

Oligocene Echinoids of North Carolina

Porter M. Kier



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ABSTRACT

Kier, Porter M. Oligocene Echinoids from North Carolina. *Smithsonian Contributions to Paleobiology*, number 83, 37 pages, 6 figures, 11 plates, 2 tables, 1997.—Oligocene echinoids are rare, which makes important this material from three quarries in North Carolina. Three species occur in the state quarry at Pollocksville: *Psammechinus carolinensis*, new species, *Maretia carolinensis*, new species, and *Agassizia* sp. At the New Bern quarry occur *Rhyncholampas gouldii* (Bouvé) *newbernensis*, new subspecies, *Agassizia mossomi* Cooke, *Psammechinus carolinensis*, new species, *Dixieus dixie* (Cooke), *Clypeaster rogersi* (Morton), and *Maretia* sp. *Periarchus lyelli* (Conrad) is found in underlying Eocene beds. The Belgrade quarry fauna consists of *Arbia aldrichi* (Clark), *Gagaria mossomi* (Cooke), *Echinocyamus wilsoni*, new species, and *Agassizia mossomi* Cooke. These echinoids indicate a middle to late Oligocene age for the Trent Formation (= River Bend) and Belgrade Formation (= River Bend).

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Introduction

Oligocene echinoids are rare, having less than one-third the number of species as in the Eocene; therefore, these new Oligocene echinoids are particularly important. Climatic cooling is considered by McKinney et al. (1992) to be the cause for the reduction in species diversity. The species described herein are abundant in three quarries in North Carolina near Pollocksville, Belgrade, and New Bern. Although some of the species are new, others have been previously described from elsewhere and are useful in suggesting the age of the beds bearing the echinoids. Four of the echinoid species of the Trent Formation (= River Bend) at the New Bern quarry occur elsewhere in beds dated as middle to late Oligocene. Likewise, three species from the Belgrade quarry that occur in the Belgrade (= River Bend) Formation are found elsewhere in the late Oligocene. The echinoids at the state quarry near Pollocksville are new species and are of little use in age determination.

Generally, the echinoids differ at the three quarries, suggesting age or environmental difference between the sites. Three of the four echinoids at the Belgrade quarry are not found at New Bern or Pollocksville. Only *Agassizia mossomi* Cooke occurs at both Belgrade and New Bern. Only two of the six Trent species at New Bern are found at either of the two other sites. *Psammechinus carolinensis*, new species, occurs at New Bern and Pollocksville, and *Agassizia mossomi* occurs at New Bern and Belgrade. None of the three species at Pollocksville occur at Belgrade, and only one of the Pollocksville species, *P. carolinensis*, occurs at New Bern.

ACKNOWLEDGMENTS.—I thank Druid Wilson who found most of the echinoids, took me to the outcrops, and encouraged me to describe these echinoids. Victor Zullo, William Harris,

and Jerry Baum visited the quarries with me and discussed the stratigraphy. They critically read the manuscript. Lauck Ward also read the manuscript and collected some of the specimens. Pete Harmatuk spent many hours in these quarries and collected many echinoids. The photography and measurement of specimens was by Arnold Powell, and the artwork was rendered by Mary Parrish.

The publication of this paper has been delayed for ten years, and I particularly thank Stephen Donovan and Rich Mooi for making many suggestions to bring it up-to-date, and for their other recommendations. Diane M. Tyler edited the manuscript for the Smithsonian Institution Press.

Occurrences

POLLOCKSVILLE QUARRY

This state quarry, utilized by the North Carolina Department of Transportation, is located 4 km NNE of Pollocksville on the left bank of the Trent River in Jones County, North Carolina. It is within the type section of the Trent Formation as proposed by Baum et al. (1978:12), and it is part of the River Bend Formation of Ward et al. (1978:10). As described by Baum et al. (1979:100), the section exposes 3.2 m of the Trent Formation, with the echinoids occurring in a sandy biosparite.

Zullo and Baum (1979:235) consider the Trent to be early to middle Oligocene. Ward et al. (1978:12) consider these beds (part of their River Bend Formation) to be middle Oligocene (late Vicksburgian) on the basis of the abundance of *Pecten perplanus byramensis* Gardner. Ward (pers. comm., 1984) now thinks that these beds are late Oligocene (Chickasawhayen).

Three species occur in these beds: *Psammechinus carolinensis*, new species, *Maretia carolinensis*, new species, and *Agassizia* sp. The first two species are represented by a large number of specimens, but only two have been found of *Agassizia* sp. None of the species is useful in dating the beds. *Maretia carolinensis* and *Psammechinus carolinensis* are very distinct from any other species of their genus in this

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hemisphere. *Agassizia* sp. is too poorly represented to be able to ascertain the degree of its affinity with the species it most closely resembles, *Agassizia wilmingtonica* Cooke from the middle Eocene Castle Hayne Formation of North Carolina. The fact that both *Agassizia* and *Maretia* are found at the New Bern quarry in beds referred to the Trent Formation (= River Bend of Ward et al., 1978:10) suggests that the environmental conditions at the Pollocksville and New Bern quarries were similar. That both species are very different from their congeners at New Bern suggests that the beds were not deposited at the same time. Only *Psammechinus carolinensis* occurs at both sites. Ward (pers. comm., 1984) now believes, on the basis of the mollusk fauna, that the beds where the echinoids occur at the Pollocksville quarry are Chickasawhayan, whereas the Trent or River Bend at New Bern is Vicksburgian.

NEW BERN QUARRY

This Martin Marietta Company quarry is northwest of New Bern, Craven County, North Carolina, 0.8 km NE of route 55 on county road 1402. Four or five stratigraphic units (Table 1) are recognized in the quarry. The lower beds (in ascending order) are Castle Hayne Limestone, New Bern Formation (Baum et al. (1978:9)) = Spring Garden Member of Castle Hayne Limestone (Ward et al. (1978:9)), and Trent Formation (Baum et al. (1978:12)) = River Bend Formation (Ward et al. (1978:10)). At the top, occur beds assigned to the Yorktown/Duplin by Baum et al. (1979:103) and to Duplin/Croatan Formations by Ward et al. (1978:18).

Zullo and Harris (pers. comm., 1984) have found, below an unconformity at the base of the River Bend Formation, a bryozoan biomicrudite that they consider to be the Castle Hayne Limestone equivalent to the Ward et al. (1978:8) Comfort Member. *Periarchus lyelli* (Conrad) occurs in large numbers in these beds. It also is present in small numbers in the

New Bern Formation = Castle Hay Formation (Spring Garden Member). This is the only echinoid found in either formation and confirms the Eocene age of these beds.

Echinoids are very common in the overlying Trent or River Bend Formation. Two species occur in great numbers, *Rhyncholampas gouldii* (Bouvé) *newbernensis*, new subspecies, and *Agassizia mossomi* Cooke. A few specimens are present of *Dixieus dixie* Cooke, *Clypeaster rogersi* (Morton), and *Maretia* sp. One specimen was found of *Psammechinus carolinensis*, new species. This species occurs in great numbers in the state quarry at Pollocksville. The fauna appears to be middle to late Oligocene. *Rhyncholampas gouldii* is known elsewhere from the Marianna Limestone (middle Vicksburgian), Bryam Limestone (late Vicksburgian), Suwannee Limestone (Vicksburgian–Chickasawhayan), and Flint River Formation (Chickasawhayan). *Agassizia mossomi* is known from the Suwannee and *Clypeaster rogersi* from the Marianna and Flint River. The age of *Dixieus dixie* is uncertain. It has been found before at a locality where both the late Eocene Ocala and the Suwannee Limestone occur.

No echinoids are present in the beds overlying the Trent Formation.

BELGRADE QUARRY

The Martin Marietta Belgrade quarry (see Baum et al. (1979:98) and Ward et al. (1978:19) for descriptions of section) is east of the intersection of route 1434 and U.S. 17, Belgrade, Onslow County, North Carolina. According to Baum et al. (1979:98), 11 meters of section is exposed. The lower eight meters is their type section for the Belgrade Formation (Baum et al. (1978:13)). Ward et al. (1978:20) refer this part of the section (Table 2) to their River Bend Formation. Baum et al. (1979:99) assign a lower Miocene age to these beds, but Ward et al. (1978:12) consider them late Oligocene, Chickasawhayan. Three echinoid species occur 1–45 cm below the

TABLE 1.—Stratigraphic occurrences of echinoids at the New Bern quarry.

Baum et al. (1978)		Ward et al. (1978)		Echinoid species
Early-Middle Oligocene	Trent Formation	Middle-Late Oligocene	River Bend Formation	<i>Psammechinus carolinensis</i> , new species <i>Dixieus dixie</i> Cooke <i>Rhyncholampas gouldii newbernensis</i> , new species <i>Clypeaster rogersi</i> (Morton) <i>Agassizia mossomi</i> Cooke <i>Maretia</i> sp.
	New Bern Formation	Middle Eocene	Castle Hayne Formation (Spring Garden Member)	<i>Periarchus lyelli</i> (Conrad)
Eocene	Castle Hayne Formation			<i>Periarchus lyelli</i> (Conrad)

TABLE 2.—Stratigraphic occurrences of echinoids at the New Bern quarry.

Baum et al. (1978)		Ward et al. (1978)		Echinoid species
Early Miocene	Belgrade Formation	Late Oligocene	River Bend Formation	<i>Arbia aldrichi</i> (Clark) <i>Gagaria mossomi</i> (Cooke) <i>Agassizia mossomi</i> Cooke <i>Echinocyamus wilsoni</i> , new species

top of this formation: *Arbia aldrichi* (Clarke), *Gagaria mossomi* (Cooke), and *Agassizia mossomi* Cooke. All three of these species occur elsewhere in the late Oligocene. *Arbia aldrichi* occurs in the Chickasawhayan and Paynes Hammock formations (Chickasawhayan). *Gagaria mossomi* and *Agassizia mossomi* occur in the Suwannee Limestone (Vicksburgian–Chickasawhayan). The specimens of *A. mossomi* at Belgrade are slightly different from those at the New Bern quarry, which occur in beds considered to be late Oligocene.

Specimens of *Echinocyamus wilsoni*, new species, were collected from this quarry from beds that Druid Wilson (pers. comm., 1985) believes occur lower in the Belgrade Formation.

Ecology

These echinoids are similar enough to living species that it is possible to infer their living habits. *Periarchus lyelli* (Conrad) is found at the New Bern quarry in both the Castle Hayne Limestone (Comfort Member) and New Bern (Castle Hayne, Spring Garden Member) formations. These formations are a biomicrudite (Zullo, pers. comm., 1985) and a sandy biosparidite (Baum et al., 1979:102), respectively. The sediment that formed these rocks would have provided the sandy environment for this sand dollar.

The Trent Formation (River Bend Formation) is a sandy biosparite (Baum et al., 1979:102). Four of the five species found in this formation would have lived buried in sediment. The spatangoid *Maretia* sp. probably lived within a burrow with a tube leading posterior for a drainoff as indicated by the presence of a subanal fasciole. The lack of a deep anterior groove and the lack of crowding of the porepairs in the anterior ambulacrum indicate a limited funnel-building ability. *Agassizia mossomi* Cooke most likely also lived buried in the sediment. Modern species of this genus apparently live in sandy environments (Kier, 1984:60). They lack the well-developed funnel-building tubefeet needed for maintenance of a tunnel through mud to the surface. Modern species have been collected only on sandy bottoms. *Clypeaster rogersi* (Morton) presumably lived like the modern *Clypeaster subdepressus* (Gray), which it resembles. This species lives (Kier and Grant, 1965:30) in sand buried as deeply as 25 mm below the surface, or it moves along the top of the sand with sand and shell fragments held by its tubefeet over the top of its test. The

cassiduloid *Rhyncholampas gouldii newbernensis*, new subspecies, no doubt lived like the modern cassiduloid *Cassidulus cariboeorum* Lamarck. This species lives buried (Gladfelter, 1978; Kier, 1975; Mooi, 1990) in the sand, but because it cannot build a funnel, the sediment has to be well aerated. *Dixieus dixie* Cooke was a regular echinoid and lacked the ability to bury. It probably fed on grasses growing on the sediment.

The environment during the deposition of the sandy biosparite of the Trent Formation (River Bend Formation) at the state quarry at Pollocksville probably was similar to that of the New Bern quarry. Species of *Maretia* and *Agassizia* likewise occur here. These genera also occur in a biomicrudite in the Belgrade Formation (River Bend Formation) at the Belgrade quarry. The most common species is again *Agassizia mossomi*, suggesting well-aerated sediments. The two regulars, *Arbia aldrichi* (Clarke) and *Gagaria mossomi* (Cooke), probably lived on top of the sediment and fed on grasses. Finally, *Echinocyamus wilsoni* presumably lived buried in the sediment. Modern species of *Echinocyamus* live buried in a coarse- or fine-grained bottom (Mortensen, 1948:162).

In summary, the fauna at the three quarries is dominated by species that would have lived buried or partially buried in well-aerated sediments. The water was probably warm. Modern clypeasterids are confined to tropical and subtropical coasts. *Agassizia* has two extant species, both of which are found only in tropical waters.

Family PHYMOSOMATIDAE Pomel

Genus *Dixieus* Cooke

Dixieus dixie (Cooke)

PLATE 1: FIGURES 1–4

Phymosoma dixie Cooke, 1941:17, pl. 2: fig. 15.

Dixieus dixie (Cooke).—Cooke, 1948:607; 1959:24, pl. 5: figs. 8–10.—Mortensen, 1951:558, fig. 281.

DESCRIPTION.—Only one specimen (USNM 398317 from New Bern quarry) was collected during this study. Its dorsal side is weathered with the tuberculation partially destroyed, but the ventral side is well preserved. Its tuberculation, number of plates, nature of its ambulacra, size of its peristome, depth of its

peristomial slits, and shape of its test are very similar to the holotype.

COMPARISON WITH OTHER SPECIES.—This specimen differs from the specimens referred to *Dixieus* cf. *D. dixie* (Cooke) by Kier (1980:21) from the middle Eocene Castle Hayne Limestone. It differs in having more plates relative to its size than in the Castle Hayne specimen. The New Bern specimen, which is 32 mm in diameter, has 196 porepairs in an ambulacrum or 6.1 porepairs per mm of length. The ratio in the holotype from Florida is also 6.1, whereas the two Castle Hayne specimens have ratios of 4.3 and 4.5.

MATERIAL.—USNM 398317, in float from Trent Formation, New Bern quarry, North Carolina, Judy Raypor collector. USGS 12747 (holotype) and USGS 1515c (paratype), from a quarry east of the Steinhatchee River north of U.S. Highway 19 near Clara, Dixie County, Florida.

The holotype and paratype were considered by Cooke (1959:24) to be from the late Eocene Ocala Limestone; however, according to Druid Wilson (pers. comm., 1985) the fauna at this locality is a mixture of fossils from the Ocala Limestone and Oligocene Suwannee Limestone. USGS 15150 is cataloged as "Suwannee ls. and Ocala ls."

OCCURRENCE.—Florida: Suwannee Limestone and Ocala Limestone, Dixie County.

North Carolina: Trent Formation, New Bern quarry.

Family ARBACIIDAE Gray

Genus *Arbia* Cooke

Arbia aldrichi (Clark)

FIGURE 1; PLATE 1: FIGURES 5, 6

Coelopleurus aldrichi Clark, 1915:158, pl. 73: figs. 6a,b, 7a-c.

Arbacia aldrichi (Clark).—Cooke, 1941:11.

Arbia aldrichi (Clark).—Cooke, 1948:606; 1959:21, pl. 3: figs. 15-17.—Mortensen, 1951:558, fig. 280a-c.

DESCRIPTION.—Three specimens and three fragments are available from this study. Parts of the specimens are sufficiently well preserved to permit certainty as to the identification of the specimens. They are similar in all respects to the holotype and paratype of this species. Cooke (1959:22) considered both of Clark's figured specimens to be cotypes, but Clark in his figure explanation (1915, pl. 73) states that the specimen in his figures 6a and 6b is the type. Mortensen (1951:558) regretted that no detail drawings were available showing the ambulacral structure. I include, herein, drawings of ambulacral plates in the figured paratype (Figure 1B) and in one of the specimens from Belgrade quarry (Figure 1A).

It has not been noted previously that some of the primary tubercles are crenulate. These crenulations are present on well-preserved tubercles on the holotype, on some of the Belgrade quarry specimens, and on a specimen from the Paynes Hammock Sand of Mississippi.

MATERIAL.—USNM 398318, 1 specimen, 45 cm below top

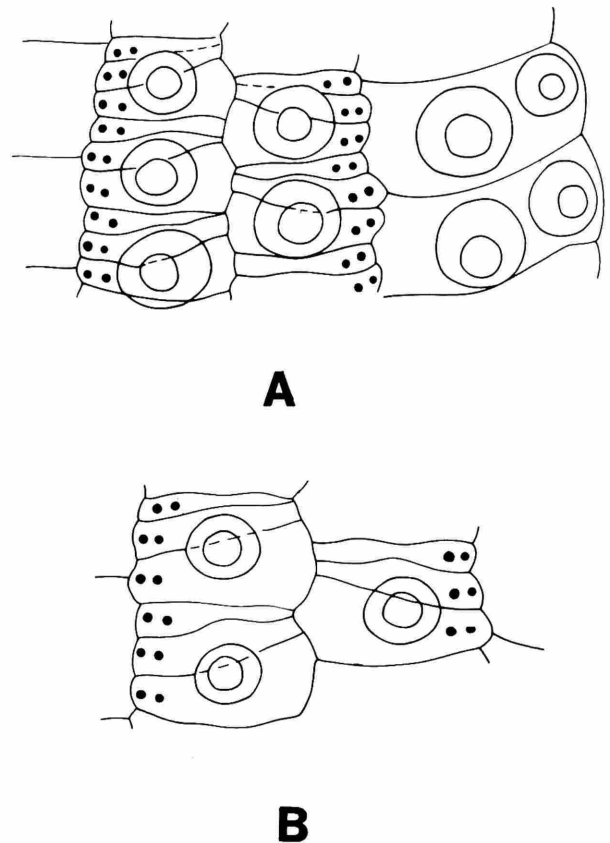


FIGURE 1.—*Arbia aldrichi* (Clark): A, ambulacrum and part of interambulacrum at ambitus of USNM 398318, from Belgrade Formation (of Baum et al., 1978) at Belgrade quarry ($\times 6$); B, ambulacral plates near ambitus of paratype USNM 559594B, from St. Stephens Limestone, Perdue Hill, Alabama ($\times 8$).

of indurated limestone, Belgrade Formation, Belgrade quarry, North Carolina, Druid Wilson collector. USNM 398319, 1 specimen, near contact with indurated limestone, Belgrade Formation, Belgrade quarry, Druid Wilson collector. USNM 559594B, 1 cotype, St. Stephens Limestone, Perdue Hill, Alabama.

OCCURRENCE.—North Carolina: Three specimens and fragments were collected by Druid Wilson from the south face of Belgrade quarry toward the northeast corner in a dark bed approximately 5-25 cm below contact with indurated limestone. According to Wilson (pers. comm., 1984), this horizon is high in zone C of Baum et al. (1979, fig. 1).

Alabama: The type specimens (cotypes, USNM 559494) come from the late Oligocene St. Stephens Limestone at Perdue Hill, Monroe County, Alabama.

Mississippi: One specimen is from the late Oligocene Paynes Hammock Sand at Patton Creek in Mississippi. According to Cooke (1959:22), Mac Neil originally referred the bed at Patton Creek to the upper Chickasawhay Formation, but later he called it the Paynes Hammock Sand Formation.

Family Uncertain

Genus *Gagara* Duncan*Gagara mossomi* (Cooke)

PLATE 2: FIGURES 1-5

Thylechinus (*Gagara*) *mossomi* Cooke, 1941:13, pl. 2: fig. 16; pl. 3: figs. 6-9; pl. 4: figs. 3-5.

Gagara mossomi (Cooke).—Cooke, 1959:17, pl. 3: figs. 10-14.

DESCRIPTION.—Six new specimens were found of this species. One of these specimens is beautifully preserved, with the surface of the test not weathered and with the details of the ornamentation clearly visible. This specimen is similar in all respects to the type specimens of the species in that it has: (1) a similar number of plates; (2) similar crenulate, imperforate tubercles that are arranged in the same way; (3) ambulacral plates of similar number and arrangement; and (4) a test of similar shape. Because this specimen is far better preserved than any other specimens yet collected of this species, many photographs are included.

OCCURRENCE.—North Carolina: Six specimens were collected by Druid Wilson from the south face of Belgrade quarry toward the northeast corner in a dark bed approximately 5–25 cm below contact with indurated limestone. According to Wilson (pers. comm., 1984), this horizon is high in zone C of Baum et al. (1979, fig. 1).

Florida: The species previously was known only from the (Vicksburgian–Chickasawhayan) Oligocene Suwannee Limestone of Florida.

Family ECHINIDAE Gray

Genus *Psammechinus* Agassiz and Desor*Psammechinus carolinensis*, new species

FIGURE 2; PLATE 3: FIGURES 1-4; PLATE 4: FIGURES 1-5

DIAGNOSIS.—The species is characterized by large primary tubercles, slightly arcuate porepairs, and high ambulacral plates.

DESCRIPTION.—Twenty-nine specimens were measured for the following characteristics.

Shape and Size: Diameter (D) varying from 5.4 to 18.1 mm (mean 10.9); height varying from 46.5 to 58.7 percent of D (mean 52.5). Marginal outline of test circular; test very slightly depressed around peristome.

Apical System: No plates preserved; diameter of opening 19.4–27.2 percent of D (mean 23.5).

Ambulacra: Narrow, width 20.0–30.1 percent of D (mean 25.7). Plates trigeminate (Figure 2), arranged in echinoid pattern with each compound plate with three elements, demiplate between two primary plates, adoral one being largest; 10 compound plates in single poriferous zone of specimen 6.9 mm in diameter, 14 in specimen 11.0 mm in

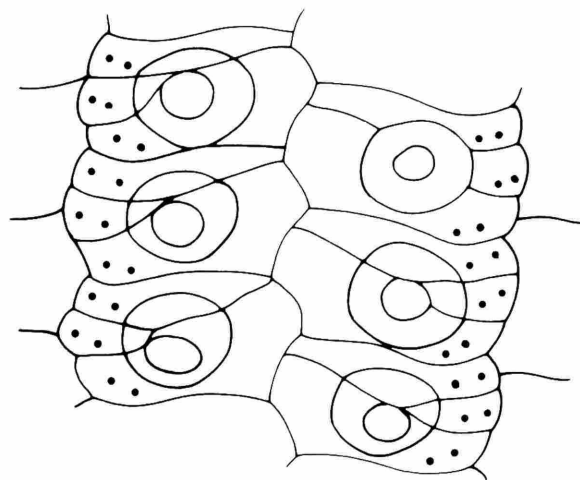


FIGURE 2.—*Psammechinus carolinensis*, new species: ambulacral plates near ambitus of the holotype, USNM 398321, from float of the Trent Formation, Pollocksville state quarry ($\times 20$).

diameter, and 18 in specimen 18 mm in diameter. Porepairs arranged in arcs of three (Plate 3: Figure 4) with 36 porepairs in poriferous zone of specimen 8.3 mm in diameter, 45 in specimen 12.8 mm in diameter, and 55 in specimen 16.2 mm in diameter. No phyllodes or crowding of porepairs at margin of peristome.

Interambulacra: Plates low, at ambitus same height or slightly higher than adjacent compound ambulacral plate; 9 plates in single column of specimens 5.4 mm in diameter, 12 in specimen 11.1 mm in diameter, 15 in specimen 18.1 mm in diameter.

Peristome: Circular, large, diameter 35.7–50.7 percent of D (mean 42.0). Peristomial (“gill”) slits slightly developed (Plate 3: Figure 2).

Lantern Supports: Auricles joining to form arch (Plate 4: Figure 5).

Tuberculation: Ambulacra with two vertical rows of primary, imperforate, noncrenulate tubercles in each area (Plate 4: Figure 3). Two inner rows of much smaller secondary tubercles (more distinct on larger specimens). On compound plate, primary tubercle occupies full height of plate, secondary tubercle forming part of inner row of tubercles occurring near medial suture; three or four smaller tubercles irregularly situated on plate.

Interambulacra with two vertical rows of primary, imperforate, noncrenulate tubercles in each area (Plate 4: Figure 4). Tubercle in middle of each plate occupying almost entire height of plate. Two inner rows of much smaller secondary tubercles; irregularly arranged secondary tubercle of varying size between primary tubercle and ambulacra.

REMARKS.—This species is referred to the order Echinoida because of its nonsculptured test, shallow peristomial slits,

imperforate, noncrenulate tubercles, and ambulacral plates compounded in the echinoid manner. Of all the genera in this order it is most similar to *Psammechinus*. Unfortunately, two of the main characters of the genus, the strongly plated buccal membrane and the structure of the globiferous pedicellariae are not known on this species, so it is not possible to be certain that this species belongs to *Psammechinus*.

COMPARISON WITH OTHER SPECIES.—This species is easily distinguished from the Yorktown Formation (Pliocene) species of *Psammechinus*, *P. philanthropus* (Conrad), by its larger primary tubercles (relative to the secondary), its less arcuate porepairs with the adoral-most porepairs in each compound plate less shifted medially, and its higher ambulacral plates.

MATERIAL.—Hundreds of specimens occur concentrated and jumbled in a sandy biomicrudite in the Pollockville state quarry. The tests occur haphazardly. This fact together with the absence of any jaws, teeth, or apical-system plates suggests that the specimens were transported after death. Most of the specimens are covered with angular quartz sand grains, which are partially embedded into their tests.

Holotype: USNM 398321, from float of the Trent Formation, Pollockville state quarry, North Carolina.

Figured Paratypes: USNM 398322, 398323, 398474, same data as holotype.

OCCURRENCE.—North Carolina: Hundreds of specimens occur in the Pollockville state quarry. One specimen also was collected presumably from the Trent Formation, New Bern quarry.

Family CASSIDULIDAE Agassiz and Desor

Genus *Rhyncholampas* Agassiz

Rhyncholampas gouldii gouldii Bouvé

Rhyncholampas gouldii Bouvé, 1846:192. [For a complete synonymy and list of localities see Cooke (1959:37).]

Rhyncholampas gouldii newbernensis, new subspecies

FIGURE 3; PLATE 5: FIGURES 1-7

DIAGNOSIS.—The subspecies is characterized by long petals, a large peristome, a low test, and the periproct with a high opening.

DESCRIPTION.—The descriptions of the following characteristics are based on 34 specimens that are generally well preserved and not distorted in shape.

Shape and Size: Length 19.2–44.7 mm (mean 33.0); width 83.4–97.5 percent of L (mean 92.1); height 41.1–50.9 percent of L (mean 46.0). Test inflated with greatest height slightly posterior to apical system; oral surface flat, greatest width posterior to center.

Apical System: Anterior, distance from anterior margin 48.3–56.6 percent of L (mean 52.4); monobasal, 4 genital pores, absent on specimens less than 20 mm long.

Ambulacra: Anterior petal short, extending three-fifths distance from apical system to anterior margin; length 29.6–39.5 percent of L (mean 35.0). Anterior petal narrower than other petals, greatest width 10.3–13.2 percent of L (mean 11.8). Anterior petal closing distally, with 76 porepairs in specimen 44.7 mm long, 44 in specimen 19.2 mm long. Anterior paired petals (II, IV) extending almost two-thirds distance from apical system to margin; length 32.7–43.2 percent of L (mean 36.3); greatest width 11.2–13.9 percent of L (mean 12.7). Anterior paired petals with 72 porepairs in specimen 44.7 mm long, 48 porepairs in specimen 19.2 mm long.

Posterior petals (V, I) extending three-fifths distance from apical system to posterior margin; length 34.8–49.0 percent of L (mean 40.8); greatest width 9.9–14.3 percent of L (mean 12.5). Posterior petals with 84 porepairs in specimen 44.7 mm long, 46 porepairs in specimen 19.2 mm long. Posterior petals closing distally. Poriferous zones equal in length in anterior petal, but in anterior paired petals posterior poriferous zones longer, with 1.3 more porepairs; in posterior petals, anterior poriferous zone longer by 1–3 porepairs.

Phyllodes single pored, well developed (Plate 5: Figure 6); a specimen 44 mm long with 22 pores in phyllode in ambulacrum III, 26 in II, 22 in I; inner series of pores with approximately 5 pores in each phyllode.

Interambulacra: Small, irregularly arranged pits in mid-zone of interambulacrum 5; a few in interambulacra 2 and 3.

Peristome: Anterior of center, distance from anterior margin 22.9–38.2 percent of L (mean 34.1); width 10.0–17.3 percent of L (mean 13.4); height 7.5–13.0 percent of L (mean 9.6). Bourrelets strongly developed.

Periproct: Supramarginal, transverse with slight trough extending posteriorly.

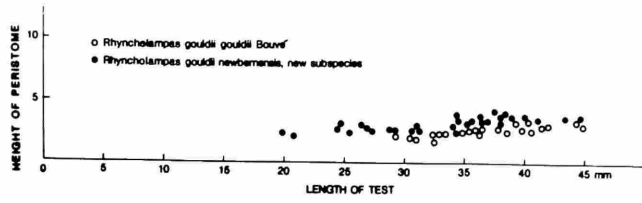
REMARKS.—Specimens of this subspecies are distinguished from species of *Rhyncholampas gouldii gouldii* by the following features: (1) longer petals (Figure 3E–G); (2) peristome slightly higher and wider (Figure 3A,B); (3) lower test (Figure 3D); and (4) higher periproct (Figure 3C). The presence of overlap in most of these characters between the two taxa prevents their consideration as separate species. In all other characters the two taxa are indistinguishable.

MATERIAL.—*Holotype*: USNM 398324, from float of the Trent Formation, New Bern quarry, North Carolina.

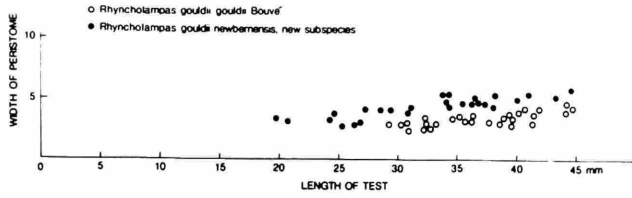
Figured Paratype: USNM 398325, same data as holotype.

Nonfigured Paratypes: USNM 492065–492096, same data as holotype.

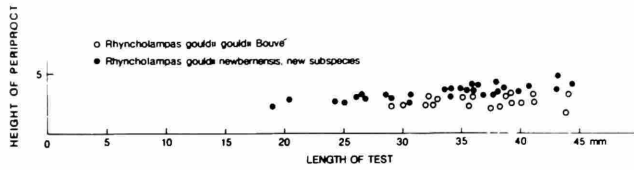
OCCURRENCE.—North Carolina: Trent Formation, New Bern quarry.



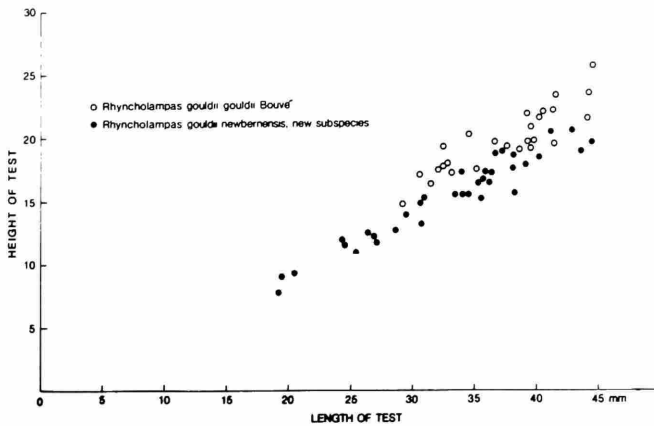
A



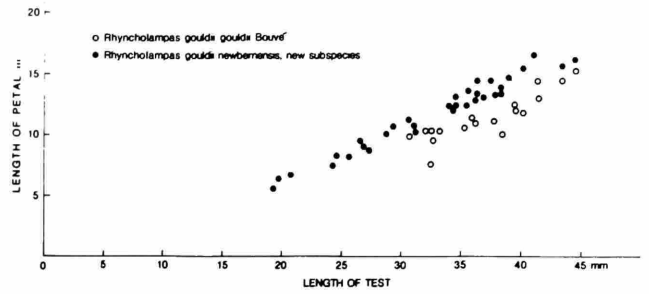
B



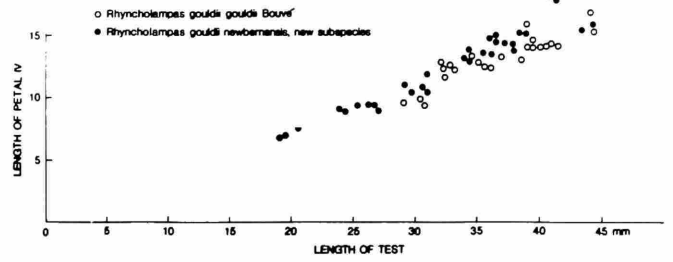
C



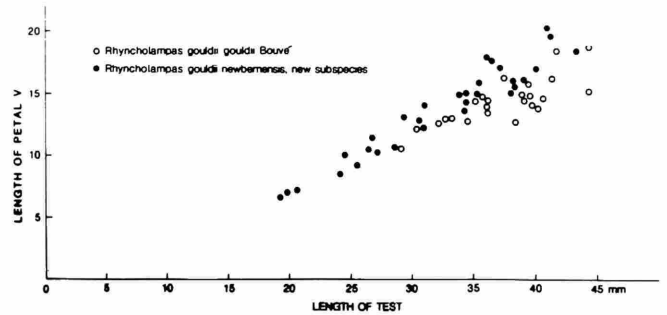
D



E



F



G

FIGURE 3.—Scattergrams showing difference between specimens of *Rhyncholampas gouldii gouldii* Bouvé and *Rhyncholampas gouldii newbernensis*, new subspecies: A, height of peristome; B, width of peristome; C, height of periproct; D, height of test; E, length of petal III; F, length of petal IV; G, length of petal V.

Family FIBULARIIDAE Gray

Genus *Echinocyamus* van Phelsum

***Echinocyamus wilsoni*, new species**

FIGURE 4A-E

DIAGNOSIS.—The species is characterized by a wide test, an average width of 82 percent of the length, the anterior petal slightly shorter than other petals, and the periproct situated at two-thirds the distance from the peristome to the posterior margin of the test.

DESCRIPTION.—The description is based on eight specimens from the Belgrade quarry. These specimens were encrusted with a secondary coat of calcite, which has obscured the surface ornamentation.

Shape and Size: Length (L) 2.0–3.5 mm long (mean 2.8); width 79.6–84.7 percent of L (mean 82.2); height 46.2–52.5 percent of L (mean 49.0). Greatest height at apical system.

Apical System: Located anterior of center at distance from anterior margin equal to 42.6–45.7 percent of L (mean 43.4); four genital pores.

Ambulacra: Petal III slightly shorter than other petals but with approximately same number of porepairs; 8 porepairs in petal in specimen 2.45 mm long, 8–10 in specimen 2.95 mm long, and 12 in specimen 3.4 mm long; see Figure 4A–C for shape of petals. Distribution of accessory pores not discernible because of poor preservation of specimens.

Peristome: Central, opening circular, diameter 16.0–20.4 percent of L (mean 18.5).

Periproct: Inframarginal, located nearer to posterior margin than to peristome, approximately two-thirds distance from peristome to posterior margin; distance from posterior margin to posterior edge of peristome equal to 10.0–13.0 percent of L (mean 11.1).

COMPARISON WITH OTHER SPECIES.—No other species of *Echinocyamus* is known from the Oligocene of North America. Only one species is known from the Miocene, *Echinocyamus chipolanus* Cooke, from the lower Miocene Chipola Formation in Florida. Unfortunately, only one specimen is known of this species, and it was broken after being figured (Cooke, 1959:32). Cooke's figures (1959, pl. 9: figs. 1–3) show little about the nature of the petals, but its peristome appears to be much larger than that of *E. wilsoni*.

The much wider test of *Echinocyamus wilsoni* easily distinguishes the new species from *E. parvus* Emmons and *E. bisexus* Kier from the middle Eocene Castle Hayne Limestone of North Carolina and Lake City Formation of Georgia, respectively. It differs from *E. caribbeanensis* Kier from the middle Eocene of Barbados in having a shorter anterior petal (III) and a more anteriorly situated periproct. *Echinocyamus meridionalis* Meyer from the middle Eocene of Alabama has a much flatter, lower test and a more posterior periproct. *Echinocyamus huxleyanus* Meyer, also from the middle Eocene

of Alabama, and *E. macneili* Cooke, from the late Eocene of Alabama, have narrower tests.

MATERIAL.—*Holotype:* USNM 398476, from low in the Belgrade Formation, Belgrade quarry, North Carolina.

Figured Paratypes: USNM 398477–398479, same data as holotype.

Nonfigured Paratypes: USNM 492097–492100, same data as holotype.

OCCURRENCE.—North Carolina: The species is known only from Belgrade quarry (lower bed).

Family PROTOSCUTELLIDAE Durham

Genus *Periarchus* Conrad

***Periarchus lyelli* (Conrad)**

PLATE 6: FIGURES 1, 2

Scutella lyelli Conrad, 1834:152.

Periarchus lyelli (Conrad).—Kier, 1968:40, pl. 5: figs. 4, 5; 1980:40, figs. 17, 18; pl. 13, pl. 14: figs. 1–7.—Toulmin, 1969:474, pl. 4: figs. 5–7; 1977:344, pl. 68: figs. 4–6.—Banks, 1978:109, 146, 149. [For a pre-1968 synonymy, see Cooke, 1959:41, 42.]

DESCRIPTION.—The dorsal surface of the two most complete specimens (USNM 398326, 398327) show that they definitely belong to this species.

MATERIAL.—USNM 398326 and 398327 are from float in the New Bern quarry, Pete Harmatuk, collector. Jerry Baum and Victor Zullo (pers. comm., 1984) state that the matrix on USNM 398326 is middle Eocene, Castle Hayne Limestone (which occurs at the bottom of the New Bern quarry), whereas the matrix on USNM 398327 is late Eocene, New Bern Limestone of Baum et al. (1978) or Spring Garden Member of the Castle Hayne Limestone. In addition, there are 24 fragments of specimens.

OCCURRENCE.—North Carolina: Middle Eocene, Castle Hayne Limestone, New Bern quarry, and late Eocene, New Bern Formation, New Bern quarry.

The species is known elsewhere from the middle and late Eocene of Florida, Alabama, Georgia, South Carolina, Mississippi, and Louisiana.

Family CLYPEASTERIDAE Agassiz

Genus *Clypeaster* Lamarck

***Clypeaster rogersi* (Morton)**

PLATE 6: FIGURES 3, 4

Scutella rogersi Morton, 1834:77, pl. 13: fig. 3. [For a complete synonymy see Cooke, 1959:36.]

DESCRIPTION.—Although only three fragments are present, one of them (USNM 398475) shows enough of the shape of the test and part of the petals to make identification fairly certain (Plate 6: Figure 4). This specimen is figured for comparison

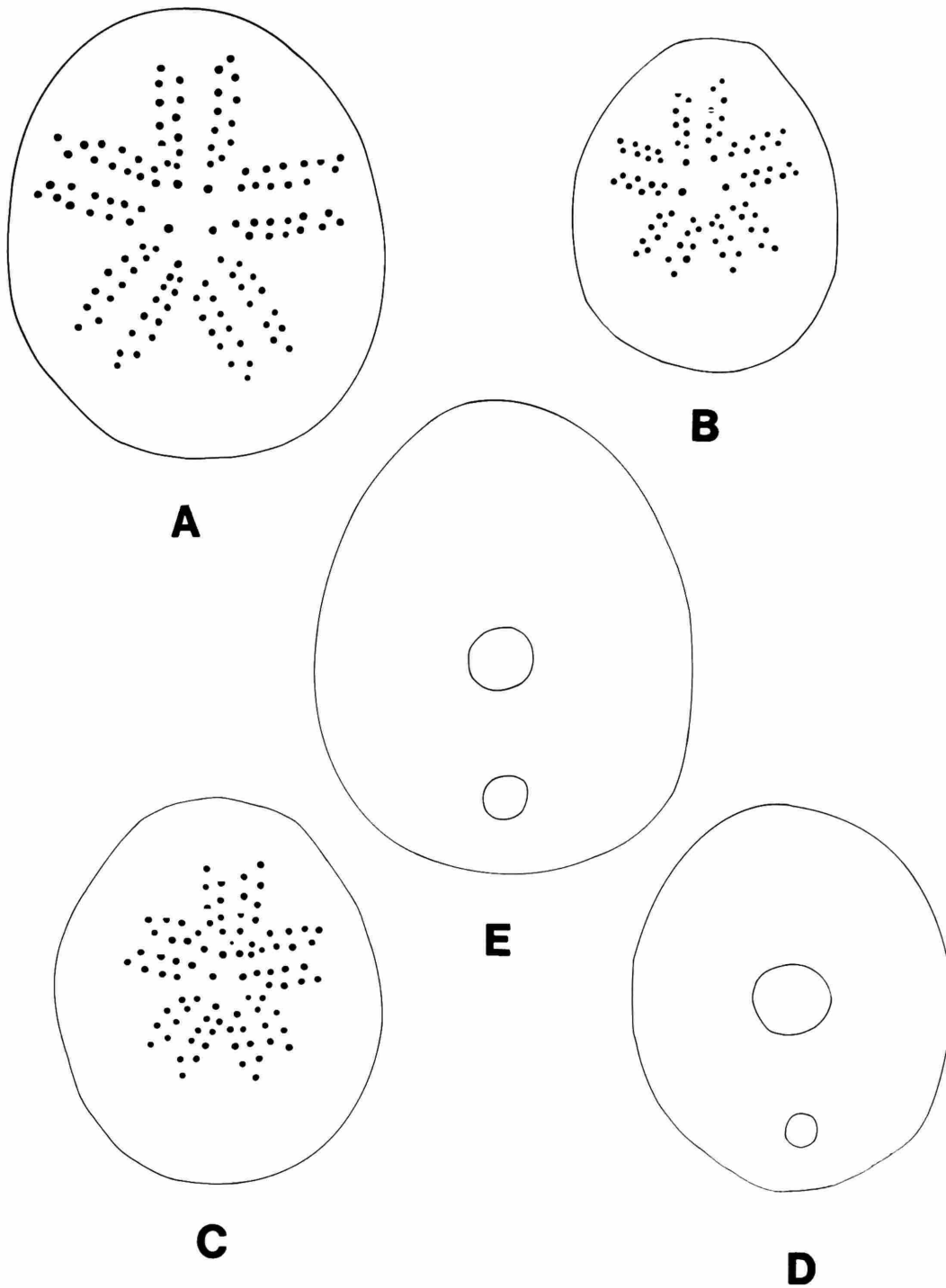


FIGURE 4.—*Echinocyamus wilsoni*, new species: A, dorsal view of holotype USNM 398476 ($\times 20$); B, dorsal view of paratype USNM 398477 ($\times 20$); C,D, dorsal and ventral views, respectively, of paratype USNM 398478 ($\times 20$); E, ventral view of paratype USNM 398479 ($\times 20$). All specimens from low in the Belgrade Formation (Baum et al., 1978) at the Belgrade quarry.

with a specimen of *C. rogersi* (Plate 6: Figure 3) from the Marianna Limestone.

MATERIAL.—USNM 398475, from float of Trent Formation, New Bern quarry. USNM 372897, Oligocene, Marianna Limestone, at Whitsett's quarry, ~3 mi south of Collumburg, Alabama.

OCCURRENCE.—North Carolina: Trent Formation, New Bern quarry. Known elsewhere from the Oligocene Flint River Formation, Marianna Limestone and Suwannee Limestone of Mississippi, Alabama, and Florida.

Family SCHIZASTERIDAE Lambert

Genus *Agassizia* Agassiz and Desor

Agassizia mossomi Cooke

FIGURE 5; PLATE 7: FIGURES 1–8; PLATE 8: FIGURES 1–8

Agassizia (Anisaster) mossomi Cooke, 1942:46, pl. 5: figs. 14–17; 1959:76, pl. 32: figs. 5–9.

DESCRIPTION.—Sixteen specimens from the New Bern quarry and 20 specimens from the Belgrade quarry can be referred to this species. Because the original description by Cooke was based on only two poorly preserved specimens, the New Bern specimens are described herein. They are generally well preserved and not distorted, but the exterior of the tests are weathered, which has enlarged the petaloid pores and obscured the fascioles.

Shape and Size: Length (L) 16.9–33.1 mm; width 91.8–100+ percent of L (mean 98.4); height 75.4–94.1 percent of L (mean 84.9). Greatest height anterior to apical system; greatest width central.

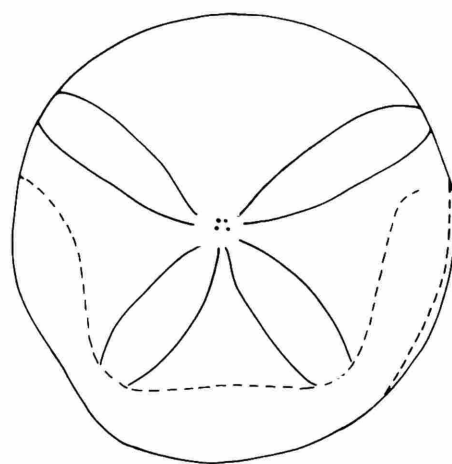
Apical System: Anterior, located at distance from anterior margin, equal to 22.0–39.8 percent of L (mean 33.6). Four genital pores.

Ambulacra: Ambulacrum III in slight groove running from apical system to lower anterior margin. Ambulacral pores small throughout length of ambulacrum.

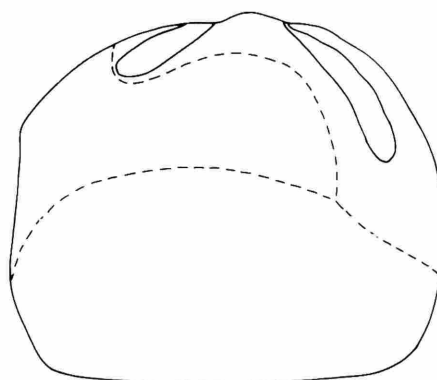
Anterior petals (II and IV) long, extending to margin, length 45.8–56.1 percent of L (mean 50.8); width 10.0–14.8 percent of L (mean 12.3). Interporiferous zones narrower than single poriferous zone; pores elongated transversely. Petals curving convexly anteriorly. Anterior poriferous zone with adapical pores greatly reduced in size. First petaloid porepairs in plate 11. Specimen 25 mm long with 50 petaloid porepairs, specimen 32 mm long with 54.

Posterior petals extending two-thirds distance from apical system to margin; length 36.2–47.0 percent of L (mean 39.6); width 11.3–14.8 percent of L (mean 12.7). Specimen 25 mm long with 44 petaloid porepairs, specimen 32 mm long with 46. Not possible to determine which plate bears first petaloid porepair.

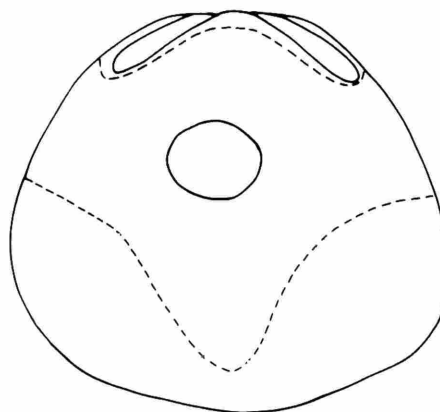
Peristome: Anterior, located at distance from anterior



A



B



C

FIGURE 5.—*Agassizia mossomi* Cooke: A,B,C, dorsal, right side, and rear views, respectively, of USNM 398328 from float of the Trent Formation, New Bern quarry ($\times 2$).

margin equal to 21.5–28.7 percent of L (mean 24.7). Wider than high, with width 20.0–28.5 percent of L (mean 22.5); height 8.0–15.3 percent of L (mean 9.8).

Periproct: Located high on vertical posterior truncation; width greater than height.

Fascioles: Peripetalous fasciole (Figure 5) indented deeply into posterior interambulacra; passing around test low on margin at great distance below end of anterior petals. Lateroanal fasciole with deep indentation below periproct.

Oral-plate Arrangement: Plate sutures not clear, but labrum appears to be very short.

REMARKS.—Twenty specimens were collected at the Belgrade quarry, which appear to be conspecific with the specimens of *A. mossomi* from New Bern. Their relative dimensions overlap those of the New Bern specimens, and in general appearance they are almost indistinguishable. The petals in the Belgrade specimens are slightly shorter, with petal II having a length of 37.9–47.8 percent of L (mean 44) in the Belgrade specimens as opposed to 45.8–56.1 percent of L (mean 50.8) in the New Bern specimens. Petal V has a length in the Belgrade material of 28.8–36.2 percent of L (mean 33.2) as opposed to 36.2–47.0 (mean 39.6) in the New Bern specimens. The petals also are slightly narrower in the Belgrade specimens. These differences appear to be too slight to warrant specific or subspecific differentiation. Five of the Belgrade specimens are illustrated on Plate 8: Figures 1–8.

MATERIAL.—USNM 398328, 398329 are from float of Trent Formation, New Bern Quarry, North Carolina. The Belgrade specimens (USNM 398330–398334) were collected by Druid Wilson from the south face of the quarry toward the northeast corner in a dark bed approximately 1–45 cm below the contact with an indurated limestone. According to Wilson (pers. comm., 1984), this horizon is high in zone C of the Belgrade Formation of Baum et al. (1979, fig. 1).

OCCURRENCE.—North Carolina: Trent Formation, New Bern quarry and zone C of the Belgrade Formation of Baum et al. (1979, fig. 1), Belgrade quarry.

Florida: Cooke's type specimens, Oligocene Suwannee Limestone, Florida Rock Products quarry, ³/₄ mi SW of Brooksville, Florida.

Agassizia sp.

PLATE 9: FIGURES 1–7

DESCRIPTION.—Two specimens (one partially crushed) with exterior well preserved, showing details of ornamentation.

Shape and Size: One specimen (USNM 398335), with original shape preserved, having length (L) 14.4 mm, height 11.4 mm (height 79.2 percent of L), and width 12.7 mm (width 88.2 percent of L). Greatest height at apical system.

Apical System: Four genital pores, ethmolytic, located

posterior to center at distance from anterior margin of 65.2 percent of L.

Ambulacra: Anterior ambulacrum III not petaloid, adapically in very faint groove not continuing to margin. Anterior petals (II and IV) long, length 37.5 percent of L; petal depressed in slight groove, petal narrow, nearly straight. Porepairs of anterior poriferous zone greatly reduced in size; in one specimen two enlarged porepairs at end of one petal, four in other anterior petal; in other specimen one or two enlarged porepairs in each anterior zone; 16 enlarged petaloid porepairs in posterior poriferous zone of anterior petal in specimen 14.4 mm long; 14 in specimen 13.3 mm long.

Posterior petals (V and I) short with length 24.3 percent of L. Petals wide, width 8 percent of L, in shallow groove; 23 petaloid porepairs in petal in specimen 14.4 mm long, 20 in specimen 13.4 mm long. Interporiferous zone narrow, one-half width of single poriferous zone.

Peristome: Anterior, located at distance from anterior margin to anterior edge of peristome equal to 21.5 percent of L; opening wider than high, width 21.2 percent of L, height 11.9 percent of L.

Periproct: Located high on posterior truncation; opening wider than high, width 23.3 percent of L, height 7 percent of L.

Fascioles: Peripetalous fasciole narrow, curving sharply into interambulacra 4 and 1, straight across interambulacrum 5; from ends of anterior petals fasciole curves sharply adorally passing around anterior of test below margin. Lateroanal fasciole passing in deep lobe below periproct crossing ambulacra V or I. Not possible to determine specific plate crossed by fasciole.

REMARKS.—These specimens resemble *Agassizia wilmingtonica* Cooke from the middle Eocene Castle Hayne Formation of North Carolina. They differ in having a higher peristome, and a test that is wider posteriorly with its posterior margin less pointed, and a more vertical, less overhanging, posterior truncation. With only two small specimens (one slightly crushed), it is not possible to know the significance of these differences.

MATERIAL.—USNM 398335, 398336, from float of the Trent Formation, Pollocksville state quarry.

OCCURRENCE.—North Carolina: Trent Formation, Pollocksville state quarry.

Family SPATANGIDAE Gray

Genus *Maretia* Gray

Maretia carolinensis, new species

FIGURE 6; PLATE 9: FIGURES 8, 9; PLATE 10: FIGURES 1–7; PLATE 11: FIGURES 1, 2

DIAGNOSIS.—The species is characterized by a wide test with width equal to length and by wide petals.

DESCRIPTION.—Twenty-four specimens (most fragments) are referred to this species. All specimens are badly weathered, but one shows a fasciole.

Shape and Size: Five specimens show the dimensions of the test. Length (L) 27.0–52.2 mm (mean 37.7); width approximately same as length; width 99–103 percent of L (mean 101); greatest width central to slightly anterior; height 39–44 percent of L (mean 42.7) with the greatest height near posterior margin. Adorally, test depressed around peristome.

Apical System: Located anterior at distance from anterior margin equal to 40–45 percent of L (mean 44.9). Four genital pores, ethymolytic with genital 2 extending posteriorly (Figure 6A).

Ambulacra: Anterior ambulacrum III not petaloid, in groove extending from apical system to peristome; pores minute in slight peripodia. Anterior petals long, wide; length 36.6–42.6 percent of L (mean 40.1); width 11–13 percent of L (mean 12.6). Pores deeply conjugate; adapically (approximately one-half length of petal) pores in anterior poriferous zones greatly reduced in size; petals closing distally with 50 petaloid porepairs in specimen 52.2 mm long, 50 in specimen 47.5 mm long, 44 in specimen 36 mm long, and 42 in specimen 27 mm long. Not possible to determine which plate bears first petaloid porepair.

Posterior petals with length 35.6–43.6 percent of L (mean 39.3), width 11.9–14.8 percent of L (mean 13.2); 50 porepairs in specimen 52.2 mm long, 50 in specimen 47.5 mm long, 44 in specimen 36 mm long, and 42 in specimen 27 mm long.

Peristome: Anterior, located at distance from anterior margin equal to 33 percent of L (measurable on one specimen). Labiate, wider than high with width (measurable on two specimens) 19 percent of L and height 8 percent of L (measurable on one specimen).

Periproct: Situated high on vertical posterior truncation (Plate 10: Figure 3), opening with height equal to width, height 12.2–12.5 percent of L (mean 12.4). Occurring in plates 5–9.

Fascioles: No peripetalous fasciole. Subanal fasciole very broad, width of area circumscribed by fasciole 51 percent of L, height approximately 15 percent of L. Not possible to determine on which plates fasciole occurs.

Tuberculation: Large tubercles on dorsal surface in all interambulacra except posterior interambulacrum. Tubercles in deep pits. Ventrally, large tubercles in ambulacra and interambulacra except posterior paired ambulacra and posterior interambulacrum where tuberculation absent anteriorly from peristome to midway to posterior margin, tubercles small from midway to posterior margin.

Oral-plate Arrangement: Labrum long and narrow (Figure 6B; Plate 9: Figure 9) with length 16.1–20.3 percent of L (mean 17.7), extending posteriorly to or just posterior to suture between second and third adjacent ambulacral plates. Sternal plates long and narrow, length on single measurable specimen 34 percent of L, width of paired plates equals 20 percent of L.

COMPARISON WITH OTHER SPECIES.—This species is easily

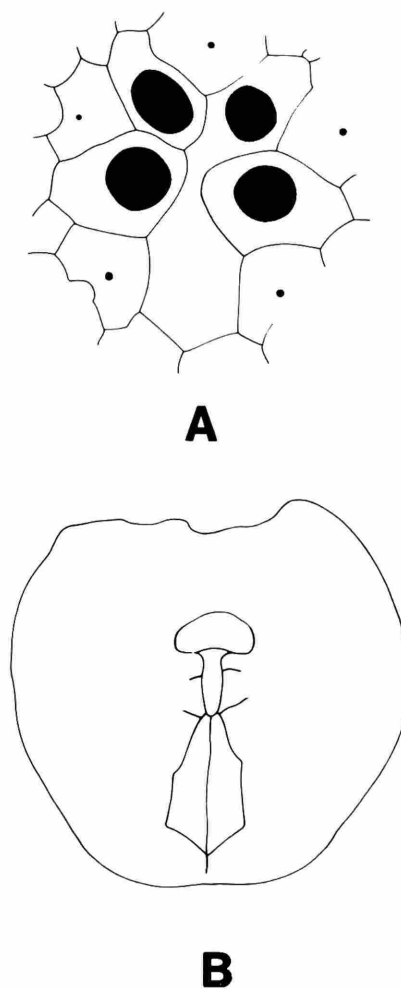


FIGURE 6.—*Maretia carolinensis*, new species: A, apical system of paratype USNM 398339 ($\times 20$); B, labrum and plastron of paratype USNM 398337 ($\times 1$). Both specimens from float of the Trent Formation at Pollocksville state quarry.

distinguished from the other two species of *Maretia* known from the United States. It differs from *Maretia subrostrata* (Clark) from the middle Eocene Castle Hayne Limestone of North Carolina in its wider test, with width 99–103 percent of L versus 89 percent of L in *M. subrostrata*. Its petals are much wider, with the width of the anterior petals 13 percent of L and the width of the posterior petals 15–18 percent of L versus 10 and 11 percent, respectively, in the Eocene species. Finally, in *M. carolinensis* the greatest width of the test is central whereas in *M. subrostrata* it is anterior.

Maretia carolinensis differs for the above same reasons from *M. arguta* (Clark) from the Winiona Sand of Lower Lisbon age of Mississippi. As noted by Cooke (1959:81) and Kier (1980:50), *M. arguta* may be conspecific with *M. subrostrata*.

MATERIAL.—**Holotype:** USNM 398338, from float of the Trent Formation, Pollocksville state quarry.

Figured Paratypes: USNM 398337, 398339–398341, same data as holotype.

Nonfigured Paratypes: USNM 492101–492124, same data as holotype.

OCCURRENCE.—North Carolina: Trent Formation, Pollocksville state quarry.

***Maretia* sp.**

PLATE 11: FIGURES 3–5

DESCRIPTION.—One specimen and several fragments can be referred to this genus. The specimens are too fragmentary to

permit specific identification. They are easily distinguished from *Maretia carolinensis*, new species from Pollocksville by their much narrower petals and narrower test. They resemble *Maretia subrostrata* (Clark) from the middle Eocene Castle Hayne Formation from North Carolina, but they appear to differ in having more deeply sunken dorsal tubercles. Until more specimens are found, it is not possible to determine whether these specimens are *M. subrostrata*.

MATERIAL.—USNM 398472, 398473, from float of Trent Formation at New Bern quarry.

OCCURRENCE.—North Carolina: Trent Formation. New Bern Quarry.

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Plates

PLATE 1

Dixieus dixie (Cooke)

- 1, 2, 3, 4. Dorsal, ventral, and side views, respectively, of USNM 398317 from Trent Formation float at New Bern quarry ($\times 2$).

Arbia aldrichi (Clark)

5. Dorsal view of USNM 398318, from the Belgrade Formation (Baum et al., 1978) at Belgrade quarry, 45 cm below top of indurated limestone ($\times 2$).
6. Ventral portion of test of USNM 398319, from the Belgrade Formation (Baum et al., 1978) at Belgrade quarry, near contact with indurated limestone ($\times 5$).

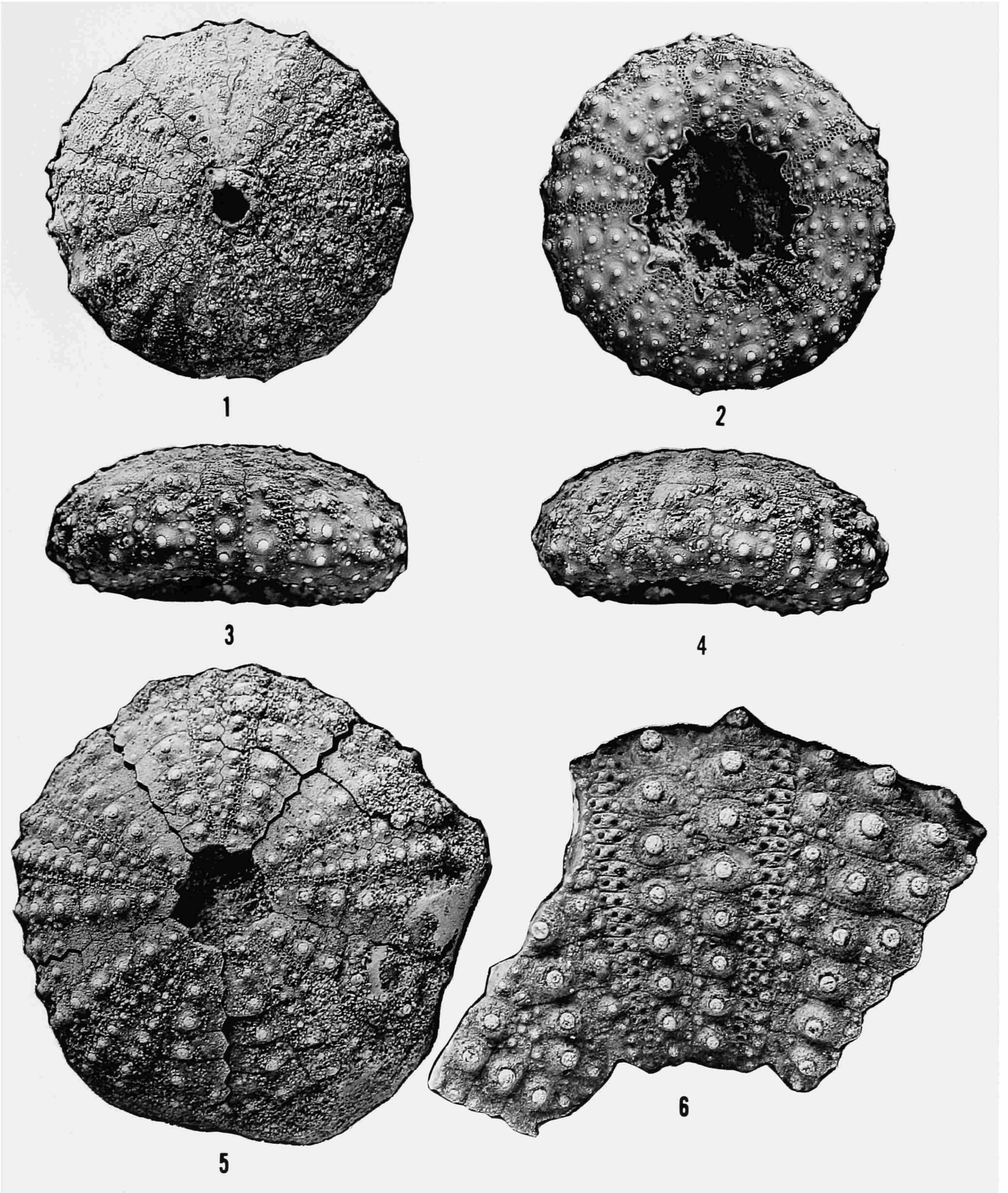


PLATE 2*Galaria mossomi* (Cooke)

- 1, 2, 3, 4. Dorsal, ventral, and side views, respectively, of USNM 398320, from the Belgrade Formation (Baum et al., 1978) at Belgrade quarry, approximately 30 cm below indurated limestone (×4).
5. Ambulacrum of the same specimen (×8).

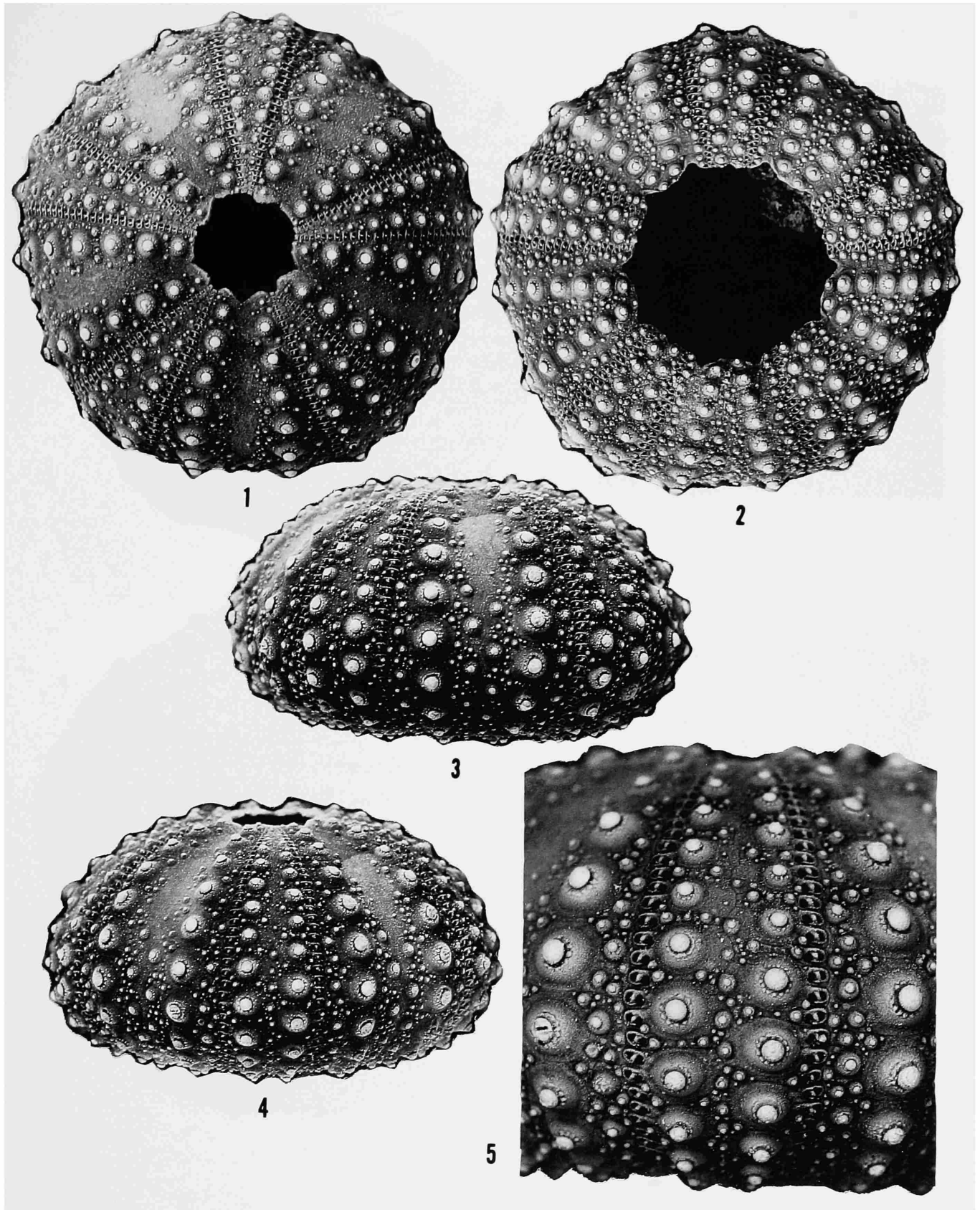
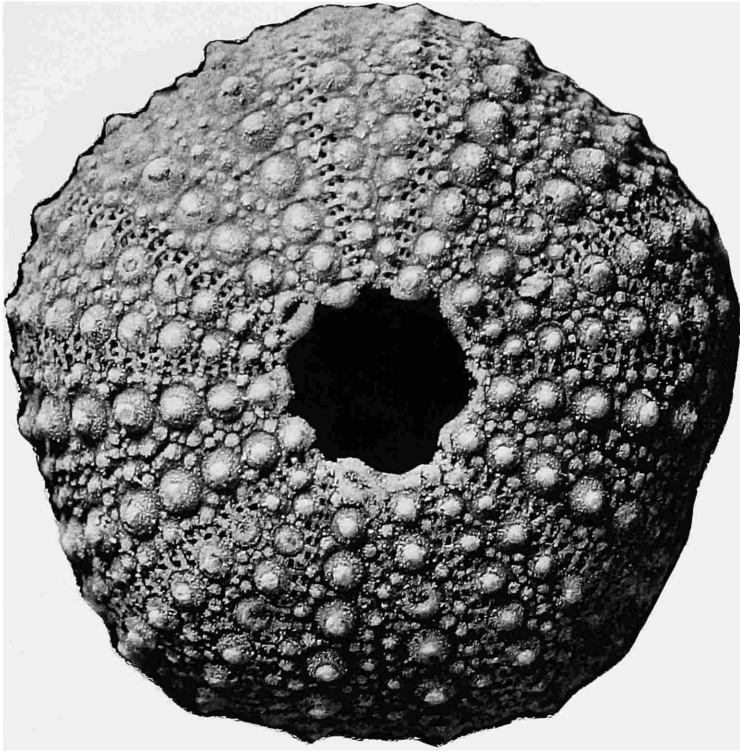


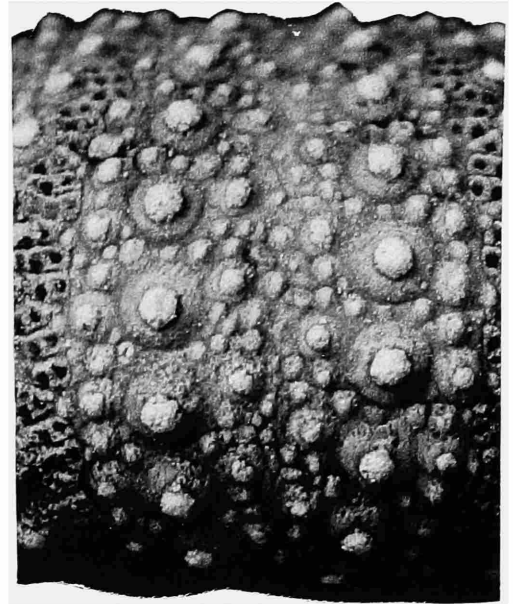
PLATE 3

Psammechinus carolinensis, new species

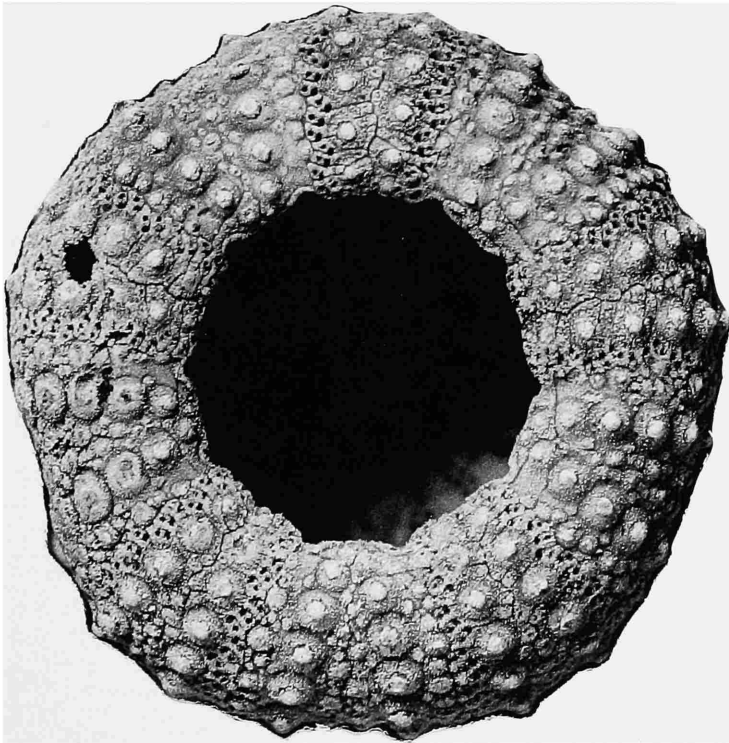
- 1, 2. Dorsal and ventral views, respectively, of the holotype, USNM 398321, from float of the Trent Formation, Pollocksville state quarry ($\times 8$). Additional views of this specimen are on Plate 4: Figures 1–4.
- 3, 4. Interambulacral and ambulacral views of paratype USNM 398322 from the same locality as the holotype ($\times 15$).



1



3



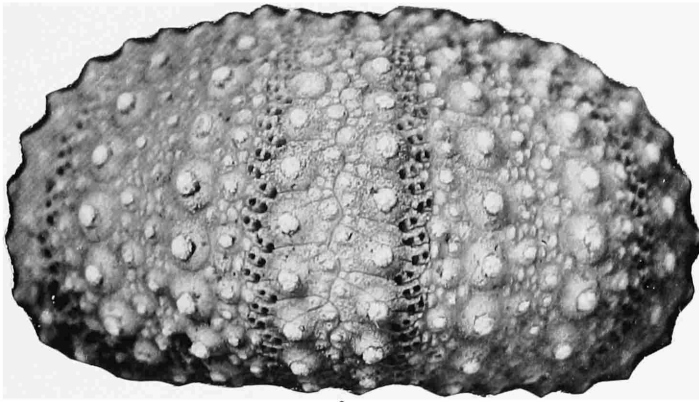
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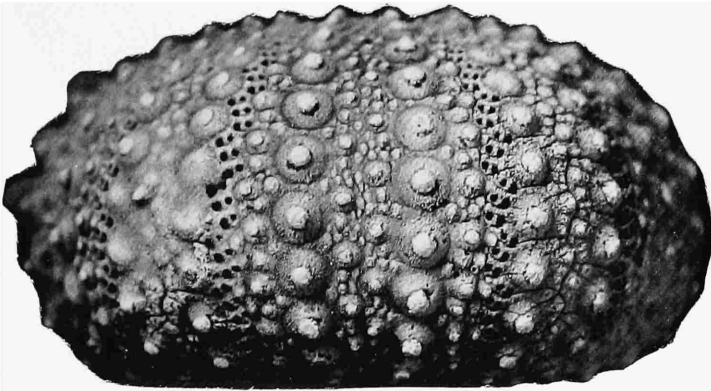
4

PLATE 4*Psammechinus carolinensis*, new species

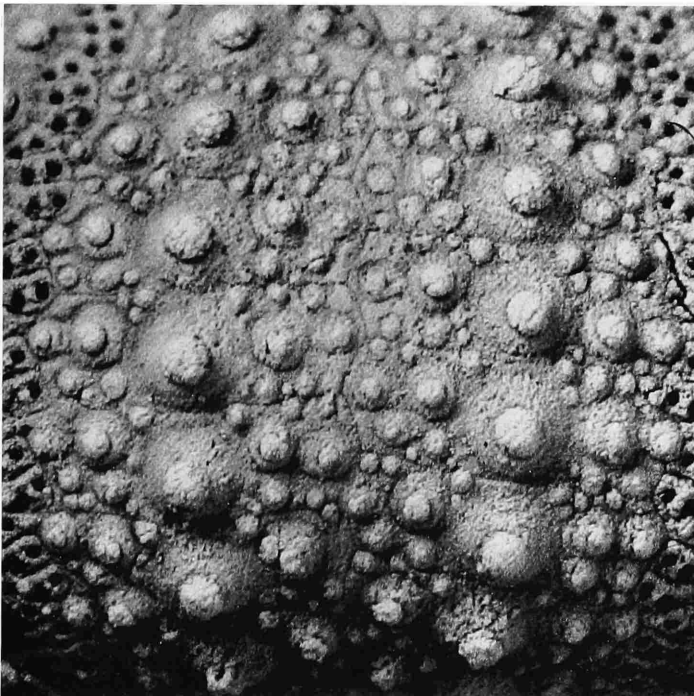
- 1, 2. Side views of the holotype, USNM 398321, from float of the Trent Formation, Pollocksville state quarry ($\times 8$). Additional views of this specimen are on Plate 3: Figures 1, 2.
- 3, 4. Ambulacral and interambulacral views of USNM 398474 ($\times 15$).
5. Auricles in USNM 398323 from same locality as holotype ($\times 10$).



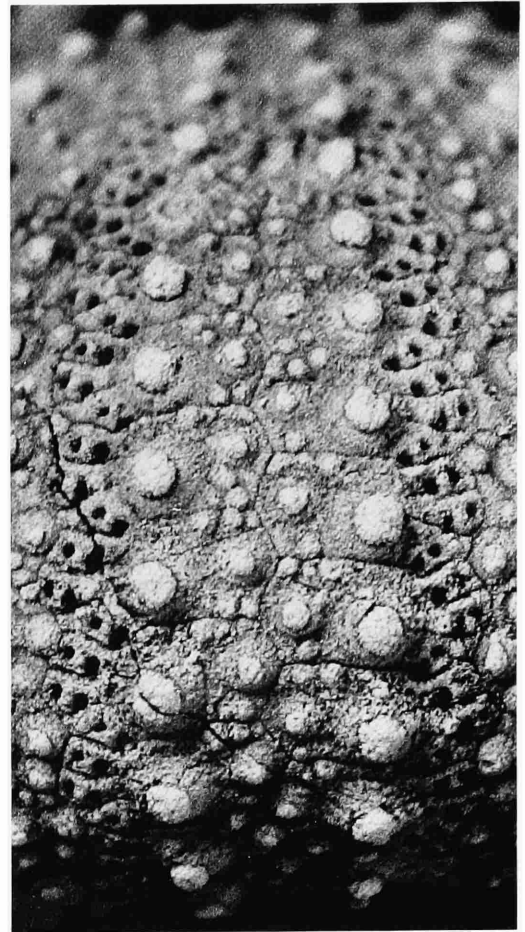
1



2



4



3



5

PLATE 5*Rhyncholampas gouldii newbernensis*, new subspecies

- 1, 2, 3, 4. Dorsal, ventral, rear, and right side views, respectively, of the holotype, USNM 398324, from float of the Trent Formation, New Bern quarry (×2).
- 5, 6, 7. Dorsal, ventral, and right side views, respectively, of paratype USNM 398325 from the same locality as the holotype (×2).

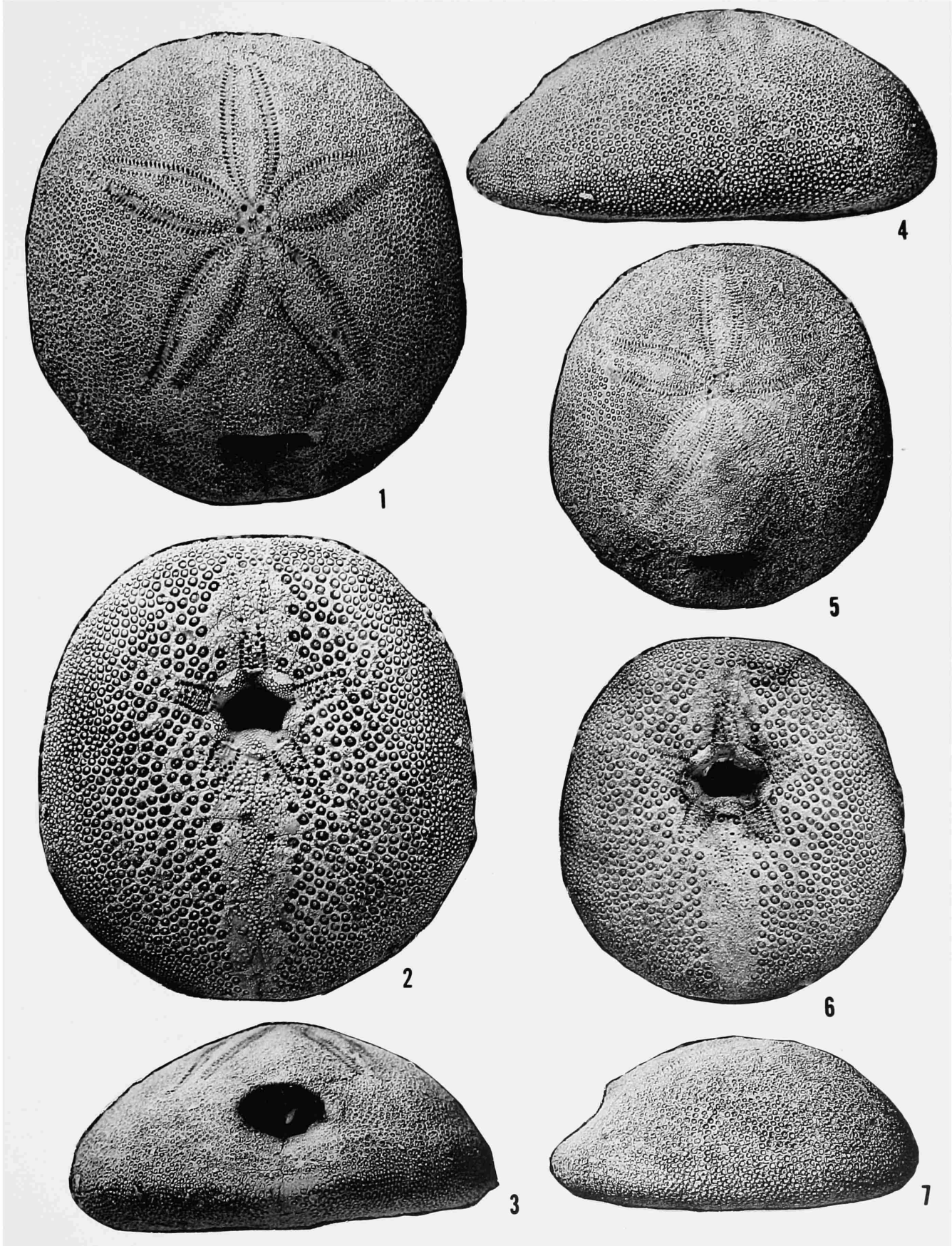


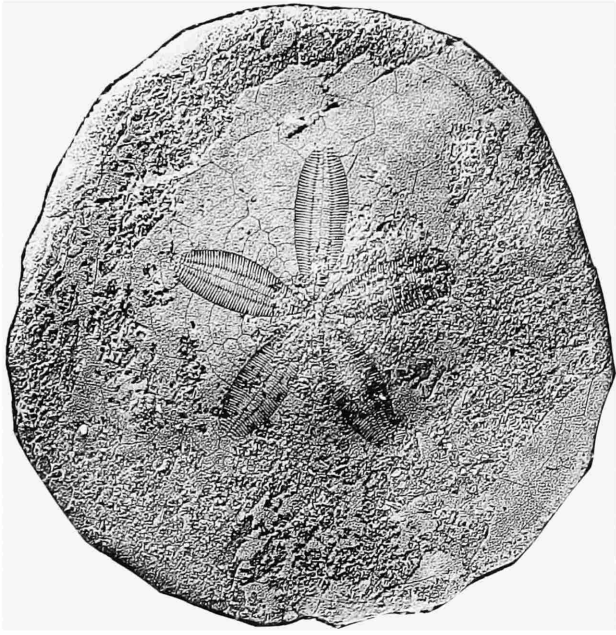
PLATE 6

Periarchus lyelli (Conrad)

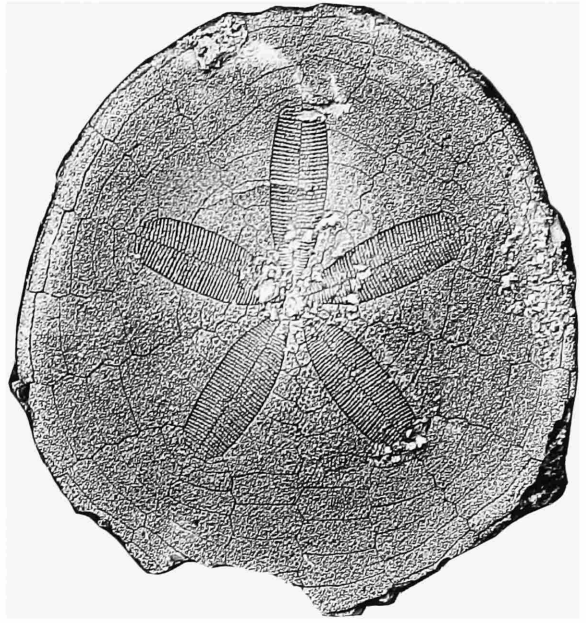
1. Dorsal view of USNM 398326 ($\times 1$). Specimen collected by Pete Harmatuk from float in the New Bern quarry.
2. Dorsal view of USNM 398327 from float in the New Bern quarry ($\times 2$).

Clypeaster rogersi (Morton)

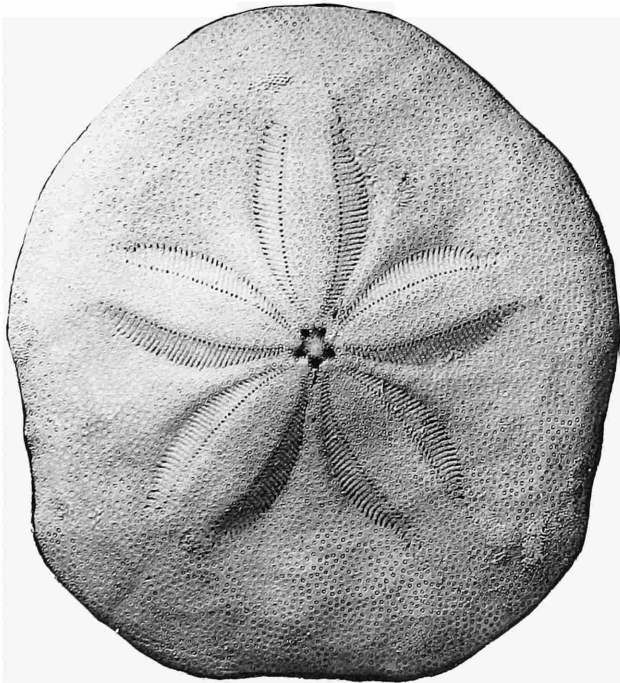
3. Dorsal view of USNM 372897 from Oligocene, Marianna Limestone, at Whitsett's quarry, about 3 mi south of Collumburg, Alabama ($\times 1.5$). This photograph is included for comparison with a specimen from the New Bern quarry figured on this plate, Figure 4 ($\times 1.5$).
4. Dorsal view of fragment (USNM 398475) from float from the Trent Formation at New Bern quarry ($\times 1.5$).



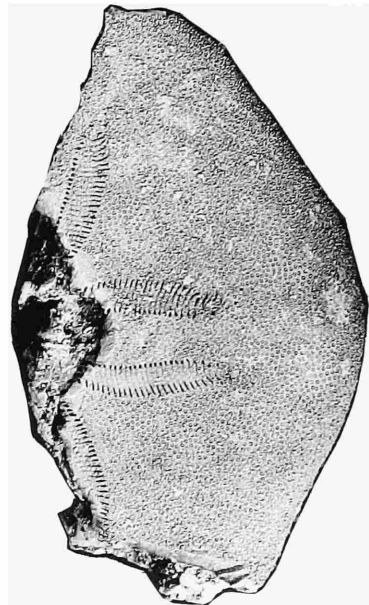
1



2



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4

PLATE 7*Agassizia mossomi* Cooke

- 1, 2, 3, 4. Dorsal, ventral, rear, and right side views, respectively, of USNM 398328 from float of Trent Formation, New Bern quarry (×2).
- 5, 6, 7, 8. Dorsal, ventral, rear, and right side views, respectively, of USNM 398329 from float of Trent Formation, New Bern quarry (×2).

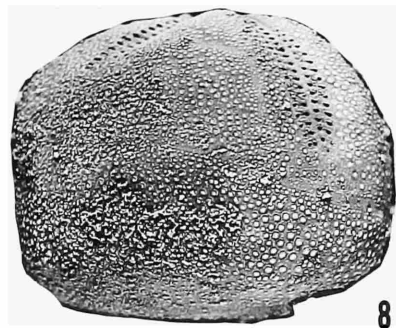
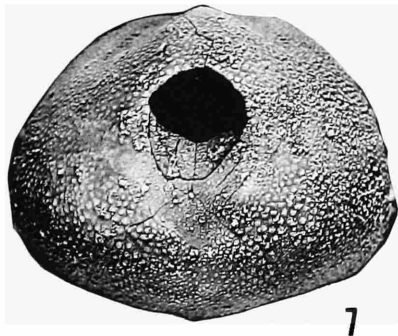
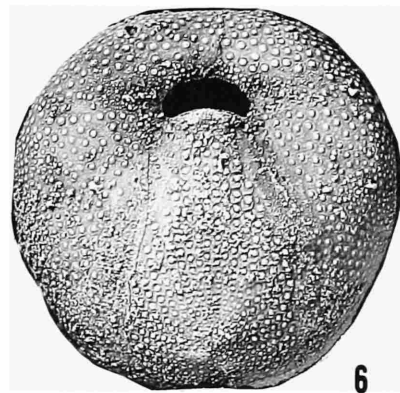
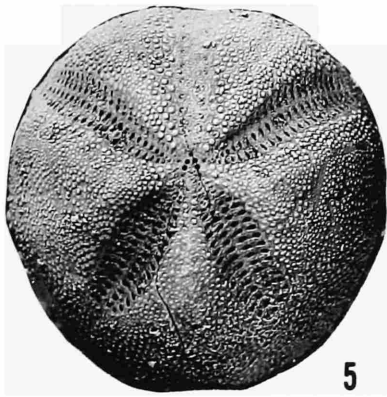
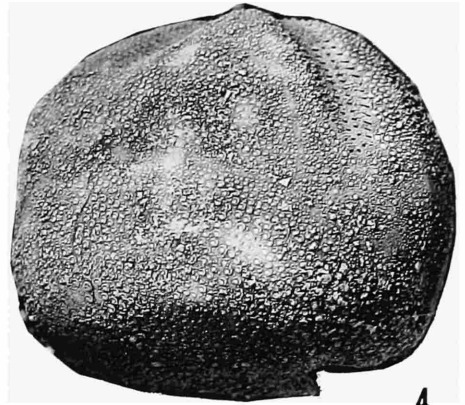
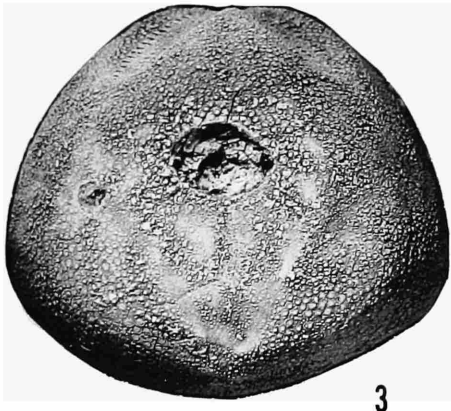
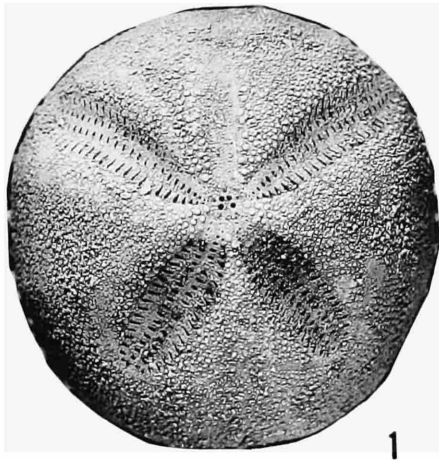


PLATE 8

Agassizia mossomi Cooke

1. Dorsal view of USNM 398330 from the Belgrade Formation (Baum et al., 1978), 45 cm below indurated limestone ($\times 2$).
2. Dorsal view of USNM 398331 from same locality ($\times 2$).
3. Dorsal view of USNM 398332 from same locality ($\times 2$).
4. Ventral view of USNM 398333 from same locality ($\times 2$).
- 5, 6, 7, 8. Dorsal, rear, right side, and ventral views, respectively, of USNM 398334 from the Belgrade Formation (Baum et al., 1978), near contact with indurated limestone ($\times 2$).

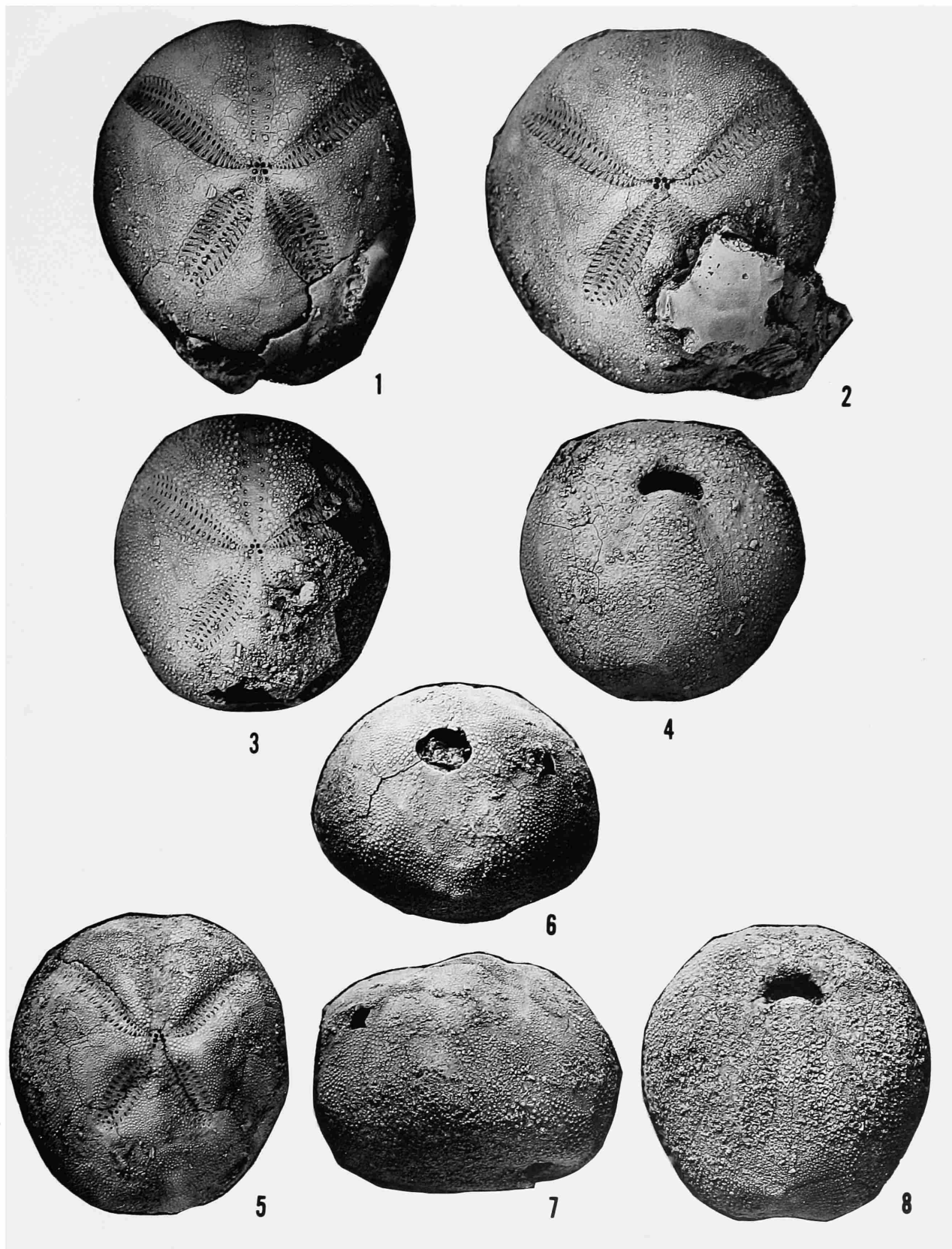


PLATE 9

Agassizia sp.

- 1, 2, 3, 4. Dorsal, rear, right side, and ventral views, respectively, of USNM 398335 from float of Trent Formation, Pollocksville state quarry (×4).
5, 6, 7. Dorsal, right side, and ventral views, respectively, of USNM 398336 from same locality (×4).

Maretia carolinensis, new species

- 8, 9. Dorsal and ventral views, respectively, of paratype USNM 398337 from float of the Trent Formation, Pollocksville state quarry (×1.5).

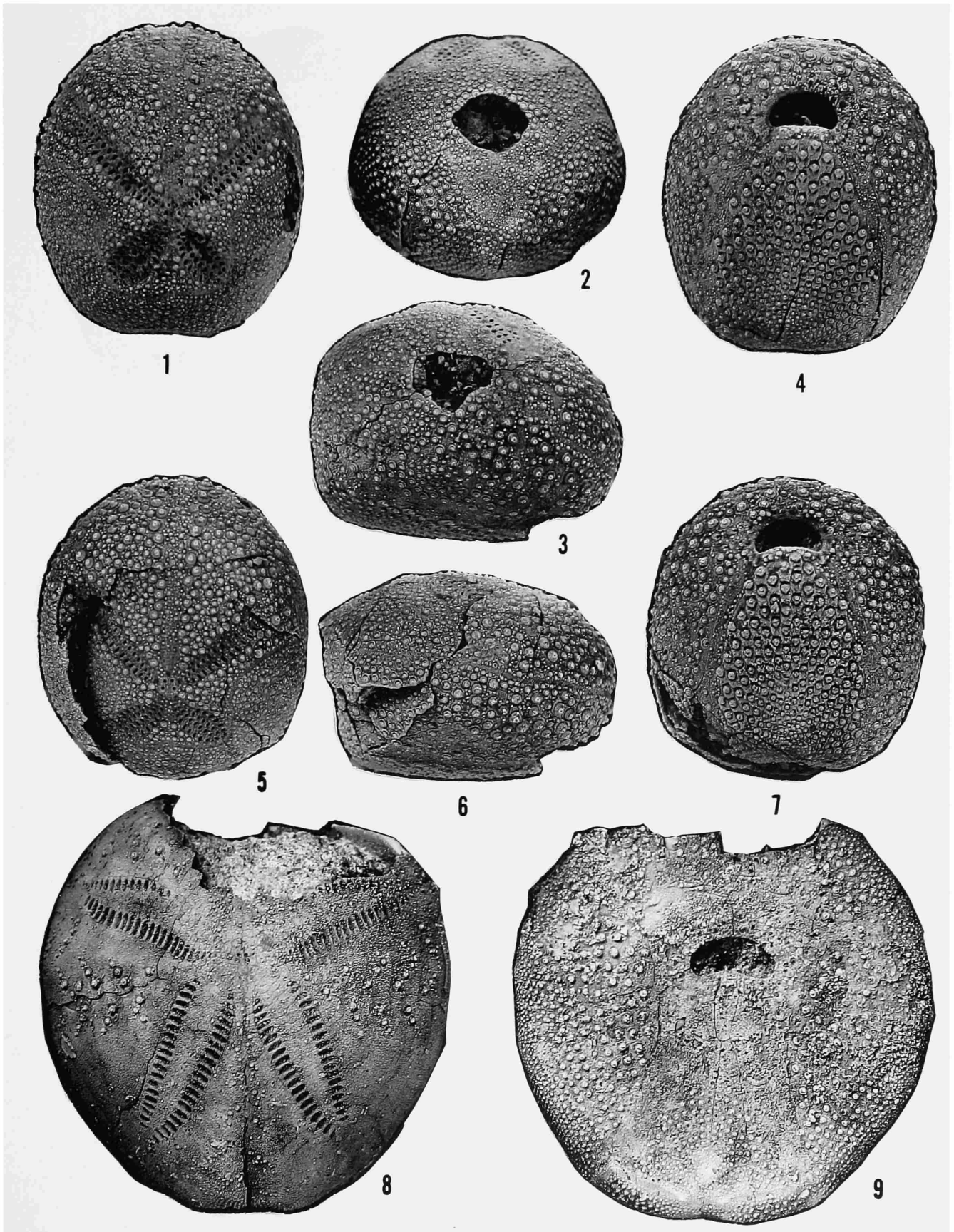


PLATE 10*Maretia carolinensis*, new species

- 1, 2, 3, 4. Dorsal, ventral, rear, and right side views, respectively, of the holotype, USNM 398338, from float from the Trent Formation at Pollocksville state quarry ($\times 1.5$).
- 5, 6, 7. Dorsal, right side, and ventral views, respectively, of paratype USNM 398339 from same locality as holotype ($\times 2$).

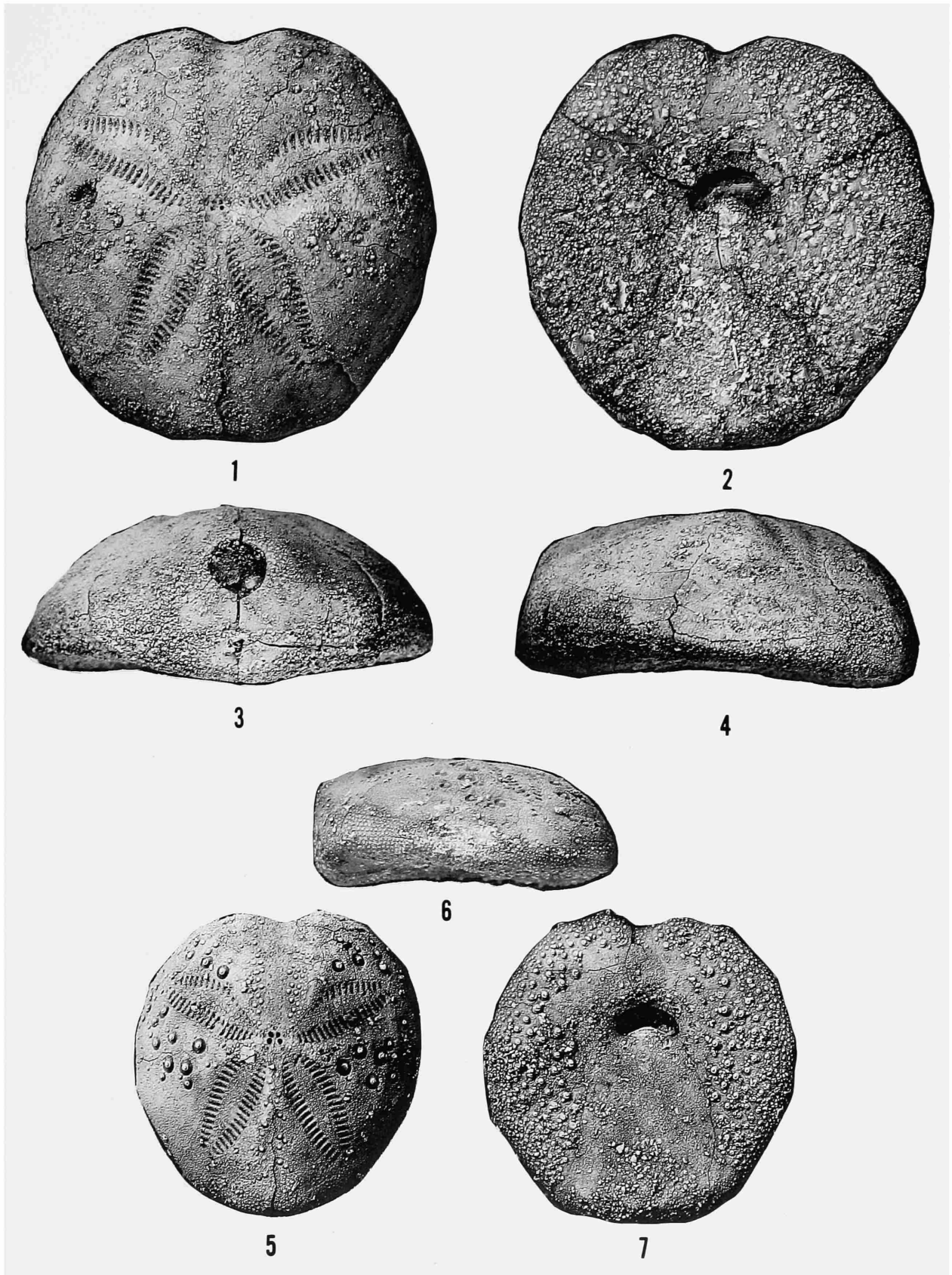


PLATE 11*Maretia carolinensis*, new species

1. Dorsal view of paratype USNM 398340 from float of the Trent Formation at Pollocksville state quarry ($\times 1.5$).
2. Dorsal view of paratype USNM 398341 from same locality ($\times 1.5$).

Maretia sp.

- 3, 4. Dorsal and ventral views, respectively, of USNM 398472 from float from the Trent Formation at the New Bern quarry ($\times 3$).
5. Dorsal view of USNM 398473 from the same locality ($\times 3$).

