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MIDDLE ORDOVICIAN OSTRACODA FROM SOUTHWESTERN DISTRICT OF MACKENZIE

M. J. Copeland

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MIDDLE ORDOVICIAN OSTRACODA DISTRICT OF MACKENZIE

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PREFACE

The presence of well preserved, silicified ostracodes has only recently been established in lower Paleozoic strata of northwestern Canada and Alaska. Based on this group of microfossils, a zonation is possible of that thick sequence of sedimentary rocks. The Middle Ordovician faunas described here demonstrate the increasingly valuable application of ostracode micropaleontology in stratigraphic correlation over great distances. Such determinations are of considerable importance in the continuing search for fossil fuel resources throughout the northwestern part of the continent because they enable gaps in the stratigraphic column to be filled, thereby providing data needed for the calibration of geological time so necessary if rocks are to be precisely correlated.

OTTAWA, March 20, 1974

D.J. McLaren
Director, Geological Survey of Canada

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ABSTRACT

Silicified Middle Ordovician ostracodes of Whiterock to Barneveld ages occur in southwestern District of Mackenzie within a stratigraphic interval of about 3,000 feet. This fauna of 36 species (9 new) occurs in the Sunblood and Whittaker formations and an unnamed intervening stratigraphic unit. Because of their wide-spread geographic occurrence throughout North America, these faunas are of considerable stratigraphic importance.

RÉSUMÉ

Des ostracodes silicifiés de l'Ordovicien moyen (d'âge Whiterock à Barneveld) se trouvent dans le sud-ouest du district de Mackenzie à l'intérieur d'un intervalle stratigraphique d'environ 3,000 pieds. Cette faune de 36 espèces (dont 9 nouvelles) se trouve dans les formations de Sunblood et de Whittaker et une unité stratigraphique sans nom située entre les deux. À cause de leur très grande répartition géographique à travers l'Amérique du Nord, ces faunes sont d'une importance stratigraphique considérable.

INTRODUCTION

The silicified ostracodes reported here were found in 52 collections from 10 stratigraphic sections located within the southwestern part of District of Mackenzie near the boundaries of British Columbia and Yukon Territory (text-fig. 1). They were obtained from acid residues that also contained well preserved Ordovician trilobites and brachiopods. The author wishes to thank Rolf Ludvigsen, University of Western Ontario, for permission to study these specimens, and J.M. Berdan, United States Geological Survey, for discussions of several pertinent problems.

Silicification of these specimens is not perfect, but is sufficiently good to permit identification of 36 taxa, 9 new. Several species have been previously recorded from Baffin Island, Ontario and Newfoundland in Canada, and Iowa, Nevada, Oklahoma, Virginia and Minnesota in United States; their occurrence in the Northwest Territories of Canada permits correlation with central and eastern North America (text-fig. 2). Because some of those areas are more than 2,000 miles south and east of the present localities it is interesting to speculate on the conditions in which these faunas existed, particularly as regards the Ordovician equatorial position.

STRATIGRAPHY

In southwestern Mackenzie Mountains a thick sequence of limestone, dolomite and shale comprises, in ascending order, the Sunblood Formation, an unnamed stratigraphic unit and the Whittaker Formation. In the sections investigated by Ludvigsen, rocks of Whiterock and Chazy(?) ages comprise about 1,400 to 1,600 feet of the Sunblood Formation; possibly some of the upper part of the Sunblood Formation and all of the 600-foot-thick unnamed unit are of Porterfield and early Wilderness ages; and strata of the lower 500 feet of the Whittaker Formation are of Wilderness and early Barneveld ages.

The lower 800 feet of the composite section shown on Text-figure 3 may be assigned with reasonable assurance to the Whiterock Stage. *Eoleperditia bivia* (White) from the basal 600 feet is also present in the upper Pogonip Group of Nevada and lower Table Head Formation of Newfoundland. This Whiterock species is the oldest of several very similar *Eoleperditia* species that occur in younger Mohawkian strata of Tennessee (*Leperditia ampla* (Ulrich) of Kirk, 1928 ≈ *Isochilina pondi* Ulrich and Bassler) and Wyoming (J.M. Berdan, pers. comm.). *Cryptophyllus magnus* (Harris), known only from the Oil Creek Formation of Oklahoma[1], occurs 500 to 800 feet above the base of the composite section. Cooper (1956) considered the Oil Creek Formation as Whiterock whereas Harris (1957) assigned it to the Chazy. The presence of the stratigraphically important trilobite *Pseudomera* in the upper Pogonip Group, Oil Creek Formation and Sunblood Formation (Gabrielse *et al.*, 1973, p. 56) is generally considered indicative of the *Anomalorthis* zone of the Whiterock Stage (Ross, 1967, p. D24).

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[1]It is known that ostracodes occur in the Alsate Creek section, west Texas "that suggest correlation with the Oil Creek Formation" (Harris, *in* Berry, 1972, p. 77, 78).

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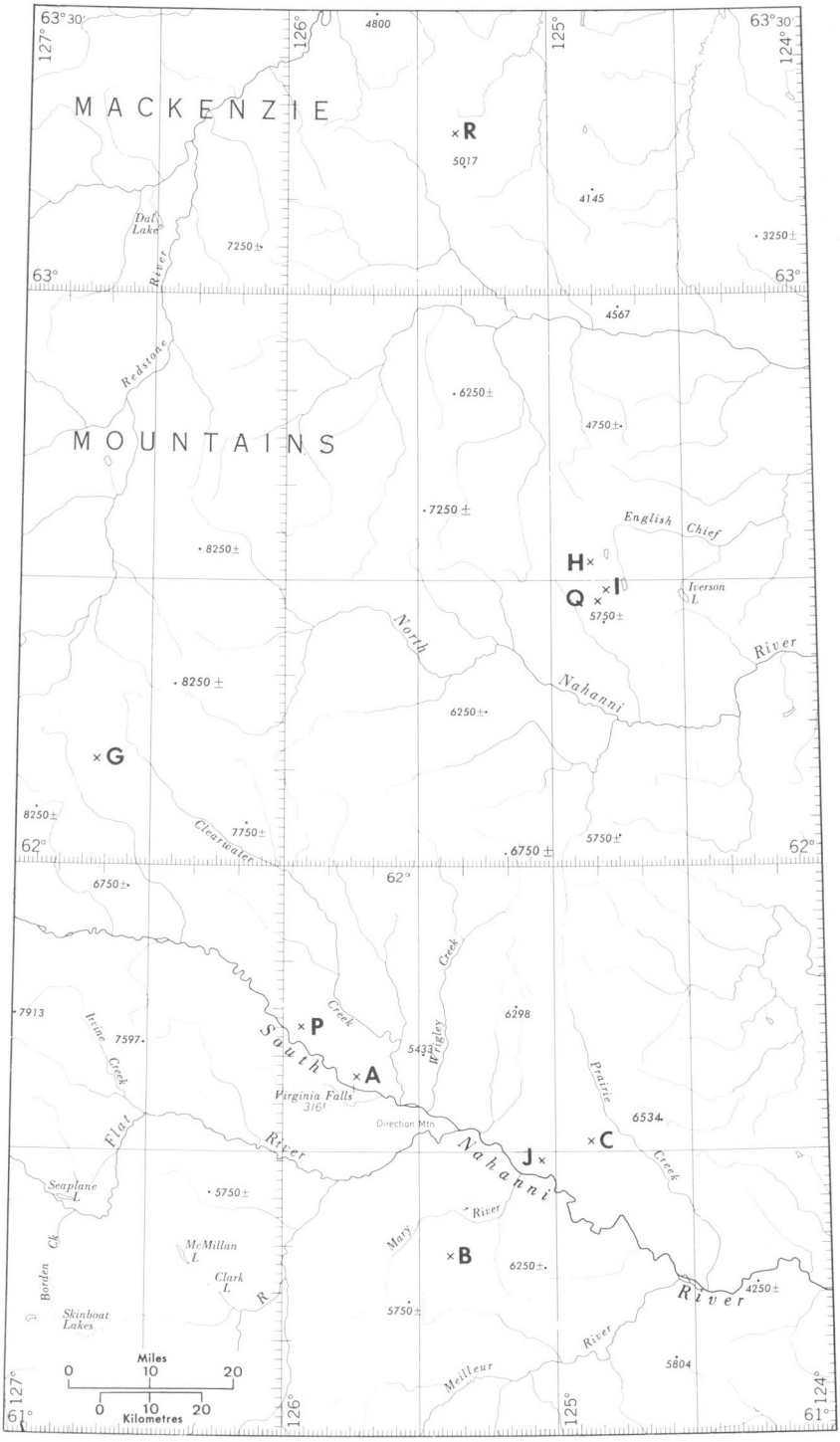
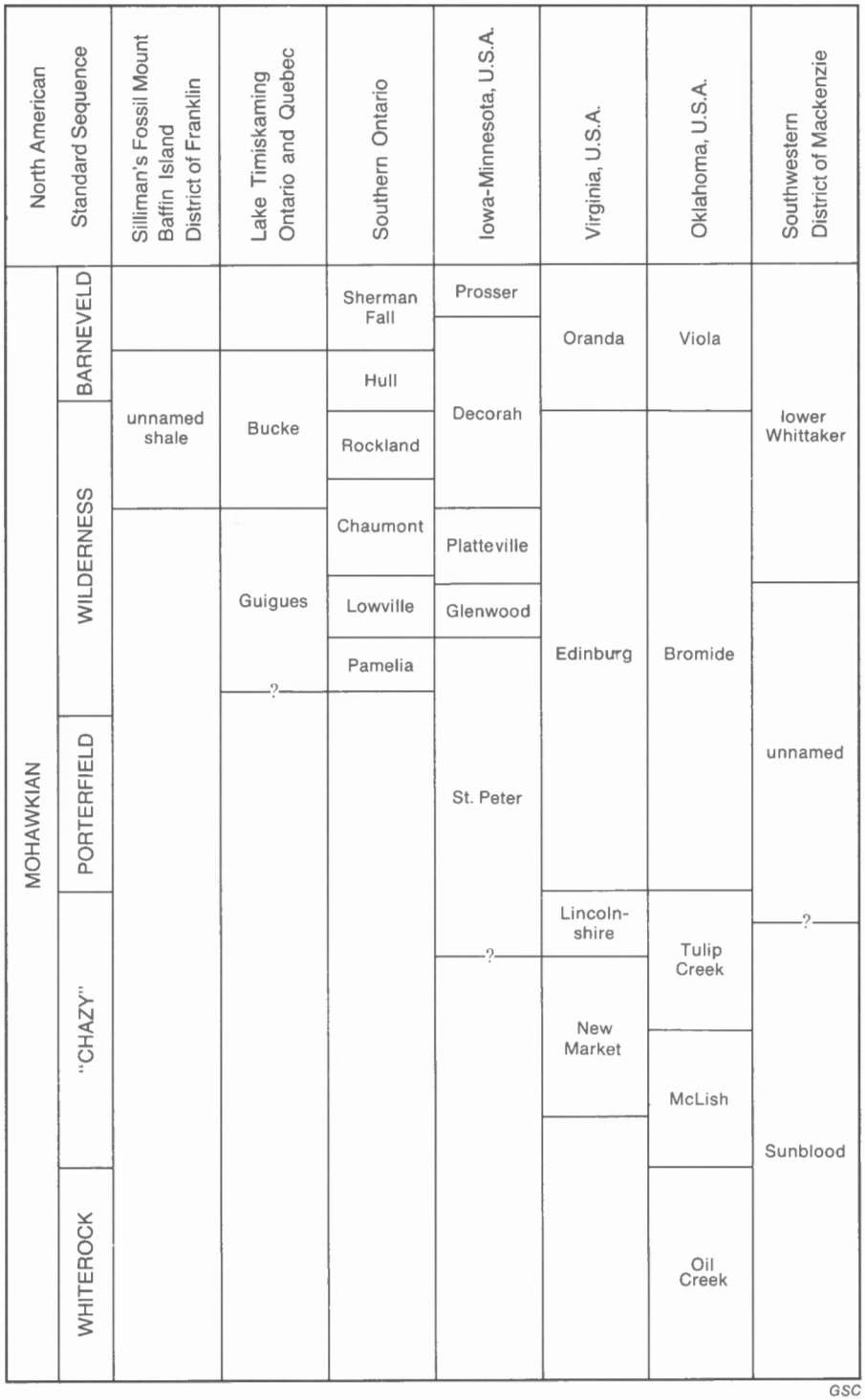


Text-figure 1. Map showing localities of sections discussed in this paper.



Text-figure 2. Suggested correlation of Mohawkian stratigraphic sequences discussed in this paper.

The upper 600 to 800 feet of the Sunblood Formation (800 to 1,400- or 1,600-foot interval of the composite section) are questionably referred to the Chazy Stage. They lack stratigraphically useful ostracodes but are bounded by distinctive older (Whiterock) and younger (Porterfield) faunas.

The 600-foot-thick unnamed unit intervening between the Sunblood and Whittaker formations bears, in its lower part, a distinctive ostracode fauna. As well as a wide range of typical "Black River" species, this basal 300-foot interval contains several genera reported by Kraft (1962) from the lower 50 feet of the Porterfieldian Edinburg Formation of Virginia. A primitive tetradellid (*Tetradella perplexa* n. sp.) also occurs in these beds; the lobation of this species indicates its probable position to be older than any known North American species and younger than "*T.*" *palmata* (Krause) and "*T.*" *marchica* (Krause) from the Baltic region (Neckaja, 1953). The Porterfield age of this lower ostracode fauna is indicated whereas a cosmopolitan Wilderness-type fauna occurs throughout the upper 300 feet of this unit.

A widespread ostracode fauna prevails throughout the 500-foot-thick lower Whittaker Formation of the composite section. This is the typical Minnesota-Ontario-Baffin Island fauna reported by Kay (1934, 1940), Copeland (1965; *in* Steele and Sinclair, 1971, p. 42) and others. The presence of *Pteroleperditia* sp. cf. *P. armata* (Walcott), possibly above a fault in Section B, could indicate mid-Wilderness (possibly Lowville) equivalence for that part of the section. *Diplopsis socialis* Levinson, *Ceratopsis quadrifida* (Jones) and *Dicranella bicornis* Ulrich are well known representatives of the late Wilderness "Decorah" fauna and the associated nodose *Tetradella*? sp. (possibly a quadrijugatorid), ?*Krausella* sp. cf. ?*K. acuta* (Teichert) and *Oepikium* sp. are more typically of younger Barneveld age.

MOHAWKIAN OSTRACODE DISTRIBUTION

This is the first Middle Ordovician ostracode succession reported from western Canada. It corresponds in part with the composite ostracode succession reported in eastern North America and provides a valuable criterion on which to base continental correlation. The resulting faunal sequence reflects the general transgression of North America Mohawkian seas, in that restricted older (Whiterock and Porterfield) ostracode faunas occur along the continental margins (Ross and Ingham, 1970, p. 406) with extensive younger (Wilderness and Barneveld) ostracode faunas occupying much of the continental platform. The geographic occurrence of this fauna may reflect faunal adaptability or position relative to continental shelves (Ross and Ingham, 1970, p. 403), or both.

The Middle Ordovician paleoequator has been determined by paleomagnetic methods as having occupied a generally southwest-trending position through Newfoundland (Strakhov, 1967) or Hudson Bay (Irving, 1964). Based on the east-west distribution of essentially similar Mohawkian ostracode faunas more than 2,000 miles apart, the latter equatorial position may be more acceptable. This seems to be in fundamental agreement with Ordovician biogeographic studies by Whittington and Hughes (1972), Nitecki (1972), Chugaeva *et al.* (1973), and Burrett (1973). These faunas might have attained wider distribution through 35 degrees of equatorial latitude than through the same distance in one hemisphere. Also, the proto-North America continental margins would have been equidistant from the equator and thus of relatively similar temperature conditions.

Such a hypothesis may be inferred, and environmental conditions postulated, on our knowledge of Mohawkian ostracode faunas. The Whiterock *Eoleperditia bivia* (White) fauna occupied both geosynclinal belts (Toquima-Table Head Faunal Realm of Ross and Ingham, 1970), which at that time may not have been particularly deep as attested by the occurrence in Northwest Territories of *Cryptophyllus magnus* (Harris) which also flourished in the relatively shallow-water Oil Creek Formation of Oklahoma. It was not until

late Chazy time in eastern North America that a deeper water ostracode fauna began to develop and reached its maximum expression in Porterfield time in both Appalachian and Cordilleran geosynclinal belts. Many previously unknown ostracode genera evolved at that time and were prominent throughout the rest of the Ordovician (*Tetradella, Bolbopisthia, Eurychilina, Krausella*). The transgressive late Wilderness-early Barneveld ostracode fauna that flourished on the North American continental platform is clearly related to the Porterfield fauna. This "Decorah" fauna contains many previously established genera but some more bizarre forms (*Dicranella, Ceratopsis, Pteroleperditia, Oepikium*) are also present and are distinctive faunal elements.

Little similarity exists between Baltic and North American Middle Ordovician ostracode faunas. Sarv (1972, p. 203-210) has shown that five palaeocopid genera are common to both: *Oepikium, Oepikella* and *Leperditella* occur throughout the Baltic Middle Ordovician and *Schmidtella* and *Tetradella* only in the late Middle Ordovician. Of those genera, *Oepikium* is of earlier occurrence in the Baltic region and *Schmidtella* and *Tetradella* are of earlier occurrence in North America. (Some Russian species of "*Tetradella*" may, however, be older than presently known North American *Tetradella* species).

RELATIONSHIP TO OTHER NORTH AMERICAN MOHAWKIAN OSTRACODE FAUNAS

Some North American ostracode faunas correlative with those discussed here are shown on Text-figure 4. Faunal similarities among the upper Pogonip Group (Nevada), and lower Table Head (Newfoundland), Oil Creek (Oklahoma) and Sunblood formations have been discussed previously. The Whiterock equivalence of part of the Sunblood Formation was reported by Ross and Ingham (1970, p. 400), "B.S. Norford (1969, written commun.), has informed us of ... a "Whiterock" brachiopod assemblage at South Nahanni River, southwestern part of the District of MacKenzie [*sic*]", and is indicated on their reconstruction of the Toquima-Table Head Faunal Realm (*ibid.*, fig. 1).

The ostracodes directly overlying this South Nahanni Whiterock fauna are not indicative of a specific Mohawkian age. No ostracode faunas of similar age are reported from western North America and comparison is possible only with those of the Simpson Group of Oklahoma (Harris, 1957) and Lincolnshire Formation of Virginia (Kraft, 1962). The reported "Chazy" and "Black River" ostracode zones of *Aparchites kauffmanensis* and *Monoceratella teres* (Swain, 1957) from eastern United States have no apparent application to the present collections.

Only long ranging Middle Ordovician ostracode species are common to the present collections and the McLish and Bromide formations of Oklahoma described by Harris (1957). It is sometimes difficult to determine equivalence of some species reported by Harris, but, on the whole, the ostracode fauna of the Simpson Group is unique. *Krausella minuta*? (Harris), *Schmidtella affinis* Ulrich, *Bairdiocypris* sp. cf. *B. granti* (Ulrich), *B.* sp. cf. *B. cylindrica* (Hall), *Eoleperditia fabulites* (Conrad) and ?*Krausella* sp. cf. ?*K. acuta* (Teichert) are present but are long ranging even in the present collections and of limited stratigraphic use. Also, *Diplopsis socialis* Levinson occurs in both areas. Topotypic specimens of this species were obtained from S.A. Levinson and their similarity to specimens from the present collections is unquestioned. As a result, many specimens previously referred by the present author to *Oepikella* sp. cf. *O. frequens* (Steusloff) or *Diplopsis* sp. cf. *D. frequens* (Steusloff), and morphologically similar specimens obtained from acid residues of the Edinburg Formation of Virginia are considered as *D. socialis*.

The silicified ostracode faunas of the Lincolnshire and Edinburg formations of Virginia have been well illustrated by Kraft (1962). Several long ranging species from those formations are present in the Simpson Group and the present collections. Dr. G.A. Cooper, United States National Museum, provided bulk samples of Edinburg limestone containing silicified ostracodes.

Other Occurrences	Ostracode Species	*Eoleperditia bivia* (White)	*Schmidtella?* sp. cf. *S.? subrotunda* Ulrich	*Cryptophyllus magnus* (Harris)	*Krausella minuta?* (Harris)	*"Aparchites"* sp. cf. *"A." fimbriatus* (Ulrich)	*Krausella inaequalis* Ulrich	*Schmidtella affinis* Ulrich	*Bairdiocypris* sp. cf. *B. granti* (Ulrich)	*Cryptophyllus oboloides* Ulrich and Bassler	*Euprimitia krafti* n. sp.	*Oepikella labrosa* Copeland	*Eoleperditia fabulites* (Conrad)	*Isochilina* sp. cf. *I. gregaria* (Whitfield)	*Diplopsis socialis* Levinson	*?Krausella* sp. cf. *?K. acuta* (Teichert)	*Tetradella?* sp.	*Ceratopsis quadrifida* (Jones)	*Bairdiocypris* sp. cf. *B. cylindrica* (Hall)	*Pteroleperditia* sp. cf. *P. armata* (Walcott)	*Dicranella bicornis* Ulrich
Nevada	Antelope Valley Fm.	×																			
Newfoundland	lower Table Head Fm.	×																			
Oklahoma	Bromide Fm.							×					×		×				×		
	Tulip Creek Fm.							×					×		×				×		
	McLish Fm.				×			×	×				×						×		
	Oil Creek Fm.			×	×				×												
Virginia	Edinburg Fm.				×	×	×	×			×				×				×		
	Lincolnshire Fm.				×	×	×	×			×				×						
Southern Ontario (General)	Rockland						×	×	×	×			×		×		×	×	×		
	Chaumont					×				×			×						×		
	Lowville												×							×	
	Pamelia												×	×							
Minnesota and Iowa	Decorah Fm.		×			×	×	×	×	×			×		×			×	×		×
Lake Timiskaming	Bucke Fm.					×	×	×	×	×		×	×		×						
Baffin Island	Silliman's Fossil Mount, unnamed shale				×	×	×	×	×			×			×	×	×	×	×		×

GSC

Text-figure 4. Other occurrences of ostracode species identified in the present study.

The fauna of the lower part of the Edinburg Formation equates at the generic level with that obtained from collection A-125 of the present study. *Eokloedenella*, *Euprimitia?* and *Bolbopisthia* are common to both areas. This does not establish the exact stratigraphic position of the present collections, but probable correlation with the lower (Porterfield) part of the Edinburg Formation seems a valid assumption. The occurrence with *Bolbopisthia* of a primitive tetradellid (*Tetradella perplexa* n. sp.) may raise the question of possible Chazy age for collection A-125. This is considered unlikely as the rest of the ostracode fauna occurring in that interval appears more probably of post Chazy age.

Ostracode faunas from southern Ontario (Kay, 1934; Copeland, 1965, p. 4) and Ottawa Valley (Copeland, *in* Steele and Sinclair, 1971, p. 42, pl. XXIII) are readily equated with those of the Decorah Formation of Iowa and

Minnesota (Kay, 1940), Bucke Formation of Lake Timiskaming, Ontario and the shaly beds at Silliman's Fossil Mount, Baffin Island. Minor differences occur in the fauna at each locality but the principal faunal elements are present at all. These faunas correlate most readily with the late Wilderness-early Barneveld collections from the lower Whittaker Formation of the present report. In particular, *Ceratopsis quadrifida* (Jones), *Dicranella bicornis* Ulrich and the nodose *Tetradella*? sp. are indicative of the age of this fauna.

The ambiguity of the Baffin Island faunas from Silliman's Fossil Mount - Middle Ordovician ostracodes listed by Warthin (*in* Miller *et al.*, 1954, p. 19) and Upper Ordovician shelly faunas - may be explained by reference to the stratigraphic sequence at Lake Timiskaming, Ontario. At the latter locality, late Wilderness-early Barneveld microfauna of the shaly Bucke Formation lie disconformably beneath late Barneveld dolomitic limestone of the Farr Formation (Copeland, 1965; Sinclair, 1965). It appears that a similar stratigraphic sequence may be present at Silliman's Fossil Mount; Miller *et al.* (1954, p. 6) indicate the section there to be, in descending order, "50 feet ... of massive dolomitic limestone, ... 75 feet of thin-bedded limestone and dolomite, and the lower 175 feet of calcareous shale with some interbedded limestone." Ostracodes collected stratigraphically by Miller from the lower 175 feet of calcareous shale, and preserved in collections of the United States National Museum, were examined and their late Wilderness-early Barneveld faunal affinities were confirmed. Roy's collections from the same locality were from talus and therefore of unknown stratigraphic position (1941, p. 44). Examination of type specimens described by Roy and deposited in the Field Museum of National History, Chicago, however, indicates their similarity to those reported by Warthin.

In summary, ostracode faunas representative of three stages of the Mohawkian Series occur in parts of the Sunblood to Whittaker formations of southwestern District of Mackenzie. The oldest, represented by *Eoleperditia bivia* (White) and *Cryptophyllus magnus* (Harris) is of Whiterock age; the intermediate fauna, of Porterfield age, is marked by the occurrence of *Bolbopisthia ludvigseni* n. sp.; and *Ceratopsis quadrifida* (Jones) is indicative of the youngest fauna of Wilderness-Barneveld age. Within this Mohawkian sequence, Chazyan ostracodes are not certainly recognized. This is not unexpected as a definitive Chazyan ostracode fauna has yet to be documented in North America. This North American ostracode sequence has little in common with that developed in northern Europe or Russia, therefore, no intercontinental equivalence is postulated; this may be possible, however, from Rolf Ludvigsen's detailed examination of associated trilobite and brachiopod faunas.

LOCALITY REGISTER

(Capital letter indicates locality of Section (as on text-fig. 1); number indicates footage above base of measured section; GSC locality numbers are appended for Section P)

Section A — 61°38'N, 125°44'W — Sunblood Mountain

Measured east from saddle behind peak of Sunblood Mountain; section started in uppermost beds of orange weathering Sunblood Formation.

A-125: *Eurychilina sunbloodensis* n. sp.
Leperditella sp.
aechminid indet.
Cryptophyllus oboloides (Ulrich and Bassler)
Schmidtella affinis Ulrich
"*Aparchites*" *fimbriatus* (Ulrich)
Bairdiocypris sp. cf. *B. granti* (Ulrich)
Tetradella perplexa n. sp.
Steusloffina borealis n. sp.
Bolbopisthia ludvigseni n. sp.
Krausella minuta? (Harris)
Euprimitia? *krafti* n. sp.

A-220: *Eokloedenella whittakerensis* n. sp.

A-365: *Bolbopisthia ludvigseni* n. sp.
Krausella minuta? (Harris)
Schmidtella affinis Ulrich

A-385: Ostracodes indet.

Section B — 61°19'N, 125°23'W — Mary Range

Seven miles southwest of junction of Mary River and May Creek, section started 1½ miles northwest of Benchmark 5,091 feet in Sunblood Formation.

B-1005: *Eokloedenella whittakerensis* n. sp.
Eoleperditia fabulites (Conrad)

B-1450: *Bolbopisthia lenzi* n. sp.
Schmidtella affinis Ulrich

B-1600-1700: *Pteroleperditia* sp. cf. *P. armata* (Walcott)

Section C — 61°31'N, 124°52'W — Prairie Creek

Four miles west of Prairie Creek; section started in core of drag fold over Gate Fault in upper Sunblood Formation.

C-590: *Krausella inaequalis* Ulrich

C-640: *Schmidtella affinis* Ulrich
"*Aparchites*" *fimbriatus* (Ulrich)
Diplopsis socialis Levinson
Ceratopsis quadrifida (Jones)
Krausella inaequalis Ulrich
?*Krausella* sp. cf. ?*K. acuta* (Teichert)
Tetradella? sp.

C-655: *Eurychilina prairiensis* n. sp.
"Aparchites" fimbriatus (Ulrich)
Diplopsis socialis Levinson
?Krausella sp. cf. *?K. acuta* (Teichert)
Krausella inaequalis Ulrich
Tetradella? sp.
Ceratopsis quadrifida (Jones)

Section G — 62°11'N, 126°42'W — Flood Creek

G-1425: *Eoleperditia bivia* (White)

G-1745: *Leperditella* sp. cf. *L. germana* (Ulrich)

G-1825: *Leperditella* sp. cf. *L. germana* (Ulrich)
Schmidtella? sp. cf. *S.? subrotunda* Ulrich

G-1850: *Leperditella* sp. cf. *L. germana* (Ulrich)
Schmidtella? sp. cf. *S.? subrotunda* Ulrich

G-2005: *Eoleperditia bivia* (White)

G-2170: *Eoleperditia*? sp.
Leperditella sp. cf. *L. germana* (Ulrich)
Cryptophyllus magnus (Harris)

G-2795: *Leperditella* sp. cf. *L. germana* (Ulrich)

G-2910: *Leperditella* sp. cf. *L. germana* (Ulrich)

Section H — 62°32'N, 124°51'W — Whittaker Anticline

Three miles northwest of northern tip of Trench Lake; measured from core of Whittaker Anticline.

H-1300: *Leperditella* sp.

H-1850: *?Krausella* sp. cf. *?K. acuta* (Teichert)
Bolbopisthia sp.

H-1920: *Krausella inaequalis* Ulrich
?Krausella sp. cf. *?K. acuta* (Teichert)
Dicranella bicornis Ulrich
Tetradella? sp.
Ceratopsis quadrifida (Jones)

H-1975: *Oepikella labrosa* Copeland
Eurychilina sp.
Oepikium sp.
?Krausella sp. cf. *?K. acuta* (Teichert)
Dicranella bicornis Ulrich
Tetradella? sp.

Section I — 62°29'N, 124°47'W — Whittaker Anticline

Four miles west of south end of Trench Lake.

I-780: *Oepikella*? sp.

I-1275: *Krausella inaequalis* Ulrich
"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)
Bolbopisthia lenzi n. sp.
Eurychilina sp.
Diplopsis socialis Levinson

I-1410: *Ceratopsis quadrifida* (Jones)
"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)
Bairdiocypris sp. cf. *B. cylindrica* (Hall)
Eurychilina prairiensis n. sp.

Section J — 61°29'N, 125°03'W — Funeral Range

Eighty feet below base of Ordovician-Silurian quartzite unit.

J-220: *Eurychilina prairiensis* n. sp.
?*Krausella* sp. cf. ?*K. acuta* (Teichert)
Diplopsis socialis Levinson
Ceratopsis quadrifida (Jones)
Schmidtella affinis Ulrich
Milleratia sp.
Bairdiocypris cylindrica (Hall)

Section P — 61°43'N, 125°56'W — Sunblood Range

		(GSC Loc. No.)
Twelve miles northwest of Sunblood Mountain.		
P-10:	*Eoleperditia bivia* (White)	(C-26344)
P-30:	*Leperditella* sp. cf. *L. germana* (Ulrich) *Schmidtella*? sp. cf. *S.*? *subrotunda* Ulrich	(C-26342)
P-55:	*Schmidtella*? sp. cf. *S.*? *subrotunda* Ulrich *Leperditella* sp. cf. *L. germana* (Ulrich) *Cryptophyllus magnus* (Harris) *Eoleperditia* sp. *Isochilina*? sp.	(C-26341)
P-105:	*Eoleperditia* sp. *Cryptophyllus magnus* (Harris)	(C-26340)
P-300:	*Krausella minuta*? (Harris)	(C-26334)
P-330:	"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich) *Bairdiocypris* sp. ostracode indet.	(C-26333)
P-740:	*Krausella inaequalis* Ulrich *Leperditella* sp. cf. *L. germana* (Ulrich)	(C-26330)
P-1090:	*Leperditella* sp. cf. *L. germana* (Ulrich)	(C-26328)

P-1127: *Leperditella* sp. cf. *L. germana* (Ulrich) (C-26327)

P-1130: *Leperditella* sp. cf. *L. germana* (Ulrich) (C-26326)

P-1187: *Schmidtella affinis* Ulrich (C-26325)

P-1405: *Eoleperditia*? sp. (C-26322)
Leperditella mundula (Ulrich)

P-1485: *Bolbopisthia ludvigseni* n. sp. (C-26320)
"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)
"*Aparchites*" sp.
Bairdiocypris sp. cf. *B. granti* (Ulrich)
Ludvigsenites mackenziensis n. sp.
Eurychilina sunbloodensis n. sp.
Krausella minuta? (Harris)

P-1497: *Leperditella mundula* (Ulrich) (C-26319)
"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)
Bolbopisthia ludvigseni n. sp.
Ludvigsenites mackenziensis n. sp.
Krausella minuta? (Harris)

P-1512: "*Aparchites*" sp. (C-26318)
Bairdiocypris sp. cf. *B. granti* (Ulrich)
Ludvigsenites mackenziensis n. sp.

P-1575: *Eurychilina* sp. (C-26315)
Oepikella sp. cf. *O. labrosa* Copeland
Leperditella mundula (Ulrich)

P-1585: *Leperditella mundula* (Ulrich) (C-26314)
Oepikella sp. cf. *O. labrosa* Copeland

P-1595: *Leperditella mundula* (Ulrich) (C-26313)
Oepikella labrosa Copeland
Oepikella sp. cf. *O. labrosa* Copeland

P-1665: *Isochilina* sp. cf. *I. gregaria* (Whitfield) (C-26311)

P-1931: *Schmidtella affinis* Ulrich (C-26306)
Leperditella mundula (Ulrich)

P-1945-1955: *Leperditella mundula* (Ulrich) (C-26305)

P-2038: *Eoleperditia*? sp. (C-26302)
Bolbopisthia sp. cf. *B. lenzi* n. sp.
Bairdiocypris sp. cf. *B. granti* (Ulrich)

P-2050: *Eurychilina prairiensis* n. sp. (C-26301)
"*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)

Section Q — 62°28'N, 124°49'W — Whittaker Anticline

Four and one-half miles west-southwest of south end of Trench Lake.

Q-130: *Schmidtella affinis* Ulrich
Bolbopisthia sp. cf. *B. ludvigseni* n. sp.
Krausella inaequalis Ulrich

Q-530: ?*Krausella* sp. cf. ?*K. acuta* (Teichert)
Bairdiocypris sp. cf. *B. cylindrica* (Hall)
Leperditella sp.

Section R — 63°17'N, 125°21'W — Dusky Range

Three miles northwest of Benchmark 4007, 180 feet above base of Whittaker Formation.

R-625: *Krausella inaequalis* Ulrich
?*Krausella* sp. cf. ?*K. acuta* (Teichert)

SYSTEMATIC DESCRIPTIONS

Subclass Ostracoda Latrielle, 1806
Order Bradorina? Raymond, 1935
(= Archaeocopida Sylvester-Bradley, 1961)
Family Beyrichonidae? Ulrich and Bassler, 1931
Genus *Ludvigsenites* n. gen.
Type species *Ludvigsenites mackenziensis* n. sp.

Diagnosis. Carapace elongate, bilobate, subtriangular, with conical anterodorsal "eye tubercle" and inclined median sulcus; anterior lobe low, with near marginal process, inflated posterior lobe with prominent tubercle. Hinge long, straight, adont. Shell black, smooth, with polygonal structure, composition unknown.

Remarks. The downward-curved, hooklike anterior process is situated in a position somewhat similar to that of the cypridinacean rostrum. It is a platform-like marginal extension of the anterior lobe and is slightly removed from the contact margin of the valve. The posterior tubercle rises from the lateral surface of the posterior lobe; it, too, projects past the closure of the valves. The lobate areas connect ventral of the near median, inclined sulcus in the area of the ventral angulation of the valves. The free margin of the right valve bears a fine, near marginal ridge extending from the posterior cardinal angle to the base of the anterior process. This may serve as a line of closure against which the left valve abuts.

The polygonal wall structure is similar, but finer, than that shown by Müller (1964) for the bradorinid genera *Falites* Müller and *Reticulocambria* Müller, both of Cambrian age from Sweden. There is little similarity in shape and ornamentation between *Falites* and *Ludvigsenites*, and the bilobate *Reticulocambria* lacks an eye tubercle and terminal process. Studies of Cambrian bradorinids from North America (Ulrich and Bassler, 1931) and Australia (Öpik, 1963, 1968) show that many of the generally accepted morphological characteristics of the 'higher' ostracodes are lacking or poorly developed in this 'lower' group. *Ludvigsenites mackenziensis* n. sp. is the youngest yet described bradorinid(?) known to the author and in several aspects is intermediate between the 'lower' and 'higher' ostracodes. In shell structure, composition and shape, and, to an extent, hingement and "eye spot" it resembles the 'lower' bradorinids; in lobation, valvular overlap and ornamentation it is related to the 'higher', more conventional ostracodes. Age: Middle Ordovician, lower Porterfield Stage.

Ludvigsenites mackenziensis n. sp.
Plate IX, figures 21-23; Text-figure 5, numbers 1-4

Description. As for the genus.

Length of holotype, GSC No. 38424, a right valve, 4.5 mm, height (from hinge to ventral margin) 2.2 mm, width (in posterior third of valve) 1.4 mm.

Number of specimens studied, 5.

Types. Holotype, GSC No. 38424; paratypes, GSC Nos. 38423, 38425, a,b.
Occurrences. Localities P-1485, P-1497, P-1512, Porterfield Stage, lower part of unnamed formation.

Order Leperditicopida Scott, 1961
Family Leperditiidae Jones, 1856
Genus *Eoleperditia* Swartz, 1949
Type species *Cytherina fabulites* Conrad, 1843
Eoleperditia fabulites (Conrad), 1843
Plate V, figures 6-9

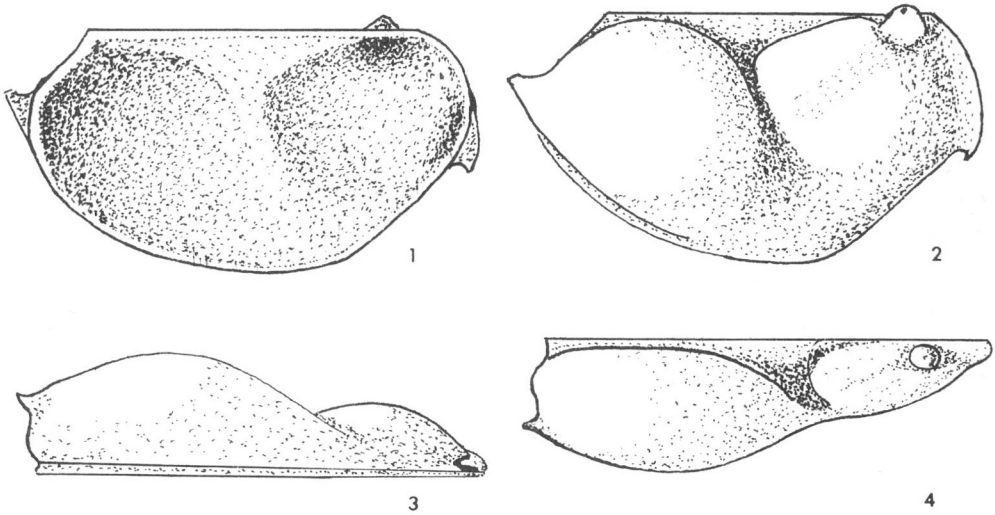
Cytherina fabulites Conrad, 1843, p. 332.
Leperditia fabulites (Conrad), Jones, 1856, p. 89; (authors).
Leperditia canadensis josephiana Jones, 1858, p. 94, pl. 11, fig. 16; (authors).
Eoleperditia fabulites (Conrad), Swartz, 1949, p. 318, pl. 66, figs. 1-10;
Harris, 1957, p. 129, pl. 1, figs. 1a, b; (authors).

Remarks. Specimens from the present collections exhibit the typical lateral outline of this species shown by Swartz (1949). The eyespot is weak to indistinguishable and the antero- and posteroventral parts of the right valve undulate ventral of the inner prongs. Externally, the prongs are distinguished by a longitudinal depression consisting of four or five pits; four or five prongs mark this depression on the interior of the right valve. The hinges of a few specimens appear to be slightly denticulate but this may be due to silicification. No muscle scar is visible.

Number of specimens studied, more than 100.

Types. Hypotypes, GSC Nos. 35167-35170.

Occurrence. Locality B-1005, Porterfield Stage, unnamed formation; of general Wilderness-Barneveld age in North America.



1. Interior view of left valve.
2-4. Exterior, ventral and dorsal views of right valve.

Text-figure 5. Diagrammatic representations of *Ludvigsenites mackenziensis* n. sp., X ca. 13.

Eoleperditia bivia (White), 1877
Plate IX, figures 18-20

Leperditia bivia White, 1877, p. 58, pl. 3, figs. 7a-d.
Eoleperditia bivia (White), Berdan *in* Whittington and Kindle, 1963, p. 747; (authors).

Remarks. This species is distinguished by its relatively equilateral shape, distinct cardinal angles, and the presence on the right valve of single anterior and posterior ventral pits marking the locations of interior prongs. These two inner prongs of the right valve may bifurcate distally or form short denticulate ridges but their external expressions remain two distinct pits situated symmetrically on the ventral margin of the valve. Comparison with *E. fabulites* shows that the right valve of that species bears four or five discrete antero- and posteroventral internal prongs, each marked on the exterior of the valve by a discrete pit or by a depression situated within a longitudinal furrow.

Number of specimens studied, more than 30 (few complete).

Types. Hypotypes, GSC Nos. 38420-38422.

Occurrences. Localities P-10, G-1425, G-2005, Whiterock Stage, Sunblood Formation; upper part of the Pogonip Group (Antelope Valley and Lehman Formations) in Nevada; 176 to 485 feet above the base of bed 8, lower Table Head Formation, western Newfoundland (Berdan *in* Whittington and Kindle, 1963, p. 747); Glenogle Formation, southern British Columbia.

Genus *Pteroleperditia* Hamada, 1959
Type species *Herrmannina ehlersi* Kesling, 1958
Pteroleperditia sp. cf. *P. armata* (Walcott), 1883
Plate IX, figure 24

Leperditia (*Isochilina*) *armata* Walcott, 1883, p. 7.
Isochilina armata (Walcott), Jones, 1903, p. 304; (authors).
Pteroleperditia armata (Walcott), Hamada, 1959, p. 51.
Ceratoleperditia armata (Walcott), Harris, 1960, p. 213.

Remarks. The figured specimen is 5.2 mm long and 3.1 mm high. The horizontal, hollow, elliptically shaped spine is 1.7 mm wide at its junction with the lateral surface of the valve and extends 1.0 mm outward, curving posteriorly to its broken tip; its upper surface is 2.4 mm ventral of the dorsal line, 1.5 mm from the anterior margin and 2.0 mm from the posterior margin. The horizontal position of the lateral spine presents some difficulty in comparison with *P. armata* (Walcott) in that Walcott's description indicates that "a strong unciform-shaped spine projects obliquely outward, the apex extending beyond the ventral margin". The type specimen of *P. armata* cannot be found so it is impossible to verify this statement; whether the attitude of the lateral spine is of specific value is unknown.

Number of specimens studied, one left valve.

Type. Hypotype, GSC No. 38426.

Occurrence. Locality B-1600-1700, Wilderness Stage, lower part of Whittaker Formation; Wilderness Stage of eastern North America.

Order Palaeocopida Henningsmoen, 1953
Superfamily Hollinacea Swartz, 1936
Family Eurychilinidae Ulrich and Bassler, 1923
Genus *Eurychilina* Ulrich, 1889
Type species *Eurychilina reticulata* Ulrich, 1889
Eurychilina sunbloodensis n. sp.
Plate I, figures 1-11; Text-figure 6, number 4

Description. Valves subelliptical in lateral view, dorsally truncate, greatest height slightly posterior of median, greatest length slightly ventral of median. Dorsum long, straight, slightly sunken between low dorsal ridge on each valve; anterior margin more narrowly rounded than posterior margin; ventral margin of heteromorph more broadly curved than that of tecnomorph. Frill striated, broad, extending to dorsal corners of valve; widest in posteroventral part. Frill of tecnomorph flat, outward flaring especially near dorsal corners. Frill of heteromorph flat, with narrow, deep, well-defined brood pouch extending along anteromedian to posteroventral part of domicilium margin; width of brood pouch about 0.4 to 0.6 that of entire frill. Ventral partition of brood pouch almost touching domicilial margin anteriorly and posteriorly.

Valve surface papillose with few to numerous granules. S_2 reverse-comma shaped, deep, in dorsal half of domicilium and slightly anterior of mid valve. L_2 a broad, rounded knob, not reaching dorsal ridge and only indistinctly set off from L_1 by a slight anterior depression (S_1); S_1 and S_2 joining dorsally of L_2. Domicilium surface with a faint, near marginal, groove or angulation representing the inner contact margin of the valve, and low ridge extending along the entire dorsum. Subvelar channel deep, extending to nodose marginal ridge.

Length of holotype, GSC No. 35115, a heteromorphic right valve, 2.3 mm, height 1.5 mm.

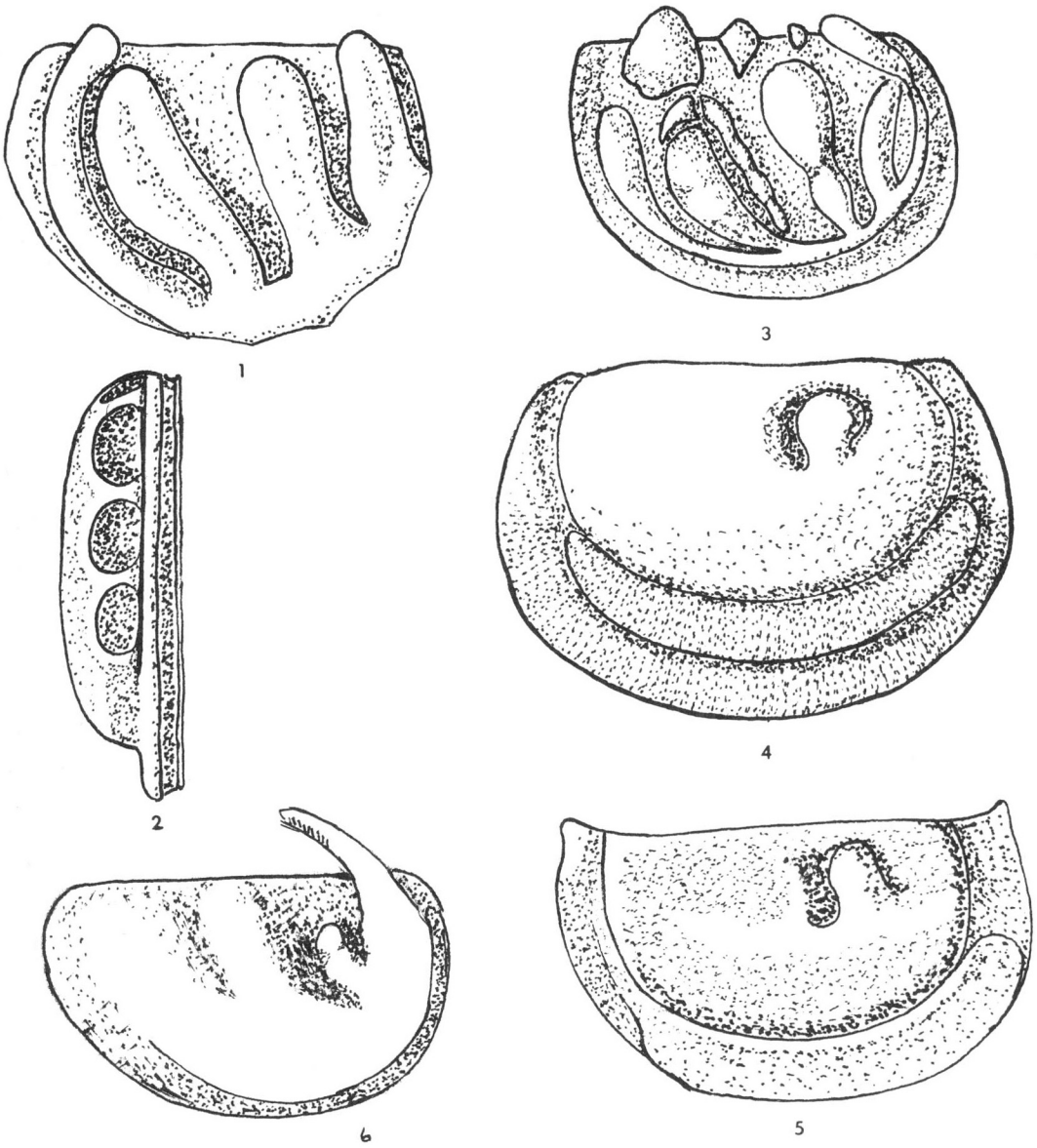
Number of specimens studied, more than 100.

Types. Holotype, GSC No. 35115; paratypes, GSC Nos. 35108-35114, 35116-35118.

Occurrences. Localities A-125, P-1485, Porterfield Stage, unnamed formation.

Remarks. This species most nearly resembles *Eurychilina nodosa* Swain, 1962 (Not Kraft, 1962) and *Eurychilina mattea* Kraft, 1962 from the Lincolnshire and Edinburg formations of Virginia and, questionably, the Crown Point Formation of New York. Each of these species bears a well-defined brood pouch occupying about 0.5 of the frill width. The ventral margin of the brood pouch is a subdistal ridge (Kesling, 1960, p. 354) extending nearly at 90 degrees with the velar frill and not touching the domicilial margin anteriorly or posteriorly. *E. sunbloodensis* n. sp. is apparently less papillose than *E. mattea* and is not nodose as is *E. nodosa* (some similarity may exist between *E. nodosa* and *E. tuberculata* Teichert, 1937 but this is unknown at present). Also, *E. sunbloodensis* bears a low dorsal ridge on each valve, which is not reported for *E. mattea* or *E. nodosa*.

It may prove desirable, in future, to subdivide the genus *Eurychilina* into those species bearing a well-defined, sausage-shaped brood pouch less than the full width of the frill, the ventral side of which is limited by a distinct subdistal ridge extending at right angles from the velar frill, and those species bearing a less distinct, more simple brood chamber formed by the general internal concavity of most or all of the velar frill. When the free margins are in contact, carapaces of the first group of species (such as *E. sunbloodensis*) have a closed heteromorphic brood pouch (Pl. I, fig. 2) with flaring or gaping distal velar frill extending from the surface of the pouch, whereas in the same condition, carapaces of the second group of species (such as *E. prairiensis* n. sp.) have the concave portion of the velar frill tightly appressed distally to form a brood chamber, the more distal portion of the velar frill (if any) extending from that point of contact.



1,2. *Tetradella perplexa* n. sp.
Right lateral and ventral views of heteromorphic valves, X60.
3. *Tetradella*? sp.
Right lateral view of tecnomorphic valve, X75.
4. *Eurychilina sunbloodensis* n. sp.
Right lateral view of heteromorphic valve, X30.
5. *Eurychilina prairiensis* n. sp.
Right lateral view of heteromorphic valve, X30.
6. *Ceratopsis quadrifida* (Jones)
Right lateral view of valve, X30.

Text-figure 6. Diagrammatic representations of tetradellid, eurychilinid and ceratopsid species discussed in this paper.

Eurychilina prairiensis n. sp.
Plate IV, figures 3, 4; Plate VII, figures 4-15; Text-figure 6, number 5

Description. Valves preplete, subelliptical in lateral view, dorsally truncate, greatest height in anterior half, greatest length slightly dorsal of median. Dorsum long, straight, slightly sunken between dorsal shoulders of both valves; anterior margin more narrowly rounded than posterior, ventral margin of heteromorph more broadly rounded than that of tecnomorph. Frill smooth, distally striate on tecnomorphic valves and posteriorly spinose on both dimorphs, with anterior and posterior alae extending above dorsal line. Frill on tecnomorph flat to flaring ventrally, with a slight fold posteriorly. Frill of heteromorph rising abruptly from well-marked contact margin of domicilium, with laterodorsal angulation and smooth distal extension curving inward marginally parallel with the domicilial margin to contain the brood chamber. Brood chamber deep, interiorly with tubules, and extending along anteroventral to posterior part of frill between contact and velar margins, broadest anteriorly and diminishing to a narrow channel posteriorly, open anteriorly and posteriorly along contact margin. Brood chamber bordered ventrally by slight distal ridge of velar structure.

Domicilial surface evenly and coarsely papillose; frill smooth to finely papillose. S_2 small, pit-like at posteroventral side of L_2 and extending dorsally as a shallow groove delimiting L_2 dorsally. S_1 indistinct. L_2 a large round knob not reaching dorsum. Domicilium with a longitudinal axis of greatest width parallel with the dorsum and extending ventral of S_2. Subvelar channel indistinct, with a nodose(?) marginal ridge.

Length of holotype, GSC No. 35259, a heteromorphic right valve, 2.5 mm, height 1.4 mm.

Number of specimens studied, more than 50.

Types. Holotype, GSC No. 35259; paratypes, GSC Nos. 35154, 35155, 35251-35258, 35260-35262.

Occurrences. Localities C-655, I-1410, J-220, P-2050, Wilderness Stage, lower Whittaker Formation.

Remarks. This species belongs with the group of *Eurychilina subradiata* Ulrich in nature of the frill and the sharp angle at which it joins the domicilium. The external expression of the brood chamber and the posterior velar spines or denticles are not present on *E. subradiata*, and the domicilium of that species is smooth rather than papillose. Both species appear to bear a low central horizontal angulation across the domicilium but this is far more pronounced on *E. subradiata* than on the present species.

Genus *Euprimitia* Ulrich and Bassler, 1923
Type species *Primitia sanctipauli* Ulrich, 1894
Euprimitia? krafti n. sp.
Plate VII, figures 16, 17

?Milleratia tumblingrunensis Kraft (part), 1962, Pl. 6, figs. 7a, b, 8a, b.

Description. Valves subovate in lateral view, greatest height posterior, greatest length near median. Lateral surface flat to slightly undulating, sunken below velar ridge. Velar ridge smooth and rounded, along entire free margin and joining with prominent smooth, dorsal crest. Smooth velar ridge encroaching on lateral surface more pronouncedly at anterodorsal corner and forming flattened posteroventral flange, more prominent on heteromorphic specimen. Lateral surface of valves randomly to somewhat linearly and coarsely

punctate to reticulate, relatively flat, with low horizontal undulation parallel with venter. L_2 a low, smooth, rounded node in anterior third of valve, posteriorly with faint zygal arch ventral of S_2. S_2 in anterior half of valve, pit-like posteroventral of L_2 and constricted dorsally of L_2 by prominent, flange-like dorsal crest. Hinge sunken between dorsal crests of both valves.

Length of holotype, GSC No. 35263, 0.8 mm, height 0.6 mm.

Number of specimens studied, 2.

Types. Holotype, GSC No. 35263 (two disarticulated and separated heteromorphic valves); paratype, GSC No. 35264 (two disarticulated but adhering tecnomorphic valves).

Occurrence. Locality A-125, Porterfield Stage, unnamed formation.

Remarks. This species bears a relatively more prominent L_2 and is less convex ventrally than most species of the genus. The presence of a complete and prominent dimorphic velar ridge distinguishes it from *Milleratia* as do the flattened lateral surface and coarsely punctate-reticulate ornamentation. The two specimens figured by Kraft (1962) appear to differ slightly from the present specimens but are quite similar. They are not conspecific with the other type specimens of *Milleratia tumblingrunensis* Kraft. One (Kraft, 1962, Pl. 6, figs. 7a, b) is probably a heteromorphic valve, the other (*ibid.*, figs. 8a, b) may be a tecnomorph. The exact stratigraphic positions of these two specimens within the Lincolnshire-Edinburg formations is not reported.

Family Piretellidae Öpik, 1937
Genus *Dicranella* Ulrich, 1894
Type species *Dicranella bicornis* Ulrich, 1894
Dicranella bicornis Ulrich, 1894
Plate VIII, figures 11-13

Dicranella bicornis Ulrich, 1894, p. 665, pl. 44, fig. 26, pl. 46, figs. 39, 40; Kay, 1940, p. 260, pl. 33, figs. 1-3.

Discussion. These specimens agree in all respects with those described by Kay (1940). The type specimen (USNM 41366) bears no velar frill along the posterior margin. The drawing by Ulrich (1894, fig. 39) is an incorrect interpretation (J.M. Berdan, pers. comm.). Heteromorphs bear a wide, concave velar frill extending from the anterior cardinal angle to near the posteroventral corner of the valve, whereas the tecnomorphic velum is equally long and wide but plane to slightly flaring. The posterior margin of the valve in both dimorphs bears minute denticles or spines. The position of this genus within the Piretellidae is strongly indicated as suggested earlier by Schmidt.

Length of hypotype, GSC No. 35447, 1.65 mm, height (including posterior spine) 1.3 mm.

Number of specimens studied, 18.

Types. Hypotypes, GSC Nos. 35447-35449.

Occurrences. Localities H-1920, H-1975, Barneveld Stage, lower Whittaker Formation; Decorah Formation, Minnesota.

Genus *Oepikium* Agnew, 1942
Type species *Biflabellum tenerum* Öpik, 1935
Oepikium sp.
Plate VIII, figures 9, 10

Remarks. The specimens are coarsely silicified but show the typical prominent S_2, large, round L_2 near mid-height of the domicilium and extremely broad velar frill. The frill extends from the anterior cardinal angle and terminates abruptly at a right angle at the posteroventral corner of the valve. The frill is equal or greater in width than the height of the domicilium. The posterior margin of the valve is probably denticulate.

Length of figured specimen, GSC No. 35445, including frill, 2.67 mm, height 1.9 mm.

Number of specimens studied, 4.

Locality. H-1975. (The other known North American occurrence of *Oepikium* sp. is at Lake Timiskaming, Ontario in strata of the Farr Formation).

Types. Figured specimens, GSC Nos. 35445, 35446.

Occurrence. Locality H-1975, Barneveld Stage, lower Whittaker Formation.

Family Quadrijugatoridae Kesling and Hussey, 1953
Genus *Ceratopsis* Ulrich, 1894
Type species *Beyrichia chambersi* Miller, 1874
Ceratopsis quadrifida (Jones)
Plate IV, figure 10; Plate VI, figures 1, 2;
Plate VII, figures 1-3; Text-figure 6, number 6

Beyrichia sp. nov. Jones, 1890, p. 553.
Beyrichia quadrifida Jones, 1891, p. 66, pl. XI, figs. 9a, b.
Ceratopsis quadrifida (Jones), Ulrich and Bassler, 1909, pl. 39, figs. 21, 22; Kay, 1934, p. 340, pl. 44, fig. 27; Kay, 1940, p. 257; Warthin (*in* Miller *et al.*), 1954, p. 19; Copeland, 1965, p. 4.

Discussion. This species occurs at many localities in Canada and United States in strata of late Wilderness and early Barneveld age. Most of the present specimens are poorly preserved and have longer, more posteriorly directed anterior spines than those described by Kay. Jones' original specimen (GSC No. 17707) lacks the anterior spine so it is impossible to determine if this may be of specific importance. The nodose, almost dissected, character of L_2 is variable in all collections observed, a fact noted by Jones (1891, p. 66) from the original collections.

Number of specimens studied, more than 40.

Types. Hypotypes, GSC Nos. 35161, 35174, 35175, 35248-35250.

Occurrences. Localities C-640, C-655, J-220, I-1410, H-1929, Wilderness and Barneveld Stages, Whittaker Formation. Elsewhere in the Hull and Sherman Fall formations of southern Ontario; lower Trenton of Quebec; Decorah Formation of Iowa; unnamed shale at Silliman's Fossil Mount, Baffin Island.

Family Tetradellidae Swartz, 1936
Genus *Tetradella* Ulrich, 1890
Type species *Beyrichia quadrilirata* Hall and Whitfield, 1875
Tetradella perplexa n. sp.
Plate II, figures 1-7; Text-figure 6, numbers 1, 2

Description. Valves preplete, subovate, dorsally truncated; dorsal margin long, straight; greatest height in anterior half, greatest length near median.

Quadrilobate, lobes joined ventrally to histial ridge. L_1 straight, slightly depressed medially, extending from histium to dorsal margin; L_2 straight, broad, not extending to dorsal margin; L_3 broadest lobe, inclined slightly posterodorsally, not reaching dorsal margin; L_4 narrow, curved nearly parallel with velum along entire posterior part of valve and extending above dorsal margin. Trisulcate, S_1 thin, straight; S_2 deep, long; S_3 thin and lunate, concave anteriorly.

Tecnomorphs with entire velum, separated from histium by deep channel, subvelar field channeled to marginal structure. Heteromorphs with subhistial area (antrum) divided anteriorly and ventrally into four loculi; velum complete as in tecnomorphs, sublocular in position; subvelar field channeled to marginal structure.

Surface of lobate area papillose, sulcal areas less papillose to nearly smooth.

Length of holotype, GSC No. 35124, 1.0 mm, height 0.73 mm.

Number of specimens studied, more than 15.

Types. Holotype, GSC No. 35124; paratypes, GSC Nos. 35119-35123, 35125.

Occurrence. Locality A-125, Porterfield Stage, unnamed formation.

Remarks. This is a very simple tetradellid species, somewhat resembling "*T.*" *palmata* (Krause) and "*T.*" *marchica* (Krause) in lateral view. Dimorphism in those species has not been adequately described so their exact taxonomic position is unknown. They are, however, extremely old tetradellid-like forms.

Guber (1971) has described several *Tetradella* species from North America, the oldest, *T. buckensis* Guber, being of late Wilderness age. The present, much older, species exhibits several primitive morphological structures unknown for other North American species. The lobes of *T. perplexa* are simple, only L_1 exhibits the least tendency to anterior and posterior division. The loculi of *T. perplexa* are supravelar in position, locular walls terminate abruptly against the promixal surface of the velum and are set off from the histium by a bisection line. The velum extends ventral of the locular walls and appears also to indicate a locular-velar bisection line. If this is true, it substantiates the conclusions by Guber (1971, p. 10) that locular walls are folds of the antral surface and not of histial or velar origin. Also, the presence of four well-developed loculi in *T. perplexa* suggests the pre-Black River ancestry of *Tetradella*.

Tetradella? sp.
Plate V, figure 12; Text-figure 6, number 3

Description. Valves preplete, dorsally truncated; dorsal margin long, straight; greatest length near median, greatest height in anterior quarter.

Quadrilobate, lobes joined ventrally to histial ridge. L_1 divided into two crests, anterior crest lunate, a continuation of histium, constricted medially, upper part extending above dorsum, directed posterodorsally, posterior crest slightly curved anteriorly toward median constriction of anterior crest. L_2 club-shaped, constricted medially, not extending to dorsum but with tubercle on dorsal margin directly above dorsal node of L_2. L_3

divided into two crests, anterior crest thin, with four nodes along its length, posterior crest broad ventrally, constricted near its upper end, with a dorsal tubercle. A large node occurring above L_3 and extending above the dorsal margin separated from L_3 by a horizontal furrow. L_4 thin, club-shaped, extending parallel with posterior margin and reaching slightly above mid-height of valve.

Trisulcate, S_1 thin, shallow, reverse S-shaped; S_2 long, deep, divided by a large node on the dorsal margin; S_3 thin, shallow, lunate, concave anteriorly.

Tecnomorph with broad, entire velum separated from histium by deep channel, subvelar field channeled to marginal structure. Velum mostly smooth, but posteriorly tuberculate.

Surface of lobate area tuberculate, sulcal areas smooth.

Number of specimens studied, 8.

Length of figured specimen, GSC No. 35173, 0.95 mm, height 0.70 mm.

Type. Figured specimen, GSC No. 35173.

Occurrences. Localities C-640, C-655, H-1920, H-1975, Wilderness and Barneveld stages, lower Whittaker Formation.

Remarks. Only tecnomorphic specimens have been found, precluding exact generic identification; the possibility that these specimens are immature or represent a species of *Kiesowia* cannot be discounted. Some similarity exists between the present specimens and ?*T. regularis* Keenan (*see* Guber, 1971, pl. 4) from the Maquoketa shale of Missouri. This similarity is based primarily on the general lobal disruption and the presence, along the dorsal margin, of dissociated tubercles. ?*T. regularis* appears to have more gross lobation than the present species and to have L_1 divided. ?*T. septinoda* Keenan (*see* Guber, 1971, pl. 4), from the same stratigraphic position as ?*T. regularis*, has nodose lobes but lacks dorsal tubercles and appears to have L_3 divided at the histium in more typical *Tetradella* style. Only tecnomorphic (or immature) specimens of these species from Missouri are available, precluding more exact identification. It should be noted that the present specimens are silicified; there is a possibility that this manner of preservation may contribute much to the lobal disruption described here.

Superfamily Oepikellacea Jaanusson, 1957
Family Oepikellidae Jaanusson, 1957
Genus *Diplopsis* Levinson, 1961
Type species *Diplopsis socialis* Levinson, 1961

Diplopsis socialis Levinson, 1961
Plate IV, figures 5-8

Oepikella cf. *O. frequens* (Steusloff), Warthin (*in* Miller *et al.*), 1954, p. 19.
Oepikella cf. *O. maccoyi* (Salter), Warthin (*in* Miller *et al.*), 1954, p. 19.
Aparchites maccoyii (Salter), Harris, 1957, p. 138-140, pl. 2, figs. 2a-c, 3a, b, 4.
Oepikella frequens (Steusloff), Kraft, 1962, p. 32, pl. 3, figs. 15a-c; pl. 4, figs. 1-14; Fig. 71-o; (authors).
Diplopsis socialis Levinson, 1961, p. 361, pl. 1, figs. 2a-e.
Diplopsis sp. cf. *D. frequens* (Steusloff), Copeland, 1965, p. 28, pl. IX, figs. 8-20; Copeland (*in* Steele and Sinclair), 1971, pl. XXIII, fig. 8.

Remarks. The description of this species by Levinson is adequate; the differences between *Oepikella* Thorslund and *Diplopsis* Levinson (*Oepikella* with angular cardinal angles, restricted frill of heteromorphs and absence of antero- and posteroventral spines on tecnomorphs) are valid criteria on which to base identification. At present the relationship of the European species

Oepikella frequens (Steusloff) to *Diplopsis* is uncertain. The possibility that *Oepikella frequens* (Steusloff) and *Diplopsis socialis* Levinson are synonymous should be investigated.

Specimens of *D. socialis* from the upper part of the Bromide Formation of Oklahoma, Edinburg Formation of Virginia and shale from Silliman's Fossil Mount, Baffin Island (Miller *et al.* collection) were obtained from Drs. Levinson, Cooper and Berdan respectively. Also, specimens in the author's collection from the Bucke Formation and Braeside beds of Ontario have been examined. It is considered that specimens from all those localities are synonymous with the present collections. At present, relationship, if any, of the Decorah species *Aparchites carinatus* Kay to *D. socialis* is unknown.

Number of specimens studied, more than 50.

Types. Hypotypes, GSC Nos. 35156-35159.

Occurrences. Localities C-640, C-655, J-220, I-1275, Wilderness Stage, lower Whittaker Formation; widespread in North America.

Genus *Oepikella* Thorslund, 1940
Type species *Oepikella tvarensis* Thorslund, 1940
Oepikella labrosa Copeland, 1965
Plate VIII, figure 14

Oepikella labrosa Copeland, 1965, p. 27, pl. VII, figs. 16, 22-24, pl. IX, figs. 21-25, pl. X, figs. 26, 27.

Remarks. Specimens in the present collections are similar in shape, but smaller than those described from Lake Timiskaming, Ontario (Copeland, 1965). The length of the velar dolon and the height of the domicilium are distinctive features of this species.

Number of specimens studied, 2.
Length of hypotype, GSC No. 35450, 2.5 mm, height 2.0 mm.

Type. Hypotype, GSC No. 35450.

Occurrences. Localities P-1595, H-1975, Porterfield to Barneveld stages, unnamed formation and Whittaker Formation; Bucke Formation, Lake Timiskaming, Ontario. *Oepikella* sp. cf. *O. labrosa* is recorded in the present study from localities P-1575, P-1585 and P-1595.

Family Aparchitidae Jones, 1901
Genus *Aparchites* Jones, 1889
Type species *Aparchites whiteavesi* Jones, 1889
"*Aparchites*" *fimbriatus* (Ulrich), 1892
Plate III, figure 16; Plate IV, figure 9

Leperditia fimbriata Ulrich, 1892, p. 268.
Aparchites fimbriatus (Ulrich), Ulrich, 1894, p. 645, pl. 45, figs. 10-12; Kraft, 1962, p. 28, pl. 2, figs. 1-11, pl. 3, fig. 3, Fig. 7a-e; Copeland, 1970, p. 23, pl. IV, fig. 28; (authors).

Remarks. The exact taxonomic position of this species is in doubt. Its assignment to *Aparchites* is questionable because of its spinose velum (only on the left valve) and unknown dimorphism; its relationship to the prominently dimorphic oepikellids (notably *Oepikella* and *Diplopsis*) is dubious.

Number of specimens studied, more than 30.

Types. Hypotypes, GSC Nos. 35151, 35160.

Occurrences. Localities A-125, C-640, C-655, I-1275, I-1410, P-330, P-1485, P-1497, P-2050, Whiterock to Wilderness stages, Sunblood to Whittaker formations; widespread in North America.

Superfamily Kloedenellacea Ulrich and Bassler, 1908
Family Kloedenellidae Ulrich and Bassler, 1908
Genus *Bolbopisthia* Guber and Jaanusson, 1964
Type species *Thomasatia carinata* Kraft, 1962
Bolbopisthia ludvigseni n. sp.
Plate II, figures 12-18; Plate III, figures 1-4; Plate V, figures 1-3; Plate VIII, figure 8.

Description. Laterally amplete, contact margin slightly preplete, greatest height in posterior half. Trilobate, L_1 elongate oval, crested, extending above dorsum in posterodorsal direction from anterior end of carina; L_2 oval, knob-like, anterior and dorsal of mid valve, ventral of posterior end of L_1; L_3 crested, extending above dorsum, broadly rectangular, anteroventrally with slight indication of zygal ridge below S_2. L_3 of heteromorphic valves more swollen than that of tecnomorphic valves. Bisulcate, S_1 and S_2 forming a single sulcus dorsally; S_1 extending ventral of L_1, separating L_1 from carina and limiting anterior side of L_2; S_2 deep, reverse comma-shaped, limiting posterior side of L_2 and extending to zygal area. Carinal ridge extending from anteroventral side of L_1 parallel with velar margin to posteroventral corner of valve, and forming a posteriorly directed spine or spur. Posterior edge of L_3 continuous with carina. Carina a prominent ridge in heteromorphic valves, posteriorly with a smoothly continuous posteriorly directed spur; tecnomorphic valves with a low rounded carina, posteriorly with a prominent, laterally directed spine. Velar ridge of left heteromorphic valve prominent, not marginal, that of right valve thin, marginal. Velar ridge of tecnomorphic valve thin, ridge-like on left valve, almost indistinguishable on margin of right valve. Surface papillose.

Length of holotype, GSC No. 35131, a heteromorphic left valve, 1.9 mm, height 1.2 mm.

Number of specimens studied, more than 60.

Types. Holotype, GSC No. 35131; paratypes, GSC Nos. 35130, 35132-35139, 35162-35164, 35444, a.

Occurrences. Localities A-125, A-365, P-1485, P-1497, Q-130?, Porterfield Stage, unnamed formation.

Remarks. This species does not bear the ventral ridge of L_1 or the pronounced dorsal furrow of L_3 present on *B. carinata* (Kraft). Instead, L_1 of *B. ludvigseni* is an isolated oval node and L_3 is relatively uniform in lateral elevation with only a faint undulation marking the dorsal and ventral sides of the ridge posteroventral of S_2. Also, the tecnomorphic carinal spine of *B. ludvigseni* is more prominent than that of *B. carinata* and directed posterolaterally rather than posteriorly. Photographs of *Bolbopisthia* species described by Kirk (1928) as *Drepanella progressa* and *Drepanella progressa* var. *reticulata*, were provided by J.M. Berdan, United States Geological Survey. These specimens have a broad L_1 continuous with the ventral side of L_2, L_3 bears no furrows and the surface ornamentation of the latter is coarsely punctate or reticulate.

Bolbopisthia lenzi n. sp.
Plate VIII, figures 1-7

Description. Species with similar lobation and sulcation as *Bolbopisthia ludvigseni* n. sp. Carinal ridge extending from anteroventral side of L_1 parallel with velar margin and terminating abruptly at mid posterior part of valve. Posterior edge of L_3 continuous with carina. Carina prominent in heteromorphic valves, posteriorly merging with posterior edge of L_3; tecnomorphic valves with less prominent carina, terminating posteriorly in a small spur. Velar ridge of left heteromorphic valve prominent, not marginal, that of right valve thin, marginal. Velar ridge of tecnomorphic valve thin, ridge-like on left valve, thin, marginal on right valve. Surface papillose.

Length of holotype, GSC No. 35440, a carapace, 2.2 mm, height 1.4 mm, width 1.45 mm.

Number of specimens studied, more than 40.

Types. Holotype, GSC No. 35440; paratypes, GSC Nos. 35437-35439, 35441-35443.

Occurrences. Localities I-1275, B-1450, P-2038(?), Wilderness Stage, upper part of unnamed formation and lower part of Whittaker Formation.

Remarks. This species is very similar to *B. ludvigseni* n. sp. but the carina is thinner, longer and does not terminate in a pronounced spine. The velum is more ridge-like on both dimorphs.

Superfamily Leperditellacea Ulrich and Bassler, 1906
Family Leperditellidae Ulrich and Bassler, 1906
Genus *Eokloedenella* Kraft, 1962
Type species *Eokloedenella posterodepressa* Kraft, 1962
Eokloedenella whittakerensis n. sp.
Plate VI, figures 8-14

Description. Valves subovate in lateral view, postplete, truncated dorsally. Greatest length in dorsal half, greatest height in posterior half. Cardinal angles obtuse, anterior angle greater than posterior; anterior margin more narrowly rounded than posterior, ventral margin sloping posteriorly, evenly rounded. Carapaces moderately convex, some longer specimens with greatest convexity slightly more anterior in position to that of shorter specimens.

Surface finely papillose. An indistinct sulcus (S_2) present slightly anterior of mid length, extending vertically from dorsum about one-third the distance to ventral margin. L_2 indistinct or absent. Posterior surface of valve with abrupt angular depression, parallel to and near the contact margin, extending from dorsum to posteroventral part of valve.

Valve interior depressed anteriorly and posteriorly, connecting beneath internal expression of S_2. Hinge straight, contact edge with median depression on both valves. Contact margin smooth, contact furrow on left valve near free margin; right valve with marginal ridge slightly overhanging edge of left valve along free margin.

Length of holotype, GSC No. 35187, a carapace, 2.8 mm, height 1.8 mm, width 1.4 mm.

Number of specimens studied, more than 200.

Types. Holotype, GSC No. 35187; paratypes, GSC Nos. 35181-35186.

Occurrences. Localities A-220, B-1005, Porterfield Stage, unnamed formation.

Remarks. This species is much larger than *E. posterodepressa* Kraft, bears a much less prominent S_2 and longer posterior depression. Also, *E. whittakerensis* is not ornamented posterodorsally.

Guber and Jaanusson (1964, p. 8) suggest that *Eokloedenella* is leperditellid rather than kloedenellid as considered by Kraft (1962, p. 56). Based on the absence of stragular process and kloedenellid domiciliar dimorphism this appears valid and is also true of *E. whittakerensis*.

Genus *Leperditella* Ulrich, 1894
Type species *Leperditella rex* Coryell and Schenck, 1941
Leperditella mundula (Ulrich), 1892
Plate IX, figures 1-5

Leperditia mundula Ulrich, 1892, p. 265, pl. IX, figs. 4-8.
Leperditella mundula (Ulrich), Ulrich, 1894, p. 636, figs. 46e-h.

Remarks. This species is distinguished by its punctate surface, faint sulcal depression and presence of an obscure, non punctate oval area anterior of mid valve. A slightly defined anterior node is observable on some specimens in the position of the leperditiid "eye spot". This node is clearly discernible on the interior surface of the valves as shown by exfoliated specimens (Pl. IX, fig. 1). Specimens in the present collections are from 2.4 mm to 3.0 mm long and 1.5 mm to 1.9 mm high.

Number of specimens studied, more than 100.

Types. Hypotypes, GSC Nos. 38403-38407.

Occurrences. Localities P-1405, P-1497, P-1575, P-1585, P-1595, P-1931, P-1945-1955, Porterfield and Wilderness stages, unnamed formation; Stones River, Highbridge, Kentucky.

Leperditella sp. cf. *L. germana* (Ulrich), 1892
Plate IX, figures 7-12

Leperditia germana Ulrich, 1892, p. 266, pl. IX, figs. 16-18.
Leperditella germana (Ulrich), Ulrich, 1894, p. 636, 638, pl. XLV, figs. 24-26.

Remarks. Specimens in the present collections are smaller than those reported by Ulrich, the largest valve being 1.9 mm long and 1.2 mm high. They are otherwise very similar to those figured by Ulrich, in having a noticeable sulcal depression and slight marginal flattening particularly of the left valve. Examination of numerous carapaces indicates that some specimens are wider posteriorly (heteromorphs?) than others (tecnomorphs?). If this is a dimorphic characteristic it is similar to that reported by Guber and Jaanusson (1964) for species of *Primitiella*, a genus separated from *Leperditella* only with great difficulty. The present specimens, however, do not possess an anterior strangular process which occurs on all monotiopleurids.

Number of specimens studied, more than 100.

Types. Hypotypes, GSC Nos. 38409-38414.

Occurrences. Localities G-1745, G-1825, G-1850, G-2170, G-2795, G-2910, P-30, P-55, P-740, P-1090, P-1127, P-1130, Whiterock and Chazy stages, Sunblood Formation; Platteville Formation, Wisconsin.

Genus *Schmidtella* Ulrich, 1892
Type species *Schmidtella crassimarginata* Ulrich, 1892
Schmidtella affinis Ulrich, 1894
Plate III, figures 12-15; Plate V, figures 10, 11

Schmidtella affinis Ulrich, 1894, p. 641, pl. 43, figs. 45-47; Harris, 1957, p. 162, pl. 3, figs. 1a-c, 14; Kay, 1940, p. 241, pl. 29, figs. 1-4; (authors).

Remarks. This species is very similar to *S. concentrodepressa* Kraft, 1962, but has a more convex dorsum and its greatest length is near median rather than in the ventral third. Also, the depressed zone is parallel with the entire free margin of *S. affinis* rather than ventral as reported by Kraft for *S. concentrodepressa*.
Number of specimens studied, more than 50.

Types. Hypotypes, GSC Nos. 35147-35150, 35171, 35172.

Occurrences. Localities A-125, A-365, B-1450, C-640, J-220, P-1187, P-1931, Q-130, Porterfield and Wilderness stages, Sunblood to Whittaker formations; McLish, Tulip Creek and Bromide formations, Oklahoma; Decorah Formation, Minnesota.

Schmidtella? sp. cf. *S.*? *subrotunda* Ulrich, 1894
Plate IX, figure 6

Schmidtella subrotunda Ulrich, 1894, p. 643, pl. XLV, figs. 39-42.

Remarks. This questionable schmidtellid bears a near-median lateral depression probably marking the position of the adductorial scar. This depression may be lacking on nearly half of the specimens from one collection; otherwise the specimens are identical. The valves are slightly flattened marginally, but the marginal border referred to by Ulrich appears to be emphasized by the ventral overlap of the right (?) valve.
Number of specimens studied, more than 30.

Type. Hypotype, GSC No. 38408.

Occurrences. Localities P-30, P-55, G-1825, G-1850, Whiterock Stage, Sunblood Formation; Decorah Formation, Minnesota.

Genus *Cryptophyllus* Levinson, 1951
Type species *Eridoconcha oboloides* Ulrich and Bassler, 1923
Cryptophyllus oboloides (Ulrich and Bassler), 1923
Plate III, figures 9, 10

Eridoconcha oboloides Ulrich and Bassler, 1923, p. 296, fig. 14:6-8.
Cryptophyllus oboloides (Ulrich and Bassler), Levinson, 1951, p. 558.

Remarks. This species is widespread throughout Middle Ordovician strata of North America. It is distinguished by its triangular shape in lateral view, few retained molt stages, and general lack of surface ornamentation.
Number of specimens studied, more than 10.

Types. Hypotypes, GSC Nos. 35144, 35145.

Occurrences. Locality A-125, Porterfield Stage, unnamed formation; widespread North American Middle Ordovician species.

Cryptophyllus magnus (Harris), 1931
Plate IX, figures 13-16

Eridoconcha magnus Harris, 1931, p. 91, pl. V, figs. 3a, b; (authors).
Cryptophyllus magnus (Harris), Levinson, 1951, p. 557, 558.
Cryptophyllus magnum (Harris), Harris, 1957, p. 181, pl. 5, figs. 10a, b.

Remarks. This large, highly umbonate species retains numerous molts. The umbo is highly arched above the hinge and on its inner surface bears a well-defined median ridge. Depending on the number of retained molts, the umbo may be highly pointed or more lowly arched; lowly arched specimens retain fewer molts and, if sufficient molts have been removed, may display a short median umbonal sulcus, represented internally by the previously mentioned median ridge.
Number of specimens studied, more than 15.

Types. Hypotypes, GSC Nos. 38415-38418.

Occurrences. Localities G-2170, P-55, P-105, Whiterock Stage, Sunblood Formation; Oil Creek Formation, Oklahoma.

Order Podocopida Sars, 1866
Superfamily Healdiacea Harlton, 1933
Family Krausellidae Berdan, 1961
Genus *Krausella* Ulrich, 1894
Type species *Krausella inaequalis* Ulrich, 1894
Krausella inaequalis Ulrich, 1894
Plate IV, figures 1, 2; Plate V, figures 4, 5

Krausella inaequalis Ulrich, 1894, p. 692, pl. 44, figs. 44-46; (authors).

Remarks. This species is distinguished by the pronounced left over right valve overlap, particularly ventrally, and the short but strong posterior spine of the right valve. The left valve is smoothly curved posteriorly and both valves project anteroventrally.
Complete revision of Ordovician krausellid species is required before their taxonomic positions and stratigraphic ranges can be certainly determined. Several taxa, as presently understood, grade imperceptibly together (i.e., *K. inaequalis* Ulrich, *K. arcuata* Ulrich, *K. calvini* Kay, *K. rawsoni* Roy, *K. hanseni* (Teichert), *K. variata* Kraft) and result in obvious confusion. Until these and other *Krausella* species are carefully studied their relationships are in doubt.
Number of specimens studied, more than 30.

Types. Hypotypes, GSC Nos. 35152, 35153, 35165, 35166.

Occurrences. Localities C-590, C-640, C-655, R-625, I-1275, Q-130, H-1920, P-740, Chazy to Barneveld stages, Sunblood to Whittaker formations; of widespread occurrence.

Krausella minuta? (Harris)
Plate III, figures 5-8

Rayella minuta Harris, 1957, p. 255, pl. 10, figs. 8a, b.

Remarks. This is a small krausellid, ovate in lateral view, with left valve narrowly overlapping right and fine posterior spine of right valve near mid

height of carapace. This species belongs within a lineage consisting, in part, of *Krausella calvini parva* (Harris), *Bythocypris? spinosa* Harris and *Krausella brevicornis* (Keenan).

Number of specimens studied, 25.

Types. Hypotypes, GSC Nos. 35140-35143.

Occurrences. Localities A-125, A-365, P-300, P-1485, P-1497, Whiterock to Porterfield stages; Oil Creek and McLish formations, Oklahoma.

?*Krausella* sp. cf. ?*K. acuta* (Teichert)
Plate VI, figures 3-5, 17-19

Basslerites acutus Teichert, 1937, p. 118, pl. XXIV, fig. 7.
?*Basslerites canadensis* Teichert (part), 1937, pl. XXIV, fig. 6.

Remarks. This species is provisionally placed in *Krausella* on the basis of the posterior projection of the right valve past that of the left. However, the typical krausellid spine is lacking and both valves taper posteriorly, that of the right overreaching the left. Most species of *Basslerites* Teichert, 1937 (non Howe, 1937) are typical krausellids, except for *B. acutus* Teichert, and possibly, the above mentioned specimen of *B. canadensis* Teichert. Without examining the type material no decision can be reached about those specimens.

The present specimens bear a straight, inclined hinge in the median half of the valve, slightly sunken between the dorsal shoulders of the valves. The dorsum is highly arched anteriorly and bears an angulation at the posterior end of the hinge. The left valve overlaps the right valve anteriorly and may narrowly overlap the right along the ventral margin but this is indistinguishable on some specimens. The posterior angulation of the left valve curves dorsally to intersect the dorsal line of the projection of the right valve. As in typical *Krausella*, specimens of this species have the contact margin withdrawn anteriorly and posteriorly from the lateral valve surface.

Number of specimens studied, 30.

Types. Hypotypes, GSC Nos. 35176-35178; 35190-35192.

Occurrences. Localities C-640, C-655, J-220, R-625, H-1850, H-1920, H-1975, Q-530, Wilderness and Barneveld stages, lower Whittaker Formation; Melville Peninsula, Canadian Arctic.

Order and Family Uncertain
Genus *Steusloffina* Teichert, 1937
Type species *Steusloffina ulrichi* Teichert, 1937
Steusloffina borealis n. sp.
Plate II, figures 8-10

Description. Valves preplete, subtriangular in lateral view, dorsally truncated; greatest length in dorsal half, greatest height in anterior quarter. Anterior margin more broadly rounded than posterior, posterior margin subacuminate, venter lowly curved, inclined posteriorly. Left valve strongly overlapping right at cardinal angles, and less strongly overlapping right along venter. Hinge long, situated in median two thirds of valve, sunken between smooth dorsal shoulders of both valves.

Surface of valves finely papillose with prominent projection at mid height of valves and slightly posterior of mid length. Projection circular in cross-section and nearly at right angle to valve, with slight distal curvature

in a posterior direction. Spine-like projections on all specimens presumably broken distally but tapering very gradually so actual length cannot be estimated.

Length of holotype, GSC No. 35126, 1.3 mm, height 0.6 mm.
Number of specimens studied, 15.

Types. Holotype, GSC No. 35126; paratypes, GSC Nos. 35127, 35128.

Occurrence. Locality A-125, Porterfield Stage, unnamed formation.

Remarks. This species agrees in most respects with the generic diagnosis by Teichert (1937) but the figured specimens of *S. borealis* have the lateral projections and posterior margin preserved, which the type specimen of *S. ulrichi* does not. It has been assumed that the crater-like depression near mid valve of *S. ulrichi* is a broken off spine. In other respects, *S. ulrichi* appears to have a more prominent dorsal shoulder than *S. borealis* and less pronounced left/right overlap at the cardinal angles.

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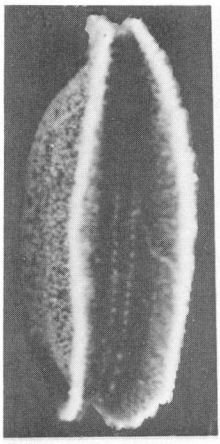
Illustrations of Fossils
Plates I to IX

PLATE I

(All specimens from locality A-125; magnification X30)

Figures 1-11. *Eurychilina sunbloodensis* n. sp. (page 16)

1. Ventral view of tecnomorphic carapace, paratype, GSC No. 35108.
2. Ventral view of heteromorphic carapace, paratype, GSC No. 35109.
3. Dorsal view of tecnomorphic carapace, paratype, GSC No. 35110.
4. Right lateral view of heteromorphic valve, paratype, GSC No. 35111.
5. Right lateral view of immature carapace with valves disarticulated, paratype, GSC No. 35112.
6. Interior view of left heteromorphic valve, paratype, GSC No. 35113.
7. Left lateral view of tecnomorphic valve, paratype, GSC No. 35114.
8. Right lateral view of heteromorphic valve, holotype, GSC No. 35115.
9. Interior view of right tecnomorphic valve, paratype, GSC No. 35116.
10. Left lateral view of tecnomorphic valve, paratype, GSC No. 35117.
11. Right lateral view of tecnomorphic valve, paratype, GSC No. 35118.



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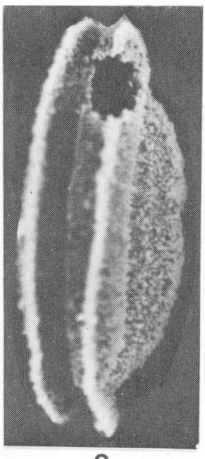

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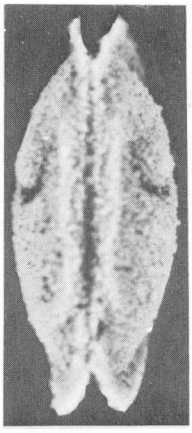

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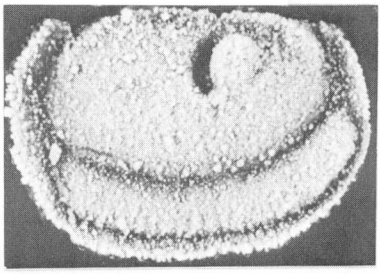

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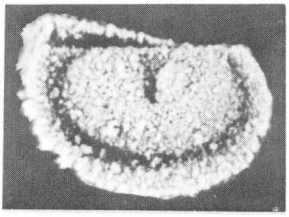

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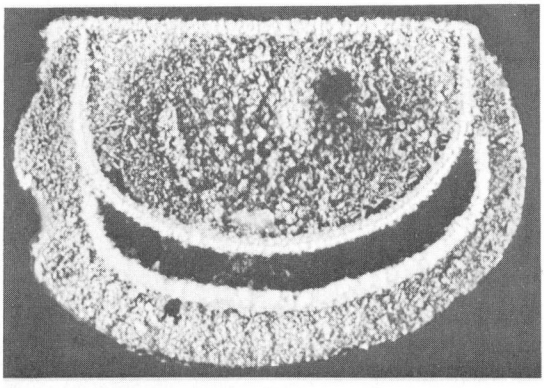

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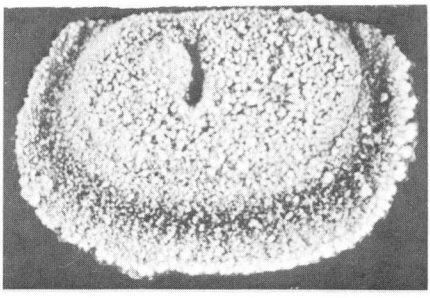

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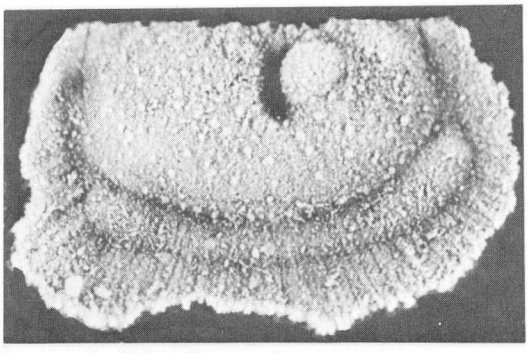

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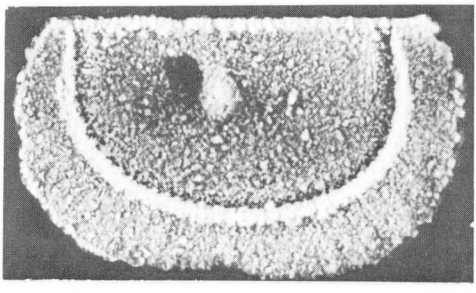

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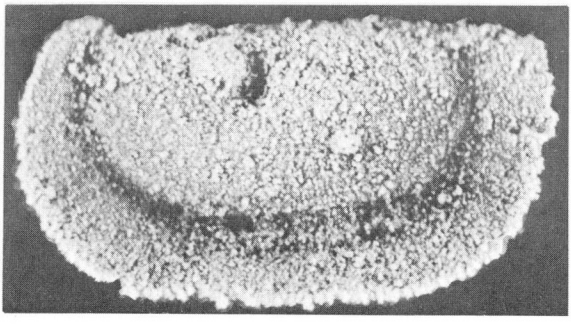

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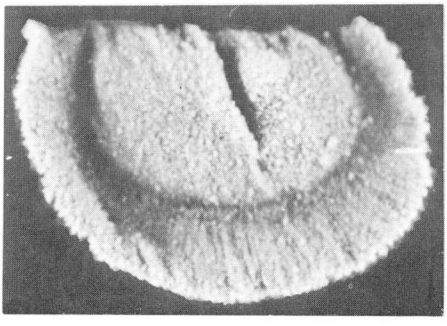

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PLATE II

(All specimens from locality A-125; magnification X30)

Figures 1-7. *Tetradella perplexa* n. sp. (page 21)
1. Left lateral view of heteromorphic carapace, paratype, GSC No. 35119.
2. Left lateral view of tecnomorphic valve, paratype, GSC No. 35120.
3. Ventral view of tecnomorphic carapace, paratype, GSC No. 35121.
4, 5. Ventral views of two heteromorphic carapaces, paratypes, GSC Nos. 35122, 35123.
6. Right lateral view of heteromorphic valve, holotype, GSC No. 35124.
7. Left lateral view of tecnomorphic valve, paratype, GSC No. 35125.

Figures 8-10. *Steusloffina borealis* n. sp. (page 29)
8. Right lateral view of carapace, holotype, GSC No. 35126.
9. Dorsal view of carapace, paratype, GSC No. 35127.
10. Ventral view of carapace, paratype, GSC No. 35128.

Figure 11. Aechminid indet.
Left lateral view of carapace, figured specimen, GSC No. 35129.

Figures 12-18. *Bolbopisthia ludvigseni* n. sp. (page 24)
12. Interior view of right heteromorphic valve, paratype, GSC No. 35130.
13. Left lateral view of heteromorphic valve, holotype, GSC No. 35131.
14, 16. Ventral views (coated and uncoated) of heteromorphic valve, paratype, GSC No. 35132.
15. Dorsal view of heteromorphic valve, paratype, GSC No. 35133.
17. Left lateral view of heteromorphic valve, paratype, GSC No. 35134.
18. Left lateral view of heteromorphic valve, paratype, GSC No. 35135.

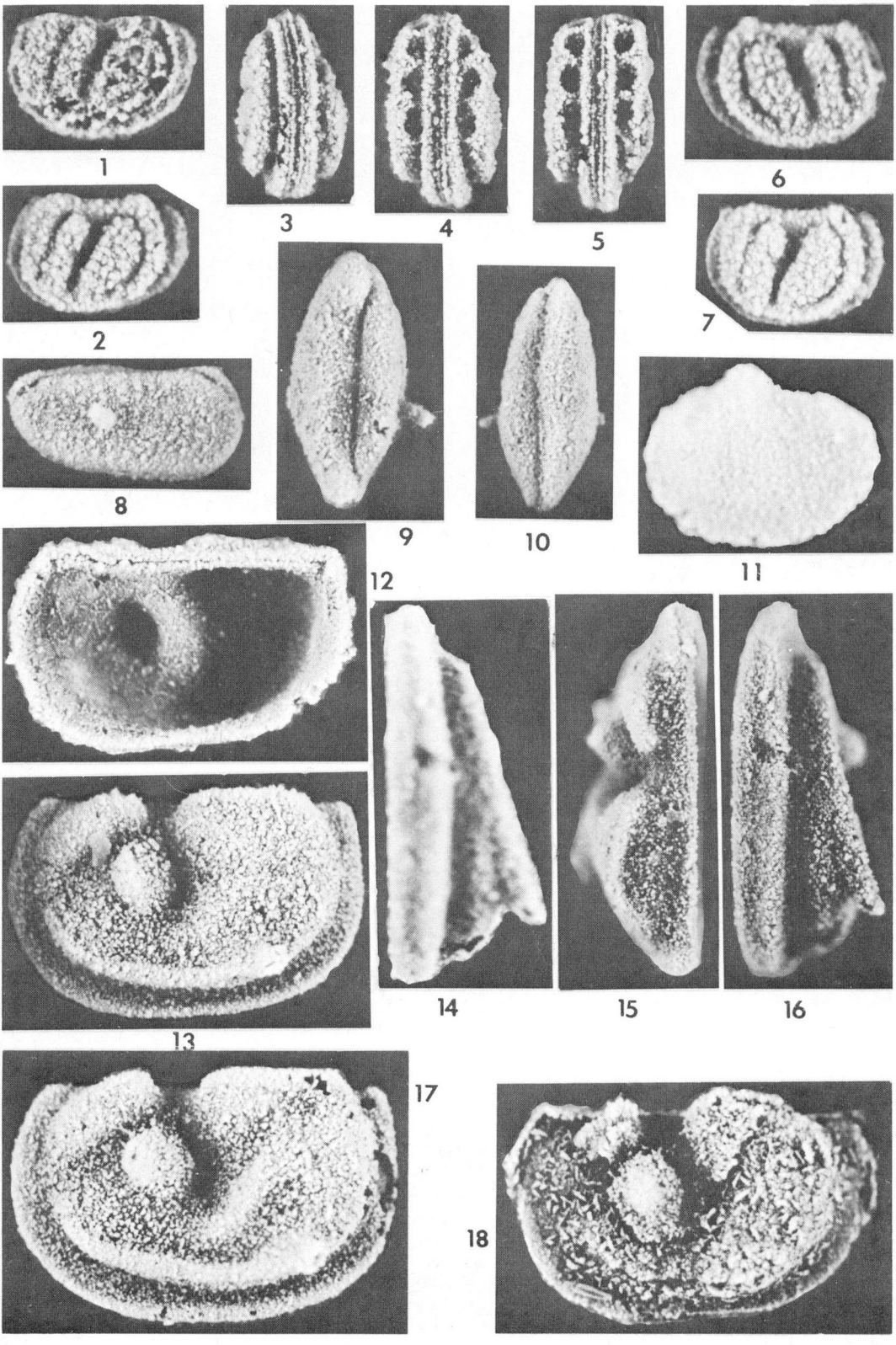
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PLATE III

(All specimens from locality A-125; magnification X30)

Figures 1-4. *Bolbopisthia ludvigseni* n. sp. (page 24)
1. Ventral view of right tecnomorphic valve, paratype, GSC No. 35136.
2. Dorsal view of right tecnomorphic valve, paratype, GSC No. 35137.
3. Ventral view of right tecnomorphic valve, paratype, GSC No. 35138.
4. Ventral view of tecnomorphic carapace, paratype, GSC No. 35139.

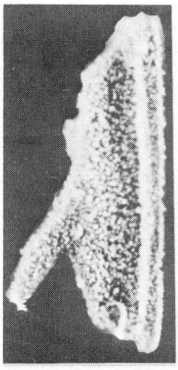
Figures 5-8. *Krausella minuta*? (Harris) (page 28)
5. Right lateral view of carapace, hypotype, GSC No. 35140.
6. Interior view of right valve, hypotype, GSC No. 35141.
7. Left lateral view of carapace, hypotype, GSC No. 35142.
8. Dorsal view of carapace, hypotype, GSC No. 35143.

Figures 9, 10. *Cryptophyllus oboloides* (Ulrich) (page 27)
9. Dorsal view of carapace, hypotype, GSC No. 35144.
10. Right lateral view of carapace, hypotype, GSC No. 35145.

Figure 11. *Leperditella* sp.
Right lateral view of valve, figured specimen, GSC No. 35146.

Figures 12-15. *Schmidtella affinis* Ulrich (page 27)
12. Right lateral view of valve, hypotype, GSC No. 35147.
13. Left lateral view of valve, hypotype, GSC No. 35148.
14. Right lateral view of valve, hypotype, GSC No. 35149.
15. Left lateral view of valve, hypotype, GSC No. 35150.

Figure 16. "*Aparchites*" *fimbriatus* Ulrich (page 23)
Left lateral view of carapace, hypotype, GSC No. 35151.



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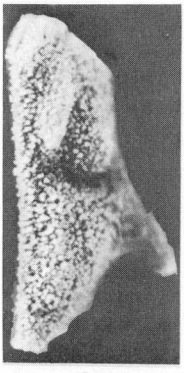

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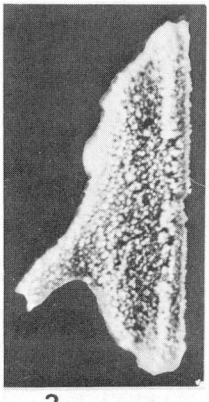

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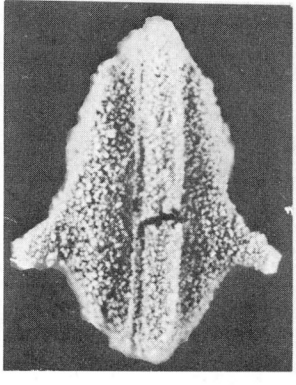

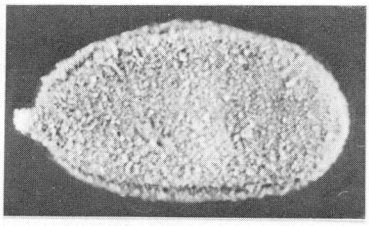

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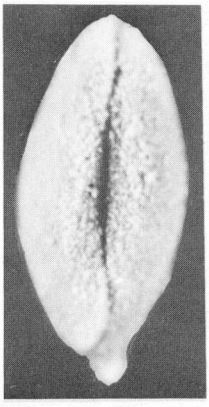

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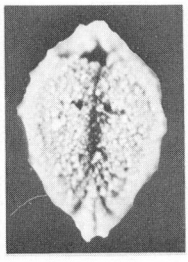

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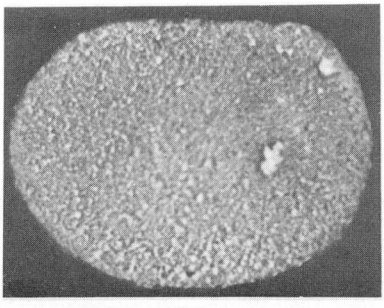

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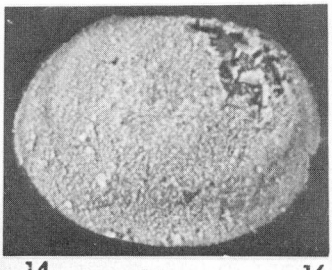

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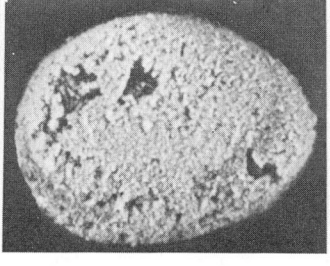

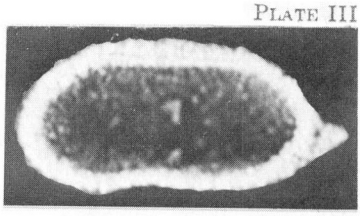

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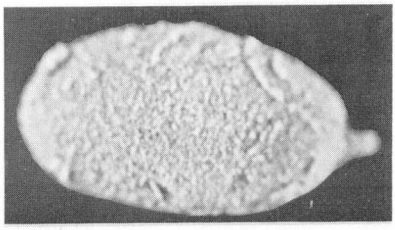

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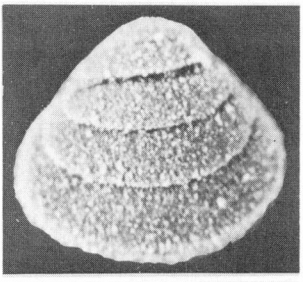

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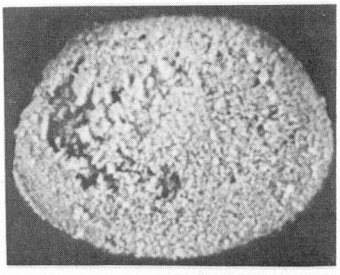

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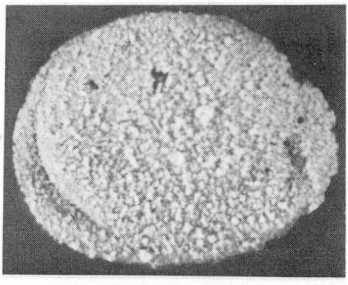

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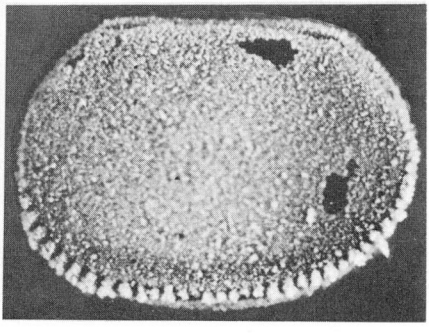


PLATE IV

(All specimens from locality C-655; magnification X30)

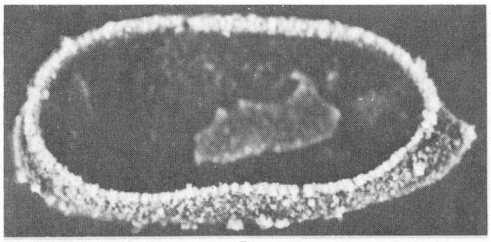
Figures 1,2. *Krausella inaequalis* Ulrich (page 28)
1. Interior view of right valve, hypotype, GSC No. 35152.
2. Right lateral view of carapace, hypotype, GSC No. 35153.

Figures 3,4. *Eurychilina prairiensis* n. sp. (page 18)
3. Right lateral view of tecnomorphic valve, paratype, GSC No. 35154.
4. Left lateral view of tecnomorphic valve, paratype, GSC No. 35155.

Figures 5-8. *Diplopsis socialis* Levinson (page 22)
5. Left lateral view of tecnomorphic carapace, hypotype, GSC No. 35156.
6. Left lateral view of heteromorphic valve, GSC No. 35157.
7. Interior view of left heteromorphic valve, hypotype, GSC No. 35158.
8. Interior view of right tecnomorphic valve, hypotype, GSC No. 35159.

Figure 9. *"Aparchites" fimbriatus* Ulrich (page 23)
Left lateral view of valve, hypotype, GSC No. 35160.

Figure 10. *Ceratopsis quadrifida* (Jones) (page 20)
Right lateral view of valve, hypotype, GSC No. 35161.



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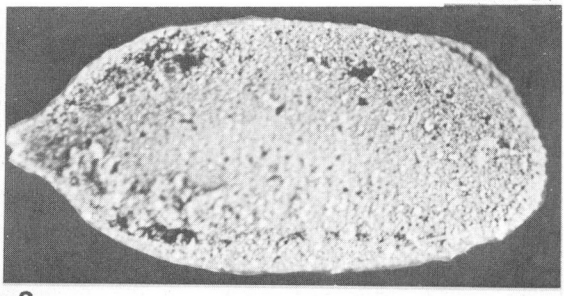

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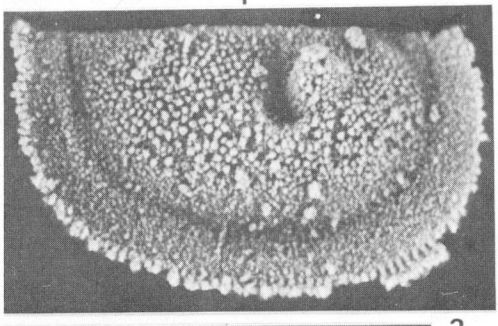

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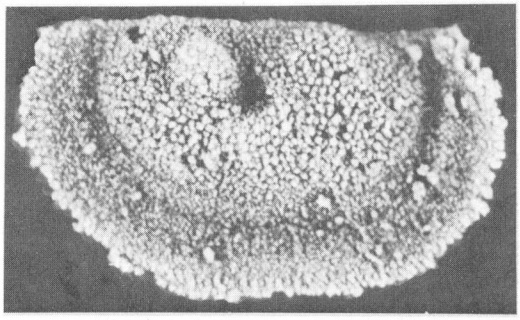

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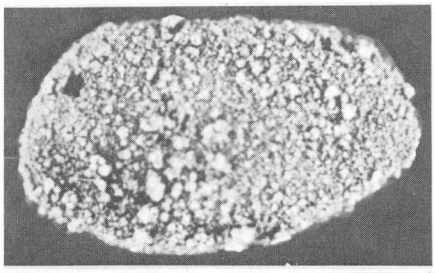

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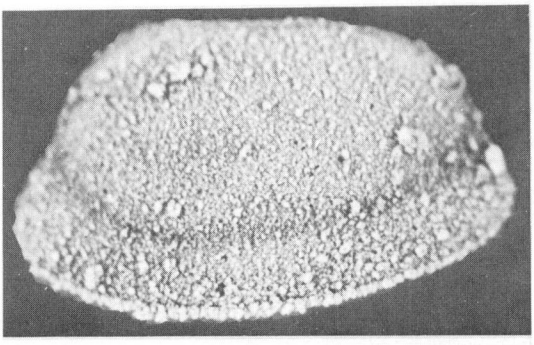

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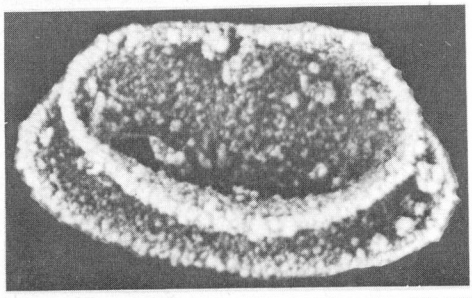

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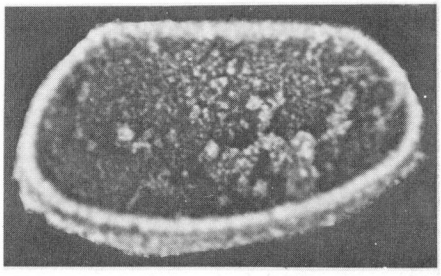

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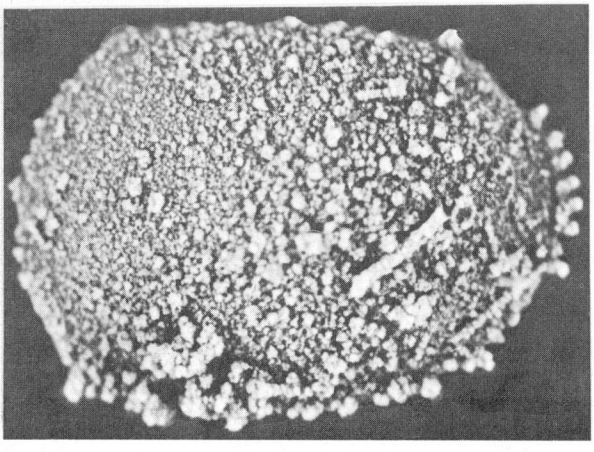

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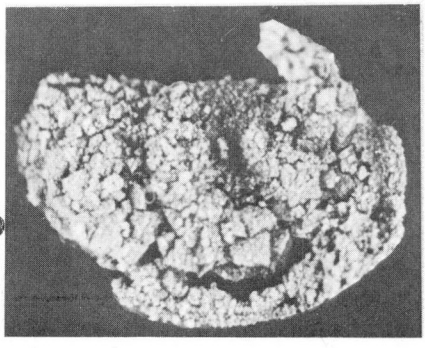

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PLATE V

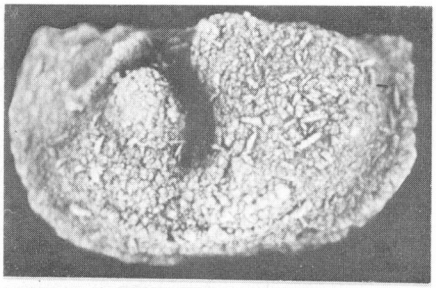
Figures 1-3. *Bolbopisthia ludvigseni* n. sp. (page 24)
Left lateral views of three heteromorphic valves, X30, locality A-365, paratypes, GSC Nos. 35162-35164.

Figures 4,5. *Krausella inaequalis* Ulrich (page 28)
4. Interior view of left valve, X30, locality A-365, hypotype, GSC No. 35165.
5. Interior view of right valve, X30, locality A-365, hypotype, GSC No. 35166.

Figures 6-9. *Eoleperditia fabulites* (Conrad) (page 14)
6. Lateral view of left valve, X11, locality B-1005, hypotype, GSC No. 35167.
7. Interior view of right valve, X11, locality B-1005, hypotype, GSC No. 35168.
8. Interior view of left valve, X11, locality B-1005, hypotype, GSC No. 35169.
9. Lateral view of right valve, X11, locality B-1005, hypotype, GSC No. 35170.

Figures 10,11. *Schmidtella affinis* Ulrich (page 27)
10. Right lateral view of an exfoliated valve, X30, locality A-365, hypotype, GSC No. 35171.
11. Right lateral view of a partly exfoliated valve, X30, locality A-365, hypotype, GSC No. 35172.

Figure 12. *Tetradella*? sp. (page 21)
Right lateral view of tecnomorphic valve, X30, locality C-655, figured specimen, GSC No. 35173.



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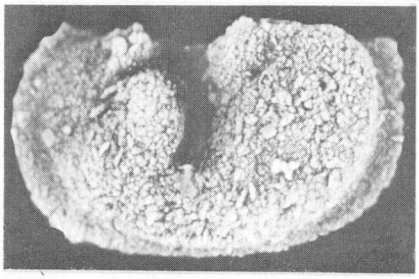

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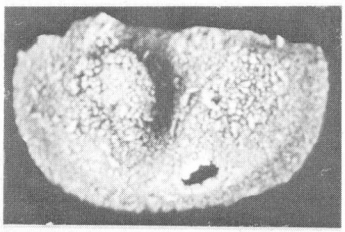

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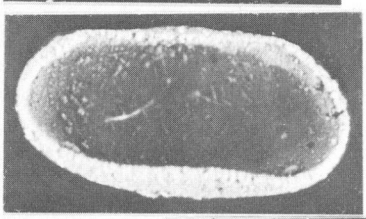

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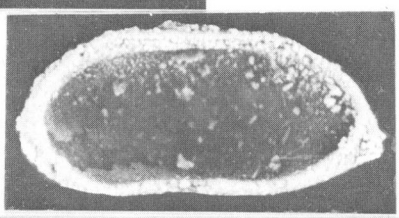

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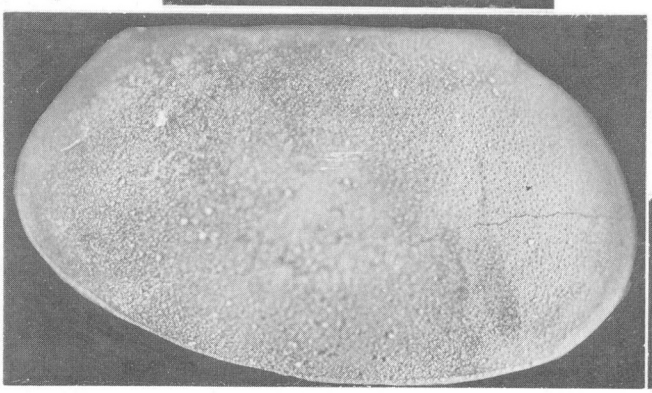

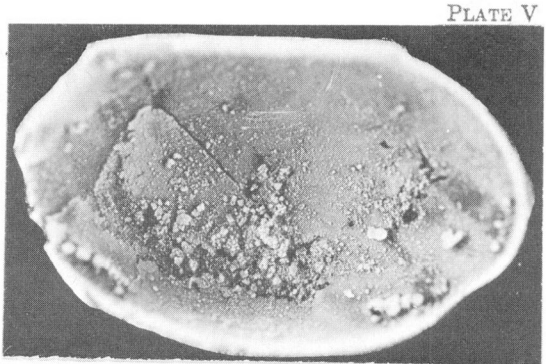

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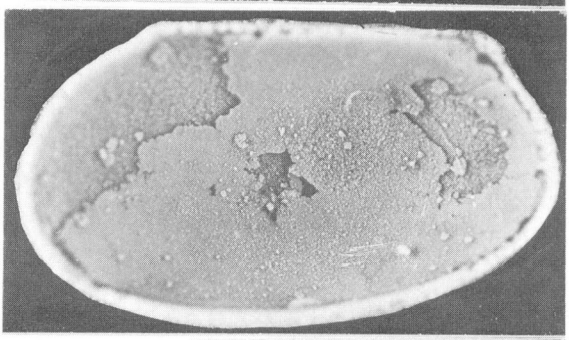

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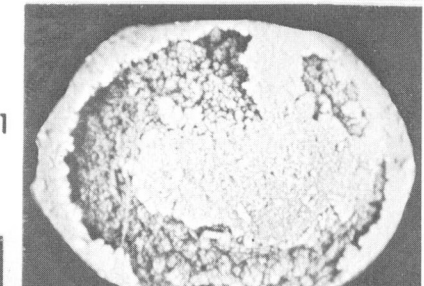

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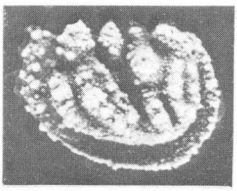

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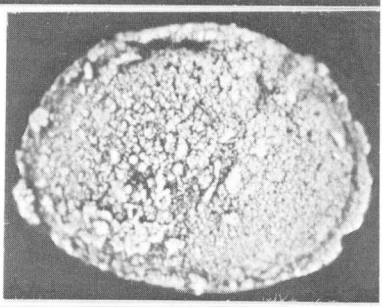

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PLATE VI

Figures 1,2. *Ceratopsis quadrifida* (Jones) (page 20)
1. Left lateral view of valve, X30, locality J-220, hypotype, GSC No. 35174.
2. Right lateral view of immature valve, X30, locality J-220, hypotype, GSC No. 35175.

Figures 3-5. *?Krausella* sp. cf. *?K. acuta* (Teichert) (page 29)
3. Dorsal view of a carapace, X30, locality J-220, hypotype, GSC No. 35176.
4. Left lateral view of carapace, X30, locality J-220, hypotype, GSC No. 35177.
5. Right lateral view of valve, X30, locality J-220, hypotype, GSC No. 35178.

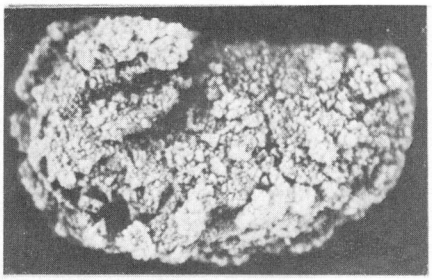
Figure 6. *Milleratia* sp.
Right lateral view of valve, X30, locality J-220, figured specimen, GSC No. 35179.

Figure 7. *Bairdiocypris cylindrica* (Hall)
Lateral view of carapace, X30, locality J-220, hypotype, GSC No. 35180.

Figures 8-14. *Eokloedenella whittakerensis* n. sp. (page 25)
8. Interior view of right valve, X15, locality A-220, paratype, GSC No. 35181.
9. Ventral view of carapace, X15, locality A-220, paratype, GSC No. 35182.
10. Dorsal view of carapace, X15, locality A-220, paratype, GSC No. 35183.
11. Left lateral view of valve, X15, locality A-220, paratype, GSC No. 35184.
12. Interior view of left valve, X15, locality A-220, paratype, GSC No. 35185.
13. Right lateral view of valve, X15, locality A-220, paratype, GSC No. 35186.
14. Left lateral view of carapace, X15, locality A-220, holotype, GSC No. 35187.

Figures 15,16. *Leperditella* sp.
15. Interior view of right valve, X15, locality H-1300, figured specimen, GSC No. 35188.
16. Interior view of left valve, X15, locality H-1300, figured specimen, GSC No. 35189.

Figures 17-19. *?Krausella* sp. cf. *?K. acuta* (Teichert) (page 29)
17. Right lateral view of valve, X30, locality C-640, hypotype, GSC No. 35190.
18. Ventral view of carapace, X30, locality C-640, hypotype, GSC No. 35191.
19. Interior view of right valve, X30, locality C-640, hypotype, GSC No. 35192.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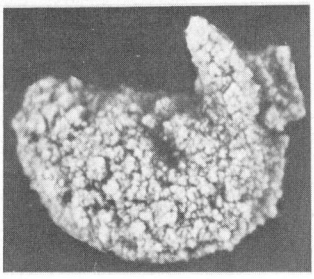
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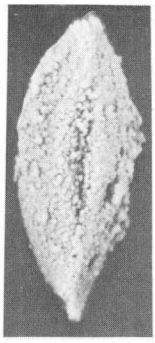
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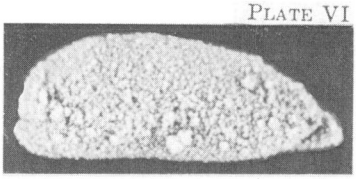
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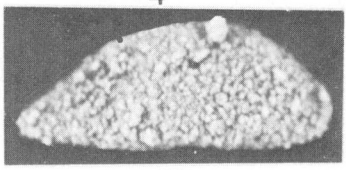
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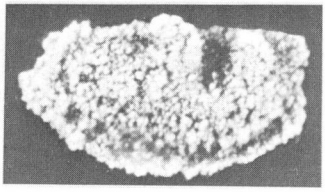
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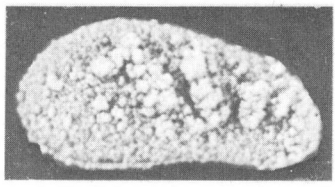
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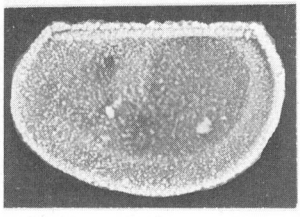
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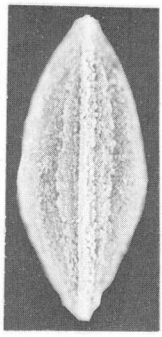
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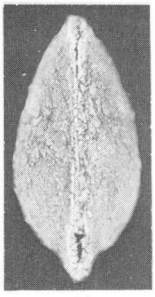
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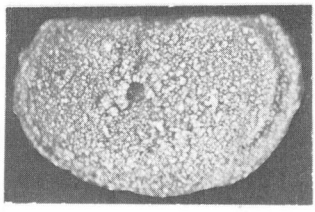
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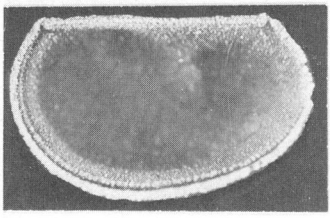
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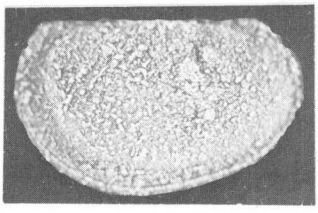
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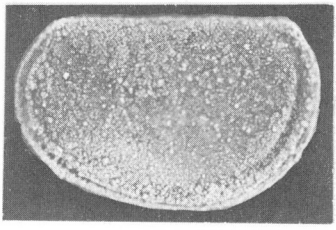
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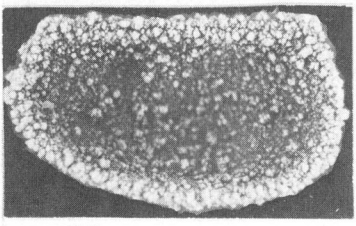
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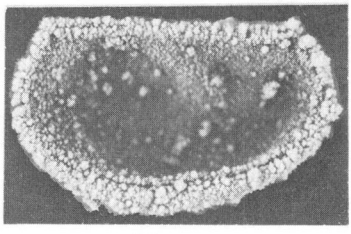
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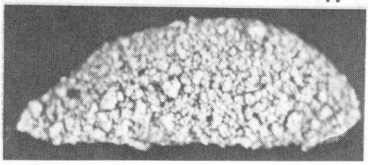

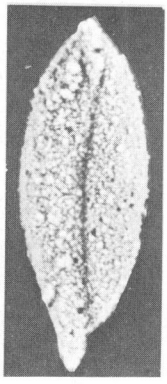
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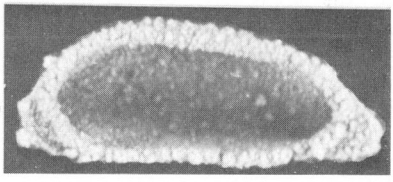
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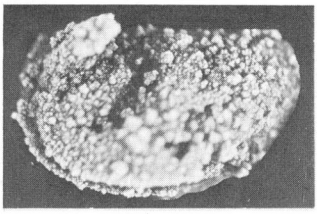
PLATE VII

(Figures 1-15 from locality C-655; magnification X20)

Figures 1-3. *Ceratopsis quadrifida* (Jones) (page 20)
Left and right lateral views and right interior view of three valves, hypotypes, GSC Nos. 35248-35250.

Figures 4-15. *Eurychilina prairiensis* n. sp. (page 18)
4. Left lateral view of tecnomorphic valve, paratype, GSC No. 35251.
5,6. Interior views of right and left tecnomorphic valves, paratypes, GSC Nos. 35252, 35253.
7,8. Right lateral views of two tecnomorphic valves, paratypes, GSC Nos. 35254, 35255.
9. Interior view of right heteromorphic valve, paratype, GSC No. 35256.
10,11. Right lateral views of two heteromorphic valves, paratypes, GSC Nos. 35257, 35258.
12. Right lateral view of heteromorphic valve, holotype, GSC No. 35259.
13. Right lateral view of heteromorphic valve, paratype, GSC No. 35260.
14,15. Interior views of two left heteromorphic valves, paratypes, GSC Nos. 35261, 35262.

Figures 16,17. *Euprimitia? krafti* n. sp. (page 18)
16. Right lateral view of tecnomorphic specimen, X40, locality A-125, paratype, GSC No. 35264.
17. Left lateral view of heteromorphic valve, X40, locality A-125, holotype, GSC No. 35263 (right valve of same specimen unfigured).



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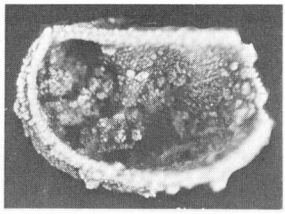

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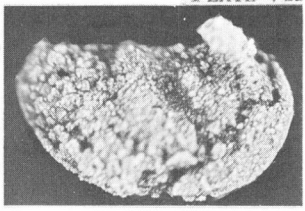

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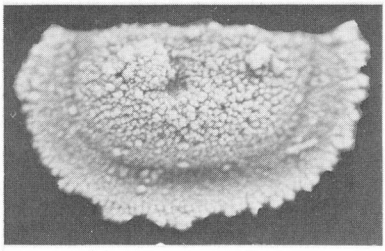

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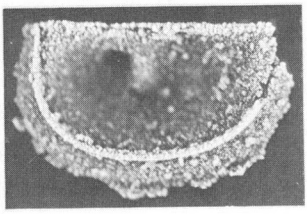

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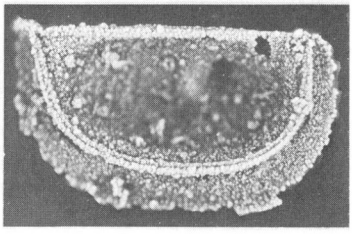

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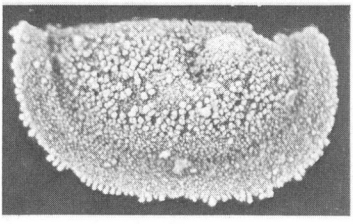

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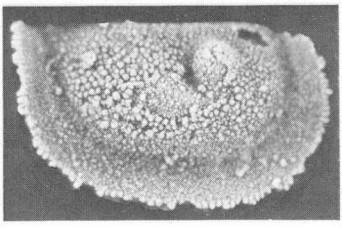

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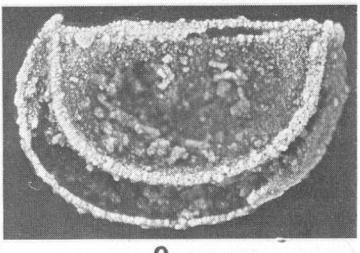

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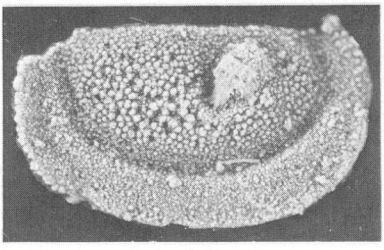

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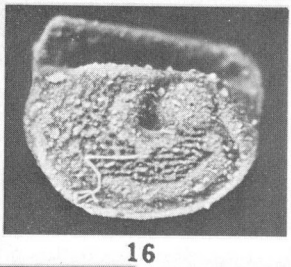

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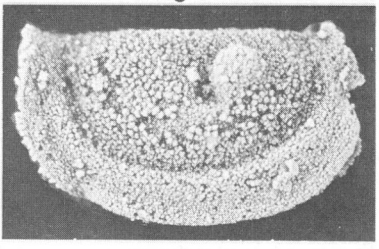

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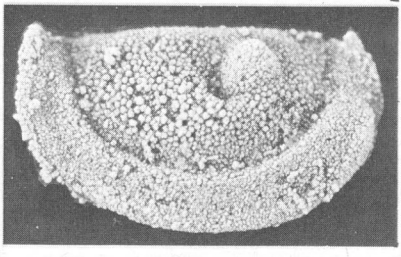

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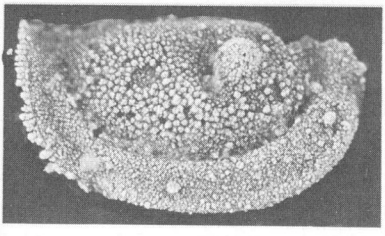

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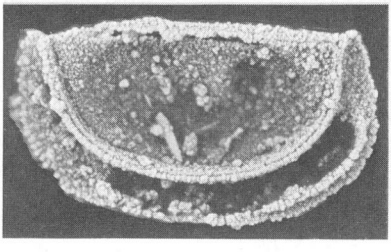

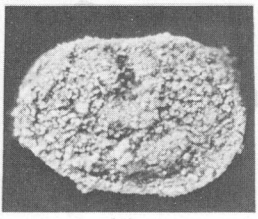

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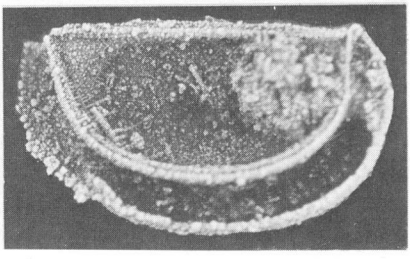


PLATE VIII

(All figures X20)

Figures 1-7. *Bolbopisthia lenzi* n. sp. (page 25)
1,2. Interior and lateral views of two tecnomorphic right valves, locality I-1275, paratypes, GSC Nos. 35437, 35438.
3. Interior view of a heteromorphic left valve, locality I-1275, paratype, GSC No. 35439.
4. Right lateral view of a heteromorphic carapace, locality I-1275, holotype, GSC No. 35440.
5. Ventral view of a tecnomorphic carapace, locality I-1275, paratype, GSC No. 35441.
6. Left lateral view of a tecnomorphic valve, locality I-1275, paratype, GSC No. 35442.
7. Left lateral view of a tecnomorphic carapace, locality I-1275, paratype, GSC No. 35443.

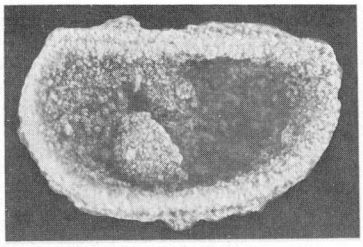
Figure 8. *Bolbopisthia ludvigseni* n. sp. (page 24)
Ventral view of two valves mounted in position as a carapace, locality A-125, paratypes, GSC Nos. 35444,a.

Figures 9,10. *Oepikium* sp. (page 20)
Interior and lateral views of two left valves, locality H-1975, figured specimens, GSC Nos. 35445, 35446.

Figures 11-13. *Dicranella bicornis* Ulrich (page 19)
Interior and lateral views of two right valves and lateral view of a left valve, locality H-1975, hypotypes, GSC Nos. 35447-35449.

Figure 14. *Oepikella labrosa* Copeland (page 23)
Left lateral view of a heteromorphic valve, locality P-1595, hypotype, GSC No. 35450.

Figures 15,16. "*Aparchites*" sp. cf. "*A.*" *fimbriatus* (Ulrich)
Interior and lateral views of two right valves, locality I-1275, figured specimens, GSC Nos. 35451, 35452.



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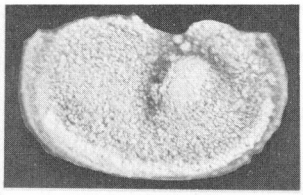

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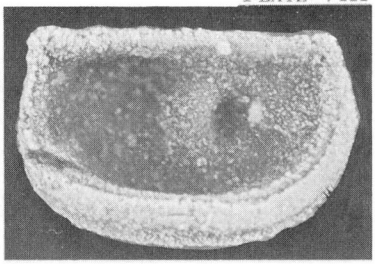

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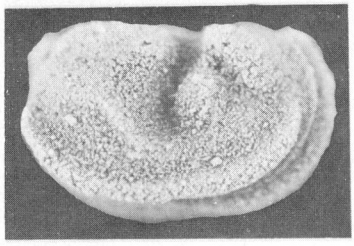

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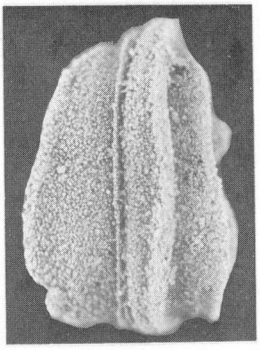

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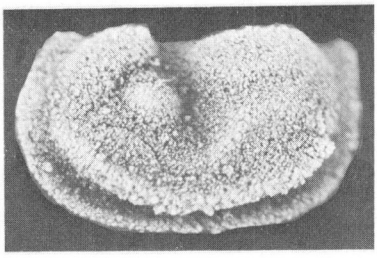

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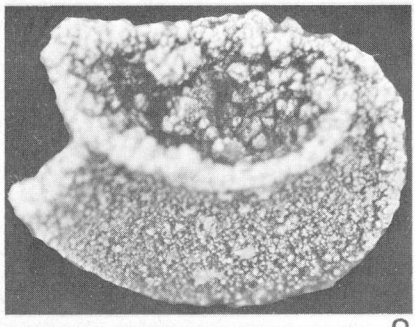

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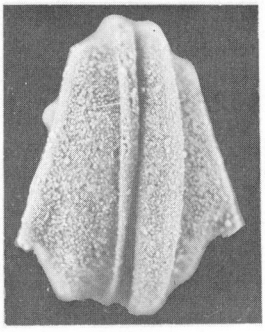

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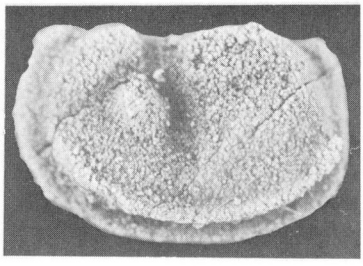

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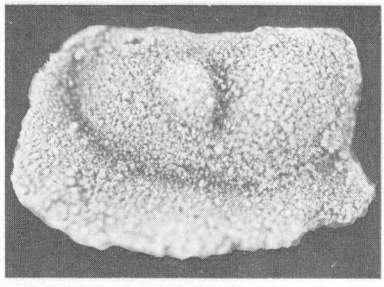

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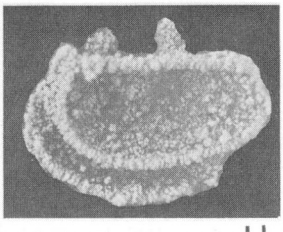

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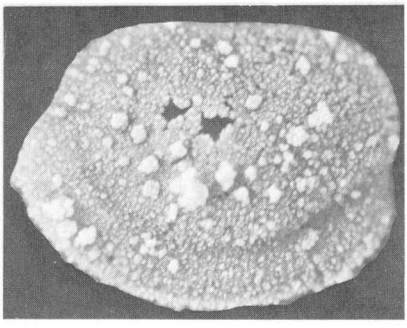

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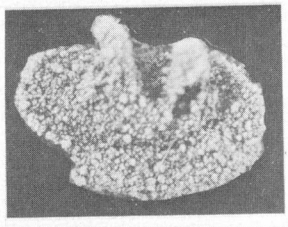

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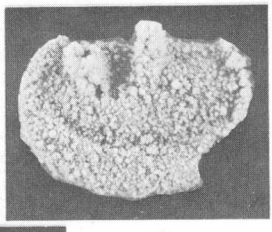

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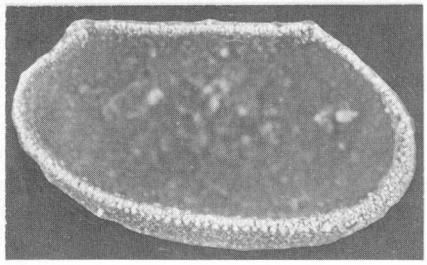

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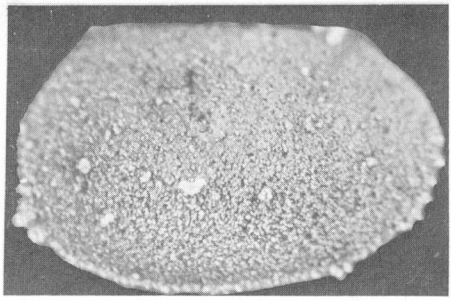

PLATE IX

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2,3. Left lateral and interior views of two valves, X14, locality P-1405, hypotypes, GSC Nos. 38404, 38405.
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Figures 21-23. *Ludvigsenites mackenziensis* n. sp. (page 13)
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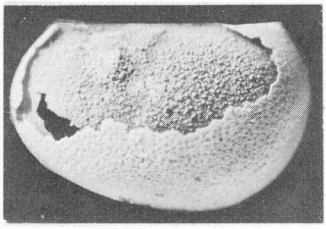
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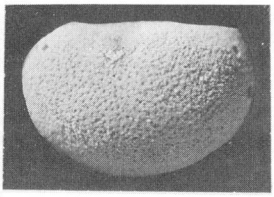
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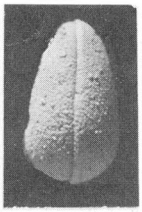
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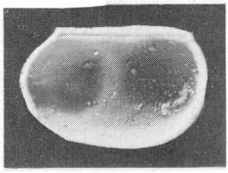
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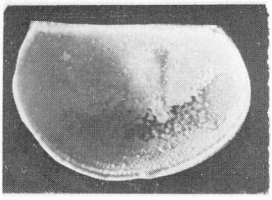
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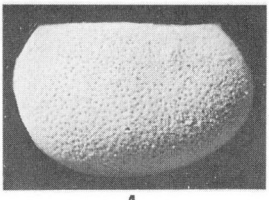
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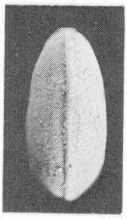
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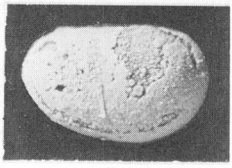
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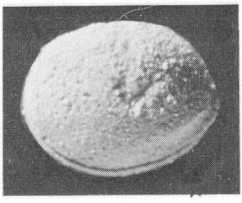
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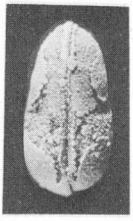
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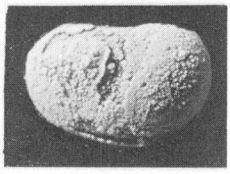
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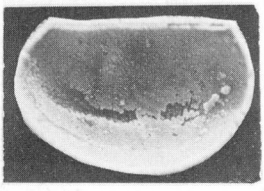
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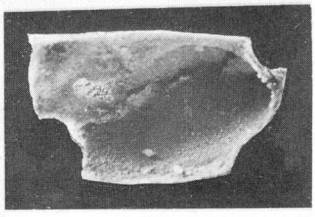
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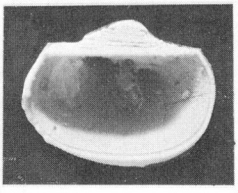
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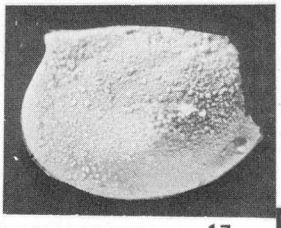
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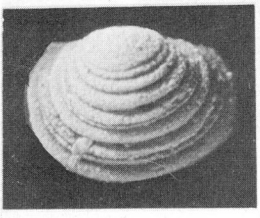
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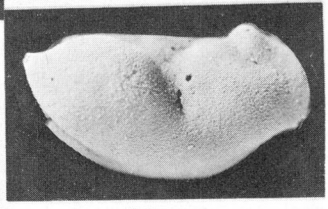
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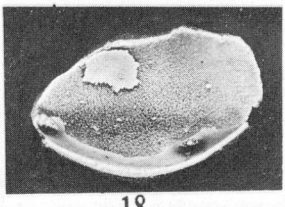
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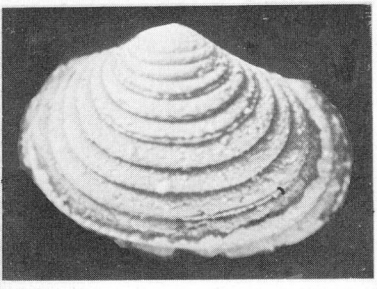
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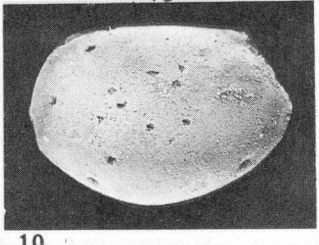
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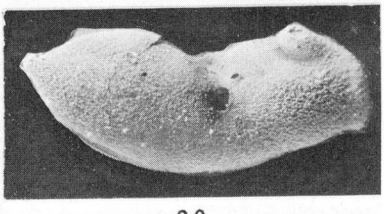
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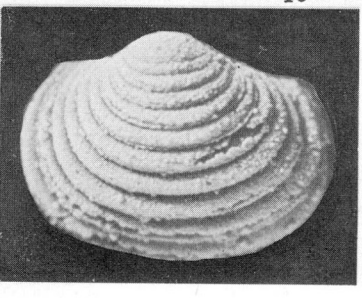

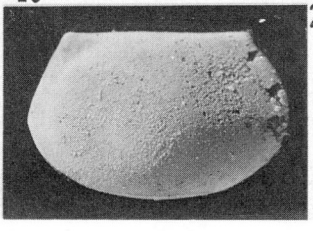
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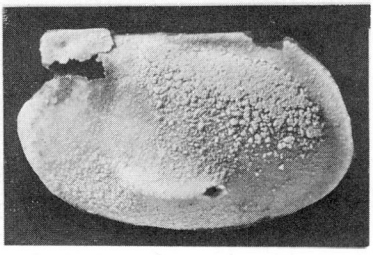

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