New Upper Cretaceous Amphineura (Mollusca)

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CONTRIBUTIONS TO PALEONTOLOGY

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Description of chitons from the Gulf Coastal Plain and Puerto Rico

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By ALLYN G. SMITH,[1] NORMAN F. SOHL, and ELLIS L. YOCHELSON

ABSTRACT

Cretaceous Amphineura are extremely rare; the North American record previously consisted of two valves referred to a single species. Five isolated valves from the Ripley Formation in Georgia are here assigned to the new species *Chiton* (*Chiton*) *berryi*. Three additional valves from the San Germán Formation as used by Mattson (1960) in Puerto Rico are placed in two additional new species, *C.* (*Chiton*) *rossi* and *Aulachochiton praecursor*.

The first two new species constitute the second and third reports of *Chiton* in the Cretaceous of North America. The discovery of *Aulachochiton praecursor* in the San Germán Formation in Puerto Rico extends the range of that genus into the Mesozoic; heretofore, it had been known fossil only from beds in Tasmania as old as early Miocene.

INTRODUCTION

Although authentic examples of Amphineura valves are known from rocks as old as youngest Cambrian, the geologic record of this class is meager. Representatives are among the rarest of molluscan fossils, and it is hoped that by directing attention to these occurrences additional specimens will be observed and collected. Paleozoic amphineurans are better known and more abundant than those of the Mesozoic. More than 100 Paleozoic species are described, whereas only about 30 Mesozoic species have been reported. No undoubted Amphineura have been reported from the Triassic.

Recent Amphineura occupy a variety of habitats. Most commonly, they cling to rocky subtrates, but a few species are known that adhere to dead shells and isolated pebbles, live in holes in coral or burrow into tough algal holdfasts. The eight calcareous plates surrounded by a tough girdle allow for appreciable body flexibility and permit the animal to adhere to rough, irregular surfaces. Except for a few primitive genera, the modern amphineuran fauna is characterized by anterior extensions or sutural laminae on seven of the eight separate plates which permit some small amount of overlap, thereby increasing the strength of the animal, without reducing its flexibility.

[1] California Academy of Sciences, San Francisco, Calif.

Present-day Amphineura live mostly in shallow water, but some species are abyssal; one has been found at a depth of 12,000 feet.

The meager geologic record of Cretaceous Amphineura may be used as an argument for a worldwide paucity of rocky shore habitats during that period. However, all the new Cretaceous amphineuran species herein described have well-developed sutural laminae and are of sufficiently large size to indicate a habitat on a fairly extensive solid or rocky substrate.

The terminology and supraspecific classification here used follow Smith (1960).

GEOLOGIC OCCURRENCE

The two occurrences of Upper Cretaceous Amphineura here recorded are similar in age range but come from distinct, sharply separated faunal provinces and, individually, from deposits representing decidedly different ecologic situations.

COASTAL PLAIN PROVINCE

The five isolated valves of *Chiton* (*Chiton*) *berryi* come from the medial part of the Ripley Formation at U.S. Geological Survey Mesozoic locality 25923 (fig. 1), at the former site of Mercers Mill on Tabannee Creek, 0.2 mile upstream from the bridge of the Central of Georgia Railroad, near Georgetown, Quitman County, Ga. About 11 feet of dominantly dark-gray to nearly black clayey silty micaceous fossiliferous sand are exposed in the streambanks at this locality. The specimens of *C.* (*Chiton*) *berryi* were colected in a lenticular 9-inch bed of light-colored, less argillaceous, and better sorted sand about 5 feet above the base of the section. This sand contained a great concentration of shell material that obviously had been size sorted, presumably by current activity.

Several hundred pounds of material was excavated from this lens, most of which was concentrated by sieving and washing at the outcrop. This concentrate was picked and prepared in the laboratory. Thus, the five isolated plates found constitute a very low numerical

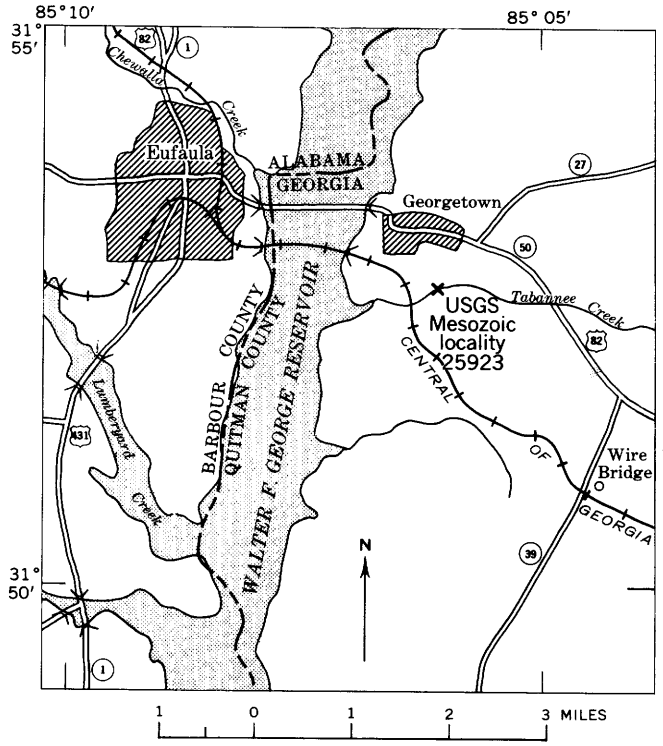

FIGURE 1.—Map showing USGS Mesozoic locality 25923, Quitman County, Ga.

representation relative to the abundance of other mollusks. Inasmuch as these plates are part of a transported shell concentrate, it is unlikely that they belonged to the same individual; excellent preservation exhibited by these plates and the associated shell material precludes transport for any great distance.

The associated diverse assemblage of mollusks contains a typical Ripley Formation association as described by Wade (1926) and Sohl (1960; 1964), and is a shallow-water inner shelf assemblage.

Chiton (*Chiton*) *cretaceus* Berry (1940, p. 211–213) is based upon two plates, one from the Coon Creek Tongue of the Ripley Formation on Coon Creek, Tenn. (Sohl, 1960, p. 27), and the other from the Monmouth Formation near Brightseat, Md. (Gardner, 1916). Both specimens occur in sands lithologically similar to those in which *C.* (*Chiton*) *berryi* was collected. The associated fauna is similar in composition, and thus the tendency is to infer that all lived under virtually similar ecologic conditions.

Although no indication of proximity to a rocky intertidal habitat is present in any of the three deposits, the anomalous occurrence of chitons of this size requires at least the local availability of a rocky substrate more extensive than mere random distribution of scattered large shells or pebbles. Shells or cobbles would provide firm attachment spots but insufficient grazing areas for feeding (Spencer Thorpe, written commun., 1967).

The plates of *C.* (*Chiton*) *berryi* from the middle part of the Ripley Formation are associated with *Exogyra costata* and are of latest Campanian age. They occur at a stratigraphic level that lies between the Tennessee and Maryland units that have yielded *C.* (*Chiton*) *cretaceus*.

The two occurrences of *C.* (*Chiton*) *cretaceus* are near the upper and lower limits of the *Exogyra costata* zone. Berry (1940, p. 213) erred in assuming that both of his specimens came from beds of the same age. The specimen from the Coon Creek Tongue of the Ripley Formation of Tennessee occurs with *Exogyra cancellata* and is correlative with the lowest part of the *E. costata* zone of late Campanian age. The Maryland specimen is from the Monmouth Formation from beds in the upper part of the *Exogyra costata* zone; it is associated with *Sphenodiscus* and scaphitid ammonites similar to forms found in the *Baculites clinolobatus* zone of the uppermost Pierre Shale of South Dakota. This association is suggestive of an early Maestrichtian age.

CARIBBEAN PROVINCE

Chiton (*Chiton*) *rossi* and *Aulachochiton praecursor* come from silicified limestones of the San Germán Formation as used by Mattson (1960) in the Sabana Grande quadrangle of southwestern Puerto Rico. The samples were collected from U.S. Geological Survey Mesozoic locality 29075 (fig. 2) in the saddle near the 50-meter-high hill east of Quebrada Jicara, about 2.95 miles southwest of Sabana Grande, Barrio Lajas Arriba,

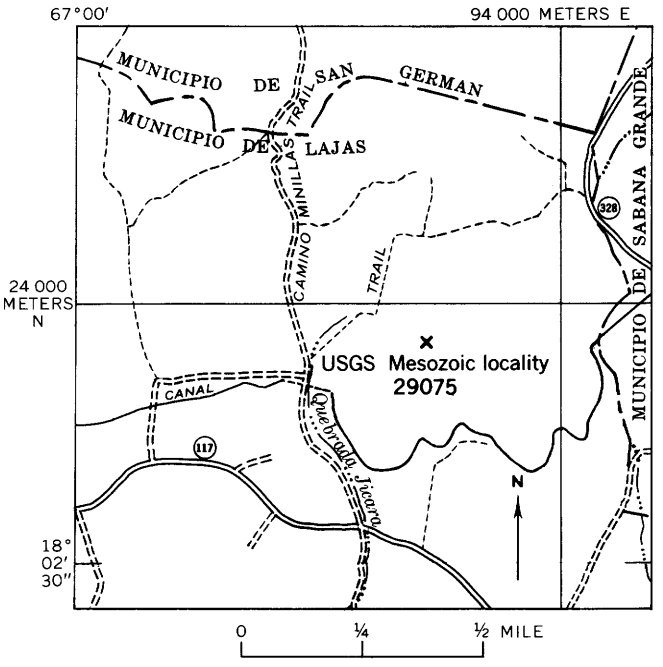

FIGURE 2.—Map showing USGS Mesozoic locality 29075, Municipio de Lajas, P.R. Base from U.S. Geological Survey Sabana Grande, P.R., 7½-minute quadrangle.

Municipio de Lajas (Puerto Rico Meter Grid 95,280 E, 21,900 N). All amphineuran specimens have been recovered from the residue of acidized limestone blocks and are silicified. The outcrops of the limestone at this locality are obscured by slope wash and very dense overgrowth. Individual blocks contain different faunal assemblages, and it is obvious that more than one ecologic niche is involved.

The fauna of the San Germán Formation at this locality is dominated by rudistid pelecypods and by nerineid and actaeonellid gastropods; but a host of other types of mollusks, an abundance of corals, other invertebrates, and coralline algae also occur. The fauna is obviously a warm-water or tropical type with affinities to the Mediterranean Tethyan region. These Cretaceous tropical-reef, back-reef, and lagoonal associations contrast strongly with the coeval Gulf Coast faunas associated with *C.* (*Chiton*) *berryi*. Of special note is the rarity of rudistid pelecypods and the absence of nerineid and actaeonellid gastropods in the Late Cretaceous Coastal Plain province.

The San Germán Formation is Maestrichtian in age, according to Mattson (1960, fig. 2). The fauna from Mesozoic locality 29075, however, does not appear to represent the highest Maestrichtian levels but is more likely from beds of early or middle Maestrichtian age.

PREVIOUS REPORTS OF CRETACEOUS AMPHINEURA (POLYPLACOPHORA)

Smith (unpub. data) has complied a catalog of Mesozoic chitons in which he notes that three authors report a total of eight occurrences of Cretaceous taxa. The earliest Cretaceous chiton, both stratigraphically and also by date of discovery, is *Chiton sallustii* described by Parona (1909) from the Cenomanian of Italy. This species is assigned to the order Neoloricata because the single intermediate valve, on which *C. sallustii* is based, possesses sutural laminae and hence has an articulamentum layer. It is somewhat worn and unassignable to genus, but in all probability does not belong to *Chiton* as the genus is now restricted. Berry (1940) described *Chiton cretaceus* from two isolated valves found in Campanian and Maestrichtian age rocks in Tennessee and Maryland; Smith (1960, p. I65) placed this species in the typical subgenus.

Bergenhayn (1943) described *Oligechiton triangulatus* and *Scanochiton jugatus* from the Senonian of Sweden (*mammilatus* zone); both are monotypic genera. Presumably, all of Bergenhayn's (1955) additional Senonian material is from the *mammilatus* zone, but this is not specifically indicated for all specimens. In his 1955 paper, Bergenhayn described two more monotypic genera, *Haeggochiton haeggi* and *Iveochiton levis*, and four unnamed species that were referred informally to "*Chiton*." Not all the unnamed material was figured, and none can be assigned with certainty to any particular genus. The large number of monotypic genera described by Bergenhayn is an indication of the paucity of our knowledge of fossil Amphineura; all have been placed in the order Paleoloricata (Smith, 1960), though the ordinal classification should be reevaluated in the future.

SYSTEMATIC PALEONTOLOGY

Order NEOLORICATA Bergenhayn

Suborder ISCHNOCHITONINA Bergenhayn

Family CHITONIDAE Rafinesque

Genus CHITON Linnaeus

Subgenus CHITON Linnaeus

Chiton (Chiton) berryi, n. sp.

Plate 1, figures 1–3

Description.—Intermediate valves rather narrow and having an extremely short sutural plate. Tegmentum alate, having a wide rounded false beak with a broad shallow sinus trending gently posteriorly and strongly laterally on either side and occupying most of the anterior margin to the inner edge of the lateral area, there curving more strongly toward the posterior, turning a bluntly rounded angulation to the posterior margin, and proceeding nearly normal to the median line before bending slightly backward and continuing straight to join at a distinct, wide apex. Jugal angle near 90°, the lateral slopes virtually flattened. Jugal area low, rounded; broader at anterior; distinctly arched; ornamented by 10 or 11 straight, diverging, very low and closely spaced flattened ridges separated by low, rounded grooves. Lateropleural areas not reaching lateral margins; flattened in both profile and plan except for ornament and not otherwise clearly set off from the jugal area; ornamented by 11 or 12 wide, flattened, longitudinal ridges; those closest to the medial jugal area being narrow, slightly curved, and cut off by its ornament, and those closest to the lateral margin being about twice as wide as those nearest the jugum, and gently sinuous. Sides of ornamental ridges vertical; adjoining groves having a flat base, the width of the grooves increasing irregularly toward the side margins. Lateral areas bounded by a rounded ridge trending about 65° from the longitudinal axis; both lateral areas raised with reference to lateropleural areas, but gradually sloping downward toward the posterior margin; ornamented by rows of pits normal to the ridge, except on the thickened posterior margin where arcuate crenulations approximate the extension of these rows.

A thin shell layer lies below the tegmentum having the same outline as the upper layer, but less than one-

third the thickness. Sutural laminae in the third shell layer simple, curved in outline, having their maximum width about two-thirds of the distance from jugum to lateral margin, and a sharp-edged smooth anterior margin convex forward. Sutural plate set off from the sutural laminae only by exceedingly short slits and hardly protruding beyond the false beak; the anterior edge smooth. Insertion plates small; a single short narrow slit just posterior of lateral ridge; part of insertion plate, posterior to slit, blunt and terminally coarsely pectinate; the pectinations extending down the outside plate and showing only faint indications of striae on the inside; terminal part of plate just anterior to slit also pectinate for a short distance, the rest of the edge being sharp, the eaves hardly overlapping.

Tegmentum extending only a very short distance onto the ventral side of the valve in the form of an apical area, extending virtually in a straight line so that the median section is the only part not confined to the margin; no indication of an apical pocket. Hypostracum well developed with slit rays forming a line of en echelon, elongate narrow pores from the slits and for the most part just posterior to the trend of the exterior lateral ridge; fine arcuate growth lines occurring between this line and the posterior margin, having two prominent broad, bow-shaped ridges anterior to the pore line; anterior of hypostracum thinner and ornamented by striations normal to the median line.

Discussion.—The pectinated termination of the insertion plates is a characteristic feature of *Chiton*. The single-slitted nature of these plates is characteristic of the typical subgenus, whereas a multiple-slitted plate is a normal feature on the subgenus *Radsia*. One unfigured paratype has a single slit on one side and a double slit on the other. Variation from the normal is known in rare living animals of *Chiton* (*Chiton*), and the difference seen in this one fossil plate is not judged to be significant.

The only specific level comparison that need be made in the North American Cretaceous is to *Chiton* (*Chiton*) *cretaceus* Berry (1940, p. 211–213). Both specimens of that species, a head valve from Brightseat, Md., and an intermediate valve from Coon Creek, Tenn., show pustulose ornament strikingly different from the ridges of *C.* (*Chiton*) *berryi*. In detail, the intermediate valve of *C.* (*Chiton*) *cretaceus* is subquadrilateral in outline rather than alate and shows a different configuration of ridges on the inner surface.

Five intermediate valves of *C.* (*Chiton*) *berryi* are available. The best specimen, which is probably the second valve in the series (valve "ii") on the living animal is chosen as holotype; the remainder of the hypodigm are designated paratypes. No anterior or posterior valves are available. The size relations are such that all those intermediate plates could have come from a single animal. However, there is some indication that one of the less well preserved and unfigured paratypes is also a valve "ii." Further, the geologic occurrence suggests that valves from several specimens may have been mixed together.

Several specimens are exceedingly well preserved, and are brownish on the posterior of the hypostractum and white anterior to the ridges. This may be the original color pattern and perhaps the original color. The exterior of the tegmentum is a uniform light brown in the unbleached specimens.

The specific name recognizes the pioneer work of C. T. Berry on American Mesozoic Amphineura.

Types: Holotype, USNM 157875; figured paratypes, USNM 157876, 157877; unfigured paratypes, USNM 157878, 157879.

Occurrence: Upper Cretaceous, Ripley Formation at USGS Mesozoic loc. 25923.

Measurements, in millimeters, of the specimens are as follows:

Specimen	Width of		Length of jugum	Height of valve	Maximum [1] length of laminae
	Surface	Valve			
Holotype: USNM 157875	4.7	7.3	3.7	3.4	0.9
Figured paratype:					
USNM 157876	3.3	5.4	2.2	2.2	.8
USNM 157877	5.6	8.7	3.0	3.7	.7
Unfigured paratype:					
USNM 157878	3.9	6.2	2.5	2.6	----
USNM 157879	3.4	5.5	2.5	2.9	.5

[1] Measured parallel to jugum (longitudinal line of valve).

Chiton (Chiton) rossi n. sp.

Plate 1 figures 5–8

Description.—Head valve rather narrow and broadly arched, more than twice as high as wide. Tegmentum surface simple, without development of lateropleural areas and without any differentiation of the medial area, except for a slight additional posterior arching at maturity. Ornament probably confined to small pustules, detail of arrangement unknown. Anterior margin well rounded, following the arc of a circle; lateral margins exceedingly short and bluntly rounded; posterior margins straight, converging slightly toward anterior so that a wide shallow posterior sinus is formed. Articulamentum layer thick at anterior, without eaves but with a distinct gap between this and the tegmentum and projecting distinctly forward. Insertion plate divided into "teeth" by at least 13 distinct slits, the teeth being subequal in width except at the far lateral margins in juvenile stage, with smaller teeth occurring centrally and larger ones laterally at maturity; width of teeth varying and deviating from strict bilateral symmetry, bearing pectinations on outer surfaces and, at maturity, also on upper surfaces. Posterior margin

simple, except for more prominent central arching at maturity. Interior of valve in juvenile stage simple, except for a posterior thickening in sinus set off from the remainder of the valve by a distinct ridge, this feature possibly being the edge of the tegmentum reflected onto the inner surface of the articulamentum in an apical area; at mature stage, the inner surface of hypostracum marked by a shallow median trough and a pair of lateral thickenings, all the features being gently curved in profile.

Presumed valve "ii" rather wide with a single slit on each side, terminally pectinated insertion plates, and prominent sutural laminae. Tegmentum outline broadly subquadrate and simple; immediate central edge of anterior margin unknown but remainder of margin inclined uniformly gently backward to near juncture with lateral area, marked by a bluntly rounded angulation; lateral margins straight and directed slightly inward to rather sharp juncture with the simple posterior margin. Jugal angle near 60°, but with lateral parts of valve arching slightly downward. Jugum little rounded; distinctly arched longitudinally and produced downward posteriorly; seemingly without distinctive ornament; jugal area not differentiated. Lateropleural areas wide and reaching the lateral edge of valve; ornamented by more than 25 elongate high round-topped ridges separated by grooves of nearly uniform width having nearly vertical sides and flattened bottoms, the ridges being of uniform width near the jugal region and through about two-thirds of their total length, but widening near the lateral edge of the valve where they are twice the width of the grooves; ridges and interspaces longitudinal, and along inner two-thirds parallel to jugum of valve, but slightly arcuate posteriorly in the outer parts, coordinate with the widening of the ridges. Lateral areas set off by a raised slope trending about 75° from the longitudinal line of the valve, the inner part of which begins well below the jugal area; lateral areas divided into three parts, the anterior consisting of an upper flattened surface posterior of the raised slope, and the posterior consisting of two narrower and lower areas; the combined width of the last two areas equaling that of first, and being set off from it and each other by deep furrors, widely V-shaped in profile.

Sutural laminae wide and presumbly with a smooth anterior edge, curving so that the laminae taper gradual toward the lateral part, but bend abruptly inward toward the medial jugal area. Sutural plate set off from sutural laminae by a wide, deep slit on either side; plate extending forward for about half the maximum width of the laminae; coarsely pectinate on its anterior edge. Insertion plates cut by a short, wide slit, inclined slightly forward and downward and situated along a line just posterior to the anterior edge of the tegmental ridge between lateral and lateropleural areas. Terminal part of insertion plates thickened at ends, particularly just anterior and just posterior to slit, bearing prominent, irregular, and coarse pectinations on the outside surfaces, the posterior one-fourth of the plates being more finely pectinate. Eaves hardly projecting.

Posterior edge of tegmentum just overlapping onto inner surface of articulamentum, forming an apical area, the zone of overlap being only slightly wider in the median area, without development of a pocket. Inner surface of hypostracum smooth, but thickened by a prominent, rather wide ridge, trending across the valve just anterior to the insertion-plate slits, the ridge being lower and less prominent in the median area. Medial part of hypostracum preserved in some specimens, with a closed row of pores forming slit rays on the inner surface of the articulamentum from the insertion-plate slits to the posterior edge, following the trend of the tegmental ridge separating lateropleural and lateral areas. Presumed plates "iii" to "vii" narrower than "ii" but poorly known.

Discussion.—Although both *Chiton* (*Chiton*) *rossi* and *C.* (*Chiton*) *berryi* show ornament characteristic of some species of *Ishnochiton*, both have terminally pectinated insertion plates, a feature of *Chiton* in the strict sense. At the present state of our knowledge, it seems unlikely that either *Chiton* or *Ishnochiton*, both broad genera, is typified by a particular ornament; ornament pattern is judged to be only a feature of species rank significance within these two taxa.

The more rectangular shape, larger size, and more prominent sutural plates are the main features distinguishing *C.* (*Chiton*) *rossi* from *C.* (*Chiton*) *berryi*. The narrow lateral areas and closely spaced tegmental ridges of the intermediate valves differentiate *C.* (*Chiton*) *rossi* from the corresponding valves in *C.* (*Chiton*) *cretaceus*.

Two isolated intermediate valves of *C.* (*Chiton*) *rossi* from USGS Mesozoic locality 29075 were available; both are definitely from disarticulated animals. The wider one, here designated holotype, shows worm tubes cemented to the hypostracum; the narrower paratype shows elongate etchings on this inner surface. The holotype may be a valve "ii," and the paratype one of the more posterior valves.

These two intermediate valves are nearly identical in length and angle and undoubtedly belong to the same species. On the paratype valve, which is badly worn, the inner ridge is narrower than on the holotype. Except for this feature and overall width, it differs from the holotype only in the presence of slit rays. The occurrence of the slit rays in the narrower valve and their seeming absence in the holotype, in spite of identical

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PLATE 1

PLATE 1

[Figures 1–3 are from the Ripley Formation at USGS Mesozoic loc. 25923. Figures 4–8 are from the San Germán Formation as used by Mattson (1960) at USGS Mesozoic loc. 29075]

FIGURES 1–3. *Chiton (Chiton) berryi* Smith, Sohl, and Yochelson, n. sp. (p. G3).

1. Paratype, USNM 157876: a–d, ventral, dorsal, anterior, and posterior views, respectively. × 5.
2. Holotype, USNM 157875: a–d, dorsal, ventral, anterior, and posterior views; e, dorsal view, specimen uncoated, showing color pattern of sutural laminae. × 5.
3. Paratype, USNM 157877: a–d, ventral, anterior, posterior, and dorsal views, respectively. × 5.

4. *Aulachochiton praecursor* Smith, Sohl, and Yochelson, n. sp. (p. G6).
   Holotype, USNM 157880: a–d, dorsal, oblique ventral, ventral, and right side views, respectively. × 3.

5–8. *Chiton (Chiton) rossi* Smith, Sohl, and Yochelson, n. sp. (p. G4).

5. Paratype, USNM 157881: a, oblique anterior view, × 3; b, posterior view, × 3; c, ventral view, × 1.5; d, oblique ventral view emphasizing posterior sinus, × 1.5.
6. Paratype, USNM 157882: a–d, oblique anterior, dorsal, ventral, and anterior views. × 3.
7. Paratype, USNM 157883: a, dorsal view, × 1.5; b, ventral view, × 1.5; c, interior view showing pores, × 3; d, oblique dorsal view showing details of slit, × 3.
8. Holotype, USNM 157884: a, anterior view; b, dorsal view; c, oblique dorsal view showing details of slit; d, ventral view. × 3.

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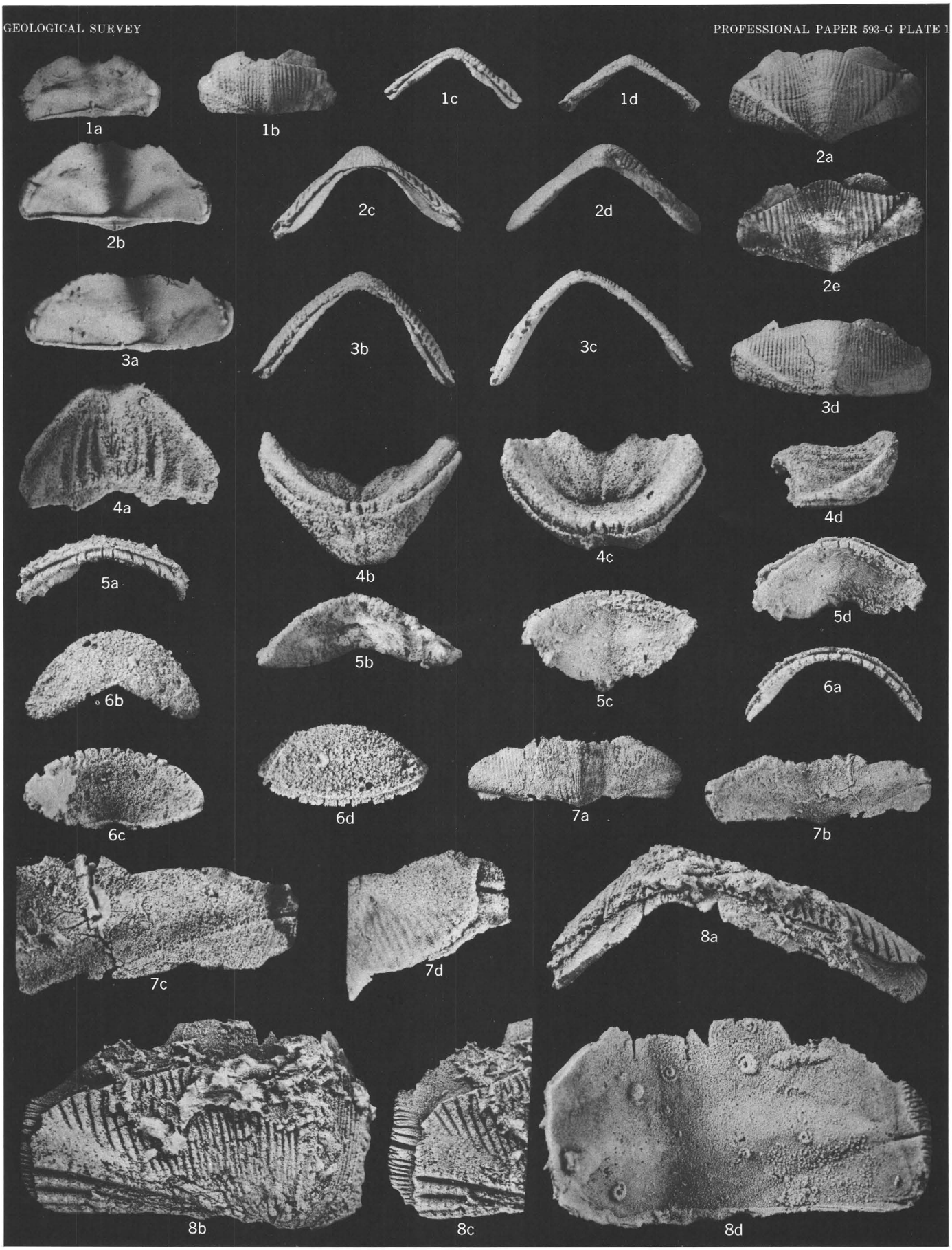

CHITON (CHITON) AND *AULACHOCHITON*