Ostracodes of the Maple Mill Shale Formation (Upper Devonian) of southeastern Iowa, U.S.A.

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ABSTRACT: The Upper Devonian Maple Mill Shale Formation in southeastern Iowa, U.S.A., has yielded a diverse and unusual ostracode fauna consisting of eighteen benthic species and one (probably planktonic) entomozoacean species. Only two species have been previously described. Although the remaining species are considered new, because of poor preservation only three are named herein: *Triceratina lethiersi* n. sp., *Graphiadactylloides kalonaensis* n. sp. and *Entomozoe (Nehdentomis?) kindlei* n. sp. At the species level the fauna is unique. The absence of Bairdiacea suggests a low oxygen (hypoxic) environment. Conodonts indicate that the ostracode-bearing layer correlates with the *Scaphignathus velifer* Zone and fragments of cephalopods indicate the *Platyclymenia* do III-IV Zone.

STRATIGRAPHY OF THE MAPLE MILL SHALE

Bain (1895) proposed the name Maple Mill Shale for the shaley interval below the English River Siltstone Formation and above the McCraney Limestone Formation (previously called Louisiana Limestone Formation) in southeastern Iowa, U.S.A. He gave the location of the type section as SE1/4, NW1/4, Sec. 4, T.77N., R.8W., Washington County. Dorheim et al. (1969) reported finding only löss and till at that location. They suggested that the type section coordinates were a typographical error. The closest exposure of Maple Mill Shale to Bain's published type section is SW1/4, SE1/4, NW1/4, SE1/4, Sec. 8, T.77N, R.8W., Washington County, the section Dorheim et al. (1969) designated as the type section of the English River Formation. Herein, we recognize that section as also being the type section for the Maple Mill Shale Formation.

The Maple Mill Shale is eight to twenty meters thick in the central portion of Iowa. It thickens to the southeast and southwest, attaining a maximum thickness of about fifty-five meters. The formation crops out mainly in the southeastern portion of the state. Exposures rarely exceed six meters in height. In outcrop, the shale varies in colour from light greenish-gray or olive-gray to yellow and can appear mottled. In a well core from near Columbus Junction, Iowa (text-fig. 1), the upper eight meters of the shale is bluish-gray. The Maple Mill Shale tends to be dolomitic, laminated, hard and somewhat brittle. Where erosion does not remove debris, exposures quickly weather to produce vegetated slopes. Locally, silty to sandy layers occur near the top of the formation. The contact between the Maple Mill and overlying English River Siltstone is gradational. Frequently, the two formations are mapped together.

Moore (1928) placed the Maple Mill Shale Formation as the base of the Hannibal Shale Formation and later (1935) correlated the Maple Mill Shale and English River Siltstone with the Hannibal Shale. Laudon (1929) and Stainbrook (1950) recognized the Maple Mill Shale as the basal Carboniferous (Mississippian, Kinderhookian) formation in southeastern Iowa. Thomas (1949) and Straka (1968) placed the Devonian-Carboniferous boundary between the Maple Mill Shale and English River Siltstone. Collinson (1967, text-fig. 3) illustrated the Devonian-Carboniferous boundary atop the English River Siltstone. Dorheim et al. (1969) incorporated, in descending order, the English River Siltstone, Maple Mill Shale, Aplington Formation and Sheffield Formation into the Yellow Springs Group. They placed the Devonian-Carboniferous boundary at its top. Currently, the Maple Mill is generally accepted as Devonian.

The only published, detailed biostratigraphic research on the Maple Mill Shale has been with conodonts. Peterson (1947) concluded that the Maple Mill Shale was Carboniferous (Kinderhookian) in age. Thomas (1949) and most subsequent conodont workers recognized the Maple Mill Shale as Late Devonian. Beinert (1968) reported that the Maple Mill Shale contained an admixed conodont fauna from as low as the *Palmatolepis triangularis* Zone. He interpreted the exposed Maple Mill Shale as part of the *Polygnathus styriacus* Zone. Subsequently, Klapper et al. (1971) placed the exposed Maple Mill Shale in southeastern Iowa into the subjacent *Scaphignathus velifer* Zone. They suggested that conodont admixing is less than a zone in magnitude.

KALONA CLAY PIT SECTION

Closely spaced, sequential samples of the Maple Mill Shale were collected at the High Bridge, Kalona Clay Pit, Walker Farm and Maple Mill Shale type sections (text-fig. 1). In addition, an eight-meter-long core of the upper Maple Mill Shale from near Columbus Junction, Iowa, was processed for fossils. Although a few ostracodes were recovered from all exposures, only the Kalona Clay Pit section yielded a substantial number of ostracodes and only this section produced ammonoid fragments. These ostracodes form the basis of the present study.

The Kalona Clay Pit was opened by the Farley Brothers Brick Company early in the twentieth century as a source of clay for

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making building and paving bricks. After a short period of operation, the pit was abandoned. In 1978 the exposed Maple Mill section in the Kalona Clay Pit was approximately 4.5 meters high, eight meters long and capped by a .75 meter exposure of English River Siltstone. The channel of a small, unnamed, intermittent tributary of the English River formed the base of the outcrop. The lower contact of the formation was not visible at this location.

Two beds of significance occur in this exposure (text-fig. 1). About 1.75 meters above the stream channel and extending laterally for nearly three meters crops out a layer (Sample KM^2-6) rich in phosphatic microfossils. Beinert (1968) named this bed the "concentrate horizon." Samples from strata laterally equivalent to the "concentrate horizon" yielded a better preserved, but less abundant, fauna of phosphatic microfossils. The other significant layer occurs approximately 3.25 meters above the stream bed and rests upon the first continuous unit of siltstone within the Maple Mill Shale at this location. This .25 meter layer of shale (Sample KM^2-13) yielded the most abundant and diverse ostracode and cephalopod fauna. The cephalopods were identified as *Platyclymenia* spp. (Brian Glenister, University of Iowa, Iowa City, personal communication to Chauffe 1978). This places the layer within the *Platyclymenia* do III-IV Zone.

GENERAL PALEONTOLOGY OF THE MAPLE MILL SHALE FORMATION

The Maple Mill Shale contains a diverse fauna of microfossils, including: conodonts, fish remains, sporocarps?, ostracodes, gastropods, foraminifera, pelecypods, brachiopods, echinoderms, scolecodonts (individual and as simple apparatuses) and conularids. In addition, a few ammonoid fragments and numerous fossils of uncertain affinities, such as *Gluteus minimus* (Davis and Semken1975) and numerous microscopic phosphatic ring-like structures most probably related to the *Hyolitheminthes* (Müller et al. 1974), have been recovered. Except for conodonts, none of the microfauna has been previously described in detail.

In the study area, nearly all calcareous microfossils have been replaced by either pyrite or marcosite. Presence of only microscopic brachiopods, echinoderms and gastropods suggests that the depositional environment may have been inhospitable for adult forms. Possibly, the bottom environment was hypoxic (low oxygen) and the small specimens were either epipelagic or represent a dwarfed fauna.

Fossils are scarce throughout most of the shale. Yet, in a few layers, especially in Beinert's (1968) "concentrate horizon", microfossils are extremely abundant. The concentrate layer occurs in several Maple Mill Shale exposures as a series of discontinuous shaley to silty lenses up to 6cm thick. At some exposures, especially Walker Farm (locality 4), phosphate nodules and marcosite rosettes are common in the layer.

Recovered phosphate nodules come mainly from the concentrate layer and are rounded, polished and vary in length up to 4cm. They range in colour from gray to black and most display borings. Invariably, softer gray nodules are more extensively bored than harder black nodules. Dissolution of nodules in 10% HCl, as outlined in Chauff (1978), yielded silty sediment, but no fossils. Conodonts from the concentrate lenses are large, show abrasion and are considered to be reworked. The lenticular shape of the deposits, concentration of phosphates nodules and reworking and sorting of conodonts suggest that the concentrate lenses are lag deposits filling shallow depressions, possibly channels.

MAPLE MILL SHALE FORMATION OSTRACODE FAUNA

Most of the Maple Mill Shale sequence yielded few ostracodes. The nineteen species described herein have been recovered from one interval of the Kalona Clay Pit Section (text-fig. 1, KM^2-13). This irregular distribution may have been caused by differential preservation and/or environmental controls on the distribution of the fauna at the time of deposition.

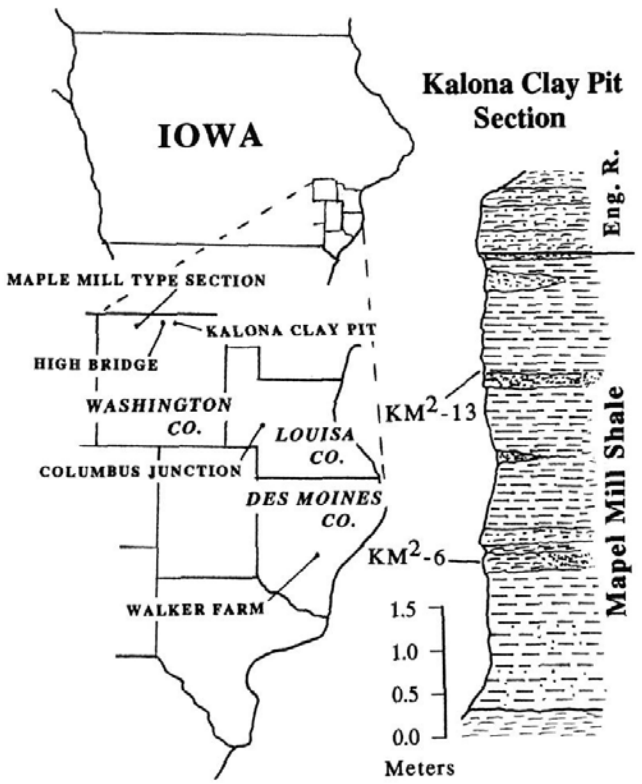
In several respects, the ostracode fauna of the Maple Mill Shale is similar to the uppermost Devonian ostracode faunas from the Big Valley Formation in Saskatchewan and Alberta, Canada (Lethiers 1978). At the generic level, both the Maple Mill and Big Valley formations contain the genera *Drepanella, Triceratina, Beyrichiopsis, Sargentina, Graphiadactylloides, Bairdia* and *Acratia*. Yet, at the species level the two faunas are fairly different and apparently endemic. Only two species, *Drepanella bisonteformis* Lethiers 1978 and *Acratia cf. tichonovitchi* Egorov 1953 (*sensu* Lethiers 1981), are present in both faunas. In the Big Valley fauna in Saskatchewan, *D. bisonteformis* occurs in do V-do VI (Lethiers 1978, 1981). *Graphiadactylloides kalonaensis* n. sp. in the Maple Mill fauna is closely related to *G. striatoreticulatus* Green 1963 from the Big Valley Formation (Uppermost Devonian) of Saskatchewan and the Banff and Exhaw formations (Tournaisian) of Alberta (Green 1963).

The Maple Mill Shale ostracode fauna includes a number of forms, such as *Graphiadactylloides, Cornigella* and *Triceratina*, which appear to reach their acme during the Mississippian (*cf.* Cooper 1941; Green 1963). Entomozoacean ostracodes in the Devonian and Carboniferous of North America are very rare. Kindle (1919) recovered them from the Mackenzie River Valley Formation (Frasnian). Subsequently, Stewart and Hendrix (1945), Green (1963), Loranger (1971) and Lethiers (1978, 1981) reported entomozoacean ostracodes from the Devonian and Carboniferous and Kohn and Dewey (1992) from the Permian. *Entomozoe (Nehdentomis?) kindlei* n. sp. is abundant in the Maple Mill Shale assemblage and is clearly related to European and Chinese Famennian species.

Maple Mill Shale benthonic ostracodes display a weak connection with the ostracode faunas from Europe and the East European Platform. Possibly, the entire Maple Mill assemblage consists of new, endemic species. This suggests special environmental conditions for the deposition of the Maple Mill or possible geographical barriers.

OSTRACODE PALEOECOLOGY OF THE MAPLE MILL SHALE

The paleoecology of some Paleozoic marine ostracodes has been established by comparison with closely related extant forms. Yet, for many Paleozoic ostracode assemblages, there are no modern counterparts. Becker (1971, 1975 [in Bandel and Becker 1975], 1981) and Bless (1983) proposed several models for the paleoecology of Devonian and Carboniferous ostracodes. These paradigms were revised by Becker and Bless (1990). They distinguished four main marine ostracode assemblages: (1) Eifelian Assemblage from high energy environments, (2) Thuringian Assemblage from low energy environments, (3) Entomozoacean Assemblage, probably pelagic, and (4) Mixed Assemblages *sensu* Becker and Bless



TEXT-FIGURE 1
Map locating primary sections discussed in text and diagramatic representation of Maple Mill Shale Formation section at Kalona Clay Pit. Layer KM^2-6 is the concentrate layer. Layer KM^2-13 produced abundant ostracods and some cephalopod fragments. Eng. R. = English River Siltstone Formation.

(1990). The Maple Mill Shale ostracode assemblage represents a Mixed Assemblage, containing binodicope-quasillitacean and entomozoacean faunas. The fauna mainly consists of ornamented forms with only a few smooth species. The ornamented and spinose forms such as *Graphiadactylloides*, *Drepanella* and *Beyrichiopsis* usually occur in different environments and are not typical of Eifelian or Thuringian assemblages, but are related to the Eifelian Assemblage. Mixtures of the Eifelian and Entomozoacean assemblages were not observed by Becker and Bless (1990), although a few entomozoacean specimens were noted among shallow-water ostracode faunas, as in the Big Valley Formation faunas. Entomozoaceans specimens can be abundant in dysoxic, restricted marine environments (see Lethiers and Casier 1995).

The ostracode assemblage of the Maple Mill Shale shows a remarkable and persistent absence of bairdiid ostracodes. Assemblages of comparable age in North America, Europe and Russia practically always contain a large number of bairdiids. The Upper Devonian ostracode faunas from Canada are often dominated by bairdiids (Lethiers 1978, 1981; Braun 1967). The absence of bairdiaceans in the Maple Mill Shale assemblage may suggest that environmental conditions were inhospitable for them. According to Bless et al. (1988, p.348), communities in which bairdiaceans are absent or rare may represent a special subassemblage category within the Eifelian Assemblage (mixed marine ostracode assemblage). Lethiers and Bouquillon (1986) described several Devonian assemblages from northern France, where bairdiaceans are absent. According to those authors, their assemblages indicated "shallow marine environments with more or less restricted conditions" (see also Lethiers and Raymond 1991). The absence of bairdiaceans, which required well-oxygenated, stenohaline waters, can be explained if the Maple Mill Shale was deposited in a sea with restricted circulation and oxygen-poor (hypoxic) bottom waters. The high frequency of complete carapaces and the absence of bioturbation in the Maple Mill Shale is indicative of quiet bottom conditions. Additionally, the presence of only microscopic (juvenile or dwarf) brachiopods, echinoderms and gastropods implies that the environment was inhospitable (hypoxic) to larger forms. These normally benthic organisms may have been epipelagic and died when they sank to the bottom. Alternatively, they may have lived on the bottom, but reduced oxygen availability in the bottom waters may have restricted their growth. In contrast, the ostracodes were probably good swimmers and remained in the water column. It is also possible that the majority of the ostracods were filter-feeders that could survive in low-oxygenated water (see Lethiers and Whatley 1994).

Distribution pattern of Devonian entomozoaceans, such as *Entomozoe (Nehdentomis)*, places them in a select group of (pelagic) ostracode species which managed to cross the otherwise relatively sharp provincial ostracode boundary between European and American Devonian ostracode faunas. The occurrence of entomozoaceans in the Devonian deep-water facies in Europe and China supports the proposal (Gooday 1983; Becker and Bless 1990; Olempska 1992) that the group was mainly planktonic. In contrast, Casier (1987), Wilkinson and Riley (1990) and Kohn and Dewey (1992) prefer to suggest a nectobenthonic habitat for the entomozoaceans in a shallow shelf setting.

The genus *Aechmina* is abundant in the Maple Mill Shale assemblage. This is another widely occurring, possibly planktonic, form of Paleozoic ostracode. The long hollow spine on each valve could be volumetrically greater than the domicilium itself and may be an adaptation to a planktonic mode of life. It is difficult to envisage how the large spine could be consistent with a benthic habitat (*cf.* Siveter 1984). The spines may have functioned as a flotation device (Henningsmoen 1965) or perhaps served temporarily to attach the ostracode to floating algae (Kesling 1953; Vannier 1986).

SYSTEMATICS

Because of poor preservation, most new species are retained in open nomenclature. The specimens described herein are retained at the Instytut Paleobiologii PAN.

Class OSTRACODA Latreille 1802
Order PALAEOCOPIDA Henningsmoen 1953
Superfamily BEYRICHIACEA Matthew 1886
Family TREPOSELLIDAE Henningsmoen 1959

Treposellidae genus indeterminate
Plate 2, figure 10, 11

Description: Poor preservation prohibits a detailed description of this species. Valve outline is slightly preplete with a long, straight dorsal margin. Greatest posterior extension at mid-height. Trilobate, L1 and L3 bear small dorsal spines. L2 is a round node. S1 is poorly defined and S2 terminates in the central part of the valve. Carapace surface is smooth.

Remarks: This species is similar to *Parabouchekius martinssoni* Jones 1985, from latest Devonian of Bonaparte Basin, Australia (Jones 1985). Because only two poorly preserved specimens were recovered, the species is not named.

Material: Two specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale Kalona Clay Pit section, Iowa, U.S.A.

Superfamily DREPANELLACEA Ulrich and Bassler 1923
Family AECHMINIDAE Boucek 1936
Remarks: According to many authors, six "drepanellacean" families are not palaeocopes, but constitute a separate major group, the order Binodicopa Schallreuter 1972 (see Whatley et al. 1993).

Genus *Cornigella* Warthin 1930
Type species: *Cornigella minuta* Warthin 1930

Cornigella sp.
Plate 1, figures 11-13

Description: Carapace is small and subovate in lateral view with straight dorsal margin and convex ventral margin. Ends are rounded with anterior broader than posterior. Cardinal angles are obtuse. Greatest height is anterior of mid-length. Surface of each valve is marked by eight spinose nodes. Two nodes are larger and extend above the dorsal margin. The largest spine is posterior of mid-length. Of the remaining nodes, one is located in the middle of the anterior part, another slightly below the middle of the posterior margin, two occur in the ventral part and a small node occurs near the hinge line at the anterior and posterior ends. Surface is smooth.

Remarks: Cooper (1946) considered nearly all forms of this genus to be con-specific with *Cornigella tuberculospinosa* (Jones and Kirkby 1886) because no clear differences could be distinguished among them. *Cornigella* sp. from the Maple Mill Shale resembles *Cornigella minuta* Warthin 1930 from the Middle Pennsylvanian (Upper Carboniferous) of the Wetumka and Holdenville formations, but differs in possessing much larger nodes and a smooth valve surface. The Maple Mill Shale specimens differs from *C. tuberculospinosa* by the presence of two additional nodes in the antero- and posterodorsal parts.

Material: Threee specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Genus *Aechmina* Jones and Holl 1869
Type species: *Aechmina cuspidata* Jones and Holl 1869

Aechmina sp.
Plate 3, figures 10-13

Description: Valves are slightly preplete in lateral outline with straight dorsal margin, broadly convex ventral margin and more rounded anterior than posterior end. Greatest length is about mid-height. Cardinal angles are obtuse. Distinct dorsal spine is located just anterior of mid-length and tapers rapidly upward. Although spine is broken on all specimens recovered, its length is presumably greater the height of the valve. Marginal structures are not preserved. Valve surface is smooth.

Remarks: Because of poor preservation, the species is not named. It resembles many Paleozoic *Aechmina* species with long centro-dorsal spines. *Aechmina* ranges from Ordovician into Mississippian (Lower Carboniferous).

Material: 16 specimens, mostly broken.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Family DREPANELLIDAE Ulrich and Bassler 1923
Genus *Drepanella* Ulrich 1890
Type species: *Drepanella crassinoda* Ulrich 1890

Drepanella bisonteformis Lethiers 1978
Plate 1, figures 4-6

Drepanella bisonteformis LETHIERS 1978, p. 12-13, pl. 1, figs. 2-4.

Description: Carapace is small and sub-rectangular in lateral outline with a slightly depressed straight hinge line and broadly convex ventral margin. Cardinal angles are obtuse, but only slightly greater than 90°. Valve is marked by three prominent nodes. The posterior node developed from the termination of a ridge which extends nearly parallel to the posterior and ventral valve margin. Ridge begins posterior to the midpoint of the ventral outline and extends essentially parallel to the carapace outline to its termination slightly above the anterior cardinal angle. Two dorsal nodes project prominently above the hinge line. Between the anterior node and ventral ridge, another crescent-shaped, moderately high, sharply defined ridge extends from near the middle of the valve, nearly parallel to the antero-ventral margin. A small preadductorial node is present between the two dorsal nodes. Valve surface is reticulate.

Remarks: *Drepanella bisonteformis* differs greatly from other species of the genus in possessing a well developed marginal ridge along the posterior margin. Along the anterior margin the ridge is low. The orientation of the carapace is defined by the presence of the median sulcus and small preadductorial node. *Drepanella bisonteformis* is similar to some species of *Acantonodella* (*A. lutkevichi* and *A. terciocornuta*) from the Upper Devonian of the Russian Platform (Zaspelova 1952), but can be distinguished by its small ridge in the antero-ventral part and the well developed posterior marginal ridge.

Material: Twenty-five specimens, some preserved as steinkerns.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Drepanella* cf. *bisonteformis Lethiers 1978
Plate 1, figures 7-10

Remarks: Unlike the holotype, the specimens illustrated herein possess nearly smooth carapaces, possibly an artifact of poor preservation. They differ slightly from the holotype in that the anterior medioventral node is developed as a spine, and the ridge is not clear.

Material: Four specimens.

Occurrence: Upper Devonian (Famennian), Big Valley Formation (do V-VI), Canada; Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Superfamily YOUNGIELLACEA Kellett 1933
Family YOUNGIELLIDAE Kellett 1933
Genus *Moorites* Coryell and Billings 1932
Type species: *Morrites hewetti* Coryell and Billings 1932

Moorites* sp. aff. *M. copelandi Lethiers 1981
Plate 3, figures 7, 8

Description: Carapace is small, subquadrate and slightly preplete in lateral view with almost straight, subparallel dorsal and ventral margins. Ends are rounded. Poorly developed marginal rims are most prominent along the anterior end. Valve surface is reticulate.

Remarks: Specimens are poorly preserved. They are most similar in shape and ornamentation to *M. copelandi* Lethiers 1981 from do V-VI of Alberta and the Northwest Territories of Western Canada (Lethiers 1981).

Material: Four specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Order KLOEDENELLOCOPIDA Scott 1961
Superfamily BEYRICHIOPSACEA Henningsmoen 1953
Family BEYRICHIOPSIDAE Henningsmoen 1953
Genus *Beyrichiopsis* Jones and Kirkby 1886
Type species: *Beyrichiopsis fimbriata* Jones and Kirkby 1886

***Beyrichiopsis*?** sp.
Plate 1, figures 1, 2

Description: Carapace is suboval in lateral view with long, straight dorsal margin, convex ventral margin and rounded anterior and posterior ends. Greatest height is anterior and greatest length is slightly below mid-height. Preadductorial node is small and rounded. Two spines, one in the antero-ventral portion and the other in the postero-dorsal region, ornament the surface. Spinose marginal ridge extends from anterior to posterior cardinal corners.

Remarks: Surface of the single specimen is poorly preserved and it is difficult to determine if lateral carina are absent or destroyed. The specimen is similar *to B. bispinosa* Green 1963 from the Lower Mississippian (Lower Carboniferous) Banff Formation of Canada (Green 1963) and to *B. modesta* Ulrich and Bassler 1932 from the Lower Mississippian of Tennessee in that it lacks a dorsal ridge and carina.

Material: Two specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Beyrichiopsidae? genus indeterminate
Plate 1, figure 3

Description: Laterial outline is slightly preplete. The greatest domicilial convexity is in the ventro-central region. Adductorial sulcus is short, narrow and does not extend to the dorsal margin, but terminates slightly below a small, round preadductorial node. Marginal sculpture consists of a row of small spines. Lateral surface of domicilium faintly reticulate.

Remarks: The specimen shows certain morphological characters, such as the marginal structure, similar to those occuring in some *Beyrichiopsis* species, but it lacks lateral carina. The specimen is also similar to some *Knoxiella* species, but possesses a spinose marginal structure.

Material: One specimen.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Order PODOCOPIDA Sars 1866
Suborder METACOPINA Sylvester-Bradley 1961
Superfamily THLIPSURACEA Ulrich 1894
Family QUASILLITIDEA Coryell and Malkin 1936
Genus *Graphiadaclylloides* Green 1963
Type Species: *Graphiadactylloides moreyi* Green 1963

Graphiadactylloides kalonaensis Olempska and Chauffe **n. sp.**
Plate 2, figures 1-4

Graphiadactylloides sp. aff. *G. maridgei* (Benson) *sensu* GREEN 1963, p. 182, pl.16, fig. 16, 17.

Holotype: The specimen illustrated on plate 2, figure 1.

Type Horizon: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale

Type locality: Kalona Clay Pit section, Iowa, U.S.A.

Derivation of name: From the type locality.

Diagnosis: Species has pronounced postero-ventral and anterior spines and a finger-print surface ornamentation.

Description: Carapace is subrhomboidal in lateral view with almost straight dorsal margin, evenly convex anteroventral and straight to slightly concave centroventral margins, rounded anterior margin and posterior margin truncated in the ventral part. Greatest length is at mid-height and greatest height slightly behind the anterodorsal angle. Hinge is slightly depressed. Larger left valve overlaps right valve moderately at the cardinal angles and on the remainder of the free margin. Lateral surface is ornamented by fine ribs arranged in a finger-print pattern concentric about the center of the posterior area. Valves possess well developed posteroventral and anterior spines. A narrow marginal flange arises on the anteroventral margin and extends anteriorly to mid-height and terminates in the anterior spine. A central muscle spot is lacking.

Remarks: *Graphiadactylloides kalonaensis* n. sp. is closely related to the Mississippian (Lower Carboniferous) species *G. striatore ticulatus* Green 1963 and is similar in surface ornament to *G. moreyi* Green 1963 and *G. moridgei* (Benson 1955), but differs somewhat in shape and in the presence of ornamentation on the anterior part of the carapace.

Material: Three carapaces and one valve.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

***Graphiadactylloides* sp. 1**
Plate 2, figure 5

Description: Carapace is subrhomboidal in lateral outline and possesses small spines in the postero-ventral part and a well developed anterior spine. Distinctive finger-print ornament is present on the posterior half of the carapace, but the anterior portion appears smooth.

Remarks: The species is similar in its partial absence of ornament to *G. moridgei* (Benson 1955) and *G. moreyi* Green 1963, but differs somewhat in shape and form of ornamentation. It is difficult to determine if the absence of ornament is a character of the valve or an artifact of preservation.

Material: One specimen.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill

Shale, Kalona Clay Pit section, Iowa.

Graphiadactylloides sp. 2
Plate 2, figures 6-9

Remarks: There are a few poorly preserved specimens of subovate *Graphiadactylloides* with fine reticulate surface ornament and anterior and posteroventral spines. The specimens differ from *G. kalonaensis* n. sp. in the reticulate surface pattern, smaller anterior spine and less elongate shape. The surface ornament is similar to *G.* sp. D (*sensu* Green 1963) from the Lower Mississippian of Alberta, Canada.

Material: Three specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa.

Suborder PODOCOPINA Sars 1866
Superfamily CYTHERACEA Baird 1845

Family **Monoceratinidae** Szczechura 1964, emend. Sohn 1988

Remarks: The revision of Monoceratinidae was conducted recently by Sohn (1983, 1988) and of Bythocytheridae by Schornikov (1988) and Schornikov and Michailova (1990), but many taxonomic problems remain. The Maple Mill Shale specimens are poorly preserved and internal structures are not visible.

Genus *Monoceratina* Roth 1928
Type species: *Monoceratina ventrale* Roth 1928

***Monoceratina*?** sp.
Plate 3, figure 4-6

Description: Carapace is subrhomboidal in lateral view with long, straight dorsal margin, slightly concave ventral margin in mid-length, broadly convex anterior end and elongate posterior end. Cardinal angles are obtuse. Median sulcus is absent. Ventro-lateral inflation occupies postero-ventral part. Surface is reticulate and no lateral spine is present.

Remarks: This species differs from others of *Monoceratina* by lacking a postero-ventral spine and having a poorly developed sulcus. Gründel and Kozur (1971) considered Monoceratininae to be a junior synonym of the Tribe Bythocytherini Sars 1926 (*cf.* Sohn 1988). Gründel and Kozur (1971) removed species with poorly developed sulci from *Monoceratina* to *Pseudomonoceratina* Gründel and Kozur 1971. The Maple Mill specimens are similar to *Monoceratina sublimis* Polenova 1952 in lateral outline and in the absence of a sulcus. Schornikov and Michailova (1990) placed *M. sublimis* into the genus *Asperobythere* Schornikov and Michailova 1990.

Material: Fifty-five specimens, mostly steinkerns.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Genus *Triceratina* Upson 1933
Type species: *Triceratina wrefordensis* Upson 1933

Triceratina lethiersi Olempska and Chauffe **n. sp.**
Plate 3, figure 1-3

Holotype: The specimen illustrated on Plate 3, figure 1 and 2.

Type horizon: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale.

Type locality: Kalona Clay Pit section, Iowa, U.S.A.

Derivation of name: In honour of Professor F. Lethiers of Paris.

Diagnosis: Carapace is 0.5 to 0.7mm long with one node in the dorso-anterior part, one in the ventro-anterior part and a spine near the ventral margin, slightly behind mid-length.

Description: Carapace is subrectangular in lateral view with straight dorsal margin, nearly straight or slightly convex ventral margin, rounded anterior margin and ventrally truncated posterior margin. Sulcus extends to mid-height. Dorsal swelling is situated above a prominent forward-projecting ventral spine. Two nodes are located in the anterior part, one in the antero-dorsal and the other in the antero-ventral. Valve surface is reticulate.

Remarks: *T. lethiersi* n. sp. can be distinguished from *T. wrefordensis* Upson 1933 (Lower Permian of Nebraska) and from *T. inconsueta* (Croneis and Gutke 1939) from the Upper Mississippian of Illinois (see also Cooper 1941) by the presence of two anterior nodes. It can be differentiated from *T. nasuta* Gründel 1961 from *Gattendorfia* Stage of Thuringia by the development of a reticulate surface, larger ventral spine and lack of an anterior spine. The new species differs from *T. christopheri* Lethiers 1978 from the Late Famennian of western Canada (Lethiers 1978, 1981) in having two distinct nodes, straight S2 and prominent ventral spine.

Material: Forty carapaces, many preserved as steinkerns.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Family HEALDIIDAE Harlton 1933
Genus *Cytherellina* Jones and Holl 1869
Type species: *Beyrichia siliqua* Jones 1855

Cytherellina sp.
Plate 4, figures 3-5

Description: Carapace is elongate in lateral view, about twice as long as high. Maximum width is in the posterior portion. Dorsal margin is slightly arched and ventral margin almost straight. Ends are rounded with the posterior higher than the anterior. Two shallow oblique, transverse sulci are located near the mid-length of the valve with a round to suboval node between them. Sulci are more visible on internal molds than the shell surface. Left valve overlaps the right, markedly on the ventral margin. Bow-shaped projection is broad. Surface is finely punctate.

Remarks: Species of *Cytherellina* are considered to have no external sculpture and the sulci in the type species are visible only on steinkerns. On Maple Mill specimens, sulci are poorly visible on the surface and clearly visible on internal molds. This species is similar in lateral outline to some European Middle Devonian species, such as *C. obliqua* (Kummerow 1953) and *C.* sp. 1 and *C.* spp *sensu* Groos 1969, but differs in having more clearly visible sulci. The external depressions on the Maple Mill species are in similar positions to those on the internal molds of *C. siliqua* (Jones 1855), the type species.

Material: Thirty-three specimens, several preserved as steinkerns.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Genus *Waylandella* Coryell and Billings 1932
Type species: *Waylandella spinosa* Coryell and Billings 1932

***Waylandella*?** sp.
Plate 4, figures 1, 2

Description: Carapace is elongate-oval in lateral view with a convex dorsal margin, almost straight ventral margin and maximum height and width at or just posterior to mid-length. Left valve is larger and slightly overlaps right valve. Small postero-ventral spines are present near the margin of both valves. Valve surface is smooth.

Remarks: This species is placed, with question, in *Waylandella* on the basis of its overall shape, possession of the postero-ventral spines and general nature of the overlap. Maple Mill specimens are similar to *W. dartyensis* Benson and Collinson 1958 from the Mississippian of Illinois in general outline and the presence of small postero-ventral spines, and to *W.? punctata* Green 1963 from the Mississippian of the Banff Formation, Alberta. They differ from the type species of *Waylandella* in lateral outline, which is more similar to *Healdianella* Posner 1951, but can be distinguished by the presence of postero-ventral spines.

Material: Two specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Superfamily BAIRDIACEA Sars 1888
Family BAIRDIIDAE Sars 1888
Genus *Acratia* Delo 1930
Type species: *Acratia typica* Delo 1930

Acratia* cf. *tichonovitchi Egorov 1953, *sensu* Lethiers (1981)
Plate 1, figure 14

Acratia (Cooperuna) cf. tichonovitchi EGOROV 1953, *sensu* Lethiers (1981, p. 84, pl. 18, figs. 170, 171).

Description: Carapace is medium-sized, elongate and fusiform in lateral outline. Length is more than twice height. Maxium length is below mid-height and maximun height at mid-length. The greatest width is subcentral. Straight dorsal margin gradually becomes anterior and posterior ends. Ventral margin is subparallel to dorsal and slightly concave in mid-length. Antero-ventral beak and notch are visible. Posterior end is pointed just below mid-height. Left valve bearly overlaps right valve all around, especially antero-dorsally and mid-ventrally. Carapace surface is smooth.

Remarks: In lateral outline the species is similar to *A cratia* sp. (No. 272), illustrated by Braun (1967) from the Frasnian of Canada.

Material: Sixteen specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A. and Famennian (do V-do VI) in the Northwest Territories of Canada.

Genus *Bairdia* McCoy 1844
Type species: *Bairdia curta* McCoy 1844

Bairdia sp.
Plate 3, figure 9

Remarks: One specimen of *Bairdia* sp. was recovered. Unfortunately, it is too poorly preserved to be described in detail. The lateral outline looks like that of *Bairdia (Bairdia) calgaryensis*

PLATE 1

Specimens are from Sample KM^2- 13 from the exposed Maple Mill Shale in the Kalona Clay Pit in southeastern Iowa and are retained at the Instytut Paleobiologii PAN in Warsaw, Poland.

1-2 *Beyrichiopsis?* sp. 1. Lateral view of left valve, X50. 2. Internal view of right valve, X56.

3 Beyrichiopsidae? genus indeterminate 3. Lateral view of right valve, X56

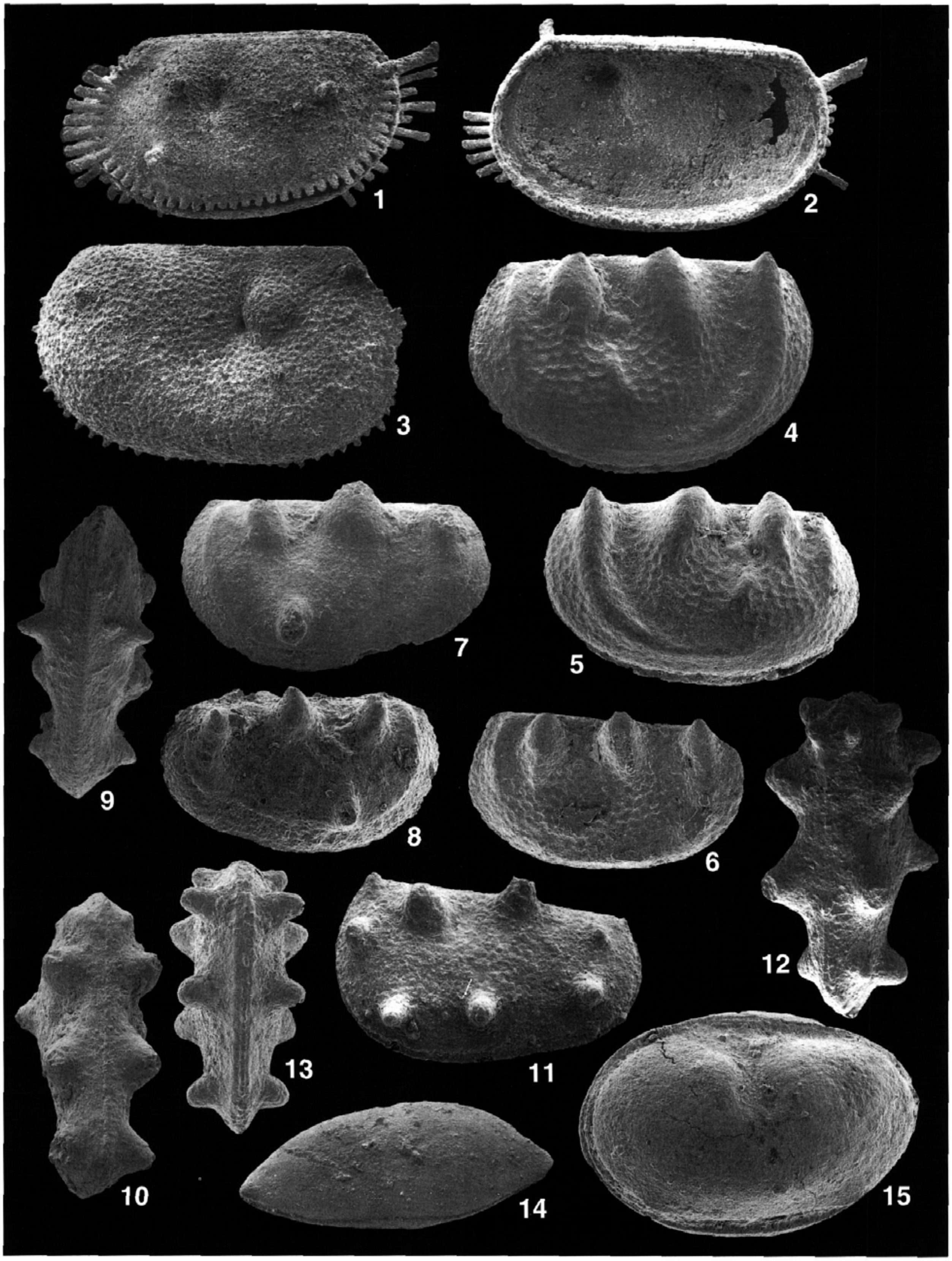
4-6 *Drepanella bisonteformis* Lethiers, 1978. 4. Lateral view of left valve, X120. 5. Lateral view of right valve, X140. 6. Lateral view of left valve X120.

7-10 *Drepanella cf. bisonteformis* Lethiers, 1978. 7. Lateral view of right valve, X120. 8. Lateral view of left valve, X140. 9. Ventral view, X120. 10. Dorsal view, X120.

11-13 *Cornigella* sp. 11. Lateral view of left valve, X105. 12. Dorsal view, X120. 13. Ventral view, X120.

14 *Acratia cf. tichonovitchi* Egorov, 1953, (*sensu* Lethiers, 1981) 14. Lateral view of right valve, X70.

15 *Sargentina* sp. 15. Lateral view of left valve, X88.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Lethiers 1978 from the Big Valley Formation, Famennian (do V-do VI) of Saskatchewan, Canada.

Material: One specimen.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Suborder PARACOPOCOPINA Gramm 1984
Family SERENIDAE Rozhdestvenskaja 1972, emend. Sohn 1988
Genus *Sargentina* Coryell and Johnson 1939
Type species: *Saragentina allani* Coryell and Johnson 1939

Remarks: Many taxonomic problems still exist within this group. According to Sohn (1961), the genus should be placed into Order Palaeocopida, suborder and family uncertain, because of the presence of a calcified inner lamella. According to Lethiers (1981) it should be placed into Superfamily Kloedenellacea Ulrich and Bassler 1908 and Family Serenididae Rozhdestvenskaja 1972. In contrast, Abushik (1990) would place it into Superfamily Knoxitacea Egorov 1950 and Family Knoxitidae Egorov 1950.

Sargentina **sp.**
Plate 1, figure 15.

Description: Thick carapace is sub-ovate in lateral outline with slightly convex dorsal margin, convex ventral margin and rounded ends with the anterior more broadly rounded than the narrower posterior. Larger right valve prominently overlaps left valve around the entire margin, especially along the venter. Narrow rim is present along the free margin of the smaller left valve. Dorso-median sulcus is deeper in the lower part, becoming abruptly shallower toward the dorsum. Small preadductorial node is present near the sulcus. Greatest length is about mid-height and greatest height is in the anterior part. Valve surface is smooth.

Remarks: Specimens from the Maple Mill differ in outline and a more shallow sulcus from *Sargentina*? n. sp. A *sensu* Lethiers (1981) from the Late Famennian (do III-IV) of Canada.

Material: Two specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

Order MYODOCOPIDA Sars 1866
Suborder CLADOCOPINA Sars 1866
Family ENTOMOZOIDAE Pribyl 1951
Genus *Entomozoe* Pribyl 1951
Subgenus *Nehdentomis* Matern 1929
Type species: *Entomis (Nehdentomis) nehdensis* Matern 1929

Entomozoe (Nehdentomis?) kindlei **Olempska and Chauffe n. sp.**
Plate 4, figures 6-13

Holotype: The specimen illustrated on Plate 4, figure 6.

Type horizon: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale.

Type locality: Kalona Clay Pit section, Iowa, U.S.A.

Derivation of name: Named in honour of E. M. Kindle.

Diagnosis: Lateral outline is symmetrically oval. Sulcus is absent, but muscle pit well defined and elongate. Dorsal depression is poorly visible. Surface contains 35-40 longitudinal ribs of which 5 or 6 extend concentrically around each valve.

Description: Valve is symmetrically oval in lateral outline with slightly curved dorsal margin and more strongly curved ventral margin. Posterior end is more broadly rounded than narrower anterior end. Antero-ventral margin slightly concave. Shallow oval muscle pit measures between 50 and 80μm in diameter and interrupts 4 to 5 ribs. Sulcus is absent and dorsal depression poorly developed. In adult forms, valve surface is ornamented by 35 to 40 longitudinal ribs of which 5 to 6 extend concentrically around each end of the valve. Above the muscle pit, the ribs are almost straight. Ventral ribs curve slightly and five to six inner dorsal ribs end at a low angle against the innermost curved ventral ribs. A few intercalatory and bifurcatory ribs are usually present. Variably developed cross-ribs may join the longitudinal ribs.

Remarks: These specimens are only questionably assigned to subgenus *Nehdentomis*, from which they are distinguished by the absence of a sulcal depression. These are also similar to *Rabienites* Tschigova 1977, but that genus is in need of revision. The specimens have similar ornamentation as *Entomozoe (N.) pseudorichterina* Matern 1929, but can be distinguished by the absence of a sulcus.

PLATE 2

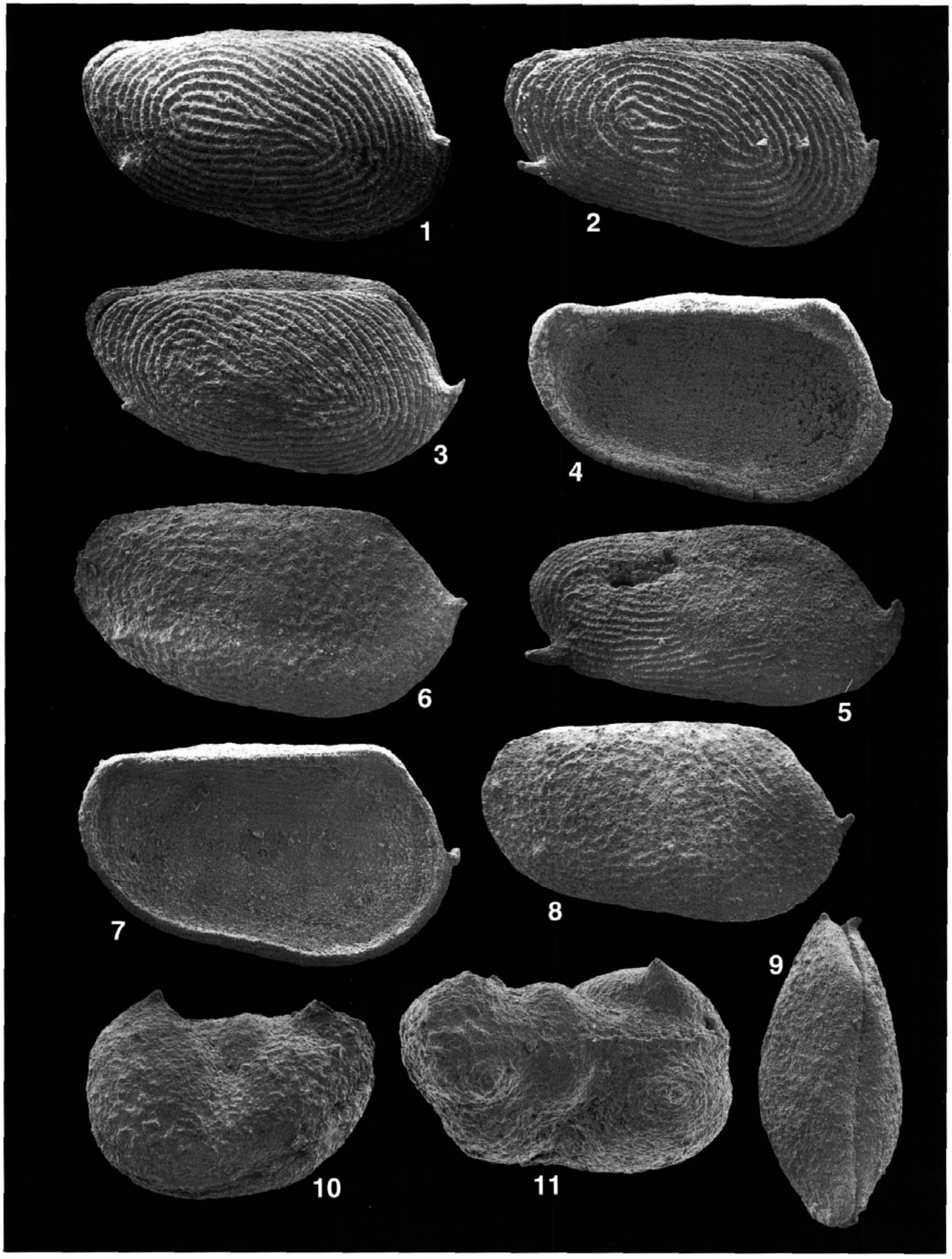
Specimens are from Sample KM^2- 13 from the exposed Maple Mill Shale in the Kalona Clay Pit in southeastern Iowa and are retained at the Instytut Paleobiologii PAN in Warsaw, Poland.

1-4 *Graphiadactylloides kalonaensis* n. sp. 1. Lateral view of right valve, holotype, X56. 2. Lateral view of right valve, X56. 3. Lateral view of right valve, X56. 4. Internal view of left valve, X55.

5 *Graphiadactylloides* sp. 1 5. Lateral view of right valve, X56.

6-9 *Graphiadactylloides* sp. 2 6. Lateral view of right valve, X53. 7. Internal view of left valve, X56. 8. Lateral view of right valve, X53. 9. Dorsal view, X42.

10-11 Treposellidae genus indeterminate. 10. Lateral view of left valve, X105. 11. Dorsal view, X105.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Material: Seventy specimens.

Occurrence: Upper Devonian, Famennian (*Platyclymenia* Zone), Maple Mill Shale, Kalona Clay Pit section, Iowa, U.S.A.

LOCALITY REGISTER

1. Kalona Clay Pit - 0.2km south of bridge over the English River on the east side of Highway 1, in a valley of an unnamed intermittent tributary of the English River, directly opposite a culvert: NW1/4, NW1/4, NW 1/4, Sec. 19, T.77N, R.7W., Kalona Quadrangle, Washington County, Iowa.

2. High Bridge - Directly opposite bridge and along south side above a dirt road that extends along the length of the exposure: S1/2, SE1/4, SWl/4, Sec. 17, T.77N, R.7W, Kalona Quadrangle, Washington County, Iowa.

3. Maple Mill Type Section - On the southeast bank of the English River, 200 meters downstream of a bridge, NWl/4, NWl/4, SE1/4, Sec.8, T.77N, R.8W, Wellman Quadrangle, Washington County, Iowa.

4. Walker Farm - Northeast bank of unnamed tributary to Yellow Spring Creek, SW1/2, NWl/4, SE1/4, Sec. 27, T.71N, R.2W, Kingston Quadrangle, Des Moines County, Iowa.

ACKNOWLEDGMENTS

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REFERENCES

ABUSHIK, A. F., 1990. Prakticeskoje rukowodstwo po mikrofaunie SSSR. Tom 4. Ostrakody Paleozoja (Practical manual on microfauna of USSR. Vol. 4. Paleozoic Ostracoda), "Nedra" Leningrad: 356p.

BAIN, H. F., 1895. Geology of Washington County. Iowa Geological Survey, 5: 115-173 [1896].

BANDEL, K. and BECKER, G., 1975. Ostracoden aus paläozoischen-pelagishen Kalken der Karnischen Alpen (Silurium bis Unterkarbon). Senckenbergiana lethaea, 56: 283p.

BECKER, G., 1971. Paleoecology of Midle Devonian ostracods from the Eifel Region, Germany. Bulletin Centre de Recherches Pau -SNPA, 5 (supplement): 801-816.

———, 1981. Ostracoda aus cephalopoden-führendem Oberdevon im Kantabrischen Gebirge (N-Spanien). 1. Hollinacea, Primitiopsacea, Kirkbyacea, Healdiacea und Bairdiocypridacea. Palaeontographica, A, 173:1-63.

BECKER, G. and BLESS, M. J. M., 1990. Biotope indicative features in Palaeozoic ostracods: a global phenomenon. In: Whatley, R., and Maybury, C., (eds.). Ostracoda and global events. British Micropalaeontological Society Publication Series, Chapman and Hall, London: 421-436.

BEINERT, R. J., 1968. Conodonts of the Maple Mill Shale, southeast Iowa, University of Iowa (Thesis), Iowa City, l00p.

BLESS, M. J. M., 1983. Late Devonian and Carboniferous ostracode assemblages and their relationship to the depositional environment. Bulletin de la Société Belge de Géologie, 92: 31-52.

BLESS, M. J. M., STREEL, M., and BECKER, G., 1988. Distribution and paleoenvironment of Devonian to Permian ostracode assemblages in Belgium with reference to some Late Famennian to Permian marine nearshore to "brackish-water" assemblages dated by microspores. Annales de la Société Géologique de Beligique, 110 (1987): 347-362.

BRAUN, W., 1967. Upper Devonian ostracod faunas of Great Slave Lake and northeastern Alberta, Canada. International Symposium on the Devonian System, Calgary. Alberta Society of Petroleum Geologist, 2: 617-652.

CASIER, J.-G., 1987. Étude biostratigraphique et paléoécologique des ostracodes du recif de Marbre Rouge du Haumont á Vodelée (partie superineur du Frasnien, Bassin de Dinant, Belgique). Revue Paléobiologie 6: 193-204

CHAUFF, K. M., 1978. Recovery of Ordovician conodonts by hydrochloric acid from phosphate nodules reworked into the Sulphur

PLATE 3

Specimens are from Sample KM^2- 13 from the exposed Maple Mill Shale in the Kalona Clay Pit in southeastern Iowa and are retained at the Instytut Paleobiologii PAN in Warsaw, Poland.

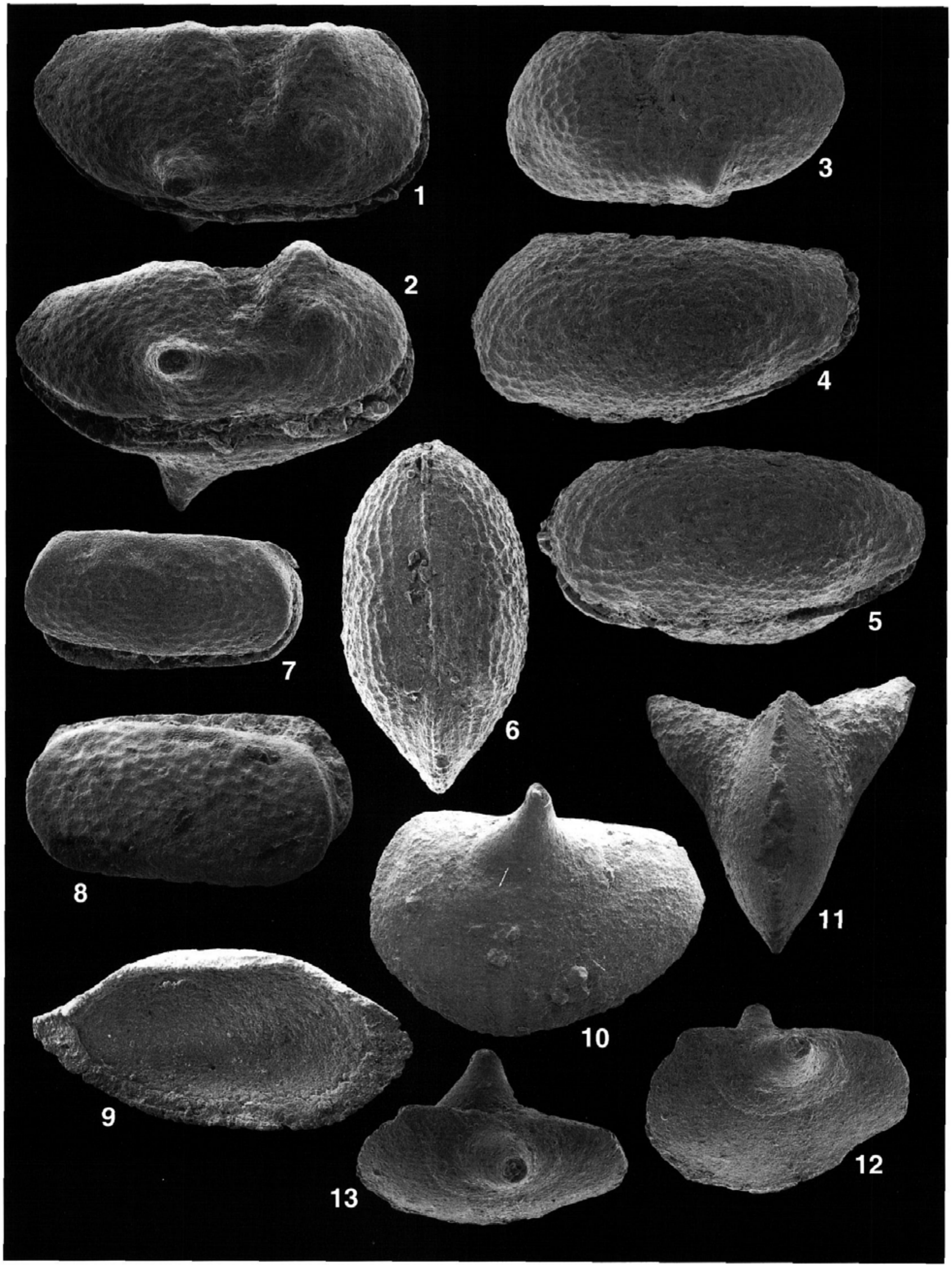
1-3 *Triceratina lethiersi* n. sp. 1-2. Lateral and latero-ventral views of right valve, holotype, X140. 3. Lateral view of left valve, X140.

4-6 *Monoceratina*? sp. 4-5. Lateral and latero-ventral views of left valve, X120. 6. Ventral view, X105.

7-8 *Moorites* sp. *aff. M. copelandi* Lethiers, 1981. 7. Lateral view of right valve, X140. 8. Lateral view of left valve, X140.

9 *Bairdia* sp. 9. Internal view of left valve, X56.

10-13 *Aechmina* sp. 10. Lateral view of left valve, X84. 11. Posterior view, X84. 12-13. Lateral and dorso-lateral views of right valve, X105.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Springs Formation (Devonian) in Missouri, U.S.A. Geological Magazine. 115 (3): 205-210.

COLLINSON, C., 1967. Devonian of the north-central region, United States. In: International Symposium on the Devonian System, Calagary, Alberta, Sept. 1967. Alberta Society of Petroleum Geologist, 1: 963-971.

COOPER, C., 1941. Chester ostracodes of Illinois. State Geological Survey. Report of Investigations, 77: 101p.

———, 1946. Pennsylvanian ostracodes of Illinois. State Geological Survey, Bulletin, 70: 9-126.

DAVIS, R. A. and SEMKEN, H. A., JR., 1975. Fossils of uncertain affinity from the Upper Devonian of Iowa. Science, 187: 251-254.

DORHEIM, F. H., KOCH, D. L., and PARKER, M. C., 1969. The Yellow Springs Group of the Upper Devonian in Iowa. Iowa Geological Survey, Report of Investigations, 9: 1-30.

GOODAY, A., 1983. Entomozoacean ostracods from the Lower Carboniferous of South-western England. Palaeontology, 26: 755-788.

GREEN, R., 1963. Lower Mississippian ostracodes from the Banff Formation, Alberta. Research Council of Alberta, 11: 237p.

GRÜNDEL, J. and KOZUR, H., 1971. Zur Taxonomie der Bythocytheridae und Tricorninidae (Podocopida, Ostracoda). Monatshefte der Deutschen Akademie der Wissenschaften zu Berlin, 13: 907-937.

HENNINGSMOEN, G., 1965. On certain features of Palaeocope ostracodes. Geologiska Fbreningens i Stockholm Förhandlingar, 86: 329-334.

JONES, P., 1985. Treposellidae (Beyrichiacea: Ostracoda) from the latest Devonian (Strunian) of the Bonaparte Basin, Western Australia. Journal of Australian Geology and Geophysics, 9: 149-162.

KESLING, R. V., 1953. Ostracods of the family Aechminindae from the Arkona Shale of S. Ontario. Contributions from the Museum of Paleontology, University of Michigan, 11: 1-10.

KINDLE, E. M., 1919. The discovery of a portage fauna in the Mackenzie River Valley. Museum Bulletin, Department of Energy and Mines, 29 (Geology Series 36): 1-8.

KLAPPER, G., SANDBERG, C. A., COLLINSON, C., HUDDLE, J. W., ORR, R. W., RICKARD, L. V., SCHUMACHER, D., SEDDON, G., and UYENO, T. T., 1971. North Americal Devonian conodont biostratigraphy. *In* Sweet, W. C., and Bergström, S. M., (eds.), Symposium on conodont biostratigraphy. Geological Society of America, Memoir 127: 285-316.

KOHN, P. and DEWEY, CH., 1992. On *Richterina permiana* Kohn and Dewey *sp. nov*. Stereo-Atlas of Ostracod shells, 19(6): 71-74.

LAUDON, L. R., 1929. The stratigraphy of the Kinderhook Series of Iowa. Iowa Geological Survey, 35: 333-451.

LETHIERS, F., 1978. Ostracodes du Devonien terminal de la Formation Big Valley, Saskatchewan et Alberta. Palaeontolographica A, 162: 81-143.

———, 1981. Ostracodes du Devonien terminal de l'ouest du Canada: systématique, biostratigraphie et paléoécologie. Geobios, Mémoire Spécial, 5: 236p.

LETHIERS, F. and BOUQUILLON, A., 1986. Les Ostracodes dévoniens et carboniferes du sondage d 'Epinoy 1 (nord de la France): leurs enseignements. B.R.G.M., Géologie de la France, 1: 125-137.

LETHIERS, F. and CASIER, J.-G., 1995. Les ostracodes du Frasnien terminal ("Kellwasser" supérieur) du Coumiac (Montagne Noire, France). Revue Micropaléontologie, 38(1): 63-77.

LETHIERS, F. and RAYMOND, D., 1991. Les crises du Dévonien supérieur par l' étude des faunes d' ostracodes dans leur cadre paléogéographique. Palaeogeography, Palaeoclimatology, Palaeoecology, 88: 133-146.

LETHIERS, F. and WHATLEY, R., 1994. The use of Ostracoda to reconstruct the oxygen levels of Late Paleozoic oceans. Marine Micropaleontology, 24: 57-69.

LORANGER, D. M., 1971. Ostracods, trace elements and Frasnien reefs in Sturgeon Lake area. Bulletin Centre de Recherches Pau-SNPA, 5 (supplement): 769-786.

MOORE, R. C., 1928. Early Mississippian formations in Missouri. Missouri Bureau of Geology and Mines, 21 (2nd. series): 283p.

———, 1935. The Mississippian System in the Upper Mississippi Valley region. In Guidebook, 9th Annual Field conference, Kansas Geological Society: 239-245.

MÜLLER, K. J., NOGAMI, Y., and LENZ, H., 1974. Phosphatische Ringe als Mikrofossilien im Altpalaozoikum. Palaeontographica, 146: 79-99.

OLEMPSKA, E., 1992. Shell structure of the entomozoaceans: allegedly planktonic ostracodes of the Palaeozoic. Acta Palaeontologica Polonica, 36 (4): 373-398.

PETERSON, R. F., 1947. Conodonts from the Maple Mill Formation of southeastern Iowa, University of Iowa (Thesis), Iowa City: 71p.

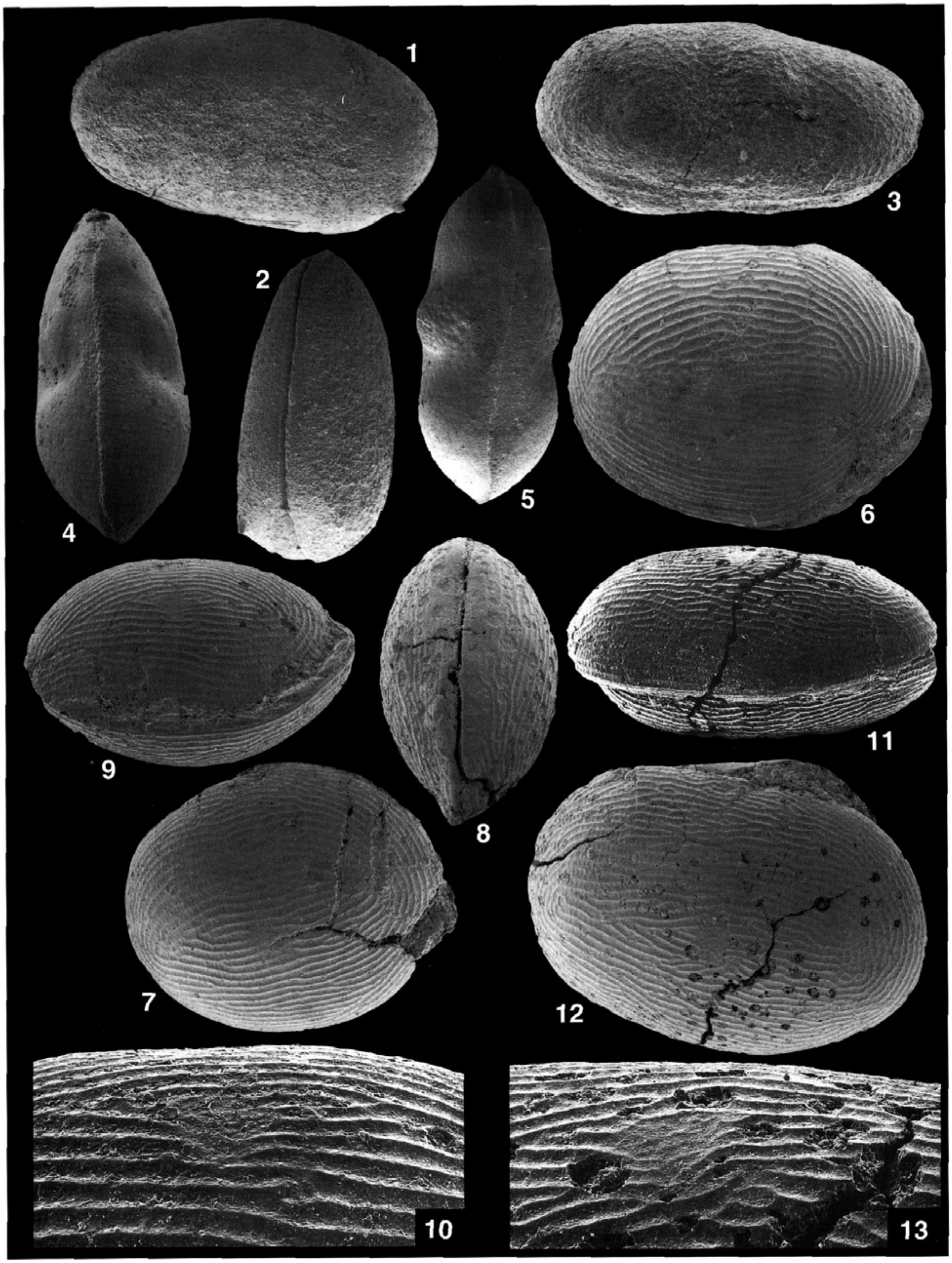
PLATE 4

Specimens are from Sample KM^2- 13 from the exposed Maple Mill Shale in the Kalona Clay Pit in southeastern Iowa and are retained at the Instytut Paleobiologii PAN in Warsaw, Poland.

1-2 *Waylandella*? sp 1. Lateral view of left valve, X42. 2. Ventral view, X35.

3-5 *Cytherellina* sp. 3. Lateral view of right valve, X70. 4. Dorsal view, X70. 5. Ventral view, X70.

6-13 *Entomozoe (Nehdentomis?) kindlei* n. sp. 6. Lateral view of right valve, holotype, X45. 7. Lateral view of right valve, X45. 8. Ventral view, X45. 9-10. Lateroventral view, X45, detail of muscle scar, X170. 11-13. Ventral and lateral views, X45, and detail of muscle scar, X170.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SCHORNIKOV, E. T., 1988. The pathways of morphological evolution of Bythocytheridae. In: Hanai, T., Ikeya, N. and Ishizaki, K. (eds.). Evolutionary biology of Ostracoda. Proceedings of the Ninth International Symposium on Ostracoda, Kondansha Ltd., Tokyo: 951-965.

SCHORNIKOV, E. T. and MICHAILOVA, E. D., 1990. Ostrakody Bythocytheridae rannego etapa razvitija (Ostracodes Bythocytheridae at early stage of development). Nauka Publishers: 278p.

SIVETER, D., 1984. Habitats and modes of life of Silurian ostracodes. Special Papers in Palaeontology, 32: 71-85.

SOHN, I. G., 1961. Palaeocopida. In: Moore, R. C. (ed.), Treatise on Invertebrate Paleontology, Part Q, Arthropoda 3. Geological Society of America, Lawrence: 197p.

———, 1983. Ostracodes of the "Winifrede Limestone" (Middle Pennsylvanian) in the region of the proposed Pennsylvanian System stratotype, West Virginia. Bulletins of American Paleontology, 84 (316): 5-53.

———, 1988. Revision of the Mississippian new ostracode genera in Coryell and Johnson 1939. Micropaleontoloty, 34: 52-62.

STAINBROOK, M. A., 1950. The fauna and correlation of the McCraney Limestone of Iowa and Illinois. American Journal of Science, 248 (3): 209-212.

STEWART, G. A. and HENDRIX, W. E., 1945. Ostracoda of the Olentangy shale, Franklin and Delaware counties, Ohio. Journal of Paleontology, 19: 96-115.

STRAKA, J. J., 1968. Conodont zonation of the Kinderhookian Series, Washington County, Iowa. University of Iowa Studies in Natural History, 21 (2): 71p.

THOMAS, L. A., 1949. Devonian-Mississippian Formations of southeast Iowa. Geological Society of America, Bulletin 60: 403-438.

VANNIER, J., 1986. Ostracodes Binodicopa de l'Ordovicien (Arenig-Caradoc) Ibero-Armoricain. Partie 1. Palaeontolographica A, 193: 77-143.

WHATLEY, R. C., SIVETER, D., and BOOMER, I. D., 1993. Arthropoda (Crustacea: Ostracoda). In: Benton, M. J., (ed.). The Fossil Record 2, Chapman and Hall, London: 343-356.

WILKINSON, I. P. and RILEY, N.J., 1990. Namurian entomozoacean Ostracoda and eustatic events. In: Whatley, R., and Maybury, C., (eds.). Ostracoda and global events. British Micropalaeontological Society Publication Series, Chapman and Hall, London: 161-172.

ZASPELOVA, V.S., 1952. Ostrakody semeystva Drepanellidae iz otlozheniy verkhnego Devona Russkoy Platformy (Ostracoda of the family Drepanellidae from the upper Devonian deposits of the Russian Platform). Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatelskogo Geologo-Rozveolochnogo Institute (UNIGRI), Novaja Senia 60 (Mikofauna SSSR:5): 157-215.

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