ABSTRACT—Abundant silicified polyplacophorans from numerous localities in the Ordovician in Kentucky and other localities in Virginia, Wisconsin, and Minnesota are described systematically. New species are: Spirochelodes cressanti, Calceochiton floweri, Precaenochiton baueri, Orthochiton recusus, Helminthochiton blackii, H. marginatus, and Alastege martini; new genera and species are: Listrochiton weiri, Litochiton crebatus, and Amblytochiton incomptus; and new families are Litochitonidae and Alastegidae. *Hemileucocella* *exposa* Ulrich and Bridge in Butts, 1941 and *Chelodes* cf. *C. mirabilis* (Butts, 1926), from the Chepulite Formation in Virginia are also described. Comparisons are made with *Chelodes whitehousei* Runnegar, Pojeta, Taylor, and Collins, 1979 from Australia and *Calceochiton hachiae* Flower, 1968 from New Mexico.

Listings of the fauna associated with the chitons are given for the Kentucky occurrences; taphonomic discussions of these are included.

INTRODUCTION

Of all Paleozoic mollusks, polyplacophorans are the least known and understood; this is especially true of their earliest history in Cambrian and Ordovician rocks. For this paper we have more specimens for study than had heretofore been available worldwide for Ordovician chitons. *Van Bellen* (1983) listed 10 generic names that had been applied to Ordovician polyplacophorans to that date. Subsequently, at least two additional generic names have been used (*Runnegar* et al., 1979; *Pojeta* et al., 2003). For the specimens described here, 11 generic names are used, three of which are new and two others which had not been applied to Ordovician chitons. This 42% increase brings the number of known Ordovician chiton genera to 17.

Most of the specimens available for this study were collected by paleontologists and geologists of the U.S. Geological Survey and Kentucky Geological Survey as part of the Cooperative Geologic Mapping Program of the Commonwealth of Kentucky, 1960–1978 (*Cressman* and *Noger*, 1981). The 17 tons (15,422 kg) of limestone yielded about 200,000 silicified Ordovician invertebrates (*Pojeta*, 1979a). The vast majority of the specimens are from Kentucky; however, a few are from Ohio and Indiana, and most of these are not silicified. The bulk of these fossils have been described in a series of monographs published as U.S. Geological Survey Professional Papers (1066A-P) edited by *Pojeta* (1979c–1995).

In Kentucky, the Ordovician lithostratigraphy, facies analyses, and environments of deposition of the rock units were dealt with by *Cressman* and *Karklins* (1970), *Cressman* (1973), *Cressman* and *Noger* (1976), and *Weir* et al. (1979, 1984). This information was summarized by *Pojeta* (1979c).

Biostratigraphic correlation of the Ordovician rocks of Kentucky, Indiana, and Ohio was conducted by the faculty and students at Ohio State University (*Sweet*, 1979; *Pojeta*, 1977c, 1984). *Sweet* (1984), *Leslie* (2000), and *Richardson* and *Bergström* (2003), among others, have considered the correlation of these rocks.

This paper is the fourth in a series of monographs dealing with the Ordovician mollusks from Kentucky and nearby states: 1) scaphopods (*Pojeta* and *Runnegar*, 1979); 2) monoplacophorans/bellerophonts (*Wahlman*, 1992); and 3) nautiloid cephalopods (*Frey*, 1995). Incidental to other studies, the rostroconchs were described by *Pojeta* and *Runnegar* (1976) as were some of the pelecypods (*Pojeta*, 1971, 1978, 1985, 1988, 1997; *Pojeta* and *Palmer*, 1976; *Pojeta* and *Runnegar*, 1985). *Wagner* (1990, p. 109–111) described a species of lophospirid gastropod.

Fifty-five thousand silicified mollusks were obtained using the method of *Pojeta* (1979c). Of these, 1,038 (1.9%) disarticulated silicified plates of Ordovician Polyplacophora were found from 18 localities (Appendix A) in the Inner Blue Grass Region of Kentucky. Thus, although widely distributed, polyplacophorans form a small part of the total molluscan fauna. The oldest polyplacophoran specimen found is a single plate from the Turonian (Blackriverian) Camp Nelson Limestone; the youngest specimen, also a single plate, is from the Chatfieldian Devils Hollow Member of the Lexington Limestone (*Frey*, 1995, p. 7) (Fig. 1). All of the specimens are Turonian or Chatfieldian (Mohawkian, Middle Ordovician) in age (*Leslie*, 2000, p. 1,124). The Kentucky specimens are classified in five new species placed in five genera, two of which are new (Fig. 1). Taphonomic discussion and listing of associated faunas are given in Appendix B and Table 13.

Morphology.—In several instances, head and tail plates are present along with the more numerous intermediate plates. Head and tail plates are often more difficult to differentiate in the *Paleolaricata* than in the *Neolaricata* where sutural laminae and/or insertion plates are present. Head plates range from flat to transversely arched, semiovall, being wider than long, to subrectangular in shape, longer than wide. The anterior and lateral slopes diverge from a posterior apex varying in steepness, depending on the magnitude of arching of the posterior margin. Ventrally, the posterior margin bears a short apical area or ridge. Tail plates are usually longer than wide, or subquadrate, but may be triangularly elongate in shape, and gently to strongly arched. A mucro is commonly present either at or just anterior to the posterior margin. A jugum may be present, but is uncommon. An embayment or sinus in the anterior margin may be present and an apical area is not present.

Preservation.—In general, the silicification of Kentucky Ordovician mollusks (*Pojeta* and *Runnegar*, 1979; *Wahlman*, 1992; *Frey*, 1995) is not as complete, or sturdy, as that of the brachiopods (*Neuman*, 1967; *Alberstadt*, 1979; *Howe*, 1979; *Pope*, 1982). As a working hypothesis, it is suggested that the differences in silicification reflect the original mineralogy of the shells—aragonite in most mollusks and calcite in most articulate brachiopods (*Carter*, 1990, p. 68, 77, 97, 117, 143, 181, 265). Other areas having silicified faunas in limestones need to be examined.

Diversity.—Only two or three species are known from any of the units indicating a low stratigraphic diversity during the Ordovician in the United States. Upper Paleozoic occurrences of polyplacophorans often show a greater diversity (e.g., *Hoare* and *Smith*, 1984; *Debrock* et al., 1984; *Houk*, 2001). *Cherns* (2004, p. 454, fig. 6) discussed and diagrammed the known diversity of Paleozoic paleolaric and neolaric chiton species and indicated a bias caused by a few detailed studies. Two major peaks of paleolaric, Lower Ordovician and Middle Silurian, are present. The present study raises the Middle Ordovician count by over 150%.

Stratigraphic summary.—The disarticulated plates from central Kentucky occur in Mohawkian rocks (Middle Ordovician), in
from the Hitt Canyon Formation of the El Paso Group in New Mexico and Oneota Dolomite in Wisconsin; Runnegar et al. (1979) from the Gasconade Dolomite in Missouri; Stinchcomb and Darrough (1995) from the Gasconade Dolomite in Missouri; Hoare (2000b) from the Oneota Dolomite in Minnesota and Odenville Formation in Alabama; Pojeta et al. (2003) from the Forreston Member, Grand Detour Formation in Wisconsin, and Vendrasco and Runnegar (2004) from the upper Gasconade Dolomite in Missouri.

**SYSTEMATIC PALEONTOLOGY**

The specimens included herein are reposited in the following places: 1) United States National Museum of Natural History (USNM); 2) New Mexico Museum of Natural History (NMMNH); 3) Department of Geology and Geophysics, University of Minnesota (UMPC); and 4) Queensland Museum, Australia (QM).

Eighteen localities (Appendix A) are in the Cambrian–Ordovician register of the U.S. Geological Survey (USGS) in Reston, Virginia, followed by a four-digit number and the letters CO, e.g., USGS 6034-CO; if the four-digit number is preceded by the letter ‘D,’ the locality is in the Cambrian–Ordovician register in the Denver catalog, e.g., USGS D-1138-CO. Additional locality details, including exact coordinates on the pertinent USGS geologic quadrangle maps, are given in USGS Professional Papers 1066A-P.

**Class Polyplacophora de Blainville, 1816**

**Diagnosis.**—Mollusks with a head, elongated body, and dorsal shell ordinarily consisting of eight articulated plates; shell surrounded by a muscular mantle border that is covered by a cuticle in which spicules are embedded.

**Occurrence.**—Upper Cambrian–Holocene.

**Subclass Paleoloricata Bergenhayn, 1955**

**Diagnosis.**—Polyplacophorans with thick plates with large apical areas; shell of two calcareous layers, the outer tegmentum and the inner hypostracum; articulamentum lacking, suture lamellae and insertion plates absent.

**Occurrence.**—Upper Cambrian–Lower Devonian.

**Order Chelodida Bergenhayn, 1943**

**Diagnosis.**—Paleoloricates with elongate intermediate body plates not differentiated into lateral and central areas.

**Occurrence.**—Upper Cambrian–Lower Devonian.

**Family Matthiavidae Walcott, 1886**


**Diagnosis.**—Chelodids with intermediate body plates significantly longer than wide, triangular in dorsal profile; apical area large; plates with significant overlap.

**Occurrence.**—Upper Cambrian–Lower Devonian.

**Genus Chelodes Davidson and King, 1874**

**Type species.**—Chelodes bergmani Davidson and King, 1874.

**Diagnosis.**—Following Cherns (1998a): intermediate plates wedge-shaped, arched, broad anteriorly, slowly tapering to a posterior point, which can be rounded; ventral apical area large, flattened to gently depressed, anterior edge roundly concave, not V-shaped, sinus shallow.

**Occurrence.**—Upper Cambrian–Lower Devonian.
ORDOVICIAN POLYPLACOPHORA FROM NORTH AMERICA

FIGURE 2—Chelodes cf. C. mirabilis (Butts, 1926). Chepultepec Formation, Virginia. 1–11, Intermediate plates; 1–4, dorsal, ventral, left lateral, and anterior views, USNM 523869; 5–7, dorsal, right lateral, and ventral views, USNM 523870; 8–11, dorsal, ventral, anterior, and left lateral views, USNM 523871; 12–19, tail plates, 12, ventral view showing pit near posterior end, USNM 523872; 13–15, dorsal, ventral, and right lateral views, USNM 523873; 16–19, left lateral, anterior, ventral, and dorsal views, USNM 523874. All figures X2.

CHELODES cf. C. MIRABILIS (Butts, 1926)

Description.—Large, thick, subtriangular plates; tail plate elongate with convex anterior margin, broadly convex posterolateral margins; lateral slopes steep posteriorly, more gentle anteriorly; posterior apex overhanging margin above convex posterior slope; ventral surface concave with indication of small pocket posteriorly leading towards apex.

Intermediate plates broadly convex transversely, with shallow, broad, anterior sinus; anterolateral corners narrowly rounded; posterolateral margins nearly straight or convex posteriorly; ventral surface more deeply concave in anterior one-third of length than posteriorly; apical area large, covering approximately one-third of length, extending laterally to near midlength.

Head plate unknown.

Material examined.—Three tail plates and three intermediate plates, USNM 523869–523874.

Occurrence.—Chepultepec Dolomite (Ibexian), at the south portal of the Natural Tunnel, Scott Co., Virginia. Butts’s holotype specimen is from the Odenville Limestone (Whiterockian) near Leeds, Alabama.

Discussion.—The coarse siliceous replacement of the specimens has obliterated details of the ornamentation and some of the structure. The dorsal surface was probably smooth. Chelodes cf. C. mirabilis differs from C. bergmani, C. gotlandicus Lindström, 1884, and C. actinis Cherns, 1998a by having a shallower anterior sinus and, in the case of the last species, a larger apical area in the intermediate plates. Tail plates cannot be compared because they are known only in C. cf. C. mirabilis. The head plate of C. mirabilis is unknown while that of C. actinis is flat and elongate in shape.

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† Estimated.
**SPICUCHELODES CRESSMANI** new species

Figure 3

**Diagnosis.**—Tail plate elongately triangular with a narrow border on posterior ventral surface; intermediate plates narrowly triangular, strongly arched transversely, with large V-shaped apical area enclosing a small pocket; head plate elongate oval.

**Description.**—Tail plate elongate, triangular, strongly arched transversely, with shallow sinus; lateral slopes gentle, extending from median angularity; ventral surface with distinct, flat, narrow border posteriorly becoming narrower extending to near midlength; narrow, rounded ridge, separated from flat border by narrow concave space which extends posteriorly above apex forming a small pocket anterior to flat border; smooth except for faint comarginal growth lines.

Intermediate plates elongate, triangular, strongly arched transversely; anterior margin with shallow sinus, posterolateral margins straight or slightly concave; lateral slopes gently convex extending from median angularity; ventral surface concave with shallow anterior concavity and large apical area with V-shaped anterior margin; with or without surface ornament and dorsal radial folds.

**Occurrence.**—Middle Ordovician (Turinian)—Middle Silurian (Wenlockian).

**Discussion.**—Spicuchelodes differs from Chelodes in the sharply triangular intermediate plates which have a more pointed posterior apex and the pronounced V-shaped anterior margin of the ventral apical area.

**SPICUCHELODES CRESSMANI** new species

Figure 3

**Diagnosis.**—Tail plate elongately triangular with a narrow border on posterior ventral surface; intermediate plates narrowly triangular, strongly arched transversely, with large V-shaped apical area enclosing a small pocket; head plate elongate oval.

**Description.**—Tail plate elongate, triangular, strongly arched transversely, gently arched longitudinally; anterior margin with shallow sinus; lateral slopes flat, extending from median angularity; ventral surface with distinct, flat, narrow border posteriorly becoming narrower extending to near midlength; narrow, rounded ridge, separated from flat border by narrow concave space which extends posteriorly above apex forming a small pocket anterior to flat border; smooth except for faint comarginal growth lines.

Intermediate plates elongate, triangular, strongly arched transversely; anterior margin with shallow sinus, posterolateral margins straight to slightly convex; lateral slopes gently convex extending from median angularity; ventral surface concave with shallow anterior concavity and large apical area with V-shaped anterior margin; with or without surface ornament and dorsal radial folds.

**Occurrence.**—Middle Ordovician (Turinian)—Middle Silurian (Wenlockian).

**Discussion.**—Spicuchelodes cressmani differs from the type species *S. pilatis* by the lack of a spiculoïde dorsal ornamentation and any indication of radial folds or central and lateral areas. Tail and head plates of the type species are unknown.

It has been possible to compare numerous specimens of *Chelodes whitehousei*, from the Datsonian (Upper Cambrian) Nina-maroo Formation of Queensland, Australia (Fig. 4), with several fragmental specimens of *Calceochiton hachitae* Flower, 1968 from the Ibexian (Lower Ordovician) Hit Canyon Formation of New Mexico (Fig. 5.22–5.25) which have somewhat similar shapes to *S. cressmani*. Also, numerous specimens of *Calceochiton* *floweri* n. sp. (Fig. 5.1–5.21) from the Lower Ordovician (Ibexian) Oneota Dolomite near Sauk City, Wisconsin, are available for study [Flower (1968) called these specimens *Calceochiton* cf. *C. gibberosum* (Sardeson, 1896)]. Unfortunately, the types of *Calceochiton hachitae* were not available for examination. Our fragmentary specimens of *C. hachitae* (Fig. 5.22–5.25), as well as the three specimens illustrated by Flower (1968), are difficult to compare with other taxa. However, the specimens from New Mexico are quite different from the Wisconsin specimens which had previously been placed in *C. hachitae* by Smith and Hoare (1987, p. 30).

In comparison with *Spicuchelodes cressmani*, the plates of *Calceochiton hachitae* and *C. floweri* are much thicker with a larger pocket beneath the apical area of the intermediate plates, a curved instead of V-shaped anterior margin of the apical area, and the plates are consistently narrower (compare Figs. 3, 5, and Flower, 1968, pl. 1, figs. 1–9).

*Chelodes whitehousei* also has much thicker plates than *Spicuchelodes cressmani* and has the anterior margin of the apical area curved instead of V-shaped. The tail plate is narrower, more sharply arched transversely, and often with a prominent overhang above the posterior margin. One of the tail plates of *C. whitehousei* shows evidence of breakage or predation (Fig. 4.8–4.11). The posterior end has been removed and the individual was able to secrete a new plate beneath the original. Evidently the damage to the shell-secreting mantle was not significant, or, the mantle was regenerated to be able to secrete new shell material. The head plate is subrectangular in shape rather than oval (Fig. 4.1–4.4).

**Etymology.**—For Earle R. Cressman, in acknowledgment of his outstanding work in studying, interpreting, and mapping the Middle Ordovician rocks of the Inner Blue Grass Region of Kentucky, and his extensive help in collecting the fossiliferous silicified blocks of rock used in this study.

**Figured types.**—Holotype, USNM 523886 (Fig. 3.29–3.31), USGS D-1138-CO; figured paratypes, USNM 523875–523882, USGS 6034-CO; 523883, 523885, 523887, USGS D-1138-CO.

**Unfigured paratypes.**—USNM 523888, USGS 5078-CO, one plate; USNM 523888A, USGS 5081-CO, one plate; USGS 523888B, USGS 6034-CO, 71 plates; USNM 523888C, USGS 6035-CO, 56 plates; USNM 523888D, USGS D-1138-CO, 144 plates.

Specimens include two tail plates, one head plate, and 282 intermediate plates.

**Measurements.**—See Table 2.

**Occurrence.**—Tyro and Camp Nelson limestones (Turinian) in Kentucky.
FIGURE 3—Spicachelodes cressmani n. sp. Tyrone Limestone, Kentucky. 1–27, Intermediate plates; 1–3, dorsal, ventral, and right lateral views, 6034-CO, USNM 523875; 4, 5, dorsal and ventral views, 6034-CO, USNM 523876; 6–8, dorsal, ventral, and right lateral views, 6034-CO, USNM 523877; 9–11, anterior, dorsal, and ventral views, 6034-CO, USNM 523878; 12, 13, dorsal and ventral views, 6034-CO, USNM 523879; 14–16, dorsal, anterior, and ventral views, 6034-CO, USNM 523880; 17–19, right lateral, dorsal, and ventral views, 6034-CO, USNM 523881; 20–22, dorsal, ventral, and anterior views, 6034-CO, USNM 523882; 23–25, left lateral, dorsal, and ventral views, D-1138-CO, USNM 523883; 26, 27, ventral and right lateral views, D-1138-CO, USNM 523884; 28–31, tail plates; 28, ventral view, D-1138-CO, USNM 523885, X3; 29–31, holotype, dorsal ventral, and left lateral views, D-1138-CO, USNM 523886, X3; 32–35, head plate, anterior, dorsal, ventral, and left lateral views, D-1138-CO, USNM 523887, X3. All figures X2 except where noted.
apical area extending one-half or more of length of plate forming a large pocket; shell thickest slightly posterior to anterior margin giving the anterior portion of the plate a scooplike shape (Fig. 5.3); dorsal surface smooth except for comarginal growth lines anteriorly.

Head and tail plates unknown.

Etymology.—For the late Rousseau H. Flower, who first studied these specimens and for his extensive paleontological and stratigraphic studies.

Figured types.—Holotype, NMMNH P-41263 (Fig. 5.19-5.23); paratypes, NMMNH P-41255-P-41262, P-41264.

Unfigured paratypes.—Over 100 specimens, P-41264.

Measurements.—See Table 3.

Occurrence.—Oneota Dolomite (Ibexian) in the vicinity of Sauk City, Sauk Co., Wisconsin.

Discussion.—The specimens here assigned to the new species *Calceochiton floweri* were placed in the species *C. cf. C. gibberosum* by Flower. In Sardeson’s 1896 paper, cited by Flower, the only taxon to which Sardeson (p. 102) applied the name “gibberosum” was what he considered to be a fragment of a cephalopod *Ascoceras gibberosum* which he named as a new species. Apparently, Flower did not agree with Sardeson’s placement of *A. gibberosum* in the Cephalopoda. The one specimen of *A. gibberosum* figured by Sardeson is illustrated by cartoonlike line drawings that show what he called septa. This specimen, and an unstated number of others in Sardeson’s possession in 1896, were discarded in 1911 (R. E. Sloan, oral commun., 2003). Examination of the specimens in the collection from Wisconsin described by Flower leaves considerable doubt that they are similar to the Sardeson’s specimen of *Ascoceras gibberosum* and they are here described as the new species *Calceochiton floweri*. Because of the lost specimens, and poor illustration, the name *Ascoceras gibberosum* Sardeson, 1896 should be restricted to the lost material and treated as a nomen dubium.

*Calceochiton floweri* differs from *C. hachitae* by being wider, more broadly rounded transversely, and developing a thicker shell just posterior to the anterior margin. The head and tail plates of *C. hachitae* are also unknown. Three fragmental specimens of *C. hachitae* are illustrated in Figure 5.22-5.25.

Spelman (1966, p. 100–102, pl. 20, figs. 10–25) found some poorly preserved chiton plates in the Stonehenge Limestone and Larke Dolomite in central Pennsylvania. The specimens from the Larke Dolomite (figs. 19–25) have the characteristics of *Calceochiton*, similar to *C. floweri*.

**Genus HEMITHECELLA Ulrich and Bridge in Butts, 1941**

*Type species.*—Hemithecella expansa Ulrich and Bridge in Butts, 1941.

*Diagnosis.*—Intermediate plates anteriorly broad transversely as in *Chelodes*; long narrow pocket beneath large apical area.

**Table 2**—Measurement (in mm) of *Spicuchelodes cressmani* n. sp.

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* Holotype.
† Estimated.

**Figure 4**—*Chelodes whitehousei* Runnegar, Pojeta, Taylor, and Collins, 1979. Ninmaroo Formation, Queensland, Australia. 1–4, Head plate, dorsal, anterior, and left lateral views, QMF 44551; 5–7, intermediate plate, dorsal, ventral, and right lateral views, QMF 44553; 8–11, tail plate, dorsal, posterior, right lateral, and ventral views of damaged plate (arrows indicate damaged area), QMF 44559. All figures X2.

**Occurrence.**—Ordovician (Ibexian).

**Hemithecella expansa** Ulrich and Bridge in Butts, 1941

*Figure 6*

*Hemithecella expansa* Ulrich and Bridge in Butts, 1941, p. 19, pl. 68, fig. 6; Runnegar, Pojeta, Taylor, and Collins, 1979, p. 1389, pl. 1, figs. 31, 32; Smith and Hoare, 1987, p. 28; Stinchcomb and Darrough, 1995, p. 58, figs. 6.7-6.15, 8.13, 8.14; Vendrasco and Runnegar, 2004, fig. 13.1–13.5.

Description.—Probable tail plate thick, subtriangular, flatly arched medially with steep convex lateral and posterior slopes; anterior margin shallowly concave, posterior margin gently convex; ventral surface broadly concave.

Intermediate plates triangular; anterior margin concave, lateral margins convex anteriorly becoming straighter posteriorly leading to pointed apex; dorsal surface convex; ventral surface concave leading posteriorly to long, narrow pocket under large apical area.

Head plate subquadrangular, strongly arched; anterior margin with shallow concavity arched dorsally; lateral margins convex, posterior margins shallowly concave, not pointed; ventral surface deeply concave with strong transverse ridge near midlength separating shallower anterior area from deeper posterior area; comarginal growth lines present laterally and anteriorly.

Measurements.—See Table 4.
FIGURE 5—Calceochiton floweri n. sp. Oneota Dolomite near Sauk City, Wisconsin. 1–21, Intermediate plates; 1, 2, dorsal and left lateral views, NMMNH P-41255; 3–5, anterior, dorsal, and ventral views, NMMNH P-41256; 6–8, dorsal, anterior, and ventral views, NMMNH P-41257; 9, 10, dorsal and ventral views, NMMNH P-41258; 11, 12, dorsal and ventral views, NMMNH P-41259; 13, 14, dorsal and ventral views, NMMNH P-41260; 15, 16, dorsal and ventral views, NMMNH P-41261; 17, 18, dorsal and ventral views, NMMNH P-41262; 19–21, holotype, dorsal, ventral, and right lateral views, NMMNH P-41263; 22–25, Calceochiton hachiae Flower, 1968, Hitt Canyon Formation, New Mexico. 22, 23, Intermediate plate fragment, ventral and anterior views, loc. 5500, NMMNH P-41251; 24, Intermediate plate fragment, ventral view, loc. 5500, NMMNH P-41252; 25, Intermediate plate fragment, ventral view, loc. 5500, NMMNH P-41253. All figures X3.

TABLE 3—Measurements (in mm) of Calceochiton floweri n. sp.

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* Holotype.
† Estimated.

Material examined.—One probable tail plate, two head plates, and 25 intermediate plates, USNM 523889–523899.

Occurrence.—Chepultepec Formation (Ibexian) at the south portal of the Natural Tunnel, Scott Co., Virginia. Also reported from the Gasconade Dolomite (Ibexian) in Missouri (Stinchcomb and Darrough, 1995).

Discussion.—All of the plates are incomplete to a greater or lesser extent and the coarse silicification distorts the surface and various characters. However, the general characteristics are unmistakable.

The holotype of H. expansa is an internal mold of an intermediate plate from the Gasconade Dolomite in Missouri (USNM
**FIGURE 6—Hemithecella expansa** Ulrich and Bridge in Butts, 1941. Chepultepec Formation, Virginia. 1–4, Head plate, dorsal, right lateral, posterior, and ventral views, USNM 523889; 5–24, intermediate plates; 5–7, ventral, right lateral, and anterior views, USNM 523890; 8, ventral view, USNM 523891; 9, ventral view, USNM 523892; 10–12, ventral, dorsal, and left lateral views, USNM 523893; 13–15, ventral, right lateral, and dorsal views, USNM 523894; 16–18, dorsal, ventral, and anterior views, USNM 523895; 19–22, dorsal, ventral, right lateral, and posterior views, USNM 523896; 23, 24, dorsal and left lateral views, USNM 523897; 25–29, tail plate, dorsal, ventral, left lateral, posterior, and anterior views, USNM 523898. All figures ×2.
Description.—Head plate strongly arched posteriorly; anterior margin convex rounding into convex lateral margins; posterior margin not observed; ventral surface deeply concave posteriorly; dorsal surface not observed.

Etymology.—For Carl Bauer, operator of Bauer's quarry, near Beloit, Wisconsin, who graciously allowed permission for collecting purposes. Access to the quarry is highly controlled requiring Mr. Bauer's permission.

Figured types.—Holotype, USNM 523969 (Fig. 7.27); paratypes, USNM 523958–523963, 523965, 523967, 523969–523072. Unfigured paratype.—Thirty-three specimens, USNM 523974.

Specimens include one head plate, two tail plates, and 43 intermediate plates.

Measurements.—See Table 5.

Occurrence.—Forreston Member, Grand Detour Formation, Platteville Group (Turinian), Bauer's Quarry west of Beloit, Rock County, Wisconsin.

Discussion.—Preacanthochiton baueri mainly differs from P. cooperi in lacking pustulose ornament. Molds of P. cooperi illustrated by Runnegar et al. (1979, pl. 2, figs. 62, 64) show a similar shape to some plates of P. baueri, although they are considerably smaller as in the tail plate illustrated by them (pl. 2, fig. 63). The specimens assigned by Bergenhayn (1960) to Preacanthochiton productus are placed in the new genus Listrochiton.

Preacanthochiton was included under doubtful Paleozoic genera by Van Belle (1975, p. 129) and was rejected as a chiton by him in 1983 (p. 154). Sirenko and Starobogatov (1977) believed that Preacanthochiton had not been demonstrated to be a chiton. Vendrasco and Runnegar (2004, p. 984) recognized the Preacanthochitonidae as valid polyplacophorans. The specimens herein placed in Preacanthochiton are clearly polyplacophorans, having head, intermediate, and tail plates, and apical areas. All specimens were collected by J. DuFoe, Rockton, Illinois, from the same bed as Echinochiton diffoi Pojeta, Eernisse, Hoare, and Henderson, 2003, p. 651, in Bauer's quarry.

Genus LISTROCHITON new genus

Type species.—Listrochiton weiri n. sp.


Diagnosis.—Plates thick, smooth; tail plate elongate, subrectangular, with weak jugum ending in a mucro just anterior to posterior margin, posterior margin arched dorsally; intermediate plates subtriangular with moderate to deep anterior sinus; head plate subcircular, coming to a point posteriorly.

Description.—Head plate semicircular, pointed posteriorly; intermediate plates subtriangular, moderatley arched, anterior margin concave; tail plate elongate, subrectangular, strongly arched, mucro anterior to posterior margin, concave ventral surface commonly having a pit beneath mucro.

Etymology.—Greek, listron, spade or shovel, chiton, tunic referring to the shape of the intermediate plates.

Occurrence.—Eminence Dolomite (Upper Cambrian) of Missouri; Lexington Limestone (Middle Ordovician) of Kentucky; and Gasconade Dolomite (Lower Ordovician) of Missouri.

Discussion.—Bergenhayn (1960) included elongated tail plates in his definition of Preacanthochiton. However, tail plates of P. cooperi, the type species of the genus, are broader, flatter, and semioval in shape, as shown by Runnegar et al. (1979, p. 1391, pl. 2, figs. 62–66), where they figured tail and intermediate plates of P. cooperi; whereas, the tail plate of Listrochiton is elongate and subrectangular (Fig. 8.34–8.49). The Cambrian Orthischiton Vendrasco and Runnegar, 2004 differs from Listrochiton by having straight-sided anterolateral margins on the intermediate plates.

Head plate strongly arched posteriorly; anterior margin convex rounding into convex lateral margins; posterior margin not observed; ventral surface deeply concave posteriorly; dorsal surface not observed.
Figure 7—Preacanthochiton baueri n. sp. Forreston Member, Grand Detour Formation, Wisconsin. 1, 2, Head plate, ventral mold, dorsal and right lateral views, USNM 523970; 3–25, intermediate plates; 3–6, dorsal mold, dorsal cast, left lateral cast, and anterior cast, USNM 523958; 7, dorsal mold, USNM 523965; 8, ventral mold, USNM 523962; 9, 10, dorsal and ventral molds, USNM 523971; 11–14, dorsal mold, dorsal cast, left lateral cast, and anterior cast, USNM 523959; 15, 18, dorsal and ventral molds, USNM 523963; 16, dorsal mold, USNM 523960; 17, dorsal mold, USNM 523966; 19, dorsal mold, USNM 523972; 20, dorsal mold, USNM 523961; 21, dorsal mold, USNM 523964; 22–25, dorsal mold, dorsal cast, left lateral cast, and anterior cast, USNM 523967; 26, 27, tail plates; 26, ventral mold, USNM 523973; 27, holotype, ventral mold, USNM 523969. All figures ×2.
vertical instead of sloping posterior end on tail plates with a terminal mucro, and a smaller circular head plate.

**LISTROCHITON WEIRI** new species

Figure 8

**Diagnosis.**—As for the genus.

**Description.**—Tail plate subrectangular, strongly arched transversely, having subparallel, slightly convex, lateral margins; posterior margin flatly convex, arched dorsally; anterior margin with shallow concavity; jugal area triangular, faintly set off from lateral areas, ending just anterior to posterior margin and simulating a mucro; narrow marginal ridge or plate thickening sometimes present ventrally on posterior margin; comarginal growth lines, when preserved, most prominent anterolaterally.

Intermediate plates subtriangular, flatly arched transversely; anterior margin with shallow to deep sinus and strong convex transversely; on ventral surface below mucro; head plate subquadrangular, anterior slope less steep; lateral margins convex, anterior margin narrowly concave posteriorly than anteriorly; ventral surface more deeply concave posteriorly than anteriorly; comarginal growth lines most evident anteriorly.

Head plate small, subsemicircular, broadly arched transversely; anterior margin flatly convex, arched slightly, curving uniformly into linear posterior margins leading to apex; ventral surface with large triangular apical area extending laterally to near midlength; comarginal growth lines most evident anteriorly.

**Etymology.**—For Gordon W. Weir, U.S. Geological Survey, in acknowledgment of his extensive work in studying, interpreting, and mapping the Upper Ordovician rocks of the Blue Grass Region of Kentucky, and his help in collecting the fossiliferous silicified blocks of the rock that made this study possible.

**Figured types.**—Holotype, USNM 523919 (Fig. 8.35–8.37), USGS 6915-CO; paratypes, USNM 523900, 523902–523905, 523910, 523911, 523918, 523920, USGS 6915-CO; USNM 523901, 523906–523909, 523915–523917, 523921, USGS 5916-CO; USNM 523912–523914, 523922–523924, USGS 5015-CO.

**Unfigured paratypes.**—USNM 523925, USGS 6915-CO, 253 plates; USNM 523925A, USGS 6916-CO, 190 plates; USNM 523925B, USGS 6138-CO, 15 plates; USNM 523925C, USGS 4928-CO, one plate; USNM 523925D, USGS 5036-CO, one plate.

Specimens include six head plates, 12 tail plates, and 46 intermediate plates.

**Measurements.**—See Table 6.

**Occurrence.**—Salvisa Bed, Perryville Limestone Member, Cornishville Bed, Perryville Limestone Member, Grier Limestone Member, and Devils Hollow Member, Lexington Limestone (Chattfieldian) in Kentucky.

**Discussion.**—*Listrochiton weiri* differs from *L. productus* (Bergenhayn, 1960) in that the tail plate has a more strongly elevated mucro at the end of a narrower jugal area.

The specimens shown in Figure 8.17–8.20 are difficult to interpret. First impressions suggest that each represents two articulated plates; however, it was not possible to discern two apical areas on either specimen. Thus, they are interpreted as single plates showing unusual anterior growth. Similar patterns of plate growth in the Silurian *Chelodes* and *Thaïrolepex* Chernels, 1988b, from Gotland, Sweden, are interpreted as indicating seasonal growth (Chernels, 1999, p. 174).

**Genus ORTHRIOCHITON** Vendrascó and Runnegar, 2004

**Type species.**—*Orthriochiton utahensis* Vendrascó and Runnegar, 2004.

**Emended diagnosis.**—Small; intermediate plates with straight side slopes; tail plate with posterior mucro, ventrally sloping posterior margin, and pit underneath mucro; head plate flat, subcircular to more elongate, and transversely convex.

**Occurrence.**—Upper Cambrian (Millardian)–Lower Ordovician (Ibexian).

**ORTHRIOCHITON RECAVUS** new species

Figure 9

**Diagnosis.**—Strongly arched plates; tail plate with a small pit on ventral surface below mucro; head plate subquadrangular; transversely convex.

**Description.**—Tail plate subrectangular, strongly arched transversely, slightly convex longitudinally; lateral slopes steep, convex, posterior slope steep, extending from mucro located one-fourth to one-fifth the length from posterior margin; anterior margin narrowly convex; ventral surface deeply concave with small pit under position of mucro; surface smooth except for comarginal growth lines.

Intermediate plates subtriangular, strongly arched transversely, thick; anterior margin strongly concave, posterolateral margins convex; greatest thickness posterior to midlength changing concavity of ventral surface, posterior portion less deep; surface smooth except for comarginal growth lines.

Head plate subquadrangular with steep lateral slopes, anterior slope less steep; lateral margins convex, anterior margin narrowly convex, posterior margin nearly straight; ventral surface more deeply concave posteriorly than anteriorly; comarginal growth lines faint.

**Etymology.**—Latin, *recaevus*, arched inward, concave.

**Figured types.**—Holotype, NMMNH P-41274 (Fig. 9.25–9.27); paratypes, NMMNH P-41265-P-41273, P-41275.

**Unfigured paratypes.**—Thirty-seven intermediate and tail plates, NMMNH P-41276.

Specimens include one head plate, four tail plates, and 43 intermediate plates.

**Measurements.**—See Table 7.

**Occurrence.**—Oneota Dolomite (Ibexian) in the vicinity of Sauk City, Wisconsin.

**Discussion.**—*Orthriochiton recaevus* differs from *O. utahensis* in having less sharply arched intermediate plates, a broad U-shaped anterior sinus instead of being deeply V-shaped, and are more triangular in shape. The tail plate posterior to the mucro is steeply convex rather than vertical.

The silicified specimens of *O. recaevus* studied are not well preserved. Some of the intermediate plates (Fig. 9.17, 9.18, 9.20–0.22) appear to be elongate rather than equidimensional in length and width. Other intermediate plates appear to be equidimensional (Fig. 9.8, 9.13). The anterior end of the head plate is probably incomplete (Fig. 9.1, 9.2). The apparent lack of an apical area on the intermediate plates is probably preservational.

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**Table 5**—Measurements (in mm) of *Preacanthochiton baueii* n. sp.

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* Holotype.
† Estimated.
FIGURE 8—Listrochiton weiri n. gen. and sp. Salvisa Bed, Perryville Limestone Member, Lexington Limestone, Kentucky. 1–5, Head plates; 1–3, dorsal, ventral, and posterior views, 6915-CO, USNM 523900; 4, 5, dorsal and right lateral views, 6916-CO, USNM 523901; 6–33, intermediate plates; 6, 7, dorsal and ventral views, 6915-CO, USNM 523902; 8, 9, dorsal and right lateral views, 6915-CO, USNM 523903; 10, dorsal view, 6915-CO, USNM 523904; 11, 12, dorsal and ventral views, 6915-CO, USNM 523905; 13, 14, dorsal and posterior views, 6916-CO, USNM 523906; 15, 16, dorsal and ventral views, 6916-CO, USNM 523907; 17, 18, dorsal and ventral views, 6916-CO, USNM 523908; 19, dorsal view, 6916-CO, USNM 523909; 20, dorsal view, 6915-CO, USNM 523910; 21, 22, dorsal and anterior views, 6915-CO, USNM 523911; 23, 24, right lateral and dorsal views, 5015-CO, USNM 523912; 25, 26, dorsal and ventral views, 5015-CO, USNM 523913; 27, dorsal view, 5015-CO, USNM
Family LITOCRITONIDAE new family

Type genus—Litochiton new genus.

Diagnosis.—Chelodids with strongly arched, thick plates, longer than wide with subparallel lateral margins; anterior margin concave; ventral surface with marked change in concavity; apical area a narrow ridge on posterior and posterolateral margins.

Occurrence.—Oneota Dolomite (Ibexian; Lower Ordovician), Minnesota.

Discussion.—The Litochitonidae is distinguished by the laterally subparallel elongate plates. The change in concavity on the ventral surface and narrow ridgelike apical area on the intermediate plates are much different from other families assigned to the Chelodida.

GENUS LITOCRITON new genus

Type species—Prochiton crebatus n. sp.

Diagnosis.—Smooth, thick, strongly arched intermediate plates; posterior margin bluntly convex to pointed; anterior margin with prominent sinus; apical areas narrow, ridgelike on posterior and lateral margins; prominent transverse change in concavity of ventral surface.

Description.—Intermediate plates smooth, subtriangular, thick, strongly arched, boxlike; anterior margin with deep sinus; posterior margins bluntly convex to pointed; apical area narrow, ridgelike on posterior and lateral margins; tail plate smooth, subrectangular, sharply arched; posterior margin convex, arched dorsally; narrow ridge bordering posterior and lateral margins ventrally; dorsal surface of plates with distinct comarginal growth lines.

Etymology.—Greek, litos, plain, simple; chiton, tunic.

Occurrence.—Oneota Dolomite (Ibexian; Lower Ordovician), Minnesota.

Discussion.—Monotypic Prochiton differs from Chelodida in lacking the large, triangular, apical area, the plates are more strongly and narrowly arched, and the shape of the plates is subrectangular rather than subtriangular. Litochiton has triangular intermediate plates. Thaëroplax has subparallel margins on the intermediate plates, but the plates are strongly pointed posteriorly with larger apical areas.

LITOCRITON CREBATUS new species

Figure 10

non Ascoceras gibberosum SARDESON, 1896, p. 102, pl. 6, figs. 8–10;
Powell, 1925, p. 69, pl. 7, figs. 13–17.


Diagnosis.—As for the genus.

Description.—Tail plate arched, subrectangular, side slopes flat; anterior margin with deep U-shaped sinus; lateral margins nearly straight, parallel; posterior margin bluntly convex, arched dorsally; ventral surface smooth, not thickened; border narrow, ridgelike on posterolateral parts of plate; dorsal surface smooth with numerous fine and coarse comarginal growth lines.

Intermediate plates longer than wide, strongly arched, side slopes convex; anterior margin with broad, thin sinus; lateral margins nearly straight, subparallel; posterior margin convex forming bluntly triangular termination; ventral surface with strong break in concavity, one-quarter the length from posterior margin; apical area narrow, ridgelike along posterior and lateral margins, rarely extending anteriorly across posteroventral surface; sometimes, narrow, deeper area borders anterior sinus ventrally; dorsal surface smooth with numerous comarginal growth lines.

Head plate unknown.

Etymology.—Latin, crebatus, thick.

Figured types.—Holotype, UMPC 8212 (Fig. 10.1–10.4); para-types, UMPC 8214, 8214A–C, 8215A, B, E.

Unfigured paratypes.—Nine plates, UMPC 8214.

Specimens include one tail plate and 18 intermediate plates.

Measurements.—See Table 8.

Occurrence.—Oneota Dolomite (Ibexian) near Rushford, Wisconsin Co., Minnesota.

Discussion.—The taxonomic status of the collection of specimens, here called Litochiton crebatus, has been misconstrued several times in the literature. Flower (1968) misunderstood Ascoceras gibberosum Sardean, 1896 (see discussion under Calceochiton floweri n. sp. above). Smith (in Smith and Toomey, 1964, p. 14), when examining what he thought to be the type specimen of A. gibberosum, reckoned that it belonged to the Chelodidae; however, he was uncertain of the assignment to Chelodes. When Smith examined the collection of 19 specimens, he assigned them to Chelodes gibberosus (Sardegan) (Smith and Hoare, 1987, p. 29). Herein, examination of the 19 specimens, plus three additional specimens located at the Science Museum of Minnesota, shows that they differ significantly from Chelodes, and from Sardegan’s illustrations of Ascoceras gibberosum; and it was learned that they are not Sardegan’s type specimens which were apparently discarded in 1911 (see Calceochiton floweri above). Labels with the 19 specimens may have been made by the collector, C. R. Stauffer, or someone else at a later date; these labels use Smith’s species designation, but note incorrectly that the specimens are gastropods.
Family HELMINTHOCHITONIDAE Van Belle, 1975

**Diagnosis.**—Septemchitonids with intermediate plates possessing an anterior sinus of variable depth; shape not triangular.

**Occurrence.**—Ordovician–Devonian.

**Genus HELMINTHOCHITON** Salter, 1846

**Type species.**—*Helminthochiton grijfithi* Salter, 1846.

**Diagnosis.**—Helminthochitonids with quadrangular to rectangular intermediate plates.

**Occurrence.**—Ordovician–Devonian.

**Discussion.**—The misapplication of *Helminthochiton* for upper Paleozoic taxa with sutural plates was detailed in Hoare (2002, p. 95).

**HELMINTHOCHITON BLACKI** new species

**Figure 11.1–11.28**

**Diagnosis.**—Thin, flatly arched intermediate plates with subparallel, straight lateral margins; jugal area present, not strongly pronounced; narrow apical area bordering posterior margins.

**Description.**—Tail plate, strongly arched with flat lateral slopes; lateral margins convex converging on a convex posterior margin; low mucro anterior to posterior margin.

Intermediate plates thin, smooth, shape variable, subquadrangular to rectangular, or pointed posteriorly making them hexagonal; flatly arched transversely; anterior margin with deep sinus; lateral margins essentially straight and subparallel; posterior margins straight to slightly concave, subparallel to anterior margin; central jugal area low, fairly distinct from lateral areas; ventral

**Table 7—Measurements (in mm) of *Orthriochiton recavus* n. sp.**

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* Holotype.
† Estimated.
FIGURE 11.—Litochiton crebatus n. gen. and sp. Oneota Dolomite, Kentucky. 1-4, holotype, dorsal, left lateral, posterior, and ventral views, UMPC 8212; 5-8, dorsal, ventral, left lateral, and posterior views, UMPC 8215A; 9-12, dorsal, right lateral, posterior, and ventral views, UMPC 8215E; 13, 14, dorsal and ventral views, UMPC 8215B; 15, ventral view, UMPC 8214A; 16, 17, anterior and dorsal views, UMPC 8214B; 18-21, tail plate, dorsal, left lateral, posterior, and ventral views, UMPC 8214C. All figures ×2.

surface with narrow apical area extending to juncture of posterior and lateral margins; faint comarginal growth lines.

Head plate unknown.

Etymology.—For D. F. B. Black, U.S. Geological Survey, for his extensive geologic mapping of the Ordovician rocks of Kentucky, and his help in collecting blocks of limestone containing silicified fossils.

Figured types.—Holotype, USNM 523927 (Fig. 11.3-11.5), USGS 6131-CO; paratypes, USNM 523926, 523928, 523930, 523933, 523934, USGS 6131-CO; USNM 523935, USGS 6134-CO; USNM 523932, USGS 5101-CO; USNM 523929, USGS 4959-CO; USNM 523931, USGS 5094-CO, one plate; USNM 523933, USGS 6134-CO, 15 plates.

Unfigured paratypes.—USNM 523936A, USGS 6131-CO, 24 plates; USNM 523936B, USGS 5094-CO, one plate; USNM 523936C, USGS 5096-CO, two plates; USNM 523936D, USGS 5101-CO, one plate; USNM 523936E, USGS 4959-CO, one plate; USNM 523936F, USGS 6134-CO, 15 plates.

Specimens include one tail plate and 53 intermediate plates.

Measurements.—See Table 9.

Occurrence.—Forreston Member, Grand Detour Formation, Platteville Group (Turinian), Bauer’s Quarry west of Beloit, Rock County, Wisconsin. From the same bed as Echinichiton dufrei.

Discussion.—Helminthochiton blacki differs from the European H. griffithi, H. grayanus de Koninck, 1860, H. thraivensis Reed, 1911, and H. aequituba Robson, 1913 in having much more flatly arched plates. In general, the intermediate plates of H. grayanus compare closely, in terms of the subquadrangular shape, to those of H. blacki.

All species previously assigned to this genus from upper Palaeozoic rocks have sutural laminae and are now placed in Gryphochiton Gray, 1847. The Helminthochitonidae Van Belle, 1975 range as Ordovician–Devonian.

HELMINTHOCHITON MARGINATUS new species

Figure 12

Diagnosis.—Tail plate oval with mucro located anterior to posterior margin; intermediate plates longer than wide, arched, with distinct jugum.

Description.—Tail plate arched, oval, elongate, widest and highest posteriorly; jugal area narrow, mucro one-third of length anterior of posterior margin; posterior margin convex; lateral margins convex converging towards narrowly convex anterior margin; ventral surface not observed; dorsal surface with prominent comarginal growth lines.

Intermediate plates longer than wide, subrectangular, moderately arched; anterior margin with prominent sinus, anterolateral margins sharply convex; lateral margins nearly parallel; posterior margins convex, not pointed; dorsal surface with distinct jugum; lateral areas concave marked by faint radial lines extending from apex, with prominent comarginal growth lines; ventral surface deeply concave beneath jugal area; apical area narrow, extending to junction of posterior and lateral margins.

Head plate arched posteriorly; anterior margin convex rounding smoothly into flatly convex lateral margins, posterior margin nearly straight; side slopes on ventral surface concave, venter deeply concave medially.

Etymology.—Latin, marginatus, furnished with a border.

Figured types.—Holotype, USNM 523981 (Fig. 12.18-12.21); paratypes, USNM 523975-523980, 523982, 524902-524904.

Unfigured paratypes.—Eleven specimens, USNM 524904A.

Specimens include one head plate, one tail plate, and 20 intermediate plates.

Measurements.—See Table 10.

Occurrence.—Forreston Member, Grand Detour Formation, Platteville Group (Turinian), Bauer’s Quarry west of Beloit, Rock County, Wisconsin. From the same bed as Echinichiton dufrei.

<table>
<thead>
<tr>
<th>Plate</th>
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<th>Width</th>
<th>Height</th>
<th>Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>8212*</td>
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<tr>
<td>8214A</td>
<td>10.8</td>
<td>9.3</td>
<td>5.8</td>
<td>1</td>
</tr>
<tr>
<td>8214B</td>
<td>12.2</td>
<td>10.0</td>
<td>6.8</td>
<td>1</td>
</tr>
<tr>
<td>8214C</td>
<td>12.3†</td>
<td>8.8</td>
<td>5.2</td>
<td>T</td>
</tr>
<tr>
<td>8215A</td>
<td>13.4</td>
<td>8.4</td>
<td>6.9</td>
<td>I</td>
</tr>
<tr>
<td>8215B</td>
<td>13.1</td>
<td>10.4†</td>
<td>7.1</td>
<td>I</td>
</tr>
<tr>
<td>8215E</td>
<td>12.7</td>
<td>9.8</td>
<td>6.0</td>
<td>I</td>
</tr>
</tbody>
</table>

* Holotype.
† Estimated.

5101-CO, one plate; USNM 523936E, USGS 4959-CO, one plate; USNM 523936F, USGS 6134-CO, 15 plates.
Discussion.—*Helminthochiton marginatus* occurs with *Preecanthochiton baueri* n. sp. and is readily distinguished in later growth stages by the difference in growth patterns. Both species have subquadrangular intermediate plates with less distinct jugal areas in early growth stages (compare Figs. 7, 12). Whereas *P. baueri* continues to develop subquadrangular plates with a weak jugal area in latter growth, *Helminthochiton marginatus* develops subrectangular plates with a distinct, narrower, jugal area and becomes sharply arched.

In shape, *H. marginatus* is similar to Silurian species of *Thairoplax*, such as *T. pelta* Cherns, 1998b, *T. birhombivalis* Bergenhayn, 1955, and *T. merriami* Hoare, 2000a; however, these species of *Thairoplax* have prominent pointed shapes and large apical areas. Species of *Paleochiton* Smith in Smith and Toomey, 1964

---

**Figure 11**—*Helminthochiton blacki* n. sp. Curdsville and Grier Limestone members, Lexington Limestone, Kentucky. 1–25, Intermediate plates; 1, 2, dorsal and anterior views, 6131-CO, USNM 523926; 3–5, holotype, dorsal, ventral, and left lateral views, 4959-CO, USNM 523927; 6–8, dorsal, ventral, and left lateral views, 6131-CO, USNM 523928; 9, 10, dorsal and ventral views, 4959-CO, USNM 523929; 11–13, dorsal, ventral, and posterior views, 6131-CO, USNM 523930; 14–16, right lateral, dorsal, and ventral views, 5096-CO, USNM 523931; 17–19, dorsal, ventral, and anterior views, 5101-CO, USNM 523932; 20–22, left lateral, dorsal, and ventral views, 6131-CO, USNM 523933; 23–25, dorsal, ventral, and anterior views, 6131-CO, USNM 523934; 26–28, tail plate, posterior, dorsal, and ventral views, 6134-CO, USNM 523935. All figures X3.
have more strongly arched intermediate plates with distinct apical areas and the tail plate is narrowly elongate, as in the Silurian \( P. \) *siskiyouensis* Hoare, 2000a. Kluessendorf (1987) described several Silurian chiton morphotypes from Wisconsin, Illinois, and Iowa, based upon internal molds. None of these approach \( H. \) *marginatus* in shape.

**Family ALASTEGHDAE** new family

*Type genus.*—*Alastega* Cherns, 1998b.

* Included genera.*—The type genus and *Amblytochiton* n. gen.

*Diagnosis.*—Small septemchitonids with strongly to broadly arched plates; head plate subrectangular; intermediate plates with anterior sinus, triangular, not quadrangular or rectangular in shape; tail plate arched posteriorly.

**Occurrence.**—Ordovician (Turinian) of North America and Silurian (Wenlockian) of Sweden.

**Discussion.**—Taxa of the Alastegiidae differ from other families of the Septemchitonida by the relatively short, broadly triangular, thin intermediate plates and posteriorly arched tail plates.

**Genus ALASTEGA** Cherns, 1998b

*Diagnosis.*—Alastegiids with large apical areas on intermediate plates.

**Occurrence.**—As for the family.

**ALASTEGA MARTINI** new species

*Figure 13*

*Diagnosis.*—Tail plate smooth, elongate, narrowly subtriangular, roundly arched transversely, posterior margin arched dorsally;
intermediate plates roundly arched, broad triangularly, pointed with deep anterior sinus; head plate strongly arched, pointed.

Description.—Tail plate roundly arched transversely, narrow, subtriangular, anterior margin with moderately deep sinus, lateral margins broadly convex, curving more strongly posteriorly to apex; posterior ventral margin arched dorsally with narrow thickened margin, no distinct jugal area, lateral slopes convex; ventral surface smooth; comarginal growth lines present.

Intermediate plates thin, roundly arched, broadly triangular, pointed; anterior margin with deep sinus; anterolateral margins sharply projecting, leading to straight or slightly convex postero-lateral margins, ending in a posterior apex; ventral surface with distinct, large, apical area becoming narrower laterally, extending to or past midlength; comarginal growth lines present.

Head plate subquadrangular, strongly arched transversely; anterior margin with shallow sinus; lateral and posterior margins flatly convex; ventral surface with large, triangular apical area extending laterally to junction of lateral and posterior margins; prominent comarginal growth lines.

Etymology.—For Martin Pojeta, brother of John Pojeta Jr.
Table 11—Measurements (in mm) of Alastega martini n. sp.

<table>
<thead>
<tr>
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<th>Height</th>
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<td>10.3</td>
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</tr>
<tr>
<td>523938</td>
<td>11.3</td>
<td>10.5</td>
<td>4.2</td>
<td>I</td>
</tr>
<tr>
<td>523940</td>
<td>7.5</td>
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<td>4.0</td>
<td>I</td>
</tr>
<tr>
<td>523939</td>
<td>10.0</td>
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<td>4.3</td>
<td>I</td>
</tr>
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</tr>
<tr>
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<td>3.5</td>
<td>I</td>
</tr>
<tr>
<td>523943</td>
<td>11.3</td>
<td>11.0</td>
<td>—</td>
<td>I</td>
</tr>
<tr>
<td>923945*</td>
<td>14.2</td>
<td>7.3</td>
<td>4.0</td>
<td>T</td>
</tr>
</tbody>
</table>

* Holotype.
† Estimated.

**Figure 14**—Amblytochiton incomptus n. gen. and sp. Tyrone Limestone, Kentucky. 1–4, Head plate, dorsal, ventral, anterior, and right lateral views, 6034-CO, USNM 523947; 5–16, intermediate plates; 5, 6, dorsal and anterior views, 6034-CO, USNM 523948; 7, dorsal view, 6034-CO, USNM 523949; 8, dorsal view, 6034-CO, USNM 523950; 9, 10, dorsal and ventral views, 6034-CO, USNM 523951; 11, 12, dorsal and ventral views, 6034-CO, USNM 523952; 13, dorsal view, 6034-CO, USNM 523953; 14, 15, dorsal and right lateral views, 6034-CO, USNM 523954; 16, dorsal view, 6034-CO, USNM 523955; 17–20, tail plate, holotype, dorsal, left lateral, posterior, and ventral views, 6034-CO, USNM 523956. All figures ×3.

Intermediate plates subtriangular, flatly arched transversely; anterior margin with shallow to moderately deep sinus; lateral margins convex, converging posteriorly; posterior margins nearly straight, pointed; ventral surface with low, narrow apical area tapering laterally to junction of posterior and lateral margins; comarginal growth lines present.
Head plate subquadangular, flatly arched; anterior and lateral margins flatly convex, posterior margin unknown; anterior margin slightly arched dorsally; ventral surface with indication of an apical area extending laterally to midlength.

**Etymology.**—Latin, in, without; **comptus**, adorned.

**Figured types.**—Holotype, USNM 523956 (Fig. 14.17–14.20), USGS 6034-CO; paratypes, USNM 523947–523955.

**Unfigured paratype.**—USNM 523957.

Specimens include one head plate, one tail plate, and nine intermediate plates.

**Measurements.**—See Table 12.

**Occurrence.**—Tyro Limestone (Turinian) in Kentucky.

**Discussion.**—None of the plates of *A. incomptus* is complete; however, the characters, when pieced together, provide the basis for distinguishing the species.

**ACKNOWLEDGMENTS**

We appreciate the assistance of A. B. Heckert, New Mexico Museum of Natural History, J. Hoff and K. C. Rogers, Science Museum of Minnesota, and D. L. Fox, Department of Geology and Geophysics, University of Minnesota, for facilitating the loan of specimens. Likewise, P. Jell and K. Spring, Queensland Museum, Brisbane, Australia, graciously gave us an extended loan of specimens. B. S. Kues, University of New Mexico, was helpful with our study of Flower’s locality. R. E. Sloan, Department of Geology and Geophysics, University of Minnesota, provided helpful information concerning some of the Minnesota specimens. J. DuFoe generously gave us the specimens he collected from near Beloit, Wisconsin; J. and M. L. Pojeta spent two days in the field with him. We thank C. Bauer for allowing DuFoe and the Pojetas to collect in his quarry. M. Balanc, USGS, picked through the silicified residues from Kentucky separating the various major taxa. S. M. Kidwell, Department of Geophysical Sciences, University of Chicago, read a draft of the taphonomic sections. We are grateful for the identification of the associated invertebrate faunas by E. L. Yochelson, R. B. Neuman, J. M. Berdan, and W. A. Oliver Jr., all of the U.S. Geological Survey. M. Parrish, Department of Paleobiology, Smithsonian Institution, drafted Figure 1. The paper benefited from reviews by T. J. Dutro Jr. and J. E. Repetski, U.S. Geological Survey, L. Chetns, Department of Earth Sciences, Cardiff University, P. Jell, Queensland Museum, and an anonymous reviewer.

**REFERENCES**


ORDOVICIAN POLYPLOID PHORA FROM NORTH AMERICA


RICHARDSON, G. J., AND S. M. BERGSTROM. 2003. Regional stratigraphic relations of the Trenton Limestone (Chattahelian, Ordovician) in the
APPENDIX A

COLLECTION LOCALITIES IN KENTUCKY

USGS 5078-CO. Camp Nelson Limestone exposed along road up from Kentucky River lock number 7 to High Bridge, Kentucky, and junction with Kentucky Route 29, Jessamine Co., Wilmore Quadrangle. Sample from 8.54 m above base of section. (Same locality as USGS 7875-CO.)

USGS 5081-CO. Tyrone Limestone exposed in road and railroad cuts along road towards Kentucky utilities plant on east side of Blackburn Memorial Bridge Crossing Kentucky River, Woodford Co., Tyrone Quadrangle. Sample from float 10.68 m below top of limestone.

USGS 6034-CO. Tyrone Limestone exposed on New Watts Mill Road, 0.14 km northwest of intersection with Kentucky Route 39, Jessamine Co. Sample from 34.2 m above base of section. Section G of Cressman and Noger (1976), very near the top of the exposure (marked by the letter "J"), immediately below the Pencil Cave Bentonite of Drillers [= Deicke K Bentonite; Kolata et al. (1996, p. 26); Leslie (2000) and Saltzman et al. (2003)]. Also, locality 6034-C is marked by the letters "AAA" on the geologic map of the Little Hickman Quadrangle (Wolcott, 1969).

USGS 6035-CO. Tyrone Limestone. Same locality as USGS 6034-CO. Sample from 27.1 to 28.7 m above base of section.

USGS D-1138-CO. Tyrone Limestone exposed in creek to west and parallel with Marble Creek northwest of the YMCA Camp, Jessamine Co. Sample from 8.8 m above base of unit. USGS D-1138-CO is marked by the letter "B" on the geologic map of the Valley View Quadrangle (Greene, 1966).

USGS 5101-CO. Lower part of the Curdsville Limestone Member, Lexington Limestone, exposed on Kentucky Route 169 just west of Hickman Creek crossing, Fayette Co. Sample from lower portion of limestone. USGS 5101-CO is not marked on the geologic map of the Nicholasville Quadrangle (MacQuown, 1968).

USGS 6134-CO. Lower part of the Curdsville Limestone Member, Lexington Limestone, exposed in road 0.32 km west of Dix River crossing of Kentucky Route 52, Garrard Co. Sample from lower 0.92 m of member. USGS 6134-CO is marked on the geologic map of the Bryantsville Quadrangle by the letter 'H' (Wolcott and Cressman, 1971).

USGS 6131-CO. Upper part of the Curdsville Limestone Member, Lexington Limestone, exposed on Kentucky Route 33 just north of bridge crossing of Mocks Branch, 4.02 km north of Danville, Franklin Co. Sample from 7 m above Tyrone-Lexington contact. USGS 6131-CO is marked with a red 'X' on the graphic stratigraphic column on the geologic map of the Danville Quadrangle (Cressman, 1972).

USGS 4928-CO. Grier Limestone Member, Lexington Limestone exposed 0.81 km east and 2.58 km south of northwest corner of Salvisa Quadrangle, Anderson Co. Sample from 6.7 km below base of Brannon Member.

USGS 4959-CO. Grier Limestone Member, Lexington Limestone, exposed in road on west side of Kentucky River at bridge crossing of Central Kentucky Parkway, on north side of parkway, Anderson Co. Sample from 45.4 to 46.4 m above Tyrone Limestone. USGS 4959-CO is from just below the top of the Grier Limestone Member from Cressman's (1973, pl. 1) Salvisa B section (= Section 176) and is marked by the letter 'B' on the geologic map of the Salvisa Quadrangle. Specimens were not counted, they are placed in nine species.

USGS 5094-CO. Grier Limestone Member, Lexington Limestone, exposed in road cuts along Devils Hollow Road 1.1 km south of Buttimmer Hill, Franklin Co. Frankfort West Quadrangle. Sample from 13.7 m above Macedonio Bed.

USGS 5096-CO. Grier Limestone Member, Lexington Limestone, exposed in abandoned railroad bed near top of north bluff of Kentucky River 0.64 km southeast of YMCA Camp, near the notation "YMCA Camp" on the geologic map of the Valley View Quadrangle (Greene, 1966), just east of the Kentucky River Fault, Jessamine Co. Sample from near top of bluff.

USGS 6136-CO. Fauconier Bed, Perryville Limestone Member, Lexington Limestone, exposed in roadcut on Kentucky Route 52, 2.33 km east of junction with U.S. Route 150, 0.24 km east of crossing of Kentucky Route 52 and Banks Branch Run, Boyle Co., Bryantsville Quadrangle. Sample from basal 0.92 to 1.2 m of member.

USGS 5015-CO. Salvisa Bed, Perryville Limestone Member, Lexington Limestone, exposed in quarry 0.64 km south of Perryville on east side of Mitchellsburg Road, east side of Chaplin River, Boyle Co. Sample from 1.53 m above base of bed. On the geologic map of the Perryville Quadrangle, Cressman (1974) labeled USGS 5015-CO, 6915-CO, and 6916-CO with the letters 'B', 'C', and 'D'. Cressman (1973, p. 6 and 24) named, numbered, and described the sections from which the collection came as Perryville Section A (= Perryville North), Section 30A (USGS 6915-CO and 6916-CO) and Perryville Section B (= Perryville South), Section 30B (USGS 5015-CO).

USGS 6915-CO. Salvisa Bed, Perryville Limestone Member, Lexington Limestone, exposed in Boyle County quarry on the west side of U.S. Route 68, 2.1 km northeast of Perryville, Boyle Co., Perryville Quadrangle. Sample from basal 0.61 m of bed on northwest wall of quarry.

USGS 6916-CO. Salvisa Bed, Perryville Limestone Member, Lexington Limestone. Same locality as USGS 6915-CO. Sample from east wall of quarry.

USGS 6138-CO. Comishville Bed, Perryville Limestone Member, Lexington Limestone. Same locality as 6136-CO. Sample from 4.9 m above Perryville-Tanglewood Members contact.

USGS 5036-CO. Devils Hollow Member, Lexington Limestone, exposed in stream on Squires Road 2.9 km southwest of intersection with U.S. Route 421 (upstream 0.3 km), Fayette Co., Colestown Quadrangle. Sample from 18.3 m above base of Brannon Member.

APPENDIX B

TAPHONOMY OF SILICIFIED KENTUCKY ORDOVICIAN CHITON-BEARING SHELL BEDS

Using probable environments of deposition, silicified Kentucky Ordovician mollusk-rich chiton-bearing shell beds can be grouped into those occurring in very shallow nearshore subtidal, lagoonal, and open marine deposits (Table 13).

Nearshore subtidal deposits.—The oldest abundant fauna is found in the Tyrone Limestone (USGS 6034-CO and D-1138-CO). The Tyrone Limestone accumulated in quiet shallow water and was periodically exposed to the air (Cressman, 1973, p. 13). Cressman and Noger (1976) concluded that the Camp Nelson and Tyrone limestones (High Bridge Group) were deposited in tidal flat and immediate subtidal carbonate environments analogous to those seen today in the Bahamas and Florida Bay. Mollusks dominate these biopsamptite shell beds, being represented by 5,332 specimens placed in 36 species. The molluscan fauna is dominated by pteriomorph pelecypods and gastropods. Of the 5,320 pelecypods, 2,218 are pteriomorphs, of which 2,000 belong to the single species Terydonta subovata Ulrich, 1894a. The gastropods total c. 2,593 specimens, but have not been studied in detail. The pelecypods are disarticulated as are the polyplacophorans. Most of the cephalopods are pieces of phragmocome or siphuncle; one nearly complete Oncoceras Hall, 1847 was found (Frey, 1995, pl. 19, figs. 11–14). Not all mollusk specimens could be identified to species, because some are small fragments probably resulting from incomplete silicification.

The nonmolluscan fauna is sparse both in number of species and diversity. The specimens were not counted, they are placed in nine species.

The overlying bentonite is assumed to account for the silicification of the fossils in this bed. The beds immediately below USGS 6034-CO are micrites and pelmicrites having mud cracks and some brecciated layers, and generally lack fossils. USGS 6034-CO is the most mollusk-rich shell bed of any of the 1,100 collections made during the Kentucky mapping project. A total of 12,500 fossils were obtained; 10,000 of these are mollusks that are not weathered or worn.

USGS D-1138-CO is also from high in the Tyrone Limestone below bentonite bands and the fossils are silicified. This collection is essentially in the same stratigraphic position, and has much the same lithology as USGS 6034-C. The two collections are on adjacent east-west quadrangles. The shell bed at USGS D-1138-CO has much greater abundance of the tabulate coral T. cellulosum of the tabulate coral (Hall, 1847) (identified by W. A. Oliver, USGS) and lacks the numerous pelecypods and cephalopods occurring in very shallow nearshore subtidal, lagoonal environments analogous to those seen today in the Bahama and Florida Bay.

Specimens were not counted, they are placed in nine species. The nonmolluscan fauna is sparse both in number of species and diversity. The specimens were not counted, they are placed in nine species.
Table 13—Summary of number of species, specimens, and weight of rock digested in the taphonomic analysis of Kentucky localities. ? = specimens not counted or identified.

<table>
<thead>
<tr>
<th>Fauna</th>
<th>Number of species</th>
<th>Number of specimens</th>
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<tr>
<td><strong>NEARSHORE SUBTIDAL DEPOSITS</strong></td>
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<tr>
<td>Tyrone Limestone; 6034-CO [665.9 kg (1,468 lbs)] and D-1138-CO [90.9 kg (200 lbs)]</td>
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<tr>
<td>chitons</td>
<td>2</td>
<td>238</td>
</tr>
<tr>
<td>pteriomorph pelecypods</td>
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<td>55</td>
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<tr>
<td>nautiloids</td>
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</tr>
<tr>
<td>gastropods</td>
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<td>2,593</td>
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<tr>
<td>bellerophonts</td>
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</tr>
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<td>Total mollusks</td>
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<td>2</td>
</tr>
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<td>few frags.</td>
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<tr>
<td>corals</td>
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<td>7</td>
</tr>
<tr>
<td>ostraecodes</td>
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<td>?</td>
</tr>
<tr>
<td>Total other fauna</td>
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<td><strong>LAGOONAL DEPOSITS</strong></td>
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<td>Salvisa Bed; 5015-CO [645.5 kg (1,423 lbs), 6915-CO [241.3 kg (532 lbs), and 6916-CO [107 kg (236 lbs)]</td>
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<td>chitons</td>
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<td>few frags.</td>
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<tr>
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<td>92 (5015-CO only)</td>
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<tr>
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<td>1,444</td>
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</tr>
<tr>
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<td>frags.</td>
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<td>trilobites</td>
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<td>?</td>
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<td>7</td>
<td>?</td>
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<tr>
<td>Total other fauna</td>
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<td><strong>OPEN-MARINE DEPOSITS</strong></td>
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<tr>
<td>Lower part of the Curdsville Limestone Member; 5101-CO [362.4 kg (799 lbs)] and 6134-CO [286.7 kg (632 lbs)]</td>
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<td></td>
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<tr>
<td>chitons</td>
<td>18</td>
<td></td>
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<td>pteriomorph pelecypods</td>
<td>2</td>
<td>532</td>
</tr>
<tr>
<td>palaeotaxodont pelecypods</td>
<td>3</td>
<td>39</td>
</tr>
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<td>heterodont pelecypods</td>
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<td>32</td>
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<td>other pelecypods</td>
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<td>2</td>
</tr>
<tr>
<td>nautiloids</td>
<td>7</td>
<td>few frags.</td>
</tr>
<tr>
<td>gastropods</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>monoplacophorans/bellerophonts</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>Total mollusks</td>
<td>20</td>
<td></td>
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<tr>
<td>orthid brachiopods</td>
<td>5</td>
<td>13 (5101-CO only)</td>
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<td>rhyynchonellid brachiopods</td>
<td>1</td>
<td>25 (5101-CO only)</td>
</tr>
<tr>
<td>strophomenid brachiopods</td>
<td>2</td>
<td>4 (5101-CO only)</td>
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<tr>
<td>spiriferid brachiopods</td>
<td>1</td>
<td>10 (5101-CO only)</td>
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<td>pteriomorph brachiopods</td>
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<td>Total brachiopods</td>
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<td>echiurans</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>receptaculitids</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total other fauna</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Upper part of the Curdsville Limestone Member; 6131-CO [320.7 kg (707 lbs)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chitons</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>pteriomorph pelecypods</td>
<td>2</td>
<td>1,254</td>
</tr>
<tr>
<td>palaeotaxodont pelecypods</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>nautiloids</td>
<td>3</td>
<td>few frags.</td>
</tr>
<tr>
<td>gastropods</td>
<td>3</td>
<td>?</td>
</tr>
<tr>
<td>monoplacophorans/bellerophonts</td>
<td>2</td>
<td>?</td>
</tr>
<tr>
<td>Total mollusks</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>orthid brachiopods</td>
<td>4</td>
<td>?</td>
</tr>
<tr>
<td>strophomenid brachiopods</td>
<td>2</td>
<td>?</td>
</tr>
<tr>
<td>rhyynchonellid brachiopods</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>spiriferid brachiopods</td>
<td>1</td>
<td>?</td>
</tr>
<tr>
<td>Total brachiopods</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

Bed resembles much of the limestone in the Tyrone Limestone” (Cressman, 1973, p. 25). “Microscopically, the light-colored calcite is ranges from featureless micrite to pelmizite in which occur micrite micrite pellets” (Cressman, 1973, p. 28). Cressman (1973, p. 28–30) noted that the Salvisa Bed was deposited in shallow quiet water, no more than 1.83 m (6 ft) deep, protected by calcarenite bars of the contemporaneous Tanglewood Limestone Member, Lexington Limestone. Probably these bars restricted circulation, causing higher salinities during Salvisa deposition. Thus, it is likely that the silicified shell beds in the Salvisa Bed were deposited in a lagoonalike environment.

The rocks are petrolierous beds of calcilutite 5–15 cm (2–6 in.) thick, and differ markedly from the underlying and overlying units which contain calci-silicate or have nodular bedding. The color of Salvisa rocks ranges from light to dark gray. Fossils are common. The lightest-colored beds yielded few fossils. The darkest-colored beds are the most petrolierous and the fossils are broken and fragmented and the fauna is dominated by bryozoans and contains ostraecodes. The intermediate-colored beds yielded the most whole fossils; in these beds, the whole shells were at various angles to bedding and the pelecypods were both convex side up or down. The polyplacophorans are disarticulated; this is also largely the case with the pelecypods, and the shells were probably moved; although robust shells, such as the rhynchonellids, could remain articulated. The shells are not worn or abraded. A few of the cyrtodontid pelecypods were ar-ticulated, but the valves separated as acid-etching progressed. In the lighter-colored beds, fossils tend to be whole and the fauna is dominated by cyrtodontid and palaeotaxodont pelecypods, disarticulated chiton plates, and Tetradian corals.

Mollusks (2,029 specimens) and brachiopods (1,722 specimens) dominate the fauna. Mollusks are placed in 27 species. Pelecypods are represented by 1,125 valves, of which 369 are pteriomorphs and 708 are palaeotaxodonts. The pteriomorph fauna is dominated by the species Cyrtodontia sabovata (252 specimens) and the palaeotaxodont fauna is dominated by the species Deceptus aff. D. hartsvillensis (Safford, 1869) (546 specimens).

The brachiopod fauna is dominated by the rhyynchonellid Orthokrychula linnellii (James, 1881) (1,444 specimens) and the spiriferid Zygospirifer sp. (244 specimens). There are also 31 specimens of two species of orthids and three species of a strophomenid.

The remaining fauna includes two species of corals, but is dominated by trilobites and ostraecodes.

In comparing the Tyrone Limestone faunas in which Spiculicholodes cressmani n. sp. occurs with those in the Salvisa Bed in which the younger species Listrochiton weiri n. gen. and sp. occurs, the major similarities are: 1) both occur in similar rock types; 2) both contain large numbers of pteriomorph and palaeotaxodont pelecypods; and 3) both contain Tetradian Dana, 1846. The major differences are: 1) the almost complete exclusion of the nonmollusks in the Tyrone Limestone (USGS 6034-CO) and the greater diversity of nonmollusks in the Salvisa Bed, to the point where mollusks and brachiopods occur in almost equal numbers, although there are 26 species of mollusks compared to...
five species of brachiopods, with two species dominating the brachiopod fauna; 2) the exclusion of identifiable cephalopods in the Salvisa Bed; and 3) the significant arthropod fauna in the Salvisa Bed represented by five species of trilobites and seven species of ostracodes, although in the Tyrone Limestone (D-1138-CO), a significant ostracode fauna occurs with Spicichelodes cressmani.

Open-marine deposits.—The sequence of rock units from the Curdsville Limestone Member through the Grier Limestone Member, Lexington Limestone, represents a transgression and deepening water (Cressman, 1973). “The basal Curdsville bioclastic calcarenites and calcirudites were deposited in agitated water of the inner infralittoral zone. The discontinuity [between the older Tyrone and the younger Curdsville] then resulted from a slight deepening of the water which permitted the formation of waves of sufficient energy to erode the uppermost part of the Tyrone Limestone and to break, sort, and transport the debris of fossils that could thrive in the more aerated water” (Cressman, 1973, p. 13).

“The bioclastic calcarenite and calcirudite, crossbedded in part, of the lower Curdsville indicate formation in a high-energy environment, probably in water above surf base; however, the lower Curdsville also contains beds of calcisiltite, unaltered fossils, and articulated pelecypods, all indicative of a low energy environment. The most likely explanation of the frequent [changes in bed lithologies] is that the coarser fragments accumulated in small bars while the finer material was deposited in topographic lows. Migration of the bars would have resulted in interbedding of coarser and finer grained sediments” (Cressman, 1973, p. 14). The thin discontinuous bentonites in the Curdsville are thought to be the source of the silica that replaced the calcium carbonate of the fossils.

USGS 5101-CO and 6134-CO are from the lower Curdsville at the start of the transgression and are shallow open-marine deposits. This part of the Curdsville is “crystalline, bioclastic limestones that consist of calcirudites, crossbedded and ripple-marked calcarenites, and laminated calcisiltites. The grains are abraded sorted fragments of crinoids, bryozoans, and brachiopods. Whole and broken brachiopod and mollusk shells are common, and many silicified” (Cressman, 1973). Mollusks are dominant, in both numbers and diversity. Brachiopod diversity is high but the number of specimens is small compared to the mollusks.

Mollusks are represented by 605 valves, of which 466 belong to the pelecypod species Vanuxemia gibbosa Ulrich, 1894a. The univalves were not counted. Brachiopods are represented by 10 species, but only the eight species in USGS 5101-CO were counted.

The remaining identified fauna is two species of corals and two species of echinoderms.

The upper Curdsville “consists of irregularly bedded fusiferous limestone interbedded with bioclastic calcarenite” (Cressman, 1973, p. 13, 14). “The upper Curdsville was probably deposited in deeper water because none of the shell beds are composed of broken and abraded shells, as occurs in some beds of the lower Curdsville. This vertical sequence of rock types in the Curdsville, high-energy, shallow-water deposits in the lower part grading to deeper water deposits at the top, record a marine transgression” (Cressman, 1973, p. 14).

USGS 6131-CO is from the upper Curdsville Limestone Member, Lexington Limestone. Only the chiton and pelecypod specimens were counted. A total of approximately 2,000 specimens were obtained from this collection; of these, 1,312 were pelecypods. The pteriromorph Vanuxemia gibbosa was represented by 1,247 valves. Mollusks are placed in 11 species. Brachiopods are represented by eight species.

The Grier Limestone Member of the Lexington Limestone is a deeper water open-marine deposit compared to the Curdsville Limestone Member. Of the environment of deposition of the Grier Limestone Member, Lexington Limestone (Cressman, 1973, p. 19–20) stated: “The abundance, kind, and state of preservation of the fossils and the poor sorting of the limestone indicate that most of the member was deposited in shallow, aerated, only moderately agitated water. Much of the sea floor was populated by a mixed bryozoan-crinoid fauna. The lenticular and nodular beds very closely resemble structures in recent sediments that are attributed to churning by burrowing organisms. Some of the pelecypods were infaunal, but most of the churning must have been by soft-bodied organisms that left no fossil record”.

“Currents were sufficient to supply oxygen and food to the large fauna of suspension feeders, distribute crinoid columns, and winnow some of the carbonate mud, but they were too weak to thoroughly comminate and sort the skeletal debris or to remove all of the lime mud. Much of the Grier probably accumulated in depths of less than 15 m of water” (Cressman, 1973, p. 21).

USGS 4959-CO and 5096-CO are dominated numerically by gastropods and brachiopods. Mollusks are placed in 23 species. Of the 181 valves of cephalopods, 129 belong to the palaeoaxodont species Decipax cf. D. hartsvillensis. The gastropod fauna is dominated by the species Loxopolus (Lophospira) burenensis Ulrich and Scofield, 1897; specimens were not counted, but were estimated as some hundreds of individuals.

Brachiopods are represented by six species. Of the 821 brachiopod specimens, 250 are Rhynchotrema increbescens (Hall, 1847) and 450 are Zygospira sp.

OBSERVATIONS

1. In all three environments of deposition, molluscan diversity is greater than brachiopod diversity.

The nearshore subtidal environment, mollusks and brachiopods total 38 species, of which mollusks represent 94.74%. Of the total number of species present, mollusks represent 83.72%; brachiopods 6.28% of the species.

Comparing mollusk versus brachiopod species diversity in the other shell beds studied, the numbers are: Salvisa Bed, mollusks 84.38%; lower Curdsville, mollusks 66.67%; upper Curdsville, mollusks 57.89%; Grier Limestone, mollusks 79.31%.

2. Cephalopods are only significant in the nearshore subtidal deposits, where they represent 50% of the mollusk species present, but only 3.38% of the identifiable specimens.

In all three environments of deposition, cephalopod faunas are dominated by palaeoaxodonts and pteriromorphs, to almost the complete exclusion of the other known subclasses.

3. In all three environments of deposition, cephalopod faunas are dominated by a single species.

5. Gastropods are coeval to, or exceed, the pelecypods in number of specimens in the shallow subtidal and deeper water open-marine environments of deposition.

6. In the lagoonal and open-marine environments of deposition, the brachiopod fauna is dominated by one or two species.

7. In all three environments of deposition, chiton species show low diversity.

8. In none of the collections of chiton plates was there a ratio of 1:6:1 of head, intermediate, and tail plates.

FAUNAL LISTS AND SPECIES COUNTS

USGS 6034-CO

MOLLUSCA

Polyplacophora:—Spicichelodes cressmani n. sp., 79 intermediate plates; Amblyoctonich and Scombrius sp., nine intermediate plates, one head plate; one tail plate.

Pelecypoda:—A total of 2,256 disarticulated valves of palaeoaxodonts and pteriromorphs were found. The most abundant species is the pteriromorph Cyrtodonta superba Ulrich and Scofield, 1897, 2,000 valves. Other pteriromorphs are: Vanuxemia gibbosa Ulrich and Scofield, 1897, 180 valves; Vanuxemia sp. indet., 12 fragments; Cleidomychia sp., 25 valves.

The palaeoaxodonts are: Ctenodonta nasuta Ulrich and Scofield, 1847, 33 valves; C. logani Saller, 1859, one valve; Tancrodelius sp., 17 valves.

Bellerophontina:—Salpingostoma kentuckyense Ulrich and Scofield, 1897, 45 specimens; Pterotheca expansa (Emmons, 1842), three specimens.

“Nautioida”:—The 180 specimens of nautioids were studied by Frey (1995). He listed 18 species—three eillemnerceroids, six othoceroids, one endocerid, three actinocerids, one taphycerid, and four oncocerids.

Gastropoda:—The approximate number of identifiable gastropods is 2,500 specimens; however, they have not been studied systematically. Wagner (1990) examined the lophospirids, but he did not publish the results.

OTHER FAUNA

The nonmolluscan fauna from USGS Collection 6034-CO is sparse and was not counted. Included in the fauna is the brachiopod Camerella sp. (identified by R. B. Neuman), the corals Lambeophyllum? sp. (Eliss, 1983) and Tetradium sp., and indeterminate ostracodes.
USGS D-1138-CO
MOLLUSCA

Polynoplacophora—Spisochelodes cressmani n. sp., 145 intermediate plates, one head plate, two tail plates. 

Pelecyphoda—Tancrediopsis sp., four specimens; Cyrtodonta sp., one specimen.

Gastropoda (identified by E. L. Yochelson)—Ninety-three specimens assigned to the genera Loxopectus (Lophospira) sp., Entomaria sp., Helicotrema sp., Trochomena (Trochomenella) sp., Holocenea sp., and Murchisonia (Hormotoma) sp.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman)—Soverbyella sp., two specimens.

Ostracoda (identified by J. M. Berdan and Berdan (1984), not counted)—Eoleperdita fabulites (Conrad, 1843), Ceratoeoleperdita kentuckyensis (Ulrich, 1891), Leperditella spp., Aptochilia sp., and Kraussella sp. 

Corals (identified by W. A. Oliver)—Tetradium cf. T. cellulosum and a streptelasmid.

USGS 5015-CO, 6915-CO, AND 6916-CO
MOLLUSCA

Polynoplacophora—Listrochinotus weirii n. sp., 449 intermediate plates, six head plates, 12 tail plates; Alastega martini n. sp., 204 intermediate plates, one head plate, two tail plates.

Pelecyphoda—A total of 1,125 disarticulated valves, dominated by pteriomorphs and palaeotaxodonts, were counted. The pteriomorphs are: Cyrtodonta subovata, three valves; C. grandis (Ulrich, 1890c), 252 valves; Vanuxemia aff. V. sardesoni (Ulrich, 1892a), 97 valves; Ambonychella cf. A. ulrichi (Pojeta, 1962), 16 valves; Palaeopteria aff. P. parvula Whiteaves, 1897, one valve.

The palaeotaxodonts are: Cenodonta nasuta, 119 valves; C. aff. C. longa (Ulrich, 1892b), 43 valves; Deceptrix aff. D. hartssheilensis Safford, 1869, 546 valves.

The remaining 48 specimens are assigned to: Colpomya sp., eight valves; Lyrodesma sp., one valve; Whiteavesia sp., four valves; and a number of modiomorphid fragments.

Rostoconchidae—Bransonion cressmani Pojeta and Runnager, 1976, 25 specimens.

Gastropoda (identified by E. L. Yochelson, for collection 5015-CO only)—Clathropsia cf. C. subcomica (Hall, 1847), three specimens; Loxopectus (Lophospira) humilis Ulrich and Scofield, 1897, eight specimens; L. (L.) mediils Ulrich and Scofield, 1897, four specimens; L. (L.) obliqua Ulrich and Scofield, 1897, 75 specimens; Stropheostyla sp. indet., two specimens.

Monoplacophora/Bellerophontina (identified by E. L. Yochelson for collection 5015-CO only) (monographed by Wahlman, 1992)—Pilina sp. indet., five specimens; Cyrtolites retrorsus Ulrich and Scofield, 1897, four specimens; Tropidococcus cf. T. subacutus Ulrich and Scofield, 1897, 10 specimens; Bucanopsis carinifera Ulrich and Scofield, 1897, 15 specimens; Sphenosphaera clausa Ulrich and Scofield, 1897, 14 specimens; Carinopus minutus (Hall, 1861), 15 specimens.

OTHER FAUNA

Brachiopoda (identified by R.B. Neuman for 6915-Co and 6916-Co) (monographed by Alberstadt, 1979; Howe, 1979; and Walker, 1982)—Hebrellia frankfortensis Forerste, 1909, 24 specimens; Orthorhynchula linneyi, 1,444 specimens; Zygospira sp., 244 specimens; Platystrophia sp., seven specimens; Rafinesquina aff. Rafinesquina sp. indet., seven valves; Synechotrocha subulata Ulrich and Scofield, 1897, 15 specimens; Bucanopsis carinifera Ulrich and Scofield, 1897, 14 specimens; Sphenosphaera clausa Ulrich and Scofield, 1897, 50 specimens; Carinopus minutus (Hall, 1861), 15 specimens.

USGS 6134-CO
MOLLUSCA

Polynoplacophora—Helminthochiton blacki n. sp., 15 intermediate plates, one tail plate.

Pelecyphoda—The faunule is dominated by one pteriomorph species; Vanuxemia gibbosa, 415 valves; Cyrtodonta subovata, 59 valves; Ctenodonta aff. C. nasuta, four valves; C. aff. C. longa, one valve; Tancrediopsis sp., 34 valves.

Gastropoda—(identified by E. L. Yochelson, not counted); Loxopectus (Lophospira) sp. indet.; cf. Onospira sp.;? Raphiostoma sp.;? Liospira sp.; Helicotrema sp. indet.; Murchisonia (Hormotoma) sp. indet.

Monoplacophora/Bellerophontina (identified by E. L. Yochelson, not counted)—Cyrtolites sp. indet.; Sinuites sp. indet.; Carinopus sp. indet.; Tropidiscus sp.; cf. Bucanopsis sp.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman, not counted)—Camerella? sp.; Dalmanella sp.; Pionodema? sp.; Platystrophia amoena longicardi-nalis McEwan, 1919; Rafinesquina sp.; Rhynchotrema cf. R. increbescens (Hall, 1847); Zygospira sp.

Echinodermata (Parsley, 1981)—Amygdalocystites floreals Billings, 1854, one specimen.

Receptaculids—Two specimens.

USGS 5101-CO
MOLLUSCA

Polynoplacophora—Helminthochiton blacki n. sp., two intermediate valves.

Pelecyphoda—Vanuxemia gibbosa, 51 valves; Cyrtodonta subovata, seven valves; Liospira aff. L. ornata Ulrich, 1894a, one valve.

Gastropoda (identified by E. L. Yochelson)—Liospira sp. indet., one specimen; Loxopectus (Lophospira) sp. indet., two specimens.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman)—Dinorthis pectinella (Eimm, 1842), two specimens; Hesperohoris sp., six specimens; Platystrophia sp., two specimens; Rafinesquina sp., one specimen; Rhynchotrema sp., 25 specimens; Soverbyella carvalidensis (Foerste, 1912), six specimens; Zygospira sp., 10 specimens; dalmanellid indet., three specimens.

Corals (identified by W. A. Oliver, not counted)—Streptelasmid; ?Necto- topora sp.

Echinodermata (Branstrator, 1979)—Stenaster cf. S. obtusus (Forbes, 1848), three brachial fragments.

USGS 6131-CO
MOLLUSCA

Polynoplacophora—Helminthochiton blacki n. sp., 30 intermediate plates.

Pelecyphoda—Vanuxemia gibbosa, 1,247 valves; Cyrtodonta subovata, seven specimens; Similodonta aff. S. hermitagensis Basiller, 1932, 52 specimens; Tancrediopsis cuneata (Hall, 1856), five specimens; Ctenodonta cf. C. nasuta (Hall, 1847), one specimen.

Gastropoda (identified by E. L. Yochelson, not counted)—Loxopectus (Lophospira) cf. L. (L.) medialis; Liospira sp. indet.; Murchisonia (Hormotoma) sp. indet.

Monoplacophora/Bellerophontina (identified by E. L. Yochelson, not counted)—Bucanopsis sp. indet.; Sphenosphaera sp. indet.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman, not counted)—Dalmanella fertulis (Ulrich in Basiller, 1909); Dinorthis pectinella; Hesperohoris sp.; Platystrophia amoena McEwan, 1919; Rafinesquina sp.; Rhynchotrema cf. R. increbescens; Soverbyella carvalidensis; Zygospira sp.

FAUNA OF COLLECTION USGS 4959-CO
MOLLUSCA

Polynoplacophora—Helminthochiton blacki n. sp., two intermediate plates.

Pelecyphoda—Cyrtodonta subovata, 12 valves and many fragments; Vanuxemia gibbosa, seven valves and many fragments; Ambonychella sp., indet., five valves; Ctenodonta aff. C. longa, nine valves.
Scaphopoda:—Rhytiodentalium kentuckyensis Pojeta and Runge, 1979, eight specimens.

Gastropoda (identified by E. L. Yochelson):—Loxoplocus (Lophospira) burgenensis Ulrich and Scofield, 1897, 30 specimens; Marchisonia (Hormotoma) salteri nitida Ulrich and Scofield, 1897, 50 specimens.

Monoplacophora/Bellerophontina (identified by E. L. Yochelson):—Bucania sp. indet. (not counted); Bucanopsis carinifera, four specimens; Sphenosphaera clausus, seven specimens; Carinaropsis cymbula, two specimens.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman):—Hebertella frankfortensis, 10 specimens; Lingulella? sp., four specimens; Rafinesquina sp., 50 specimens; Rhynechotrema increbescens, 250 specimens; Zygospira sp., 250 specimens.

FAUNA OF COLLECTION USGS 5096-CO

MOLLUSCA

Polyplacophora:—Helminthochiton blacki n. sp., three intermediate plates.

Pelecypoda:—Deceptrix cf. D. hartsyllensis, 125 specimens; Ctenodonta socialis Ulrich, 1894a, two specimens; Ambonychia radiata Hall, 1847, 10 specimens; Cycloconcha aff. C. ovata Ulrich, 1893, one specimen; Modiolodon oviformis (Ulrich, 1890a), two specimens and 30 fragments.

Nautiloids (Frey, 1995):—Isorthoceras alberti (Miller and Faber, 1894), two specimens.

Gastropoda (identified by E. L. Yochelson):—Liospina progne (Billings, 1860) (not counted); Clathrospira subconica, one specimen; Loxoplocus (Lophospira) burgenensis, hundreds of specimens; Holopea sp., one specimen.

Monoplacophora/Bellerophontina (identified by E. L. Yochelson):—Sphenosphaera troosti burgenensis (Ulrich and Scofield, 1897), nine specimens; S. clausus, 10 specimens; Cyrtolites retrorsus, two specimens; Bucania cf. B. subalata, two specimens; Bucanopsis carinifera, three specimens.

OTHER FAUNA

Brachiopoda (identified by R. B. Neuman):—Hebertella frankfortensis, 35 specimens; Pionodema sp., 10 specimens; Rafinesquina sp., 12 specimens; Zygospira sp., 200 specimens.