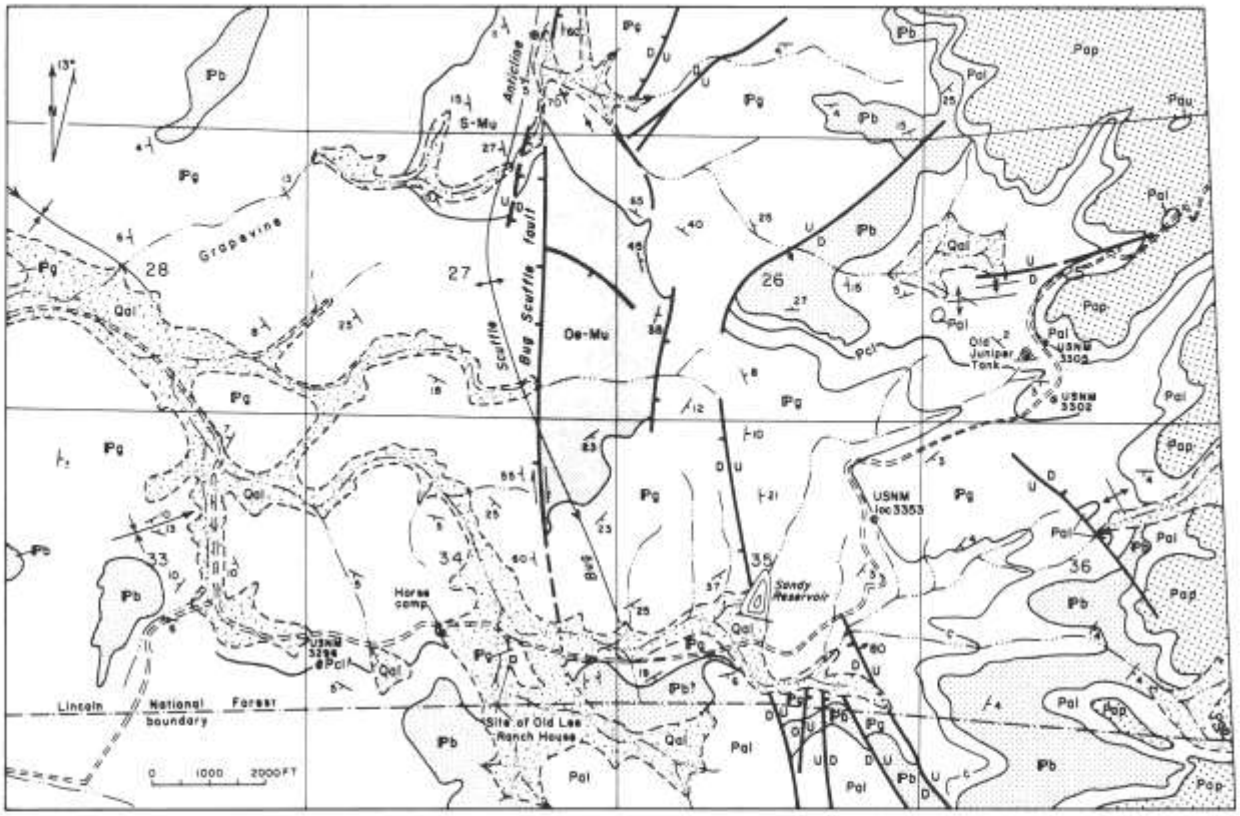

FIGURE 1—Geologic map of Grapevine Canyon and vicinity, Sacramento Mountains, T19S, R11E, Otero County, New Mexico, showing USNM localities 3296, 3302, 3305, and 3353; after L. C. Pray, 1961, pl. 2, and pers. comm. Abbreviations: **Qal,** Quaternary alluvium; **Pua,** upper member of Abo Shale; **Pap,** Pendejo Tongue of Hueco Formation; **Pal,** lower member of Abo Formation; **Pb,** Beeman Formation; **Pg,** Gobbler Formation; **Pcl,** marker bed in the upper part of Gobbler Formation; **-C-,** crinoid bed in Gobbler Formation, ca 1,280 ft above the base; **Oe–Mu,** El Paso to Helms Formations, undifferentiated; **S–Mu,** Fusselman to Helms Formations, undifferentiated.

the taxonomic work and to prepare additional drawings. Sadly, Harrell L. Strimple's long and distinguished career in the study of the Echinodermata was terminated on August 21, 1983, by his death at Iowa City, Iowa.

Localities and stratigraphy

The original drawing for Fig. 1 was furnished by L. C. Pray from his field notes prior to the publication of his report on the Sacramento Mountains (Pray, 1961, pl. 2). Additional notations are by the senior author. *Exsulacrinus alleni* n.gen. et sp. is from USNM loc. 3353 (Fig. 1). Keyte mentions in field notes furnished to G. A. Girty, USGS, to accompany the collections, "10', massive Is, gray, weathers brown west of ranch house. *Allorisma termuilo,* about 50' above crinoid layer" (USGS loc. 7344a). W. T. Allen and the senior author identified this molluskan limestone and obtained a very rich collection of silicified mollusks, mostly gastropods, from it at USNM loc. 3296 (Fig. 1). The limestone *(Pcl,* Fig. 1) at USNM loc. 3296 is believed to correlate with the limestone ledge just below USNM loc. 3302. The locality from which Keyte, Blanchard, and Baldwin collected the crinoids is not determined with precision. However, from study of the area and combination of all the notes, the collection appears to have come from the top of the massive limestone of the Magdalena limestone about 50 ft below the mollusk-rich limestone ledge so well exposed above and to the south of the road, just to the west side of the site of the old Lee Ranch House and the Horse Camp. This would put the locality somewhere near the center of sec. 34, T19S, R11E. In the summer 1951, W. T. Allen, G. A. Cooper, and the senior author found silicified crinoids at the top of the massive limestone at USNM loc. 3353 (Fig. 1). It is believed that bed "c" at USNM loc. 3353 correlates with Keyte's "Crinoid bed," even though Keyte's locality seems to be about one-half mile west and north of the old Lee Ranch House (Fig. 1).

Material collected from Grapevine Canyon by Keyte, Blanchard, and Baldwin is labeled as USGS localities 7344 and 7344a through 7344k. Crinoids and crinoid fragments were in 7344, 7344a, 7344e, and 7344i. However, at one time or another the crinoid material was inadvertently placed in 7244j. Although none of the localities can be positively identified, the notes indicate that all have come from a relatively small area of Grapevine Canyon, from a relatively restricted part of the sequence near the top of the massive limestone, and from just above the top of the massive limestone of the Magdalena Formation, called by L. C. Pray (1961) and herein the Gobbler Formation.

Prior to the publication of *Geology of the Sacramento Mountains escarpment, Otero County, New Mexico* (L. C. Pray, 1961), the Pennsylvanian strata in the Grapevine Canyon area were known simply as the Magdalena limestone. In that report, L. C. Pray (1961, p. 80) introduced the name Gobbler Formation for the lower 1,200 to 1,600 feet of the Pennsylvanian strata of the Sacramento Mountains. The distribution of the Gobbler Formation in Grapevine Canyon is shown in Fig. 1. The massive limestone facies of the Gobbler Formation was named the Bug Scuffle Limestone Member by Pray (1961, p. 82). The top of the Bug Scuffle Limestone Member is marked by the bed "c" that passes through USNM loc. 3353 (Fig. 1). The Beeman Formation, which overlies the Gobbler Formation elsewhere in the mountains, is not widely present in the Grapevine Canyon area (Fig. 1). The Beeman probably is incomplete at USNM loc. 3353 because of erosion or non-deposition. The unconformity at the base of the Abo Formation onlaps the Beeman and the Bug Scuffle in turn. Pray (1961, p. 83) described the northward change of the limestone of the Bug Scuffle Limestone Member to a detrital, quartzose, and arkosic facies. The fossils collected by Allen, Cooper, and Bowsher (USNM loc. 3353) came from the top of the Bug Scuffle Limestone Member. It is thought that the crinoids collected by Keyte, Blanchard, and Baldwin (USGS loc. 7344j) also came from the top of the Bug Scuffle Limestone Member.

USNM localities 3296, 3302, and 3353 were considered by L. C. Pray (pers. comm. 1954) to contain strata that are correlative northward to lower Missourian strata. However, the collection from USNM loc. 3353 might be late Desmoinesian in age. In Negro Ed Canyon to the north, Pray (1961, p. 85, fig. 24) indicated the Desmoinesian to be coincident with the top of the Gobbler Formation. Collections from USNM loc. 3353 and USGS loc. 7344j are believed to be early Missourian or late Desmoinesian. The age of the crinoids cannot be more accurately determined.

All of the localities of Keyte, Blanchard, and Baldwin that were recorded in the USGS Locality Register by G. A. Girty are listed below along with the USNM localities of the senior author. It appears best to cite the complete descriptions because they are brief and not definitive. In 1928, when Keyte, Blanchard, and Baldwin were working in Grapevine Canyon, there were no detailed maps of the area. Notes in the files of the USGS Paleontology and Stratigraphy Section furnished by I. A. Keyte indicate that the crinoid bed is about 30 feet above the top of the massive limestone of the Magdalena. The locality descriptions, taken verbatim from the USGS Locality Register and the senior author's files, are as follows:

USNM 3296: Pennsylvanian, Desmoinesian(?), Gobbler Formation, from the south side of the access road into the canyon, 0.75 mi east of Horse Camp, 1400 ft FSL and 500 ft FWL, sec. 34, T19S, R11E, Grapevine Canyon, Sacramento Mtns., Otero County, N.M., W. T. Allen and Arthur L. Bowsher, 1950.

USNM 3302: Pennsylvanian, Desmoinesian(?), near the top of the Gobbler Formation along ranch trail, approximately 900 ft SSE of Juniper Tank, 300 ft FSL and 2250 FWL, sec. 25, T19N, R11E, Grapevine Canyon, Sacramento Mtns., Otero County, N.M., W. T. Allen and Arthur L. Bowsher, 1950.

USNM 3305: Pennsylvanian, Desmoinesian(?), near the top of the Gobbler Formation along ranch trail, adjacent to the northeast side of Juniper Tank, approximately 1320 ft FSL and 2200 ft FEL, sec. 25, T19S, R11E, Grapevine Canyon, Sacramento Mtns., Otero Co., N.M., W. T. Allen and Arthur L. Bowsher, 1950.

USNM 3353: Pennsylvanian, Desmoinesian(?), top of the Bug Scuffle Limestone Member of the Gobbler Formation, near ranch trail, 2200 ft northeast of Sandy Reservoir, 1700 ft FSL and 800 ft FEL, sec. 35, T19S, R11E, Grapevine Canyon, Sacramento Mtns., Otero Co., N.M., W. T. Allen, G. Arthur Cooper, and Arthur L. Bowsher, 1951.

USGS 7344: Pennsylvanian, [Desmoinesian(?)], Grapevine Canyon, New Mexico. Abo, Bed 7, Crinoid bed. Sacramento Mountains, 30 mi S of Alamogordo. Keyte, Baldwin, and Blanchard, June 23, 1928. [All localities 7344 and 7344a—k are in the general vicinity of the south half of sec. 34, T19S, R11E, Grapevine Canyon, Otero Co., N.M. Crinoids from 7344, 7344a, and 7344i were inadvertently placed in 7344j. Please also note that Keyte and co-workers, at the time they made the collections, considered this crinoid bed to belong in the overlying Abo Formation. It is, however, one of the uppermost beds of the Gobbler Formation.]

USGS 7344a: Three labels are the same as 7344 (Bed 7). Two others carry the inscription *"Mylina subquadrata* and *Sphaerodoma primigenia."* Magdalena, Penna., Grapevine Canyon, Sacramento Mtns., N.M., Bed 11, K.B.B. [Inadvertently mixed, in part, with 7344].

USGS 7344b: Flat top Mesa, north side of slope, Grapevine Canyon, Sacramento Mtns., N.M. From base of Magdalena to the top of precipitous scarp. Keyte, Blanchard, and Baldwin, June 25, 1928.

USGS 7344c: Magdalena, top of Mesa, Grapevine Canyon, Alamogordo, N.M.

USGS 7344d: Top of Magdalena, Grapevine Canyon, Bed 6, N.M. [Two other labels are essentially the same, except that "Bed 6" is omitted from the labels]. Keyte, Blanchard and Baldwin.

USGS 7344e: Top of Magdalena, Grapevine Canyon, Sacramento Mtns., Alamogordo, N.M.; K. & B., June 23, 1928. [Two labels read the same, but with "Crinoids" added].

USGS 7344f: Grapevine Canyon Section, Magdalena Formation, Sacramento Mountains, K. & B., June 25, 1928.

USGS 7344g: Magdalena, Penna. Near top of Magdalena, Grapevine Canyon, 20 mi S of Alamogordo, N.M. *"Hustedia mormoni"* **K. B. & B.**

USGS 7344h: Top of Magdalena, Grapevine Canyon, Alamogordo, N.M.

USGS 7344i: Top Magdalena, Grapevine Canyon, Alamogordo, Sacramento Mtns., Crinoid Ledge. K. & B., June 23, 1928.

USGS 7344j: Grapevine Canyon, S of Alamogordo, N.M., about 300 ft below the top of the Magdalena Limestone. Keyte and Blanchard.

USGS 7344k: Grapevine Canyon, Alamogordo, N.M., 300 ft above the base of the Magdalena.

Platycrinites and incompleteness of the geologic record

This collection of crinoids is especially interesting because it includes calyces of platycrinitids from

Pennsylvanian rocks. Only one other platycrinitid calyx has been described to date from the Pennsylvanian.

The genus *Platycrinites* was first described by J. S. Miller (1821, pp. 15, 73, pls. 1, 2) from Lower Carboniferous strata of England. Bassler and Moodey (1943) and Webster (1973) list more than 150 species of platycrinitids from the Early Carboniferous or Mississippian. Indeed, platycrinitids are very common fossils in Lower Carboniferous strata worldwide. On the other hand, very few platycrinitids are reported from the Upper Carboniferous rocks of any part of the world. The bibliographic and faunal indexes of Paleozoic pelmatozoan echinoderms by Bassler and Moodey (1943) and Webster (1973) list only two species of platycrinitids and 10 references of *Platycrinites* sp. from the Late Carboniferous. Most of these reports refer to fragmentary remains of crinoids. Some references to Late Carboniferous platycrinitids appear to be erroneous in either classification or age assignment (Jack and Etheridge, 1892; and, in part, Termier and Termier, 1950). In contrast, platycrinitids are known from the Permian. Three genera, 13 species, and two varieties of platycrinitids are described from Permian rocks of Timor, East Indies (Wanner, 1916, 1924, 1937; Marez Oyens, 1940).

The first platycrinitid described from the Late Carboniferous anywhere in the world is *Platycrinites spitzbergensis* (Holtedahl) from Spitzbergen (1911, pp. 13, 14, pl. 1, figs. 3-5, 6; 1913, p. 16). The types of this species are a collection of disarticulated and individual ossicles (Fig. 2a-f). The age assignment and the generic identification of the species may be found faulty when restudied, but are for now accepted. Tien (1926, pp. 43, 44, pl. III, figs. 5, 6) illustrated columnals from the Tiayuan Series (Upper Carboniferous) of north China that he referred to as *Platycrinus* sp. (Fig. 3a-f). Weller (1930, pp. 478-484, pl. 1) reported finding platycrinitid columnals in the Pennsylvanian of western Indiana (Fig. 4a-f). Moore and Strimple (1973, p. 41, pl. 3, fig. 3) illustrated a portion of the basal circlet of a platycrinitid from the lower part of the Wapanucka Limestone (Pennsylvanian) of Oklahoma (Fig. 5). Termier and Termier (1950, p. 86, pl. 212, figs. 1-6, 10, 11) reported *Platycrinites* cf. *expansus* (McCoy) and *Platycrinites tuberculatus* Miller (Figs. 6a-f, 7a, b) from the Late Carboniferous (Westphalian) of Morocco. In the same publication (pp. 86, 87, pl. 211, figs. 18, pl. 212, figs. 14, 15, 18, pl. 215, figs. 27) they reported other platycrinitids from the Westphalian of Morocco (Figs. 8a-1, 9a-b, 10a-f). We believe that some of the platycrinitids reported by Termier and Termier (1950) as Late Carboniferous are in fact Early Carboniferous. Plummer (1950, p. 88, pl. 19, fig. 14) illustrated a platycrinitid columnal from the Strawn Group (Pennsylvanian) in Texas (Fig. 11) and Heuer (1958, p. 43, pl. 3, fig. 14) reproduced Plummer's original illustration. Yakovlev and Ivanov (1956, pp. 49, 50, pl. 12, figs. 8, 9) designated a collection of fragmented columns as *Platycrinus(?) tuberculatus* n.sp. (Fig. 12a-g). These columnals are from the Carboniferous (C_3), Kara-Chatir Range, U.S.S.R. They also illustrated a radial plate (1956, pl. 12, fig. 8) from the Carboniferous (C_3) of the Kara-Chatir Range that they designated as *Platycrinus* sp. (Fig. 13) and reproduced illustrations of columnals (p. 33, fig. 8) from the Moscovian (Late Carboniferous) of the U.S.S.R. (Fig. 14a-d; after Trautschold, 1879). Moore and Jeffords (1968, p. 44, pl. 4, figs. 4-6, pl. 5, figs. 5-8) designated platycrinitid columnals from the Millsap Lake Formation (Pennsylvanian) of Texas as *Platyplateium texanum,* newly proposed genus and species (Fig. 15a-n). Another type of platycrinitid columnal from the Millsap Lake Formation was designated by them (1968, p. 45, pl. 5, fig. 9) as *Platyplateum* sp. (Fig. 16 a, b), and a third type of columnal (1968, p. 46, pl. 5, figs. la, b, 2a, b) from the Strawn Group as *Platycion mingusensis* (Fig. 17a-d). Strimple (1962, pp. 3-5, figs. 17) described and illustrated *Columnal ellipticus,* and *Columnal quadrangulatus,* platycrinitids from the Pumpkin Creek Limestone (Pennsylvanian) of southern Oklahoma (Figs. 18a-c, 19a-d). Strimple and Watkins (1969, pp. 219, 220, pl. 47, figs. 8, 9) reported and illustrated for the first time a calyx of a platycrinitid from the Early Pennsylvanian. Unfortunately, the holotype and only known specimen of this species, *Platycrinites remotus,* from the Millsap Lake Formation of Texas, is flattened and does not show the true shape of the calyx. In the same paper, Strimple and Watkins described and illustrated (1969, pl. 54, figs. 1-6) columnals from the Millsap Lake Formation of Texas that they identified as *Platycrinites tenius* (Fig. 20a-d) and *Platycrinites tenius contentus* (Fig. 21a, b). Webster and Lane (1970, p. 279, pl. 56, fig. 9) described *Platycrinites* sp. based on several isolated columnals on the surface of a piece of limestone from the mid-Pennsylvanian of Nevada (Fig. 22).

The first to report platycrinitids from Permian rocks was Stuckenberg (1875, pp. 98, 99, pl. 1, fig. 8, pl. 2, fig. 3a-c, pl. 3, fig. 2a-g), who described *Platycrinites schmidtii* from the U.S.S.R. (Figs. 23a-i, 31a, b). The calyx (Fig. 23h, i) illustrated by Stuckenberg as *Platycrinites schmidtii* (1875, pl. 1, fig. 8, pl. 2, fig. 3a) was regarded by Broadhead (1981, p. 115) as a possible synonym of *Dichocrinus expansus* de Koninck and Le Hon (1954). Broadhead (1981, p. 115) reports that Stuckenberg's platycrinitid specimens are from the Lower Carboniferous Limestone (?Tn3), Indiga River, U.S.S.R. He further reports (pers. comm. 4/1985) that the columnals (Fig. 23a-e) included by Stuckenberg (1875, pl. 3, fig. 2a-g) are platycrinitid columnals, but that they are also from the Lower Carboniferous (?Tn3) of Indiga River. One calyx (Stuckenberg, 1875, pl. 2, fig. 2b, c) (Fig. 23f, g) was not identified by Broadhead. Even if this specimen is a platycrinitid, it is not germane here because it is of Early Carboniferous age. It is mentioned herein because it is listed in earlier literature as the oldest reference to Permian platycrinitids. It is not Permian in age.

Wanner (1916) described a magnificent collection of crinoids and other echinoderms from the Permian of the Island of Timor, East Indies. The material is fabulously preserved in white limestone and specimens are abundant. Wanner (1916, p. 23) placed a new genus *Eutelocrinus* with type species *E. piriformis* in the family Platycrinitidae. This crinoid is a haplocrinid and is illustrated only for reference (Fig. 24a, b). *Neoplatycrinus dilatus* Wanner (Fig. 25a-c), *Pleurocrinus* *spectabilis* Wanner (Fig. 26a, b), and *Platycrinites wachsmuthi* (Fig. 27a-c) are typical of the abundant platycrinitids of Timor. Moore (1939, p. 229, fig. 1) described *Ellipsellipsopa latissima,* a platycrinitid columnal from the Wolfcampian, Permian, of Texas (Fig. 28a, b). Marez Oyens (1940a, p. 300, pl. 1, fig. 2) described *Platycrinites tuberculatus* from the Permian of Timor (Fig. 37a, b), but a short time later (1940b, p. 253) changed the name to *Platycrinites wrighti* because the former name was preoccupied.

Plesiocrinus piriformis Wanner (1937, p. 75, pl. 6, figs. 36-38), a haplocrinid from Timor, was placed by its author in the Platycrinitidae. It is here illustrated for reference only (Fig. 29a, b). *Platycrinites permiensis* (Yakovlev) (Yakovlev and Ivanov, 1956, p. 66, pl. 10, figs. 14-20) is based on a collection of ossicles from the Permian of the Ural Mountains, U.S.S.R. (Fig. 30a-k). Yakovlev and Ivanov (1956, pl. 18, fig. 2a, b) illustrated the stem of *Platycrinites schmidtii* (after Stuckenberg, 1875, pl. 3, fig. 2). This stem segment (Fig. 31a, b) is Early Carboniferous (Broadhead, pers. comm. 4/1985), even though it is referred to as Permian in earlier literature. Webster and Lane (1967, pp. 7-9, pl. 1, figs. 1-10) reported on Permian crinoids from Nevada. They identified a collection of columnals as *Platycrinites* sp. The collection includes, among other ossicles, two fragments that are basal circlets of platycrinitid calyces (Fig. 32a-i).

More recently, Broadhead and Strimple (1977, pp. 1169, 1170, figs. 1, 2A, pl. 1, figs. 3, 6, 7) described *Platycrinites nikondaense* from the "Permian Limestone" in the Wrangell Mountains, central Alaska. The holotype and only specimen is flattened on a slab of limestone (Fig. 56). The shape of the calyx is not clear from the photograph. In the same publication, Broadhead and Strimple (1977) presented reconstructions of the calyx and several ossicles (Fig. 33a-e), and described *Platycrinites ellesmerense* (pp. 1170-1174, fig. 2B, C, pl. 1, figs. 1, 2-5) from the Upper Permian (Guadalupian) Trold Fiord Formation of Ellesmere Island (Figs. 34a, b, 55a-d).

Two new Early Pennsylvanian platycrinitids are described in this paper: *Platycrinites nactus* n.sp. (Figs. 35a-k, 48a-g, 50a-h, 51a-p) and *Exsulacrinus alleni* n.gen. et sp. (Figs. 36a-i, 49a-e, 52a-h, 53a-l). Several specimens of each of these crinoids were collected in Grapevine Canyon in the southern part of the Sacramento Mountains, New Mexico.

Until recently, it seemed anomalous that platycrinitid calyces were not found in Upper Carboniferous rocks, because they are common in the Lower Carboniferous and relatively common in the Permian, especially in Timor, East Indies. Since Wanner's (1916) first report on platycrinitids from the Permian of Timor, occasional reports of platycrinitid ossicles from the Late Carboniferous appeared to indicate that the platycrinitid lineage extended throughout the Carboniferous and into the Permian. *Platycrinites remotus* Strimple and Watkins, 1969, is the first platycrinitid calyx reported from the Late Carboniferous anywhere in the world (Fig. 54a, b). Together with *Platycrinites nactus* n.sp. and *Exsulacrinus alleni* n.gen. et sp. described in this paper, it provides ample evidence for the existence of platycrinitids in the Late Carboniferous. It is notable that most of the reported Late Carboniferous platycrinitids are from the early part of the epoch. There still remains the perplexing question why there is such a worldwide paucity of platycrinitids in the Late Carboniferous.

The platycrinitids from the Sacramento Mountains occur in an area where the Pennsylvanian strata are massive carbonate rocks. In fact, bioherms of the Gobbler Formation in the SW 1/4 sec. 36 and SE 1/4 sec. 35, T19E, R11E (Fig. 1) indicate that the crinoids were collected from the edge of a carbonate bank or from a reefal facies. As outlined by Pray (1961, p. 82, fig. 23), the distribution and type of sediments in the Gobbler Formation appear to be that of a huge, north-trending carbonate bank grading eastward into proximal-shelf sandstone and shale. The clastic facies abut to the east against the Pedernal Landmass (Thompson, 1942, p. 12) from which they were largely derived. The carbonates grade westward into basinal facies of the Orogrande Basin (Pray, 1959). Reefs are common on the western edge of the bank. The carbonate banks and associated carbonates make up the frontal scarp of the Sacramento Mountains. Continuity of the massive carbonates of the Gobbler Formatin is obvious along the western front of the mountains. The bank trends generally in a northerly direction and the western front of the Sacramento Mountains is the shelf edge of the bank. No collections have been reported from this extensive carbonate bank; its faunal composition is virtually unknown. The precipitous face of the Gobbler Formation will make any collecting very difficult or impossible. Faunal composition of similar carbonate banks in the Basin and Range Province is likewise generally unknown. Ecological studies of such banks have not been published.

Our knowledge of Late Carboniferous fossil assemblages in North America is based primarily on collections from deposits of shallow epeiric seas in Nebraska, Kansas, Oklahoma, Texas, Illinois, and Indiana. These deposits are chiefly widespread cyclothemic, lagoonal carbonates with interbedded clastic strata (Wilson, 1975, p. 212) of great lateral extent, formed by "shallow seas that repeatedly flooded the region and then vanished" (Moore and Merrian, 1959, p. 20). In recent years, Harbaugh (1964) and Heckel and Cocke (1969) described biohermal masses of limestone in southeastern Kansas and northeastern Oklahoma. Most of the biohermal masses in Kansas were formed in relatively shallow seas and few were bordered by easily recognizable and extensive basinal depositional environments. Also, most of the bioherms in Kansas were onlapped and covered by sediments deposited in very shallow-shelf seas (Harbaugh, 1962, p. 45, fig. 42). On the other hand, the Gobbler Formation carbonate bank is much larger than most of those in Kansas and environs, is several times longer than wide, and is bordered on the west by the very distinctive, deep Orogrande Basin. Some of the bioherms in the Sacramento Mountains are composed dominantly of phylloid algae and have a thin coronal cap of crinoidal limestone. The crinoid colonies appear to have grown on top of the algal bioherm when, or after, the bioherms became too deeply inundated for significant algal growth. The biotic association indicates deepening of the water over the algal bioherms and the crinoid growth succeeding the algal growth on this mound. The crinoidal biotope represents deeper water. The algae represent a biotope from the intertidal zone to the lower limits of the photic zone; the crinoidal biotope represents an open-marine environment lying just below the effective base of high, storm-wave activity. Small submarine banks (seccas) in the Bay of Naples (Walther, 1910; Waters, 1879) may exhibit homotaxial relations. The banks are surrounded by mud-covered bottoms at a depth of 275 feet. The tops of the submarine mounds (seccas) rise to within 125 feet of the surface of the bay and are covered by calcarenite of corals, bryozoans, and echinoderms. The corals and bryozoans are erect and cylindrical or encrusting in habit. The coral-br yozoan-echinoderm faunule on the banks is rich compared to that of the mud-covered bottoms surrounding the banks. The banks or bioherms were formed by growth in shallower water. After inundation, the original growth forms that built the mounds were succeeded by bryozoans and coralline growth of a different type. It is not known if such biotic successions characterize the Gobbler Formation in the southern Sacramento Mountains, but the senior author has observed similar successions in bioherms elsewhere in the Sacramento Mountains.

Inundation of the bioherms in the Late Carboniferous of southeastern Kansas was by very shallow seas (Harbaugh, 1962, p. 45). It appears significant that some of the limestone banks of southeastern Kansas terminate upward in oolite beds or calcarenite zones of abundant crinoid fragments. This may indicate biotic succession. Nonetheless, the Pennsylvanian bioherms and banks of the Sacramento Mountains appear to have experienced a greater degree of mobility, emergence, and submergence (Wilson, 1975, p. 214) than those of southeastern Kansas that are said to have formed mostly under "just awash conditions" (Harbaugh, 1962, p. 94). The scarcity of platycrinitids in the Pennsylvanian is probably more apparent than real. Future collecting at the summit of bioherms along carbonate-shelf edges in the Basin and Range Province may well yield a much larger number of platycrinitid calyces. The greater vertical mobility of crustal blocks on the flanks of the Transcontinental Arch and within the Basin and Range Province makes these areas the most likely ones in which Pennsylvanian bioherms were formed and deeply enough inundated for habitation by platycrinitid and related crinoids. The paucity of platycrinitids in the Pennsylvanian deposits appears to be a response to depositional environments. Carbonate-shelf-edge and reef deposits are not abundant in exposures of Pennsylvanian strata in the areas where these rocks have been most extensively studied. There remains the task of establishing the facies of Upper Carboniferous banks, their associated faunules, and completing the taxonomic work on the groups of fossils that characterize the faunules. The collection that is the subject of this report is especially interesting because of the unprecedented occurrence of platycrinitid calyces and the implications of the occurrence.

Systematic descriptions

Subphylum CRINOZOA Matsumoto, 1929
Class CRINOIDEA Miller, 1821
Subclass CAMERATA Wachsmuth and Springer, 1885
Order MONOBATHRIDA Moore and Laudon, 1943
Suborder GLYPTOCRINININA Moore, 1952
Superfamily PLATYCRINITACEA Austin and Austin, 1842
Family PLATYCRINITIDAE Austin and Austin, 1942

Genus *PLATYCRINITES* Miller, 1821

Type *species—Platycrinites laevis* Miller, 1821; SD *in* Meek and Worthen, 1865, p. 160.

Range—?Late Silurian or Devonian through Permian.

Diagnosis (after Lane, 1978)—Calyx bowl-shaped. Basals three, unequal, the small one typically in the left anterior interray and fused with the other basals in some species. Radials large, with narrow articular facets. Tegmen flat, domed or pyramidal, composed of numerous plates. Orals distinct in some species. Anal opening generally excentric, opens directly through tegmen or at distal end of anal tube that may be of varying length. Arms start from axillary first primibrachials, but some species have axillary first secundibrachials. Arms become biserial above distal axillary of branches. Proximal brachials resemble brachials of free arms, but may be fixed to tegmen by 13 interradial plates. Column transversely round proximally, but fulcral ridges extend through length of elliptical columnals. Fulcral ridges may rotate about axis of columnals, resulting in twisting of stem that is characteristic of platycrinitids. Axial canal small and round.

Remarks—Species referred to the genus *Platycrinites* exhibit a wide range of variation, particularly in the tegmen and the anal tube. Although we feel that there is a great need for a revision of the Platycrinitidae, it is beyond the scope of this study to attempt such a revision.

PLATYCRINITES NACTLIS, new species
Figs. 35a-k, 48a-g, 50a-h, 51a-p, 69a-d

Types and occurrence—Holotype USNM 118470 (Figs. 48a-d, 50a-d); paratypes USNM 118471 (Figs. 48e-g, 50e-h), USNM 118472 (four specimens, not figured), USNM 118473a-h (Figs. 35a-k, 51a-p), and USNM 118474 (74 specimens, not figured). All collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis—Differs from all other species of *Platycrinites* **in having a broad,** truncate, bowl-shaped dorsal cup, highly arched tegmen, movable articulation on radial facets, large bulbous, smooth tegmen plates, large first interradial plate of tegmen flanked by single narrow plates, and impressed radial sutures.

Etymology—Latin *nactus,* stumbled upon.

Description—A medium-sized platycrinitid with a truncated, low, bowl-shaped dorsal cup of smooth plates. The anchylosed basals have raised sutures. The high, hemispherical tegmen is composed of bulbous plates. Sutures between the radials and basals are slightly indented and a strong anal tube is located on top of the tegmen just posteriorly of the center. The cicatrix is concave and small, and the lumen penetrates the basals (Fig. 50a). The pentagonal basal circlet of anchylosed basals is almost flat. The distal margins of the basals curve only slightly upward (Figs. 48f, 69d). The sutures between the basals are produced into distinct ridges (Figs. 48f, 50a, h). The proximal margin of each radial is strongly impressed; the remainder of the radial is broadly rounded, with the sides standing nearly vertical (Fig. 50d). The lateral and proximal margins of each radial are rounded and form incised sutures with the adjacent basals and radials. The radial articular facets are wide and occupy nearly one-half of the distal margins of the radials. The facets possess a transverse fulcral ridge, indicating that there was a movable articulation between the radials and the axillary first primibrachials. The lateral portions of the distal margin of the radials curve slightly outward for the reception of the first interradial plate. Each radial supports one-half of the first large tegmen plate (Figs. 48d, e, f, 50d). A small, elongate plate lies on either side of the first tegmen plate and borders the adjacent ambulacral openings (Figs. 48d, 50d). The three plates are followed by the irregular, bulbous tegmen plates. All plates of the cup are smooth; those of the tegmen are smooth and bulbous (Figs. 48a, e, 50c, e).

The anal X (primanal) is supported equally by the distal margins of the right and left posterior radials, and is distinguished by its large size from all other plates lying on the radials. It is approximately one-fourth larger than any other plate in this position. The anal tube is strongly developed and lies posterior to the central point of the tegmen. The tegmen is highly arched; the height is one-half the height of the dorsal cup. The morphology of the arms is not known. The union of the radials to the first primibrachials was movable.

Isolated columnals were also obtained by acid etching from the slabs that yielded the calyces of *P. nactus.* Some of the columnals are believed to belong to *P. nactus* (Figs. 35a–k, 51a–p). The columnals range from nearly round (Figs. 35a, 51a) to strongly elliptical (Figs. 35h, i, 51h, i); their length is up to 2.75 times greater than the width. The round columnals bear weak fulcral ridges and have a large, elliptical lumen. The outer surfaces are smooth and lack the encircling ridge that characterizes the elliptical columnals. The more elliptical small columnals are deeply excavated about the large elliptical lumen (Figs. 35d, 51g). The fulcral ridges are very broad near their distal ends, and narrow and become knife-edged near the lumen. The outer surface of these columnals is smooth, with a broad, strong, encircling rib. The small, round columnals have fulcral ridges on opposite surfaces, but may be rotated by 90° on the axis of the stem. Many of the larger, elliptical columnals generally have fulcral ridges on opposite ends, situated in the same plane as the axis of the column (Figs. 35h, 51i), and do not contribute to twisting of the stem. However, some columnals do show strong torsion of the column (Fig. 35j, k, 511, m).

Measurements (in mm) are as follows:

	Holotype USNM 118470	*Paratype* USNM 118471
Height of dorsal cup	10.0	15.7
Width of dorsal cup	22.7	39.5
Height to width ratio of dorsal cup	0.44	0.39
Height of tegmen	12.1	22.4
Width of tegmen	21.8	36.0+
Length of anal X (primanal)	7.4	10.6
Width of anal X (primanal)	5.5	8.5
Length of posterior left first interambulacral	4.6	8.5
Width of posterior left first interambulacral	4.4	6.2
Length of anterior radial to base of the facet	7.5	12.4
Width of anterior radial	12.8	24.4
Width of anterior radial facet	5.6	7.8
Length of fulcral on anterior radial	3.8	6.0
Radius of basal circlet	6.7	12.3
Height of small basal	8.1	14.2
Diameter of basal circlet	15.6	36.2
Height of basal circlet	2.2	1.0
Width of cicatrix	4.3	6.2

Remarks—The shape of the cup of *P. nactus* somewhat resembles that of *P. truncatulus* (Hall) (Wachsmuth and Springer, 1896, pl. 67, fig. 11a, b), but the plates of the tegmen are larger, more numerous, and more highly differentiated than those of *P. truncatulus.* The cup of *P. eminulus* (Hall) (Wachsmuth and Springer, 1897, pl. 68, fig. 13a, b) resembles that of *P. nactus,* but has prominent tegmen spines that are absent in *P. nactus. P. remotus* Strimple and Watkins (1969, p. 219, pl. 52, figs. 4-6) has several small plates in the interradial position just above the radials (Fig. 54a, b), whereas *P. nactus* has only a single large plate bordered on either side by a long, narrow plate (Fig. 50d). The radials of *P. nactus* are about 15% longer than those of *P. remotus,* which results in a somewhat taller cup. The axillary first primibrachial of *P. remotus* is rigidly fixed to the radial facet and in turn supports a single axillary first secundibrachial. This plate also appears to be anchylosed to the first primibrachial. These plates are retained on all radials of *P. remotus.* Although it has been rarely discussed in the literature, there are numerous platycrinitids in which the primibrachials and the first and second secundibrachials are retained (anchylosed) on the radial facets. *P. nactus* has no arm brachials preserved on the radial facets in any ray. This is a definite difference between *P. nactus* and *P. remotus.* In other respects *P. nactus* and *P. re-*

motus are strikingly similar. Both are from Lower Pennsylvanian strata, although from widely separated localities.

The smooth plates of *P. nactus* distinguish it from *P. spitzbergensis* (Holtedahl, 1911, p. 13, pl. 1, figs. 36), which has nodes on the surface of the plates (Fig. 2a-f). The bowl shape of the *P. nactus* calyx distinguishes it from *P. wachsmuthi* Wanner (Fig. 27b), *P. apaensis* Wanner, and *P. wachsmuthi frequentior* Wanner, all of which have straight-sided, conical calyces. The tuberculated plates of *P. wrighti* Oyens (Fig. 37a, b) are readily distinguished from the smooth plates of *P. nactus*. *P. nactus* differs from all other species of *Platycrinites* by its unique combination of characters: large, smoothly rounded plates, highly arched tegmen, first primibrachials forming a moveable union with the radials, fused basals with radiating ridges, and diameter of the tegmen equal to, or less than, that of the radial circlet. The columnals are tuberculated (Figs. 31a-i, 51a-p).

The columnals illustrated by Tien (1929) (Fig. 3a-f), Plummer (1950) (Fig. 11), Yakovlev and Ivanov (1956) (Fig. 12a, b), and Moore and Jeffords (1968) (Fig. 15b) greatly resemble those of *P. nactus* (Fig. 35a-k). Also the quadrangular columnals illustrated by Webster and Lane (1967) (Fig. 32a, b) closely resemble some columnals of *P. nactus;* however, the specimens came from Permian rocks of Nevada, which makes it very unlikely that they could be conspecific with *P. nactus*. We doubt that many species of platycrinitids can be recognized solely on the basis of random columnals.

EXSULACRINUS, new genus

Type *species-Exsulacrinus alleni* n. sp.

Range-Pennsylvanian.

Diagnosis-Platycrinitids with bowl-shaped dorsal cup as in *Platycrinites,* flat tegmen as in *Pleurocrinus,* extending somewhat beyond surface of dorsal cup, and anal tube located at posterior margin of tegmen and directed upward. Basal plates three, curve upward near their distal margins; anal X (primanal) rests equally upon distal edges of right and left posterior radials.

Remarks-The flat tegmen of numerous plates differentiates *Exsulacrinus* from *Platycrinites*. The high, bowl-shaped cup of *Exsulacrinus* distinguishes it from the box-like cup of *Eucladocrinus,* the flat cup of *Plemnocrinus,* and the cone-shaped cup of *Pleurocrinus*.

EXSULACRINUS ALLENI, new species

Figs. 36a-i, 49a-e, 52a-h, 53a-1

Types and occurrence-Holotype USNM 118476 (Figs. 49a-d, 52a-c); paratypes USNM 118477 (Fig. 52d, e), USNM 118478 (Fig. 52f, g), USNM 118480 (Fig. 52h), USNM 118481 (four specimens, not figured), USNM 11848 a-f (Figs. 36a-h, 53a-1), USNM 118483 (40 specimens, not figured), and USNM 118475 (not figured). All except USNM 118475 collected by W. T. Allen, G. Arthur Cooper, and Arthur L. Bowsher from USNM locality 3353, Grapevine Canyon, Sacramento Mountains, New Mexico. USNM 118475 collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis-Distinguished by ridges around the perimeter of the tegmen plates and a series of parallel ridges surrounding the radials.

Etymology-Named after W. T. Allen.

Description-This large platycrinitid has a truncate, bowl-shaped dorsal cup and radials ornamented with short, low, tuberculated ridges. The nearly flat or very slightly arched tegmen is composed of many plates bearing tuberculated ridges (Figs. 49a, 52e). The three basals bear a distinctly flat surface on their proximal portion and this platform is nearly covered by the cicatrix (Figs. 49c, d, 52b). The surface of the basals is ornamented by subtle, irregular ridges. The basals constitute the flat base of the cup and curve upward sharply. The sutures between the basals are slightly raised and the plates seem to have been anchylosed. The first primibrachials are short, directed laterally, and anchylosed to the facets of radial plates. The arms were directed laterally (Figs. 49b, 52a, h). The axillary first primibrachial remains on all remaining rays of the holotype; it appears to be anchylosed to the radial articular facets because there are no open sutures between the brachials and the radials.

The margin of the multiplated tegmen slightly overhangs the nearly vertical sides of the cup (Figs. 49b, 52a, b). Viewed from above, the tegmen forms an irregularly shaped pentagon. The posterior interradius is slightly wider than the other interradii. The plates of the tegmen are ornamented by short, tuberculated, irregular ridges. A centrally located plate of the tegmen is larger than most, and has coarser ornamentation than the other tegmen plates (Fig. 49a). The anal tube is large and located at the posterior margin of the tegmen. The anal tube appears to have extended vertically a height equal to that of the cup. The anal-X (primanal) plate is large, longer than wide, and bears faint, tuberculated ridges along the proximal margin. The primanal is followed by as many as four irregularly polygonal plates that are slightly bulbous and support the anal tube at the posterior margin of the tegmen (Figs. 49b, 52f).

Although the cicatrix is round, this species has an elliptical and twisted column that is characteristic of platycrinitids (Figs. 49c, 53a-1). Associated with the calyces were many columnals, most of them single but a few pleuricolumnals were included (Figs. 36h, 53d). Specimens illustrated in Figs. 36a-h and 53a-1 show the characteristics of the columnals and pleuricolumnals believed to belong to this crinoid. Some columnals are almost round (Figs. 36a, 53j), whereas others are elliptical (Fig. 36g) or almost rectangular in outline (Fig. 36e). The strongly elliptical part of the column is composed of alternate nodals and internodals, or a series of nodals (Fig. 53b-d). The columnals are extremely wide, laterally compressed, and have a very small lumen. The fulcral ridge extends from the lateral extremities to the lumen; it is widest near the lumen. The facetal surface of the columnals bears a low, encircling ridge at the outer edge (Fig. 53f). The sides of the columnals are produced into a sharp, knife-edged, tuberculated ridge that in some takes on a rectangular outline (Figs. 36e, g, 53a-c).

The fulcral ridges on opposite surfaces of most columnals are in a plane (Figs. 36g, 53b), but on some large nodals the fulcral ridges are rotated across the columnal as much as 85° (Fig. 59c, f). The columnals lack cicatrices for cirri.

Remarks—Only four specimens of *E. alleni* are known and these are partly damaged calyces. Part of the posterior interradius, the right posterior ray, and part of the left posterior ray are missing from the holotype USNM 118746 (Figs. 49c, 52b, h). However, the position of the small basal and most of the anal X (primanal) can be determined in the holotype. Most of the anal-X plate and the posterior part of the tegmen, including the base of the anal tube, are preserved in the paratype USNM 118478 (Fig. 52f, h).

One fragment of a calyx appears to have a somewhat dilated tegmen and the primanal lies within the radial circlet between the left and right posterior radial plates (Figs. 49e, 52h). It is believed that this specimen (USNM 118480) is an aberration. Normally, the prim-anal is supported equally by the right and left posterior radial plates, whereas in this specimen the primanal is within the radial circlet.

The axillary primibrachials are rigidly united (anchylosed) to the radial facets.

The ornamentation of *E. alleni* is somewhat similar to that of *Platycrinites saffordi* Hall, *P. sculptus* (Hall), and *Eucladocrinus pleurovimineous* (White) from the Early Mississippian, but differs from them in the shape of the dorsal cup, details of ornamentation, etc. The shape of the dorsal cup of *Exsulacrinus alleni* is similar to that of several Early Mississippian species of platycrinitids, but differs from them in details of ornamentation, anchylosed character of the first primibrachials, and shape and character of the tegmen with its flat surface and tuberculated plates. The columnals of *E. alleni* differ from those discussed by Weller (1930) (Fig. 4e-f) in character of the facets, ornamentation of outer surface, and general shape. The columnals illustrated by Yakovlev and Ivanov (1950) (Fig. 12d, f) very closely resemble some of *E. alleni*, but *E. alleni* appears not to be conspecific with *Platycrinites(?) tuberculatus* (Yakovlev and Ivanov) (Fig. 12a-g).

E. alleni differs from *Platycrinites nactus* in having a flat tegmen, anal tube located at the extreme posterior of the tegmen, centrally excavated plates with surrounding ridges, and sharp-edged, tuberculated columnals (Figs. 36a-i, 51a-p). No other columnals illustrated in Figs. 2 through 34 closely resemble those of *Exsulacrinus alleni*.

Subclass INADUNATA Wachsmuth and Springer, 1855
Order CLADIDA Moore and Laudon, 1943
Suborder CYATHOCRININA Bather, 1899
Superfamily CODIACRINACEA Bather, 1890
Family CODIACRINIDAE Bather, 1890
Subfamily CODIACRININAE Bather, 1890
Genus *LECYTHIOCRINUS* White, 1879

LECYTHIOCRINUS SACCULUS, new species
Figs. 38a-h, 57a-h

Types and occurrence—Holotype USNM 118447 (Figs. 38a-d, 57a-d); paratypes USNM 118448 (Figs. 38e-h, 57e-h) and USNM 118449 (three fragmentary specimens, not figured). Collected by I. A. Keyte, H. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis—Cup globose. Three or five low infrabasals visible in side view. Five small radials with narrow facets bear deep, long, ambulacral grooves. Anal vent at summit of posterior basal. Calyx constricted at top.

Etymology—Latin *sacculus,* bag.

Description—This is a large species with a medium, globe-shaped cup markedly constricted at the top (Figs. 38b, c, g, 5Th, c, f, g). The ambulacral grooves are exceptionally long. Articular facets are prominent and narrow. The infrabasals are broadly curved and flare upward. The smooth infrabasal circlet is large, 8.8 mm in greatest diameter. The basals are smooth, sharply protuberant at their center, and one-fourth longer than wide. The radials are one-fourth wider than long, much narrower at the distal margin, smooth, broadly curved, and bear concave articular facets. The facets are narrow and very small. The long, well-developed intermuscular notches give the body cavity a distinct pentagonal outline. The anal vent is of medium size. The infolded distal margin of the radial plates flares upward around the body cavity and along the sides of the intermuscular notches. The sutures are not impressed. The cicatrix is very small and markedly concave. The surface appears smooth, but microscopic examination reveals a finely reticulated pattern. The calyx is smoothly rotund and constricted at the top, resembling a small sack partly closed by a drawstring (Figs. 38b, f, 57b, f).

Measurements (in mm) are as follows:

	Holotype USNM 118447	*Paratype* USNM 118448
Height of dorsal cup	12.5	12.7
Width of dorsal cup	11.1	12.2
Height to width ratio of dorsal cup	1.13	1.05
Diameter of body cavity	3.1	3.9
Length of intermuscular notch	1.3	1.5
Width of articular facet	1.3	1.9
Length of anterior radial	4.0	4.9
Width of distal margin of anterior radial	4.0	3.8
Maximum width of anterior radial	5.3	7.3
Length of right posterior basal	8.8	8.0
Width of right posterior basal	7.0	6.9
Maximum diameter of infrabasal circlet	8.8	8.2+
Height of infrabasal circlet	2.0	2.2
Length of infrabasals	5.2	5.8+
Diameter of cicatrix	1.3	—
Distance from anal orifice to top of cup	2.4	2.7
Diameter of anal orifice	2.4 × 1.4	2.5 × 2.2
Height above base to maximum diameter of cup	5.9	5.8

Remarks—This species closely resembles *Lecythiocrinus adamsi* Worthen (1883, p. 317, pl. 30, fig. 8a-d), but differs from that species in having shorter ambulacral grooves, more constricted top, proportionally narrower radials, wider basals, wider infrabasals, and a more broadly globe-shaped cup. It also resembles L. *olliculaeformis* White (1880, p. 265, pl. 1, figs. 4, 5) and L. *fusiformis* Strimple (1949, p. 20, pl. 3, figs. 11, 13, 14). *L. sacculus* differs from these two species in having much larger ambulacral grooves, more constricted top of cup, proportionately narrower radials, wider basals, wider infrabasals, and a more broadly globe-shaped cup. The maximum diameter of the cup is less in *L. sacculus* than in these two species and the same is true in reference to L. *adamsi. L. sacculus* is distinguished from other species of the genus, except *L. asymmetricus,* by its long ambulacral grooves, broadly globe-shaped cup, and markedly constricted top. *L. asymmetricus* (Moore and Strimple, 1973, p. 47, pl. 4, fig. la-c) is distinguished from L. *sacculus* by pronounced asymmetry of the cup.

Lecythiocrinus cf. *optimus* reported by Strimple (1980, p. 7, pl. 1, fig. 8) from the Gobbler Formation of the Sacramento Mountains, New Mexico, has slightly wider radial articulating facets and shorter ambulacral grooves than *L. sacculus.* L. cf. *optimus* of Strimple (1980) is from the lower part of the Gobbler Formation in the northern part of the Sacramento Mountains. L. *sacculus* is from the top of the Gobbler Formation in the southern part of the Sacramento Mountains.

Suborder POTERIOCRININA Jaekel, 1918
Superfamily LOPHOCRINACEA Bather, 1899
Family LAUDONOCRINIDAE Moore and Strimple, 1973

Genus *LAUDONOCRINUS* Moore and Plummer, 1940

Type *species—Hydreionocrinus subsinuatus* (Miller and Gurley, 1894).

Diagnosis (in part after Moore, Strimple, and Lane, 1978)—Cup moderately low, bowl-shaped, characterized by flat base and smooth contour of the surface. Summit of interradial sutures has a well-defined notch. Posterior interradial area wide and concave at top of cup.

Remarks—The family Laudonocrinidae is placed in the superfamily Lophocrinacea in the Treatise (Ubaghs, G. et al., 1978, p. T663). However, the Laudonocrinidae are very similar to the Pirasocrinidae that are discussed on p. T722 of the Treatise and are indicated in the index of the Treatise, part T, Echinodermata 2 (Ubaghs, G., et al., 1978, p. T1016) to belong to the superfamily Pirasocrinacea (p. T722). The cup of the Laudonocrinidae has a flat base, whereas the Pirasocrinidae have a deep basal concavity. In all other respects, including the umbrella-like anal sac, these two families are similar and perhaps should be placed in the same superfamily. It is beyond the scope of this report to further elaborate on this problem.

LAUDONOCRINUS SUBSINUATUS (Miller and Gurley, 1984)
Figs. 39a-e, 58a-g

1894. *Hydreionocrinus subsinuatus* Miller and Gurley, p. 40, pl. 6, figs. 11-14.
1938. *Plaxocrinus subsinuatus* (Miller and Gurley): Moore and Plummer, p. 279.
1940. *Laudonocrinus subsinuatus* (Miller and Gurley): Moore and Plummer, p. 176, 276, text-fig. 32, p1. 6, fig. 6a, b.
1943. *Laudonocrinus subsinuatus* (Miller and Gurley): Moore and Laudon, p. 58.
1944. *Laudonocrinus subsinuatus* (Miller and Gurley): Moore and Laudon, p. 165, pl. 62, fig. 10, pl. 64, fig. 10.

Types and occurrence—Hypotypes USNM 118451 (Figs. 39a-e, 58a-f) and 118452a, b (Fig. 58g, **h), collected by I. A. Keyte, W. Grant Blanchard, Jr., and H. L. Baldwin in** June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis—As for genus.

Description—The dorsal cup is smoothly rounded, shallowly bowl-shaped, and very similar to the specimen of L. *subsinuatus* illustrated by Moore and Plummer (1940, pl. 6, fig. 6a, b). The basal concavity is broad and very shallow. The cicatrix is distinctly concave and extends slightly out of the basal concavity. The infrabasal circlet lies entirely within the cicatrix. The basals and radials are broadly rounded and smooth. The impressed sutures between the radials give the cup a slightly pentalobate appearance. The posterior interradius is gently concave. The facets of the radials are slightly shorter than the maximum width of the radials. The plane of the dorsal part of the articular facets of the radials is inclined outward sharply, whereas the plane of the inner part of the facets is inclined outward gently. The lateral margins of the inner parts of the radials are sharply raised (Fig. 39b, d).

The structure of the posterior interradius is normal for the species, except that the radianal does not extend so far distally as in the type specimen of *L. subsinuatus*. The surface of the plates is smooth.

Measurements (in mm) of the hypotype USNM 118451 are as follows:

Height of dorsal cup	3.4
Width of dorsal cup	10.7
Height to width ratio of dorsal cup	0.32
Height of cicatrix	0.6
Diameter of cicatrix	2.7
Width of anterior radial	6.4
Width of anterior radial facet	4.4

Superfamily CROMYOCRINACEA Bather, 1890
Family CROMYOCRINIDAE Bather, 1890

Genus *AGLAOCRINUS* Strimple, 1961

Type *species—Ethelocrinus magnus* Strimple, 1949.

Diagnosis (after Webster, 1981)—Cup low, broad, bowl-shaped, widest at apices of basals. Base nearly flat, slopes very slightly inward. Basals form outer half of basal plane. Walls are subvertical. Sutures deeply impressed. Cup plates have granules or nodose ornamentation. Primanal (X) and radianal form part of cup. 10-12 biserial arms. Column round and heteromorphic, with pentalobate lumen.

AGLAOCRINUS aff. *MARQUISI* (Moore and Plummer, 1940)
Fig. 59

1940. *Parulocrinus marquisi* Moore and Plummer, p. 374, pl. 17, figs. 4, 75.
1966. *Paracromyocrinus marquisi* (Moore and Plummer): Strimple, p. 5.
1973. *Paracromyocrinus marquisi* (Moore and Plummer): Webster, p. 191.

Material and occurrence—USNM 118466 (Fig. 59), collected by I. A. Keyte and W. G. Blanchard, Jr., in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Remarks—A single fragment of a dorsal cup in the collection appears to belong to *Aglaocrinus marquisi* or a closely related species. Only one radial, parts of two other radials, and parts of two basals are preserved. The general shape of these plates, the strongly U-shaped sutural furrows, and the very regularly spaced ridges and furrows that extend from the sutures are very like those of *A. marquisi.* However, the form lacks the bordering ridges on basals and radials and the broad, transverse furrow of the radials that characterize *A. marquisi.* Although it may represent a new species, the fragmentary specimen is here identified only as *Aglaocrinus* aff. *marquisi.*

Genus *PARULOCRINUS* Moore and Plummer, 1940

Type *species—Ulocrinus blairi* Miller and Gurley, 1894.

Diagnosis (in part after Moore, Strimple and Lane, 1978)—Cup medium-sized, deeply bowl-shaped, without sharp constriction at summit of cup; flat-based or with very shallow concavity or weak convexity. Infrabasals subhorizontal, not visible from the side. Typically with anal-X and radianal plates in cup; proximal tip of right tube plate may enter cup.

Remarks—For the purpose of this study the diagnosis of the dorsal cup is pertinent because the only specimen available is a cup without arms, which is also true of the holotype of the type species. However, the genus *Parulocrinus* is considered to have more than 10 equibiserial arms. The number and distribution of arms vary among genera of the cromyocrinids. Hence generic assignment of cups that lack arms is equivocal, even though the cup appears to be referable to a particular species. Reference of this specimen to *Parulocrinus* is provisional.

PARULOCRINUS GLOBATUS, new species
Figs. 46a-d, 60a-k

Types and occurrence—Holotype USNM 118464 (Figs. 46a-d, 60a-d) and paratype USNM 118465 (Fig. 60e-k), collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis—Differs from other species of the genus by its bulbous radials and basals, and strongly indented sutures.

Etymology—Latin *globatus*, forming a ball.

Description—A small cromyocrinid with a hemispherical dorsal cup and a slightly downflaring infrabasal circlet bearing an encircling ridge. Plates of the cup are smooth. The infrabasal circlet is rather large and surmounted by a distinct basal concavity. The infrabasals are subhorizontal, but bear a strongly encircling ridge so the proximal margins appear to flare upward. The basals and radials are moderately bulbous and have strongly indented sutures. The dorsal ligament fossae and interarticular ligament fossae lie in the horizontal plane. The dorsal ligament fossa is narrow and runs nearly the length of the facet. The central ligament pit is broad, long, and unites with the dorsal ligament fossa (Fig. 60b). The interarticular ligament fossa is smooth and not excavated. The plane of this fossa is horizontal, and the margins flare sharply downward (Fig. 60e-k) on the primaxial brachial. A sutural groove separates the facets at their lateral edges. The articular facets are extended inwardly and greatly constrict the perimeter of the opening to the visceral cavity. The distinct intermuscular groove of the facets gives the outline of the opening to the visceral cavity a petaloid appearance. The posterior interradius has a strongly quadrate, bulbous radianal and a flat-surfaced, narrow, principal anal X (primanal).

Measurements (in mm) of the holotype (USNM 118464) are as follows:

Height of dorsal cup	9.5
Width of dorsal cup	17.7
Maximum width of dorsal cup	19.5
Distance of greatest width below top of cup	1.9
Height to width ratio of dorsal cup	0.48
Width of visceral cavity at top of cup	9.2
Diameter of the cicatrix	2.9
Length of infrabasals	4.2
Width of infrabasals	3.4
Length of basals	8.5
Width of basals	9.9
Length of anterior radial	5.7
Width of anterior radial	10.0
Length of radianal	6.0
Width of radianal	2.0 / 4.0
Length of anal X	4.6
Width of anal X	3.0
Distance of base of anal X below top of cup	3.3
Length of suture between basals	3.8
Length of suture between radials	3.7

Remarks—The small piece of limestone from which the calyx was freed by the use of dilute hydrochloric acid also produced two axillary primibrachials believed to belong to this species. One of these ossicles (USNM 118465) is illustrated in Fig. 60e-k.

This species is distinguished from all other species of *Parulocrinus* by its smooth surface, hemispherical shape of the cup, shape and arrangement of the anal X (primanal) and the radianal; both are smooth and bulbous. The encircling ridge on the horizontal infrabasals is also distinctive.

Superfamily ERISOCRINACEA Wachsmuth and Springer, 1886
Family ERISOCRINIDAE Wachsmuth and Springer, 1886

Genus *ERISOCRINUS* Meek and Woethen, 1865

Type *species—Erisocrinus typus* Meek and Worthen, **1865.**

Diagnosis (after Moore, Strimple, and Lane, 1978)—Cup broadly truncate, cone-shaped; flattened base has little or no basal concavity; cicatrix circular; cup outline tyically pentagonal when viewed from above or below. Small infrabasals (5) fused and confined to base of cup together with proximal portions of basal plates. Radial plates (5) form most of lateral walls of cup. Single anal-X (primanal) plate confined to notch between articular facets of right and left posterior radials. Arms 10, equibiserial, with flattened exteriors, pinnulate, branch on the short primaxial of each ray.

ERISOCRINUS TYPUS Meek and Worthen, 1865
Figs. 42a–i, 61a–f

1865. *Erisocrinus typus* Meek and Worthen, p. 174.
1865. *Erisocrinus nebraskensis* Meek and Worthen, p. 174.
1865. *Philocrinus pelvis* Meek and Worthen, p. 350.
1872. *Erisocrinus typus* Meek and Worthen: Meek, p. 146, pl. 1, fig. 3a, b.
1873. *Erisocrinus typus* Meek and Worthen: Meek and Worthen, p. 561, pl. 24, fig. 6a, b.
1938. *Erisocrinus typus* Meek and Worthen: Strimple, p. 6, pl. 1, figs. 14-17, pl. 2, figs. 2-5.
1940. *Erisocrinus typus* Meek and Worthen: Moore and Plummer, p. 152, fig. 5, pl. 4, figs. 4, 5, pl. 19, fig. 4, text-figs. 24, 25.
1943. *Erisocrinus typus* Meek and Worthen: Moore and Laudon, p. 135, pl. 6, fig. 3.
1944. *Erisocrinus typus* Meek and Worthen: Moore and Laudon, p. 173, pl. 62, fig. 27, pl. 65, fig. 28.
1959. *Erisocrinus typus* Meek and Worthen: Strimple, p. 120, pl. 1, figs. 14-17, pl. 2, figs. 2-5.
1960. *Erisocrinus typus* Meek and Worthen: Strimple, p. 155, fig. 2D.
1963. *Erisocrinus typus* Meek and Worthen: Tischler, p. 1066, figs. 6A, B.
1978. *Erisocrinus typus* Meek and Worthen: Moore, Strimple, and Lane, p. T705, fig. 463a—i.

Types and occurrence—Hypotypes USNM 118454 (Figs. 42a–c, 61a, b), USNM 118455 (Figs. 42e–i, 61c–f), USNM 118456a–d (Fig. 42d; three specimens not figured), and USNM 118457a–f (not figured). All collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Description—The general structure of the cup is similar to that of *E. typus*. The cup is bowl- to cone-shaped. The infrabasal circlet is small, pentagonal, and confined to the bottom of the cup. The basals flex upward rather sharply, making the bottom of the cup flat. The surfaces of the basals and radials are broadly and smoothly rounded. The cup is pentagonal in outline (Fig. 42a). The surfaces of the plates are smooth.

The anal X is small, triangular, and lies at the upper and inner edges of the right and left posterior radial plates. It is often very small and appears to be absent in some specimens (Fig. 42e, g, h).

Measurements of the hypotypes are shown in Table 1. Silicification of the specimens makes measurements of the infrabasals and basals unreliable.

Remarks—Twelve specimens are tentatively referred to this species. Moore and Plummer (1940, pp. 149-160) regarded the height to width ratio of dorsal cups to be one of the most important criteria for recognizing species of *Erisocrinus*. Our specimens range in width of dorsal cup from 8.6 to 19.5 mm. Although they are from the same locality, in fact from the same block of limestone, the height to width ratio ranges from 0.36 to 0.46. The width of the cup appears to be inversely proportional to the height to width ratio. Specimens 8.5 mm in diameter have a ratio of 0.46 and those 15 mm in diameter have a ratio of 0.36. However, the contour of the cup is less obviously related to its width. Although not true for all cups in the lot, the smaller (<12.0 mm wide) cups nevertheless tend to be bowl-shaped with a rounded base (Figs. 42d, 61d), whereas the larger ones tend to be cone-shaped (Figs. 42g, 62b). There also appears to be a considerable amount of variation in the size of the infrabasal circlet and the shallow basal concavity. A small basal concavity is present in all the specimens, but is less distinct in the larger ones.

Although it is possible that this lot of 12 specimens represents more than one species, we tentatively refer them to only one species, *Erisocrinus typus* Meek and Worthen. Further, we believe the criteria currently used to recognize species of *Erisocrinus* have not been proven reliable. Only after study of many specimens and perhaps the use of statistics and analysis of on-

Table 1—Measurements (in mm) of *Erisocrinus typus* Meek and Worthen.

	USNM accession-catalog numbers								
	118456a	*118456b*	*118454*	*118456c*	*118456d*	*118457a*	*118455*	*118457*	*118457c*
Height of dorsal cup	3.7	3.9	4.3	4.0	5.0	4.4	5.6	5.4	5.4
Greatest width of dorsal cup	8.7	9.6	9.8	10.1	10.9	12.1	13.1	13.9	15.2
Height to width ratio of dorsal cup	0.43	0.41	0.44	0.40	0.46	0.36	0.43	0.39	0.36
Height of body cavity	5.6	6.6	5.9	7.3	7.5	8.6	7.9	8.4	10.0
Diameter of cicatrix	1.4	1.9	2.7	1.8	1.4	2.4	2.7	2.8	2.5
Maximum length of radials	2.5	3.3	4.0	3.6	4.1	4.4	5.1	5.2	6.8
Maximum width of radials	5.3	6.4	6.3	6.0	6.4	7.4	8.3	8.7	9.5
Length of suture between radials	1.9	2.9	2.3	2.2	2.6	3.4	3.5	4.2	4.0

togeny of the group will it be possible to unequivocally demonstrate reliable criteria for differentiating species of this highly generalized and unornamented genus. The current sample is inadequate for such a study. Two calyces, characteristic of the group of specimens, are illustrated in Fig. 61a-f.

ERISOCRINUS aff. ERECTUS Moore and Plummer, 1940
Figs. 41a-e, 62a-d

Material and occurrence—USNM 118458 (Figs. 41a-e, 62a-d), collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Remarks—A rather large *Erisocrinus* with sharply cone-shaped cup, straight-sided radials, smooth plates, sutures not impressed, and with a large cicatrix. The single specimen available to us agrees very well with the description of *E. erectus* given by Moore and Plummer (1940, p. 157, text-fig. 26, pl. 4, fig. 3).

The measurements (in mm) of USNM 118458 are as follows:

Height of dorsal cup	8.6
Width of dorsal cup	19.1
Width to height ratio of dorsal cup	0.45
Width of body cavity	2.4
Diameter of cicatrix	3.7
Maximum length of infrabasals	3.6
Maximum width of infrabasals	3.0
Maximum length of basals	5.5
Maximum width of basals	7.2
Maximum length of anterior radial	6.3
Maximum width of anterior radial	11.6
Length of suture between basals	3.9
Length of suture between radials	5.6

ERISOCRINUS sp.
Fig. 63a, b

Material and occurrence—USNM 118459 (Fig. 63a, b), collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Remarks—The specimen may be *Erisocrinus typus* Moore and Plummer, 1940, but, because of damage to the calyx, the species cannot be identified. It appears to have a bowl-shaped cup, but the cup is lower than in E. *typus*. The specimen is illustrated primarily for the sake of completeness.

Family CATACRINIDAE Knapp, 1969

Genus ENDELOCRINUS Moore and Plummer, 1940

Type *species—Eupachycrinus fayettensis* Worthen, 1873, *in* Meek and Worthen, 1873.

Diagnosis—Characterized by a strong transverse as well as longitudinal convexity of the radials and basals, which makes them appear distinctly bulbous, or by sharp inflections of the borders of the basals and radials at angles where they meet, or by both of these features. One anal-X (primanal) plate in the cup.

ENDELOCRINUS BIFIDUS Moore and Plummer, 1940
Figs. 44a-e, 64a-h

1940. *Endelocrinus bifidus* Moore and Plummer, p. 308, pl. 12, fig. 10.
1944. *Endelocrinus bifidus* Moore and Plummer: Moore and Laudon, p. 173, pl. 65, fig. 2.
1961. *Corythocrinus bifidus* (Moore and Plummer): Strimple, p. 129.
1962. *Tholiacrinus bifidus* (Moore and Plummer): Strimple, p. 136.

Types and occurrence—Hypotype USNM 118460 (Figs. 44a-e, 64a-h), collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Description—Moore and Plummer (1940, p. 310) wrote that the distinguishing characters of this species are the "very prominent bulges of the plates, the pattern of low, connecting ridges, and somewhat angular nature of intervening hollows and the distinctive bifid appearance of the radials." The bifid appearance results from the connecting ridges of the radials (Figs. 44a, d, Ma, b). Their account fits the specimen USNM 118460 so well that a redescription is unnecessary.

Measurements (in mm) of USNM 118460 are as follows:

Height of dorsal cup	3.0
Width of dorsal cup	6.2
Height to width ratio of dorsal cup	0.48
Width of body cavity	3.7
Height of basal concavity	0.8
Width of basal concavity	1.8
Width of cicatrix	1.3
Height of proximal margin of posterior basal above basal plane	0.5
Height of distal margin of posterior basal above basal plane	1.9
Ratio of height of proximal to distal margin of posterior basal above basal plane	0.26
Length of basals	3.8
Width of basals	4.1
Length of anterior radial	1.8
Width of anterior radial	3.8
Length of anal X (primanal)	1.9
Width of anal X (primanal)	1.4
Length of suture between basals	1.9
Length of suture between radials	1.0

Remarks—This species most closely resembles *E. rectus* (Moore and Plummer, 1940, p. 310), but differs from it in the sharp ridges, angular nature of the sutures, and the bifid appearance of the radials.

ENDELOCRINUS PERASPER, new species
Figs. 45a-e, 65a-1

Types and occurrence—Holotype USNM 118461 (Figs. 45a-e, 65a-i) and paratype USNM 118462 (Fig. 65j-l), collected by I. A. Keyte, W. G. Blanchard, and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis—Characterized by bulbous and very hispidate radials and basals.

Etymology—Latin *per asper,* rough.

Description—A medium-sized *Endelocrinus* with a truncate, bowl-shaped dorsal cup about 12.6 mm in greatest diameter and 4.9 mm in height. The narrow basal concavity is high and steep-sided. The plates of the basal and radial circlets are moderately convex and the sutures are moderately depressed. The infrabasal circlet is a small pentagon at the top of the invaginated basal concavity, with only a small distal part of each plate visible beyond the cicatrix of the cup (Fig. 45c). The infrabasal circlet forms only about one-fifth of the height of the concavity, which is formed largely by the basals. The greatest curvature of the basals is at the tangent with the basal plane and the distal parts are inclined away from the cup; the extremities of the basals reach nearly three-quarters of the height of the cup (Figs. 45c, d, 65g).

The outer ligamental area of the radial facet is narrow, only slightly excavated, and slopes steeply outward (Figs. 45b, 65h). The transverse ridge is narrow, distinct, and straight (Fig. 65i). The general plane of the inner ligament area is inclined slightly outward, the midportion of the inner border slopes gently outward, and the lateral margins are sharply raised. The dorsal ligament fossa is narrow and nearly flat. The interarticular ligament pits are long, narrow, and deeply indented (Fig. 65i). The intermuscular notch on the inner margin of the facets is lacking; the body cavity appears round. The anal X (primanal) is large, hexagonal, and for half of its length extends above the dorsal cup. The width to length ratio of the anal X is 0.78.

The surfaces of the plates of the cup are slightly bulbous and covered with small hispidate pustules which are not conspicuous in the silicified specimens because of the granularity of the silicification (Fig. 65f, g, h). The sutures between the plates are markedly depressed.

Measurements (in mm) are as follows:

	Holotype USNM 118461	*Paratype* USNM 118462
Height of dorsal cup	4.9	3.4
Greatest width of dorsal cup	12.6	10.0
Height to width ratio of dorsal cup	0.38	0.34
Width of body cavity	7.7	6.0
Height of basal concavity	1.9	1.5
Width of basal concavity	4.7	3.4
Diameter of stem cicatrix	2.0	
Height of proximal margin of the posterior basal above basal plane	1.7	1.1
Height of distal margin of the posterior basal above basal plane	2.6	2.0
Ratio of height of proximal to distal margin of posterior basal above basal plane	0.67	0.55
Length of basals	7.9	6.7
Width of basals	5.9	4.1
Length of anterior radial	4.5	2.3
Width of anterior radial	8.3	5.0
Length of anal X (primanal)	3.3	2.4
Width of anal X (primanal)	2.6	1.8

Remarks-This species resembles *E. parvus* Moore and Plummer (1940, pp. 303-306), *E. rectus* Moore and Plummer (1940, pp. 300-302), and *E. petalosus* Strimple (1949, pp. 24, 25). It is distinguished from these and all other species of *Endelocrinus* by the deep basal concavity, slightly bulbous plates with hispidate pustules, shape of the cup, and outwardly inclined plane of the radial facets.

Superfamily PIRASOCRINACEA Moore and Laudon, 1943

Family PIRASOCRINADAE Moore and Laudon, 1943

Genus *SCIADIOCRINUS* Moore and Plummer, 1938

Type *species-Zeacrinus (Hydreionocrinus) acanthophorus* Meek and Worthen, 1870.

Diagnosis-Very low, discoidal dorsal cup; wide, gentle or strong basal concavity affects infrabasal circlet, all basals, and proximal tips of radials. Basals not visible in side view of the cup, except for the distal part of the posterior basal.

SCIADIOCRINUS aff. HARRISAE Moore and Plummer, 1940

Figs. 43a-d, 67a-c

Material and occurrence-USNM 118453 (Figs. 43a-d, 67a-c), collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 at USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Remarks-Two poorly preserved fragments of a dorsal cup are referred to this species. They appear to belong to a single cup, although the fit is not perfect. The specimen agrees in all preserved aspects with the description of *S. harrisae* by Moore and Plummer (1940, p. 232).

The distinguishing features of this species are its low height, a broad but strongly marked basal concavity, and the swollen appearance of the basals and radials.

Measurements (in mm) of the reconstructed specimen USNM 118453 are as follows:

Height of cup	3.9
Maximum width of cup	18.6
Height to width ratio of cup	0.21
Height of basal concavity	1.3

Genus *STENOPECRINUS* Strimple, 1961

Type *species-Perimestocrinus planus* Strimple, 1952.

Diagnosis (cup only)-Dorsal cup conically bowl-shaped; narrow, moderately deep, steep-sided basal concavity; five infrabasals; three anal plates in cup; radial facets slope upward at a moderate angle and are less than the greatest width of the radials.

STENOPECRINUS GLABER, new species

Figs. 40a-e, 66a-d

Types and occurrence-Holotype USNM 118450 (Figs. 40a-d, 66a-d), collected by **I. A.** Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Diagnosis-Characterized by deep cicatrix concavity (Fig. 40c) and extremely smooth surface of plates.

Etymology—Latin *glaber,* smooth.

Description—A medium-sized species of *Stenopecrinus* with a smooth, nearly hexagonal cup, and broad and high basal concavity. The radial sutures are not impressed. The interradius is almost flat and the dorsal ligament plane is nearly vertical. The cicatrix is small and concave. The infrabasals flare downward and extend beyond the cicatrix. The proximal ends of the basals curve sharply at the margins of the basal concavity and are nearly horizontal, curving only slightly upward. The radials are slightly rounded and serve to give the cup a smooth, low-bowl shape. The plane of the dorsal ligament surface is nearly flat and almost vertical. The general plane of the interarticular ligament area is slightly inclined outward and the lateral margins flare sharply upward. The ligament pit is deep, long, and broad. The posterior interradius appears to be normal for the genus, of type "C" of Strimple (1961, pp. 113-118).

Measurements (in mm) of the holotype (USNM 118450) are as follows:

Height of cup	4.8
Width of cup	13.5
Height to width ratio of cup	0.35
Height of basal concavity	1.6
Width of basal concavity	4.5
Diameter of cicatrix	1.9

Remarks—This species differs from most other *Stenopecrinus* species in having a relatively deep basal concavity and a small cicatrix. It resembles S. *hexagonus* Strimple (1952, p. 785), but differs from it in having a smoother cup and a wider posterior interradius.

Genus *PERIMESTOCRINUS* Moore and Plummer, 1938

Type *species—Hydreionocrinus nodulifer* Miller and Gurley, 1894.

?PERIMESTOCRINUS sp. indet.
Fig. 68a–f

Material and occurrence—USNM 118468a–c, collected by I. A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344j, Grapevine Canyon, Sacramento Mountains, New Mexico.

Description—The silicified material contains examples of axillary first primibrachials that belong to pirasocrinids. They are developed into strong spines that extend outward from the dorsal surface. The ossicles are referred to *?Perimestocrinus,* although some other members of the Pirasocrinidae have dorsal processes on the axillary first primibrachials. The strong spikelike processes seem to more closely resemble those of *Perimestocrinus.* Our knowledge of the pirasocrinid axillary first primibrachials is meager because many species are known only from the cup. *Perimestocrinus* and *Separocrinus* Knapp, 1969, have well-developed spinose processes that arise from the base of the axillary first primibrachial and extend directly upward. The ossicles could belong to either genus. Other pirasocrinids can be differentiated from these two genera. *Eirmocrinus* has bulbous knobs on the axillary first primibrachials. The axillaries of *Plaxocrinus* have short, stout spines high on the dorsal surface. *Utharocinus* has small, stout, stubby spines.

The axillary first primibrachials (Fig. 68a–f) are included in this report because they represent crinoid ossicles that occur in large quantities at many outcrops, but are generally overlooked by collectors. They may be more useful than generally thought.

Subclass FLEXIBILIA Zittel, 1895
Order TAXOCRINIDA Springer, 1913
Superfamily TAXOCRINACEA Anglein, 1878
Family SYNEROCRINIDAE Jaekel, 1878

?SYNEROCRINUS sp. indet.
Fig. 70

Material and occurrence—USNM 118467, collected by **I.** A. Keyte, W. G. Blanchard, Jr., and H. L. Baldwin in June 1928 from USGS loc. 7344J, Grapevine Canyon, Sacramento Mountains, New Mexico.

Remarks—Two fragmentary basal circlets of flexible crinoids are present in the collection. One of them is illustrated here simply to record the occurrence of this type of crinoid. It appears to be a member of the family Synerocrinidae.

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Figures 2-70

Figures 2-14

2a-f, *Platycrinites spitzbergensis* (Holtedahl) (after Holtedahl, 1911, pl. 1, figs. 3-6), Moscovian, Late Carboniferous, Spitzbergen. x 0.75

3a-f, Platycrinites sp. (after Tien, 1926, pl. III, figs. 5d-f, 6c, d), Taiyuan Series, Upper Carboniferous, China. x 1.5

4a-f, *Platycrinites* sp. (from Weller, 1930, pl. 1), Desmoinesian, Pennsylvanian, Indiana. x 1.5

5, *Platycrinites* sp. (from Moore and Strimple, 1973, pl. 3, fig. 3), Wapanucka Limestone, Pennsylvanian, Oklahoma. x 1

6a-f, *Platycrinites* cf. *expansus* (McCoy) (from Termier and Termier, 1950, pl. 212, figs. 1-6), Westphalian, Late Carboniferous, Morocco. x 1.2

7a, b, *Platycrinites tuberculatus* (Miller) (from Termier and Termier, 1950, p1. 212, figs. 10, 11), Westphalian, Late Carboniferous, Morocco. x 1.2

8a-l, *Platycrinites* sp. (from Termier and Termier, 1950, pl. 211, figs. 7-18), Westphalian, Late Carboniferous, Morocco. x 1.2

9a, b, *Platycrinites* sp. (from Termier and Termier, 1950, pl. 212, figs. 14, 15), Westphalian, Late Carboniferous, Morocco. x 3

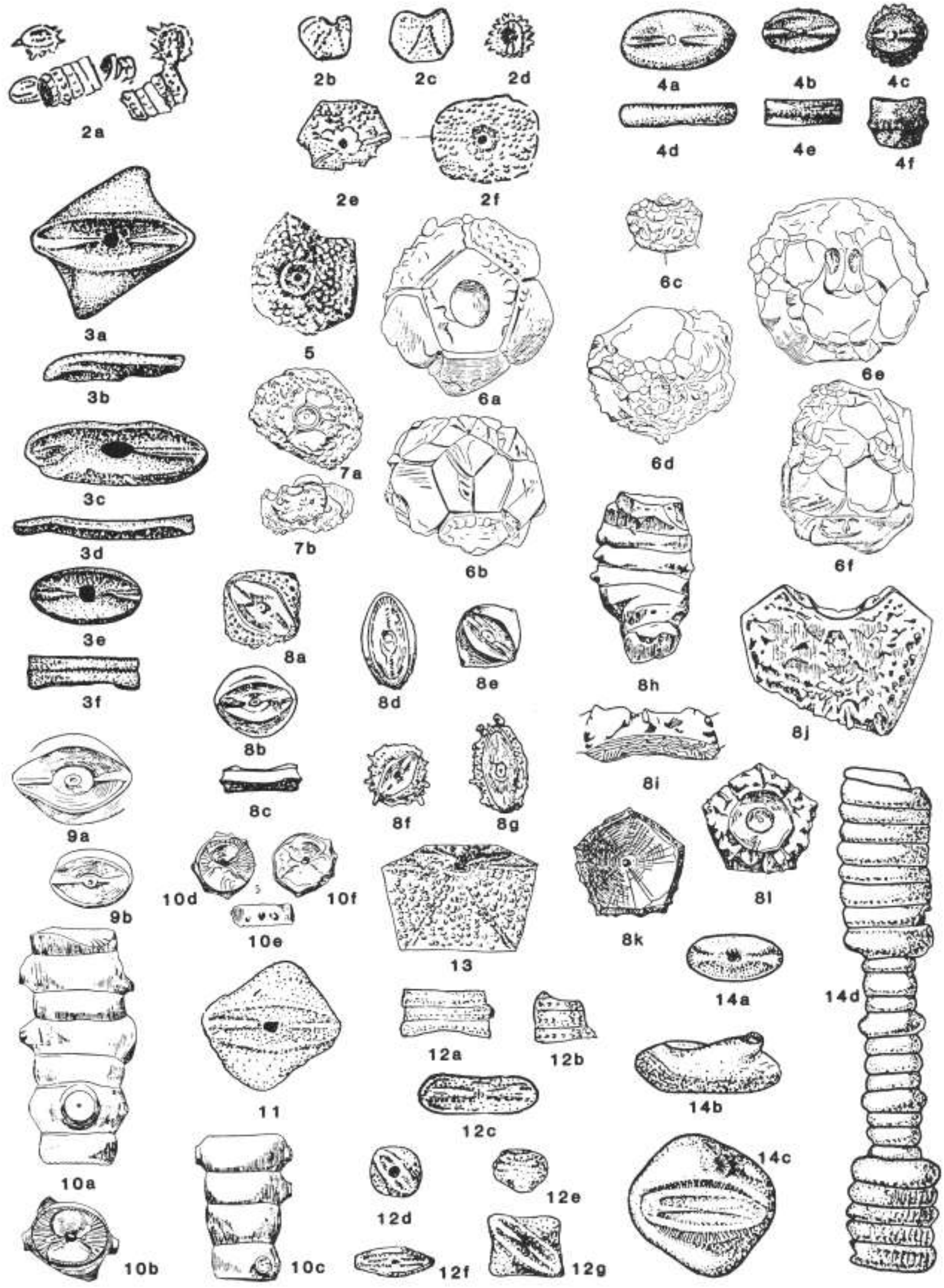
10a-g, *Platycrinites* sp. (from Termier and Termier, 1950, pl. 215, figs. 2-7), Westphalian, Late Carboniferous, Morocco. x 2

11, *Platycrinites* sp. (after Plummer, 1950, pl. 19, fig. 14; this figure was reillustrated by Heuer, 1958, pl. 3, fig. 14), Strawn Group, Pennsylvanian, Texas. x 3

12a-g, *Platycrinites(?) tuberculatus* (Yakovlev and Ivanov) (after Yakovlev and Ivanov, 1956, pl. 12, fig. 9a-g), Late Carboniferous (C_3), Kara-Chatir Range, U.S.S.R. x 1

13, *Platycrinites* sp. (after Yakovlev and Ivanov, 1956, pl. 12, fig. 8), Late Carboniferous (C_3), Timan Range, U.S.S.R. x 1

14a-d, *Platycrinites* sp. (after Trautschold's 1850 illustration that was reproduced in Yakovlev and Ivanov, 1956, pl. 12, fig. 8a-e), Late Carboniferous (C_3), Timan Range, U.S.S.R. x 1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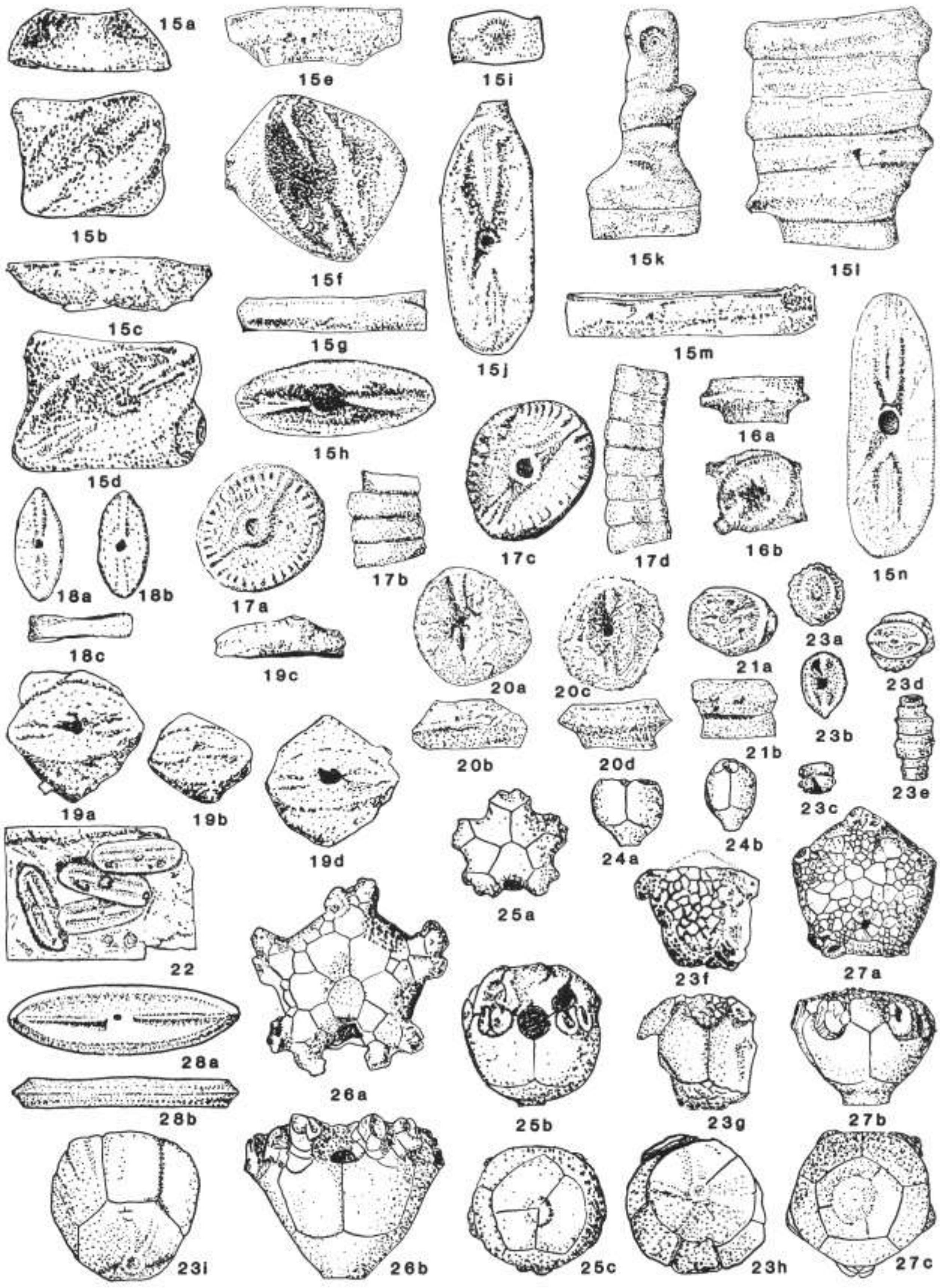
Figures 15-28

15a-n, *Platyplateium texanum* Moore and Jeffords (after Moore and Jeffords, 1968, pl. 1, figs. 4-6, pl. 5, figs. 5-8), Strawn Group, Pennsylvanian, Texas. x 2.5
16a, b, *Platyplateium* sp. (after Moore and Jeffords, 1968, pl. 5, fig. 9a, b), Strawn Group, Pennsylvanian, Texas. x 2.8
17a-d, *Platycion mingusensis* Moore and Jeffords (after Moore and Jeffords, 1968, pl. 5, figs. la, b, 2a, b), Strawn Group, Pennsylvanian, Texas. x 2.5
18a-e, *Columnal ellipticus* Strimple (after Strimple, 1962, figs. 1-3), Desmoinesian, Pennsylvanian, Oklahoma. x 1
19a-d, *Columnal quadrangulatus* Strimple (after Strimple, 1962, figs. 4-7), Desmoinesian, Pennsylvanian, Oklahoma. x 1
20a-d, *Platycrinites tenius* Strimple and Watkins (after Strimple and Watkins, 1969, pl. 54, figs. 1, 3, 4, 6), Desmoinesian, Pennsylvanian, Texas. x 1
21a, b, *Platycrinities tenius contentus* Strimple and Watkins (after Strimple and Watkins, 1969, pl. 54, figs. 2, 5), Desmoinesian, Pennsylvanian, Texas. x 1
22, *Platycrinites* sp. (after Webster and Lane, 1970, pl. 56, fig. 9), Middle Pennsylvanian, Nevada. x 0.7
23a-i, *Platycrinites schmidtii* Stuckenberg (after Stuckenberg, 1875, pl. 1, fig. 8, pl. 2, fig. 3a-c, pl. 3, fig. 2a-g), Permian, U.S.S.R. x0.8
24a, b, *Eutelocrinus piriformis* Wanner (after Wanner, 1916, pl. 98, figs. 1, 2), Permian, Timor, East Indies. x 1
25a-c, *Neoplatycrinus dilatus* Wanner (after Wanner, 1916, pl. 98, figs. 19, 23a, b), Permian, Timor, East Indies. x 1
26a, b, *Pleurocrinus spectabilis* Wanner (after Wanner, 1916, pl. 99, fig. 8a, b), Permian, Timor, East Indies. x 1.5
27a-c, *Platycrinites wachsmuthi* Wanner (after Wanner, 1916, pl. 97, fig. 5a-c), Permian, Timor, East Indies. x 0.8 (The orientation of 27c was erroneously labeled by Wanner.)
28a, b, *Ellipsellipsopa latissima* Moore (from Moore, 1939, fig. 1), Early Permian, west Texas. x 1.5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Figures 29-37

29a, b, *Plesiocrinus piriformis* Wanner (after Wanner, 1937, pl. 6, figs. 36-38), Permian, Timor, East Indies. x 2 (a), x 1 (b)

30a-k, *Platycrinites permiensis* (Yakovlev) (after Yakovlev and Ivanov, 1956, pl. 10, figs. 14-20, Permian, Ural Mountains, U.S.S.R. x 1

31a, b, *Platycrinites schmidtii* Stuckenberg (from Yakolev and Ivanov, 1956, pl. 18, fig. 23), Permian, Indiga River area, U.S.S.R. x 1.5

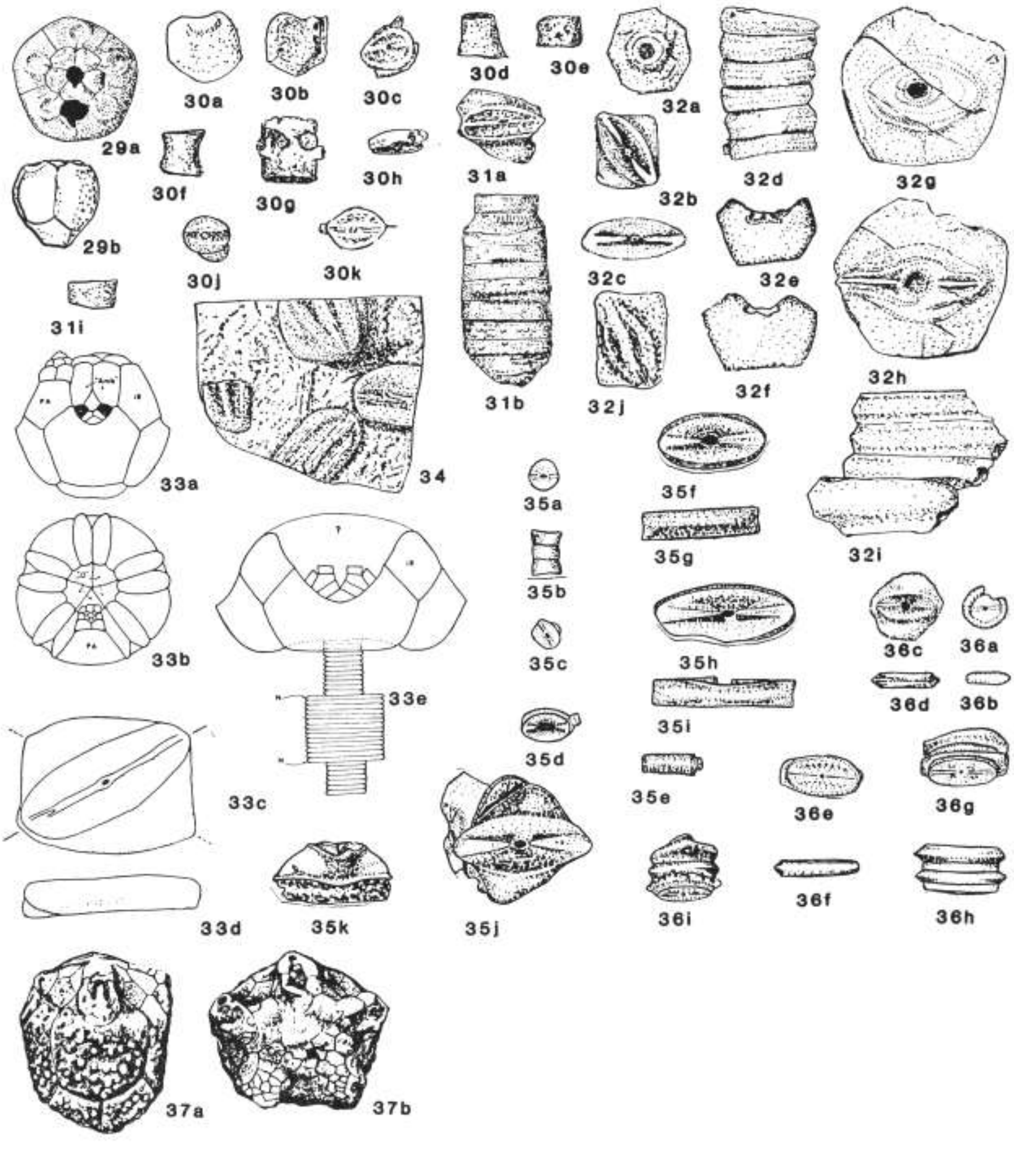
32a-h, *Platycrinites* sp. (after Webster and Lane, 1967, pl. 1, figs. 1-10), Permian, Nevada. x 0.6 33a-e, *Platycrinites nikondaensis* Broadhead and Strimple (from Broadhead and Strimple, 1977, figs. 1A, B, 2A, pl. 1, figs. 3, 6, 7), "Permian Limestone," Wrangell Mountains, east-central Alaska. x 0.5 (a-c), x 0.6 (d, e) (See also Fig. 56.)

Ma, b, *Platycrinites ellesmerense* Broadhead and Strimple (from Broadhead and Strimple, 1977, figs. 2B, C, pl. 1, figs. 1, 2, 4, 5), Late Permian, Ellesmere Island, Canada. x 0.6 (See also Fig. 55a-d.)

35a-k, *Platycrinites nactus* n.sp. (USNM 118473a-k), Desmoinesian, Pennsylvanian, Sacramento Mountains, New Mexico. x 1 (See also Fig. 51a-p.)

36a-i, *Exsulacrinus alleni* n.gen. et sp. (USNM 118472a-i), Desmoinesian, Pennsylvanian, Sacramento Mountains, New Mexico. x 1 (See also Fig. 53a-1.)

37a, b, *Platycrinites wrighti (Platycrinites tuberculatus)* (Marez Oyens) (after Marez Oyens, 1940a, pl. 1, fig. 2a, b), Permian, Timor, East Indies. x 0.7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Figures 38-44

38a—h, *Lecythiocrinus sacculus* n.sp., holotype USNM 118447 (a—d) and paratype USNM 118448 (eh). Views: **a,** apical; **b,** left anterior ray; c, posterior interradius; **d,** basal; **e,** apical; **f,** anterior ray; **g,** posterior interradius (partly damaged); **h,** basal (partly damaged). All x 1

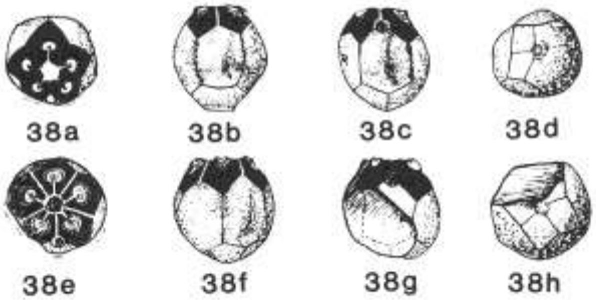
39a—e, *Laudonocrinus subsinuatus* (Miller and Gurley, 1894), USNM 118451. Views: **a,** basal; **b,** anterior ray; **c,** apical; **d,** posterior interradius; e, cross section of the cup from the right side. All, x 2 40a—e, *Stenopecrinus glaber* n.sp., holotype USNM 118450. Views: **a,** posterior interradius; **b,** basal; **c,** cross section of the cup from the right side; **d,** anterior ray; **e,** apical. All x 2

41a—e, *Erisocrinus* aff. *erectus* Moore and Plummer, 1940, USNM 118458. Views: **a,** basal; **b,** anterior ray; **c,** cross section of the cup from the right side; **d,** apical; **e,** posterior interradius. All x 1

42a—i, *Erisocrinus typus* Meek and Worthen, 1865, USNM 118454(a—c), 118454(d), and 118455(e—i). Views: **a,** basal; **b,** posterior interradius; **c,** anterior ray; **d,** posterior interradius; **e,** posterior interradius; **f,** basal; g, anterior ray; **h,** *apical; i,* cross section of the cup from the right side. All x2

43a—d, *Sciadocrinus harrisae* Moore and Plummer, 1940, USNM 118453. Views: **a,** basal; **b,** posterior interradius; **c,** cross section of the cup from the right side; **d,** anterior ray. All x 1

44a—e, *Endelocrinus bifidus* Moore and Plummer, 1940, USNM 118460. Views: **a,** anterior ray; **b,** basal; **c,** cross section of the cup from the right side; **d,** posterior interradius; **e,** apical. All x 4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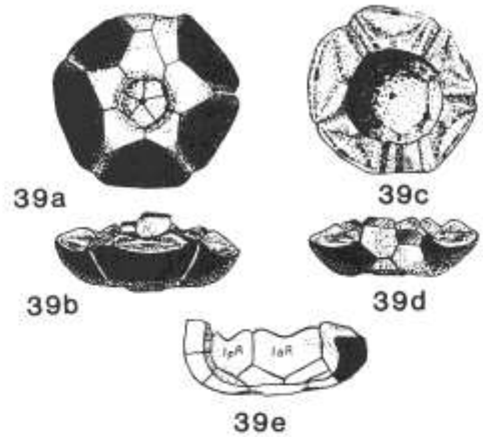
38h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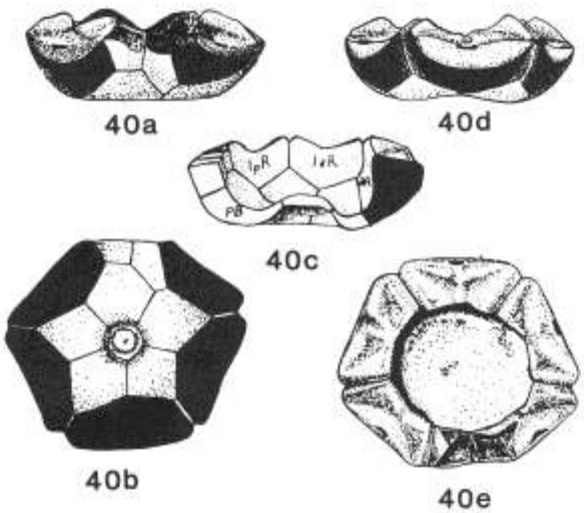
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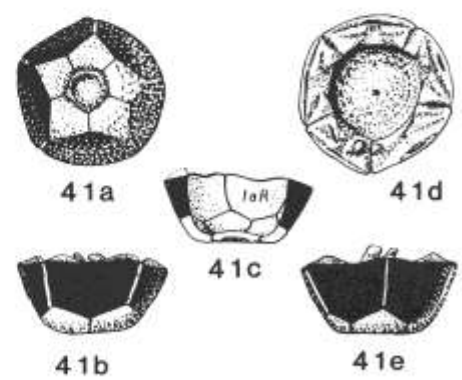
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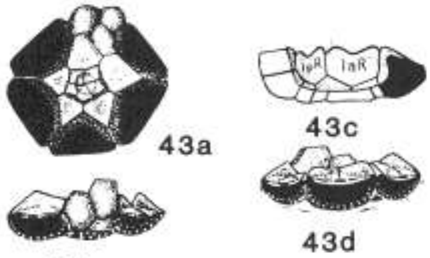
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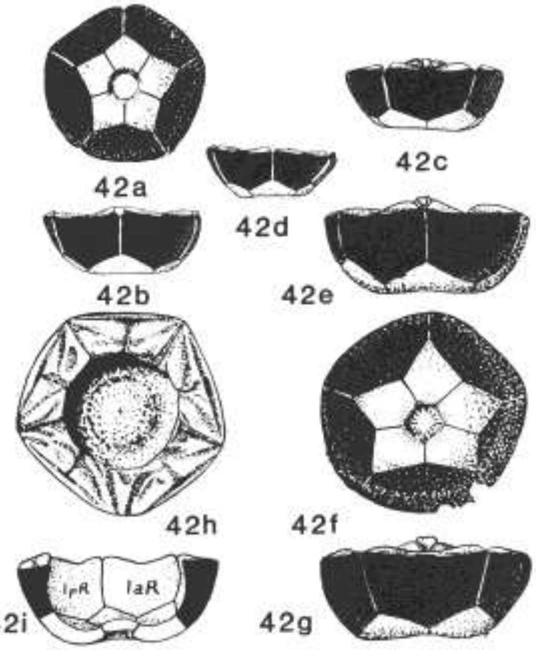
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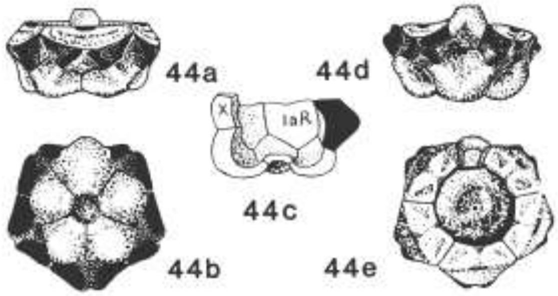

44a
44d
X
IaR
44c
44b
44e

Figures 45-49

45a–d, *Endelocrinus perasper* n.sp., holotype USNM 118462. Views: a, apical; **b,** posterior interray; c, cross section of the cup from the left side; **d,** anterior ray; **e,** basal. x 2 (a–c, e), x 1.5 (d)

46a–d, *Parulocrinus globatus* n.sp., holotype USNM 118464. Views: **a,** apical; **b,** posterior interray; c, anterior ray; **d,** basal. All x 1

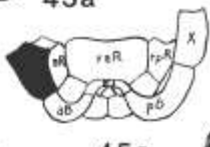
47a, b, These two figures of *Parulocrinus globatus* n.sp. were inadvertently duplicated as 60j and k. The error was discovered only after the typescript and all the composite illustrations were completed. This explanation was chosen by the senior author in preference to extensive renumbering.

48a–g, *Platycrinites nactus* n.sp., holotype USNM 118470 (a–d) and paratype USNM 118471 (e–g). Views: **a,** apical; **b,** posterior interray; **c,** basal; **d,** anterior ray; e, apical; **f,** posterior interray; g, basal. All x 1

49a–e, *Exsulacrinus alleni* n.sp., holotype USNM 118476 (a–d) and paratype USNM 118480 (e). Views: **a,** apical; **b,** posterior interray (partly reconstructed); **c,** basal; **d,** anterior ray; **e,** posterior inter-radius showing the anal plate (X) in the radial circlet—an aberration (see especially Fig. 52h). All x 1.


45a


45d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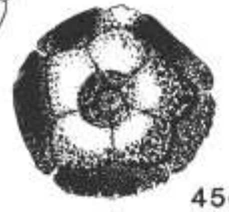
45b

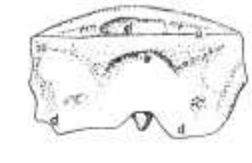

45d


46a


46c


46b


46d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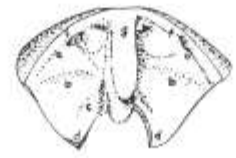

47b


48a

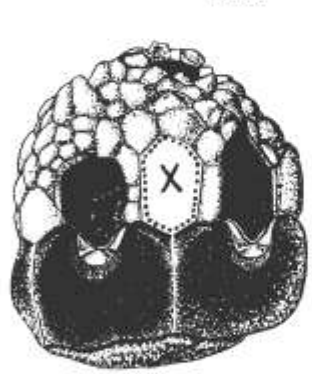

49a

48b

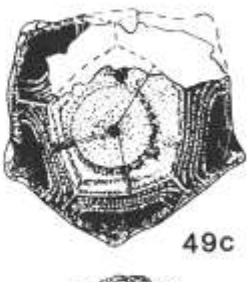

48e


49b


48c



48f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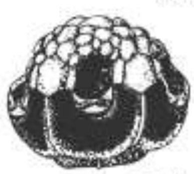
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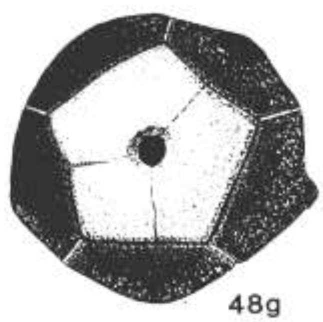
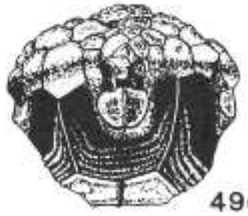

48g


49d

49e

Figures 50-56

50a–h, *Platycrinites nactus* n.sp., holotype USNM 118470 (a–d) and paratype USNM 118471 (e–h). Views: a, basal; **b,** posterior interray; **c,** apical; **d,** anterior ray; **e,** apical; **f,** posterior interray; g, anterior ray; **h,** basal. All x 1

51a–p, *Platycrinites nactus* n.sp., paratypes USNM 118473a (a, c), 118473b (d, e), 118473c (f, g), 118473d (j, k), 118473e (h, i), 118473h (1, m), 118473f (n, o), and 118473g (p). Views: **a,** proximal(?) surface of a columnal; **b,** lateral view of fused columnals; **c,** distal(?) surface of a small, round columnal; **d,** lateral view; e, articulum of specimen in *d* showing the fulcral ridge; f, lateral view of a small, elongate columnal; g, articular surface of the small, elliptical columnal shown in *f,* with a segment of a cirrus still attached; **h,** lateral view; i, articular surface of the large, elliptical columnal shown in *h;* j, lateral view; **k,** articular surface of the medium-sized, elliptical columnal shown in *j;* 1, articular surface of the distal(?) columnal of a segment of three attached columnals, showing divergent fulcral ridges (twisting of the elliptical columnals is characteristic of platycrinitids); n, proximal(?) articular surface of a weathered columnal with fulcral ridges divergent at nearly 90°; o, distal(?) articular surface of the specimen shown in *n;* **p,** anchylosed basal circlet. All x 1

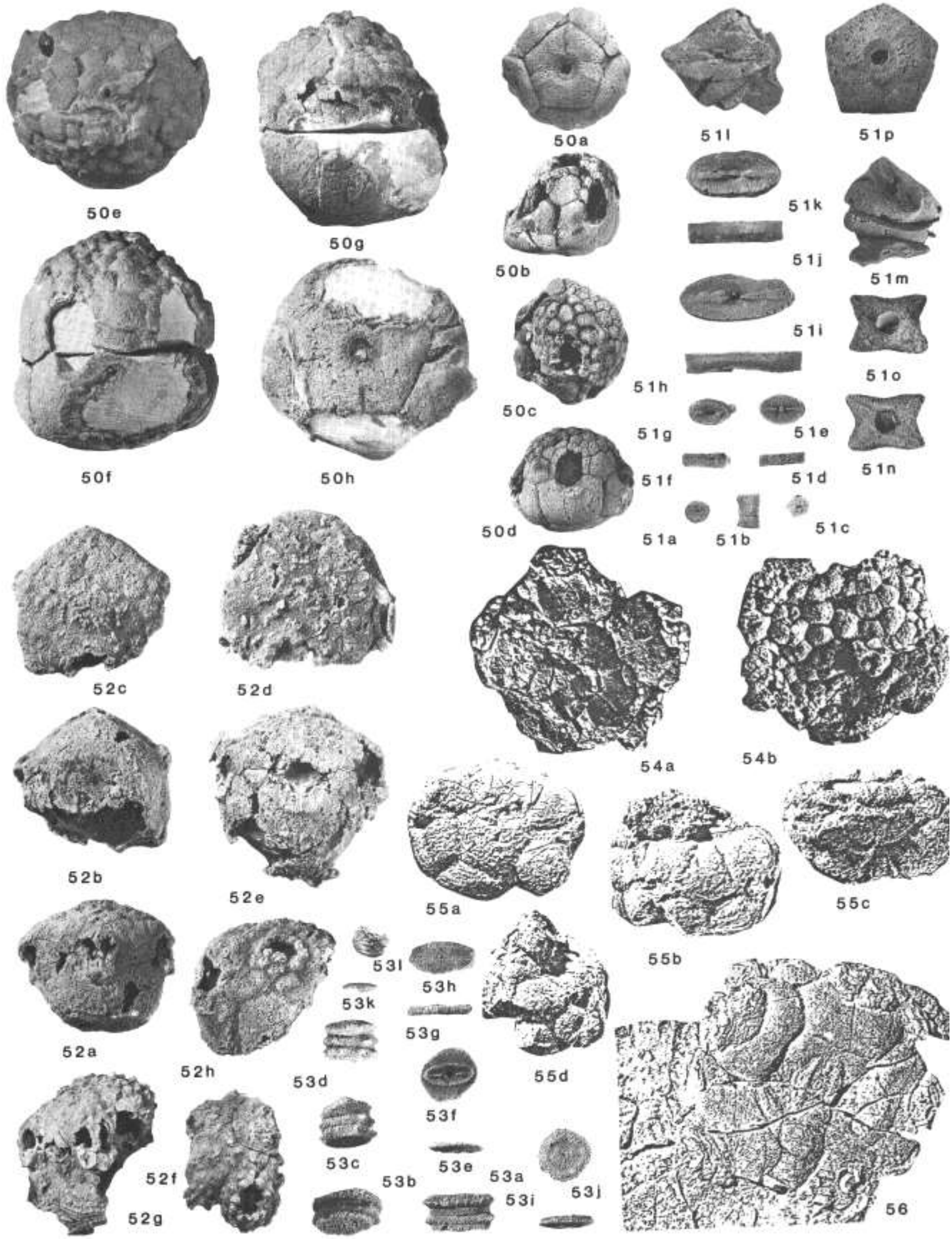
52a–h, *Exsulacrinus alleni* n.sp., holotype USNM 118476 (a–c) and paratypes USNM 118477 (d–e), 118478 (f, g), and 118480 (h). Views: a, anterior ray; **b,** basal; c, apical; d, apical; e, anterior ray; **f,** apical view showing the base of the anal tube; g, anterior ray; **h,** posterior interray showing the anal plate in the radial circlet. This is an aberrant form. A remnant of the base of the anal tube is preserved in the specimen. All x 1

53a-1, *Exsulacrinus alleni* n.sp., paratypes USNM 118482a (a, b), 118482c (c, d), 118482d (e, f), 118482b (g, h), 118482e (i, j), and 118482f (k, 1). Views: a, lateral view of a pluricolumnal; **b,** oblique view of a columnal showing a portion that lacks torsion; **c,** oblique view of a pluricolumnal; **d,** lateral view of the pluricolumnal shown in *c;* **e,** lateral view of the columnal shown in f; **f,** articular facet—a nodal columnal with divergent fulcral ridges; g, lateral view of the columnal shown in *h;* **h,** elongate columnal with a distinct fulcral ridge, articular surface; i, lateral view; j, articular surface, the ossicle is nearly round but has a tendency to be quadrangular; **k,** lateral view of the ossicle shown in *1;* 1, articulum of a very small columnal that must have been located close to the cicatrix of the calyx near the top of the column (a small piece is broken off this ossicle). All x 1

54a, b, *Platycrinites remotus* Strimple and Watkins, 1969, holotype USNM S5163 (from Strimple and Watkins, 1969, pl. 47, figs. 8, 9), Strawn Group, Pennsylvanian, Kickapoo Falls, Hood County, Texas. The holotype and only specimen is flattened and does not show the true shape of the calyx. Views: **a,** basal; **b,** apical. x 1

55a–d, *Platycrinites ellesmerense* Broadhead and Strimple, 1977, holotype, Geological Survey of Canada 34066 (from Broadhead and Strimple, 1977, pl. 1, figs. 1, 2, 4, 5). The holotype and only specimen is from the Trold Fjord Formation, Upper Permian (Guadalupian), Ellesmere lsland, Canada. Views: **a,** left antero-lateral ray; **b,** right posterior interray; **c,** posterior interray of calyx; **d,** apical—a poorly preserved asteroid on the posterior part of the tegmen somewhat obscures the view. x 0.6

56, *Platycrinites nikondaense* Broadhead and Strimple, 1977, holotype, University of Alaska 24315 (from Broadhead and Strimple, 1977, pl. 1, fig. 7), Early or mid-Permian near Nebesna, Alaska. This only specimen is crushed on the surface of a slab of limestone; the shape of the calyx is uncertain. Basal view. x 0.5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Figures 57-70

57a—h, *Lecythiocrinus sacculus* n.sp., holotype USNM 118447 (a—d) and paratype USNM 118448 (eh). Views: **a,** apical; **b,** posterior interradius (specimen slightly distorted); **c,** left anterior interradius; **d,** basal; **e,** apical; **f,** posterior interradius (slightly damaged); **g,** anterior ray; **h,** basal (damaged). All x 1

58a—h, *Laudonocrinus subsinuatus* (Miller and Gurley, 1894), hypotypes USNM 118451 (a—f), 118452a (g), and 118452b (h). Views: a, anterior interradius; **b,** basal; **c,** basal; **d,** apical; **e,** posterior interradius; **f,** posterior interradius; **g,** basal (damaged specimen); **h,** basal (damaged specimen). x 1 (a, b, d, e, g, **h),** x 2 (c, f)

59, *Aglaocrinus* aff. *marquisi* (Moore and Plummer), 1940, USNM 118466, cup fragment showing parts of a radial and a basal plate. x 1

60a—k, *Parulocrinus globatus* n.sp., holotype USNM 118464 (a—d) and paratype USNM 118465 (e—k). Views: **a,** posterior interray; **b,** apical; c, anterior ray; **d,** basal; **e,** dorsal surface of an isolated axillary first primibrachial; **f,** same view as in *e;* **g,** proximal surface of the axillary shown in *e;* **h,** same view as in *g; i,* distal surface of the axillary first primibrachial shown in *e;* j, sketch of lower (proximal) surface of the axillary first primibrachial shown in *e* (a, fulcral ridge; b, (?)nerve canal; c, adoral-muscle field; d, ventral flanges, e, dorsal-nerve canal; f, aboral ligament scars); **k,** sketch of upper (distal) surface of the axillary first primibrachial that is shown in *e* (showing features of the axillary surfaces [dichotomy]: a, poorly defined fulcral ridges; b, aboral-muscle field; c, ventral adoral-muscle field; d, ventral flanges; e, adoral-ligament scars; f, adoral rim; g, medial ridges). x 1 (a—d, f, h), x 2 (i), x 3 (e, g), x **4** (j, k)

61a—f, *Erisocrinus typus* Meek and Worthen, 1865, hypotypes USNM 118454 (a, b) and 118455 (c—f). Views: **a,** posterior interradius; **b,** basal; c, basal; **d,** anterior ray; **e,** posterior interradius; **f,** apical. All x 1

62a—d, *Erisocrinus* aff. *erectus* Moore and Plummer, 1940, USNM 118458. Views: **a,** apical; **b,** anterior ray; c, posterior interradius; **d,** basal. All x 1

63a, b, *Erisocrinus* sp. indet., USNM 118459. Views: **a,** anterior ray; **b,** basal. Both x 1

64a—h, *Endelocrinus bifidus* Moore and Plummer, 1940, hypotype USNM 118460. Views: **a,** anterior ray; **b,** basal; **c,** apical; **d,** posteror interradius; **e,** anterior ray; **f,** basal; **g,** apical; **h,** posterior interradius. x 1 (e—h), x 3 (a—d)

65a-1, *Endelocrinus perasper* n.sp., holotype USNM 118461 (a—c, e—i) and paratype USNM 118462 (d, j-1). Views: **a,** apical; **b,** posterior interradius; **c,** anterior ray; **d,** posterior interradius; **e,** basal; **f,** basal; **g,** right posterior ray; **h,** posterior interradius; i, apical; j, apical; **k,** apical; **1,** basal. x 1 (a—e, k, 1), x 3 (f—i)

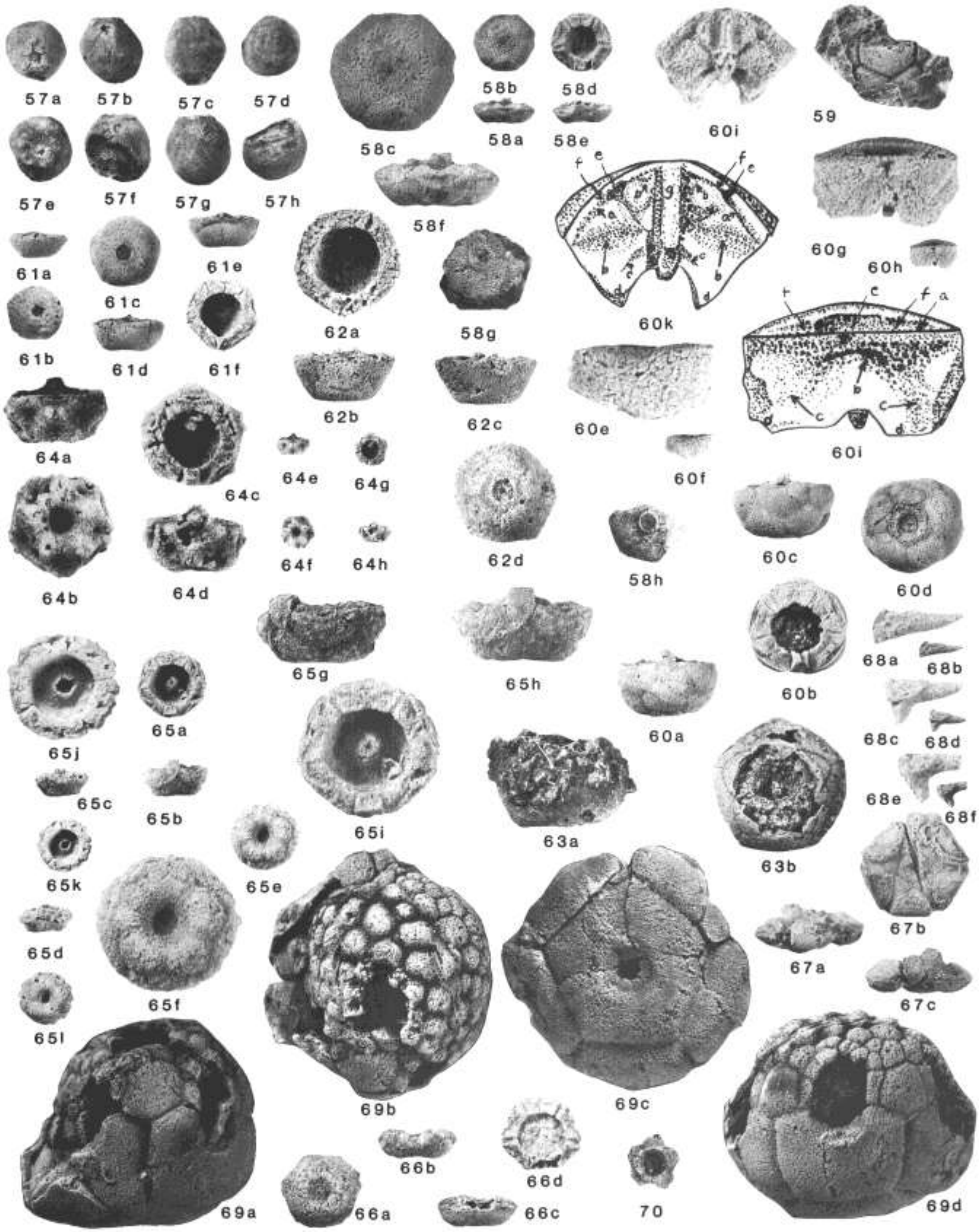
66a—d, *Stenopecrinus glaber* n.sp., holotype USNM 118450. Views: **a,** basal; **b,** anterior ray; **c,** posterior interradius; **d,** apical. All x 1

67a—c, *Sciadocrinus aff. harrisae* Moore and Plummer, 1940, USNM 118453. Views: **a,** anterior ray; **b,** basal; **c,** posterior interradius. All x 1

68a—f, *?Pirasocrinus* sp. indet., USNM 118468a (a, b), 118468b (c, d), and 118468c (e, f). Views: **a,** lateral view of axillary first primibrachial; **b,** same as a; **c,** side view of an axillary first primibrachial that is shorter than the one in *a;* **d,** *same* ossicle as in *c;* e, very short axillary first primibrachial with the spinose process on the distal upper surface of the brachial; f, same ossicle as in *e. x* 1 (b, d, f), x2 (a, c, e)

69a—d, *Platycrinites nactus* n.sp., holotype USNM 118470. Views: **a,** posterior interradius; **b,** apical; c, basal; **d,** anterior ray. All x 2

70, *?Synerocrinus* indet., UNSM 118467, basal circlet with a sunken cicatrix. x 1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Selected conversion factors*

TO CONVERT	MULTIPLY BY	TO OBTAIN
Length		
inches, in	2.540	centimeters, cm
feet, ft	3.048×10^{-1}	meters, m
yards, yds	9.144×10^{-1}	m
statute miles, mi	1.609	kilometers, km
fathoms	1.829	m
angstroms, Å	1.0×10^{-8}	cm
Å	1.0×10^{-4}	micrometers, μm
Area		
in^2	6.452	cm^2
ft^2	9.29×10^{-2}	m^2
yds^2	8.361×10^{-1}	m^2
mi^2	2.590	km^2
acres	4.047×10^3	m^2
acres	4.047×10^{-1}	hectares, ha
Volume (wet and dry)		
in^3	1.639×10^1	cm^3
ft^3	2.832×10^{-2}	m^3
yds^3	7.646×10^{-1}	m^3
fluid ounces	2.957×10^{-2}	liters, l *or* L
quarts	9.463×10^{-1}	l
U.S. gallons, gal	3.785	l
U.S. gal	3.785×10^{-3}	m^3
acre-ft	1.234×10^3	m^3
barrels (oil), bbl	1.589×10^{-1}	m^3
Weight, mass		
ounces avoirdupois, avdp	2.8349×10^1	grams, gr
troy ounces, oz	3.1103×10^1	gr
pounds, lb	4.536×10^{-1}	kilograms, kg
long tons	1.016	metric tons, mt
short tons	9.078×10^{-1}	mt
oz mt^{-1}	3.43×10^1	parts per million, ppm
Velocity		
ft sec^{-1} (= ft/sec)	3.048×10^{-1}	m sec^{-1} (= m/sec)
mi hr^{-1}	1.6093	km hr^{-1}
mi hr^{-1}	4.470×10^{-1}	m sec^{-1}

TO CONVERT	MULTIPLY BY	TO OBTAIN
Pressure, stress		
lb in^{-2} (= lb/in²), psi	7.03×10^{-2}	kg cm^{-2} (= kg/cm²)
lb in^{-2}	6.804×10^{-2}	atmospheres, atm
lb in^{-2}	6.895×10^3	newtons (N)/m², N m^{-2}
atm	1.0333	kg cm^{-2}
atm	7.6×10^2	mm of Hg (at 0° C)
inches of Hg (at 0° C)	3.453×10^{-2}	kg cm^{-2}
bars, b	1.020	kg cm^{-2}
b	1.0×10^6	dynes cm^{-2}
b	9.869×10^{-1}	atm
b	1.0×10^{-1}	megapascals, MPa
Density		
lb in^{-3} (= lb/in³)	2.768×10^1	gr cm^{-3} (= gr/cm³)
Viscosity		
poises	1.0	gr cm^{-1} sec^{-1} *or* dynes cm^{-2}
Discharge		
U.S. gal min^{-1}, gpm	6.308×10^{-2}	l sec^{-1}
gpm	6.308×10^{-5}	m^3 sec^{-1}
ft^3 sec^{-1}	2.832×10^{-2}	m^3 sec^{-1}
Hydraulic conductivity		
U.S. gal day^{-1} ft^{-2}	4.720×10^{-7}	m sec^{-1}
Permeability		
darcies	9.870×10^{-13}	m^2
Transmissivity		
U.S. gal day^{-1} ft^{-1}	1.438×10^{-7}	m^2 sec^{-1}
U.S. gal min^{-1} ft^{-1}	2.072×10^{-1}	l sec^{-1} m^{-1}
Magnetic field intensity		
gausses	1.0×10^5	gammas
Energy, heat		
British thermal units, BTU	2.52×10^{-1}	calories, cal
BTU	1.0758×10^2	kilogram-meters, kgm
BTU lb^{-1}	5.56×10^{-1}	cal kg^{-1}
Temperature		
°C + 273	1.0	°K (Kelvin)
°C + 17.78	1.8	°F (Fahrenheit)
°F − 32	5/9	°C (Celsius)

**Divide by* the factor number to reverse conversions.
Exponents: for example 4.047×10^3 (see acres) = 4,047; 9.29×10^{-2} (see ft²) = 0.0929.

Editor: Jiri Zidek
Drafters: Cherie N. Pelletier, Irean L. Rae

Type face: Palatino

Presswork: Miehle Single Color Offset
Harris Single Color Offset

Binding: Saddlestitched with softbound cover

Paper: Cover on 12 pt. Kivar
Text on 70-lb White Matte

Ink: Cover—PMS 320
Text—Black

Quantity: 700

Bowsher and Strimple CRINOIDS FROM SACRAMENTO MOUNTAINS New Mexico Bureau of Mines & Mineral Resources Circular 197