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BULLETIN 347

# BATHYMETRY OF EARLY MIDDLE ORDOVICIAN (CHAZY) OSTRACODES, LOWER ESBATAOTTINE FORMATION, DISTRICT OF MACKENZIE

M.J. COPELAND

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# PREFACE

Paleontological zonation of Middle Ordovician carbonate rocks in northwestern North America has progressed to the point where observations may be made of their biogeography, biostratigraphy and bathymetry. This detailed study of silicified Ostracoda from part of the Esbataottine Formation provides a basis for correlation of circum-cratonal early Middle Ordovician rocks of North America and consideration of their conditions of deposition. Such studies are important not only to understanding the stratigraphic framework of this part of the continent but also to our understanding of the distribution and manner of emplacement of metallic mineralization of Middle Ordovician strata of Yukon Territory and southwestern District of Mackenzie.

*W.W. Hutchison*
Director General
Geological Survey of Canada

Ottawa, March 1981

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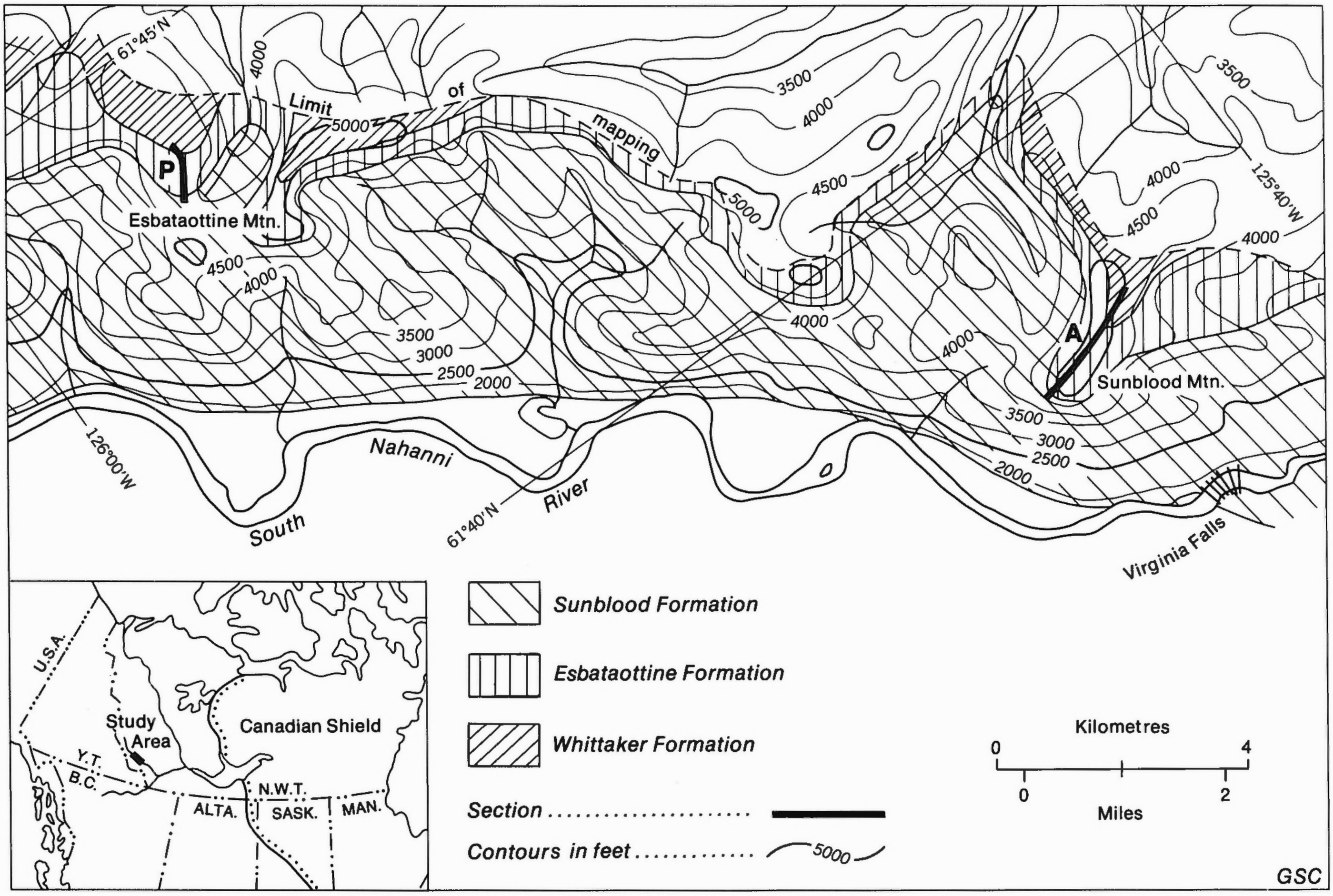

***Figure 1.*** *Locality map and sketch geological map of part of the Sunblood Range, showing location of studied sections – section A, Sunblood Mountain and section P, Esbataottine Mountain. (Chatterton and Ludvigsen, 1976, fig. 1).*

# BATHYMETRY OF EARLY MIDDLE ORDOVICIAN (CHAZY) OSTRACODES, LOWER ESBATAOTTINE FORMATION, DISTRICT OF MACKENZIE

***Abstract***

*Silicified specimens of 26 genera of early Middle Ordovician (Chazyan) ostracodes occur in two sections of the lower Esbataottine Formation in southwestern District of Mackenzie. Many of these ostracode genera are widespread in the upper Tulip Creek – lower Bromide formations of Oklahoma; the upper New Market – Lincolnshire – lower Edinburg formations of Pennsylvania and Virginia; and the Day Point – Crown Point – lower Valcour formations of New York.*

*By means of a bathymetric succession of trilobite biofacies already proposed for platform carbonate strata of the lower Esbataottine Formation, a shallow-water widespread ostracode assemblage I (=**Bathyurus-Isotelus** biofacies) and a deeper water ostracode assemblage II (=**Calyptaulax-Ceraurinella** – proximal **Dimeropyge** biofacies) may be distinguished. These ostracode assemblages occur with some modification elsewhere in North America and may be used for the first time to indicate the relative bathymetry of comparable faunas from widely separated segments of the early Middle Ordovician North American continental platform.*

*Five new genera (Palaeocopida: **Eurybolbina, Nahanniopsis, Canadabolbina, Valcouropsis;** Podocopida: **Bolboscapha**) and twelve new species are erected. In addition, taxonomic revisions and observations are presented for some previously incompletely known North American Chazy ostracode species and for those taxa observed during the study that may have affinities with Middle Ordovician ostracode faunas from Europe. At present, faunas from both regions require additional detailed study before intercontinental biogeographic considerations may be attempted.*

***Résumé***

*On trouve des spécimens silicifiés de vingt six genres d'ostracodes du début de l'Ordovicien moyen (Chazien) dans deux sections de la formation inférieure d'Esbataottine dans le sud-ouest du district de Mackenzie. Un grand nombre de ces genres d'ostracodes sont largement répartis dans la formation supérieure de Tulip Creek et la formation inférieure Bromide d'Oklahoma; la formation supérieure de New Market – Lincolnshire et la formation inférieure d'Edinburg de Pennsylvanie et de Virginie; et les formations de Day Point et de Crown Point et la formation inférieure de Valcour de New York.*

*En comparant une succession bathymétrique de biofaciès de trilobites déjà proposée pour des couches carbonatées de plate-forme de la formation inférieure d'Esbataottine, on peut distinguer un ensemble I d'ostracodes d'eau peu profonde largement répandus (= biofaciès **Bathyurus-Isotelus**) et un ensemble d'ostracodes II d'eau plus profonde (= biofaciès **Calyptaulax-Ceraurinella** – **Dimeropyge** proximal). On retrouve ces ensembles d'ostracodes, avec certaines modifications ailleurs en Amérique du Nord et on les utilise ici pour la première fois pour indiquer la bathymétrie relative de faunas comparables provenant de segments complètement séparés de la plate-forme continentale du début de l'Ordovicien moyen de l'Amérique du Nord.*

*On a établi cinq nouveaux genres (Palaeocopida: **Eurybolbina, Nahanniopsis, Canadabolbina, Valcouropsis;** Podocopida: **Bolboscapha**) et douze nouvelles espèces. En outre, on présente des revisions et des observations taxonomiques pour certaines espèces d'ostracodes du Chazy d'Amérique du Nord, dont la connaissance antérieure était incomplète, et pour les taxons observés au cours de l'étude pouvant avoir des affinités avec les faunes d'ostracodes de l'Ordovicien moyen d'Europe. Il est actuellement nécessaire de faire des études plus détaillées avant de tenter toute comparaison biogéographique intercontinentale.*

## INTRODUCTION AND ACKNOWLEDGMENTS

Silicified Middle Ordovician trilobite faunas from southern Mackenzie Mountains, District of Mackenzie have been under investigation for several years (Ludvigsen, 1975, 1977, 1978, 1979; Chatterton and Ludvigsen, 1976). Chatterton and Ludvigsen (1976) discussed the morphology, taxonomy and paleoecology of trilobite faunas from two stratigraphic sections (Fig. 1, Sections A and P) of the lower Esbataottine Formation and proposed a sequence of trilobite biofacies based on the probable bathymetry of their occurrences across a wide carbonate platform.

Associated with the trilobites are brachiopods, gastropods, bryozoans, conodonts and ostracodes. The study of each of these fossil groups within the geographic limits imposed by the suggested trilobite biofacies could provide detailed information on faunal community development across a segment of a relatively stable continental shelf environment of early Middle Ordovician age and thus possibly could be used to determine the paleoecology of other North American faunas of comparable age. The present paper attempts to place the ostracode fauna, associated in the same collections with the previously discussed trilobites from Sections A and P, into this biofacies framework. Some of these ostracodes have been described (Copeland, 1974, 1978b) and additional material has provided several previously unknown genera and species.

The author wishes to thank Rolf Ludvigsen, University of Toronto, and Brian D.E. Chatterton, University of Alberta, for placing these collections at his disposal. Alf Lenz, University of Western Ontario, and the late David Perry, University of British Columbia, also contributed much in discussions pertinent to the stratigraphy of the area. Jean M. Berdan, United States Geological Survey, Washington, D.C., provided photographs of specimens deposited in collections of the Museum of Comparative Zoology, Harvard University (MCZ), and United States National Museum (USNM).

G. Arthur Cooper, United States National Museum, Washington, D.C., presented the author with rock samples collected near Strasburg, Virginia from which silicified Middle Ordovician ostracodes were obtained. Frederick C. Shaw, Lehman College, Bronx, New York, provided acid residues of samples from Valcour Island, New York that contained numerous silicified ostracode specimens. Specimens from the Virginia and New York samples figured in this report are deposited in the type fossil collection of the United States National Museum (USNM). All Canadian specimens are deposited in the National Type Fossil Collection (GSC).

## AGE OF THE OSTRACODE FAUNA

Figure 2 shows the stratigraphic relationships of fossil collections from Sections A and P reported by Chatterton and Ludvigsen (1976). Only those collections that contain ostracodes are listed on Figures 3 and 4. Ostracodes from the lower Esbataottine Formation are the primary subject of the present report but specimens from nearly 420 m of the underlying Sunblood Formation and more than 135 m of the overlying upper Esbataottine Formation are also recorded for Section P (Fig. 4).

Specimens of 26 genera of archaeocopid (1), palaeocopid (21) and podocopid (4) ostracodes have been recovered from the lower Esbataottine Formation at Section A (110 - 385 ft = 31 -115 m interval) and Section P (1458 - 1595 ft = 445 - 470 m interval). Eleven of these genera may be considered rare. Five of these genera are unknown from rocks of early Middle Ordovician age elsewhere in North America. *Ludvigsenites* (Copeland, 1974), *Bolboscapha* n. gen. and *Nahanniopsis* n. gen. are known only from the lower Esbataottine Formation, *Piretia* was previously known only from northern Europe, and *Canadabolbina* n. gen. is reported here for the first time but is also present in the New Market Formation of southern Pennsylvania. *Tetradella* and *Steusloffina* have been recorded from younger Middle Ordovician faunas of Canada, north-central United States and Scandinavia (Copeland, 1965, 1974, 1977a; Copeland and Bolton, 1977; Hessland and Adamczak, 1974), *Tetradellina* and *Echinoprimitia*? have been reported only from the Middle Ordovician Bromide Formation of Oklahoma (Harris, 1957),

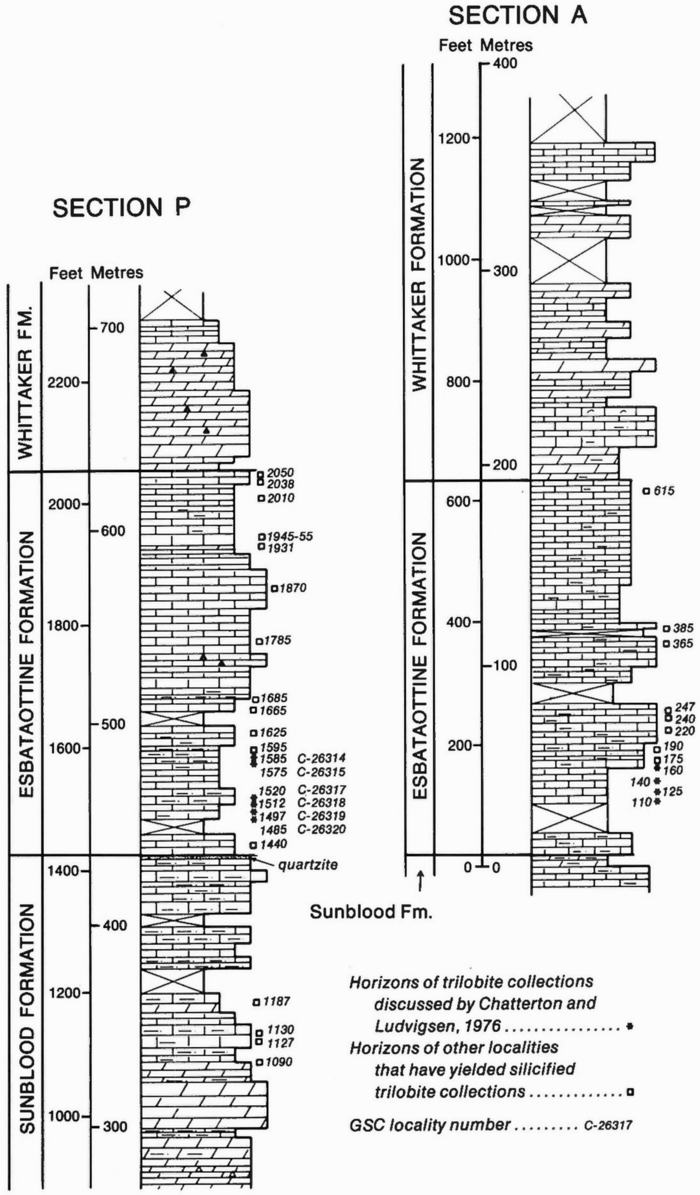

*Figure 2. Diagrammatic lithology sections of the upper part of the Ordovician succession exposed on Esbataottine Mountain (section P) and Sunblood Mountain (section A) showing horizons of trilobite collections. (Chatterton and Ludvigsen, 1976, fig. 2).*

| | ESBATAOTTINE FORMATION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A 110 | A 115 | A 125 | A 140 | A 160 | A 190 | A 220 | A 365 | A 385 |
| PALAEOCOPIDA | | | | | | | | | |
| aechminid indet. | | | ● | | | | | | |
| *Eohollina depressa* (Kay) | | ● | | ● | | | | | |
| *Eurychilina sunbloodensis* Copeland | ● | ● | ● | ● | | ● | ● | | |
| *Eurybolbina bispinata* (Harris) | | ● | ● | ● | | ● | ● | | |
| *Eurybolbina krafti* n. sp. | ● | ● | | | | | | | |
| *Euprimitia? krafti* Copeland | ● | | ● | ● | | | | | |
| *Piretia mackenziensis* n. sp. | | ● | | | | | | | |
| *Dicranella macrocarinata* Harris | | | | | | | | | ● |
| *Tetradellina harrisi* n. sp. | | ● | | | | | | | |
| *Canadabolbina multispinosa* n. sp. | ● | ● | | | | | | | |
| *Oecematobolbina varicata* (Harris) | ● | ● | | ● | | | ● | | |
| *Winchellatia nahanniensis* n. sp. | ● | ● | ● | | | | | | |
| *Bolbopisthia ludvigseni* Copeland | | | ● | | | | | ● | |
| *Tetradella perplexa* Copeland | | ● | | | | | | | ● |
| *Echinoprimitia? spinosa* n. sp. | | ● | | | | | | | |
| *'Aparchites' fimbriatus* (Ulrich) | ● | ● | ● | | | | | | |
| *Eokloedenella whittakerensis* Copeland | | | | | | | ● | | |
| *Leperditella* sp. | ● | | ● | | ● | ● | | | |
| *Cryptophyllus oboloides* (Ulrich and Bassler) | ● | ● | ● | | | | | | |
| *Ectoprimitia? pustulosa* Swain | ● | ● | ● | | | | | | |
| *Schmidtella affinis* Ulrich | ● | | ● | ● | ● | | ● | ● | ● |
| PODOCOPIDA | | | | | | | | | |
| *Bolboscapha chattertoni* n. sp. | | ● | | | | | | | |
| *Platyrhomboides quadratus* Harris | ● | ● | ● | ● | | | | | |
| *Bairdiocypris* spp. | ● | ● | ● | ● | ● | ● | ● | ● | |
| *Krausella minuta?* (Harris) | ● | ● | ● | ● | ● | ● | | | |
| *Krausella inaequalis* Ulrich | | | | | | | | ● | ● |
| *Krausella? sp. cf. K.? acuta* Teichert | | | | | | | | | ● |
| *Steusloffina borealis* Copeland | | | ● | | | | | | GSC |

*Figure 3. Occurrence of Ostracoda, section A, Sunblood Mountain, District of Mackenzie, 61° 38'N, 125° 44'W. (Stratigraphic position of samples is indicated on Figure 2).*

|  | SUNBLOOD FORMATION |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ESBATAOTTINE FORMATION |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | P10 | P30 | P55 | P105 | P115 | P300 | P330 | P725 | P740 | P1090 | P1127 | P1130 | P1185 | P1187 | P1405 | P1485 | P1497 | P1512 | P1520 | P1575 | P1585 | P1595 | P1625 | P1665 | P1685 | P1945 | P2038 | P2050 |
| ARCHAEOCOPIDA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Ludvigsenites mackenziensis* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● | ● |  |  |  |  |  |  |  |  |  |  |
| LEPERDITICOPIDA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Bivia bivia* (White) | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Bivia*? sp. |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Isochilina* cf. *I. gregaria* (Whitfield) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |
| *Isochilina*? sp. |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| PALAEOCOPIDA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Eurychilina sunbloodensis* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| *Eurychilina prairiensis* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
| *Eurychilina* sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |
| *Eurybolbina bispinata* (Harris) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| *Eurybolbina krafti* n. sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |
| *Euprimitia*? *krafti* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |
| *Oecematobolbina varicata* (Harris) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |
| *Nahanniopsis schallreuteri* n. sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |
| *Winchellatia nahanniensis* n. sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |
| *Bolbopisthia ludvigseni* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  | ● |  |  | ? |  |  |  |
| *Bolbopisthia* cf. *B. lenzi* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
| *Eoaquapulex* sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● | ● |  |  |  |  | ? | ● |
| '*Aparchites*' *fimbriatus* (Ulrich) |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  | ● |
| '*Aparchites*' sp. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |
| *Eokloedenella whittakerensis* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |
| *Leperditella* cf. *L. germana* (Ulrich) | ● | ● | ● |  | ● |  |  | ● | ● | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Leperditella mundula* (Ulrich) |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  | ● | ● | ● |  |  | ● | ● |  |  |
| *Cryptophyllus magnus* (Harris) | ● |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Cryptophyllus oboloides* (Ulrich and Bassler) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  | ● |  |  |
| *Schmidtella* cf. *S. subrotunda* Ulrich | ● | ● | ● |  | ● | ● |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Schmidtella affinis* Ulrich |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  | ● | ● |  |  |  |  | ● |  |  | ● | ● | ● |
| PODOCOPIDA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *Platyrhomboides quadratus* Harris |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| *Bairdiocypris* sp. |  |  |  |  | ● | ● | ● |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  | ● |  |  | ● |  |
| *Krausella minuta*? (Harris) |  |  |  |  |  | ● |  | ● | ● |  |  |  | ● |  |  |  | ● | ● |  |  |  |  | ● |  | ● |  |  |  |
| *Krausella inaequalis* Ulrich |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  | ● |  |  |  |  |  |  |  | ● | ● |
| *Steusloffina borealis* Copeland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |  |  |

GSC

***Figure 4.*** *Occurrence of Ostracoda, section P, Esbataottine Mountain, District of Mackenzie, 61° 43'30"N, 125° 56'W. (Stratigraphic position of samples is indicated on Figure 2).*

*Oecematobolbina* was previously described from Middle Ordovician strata of Baltoscandia (Jaanusson, 1957; Schallreuter, 1964a) and Thuringia (Blumenstengel, 1965) and recorded as *Ctenobolbina* from Oklahoma (Harris, 1957), and *Eokloedenella* was reported by Kraft (1962) from Virginia.

Species of the other 15 ostracode genera from the same intervals at Sections A and P are more widespread in early Middle Ordovician strata of North America. As shown in Figure 5, many are recorded from Oklahoma (Tulip Creek and lower Bromide formations, Harris, 1957), New York (Day Point, Crown Point and Valcour formations, Swain, 1957, 1962; Shaw, 1968) and Pennsylvania and Virginia (upper New Market, Lincolnshire and lower Edinburg formations, Kraft 1962). Except for the present occurrences in the Mackenzie Mountains, no distinctive early Middle Ordovician ostracode fauna has been documented from Canada.

| | District of Mackenzie: lower Esbataottine Formation | | Oklahoma: Tulip Ck. and lower Bromide Formations | New York: Day Point, Crown Point and lower Valcour Formations | Pennsylvania and Virginia: upper New Market, Lincolnshire and lower Edinburg Formations |
|---|---|---|---|---|---|
| | Section A110-385 | Section P1485-1595 | | | |
| *Ludvigsenites mackenziensis* | | ● | | | |
| *Eurybolbina bispinata* | ● | ● | ● | ■ | ■ |
| *Eurybolbina krafti* | ● | ● | ■ | ■ | ● |
| *Eohollina depressa* | ● | | ● | ■ | ● |
| *Eurychilina sunbloodensis* | ● | ● | ■ | ■ | ■ |
| *Euprimitia? krafti* | ● | ● | ■ | ■ | ● |
| *Piretia mackenziensis* | ● | | | ■ | |
| *Dicranella macrocarinata* | ● | | ● | ■ | ■ |
| *Oecematobolbina varicata* | ● | ● | ● | | |
| *Nahanniopsis schallreuteri* | | ● | | | |
| *Winchellatia nahanniensis* | ● | ● | ■ | ■ | ■ |
| *Tetradellina harrisi* | ● | | ■ | | |
| *Canadabolbina multispinosa* | ● | | | | ● |
| *Bolbopisthia ludvigseni* | ● | ● | | ■ | ■ |
| *Tetradella perplexa* | ● | | | | |
| *Echinoprimitia? spinosa* | ● | | ■ | | |
| *Eoaquapulex* sp. | | ● | ■ | ■ | ■ |
| *'Aparchites' fimbriatus* | ● | ● | ● | ● | ● |
| *Eokloedenella whittakerensis* | ● | | | | ■ |
| *Leperditella mundula* | | ● | ■ | ■ | ■ |
| *Cryptophyllus oboloides* | ● | ● | ● | ● | |
| *Ectoprimitia? pustulosa* | ● | | ? | ● | ● |
| *Schmidtella affinis* | ● | ● | ● | ■ | ■ |
| *Bolboscapha chattertoni* | ● | | | | |
| *Platyrhomboides quadratus* | ● | ● | ● | ■ | ● |
| *Krausella minuta?* | ● | ● | ● | ■ | ■ |
| *Krausella inaequalis* | ● | ● | ■ | ■ | ■ |
| *Krausella?* sp. cf. *K.? acuta* | ● | | ■ | ■ | ■ |
| *Steusloffina borealis* | ● | ● | | | |

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**Figure 5.** *Occurrence of Archaeocopida, Palaeocopida and Podocopida in the lower part of the Esbataottine Formation at sections A and P and in other early Middle Ordovician formations elsewhere in North America. (Circle indicates specific similarity, square indicates generic similarity).*

## ENVIRONMENT OF DEPOSITION

The despositional environment suggested by the archaeocopid palaeocopid and podocopid ostracode faunas appears to have been the same as that proposed by Chatterton and Ludvigsen (1976) for the trilobite fauna. Those authors concluded that the platform conditions under which lower Esbataottine sediments accumulated comprised a "soft bottom, carbonate mud substrate, deposited under quiet water conditions on a wide shelf ranging from littoral to, possibly, deep sub-littoral zones." That is the type of environment in which small, laterally spinose, or velate, benthonic and nektobenthonic palaeocopid ostracodes could be expected to have occurred in Middle Ordovician shallow seas. Such morphological adaptations would have permitted them to crawl on the soft substrate, swim short distances, or rest on algal mats. Also, the soft substrate could have accommodated elongate, smooth podocopid ostracodes with a shallow, mud- or algal-burrowing adaptation.

The absence of leperditicopid ostracodes in hand samples and acid residues from this stratigraphic interval of the Esbataottine Formation may imply that those large, heavy forms could not exist buried in a soft substrate, that they were restricted to a particular environmental niche that was not represented during deposition of the lower Esbataottine Formation at Sections A and P, or that their valves, because of their chemical composition, were not silicified with the rest of the ostracode fauna. The last suggestion may be questioned because of the presence of silicified leperditicopid ostracode valves in calcilutites of the underlying Sunblood and overlying upper Esbataottine formations at Section P (Fig. 4) and in similar rocks of the Crown Point Formation on Valcour Island, New York (Swain, 1957; Shaw, 1968). It seems more probable that, because of morphological and environmental adaptations, Middle Ordovician leperditicopid ostracodes "lived in a shallow-water, low-energy environment of normal marine salinity" and "may have been sensitive to minor environmental changes and adapted to a particular habitat" (Berdan, 1976, p. 42). An explanation based on environmental response rather than chemical composition of their shells would seem to be more appropriate for the absence of leperditicopid ostracodes from the lower Esbataottine fauna.

The presence of archaeocopid ostracodes in the lower Esbataottine Formation is an enigma. Specimens of *Ludvigsenites* (Copeland, 1974) from these rocks are the youngest Ordovician archaeocopid remains yet reported (see Copeland, 1978a, p.66). Based on the bathymetric trilobite biofacies concept, *Ludvigsenites* occurred in the *Calyptaulax-Ceraurinella* and *Dimeropyge* zones near the distal edge of the continental platform and may have been representative of an unknown Middle Ordovician ostracode fauna. If so, more detailed study of ostracodes from intertonguing carbonate and clastic strata of the *Dimeropyge* and graptolite-bearing biofacies may be prophetic of the poorly known, contemporaneous Road River ostracode fauna considered to have been of platform edge - continental slope habitat.

## OSTRACODE BIOFACIES

If the suggested bathymetric position of trilobite collections from the lower Esbataottine Formation (Chatterton and Ludvigsen, 1976; Ludvigsen, 1979; Hayes, 1980; Fig. 6) is accepted, ostracodes from these same collections may be categorized using the trilobite biofacies terminology. A succession of several nominal trilobite biofacies parallel with the shoreline is postulated by those authors, as shown on Figure 6. When the lower Esbataottine ostracodes are placed in this geographic context two generic assemblages (I and II) are apparent (Fig. 7). In ostracode assemblage I most of the genera that were capable of inhabiting the littoral and shallow-water *Bathyurus* and *Isotelus* biofacies (1 and 2) were also widespread across the platform, indicating either their extensive range of depth and temperature tolerance or their nektonic habit. If the observation by Benson (in Moore, 1961, p. Q60) concerning valve ornamentation (smooth), size (high in proportion to length) and weight (thin light-weight valves) of modern swimming marine ostracodes is applicable, few ostracode genera in this Middle Ordovician association would be interpreted as nektonic. It seems likely, therefore, that some genera of this group of ostracodes had greater environmental tolerance and occupied a wide range of environments.

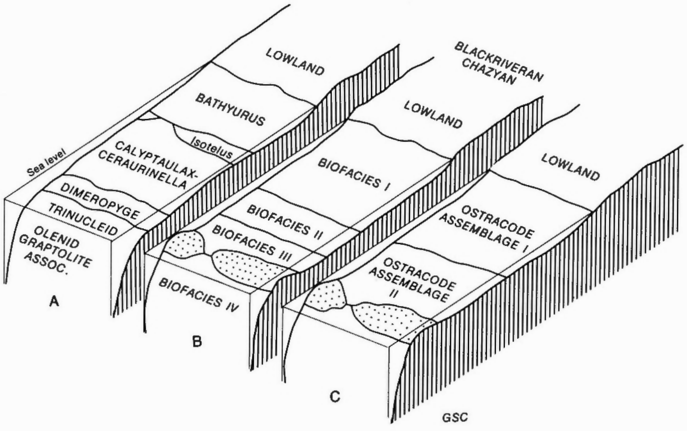

***Figure 6.*** *Comparison of biofacies schemes used herein for fauna of the lower Esbataottine Formation, sections A and P.*

*A, B. Trilobite biofacies proposed by Chatterton and Ludvigsen (1976) and Ludvigsen (1978). (From Ludvigsen, 1978, Fig. 14).*

*C. Ostracode assemblage scheme proposed herein.*

|  | Trilobite biofacies |  |  |  |  |  |
|---|---|---|---|---|---|---|
|  | *Dimeropyge* | *Calyptaulax-Ceraurinella* |  |  | *Isotelus* | *Bathyurus* |
|  | 6 | 5 | 4 | 3 | 2 | 1 |
| *Nahanniopsis* |  |  |  |  |  | ● |
| *Eokloedenella* |  |  |  |  |  | ● |
| *Eoaquapulex* |  |  |  | ● | ● | ● |
| *Oecematobolbina* |  |  | ● | ● |  | ● |
| *Leperditella* |  |  | ● | ● | ● | ● |
| *Bolbopisthia* |  | ● | ● |  |  | ● |
| *Eurybolbina* | ● | ● | ● | ● | ● | ● |
| *Eurychilina* |  | ● | ● | ● | ● | ● |
| *Schmidtella* | ● |  | ● | ● |  | ● |
| *Krausella* | ● | ● | ● | ● | ● | ● |

Ostracode assemblage I

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| *Dicranella* |  |  |  | ● |  |  |
| *Eohollina* |  |  | ● | ● |  |  |
| *Euprimitia?* |  | ● | ● | ● |  |  |
| *Platyrhomboides* |  | ● | ● | ● |  |  |
| *Tetradella* |  |  | ● | ● |  |  |
| *Piretia* |  |  | ● |  |  |  |
| *Tetradellina* |  |  | ● |  |  |  |
| *Canadabolbina* |  |  | ● |  |  |  |
| *Winchellatia* |  | ● | ● |  |  |  |
| *Echinoprimitia?* |  |  | ● |  |  |  |
| *'Aparchites'* | ● | ● | ● |  |  |  |
| *Cryptophyllus* |  | ● | ● |  |  |  |
| *Ectoprimitia?* |  |  | ● |  |  |  |
| *Bolboscapha* |  |  | ● |  |  |  |
| *Steusloffina* |  | ● | ● |  |  |  |
| *Ludvigsenites* | ● | ● | ● |  |  | GSC |

Ostracode assemblage II

***Figure 7.*** *Generic assemblages of ostracodes within the trilobite biofacies of the lower Esbataottine Formation at sections A and P.*

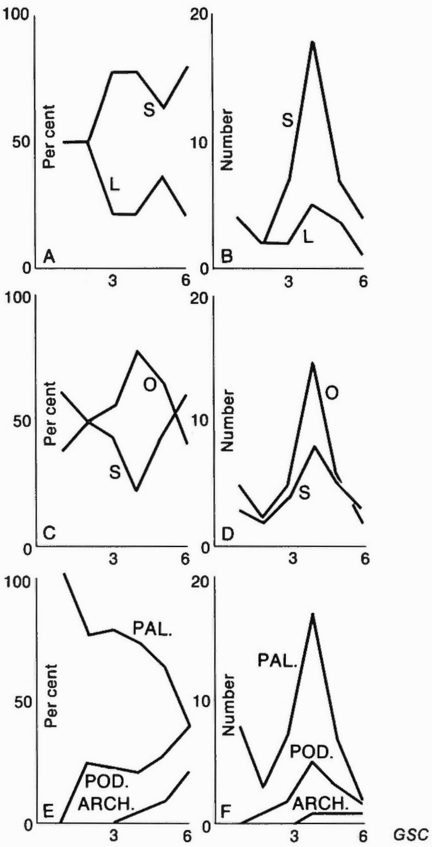

***Figure 8.*** *Size, ornamentation and taxonomic characteristics of 28 species of silicified Ostracoda from sections A and P of the lower Esbataottine Formation. Sunblood Range, based on the number of species (no.) and relative bathymetric distribution of ostracode species in trilobite biofacies (1→6) as suggested by Chatterton and Ludvigsen (1976).*

1. *Collections A-220, P-1595,* ***Bathyurus*** *biofacies.*
2. *Collections A-190, P-1585,* ***Isotelus*** *biofacies.*
3. *Collections A-140, A-160, P-1575, shallow* ***Calyptaulax-Ceraurinella*** *biofacies.*
4. *Collections A-110, A-115, A-125, P-1497, moderate depth* ***Calyptaulax-Ceraurinella*** *biofacies.*
5. *Collection P-1485, deep* ***Calyptaulax-Ceraurinella*** *biofacies.*
6. *Collections P-1512, P-1520,* ***Dimeropyge*** *biofacies.*

*A, B. Percentage (A) and number (B) of ostracode species by size, based on adult length (S= <1.2 mm, L= >1.2 mm).*

*C, D. Percentage (C) and number (D) of ostracode species based on relative ornamentation (O= 'ornamented', S= 'smooth').*

*E, F. Percentage (E) and number (F) of Palaeocopida (PAL), Podocopida (POD) and Archchaeocopida (ARCH) species.*

Many ostracode genera inhabiting the *Calyptaulax-Ceraurinella* biofacies (3 - 5) occur only in ostracode assemblage II; this includes 8 of the 11 rare genera and 9 of 14 hollinacean genera. This may indicate the preference of these genera for a cooler and deeper platformal environment. Examination of the total ostracode species (Fig. 8 B, D, F) shows that the fauna of the *Calyptaulax-Ceraurinella* trilobite biofacies (3 - 5) is by far the most diverse. Based on percentage of species (Fig. 8 A, C, D) this biofacies has a preponderance of small, ornate ostracode species and a marked seaward decline of palaeocopid species in the *Dimeropyge* biofacies (6) relative to an increase in percentage of podocopid and archaeocopid species. This shift toward dominance of podocopid and archaeocopid species in the early Middle Ordovician platform edge biofacies is, however, not reflected by the Late Ordovician Road River ostracode fauna from nearby Black Wolf Mountain (Copeland, 1977b), in which only Palaeocopida have been found, dominated by drepanellacean species. Ostracodes recovered from Road River facies strata are too few to indicate any definite taxonomic trend.

## CORRELATION AND POSSIBLE BATHYMETRY OF THE OSTRACODE FAUNA

The trilobite biofacies bathymetry proposed by Chatterton and Ludvigsen (1976) for Sections A and P of the lower Esbataottine Formation cannot be translated directly into ostracode terminology. No statistical data are available, such as that of numerical occurrence of trilobite specimens, on which to base an independent ostracode biofacies relationship. This is due to the variation in size of samples studied, the excessive number of specimens in some collections and the uncertainty of attempting to make a population count of adult specimens when complete moult stages cannot be determined for some species. As a result, the numerical data presented are based on ostracode species or genera rather than on total population.

The relationship between ostracode faunas from Sections A and P follows that proposed by Chatterton and Ludvigsen (ibid.) for the trilobite fauna, in that ostracodes and trilobites from collections A-110 to A-220 may readily be correlated with those from collections P-1485 to P-1595 (Fig. 9). Ostracode taxa (and specimens) are fewer in most

| Ostracode genera from the lower Esbataottine Fm. at Sections A and P | | | *Nahanniopsis* | *Eokloedenella* | *Eoaquapulex* | *Oecematobolbina* | *Leperditella* | *Bolbopisthia* | *Eurybolbina* | *Eurychilina* | *Schmidtella* | *Krausella* | *Dicranella* | *Eohollina* | *Euprimitia?* | *Platyrhomboides* | *Tetradella* | *Piretia* | *Tetradellina* | *Canadabolbina* | *Winchellatia* | *Echinoprimitia?* | *'Aparchites'* | *Cryptophyllus* | *Ectoprimitia?* | *Bolboscapha* | *Steusloffina* | *Ludvigsenites* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bathymetric trilobite biofacies | | Ostracode genera of shallow and/or widespread occurrence in biofacies across the platform (I) | | | | | | | | | | Ostracode genera of the deeper platform biofacies (II) | | | | | | | | | | | | | | | |
| Occurrence in the lower Esbataottine Formation of ostracode genera within the proposed trilobite biofacies of Chatterton and Ludvigsen (1976) | 6. *Dimeropyge* | | | | | | | | ● | | ● | ● | | | | | | | | | | | ● | | | | | ● |
| | 5. *Calyptaulax-* | | | | | | | ● | ● | ● | | ● | | | ● | ● | | | | | ● | | ● | ● | | | ● | ● |
| | 4. | | | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | 3. *Ceraurinella* | | | | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | | | | | | | | |
| | 2. *Isotelus* | | | | ● | | ● | | ● | ● | | ● | | | | | | | | | | | | | | | | |
| | 1. *Bathyurus* | | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | | | | | | | | | | | | | | |
| | SECTION A | A-385 | | | | | | | | | ● | ● | ● | | | | ● | | | | | | | | | | | |
| | | A-365 | | | | | | ● | | | ● | ● | | | | | | | | | | | | | | | | |
| | | A-220 | | ● | | ● | | | ● | ● | ● | | | | | | | | | | | | | | | | | |
| | | A-190 | | | | | ● | | ● | ● | | ● | | | | | | | | | | | | | | | | |
| | | A-160 | | | | | ● | | | | ● | ● | | | | | | | | | | | | | | | | |
| | | A-140 | | | | ● | | | ● | ● | ● | ● | | ● | ● | ● | | | | | | | | | | | | |
| | | A-125 | | | | | ● | ● | ● | ● | ● | ● | | | ● | ● | | | | | ● | | ● | ● | ● | | ● | |
| | | A-115 | | | | ● | | | ● | ● | | ● | | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | |
| | | A-110 | | | | ● | ● | | ● | ● | ● | ● | | | ● | ● | | | | ● | ● | | ● | ● | ● | | | |
| | SECTION P | P-1945 | | ● | | | ● | | | | ● | | | | | | | | | | | | | ● | | | | |
| | | P-1685 | | | | | ● | ● | | | | ● | | | | | | | | | | | | | | | | |
| | | P-1625 | | | | | | | | | ● | ● | | | | | | | | | | | | | | | | |
| | | P-1595 | ● | | ● | ● | ● | ● | ● | | | | | | | | | | | | | | | | | | | |
| | | P-1585 | | | ● | | ● | | | | | | | | | | | | | | | | | | | | | |
| | | P-1575 | | | ● | | ● | | | | | ● | | | | | | | | | | | | | | | | |
| | | P-1520 | | | | | | | ● | | | ● | | | | | | | | | | | | | | | | |
| | | P-1512 | | | | | | | | | ● | ● | | | | | | | | | | | ● | | | | | ● |
| | | P-1497 | | | | | ● | ● | | | ● | ● | | | ● | | | | | | ● | | ● | | | | ● | ● |
| | | P-1485 | | | | | | ● | ● | ● | | ● | | | ● | ● | | | | | ● | | ● | ● | | | ● | ● |

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***Figure 9.*** *Comparison of stratigraphic and bathymetric distribution of ostracode genera from the lower Esbataottine Formation at sections A and P.*

collections from Section P, compared with collections from Section A. This may be due to a slight difference in environment or food supply but does not obscure the correlation between those two stratigraphic intervals. Based on the depth-diversity relationship advanced by Chatterton and Ludvigsen a progressive lowering of sea level is indicated by the fauna in both sections. This is especially apparent where the number of taxa abruptly decreases above collections A-140 and P-1512. All genera indicative of the older, deeper water (*Calyptaulax-Ceraurinella* and proximal *Dimeropyge* biofacies) ostracode assemblage II disappear from superjacent strata and only a few specimens of three of those ostracode genera (*Dicranella*, *Tetradella* and *Cryptophyllus*) reappear much higher in the sections (Fig. 9). The shallow-water or widespread ostracode assemblage I, however, persists throughout the lower Esbataottine Formation without obvious disruption (Fig. 10).

With these criteria, it may be possible to interpret the relative ages and bathymetry of closely comparable North American Middle Ordovician ostracode faunas. Only three stratigraphically documented ostracode successions present themselves (Fig. 11)---those from the upper Tulip Creek - lower Bromide formations of Oklahoma, the upper New Market - Lincolnshire - lower Edinburg formations of Pennsylvania, and Virginia and Day Point - Crown Point - lower Valcour formations of New York (Figs. 12 - 14).

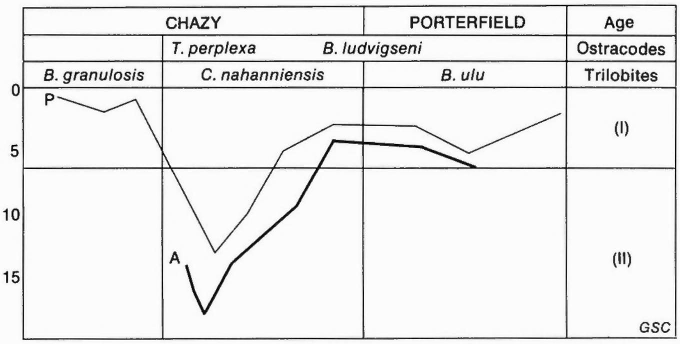


***Figure 10.*** *Number of ostracode species recovered from localities in sections A and P plotted on a zonal scale with inferred bathymetric limits of ostracode assemblages I and II.*

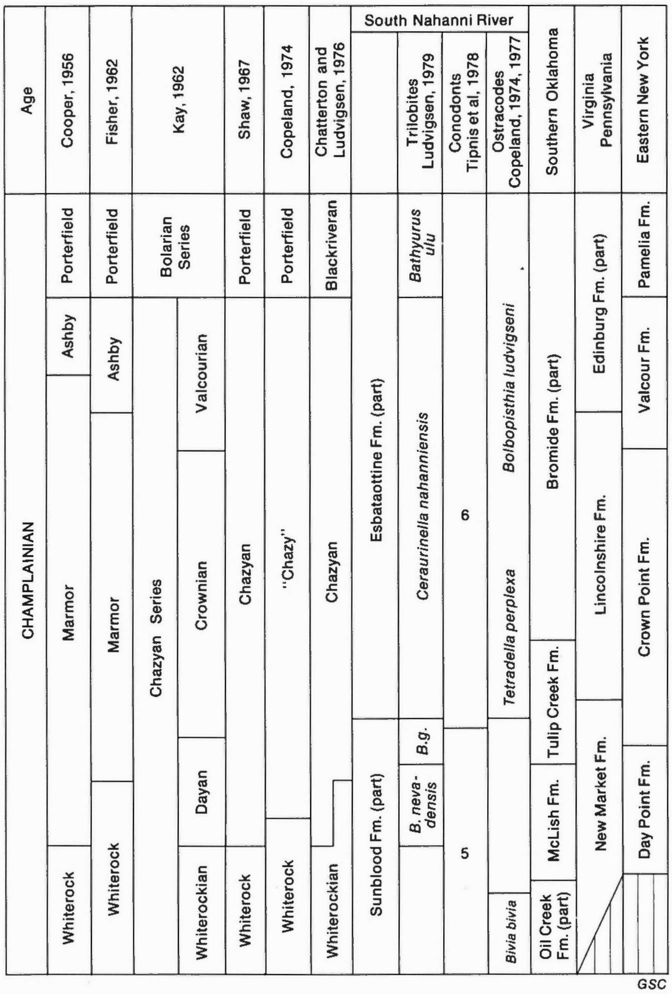


***Figure 11.*** *Correlation of North American lower Middle Ordovician formations based on ostracode occurrences and suggested early Champlainian stage terminology (in part, after Shaw, 1968).*

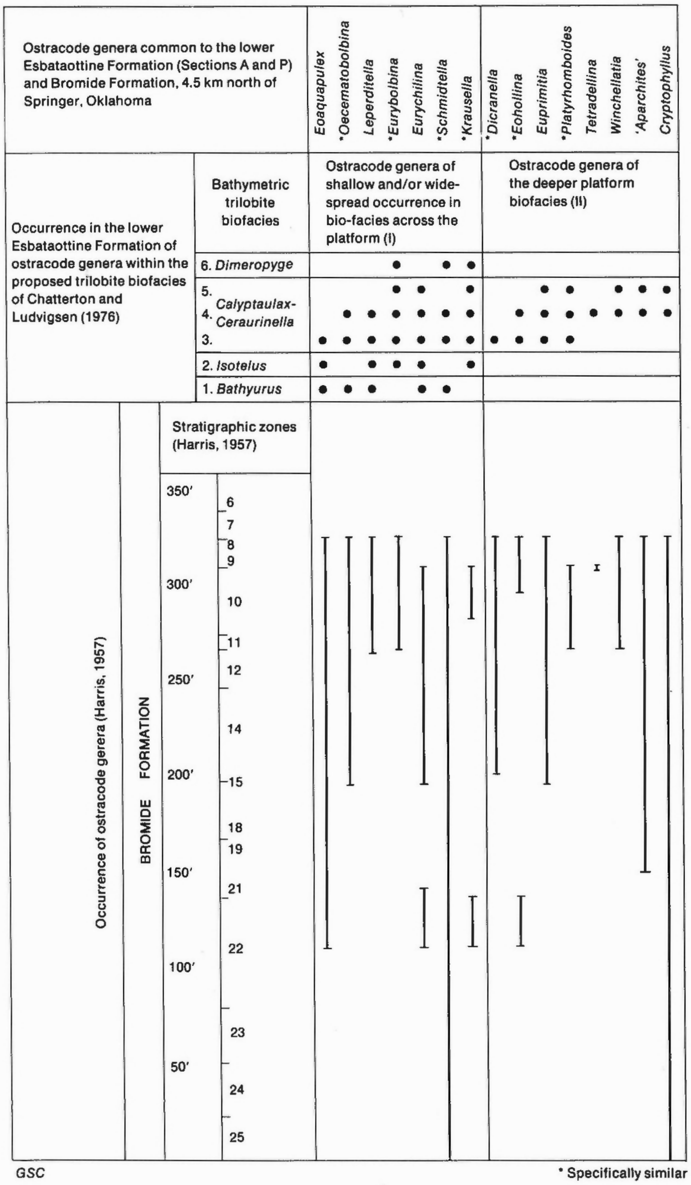
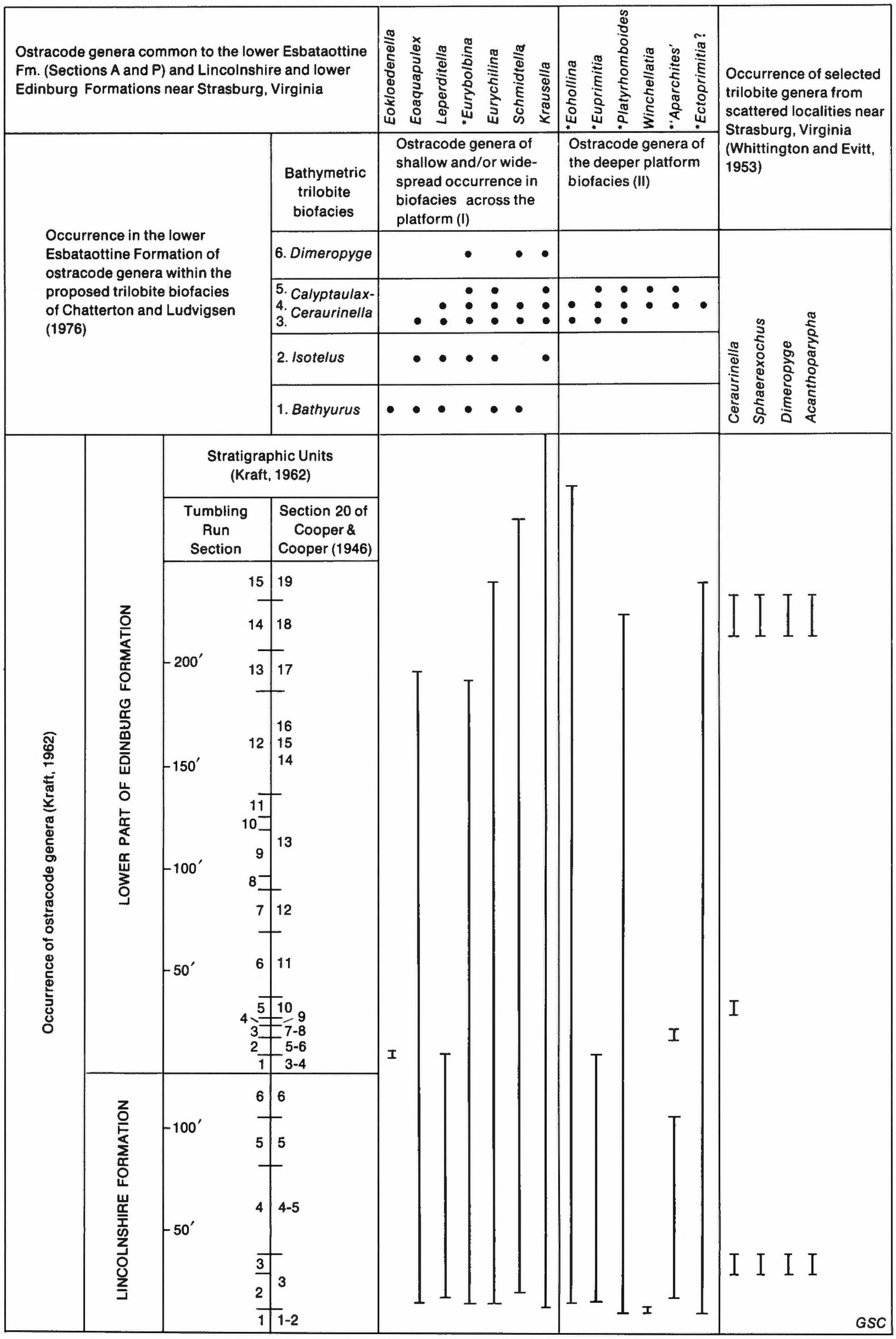


***Figure 12.*** *Comparison of stratigraphic and bathymetric distribution of ostracode genera common to the lower Esbataottine Formation at sections A and P and Bromide Formation, U.S. Highway 77 section, 4.5 km north of Springer, Oklahoma (after Harris, 1957).*



*Specifically similar

***Figure 13.*** *Comparison of stratigraphic and bathymetric distribution of ostracode genera common to the lower Esbataottine Formation at sections A and P and Lincolnshire and lower Edinburg formations near Strasburg, Virginia.*

Published sections of those formations each have from 13 to 17 ostracode genera (some of which are specifically similar; Fig. 5) in common with the lower Esbataottine ostracode fauna. Figures 12 to 14 are similar in construction to Figure 9, with the available stratigraphic data presented in the context of ostracode assemblages I and II as developed from Sections A and P of the lower Esbataottine Formation.

The early deeper water (***Calyptaulax-Ceraurinella*** and proximal ***Dimeropyge*** biofacies) ostracode assemblage II of Sections A and P appears to compare most probably to zones 15 - 8 (ca. 130 ft = 40 m) of the Bromide Formation, Simpson Group along U.S. Highway 77 near Springer, Oklahoma (ca. 34°20'N, 97°08'W) (after Harris, 1957, Ostracoda Range Chart 2; Fig. 10). The faunal similarity is even more pronounced in an 18.5 m interval of Harris' zones 12 - 8 but is abruptly terminated at the upper limit of zone 8. No explanation is advanced by Harris for this complete faunal disruption well within the Bromide Formation but the overlying zones 7 - 1 are more calcareous than the underlying strata and may represent very shallow water deposition, indicated by leperditicopid ostracodes. Fifteen ostracode genera are known to be common to Sections A and P of the lower Esbataottine Formation and the Bromide Formation at this locality. Unlike the other Middle Ordovician ostracode faunas discussed herein, most of Harris' type ostracode specimens from the Simpson Group are calcareous, rather than siliceous, and many of them are abraded. Several type specimens of species from the Simpson Group (McLish to Corbin Ranch formations) are figured here (Pl. 4, figs. 6 -11). Some may be closely related to species from the lower Esbataottine Formation but many of the Simpson type specimens are too poorly preserved to permit comparison.

Thirteen genera of ostracodes are common to silicified faunas of the Lincolnshire and lower Edinburg formations at Tumbling Run, Virginia (Fig. 11, after Kraft, 1962) and Sections A and P of the lower Esbataottine Formation. Species of 12 of these genera appear abruptly about 3 m above the base of the Lincolnshire Formation and most occur throughout the formation (ca. 33m) and 3 m or more into the overlying lower Edinburg Formation. Deeper water genera of ostracode assemblage II are few in younger strata of the lower Edinburg Formation. This may reflect minor decrease in water depth or be due to the selective silicification of fossils that is reported to occur throughout the formation (Whittington and Evitt, 1953; Kraft, 1962). The absence of leperditicopid ostracodes from this fauna may reflect substrate conditions similar to that proposed by Chatterton and Ludvigsen (1976) for the lower Esbataottine Formation. The composition of the Lincolnshire – lower Edinburg formations ostracode fauna is very similar to that of the lower Esbataottine fauna. This similarity is remarkable, considering the geographic position of these two occurrences about 20 degrees on either side of the projected Middle Ordovician equator.

Only one rare ostracode species of the lower Esbataottine fauna occurs in the Pennsylvania-Virginia area. This is ***Canadabolbina multispinosa*** n. sp., which occurs in the upper part of the New Market Formation, Chambersburg Quadrangle, Pennsylvania. Also present with ***C. multispinosa*** at this locality (USGS 295i, collected by G.W. Stose) is ***Dicranella*** sp., very similar to ***D. fimbriata*** n. sp. of this report, and *Krausella minuta*? (Harris).

Less generic similarity is apparent between the lower Esbataottine ostracode fauna and the silicified fauna of the Day Point – Crown Point formations reported by Swain (1957, 1962) from northern New York. If comparison is attempted (Fig. 14), it would appear most probable that the lower Esbataottine ostracode fauna is most similar to that within the lower 30 m or more of the reefal Crown Point Formation and that it straddles the boundary between the *Bullatella kauffmanensis* and *Monoceratella teres* zones of Swain (1957).

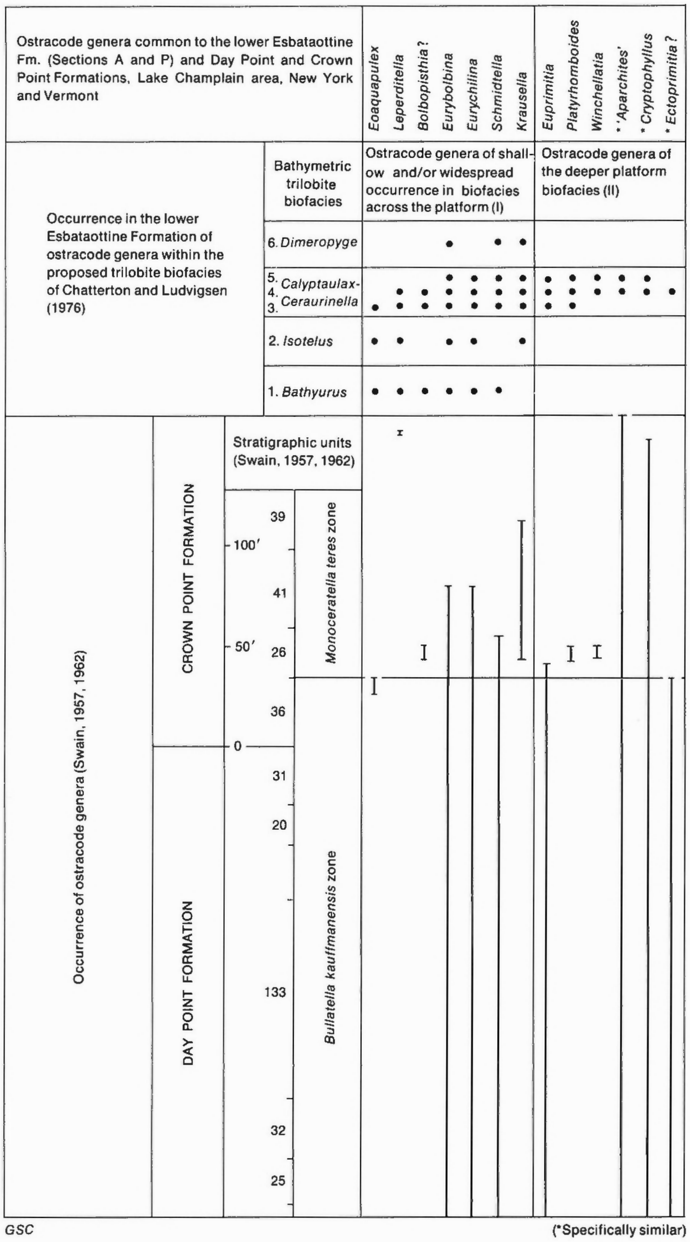


***Figure 14.*** ***Comparison of stratigraphic and bathymetric distribution of ostracode genera common to the lower Esbataottine Formation at sections A and P and Day Point and Crown Point formations, Lake Champlain area, New York and Vermont.***

Both Swain (1957, 1962) and Fisher (1968) indicated that no Day Point strata are present on Valcour Island. Oxley and Kay (1959, Section 15) and Shaw (1968, Pebble Beach), however, indicated that thick Chazy strata are present along the south shore of Valcour Island, and Shaw measured 20.5 m of Day Point, about 105 m of Crown Point and more than 30 m of Valcour strata at that locality. Shaw submitted six collections of silicified ostracodes from the Pebble Beach locality on Valcour Island. They indicate a somewhat different distribution of ostracodes from that reported by Swain (19 57, 1962; Fig. 14).

Examination of Figure 15 shows that eleven genera from the six Pebble Beach samples also occur in the lower Esbataottine fauna. The criteria in Figure 7 show that five of these genera, *Eurybolbina*, *Eurychilina*, *Leperditella*, *Schmidtella* and *Krausella*, occur in ostracode assemblage I and are widespread across the platform and slope margin. The other six genera, "*Aparchites*", *Cryptophyllus*, *Dicranella*, *Eohollina*, *Piretia* and *Winchellatia*, are present in ostracode assemblage II and in the *Calyptaulax-Ceraurinella* biofacies. It is probable, therefore, that this sampled interval of the Day Point to Valcour formations represented a relatively stable, low-energy outer shelf environment, as previously suggested by Shaw and Fortey (1977, p. 423).

| | PB5 | PB15 | PB79 | PB81 | PB175 | PB420 |
|---|---|---|---|---|---|---|
| Leperditicopida | | | | | | |
| *Tirisochilina anna* (Jones) | | | | ● | | |
| Palaeocopida | | | | | | |
| *Anisocyamus elegans* (Harris) | | ● | | | | |
| '*Aparchites*' *fimbriatus* (Ulrich) | ● | ● | ● | ● | ● | ● |
| *Aparchites pembertonensis* Swain | ● | | | | | |
| *Bromidella spiveyi* Harris | ● | ● | ● | ● | ● | ● |
| ?*Budnianella ellipticalis* Swain | ● | ● | ● | | | |
| *Budnianella shenandoahense* Swain | ● | | | | | |
| * *Cryptophyllus oboloides* (Ulrich and Bassler) | ● | | ● | | | |
| *Dicranella fimbriata* n. sp. | ● | | ● | | | |
| *Eohollina depressa* (Kay) | ● | ● | ● | | | |
| *Eurybolbina bulbinoda* (Swain) | ● | ● | ● | | | |
| *Eurybolbina clintonensis* (Swain) | | | ● | | | |
| *Eurybolbina krafti* n. sp. | | | | | | ● |
| *Eurychilina*? *mattea* Kraft | ● | | | | | ● |
| *Eurychilina*? *placida* Swain | ● | ● | ● | ● | ● | ● |
| * *Leperditella* sp. | ● | ● | | ● | | |
| *Lomatopisthia* simplex (Harris) | | ● | | | | |
| *Piretia shawi* n. sp. | ● | ● | ● | ● | ● | |
| *Primitiella*? sp. | ● | | ● | | | |
| *Schmidtella crassimarginata* Ulrich | | ● | ● | | | |
| *Sigmobolbina*? *crescentica* Swain | | ● | | | | |
| *Valcouropsis shawi* n. sp. | | ● | | | | |
| * *Winchellatia* sp. | ● | | ● | ● | ● | |
| Podocopida | | | | | | |
| *Acanthoscapha champlainensis* Swain | ● | ? | | | | |
| "*Bythocypris*" sp. | ● | | | ● | | ● |
| * *Krausella* sp. | ● | | ● | ● | ● | |
| *Monoceratella* sp cf. *M. teres* Teichert | ● | | | | ? | |
| *Ovornina (Margoplanitia) valcourensis* n. sp. | ● | | ● | | | |

*GSC*

***Figure 15.*** *Ostracode species identified from six samples collected by F.C. Shaw from measured section at Pebble Beach, south end of Valcour Island, Lake Champlain, New York, ca 44°36'30"N, 73°25'W. Stratigraphic position of samples are: PB5 and PB15, 19 m and 16 m below top of Day Point Formation; PB79, PB81 and PB175, 3.3 m, 4 m and 32 m above base of Crown Point Formation and PB420, 22 m above base of Valcour Formation (data from Shaw, 1968, Appendix B). (*Species not figured herein).*

## SYSTEMATIC PALEONTOLOGY

Order Palaeocopida Henningsmoen, 1953

Suborder Beyrichicopina Scott, 1961

Superfamily Hollinacea Swartz, 1936

Family Hollinidae Swartz, 1936

Genus *Eohollina* Harris, 1957

Type species. *Beyrichia irregularis* Spivey, 1939

*Eohollina depressa* (Kay)

Plate 2, figures 18, 19; Plate 6, figures 9, 10;
Plate 7, figure 5

*Bromidella depressa* Kay, 1940, p. 263, Pl. 34, figs. 12 - 15.
*Eohollina depressa* (Kay). Harris, 1957, p. 208, Pl. 7, figs. 1a, b, 2a - d.
?*Eohollina depressa papillata* Harris, 1957, p. 209, Pl. 7, figs. 3a, b.
*Bromidella depressa* Kay. Kraft, 1962, p. 43, Pl. 15, figs. 8 - 17, Fig. 14 g, h.
*Eohollina depressa* (Kay). Copeland, 1965, p. 9, Pl. VIII, figs. 14 - 16, 21 - 23.

*Types*. Hypotypes from Esbataottine Formation, localities A-115, A-140; Day Point and Crown Point formations, Valcour Island.

*Remarks*. This species is widespread in North America. Kay (1940) originally described it from the Ion and Guttenberg members of the Decorah Formation in northwestern Iowa, Minnesota and western Wisconsin. Harris (1957) reported it as an index fossil of the Bromide Formation and a subspecies *Eohollina depressa papillata* from the Tulip Creek Formation of Oklahoma. Kraft (1962) recorded it from the upper part of the Lincolnshire Formation and lower part of the Edinburg Formation near Strasburg, Virginia. Copeland (1965) figured specimens from the Bucke Formation, Lake Timiskaming, Ontario.

Little similarity exists between *Eohollina* and *Bromidella*, although species of these genera have been widely compared. Type specimens of *Bromidella reticulata* Harris, 1931 (herein Pl. 2, figs. 20, 21) and *Bromidella spiveyi* Harris, 1957 (herein Pl. 2, figs. 22, 23) from the Tulip Creek and McLish formations of Oklahoma are shown for comparison.

Family Eurychilinidae Ulrich and Bassler, 1923

Genus *Eurychilina* Ulrich, 1889

Type species. *Eurychilina reticulata* Ulrich, 1889

*Eurychilina sunbloodensis* Copeland, 1974

Plate 4, figures 13 - 19

*Eurychilina sunbloodensis* Copeland, 1974, p. 16, Pl. I, figs. 1 - 11, Text-fig. 6, no. 4; 1978b, Pl. I, fig. 10.

*Remarks*. The dolonate portion of the heteromorphic frill appears to vary in width (Pl. 4, figs. 13 - 16). This may be due to difference in instar stage, that is, the broader dolon may occur in the ultimate moult and the narrower dolon in the penultimate moult. However, there appears to be no appreciable variation in measurements between the two extremes and no differentiation appears on scatter diagrams.

A row of short marginal denticles parallels the contact margin of both dimorphs. This was not previously reported for this species.

*Types.* Hypotypes, GSC 49794 - 49800.

*Occurrences.* Esbataottine Formation, localities A-110 to A-140, A-190, A-220, P-1485.

### Genus *Eurybolbina* n. gen.

Type species. *Eurybolbina krafti* n. sp.

Included species. *Ctenobolbina bispinata* Harris, 1957

*Ctenobolbina punctata* Ulrich, 1891

*'Ctenobolbina' mackenziensis* Copeland, 1978a

*Ctenobolbina clintonensis* Swain, 1962

*Eurychilina bulbinoda* Swain, 1962 (non Kraft, 1962)

*Diagnosis.* Uni- to bisulcate; S1 if present, short, indistinct; S2 long, most prominent near midvalve as curved elongate furrow with anterior edge bounded by low L2 node. Velar structure complete, restricted posteriorly, with or without posteroventral velar spine; dimorphic, tecnomorphs with narrow velar flange, heteromorphs with incurved frill sometimes forming anteroventral sausage-shaped chamber. Surface reticulate or minutely papillose.

*Discussion.* Species contained in this genus have previously been assigned to *Ctenobolbina*. *Eurybolbina* differs from *Ctenobolbina* in being unisulcate, with only a short S2, or bisulcate, with the addition of an indistinct S1, in lacking an alate process on the ventral part of the domicilium and in having a ventrally restricted velum. *Ctenobolbina* has an indistinct S1, a long S2, a more or less well defined S3, it may or may not have an alate domicilial process and it has an unrestricted velum. In some respects *Eurybolbina* may resemble *Eurychilina* but species of the latter genus bear a short S2 with a distinct ventral pit posterior of a nodelike L2 and the velum is not restricted posteriorly. Other species poorly understood at present and assigned to *Ctenobolbina* probably should be included in *Eurybolbina*.

*Age.* Middle Ordovician to Middle Silurian.

### *Eurybolbina krafti* n. sp.

Plate 2, figures 11 - 17; Plate 9, figure 16

?*Ctenobolbina bispinata* Harris, 1957, p. 214 (part).

*Ctenobolbina obliqua* Ulrich. Kraft, in Moore, 1961, p. Q135, Fig. 67 nos. 1a - f; Kraft, 1962, p. 46, Pl. 11, figs. 7 - 13, Figs. 10j, k.
New genus 1 n. sp. 2 Ludvigsen, 1979, p. 8.
New genus 1 (part). Hayes, 1980, p. 1386.

*Description.* Valve preplete; hingeline straight, four-fifths greatest length. Cardinal angles abrupt, obtuse, anterior greater than posterior. Anterior margin broadly curved, confluent with venter; posterior margin more narrowly rounded.

Bisulcate, S1 shallow, joined to prominent S2 dorsal of lowly rounded L2. S2 deep, inverted comma - shaped, situated near midvalve, with shallow sulcal depression extending from beneath L2 nearly to the velar fill. L3 broad. Domicilium surface covered with polygonal reticulae.

Velar frill prominent, some specimens with projecting cardinal angles, broadest anteriorly and anteroventrally, narrowing posteriorly and in anterocardinal region. All but posterior margin of valve obscured by velum in lateral view. Velum of tecnomorphic valve narrower than that of heteromorphic valve, planar or slightly flaring laterally. Velum of heteromorphic valve broad, concave proximally, with denticulate outer margin. Subvelar field deeply channeled to denticulate marginal ridge.

Measurements of holotype USNM 245132: length 1.50 mm, height 0.90 mm.

Number of specimens studied: more than 35.

*Types.* Holotype, USNM 245132; paratypes, USNM 245130, 245131, 245133, GSC 49417 - 49419, USNM 306762.

*Occurrences.* Lincolnshire and Edinburg formations, Strasburg, Virginia; Esbataottine Formation, localities A-110, A-115, P- 1520; ? Bromide Formation of Oklahoma, Valcour Formation, New York.

*Remarks.* This species has been well described by Kraft (1962, p. 46), who pointed out that the Lincolnshire-Edinburg specimens lack the small posteroventral tubercle that is present on *Ctenobolbina obliqua* Ulrich from the Prosser Formation at Kenyon, Minnesota. Schmidt (1941, p. 36) placed *C. obliqua* in the genus *Ctenentoma*, based on the presence of this tubercle.

### *Eurybolbina bispinata* (Harris), 1957

Plate 2, figures 1 - 10

*Ctenobolbina bispinata* Harris, 1957, p. 214 (part), Pl. 9, figs. 1a - c.
New genus 1 n. sp. 1. Ludvigsen, 1979, p. 8.
New genus 1 (part). Hayes, 1980, figure 5.

*Description.* Valve preplete; hinge line straight, four-fifths greatest length. Cardinal angles abrupt, obtuse, anterior greater than posterior. Anterior margin broadly curved to gently rounded venter. Posterior margin more narrowly rounded.

Bisulcate, S1 shallow, nearly indistinguishable, anterior of lowly rounded, circular L2. S2 deep, near midvalve, inverted comma - shaped. L3 broad, joined to L1 ventrally of S2. Domicilium surface finely reticulate.

Velar frill prominent, with antero- and posterodorsal cardinal projections, broadest anteriorly and anteroventrally, produced into prominent, posteriorly directed, posteroventral spine and narrowing considerably across the posterior part of the valve to join posterodorsal projection. All but the posterior margin of the valve obscured by velum in lateral view. Velum of tecnomorphic valve narrower than that of heteromorphic specimens, planar or slightly flaring laterally. Velum of heteromorphic specimens broad, concave ventrally. Subvelar field channeled to denticulate marginal ridge.

Measurements of hypotype GSC 49411: length 1.20 mm, height 0.75 mm

Number of specimens studied: more than 40.

*Types.* Hypotypes, GSC 49408 - 49416.

*Occurrences.* Esbataottine Formation, localities A-115, A-125, A-140, A-190, A-220, P-1485, P-1595; Bromide Formation, Oklahoma.

*Remarks.* The velar structure of this species is very distinctive in that it forms a posteroventral spine in both dimorphs. Harris' statement that the "carina of male valves extends from the angle to angle and possesses no post-ventral spine, or but rudiment thereof" is incorrect. He figured only a tecnomorphic carapace (herein Pl. 2, fig. 10), which he apparently considered as heteromorphic. The so-called 'male valves' to which he referred but did not figure should probably be considered as "*Eurybolbina*" *krafti* n. sp.

### *Eurybolbina bulbinoda* (Swain)

Plate 7, figures 3, 4, 6 - 8

*Eurychilina bulbinoda* Swain, 1962, p. 726, Pl. 109, fig. 4a, b.
non *Eurychilina bulbinoda* Kraft, 1962, p. 38, Pl. 10, fig. 4-8; Fig. 13 h, i.

*Description.* Valve preplete, hinge line straight, almost equal to valve length. Cardinal angles abrupt, slightly obtuse, posterior angle developed into prominent acroidal spine.

Bisulcate, S1 shallow, short; S2 deeper, also short and curved posteriorly of bulblike near-dorsal L2. L3 broad, joined to L1 beneath S2. Domicilium surface granular.

Velar frill prominent, extending from anterior cardinal angle to posteroventral corner as flangelike frill and continuing to posterior cardinal angle as threadlike ridge, broadest anteroventrally. Some variation in width of anteroventral part of frill. Dimorphism not noted.

Measurements of hypotype USNM 306701: length 0.8 mm, height 0.5 mm

Number of specimens studied: more than 25.

*Types.* Hypotypes, USNM 306701, 306702, 306704 - 306706.

*Occurrences.* Day Point Formation, localities PB5, 15 and 79 (Shaw) and Crown Point Formation, 14 to 15 m above its base (Swain), southern end of Valcour Island, New York.

*Remarks.* This species differs from *E. krafti* n. sp. in being granular rather than reticulate and in having L2 in a dorsal marginal position rather than situated much lower on the lateral surface of the valve.

## Family Piretellidae Öpik, 1937

## Genus *Piretia* Jaanusson, 1957

Type species. *Piretia geniculata* Jaanusson, 1957

Jaanusson (1957, p. 282) erected this genus to include unisulcate piretellids with little domiciliar ornamentation, long and deep S2 and a strongly convex, anteroventral heteromorphic dolon. Figures shown by Jaanusson (ibid., p. 283) indicate that the sulcus does not reach the velar structure. However, illustrations by Schallreuter (1973, Pl. 18) show the sulcus extending considerably ventral of the preadductorial node, possibly to the dorsal margin of the velar dolon. The velar dolon of species of *Piretia* is more completely set off from the domicilium than that of *Uhakiella*, but is not radially striate like that of *Piretella*.

### *Piretia mackenziensis* n. sp.

Plate 1, figures 20 - 26

*Description.* Amplete to preplete; hinge line long, equal to greatest length of valve. Cardinal angles abrupt, nearly 90 degrees; posterior margin more broadly curved than anterior margin. Unisulcate, S2 inverted comma - shaped, deep, curving posteriorly of low, round preadductorial node and extending in sigmoidal curve as shallow furrow to velar structure.

Strongly dimorphic; heteromorphic valves with broad, incurved dolon well set off from domicilium along ventral and anteroventral margin; numerous strong, velar spines along anterior margin, 8 or 9 spines crossing length of dolon and 4 or 5 stronger spines posterior of dolon to posterior cardinal angle. Tecnomorph with complete row of velar spines increasing in size toward posterior margin. Free margin of heteromorphic valves incomplete beneath dolon, extending very short distance into dolonal cavity and dying out abruptly.

Surface of domicilium and dolon finely granular.

Measurements of holotype GSC 49400: length 1.00 mm, height 0.60 mm.

Number of specimens studied: more than 30.

*Types.* Holotype, GSC 49400; paratypes, GSC 49394 - 49399.

*Occurrences.* Esbataottine Formation, locality A-115, District of Mackenzie.

*Remarks.* The spinose nature of the velar structure of *P. mackenziensis* appears more similar to that of *P. erinacea* Schallreuter, 1964 and *P. ruchholzi* Schallreuter, 1965, than to the figures shown by Jaanusson (1957). Just as with the present material, those figured by Schallreuter are silicified whereas the material shown by Jaanusson is calcareous. This difference in preservation presents several difficulties at the specific and generic levels. Comparison with the species described by Schallreuter, however, shows that *P. mackenziensis* has much more strongly developed velar spines, the dolon is more smoothly rounded with the margin of the valve, and the domicilium surface is not finely spinose.

A distinctive feature of *P. mackenziensis* is the disappearance of the free margin of heteromorphic valves beneath the dolon. This appears to be consistent for all heteromorphic specimens on which this area of the valve is visible. Few piretellids exhibiting this feature have been described. Schallreuter (1969, Pl. 3, fig. 3) showed a similar feature on a specimen of *Uhakiella jaanussoni skageni* Schallreuter. Whether this may be an incipient beyrichiid characteristic is unknown.

### *Piretia shawi* n. sp.

Plate 6, figures 11 - 19

*Description.* Amplete to preplete, hinge line long, equal to greatest length of valve. Cardinal angles abrupt, nearly 90 degrees, with prominent acroidal spines. Posterior margin more broadly curved than anterior margin on adult specimens, both margins about equally curved on immature specimens. Unisulcate to weakly bisulcate, S1 very shallow, S2 inverted comma - shaped, deep, curving posteriorly of low, round preadductorial node and extending in sigmoidal curve as shallow furrow nearly to velar structure.

Strongly dimorphic, heteromorphic valves with broad, incurved dolon well set off from domicilium along ventral and anteroventral margin. Strong tubulous velar frill along free margins; tubules may be coalesced, individual or united distally at velar margin by frill rim. Velum crosses heteromorphic dolon as row of strong individual spines. Subvelar field with low median ridge on which a row of long, discrete spines may be developed.

Surface of valve finely granular.

Measurements of holotype USNM 306692: length 1.40 mm (without acroidal spines), height 0.7 mm.

Number of specimens studied: more than 25.

*Types.* Holotype, USNM 306692; paratypes, USNM 306687 - 306691, 306693 - 306695.

*Occurrences.* Day Point Formation, localities PB5 and 15, Crown Point Formation, localities PB79, 81, 175; southern end of Valcour Island, New York.

*Remarks.* The nature of the velar frill and subvelar field differentiates this species from other species of *Piretia*. Probably the tubules of the velum were coalesced by a thin velar surface that extended between the tubules from the velar ridge to the thickened velar rim. The silicification of this surface is not complete in any specimens examined but its presence is suggested in Plate 6, figures 14, 18 and 19. As shown by Schallreuter (1973, Pl. 17, fig. 5), the subvelar field of *P. erinacea* Schallreuter, 1964 bears a row of near-marginal denticles. These are low tubercles, however, rather than the delicate, long spines that are present rarely on some specimens of *P. shawi* (i.e., Pl. 6, fig. 17).

### Genus *Dicranella* Ulrich, 1894

Type species. *Dicranella bicornis* Ulrich, 1894

### *Dicranella macrocarinata* Harris, 1931

Plate 5, figures 17 - 19

*Dicranella macrocarinata* Harris, 1931, p. 92, Pl. 14, figs. 3a, b;Harris, 1957, p. 230, Pl. 7, figs. 7a, b, 8a, b.

*Remarks.* The present specimens appear to agree more closely with *D. macrocarinata* than with *D. bicornis* Ulrich, previously reported by Copeland (1974, p. 19, Pl. VIII, figs. 11 - 13; 1978b, p. 106, 107) from the Whittaker Formation of Whittaker Anticline, District of Mackenzie. The valves of *D. macrocarinata* are more elongate and the prominent pre- and postadductorial lobes are directed posterodorsally rather than dorsally as on *D. bicornis*.

The heteromorphic velar dolon of this species is broad and incurved along the anterior and ventral margins of the valve, terminating abruptly anterior of the posteroventral part of the valve. The dolon and flaring tecnomorphic frill are set off from the domicilium by a shallow groove or furrow. The velar structure may be continued along the posterior margin of the valve by a row of gently rounded tubercles that are almost obscured by the coarse silicification of the valve surface.

Measurements: heteromorphic specimen 1.8 mm long, 1.0 mm high (without dorsal spines); tecnomorphic specimen 1.6 mm long, 0.8 mm high (without spines).

Number of specimens studied: 9.

*Occurrences.* Tulip Creek Formation, zone 36, Oklahoma; Esbataottine Formation, locality A-385, District of Mackenzie.

### *Dicranella fimbriata* n. sp.

Plate 6, figures 1, 2; Plate 9, figures 18, 19

*Description.* Valves preplete, hinge straight, nearly equal to length of valve, cardinal angles obtuse. Unisulcate, S2 deep, narrow, in dorsal half of valve; L1 and L2 highly elevated above lateral surface of valve, produced dorsally into strong, rounded nodes projecting above dorsal margin, L2 the larger. Velar structure in tecnomorphs a near-marginal bend produced anteroventrally into narrow flange; in heteromorphs anteroventral flange is much wider, giving anterior of valve a square or angular outline. Subvelar field with complete row of spines directed anteriorly along anterior margin, longer and curved posteroventrally along anteroventral margin and decreasing in size posteriorly.

Surface finely granular, granules on velum aligned in rows parallel with velar edge.

Measurements of holotype USNM 306765: length 1.0 mm, height 0.75 mm.

Number of specimens studied: more than 15.

*Types.* Holotype, USNM 306765; paratypes, USNM 306677, 306678, 306764.

*Occurrences.* Day Point Formation, Valcour Island, New York, locality PB5, 19 m below the top of the formation (USNM 306677, 306678) and Crown Point Formation, Valcour Island, New York, locality PB79, 3.3 m above the base of the formation (USNM 306764, 306765).

*Remarks.* Another Middle Ordovician species, *Dicranella spinosa* Ulrich, 1894, bears short posteroventral denticles in a subvelar position but these denticles do not continue beneath the anteroventral velar flange. In addition, *D. spinosa* has a much broader S2, and L1 is a low node not extending above the dorsal margin.

## Family *Tvaerenellidae* Jaanusson, 1957

### Genus *Nahanniopsis* n. gen.

Type species. *Nahanniopsis schallreuteri* n. sp.

*Diagnosis.* Trilobate, bisulcate, sulci long, narrow, indistinct on lateral surface. All lobes spinose, with long, distinct, clavate processes each distally coronate with numerous papillae. Near-marginal row of processes (histial?) surmounts continuous ridge (velar?) or bend and delimits near-marginal (subvelar?) field with denticulate margin. Dimorphism unknown.

*Remarks.* This genus most closely resembles *Quadritia* Schallreuter (1966, p. 204; also see 1976, p. 178) and very superficially *Kiesowia* Ulrich and Bassler (1908). *Quadritia* species bear 4 clavate and distally denticulate or spinose nodes on the ventral half of the valve, and *Q. krausei* Schallreuter (1976) also has 3 spinose dorsal nodes and a preadductorial lobe. The type and only known species of *Nahanniopsis* bears up to 21 clavate processes of which 11 (12?) are situated along the ventral surface, 3 are dorsal and 6 (7?) are lateral.

The pronounced nodes of *Q. quadrispina* (Krause) as illustrated by Schallreuter (1976, Pl. 3, figs. 1 - 3) are clavate and bear small distal denticles. Those of *Q. krausei* Schallreuter (1976, Pl. 3, figs. 4 - 6) are each terminally produced into a spine with prominent spinules along its length. The marginal spines of *Q. krausei* and *Q. quadrispina* are more prominent than those of *N. schallreuteri*, but the smaller marginal denticles of the right valve of *N. schallreuteri* appear to form a single row exterior of the valve closure, whereas those of the left valve form two rows, one exterior of and the other interior of the valve closure. Possibly the interior row of denticles served as a 'stop ridge' against which the free margin of the right valve abutted when closed.

Any similarity with species of *Kiesowia* is based on the nodose ornamentation of the valve surface common to both genera. That of *Kiesowia* consists of numerous nodes scattered on the valve surface, sometimes relatively smooth but usually papillose or pustulose, never extended as elongate processes such as those of *Quadritia* or *Nahanniopsis*.

### *Nahanniopsis schallreuteri* n. sp.

Plate 5, figures 4 - 16; Figures 16, 17

New genus 2 n. sp. 1. Ludvigsen, 1979, p. 9.
New genus 2. Hayes, 1980, Fig. 5.

*Description.* Valves amplete to slightly postplete. Hinge long, approximately four-fifths valve length. Free margin evenly rounded, cardinal angles obtuse, equal.

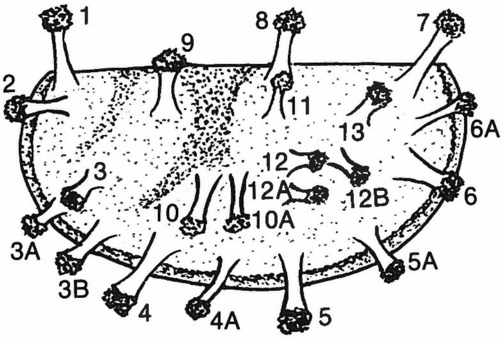


***Figure 16.*** ***Nahanniopsis schallreuteri*** *n. sp. Generalized left valve showing the relative positions of 21 clavate processes.*

| VALVE | LENGTH (mm) (without processes) | HEIGHT (mm) | CLAVATE PROCESS VARIATION Not present 13 | Present 3A | 3B | 4A | 5A | 6A | 10A | 12A | 12B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L | 1.10 | 0.65 | ● | | | | | | | | |
| R | 1.20 | 0.70 | | ● | ● | ● | ● | | | | |
| L | 1.25 | 0.68 | | | | | ● | | | | |
| R | 1.27 | 0.68 | | | | | | | | ● | |
| L | 1.30 | 0.70 | | | | | ● | ● | | ● | |
| L | 1.30 | 0.70 | | ● | | | | | | ● | |
| R | 1.30 | 0.70 | ● | | | | ● | | | | |
| L | 1.30 | 0.70 | ● | | | | | | | | |
| R | 1.32 | 0.80 | | | | | | | | ● | ● |
| R | 1.35 | 0.80 | ● | | | | | | | ● | |
| R | 1.42 | 0.80 | ● | | | ● | ● | | | | |
| L | 1.45 | 0.80 | | | | | ● | | ● | | |

GSC

***Figure 17.*** *Specimen size and variation in occurrence of clavate processes of twelve valves of* ***Nahanniopsis schallreuteri*** *n. sp.*

Bisulcate, S1 a low furrow anterior of preadductorial node. S2 slightly deeper than S1, inclined anteroventrally, not reaching valve margin.

Lobes with up to 21 papillose, clavate processes (Fig. 16) of which 12 are consistent (1 - 12), one (13) occurs on three-quarters of the specimens and 8 (A and B series) occur randomly on half or less of the specimens (Fig. 17). L1 restricted to anterodorsal corner of valve, bears 2 processes, 1 (anterior acroidal) and 2 (subacroidal); L2 a low ridge bearing up to 4 processes, 9 (preadductorial), in dorsal position and 3, 3A and 3B (anterior uncular) ventrally near anteroventral margin; L3, the postadductorial lobe, somewhat more inflated than anterior lobes and bearing up to seventeen processes (4, 4A, anterior calcarine; 5, 5A, posterior calcarine; 6, 6A, posterior uncular; 7, posterior acroidal; 8, lobular; 10, 10A, subadductorial; 11, 12, 12A, 12B, 13, domicilial). Four processes of postadductorial lobe are anterior (4) or ventral (10, 10A, 4A) of adductorial sulcus; remaining processes confined to posterior half of valve.

Up to twelve processes (1 - 7 inclusive; Pl. 5, fig. 9) form near-marginal series that may be considered 'histial'. On most specimens this series surmounts a continuous ridge or bend that may be considered 'velar' and delimits a 'subvelar' field extending to denticulate, complete, marginal structure. Marginal structure of right valve consists of single row of denticles exterior of valve closure; that of left valve consists of two rows of denticles, one on either side of valve closure; interior row possibly constitutes a 'stop ridge' against which right valve abuts on closure.

Hingement consists of groove with terminal pits in right valve to accommodate dorsal edge and cardinal corners of left valve.

Number of specimens studied: 26.

*Types.* Holotype, GSC 49808; paratypes, GSC 49801 - 49807, 49809 - 49812, 49856, 49857.

*Occurrence.* Esbataottine Formation, locality P-1595, District of Mackenzie.

*Remarks.* The number, shape, ornamentation and distribution of valve processes distinguish this species. The bisulcate nature of *N. schallreuteri* is well demonstrated by the valve interior. Also evident from interior views (Pl. 5, fig. 6, 10) is the thickness of the shell of this species, indicated by the silicified outer and inner surfaces of the valve and the absence of the intervening (dissolved?) calcareous layer. The outer layer displays pores that extend the length of the surface processes. The inner layer bears a shallow depression in the position of each surface process, in the centre of which there may be a circular boss or plug. It cannot be determined if there is a connection at the base of each process between the outer and inner shell layers. This would be probable if the processes had sensory rather than protective adaptation.

### Family Quadrijugatoridae Kesling and Hussey, 1953

### Genus *Tetradellina* Harris, 1957

Type species. *Tetradellina henningsmoeni* Harris, 1957

This genus was originally placed in the Tetradellidae by Harris (1957) based on the presence of four vertical ridges, and distinguished from *Tetradella* by the lack of a velar ridge or flange. Kesling (in Moore, 1961, p. Q153) considered *Tetradellina* as a junior synonym of *Quadrilobella* Ivanova, 1955 and, possibly, of *Quadrijugator* Kesling and Hussey, 1953, both of which have some or all of the vertical lobes joined ventrally along a velar structure. *Tetradellina,* however, differs fundamentally from these genera because "the vertical ridges are not united basally" (Harris, 1957, p. 250). A revised diagnosis follows.

*Diagnosis.* Quadrilobate; L2 shorter than the other lobes, not extending to dorsum; all lobes extending to or beyond ventral margin. Ventral field at right angle to domicilium surface, extending from sharp bend beneath lobate ridges to poorly defined marginal structure. Dimorphism unknown.

*Generic characters.* L1 of constant width, curved parallel with anterior margin, extending above dorsum in position of an anterodorsal cardinal process. L2 short, straight, of constant width, extending about two-thirds to four-fifths of valve height. L3 longest lobe, straight, extending above dorsum, of variable width. L4 straight, extending to or above dorsum, short, about same length as L2, somewhat swollen ventrally.

Ventral parts of lobes extending to or below ventral field of valve. Ventral field limited distally by low (denticulate?) marginal ridge at valve closure, limited proximally by abrupt, 90-degree bend of valve beneath ventral parts of lobate areas. If line of bend is interpreted as velar structure, ventral parts of lobes extend across and with no perceptible variation at their juncture with it, only L1 and L4 conforming to marginal contour of valve. Domicilium surface granulose, deeply depressed between lobes, more so between L1 and L2.

*Discussion.* As stated by Jaanusson (1957, p. 338) the velar structure of some quadrijugatorids may be developed as a flange, ridge or sharp edge. This structure serves to connect, or nearly connect, the four lateral lobes of the domicilium ventrally. In *Tetradellina*, however, the sharp edge or bend (here termed velar) lies beneath the lobal structures, the pointed extremities of which extend in hollow, conelike fashion, to or beyond the ventral margin of the valves in lateral view. Internally, these lobes are unconnected and are appressed to but not integrated with the velar bend.

### *Tetradellina harrisi* n. sp.

Plate 2, figures 25 - 32

*Description.* Valves slightly preplete, subquadrate in lateral view. Hinge line long, straight; posterior cardinal angle 90 degrees, anterior cardinal angle 110 degrees. Anterior margin curved, posterior margin straight with abrupt angle to straight, anteriorly inclined venter.

Quadrilobate; L1 extending above hinge line, curved parallel with anterior margin of valve; L2 short, extending four-fifths of valve height and projecting beneath ventral margin of valve; L3 longest lobe, extending above and below valve margin; L4 short, straight, slightly swollen ventrally, extending along posterior margin of valve. Ventral parts of lobes appressed to but not otherwise connected with velar bend marking proximal edge of ventral field. Ventral field at right angle to domicilium surface. Indistinct denticulate(?) marginal ridge at valve closure.

Domicilium surface granulose, deeply sunken between lobes, more so between L1 and L2. Dimorphism unknown.

Measurements of holotype GSC 49429: length 0.60 mm, height 0.40 mm.

Number of specimens studied: more than 20.

*Types.* Holotype, GSC 49429; paratypes, GSC 49422 - 49428.

*Occurrence.* Esbataottine Formation, locality A-115, District of Mackenzie.

*Remarks.* Variation between the two known species of *Tetradellina* rests primarily in the orientation and length of their lobate areas. *T. henningsmoeni* Harris (herein Pl. 2, fig. 24) bears smooth lobes similar in position to *T. harrisi*, which do not extend beyond the ventral margin in lateral view. In addition, L1 and L4 are both curved parallel with the lateral margins of the valve and all four lobes tend to diminish in height ventrally. The velar bend of *T. henningsmoeni* appears to be less abrupt than that of *T. harrisi* but this and the relative smoothness of the lobes of *T. henningsmoeni* may be due to preservation. In contrast, the lobate areas of *T. harrisi* are granular, only L1 is curved parallel with the anterior margin and all four lobes extend beyond the ventral margin.

## Family Sigmoopsidae Henningsmoen, 1953

### Genus *Canadabolbina* n. gen.

Type species. *Canadabolbina multispinosa* n. sp.

*Diagnosis.* Unisulcate, S2 short, situated in dorsal half of valve. Ventral part of postadductorial area produced into elongate, posteriorly curved spine. Tecnomorphs without histial structure, with prominent, continuous velar structure of numerous spinose projections. Heteromorphs with broad, curved, flangelike histial dolon set off from domicilium by low undulation; prominent velar structure of numerous spinose projections confluent anteriorly and posteriorly with curved histial dolon and extending ventral of histial dolon as radially striate ridge. Both dimorphs with a marginal flange consisting of minute spinules.

*Generic characters.* This genus appears to be intermediate between ***Brevibolbina*** Sarv, 1959 and ***Lomatobolbina*** Jaanusson, 1957. The short S2 and broad, flangelike histial dolon is similar to that of some species of ***Brevibolbina*** but the broad, spinose velum is unknown for, species of ***Brevibolbina*** or ***Lomatobolbina***. Jaanusson (1957, p. 391, 397) commented on the external similarity of ***Lomatobolbina***, ***Sigmobolbina*** and ***Winchellatia***, but he pointed out that ***Sigmobolbina*** lacked a tecnomorphic histial structure but possessed a distinct velar structure, and that ***Winchellatia*** lacked a velar structure in both dimorphs. ***Lomatobolbina***, however, possesses a tecnomorphic histial structure with or without a velar structure and heteromorphic histium only. In contrast, ***Canadabolbina*** possesses heteromorphic histial and velar structures but only a tecnomorphic velar structure. Jaanusson was quite correct in rejecting the histial nature of the lateral spine on all of these genera. Interpretation of the ventral structures of ***Brevibolbina*** is more difficult but it would appear that (a) only the heteromorphic histial structure is present, and (b) the tecnomorphic structure may be interpreted as histial or velar.

### *Canadabolbina multispinosa* n. sp.

Plate 3, figures 4 - 15

New genus 3 n. sp. 1. Ludvigsen, 1979, p. 8.
New genus 3. Hayes, 1980, Fig. 5.

*Description.* Valve preplete; hinge line long, straight, cardinal angles obtuse. Essentially bilobate, S2 short, in dorsal half of valve posterior of small, circular L2, not extending to histium. Large, strong spine projecting laterally with posterior distal curvature situated ventral of S2 and slightly dorsal of undulation marking juncture of domicilium and histial dolon of heteromorphs and well above velar structure of tecnomorphs.

Dimorphic, tecnomorphs with spinose velar frill extending to cardinal angles, of nearly uniform breadth throughout but narrowing dorsally. Heteromorphs with inwardly concave flange- or winglike anteroventral histial dolon only weakly marked off from domicilium and curving toward free margin anteriorly and posteriorly. Heteromorphic velum consisting of broad spinose frill extending to cardinal angles, ventrally and anteroventrally in contact with histial dolon and extending beneath dolon as a radially striate ridge. Marginal structure of both dimorphs consisting of spiniferous flange.

Surface of domicilium, dolon and lateral spine smooth to finely granular.

Measurements of holotype GSC 49437: length 1.30 mm, height 0.7 mm.

Number of specimens studied: more than 30.

*Types.* Holotype, GSC 49437; paratypes, GSC 49433 - 49436, 49438 - 49444.

*Occurrences.* Esbataottine Formation, localities A-110, A-115, District of Mackenzie; New Market Limestone, Chambersburg Quadrangle, Pennsylvania (USGS 295i).

*Remarks.* Some of the velar spines tend to be fused for part or all of their lengths, others become joined distally. This may be the result of silicification.

### Genus *Oecematobolbina* Jaanusson, 1957

Type species. *Oecematobolbina nitens* Jaanusson, 1957

Distinctive histial ornamentation readily identifies species of this genus. In the original diagnosis of the genus, Jaanusson defined this histial ridge as being "two ridge-like thickenings and, in some species, two rows of oblong pits or depressions" on tecnomorphic specimens and a "broader, flange-like histial structure which is partitioned internally by radial septa into numerous wide, originally empty chambers" on heteromorphic specimens. Schallreuter (1964a) subdivided the genus into the subgenera *Oecematobolbina* and *Cetona*, the latter being defined as having two flanges with an intervening row of diamond-shaped spaces. Presumably, Schallreuter was referring to a heteromorphic specimen as he described the tecnomorphic specimen of *O. (Cetona) cetona* as having a shorter lower flange. Two major difficulties arise: Jaanusson's internal partitions of the heteromorphic histium cannot be found on silicified specimens for unknown reasons, and Schallreuter's subgeneric distinction appears untenable in the light of the present material from District of Mackenzie. Accordingly, the present discussion will concentrate on examination of the genus *Oecematobolbina* as it applies to North American species.

Previously, only one species and one subspecies of *Oecematobolbina* have been described from North America, in rocks of the Tulip Creek and Bromide formations of Oklahoma. These are *Ctenobolbina cancellata* Harris (herein Pl. 1, fig. 19) and *Ctenobolbina cancellata varicata* Harris (herein Pl. 1, fig. 18). As with many other specimens figured by Harris, both type specimens are slightly abraded, but in the light of the material being presently described, both are heteromorphic individuals, one bearing four(?) histial flanges and the other, three. The corresponding tecnomorphic individuals may comprise any of a number of species such as *Ctenobolbina projecta* Harris (herein Pl. 3, fig. 17), *Acanthobolbina loeblichi* Harris (herein Pl. 3, fig. 18), *Ctenobolbina inflata* Harris (herein Pl. 3, fig. 19) or others. It will probably not be possible to make this determination from the type specimens.

#### *Oecematobolbina varicata* (Harris)

Plate 1, figures 1 - 18

*Ctenobolbina cancellata varicata* Harris, 1957, p. 215, Pl. 9, figs. 3a, b.

*Description.* Valve preplete, hinge line long, cardinal angles obtuse. Bilobate, S2 broadest dorsally, deepest posterior of L2, curving to meet upper flange of heteromorphic histium not extending to tecnomorphic histium. L2 small, circular, lying on posterior side of L1. L3 broad, elevated in anteroventral part adjacent to S2, elevation a small, low ridge on heteromorphic valves, low, posteriorly directed alate projection on tecnomorphic valves and posteriorly directed spine on immature valves.

Histium consisting of three fluted flanges on heteromorphic valve, single smooth flange on tecnomorphic valve and somewhat discontinuous ridgelike bend on immature specimens. Histium extending from anterodorsal part of valve to near posteroventral corner, the three heteromorphic histial flanges joining anteriorly and posteriorly and extending short distance posterior from their juncture as single flange. Marginal flange present along valve contact, exposed in lateral view at anterodorsal corner and in posteroventral half of valve and consisting of low ridge on which is a row of fine denticules.

Surface of valves granulose.

Measurements of hypotype GSC 49378: length 0.90 mm, height 0.55 mm.

Number of specimens studied: more than 75.

*Types.* Holotype, MCZ 4609; hypotypes, GSC 49377 - 49493.

*Occurrences.* Esbataottine Formation, localities A-110, A-115, A-140, A-220, P-1595, District of Mackenzie; Bromide Formation, Oklahoma.

*Remarks.* There is no doubt that the heteromorphic and tecnomorphic specimens from the present collections comprise the dimorphs of the same species. They are of about equal number in each collection and no other species occur with which they could be mistaken. The European specimens described by Jaanusson and Schallreuter bear a double histial flange on tecnomorphic specimens whereas tecnomorphs of the present species bear a single, unfluted flange. The pronounced lateral spine of immature specimens and less pronounced alate projection of tecnomorphic specimens of *O. varicata* are not known from the European species. The exact relationship of *O. varicata* (Harris) and *O. cancellata* (Harris) is unknown as the type specimen of *O. cancellata* (herein Pl. 1, fig. 19) is abraded and coated with matrix, making its exact determination unlikely at this time.

### Genus *Winchellatia* Kay, 1940

Type species. *Winchellatia longispina* Kay, 1940

#### *Winchellatia nahanniensis* n. sp.

Plate 3, figures 16, 25 - 30

*Description.* Preplete, hinge line long, straight, cardinal angles with small protuberance, anterior cardinal angle about 100 degrees, posterior cardinal angle nearly 90 degrees. Anterior margin broadly rounded to meet sloping ventral and posterior curvature.

Bilobate, S2 broad, deep, extending to midvalve, posterior of low, rounded L2. L1 separated from L2 by shallow undulation in anterodorsal part of valve. L1 and broad L3 projecting slightly above hinge line. Long, posterolaterally directed spine on L3 posteroventral of S2. Histial ridge low, extending from anteroventral corner to slightly posterior of ventral spine. Anterior and posterior margins curving to point of closure. Dimorphism unknown.

Surface finely papillose. No marginal flange.

Measurements of holotype GSC 49451: length 1.25 mm, height 0.80 mm.

Number of specimens studied: more than 25.

*Types.* Holotype, GSC 49451; paratypes, GSC 49445, 49450, 49452 - 49455.

*Occurrence.* Esbataottine Formation, localities A-110, A-115, A-125, P-1485, P-1497, District of Mackenzie.

*Remarks.* Jaanusson (1957, p. 218) pointed out that histial structures of species of *Acronotella* may possibly be similar to those of *Lomatobolbina*. The same may be said for *Acronotella* and *Winchellatia*. *A. shideleri* Ulrich and Bassler, 1923 has a near-marginal (histial or velar) structure (herein Pl. 5, figs. 1-3), and thus possible similarity with *Kraftella* Pribyl, 1968 and *Monoceratella* Teichert, 1937 is invalidated. These two genera have little similarity to the Tricorninidae as proposed by Pribyl (1968).

*Winchellatia nahanniensis* may be distinguished from other species of the genus by the inconspicuous width and short lengths of its histium and its large size. If the present discussion deals only with tecnomorphic specimens the stated histial size and length may not prove to be valid as a specific criterion, but tecnomorphs of no other winchellatiid species appear to have histial structures similar to that of *W. nahanniensis*.

### Family uncertain

### Genus *Echinoprimitia* Harris, 1957

Type species. *Echinoprimitia imputata* Harris, 1957

*Remarks.* Scott (in Moore, 1961, p. Q163) redefined the genus as follows: "Small, subrectangular, straight-backed; valves subequal, S2 present; marginal spines present along anterior and part of ventral margins; spine anterodorsal to S2." The type specimen of *Echinoprimitia imputata* (Pl. 4, fig. 12) is extremely small (0.47 mm) and may be immature. This, coupled with the generally abraded condition of the Bromide specimens makes even a generic designation questionable. It is possible that *E. imputata* may represent an aberrant leperditellid, the sulcus (S2) becoming evident if spines are removed from the anterodorsal region of the valve.

### *Echinoprimitia*? *spinosa* n. sp.

Plate 1, figures 30 - 33

*Description.* Valve twice as long as high, subquadrate, with long, straight hinge line and nearly evenly rounded extremities. Surface marked with numerous spines, 6 of which are most prominent and aligned along dorsal margin. Rest of valve irregularly spinose, 2 irregular rows of intermediate-size spines longitudinally across midvalve and scattered, small spines in anterior half of valve. Marginal closure granular but apparently not with recognizable marginal flange or defined row of tubercles.

Measurements of holotype GSC 49406: length 0.70 mm, height (including dorsal spines) 0.40 mm.

Number of specimens studied: 6.

*Types.* Holotype, GSC 49406; paratypes, GSC 49404, 49405, 49407.

*Occurrence.* Esbataottine Formation, locality A-115, District of Mackenzie.

*Remarks.* Whether *E.*? *spinosa* is congeneric with *E. imputata* is uncertain. Both are spinose palaeocopid ostracodes of subquadrate lateral outline that may, at present, be placed nowhere else. *E*? *spinosa* n. sp. is much more spinose than *E. imputata* Harris and bears a dorsal row of three to six major spines extending above the dorsal margin whereas *E. imputata* is relatively nonspinose at or above midheight and has only one major anterodorsal spine. The ventral row of spinules present on *E. imputata* is not observable on E.? spinosa but may be hidden by the generally spinose nature of the valves of *E.*? *spinosa.* The approximate similarity in age of both species suggests that a taxonomic relationship may exist but this assumption should not be considered without serious reservation.

### Genus *Ectoprimitia* Bouček, 1936

Type species. *Primitia corrugata* Krause, 1892

### *Ectoprimitia*? *pustulosa* Swain, 1957

Plate 4, figures 1 - 5

*Ectoprimitia pustulosa* Swain, 1957, p. 568, Pl. 62, figs. 18a, b.
*Ectoprimitia diminucarina* Kraft. Swain, 1957, p. 568.
*Ectoprimitia*? *diminucarina* Kraft, 1962, p. 72, Pl. 5, figs. 15a-c, Pl. 6, figs. 1 - 5, Fig. 12n.

*Remarks.* This species has been adequately described by Swain (1957) and Kraft (1962). The present specimens seem to be more granulose than those described by Kraft and appear more similar to the ones reported by Swain. This may be due to the relative degree of silicification. Variation of the near-marginal ridge ("submarginal thin frill or velum" of Swain, "velate frill" of Kraft) may indicate a dimorphic characteristic as some specimens bear an uninterrupted ridge (Pl. 4, figs. 1, 4, 5) and others have the ridge much diminished in width or apparently lacking on the posterior part of the valve (Pl. 4, figs. 2, 3). This might indicate a sigmoopsid characteristic and thus the inclusion of this species within *Ectoprimitia* is questionable.

Measurements of several specimens: length 0.70 - 0.80 mm, height 0.45 - 0. 50 mm.

Number of specimens studied: more than 40.

*Types.* Hypotypes, GSC 49789 - 49793.

*Occurrences.* Crown Point Formation, Valcour Island, New York, above base (Swain, 1957); Lincolnshire Formation (upper part) and Edinburg Formation (lower part), near Strasburg, Virginia; Esbataottine Formation, localities A-110 to A-125, District of Mackenzie.

### Genus *Valcouropsis* n. gen.

*Type species. Valcouropsis shawi* n. sp.

*Diagnosis.* Exteriorly nonsulcate, with dorsal umbo or elongate rounded elevation extending above the hinge line; a similar ventral bend or elevation that may overhang the ventral margin in lateral view and planar or concave lateral valve surface, especially posteriorly. Shell wall in two widely separated layers, inner layer with faint indication of a dorsomedian sulcus.

*Remarks.* The taxonomic position of this genus within the Palaeocopida is unkown. Based on the umbonal type of dorsal elevation, it may loosely be compared with *Schmidtella.* Species of *Schmidtella*, however, tend to be less elongate and have umbones more smoothly continuous with the lateral surface than those of *Valcouropsis.* Some similarity exists with *Pachydomelloides* Swain, 1962 especially as regards the thick structure of the shell walls, but that genus, as presently known, lacks dorsal and ventral elevations and is considered by Swain to belong to the Podocopida.

### *Valcouropsis shawi* n. sp.

Plate 8, figures 11 - 18

*Description.* Valves ovate to semiquadrate in lateral view, ends broadly rounded. Hinge about three-fourths greatest length, with pronounced umbonate and rounded dorsal elevation extending entire length of hinge. Rounded ventral elevation (bend?) of same length extends along much of ventral edge of valve, obscuring ventral closure of valves in lateral view. Ventral margin of right valve with pronounced median flap. Lateral surface of valve planar, moderately or pronouncedly concave, giving valve modified fish tail outline in end view. Valve surface more deeply concave posteriorly giving dorsal and ventral elevations more ridgelike appearance posteriorly. Valve surface smooth or finely granular, the granules aligned to form faint striae.

Shell thick (dissolved in present specimens) represented only by silicified inner and outer surfaces; inner wall surface with faint vertical elevation in position of median sulcus, not present on outer wall surface.

Measurements of holotype USNM 306737: length 1.9 mm, height 1.05 mm.

Number of specimens studied: 9.

*Types.* Holotype, USNM 306737; paratypes, USNM 306732 - 306736, 306738, 306739.

*Occurrence.* Day Point Formation, Valcour Island, New York, 16 m below top of formation.

### Order Podocopida Müller, 1894

### Suborder Podocopina Sars, 1866

### Superfamily Bairdiacea Sars, 1888

### Family ?Beecherellidae Ulrich, 1894

### Genus *Platyrhomboides* Harris, 1957

Type species. *Platyrhomboides quadratus* Harris, 1957

### *Platyrhomboides quadratus* Harris, 1957

Plate 3, figures 20 - 24

*Platyrhomboides quadratus* Harris, 1957, p. 256, Pl. 10, figs. 4a - c.
*Platyrhomboides virginiensis* Swain, 1962, p. 740, Pl. 110, figs. 8a - e, Pl. 111, figs. la - d; Kraft, 1962 p. 61, Pl. 16, figs. 3 - 5, Fig. 14L.
*Velapezoides virginiensis* (Swain, non Kraft). McGill, 1966, p. 123.
*Platyrhomboides quadratus* Harris. Schallreuter, 1968, p. 86, 88.
*Platyrhomboides virginiensis* (Swain, non Kraft). Schallreuter, 1968, p. 86, 88.

*Types.* Hypotypes, GSC 49446 - 49449, USNM 245134.

*Occurrences.* Esbataottine Formation, localities A-110 to A-140, P-1485; Edinburg Formation, basal 6.1 m, south side of road 0.32 km East of Strasburg, Virginia.

*Remarks.* The trapezoidal outline of specimens of this species varies considerably and may lead to uncertainty as to their orientation. In general, the greater height is considered posterior, as defined by Harris (1957, p. 256). As with most specimens from the Bromide Formation, the type of *P. quadratus* appears to be abraded. This has rendered the ventrolateral and dorsal ridges less prominent than those displayed by silicified specimens from Virginia and the Northwest Territories. Harris figured the type specimen of *P. quadratus* in anterior view (1957, Pl. 10, fig. 4c) and indicated only a dorsal overreach of the valves in the region of the hinge line similar in position to that of the dorsal ridge of *P. virginiensis* Swain. This apparent lack of a dorsal ridge on each side and parallel with the hinge line of *P. quadratus* was cited by Kraft in support of the erection of *P. virginiensis.* Examination of the type specimen from Oklahoma shows that the dorsal and ventrolateral ridges are abraded and probably should be as pronounced as that of *P. virginiensis.* The specimens from Northwest Territories agree in all particulars with the type specimen and specimens from Virginia that possess well marked ventrolateral and dorsal ridges on both valves. A dorsal ridge (or crista) on the type species of *Platyrhomboides* is here cited as a valid criterion on which to base distinction between species of *Platyrhomboides* and the posteriorly spinose *Beecherella.* Such a dorsal ridge is not present on Ordovician species described by Schallreuter (1968, p. 85, 87) as *Platyrhomboides* or the Silurian species *"Beecherella" berdanae* Copeland, 1964 referred by Schallreuter to *Platyrhomboides.*

Specimens figured here from the Northwest Territories and Virginia exhibit well developed internal vestibules interior of the inner marginal flange at the antero- and posteroventral angulations. This is not visible from the type carapace figured by Harris or the specimens figured by Swain (1962, Pl. 110, fig. 8e, Pl. 111, figs. lb, d) from 13.7 to 15.2 m above the base of the Crown Point Formation, Valcour Island, New York. It is difficult to discern the presence of a duplicature along the inner edge of the ventral marginal flange but an angulation that may approach a ridge occurs along this line. Possibly, silicification was sufficiently imperfect that the inner lamella was not preserved.

### Superfamily indet.

### Family Tricorninidae Blumenstengel, 1965

### Genus *Ovornina* Gründel, 1966

### Subgenus *Margoplanitia* Knüpfer, 1968

Type species. *Ovornia (Margoplanitia) brevispina* Knüpfer, 1968

### *Ovornia (Margoplanitia) valcourensis* n. sp.

Plate 8, figures 22 - 25

*Description.* Valve preplete; greatest length near dorsal margin; posterior cardinal angle acute, slightly rounded, posteroventral margin sloping to greatest height of valve in anterior third of valve; anteroventral margin abruptly rounded to anterior margin; anterior cardinal angle nearly 90 degrees. Anterior and anteroventral margins with shallow, near-marginal thickening parallel to margin, giving impression of marginal flange. Surface smooth, more elevated posterodorsally with slight dorsal depression at one-third length from anterior in position of S2, otherwise evenly curved from lateral margins to very long, thin, hollow spine at midlength of valve, slightly ventral of midheight. Spine is of equal strength throughout length, extending at right angles to valve with slight posterior swing.

Measurements of holotype, USNM 306744: length 1.2 mm, height, 0.5 mm.

Number of specimens studied: 9.

*Types.* Holotype, USNM 306744; paratypes, USNM 406743, 306745, 306746.

*Occurrence.* Day Point Formation, localities PB5 and PB79, Valcour Island, New York.

*Remarks.* This species is most similar to *Ovornina (Margoplanitia) haehneli* (Blumenstengel), 1965 in having a very preplete outline and a prominent lateral spine. *O. (M.) valcourensis*, however, appears to bear a faint depression in the position of S2, the posterior cardinal angle is more acute and the lateral spine does not appear to taper, at least for the length of spine preserved on the present specimens.

### Family uncertain

### Genus *Bolboscapha* n. gen.

Type species. *Bolboscapha chattertoni* n. sp.

Included species. ?*Budnianella nodosa* Swain, 1962

*Diagnosis.* Acanthoscaphidlike ostracodes, with lobation consisting of anteromedian L2 set off from domicilium by connected S1-S2. Ventroterminal areas laterally compressed in dorsoventral plane; anterior and posterior ends may be produced as spines. Valve overlap and duplicature unknown.

*Remarks.* Well defined lobation such as expressed by *B. chattertoni* is unkown in the Beecherellidae. In addition, the possible lack of a duplicature would seem to restrict *Bolboscapha* from inclusion in that family as it is presently constituted. Some vague similarity may exist between *Bolboscapha* and the entomozoacean genus *Vltavina* Bouček, 1936 but this is only remote. Bouček, (1936, p. 48), however, commented on the similarity in outline between *Vltavina bohemica* and *Entomis aciculata* Jones (1873). Examination of the figures of *E. aciculata* shown by Jones (1874, p. 511, Text-fig. 4a, b) indicates considerable similarity of lobation and outline between that species and *B. chattertoni*, but this may be more imagined than real. Neither *Vltavina bohemica* nor *Entomis aciculata* possess compressed ventroterminal flanges of acanthoscaphid type similar to those of *Bolboscapha chattertoni*.

### *Bolboscapha chattertoni* n. sp.

Plate 3, figures 1 - 3

New genus 4, n. sp. 1 Ludvigsen, 1979, p. 8.
New genus 4. Hayes, 1980, Fig. 5.

*Description.* Valve long, hinge equal to greatest length of domicilium. Anterior and posterior cardinal angles produced as spines. Anterior and posterior margins compressed, invaginated ventrally slightly anterior of midlength. Domicilium broadly inflated above marginally compressed areas, tapering toward hinge line. Prominent bulbous node, L2, in anterodorsal quarter, surrounded by continuous sulcus (S1-S2). Valve interior with broad marginal areas except midventrally, deep domiciliar cavity and deeper L2 surrounded by shallow ridge. Valve surface finely granular.

Measurements of holotype GSC 49430: lenght 1.20 mm, height 0.45 mm.

Number of specimens studied: 3 left valves.

*Types.* Holotype, GSC 49430; paratypes, GSC 49431, 49432.

*Occurrence.* Esbataottne Formation, locality A-115, District of Mackenzie.

*Remarks.* Relative size and overlap cannot be determined, as only left valves have been studied. If overlap does occur, it is probable that the area of the ventral invagination would be its greatest extent as the marginal flanges of each valve would meet smoothly.

*Bolboscapha chattertoni* n. sp. has more prominent cardinal angles drawn out into spines, more prominent L2 and more broadly curved antero- and posteroventral margins than ?*B. nodosa* (Swain). Also, the midventral marginal invagination of the left valve of *B. chattertoni* appears to be more pronounced than that of ? *B. nodosa*.

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Plate 1

(All figures x 40, except 18 and 19, x 30)

Figures 1 - 18. *Oecematobolbina varicata* (Harris), 1957

(1, 2) Heteromorphic right valves, loc. A-140, hypotypes, GSC 49377, 49378.
(3) Heteromorphic right valve, loc. A-220, hypotype, GSC 49379.
(4) Heteromorphic left valve, loc. A-220, hypotype, GSC 49380.
(5) Heteromorphic left valve, loc. A-115, hypotype, GSC 49381.
(6) Heteromorphic left valve, loc. A-220, hypotype, GSC 49382.
(7) Heteromorphic carapace, ventral view, loc. A-220, hypotype, GSC 49383.
(8) Heteromorphic left valve, loc. A-220, hypotype, GSC 49384.
(9) Tecnomorphic left valve, loc. A-220, hypotype, GSC 49385.
(10) Tecnomorphic right valve, loc. A-220, hypotype, GSC 49386.
(11) Tecnomorphic right valve, loc. A-115, hypotype, GSC 49387.
(12) Tecnomorphic right valve, A-220, hypotype, GSC 49388
(13) Tecnomorphic left valve, ventral view, loc. A-115, hypotype, GSC 49389.
(14) Tecnomorphic right valve, ventral view, loc. A-220, hypotype, GSC 49390.
(15) Tecnomorphic left valve, loc. A-115, hypotype, GSC 49391.
(16) Tecnomorphic right valve, loc. A-115, hypotype, GSC 49392.
(17) Tecnomorphic left valve, loc. A-115, hypotype, GSC 49393.
(18) Heteromorphic carapace, right view, Bromide Formation, zone 24, holotype MCZ 4609 (Harris, 1957, p. 215, Pl. 9, figs. 3a, b).

Figure 19. *Oecematobolbina cancellata* (Harris), 1957

Heteromorphic left valve, Tulip Creek Formation, zone 35, holotype MCZ 4608 (Harris, 1957, p. 214, Pl. 9, figs. 2a, b).

Figures 20 - 26. *Piretia mackenziensis* n. sp.

(20) Tecnomorphic right valve, loc. A-115, paratype, GSC 49394.
(21) Heteromorphic right valve, interior view, loc. A-115 paratype GSC 49395.
(22, 23) Heteromorphic right valves, loc. A-115, paratypes, GSC 49396, 49397.
(24) Heteromorphic left valve, loc. A-115, paratype, GSC 49398.
(25) Heteromorphic right valve, interior view, loc. A-115, paratype, GSC 49399.
(26) Heteromorphic right valve, loc. A-115, holotype, GSC 49400.

Figures 27 - 29. *Euprimitia? krafti* Copeland, 1974

(27) Heteromorphic right valve, loc. A-140, hypotype, GSC 49401.
(28) Tecnomorphic right valve, loc. A-140, hypotype, GSC 49402.
(29) Heteromorphic right valve, loc. A-140, hypotype, GSC 49403.

Figures 30 - 33. *Echinoprimitia? spinosa* n. sp.

(30) Left valve, loc. A-115, paratype, GSC 49404.
(31) Right valve, interior view, loc. A-115, paratype, GSC 49405.
(32) Right valve, loc. A-115, holotype, GSC 49406.
(33) Left valve, loc. A-115, paratype, GSC 49407.


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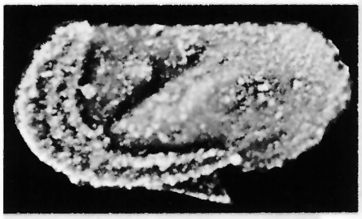
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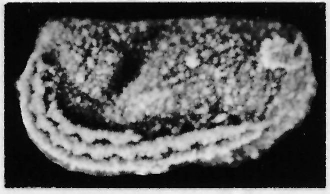
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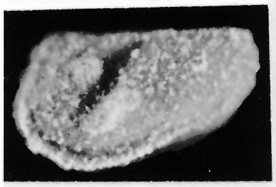
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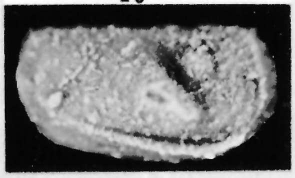
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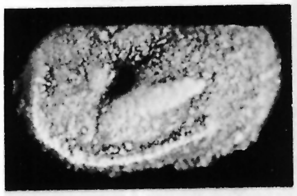
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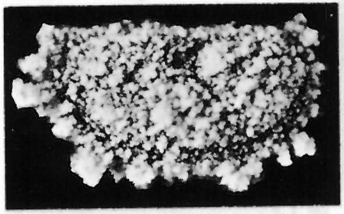
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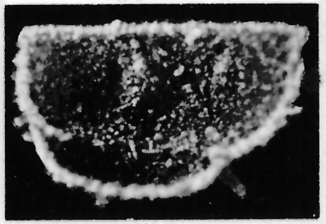
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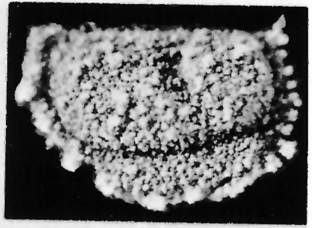
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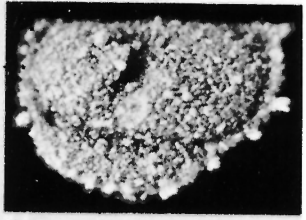
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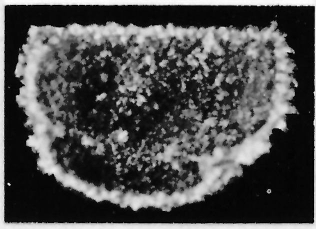
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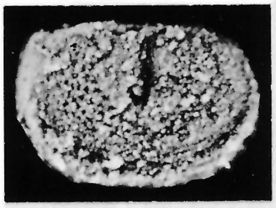
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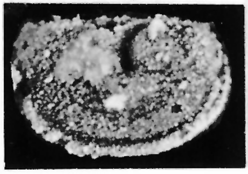
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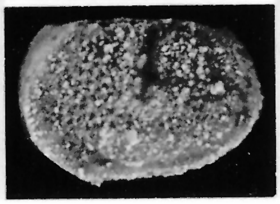
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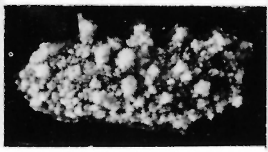
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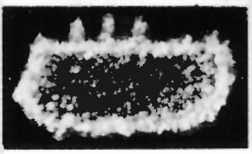
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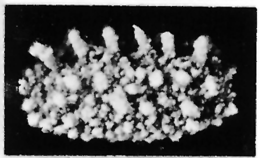
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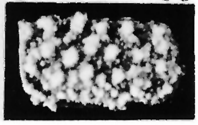
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Plate 2

(All figures x 40, except 10 and 20 - 24, x 30)

Figures 1 - 10. *Eurybolbina bispinata* (Harris), 1957

(1, 2) Tecnomorphic left valves, loc. A-115, hypotypes, GSC 49408, 49409.
(3) Heteromorhic right valve, loc. A-115, hypotype, GSC 49410.
(4) Heteromorphic left valve, loc. A-115, hypotype, GSC 49411.
(5, 6) Tecnomorphic left valves, loc. A-220, hypotypes, GSC 49412, 49413.
(7) Heteromorphic right valve, loc. A-220, hypotype, GSC 49414.
(8) Heteromorphic right valve, loc. A-115, hypotype, GSC 49415.
(9) Heteromorphic right valve, loc. A-115, hypotype, GSC 49416.
(10) Tecnomorphic carapace, left view, Bromide Formation, zone 3, holotype, MCZ 4607 (Harris, 1957, p. 214, Pl. 9 figs. 1a - c).

Figures 11 - 17. *Eurybolbina krafti* n. sp.

(11) Tecnomorphic right valve, loc. A-110, paratype, GSC 49417.
(12) Tecnomorphic left valve, interior view, loc. A-115, paratype, GSC 49418.
(13) Tecnomorphic right valve, Edinburg Formation, basal 6.1 m, 0.32 km east of Strasburg, Virginia, paratype USNM 245130.
(14) Heteromorphic left valve, same locality as figure 13, paratype, USNM 245131.
(15) Heteromorphic right valve, same locality as figure 13, holotype, USNM 245132.
(16) Heteromorphic left valve, loc. A-115, paratype GSC 49419.
(17) Tecnomorphic right valve, same locality as figure 13, paratype, USNM 245133.

Figures 18, 19. *Eohollina depressa* (Kay), 1940

(18) Heteromorphic right valve, loc. A-140, hypotype, GSC 49420.
(19) Tecnomorphic left valve, loc. A-115, hypotype, GSC 49421.

Figures 20, 21. *Bromidella reticulata* Harris, 1931

(20) Tecnomorphic right valve, Tulip Creek Formation, zone 35, hypotype, MCZ 4630A (Harris, 1957, p. 236).
(21) Heteromorphic right valve, Tulip Creek Formation, zone 36, holotype, MCZ 4630 (Harris, 1957, p. 236, Pl. 8, fig. 3).

Figures 22, 23. *Bromidella spiveyi* Harris, 1957

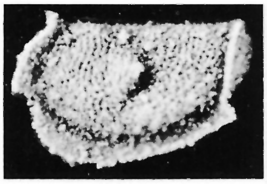
(22) Heteromorphic left valve, McLish Formation, zone 61, holotype, MCZ 4632 (Harris, 1957, p. 237, Pl. 8, fig. 2).
(23) Tecnomorphic right valve, McLish Formation, zone 61, paratype, MCZ 4632A (Harris, 1957, p. 237).

Figure 24. *Tetradellina henningsmoeni* Harris, 1957

Right view of carapace, Bromide Formation, zone 10, holotype, MCZ 4643 (Harris, 1957, p. 251, Pl. 8, figs. 14a, b).

Figures 25 - 32. *Tetradellina harrisi* n. sp.

(25, 26) Right valves, loc. A-115, paratypes, GSC 49422, 49423.
(27, 28) Left valves, loc. A-115, paratypes, GSC 49424, 49425.
(29) Right valve, loc. A-115, paratype, GSC 49426.
(30) Right valve, interior view, loc. A-115, paratype, GSC 49427.
(31) Left valve, interior view, loc. A-115, paratype, GSC 49428.
(32) Left valve, loc. A-115, holotype, GSC 49429.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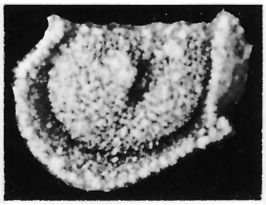
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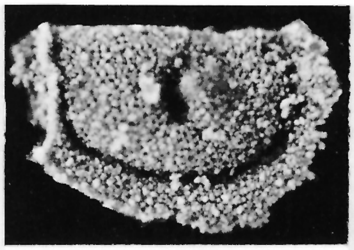
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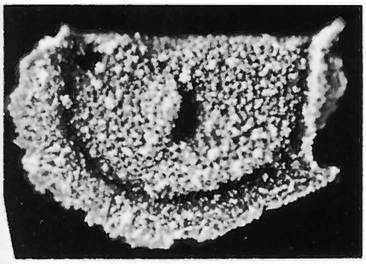
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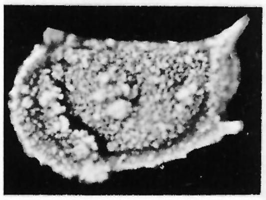
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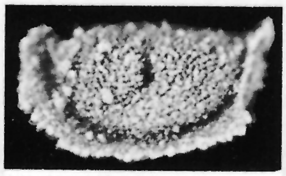
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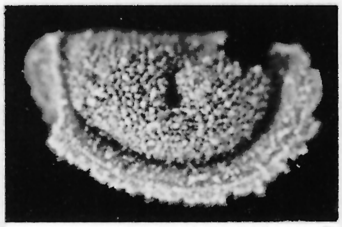
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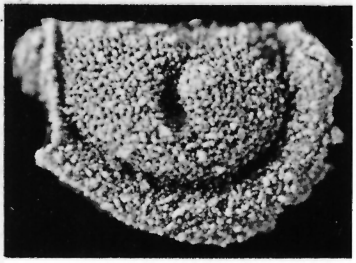
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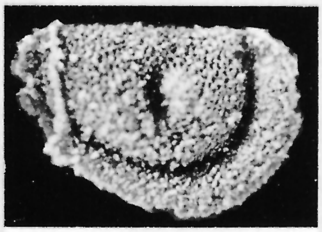
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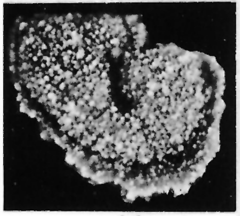
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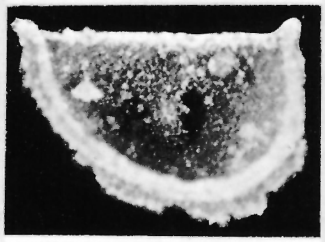
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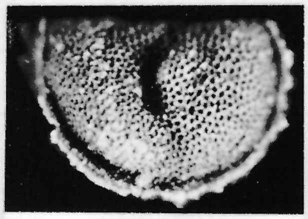
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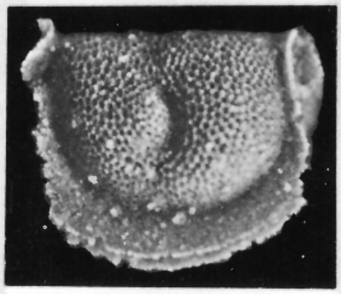
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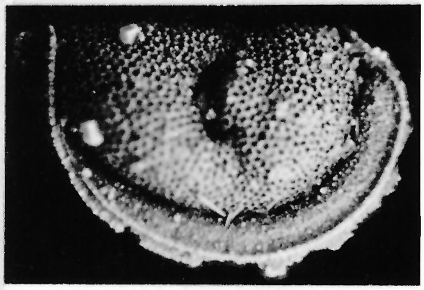
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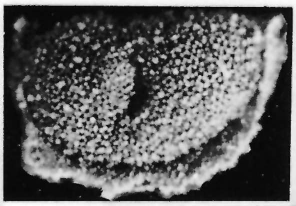
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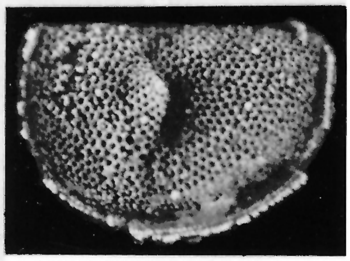
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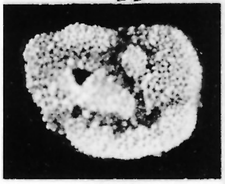
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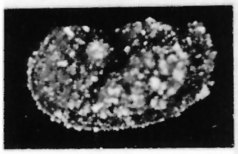
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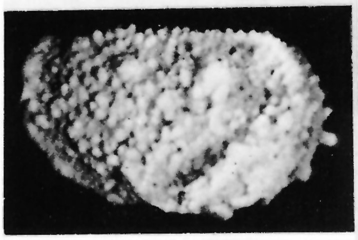
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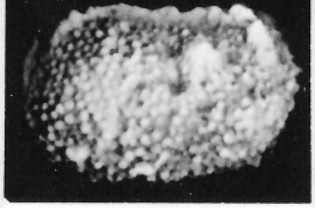
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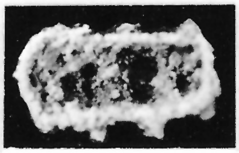
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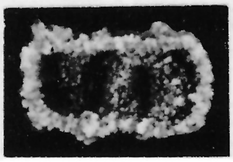
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Plate 3

(All figures x 40, except 17 - 19, x 30)

Figures 1 - 3. *Bolboscapha chattertoni* n. sp.

(1) Left valve, loc. A-115, holotype, GSC 49430.
(2) Left valve interior, loc. A-115, paratype, GSC 49431.
(3) Left valve, loc. A-115, paratype, GSC 49432.

Figures 4 - 15. *Canadabolbina multispinosa* n. sp.

(4) Heteromorphic left valve, loc. A-115, paratype, GSC 49433.
(5, 6) Heteromorphic right valves, loc. A-115, paratypes, GSC 49434, 49435.
(7) Heteromorphic left valve, loc. A-115, paratype, GSC 49436.
(8) Heteromorphic left valve, loc. A-115, holotype, GSC 49437.
(9) Heteromorphic right valve, loc. A-115, paratype, GSC 49438.
(10, 11) Tecnomorphic left valves, loc. A-115, paratypes, GSC 49439, 49440.
(12) Tecnomorphic right valve, loc. A-115, paratype, GSC 49441.
(13) Tecnomorphic left valve, loc. A-115, paratype, GSC 49442.
(14) Tecnomorphic right valve, loc. A-115, paratype, GSC 49443.
(15) Tecnomorphic right valve, loc. A-115, paratype, GSC 49444.

Figures 16, 25 - 30. *Winchellatia nahanniensis* n. sp.

(16) Right valve, loc. A-115, paratype, GSC 49445.
(25) Left valve, loc. A-115, paratype, GSC 49450.
(26) Right valve, loc. A-110, holotype, GSC 49451.
(27) Left valve, ventral view, loc. A-115, paratype, GSC 49452.
(28) Left valve, loc. A-110, paratype, GSC 49453.
(29, 30) Right valves, locs. A-115 and A-110, paratypes, GSC 49454, 49455.

Figure 17. *Ctenobolbina projecta* Harris, 1957

Right view of carapace, McLish Formation, zone 66, holotype, MCZ 4614 (Harris, 1957, p. 218, Pl. 9, figs. 8a, b).

Figure 18. *Acanthobolbina loeblichi* Harris, 1957

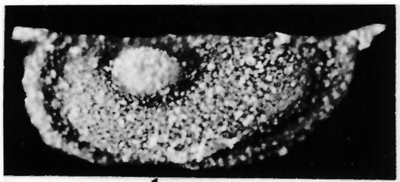
Right view of carapace, Bromide Formation, zone 3, holotype, MCZ 4618 (Harris, 1957, p. 223, Pl. 9, figs. 13 a, b).

Figure 19. *Ctenobolbina inflata* Harris, 1957

Left view of carapace, Tulip Creek Formation, zone 36, holotype, MCZ 4610 (Harris, 1957, p. 215, Pl. 9, figs. 6a, b).

Figures 20 - 24. *Platyrhomboides quadratus* Harris, 1957

(20) Left valve?, loc. A-140, hypotype, GSC 49446.
(21) Left valve, loc. A-110, hypotype, GSC 49447.
(22) Right valve, loc. A-115, hypotype, GSC 49448.
(23) Right valve, loc. A-110, hypotype, GSC 49449.
(24) Right valve, Edinburg Formation, basal 6.1 m, 0.32 km east of Strasburg, Virginia, hypotype, USNM 245134.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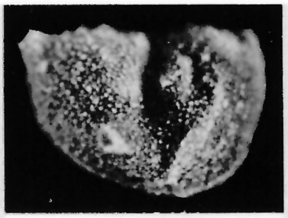
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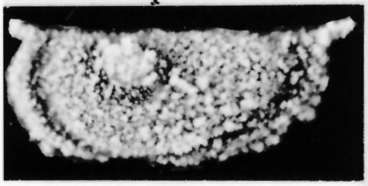
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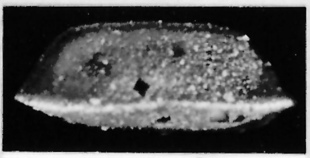
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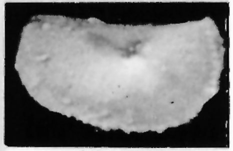
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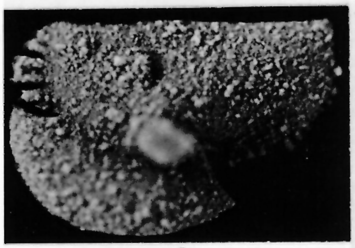
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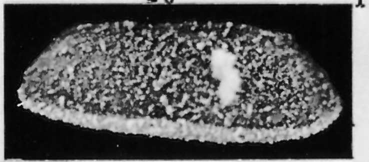
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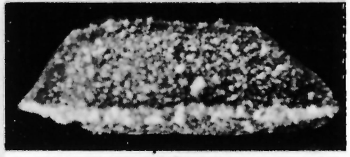
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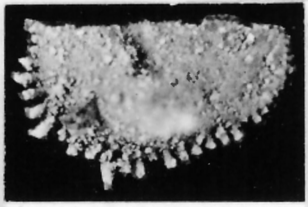
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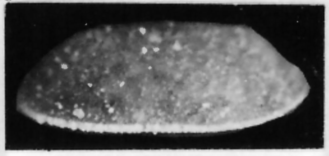
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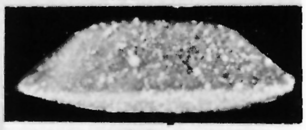
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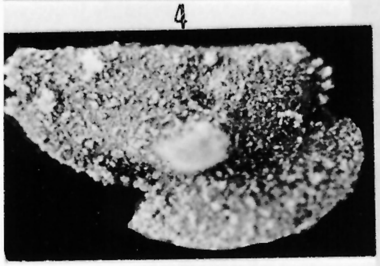
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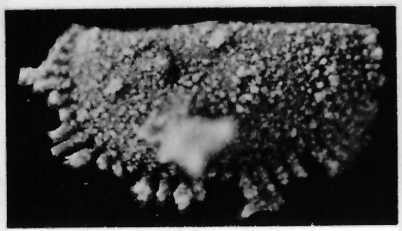
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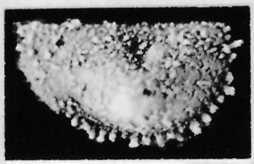
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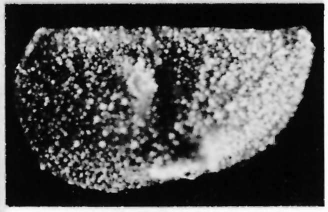
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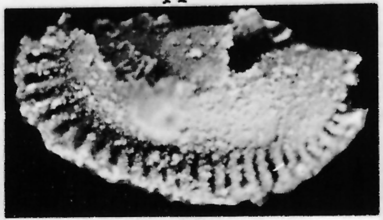
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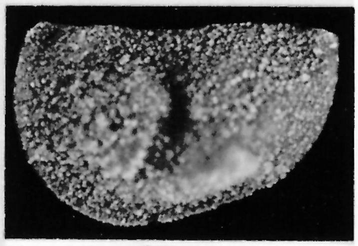
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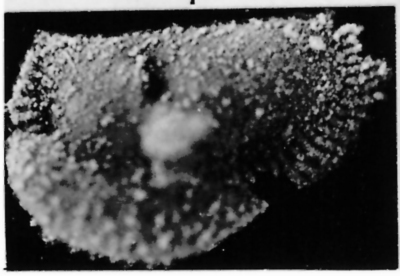
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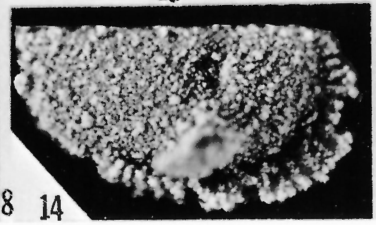
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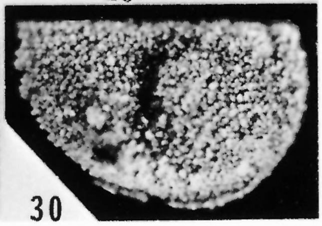
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Plate 4

(All figures x 40, except 6 - 12, x 30)

Figures 1 - 5. *Ectoprimitia? pustulosa* Swain, 1957

(1, 2) Right valves, loc. A-110, hypotypes, GSC 49789, 49790.
(3) Left valve interior view, loc. A-110, hypotype, GSC 49791.
(4) Left view of carapace, loc. A-110, hypotype, GSC 49792.
(5) Ventral view of carapace, loc. A-110, hypotype, GSC 49793.

Figure 6. *Ctenobolbina abrupta* Harris, 1957

Left view of valve, Corbin Ranch Formation, zone 13, holotype MCZ 4604 (Harris, 1957, p. 213, Pl. 8, figs. 18a - c).

Figure 7. *Winchellatia cornuta* Harris, 1957

Right view of carapace, Tulip Creek Formation, zone 35, holotype MCZ 4615 (Harris, 1957, p. 220, Pl. 9, figs. 4a, b).

Figure 8. *Coelochilina alatispinata* Harris, 1957

Right view of valve, Tulip Creek Formation, zone 31, holotype MCZ 4634 (Harris, 1957, p. 240, Pl. 8, figs. 5a, b. Notation on slide "Spine broken off".).

Figures 9 - 11. *Winchellatia longispina* Kay, 1940

(9) Left valve, Bromide Formation, zone 10, hypotype, MCZ 4616A (Harris, 1957, p. 220, Pl. 9, fig. 10).
(10) Right valve, Bromide Formation, zone 10, hypotype, MCZ 4616C (Harris, 1957, p. 220, Pl. 9, figs. 9a - d).
(11) Left view of carapace, a cast, Bromide Formation, zone 10, hypotype, MCZ 4616B (Harris, 1957, p. 220, Pl. 9, figs. 11a - d).

Figure 12. *Echinoprimitia imputata* Harris, 1957

Left view of carapace, Bromide Formation, zone 3, holotype, MCZ 4583 (Harris, 1957, p. 191, Pl. 6, figs. 5a, b).

Figures 13 - 19. *Eurychilina sunbloodensis* Copeland, 1974

(13, 14) Heteromorphic right valves, interior and exterior, loc. A-115, hypotypes, GSC 49794, 49795.
(15) Heteromorphic left valve, interior, loc. A-115, hypotype, GSC 49796.
(16) Heteromorphic right valve, loc. A-115, hypotype, GSC 49797.
(17) Tecnomorphic right valve, interior, loc. A-115, hypotype, GSC 49798.
(18, 19) Tecnomorphic left valves, loc. A-115, hypotypes, GSC 49799, 49800.


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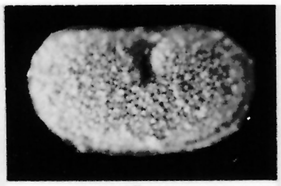
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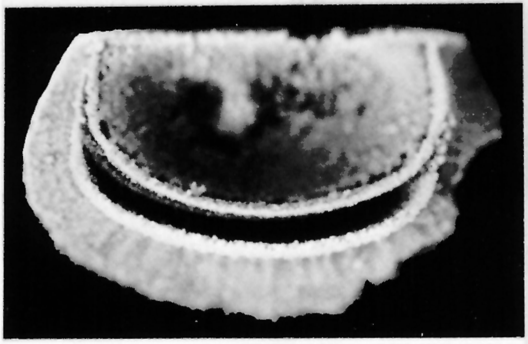
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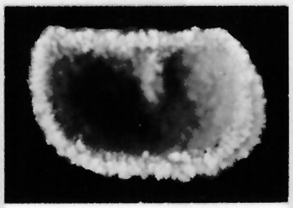
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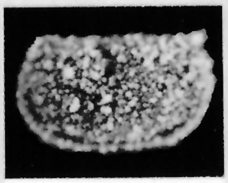
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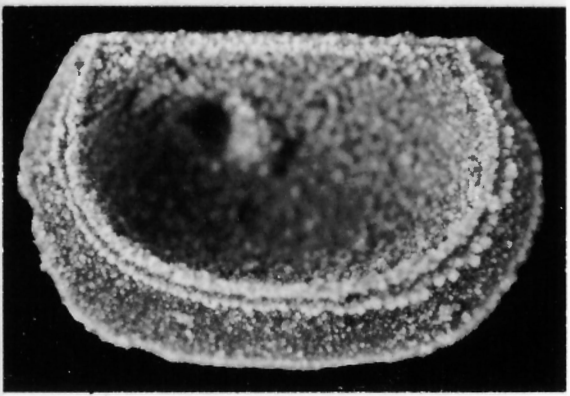
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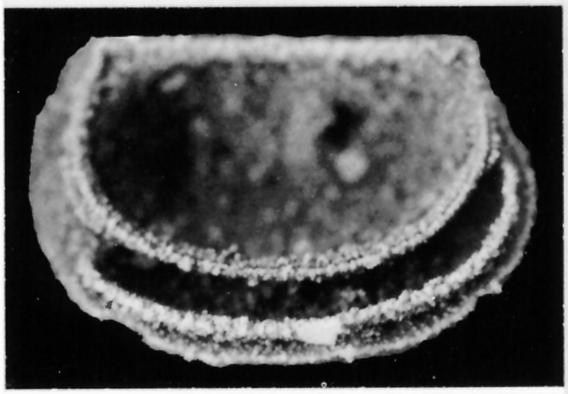
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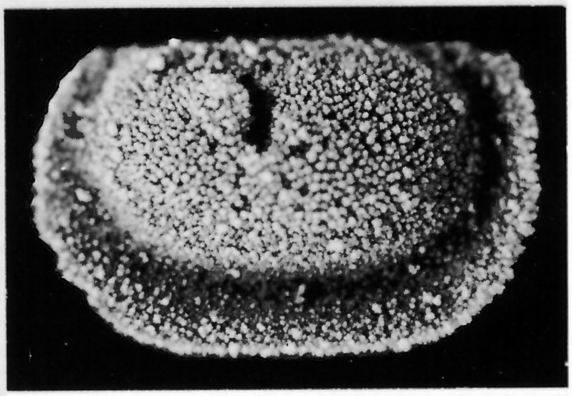
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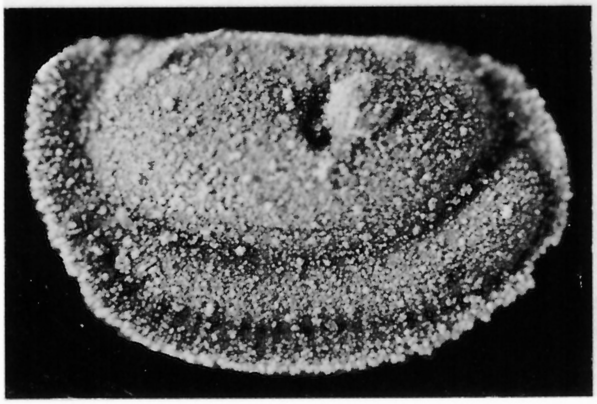
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Plate 5

(All figures x 40, except 1 - 3, x 30)

Figures 1 - 3. *Acronotella shideleri* Ulrich and Bassler, 1923

Right, ventral and dorsal views of a carapace, Richmond Group (Elkhorn Formation), Richmond, Indiana, holotype, USNM 66924.

Figures 4 - 16. *Nahanniopsis schallreuteri* n. sp.

(4) Left valve, loc. P-1595, paratype, GSC 49801.
(5) Left valve, loc. P-1595, paratype, GSC 49802.
(6) Left valve, interior view, loc. P-1595, paratype, GSC 49803.
(7) Right valve, loc. P-1595, paratype, GSC 49804.
(8) Left valve, dorsal view, loc. P-1595, paratype, GSC 49805.
(9) Right valve, ventral view, loc. P-1595, paratype, GSC 49806.
(10) Right valve, interior view, loc. P-1595, paratype, GSC 49807.
(11) Left valve, loc. P-1595, holotype, GSC 49808.
(12) Left valve, loc. P-1595, paratype, GSC 49809.
(13) Right valve, loc. P-1595, paratype, GSC 49810.
(14) Right valve, loc. P-1595, paratype, GSC 49811.
(15) Right valve, loc. P-1595, paratype, GSC 49812.
(16) Right valve, loc. P-1595, paratype, GSC 49856.

Figures 17 - 19. *Dicranella macrocarinata* Harris, 1931

(17) Heteromorphic right valve, interior view, loc. A-385, hypotype, GSC 49858.
(18) Tecnomorphic left valve, loc. A-385, hypotype, GSC 49859.
(19) Tecnomorphic left valve, loc. A-385, hypotype, GSC 49860.


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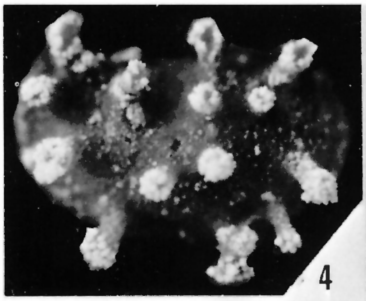
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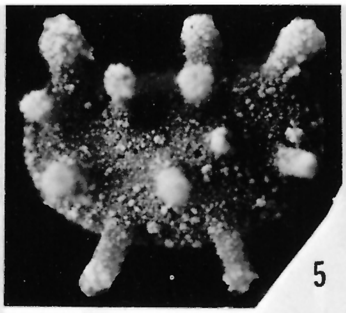
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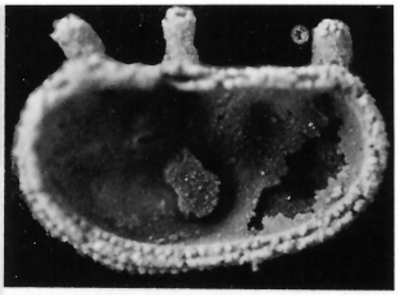
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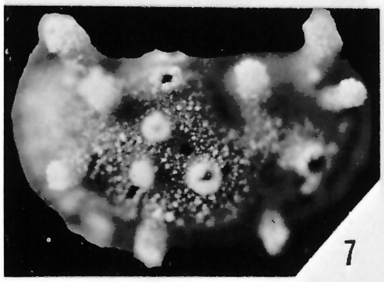
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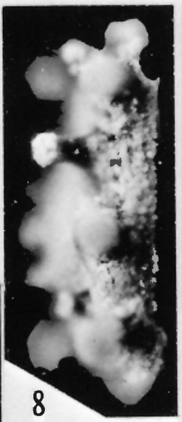
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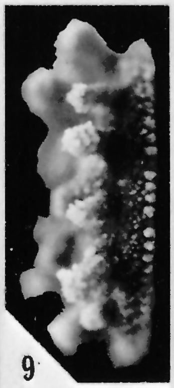
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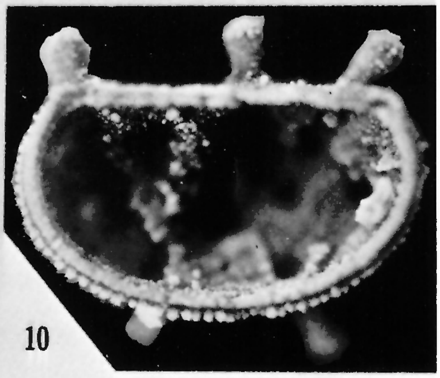
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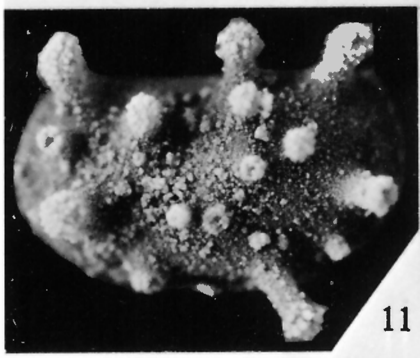
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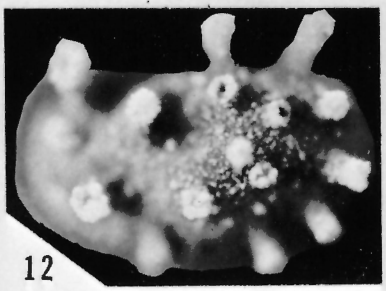
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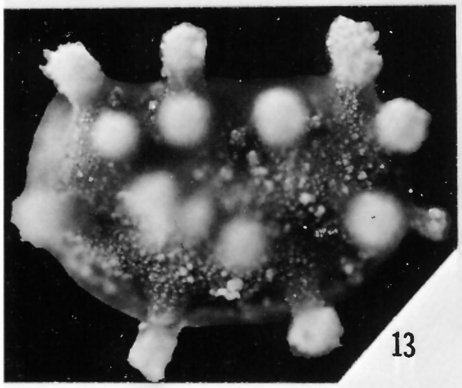
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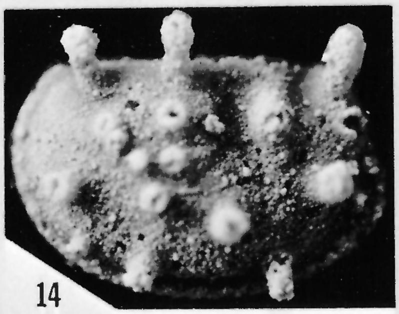
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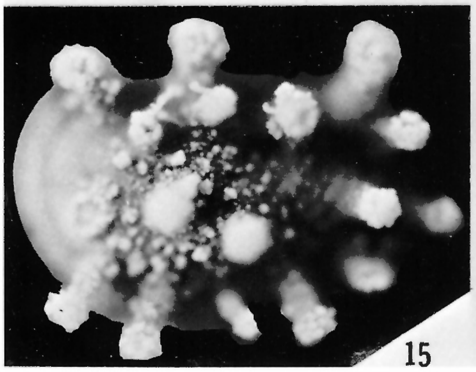
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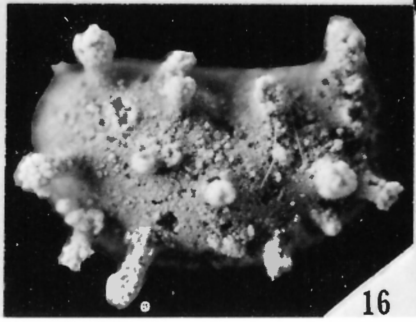
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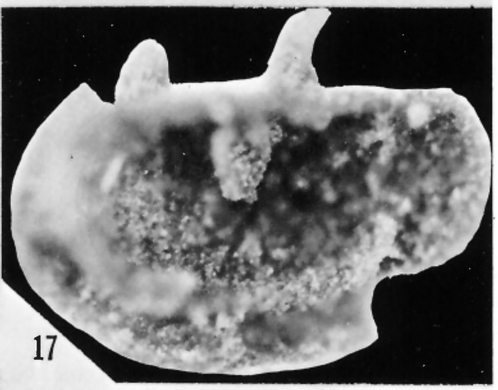
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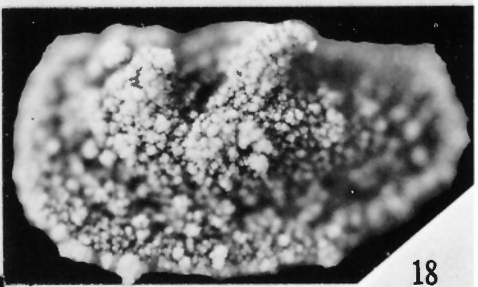
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## Plate 6

(All figures x 40, Day Point Formation, loc. PB5)

Figures 1, 2. *Dicranella fimbriata* n. sp.

Left interior and right lateral views of two tecnomorphic valves, paratypes, USNM 306677, 306678.

Figures 3 - 8. *Bromidella spiveyi* Harris, 1957 (=*Eurychilina multipustulosa* Swain, 1962)

Lateral views of four immature left valves and two immature right valves, hypotypes, USNM 306679 - 306684.

Figures 9, 10. *Eohollina depressa* (Kay), 1940

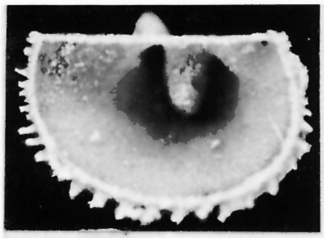
Lateral and interior views of two heteromorphic left valves, hypotypes, USNM 306685, 306686.

Figures 11 - 19. *Piretia shawi* n. sp.

(11 - 13) Two right and one left lateral views of three tecnomorphic valves, paratypes, USNM 306687 - 306689.
(14) Right lateral view of an incomplete heteromorphic valve, paratype, USNM 306690.
(15) Right lateral view of an immature valve, paratype, USNM 306691.
(16) Left lateral view of a tecnomorphic valve, holotype, USNM 306692.
(17 - 19) Two left and one right lateral views of three tecnomorphic valves, paratypes, USNM 306693 - 306695.

Figures 20 - 22. *Bromidella spiveyi* Harris, 1957

Right lateral views of three heteromorphic valves, hypotypes, USNM 306696 - 306698.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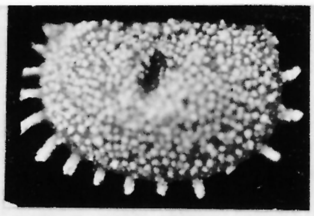
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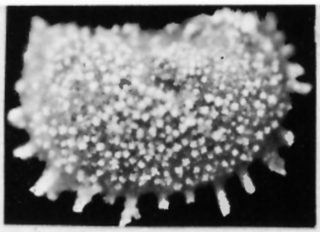
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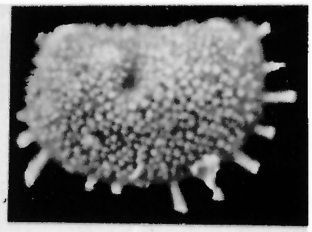
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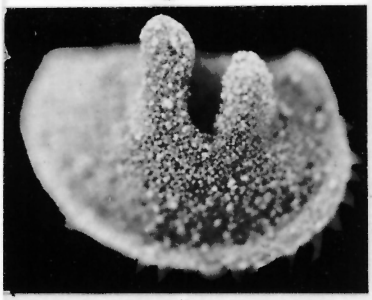
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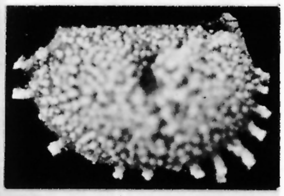
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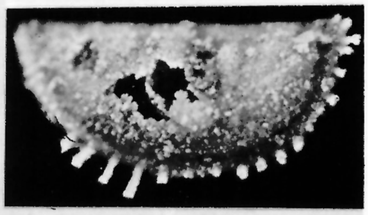
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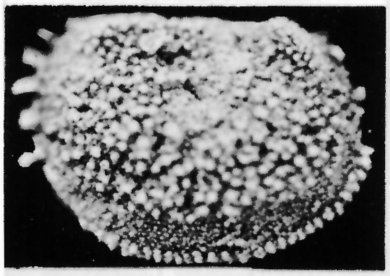
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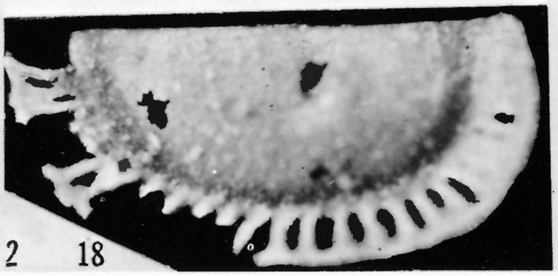
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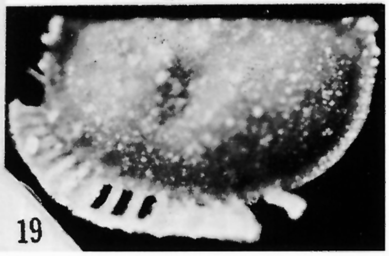
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Plate 7

(All figures x 40, Day Point Formation, loc. PB5)

Figure 1. *Monoceratella* cf. *M. teres* Teichert, 1937

Right lateral view of a valve, hypotype, USNM 306699.

Figure 2. *Cryptophyllus oboloides* (Ulrich and Bassler), 1923

Lateral view of a valve, hypotype, USNM 306700.

Figures 3, 4. *Eurybolbina bulbinoda* (Swain), 1962

Left lateral views of two valves, hypotypes, USNM 306701, 306702.

Figure 5. *Eohollina depressa* (Kay, 1940)

Ventral view of a carapace (anterior toward top of plate), hypotype, USNM 306703.

Figures 6 - 8. *Eurybolbina bulbinoda* (Swain), 1962

(6) Ventral view of a carapace (anterior toward bottom of plate), hypotype, USNM 306704.
(7) Right lateral view of a valve, hypotype, USNM 306705.
(8) Left lateral view of a carapace, hypotype, USNM 306706.

Figures 9, 10. ?*Budnianella ellipticalis* Swain, 1962

Right lateral views of two valves, hypotypes, USNM 306707, 306708.

Figure 11. *"Aparchites" fimbriatus* (Ulrich), 1892

Left lateral view of an immature valve, hypotype, USNM 306709.

Figure 12. *Primitiella*? sp.

Right lateral view of a valve, figured specimen, USNM 306710.

Figure 13. *"Aparchites"* cf. *"A." fimbriatus* (Ulrich), 1892

Internal view of left valve, hypotype, USNM 306711.

Figures 14 - 22. *Eurychilina*? *placida* Swain, 1962

Four left and five right lateral views of nine valves, hypotypes, USNM 306712 - 306720.

Figure 23. *Eurychilina*? *mattea* Kraft, 1962

Right lateral view of a valve, hypotype, USNM 306721.


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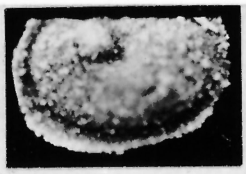
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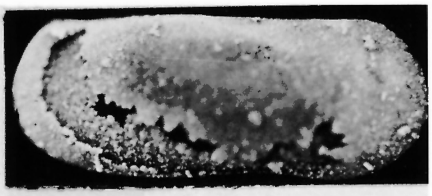
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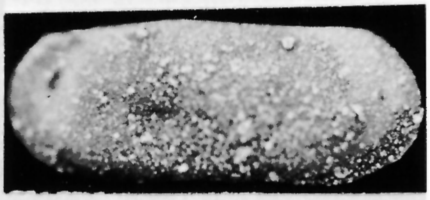
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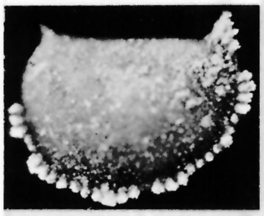
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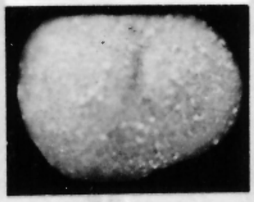
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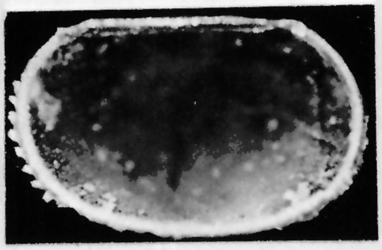
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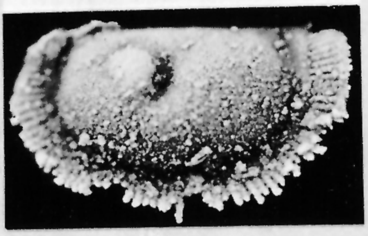
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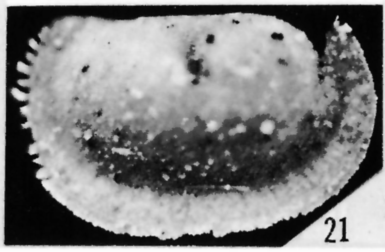
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Plate 8

(All figures x 40, Day Point Formation, Valcour Island, loc. PB15, except figures 10, 19 - 25, loc. PB5)

Figure 1. *Dicranella fimbriata* n. sp.

Left lateral view of a tecnomorphic valve, holotype, USNM 306722.

Figure 2. *Bromidella spiveyi* Harris, 1957

Left lateral view of a valve, hypotype, USNM 306723.

Figure 3. *Eurychilina? placida* Swain, 1962

Right lateral view of a valve, hypotype, USNM 306724.

Figure 4. *Sigmobolbina? crescentica* Swain, 1962

Right lateral view of a valve, hypotype, USNM 306725.

Figure 5. *Lomatopisthia simplex* (Harris), 1957

Left lateral view of a valve, hypotype, USNM 306726.

Figures 6, 7. *Anisocyamus elegans* (Harris), 1957

Left lateral and ventral views of two carapaces, hypotypes, USNM 306727, 306728.

Figure 8. *Acanthoscapha?* sp.

Left lateral view of an incomplete valve, figured specimen, USNM 306729.

Figure 9. *Schmidtella crassimarginata* Ulrich, 1892

Left lateral view of a valve, hypotype, USNM 306730.

Figure 10. *?Budnianella ellipticalis* Swain, 1962

Left lateral view of a valve, hypotype, USNM 306731.

Figures 11 - 18. *Valcouropsis shawi* n. sp.

(11 - 14) Interior, two lateral and interior views of four right valves, paratypes, USNM 306732 - 306735.
(15) Left lateral view of a broken valve showing interior shell layer, paratype, USNM 306736.
(16) Left lateral view of a valve, holotype, USNM 306737.
(17, 18) Right ventral (anterior toward bottom of plate) and right dorsal (anterior to top of plate) views of two valves, paratypes, USNM 306738, 306739.

Figure 19. *Budnianella shenandoahense* Swain, 1957

Left lateral view of a valve, hypotype, USNM 306740.

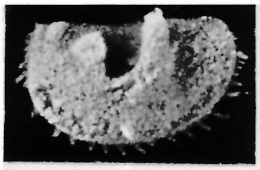
Figure 20. *Aparchites pembertonensis* Swain, 1957

Right lateral view of a valve, hypotype, USNM 306741.

Figure 21. *Acanthoscapha champlainensis* Swain, 1962

Left lateral view of a valve, hypotype, USNM 306742.

Figures 22 - 25. *Ovornina (Margoplanitia) valcourensis* n. sp.
(22, 23) Right lateral and left lateral views of two valves, paratype, USNM 306743 and holotype, USNM 306744.
(24, 25) Ventral and dorsal views of two valves, paratypes, USNM 306745, 306746.



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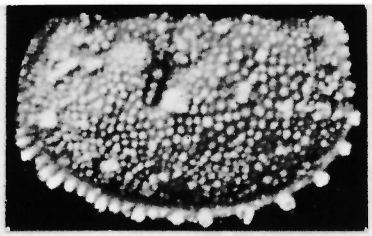

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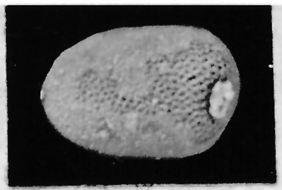

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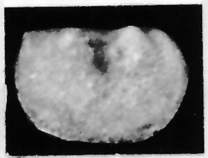

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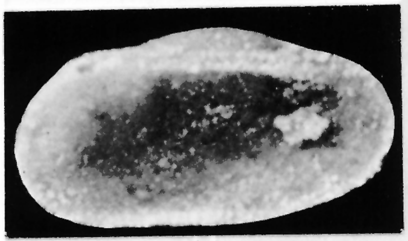

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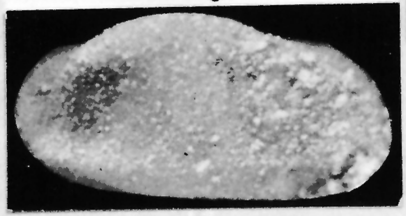

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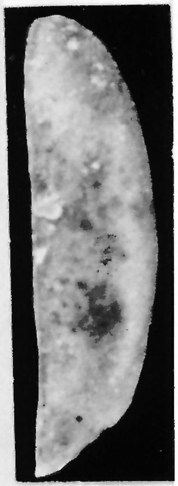

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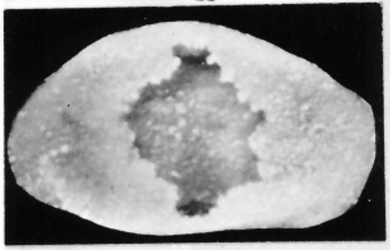

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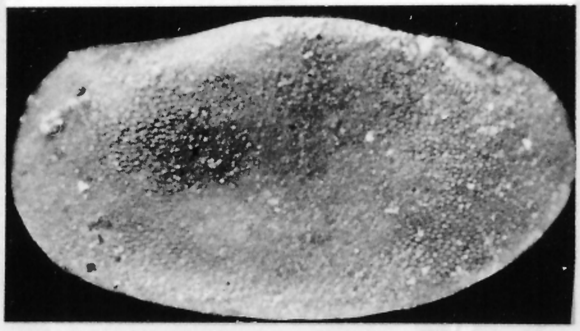

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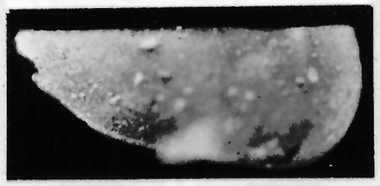

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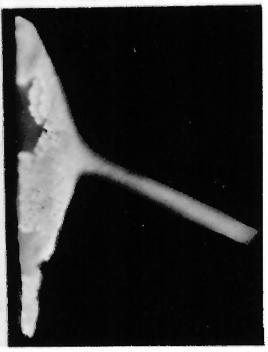

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Plate 9

(All figures x 40, except figures 9, 10, x 10, and figure 11, x 14)

Figure 1. *"Aparchites" fimbriatus"*? Ulrich, 1892

Left lateral view of a valve, loc. PB420, 22.4 m above base of Valcour Formation, hypotype, USNM 306747.

Figure 2. *Cryptophyllus oboloides* (Ulrich and Bassler), 1923

Left lateral view of a valve, loc. PB79, 3.4 m above base of Crown Point Formation, hypotype, USNM 306748.

Figure 3. *Eurychilina placida* Swain, 1962

Interior view of right valve, loc. PB81, 4 m above base of Crown Point Formation, hypotype, USNM 306749.

Figure 4. *Budnianella shenandoahense* Swain, 1962

Right lateral view of a valve, loc. PB79, hypotype, USNM 306750.

Figures 5, 6. *Eurybolbina clintonensis* (Swain), 1962

Right and left lateral views of two valves, loc. PB79, hypotypes, USNM 306751, 306752.

Figure 7. *Bromidella spiveyi* Harris, 1957

Left lateral view of a valve, loc. PB81, hypotype, USNM 306753.

Figure 8. *Eurychilina? placida* Swain, 1962

Left lateral view of a valve, loc. PB81, hypotype, USNM 306754.

Figures 9 - 11. *Tirisochilina anna* (Jones), 1858

Left, right and left lateral views of a carapace and two valves, loc. PB81, hypotypes, USNM 306755 - 306757.

Figures 12, 13. *Monoceratella* cf. *teres* Teichert, 1937

Right and left lateral views of two valves, loc. PB175, 32.6 m above base of Crown Point Formation, hypotypes, USNM 306758, 306759.

Figures 14, 15. *Eurychilina? mattea* Kraft, 1962

Left and right lateral views of two valves, loc. PB420, hypotypes, USNM 306760, 306761.

Figure 16. *Eurybolbina krafti* n. sp.

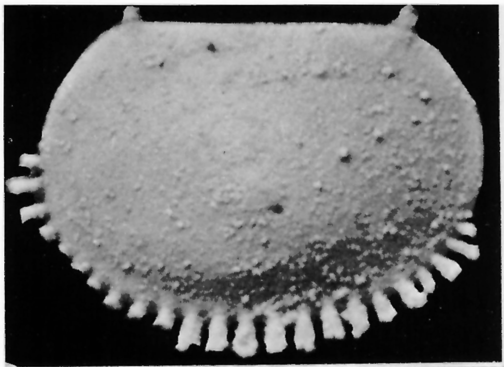
Left lateral view of a valve, loc. PB420, paratype, USNM 306762.

Figure 17. ?*Budnianella ellipticalis* Swain, 1962

Left interior view of a valve, loc. PB79, hypotype, USNM 306763.

Figures 18, 19. *Dicranella fimbriata* n. sp.

Right lateral views of two heteromorphic valves, loc. PB79, paratype, USNM 306764, holotype, USNM 306765.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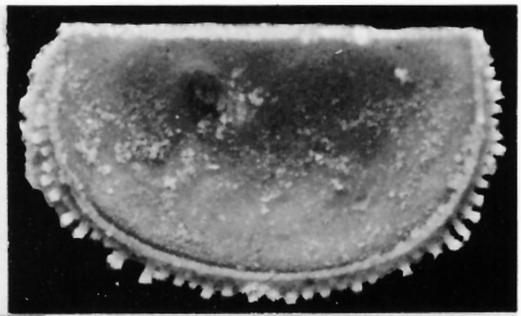
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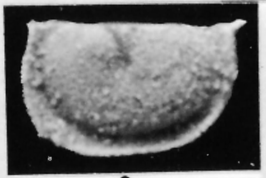
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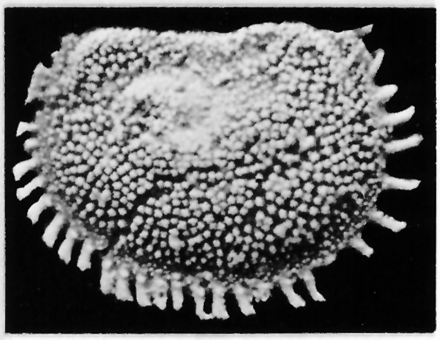
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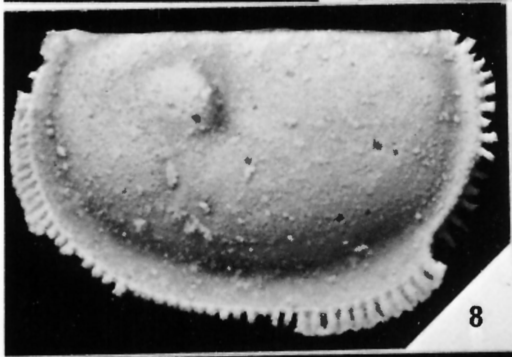
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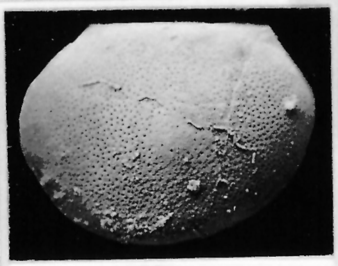
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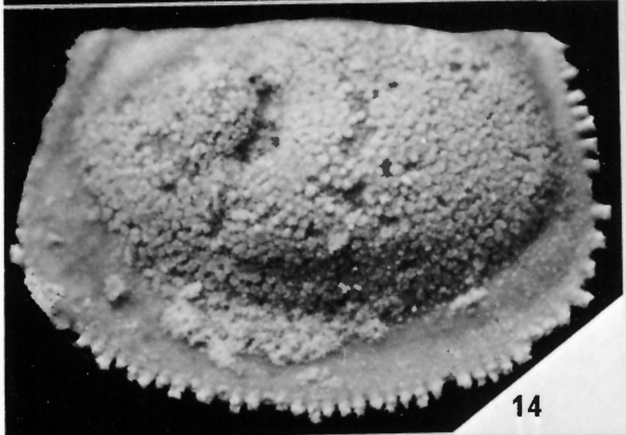
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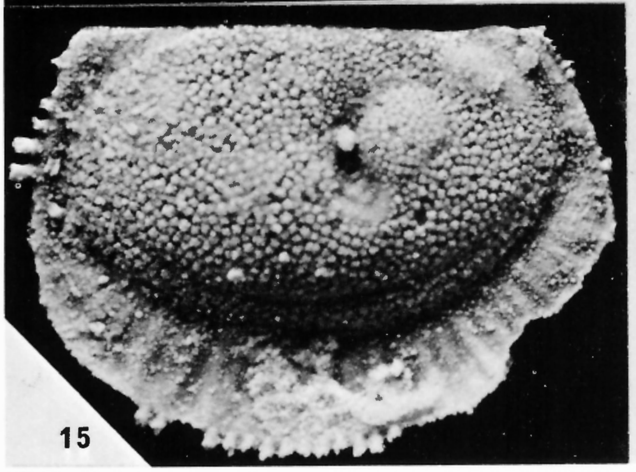
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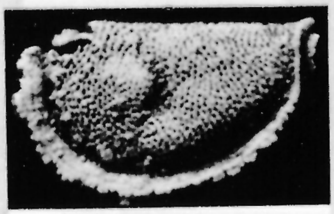
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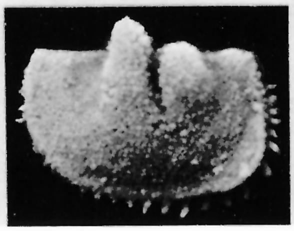
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