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LOWER MISSISSIPPIAN OSTRACODES FROM THE BANFF FORMATION, ALBERTA

by

Robert Green

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Lower Mississippian Ostracodes from the Banff Formation, Alberta

ABSTRACT

Ostracodes are common in the Lower Mississippian Banff Formation and equivalent strata in the Rocky Mountains and Peace River region of Alberta.

The type Banff Formation—divisible into three members—contains three, possibly five, ostracode zones; a major faunal change takes place near the top of the middle member. Northward from Banff a calcarenite unit, called Pekisko, is intercalated between the middle and upper members. Ostracode faunas from above the Pekisko unit in the Mountains and in the Peace River region are correlative with those of the type upper member.

The basal Banff sandstone at Jasper contains a conodont fauna of earliest Mississippian age. The ostracode faunas of the overlying Banff lower member are thus considered to be of Kinderhook (Chouteau) age. The type Banff middle member faunas are also considered to be Kinderhookian, and the Kinderhook-Osage boundary is placed at the level of the faunal change near the top of the middle member. The type upper Banff, Shunda-equivalent, strata are considered to be of early Osage (Fern Glen) age.

Type Banff Formation strata are predominantly fine-grained limestones with variable amounts of silt-size quartz. Chert nodules and siliceous segregations are common. The carbonate percentage increases upward through the formation, and averages 78 per cent. Five main rock types are recognizable: (1) laminated, unfossiliferous micrite, (2) micrite with fine-grained organic detritus, (3) micrite with up to 10 per cent larger bioclastic fragments, (4) micrite with 10 to 50 per cent larger bioclastic fragments, (5) biocalcarenite with fine-grained matrix. Six rock units were established in the type Banff Formation on the basis of these lithologic facies.

Ostracodes are absent from lithofacies 1 and 5, and are most common in lithofacies 3. The five lithofacies reflect fluctuations in current sorting; the mean size of ostracode valves varies with lithofacies, indicating current modification of initial ostracode assemblages. Comparison of size-frequency distribution data for theoretical death assemblages and observed assemblages indicates that current-modified death assemblages may be recognizable.

Statistical analysis applied to the ostracode data differentiates three generic groups of ostracodes; Group I comprises *Amphissites, Beyrichiopsis, Coryellina, Craspedographylus, Cribroconcha, Editia, Kirkbya, Knoxina, Mammoides, Paraparchites, Rectobairdia, Silenites, Tetrasacculus* and *Waylandella*; Group II comprises *Cornigella, Glyptopleura, Kirkbyellina* and *Monoceratina*; Group III com-

prises *Bairdia* and *Geffenina*. Group I genera tend to be not associated with Group II genera, and are prevalent in the type Banff upper member and in Plains sections. Group II genera occur predominantly in the type Banff lower and middle members and in member A at Jasper; they are absent from Plains sections. Regional differences in ostracode morphology also exist; these are consistent, although not complete, and are believed related to environmental differences, the more highly ornamented forms of any one taxon always being associated with the darker, deeper water carbonates. It is concluded that Groups I and III forms represent shallow-water shelf environments, possibly on a lime silt-sand substratum, and that Group II forms represent a deeper water, shelf-margin environment, possibly on a lime silt substratum.

The ostracode faunas are classified into 130 forms, of which 99 are new, and 18 are conspecific or comparable with previously described species.

INTRODUCTION

The microfaunas of the Paleozoic rocks of Western Canada are largely undescribed, the most detailed descriptions to date being concerned with fusulinid foraminifera of British Columbia. Loranger (1954, 1958) described a Late Devonian ostracode fauna and indicated the probable zonal value of some Mississippian ostracodes, and Copeland (1960) noted the occurrence of a Kinderhookian ostracode fauna in the Crowsnest Pass. No comprehensive papers on the ostracode faunas have been published.

In order to compensate in part this deficiency in knowledge, a study of ostracode and foraminiferal faunas of the Mississippian rocks of Alberta was undertaken by the writer at the Research Council of Alberta in 1956. This report presents the results of an examination of the ostracodes of the type section of the Banff Formation, and of a small number of incomplete sections elsewhere in the province. Relatively detailed sampling was carried out through the type section of the Banff Formation and sufficient microfossils were recovered from the samples to indicate ranges of ostracode species, evolutionary changes within and between species, and to allow conclusions to be drawn concerning the local distributions of the ostracodes and their probable zonal and ecological significance.

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STRATIGRAPHIC NOMENCLATURE OF THE MISSISSIPPIAN ROCKS

The stratigraphic nomenclature of the Mississippian rocks of Alberta has been widely discussed during the past few years (e.g. Beales, 1950; Clark, 1949; Douglas, 1953; Moore, 1958; Penner, 1959). Many names have been proposed for the various rock units of the Mississippian System in Alberta; the confusion and partial duplication of nomenclature prior to 1955 has been admirably summarized by Moore (1958) and in large part clarified by him. Some of the outstanding problems in correlation and nomenclature are discussed by Nelson (1960, 1961) and Green (1962).

The name "Banff" was applied by McConnell (1887) to a succession of thick limestone and shaly units in the Bow Valley (Fig. 1), now known to range in age from Late Devonian to Triassic. The term was restricted by Kindle (1924) to a sequence of dark colored, argillaceous limestones (McConnell's "Lower Banff Shales"), overlain by massive light colored limestone—Rundle Formation—and the north end of Mount Rundle (Fig. 1) was designated as the type locality of both formations. Warren, in 1927, subdivided the type Banff Formation into three members, with thicknesses, in ascending order, of 308, 146, and 954 feet, the lowest member including the 35-foot thick Exshaw Shale. A re-examination of this section by Beales (1950) resulted in his indicating different thicknesses for the three members, namely 250 ± feet, 600 ± feet, and 550 to 600 feet, in ascending order. Beales' middle member is thus apparently four times the thickness of Warren's middle member. This discrepancy is explicable in that Beales (*ibid.*, p. 14) notes the presence of a more resistant unit (unit 4, Table 1)—the "main middle Banff fossil zone" —130 feet thick, at the top of the middle member. This unit is particularly distinctive where it outcrops towards the foot of the north end of Mount Rundle, and is the main cliff-forming unit in the middle part of the Banff Formation. The lithology and fossiliferous nature of the unit leave little doubt that it constitutes Warren's middle Banff member.

Douglas (1953) gave the name "Pekisko" to a 440-foot thick unit of the Livingstone Formation in the Mount Head area (Fig. 1) south of Banff. The Livingstone Formation constitutes the basal unit of the Rundle Group in the Mount Head area, and this term is also applied to the massive, coarse-grained, crystalline, fragmental limestones at the base of the Rundle Group in the Banff area. Northeastward from the Mount Head area a dark-colored limestone or dolomite unit is intercalated between the Pekisko and the overlying Turner Valley Members of the Livingstone Formation. Farther

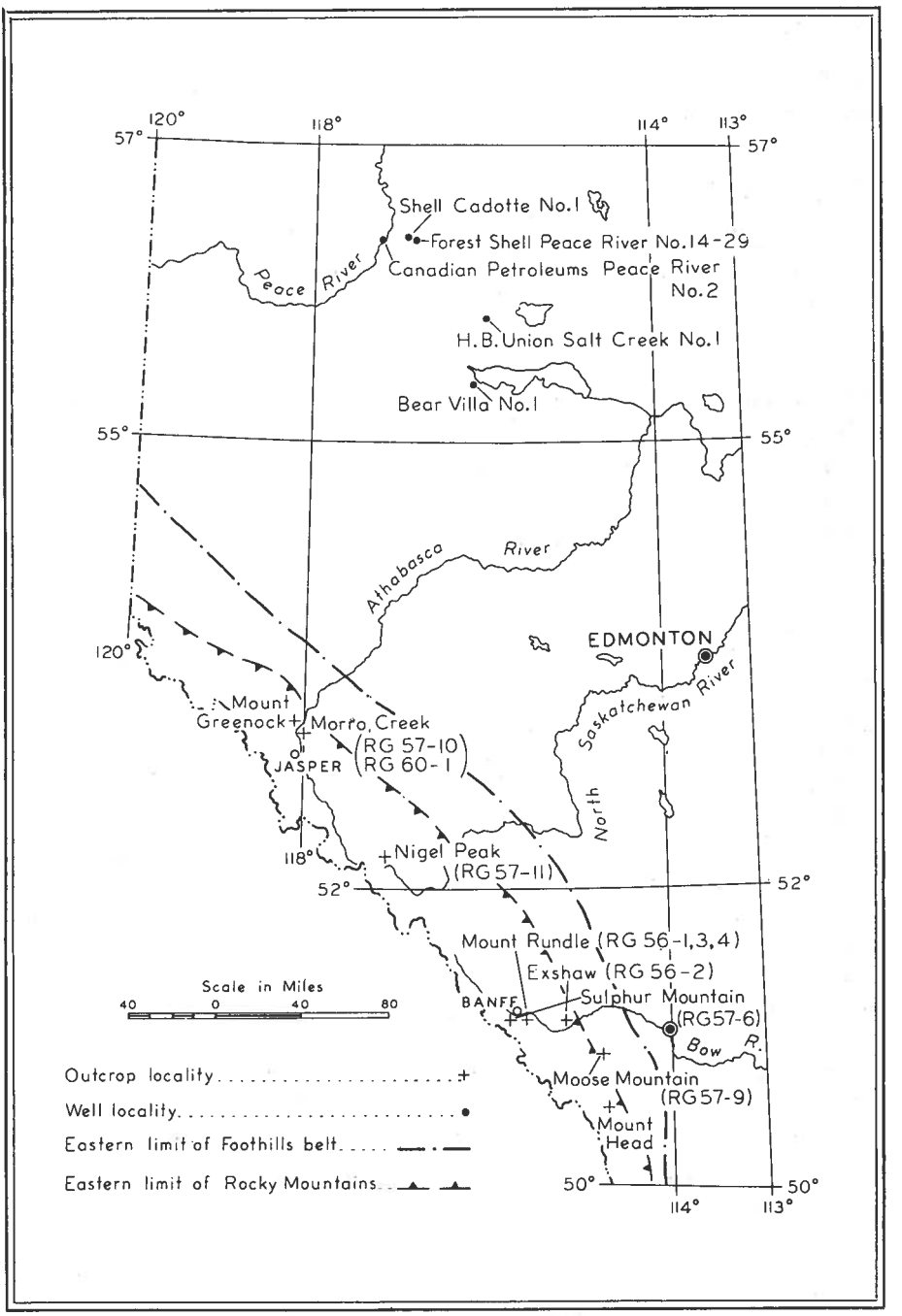

FIGURE 1. Index map of western Alberta showing locations of sampled outcrop sections and wells.

northward this "dark lime" unit attains sufficient significance to warrant a separate name and the term Shunda is applied to it. In the Bow Valley the Pekisko and Shunda Members become successively less distinctive when traced westward through successive fault blocks, and are only doubtfully recognizable westward from Exshaw (Fig. 1). Moore (1958) has suggested that the Pekisko of the Turner Valley and Moose Mountain areas is "at least partly homotaxial with" and an age equivalent of the Banff middle member of Warren (1927) and Clark (1949) (*not* of Beales, 1950) and that the Shunda is probably homotaxial with the upper member of the type Banff Formation.

North of the Bow River, in the central Foothills region, both Pekisko and Shunda units are given formational status. They are recognizable northward to and beyond the Athabasca River. In the Mount Greenock area (Fig. 1), adjacent to the Athabasca River near Jasper, Moore (1958) and Nelson and Rudy (1959) recognized probable Pekisko and Shunda equivalents in the lower part of Brown's (Brown, 1952) "Rundle Formation". Nelson and Rudy traced these units southward through the Mountains to where the Pekisko Formation lenses out about 10 miles north of Banff. On the basis of their study they consider that the Pekisko and Shunda Formations of the central Foothills and Mountains are faunally equivalent to the upper member of the type Banff Formation only. At Mount Greenock the Banff Formation below the Pekisko Member was divided by Nelson and Rudy into two members, denoted "A" and "B". These units are equated with the lower and middle members, respectively, of the type Banff Formation.

As in its type area the Pekisko Member is the basal unit of the Rundle Group, the base of this group is placed at the base of the Pekisko Member in the Mount Head area and at the base of the Pekisko Formation of the Plains and Foothills. On the other hand, at Banff the base of the Rundle Group is placed at the base of the Livingstone Formation (the top of the type Banff Formation). Accepting either Moore's or Nelson and Rudy's correlation, or both, it is apparent that the Banff Formation of the Jasper area and of the Plains—that below the Pekisko Formation—can be a time equivalent of only a part of the type Banff Formation. On this basis, Penner (1959) has proposed that "in order that it conforms to Plains usage" the Banff-Rundle contact be placed at the base of the Pekisko Formation of the Plains and, accepting Moore's (1958) correlation, at the base of Warren's middle member of the type Banff Formation. The redefined type Banff Formation must thus become the present lower member, 250 feet thick (Beales, 1950), plus the lowest 450 feet of the middle member of Beales.

Table 1. Rock Unit Nomenclature of the Type Banff Formation and Equivalent Strata

Banff area			Sunwapta Pass area		Mount Greenock area		Peace River region
Livingstone Formation			Turner Valley Formation		Turner Valley Formation		Debolt Formation
Banff Formation	Upper Member	Unit 6	Banff Formation	Upper Member	Shunda Formation		Shunda Formation
		Unit 5					
	Middle Member	Unit 4		Pekisko Member	Pekisko Formation		Pekisko Formation
		Unit 3		Member B	Banff Formation	Member B	Banff Formation
		Unit 2		Member A		Member A	
		Unit 1				Sandstone unit	
Exshaw Formation			Exshaw Formation				Exshaw Formation

This suggested usage is incorrect for several reasons:

(1) if the procedure is accepted, the type Banff-Rundle contact becomes potentially variable in position, depending upon which correlation of the Plains Pekisko Formation with the type section is accepted (cf. Moore, 1958; Nelson, 1961; Green, 1962);

(2) the proposed redefinition of the Banff and Rundle makes these formations time-rock units; a misuse of terminology;

(3) any redefinition should be made with respect to the type localities of the Banff and Rundle Formations; the type section of a formation should not be redefined with respect to other sections of the same formation;

(4) redefinition would make both the type Banff and type Rundle non-mappable units, for Penner's proposed type Banff-Rundle contact is a much less easily recognizable horizon than the original one.

Use of the mechanism of the arbitrary cutoff, as recommended by Moore (1958), is supported herein, and thus the Banff-Rundle contact is placed at the top of the type Banff Formation, and at the base of the Pekisko Formation where that unit is overlain by a formation of Shunda lithology.

DESCRIPTIONS OF COLLECTING LOCALITIES

Sections of the Banff Formation were sampled on Mount Rundle and Sulphur Mountain near the Town of Banff (Fig. 1). The lower member of the Banff Formation was also sampled near the Village of Exshaw (Fig. 1), and the exposed portion of the Banff Formation and the Pekisko and Shunda Formations were sampled at Moose Mountain, west of Bragg Creek, and at Morro Creek, north of the Town of Jasper. Descriptions of the stratigraphic successions at the various localities are given below.

Mount Rundle: Localities RG 56-1, 56-3, 56-4

The section of the type Banff Formation sampled on the north face of Mount Rundle (Fig. 2) is composite, consisting of three parts which are located in three partially scree-filled gullies in Lsds. 6, 7, 8, 9, 10, Sec. 30, Tp. 25, R. 11, W. 5th Mer.

Access to the north face of Mount Rundle is from the golf course along the top of the Palliser Formation scarp, and across a series of scree-filled gullies; sections RG 56-1, RG 56-3 and RG 56-4 are located in the fourth, third and second gullies, respectively, the upper part of each section being a vertical cliff.

Approximately 200 feet between the base of section RG 56-1 and the top of the Devonian Palliser Formation are covered; this interval includes the Exshaw Formation. Section RG 56-1 is approximately 400 feet thick, and includes the upper part of the lower member and the lower part of the middle member of the Banff Formation. The uppermost bed sampled was traced westward along the base of the cliff at the top of the section into the next gully to the west in which section RG 56-3 was measured. Section RG 56-3 covers approximately 300 feet of strata, and extends to the top of the middle member of the Banff Formation. Section RG 56-4, some 600 feet thick, extends through the upper member of the Banff Formation and into the lower beds of the Rundle Group. Samples were taken at equal intervals throughout each of the three sections. Each sample consisted of chips taken over a 1-foot interval, and the unsampled interval averaged 4 feet.

The composite Banff section sampled totaled 1,321 feet, which, with the estimated 200-foot covered interval at the base, gives a total thickness for the Banff and Exshaw Formations of 1,451 feet, a figure that agrees closely with the 1,408-foot and 1,470-foot measurements of Warren (1927) and Beales (1950), respectively.

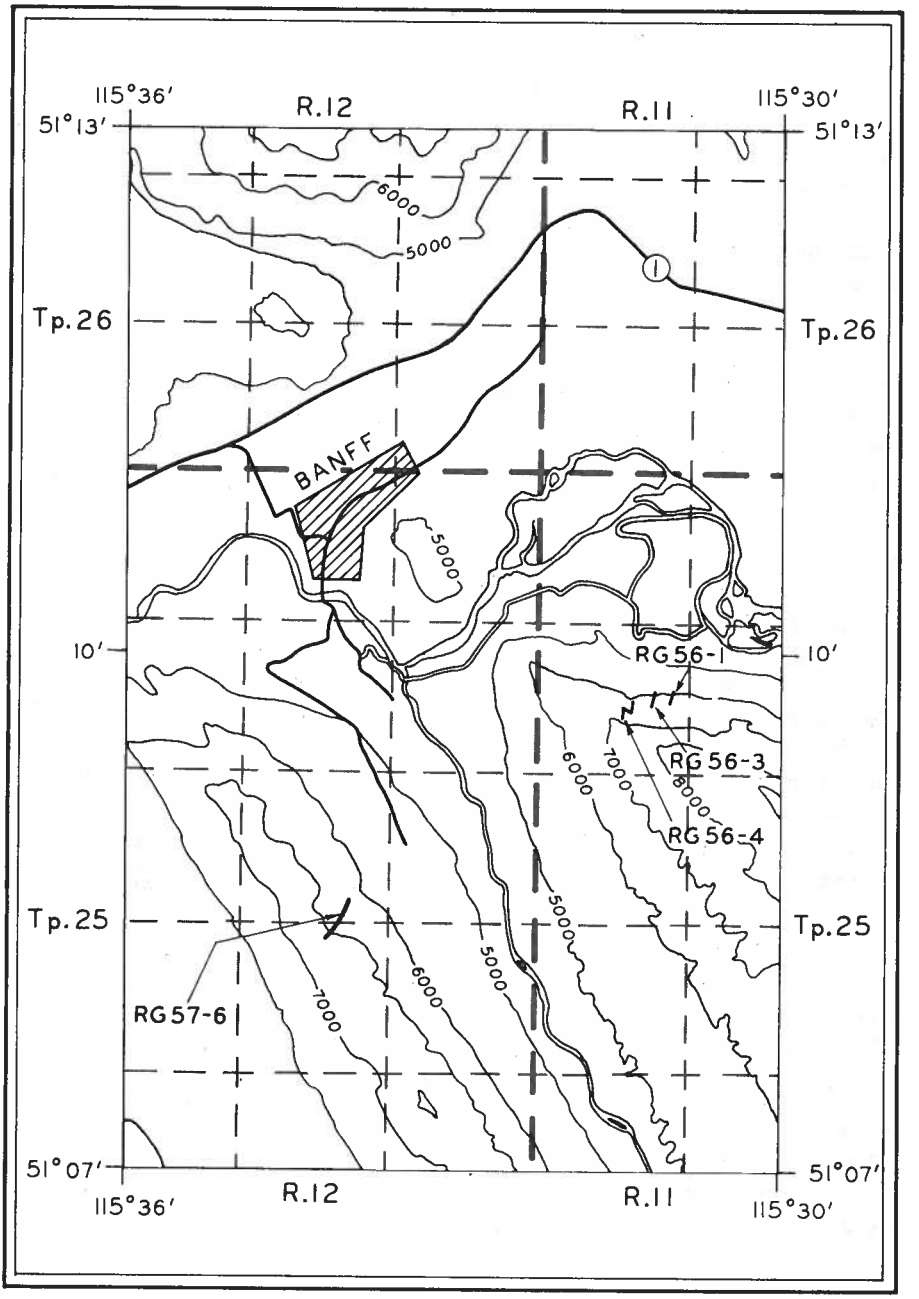

FIGURE 2. Locations of sampled sections in the Banff area. Sections RG 56-1, RG 56-3 and RG 56-4 comprise the Banff Formation type section; section RG 57-6 extends through the Banff Formation on Sulphur Mountain.

Exshaw: Locality RG 56-2

As most of the lower member of the type section of the Banff Formation was obscured, a relatively complete section through this unit, and through the lower half of the middle member, was sampled in the vicinity of Exshaw (Fig. 1). The section is exposed along the old Calgary-Banff highway one-half mile west of the Exshaw cement plant quarry (NW. ¼, Sec. 24, Tp. 24, R. 9, W. 5th Mer.) and begins in the massive silty beds immediately overlying the Exshaw Formation. The beds are relatively well exposed, and dip westward at approximately 45 degrees. The sampled interval totaled 540 feet and sampling was carried out at 5-foot intervals as on the type Banff section. The uppermost, intermittently exposed beds were not measured or sampled. Beach (1943) states that the section along the Banff highway west of Exshaw measured 614 feet (p. 43), and that a section three-quarters of a mile west of Exshaw totaled 584 feet (p. 44).

Moose Mountain: Locality RG 57-9

The section of Mississippian strata exposed in the Moose Mountain dome along Canyon Creek (Secs. 28, 29, Tp. 22, R. 6, W. 5th Mer.) (Fig. 1) has been examined by a number of geologists. In the centre of the dome the basal beds of the Banff Formation are not exposed, but well logs indicate them to be about 200 feet thick (Beach, 1943; Woodward *et al.*, 1959). Beach's measurement of the Banff Formation (up to the base of the Pekisko Formation) indicated a total thickness of 510 feet; Woodward *et al.* (1959) indicated an exposed thickness of close to 400 feet, and the measurement on the east side of the dome during the course of sampling for this study gave a thickness of 427 feet. Thus Fox's (1954) figure of 205 feet of exposed beds on the east limb of the dome appears somewhat low.

Through the Moose Mountain section 1-foot channel samples were collected, in the manner previously indicated, at 5- or 10-foot intervals or at significant changes in lithology. The Pekisko and Shunda Formations, with thicknesses of 340 and 187 feet, respectively, were sampled in the same manner.

Jasper: Localities RG 57-10, RG 60-1

A relatively complete section of the Banff, Pekisko and Shunda Formations was sampled on Morro Creek, a tributary of the Athabasca River (W. ½, Sec. 3, Tp. 47, R. 1, W. 6th Mer.) (Fig. 1). In this area the Exshaw Formation is absent and, as indicated by DeWit

and McLaren (1950), a thin sandstone bed at the base of the Banff Formation rests directly on the Devonian Palliser Formation. Brown (1952) measured the section along Morro Creek and his publication was used as a guide in sampling. The top of the lower member of the Banff Formation (member A) was placed at 177 feet above the base, following the usage of Nelson and Rudy (1959). Samples (RG 60-1) were taken at 20-foot intervals through the section, or at each distinct change in lithology. The total sampled interval comprised some 1,020 feet, positioning of the upper limit of the Shunda Formation being somewhat arbitrary.

In addition, spot samples (RG 57-10) were taken from an isolated outcrop of lower Banff beds 1,200 feet east-southeast of Athabasca Point. These beds lie 30 to 40 feet above the base of the Banff Formation and are exposed approximately one-half mile north of the Morro Creek section.

Sulphur Mountain: Locality RG 57-6

The section measured on Sulphur Mountain was described by Fox (1955), and is situated in the SE. ¼, Sec. 23, Tp. 25, R. 12, W. 5th Mer. (Fig. 2). The sampled section measured 1,424 feet, including some 100 feet of beds placed in the Exshaw Formation by Harker and McLaren (1958). On this basis the Banff Formation has a thickness of 1,324 feet. Samples were taken systematically at 10-foot intervals throughout.

Nigel Peak: Locality RG 57-11

A complete section of the Banff Formation is exposed on the west flank of Nigel Peak (Fig. 1), a mountain situated on the east side of Sunwapta Pass and on the boundary between Banff and Jasper National Parks. This section was described by Spreng (1953) who gave a thickness of 1,755 feet for the Banff Formation. The basal 250 feet of the formation are predominantly limy shale, above which limestone becomes more common in the next 630-foot interval. Spreng's "Cliff 1", 230 feet thick, is a coarse-grained crinoidal limestone and is probably the Pekisko equivalent (Green, 1962) (Table 1). Above this unit lie 740 feet of alternating shales and limestones; within this sequence, in the interval 1,180 to 1,310 feet above the formation base, a rich crinoid fauna is present, which has been described by Laudon, Parks and Spreng (1952).

This section was not sampled in detail, but a number of spot samples were taken throughout the sequence.

Peace River Region Wells

Samples from several wells in the Peace River region (Fig. 1) were examined during the course of this study.

In Bear Villa No. 1 well (Lsd. 7, Sec. 8, Tp. 74, R. 14, W. 5th Mer.), much of the Mississippian portion of the section was cored; the rock units penetrated in this well include the lower part of the Debolt Formation, the Shunda equivalent, the Pekisko, Banff and Exshaw Formations. The cored intervals ranged from 5 to 20 feet, and one composite sample from each interval was studied.

An incomplete set of 32 drill-cuttings samples was obtained from Canadian Petroleums Peace River No. 2 well (Lsd. 1, Sec. 11, Tp. 85, R. 21, W. 5th Mer.). The intervals sampled ranged from 1 to 5 feet, and were of the Debolt, Pekisko and Banff Formations, and of the Shunda Formation equivalent. Limited numbers of ostracode-bearing drilling cuttings were also obtained from three other wells: nine samples from Forest Shell Peace River No. 14-29 well (Lsd. 14, Sec. 29, Tp. 85, R. 18, W. 5th Mer.), seven samples from Shell Cadotte No. 1 well (Lsd. 16, Sec. 23, Tp. 85, R. 19, W. 5th Mer.) and two samples from Hudson's Bay Union Salt Creek No. 1 well (Lsd. 12, Sec. 9, Tp. 79, R. 13, W. 5th Mer.).

LABORATORY TECHNIQUES

The majority of the samples of Banff Formation sediments from the Mountains sections consisted of fine-grained, hard, brittle, carbonate rocks with a varying silica content. Standard micropaleontological techniques, such as crushing to obtain disaggregation, were unsuccessful in separating microfossils from these rocks and an acid disintegration method, found to be the most successful, has been generally applied.

Samples were crushed to fragments less than one inch in diameter, and 200 to 300 gram portions were placed in dilute (5 to 10 per cent by volume) hydrochloric acid. New acid was added as the rate of reaction decreased. When the sample had disintegrated, or when new acid failed to induce effervescence, the residue was gently washed through sieves, dried, and examined for microfossil content. Of the samples from the type Banff Formation, over 75 per cent contained silicified organic fragments. Of 13 selected samples from the Sulphur Mountain section only one contained silicified organic fragments; for this reason the Sulphur Mountain section was not studied in detail.

The samples from the Moose Mountain section typically consisted of hard, well-indurated rocks with no silicified organic material, and little success has been achieved in extracting microfaunas from these sediments.

Most of the light-colored shaly rocks from the Peace River region were easily broken down by boiling in water. The hardest, more limy samples were disintegrated by crushing, or by soaking in water, boiling and then agitating in a Waring blendor. Considerable damage was inflicted on the microfossils during extended periods of agitation in the blendor.

In general, the silicified microfossils are preserved in white translucent silica, commonly with adventitious silica grains adhering to the surface. Details of structure and ornamentation were often difficult to discern and evaluate initially. Much of this difficulty was overcome by coating the fossil material with ammonium chloride for general study purposes, as well as for photography.

The photographs of the microfauna reproduced herein were taken with a Zeiss Photomicroscope, using a Leitz 42 mm. Microsummar lens; two spotlights gave incident illumination.

CARBONATES OF THE TYPE BANFF FORMATION

Mineral Composition

Data obtained from microscopic examination, X-ray diffraction powder patterns, and acid treatment of selected samples show that the rocks of the Banff Formation are predominantly fine-grained limestones, commonly with significant amounts of silt-size quartz, and with minor amounts of dolomite, clay minerals, feldspar, pyrite and organic matter.

The most abundant detrital constituent is very fine grained calcite which has been mixed with minor amounts of clay minerals and silt-size corroded quartz and feldspar to form fine-grained to finely laminated micrites (Folk, 1959). Varying amounts of coarser bioclastic fragments may also be present. The origin of the calcite matrix is uncertain, but some may have been derived from the breaking up of fossil debris; part appears to have been derived by recrystallization, as in some instances "ghosts" of fossil fragments are discernible.

The proportion of quartz to feldspar is uncertain, although interpretation of X-ray diffraction powder patterns indicates that quartz is the more abundant constituent. Some feldspar grains show cross-hatch twinning characteristic of microcline, but the mineralogic nature of most grains has not been determined.

An X-ray diffraction powder pattern of the oriented clay fraction of one untreated sample shows that clay minerals of the illite group are present in association with trace amounts of chlorite. The presence of illite-group minerals was also indicated in most X-ray diffraction powder patterns of acid-insoluble residues. Detrital grains of micaceous minerals were noted in some samples.

Finely disseminated organic carbon is a ubiquitous constituent, and from some samples small quantities of kerogens have been recovered (R. M. Elofson, pers. comm.). The organic matter probably does not exceed one or two per cent, but it is this component that imparts the dark grey to black color to the rocks.

Some of the rocks show selective replacement by silt-size dolomite rhombs, although the mineral does not exceed about five per cent in most samples. The other main authigenic constituent is pyrite or marcasite, present as small octahedra and crystal aggregates in most samples, and commonly partly altered to red iron oxides.

Selective replacement of organic fragments by single quartz crystals or crystal aggregates is a common feature. The amount of replacement varies among samples, ranging from nil to complete replacement of all organic fragments; replacement of individual fragments varies from complete to incomplete. Some replacement of patches and lenses of the calcite matrix by quartz crystal aggregates is apparent, and some samples are predominantly acid-insoluble; in these it is difficult to determine whether the rock was originally a siltstone, or whether it constitutes an almost complete replacement of a calcite rock by silica.

Dark-brown to black chert nodules, discrete or in layers, and siliceous or cherty segregations are common. Lamination is continuous from the adjacent carbonate through the chert nodules, and the only differences in appearance between the nodules and the adjacent carbonate are the darker color of the nodules and the common presence of sponge spicules within the nodules. Contacts between the carbonate and the chert nodules are typically gradational.

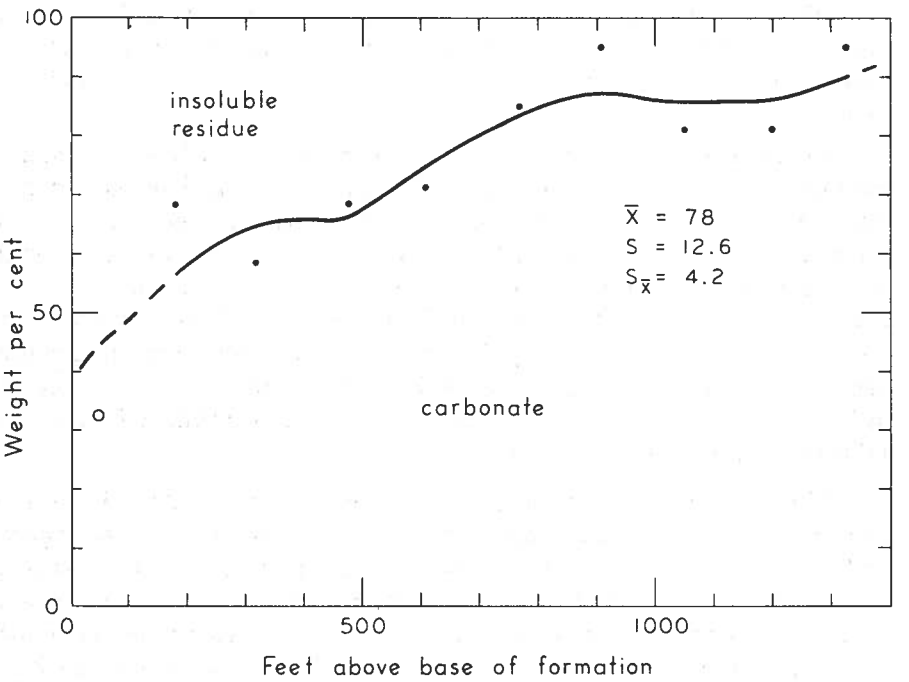

FIGURE 8. Variation in carbonate content of nine selected samples from the type Banff Formation. The tenth (lowest) sample is considered representative of the basal siltstone unit and was obtained from the section west of Exshaw.

Variation in Carbonate Content

A general idea of the vertical variation in carbonate content of the rocks was obtained from acid treatment of nine selected samples. The weight of the soluble residue, assumed to be carbonate minerals, averages 78 per cent, ranging between 58 and 96 per cent. A tenth sample, from the basal silty unit of the Banff Formation at Exshaw, contained an estimated 33 per cent carbonate. The carbonate content appears to increase upward through the type section (Fig. 3), and is over 95 per cent where the Banff Formation grades into the overlying Livingstone Formation.

With the exception of the sample from Exshaw, all samples fall within the category of limestone. It is thus apparent that application of the term "shale" to the Banff strata is based upon the thin-bedded nature and dark color of the rocks and upon their platy or shaly weathering habit.

Lithologic Facies

Illing (1959) and Walpole and Carozzi (1961) made lithological studies of Alberta Mississippian sediments, established a number of facies classes, and interpreted these in terms of depositional environment.

In the Moose Mountain section (Illing, 1959) much of the Banff Formation consists of "limy and silty shales and argillaceous cherty limestone composed of a lime-paste with scattered fossils and fossil relics". These sediments (Phase A) are considered to be normal marine limestones formed under anaerobic bottom conditions, and below wave base. The black nodular chert and preservation of silicified fossil debris are considered to indicate an early diagenetic origin for the chert. Illing considers that the sediments become lighter colored, coarser grained, and contain more organic fragments (Phase B) towards wave base.

Walpole and Carozzi (1961) recognized essentially the same lithofacies classes as did Illing. Their "microfacies 1", the equivalent of Illing's "Phase A", consists of dark-grey, argillaceous, thin-bedded, very fine grained biocalcarenite to biocalcisiltite. Crinoid fragments, sponge spicules and ostracode fragments are stated to be the most abundant detrital components. The dark color of the rock is derived from the groundmass, which is either a very fine grained bioclastic matrix (comminuted organic detritus), or a cryptocrystalline cement —suggested to be the product of recrystallization of the bioclastic matrix. Argillaceous and pyritic material may be present. These authors suggest that all of the bioclastic components are trans-

ported seaward from shoal areas by wave and current action, apparent differences of biologic association in different facies being accounted for by current sorting. Thus in "microfacies 1" sponge spicules and ostracode fragments may be present in substantial quantity.

The major portion of the sediments of the type Banff section may be placed in Illing's "Phase A" and Walpole and Carozzi's "microfacies 1". Only in the uppermost 100 feet do shallower-water facies appear, gradational to the coarse-grained biocalcarenites of the overlying Livingstone Formation. Within the open-marine limestone facies several distinctive but intergradational subfacies can be recognized. These are as follows:

(1) very fine grained limestone and silty limestone, well sorted, laminated, unfossiliferous

(2) very fine grained limestone and silty limestone, well sorted, partly laminated, with fine-grained organic detritus, mainly spines

(3) fine-grained limestone and silty limestone, well sorted, unlaminated, with scattered larger organic fragments in a groundmass of fine-grained organic detritus

(4) fine-grained limestone and silty limestone, containing 10 to 50 per cent larger fossil fragments.

In the laminated, unfossiliferous limestones any finely comminuted organic detritus originally present is no longer recognizable due to recrystallization.

In the very fine grained rocks with recognizable organic detritus, spines predominate, with lesser quantities of ostracode valves and echinoderm fragments. Sponge spicules were seldom recovered from insoluble residues, and most of the cylindrical objects consist of fine hollow spines, up to 1 centimetre in length. From some of the coarser-grained rocks, fragments of brachiopod valves with attached fine spines were recovered, and it is thus considered that the hollow spines are predominantly brachiopod detritus. Sponge spicules were recognized mainly in thin sections cut through chert nodules.

The fine-grained limestones with organic fragments of several sizes are the most common lithologic type in the Banff Formation. The predominant fine-grained organic detritus consists of hollow spines, ostracodes and crinoid fragments, while crinoid, echinoid, brachiopod and bryozoan fragments comprise the larger organic fragments. The ostracodes are present mainly as single valves, but in some instances as complete carapaces. Little evidence of attrition

is apparent, as fine spines, frills and other delicate features of surface ornament are commonly unbroken. Crinoid ossicles and columnals are generally disarticulated, but in many cases show little evidence of wear. Complete shells of embryonic brachiopods are not uncommon, but single, broken valves of mature individuals are typical. Bryozoan fragments are also present.

The fine-grained limestones with significant amounts of larger organic fragments are gradational to the biocalcarenites with fine-grained matrix. The kinds of organic fragments present are essentially the same as in the other lithologic types, but the proportions differ. Crinoid fragments are the most abundant, and echinoid and brachiopod remains are also common. Ostracodes are common in some samples, and typically consist of somewhat different forms than in the finer-grained limestones, larger species predominating. Bryozoa, gastropods, pelecypods and single corals may be present, either complete or as fragments. Evidence of attrition is more abundant in those rocks with higher percentages of large organic fragments.

Stratigraphic Variation of Lithologic Facies

The basal beds of the type Banff Formation were not exposed in the section measured. Samples from other sections suggest that these strata are probably calcareous siltstones with a moderate clay content.

The upper beds of the lower member (unit 2, Fig. 4) are predominantly very fine grained, laminated, silty limestones with fine-grained organic detritus. In the lower 300 feet of the middle member (unit 3, Fig. 4) these very fine grained silty limestones still predominate, but alternate with fine-grained, silty limestones with scattered larger organic fragments. This latter lithologic type predominates from about 300 to 500 feet above the base of the middle member, where silt content decreases, and in the upper 100 feet (unit 4, Fig. 4) of the member larger fossil fragments and complete fossils become more common.

Through the lowest 100 feet of the upper member (unit 5, Fig. 4) there is a relatively sharp return to very fine grained, laminated, unfossiliferous limestones alternating with silty limestones of the same class. This lithologic type and the laminated limestones with fine-grained organic detritus predominate through the lowest 350 feet of the upper member, their silt content being variable. The upper 250 feet of the upper member (unit 6, Fig. 4) exhibit a gradual and continuous change from limestones with fine-

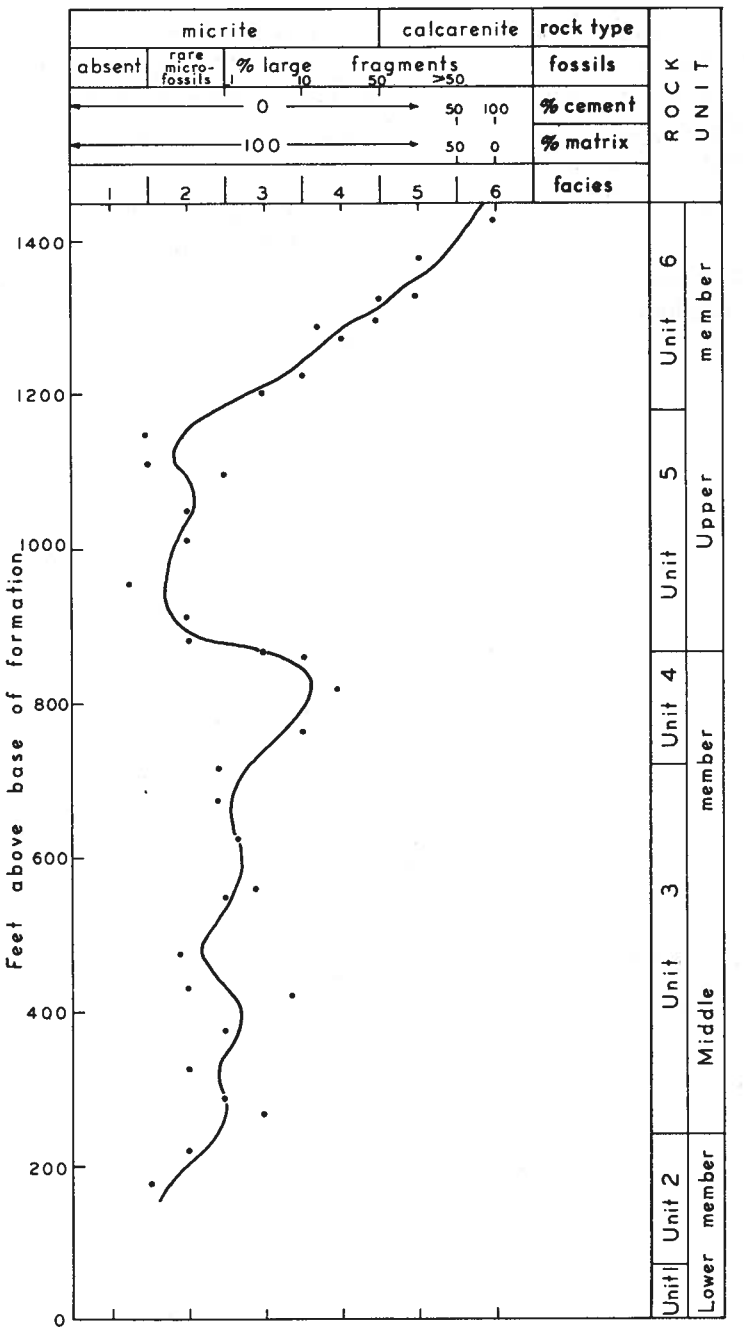

FIGURE 4. Stratigraphic variation in lithologic facies of the type Banff Formation. The points represent individual determinations made from thin section study; the line represents the average facies type and was constructed using the method of moving averages.

grained organic detritus to biocalcarenites with a fine-grained organic matrix in the uppermost beds of the formation. In general the silt content decreases, but uncommon beds of calcareous and dolomitic siltstone to fine-grained calcareous sandstone are present in the upper half of this unit.

Dolomite is present throughout the formation, but in significant amounts probably only in certain beds of the upper member. Thus the qualifying adjective "dolomitic" may be applicable to a number of the lithologic terms for this member.

DISTRIBUTION OF OSTRACODES IN THE TYPE BANFF FORMATION

Knowledge of the distribution of ostracodes in the rocks of the Banff Formation is limited by the methods used to determine their abundance in individual samples. Thus, although population counts are based on silicified material from acid-treated samples, microscope examination (p. 15) shows that secondary silicification of organic remains ranges from complete through partial to nonexistent. However, in 13 samples from which no silicified ostracodes were obtained, thin-section examination indicated the absence of ostracodes in 11 of these. Both samples containing nonsilicified ostracodes came from the uppermost 150 feet of the formation. It is then reasonable to assume that ostracode distribution data based on their silicified remains are correct for about 85 per cent of the samples.

Two hundred samples from the type section of the Banff Formation were acid treated to obtain silicified organic residues. Of these samples 158 were fossiliferous, and 121 contained ostracodes. Eleven samples came from the lower member and of these, 9 (82 per cent) contained ostracodes. From the middle member 67 of 100 samples contained ostracodes, and 45 (50 per cent) of 89 samples from the upper member. Thus, for the whole formation, 61 per cent of the samples contained silicified ostracodes.

The number of individual valves obtained from a 300-gram sample averaged about 30, and ranged from zero to approximately 600. These figures are much lower than those obtained by Echols and Gouty (1956) for ostracodes in four samples from the Fern Glen Formation of Missouri, which contained approximately 150 to 800 valves per 300 grams of sample. Relative numerical distributions of silicified ostracode valves are indicated in figure 5.

Ostracodes were recovered in small numbers from the very fine grained, even-grained limestones composed largely of comminuted organic detritus and in larger numbers from the fine-grained limestones with scattered (1-10% by area) larger organic fragments (cf. Figs. 4 and 5). Recovery was variable from fine-grained limestones with 10 to 50 per cent organic fragments; in general, smaller numbers of ostracodes were present in those rocks with the higher percentages of organic fragmental material. No ostracodes were obtained from the very fine grained, laminated limestones and siltstones, nor from the biocalcarenites in the uppermost 150 feet of the formation. Little secondary silicification is present in the biocalcarenites, and it also appears that delicate organic material such as ostracode tests was comminuted in those rocks containing abundant large fossil fragments.

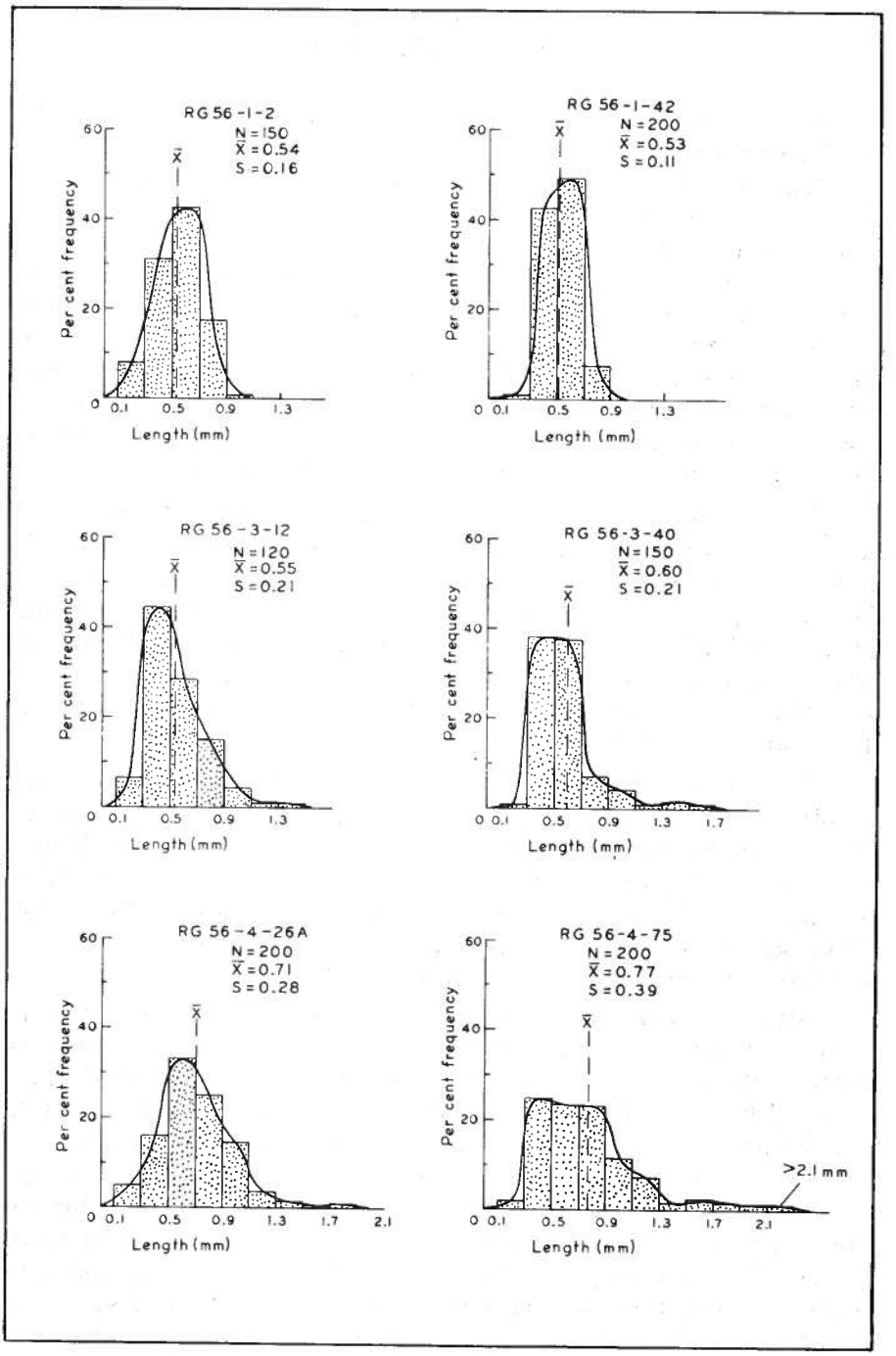

FIGURE 6. Size-frequency histograms and curves of the long dimensions of ostracodes in six selected samples from the type Banff Formation.

Factors Controlling Distribution

The data show that there is a definite relationship between ostracode frequency and rock types of the Banff Formation. The underlying causes of this relationship are not, however, immediately obvious, as the observed distribution of the fossils is a function of:

(1) biological (genetic) factors
(2) environmental (ecologic) factors
(3) processes of sedimentation (current sorting)
(4) preservation (silicification).

The initial population size-distribution of the organisms is first determined by biological and environmental factors and is then modified by physical and chemical processes of sedimentation and lithification to produce that distribution now observed in the rocks. It is therefore necessary to evaluate the effect of sedimentary processes and lithification on the present distribution of the organisms before attempting to interpret their evolutionary and ecologic significance.

The gross lithologic facies of the Banff Formation appear to reflect fluctuations in current sorting, giving rise to a series of gradational rock types largely characterized by differences in grain size and thus in part by bioclastic content. As the ostracode carapaces and valves are also bioclastic "grains", they would presumably be carried by currents along with the other detritus, their initial size-frequency distribution being modified by processes of sorting. If this theory is correct, the mean size of the ostracodes should vary with changes in lithology.

To test this hypothesis, the sizes of silicified ostracodes from three types of rock were measured. The ostracodes are from six samples, two from each of the three main lithologic facies: very fine grained, well-sorted limestones; fine-grained limestones with less than 10 per cent large organic fragments; and fine-grained limestones with 10 to 50 per cent large organic fragments. For each sample the long dimension of more than 100 randomly selected ostracodes was measured (Table 2), and size-frequency histograms and curves of the data were constructed (Fig. 6).

The mean sizes of the ostracodes in the samples (Fig. 6) do show a variation with change in lithology and visual inspection of the histograms suggests that the size distributions of the ostracodes also differ among the three lithologies. The significance of these differences was determined by grouping the data of table 2 into the 3 x 5

Table 2. Size-Class Distributions of Long Dimensions of Ostracodes from Six Selected Samples of the Type Banff Formation

Class interval (mm.)	Lithofacies 2				Lithofacies 3				Lithofacies 4			
	56-1-2		56-1-42		56-3-12		56-3-40		56-4-26A		56-4-75	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0.1 - 0.2	1	0.7	0	0.0	1	0.8	0	0.0	1	0.5	0	0.0
0.2 - 0.3	11	7.3	2	1.0	7	5.8	1	0.8	9	4.5	4	1.9
0.3 - 0.4	15	10.0	12	6.0	14	11.7	8	5.3	7	3.5	14	6.7
0.4 - 0.5	32	21.3	73	36.5	39	32.6	49	32.6	25	12.5	38	18.1
0.5 - 0.6	41	27.3	80	40.0	24	20.0	36	24.0	43	21.5	28	13.3
0.6 - 0.7	23	15.3	18	9.0	10	8.3	20	13.3	23	11.5	22	10.5
0.7 - 0.8	16	10.7	10	5.0	12	10.0	17	11.1	25	12.5	28	13.3
0.8 - 0.9	10	6.7	5	2.5	6	5.0	9	6.0	25	12.5	21	10.0
0.9 - 1.0	1	0.7	—	—	2	1.7	3	2.0	11	5.5	13	6.2
1.0 - 1.1	—	—	—	—	3	2.5	3	2.0	18	9.0	11	5.2
1.1 - 1.2	—	—	—	—	0	0.0	0	0.0	4	2.0	7	3.3
1.2 - 1.3	—	—	—	—	1	0.8	1	0.8	3	1.5	8	3.8
1.3 - 1.4	—	—	—	—	1	0.8	2	1.3	3	1.5	3	1.4
1.4 - 1.5	—	—	—	—	—	—	0	0.0	0	0.0	0	0.0
1.5 - 1.6	—	—	—	—	—	—	1	0.8	1	0.5	4	1.9
1.6 - 1.7	—	—	—	—	—	—	—	—	0	0.0	1	0.5
1.7 - 1.8	—	—	—	—	—	—	—	—	1	0.5	2	1.0
1.8 - 1.9	—	—	—	—	—	—	—	—	1	0.5	1	0.5
1.9 - 2.0	—	—	—	—	—	—	—	—	—	—	3	1.4
2.0 - 2.1	—	—	—	—	—	—	—	—	—	—	0	0.0
2.5 - 2.6	—	—	—	—	—	—	—	—	—	—	1	0.5
2.6 - 2.7	—	—	—	—	—	—	—	—	—	—	1	0.5
Total	150	100.0	200	100.0	120	100.0	150	100.0	200	100.0	210	100.0
Mean size (mm.)	0.54		0.53		0.55		0.60		0.71		0.77	
s(1)	0.16		0.11		0.21		0.21		0.28		0.39	

(1) standard deviation

contingency table shown in table 3, and by applying a chi-square test to the resulting frequencies. The calculated value of chi-square is 156.14, which for 8 degrees of freedom has a probability of less than 0.01. Thus, the size-frequency distributions of ostracodes in the three rock types are significantly different, the most conspicuous

Table 3. Contingency Table Showing the Size-Frequency Distribution of Ostracodes with Respect to Lithologic Type

Ostracode size-class interval (mm.)	Lithofacies			Total
	2	3	4	
0.1 - 0.4	41	31	35	107
0.4 - 0.6	226	148	134	508
0.6 - 0.8	67	59	98	224
0.8 - 1.0	16	20	70	106
>1.0	0	12	73	85
Total	350	270	410	1030

Chi-square = 156.14**; $p < 0.01$ for 8 degrees of freedom

differences occurring in the larger-size classes. As expected, most of the larger ostracodes are present in the two coarser-grained rock types, particularly in that with 10 to 50 per cent bioclastic detritus, thus indicating that at least some of the ostracode carapaces and

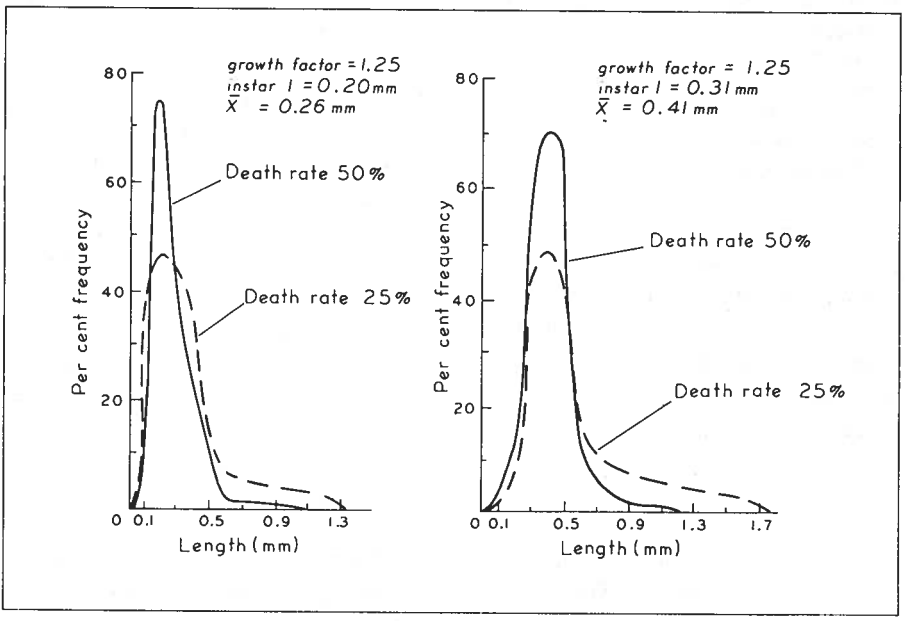

FIGURE 7. Theoretical size-frequency curves illustrating unmodified ostracode death assemblages.

valves were transported into their present positions in the rocks wherein they are now preserved.

If current sorting be accepted as a modifying factor, then there is question as to whether any one fossil assemblage represents an unmodified death assemblage. To answer this, a series of frequency curves was constructed (Fig. 7), which portray theoretically non-sorted (unmodified) assemblages. The curves are based on theoretical death rates and theoretical initial instar sizes, with an assumed growth rate of 1.25 in the length dimension from one instar to the next. Also, a similar frequency curve was constructed from Spjeldnaes' (1951) data on *Beyrichia jonesi* Boll (Fig. 8), the theoretical curve being based upon a growth factor of 1.28 and a mean death rate of 32 per cent. All of these curves are markedly skewed towards the larger-size classes, the length of the "tail" varying in size and shape. None of the frequency curves based on ostracode assemblages from the Banff Formation closely resembles the theoretical curves (Fig. 8), and thus it may be concluded that none of those assemblages represents an unmodified death assemblage.

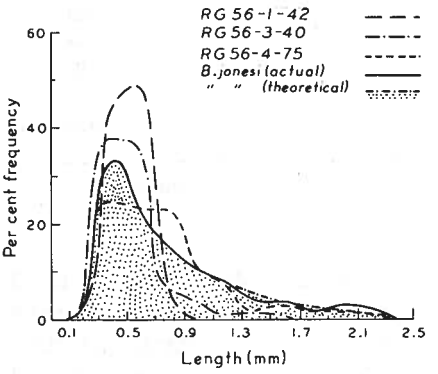

FIGURE 8. Comparison of actual and theoretical size-frequency curves for Beyrichia jonesi *(Boll) with size-frequency curves for Banff Formation ostracodes. The data for* Beyrichia jonesi *(Boll) were obtained from Spjeldnaes (1951).*

It then remains to be determined whether the size-frequency curves based on the observed data represent modified death assemblages or wholly resorted assemblages deposited in a foreign environment. This is a question of determination of the degree of modification of the original natural assemblages by current action. If a death assemblage on the sea floor is modified by a current action, then the following situations may prevail:

(1) strong currents: complete removal of the ostracodes, sorting, and redeposition in a foreign environment;

(2) moderate currents: removal of the small- and medium-size fractions of the assemblage; new material may be added to the large-size fraction;

(3) gentle currents: removal of the small-size fraction, possible addition of new material to the medium-size

fraction; the large-size fraction remains essentially unmodified;

(4) very gentle currents: possible addition of new material to the small-size fraction; the medium- and large-size fractions remain essentially unmodified.

The original fossil assemblages will thus be wholly destroyed by strong current action, but only partly destroyed by moderate to weak currents. However, in order to interpret ecological variation among assemblages, the original and extraneous elements of the modified assemblages must be differentiated.

After modification by moderate currents, an assemblage may well consist of large individuals originally from one or several different environments. The original elements of such a mixed assemblage cannot be differentiated *per se*. The action of gentle currents leaves the large-size fraction unmodified, and very gentle currents leave both the large- and medium-size fractions unmodified. Thus, for assemblages affected by gentle to very gentle current action, the "tails" of the observed size-frequency curves should approximate that of a theoretical curve. If such an approximation is recognizable, then at least the large individuals of the assemblages should have ecologic significance. The comparison made in figure 8 suggests that the assemblage from lithofacies 4 (sample RG 56-4-75) is only slightly modified, and that that from lithofacies 3 (sample RG 56-3-40) has undergone somewhat more sorting modification.

Consideration should also be given to the ostracode material that is removed by current action. If this material is deposited in an environment where indigenous assemblages are already present, then it will augment certain size-fractions of those assemblages, as indicated above. If the ostracode material is carried into environments deleterious to ostracode life, then it will be deposited probably as moderately well sorted size fractions. Redeposited ostracode material will be recognizable as such in the small- and medium-size fractions by the absence of the large or adult individuals of the unmodified death assemblage, such as those of lithofacies 2 (see Fig. 6, samples RG 56-1-2, RG 56-1-42). An assemblage of predominantly large, well-sorted individuals, however, may be extraneous to the rocks in which it is now preserved or may represent the unmodified remnant of an autochthonous death assemblage.

Limits of the Ostracode Environment

The absence of ostracodes from the very dark, very fine grained, laminated limestones (lithofacies 1, Fig. 4) is of significance with

respect to the environments in which the ostracodes lived. These laminated strata, as evidenced by their lithology, were deposited probably well below wave base in an environment with little water circulation and thus with a paucity of oxygen. Such an environment would not be conducive to ostracode life. The ostracode assemblages from lithofacies 2 (Fig. 4) are indicated above to be foreign to that lithofacies, which, by the absence of an indigenous assemblage, also consists of sediments deposited in an environment not conducive to ostracode life. The assemblages from lithofacies 3 and 4 (Fig. 4) have been categorized above as modified death assemblages. Lithofacies 5 consists of sediments of medium to coarse grain, which rarely contain ostracode valves. Lithofacies 6, consisting of coarse-grained sediments, also lacks ostracode valves. While it is theoretically possible that ostracodes lived in and adjacent to the sediments of these last-mentioned two lithofacies, the fact that the average grain size of the organic fragments of these calcarenites is considerably greater than the average size of ostracodes precludes the presence of relatively thin shelled crustaceans, at least during the time of sediment deposition.

It may then be concluded that the life environment of most of the Banff Formation ostracodes was in or adjacent to the fine-grained (silt size) and fine- to medium-grained (silt to sand size) sediments of lithofacies 3 and 4. The ostracodes were absent from the very fine grained (fine silt to ?clay size) sediments of lithofacies 1 and 2 because of unsuitable ecologic conditions. They were also predominantly absent from the medium- to coarse-grained (medium to coarse sand-size) sediments because of an unsuitable substratum and probable strong water agitation.

These conclusions must, however, be qualified by two other points not yet considered. The first is that the observed size-frequency distribution curves of the ostracodes represent only a selected part of the total clastic fraction of the sediments considered, except for the assemblages from lithofacies 2. Thus the ostracode valves form only part of a relatively well sorted sediment, and it may be that the resemblance of the size-frequency distribution curves to those of theoretical modified death assemblages is purely fortuitous. If this should be the case, then no ostracode assemblage is necessarily indicative or representative of the former indigenous population, nor can they be used with confidence to make any interpretation of original ecologic conditions. The preservation of delicate ornamental features, however, militates against the probability of the ostracodes having been transported far from their original habitat or habitats.

The second point to be taken into account is that the data on which the discussion is based have been affected by other factors not

considered, such as speciation, variation in growth rates, in initial instar sizes and in death rates, differences in ecologic association, variation in valve shape and form, the destructive effects of scavengers, imperfect sampling techniques, and so on. It is not possible to consider all of these factors in interpreting the size-frequency distributions of the Banff ostracodes using the data at hand, and the interpretation of the distributions discussed above must therefore be considered somewhat tentative.

Even so, the rationality of part of the discussion is difficult to refute: that the life environment of the ostracodes lay between the depositional environments of the coarse-grained calcarenites and of the fine-grained laminated limestones. This being so, then it is entirely possible that modified death assemblages might be present in the rocks representing the intervening lithofacies and environments.

ASSOCIATIONS AMONG THE OSTRACODES

The work of several investigators (Benson, 1959; Swain, 1955; Elofson, 1941) indicates that Recent marine ostracodes typically characterize distinct biocoenoses. Benson's work off the west coast of Mexico illustrates the possibility of recognition of biofacies in recent sediments on the basis of ostracodes alone. Benson *(ibid.,* Fig. 11) presents quantitative data on the Recent ostracode distributions, but makes qualitative interpretation of them. On the other hand, Johnson (1962) has applied statistical analysis to quantitative data for a Recent molluscan community to illustrate applicability of the procedure and ecologic significance of the results. He next applied the same technique to data for Pennsylvanian fossils from western Illinois. As Johnson pointed out, it is the exception rather than the rule that evidence of original or primary association is found in fossil assemblages. Thus some objective method or methods must be used to determine the existence and significance of any recurring association of fossil taxa. A statistical analysis is the best method of achieving this.

Johnson stated (p. 33), "The method of analysis used here is based on the simple assumption that animals that lived together will more often be preserved together than animals that lived apart. Ecological factors are expected to affect the joint occurrences of two species in a more consistent way than factors influencing accumulation and preservation. The forces and processes involved in the transportation and preservation of shells can be selective with regard to size, shape, and composition of remains. It seems unlikely that such processes could result in a large number of joint occurrences of two species that had not lived together. It is less probable that such processes could produce the consistent associations of many species as found in this study." This statement is particularly applicable to the data for the Banff Formation ostracodes, as these comprise a fossil group of essentially the same type and size range, and as such will be less strongly affected by sorting processes than will a fossil group composed of several taxa with a wider range of size and shape.

On this basis then, although it has been shown in the previous section that most of the death assemblages of the Banff Formation ostracodes have been modified, and that some—if not all—assemblages have been brought into the rocks in which they are now preserved, it is still probable that associations of various taxa will have some ecologic significance. Evaluation of this significance for the data available has been made by use of a chi-square test using the same procedure as that of Johnson (1962). For any two taxa, data are grouped in a 2 by 2 contingency table, based on their presence

in and absence from the total number of fossiliferous samples (Table 4). In the example given, species of the genus *Geffenina* are present in 35 out of 75 samples in which ostracodes are identifiable; *Cribroconcha* is present in 12 samples. Species of the two genera occur together in 10 samples and are absent from 38 samples. The calculated value of chi-square is 6.06, which for one degree of freedom has a probability of less than 0.05. Thus the occurrence together of species of these two genera is significant, and the null hypothesis that they are not associated is rejected. A significant value of chi-square may also be obtained (Table 5) if two taxa tend not to be associated (negative association).

Table 4. Contingency Table Showing the Distribution of *Geffenina* and *Cribroconcha* in Seventy-five Banff Formation Samples

TAXON		*Geffenina* present	*Geffenina* absent	Total
Cribroconcha	present	10	2	12
	absent	25	38	63
Total		35	40	75

Chi-square = 6.06*; $p < 0.05$ for 1 degree of freedom

Table 5. Contingency Table Showing the Distribution of *Geffenina* and *Beyrichiopsis glyptopleuroides* in Seventy-five Banff Formation Samples

TAXON		*Geffenina* present	*Geffenina* absent	Total
Beyrichiopsis glyptopleuroides	present	11	23	34
	absent	24	17	41
Total		35	40	75

Chi-square = 6.22*; $p < 0.05$ for 1 degree of freedom

A qualitative aspect must be introduced, by necessity, into this statistical interpretation, for as has been pointed out by several workers (e.g. Fager, 1957; Johnson, 1962) two taxa that are present

in a large number of samples will show little or no association, whilst two taxa that occur together rarely may show significant association if they are absent from a large number of samples. Chi-square values may be determined from table 6, following the method used by Siegel (1956, p. 107), by use of the formula illustrated. If N is large, then a large chi-square value is dependent upon a large value of AD (positive association) or of BC (negative association). Where two taxa are present in most samples and are commonly associated, D is small, AD approaches BC and thus chi-square is small. Where two taxa occur only rarely, D will be large, AD will be large, and thus a large chi-square value will be indicated. The qualitative aspect is

Table 6. Contingency Table Showing Distribution of the Terms of the Chi-square Equation

A	B	A+B
C	D	C+D
A+C	B+D	N

$$\text{chi-square} = \frac{N\left[(AD - BC) - \frac{N}{2}\right]^2}{(A+B)(C+D)\ (A+C)(B+D)}$$

introduced in determining the lower limit of frequency of occurrence of any one taxon above which chi-square values may be considered as not distorted or inflated. As indicated by Johnson (*ibid.*), no test of significance for this has yet been devised.

A number of modifying factors also affect the frequencies of occurrence of the ostracode genera. The most important of these is probably that of preservation: where preservation was imperfect, then the strongly ornamented forms were the most easily identifiable, either on a specific or generic level, whilst smooth forms were in some cases wholly indeterminate. Also, in the finer-grained sediments where sorting action has been significant, small instars of the predominantly smooth species were not always identifiable. Thus smooth ostracodes tended to be specifically determinate more com-

	Bairdia	Mammoides	Acratia	Geffenina	Beyrichiopsis (s.l.)	Glyptopleura	Monoceratina	Beyrichiopsis (s.s.)	Cornigella	B. glyptopleuroides	Pseudoparaparchites	Editia	Amphissites	Cribroconcha	Craspedographylus	Paraparchites	Tetrasacculus	Kirkbya	Rectobairdia	Waylandella	Kirkbyellina	Knoxina	Moorites	Silenites	Discoidella	Coryellina	Kirkbyella	Acanthoscapha	Microcheilinella	Namaia	Pseudochilina	Richterina	Libumella	Halliella	Number of occurrences
Graphiadactylloides	27	25	24	20	19	14	16	16	14	6	11	8	9	4	7	6	6	5	5	5	7	5	3	5	5	2	4	3	1	1	1	2	1	1	44
Bairdia		21	22	24	16	14	12	10	11	9	11	8	6	5	8	7	5	5	3	7	5	4	2	4	4	2	4	2	2	2	2	1	1	1	35
Mammoides			20	19	18	11	10	13	10	8	9	7	8	7	6	9	7	5	2	6	4	4	3	3	3	2	4	3	1	1	0	0	0	0	36
Acratia				20	18	11	10	17	7	4	10	9	6	8	6	6	7	6	3	7	3	3	3	4	4	4	2	3	3	1	2	1	1	1	35
Geffenina					14	11	10	9	10	8	9	9	9	10	7	8	6	7	4	7	5	5	5	5	4	5	4	2	3	2	2	2	1	1	34
Beyrichiopsis (s.l.)						10	13	18	10	14	8	10	7	8	7	8	8	8	6	5	6	6	3	3	2	2	4	3	1	1	0	0	0	0	29
Glyptopleura							9	9	11	2	7	5	6	3	2	4	5	4	1	2	4	3	1	2	2	1	3	4	0	1	0	0	0	0	19
Monoceratina								13	9	2	5	6	6	3	2	4	5	6	2	3	5	4	1	2	2	1	4	2	0	1	0	1	1	0	19
Beyrichiopsis (s.s.)									4	3	7	4	3	8	4	7	3	6	6	5	5	6	3	3	1	2	3	2	1	0	0	0	0	0	18
Cornigella										7	6	5	5	2	4	3	5	3	1	1	6	2	2	1	2	0	3	1	0	1	0	1	0	0	16
B. glyptopleuroides											3	8	7	2	5	4	7	5	3	2	2	2	1	2	2	1	2	3	1	1	0	0	0	0	14
Pseudoparaparchites												5	5	2	3	4	5	3	1	3	4	3	2	2	3	1	3	2	0	1	0	1	0	0	13
Editia													7	4	4	3	4	5	2	2	2	3	1	3	2	2	2	1	2	1	0	1	0	0	13
Amphissites														4	4	6	7	4	4	3	3	5	1	3	2	1	3	2	1	1	0	1	1	0	12
Cribroconcha															4	8	4	3	5	5	1	5	2	2	2	5	2	2	2	1	1	1	1	1	10
Craspedographylus																4	3	3	4	2	2	2	1	3	1	2	2	3	1	1	1	0	0	0	10
Paraparchites																	4	5	5	4	3	5	2	4	2	2	3	2	1	2	1	1	1	1	9
Tetrasacculus																		5	1	1	3	3	1	2	0	1	3	1	0	1	0	0	1	0	9
Kirkbya																			2	2	2	2	1	2	1	2	2	1	1	1	1	1	1	0	9
Rectobairdia																				4	1	2	1	2	1	2	2	2	1	1	1	0	0	0	8
Waylandella																					1	3	2	3	2	2	2	2	1	1	1	0	0	1	8
Kirkbyellina																						2	1	1	2	0	2	0	0	1	0	1	1	0	7
Knoxina																							1	2	2	1	3	1	0	1	0	0	0	0	6
Moorites																								0	2	0	1	3	1	1	0	0	0	0	6
Silenites																									1	3	2	2	1	2	1	0	0	1	5
Discoidella																										1	2	2	0	1	1	0	0	1	5
Coryellina																											1	2	1	1	1	0	0	1	5
Kirkbyella																												2	0	1	0	0	0	0	4
Acanthoscapha																													0	0	0	0	0	0	4
Microcheilinella																														0	0	1	1	0	3
Namaia																															1	0	0	1	2
Pseudochilina																																1	1	1	2
Richterina																																	1	1	2
Libumella																																		1	1
Halliella																																			1
Total possible number of occurrences																																			75

Table 7. Joint Occurrences of Thirty-three Genera and One Species in the Type Banff Formation

monly in the medium-grained than in the fine-grained sediments. It may then be that a restriction of certain taxa to medium-grained sediments is more apparent than real, and that this may lead to incorrect conclusions concerning local ranges and ecologic significance.

Grouping of the taxa into related forms was made in the manner outlined by Johnson (*ibid.*). The level of significance of chi-square values for grouping of taxa was placed at 0.5 per cent, the lowest level at which most of the taxa were bonded together.

Of the 158 fossiliferous samples from the Banff Formation, ostracodes were present in 121, determinate in 75. Data from these 75 samples were used in the analysis. Joint occurrences of 33 genera were tabulated (Table 7). Classification for this association study was made predominantly on a generic basis as individual specific occurrences are mainly low numerically, and thus would tend to give anomalously high chi-square values. The one species tabulated, *Beyrichiopsis glyptopleuroides,* is considered to represent a different lineage to that of other *Beyrichiopsis* species, and thus is classified separately. Chi-square values were calculated for each of 289 pairs among 25 taxa; the 8 remaining genera which occurred less than 5 times were not considered. Of the 289 possible pairs, 19 (for 18 genera) were positively associated at the 0.1 per cent level of significance, and 29 (for 20 genera) were positively associated at the 0.5 per cent level of significance; 2 pairs were negatively associated at the 2.5 per cent level of significance. Of the 5 genera and 1 species unassociated at the 0.5 per cent level, 2 entered association at the 1.0 per cent level, and 2 at the 2.5 per cent level. Of the 2 remaining genera, 1 entered association at the 5.0 per cent level, and the other remaining unassociated is particularly small in size, and thus is strongly subject to incomplete recovery in samples.

The genera were grouped together on a trial and error basis, and three groups were recognized (Fig. 9) ; Group I consists of 14 genera, Group II of 4 genera and Group III of 2 genera. A three-part subdivision of Group I appeared below the 0.1 per cent level ($\chi^2=10.83$) at the level of $\chi^2=20$, where a split into two pairs and one trio of associated genera developed (Fig. 10).

The distribution of selected genera with respect to lithofacies was examined and tested by means of the chi-square test. No correlation was found. In the light of conclusions drawn previously concerning the gross ostracode distribution relative to lithofacies—that lithofacies are correlative with size-frequency distributions of ostracodes—this is not unexpected.

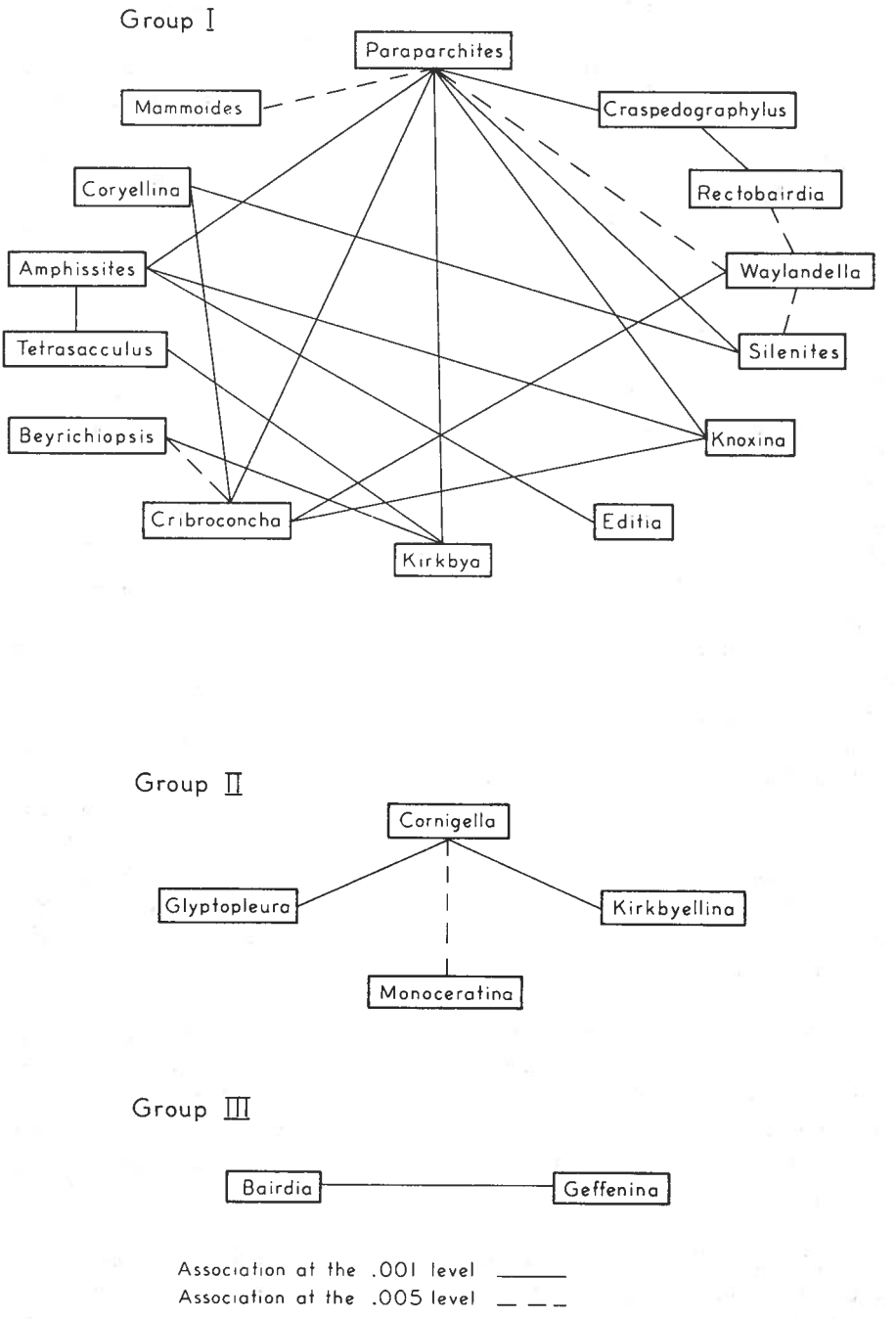

FIGURE 9. Association groups of genera from the type Banff Formation.

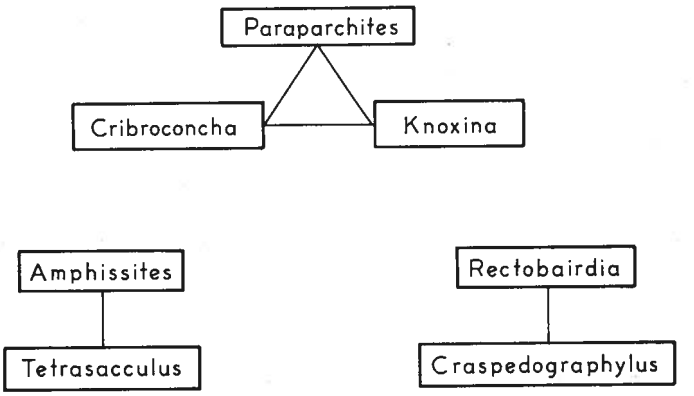

FIGURE 10. Subdivision of Group I at the level of significance for which the calculated value of chi-square is 20.

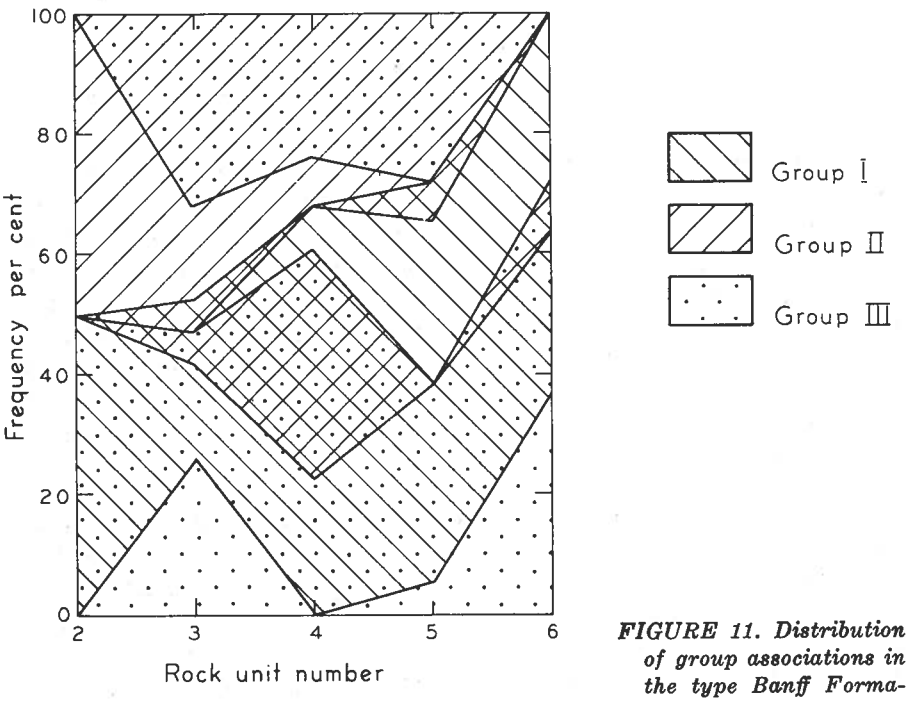

FIGURE 11. Distribution of group associations in the type Banff Formation.

The occurrences of members of the groups with respect to one another are tabulated in table 8. From this table it is apparent that members of Groups I and II seldom occur together and that members of Group III more commonly are associated with Group I and II members than not. These relationships are graphically portrayed on figure 11, in which group distributions relative to stratigraphic units are presented. Group I genera unassociated with other grouped genera occur predominantly in the upper member (units 5, 6), and unassociated Group II genera wholly in the lower and middle members (units 2, 3, 4). Group III genera occur throughout the formation, being present in almost 80 per cent of the samples considered.

Table 8. Numerical Distribution of Group Associations in the Type Banff Formation

Group	I	II	III	Total number of occurrences
I	9	2	16	34
II	2	5	14	28
III	16	14	10	47
	Group I + II + III	7		
	Number of samples	63		

Although these distinct groups exist, and although two groups tend to be present but unassociated in different parts of the formation, no relationship to any lithologic characteristic can be determined statistically. If it is assumed, as is probable, that these three groups represent biologic associations, then it appears that any controls that existed over their distribution are not represented in the major components of the rocks in which the genera are now preserved. Again this is not unexpected, as it has been shown that considerable current sorting and redistribution of death assemblages likely have taken place.

However, as no member of Group II was present in any of the 22 fossiliferous samples from wells considered in this paper, nor in numerous additional fossiliferous well samples also examined, the distribution probably is of significance, vertically in the type Banff Formation and also geographically. The only conclusion that can be drawn is that Group II genera are present mainly in the lower and middle members, the units in which dark, finer-grained sediments

and lower carbonate contents prevail. The predominance of Groups I and III increases in those rocks with increasing grain size of the sediments, with greater carbonate content and with lighter color.

The work of Remane (1940) and Elofson (1941), substantiated by Benson (1959), has illustrated the control exercised on geographic ostracode distribution by sediment type on the sea floor; the control is on ostracode abundance as well as types. Because of the recrystallization and replacement by silica that has taken place in the Banff Formation sediments, the sizes of the original sediment grains may not have been those of the present strata. Again it can only be suggested that Group I and Group II distributions may have been in part controlled by the character of the substratum, Group II possibly having lived on a lime silt substratum and Group I on a lime silt-sand substratum.

Table 9. Levels of Significance at which Unassociated Taxa Enter Group Association

Unassociated taxon	Taxon with which association is made	Group	Probability level
Mammoides	*Paraparchites*	I	0.005
Monoceratina	*Cornigella*	II	0.005
Beyrichiopsis glyptopleuroides	*Mammoides*	I	0.01
Pseudoparaparchites	*Bairdia*	III	0.01
Pseudoparaparchites	*Tetrasacculus*	I	0.01
Graphiadactylloides	*Bairdia*	III	0.025
Discoidella	*Paraparchites*	I	0.025
Discoidella	*Coryellina*	I	0.025
Acratia	*Bairdia*	III	0.05
Acratia	*Beyrichiopsis*	I	0.05
Acratia	*Waylandella*	I	0.05
Moorites	*Beyrichiopsis glyptopleuroides*	I	>0.05

MORPHOLOGIC DIFFERENCES AND PALEOECOLOGY

Examination of the stratigraphic distributional data for the ostracodes has shown that three distinct associations exist at the generic level. It has also been indicated that there appears to be some control over the geographic distribution of these three groups. One aspect that is yet to be considered is whether any other lines of evidence support the concept of regional or vertical changes in gross environment. Possibly the most promising aspect worthy of consideration is that of morphology of the individual ostracodes: to determine whether there are consistent morphologic differences among members of the same taxon (species, genus, family or association group) in ostracode collections from different parts of the same section or from different areas.

Study of the ostracode faunas indicates that morphologic differences do exist among some taxa, but before detailed examination of these differences is made, consideration should be given to other factors that might cause apparent differences in shell morphology. The two major factors affecting appearance are:

(1) attrition of the carapace prior to burial, and

(2) changes due to compaction and diagenetic effects.

The effect of wave or current action is to wear down protuberances and irregularities on the carapace surface and thus to produce apparently smoother individuals. By this mechanism, for instance, a broad spinose frill may be reduced to a row of blunt spine bases, large spines to low nodes, and sharp angular carinae to low rounded carinae. Where such effects are apparent, there probably should also be wear of the surface ornament and rounding of angularities. The effects of compaction and diagenesis are probably somewhat more difficult to define. Compaction of a silty or muddy sediment will commonly lead to crushing and distortion of the carapace, whilst in a limestone it commonly will have no effect whatsoever owing to the initial rigidity of the sediment structure. Diagenetic processes most commonly lead to a replacement of the original shell material of the ostracode by other minerals, such as silica or pyrite. Replacement can take place in a manner so as to preserve every fine detail of shell structure and surface ornament, but can also take place so as to obscure or destroy shell features or to produce a thickening or coarsening of surface ornamental features. Also, as is commonly the case with the Banff Formation material, silicification may result in organic fragments in contact being cemented together, and in silt-

size silica grains becoming cemented to the surfaces of ostracode carapaces (e.g. Pl. 6, Fig. 22; Pl. 8, Figs. 23, 24; Pl. 12, Figs. 12, 13, 14).

The ostracode material collected from the various localities varies considerably in appearance and in mode of preservation. The faunas from Sulphur Mountain, Mount Rundle and Jasper are silicified or, much less commonly, partly to wholly replaced by iron sulfide; the faunas from Sunwapta Pass and from the Peace River region are predominantly preserved in calcite, with a few specimens being pyritized.

The ostracodes preserved in the dark-grey limestone and silty limestones—from the Mount Rundle, Sulphur Mountain and Morro Creek sections—are found mainly as single valves, and commonly with fine spines, frills and other surface features preserved (e.g. Pl. 1, Figs. 4-7; Pl. 2, Figs. 15, 21; Pl. 4, Figs. 17, 18; Pl. 8, Fig. 23; Pl. 15, Figs. 19, 20, 24). This suggests that the mechanical forces that acted upon the organic detritus were for the most part relatively gentle in character. Where small valves or carapaces were recovered from the insoluble residues, preservation was commonly good, fine details of ornament being preserved in silica; where faunas were recovered from the coarser-grained rocks, preservation was in some cases much less perfect, the silicified carapaces commonly being composed of larger crystals, the fine detail of surface ornament thus being destroyed (e.g. Pl. 5, Figs. 7-11; Pl. 6, Figs. 1-3).

The faunas of the light-grey and greenish limy shales and limestones from Sunwapta Pass and the Peace River region were found mainly as complete carapaces and in many cases with the more delicate surface ornamental features broken or abraded (e.g. Pl. 3, Figs. 14-20; Pl. 15, Figs. 1-9). It is probable that some of this abrasion is a result of the mechanical method of sample breakdown to recover the calcareous faunas—the chemical method applied to the silicified faunas being much more likely to maintain preservation of fragile structures. However, from the fossil material it can be seen that some of the breakage, at least, occurred prior to burial. The preservation of these ostracode faunas, in calcite or pyrite, is predominantly good to excellent.

In summary, no incontrovertible evidence of thickening of spines, carinae, or frills due to mode of preservation has been noted; difficulty in cleaning of calcareous specimens has given rise to the effect, in the illustrations, of apparently subdued surface ornament in some specimens. The effects of compaction are evident in only a few specimens (e.g. Pl. 12, Figs. 17, 18; Pl. 13, Figs. 19, 29; Pl. 17, Figs.

12, 21, 22, 29). The effects of abrasion and wear are commonly seen, and must be taken into consideration when making comparisons of shell morphology.

A relatively small percentage of the ostracode species described have been recorded from more than one section, and it is these species that must be considered in an examination of intraspecific morphologic variation. *Beyrichiopsis carinata* is the most widespread species, being recorded from the Peace River region, Sunwapta Pass and Banff. The specimens from the Peace River region (Pl. 3, Figs. 21-23) bear strong carinae and submarginal ridges, the submarginal ridge typically being striate to spinose only posteroventrally and posteriorly. The specimens from Sunwapta Pass (Pl. 3, Figs. 24-26) differ in possessing a posterodorsal spine at which the carina typically terminates. The specimens from Banff (Pl. 3, Figs. 27-29) also possess the posterodorsal spine, but the carina typically terminates in the posteroventral area, possibly in a small spine (Fig. 29). The submarginal ridge and carina are less strongly developed than in the Peace River region specimens, and the submarginal ridge is more striate and may be broader (Fig. 29).

One of the few other species with apparent regional morphological differences is *Craspedographylus acrolimbus,* in which the specimens from Banff (Pl. 15, Figs. 11, 12) appear to be more spinose than those from Sunwapta Pass (Pl. 15, Figs 1-6). This difference may well not be significant: the Sunwapta Pass material probably has undergone more abrasion, resulting in loss of the anterior horn and rounding of the short posteroventral spine in many specimens.

In *Waylandella? punctata,* the posteroventral spine is more strongly developed in the specimens from Banff and Sunwapta Pass than in those from the Peace River region.

Consistent regional differences between species of the same genus are more common than intraspecific variation. Within the genus *Beyrichiopsis* none of the species from the Peace River region—*B. carinata, B.* sp. aff. *B. glyptopleuroides, B.* sp. A, *B.* sp. B—bears posterior spines, all species have carinae, and three species bear in the anterior region relatively strong rounded submarginal ridges. The species from Sunwapta Pass—*B. bispinosa*—bears two lateral spines, has a spinose submarginal ridge and lacks carinae; the species from Banff—*B. banffensis, B. bicarinata, B. glyptopleuroides* and *B.* sp. C—all have broad spinose submarginal ridges, one bears a lateral spine and no carinae, two bear two strong carinae, and the fourth lacks both spines and carinae. There thus is a general tendency for the Sunwapta Pass and Banff species to have spinose submarginal

ridges and for the Peace River species to have smooth strong submarginal ridges. In fact, no spinose species were collected from the Peace River region faunas.

In the genus *Coryellina,* the strongly spinose species, *C. spinosa,* was recorded from the Banff section whilst the species with vestigial spines, *C. obesa,* was collected from Sunwapta Pass and the Peace River region. The two species occur in the type Banff upper member or in equivalent strata.

In the genus *Craspedographylus, C. acrolimbus* bearing posterior spines was collected from Sunwapta Pass and Banff, whilst *C.? inornatus* having a subdued anterior horn and lacking posterior spines is recorded from the Peace River region. All of the Banff species of *Craspedographylus* bear posterior spines; and the most highly spinose species, *C.* sp. A, is recorded only from the Banff section.

The species of *Graphiadactyllis* from the Peace River region, *G. subrhomboidalis* and *G.* sp. A, either lack or have extremely subdued anterior horns, and lack posterodorsal spines. More strongly developed anterior horns are apparent in the two species from Sunwapta Pass and Banff, *G.* sp. B and *G.* sp. C, and also *G.* sp. B possesses a posterodorsal spine.

The genera *Cornigella, Glyptopleura, Kirkbyellina, Monoceratina, Mammoides, Pseudoparaparchites* and *Graphiadactylloides* are among those not recorded from the Peace River region. The first-mentioned four genera comprise Group II, *Mammoides* is a member of Group I, and the other two genera are unassociated. Their absence from the Peace River region is of significance in that five of the genera are spine bearing, and the two others bear strong surface ornamental features. Only a few genera, such as *Seminolites, Bythocyproidea, Sulcella* and *Paracavellina,* are recorded from the Peace River region and not from Banff; *Seminolites* is characterized by some ridged surface ornament, but the other three genera are essentially smooth shelled.

There is thus a tendency for the more highly ornamented and spinose genera, species and variants of the same species to occur in the dark-colored limestones and silty limestones, such as at Banff and Jasper, and for certain genera, species and specific variants with subdued to no surface ornament to occur in the lighter-colored limestones and shales, as in the Peace River region. Whilst this lithologic and regional differentiation is not complete, it is nevertheless wholly consistent, the more spinose forms of any taxon always being found in the darker limestones. The Sunwapta Pass faunas appear to be intermediate in character between those of the Peace River and Banff regions, as the "Peace River forms" of some taxa occur at Sun-

wapta Pass, associated with the "Banff forms" of other taxa. This situation suggests that the regional differences between the faunas will not everywhere be clear-cut, and that lateral gradational changes in gross faunal morphology are to be expected.

No stratigraphic changes in gross morphology are apparent, except that at the generic group level in the type Banff section. This vertical group differentiation was outlined previously (p. 36), wherein the more highly ornamented Group II genera tended not to be associated with Group I genera.

The apparent complete absence of Group II genera from the light-colored sediments of the Peace River area can possibly be interpreted in terms of paleoecology. The Plains region of Alberta probably was a shallow-water shelf area during early Mississippian time, the shelf margin extending from west of Sunwapta Pass southward through the general Banff area (Green, 1962). The probable restriction of Group II genera to the general Banff region may be taken to suggest association with deeper-water conditions, species of these genera thus comprising a Mississippian deeper-water ostracode fauna. This hypothesis is supported by the lithologic evidence of dark color of the sediments, the organic material responsible for the color probably having accumulated in an oxygen-poor environment with little water circulation (Weller, 1959). Additional elements of this suggested deeper-water fauna probably are present in the type Banff Formation faunas, but have not yet been recognized because of inadequate records of faunal occurrences.

A detailed synopsis of the ecological relationships of species of the genera belonging to Groups I and III cannot be made at present, because firstly, as indicated above (p. 33), no definite conclusions relating species occurrences to containing rocks can be drawn for the type Banff Formation section, and secondly, no lithologic studies have yet been made of the containing rocks of the ostracode faunas of the Peace River region.

It is considered that no valid comparison of morphology and ecology of living and fossil Mississippian faunas can be made at present, as the Mississippian faunas discussed herein were associated wholly with a carbonate environment, whilst recent faunas that have been studied in detail (e.g. by Elofson, 1941; Swain, 1955; Benson, 1959) are associated with predominantly noncarbonate environments.

Hence, it can be stated only that the ostracodes belonging to the genera of Groups I and III are elements of shallow-water shelf faunas, the detailed ecologic relationships of which have not yet been discerned.

STRATIGRAPHIC DISTRIBUTION OF THE OSTRACODES

The large assemblages of ostracodes obtained from Banff strata are of considerable value in adding to the biologic and evolutionary knowledge of Mississippian ostracodes. The large stratigraphic interval (1,300 feet) over which collections were made is sufficiently great to illustrate evolutionary changes within certain genera and also the stability of other ostracode species. The influence of ecologic control is also illustrated by the change in faunas near the top of the Banff middle member.

In the Banff Formation faunas, twenty families of ostracodes are represented; twelve are classed as Palaeocopida, seven as Podocopida, and one as Myodocopida. The family Bairdiidae is represented by the largest number of genera (six), and the families Healdiidae and Quasillitidae rank next with four genera each; the Beyrichiopsidae are represented by three genera, and seven families by two genera. The remaining ten families are represented by one genus each; five genera are unclassified with respect to familial affinity. Some occurrences of little significance are not discussed in the following section.

Bairdiidae

The Bairdiidae are represented by the genera *Bairdia, Acratia, Bairdiacypris, Cryptobairdia, Orthobairdia,* and *Rectobairdia,* all typical Mississippian forms.

Unclassifiable immature instars of *Bairdia* (*sensu lato*) species are common in the lower and middle members at Banff, but mature specimens appear only in the uppermost middle member (upper unit 4), where *Bairdia* sp. aff. *B. egorovi, B.* sp. aff. *B. grahamensis, B.* sp. A, *B.* sp. C and *B.* sp. D are recorded (Fig. 12). *Bairdia* sp. aff. *B. egorovi, B.* sp. A and *B.* sp. D range into the lower part of unit 6. The appearance of these species in the upper part of the middle member suggests an association with Group I genera, and thus an ecologic control over their stratigraphic distribution. *Bairdia* sp. C is recorded also from the upper part of the Pekisko Formation in the Peace River region.

Bairdia kinderhookensis, from the Chouteau Formation of Missouri, was obtained only from the basal Banff strata at Jasper (Fig. 13) associated with *B.* sp. aff. *B. kinderhookensis* and *B.* sp. aff. *B. whitesidei. Bairdia* sp. B was obtained only from Shunda-equivalent strata in the Peace River region.

The genus *Acratia* is represented by three species, and commonly by specimens indeterminate specifically. A distinctive species is present in the basal Banff strata at Jasper, and a species closely similar to *Acratia similaris* Morey appears in the middle of unit 3 at Banff (Fig. 12) and ranges into the upper part of unit 4. This species is replaced by *A. similaris* Morey proper and *A. fabaeformis* in the middle of unit 5; the latter species ranges into the lower part of unit 6. It is also present in upper Banff strata at Sunwapta Pass and in upper Shunda-equivalent strata in the Peace River region. *A.* sp. cf. *A. similaris* is considered intermediate between the basal Banff species and *A. similaris,* and probably represents an evolutionary lineage from the former to the latter.

The genus *Bairdiacypris* is represented by one doubtful species from the basal Banff beds at Jasper. *Cryptobairdia* is represented by one species from high Shunda or lower Debolt beds in the Lesser Slave Lake area. *Orthobairdia* also is represented by one species, from the lower beds of unit 6 at Banff.

Rectobairdia is probably the most important bairdiid genus in the collections studied, being represented by eight species. Only one species was identified from type Banff strata: *R. confragosa* from unit 6; this species also occurs in upper Banff (post-Pekisko) strata at Sunwapta Pass. Three species—*R. morroensis, R.* sp. cf. *R. distressa, R.* sp. A—were obtained from the lower Banff strata at Jasper; *R. morroensis* is probably characteristic of these strata. *R.* sp. aff. *R. fragosa* probably typifies Shunda-equivalent strata, being recorded from these beds at Sunwapta Pass and in the Peace River region. *R.* sp. cf. *R. sinuosa* was obtained from Plains Banff strata in the Peace River region; the original species was described from the Chouteau Formation of Missouri (Morey, 1936). *R. subparallela,* from the basal Mississippian strata of Missouri (Morey, 1935; Mehl, 1960), was collected from basal Banff strata in the Peace River region and from upper type Banff equivalent strata at Sunwapta Pass. *R.* sp. B was obtained from the Banff Formation of the Peace River region.

Healdiidae

The Healdiidae are represented by the genera *Healdia, Cribroconcha, Seminolites* and *Waylandella.* The one species of *Healdia,* from the type Banff upper member, appears to be a long-ranging form, having been recorded by Copeland (1960) from the basal Banff in the Crowsnest Pass. Species of *Cribroconcha* occur uncommonly throughout the Banff Formation, and insufficient data are available

to indicate whether they are of value zonally and whether the one formal species described is in fact long ranging or is composite. *Seminolites* species appear to be of stratigraphic value; a species from the middle type Banff doubtfully referred to the genus can only be a very early representative of this stock, and shows relationships to the Thlipsuridae of Middle Devonian age. The later species, *S. nelsoni* and *S. stelcki,* from Shunda strata of the Peace River region, are more typical of the genus, but still possess an "early" feature—that of difference in amount of ornament between the two valves (cf. Pl. 13, Figs. 21 and 22, Figs. 24 and 25). *S. stelcki,* from lower Shunda beds, also tends to have pits arranged in rows (Pl. 13, Figs. 28, 29), whilst the stratigraphically higher *S. nelsoni* has pits grouped inside the ridges (Pl. 13, Figs. 21, 33). Whether there was a rapid evolutionary change between these two species in mid-Shunda time, or whether they represent contemporaneous ecologically controlled species is yet to be determined. *Waylandella? punctata* appears in the upper middle type Banff strata and ranges into lower unit 6 beds. Its local range, along with that of other species, is suggestive of ecologic control. It is, however, also recorded from upper Banff strata at Sunwapta Pass, and upper Pekisko and lower Shunda strata in the Peace River region, a range that is in agreement with that of the type Banff section.

Quasillitidae

Representatives of the Quasillitidae are probably the most abundant numerically in the Banff Formation type section, and are of considerable importance in Lower Mississippian rocks elsewhere in the Province. Four genera are represented: *Eriella, Graphiadactyllis, Graphiadactylloides* and *Craspedographylus. E.? cribraria,* from basal Banff strata in the Peace River region, and probably also from Big Valley strata in southeastern Alberta, is questionably the end product of the *Eriella* [*Abursus*] lineage from the Beaverhill Lake and Ireton strata of central and northern Alberta. It has a general similarity in shape and surface ornament to these earlier Late Devonian forms, but is of considerably larger size and has almost lost the posteroventral spines. The lower beds of Banff member A at Jasper yield *Eriella?* sp. and valves of a species with an ornament intermediate in type between that of *E.? cribraria* and *E.?* sp. (see also Copeland, 1960, Pl. 1, Fig. 16). The similarity in shape between these two species is illustrated on plate 14 (Figs. 20, 21). It may thus be suggested that *Eriella?* sp., and thus possibly *Graphiadactylloides? granopunctatus* (Ulrich and Bassler), arose from the stock of Late Devonian reticulate quasillitids, most likely in very early

Mississippian time, and that their presence serves as an excellent Mississippian age designate. The general similarity in shape and of ornament between the specimens illustrated by Copeland (1960) as *"Graphiadactyllis fernglenensis"* (Pl. 1, Figs. 12, 13) and as *"Graphiadactyllis granopunctatus"* (Pl. 1, Fig. 16) suggests a fairly close relationship between the two. The former has been included in this paper in *Graphiadactylloides paucituberculatus,* a species with an indistinct but persistent posteroventral spine and a variable flange structure; its range is from the upper beds of the Exshaw Formation (Copeland, 1960) into the type Banff upper member, and it appears to be confined to the dark limestone and shale facies. Immature instars probably referable to this species occur through much of the type Banff middle member. *Graphiadactylloides* spp. C and D probably also belong to the same species group, but cannot be assigned with certainty at present due to lack of well-preserved material.

The most useful lineage, stratigraphically, of this genus is that of *Graphiadactylloides striatoreticulatus—G. moreyi—G. moridgei—G.* sp. A, by use of which some subdivision of the type Banff Formation can be made. The earliest species, *G. striatoreticulatus,* is recorded from the upper beds of the Exshaw Formation in the Crowsnest Pass (Copeland, 1960), the lower part of the Banff member A at Jasper, and from the upper part of the lower member and the lower half of the middle member at Banff. This species is replaced in the upper part of the type Banff middle member by *G. moreyi,* a species with a narrower posterior zone of vertical riblets, and with less convoluted riblets in the posterocentral area. *G. moreyi* ranges through the lower part of the upper member and probably gives rise to the complex of *G.* sp. aff. *G. moreyi—G. moridgei—G.* sp. A, species that are present in the middle to upper beds of the upper member. In these forms the locus of the riblets—situated in the posterocentral area in *G. moreyi*—gradually moves towards the posterodorsal angle. The apparent absence of a well-developed flange in *G.* sp. A is due to imperfect preservation.

Species of *Graphiadactyllis* were obtained mainly from samples from the Peace River region. *G. subrhomboidalis* was obtained from Banff and from lower Shunda strata, and *G.* sp. A from the Pekisko Formation. Both species are characterized by the absence of posterior spines and of anterior horns, and possess ribbed surface ornament.

The third group of quasillitid ostracodes, placed in the new genus *Craspedographylus,* are characterized by a strong external expression of the flange as a ridge or as a broad frill. The species in this group are *C. acrolimbus, C. comptilimbus, C.? inornatus* and four, possibly

five, additional species. *C. acrolimbus* is recorded from the Banff upper member in the type section and at Sunwapta Pass. Adult instars of the species possess the flange ridge typical of the genus and a posterodorsal spine. Immature instars (Pl. 15, Figs. 8, 9) lack the external flange ridge, which is represented by a frill-like structure, tipped anteriorly by a large spine or horn at midheight; a posteroventral spine is situated at the tip of a short posteroventral ridge. *C.* sp. C, from the type Banff lower and middle members, may be constituted of immature instars of *C. acrolimbus* (cf. Pl. 15, Figs. 8, 9 and Figs. 10, 18) although the Banff specimens possess a fairly strong posterior shoulder which immature instars of *C. acrolimbus* do not. *C.* sp. C also bears a considerable resemblance to *C.* sp. A which possesses an extremely broad anterior frill-like flange tipped anteriorly at midheight by a large horn (Pl. 15, Fig. 20), and also an extremely long and thick posteroventral spine (Pl. 15, Fig. 19). The morphology of *C.* sp. A is thus almost identical to that of immature instars of *C. acrolimbus* (Pl. 15, Fig. 8), although the size is that of the adult. This may be construed as an example of proterogenesis in one lineage of this group of quasillitid ostracodes, *C.* sp. A thus being considered as slightly later than *C. acrolimbus.*

The representative of this group in the Mississippian strata of the Plains is *C.? inornatus,* essentially similar in outline and in major shell features to *C. acrolimbus* from the Mountains sections, but as is the case with many of the Plains Mississippian forms, lacking well developed spines and delicate surface ornamental features. *C.? inornatus* was obtained from lower Shunda strata in the Peace River region; it has a less well developed flange ridge than *C. acrolimbus,* has a subdued anterior horn, lacks posterior spines and has a wholly unornamented lateral surface. Its close relationship to *C. acrolimbus* is nevertheless quite apparent (cf. Pl. 15, Figs. 4, 5, 6 and 13, 14, 15). A species similar to both *C.? inornatus* and *C. acrolimbus* is present in the upper beds (unit 4) of the type Banff middle member: *C.* sp. B lacks the pronounced posterodorsal spines of *C. acrolimbus,* has a more sharply defined flange ridge and anterior horn than *C.? inornatus,* and in addition possesses a small posteroventral spine. *C.* sp. B also appears to be intermediate in morphology between *C.? inornatus* and *C. comptilimbus*; again, inadequate preservation of fine ornamental detail adds to the difficulty of classification and determination of precise interrelationships. *C. comptilimbus,* from the type Banff upper member, differs from the previously mentioned species of this group in having a complete surface ornament of reticulae or of riblets and in having a reduced development of the flange ridge ventrally. The presence, however, of strong anterior and posterior ridges indicates the affinities of *C. comptilimbus* to this genus.

One sample from the lower part of the type Banff middle member contained specimens showing a close relationship to *C. comptilimbus*: *C.* sp. D is represented by immature instars which possess relatively poorly developed flange ridges and, in addition, an anteroventral flange frill. Whether or not this form is conspecific with *C. comptilimbus* depends upon whether the frill persists into adult instars, and also upon whether differences in the details of surface ornament are considered significant.

Two species are doubtfully related to the species placed in *Craspedographylus*: *Graphiadactylloides* sp. B. and *G.* sp. E. *G.* sp. B from the type Banff upper member occurs associated with *C. comptilimbus,* but has much less distinct flange ridges and variable surface ornament; precise relationships of this species (or these species) remain unknown. *G.* sp. E occurs in the type Banff middle member (unit 3) and may be associated with *C.* sp. D. The absence of flange ridges in this species suggests that it is distinct from *C.* sp. D, and that it is probably not related to *Craspedographylus.*

Beyrichiopsidae

The Beyrichiopsidae, represented by three genera, *Beyrichiopsis, Knoxina* and *Geffenina,* are of wide distribution and considerable importance in Lower Mississippian rocks. *Beyrichiopsis* is represented by probably eleven species, and as it presently stands is doubtless polyphyletic. Until additional refinement is established at a generic level, however, this situation must stand. Some species of this genus in Alberta Mississippian rocks comprise the stocks from which arose *Glyptopleurina* and one major lineage of *Glyptopleura.* In the Banff type section *B. glyptopleuroides* ranges from the lower member into unit 6; it is present also in the basal Banff strata at Jasper, and in upper Banff strata at Sunwapta Pass. Although definitely *Glyptopleura*-like in appearance, this species is placed in *Beyrichiopsis* because of its possessing a marginal frill and an anterior lobe. The frill is best developed in the stratigraphically lowest specimens, and becomes less distinctive in later forms. A short submarginal ridge appears in some stratigraphically higher specimens—in the Banff upper member (Pl. 4, Fig. 8)—and this species doubtless gives rise to the Meramec species *B.? elephanta* (Brayer) with an obscure marginal frill and an essentially complete submarginal ridge, and to *Glyptopleura parvacostata* Geis, which lacks a frill.

A possible sequence of evolutionary changes is illustrated by *B.* sp. A, *B. carinata* and *B.* sp. B. These appear to be of value in est-

ablishing zonation, although lateral variability of the species has yet to be determined. *B.* sp. A (Pl. 4, Fig. 15) from middle Banff strata (Table 1, Fig. 14) in the Peace River region possesses a carina that is joined to the dorsal ridge close to the anterior cardinal angle. In *B. carinata carinata* from the middle Pekisko of the Peace River region (Pl. 3, Fig. 22) the carina has become separate from the dorsal ridge; the carina becomes successively shorter (Pl. 3, Figs. 23, 25, 26) in upper Pekisko and Banff upper member forms, and *B. carinata* may give rise to *B.* sp. B (upper Shunda of the Peace River region) in which the carina joins the L_2 (Pl. 4, Figs. 19, 20). *Glyptopleurina embryonicia* Brayer from Meramec strata of Missouri closely resembles both *B. carinata* and *B.* sp. B, and differs primarily in the absence of a submarginal frill. Successive increase in complexity and number of the lateral carinae takes place in higher (Chester) species.

Two subspecies have been established for *B. carinata,* and it is considered that their morphologies are a reflection of environmental differences. *B. carinata carinata,* from the Peace River region, has strong carinae and ridges, and a subdued spinose frill. *B. carinata nigelensis* from Sunwapta Pass possesses a posterodorsal spine and a somewhat different carina, and probably a better developed frill. *B. carinata nigelensis* specimens from Mount Rundle have a well-developed striate to spinose frill, a more delicate valve structure, and may be more strongly spinose. These morphological differences in essentially contemporaneous forms are believed to indicate environmental differences between the three areas, probably differences in substratum composition or form. The more delicate ornamental features (frill and spines) are taken as indicative of a softer or finer-grained substratum, whilst the strong carinae and reduced frills probably indicate a harder or coarser-grained substratum.

The delicate ornamental features of *B. carinata* from the Mount Rundle section are duplicated in *B. banffensis,* a broad-frilled, spinose, noncarinate species also from the type Banff upper member. This species is closely related to *B. bispinosa,* associated with *B. carinata* at Nigel Peak. *B. bispinosa* has a frill composed of stronger and probably shorter spines, and has stronger spines and thicker valves.

Several other species, of unknown stratigraphic value, occur in the Banff Formation: *B. bicarinata* and *B.* sp. C of the type Banff upper member, *B.* sp. C from the type Banff middle member, and *B.* sp. D from Banff member A at Jasper are all strongly frilled forms, whilst *B.* sp. aff. *B. glyptopleuroides* from upper Pekisko strata of the Peace River region has only a poorly developed submarginal frill; these differences are again considered a reflection of environments.

The two species of *Knoxina, K. costata* and *K. marginata,* both occur in the Mount Rundle section. *K. marginata,* from the middle of the upper member, possesses a relatively broad flange bordered by a narrow marginal ridge; the flange is somewhat narrower in the earlier species, *K. costata,* from the lower part of the middle member. A very narrow flange with a spinose marginal ridge is present in a closely related species from lower Upper Devonian strata of the same region. The Devonian species possesses several distinct crests and in *K. costata* three major crests are present. It appears that these major crests break down and are replaced by numerous small crests, giving rise to *K. marginata.*

The genus *Geffenina* is represented by three closely related species, none of which exactly complies with the generic definition. All features of the genus are, however, present in the three species, and in this case it is considered not illogical to place them in *Geffenina.* The earliest species, *G. warreni,* appears in Banff member A at Jasper, and at Banff ranges through most of the middle member. It possesses relatively strong posterior spines—especially in the instars—and a dorsal valve overlap similar to that of some Devonian species of *Kloedenella.* In *G. nigelensis,* which ranges through the middle of the type Banff upper member and which is present in the upper member at Sunwapta Pass, the dorsal overlap is reduced and the posterior spines are less conspicuous. The better preserved material from Sunwapta Pass exhibits marginal denticles, which warrant the assignment to a genus of the Beyrichiopsidae. A change in form of the centroposterior depression is considered another differentiating specific feature. It is considered at present that *G. nigelensis* evolved from *G. warreni* and that as such the two species should be of zonal value. The significance of the third species, *G.? aspinifera,* is much less certain; no marginal structures are preserved in this species, it lacks posterior spines, and thus is referred to *Geffenina* on the basis of general structural similarity to the other two species. Its distribution is through the type Banff unit 4 (upper part) and lower unit 6: the species is confined to the coarser-grained strata above the faunal break in the section.

The genus *Pseudochilina* is of doubtful affinity to the Beyrichiopsidae. Two species from the Banff Formation are referred to this genus. The lower species ranges through Banff member A at Jasper and into basal member B strata. The higher species, *P. marginata,* with instars resembling adults of the earlier species, occurs only in the upper beds of unit 4 at Banff. A two-part stratigraphic subdivision may then be possible on the basis of these two forms.

Aechminellidae

Two genera from the type section of the Banff Formation belong to the Aechminellidae. Each genus, *Mammoides* and *Cornigella,* is represented by one species. *M. longispinosa* ranges through the whole type Banff Formation and is one of the few species collected in the Sulphur Mountain section. A significant change in mean form ratio takes place in the species with time (Fig. 17), but as variation in form ratios in any one population may exceed the total variation of the mean form ratio during Banff time, this change has only very doubtful stratigraphic application. The species of *Cornigella, C.* sp. cf. *C. golcondensis,* ranges through the lower and middle type Banff members, and is absent from the upper and uppermost middle member strata. This species, conservative in form, is almost identical with *C. golcondensis* from the Chester beds of Illinois and has probably an ecologically controlled distribution.

Kirkbyellidae

The genus *Kirkbyella* is represented by three, possibly four species, all of limited occurrence. *K. (Berdanella) annensis* occurs in upper Banff strata at Sunwapta Pass, *K. (Berdanella) bowensis* and *K. (Berdanella) reticulata* in the Banff upper member (unit 6) at Banff, and *K.* sp. aff. *K. reticulata* in the lower-middle member (unit 3) at Banff. As all occurrences are single, no local stratigraphic significance can be given to these species.

Hollinidae

The Hollinidae are represented by two occurrences of instars of a *Hollinella* species and by *Tetrasacculus,* the one species of which—*T. calcaratus*—ranges through 1,200 feet of the type Banff Formation. This species is recorded from the type section and from a single occurrence in the Sulphur Mountain section. Ecologic control over its distribution is again suggested.

Kirkbyidae

The Kirkbyidae, represented by at least two species of *Kirkbya,* are of limited occurrence in the Banff Formation. Present records are too sparse to indicate any precise stratigraphic significance to the species. *K.* sp. cf. *K. keiferi* is recorded from the type Banff upper-

middle member, and *K.* sp. from member A at Jasper and from the lower Debolt Formation in the eastern Peace River area. Specifically indeterminate instars occur throughout the type Banff Formation.

Amphissitidae

Evolutionary changes in species of the genus *Amphissites* are probably of considerable value in achieving a subdivision of the type Banff Formation. *A.* sp. aff. *A. similaris,* with anterior and posterior carinae of similar length (Pl. 2, Figs. 20, 21), ranges through member A into the basal beds of member B at Jasper. This species probably develops, in the type Banff middle member, into *A. similaris* which differs from it primarily in having a shorter or less distinct anterior carina (Pl. 2, Figs. 14, 16). Young instars of both of these species (Pl. 2, Figs. 18, 19) bear on the central node a carina—a feature of adults of an *Amphissites* species from the lower Upper Devonian Perdrix Formation. A continuous evolutionary change from Late Devonian into Early Mississippian time is thus indicated for these species, a change that is illustrated in part by recapitulation in instars of the latest species, *A. similaris.*

Youngiellidae

The Youngiellidae are represented by two genera and three species, all of single occurrence. Thus neither the species of *Glyptopleuroides* nor of *Moorites* are of significance at present, except in extending the generic ranges into Lower Mississippian strata.

Glyptopleuridae

One lineage of the genus *Glyptopleura* is represented by two species in the Banff Formation type section and another by ancestral forms of relatively widespread distribution (see *Beyrichiopsis glyptopleuroides,* p. 99). The recorded range of the earlier species, *G. primitiva,* is through most of the strata of the type Banff middle member (from 340 to 760 feet above the base of the formation). In one sample (RG 56-3-40) it occurs with forms gradational to *G.* sp. cf. *G. belphegora,* a species that replaces it through upper-middle and upper type Banff strata. Thus, after a period of relative stability, *G. primitiva* apparently underwent rapid evolution to give rise to *G.* sp. cf. *G. belphegora,* a species that apparently persisted with little change into Meramec strata (Brayer, 1952, Pl. 27, Fig. 3). It is possible, however, that the relatively abrupt replacement of the one species by

the other is due to ecologic and not evolutionary change; this is considered unlikely, though, as the change takes place below the ecologic break in the type Banff Formation.

Miltonellidae

Two genera are referred with question to the Miltonellidae; these are *Libumella* and *Namaia,* each represented by one species. Species of both genera are of relatively limited occurrence. *Libumella* is represented in Michigan Middle Devonian strata by *L. hypercala,* from which *L. athabascensis* probably developed by increase in size and change in lateral outline. The latter species was recorded in the Jasper section from Banff member A and the lower beds of member B. *N. reticulata,* from the type Banff middle member (unit 4), is closely related to *L. athabascensis* and also to species of *Savagellites.* If species of these three genera represent an evolutionary continuum, then their presence in any section will serve as an excellent guide to a gross age determination.

Leperditellidae

The Leperditellidae are represented by one genus, *Coryellina,* the two species of which may be of significance ecologically. *C. spinosa* ranges through the upper-middle and upper members of the type Banff Formation, appearing above the faunal break, and was recorded also by Copeland (1960) from the top of the Exshaw Formation in the Crowsnest Pass. *C. obesa* is recorded from the Pekisko Formation in the Peace River region and from the Banff upper member at Sunwapta Pass. Thus the recorded vertical ranges of the two species overlap, whilst their lateral distributions do not. As with the Beyrichiopsidae, the more strongly spinose species occurs in the black-limestone facies (type Banff Formation) whilst the poorly spinose species is recorded from the light-grey limestone to green shale facies.

Paraparchitidae

The genus *Paraparchites* is of relatively common occurrence in Alberta Mississippian rocks; the other genus representing this family is *Pseudoparaparchites,* which at present is recorded only from Banff and Sunwapta Pass. *Paraparchites* is represented by approximately five species. *P. productus* is present in one sample from the Banff upper member at Sunwapta Pass where it is associated with *P. pinguis.* The latter species also occurs in the middle beds of the type

Banff upper member; probable instars of the same species are present in upper Pekisko strata in the Peace River region, associated with specimens of *P. nicklesi*. *P. nicklesi* was also recorded from lower Shunda beds of the Peace River region. A larger but closely similar form, *P.* sp. cf. *P. nicklesi*, occurs near the top of the type Banff middle member. *P.* sp. aff. *P. nicklesi*, from Banff member A at Jasper, is a distinctive form which probably will be of zonal value. *Pseudoparaparchites montis*, from the Banff upper member at Sunwapta Pass and Banff, is of relatively rare occurrence. Instars, probably of the same species, are fairly commonly distributed through the type Banff lower and middle members.

Beecherellidae

The genus *Acanthoscapha*, with a previously recorded range of Upper Silurian to Middle Devonian (Berdan, in Moore, 1961), is represented by one species questionably referred to it. *A.? banffensis* ranges through most of the Banff Formation, but is of limited occurrence. The main significance of the occurrences is in extending the range of the Beecherellidae, and possibly of *Acanthoscapha*, from the Middle Devonian into the Lower Mississippian.

Berounellidae

Two species referred to the genus *Kirkbyellina* represent the Berounellidae. Both species at present have been collected from the type Banff middle member, *K.* sp. A having a recorded range of 60 feet in the lower part of the member and *K.* sp. B a range of 100 feet in the upper part of the member. A two-part division of the middle member may then be possible by use of these two species if it can be assumed that *K.* sp. A developed into *K.* sp. B. Species of this genus are not recorded from the type Banff upper member and thus these forms appear to be of ecologic significance also. Immature instars of *K.* sp. A were also collected from one locality in Banff member A at Jasper.

Bythocytheridae

The Bythocytheridae, represented by the genus *Monoceratina*, have an interesting distribution in the Mississippian strata. *M.* sp. cf. *M. tennesseensis* was recorded from one locality in the type Banff upper member and possibly from one locality in the middle member (unit 4). Its previous record was from the Ridgetop Formation (Osage) of Tennessee (Bassler, 1932). *M. tricostata* has a range

through part at least of the type Banff lower member and through the middle member below the faunal break. Its abrupt disappearance in the middle of unit 4 is considered indicative of ecologic control over its distribution. This species also occurs in Banff member A at Jasper. *M. virgata* is a long-ranging species, being present in the lower beds of member A at Jasper and through the type Banff middle and upper members. An almost identical form is present in the Upper Devonian Perdrix Formation in the Jasper area. Three additional species, *M.* sp. A, *M.* sp. B, and *M.* sp. C, are present in lower member A strata at Jasper and one—*M.* sp. A—also is present in the lower strata of the type Banff middle member.

Cavellinidae

Two genera of the Cavellinidae—*Paracavellina* and *Sulcella*—are each represented by one species, the species occurring together in upper Shunda strata in the Peace River region.

Entomozoidae

The Entomozoidae are represented by one species of *Richterina*. *R.* sp. aff. *Fossirichterina intercostata* (Matern) was obtained from two localities, one in the lower and one in the middle member of the Banff Formation.

Genera of Uncertain Familial Affinity

Several genera represented in the Banff Formation are of uncertain affinity with respect to family, to suborder, or to both. These genera are *Editia, Hastacypris, Microcheilinella, Silenites,* and *Discoidella.*

The most valuable genus, stratigraphically, is *Editia* which is represented by two species, *E. albertensis* and *E. brayeri. E. brayeri* was collected from the upper half of the type Banff middle member, ranging through the upper part of unit 3 and most of unit 4 to the level of the faunal change. Although the disappearance of this species at the level of faunal change is probably a function of ecologic control, it is suggested that *E. brayeri* gave rise to *E. albertensis* through a simple change of form of the carinae, the change taking place stratigraphically at, or a short distance above, the type Banff middle-upper member contact. *E. albertensis* appears in the section 130 feet above this contact: in the lowest samples containing determinate ostracodes.

It ranges through that part of the upper member from which ostracodes were obtained, and was also recorded from Shunda strata in the Peace River region.

The genus *Hastacypris* is represented by a single species occurrence in the type Banff upper member. The genus *Microcheilinella* is represented by two species, one—similar to *M. spinosa* (Geis)—from the type Banff section and the other, with a general resemblance to *Tubulibairdia amaliae* (Kummerow), from Banff member A at Jasper.

One species of *Silenites*, *S.* sp. cf. *S. warei* Morey, was collected from the Banff upper member at Sunwapta Pass and in the type section from the middle member above the faunal break. The distribution of this species probably is ecologically controlled, for the genus—and hence the single species—is a member of Group III in the generic ecological grouping.

The one species of *Discoidella*, *D.* sp. aff. *D. ampla* Cooper, has a sparse distribution through the type section of the Banff Formation.

FAUNAL SUBDIVISIONS, CORRELATION AND AGES OF THE FAUNAS

The ostracode faunas described from the Lower Mississippian rocks of Alberta have been classified into 130 forms (Table 10), of which 99 are new, 13 have affinities with previously described species, 11 are comparable with previously described species, and 7 are considered conspecific with previously described species. Of the 99 new forms, 47 are described formally and named, 27 are *nomenclatura aperta,* and the remainder are comparable to or have affinities with new species, or are specifically indeterminate.

It is therefore apparent that age determinations of the Mississippian rocks in question, based upon ostracodes and upon extraprovincial correlations, can be made only to a very limited extent, as probably few more than 20 species can be used for this. Intraprovincial correlation can be somewhat more precise, as a number of species occur in more than one section. Again, however, this is limited because only the Banff type section is well documented, with 82 forms or species. The Jasper section yielded faunas (32 species) from relatively few samples, the Peace River samples (containing 31 species) are from scattered localities, and the Sunwapta Pass material is from essentially one locality, which yielded 20 species. The first

Table 10. Summary of Taxonomic Status of Banff Formation Ostracodes

Taxonomic status of species	LOCALITY				Total
	Banff	Nigel Peak	Jasper	Peace River	
previously described species	3	2	1	2	**7**
compared to described species	9	2	2	2	**11**
affinities with described species	5	2	6	3	**13**
new form	65	14	23	24	**99**
Total	82	20	32	31	**130**
Number of fossiliferous samples	75	2	4	38	**119**

step to be made is then to subdivide the type section of the Banff Formation on the basis of its contained faunas, and then to determine whether any of the resultant faunal groups have possible zonal significance by considering the faunal records from the other areas.

Faunal Subdivisions of the Type Banff Formation

Recorded vertical ranges of all species from the type section of the Banff Formation are presented in figure 12. Seven species are long-ranging, being recorded from at least half of the total sampled section. The recorded ranges of other species are strongly influenced by factors of sorting and preservation, a fact that is well illustrated in the species range chart. Well-preserved and large faunas were recovered from four samples (RG 56-1-42, RG 56-3-51, RG 56-4-26A, and RG 56-4-75); other samples yielded either less substantial or more poorly preserved faunas, but in large part in sufficient quantity overall to permit a faunal subdivision to be made. Ostracodes were obtained from samples between 170 and 1,260 feet above the base of the formation, and within this interval one substantial gap in the faunal record exists: from 825 to 990 feet above the base of the formation—the uppermost beds of the middle member and the lowest 130 feet of the upper member. The following discussion of faunal distribution is then subject to modification by these various influencing factors, and also to the effects of ecologic controls discussed previously.

One major break or change in the ostracode faunas is apparent from the species range chart (Fig. 12): that which takes place over a 50-foot interval between 770 and 820 feet above the formation base —approximately at 800 feet. At this level a number of species that range through the lower part of the formation disappear and at or above this position a number of other species appear. (Because of the gap in the faunal record in the 165-foot interval above 800 feet, all species that appear at 990 feet must be considered as theoretically ranging down to the 800-foot level). The species ranging up to this interval are as follows:

Monoceratina tricostata
Pseudoparaparchites sp. cf. *P. montis*
Craspedographylus sp. C
Graphiadactylloides striatoreticulatus (sensu lato)
Cornigella sp. cf. *C. golcondensis*
Glyptopleura primitiva
Geffenina warreni
Editia brayeri
Kirkbyellina sp. B.

Of these nine species, *M. tricostata, C.* sp. cf. *C. golcondensis, G. primitiva* and *K.* sp. B belong to the four genera of Group II, and thus the unsupported evidence of their restriction to the lower and middle members can be interpreted only as evidence of ecologic control.

This group of nine species is replaced in the 770- to 820-foot interval and above by a larger group, consisting of:

Amphissites similaris
Glyptopleura sp. cf. *G. belphegora*
Monoceratina sp. cf. *M. tennesseensis*
Geffenina aspinifera
Coryellina spinosa
Bairdia sp. aff. *B. egorovi*
Bairdia sp. A
Bairdia sp. D
Graphiadactylloides moreyi
Waylandella? *punctata*
Silenites sp. cf. *S. warei*
Michrocheilinella sp. aff. *M. spinosa*

and at the 990-foot interval by the additional species:

Beyrichiopsis carinata
Knoxina marginata
Geffenina nigelensis
Paraparchites pinguis
Editia albertensis
Acratia fabaeformis
Craspedographylus acrolimbus
Craspedographylus comptilimbus
Craspedographylus? sp. E.

Again, on the basis of previous discussion of ecologic grouping, the unsupported evidence of the presence of *C. spinosa, W.*? *punctata, S.* sp. cf. *S. warei, B. carinata, K. marginata, P. pinguis* and *E. albertensis*—belonging to seven of the twelve Group I genera—is an indication only of the previous existence of specific suitable environmental conditions.

The presence of these two assemblages, one below and one above the 770- to 820-foot interval (Figs. 12, 13), is evidence of a change having taken place in the ostracode faunas at this level. Whether or not this was a local or a regional change remains yet to be determined. If the change were regional and essentially isochronous, then this could be of value as a regional zonal marker; however, incomplete data from Plains areas at present suggest the widespread presence of Groups I and III genera and the absence of Group II genera. From

this is inferred the unlikelihood of the gross faunal change being of value as a regional time-marker, but rather its significance purely as an ecologic and possibly a facies indicator.

However, in addition to the gross faunal change towards the top of the type Banff middle member, there also is evidence of some evolutionary change at this position. The most precisely positioned change is the replacement of *Glyptopleura primitiva* by *G.* sp. cf. *G. belphegora* at 770 feet (Figs. 12, 13), both species occurring together in one sample. *Geffenina warreni* ranges up to 820 feet, where it is associated in one sample with *G.*? *aspinifera*—an upper fauna member. *G. nigelensis* is its second replacing species, appearing at 990 feet. *Editia brayeri,* ranging from 570 to 800 feet, is replaced at 990 feet by *E. albertensis* (Fig. 13). Thus species of the genera *Glyptopleura, Geffenina* and *Editia* can be used to establish three, possibly five local range zones in the type Banff Formation, the zonal boundaries lying at approximately 340, 570, 770, ?820, ?990 and 1,230 feet above the formation base.

The two species of *Kirkbyellina* are probably of value in subdividing the lower faunal assemblage into two parts at approximately 500 feet above the base of the formation; this is dependent upon the relationship of *K.* sp. A to *K.* sp. B, as mentioned previously (p. 54); if relative superposition is evolutionary then the species are of range zone value, if ecologic then the species are of local range zone value only.

In the type Banff upper member, a local range zone boundary can be placed at 1,060 feet based on the range of *Graphiadactylloides moreyi* up to the boundary and also on the presence of *G. moridgei* and *G.* sp. A above it.

Thus, two major assemblages can be recognized between approximately 200 and 1,250 feet above the base of the type Banff Formation and a number of local range zones can be established within the ranges of these assemblages. The diagnostic fauna of the interval from 200 to 800 feet is as follows:

Monoceratina tricostata
Beyrichiopsis glyptopleuroides (early form)
Pseudoparaparchites sp. cf. *P. montis*
Craspedographylus sp. C
Graphiadactylloides striatoreticulatus
Cornigella sp. cf. *C. golcondensis*
Glyptopleura primitiva
Geffenina warreni
Kirkbyellina sp. A
Kirkbyellina sp. B

Amphissites sp. cf. *A. similaris*
Knoxina costata
Graphiadactylloides sp. cf. *G. paucituberculatus*
Graphiadactylloides sp. E
Editia brayeri.

Of these species, *Kirkbyellina* sp. A and *Knoxina costata* are considered to characterize the interval between 300 and 500 feet, and *Kirkbyellina* sp. B and *Editia brayeri* characterize the 500- to 800-foot interval (Fig. 13).

The interval from 800 to 1,250 feet is characterized by:

Beyrichiopsis glyptopleuroides (late form)
Beyrichiopsis carinata
Beyrichiopsis banffensis
Kirkbya sp. cf. *K. keiferi*
Amphissites similaris
Glyptopleura sp. cf. *G. belphegora*
Monoceratina sp. cf. *M. tennesseensis*
Geffenina aspinifera
Geffenina nigelensis
Coryellina spinosa
Bairdia sp. aff. *B. egorovi*
Bairdia sp. A
Bairdia sp. D
Graphiadactylloides moreyi
Graphiadactylloides sp. aff. *G. moreyi*
Graphiadactylloides moridgei
Graphiadactylloides sp. A
Graphiadactylloides paucituberculatus
Waylandella? *punctata*
Silenites sp. cf. *S. warei*
Microcheilinella sp. aff. *M. spinosa*
Knoxina marginata
Paraparchites pinguis
Editia albertensis
Acratia fabaeformis
Acratia similaris
Craspedographylus acrolimbus
Craspedographylus comptilimbus
Craspedographylus sp. B
Craspedographylus? sp. E
Kirkbyella bowensis
Kirkbyella reticulata
Rectobairdia confragosa
Namaia reticulata.

Of these species *Craspedographylus* sp. B, *Kirkbya* sp. cf. *K. keiferi* and *Namaia reticulata* range through the interval 770 to 820 feet. *Graphiadactylloides moreyi* characterizes the interval 820 to 1,060 feet; between 990 and 1,060 feet this species is associated with *Knoxina marginata, Geffenina nigelensis, Editia albertensis* and *Craspedographylus* spp. The interval 1,060 to 1,230 feet is typified by *Beyrichiopsis banffensis* and *Graphiadactylloides paucituberculatus* and the interval 990 to 1,230 feet by nine species listed previously (p. 59). A distinctive fauna, from one sample (RG 56-4-75), occurs at the 1,230-foot level (Fig. 12) but the range zones of the component species are not known.

It should be noted that the zonal subdivision made in the type Banff section can only be on a local range zone basis. Some range-zone boundaries are doubtless truly "local" and will be subject to modification as other sections are studied; other boundaries probably are precise, and should prove to be of regional value in biostratigraphic studies.

Fauna of the Banff Formation at Jasper

The recorded range of ostracode faunas of the Banff Formation at Jasper (Fig. 14) is from 35 to 237 feet above the base: through the upper 140 feet of member A and the lowest 60 feet of member B. The major portion of the faunas was obtained from an interval 30 to 40 feet above the base of member A and the remainder from the interval 2 to 60 feet above the base of member B.

The fauna from Jasper (Fig. 14) is closely related but not identical to that of the type Banff Formation; the first 12 species listed are recorded from the type Banff Formation also; the remaining 13 species are not recorded from Banff. One of the stratigraphically important species of the latter group is *Amphissites* sp. aff. *A. similaris,* which differs from the type-Banff forms in having carinae of equal length and a carinate node (Fig. 13). This is a more primitive feature (from comparison of species of this genus from the Devonian Perdrix Formation) and thus indicates that the member A fauna is earlier than the type Banff faunas. The specimens of *Graphiadactylloides striatoreticulatus* from member A may also be considered, from the form of the surface ornament, to be somewhat more primitive than the type Banff middle member forms. The presence of the other species does little more than extend their range zones down to close to the base of the Banff Formation (Fig. 13), and thus to add additional evidence to the suggestion (p. 60) that the lower half of the Banff Formation contains one major faunal assem-

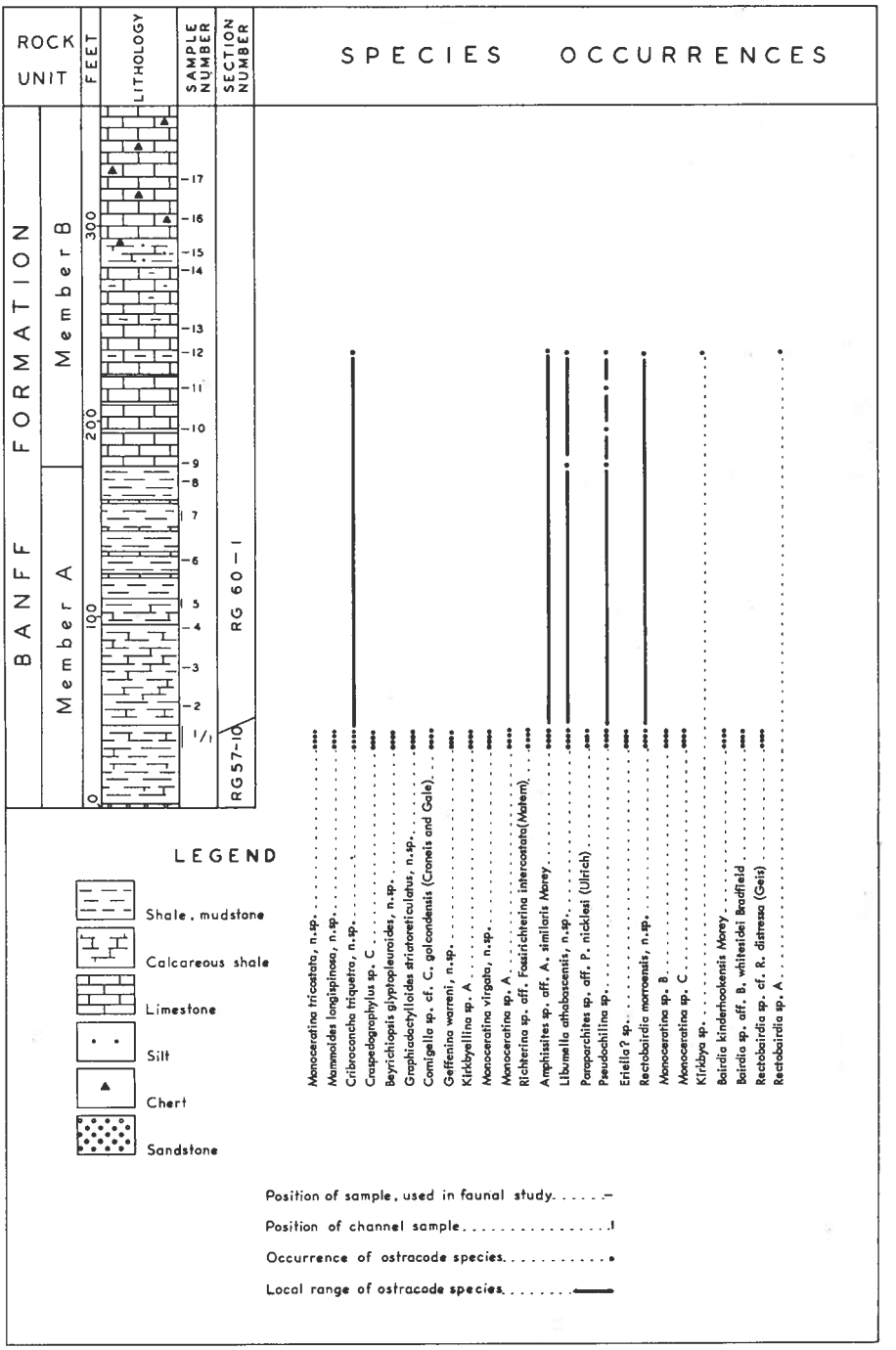

FIGURE 14. Recorded ranges of ostracode species in the Banff Formation, Morro Creek section.

blage. Zonally, the extension of the range zones of five of the species is not significant as they are in any case long ranging. However, in the case of other species, the range zones of *Geffenina warreni* and *Kirkbyellina* sp. A must be extended downward from the lower part of the middle member by some 350 feet into the lower beds of the lower member (Fig. 13). The range zone of *Monoceratina* sp. A can be established as encompassing the lower member and the lower beds of the middle member.

Of the species unrecorded at Banff, several are distinctive and may prove to be of stratigraphic value: *Libumella athabascensis,* ranging through member A into member B (Fig. 14), may give rise to *Namaia reticulata* from the upper-middle member beds at Banff; *Pseudochilina* sp., with the same range as *L. athabascensis,* probably developed into *P. marginata* from the upper unit 4 beds at Banff; *Rectobairdia morroensis,* also ranging through member A into member B, is a distinctive species but has not been recorded elsewhere. Other species of probable zonal value are *Bairdia kinderhookensis, Paraparchites* sp. aff. *P. nicklesi* and *Monoceratina* spp.

In summary, the faunas from Banff member A and from lower member B at Jasper indicate that these strata are earlier than the most of the type Banff middle member—or, specifically, the faunas are earlier than that recorded from 380 feet above the base of the type Banff Formation.

Sunwapta Pass Ostracode Fauna

The ostracode fauna from the Nigel Peak section of the Banff Formation was collected from the upper part of the Banff Formation above the Pekisko unit and a short distance above the upper Banff crinoid zone of Spreng (1953). The fauna obtained from this interval is as follows:

Acratia fabaeformis
Amphissites sp. cf. *A. similaris*
Beyrichiopsis bispinosa
Beyrichiopsis carinata nigelensis
Beyrichiopsis glyptopleuroides
Coryellina obesa
Craspedographylus acrolimbus
Cribroconcha triquetra
Geffenina nigelensis
Graphiadactyllis sp. B

Graphiadactylloides sp. aff. *G. moridgei*
Kirkbyella annensis
Paraparchites pinguis
Paraparchites productus
Pseudoparaparchites montis
Rectobairdia confragosa
Rectobairdia sp. aff. *R. fragosa*
Rectobairdia subparallela
Silenites sp. cf. *S. warei*
Waylandella? punctata.

Of this fauna, ten species are present in the type Banff upper member, two species are long ranging at Banff, and eight species are not recorded at Banff. Of the ten species from the type Banff upper member, eight range from 990 to 1,230 feet, but all ten are present only at 1,230 feet above the formation base. Thus the Sunwapta Pass faunas must be correlated, on the basis of local range zones, with that fauna occurring at 1,230 feet above the base of the type Banff Formation. However, this correlation cannot necessarily be considered precise; rather, a more conservative correlation of the Sunwapta Pass faunas is with type Banff Formation faunas in the interval 990 to 1,230 feet.

Peace River Region Faunas

The faunas described from the Peace River region were obtained from samples and cores of five wells and range in position from the Exshaw Formation to the lower beds of the Debolt Formation (Fig. 15). Two wells, H. B. Union Salt Creek No. 1 and Bear Villa No. 1, yielded *Eriella? cribraria* from uppermost Exshaw to lowest Banff strata. The record of *Rectobairdia subparallela* (Morey) from the basal Banff strata of Shell Cadotte No. 1 well may possibly be suspect as the specimens were collected from well cuttings which are subject to contamination; until shown otherwise, however, this record is accepted with reservation. Three species, *Beyrichiopsis* sp. A, *Rectobairdia* sp. cf. *R. sinuosa* (Morey) and *Rectobairdia* sp. B were collected from the Banff Formation in Shell Cadotte No. 1 well. The Pekisko Formation in the same well yielded *Beyrichiopsis carinata carinata, B.* sp. aff. *B. glyptopleuroides, Graphiadactyllis subrhomboidalis, Paraparchites nicklesi* (Ulrich), *P.* sp. cf. *P. pinguis,* and *Waylandella? punctata.* In H. B. Union Salt Creek No. 1 well the following species were obtained from Pekisko strata: *Beyrichiopsis carinata carinata, Coryellina obesa, Graphiadactyllis* sp. A, and *Waylandella? punctata.*

The lower half of the Shunda Formation yielded the following species in Forest Shell Peace River No. 14-29 well:

Beyrichiopsis carinata carinata
Craspedographylus? inornatus
Graphiadactyllis subrhomboidalis
Seminolites nelsoni
Waylandella? punctata.

Beyrichiopsis sp. B was recorded from middle Shunda strata in Bear Villa No. 1 well and from upper Shunda strata in Canadian Petroleums Peace River No. 2 well, where it was associated with *Seminolites stelcki, Bythocyproidea punctata, Editia albertensis, Cribroconcha triquetra, Rectobairdia* sp. aff. *R. fragosa, Paracavellina indistincta* and *Acratia fabaeformis.*

Probable lower Debolt strata in the Bear Villa well yielded *Editia albertensis, Amphissites* sp. cf. *A. similaris, Cryptobairdia* sp. aff. *C. compacta,* and *Kirkbya* sp.

The presence of *Editia albertensis* in upper Shunda and lower Debolt strata indicates a correlation with the type Banff upper member (990 to 1,230 feet above the base); this correlation is supported by the presence of late forms (see p. 97) of *Beyrichiopsis carinata carinata* in lower Shunda strata and late forms of *B. carinata nigelensis* in the 990 to 1,230 foot interval at Banff. *Craspedographylus? inornatus* is closely similar in morphology to *C. acrolimbus,* differing in having subdued spine development; these two species may be interpreted as being essentially contemporaneous although geographically distinct.

This evidence thus indicates a general correlation of the Shunda Formation of the Peace River with the upper member of the type Banff Formation.

The ostracode data from the Pekisko and Banff Formations are insufficient to indicate a correlation with the type section. However, the presence of *Eriella? cribraria* in high Exshaw to basal Banff strata is of some interest. This species is present in upper Big Valley (Upper Devonian) strata in southeastern Alberta and specimens intermediate between it and *Eriella?* sp. are present in lower member A strata at Jasper. Its occurrence in the Peace River area thus may be slightly earlier than that of *Eriella?* sp. at Jasper.

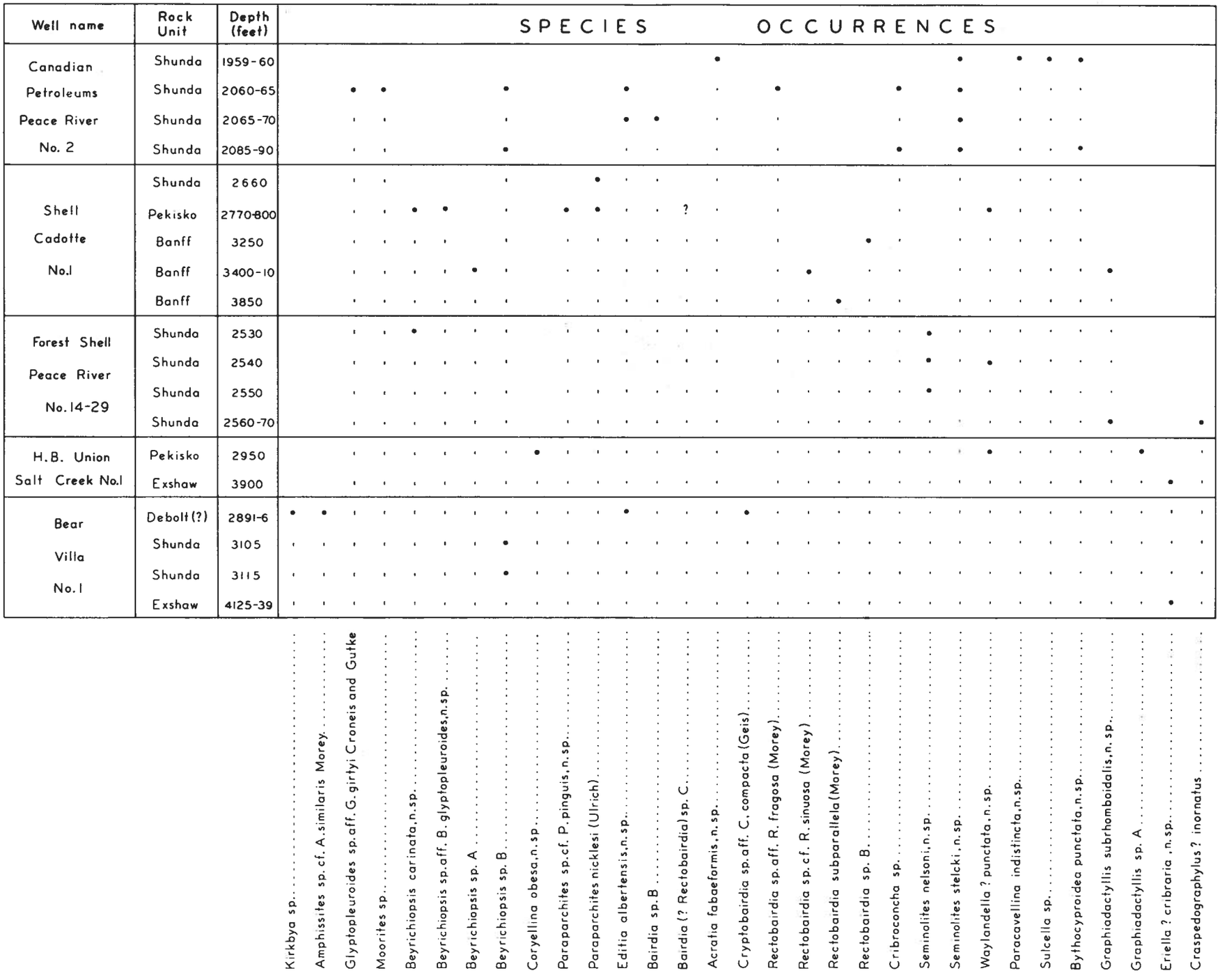

FIGURE 15. RECORDED OCCURRENCES OF OSTRACODE SPECIES FROM FIVE PEACE RIVER REGION WELLS

Table 11. Summary of Stratigraphic Ranges of Previously Described Ostracode Species Recorded from the Banff Formation

SPECIES \ AGE	Kinderhook		Osage				Meramec	Chester	Kinderhook	Osage
SPECIES \ ROCK UNIT	Bushberg Formation	Chouteau Formation	Springville Formation	Fern Glen Formation	Ridgetop Formation	Welden Formation	Salem Formation	Chester Series	Banff Formation, lower and middle members	Banff Formation, upper member
Acratia similaris Morey		x								x
Amphissites similaris Morey		x								x
Bairdia kinderhookensis Morey		x							x	
Cornigella golcondensis (Croneis and Gale)								x	cf.	
Eriella? lineata (Ulrich and Bassler)					x					cf.
Glyptopleura belphegora Brayer							x			cf.
Graphiadactylloides moridgei (Benson)		x	x	x						x
Kirkbya keiferi Benson				x						cf.
Kirkbyella annensis Benson and Collinson		x	x							x
Monoceratina tennesseensis (Ulrich and Bassler)					x	x				cf.
Paraparchites nicklesi (Ulrich)	x	x	x	x					x	x
Rectobairdia distressa (Geis)							x		x	
Rectobairdia sinuosa (Morey)		x							cf.	
Rectobairdia subparallela (Morey)	x	x							x	x
Silenites warei Morey		x								cf.

Age of the Banff Formation

The first consideration to be made in determination of the age of the Banff Formation is that of ranges of previously described species recorded from the Banff Formation and of species with which Banff forms have been compared. These species ranges are recorded in table 11; six species apparently are confined to Kinderhook strata, three to Osage, and two to Meramec rocks. Three species have recorded ranges of Kinderhook to Osage strata. All three "restricted" Osage species occur in the upper part of the type Banff middle member or in the upper member. Three of the "restricted" Kinderhook species have this same distribution. The age determination based on the ostracodes thus appears somewhat inconclusive. This shortcoming is mainly a function of inadequate knowledge of ranges of the ostracode species in the type Lower Mississippian in the Mississippi Valley. However, if it be assumed that the appearance of the "new" (Osage) elements in the upper member of the Banff Formation is of more significance than persistence of "old" (Kinderhook) faunal elements, then the Kinderhook-Osage boundary may conveniently be placed at the level of the faunal change in the upper part of the type Banff middle member: between 770 and 820 feet (800 feet) above the base of the type Banff Formation. If this procedure be accepted, then the lower Osagian portion of the type Banff Formation contains a mixture of Kinderhook and Osage faunal elements, a situation pointed out previously for the megafaunas of this rock unit (Harker and Raasch, 1958), which include "the sort of mixture of Burlington and Chouteau elements plus elements exclusively early Osagian which also prevails in the lower Osage complex in the Mississippi Valley" (Harker and Raasch, 1958, p. 226). Unfortunately, the exclusively lower Osage elements of the ostracode faunas are not as yet fully defined.

This positioning of the Kinderhook-Osage boundary in the upper part of the type Banff middle member is the same as that made by Harker and Raasch (1958, p. 226-7) and by Nelson (1961, Fig. 2). The uppermost middle member and the upper member of the type Banff are thus considered early Osage (Fern Glen) in age, and the lower member and lowest 500 feet of the middle member are of Kinderhook age.

However, the question still remains as to the age of the lowest Banff strata, the basal Banff sandstone at Jasper, and of the Exshaw Formation. At Banff no ostracode faunas were collected from the basal 150 feet of the Banff Formation; at Jasper the fauna obtained from 30 to 40 feet above the base of the formation is wholly Mississippian in aspect (Fig. 14) and contains *Bairdia kinderhookensis*, a

Kinderhook (Chouteau) species. The basal bed of the Banff Formation in the Jasper area is a thin arkosic sandstone lying on and filling depressions in the surface of the Palliser Formation and consisting of poorly sorted angular quartz, feldspar, and biotite grains, with occasional volcanic rock fragments, phosphatic material, fish fragments, "wood" fragments (a single type of alga), and with conodonts in the upper part. This bed may thus be considered as reworked regolith material, and the time of reworking—and thus the time of advance of the sea—is probably indicated by the conodonts in the upper part of the bed. The conodont fauna is considerable, and includes the species *Siphonodella sexplicata* (Branson and Mehl), *S. quadruplicata* (Branson and Mehl), and *S. duplicata* (Branson and Mehl). The presence of the genus *Siphonodella* is diagnostic of a Mississippian age (Mehl, 1960; Scott and Collinson, 1961) and, according to Mehl (1960, p. 96-97), the first appearance of the genus is in the *Siphonodella* Zone which in its typical faunal development includes *Siphonodella sexplicata, S. quadruplicata, S. duplicata,* and *S. lobata,* plus species of at least two other conodont genera. The presence of three of these species in the basal Banff sandstone at Jasper may thus be taken to indicate an earliest Mississippian age, not necessarily for the time of deposition of the arkose, but for the time of reworking by the sea advancing over that area.

These data then indicate that the time of advance of the post-Wabamun or post-Palliser sea over the Jasper area was later than in parts of the Peace River area, as the Exshaw Formation in the Bear Villa well contains conodonts showing affinity to those of the Grassy Creek Formation of Missouri (Res. Coun. Alberta Rept. 76, 1957, p. 24)[1].

This advance apparently was also later than in parts of southeastern Alberta, as the conodont fauna of the Exshaw Formation in the Steveville, Patricia, and Stettler areas (Cooper and Sloss, 1943; Raasch, 1956) is indicative of a Devonian age (Raasch, 1956, p. 115).

The presence of a bentonite bed in the uppermost strata of the black shale of the Exshaw Formation at Nordegg (Douglas, 1956) may be of significance in supporting this concept of age difference. According to Folinsbee and Baadsgaard (1958), this bentonite bed contains sanidine of volcanic origin. It seems not unreasonable to

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[1]J. H. Wall (pers. comm.) states that comparison was made with the fauna illustrated by Branson and Mehl (1933) as being that of the Grassy Creek Formation. Mehl (1960, p. 83) states that much of this fauna was obtained from the Saverton Formation. As both units are of late Devonian age, however, the discussion made in the text above is still valid.

suppose that the volcanic rock fragments in the basal Banff sandstone at Jasper and the volcanic ash at Nordegg were deposited simultaneously as debris from one volcanic eruption. The volcanic material at Jasper has been shown to be most probably pre-*Siphonodella* Zone (i.e. pre-Mississippian) in age, and the major part of the Exshaw Formation at Nordegg thus also must be most likely pre-Mississippian in age.

It then appears that there exist some unexplained, possibly even unrecognized, stratigraphic relationships between the Exshaw Formation and later strata of west-central Alberta which require elucidation.

The data from the Jasper area may be summarized as indicating a correlation of the basal Banff sandstone with the oldest Mississippian parts of the Bachelor Formation of central Missouri, and thus of the overlying Banff strata with the Chouteau Formation of that same area.

In the Peace River area the Devonian age of the Exshaw Formation is established, as mentioned above (p. 69). The age of the basal Banff strata in that region may then theoretically be latest Devonian also and the meagre ostracode evidence available may be interpreted as supporting this concept. The presence of *Eriella*? *cribraria* in the uppermost Exshaw to lowest Banff strata of the Peace River region and its extremely close relationship to the species of *Eriella* from the Big Valley Formation suggest a close temporal relationship of these strata, whilst the differences between the species of *Eriella* in the Peace River basal Banff and the Jasper basal Banff strata suggest that these rocks may be of somewhat different ages.

Other microfaunal data on the age of the Exshaw Formation are given by Copeland (1960) for a section in the Crowsnest Pass. The presence of *Siphonodella* spp. in the upper beds of the black shale indicates that part at least of this unit is also of Mississippian age.

FORMAL DESCRIPTIONS [1]

Subclass OSTRACODA Latreille, 1806
Order PALAEOCOPIDA Henningsmoen, 1953
Suborder BEYRICHICOPINA Scott, 1961
Superfamily BEYRICHIACEA Matthew, 1886
Family BEYRICHIIDAE Matthew, 1886
Genus HALLIELLA Ulrich, 1891

HALLIELLA? sp.

Plate 1, figures 1, 3

Description: Carapace inequivalved. Left valve overlapping right around free margins. Each valve subovate in lateral view, subtriangular in dorsal and in end view. Hinge long, straight, not depressed. Dorsal border straight; cardinal angles distinct. Anterior border evenly rounded; ventral border straight to gently convex; posterior border rounded, truncate ventrally.

S_2 a narrow sulcus, arising below the dorsal border, ending in a pit situated slightly above midheight; base of S_2 extending a short distance anteriorly.

L_2 not raised above the general valve surface, and joined to L_3 by a ventral lobe; inflation of the lobes increasing posteriorly and reaching a maximum in L_3. L_3 a highly inflate lobe, grading smoothly into the valve surface anterodorsally, and joining it at right angles posteriorly and ventrally. Shallow channel separating a submarginal ridge from the valve posteriorly and ventrally; the submarginal ridge paralleling the free margins, and joining a rather indistinct dorsal ridge at the cardinal angles. Submarginal ridge separated from a narrow marginal ridge by a distinct groove.

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[1]The differentiation of mature from immature instars has constituted a considerable problem in study of the taxonomy of the ostracodes.

It has been shown by numerous authors that ostracodes may change in relative dimensions and in surface features and ornament from one instar to the next, and thus valid comparison of one species with another can be made only by using mature individuals. Also, it is desirable that the description of any new ostracode species be based on mature individuals and if possible that the various instars be recognized. A third factor that is influenced by the recognition or nonrecognition of maturity in ostracode specimens is that of ecologic association (see page 27).

Because of this possibility of immaturity of some of the ostracodes, some taxa are described but are left as *nomenclatura aperta* until such times as definite adult instars are obtained.

Border of left valve grooved for reception of right.

Lateral surface, except for ridges and channel, ornamented by coarse scattered punctae.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0167	0.95	0.49
Specimen PO. 0168	0.84	0.46

Remarks: This species is placed tentatively in the genus *Halliella* Ulrich because of its close resemblance to the genotype *H. retifera* Ulrich. It is similar in general shape, inflation and perhaps marginal structures to *H. retifera,* but differs in the form of S_2 and in ornament.

Insufficient material is available at present to permit definite generic assignment of this species.

Occurrence: RG 56-3-52; RG 57-10-1.

Specimens: Two left valves, Nos. PO. 0167, 0168.

Superfamily DREPANELLACEA Ulrich and Bassler, 1923
Family AECHMINELLIDAE Sohn, 1961
Genus MAMMOIDES Bradfield, 1935

MAMMOIDES LONGISPINOSA, n. sp.

Plate 1, figures 2, 4-7, 11

Diagnosis: *Mammoides* species with L_2 and L_3 forming a U-shaped, spine-tipped lobe, and with L_4 bearing a posterolaterally directed spine.

Description: Carapace subquadrate to subrhomboidal in lateral view. Greatest height slightly anterior of midlength; greatest width anterior; greatest length slightly below to slightly above midheight. Length varying between 1.4 and 2.1 times the height.

Dorsal border straight, approximately four-fifths of the length. Ventral border gently convex. Anterior border moderately convex, with almost straight anterodorsal slope. Posterior border evenly rounded.

Cardinal angles distinct; anterior cardinal angle 120 degrees; posterior cardinal angle 110 degrees.

Lateral surface reticulate with three strong lobes or nodes produced into spines in most specimens. L_1 a low indistinct ridge along the anterior border; L_2 and L_3 highly variable in form, ranging from a hemispheroidal node bearing a curved blunt spine, to an elongate curved blunt-ended spine, directed posteriorly. L_2 and L_3 in most specimens joined as a distinct to indistinct U-shaped ridge; ridge absent in some specimens, the nodes and spines in this case arising out of the main carapace. L_4 generally a spine, short to long, posteriorly and outwardly directed and lying close to the posterior border. S_1 present or absent; generally where present, a shallow depression extending from near dorsal margin to about midheight. S_2 situated between the nodes or spines of L_2 and L_3; most distinctive where L_2 and L_3 present in the form of nodes. S_3 distinctive only where a U-shaped ridge developed in L_2 and L_3.

All three spines curved, in most specimens convex side toward the anterior. Spine of L_2 in a few specimens curved convex side toward the posterior.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0070	0.65	0.42	0.42
Paratype PO. 0071	0.49	0.28	—
Paratype PO. 0072	0.46	0.27	—
Paratype PO. 0073	0.45	0.27	—
Paratype PO. 0074	0.48	0.28	—

Remarks: *M. longispinosa* differs from most other species of *Mammoides* in having the posterior lateral spine situated at or above midheight. In this feature it resembles *M. dorsospinosa* Sohn; from this species it differs in that the lobes and spines are considerably larger, thus constituting much more substantial features of the carapace surface than in the Pennsylvanian species.

This species ranges through 1,200 feet of the Banff Formation, and although all the material has been referred to the one species, a definite and distinct change in shape takes place through the section. This change is gradual and more or less continuous, thus no differentiation into distinct species can be made on this basis (Fig. 16). The change in the mean form ratio between populations in the section (Fig. 17) is statistically significant at the 0.25 per cent level (i.e., this could have arisen by chance once in 400 times). However, within any one population the variations in individual form ratio may be greater than the total variation in mean form ratio of all populations

through the recorded range of the species. Thus determination of the form ratio of one or two individuals from a population will not permit determination of stratigraphic position, but the mean form ratio of a group of individuals in a sample will allow a general positioning in the stratigraphic section.

Any valid specific differentiation on the basis of shape alone is not possible. Other features of possible specific significance are

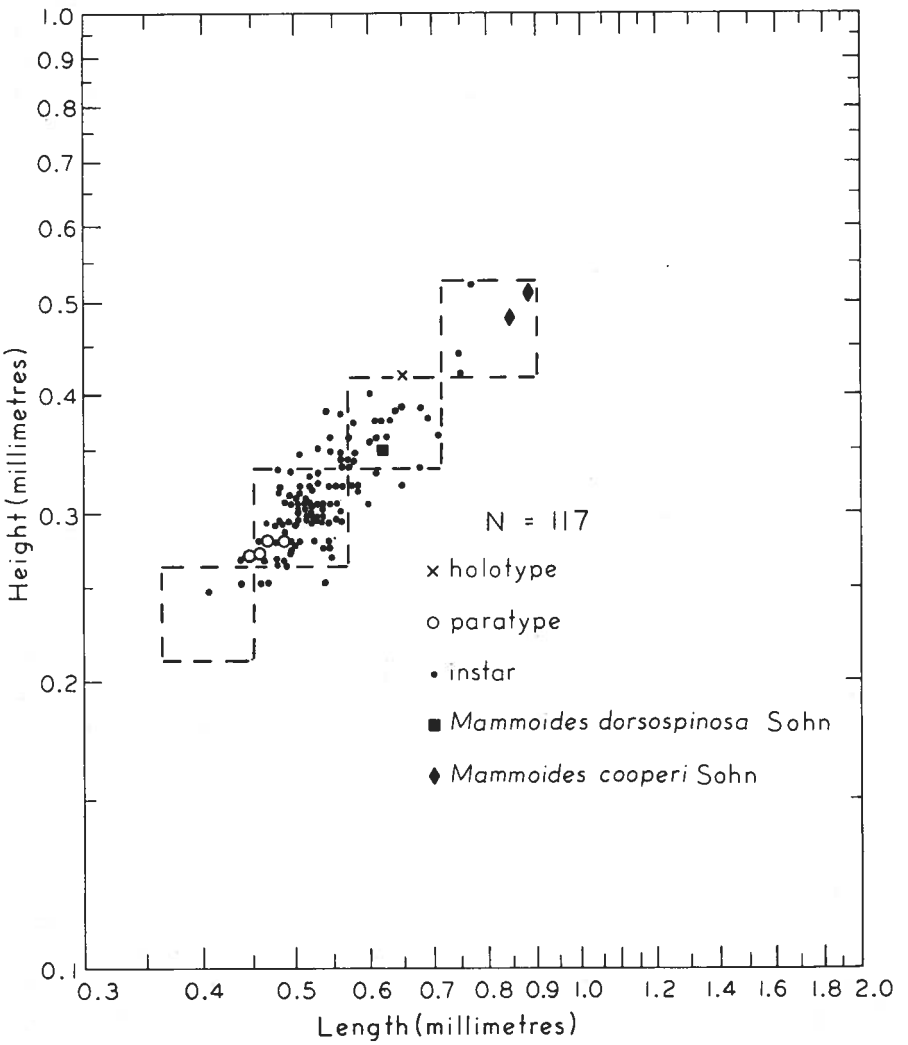

FIGURE 16. Comparative dimensions of specimens of instars of **Mammoides longispinosa**, *n. sp.*

highly variable, and variation within any one arbitrary species or subspecies will be as great or greater than that between species or subspecies.

Occurrence: RG 56-1-2, 4, 33, 34, 41, 42, 43, 70, 71, 74; RG 56-3-2, 10, 12, 14, 16, 18, 20, 21, 30, 31, 33, 35, 36, 40, 41, 43; RG 56-4-26A, 31, 43, 45, 52, 57, 59, 62, 63, 64, 68, 70, 72, 75; RG 57-10-1.

Types: Holotype, a complete carapace, No. PO. 0070; paratypes, instars, two right and two left valves, Nos. PO. 0071-0074.

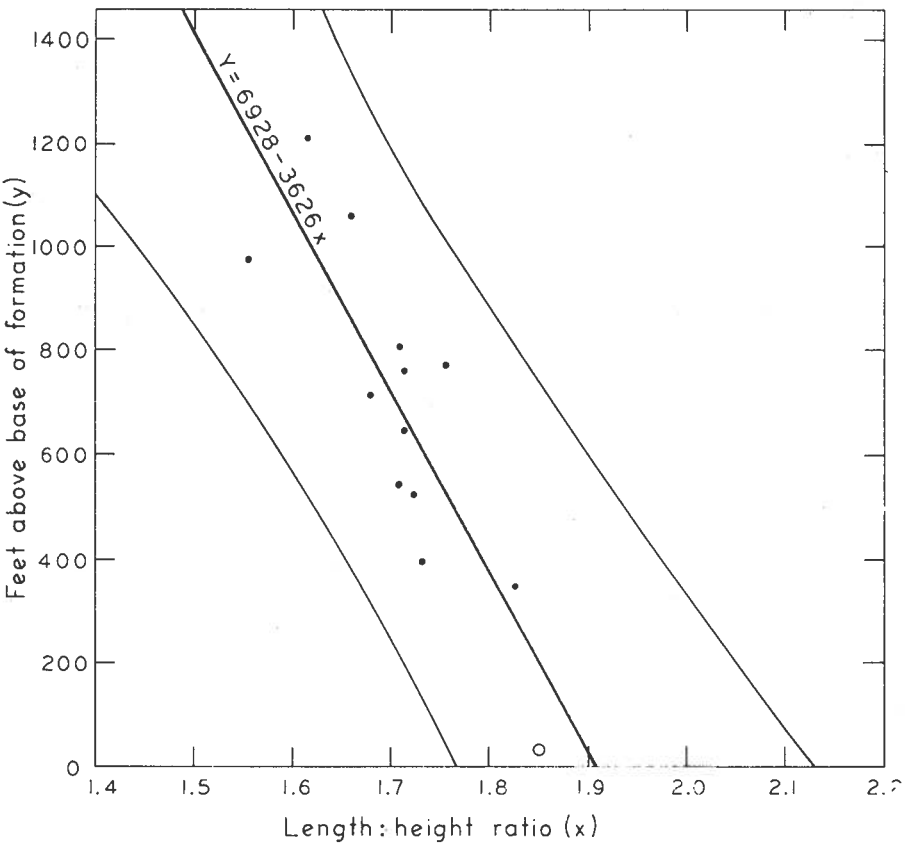

FIGURE 17. Regression of mean length:height ratio of Mammoides longispinosa, *n. sp., on stratigraphic position in terms of feet above the base of the type Banff Formation. The regression equation is indicated, and also the 95 per cent confidence limits for the regression line. The open circle represents the mean form ratio for specimens from one sample (RG 57-10-1) from the Jasper area.*

Genus CORNIGELLA Warthin, 1930

CORNIGELLA sp. cf. C. GOLCONDENSIS (Croneis and Gale)

Plate 1, figures 8-10

?*Verrucosella golcondensis* Croneis and Gale, 1938, Bull. Denison Univ. Sci. Lab., vol. 33, p. 275, pl. 5, fig. 8.

Description: Carapace small, subquadrate; valves probably equal. Greatest height anterior, between one-third and two-fifths of the length from anterior end. Greatest width anterior; greatest length slightly above midheight. Length varying between 1.5 and 1.8 times the height.

Dorsal border straight, approximately five-sixths of the length. Ventral border gently convex in anterior half, more strongly so in posterior half. Anterior and posterior borders rounded. Cardinal angles distinct. Anterior cardinal angle about 110 degrees; posterior cardinal angle about 120 degrees.

Lateral surface reticulate and also ornamented by seven rounded nodes. L_1 a low ridge along the anterior border, culminating in a small rounded to subelongate node slightly above midheight. L_2 the largest node, generally hemispheroidal and extending to or slightly above the dorsal border. L_3 rounded to subelongate, and commonly produced into a low rounded or conical tip directed upward. L_4 a low rounded node close to the posterodorsal angle and in some specimens produced dorsally.

Three additional rounded nodes located close to the ventral margin, these nodes lying slightly anterior in position to nodes L_2, L_3 and L_4. Shallow S_2 commonly present located behind and close to L_2. Small, inconspicuous marginal ridge commonly present.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0075	0.49	0.31
Specimen PO. 0076	0.47	0.27
Specimen PO. 0077	0.42	0.26

Remarks: In view of the fact that the Pennsylvanian species of this genus are reported as being highly variable in form, this species remains remarkably constant in form through the recorded range of almost 800 feet of the Banff Formation. The Banff form is comparable with the Chester species in dimensions, but differs in possibly being less coarsely reticulate, in having a less well defined marginal ridge, and commonly a slightly smaller L_1. The ventral nodes in

Cornigella tuberculospinosa (Jones and Kirkby) appear to lie farther from the ventral margin than do those of this Mississippian species.

Occurrence: RG 56-1-7, 41, 42, 43, 46; RG 56-3-11, 12, 21, 22, 34, 35, 38, 40, 41, 43, 48; RG 57-10-1.

Specimens: Two right and one left valves, Nos. PO. 0075-0077.

Family KIRKBYELLIDAE Sohn, 1961

Genus KIRKBYELLA Coryell and Booth, 1933, emend. Sohn, 1961

KIRKBYELLA (BERDANELLA) ANNENSIS (Benson and Collinson)

Plate 1, figures 25, 26

Kirkbyella annensis Benson and Collinson, 1958, Illinois Geol. Surv. Circ. 255, p. 15, pl. 4, figs. 9-11.

Remarks: Four specimens closely resembling the Illinois material were obtained. The posteroventral spine in the Alberta material may be slightly more strongly developed.

Occurrence: RG 57-11-1.

Types: Hypotype, a complete carapace, No. PO. 0078.

KIRKBYELLA (BERDANELLA) BOWENSIS, n. sp.

Plate 1, figures 14-18

Diagnosis: A subrhomboidal *Kirkbyella* species without distinct lateral ridge, and with closely spaced, ribbed to striate-reticulate surface ornament.

Description: Relationship of valves unknown. Valves subrhomboidal in lateral view. Greatest height posterior in adult forms, but anterior in some immature instars; greatest width posterior, below midheight; greatest length about halfway between midheight and dorsal border. Hinge long, straight, almost as long as maximum valve length, slightly depressed below dorsal border in posterior half. Dorsal border straight in anterior half, gently convex in posterior half. Anterior border smoothly convex, rounding smoothly into ventral border. Posterior border almost straight dorsally, rounding smoothly into ventral border. Ventral border almost straight.

Anterior cardinal angle 110 to 120 degrees, posterior cardinal angle 90 to 105 degrees.

S_2 distinct, moderately deep, arising slightly below the dorsal border, parallel sided, but widening slightly at base at about mid-

height. Posteriorly directed spine situated in the posteroventral area, the spine arising directly from the carapace and not from a lateral ridge or swelling.

Surface ornamented by closely spaced, locally anastomosing riblets; riblets wider than the intervening depressions. Cross-riblets joining the riblets at intervals. Riblets paralleling the dorsal and ventral borders in the central portion of the valve and towards the valve extremities swinging to parallel the anterior and posterior borders, and converging toward the cardinal angles. S_2 and area close to the hinge not ornamented.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0079	1.03	0.65	0.31
Paratype PO. 0080	0.86	0.61	—
Paratype PO. 0081	0.91	0.57	—
Paratype PO. 0082	0.80	0.46	—

Remarks: *K.* (*B.*) *bowensis* differs from other species of *Berdanella* in the form of the surface ornament. It differs from *K.* (*B.*) *annensis* (Benson and Collinson) and *K.* (*B.*) *reticulata*, n. sp., also in shape; it lacks the lateral ridge of *K.* (*B.*) *reticulata.*

Occurrence: RG 56-4-75.

Types: Holotype, a right valve, No. PO. 0079; paratypes, three right valves, Nos. PO. 0080-0082.

KIRKBYELLA (BERDANELLA) RETICULATA, n. sp.

Plate 1, figures 12, 13, 19-23

Diagnosis: Quadrate *Kirkbyella* species with pronounced lateral ridge, posteroventral spine, and evenly reticulate surface ornament.

Description: Relationship of valves unknown. Valves subrectangular in lateral view, subtriangular in dorsal and in end view. Greatest height posterior; greatest width posterior; greatest length slightly above midheight. Hinge long, straight, almost as long as

maximum length of valves, depressed slightly below dorsal border in posterior half. Dorsal border straight in anterior half, slightly convex in posterior half. Anterior border evenly convex, rounding into ventral border with slight angulation. Posterior border gently convex, joining ventral border with distinct angulation. Ventral border almost straight, parallel to dorsal border.

Anterior cardinal angle 115 degrees; posterior cardinal angle 105 degrees.

S_2 distinct, parallel sided, situated anterior to midlength, arising just below the dorsal border, extending vertically and ending a short distance above midheight in a shallow pit. Much of the ventral half of the valve occupied by a strong lateral ridge lying parallel to the ventral border and ending posteriorly in a strong, posteriorly directed spine.

Lateral surface, including the spine, evenly and strongly reticulate; S_2 smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0083	1.03	0.55	0.34
Paratype PO. 0084	0.76	0.42	—
Paratype PO. 0085	0.76	0.46	—
Paratype PO. 0086	0.76	0.44	—
Paratype PO. 0087	0.95	0.46	—
Paratype PO. 0088	0.87	0.49	—

Remarks: This species is differentiated from the previously described Mississippian species—*K.* (*B.*) *gutkei* (Croneis and Bristol), *K.* (*B.*) *quadrata* (Croneis and Gutke) and *K.* (*B.*) *annensis* (Benson and Collinson)—by its subrectangular outline, its strong lateral ridge that is an integral part of the valve, and by its well-developed posteroventral spine. *K.* (*B.*) *reticulata* is closely similar to *K.* (*B.*) *unicornis* (Coryell and Malkin); it differs only in its strong development of the lateral ridge.

Occurrence: RG 56-4-75.

Types: Holotype, a right valve, No. PO. 0083; paratypes, three right valves, Nos. PO. 0084-0086, and two left valves, Nos. PO. 0087-0088.

KIRKBYELLA (BERDANELLA) sp. aff. K. (B.) RETICULATA, n. sp.

Plate 1, figure 24

Remarks: One immature instar was obtained of a species resembling *K. reticulata*, n. sp. It differs from that species in having lineal elements in the reticulate ornament, which in the anterodorsal area lie parallel to the anterior border and which parallel the ventral border in the ventral half of the valve.

Occurrence: RG 56-1-42.

Specimen: A left valve, No. PO. 0089.

Superfamily HOLLINACEA Swartz, 1936
Family HOLLINIDAE Swartz, 1936
Genus HOLLINELLA Coryell, 1928

HOLLINELLA sp.

Plate 2, figure 1

Remarks: Immature instars of a species of *Hollinella* are present in two samples.

Occurrence: RG 57-1-42; RG 57-10-1.

Specimen: A left valve, No. PO. 0023.

Genus TETRASACCULUS Stewart, 1936

TETRASACCULUS CALCARATUS, n. sp.

Plate 2, figures 2-9

Diagnosis: Species of *Tetrasacculus* with anteroventral and posteroventral spines and a relatively short sulcus in the male; in the female four loculi and an indistinctly scalloped frill.

Description of male: One adult male valve available. Carapace subovate in lateral view. Greatest height anterocentral; greatest width centroventral; greatest length close to dorsal border. Dorsal border almost straight; anterior border rounded; ventral and posterior borders gently rounded, posterior border acutely tapering toward posterior end.

Anterior cardinal angle 130 degrees; posterior cardinal angle 120 degrees.

Valve unisulcate. S_2 arising close to midpoint of dorsal border and extending anteroventrally, deepening and widening to about midheight; S_2 more oblique below midheight and short.

L_1 evenly rounded; L_2 flattened posteroventrally and extending anteroventrally into a low swelling at about midlength below S_2.

A narrow submarginal ridge present anteriorly; the ventral and posteroventral margins imperfectly preserved, but widely spaced spines discernible.

Spur present anteroventrally and also posteroventrally; posteroventral spur situated slightly behind midlength. Anterior spur expanded towards the end, apparently in a somewhat similar manner to that of *Hanaites platus* (Kesling and McMillan); preservation incomplete.

Surface with scattered granules centrally and with scattered spines ventrally and along the anterior and posterior borders.

Description of female: One adult female valve available. Outline and general shape similar to that of male. Female proportionately shorter than male and more inflate anteroventrally. Four loculi situated along the anterior and ventral margins. Frill moderately wide, not scalloped, extending along half of the ventral border and along the anterior border almost to midheight. A posterolaterally directed spine present on the frill border below the end of S_2. Anterior three loculi rounded; posterior loculus smaller and more quadrate, perhaps partially distorted during preservation. Surface with scattered granules.

Description of instars: Instar A—1 (male). Differing from the adult male in lack of the posteroventral spur. Anteroventral spur represented by a strong, curved, posterolaterally directed spine. A narrow submarginal ridge present ventrally and posteroventrally. S_2 and submarginal area smooth; remainder of lateral surface reticulate.

Instar A—1 (female). Differing from adult female in possessing up to three loculi instead of four. Submarginal area, S_2, and frill smooth; remainder of surface reticulate.

Instar A—2. Potential males and females differentiated by their relative proportions (Fig. 18). Both instars closely similar to instar

A—1 males. With the absence of the frill in the female instars, S_2 extends almost to the anteroventral border.

Instar A—3. Differing from instar A—2 in having the mid-ventral swelling defined posterodorsally as well as anteroventrally; swelling thus is a distinct elliptical node.

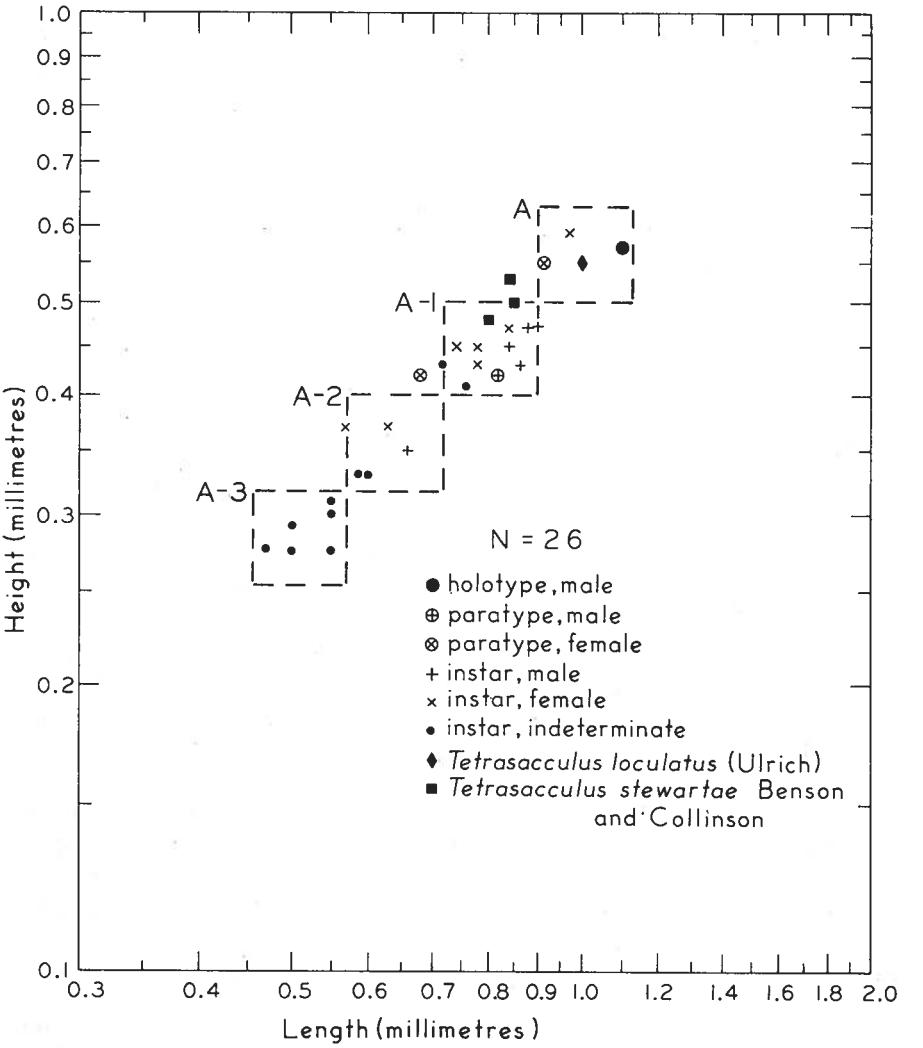

FIGURE 18. Comparative dimensions of specimens of instars of **Tetrasacculus calcaratus**, *n. sp., and of the type specimens of* **T. loculata** *(Ulrich) and* **T. stewartae** *Benson and Collinson.*

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0024	1.10	0.57
Paratype PO. 0025	0.91	0.55
Paratype PO. 0026	0.68	0.42
Paratype PO. 0027	0.82	0.42
Paratype PO. 0028	0.55	0.30
Paratype PO. 0029	0.55	0.31

Remarks: *T. calcaratus,* n. sp., differs from *T. stewartae* Benson and Collinson in having in the female a broader frill which is not scalloped and which possesses a marginal spine. The males differ in that the anteroventral spur is anterolaterally directed in *T. stewartae* and is curved and posterolaterally directed in *T. calcaratus.* It is believed—as suggested by Benson and Collinson (1958, p. 10)—that the described specimens of *T. stewartae* are not mature and that they represent the penultimate instar (Fig. 18) : the dimensions and form are closer to those of the penultimate instars of *T. calcaratus* than to those of the adult forms. One female penultimate instar of *T. calcaratus* was found in which three loculi were developed; loculi were absent in the other females of this instar.

T. loculata (Ulrich) differs from *T. calcaratus* in that the frill is scalloped and in that a small node is present in the position of L_2.

T. kalugaensis Samoilova and Smirnova is only half the size of *T. calcaratus,* has more widely spaced loculi, coarser reticulation, and possesses an S_2 extending almost to the ventral margin.

Occurrence: RG 56-1-4, 42, 46; RG 56-3-38, 40, 43; RG 56-4-59, 68, 75.

Types: Holotype, an adult male right valve, No. PO. 0024; paratypes, one adult female left valve, No. PO. 0025, one immature female right valve, No. PO. 0026, one immature male right valve, No. PO. 0027, and two immature right valves, Nos. PO. 0028-0029.

Superfamily KIRKBYACEA Ulrich and Bassler, 1906
Family KIRKBYIDAE Ulrich and Bassler, 1906
Genus KIRKBYA Jones, 1859

KIRKBYA sp. cf. K. KEIFERI Benson

Plate 2, figures 10, 11

?*Kirkbya keiferi* Benson, 1955, Jour. Paleont., vol. 29, p. 1037, pl. 107, figs. 14-16.

Remarks: Several late instars closely resembling *K. keiferi* Benson have been obtained from the upper part of the middle member of the Banff Formation. As preservation is imperfect, they are referred to this species with qualification.

Occurrence: RG 56-3-40, 52.

Specimens: One right and one left valve, Nos. PO. 0149, 0150, respectively.

KIRKBYA sp.

Plate 2, figure 12

Diagnosis: A species of *Kirkbya* ornamented with fine, locally inosculating riblets; the areas between the riblets ornamented with fine reticulations.

Remarks: This species is at present recorded from only two localities, one high in the Banff Formation and one in the lower member.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0151	1.18	0.61

Occurrence: RG 60-1-12; Bear Villa No. 1 well, core 115, 2,891 feet.

Specimen: A right valve, No. PO. 0151.

KIRKBYA spp.

Plate 2, figure 13

Remarks: Instars of *Kirkbya* species, many resembling those of *K. fernglenensis* Benson, were obtained from several samples.

Occurrence: RG 56-1-42; RG 56-3-38, 40, 43; RG 56-4-75.

Specimen: A left valve, No. PO. 0152.

Family AMPHISSITIDAE Knight, 1928
Genus AMPHISSITES Girty, 1910

AMPHISSITES SIMILARIS Morey

Plate 2, figures 14-18

Amphissites similaris Morey, 1936, Jour. Paleont, p. 115, pl. 17, fig. 6.

Remarks: Specimens agreeing with Morey's description in almost all respects are present in the upper part of the Banff Formation.

The holotype of *A. similaris* Morey was examined in the course of this study. This specimen (Plate 17, Fig. 6, Morey, 1936) is a right valve with dimensions: length, 1.04 mm., height, 0.56 mm. The valve probably has been somewhat flattened and distorted during preservation and part of the dorsal border is missing. The outer rim and inner ridge both are worn and thus appear narrower than where well preserved.

Several additional features can be described from the Banff material. Seven instars have been distinguished. The kirkbyan pit

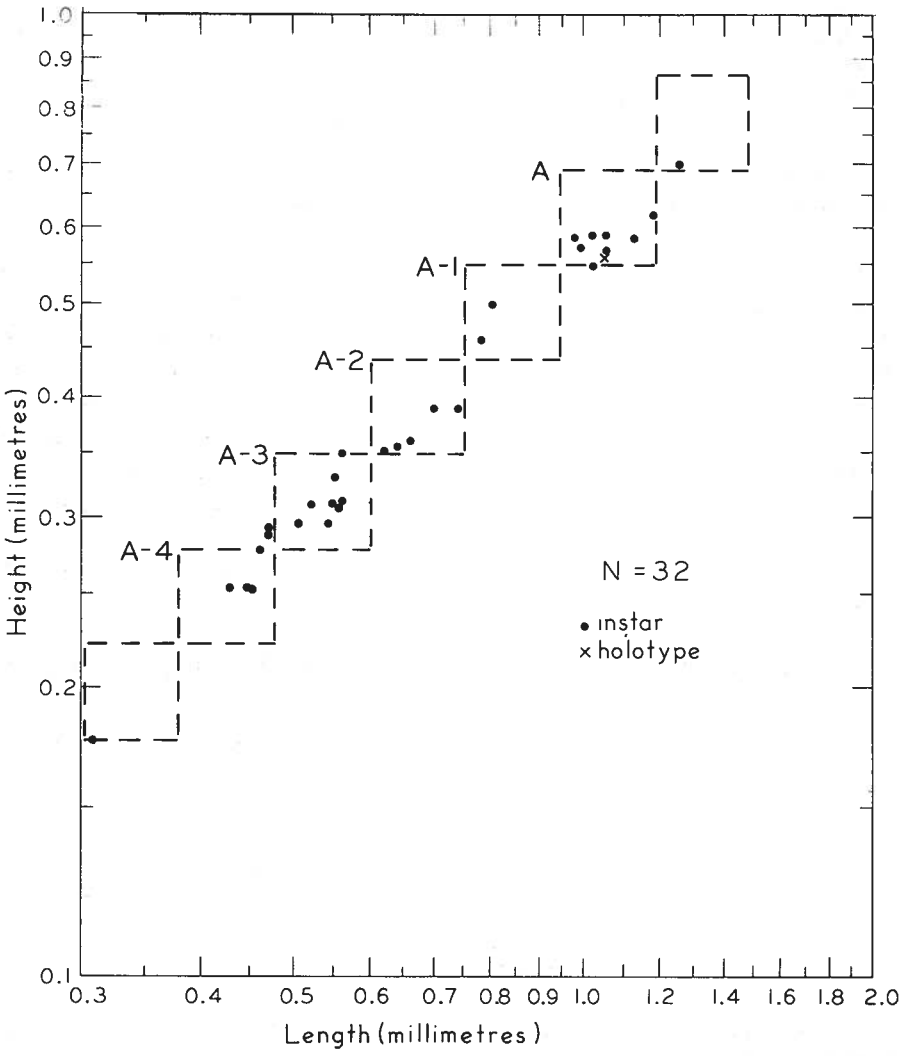

FIGURE 19. Comparative dimensions of specimens of instars of Amphissites similaris *Morey.*

is elliptical to drop shaped and is situated at the base of the postero-ventral side of the median node. The posterior carina is well developed; the anterior carina is poorly developed to indistinct, but in instars (Fig. 19) up to and including the fifth it is represented by a strong node which extends to above the dorsal border. In instars up to and including the sixth, a short, almost vertical carina may be present on the median node above the muscle-scar pit. In some adult specimens this carina is faintly visible. At the posterior cardinal angle a small smooth area is present at the base of the inner side of the frill; this area is of the size of two or three reticulations. The outer rim and inner ridge join at the posterior cardinal angle to form a short, laterally flattened, and posterodorsally directed spine. In adult forms the dorsal carina joins the posterior carina to the anterior and posterior cardinal angles.

Sohn (1961, p. 119) placed *Amphissites similaris* Morey in synonymy with *A. centronotus* (Ulrich and Bassler). He also stated (*ibid.*, p. 115) that the size of the carinae—that is, their surface expression—is probably a function of preservation. As was indicated above, the posterior carina is more strongly developed than the anterior carina in *A. similaris;* this is a consistent feature in the Banff Formation material (see Pl. 2, Figs. 14, 15, 16, 17) and thus is believed to be not fortuitous. On this basis it is considered that *A. similaris* Morey is a valid species and can be differentiated from *A. centronotus* by its strong posterior and weak anterior carinae, and by the presence of a carina on the median node in immature instars.

Instars from several samples, indistinguishable from those of *A. similaris,* have been included in this species.

Occurrence: RG 56-3-38, 40, 42, 43, 48, 50; RG 56-4-26A, 43, 68, 72, 75.

Hypotypes: Two left and three right valves, Nos. PO. 0153-0157.

AMPHISSITES sp. cf. A. SIMILARIS Morey

Plate 2, figure 19

Occurrence: RG 56-1-42, 74; RG 57-11-1; Bear Villa No. 1 well, core 115, 2,891 feet.

Specimen: An immature left valve, No. PO. 0158.

AMPHISSITES sp. aff. A. SIMILARIS Morey

Plate 2, figures 20, 21

Remarks: Specimens from the lower part of the Banff Formation differ from *A. similaris* Morey (1936) in having a more subdued median node bearing a carina and an anterior carina that is almost as strongly developed as the posterior carina. They differ from *A. centronotus* (Ulrich and Bassler) in having a carinate node and may be conspecific with *A. carinodus* Cooper.

Occurrence: RG 57-10-1; RG 60-1-12.

Specimens: Two left valves, Nos. PO. 0159, 0160.

Superfamily YOUNGIELLACEA Kellett, 1933
Family YOUNGIELLIDAE Kellett, 1933
Genus GLYPTOPLEUROIDES Croneis and Gale, 1938

GLYPTOPLEUROIDES sp. aff. G. GIRTYI Croneis and Gutke

Plate 2, figures 22, 23

Remarks: A single carapace collected shows resemblances to *G. girtyi* Croneis and Gutke (1939) from the Renault Formation of Illinois. It differs in having maximum height anterior, a slightly concave venter, a stronger posterior marginal ridge, and a less continuous groove in the centroventral to posteroventral areas.

Occurrence: Canadian Petroleums Peace River No. 2 well, 2,060-65 feet.

Specimen: A complete carapace, No. PO. 0069.

Genus MOORITES Coryell and Billings, 1932

MOORITES CALVATUS, n. sp.

Plate 2, figures 25-28

Diagnosis: *Moorites* species possessing a smooth lateral surface and a marginal frill.

Description: Carapace inequivalved, subquadrate in lateral view, sublanceolate in dorsal view. Right valve overlapping left slightly around free margins. Greatest height at anterior cardinal angle; greatest width in posterior one-third; greatest length below mid-

height. Hinge long, straight, not depressed. Dorsal border long, straight. Cardinal angles distinct, anterior cardinal angle distinctly more obtuse than posterior. Anterior border rounded, with a relatively long, gently convex, anterodorsal slope. Ventral border long, gently concave centrally, subparallel to dorsal border. Posterior border almost evenly rounded.

A relatively wide ridge paralleling the free margins of the valves; ridge almost marginal in position and indistinct to absent midventrally. A marginal frill present outside the ridge, best developed on the anteroventral border, commonly absent midventrally, and represented in some specimens by discrete spines posteriorly and anterodorsally.

Lateral surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0161	0.36	0.18	0.12
Paratype PO. 0162	0.42	0.15	—
Paratype PO. 0163	0.38	0.19	—

Remarks: *Moorites calvatus,* n. sp., differs from all other species of *Moorites* in its possession of a marginal frill. In its possession of a frill this species closely resembles *Paragraphylus reticulatus* Coryell and Rozanski; but as the holotype of this species is "a broken and corroded specimen; unrecognizable" (Moore, 1961), assignment to that genus cannot be made.

Occurrence: RG 56-1-42.

Types: Holotype, a complete carapace, No. PO. 0161; paratypes, a left valve and a right valve, Nos. PO. 0162, 0163.

MOORITES sp.

Plate 2, figure 24; Plate 8, figure 25

Diagnosis: *Moorites* sp. with a broad complete marginal ridge and a smooth lateral surface.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0164	0.51	0.30	0.19

Occurrence: Canadian Petroleums Peace River No. 2 well, 2,060-65 feet.

Specimen: A complete carapace, No. PO. 0164.

Suborder KLOEDENELLOCOPINA Scott, 1961
Superfamily KLOEDENELLACEA Ulrich and Bassler, 1908
Family GLYPTOPLEURIDAE Girty, 1910
Genus GLYPTOPLEURA Girty, 1910

GLYPTOPLEURA PRIMITIVA, n. sp.

Plate 3, figures 1-3

Diagnosis: *Glyptopleura* species with three broad lateral costae, separated from a posterior vertical ridge by a curved vertical sulcus.

Description: Relationship of valves unknown. Valves small, subrhomboidal in lateral view. Greatest height close to anterior cardinal angle; greatest width in posteroventral quarter; greatest length slightly above midheight. Hinge line long, straight, in some specimens slightly depressed below dorsal border posteriorly. Dorsal border straight to gently convex posteriorly. Anterior border almost evenly rounded, with a short straight anterodorsal slope. Posterior border rounded, truncate ventrally. Ventral border straight to gently concave centrally, almost parallel to dorsal border.

Cardinal angles subrounded, anterior more obtuse than posterior.

Three low rounded costae arising about the middle of the posterior half of the valve, extending anteriorly, undulating gently and subparallel to the dorsal border. Upper costa crossing the shallow S_2, separating the pit from the rest of the sulcus. Anteriorly the lowest ridge swinging dorsally, paralleling the anterior border and being joined by the other two ridges. Posterior vertical costa separated from horizontal costae by a slightly curved vertical sulcus. Sulcus becoming less distinct midventrally, but better developed posteriorly.

Distinct narrow submarginal ridge paralleling free margins, and defined by shallow groove. A narrow delicate structure outside the submarginal ridge possibly representing a frill.

Surface finely reticulate in well-preserved specimens.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0064	0.67	0.39
Paratype PO. 0065	0.76	0.41
Paratype PO. 0066	0.57	0.32

Remarks: *Glyptopleura primitiva*, n. sp., differs from other described species of *Glyptopleura* in possessing a posterior vertical costa. The relationship of this species to those more typical of *Glyptopleura* is discernible when specimens from a succession of samples from the Banff Formation are examined. An evolutionary change in form of ornament takes place, in which firstly the posterior sulcus becomes indistinct (Pl. 3, Fig. 2), and secondly the posterior vertical costa joins the upper and lower horizontal costae (Pl. 3, Fig. 5), thus giving rise to a species closely similar to *G. salemensis* Coryell and Blackmier and *G. belphegora* Brayer.

Occurrence: RG 56-1-33, 42, 74; RG 56-3-12, 22, 28, 31, 40, 41.

Types: Holotype, a left valve, No. PO. 0064; paratypes, two right valves, Nos. PO. 0065, 0066.

GLYPTOPLEURA sp. cf. G. BELPHEGORA Brayer

Plate 3, figures 4, 5

?*Glyptopleura belphegora* Brayer, 1952, Jour. Paleont., vol. 26, no. 2, p. 164, pl. 27, fig. 3.

Remarks: Four damaged valves of a species similar to *G. belphegora* Brayer were obtained from the middle and upper members of the Banff Formation. They differ from Brayer's species in lacking spines in the surface ornament. The costae on the lateral surface are essentially similar in both species; the marginal rim of the Banff species is somewhat more pronounced than that in the Meramec species.

Occurrence: RG 56-3-40, 43; RG 56-4-75.

Specimens: Two right valves, Nos. PO. 0067, 0068.

Family BEYRICHIOPSIDAE Henningsmoen, 1953

Genus BEYRICHIOPSIS Jones and Kirkby, 1886

Beyrichiopsis Jones and Kirkby, 1886, Geol. Mag., n.s., dec. 3, vol. 3, p. 433, 436, 437; Whidborne, 1896, Proc. Geol. Assoc., vol. 14, p. 372; Ulrich and Bassler (part), in Bassler, 1932, Tennessee Dept. Educ., Div. Geol., Bull. 38, p. 236; Posner, 1951, VNIGRI, p. 36, pl. 7, fig. 1; Posner, 1958, in Microfauna of the U.S.S.R., pt. 9, VNIGRI, vol. 115, p. 258, pl. 3, fig. 16; Robinson, 1959, Quart. Jour. Geol. Soc. London, vol. 114, p. 439; Sohn, in Moore, 1961, Treatise Invert. Paleont., pt. Q, Arthropoda 3, p. 185.

?not *Beyrichiopsis* Jones and Kirkby—Coryell and Johnson, 1939, Jour. Paleont., vol. 13, p. 215; Cooper, 1941, Illinois Geol. Surv. Rept. Invest. no. 77, pl. 2, figs. 31-34.

Beyrichia McCoy—Jones and Kirkby, 1884 (part), Proc. Berwickshire Nat. Club, vol. 10, p. 322.

Deloia Croneis and Thurman, 1939, Jour. Denison Univ. Sci. Lab., vol. 33, art. 6, p. 307; Croneis and Funkhouser, 1939, Jour. Denison Univ. Sci. Lab., vol. 33, art. 7, p. 344; Croneis and Bristol, 1939, Jour. Denison Univ. Sci. Lab., vol. 34, art. 4, p. 73; Cooper, 1941, Illinois Geol. Surv. Rept. Invest. no. 77, p. 54.

Denisonella Croneis and Bristol, 1942 (for *Denisonia* Croneis and Bristol, 1939, *not* Kreft, 1869).

Denisonia Croneis and Bristol, 1939, Jour. Denison Univ. Sci. Lab., vol. 34, art. 4, p. 76; Cooper, 1941, Illinois Geol. Surv. Rept. Invest. no. 77, p. 54.

?*Glyptopleura* Girty—Brayer, 1952 (part), Jour. Paleont., vol. 26, p. 164, pl. 27, figs. 2 a-e.

?*Glyptopleurina* Coryell—Brayer, 1952, Jour. Paleont., vol. 26, p. 168.

Leightonella Croneis and Gale, 1939, Jour. Denison Univ. Sci. Lab., vol. 33, art. 5, p. 263.

Description: Carapace inequivalved, elongate suboval in lateral view. Right valve larger, overlapping left around the free edge, and at cardinal angles. Small teeth present at cardinal angles in overlapping valve. Hinge line long, straight; hinge may be depressed posteriorly. Each valve sulcate, typically bisulcate. S_1 a shallow sulcus or semisulcus, separated from S_2 by a node-like or lobe-like L_2. S_2 stronger than S_1, broad and shallow, or narrower and deeper, with or without a distinct pit close to midheight. L_3 strongly inflate in female dimorph, defined only by S_2 in male dimorph. Each valve velate, typically with a submarginal frill paralleling the free edge; a dorsal ridge, lateral crests, a posterodorsal spine and an anterocentral spine may be present. Surface smooth, finely punctate or finely granulose. Cardinal angles typically well defined.

BEYRICHIOPSIS BANFFENSIS, n. sp.

Plate 3, figures 6-12

Diagnosis: Small reticulate *Beyrichiopsis* species with S_1, S_2, submarginal ridge and posterodorsal spine.

Description: Carapace inequivalved, suboval to elongate suboval in lateral view, elongate oval in dorsal view. Greatest height anterior; greatest width posterior; greatest length at or slightly above midheight. Right valve larger, overlapping left on free margins. Hinge long, straight, slightly depressed; dorsal border of valves straight to

slightly concave. Anterior and posterior borders rounded; ventral border straight to gently convex, almost parallel to dorsal border. Cardinal angles distinct; anterior cardinal angle 130 to 140 degrees, posterior cardinal angle 110 degrees.

Each valve trilobate, and ornamented by a submarginal ridge and a posterodorsal spine. L_1 a poorly defined lobe, arising below the anterior cardinal angle, and not extending as far as midheight. L_2 a low rounded knob, arising somewhat below the dorsal border and not extending to midheight. L_3 an ill-defined lobe occupying the posterior half of the valve. This lobe more obese in mature females, reaching maximum width at about midheight a short distance in front of the posterior cardinal angle.

S_1 a shallow depression, arising a short distance posteroventral to the anterior cardinal angle, extending ventrally and slightly obliquely posteriorward, not to midheight. S_2 an almost Y-shaped depression, arising slightly below the dorsal margin and narrowing ventrally to a pit; pit forming base of the Y, situated just above midheight.

Striate submarginal ridge arising a short distance ventral to the anterior cardinal angle, and converging towards the valve margin as far as midheight. Ridge paralleling the valve margins below midheight and becoming spinose in the posterior half of the valve. Ridge may extend to midheight or as far as a laterally directed spine developed a short distance below the posterior cardinal angle.

Surface of valves finely reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0030	0.70	0.40	0.29
Paratype PO. 0031	0.74	0.42	0.27
Paratype PO. 0032	0.72	0.40	0.30
Paratype PO. 0033	0.80	0.48	—

Remarks: This species shows closest similarity to *B. bispinosa*, n. sp., from which it differs in its smaller size and larger form ratio, in the presence of S_1 as a complete sulcus, in the form of the submarginal ridge, in the absence of the anterocentral spine, in the position of the posterodorsal spine, and in having a reticulate surface to the valves.

Occurrence: RG 56-4-43, 45, 46, 49, 50, 52, 58, 59, 68.

Types: Holotype, a complete carapace, No. PO. 0030; paratypes, two complete carapaces and one right valve, Nos. PO. 0031-0033.

BEYRICHIOPSIS BICARINATA, n. sp.

Plate 3, figure 13

Diagnosis: *Beyrichiopsis* species with an inclined carina crossing S_2, and another parallel carina below midheight. Lobation defined only by S_2.

Description: Relationship of valves not known. Valves subrhomboidal in lateral view. Greatest height anterior, greatest width slightly behind midlength, greatest length at midheight. Hinge long, straight, not depressed. Dorsal border straight. Anterior border smoothly convex. Posterior border almost straight posterodorsally, convex posteroventrally. Ventral border straight, parallel to dorsal border.

Cardinal angles distinct; anterior cardinal angle 140 degrees, posterior cardinal angle 100 degrees.

Lobation of valve determined by well-marked S_2 extending from slightly below dorsal margin almost to midheight. L_2 and L_3 ill defined, not raised above the general level of the valve.

Submarginal ridge, spinose or composed of fused spines, extending from close to the anterior cardinal angle to the posterior cardinal angle.

Carina arising on the lateral surface about halfway between S_2 and the posterior cardinal angle, and two-thirds of the distance from midheight to the dorsal margin, carina extending anteriorly and slightly ventrally, crossing the middle of S_2, and ending in the dorsal part of the anterocentral area. Somewhat shorter carina in the middle of the ventral half of the valve lying parallel to the upper carina.

Surface of valve probably smooth, but possibly faintly reticulate.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0050	0.87	0.49

Remarks: This species differs from most species of *Beyrichiopsis* in having the lobation of the valves defined only by S_2. From *B. brevicosta* (Cooper), *B. cincta* (Croneis and Bristol), and *B. cirrata* (Cooper) it differs in possessing two lateral crests instead of one.

Occurrence: RG 56-4-26A.

Types: Holotype, a right valve, No. PO. 0050.

BEYRICHIOPSIS BISPINOSA, n. sp.

Plate 3, figures 14-20

Diagnosis: *Beyrichiopsis* species possessing submarginal ridge, anterocentral spine, and posterodorsal spine.

Description of female: Carapace inequivalved, suboval to subrhomboidal in lateral view. Greatest height anterior; greatest width posterior; greatest length at or slightly below midheight. Right valve larger, overlapping left on free margins. Hinge long, straight, slightly depressed. Dorsal border of valves almost straight, slightly convex in posterior half. Anterior and posterior borders rounded, ventral border gently convex to straight, not parallel to dorsal border.

Cardinal angles distinct: anterior cardinal angle 130 degrees, posterior cardinal angle 120 degrees.

Each valve bilobate, and ornamented by a submarginal ridge and two spines. L_2 a rounded to subconical small knob to lobe bounded anteriorly by a semisulcus (S_1) and commonly showing, where rounded, traces of a very short blunt spine, laterally directed. L_3 a poorly defined lobe occupying the posterior half of the valve.

S_2 a sharply defined, deep, U-shaped depression ending in a shallow pit slightly above midheight.

Slightly inflate central ventral area set off from the remainder of the valve by shallow indistinct grooves extending antero- and posteroventrally from the area of the pit.

Strong, spinose submarginal ridge arising close to the anterior cardinal angle, paralleling the free edge, and dying out slightly behind the posterior cardinal angle.

Strong, laterally directed spine situated at point of greatest width in the centre of L_3 in the posterodorsal area. Another spine situated slightly below midheight and ventral to the anterior margin of L_2. Only spine bases discernible in the material at hand.

Surface of valves smooth to slightly pitted.

Description of male: Carapace elongate sublanceolate in dorsal view. Greatest thickness anterior, greatest length above midheight. Dorsal border straight. L_3 not as inflate as in female. Anterocentral spine commonly absent; posterodorsal spine situated midway between S_2 and the posterior margin. Other features as in female.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0034	0.93	0.55	0.42
Paratype PO. 0035	0.95	0.53	0.38
Paratype PO. 0036	0.86	0.46	0.36
Paratype PO. 0037	0.80	0.38	0.27

Remarks: In immature instars of this species, both spines are absent. This species has many features in common with *B. carinata nigelensis*. It differs, however, in the absence of dorsal ridge and carina, in possession of an anterocentral spine, and of a wholly spinose submarginal ridge.

B. bispinosa is comparable with the described species formerly placed in *Deloia* Croneis and Thurman, from which it differs primarily in possession of a distinct knob-like L_2 and of a pit.

Occurrence: RG 57-11-2.

Types: Holotype, a complete female carapace, No. PO. 0034; paratypes, a complete female, a complete male, and a complete late instar carapace, Nos. PO. 0035-0037, respectively.

BEYRICHIOPSIS CARINATA, n. sp.

Plate 3, figures 21-29

Diagnosis: *Beyrichiopsis* species with carina separated anteriorly from the dorsal ridge.

Description of female: Carapace inequivalved, suboval in lateral view, kite shaped in dorsal view, narrower at the anterior end. Greatest height anterior; greatest width posterior; greatest length at approximately midheight. Right valve larger, overlapping the left around the free edges, and slightly along the hinge line. Hinge line long, straight; hinge kloedenellid (tongue in left valve fitting groove in right valve). Dorsal border of most valves straight, but in some may rise slightly posteriorly to above the hinge line. Anterior and posterior borders rounded; ventral border slightly convex to slightly concave.

Cardinal angles distinct; anterior cardinal angle approximately 130 degrees; posterior cardinal angle about 120 degrees.

Each valve trilobate and ornamented by a dorsal ridge, a submarginal ridge, a carina, and in some forms a posterodorsal spine.

L_1, in most specimens, a poorly developed lobe arising at about mid-height and extending to three-quarter height. L_2 a distinct rounded to elliptical knob set a little below the dorsal border and bounded ventrally by a shallow groove, interpretable as a posteroventral continuation of S_1. L_3 an inflate subglobose lobe occupying the posterior one-third to two-fifths of the valve.

S_1 a shallow depression extending from somewhat below the dorsal border to approximately the base of L_2; it may be construed as continuing posteroventrally as a faint groove around the base of L_2. S_2 moderate to broad in width, and extending from slightly below the dorsal border to midheight, ending in a pit close to midheight. A shallow groove may extend from the anteroventral corner of the pit towards the anteroventral area, ending at the carina. A second broader and more distinct groove extending from the posterior side of the pit first posteroventrally and then ventrally as far as the carina and in many specimens as far as the submarginal ridge.

Dorsal ridge: (1) arising on the dorsal side of L_3 at up to one-third of the distance from the posterior cardinal to the anterior cardinal angle, (2) arising on the posterodorsal flank of L_3, or (3) absent. Dorsal ridge where present converging towards the hinge line anteriorly. Slightly behind the anterior cardinal angle, the dorsal ridge: (1) bifurcating, the anteroventral extension not reaching as far as L_1, the anterior extension becoming the submarginal ridge, or (2) continuing directly into the submarginal ridge with no indication of bifurcation.

Submarginal ridge connected distinctly to indistinctly with the dorsal ridge, paralleling the valve margins, and disappearing at any point between the posteroventral area and the posterior cardinal angle. Along the posterior margin the ridge may be represented by a series of small spines.

Carina arising on the dorsal edge of L_1, not connected to the anteroventral extension of the dorsal ridge, extending down the crest of L_1 and then roughly paralleling the valve margins except for a slight dorsalward flexure in the central ventral area, and dying out in the posterodorsal area in most specimens; in a few specimens with dorsal ridge arising in the posterodorsal area, carina dies out in the posteroventral or central posterior area.

Carina and both ridges generally striate where well preserved, but may be spinose. Remainder of the lateral surface smooth, smooth with scattered faint pits, or faintly reticulate.

Description of male: Outline in lateral view more truncate posteroventrally than in female; dorsal margin not rising above

hinge line posteriorly. Lobation as in female, except that L_3 not inflate. Grooves delineating the central ventral area less distinct than in female. The dorsal ridge lying closer to the hinge line, and the central ventral portion of the carina may be indistinct.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0038	0.91	0.55	0.37
Paratype PO. 0039	0.84	0.48	0.36
Paratype PO. 0040	0.76	0.42	0.40
Paratype PO. 0041	0.76	0.38	0.24
Paratype PO. 0042	0.73	0.44	0.38
Paratype PO. 0043	0.80	0.44	—

Remarks: This species is differentiated from *B.* sp. A by having the carina separate from the dorsal ridge. As is apparent from the description, *B. carinata* is variable in ornament and this variation is believed to have stratigraphic and evolutionary significance. The earliest forms of *B. carinata* possess a split anterior portion of the dorsal ridge and the carina, if extended, would join the anteroventral portion of the dorsal ridge. This form is believed to be confined mainly to the Pekisko Formation of the Peace River region. In stratigraphically higher forms, the anteroventral portion of the dorsal ridge disappears and the carina on L_1 does not extend quite as far toward the dorsal margin. In the stratigraphically highest forms (Banff upper member, lower Shunda Formation) the dorsal end of the carina on L_1 would, if extended, join the anterior edge of L_2.

Occurrence: RG 56-4-26A, 43, 44, 49, 75; RG 57-11-2; H. B. Union Salt Creek No. 1 well, 2,950 feet; Shell Cadotte No. 1 well, 2,770-800 feet; Forest Shell Peace River No. 14-29 well, 2,530 feet.

Types: Holotype, a complete carapace, No. PO. 0038; paratypes, four complete carapaces and a left valve, Nos. PO. 0039-0043.

BEYRICHIOPSIS CARINATA CARINATA, n. ssp.

Plate 3, figures 21-23

Remarks: This subspecies is characterized by the possession of strong, typically nonstriate and nonspinose ridges and carina, and by the lack of a posterodorsal spine.

Occurrence: H. B. Union Salt Creek No. 1 well, 2,950 feet; Shell Cadotte No. 1 well, 2,770-800 feet; Forest Shell Peace River No. 14-29 well, 2,530 feet.

Types: Holotype, a complete carapace, No. PO. 0038, H. B. Union Salt Creek No. 1 well; paratype, a complete carapace, No. PO. 0039, Shell Cadotte No. 1 well.

BEYRICHIOPSIS CARINATA NIGELENSIS, n. ssp.

Plate 3, figures 24-29

Remarks: This subspecies differs from *B. carinata carinata* in its possession of a spine situated on the posterodorsal flank of L_3 in the female, and in the male situated almost on the posterior margin a short distance below the posterior cardinal angle. In most specimens from Nigel Peak the posterior portion of the carina ends at this spine, and in most specimens from Banff the carina ends in the posteroventral area. The dorsal ridge is in general poorly developed.

The posterodorsal spine was not seen in any specimens from the Peace River region, and while its absence may be a function of preservation, this is doubted. It is considered that this subspecies occurs in the Banff-Nigel Peak region and is a product of geographic or ecologic isolation.

Because of the possibility of lateral intergradation of the forms *B. carinata carinata* and *B. carinata nigelensis*, the latter is considered a subspecies, rather than a distinct and separate species.

Occurrence: RG 56-4-26A, 43, 44, 49, 75; RG 57-11-2.

Types: Holotype, a complete female carapace, No. PO. 0040; paratypes, two complete carapaces and one left valve, Nos. PO. 0041-0043.

BEYRICHIOPSIS CURTA, n. sp.

Plate 4, figures 1, 4

Diagnosis: Short, subovate *Beyrichiopsis* species with spinose to striate submarginal flange and cardinal spines.

Description: Relationship of valves not known. Valves subovate in lateral view. Greatest height anterior; greatest width slightly below midheight, slightly posterior to midlength; greatest length at approximately midheight. Hinge long, straight, not depressed below dorsal margin. Anterior and posterior borders almost straight dorsally, convex ventrally; ventral border gently convex.

Cardinal angles distinct: anterior cardinal angle 130 degrees; posterior cardinal angle 110 degrees.

Lobation of valves determined by well-marked, elongate U-shaped S_2, arising slightly below the dorsal margin and extending to midheight. L_2 and L_3 defined only by S_2.

Submarginal spinose to striate ridge extending from the anterior cardinal angle around the free edge to the posterior cardinal angle. Large spine situated at the anterior cardinal angle in the right valve and at the posterior cardinal angle in the left valve. A major spine may well be present at all four cardinal angles but this is not determinable from the material at hand.

Lateral surface of valves smooth.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0047	0.84	0.49
Paratype PO. 0048	0.80	0.51

Remarks: *Beyrichiopsis curta* differs from other described species of *Beyrichiopsis* in its lack of crests, smaller form ratio, its subovate lateral outline, and in the presence of longer spines at the cardinal angles.

Occurrence: RG 56-1-42.

Types: Holotype, a right valve, No. PO. 0047; paratype, a left valve, No. PO. 0048.

BEYRICHIOPSIS GLYPTOPLEUROIDES, n. sp.

Plate 4, figures 2, 3, 5-11

Diagnosis: *Beyrichiopsis* species with a single U-shaped lateral crest, an incomplete submarginal crest, and a marginal frill.

Description of male: Carapace inequivalved, suboval to subrhomboidal in lateral view, elongate suboval in dorsal view. Greatest height slightly anterior of midlength; greatest width posteroventral of midpoint; greatest length slightly above midheight. Right valve larger, overlapping left on free edges and slightly at cardinal angles. Hinge line long and straight, slightly depressed below dorsal border. Dorsal border straight; anterior border rounded, somewhat truncate anterodorsally; posterior border subrounded, truncate posteroventrally. Ventral border gently convex.

Cardinal angles subrounded: anterior more obtuse than posterior.

S_1 a poorly developed semisulcus situated a short distance behind the anterior cardinal angle. S_2 a shallow sulcus, arising a short distance below the dorsal border, extending vertically not as far as midheight, and ending ventrally in a small pit.

L_2 a small rounded node, situated below the dorsal border, and immediately anterodorsal to the pit.

A U-shaped crest present on lateral surface; upper limb arising slightly above midheight close to posterior border, extending anteriorly parallel to dorsal border to cross S_2 at dorsal edge of pit, and passing into lower limb close to anteroventral border; lower limb extending posteriorly and then posterodorsally to end a short distance below point of origin.

A submarginal crest of varying length present in some specimens close to and parallel to the ventral border.

Marginal frill, striate to spinose, paralleling the free margins; frill generally complete and striate along the anterior border, and tending to become spinose posteriorly.

Lateral surface finely reticulate.

Description of female: Most features the same as those of the male form. The posterior one-third to two-fifths of the valve inflated, resulting in a well-developed L_3. Ends of the lateral crest joined posteriorly, thus making it complete. Submarginal ventral crest consistently present.

Description of instars: Instar A—1 (see Fig. 20). Valves differing from those of the adult in having the central and posterocentral portions of the lower limb of the lateral crest raised slightly above the main part of the surface on an ill-defined lateral extension of the valve.

Instar A—2. Valves differing from those of instar A—1 in having the lower limb of the lateral crest swinging closer to the central border, and almost paralleling it; limb situated on a poorly defined swelling of the valve in the central ventral area. Upper limb of the crest becoming indistinct on the posterior flank of L_2 and subdued at its crossing of S_2. Some well-preserved specimens still retaining a faintly reticulate surface.

Instar A—3. Lateral crest not extending as far posteriorly as in instar A—2 and being less distinct on the posterior flank of S_2 than in instar A—3.

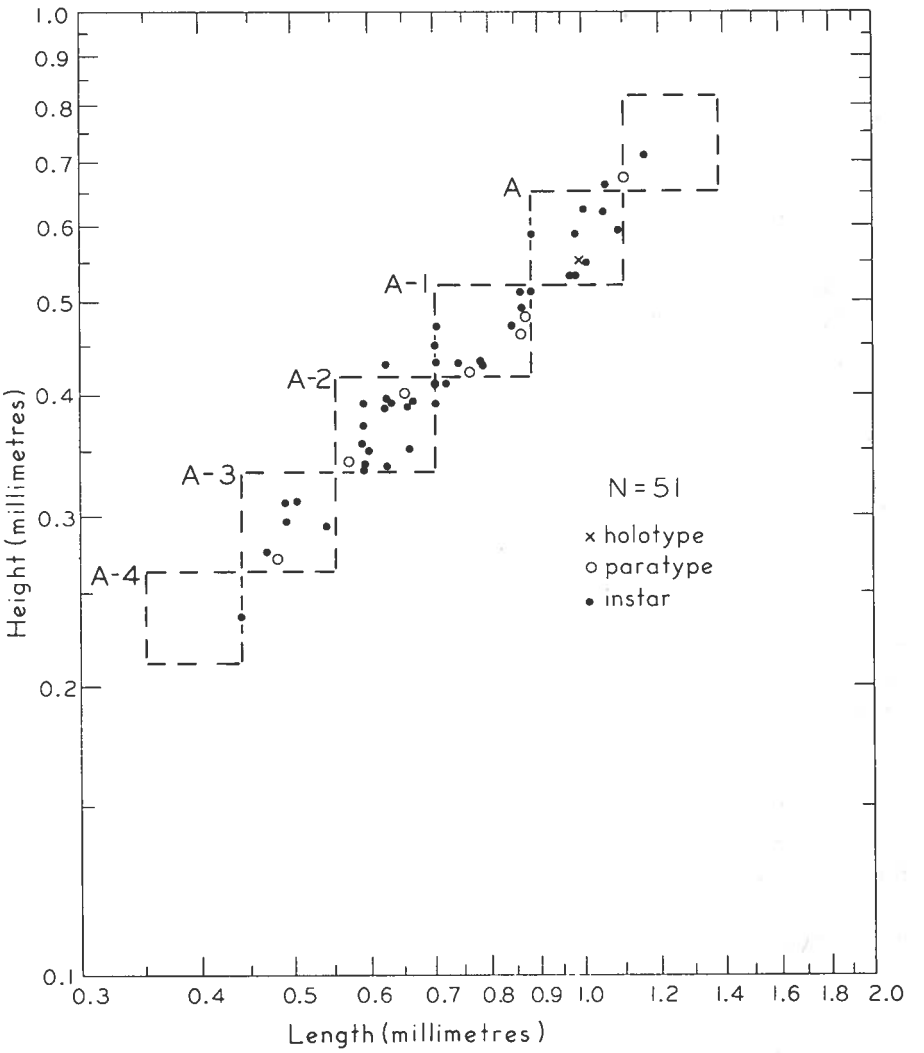

FIGURE 20. Comparative dimensions of specimens of instars of Beyrichiopsis glyptopleuroides, *n. sp.*

Instar A—4. Posterodorsal limb of the lateral crest situated on an ill-defined swelling comparable to that of the posteroventral limb in instar A—1. Limb almost drop shaped, with the apex pointing anteriorly, not crossing S_2. Anterodorsal and ventral limbs of the crest maintaining almost the same thickness as in the adult instars, and thus occupying proportionately a considerably larger area of the lateral surface. Frill present, but spinose and very delicate.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0052	0.99	0.55
Paratype PO. 0053	—	0.61
Paratype PO. 0054	0.57	0.34
Paratype PO. 0055	0.48	0.27
Paratype PO. 0056	0.86	0.46
Paratype PO. 0057	0.65	0.40
Paratype PO. 0058	0.87	0.48
Paratype PO. 0059	1.10	0.67
Paratype PO. 0060	0.76	0.42

Remarks: As presently defined this is probably a composite species. Insufficient material is on hand to permit further subdivision. It appears, however, that in stratigraphically higher forms, the short ventral crest extends farther submarginally, both anteriorly and posteriorly; also, indistinct submarginal crests appear close to the cardinal angles in these later forms.

Two closely related species, *Glyptopleura parvacostata* Geis and *B.? elephanta* (Brayer), differ in that both possess a submarginal crest which is essentially complete around valve margins. Also, *G. parvacostata* is described as not possessing a submarginal frill.

Occurrence: RG 56-1-4, 42, 43, 70; RG 56-3-12, 21, 22, 35, 38, 40, 41, 43; RG 56-4-26A, 43, 64, 68, 75, 76; RG 57-10-1; RG 57-11-1.

Types: Holotype, a male left valve, No. PO. 0052; paratypes, a female right valve, two immature left valves, two immature right valves, a female left valve, a male left valve, and one immature right valve, Nos. PO. 0053-0060, respectively.

BEYRICHIOPSIS sp. aff. B. GLYPTOPLEUROIDES, n. sp.

Plate 4, figures 12, 13, 16

Remarks: Two female carapaces of this form were collected. They differ from *B. glyptopleuroides,* n. sp., in having a poorly developed submarginal frill, in lacking the midventral crest and in possessing an undulating lateral crest. The undulating lateral crest indicates similarities to *Glyptopleura spinosa* (Jones and Kirkby) and to *G. plicatula* Posner; both these species differ, however, in lacking a frill and a node-like L_2 and in detail of the crest form; *G. plicatula* also differs in possessing spines at the posterior ends of the crest.

Occurrence: Shell Cadotte No. 1 well, 2,770-800 feet.

Specimens: Two adult female carapaces, Nos. PO. 0061, 0062.

BEYRICHIOPSIS sp. A

Plate 4, figures 14, 15

Diagnosis: *Beyrichiopsis* species with dorsal ridge splitting anteriorly into a carina and a submarginal ridge.

Description of female: Carapace inequivalved, suboval in lateral view, subtrapezoidal in dorsal view, narrower at the anterior end. Greatest height anterior; greatest width posterior; greatest length at approximately midheight. Right valve slightly larger, overlapping the left around the free edge and at the cardinal angles, and possibly slightly along the dorsal margin. Hinge line long, straight. Dorsal border of each valve almost straight but may rise slightly above hinge line in posterior half. Anterior and posterior borders rounded; ventral border straight to slightly convex.

Cardinal angles distinct, both approximately 130 degrees.

Each valve trilobate, and ornamented by a dorsal ridge, a submarginal ridge and a carina. L_1, indistinct except in dorsal view, a slight lobe extending to about three-quarter height, ventrally confluent with the rest of the valve. L_2 a distinct rounded knob, set a little below the dorsal border, bounded ventrally by a slight groove. L_3 an inflate, subglobose lobe occupying the posterodorsal one-third to two-fifths of the valve.

S_1 faint to indistinct. S_2 broad, moderately deep, extending almost half the distance from dorsal to ventral borders, and ending in a pit situated behind the posteroventral area of L_2. Distinct groove extending anteroventrally from the base of the pit; another groove curving posteroventrally and then ventrally from the posteroventral corner of S_2; both grooves extending as far as the carina, and delimiting a low swelling between them.

Dorsal ridge arising slightly anteroventral to the posterior cardinal angle and extending anteriorly, converging slightly towards the hinge line. The ridge dividing opposite the anterior cardinal angle into a submarginal ridge paralleling the valve margin, and into a carina extending ventrally down L_1. Submarginal ridge becoming indistinct a short distance below the posterior cardinal angle. Carina passing down L_1, then roughly paralleling the submarginal ridge, except for a slight flexure in the central ventral area, and ending in the posterodorsal quarter a short distance anteroventral to point of origin of dorsal ridge.

Carina striate where well preserved; submarginal ridge striate from anterior to central ventral and striate to spinose posteriorly.

Remainder of lateral surface smooth to faintly pitted to faintly reticulate.

Description of male: Outline in lateral view similar to female except in having no extension of dorsal margin above hinge line, and in being more truncate posteroventrally. Lobation similar except in lack of high inflation of L_3. Dorsal ridge closer to the valve margin, and in lateral view lying farther from the ventral and posterior margins. End of carina anteriorly directed in the posterodorsal quarter and in the middle of L_3. Only very faint grooves differentiating a much reduced ventral swelling.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0044	0.84	0.49	0.27

Remarks: *B.* sp. A shows close affinities to species described from the Lower Carboniferous rocks of Great Britain, such as *B. fimbriata* Jones and Kirkby, *B. subdentata* Jones and Kirkby, and *B. ruperti* Whidborne.

Occurrence: Shell Cadotte No. 1 well, 3,400-10 feet.

Specimen: A complete male carapace, No. PO. 0044.

BEYRICHIOPSIS sp. B

Plate 4, figures 19, 20

Remarks: A number of specimens of a small species of *Beyrichiopsis* were obtained from several samples. The species apparently is characterized by the presence of a carina arising on the knob-like L_2, extending subparallel to the valve margins and ending at a small knob situated behind S_2 and a short distance below the dorsal border. The submarginal and dorsal ridges together form an almost complete ridge parallel to the valve margins.

This species probably represents a stock from which developed the genus *Glyptopleurina.*

Occurrence: Bear Villa No. 1 well, 3,105 feet, 3,115 feet; Canadian Petroleums No. 2 well, 2,060-65 feet, 2,085-90 feet.

Specimens: A complete male carapace, No. PO. 0045, Canadian

Petroleums Peace River No. 2 well, 2,085-90 feet; a female right valve, No. PO. 0046, Canadian Petroleums Peace River No. 2 well, 2,060-65 feet.

BEYRICHIOPSIS sp. C

Plate 4, figure 18

Remarks: A species of *Beyrichiopsis* comparable in form with *B. sulcata* (Croneis and Funkhouser) occurs high in the Banff Formation; it differs from the Chester species in having a subcentral, not anterior, sulcus. Only one right valve of this species was found.

Occurrence: RG 56-4-26A.

Specimen: A right valve, No. PO. 0049.

BEYRICHIOPSIS sp. D

Plate 4, figure 17

Remarks: One broken left valve of a simple unicarinate species of *Beyrichiopsis* was collected from the basal member of the Banff Formation.

Occurrence: RG 57-10-1.

Specimen: A left valve, No. PO. 0051.

Genus KNOXINA Coryell and Rogatz, 1932

Knoxina Coryell and Rogatz, 1932, Am. Midland Nat., vol. 13, no. 6, p. 383; Croneis and Gale, 1939, Jour. Denison Univ. Sci. Lab., vol. 33, art. 5, p. 266; Croneis and Gutke, 1939, Jour. Denison Univ. Sci. Lab., vol. 34, art. 3, p. 42; Sohn, in Moore, 1961, Treatise Invert. Paleont., pt. Q, Arthropoda 3, p. 186.

Coryella Harris and Lalicker, 1932, Am. Midland Nat., vol. 13, no. 6, p. 397.

?*Chesterella* Croneis and Gutke, 1939, Jour. Denison Univ. Sci. Lab., vol. 34, art. 3, p. 44.

?*Mennerites* Egorov, 1950, Vsesoyuz. Neft. Nauch.-Issled. Geol.-Razv. Inst., p. 46.

The genus *Knoxina* was established by Coryell and Rogatz for a group of kloedenellid ostracodes possessing one or more costae and also a narrow smooth marginal flange.

The Permian species originally placed in the genus have subdued horizontal crests, and possess an inconspicuous flange. Chester species of the genus also possess a subdued flange.

The species here referred to *Knoxina* possess crests similar to those of described species of *Knoxina*, and in addition possess a well-developed flange which is spinose in the earlier species. The features of these species indicate a close relationship to species of *Beyrichiopsis* Jones and Kirkby; the presence of the flange, however, is considered distinctive, and on this basis the species described below are referred to *Knoxina*.

KNOXINA COSTATA, n. sp.

Plate 4, figures 21-27

Diagnosis: *Knoxina* species possessing ventral, anterodorsal and dorsal costae, and a bend paralleling the anterior and ventral borders.

Description: Carapace inequivalved, subovate in lateral view, elongate subovate in dorsal view. Right valve overlapping left slightly around free margins; obscure delta-shaped notches present at the cardinal angles of the right valve. Hinge obscurely cardine, straight, depressed below dorsal border along posterior half of hinge line. Dorsal border straight anteriorly, gently convex posteriorly. Cardinal angles distinct; anterior cardinal angle more obtuse than posterior. Anterodorsal border gently convex, anteroventral border more strongly convex. Ventral border straight to slightly convex, almost parallel to dorsal border. Posterior border rounded, moderately truncate ventrally.

S_1 an indistinct semisulcus. S_2 a subvertical sulcus arising close to the dorsal border and ending in a pit situated above midheight.

L_2 a distinct lobe, commonly node-like, situated well below the dorsal border, and limited ventrally by an ill-defined shallow depression extending anteroventrally from the pit. L_3 a low swelling extending slightly above the hinge line in adult instars, joining anteroventrally the ventral lobe. Ventral lobe poorly defined, being differentiated from L_2 by a broad shallow depression, and from L_3 by a slight indentation on its posteroventral edge.

Three major costae present on each valve. One arising close to the posterior cardinal angle, extending anteriorly, diverging slightly from the hinge line, and dying out at the posterodorsal corner of S_2. A second, sinuous costa arising on the crest of L_2, extending anteroventrally and dying out below midheight close to the bend. Ventral costa, in some specimens discontinuous, arising anteroventrally, extending along the centre of the ventral lobe, subparallel to the ventral border, and dying out behind midlength. Several short,

irregular costae present in some specimens between the ventral costa and the ventral part of the bend.

A well-developed bend paralleling the anterior and ventral free margins and becoming indistinct posteriorly. A smooth or finely striate flat surface separating the bend from a rudimentary unornamented to spinose marginal ridge. The smooth marginal rim also extending from the anterior cardinal angle into the posteroventral area; rim wider and more strongly developed in the right (overlapping) valve than in the left (overlapped) valve. The marginal ridge complete in some specimens, typically spinose posteroventrally.

Lateral surface finely reticulate, except for marginal rim, costae floor of pit and S_2, which are smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0119	0.87	0.49	0.23
Paratype PO. 0120	0.76	0.48	—
Paratype PO. 0121	0.65	0.36	—
Paratype PO. 0122	0.57	0.36	—
Paratype PO. 0123	0.57	0.34	—

Remarks: *Knoxina costata*, n. sp., differs from other species of *Knoxina* in its possession of distinct marginal structures. It is similar to some Russian species of *Hypotetragona* Morey in lateral ornament and in having the posterior portion of the hinge depressed, but differs in having strong marginal structures and in having costae in adult instars.

Occurrence: RG 56-1-42.

Types: Holotype, a left valve, No. PO. 0119; paratypes, two left and two right valves, Nos. PO. 0120-0123.

KNOXINA MARGINATA, n. sp.

Plate 5, figures 1-6

Diagnosis: *Knoxina* species possessing numerous short, irregular costae, and a bend paralleling the valve borders.

Description: Carapace inequivalved, subovate in lateral view, elongate subovate in dorsal view. Right valve overlapping left slightly around free margins. Hinge basically cardine, with a groove in the left valve and a tongue in the right, but in adult instars also possessing

an anterior socket in the left valve, and presumably an anterior tooth in the right valve. Dentition of posterior portion of hinge not known. Hinge straight, depressed below dorsal border in posterior half. Dorsal border straight anteriorly, gently convex posteriorly. Cardinal angles distinct, anterior cardinal angle more obtuse than posterior. Anterior and posterior borders rounded, the anterior with a long straight anterodorsal slope, the posterior being moderately truncate ventrally. Greatest height anterior; greatest width posterior.

S_1 a poorly defined semisulcus. S_2 a vertical sulcus arising below the dorsal border and ending in a shallow pit above midheight. L_2 a poorly defined lobe arising below the dorsal border, and delimited ventrally by a shallow depression extending anteriorly and anteroventrally from the base of S_2. L_3 a low swelling occupying the posterior one-half of the valve, and extending above the hinge line; ventrally passing smoothly into the ventral lobe, with a slight constriction where a shallow depression extends posteroventrally from the base of S_2. Ventral lobe poorly defined, moderately inflate.

Three major costae present: the posterodorsal costa extending anteriorly from the posterior cardinal angle into the upper part of S_2, thus constricting the sulcus. Anterior costa extending anteroventrally from the summit of L_2 almost to the bend. Ventral costa extending along the crest of the anterior part of the ventral lobe and dying out at midlength. Numerous short, undulating, and locally bifurcating costae lying adjacent to the three major costae.

A well-developed bend separating a smooth, flat to slightly channeled marginal rim from the main portion of the valve. Bend and rim strongly developed on the anterior and ventral borders, and less distinct posteriorly. A low, narrow marginal ridge present on each valve.

Lateral surface probably smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0124	0.87	0.49	0.38
Paratype PO. 0125	0.90[1]	0.51	—
Paratype PO. 0126	0.76	0.42	—

Remarks: *Knoxina marginata* differs from *K. costata,* n. sp., in having numerous minor costae on the valve surface above the ventral costa, and in having a longer anterodorsal slope.

[1]estimated

The specific name is derived from the Latin *"marginatus"* (rimmed, bordered) and refers to the distinctive smooth marginal rim of the species.

Occurrence: RG 56-4-26A, 72, 75.

Types: Holotype, a complete carapace, No. PO. 0124; paratypes, two left valves, Nos. PO. 0125, 0126.

Genus GEFFENINA Coryell and Sohn, 1938

GEFFENINA? ASPINIFERA, n. sp.

Plate 5, figures 7-15

Diagnosis: *Geffenina*? species lacking spines. L_3 separated from L_2 by S_2, and probably, in the male dimorph, from the ventral lobe by a depression parallel to the dorsal border.

Description: No adult males found; adult females only. Carapace inequivalved, subovate in lateral view, subpyriform in dorsal view. Greatest height close to L_2; greatest width close to posterior cardinal angle. Greatest length above midheight. Right valve overlapping left conspicuously around free margins, at posterior cardinal angle, and on anterior part of hinge. Hinge moderately long, straight. Margin of left valve grooved for reception of tongue in right valve. Dorsal border straight in anterior half, convex in posterior half, rising above hinge line. Anterior border rounded, somewhat flattened dorsally; posterior border evenly rounded. Ventral border gently convex.

Cardinal angles subrounded; anterior cardinal angle 130 to 140 degrees; posterior cardinal angle 120 degrees.

L_2 a low node set below the dorsal border, passing smoothly anteriorly into the valve surface. L_3 an inflate lobe occupying the posterior one-third of the valve, and reaching maximum width posteriorly; anterior slope almost flat, and constituting also the posterior flank of S_2. L_3 passing smoothly ventrally into the ventral lobe.

S_2 a subtriangular depression with a central pit; apex of the sulcus lying below the dorsal border, anterior extremity lying below the anterior border of L_2, posterior extremity lying midway between the pit and the posterior border.

Short marginal ridge lying adjacent to the hinge in the left valve, above L_2 and S_2, dying out gradually posteriorly, and being replaced anteriorly by the overlap of the right valve on the left. Fine striae

or remnants of a marginal structure present along the posterior margins.

Lateral surface apparently smooth, but may be faintly ornamented.

Description of instars: Instar A—1. Similar to adult female in most features; differing in being less inflate posteriorly, more truncate posteroventrally, and in having the posterior extremity of the subtriangular S_2 extended to form a shallow depression separating ventral lobe from L_3. L_3 an inflate lobe extending well above the hinge.

Instar A—2. Somewhat more truncate posteroventrally than instar A—1. L_3 a prominent feature extending well above hinge, and giving a *Kirkbyina*-like lateral outline to the valves.

Instar A—3. No specimens obtained of this instar.

Instar A—4. Differing from instar A—2 in having L_2 a rounded node, in lacking a ventral lobe, and in having L_3 extending from above the dorsal border anteroventrally to die out below S_2 or L_2.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0127	1.18	0.72	0.63
Paratype PO. 0128	1.14	0.72	0.57
Paratype PO. 0129	1.06	0.65	0.61
Paratype PO. 0130	0.95	0.55	—
Paratype PO. 0131	0.84	0.53	0.38
Paratype PO. 0132	0.68	0.44	—
Paratype PO. 0133	0.42	0.28	0.27

Remarks: This species is questionably placed in *Geffenina* because of its close relationship to *G. warreni,* n. sp. Adult females of *G.? aspinifera* differ from those of *G. warreni* and *G. nigelensis* mainly in lacking posterior spines. As differing instars of *G.? aspinifera* and of *G. warreni* have been collected in the same samples and as the adult forms also differ, these are believed to be two distinct species.

The adult male of *G.? aspinifera,* by inference from *G. warreni* and *G. nigelensis,* is believed to be closely similar in form to instar A—1.

The specific name is derived from the Latin "*a*" (not, absent) and "*spiniferus*" (spine-bearing).

Occurrence: RG 56-3-51, 52; RG 56-4-73, 75, 79, 83.

Types: Holotype, a complete carapace, No. PO. 0127; paratypes, four complete carapaces, one left valve, and one right valve, Nos. PO. 0128-0133.

GEFFENINA NIGELENSIS, n. sp.

Plate 5, figures 16-24

Diagnosis: *Geffenina* species with posterodorsal and posteroventral spines: L_3 and ventral lobe separated by shallow depression which may bifurcate to separate ventral lobe from posteroventral spine.

Description of male: Carapace inequivalved, subovate in lateral view. Greatest height anterior, behind anterior cardinal angle; greatest width close to midlength; greatest length slightly above midheight. Right valve overlapping left conspicuously around free margins, at posterior cardinal angle, and on anterior end of hinge. Hinge moderately long, straight, slightly depressed. Margin of left valve grooved for reception of tongue in right valve. Dorsal border straight to gently convex. Anterior and posterior borders rounded; posterior border moderately truncate ventrally. Ventral border gently convex.

Cardinal angles subrounded, anterior cardinal angle 140 degrees; posterior cardinal angle 120 degrees.

L_2 a low lobe grading smoothly anteroventrally into the surface of the valve. L_3 a low swelling bearing a short spine posterodorsally. Ventral lobe represented by an ill-defined swelling; swelling defined dorsally by a faint depression, and passing posteriorly in some specimens into a short posteroventral spine.

S_2 an almost U-shaped sulcus arising close to the dorsal border and ending in a pit a short distance above midheight. A shallow depression extending from the base of S_2 anteriorly as far as the anterior border of L_2, thus delimiting that lobe. Depression also extending posteriorly, parallel to the dorsal border, about as far as the posterior spines, and in some specimens branching around the posteroventral spine, both branches dying out before reaching the valve borders.

Area anterodorsal to L_2 commonly flattened by being laterally compressed. A groove, submarginal in position, around the free margins of the right valve marks the extent of overlap by the right valve over the left.

A poorly developed marginal ridge or row of small denticles commonly present, best developed on posterior and ventral borders, but also present anteriorly in some specimens.

Lateral surface bearing a faint reticulate ornament.

Description of female: Similar to male in most features. Differing in its increased posterior inflation, resulting in the posterior spines being less distinct than in the male form. The central shallow depression extending posteriorly from S_2 curving posteroventrally, passing between the ventral lobe and the posteroventral spines, and dying out in the posteroventral area. S_2 deeper and more subtriangular than in the male form, and the posterior portion of the hinge depressed below the dorsal border.

Description of instars: Instar A—1 (see Fig. 21). Similar to adult male in most features. Typically somewhat more subrhomboidal than the adult, and showing traces of a low ridge extending anteroventrally from L_2, and ending at about midheight.

Instar A—2. Differing from instar A—1 in having a shallow S_1 separating L_2 from the anterior ridge. Ventral lobe a less distinct feature, grading smoothly into posteroventral area. Central depression very shallow.

Instar A—3. Differing from instar A—2 in having L_2 a rounded lobe, with S_1 a short semisulcus. Central depression barely distinguishable. Posterior spines, and posteroventral and ventral row of marginal denticles present.

Instar A—4. Differing from instar A—3 in lacking central depression.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0134	0.97	0.61	0.46
Paratype PO. 0135	1.03	0.65	0.53
Paratype PO. 0136	0.95	0.55	0.42
Paratype PO. 0137	0.82	0.49	0.38
Paratype PO. 0138	0.68	0.42	0.32
Paratype PO. 0139	0.57	0.34	0.27
Paratype PO. 0140	0.49	0.27	0.23

Remarks: *Geffenina nigelensis* is a more advanced species than *G. warreni,* n. sp. It differs in having a smaller anterior overlap of the right valve along the hinge; in the male dimorphs the central horizontal depression is shallower in *G. nigelensis* than in *G. warreni,* and it extends less far anteriorly and posteriorly. The female of *G. nigelensis* possesses a depression that curves posteroventrally from the base of S_2, whereas the female of *G. warreni* does not.

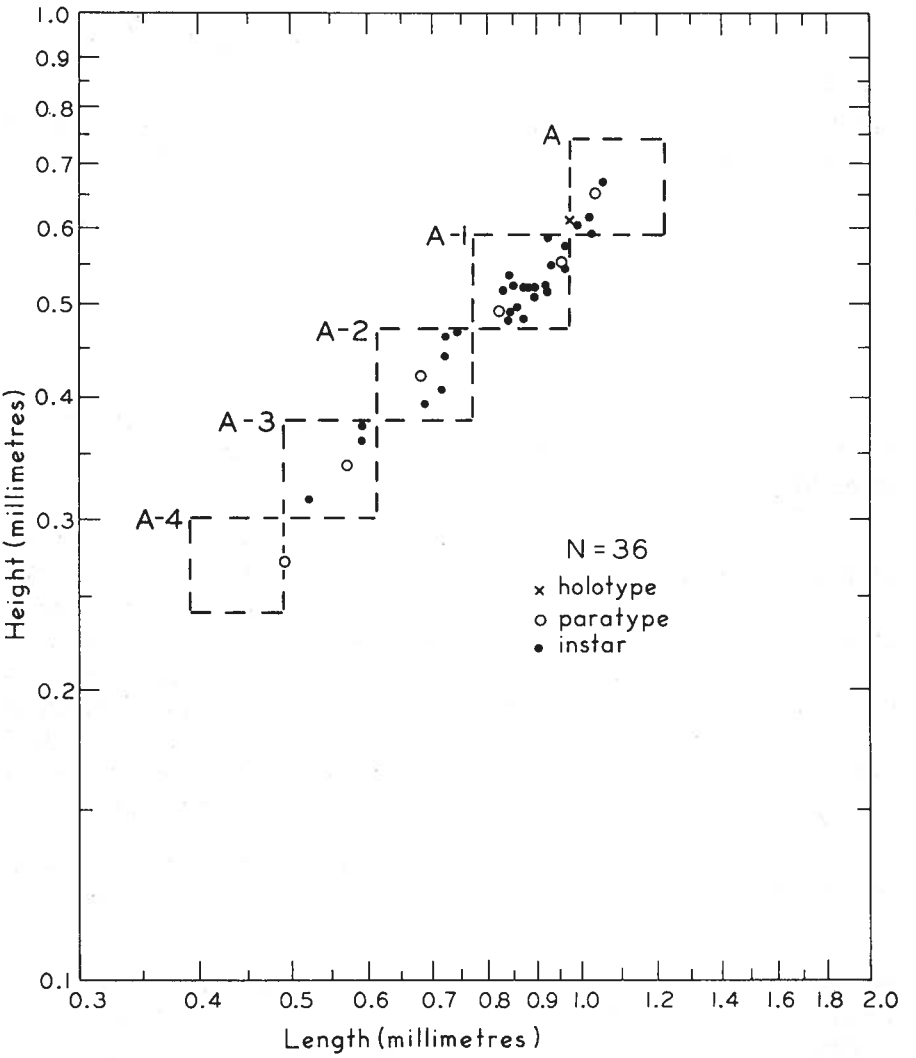

FIGURE 21. Comparative dimensions of specimens of instars of Geffenina nigelensis, *n. sp.*

Presumably both *G. warreni* and *G. nigelensis* possess a velate ridge or marginal denticles. This feature was recognized only in *G. nigelensis,* however, as much better preserved specimens were obtained of this species.

It is possible that forms intermediate between these two species will be obtained eventually. There are, however, sufficient differing features between individuals from several localities to warrant the erection of these two species.

Occurrence: RG 56-4-26A, 43, 49, 59, 64, 73, 75, 76; RG 57-11-2.

Types: Holotype, a complete male carapace, No. PO. 0134; paratypes, a complete female carapace, and five complete immature instar carapaces, Nos. PO. 0135-0140.

GEFFENINA WARRENI, n. sp.

Plate 6, figures 1-11

Diagnosis: *Geffenina* species with node-like L_2, L_3 bearing a posterodorsal spine, ventral lobe bearing a posteroventral spine. Ventral lobe separated from L_2 and L_3 by a horizontal depression extending through the pit of S_2.

Description of male: Carapace inequivalved, subovate in lateral view, sublanceolate in dorsal view. Greatest height close to anterior cardinal angle; greatest width posterior; greatest length slightly above midheight. Right valve overlapping left conspicuously around free margins, at posterior cardinal angle, and on anterior one-third to one-quarter of hinge. Hinge moderately long, straight. Margin of left valve grooved for reception of tongue in right valve. Dorsal border straight; anterior and posterior borders rounded, posterior border moderately truncate ventrally. Ventral border gently convex.

Cardinal angles subrounded; anterior cardinal angle approximately 130 degrees; posterior cardinal angle 110 to 120 degrees.

L_2 a low, barely distinguishable node passing smoothly anteroventrally into a broad, poorly defined ridge; ridge dying out near the anterior border close to midheight. L_2 flanked posteriorly by S_2 and ventrally by a depression paralleling the dorsal border and dying out in the central anterior area.

L_3 a distinct swelling occupying the posterodorsal quarter of the valve, bearing a low blunt spine posterodorsally, and separated from the ventral lobe by a well-developed depression paralleling the dorsal border.

Ventral lobe defined only by the central depression and a short blunt posteroventral spine, ventrally and anteroventrally merging smoothly into the valve surface.

S_2 a subtriangular depression, with the apex pointing towards the dorsal border, arising at about half the distance from the dorsal border to midheight and extending to a short distance below midheight. A shallow pit situated slightly above centre of the triangle,

and the two basal corners drawn out laterally to form the central depression paralleling the dorsal border.

An ill-defined anterior and ventral groove in the right valve, situated submarginally in position, marking the extent of overlap of the right valve over the left.

Lateral surface smooth or faintly reticulate.

Description of female: Female similar to the male in most features, the two dimorphs differing in the following respects: female considerably more inflate posteriorly, resulting in the absence of the posterior portion of the central depression and in S_2 appearing more triangular and relatively deeper. Maximum width towards the posterior of L_3. Posteroventral spine much less distinct than in the male form. Ventral lobe not a distinct feature as in the male, but a more integral part of the valve. Posterodorsal inflation resulting in the posterior portion of the hinge appearing channeled.

Description of instars: Instar A—1 (see Fig. 22). Similar to adult male except in having the central depression and submarginal groove of the right valve more distinct features. Central depression extending closer to the anterior border than in the adult form.

Instar A—2. Differing from instar A—1 in being more oval in lateral outline, and in having the posterior spines relatively larger in proportion to total size of valve. S_2 extending closer to the dorsal border, and L_2 tending to become a discrete node.

Instar A—3. Differing from instar A—2 in having the posteroventral spine considerably smaller than the posterodorsal spine; posterodorsal spine a dominant feature of the valve. L_2 a distinct node, bounded anteriorly by a shallow S_1. The central depression not extending anteriorly from S_2.

Instar A—4. Subcircular in lateral outline, and bearing a node-like L_2, a node-like L_3 drawn out into a very short spine, and a posteroventral swelling, generally without trace of a spine.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0141	1.10	0.68	0.57
Paratype PO. 0142	1.10	0.68	—
Paratype PO. 0143	0.95	0.57	—
Paratype PO. 0144	0.80	0.53	—
Paratype PO. 0145	0.65	0.40	0.32
Paratype PO. 0146	0.55	0.32	0.30
Paratype PO. 0147	0.49	0.34	—
Paratype PO. 0148	0.38	0.27	—

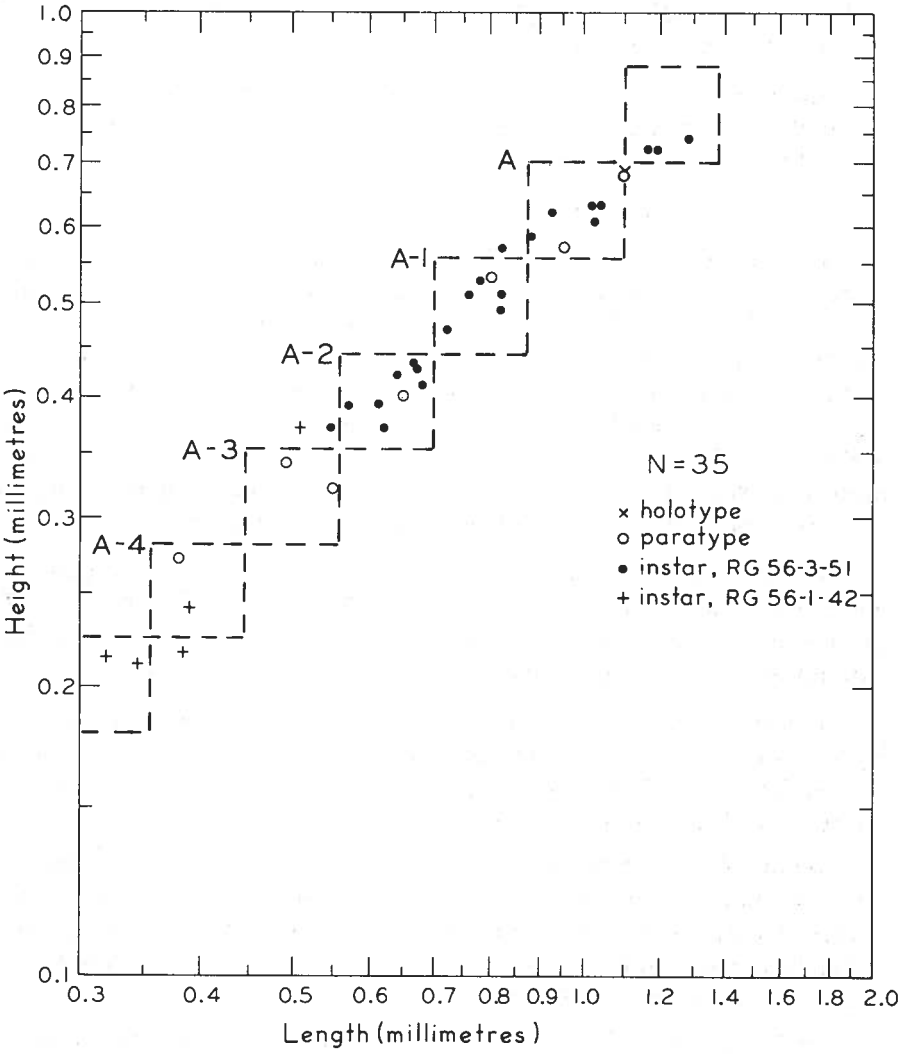

FIGURE 22. Comparative dimensions of specimens of instars of Geffenina warreni, *n. sp.*

Remarks: *G. warreni* differs from other described species of *Geffenina* in possessing posterior spines. As Sohn (in Moore, 1961) differentiated the genera *Geisina* and *Hypotetragona* on the presence or absence of posterodorsal spines, it becomes questionable as to whether *G. warreni* and *G. nigelensis* should be placed in a genus the type species of which lacks posterodorsal spines. However, at present this procedure is considered preferable to adding to the multiplicity of generic names in this ostracode superfamily.

This species is named in honour of Professor P. S. Warren, who first measured the type section of the Banff Formation on the north face of Mount Rundle.

Occurrence: RG 56-1-33, 41, 42, 71, 74; RG 56-3-2, 10, 12, 14, 22, 28, 30, 31, 35, 38, 40, 41, 43, 51; RG 57-10-1.

Types: Holotype, a complete female carapace No. PO. 0141; paratypes, a male right valve, No. PO. 0142, two complete instar carapaces, three right valves, one left valve, Nos. PO. 0143-0148.

?Genus PSEUDOCHILINA, n. gen.

Type species: *Pseudochilina marginata,* n. sp.

Generic diagnosis: Straight-hinged, almost equivalved ostracodes. Each valve bearing a broad shallow sulcus, a posterodorsal spine, a submarginal frill, and a low presulcate inflation. Lateral and marginal surfaces typically joined at a simple bend; surfaces smooth.

Generic description: Carapace nearly equivalved. Hinge line straight. Valves subquadrate to subovate in lateral view, elongate subovate in dorsal view, inflate subovate in end view.

Each valve sulcate. A shallow S_2 arising near the dorsal border at midlength and extending to midheight. Typically, a strong spine is situated posterodorsally a short distance behind S_2, and a low presulcate inflation is present.

A marginal bend may be present, separated from the main portion of the valve by a groove. A subdued spinose frill parallels the free margins.

Hinge obscurely cardine.

No dimorphism known.

Remarks: *Pseudochilina* is a genus characterized by large size, a broad shallow sulcus, a posterodorsal spine, and a submarginal frill. It lacks the hinge structure characteristic of the Kloedenellidae, and is in several respects homeomorphic to many Eurychilinidae. The marginal bend is homeomorphic to the velum of a number of species of *Eurychilina* and *Laccochilina,* and the low presulcate inflation also is reminiscent of these genera. The true velum is, however, rudimentary, and typically is reduced to an indistinct spinose frill.

Pseudoleperditia Schneider is another Lower Carboniferous genus characterized by large size, a median S_2 and a presulcate inflation. This genus differs from *Pseudochilina* in possessing an

anterodorsal spine and apparently in being nonvelate. Should a velate structure be discerned in *Pseudoleperditia,* then probably *Pseudochilina* will become a junior synonym of the Russian genus.

Primitiella latilimbata Pribyl and Snajdr, 1950, and *Primitia bovifrons* Whidborne, 1896, possess features comparable to those of *Pseudochilina,* and possibly belong to this genus.

Family relationships are uncertain; the genus is placed in the Kloedenellacea on the basis of its similarities to *Pseudoleperditia* and questionably in the Beyrichiopsidae as it possesses a rudimentary velate structure.

PSEUDOCHILINA MARGINATA, n. sp.

Plate 6, figures 12-21

Description: Carapace nearly equivalved. Hinge line straight. Valves subquadrate in lateral view, elongate subpyriform in dorsal view. Dorsal border straight; anterior border evenly rounded, passing smoothly into gently convex ventral border. Posterior border evenly rounded ventrally, almost straight dorsally. Greatest length close to midheight; greatest height a short distance in front of midlength; greatest width slightly behind midlength.

S_2 a shallow, poorly defined depression arising at midlength a short distance below the dorsal border, and extending to midheight. Sulcus in adults almost vertical, but slightly oblique in younger instars and directed posteroventrally.

L_2 typically defined only by S_2 and the submarginal depression, but a slight presulcate inflation present in a few individuals.

L_3 also defined by S_2 and the submarginal depression. A large, laterally and posterodorsally directed spine situated on L_3 immediately posterior to S_2; spine proportionately larger in successively younger instars.

A strong marginal ridge, separated from the main part of the valve by a deep depression or groove, arising at the anterior cardinal angle and paralleling the free margins to the posterior cardinal angle. Ridge widest on the anterior and posterior borders, and thinnest midventrally. A finely spinose, subdued frill present on the outer border of the ridge; typically, the frill is present on the anterior and ventral borders, but traces are visible posteriorly in well-preserved specimens.

Lateral surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0169	2.85	1.71	1.37
Paratype PO. 0170	2.96	1.67	—
Paratype PO. 0171	2.41	1.37	—
Paratype PO. 0172	1.63	1.03	—
Paratype PO. 0173	1.46	0.86	—
Paratype PO. 0174	1.22	0.70	—
Paratype PO. 0175	1.06	0.63	—

Remarks: This species was recorded from two localities in the middle member of the Banff Formation. It is sufficiently distinct from all other ostracodes to warrant erection of a new genus to contain it. *P. marginata* differs from the only other species included in this genus in possessing a well-defined marginal ridge, and in having a more strongly developed and differently situated posterodorsal spine.

The specific name is derived from the Latin "*margino*" (to provide with a margin) and refers to the strong marginal ridge.

Occurrence: RG 56-3-51, 52.

Types: Holotype, a complete carapace No. PO. 0169; paratypes, two left and four right valves, Nos. PO. 0170-0175.

PSEUDOCHILINA sp.

Plate 6, figures 22, 23

Diagnosis: Large subquadrate *Pseudochilina* species with low presulcate node, S_2, posterodorsal spine and a poorly developed submarginal frill.

Remarks: This species differs from *P. marginata* in lacking a marginal ridge, and in having the posterodorsal spine situated nearer the posterior cardinal angle, a more distinct presulcate node, and a somewhat more sharply defined S_2.

Occurrence: RG 57-10-1; RG 60-1-9, 10, 11, 12.

Specimens: Two left valves, Nos. PO. 0177, 0178.

?Family MILTONELLIDAE Sohn, 1950

?Genus LIBUMELLA Rozhdestvenskaya, 1959

Libumella Rozhdestvenskaya, 1959, Acad. Sci. U.S.S.R., Bashkirian Div., p. 134; Copeland, 1962, Geol. Surv. Can. Bull. 91, p. 43.

Macronotella Ulrich—Kesling and Kilgore, 1952, Contrib. Mus. Paleont. Univ. Michigan, vol. 10, p. 2 (*not Macronotella* Ulrich of authors).

Kirkbya Jones—Tolmachoff, 1926, Rept. Second Norwegian Arctic Exped. *Fram*, 1898-1902, no. 38, p. 28.

Ehlersia Kesling, Crafts, Darby, Shubak and Smith, 1960, Contrib. Mus. Paleont. Univ. Michigan, vol. 15, p. 307.

LIBUMELLA ATHABASCENSIS, n. sp.

Plate 7, figures 1-9

Description: Carapace inequivalved, subovate to subrhomboidal in lateral view, subelliptical in dorsal view. Left valve overlapping right around free margins and at cardinal angles. Hinge straight, slightly depressed below dorsal border. Dorsal border slightly convex; cardinal angles distinct. Anterodorsal slope straight to gently convex, moderately long; maximum anterior extension below midheight. Anterior extremity rounded, passing smoothly into gently convex ventral border; ventral border diverging slightly anteriorly from dorsal border. Posterior border convex, typically somewhat truncate ventrally. Greatest height anterior; greatest width posterior to almost central; greatest length below midheight.

Each valve with a smooth marginal ridge paralleling the free margins, and separated from the main part of the valve by a distinct bend; marginal ridge considerably wider in the left valve than in the right, and in the left valve having a shallow groove dividing it into a double ridge.

Smooth spot situated centrally; the bend, marginal ridge, and a narrow undefined dorsal border also smooth; remainder of the valve ornamented by coarse, irregular reticulations.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0005	1.48	1.01	0.93
Paratype PO. 0006	1.56	0.91	—
Paratype PO. 0007	1.46	1.03	—

Paratype PO. 0008	1.29[1]	0.84	—
Paratype PO. 0009	1.27	0.84	—
Paratype PO. 0010	1.08	0.70	—
Paratype PO. 0011	0.97	0.67	—
Paratype PO. 0012	0.89	0.59	—

Remarks: *Libumella athabascensis,* n. sp., differs from *L. hypercala* (Kesling and Kilgore) in being more rhomboidal in lateral outline, in being twice as large, and in having larger and more irregularly sized reticulations. This species is similar to *Savagellites lindahli* (Ulrich), but differs in possessing a central smooth spot instead of a pit and node, and in having a stronger marginal structure.

Occurrence: RG 57-10-1; RG 60-1-9, 12.

Types: Holotype, a complete carapace, No. PO. 0005; paratypes, five right and two left valves, Nos. PO. 0006-0012.

? Genus NAMAIA, n. gen.

Type species: *Namaia reticulata,* n. sp.

Generic diagnosis: Straight-hinged, almost equivalved ostracodes with almost evenly convex lateral surfaces. Each valve bearing a central smooth spot, a narrow slit-like sulcus, and in some a rudimentary low node in front of the smooth spot. Lateral and marginal surfaces joined at a simple bend; lateral surfaces reticulate.

Generic description: Carapace almost biconvex, with straight hinge and subequal valves. Valves in lateral view subovate to semiovate. Dorsal border straight. Lateral surface joined to marginal surface along a bend; velate structures absent.

Lateral surface evenly reticulate, except for smooth central spot and bend; marginal surface also smooth. Marginal ridge strongly developed in overlapping (left) valve, weakly developed in overlapped (right) valve.

A rudimentary low node present in front of the central smooth spot in some specimens. A distinct, narrow, slit-like sulcus extending from close to the dorsal border to the central smooth spot.

Remarks: The sulcus and bare spot are situated close to mid-length, and orientation is determined on the basis of greatest height being anterior and of the low presulcate node being homologous to

[1]estimated

that of *Savagellites* Pribyl, 1953, to which *Namaia* obviously is closely related. *Namaia* differs from *Savagellites,* however, in possessing a sulcus and a central smooth spot instead of a distinct pit. *Libumella* Rozhdestvenskaya, 1959, also is closely related and probably is the ancestor of *Namaia. Namaia* possesses the bend, marginal structure, and central smooth spot of *Libumella,* but in addition has a sulcus, and typically a presulcate node.

The generic name is derived from the Indian word *"nama"* (a weapon, bow); the samples containing the type species *Namaia reticulata* were collected in the Bow River Valley.

NAMAIA RETICULATA, n. sp.

Plate 7, figures 10-13

Description: Carapace inequivalved, subovate to semiovate in lateral view, subovate in dorsal view, subcircular in end view. Left valve overlapping right slightly around free margins and at cardinal angles. Hinge straight, slightly depressed below dorsal border. Dorsal border straight, cardinal angles distinct, obtuse. Anterior border evenly convex, passing smoothly into gently convex ventral border. Posterior border convex, truncate ventrally. Greatest height and width anterior, greatest length above midheight.

A narrow, slit-like sulcus extending from close to the dorsal border to the dorsal edge of the central smooth spot, situated at midheight. An indistinct low swelling present anterior to the smooth spot in some specimens.

An unornamented rim paralleling the free borders of the valve, and consisting of a sharp bend, a shallow channel, and a marginal ridge; marginal ridge strongly developed in the left valve and weakly developed in the right.

Rim, central spot and sulcus smooth; remainder or lateral surface evenly reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0013	1.06	0.69	0.58
Paratype PO. 0014	1.06	0.67	—

Remarks: One adult carapace, one adult right valve, and several carapaces of A—2 and A—3 instars were collected. Although the

collection is small, preservation is sufficiently adequate to show all features and to indicate that the species is representative of a new genus.

Occurrence: RG 56-3-40, 51.

Types: Holotype, a complete carapace, No. PO. 0013; paratype, a right valve, No. PO. 0014.

Superfamily LEPERDITELLACEA Ulrich and Bassler, 1908
Family LEPERDITELLIDAE Ulrich and Bassler, 1908
Genus CORYELLINA Bradfield, 1935

CORYELLINA OBESA, n. sp.

Plate 7, figures 14-19

Diagnosis: *Coryellina* species with a reticulate surface ornament and lacking strong posteroventral spines.

Description: Carapace inequivalved, highly inflate, subovate to subquadrate in lateral view, subtrapezoidal in dorsal view. Right valve overlapping left moderately around free margins, and slightly at cardinal angles. Hinge straight, depressed in a V-shaped channel along its entire length. Dorsal border straight to slightly convex; cardinal angles distinct, anterior cardinal angle more obtuse than posterior. Anterior border rounded, with steeply inclined, almost straight anterodorsal slope. Ventral border straight, short, parallel to dorsal border. Posterior border moderately rounded, truncate ventrally.

S_2 a well-defined, almost drop shaped sulcus, situated behind mid-length, extending from below the dorsal border to midheight, gently curved, convex anteriorly. L_2 and L_3 defined only by S_2; L_3 the more inflate lobe.

Short, posterodorsally directed spine situated at the posterior cardinal angle in the right valve.

Row of short spines close to and paralleling the posterior margin of each valve. Lowest, posteroventral spine slightly larger than others, and situated slightly farther from the valve margins.

Greatest height anterior, greatest width posterior, greatest length at, or slightly above, midheight.

The V-shaped channel containing the hinge, the sulcus, and a narrow undefined marginal area are smooth. Remainder of the surface finely and evenly reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0095	0.65	0.46	0.48
Paratype PO. 0096	0.65	0.44	0.46
Paratype PO. 0097	0.82	0.55	0.61

Remarks: This species differs from other species of *Coryellina* in lacking strong posteroventral spines in each valve. Its reticulate surface ornament also serves to distinguish it from most other described species.

Occurrence: Hudson's Bay Union Salt Creek well, 2,950 feet; RG 57-11-1.

Types: Holotype, a complete carapace, No. PO. 0095; paratypes, two complete carapaces, Nos. PO. 0096-0097.

CORYELLINA SPINOSA, n. sp.

Plate 7, figures 20-25

Coryellina sp., Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 4.

Diagnosis: *Coryellina* species with a smooth subsulcate inflation and a strong posteroventral spine in each valve.

Description: Carapace inequivalved, strongly inflate, subovate in lateral view, subpyriform in dorsal view. Right valve overlapping left around free margins, and slightly at cardinal angles. Hinge straight, depressed in a shallow V-shaped channel. Dorsal border straight anteriorly, straight to gently convex posteriorly. Anterior cardinal angle distinct, obtuse; posterior cardinal angle subrounded. Anterior and posterior borders rounded; posterior border moderately truncate ventrally. Ventral border gently convex. Greatest height central; greatest width posterior, below midheight; greatest length above midheight.

S_2 a short, straight, deep sulcus, almost an elongate pit in some specimens, arising below the dorsal border in front of midlength and ending above midheight; a low, smooth, ill-defined U-shaped inflation flanking the lower end of the sulcus.

Strong posteroventral spine present on each valve; distance between dorsal margin and spine 60 to 66 per cent of distance between dorsal and ventral margins; a well-developed spine present on the posterior cardinal angle of the right valve.

V-shaped channel along the hinge, a narrow undefined rim around the free margins, sulcus and U-shaped lobe smooth; remainder of the lateral surface typically finely punctate, but in some specimens apparently smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0098	0.82	0.59	0.27
Paratype PO. 0099	0.84	0.57	—
Paratype PO. 0100	0.59	0.39	—
Paratype PO. 0101	0.65	0.46	—
Paratype PO. 0102	0.78	0.55	—

Remarks: *C. spinosa,* n. sp., is differentiated from *C. obesa* by the presence of strong posteroventral spines, of a subsulcate inflation, its different surface ornament, and by the different shape of sulcus.

Two subspecies may be represented in the material available, but this cannot be determined until larger collections have been made.

Occurrence: RG 56-3-51; RG 56-4-75, 76, 83.

Types: Holotype, a left valve, No. PO. 0098; paratypes, two left and two right valves, Nos. PO. 0099-0102.

Superfamily PARAPARCHITACEA Scott, 1959
Family PARAPARCHITIDAE Scott, 1959
Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES PRODUCTUS, n. sp.

Plate 8, figures 14-21

Description: Carapace inequivalved, elongate-ovate in lateral view, sublanceolate in dorsal view. Left valve overlapping right moderately around free margins. Hinge straight, long, about equal to three-quarters of length, slightly channeled in some specimens. Dorsal border straight. Cardinal angles distinct. Ends smoothly rounded, ventral border gently convex. Greatest height a short distance behind anterior cardinal angle; greatest width posterior.

Short posterodorsal spine on each valve, situated about one-third of the length from the posterior end, and one-sixth of the height below the dorsal border. Spine does not extend above dorsal border. Surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0103	2.01	1.22	0.84
Paratype PO. 0104	1.60	0.99	0.61
Paratype PO. 0105	1.22	0.76	0.53
Paratype PO. 0106	1.06	0.67	0.46
Paratype PO. 0107	0.84	0.53	0.34
Paratype PO. 0108	0.68	0.44	0.30
Paratype PO. 0109	0.53	0.38	0.23

Remarks: This species differs from almost all other species of *Paraparchites* in its large form ratio: 1.72 as against 1.2 to 1.5. It is similar in proportions to *P. oblongus* (Jones and Kirkby), *P. dewalquei* (Jones and Kirkby), and *P. subequalis* (Reed). *P. oblongus* and *P. dewalquei* differ in lacking spines, in having subparallel dorsal and ventral borders and rounded cardinal angles. *P. subequalis* is four times as large as *P. productus* and is more rhomboidal in dorsal view.

The specific name is derived from the Latin "*productus*" (drawn out, produced) and refers to the elongate lateral outline of the species.

Occurrence: RG 57-11-2.

Types: Holotype, a complete carapace, No. PO. 0103; paratypes, six complete carapaces, Nos. PO. 0104-0109.

PARAPARCHITES PINGUIS, n. sp.

Plate 8, figures 1-7

Description: Carapace inequivalved, subovate in lateral view, subquadrate in dorsal view, almost drop shaped in end view. Left valve overlapping right slightly around free margins. Hinge slightly channeled, long, straight, about three-fifths of total length of valve. Dorsal border straight to slightly convex, formed by extension of right valve above border of left. Anterior border smoothly rounded; ventral border gently convex, posterior border more sharply rounded than anterior, somewhat truncate ventrally. Cardinal angles distinct. Greatest height anterior; greatest width below midheight and close to below posterodorsal spine. Dorsal part of the valve convex in end view, central part almost straight, and the ventral portion strongly convex. Line of contact of the valves lying ventrally in a V-shaped depression produced by the strong ventral inflation of the valves.

Short posterodorsal spine situated on each valve about one-quarter of the height below the dorsal border, and one-quarter of the length from the posterior end. Surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0110	1.90	1.29	1.06
Paratype PO. 0111	1.82	1.25	1.06
Paratype PO. 0112	1.44	0.99	0.80
Paratype PO. 0113	0.95	0.63	0.46

Remarks: *P. pinguis,* n. sp., is closely similar to *P. carbonarius* (Hall). It differs in possessing a spine on each valve, in being more truncate posteroventrally, and in possessing extreme ventral inflation of the valves.

The specific name is derived from the Latin *"pinguis"* (fat, plump) and refers to the extreme inflation of the valves.

Occurrence: RG 56-4-26A, 75; RG 57-11-1, 2.

Types: Holotype, a complete carapace, No. PO. 0110; paratypes, three complete carapaces, Nos. PO. 0111-0113.

PARAPARCHITES sp. cf. P. PINGUIS, n. sp

Plate 8, figures 8, 9

Remarks: A few specimens closely resembling *P. pinguis* were obtained from one locality. They possess a spine on each valve situated in the same relative position as in *P. pinguis* and differ only in their less inflation ventrally; in this feature they compare closely with A—2 and A—3 instars of *P. pinguis,* with which they compare in size.

Occurrence: Shell Cadotte No. 1 well, 2,770-800 feet.

Specimens: Two complete carapaces, Nos. PO. 0114, 0115.

PARAPARCHITES NICKLESI (Ulrich)

Plate 8, figures 10, 11

Leperditia nicklesi Ulrich, 1891, Jour. Cincinnati Soc. Nat. Hist., vol. 13, no. 4, p. 200, pl. 18, fig. 1a-e.

Remarks: Specimens comparable in all respects with Ulrich's species were obtained from two localities. Winkler (1955) has attempted to subdivide *P. nicklesi* of authors into a long form and a short form, referring the former to *P. carbonarius* (Hall) and the

latter to *P. subcircularis* Geis. The writer does not concur with the concept of classifying species on length: height ratios alone, and considers that *P. nicklesi* differs from *P. subcircularis* and from *P. carbonarius* by features of shape independent of height and length measurements: *P. nicklesi* has a much straighter dorsal border than *P. subcircularis* and also possesses distinct cardinal angles; *P. carbonarius* is more quadrate in dorsal view than *P. nicklesi* and is more nearly drop shaped in end view.

Occurrence: Shell Cadotte No. 1 well, 2,660 feet, 2,770-800 feet.

Hypotype: A complete carapace, No. PO. 0116; Shell Cadotte No. 1 well, 2,660 feet.

PARAPARCHITES sp. cf. P. NICKLESI (Ulrich)

Plate 8, figure 22

?*Leperditia nicklesi* Ulrich, 1891, Jour. Cincinnati Soc. Nat. Hist., vol. 13, no. 4, p. 200, pl. 18. fig. 1a-e.

Remarks: One sample yielded a species of *Paraparchites* represented by specimens ranging in length from approximately 0.5 mm. to 2.89 mm. If it is assumed that this species follows the normal laws of growth, then nine instars are represented in this collection, the first having a length of 0.5 mm. The specimens identified as *P. nicklesi* (Ulrich) by Morey (1935, 1936) from the Bushberg and Chouteau Formations of Missouri are comparable in all respects with the second, fourth and fifth instars of the Banff species. Ulrich's holotype is comparable in size with the fourth instar.

It is doubted whether all specimens identified as *P. nicklesi* (Ulrich) from the Mississippian of the United States can be classed as immature instars, but rather it is likely that the Alberta species is a different and larger form. At present, however, it is compared with Ulrich's species, until more material is obtained from additional localities.

Occurrence: RG 56-3-51.

Specimen: A complete carapace, No. PO. 0176.

PARAPARCHITES sp. aff. P. NICKLESI (Ulrich)

Plate 8, figures 12, 13

Remarks: A species resembling *P. nicklesi* (Ulrich) in lateral outline occurs near the base of the Banff Formation. It differs from

Ulrich's species in having the right valve flattened anterocentrally to anterodorsally and in having the anterodorsal border somewhat inflated.

Occurrence: RG 57-10-1.

Specimens: One left valve, No. PO. 0117; one right valve, No. PO. 0118.

PARAPARCHITES sp.

Remarks: Young instars with long posterodorsal spines were present in a few collections.

Occurrence: RG 56-1-42; RG 56-3-40.

Genus PSEUDOPARAPARCHITES Kellett, 1933

PSEUDOPARAPARCHITES MONTIS, n. sp.

Plate 7, figures 26-29

Diagnosis: *Pseudoparaparchites* species characterized by a semiovate lateral outline, a straight dorsal border, strong posterodorsal spines, and scattered pits on the posterodorsal one-half of the carapace.

Description: Carapace inequivalved, semiovate in lateral outline, sublanceolate in dorsal view. Greatest height anterior; greatest width close to posterior cardinal angle; greatest length slightly above midheight. Right valve overlapping left slightly around free margins. Hinge long, straight, slightly depressed. Dorsal border straight; anterior and posterior borders rounded, posterior border strongly truncate ventrally. Ventral border gently rounded.

Each valve slightly inflate centrally to posterodorsally; large, dorsolaterally directed spine situated in the posterodorsal area; length of complete spine almost as great as valve height.

Posterodorsal one-third of the valve ornamented with distinct scattered punctae; valve surface otherwise smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0090	0.57	0.35	0.29
Paratype PO. 0091	0.65	0.49	—
Paratype PO. 0092	0.65	0.46	—

Remarks: *Pseudoparaparchites montis* differs from most described species of *Pseudoparaparchites* in its ornament of scattered punctae in the posterodorsal area. It differs from *P. erectus* (Cooper) and *P. spinosus* (Croneis and Gale) in shape, being more truncate posteroventrally, and in lacking the dorsal swollen area of *P. spinosus*.

This species is rare in the Banff Formation. The typical form is present in the upper member of the formation; in the middle and lower members a related but more elongate and more quadrate form is present which is referred to *P. montis* with reservation.

The specific name is derived from the Latin "*mons*" (a mountain) and refers to the fact that this species has been found only in the mountain sections.

Occurrence: RG 56-4-75; RG 57-11-1.

Types: Holotype, a complete carapace, No. PO. 0090; paratypes, a left valve and a right valve, Nos. PO. 0091, 0092.

PSEUDOPARAPARCHITES sp. cf. P. MONTIS, n. sp.

Plate 8, figures 23, 24

Occurrence: RG 56-1-2, 42; RG 56-3-12, 14, 18, 28, 35, 38, 40.

Specimens: A left valve and a right valve, Nos. PO. 0093, 0094.

Order PALAEOCOPIDA, suborder and family UNCERTAIN

Genus EDITIA Brayer, 1952

Brayer (1952, p. 170) placed the genus *Editia* in the family Kirkbyidae, stating that it was closely related to both *Amphissites* and *Kirkbya*. Neither he nor Samoilova and Smirnova (1958) made any mention, however, of the presence of a kirkbyan pit or of a muscle scar, and such features are not apparent in illustrations of the type species *E. elegantis* Brayer or of *E. tulensis* Samoilova and Smirnova. Both species from the Banff Formation lack traces of a pit and of a muscle spot. The shape of the valve in internal view suggests a relationship to genera of the family Drepanellidae, and the form of the ridges is similar to that of a genus such as *Xystinotus* Kesling. The lack of nodes, however, precludes the placing of the genus in the Drepanellacea.

The genus *Editia* is therefore classified, as by Sohn (in Moore, 1961), as "suborder and family uncertain".

EDITIA ALBERTENSIS, n. sp.

Plate 9, figures 1-6

Diagnosis: *Editia* species with submarginal ridge and anterior carina joining anteroventrally. A short, almost vertical carina developed posterodorsally.

Description: Carapace inequivalved, subrhomboidal in lateral view, lanceolate in dorsal view. Greatest height anterior; greatest width posterior; greatest length above midheight, generally close to dorsal margin. Left valve slightly larger than right, overlapping slightly on free margins. Hinge long, straight, almost as long as maximum length of valve, slightly depressed. Dorsal border straight. Anterior border gently convex dorsally, strongly rounded ventrally. Ventral border straight, converging slightly posteriorly towards the dorsal border. Posterior border gently convex, strongly truncate ventrally.

Anterior cardinal angle distinct, 110 to 120 degrees. Posterior cardinal angle distinct to rounded; 90 to 100 degrees where distinct.

Several distinct ridges present on the lateral surface. Submarginal ridge arising close to the anterior cardinal angle; anterodorsally, ridge almost on the valve margin, diverging anteroventrally from the margin and joining the anterior carina towards the posterior end of the anteroventral area. Anterior carina arising on the dorsal edge of a small rounded node situated behind the anterior cardinal angle, extending almost vertically towards the ventral margin, curving posteriorly, and behind its junction with the submarginal ridge almost paralleling the ventral margin; posterodorsally, carina converging towards the margin, meeting it close to the posterior cardinal angle. Rounded node passing posteriorly into the dorsal ridge; dorsal ridge diverging posteriorly from the hinge. Dorsal ridge passing, at about one-third of the length of the hinge from the posterior cardinal angle, with sharp angulation into the posterior carina. Posterior carina extending first posteroventrally and then ventrally. In some specimens posterior carina extending ventrally to within two reticulations of the frill.

The area between the dorsal ridge and the margin, and between the submarginal ridge and the margin, finely striate, the striations running parallel to the margin. Remainder of the lateral surface

coarsely reticulate. One row of reticulae present between the ventral margin and the anterior carina; a second row of reticulations appearing posteriorly between anterior carina and the margin. The various ridges generally smooth, but in places finely striate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0016	0.51	0.32	0.20
Paratype PO. 0017	0.51	0.30	—
Paratype PO. 0018	0.53	0.32	—
Paratype PO. 0019	0.61	0.36	—

Remarks: *E. albertensis* differs from the type species—*E. elegantis* Brayer—in its different distribution of ridges and in its different shape in lateral view. *E. albertensis* is more closely similar to *E. tulensis* Samoilova and Smirnova; the Russian species is, however, relatively longer, and possesses an ornament of scattered pits instead of even reticulation. The carinal patterns are closely similar in both species.

Occurrence: RG 56-4-26A, 46, 68, 75, 76; Canadian Petroleums Peace River No. 2 well, 2,060-65 feet, 2,065-70 feet; Bear Villa No. 1 well, 2,891-6 feet.

Types: Holotype, a complete carapace, No. PO. 0016, Canadian Petroleums Peace River No. 2 well, 2,060-65 feet; paratypes, two right valves, Nos. PO. 0017, 0018, Canadian Petroleums Peace River No. 2 well, 2,065-70 feet; one right valve, No. PO. 0019, RG 56-4-75.

EDITIA BRAYERI, n. sp.

Plate 9, figures 7-9

Diagnosis: *Editia* species with posterior carina joining the submarginal ridge midventrally; anterior carina joining the posterior carina, also midventrally.

Description: Relationship of valves unknown. Valves subquadrate to subrhomboidal in lateral view. Greatest height anterior; greatest width posterior, close to midheight; greatest length above midheight, close to dorsal border. Hinge long, straight, almost as long as maximum length of valve. Dorsal border straight. Anterior border almost evenly rounded; posterior border rounded, truncate ventrally. Ventral border gently convex, with an angulation posteriorly.

Anterior cardinal angle distinct, 110 to 120 degrees. Posterior cardinal angle distinct, 90 to 100 degrees.

Lateral surface bearing a distinct pattern of ridges. Submarginal ridge arising close to the anterior cardinal angle, paralleling the valve margin anteriorly and anteroventrally, and midventrally: (1) swinging away from the valve border to become the posterior carina, or (2) bifurcating, the more distinct branch becoming the posterior carina, the less distinct branch continuing as the submarginal ridge. In case (1), where the ridge passes into the posterior carina, it is replaced *en echelon* by another ridge occupying the submarginal position from midventer to the posterior cardinal angle. Posterior carina paralleling the posterior border to its junction with the dorsal ridge at a point about one-fifth of the length in front of the posterior cardinal angle. Anterior carina arising close to the anterior cardinal angle, extending steeply posteroventrally, then paralleling the submarginal ridge to join the posterior carina centroventrally. This carina not as strongly developed as the posterior carina. Dorsal ridge extending anteriorly from its junction with the posterior carina to the anterior cardinal angle, passing along the dorsal edge of a low, smooth, slightly raised node situated a short distance behind the anterior cardinal angle.

Posterior carina lying on the posterior flank of a low swelling on the valve surface; a broad depression occupying the area between the posterior submarginal ridge and the posterior carina. A shallow, vertically elongate depression situated slightly posteroventral to centre may represent the muscle scar.

Surface of the valves finely reticulate.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0020	0.57	0.29
Paratype PO. 0021	0.61	0.35
Paratype PO. 0022	0.51	0.30

Remarks: This species differs from *E. elegantis* Brayer in possessing less ridges both posteriorly and anteriorly, and in possessing a distinct U-shaped depression between the posterior carina and the posterior submarginal ridge. It differs from *E. albertensis*, n. sp., in that the posterior and not the anterior carina joins the submarginal ridge, and that the posterior carina is abbreviated in *E. albertensis*. The ridge pattern, lateral ornament, and relative proportions are different to those of *E. tulensis* Samoilova and Smirnova. In some specimens the fainter anterior carina apparently is absent; it is uncertain whether

or not this is a consequence of imperfect preservation. Also, in some specimens there may be a poorly developed ridge outside of the feature here described as the submarginal ridge. If this should be the case, then the "submarginal ridge" of this description probably should be interpreted as the frill.

This species is named after R. C. Brayer, who established the genus *Editia*.

Occurrence: RG 56-3-2, 38, 40, 41, 43, 48.

Types: Holotype, a right valve, No. PO. 0020; paratypes, a right valve and a left valve, Nos. PO. 0021-0022.

Order PODOCOPIDA Müller, 1894
Suborder PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1888
Family BAIRDIIDAE Sars, 1888
Genus BAIRDIA McCoy, 1844

Bairdia McCoy, 1844, A synopsis of the characters of the Carboniferous Limestone fossils of Ireland, p. 200.

The genus *Bairdia* McCoy, as defined prior to 1960, included over 600 species of ostracodes (Howe, 1955). These species were, in many cases, defined and described on different criteria, thus making it extremely difficult for a worker to recognize relative weight of characters used in specific differentiation, and to compare similarities of supposedly different species.

Sohn (1960) carried out a monographic study of Paleozoic species of *Bairdia* and related genera, a work which resulted in considerable revision of classification of these species. In carrying this out with the aid of punched cards, Sohn has been able to key species of *Bairdia* and its related genera, and therein to achieve consistency in use of features for specific differentiation, as well as to indicate those morphologic features of significance for specific distinction.

Species of the genus *Bairdia* (s. lat.) are fairly common in the faunas of the Banff Formation. They are widely distributed, and occur associated with species of most other genera. In the collections, however, although immature instars may be common to abundant, mature individuals are relatively uncommon, and it has been seldom that sufficient adults of any one species have been obtained to illustrate the limits of variation of that particular species. Thus the writer has tended to be conservative in the taxonomic subdivision of species of *Bairdia* (s. lat.), the more so because it appears that some

species may be highly variable in their characters. Even so, the referring of specimens to a number of form species appears to involve, in some cases, splitting of natural populations into artificial groups. As present collections are almost all limited in size, this matter cannot yet be decided, and much of the resulting taxonomic subdivision, as set out below, is considered somewhat questionable.

Genus BAIRDIA McCoy, 1844, emend. Sohn, 1960.

Sohn (1960) emended and restricted the genus *Bairdia* McCoy "to Paleozoic species that are smooth and that have curved dorsal margins, pointed posteriors, acuminate anteriors and distinct dorsoanterior margins". Of the total of 70 species recognized by Sohn, only three are recorded from Lower Mississippian rocks, and one of these is indicated by Sohn to be a new, undescribed species.

BAIRDIA sp. aff. B. EGOROVI Sohn

Plate 9, figures 10, 11

Description: Carapace bairdioid, elongate suboval in lateral view. Left valve overlapping right except on anterior margin and posterior part of posteroventral margin. Hinge not depressed. Dorsal margin gently convex, dorsoanterior margin straight; junction of dorsoanterior margins above midheight; anterior extremity at midheight. Anterior and anteroventral margins convex, ventral margin gently concave, posteroventral margin convex. Posterior extremity pointed, situated at midheight. Dorsoposterior margin gently concave, with length approximately one-third of total length of carapace. Dorsoposterior angle subrounded, situated one-quarter of total length from posterior extremity.

Greatest height behind midlength, and approximately equal to one-half of length.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0271	2.47	1.18	0.80

Remarks: This species shows closest similarity to *B. egorovi* Sohn, from Upper Devonian (Frasnian) strata of the Russian platform. It differs from the Russian species in having maximum height behind instead of at midlength, maximum height equal to and not greater than half-length, and in being over twice as large. *B. egorovi*

also has more pronounced dorsal and ventral overlap and, in lateral view, greater angularity of the commissure at the dorsoanterior and dorsoposterior angles.

Bairdia asymmetrica Kummerow, from the Upper Mississippian of Germany, shows certain similarities to the Alberta species, but is easily distinguished by having the posterior point below midheight.

Occurrence: RG 56-3-51; RG 56-4-75.

Specimen: A complete carapace, No. PO. 0271.

BAIRDIA sp. aff. B. GRAHAMENSIS Harlton

Plate 9, figures 12-14

Description: Carapace bairdioid, subtriangular in lateral view. Left valve overlapping right except on anteroventral and posteroventral margins; overlap greatest dorsally and anterodorsally. Hinge not depressed. Dorsal margin evenly convex, dorsoanterior margin straight. Anterior extremity at midheight, anteroventral margin evenly convex, passing smoothly into straight ventral margin. Posteroventral margin evenly convex, posterior point in ventral one-third of height; posterodorsal slope straight to gently concave, long, about one-third of length.

Greatest height and width at midlength; height more than half-length.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0272	2.66	1.56
Specimen PO. 0273	2.38	1.25

Remarks: This Banff species is similar to both *B. grahamensis* Harlton (1928) and *Bairdia* sp. O Sohn (=*B. magnacurta* Morey, of Morey, 1936). It differs from both of these species in having a longer dorsoanterior slope and the anterior extremity at, instead of above, midheight. Both *B. grahamensis* and *B.* sp. O have a convex ventral margin and have the posterior point in the middle one-third of the height. *B. grahamensis* also has a concave dorsoanterior margin.

The very large size of this species also serves to distinguish it from most other species of the genus *Bairdia*.

Occurrence: RG 56-3-51.

Specimen: A left valve, No. PO. 0272; a right valve, No. PO. 0273.

BAIRDIA KINDERHOOKENSIS Morey

Plate 9, figures 15, 16

Bairdia kinderhookensis Morey, 1936, Jour. Paleont., vol. 10, p. 120, pl. 17, figs. 13, 15.

Remarks: Specimens identical with *B. kinderhookensis* Morey are present in the basal member of the Banff Formation.

Occurrence: RG 57-10-1.

Hypotype: A complete carapace, No. PO. 0274.

BAIRDIA sp. aff. B. KINDERHOOKENSIS Morey

Plate 9, figure 17

Remarks: A number of specimens closely related to *B. kinderhookensis* Morey (1936) are present in the lower member of the Banff Formation. They differ from Morey's species in having the anterior extremity below midheight, and the posterior extremity in the ventral, instead of the middle, one-third of the height.

Occurrence: RG 57-10-1.

Specimen: A complete carapace, No. PO. 0275.

BAIRDIA sp. aff. B. WHITESIDEI Bradfield

Plate 9, figures 18, 19

Remarks: Specimens from the basal member of the Banff Formation closely resemble the Pennsylvanian species *B. whitesidei* Bradfield (1935). They are differentiated from this species in being shorter relative to maximum height, in having possibly greater dorsal overlap, in having the commissure of ventral overlap straight to convex in lateral view, and in being proportionately broader.

The Banff species is also close in form to *Bairdia magnacurta* Morey of Morey, 1936 (=*B.* sp. O Sohn, 1960), but is easily distinguished by its much stronger dorsal and ventral overlap, as seen in lateral view, and in its lack of anteroventral overlap.

Occurrence: RG 57-10-1.

Specimen: A complete carapace, No. PO. 0276.

BAIRDIA sp. A

Plate 9, figure 20

Description: Carapace bairdioid, subrhomboidal in lateral view. Left valve overlapping right evenly, except on anterior extremity and ventral side of posterior extremity. Hinge not depressed. Dorsal margin gently convex, dorsoanterior margin straight, two-fifths of total length. Anterior rounded, junction of dorsoanterior and anterior margins above midheight. Anteroventral margin evenly gently convex, joining ventral margin in front of dorsoanterior angle. Ventral margin gently convex to straight, passing smoothly into gently convex posteroventral margin. Posterior extremity situated below midheight, in middle one-third of height. Posterodorsal margin concave, steeply inclined, one-third of total length. Posterodorsal angle situated one-fifth of length from posterior end.

Greatest height at or slightly in front of midlength; greatest height more than half-length. Greatest width at midlength.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0277	1.95	1.17	0.93

Remarks: This species of *Bairdia* is similar to *B.* sp. O Sohn, 1960 (=*B. magnacurta* of Morey, 1936). The Banff species differs from Morey's species in having a relatively longer dorsoanterior margin, and thus the junction of the ventral and ventroanterior margins situated in front of, and not at, the dorsoanterior angle.

Occurrence: RG 56-3-51; RG 56-4-26A, 79.

Specimen: A complete carapace, No. PO. 0277.

BAIRDIA sp. B

Plate 9, figure 22

Description: Carapace bairdioid, almost subtriangular in lateral view. Left valve overlapping right valve all around except on anterior extremity; maximum overlap midventral. Hinge slightly depressed posteriorly; posterodorsal shoulder on right valve. Dorsal margin gently convex, dorsoanterior margin long, straight. Anterior rounded, anterior extremity at approximately midheight. Ventroanterior margin gently convex, passing almost smoothly into straight to gently convex ventral margin. Posteroventral margin gently convex.

Posterior point situated below midheight, at one-third of height. Dorsoposterior slope straight, long, between one-third and one-half of total length. Posterodorsal angle situated at approximately one-third of length from posterior end.

Greatest height situated at or slightly in front of midlength, approximately equal to half-length. Greatest width at midlength.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0278	0.91	0.46	0.34

Remarks: This species bears some resemblance to *B. grahamensis* Harlton, but differs in having the posterior point situated lower, and in being relatively less high.

Occurrence: Canadian Petroleums No. 2 well, 2,065-70 feet.

Specimen: A complete carapace, No. PO. 0278.

BAIRDIA (? RECTOBAIRDIA) sp. C

Plate 9, figure 21

Description: Carapace bairdioid, subrhomboidal in lateral view. Left valve overlapping right except on anterior extremity and on ventral side of posterior extremity. Maximum overlap midventral. Hinge not depressed. Dorsal margin gently convex, dorsoanterior margin straight. Anterior extremity rounded, situated above midheight. Ventroanterior margin gently convex, ventral margin straight. Ventroposterior margin straight to gently convex. Posterior point situated below midheight, at or slightly below one-third of height. Dorsoposterior margin gently concave to straight, approximately one-third of length. Dorsoposterior angle situated at or slightly in front of one-quarter of length from posterior extremity.

Greatest height situated in front of midlength, half of maximum length. Greatest width central.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0279	1.60	0.80	0.68

Remarks: This species has similarities to both Pennsylvanian and Upper Devonian species of *Bairdia*: it is similar to *B. angustata* Cooper, which has a height greater than half of maximum length, and

to *B. nalivkini* Egorov from the Frasnian strata of the Russian Platform, which has greatest height posterior, not anterior.

The slightly convex dorsal margin of this species makes it difficult to determine whether assignment should be to *Bairdia* (s. str.) or to *Rectobairdia*. If this form does in fact belong in the latter genus, then it falls within the complex of *R. subparallela* Morey and related species. Precise generic assignment cannot be determined on the small number of specimens available.

Occurrence: RG 56-3-51; ?Shell Cadotte No. 1 well, 2,770-800 feet.

Specimen: A complete carapace, No. PO. 0279.

BAIRDIA sp. D

Plate 9, figures 23, 24

Description: Carapace bairdioid, elongate oval in lateral view. Left valve overlapping right except on anterior and posterior extremities. Maximum overlap on dorsoanterior margin. Hinge not depressed. Dorsal margin gently convex, dorsoanterior margin straight, anterior rounded, anterior extremity at midheight. Ventroanterior margin gently convex, ventral margin straight. Ventroposterior margin very slightly convex. Posterior pointed, but tip of posterior extremity blunt, situated at midheight. Dorsoposterior margin gently concave, equal to one-third of maximum length of valve. Dorsoposterior angle situated at one-quarter of maximum length from posterior end. Commissure in dorsal view straight.

Greatest height at midlength, equal to less than half of length. Greatest width central, equal to two-thirds of height.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0280	2.13	0.95	0.65

Remarks: This species is similar to *Bairdia subfusiformis* Hamilton, differing in having a straight venter, a nondepressed hinge, and a commissure that is straight in dorsal view. It is also similar to *Bairdia kansasensis* Kellett, differing in being considerably more elongate.

Occurrence: RG 56-4-75; ?RG 56-3-51.

Specimen: A complete carapace, No. PO. 0280.

? Genus ACRATIA Delo, 1930

Acratia Delo, 1930, Jour. Paleont., vol. 4, no. 2, p. 174; Shaver, in Moore, 1961, Treatise Invert. Paleont., pt. Q, Arthropoda 3, p. 203.

ACRATIA FABAEFORMIS, n. sp.

Plate 10, figures 1-4, 7

Description: Carapace inequivalved, elongate semielliptical in lateral view, elongate elliptical in dorsal view. Left valve overlapping right except along centre of hinge and on anterior border. Overlap greatest ventrally, anterodorsally, and on posterior border. Hinge almost straight, depressed below dorsal border. Dorsal border straight to gently convex, parallel to ventral border, passing with subrounded angulation into anterodorsal border; anterodorsal border becoming more strongly convex anteroventrally. Anteroventral angulation sharply rounded. Ventral border gently convex to straight anteriorly, straight to gently concave centrally, gently convex posteriorly. Posteroventral angulation distinct; angle between posterior and posteroventral borders approximately 100 degrees. Posterior border steeply inclined, straight to gently convex, joining dorsal border in a subrounded angulation. Greatest height and width posterior; greatest length close to ventral border.

Surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0264	1.37	0.78	0.64
Paratype PO. 0265	1.22	0.63	0.53
Paratype PO. 0266	1.52	0.76	—

Remarks: *A. fabaeformis*, n. sp., differs from *A. similaris* Morey and *A. deloi* Geis in its less inflation and its more steeply inclined posterior border. Its more angulate ventral border, greater relative height, and dorsoanterior angulation of the hinge, also distinguish this species from *A. similaris* Morey.

The specific name is derived from the Latin "*faba*" (a bean) and "*forma*" (in the shape of) and refers to the general shape of the carapace.

Occurrence: RG 56-4-26A, 44, 59, 64, 73, 75; RG 57-11-1; Canadian Petroleums No. 2 well, 1,959-60 feet.

Types: Holotype, a complete carapace, No. PO. 0264; paratypes, a complete carapace, and a left valve, Nos. PO. 0265, 0266.

ACRATIA SIMILARIS Morey

Plate 10, figure 9

Acratia similaris Morey, 1936, Jour. Paleont., vol. 10, p. 120, pl. 17, figs. 9, 11.

Occurrence: RG 56-4-26A, 43.

Types: Hypotype, a right valve, No. PO. 0267.

ACRATIA sp. cf. A. SIMILARIS Morey

Plate 10, figures 5, 6, 8

?*Acratia similaris* Morey, 1936, Jour. Paleont., vol. 10, p. 120, pl. 17, figs. 9, 11.

Remarks: Specimens from a number of localities in the middle of the Banff Formation resemble *A. similaris* Morey. They differ in being less inflate and lacking in most cases the slight posteroventral mucro of *A. similaris*. It is considered probable, from examination of the type material, that the holotype of *A. similaris* is somewhat squashed dorsoventrally; thus, an undamaged specimen of *A. similaris* is likely to be less inflate, to have steeper anterior and posterior slopes, and possibly a somewhat more convex ventral border. If this is so, then the specimens from the Banff Formation are closely comparable with Morey's species.

Occurrence: RG 56-1-70, ?71, ?74; ?RG 56-3-12, 35, 43, 51, 52.

Specimens: Two complete carapaces, Nos. PO. 0268, 0269.

ACRATIA sp.

Plate 10, figure 10

Diagnosis: *Acratia* species similar to *A.* sp. cf. *A. similaris* but relatively shorter and more subquadrate in lateral outline.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0270	1.06	0.53

Occurrence: RG 57-10-1.

Specimen: A complete carapace, No. PO. 0270.

ACRATIA spp.

Occurrence: RG 56-1-42; RG 56-3-41, 51; RG 56-4-26A, 75; RG 57-10-1.

Genus BAIRDIACYPRIS Bradfield, 1935

BAIRDIACYPRIS? sp.

Plate 10, figures 11, 12

Description: Carapace elongate oval in lateral view. Left valve overlapping right except on anterior and posterior extremities. Maximum overlap midventral. Dorsal margin straight, dorsoanterior margin straight, anterior evenly rounded. Anterior extremity at or slightly below midheight. Ventroanterior margin gently convex, ventral margin with shallow concavity situated slightly in front of midlength. Ventroposterior margin gently convex, posterior sharply and evenly rounded. Posterior extremity situated slightly below midheight. Dorsoposterior margin straight, equal to one-third of maximum length.

Maximum height at midlength, equal to half-length. Maximum width at midlength, equal to two-thirds of height.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0304	2.01	0.99	0.68

Remarks: This species differs from most described species of *Bairdiacypris* in having the posterior extremity situated higher and as such resembles certain species of *Bairdia*. As the posterior is, however, blunt rather than pointed, the species is placed with question in the genus *Bairdiacypris*.

Occurrence: RG 60-1-12.

Specimen: A complete carapace, No. PO. 0304.

Genus CRYPTOBAIRDIA Sohn, 1960

The genus *Cryptobairdia* was established by Sohn (1960) for a group of ostracodes differing from the genus *Bairdia* in lacking a distinct dorsoanterior margin.

CRYPTOBAIRDIA sp. aff. C. COMPACTA (Geis)

Plate 10, figures 20, 21

Remarks: Two left valves of a species of *Cryptobairdia* were collected from probable lower Debolt Formation strata. They differ from *C. compacta* (Geis) (1932) in possessing a distinctly concave instead of straight dorsoposterior margin. Sohn (1960, p. 49)

tentatively placed *Bairdia magnacurta* Morey (1935) in synonymy with *C. compacta*. This species possesses a dorsoposterior margin that may be considered gently concave; if such interpretation is made, then Morey's species, with the Alberta specimens, should be considered a separate species, *C. magnacurta* (Morey). Additional material is needed, however, before this matter can be decided satisfactorily.

Occurrence: Bear Villa No. 1 well, 2,891-96 feet.

Specimens: Two left valves, Nos. PO. 0281, 0282.

Genus ORTHOBAIRDIA Sohn, 1960

ORTHOBAIRDIA sp.

Plate 10, figures 13-15

Description: Carapace bairdioid, subrhomboidal in lateral view. Left valve overlapping right except on ventral side of anterior extremity and on ventral side of posterior extremity. Overlap maximum midventrally and on dorsal margin. Hinge not incised. Dorsal margin straight, dorsoanterior margin straight, anterior rounded, anterior extremity situated above midheight. Ventroanterior margin gently convex to straight, ventral margin concave, concavity shallow, situated in front of midlength. Ventroposterior margin straight, posterior bluntly pointed, posterior extremity situated in ventral one-third of greatest height. Dorsoposterior slope straight, between one-third and one-half of greatest length. Dorsoposterior angle situated at one-third of maximum length from posterior extremity.

Greatest height at midlength, greater than half-length. Greatest width equal to two-thirds of maximum height. Dorsal commissure in dorsal view straight.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0302	2.36	1.44	1.12
Specimen PO. 0303	2.36	1.41	1.10

Remarks: This species is differentiated from other described species of *Orthobairdia* by its long straight dorsoposterior margin. It is closest to *O. cestriensis* (Ulrich) from which it differs in having parallel dorsal and ventral margins, a longer dorsoposterior margin, and a commissure that is straight in dorsal view.

Occurrence: RG 56-4-73.

Specimens: Two complete carapaces, Nos. PO. 0302, 0303.

Genus RECTOBAIRDIA Sohn, 1960

The genus *Rectobairdia,* as established by Sohn (1960), comprises a group of bairdiid ostracodes with straight to very gently curved dorsal margins and pointed posteriors.

A large number of specimens from the Banff Formation in Alberta are referable to the genus *Rectobairdia,* and the majority of these comprise a closely related complex of forms that may represent several distinct species or alternatively a few highly variable species.

The two new species described below are considered distinctive, and a number of other forms denoted as having affinities with described species may also, when further collecting is carried out, be recognizable as distinct new species.

RECTOBAIRDIA CONFRAGOSA, n. sp.

Plate 10, figures 16-19

Description: Carapace bairdioid, elongate subhexagonal in lateral view. Left valve overlapping right except on ventral tip of posterior extremity; overlap slight on anterior extremity, and moderate around other margins. Hinge not depressed. Dorsal margin straight to very gently convex, dorsoanterior margin straight, about one-quarter of length. Anterior extremity evenly rounded, situated above midheight. Ventroanterior margin gently and evenly convex; junction of anterior and ventral margins below posterior half of dorsoanterior margin. Ventral margin straight, ventroposterior margin gently convex. Posterior point situated below midheight, in middle one-third of height. Dorsoposterior margin concave, one-third of total length. Dorsoposterior angle located at one-quarter of total length from posterior extremity. Dorsal and ventral margins subparallel, but converging slightly posteriorly.

Greatest height in front of midlength, at dorsoanterior angle; greatest height equal to or greater than half-length. Greatest width at midlength.

Commissure of dorsal overlap straight in dorsal view.

Surface punctate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0283	1.18	0.66	0.49
Paratype PO. 0284	1.25	0.72	0.53
Paratype PO. 0285	1.29	0.65	0.49

Remarks: *Rectobairdia confragosa*, n. sp., is similar to *R. fragosa* (Morey) in many respects; it differs, however, primarily in having the posterior point set higher above the ventral margin, and in being relatively higher in proportion to length. *R. confragosa* is also closely related to *R. distressa* (Geis). The Salem species differs in having the hinge incised posterodorsally and in having a somewhat longer dorsoanterior margin. *R. posneri* Sohn is distinguishable from *R. confragosa* in having the dorsal and ventral margins converging strongly posteriorly and in having a straight dorsoposterior margin.

The specific name is derived from the Latin *"confragosus"* (rough, uneven), and refers to the distinctly punctate surface of the species.

Occurrence: RG 56-4-75; RG 57-11-1.

Types: Holotype, a complete carapace, No. PO. 0283; paratypes, two complete carapaces, Nos. PO. 0284, 0285.

RECTOBAIRDIA sp. cf. R. DISTRESSA (Geis)

Plate 11, figures 7, 8

?*Bairdia distressa* Geis, 1940, Jour. Paleont., vol. 14, p. 154. new name for *B. depressa* Geis, 1932.

?*Bairdia depressa* Geis, 1932, Jour. Paleont., vol. 6, p. 178, pl. 25, figs. 12a, b.

Remarks: This species is close to *Rectobairdia subparallela* (Morey), differing primarily in having a strongly depressed hinge. It differs from *R. morroensis*, n. sp., and *R.* sp. cf. *R. sinuosa* Morey in having a concave dorsoposterior margin.

In comparison with *R. distressa* (Geis), this species is closely similar, differing only in that some specimens are relatively higher in proportion to length.

Occurrence: RG 57-10-1.

Specimen: A complete carapace, No. PO. 0286.

RECTOBAIRDIA sp. aff. R. FRAGOSA (Morey)

Plate 11, figures 1-6

Description: Carapace bairdioid, elongate subrhomboidal in lateral view. Left valve overlapping right except on ventral side of posterior acumination and on anterior extremity. Maximum overlap midventral and on dorsoanterior margin. Hinge not depressed. Dorsal margin straight to very gently convex, dorsoanterior margin

straight, occupying one-third of length. Anterior rounded, anterior extremity at midheight. Ventroanterior margin convex, joining ventral margin below posterior one-quarter of dorsoanterior margin. Ventral margin with shallow concavity, concavity situated in front of midlength. Ventroposterior margin gently convex, posterior point situated in ventral one-third of maximum height. Dorsoposterior margin concave, approximately one-third of maximum length. Dorsoposterior angle situated at one-quarter of maximum length from the posterior extremity.

Slight ventral lip present. Commissure in dorsal view gently sinuous to straight.

Maximum height at dorsoanterior angle, typically slightly greater than half-length. Greatest width in front of midlength, equal to two-thirds of maximum height.

Surface smooth.

Description of instars: Instar 8. No specimens collected.

Instar 7. Differing from adult instars in having more acuminate cardinal angles, less conspicuous dorsoanterior overlap, and a straight ventral margin.

Instar 6. Closely similar to instar 7, but differing in being somewhat more elongate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0287	1.99	1.03	0.68
Specimen PO. 0288	1.90	0.91	0.72
Specimen PO. 0289	1.90	1.03	0.72
Specimen PO. 0290	0.97	0.46	0.31

Remarks: Instar 6 of this species closely resembles *R. fragosa* (Morey), differing only in having the posterior point set somewhat higher. Because of this close similarity, it thus becomes possible that the holotype of *R. fragosa* (Morey) is a late instar of a considerably larger adult form.

R. sp. aff. *R. fragosa* is similar also to *R. sinuosa* Morey and *R.* sp. B of Sohn (1960). It differs from both primarily in having the position of greatest width in front of, rather than behind or at midlength, respectively.

Occurrence: RG 57-11-1; Canadian Petroleums No. 2 well, 2,060-65 feet.

Specimens: Four complete carapaces, Nos. PO. 0287-0290.

RECTOBAIRDIA MORROENSIS, n. sp.

Plate 11, figures 13-16

Description: Carapace bairdioid, subrhomboidal in lateral view, elongate subovate in dorsal view. Left valve overlapping right except on anterior margin and possibly on posterior part of ventroposterior margin. Maximum overlap on dorsoanterior and ventral margins. Hinge depressed posteriorly. Dorsal margin straight to gently convex, dorsoanterior margin straight, occupying anterior one-third of length. Anterior rounded, anterior extremity situated at mid-height. Ventroanterior margin gently convex to straight, ventral margin straight. Junction of ventral and ventroanterior margins situated below posterior half of dorsoanterior margin, almost below dorsoanterior angle. Ventroposterior margin straight, posterior extremity bluntly pointed, situated in ventral one-third of maximum height. Dorsoposterior margin typically convex dorsally to straight ventrally, one-third of maximum length, inclined at an angle of 65 degrees to the dorsal margin. Dorsoposterior angle situated at between one-quarter and one-fifth of maximum length from the posterior extremity. Commissure straight in dorsal view. Maximum height greater than half-length. Dorsal and ventral margins parallel. Maximum width central, equal to two-thirds of maximum height.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0291	1.67	1.03	0.76
Paratype PO. 0292	1.39	0.87	0.68
Paratype PO. 0293	1.44	0.91	0.70

Remarks: *Rectobairdia morroensis,* n. sp., is distinguished from other closely related species, such as *R. distressa* (Geis) and *R. subparallela* (Morey), by its steeply inclined, convex dorsoposterior margin. In *R. distressa* the angle of inclination of the dorsoposterior margin is 50 degrees to the dorsal margin, and in *R. subparallela* is 55 degrees. *R. subparallela* also lacks an incised hinge.

Occurrence: RG 57-10-1; RG 60-1-12.

Types: Holotype, a complete adult carapace, No. PO. 0291; paratypes, two complete penultimate instar carapaces, Nos. PO. 0292, 0293.

RECTOBAIRDIA sp. cf. R. SINUOSA (Morey)

Plate 11, figures 17-21

?*Bairdia sinuosa* Morey, 1936, Jour. Paleont., vol. 10, p. 119, pl. 17, figs. 17, 19.

Description: Carapace bairdioid, elongate subhexagonal in lateral view, fusiform in dorsal view. Left valve overlapping right except on anterior margin and ventral side of posterior extremity. Maximum overlap on lower part of dorsoposterior slope. Hinge slightly depressed posteriorly. Dorsal margin straight to very slightly convex. Dorsoanterior margin straight, approximately one-quarter of total length. Anterior extremity rounded, situated above midheight; ventroanterior margin evenly convex. Junction of ventral and ventroanterior margins below posterior half of dorsoanterior slope. Ventral margin straight to gently concave, concavity where present in front of midlength. Ventroposterior margin evenly convex. Posterior extremity bluntly pointed, situated below midheight in middle one-third of height. Dorsoposterior margin straight to very slightly concave, one-quarter of total length. Dorsoposterior angle located at one-quarter of length from posterior extremity. Dorsal and ventral margins subparallel, but converging slightly posteriorly.

In dorsal view, commissure straight along dorsal margin, curved along dorsoanterior and dorsoposterior margins.

Greatest height at dorsoanterior angle; greatest height greater than half-length. Greatest width at midlength; greatest width equal to half length.

Surface finely punctate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0294	1.33	0.78	0.70
Specimen PO. 0295	1.29	0.74	0.61
Specimen PO. 0296	1.22	0.67	0.61

Remarks: The variation in shape of the margins of this species leads to difficulty in comparison and classification. Specimens with gently concave dorsoposterior and ventral margins are very close to *R. sinuosa* (Morey) and differ only in the more even inflation of the valves and possibly in the position of maximum width. They are also closely similar to *Rectobairdia* sp. B. Sohn, but are wider and have dorsal and ventral margins converging slightly to the posterior.

Specimens with straight dorsoposterior and ventral margins are close to *R. distressa* (Geis) ; they differ from the Salem species in having the posterior point situated in the middle, not the ventral, one-third of the greatest height.

Rectobairdia confragosa, n. sp., differs from *R.* sp. cf. *R. sinuosa* in being less wide, and in having the commissure straight in dorsal view.

Occurrence: Shell Cadotte No. 1 well, 3,400-10 feet.

Specimens: Three complete carapaces, Nos. PO. 0294-0296.

RECTOBAIRDIA SUBPARALLELA (Morey)

Plate 11, figures 9-12

Bairdia subparallela Morey, 1935, Jour. Paleont., vol. 9, p. 323, pl. 28, fig. 24.

?*Bairdia subparallela* Morey—Morey, 1936, Jour. Paleont., vol. 10, p. 119, pl. 17, fig. 7.

Bairdia subparallela Morey—Sohn, 1960, U.S. Geol. Surv. Prof. Paper 330-A, p. 41.

not *Bairdia* cf. *B. subparallela* Morey—Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 9.

Remarks: Specimens from two localities are closely similar to *R. subparallela* (Morey), differing only in that the commissure may appear to be gently sinuous in dorsal view (the commissure of the holotype being straight in dorsal view), due to a partial obscuring by matrix.

In Morey's type collection at the University of Missouri, the slide labelled "holotype" contains, as stated by Sohn (1960, p. 41), a steinkern (Os 1005-3) and on this basis the species must be considered as a *nomen dubium*. However, a second slide contains a specimen (Os 1007-2) labelled "syntype", but designated as the holotype by Morey (1935, p. 324). By this specimen the species is validated and can be classified as a species of *Rectobairdia*.

The specimens from the Chouteau Limestone are stated by Morey (1936, p. 119) to be distorted; it is not possible to determine the extent of distortion, but these specimens may well represent a different species, differing from *R. subparallela* in having a more steeply inclined posterodorsal slope and the anterior extremity situated at or slightly below midheight.

Occurrence: RG 57-11-1; Shell Cadotte No. 1 well, 3,850 feet.

Hypotypes: Two complete carapaces, Nos. PO. 0297, 0298.

RECTOBAIRDIA sp. A,

Plate 12, figures 1-3

Description: Carapace bairdioid, subrhomboidal in lateral view. Left valve overlapping right except on anterior extremity; overlap

slight posteroventrally. Maximum overlap midventral and on dorsoposterior margin. Hinge depressed mid- and postero-dorsally. Dorsal margin short, straight, dorsoanterior margin long, straight, occupying one-third of maximum length. Anterior extremity rounded, situated at midheight. Ventroanterior margin convex, passing smoothly into gently convex ventral margin. Ventroposterior margin gently convex, posterior extremity bluntly pointed, situated below midheight, in middle one-third of maximum height. Dorsoposterior margin straight to gently convex, long, approaching one-half of maximum length. Dorsoposterior angle situated at one-third of maximum length from posterior extremity. Commissure gently sinuous in dorsal view.

Maximum height at midlength, greater than half-length. Maximum width at midlength, slightly less than maximum height.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0299	2.24	1.18	0.95
Specimen PO. 0300	1.37	0.76	0.61

Remarks: This species is similar to *Rectobairdia legumen* (Jones and Kirkby), but differs in having greater relative height, a convex ventroanterior margin, a longer dorsoanterior margin, a straight dorsoposterior margin, and a sinuous dorsal commissure.

From *Rectobairdia morroensis*, n. sp., it differs primarily in the position of the dorsoposterior angle, the dorsoposterior slope of *R. morroensis* being the more steeply inclined. The position of greatest width is posterior in *R. morroensis* and central in *R.* sp. A.

Occurrence: RG 60-1-12.

Specimens: Two complete carapaces, Nos. PO. 0299, 0300.

RECTOBAIRDIA sp. B

Plate 12, figures 3, 4

Description: Carapace bairdioid, elongate subtriangular in lateral view. Left valve overlapping right except on tip and ventral side of posterior extremity; overlap slight on anterior extremity and at ventroanterior angle, maximum on dorsoanterior margin. Hinge depressed posteriorly. Dorsal margin straight, dorsoanterior margin straight, anterior rounded, anterior extremity situated above midheight. Ventroanterior margin gently convex, ventral margin with shallow concavity; concavity situated in front of midlength. Junction

of ventral and ventroanterior margins below dorsoanterior angle. Ventroposterior margin gently convex, posterior point situated below midheight, in middle one-third of height. Dorsoposterior margin concave, approximately one-third of maximum length. Dorsoposterior angle situated at one-fifth of maximum length from the posterior extremity.

Dorsal and ventral margins converge strongly towards the posterior; greatest height at dorsoanterior angle, approximately equal to half-length. Maximum width at midlength, equal to two-thirds of maximum height.

Dorsal commissure straight in dorsal view.

Surface smooth with scattered punctae.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0301	1.03	0.55	0.40

Remarks: This species is similar to *Rectobairdia sinuosa* (Morey) and *Rectobairdia* sp. B of Sohn (1960). It is easily distinguished by its strongly converging dorsal and ventral margins and by the angulation in the commissure at the ventroanterior angle.

In its convergent dorsal and ventral margins, this species is similar to *R. posneri* Sohn. *R. posneri*, however, possesses a straight ventral margin and does not have the hinge incised.

Occurrence: Shell Cadotte No. 1 well, 3,250 feet.

Specimen: A complete carapace, No. PO. 0301.

Family BEECHERELLIDAE Ulrich, 1894
Genus ACANTHOSCAPHA Ulrich and Bassler, 1923

ACANTHOSCAPHA? BANFFENSIS, n. sp.

Plate 12, figures 6-14

Diagnosis: Beecherellid ostracode with long straight hinge, anterior terminal area laterally compressed, posterior end drawn out into a long hollow spine.

Description: Relationship of valves unknown: only single valves collected. Each valve elongate subrhomboidal in lateral view. Hinge long, straight, slightly depressed in central portion. Dorsal margin long, gently convex to almost straight. Maximum anterior extension on the line of the dorsal border. Anterior cardinal angle subrounded,

acute. Anteroventral margin gently and evenly convex, meeting ventral border at one-quarter of length from the anterior end. Ventral margin long, straight centrally, gently convex posteriorly. Posterior extremity of valve drawn out into a long spine set close to midheight. Dorsoposterior margin gently concave, equal to one-third of maximum length; dorsoposterior angle obtuse.

Greatest height anterior, at the anteroventral angulation; greatest width slightly anterior to midlength. Length approximately 2.5 to 3 times the height of the valve.

Laterally compressed area parallel to the anteroventral border.

Lateral surface smooth.

Duplicature present internally, widest anterodorsally and posteroventrally, and narrowest along the ventral border. A vestibule present at the anterior and posteroventral extremities. Duplicature flattened ventrally against the inner surface of the valve.

Hinge structure uncertain, but probably simple.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0312	1.03	0.42	0.19
Paratype PO. 0313	1.33[1]	0.46	—
Paratype PO. 0314	1.03	0.37	—
Paratype PO. 0315	0.80	0.31	—
Paratype PO. 0316	1.14	0.39	—

Remarks: Six right valves and one left valve of this species were collected, of which probably only two valves are of adults.

This species is doubtfully referred to *Acanthoscapha* as it lacks a posteroventral compressed area, as the posterior spine is not situated as a direct continuation of the dorsal border, and as only one imperfectly preserved left valve was found. These first two features distinguish it from other species of *Acanthoscapha*. *A.? banffensis* shows some similarity to *Celechovites cultratus* Pokorny, but lacks the distinct dorsal overlap of that genus. It may represent a new genus of the Beecherellidae.

Occurrence: RG 56-1-42; RG 56-3-38; RG 56-4-31, 75, 83.

Types: Holotype, a right valve, No. PO. 0312; paratypes, four right valves, Nos. PO. 0313-0316.

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[1]estimated

Superfamily BAIRDIACEA, family uncertain
Genus HASTACYPRIS Croneis and Gutke, 1939
HASTACYPRIS sp.

Plate 12, figures 22, 23

Remarks: Two valves of an elongate species of *Hastacypris* were collected.

Occurrence: RG 56-4-26A.

Specimens: A left valve, No. PO. 0310; a right valve, No. PO. 0311.

Superfamily CYTHERACEA Baird, 1850
Family BEROUNELLIDAE Sohn and Berdan, 1960
Genus KIRKBYELLINA Kummerow, 1939

Kirkbyellina Kummerow, 1939, Preuss. Geol. Landes. Abh., n. F., Heft 194, p. 30; Sohn and Berdan, 1960, Jour. Paleont., vol. 34, p. 480.

KIRKBYELLINA sp. A

Plate 12, figures 15-18

Remarks: One incomplete valve of a probable adult and several valves of immature instars were collected. The species appears to be congeneric with *Kirkbyellina styliolata* Kummerow in that it is unisulcate, has a U-shaped lobe surrounding the sulcus, and also a narrow tube-like posterior extension of the dorsal margin. These specimens also possess a strong posteroventral spine and, in the adult, several large hollow spines on the anterior border, anterolaterally directed. Such spines were not described by Kummerow (1939), but were illustrated by Sohn and Berdan (1960, pl. 67) in a species of *Berounella* from Lower Devonian rocks of New York State. The type species of the genus, *Berounella rostrata* Boucek, does not possess spines and as Sohn and Berdan (1960, p. 480) consider them to be of specific significance, this Banff species is placed in the genus *Kirkbyellina* Kummerow.

Kirkbyellina sp. A possesses also a well-developed duplicature and has a granoreticulate surface ornament.

Occurrence: RG 56-1-31, 42, 46; RG 57-10-1.

Specimens: One adult(?) right valve, No. PO. 0317; two immature left valves, Nos. PO. 0318, 0319.

KIRKBYELLINA sp. B

Plate 12, figures 19-21

Remarks: Two left valves and two right valves of a second species referable to *Kirkbyellina* Kummerow were obtained from the middle member of the Banff Formation. This species is subquadrate in lateral view, with the characteristic posterior tube-like extension of the dorsal margin. It possesses a broad, shallow, rather indistinct sulcus which terminates ventrally above a strong laterally directed spine. A short, subvertical carina is situated close to the anterior cardinal angle and a marginal frill extends from the anterior cardinal angle into the anteroventral area. The frill is striate, with a slightly raised outer border which parallels the valve borders. The lateral surface is reticulate.

No duplicature was observed in the four valves studied, but this may be due in part to preservation and in part to the fact that they probably are valves of immature instars.

Occurrence: RG 56-3-21, 38, 40.

Specimens: A left valve, No. PO. 0320; a right valve, No. PO. 0321.

Family BYTHOCYTHERIDAE Sars, 1926
Genus MONOCERATINA Roth, 1928

MONOCERATINA sp. cf. M. TENNESSEENSIS (Ulrich and Bassler)

Plate 13, figures 1-3

?*Bursulella*? *tennesseensis* Ulrich and Bassler, in Bassler, 1932, Tennessee Dept. Educ., Div. Geol., Bull. 38, p. 236.

?*Monoceratina tennesseensis* (Ulrich and Bassler)—Bassler, 1935, Jour. Washington Acad. Sci., vol. 25, p. 408.

Description: Relationship of valves unknown; slight notch in dorsal margin suggesting that the left valve may overlap the right. Each valve semiovate in lateral view, strongly alate in dorsal view, subtriangular in end view. Hinge long, straight, slightly depressed. Dorsal border long, straight; cardinal angles subrounded. Anterior border almost evenly convex, slightly truncate ventrally. Ventral border short, gently convex to straight, parallel to dorsal border. Posterior border sharply rounded dorsally, strongly truncate ventrally, with a long, gently convex posteroventral slope. Greatest height (exclusive of alate extension) anterior; greatest width posterior; greatest length close to dorsal border.

A broad-based spine arising from the alate extension and extending posterolaterally. Two rounded ridges arising from the spine

base; one ridge extending posterodorsally to about midheight; the second ridge paralleling the anteroventral and the anterior borders and dying out slightly above midheight. Ridges indistinct in some specimens.

Lateral surface faintly reticulate.

A duplicature present internally, widest anteriorly and posteriorly. A vestibule thus present anteriorly and posteriorly, but narrow duplicature ventrally lying almost flat against the inside of the valve.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0322	0.87	0.49	0.34[1]

Remarks: This species from the Banff Formation appears to be closely similar to Ulrich and Bassler's species from the Ridgetop Formation of Tennessee. One specimen is somewhat squashed, so that the alate spine points ventrally rather than posterolaterally. Examination of the illustrations and Bassler's brief description suggest that the types of *M. tennesseensis* may also be distorted specimens. (The type material was not examined.)

Occurrence: RG 56-4-75; ? RG 56-3-40.

Specimens: A left valve, No. PO. 0322, and an incomplete right valve, No. PO. 0323.

MONOCERATINA TRICOSTATA, n. sp.

Plate 13, figures 4-6

Description: Relationship of valves unknown. Each valve elongate subtriangular in lateral view, alate in dorsal view. Hinge long, straight, not depressed. Dorsal border straight, long; anterior cardinal angle distinct, posterior cardinal angle subrounded. Anterior border evenly convex, compressed, passing smoothly into ventral border. Ventral border straight, inclined posteriorly towards dorsal border; posteroventral border straight to gently convex, rounding sharply into dorsal border. Maximum height a short distance behind anterior cardinal angle; maximum width posterior; maximum length close to dorsal border.

A shallow, short, poorly defined sulcus situated a short distance behind the anterior cardinal angle. A second, slightly longer, posteriorly

[1]exclusive of spine

inclined sulcus behind the first sulcus, arising well below the dorsal border and extending almost to midheight. A short, posteriorly directed spine arising on the posterior side of the alate extension. A costa extending along the outer edge of the spine, curving anterodorsally, passing below the sulci, and joining the dorsal costa at the anterior cardinal angle. Two shorter, subparallel costae arising midway between the spine base and the ventral border, extending anteriorly, and dying out at the edge of the compressed border. Compressed border extending around the entire free margins of the valve; border widest anteriorly and anteroventrally, and narrow posteriorly. A low costa arising midventrally on the free margin, diverging slightly from the margin posteriorly, and dying out on the free margin below the base of the alate spine.

Dorsal ridge forming an apparent extension of the compressed border; arising at the anterior cardinal angle, and extending posteriorly parallel to the hinge for about five-sixths of the length, and then turning sharply posteroventrally, becoming less distinct, and dying out close to the posterior border.

A duplicature present internally in each valve. Duplicature broad anteriorly and posteriorly, and narrow along the ventral margin. Hinge structure indistinct, but apparently consisting of a tongue in the right valve and a groove in the left valve.

Lateral surface typically finely reticulate; the posterodorsal area reticulate, striate-reticulate, or finely striate, the striae paralleling the dorsal border. Approximately three rows of reticulations lying between the anterior and upper midventral costae, two rows between the upper and lower midventral costae, and two rows between the lower midventral costa and the inner edge of the compressed border. Compressed border also finely reticulate.

Posterodorsal area, including the sulci, smooth in some specimens. Surface ornament apparently lacking in a small number of specimens.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0324	0.475	0.238	0.171
Paratype PO. 0325	0.436	0.211	—

Remarks: *M. tricostata,* n. sp., is quite distinct from any other described species of *Monoceratina.*

The specific name is derived from the Latin *"tres"* (three) and *"costa"* (a rib) and refers to the three distinctive anteroventral ribs.

Occurrence: RG 56-1-1; RG 56-3-42, 43; RG 57-10-1.

Types: Holotype, a right valve, No. PO. 0324; paratype, a left valve, No. PO. 0325.

MONOCERATINA VIRGATA, n. sp.

Plate 13, figures 9-12

Description: Carapace inequivalved, left valve overlapping right slightly around free margins. Carapace elongate, almost drop shaped in lateral view, alate in dorsal view, subtriangular in end view. Hinge long, straight, not depressed. Dorsal border long, straight; anterior cardinal angle subrounded to indistinct, highly obtuse. Anterior border compressed, almost evenly convex, maximum forward extension at midheight, passing smoothly into ventral border. Ventral border gently convex anteriorly, almost straight posteroventrally; posteroventral border long, inclined towards dorsal border, slightly convex posteriorly. Posterodorsal border short, straight, forming an acute angle with posteroventral border; posterior cardinal angle distinct, highly obtuse. Greatest height anterior; greatest width posterior; greatest length close to dorsal border.

A short indistinct sulcus—almost a broad, shallow pit—present close to the dorsal border a short distance behind the anterior cardinal angle.

A large, curved, posterolaterally directed spine arising from the alate extension and extending more than half the distance from the spine base to the posterior extremity of the valves.

Compressed border wide anteriorly and narrowing anteroventrally, almost indistinguishable midventrally, but present as a narrow border posteroventrally.

A duplicature present internally, wide anteriorly and posteriorly, and narrow ventrally. Hinge structure indistinct, but apparently consisting of a groove in the left valve for reception of a tongue in the right valve.

Ornament on the lateral surface of several types. Six to nine fine parallel costae on the ventral and lateral sides of the alate extension curving anterodorsally and dying out below midheight; none of the costae extending onto the compressed border. Four costae present on the alate spine, joining at the spine tip. Central and posterior areas of the valve also striate, the striae or fine costae being less distinct than the anteroventral costae. In some specimens, especially immature instars, the central striae extending anteriorly as far as the

compressed border. In adults, the anterodorsal area and the compressed border typically smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0326	0.541	0.238	—
Paratype PO. 0327	0.581	0.264	—
Paratype PO. 0328	0.502	0.238	—
Paratype PO. 0329	0.541	0.238	0.277

Remarks: *M. virgata,* n. sp., differs from *M. tricostata,* n. sp., in possessing one sulcus instead of two, in having 6 to 9 anteroventral costae instead of 3 or 4, in having a stronger alate spine, and in lacking reticulate surface ornament.

The specific name is derived from the Latin "*virgatus*" (streaked, striped) and refers to the striate surface ornament.

Occurrence: RG 56-1-33, 34, 42, 43, 46, 71; RG 56-3-11, 12, 43; RG 56-4-44, 46, 48, 52, 75; RG 57-10-1.

Types: Holotype, a right valve, No. PO. 0326; paratypes, a right valve, a left valve, and a complete carapace, Nos. PO. 0327, 0328, 0329.

MONOCERATINA sp. A

Plate 13, figures 7, 8

Diagnosis: *Monoceratina* sp. closely similar to *M. virgata,* n. sp., differing in possessing only one distinct costa on the alate spine and in having the anteroventral area smooth to faintly striate.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0330	0.515	0.264
Specimen PO. 0331	0.436	0.198

Remarks: Only five valves of this species were obtained—insufficient to determine whether this is a separate species or a subspecies of *M. virgata,* n. sp.

Occurrence: RG 56-1-42; RG 57-10-1.

Specimens: Two left valves, Nos. PO. 0330, 0331.

MONOCERATINA sp. B

Plate 13, figure 13

Diagnosis: *Monoceratina* sp. with a subdued alate extension, a curved alate spine, two faint sulci, a narrow compressed border anteriorly, and a fine granulose surface ornament.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0332	0.488	0.218

Remarks: One, possibly two, specimens were collected.

Occurrence: RG 57-10-1.

Specimen: A right valve, No. PO. 0332.

MONOCERATINA sp. C

Plate 13, figure 14

Diagnosis: *Monoceratina* sp. with a subdued alate extension, a curved alate spine, two sulci—the anterior sulcus short and indistinct—a compressed border anteriorly, and a finely reticulate surface ornament.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0333	0.449	0.224

Remarks: Two specimens of this species were collected.

Occurrence: RG 57-10-1.

Specimen: A right valve, No. PO. 0333.

Suborder METACOPINA Sylvester-Bradley, 1961
Superfamily HEALDIACEA Harlton, 1933
Family HEALDIIDAE Harlton, 1933
Genus HEALDIA Roundy, 1926

HEALDIA sp.

Plate 13, figure 15

Remarks: One right valve of this species was collected. It appears closely similar to, if not conspecific with, species illustrated by Copeland (1960, Pl. 1, Figs. 10, 11).

Occurrence: RG 56-4-26A.

Specimen: A right valve, No. PO. 0190.

Genus CRIBROCONCHA Cooper, 1941

CRIBROCONCHA TRIQUETRA, n. sp.

Plate 13, figures 17-20

Diagnosis: *Cribroconcha* species with pits confined to a subtriangular area immediately anterior to the posterior ridge.

Description: Carapace inequivalved, subovate in lateral outline. Greatest height posterior; greatest width and length central. Left valve overlapping right around free margins, and moderately along hinge line. Hinge slightly depressed. Dorsal border arched; anterior slope almost straight, posterior slope evenly rounded. Anterior and posterior borders rounded; ventral border gently convex.

Surface ornamented by an almost vertical rib slightly curved, concave anteriorly, situated in the posterior area. Rib terminated both dorsally and ventrally by posteriorly directed spines. Pits present on the valve within a subtriangular area defined by the centre of the valve and the dorsal and ventral limits of the ridge. Up to five or six pits distributed in a row within a shallow depression bordering the inner side of the ridge; other pits scattered irregularly.

Narrow marginal flange paralleling the anterior border of the valve.

Lateral surface smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0187	0.49	0.38	0.27
Paratype PO. 0188	0.61	0.42	—
Paratype PO. 0189	0.49	0.34	0.26

Remarks: *Cribroconcha triquetra,* n. sp., differs from other described species of *Cribroconcha* in having pits confined to the posterocentral subtriangular area. It is similar in lateral outline to *C. costata* Cooper but differs in lacking the anterodorsal angulation of the Chester species. *C. fornicata* Cooper also possesses an anterodorsal angulation, and in addition differs in size and in position of the posterior ridge as well as in the shape and position of the pits.

The specific name is derived from the Latin "*triquetrus*" (a triangle) and refers to the typical shape of the area to which the pits are confined.

Occurrence: RG 56-1-2, ?42; RG 56-3-41, 51; RG 56-4-75; RG 57-10-1; RG 57-11-1; RG 60-1-12.

Types: Holotype, a complete carapace, No. PO. 0187; paratypes, a left valve and a complete carapace, Nos. PO. 0188, 0189.

CRIBROCONCHA spp.

Remarks: It is probable that at least two other species of *Cribroconcha* are present in the collections from the Banff Formation. Insufficient material is available to describe these forms. Both are more elongate than *C. triquetra,* n. sp. A species from the Peace River region possesses pits only in a row adjacent to the posterior ridge. A Banff species has pits scattered over the posterior half of the valve, and the posterior ridge is produced by a strong groove posterior to the ridge; the anterior (or lateral) flank of the ridge thus is part of the valve surface.

Occurrence: 1. Canadian Petroleums Peace River No. 2 well, 2,060-65 feet, 2,085-90 feet.

2. RG 56-4-75.

Genus SEMINOLITES Coryell, 1928, emend. Cooper, 1941

SEMINOLITES NELSONI, n. sp.

Plate 13, figures 21-26

Diagnosis: *Seminolites* species with pits grouped close to and inside the anterior and posterior ridges.

Description of adult: Carapace inequivalved, subovate in lateral view. Greatest height slightly anterior to midlength; greatest width posterior; greatest length close to midheight. Left valve overlapping right conspicuously around free margins. Hinge depressed on posterior half of dorsal border. Dorsal border arched, anterior and posterior slopes almost straight. Anterior and posterior borders rounded. Ventral border slightly concave.

Surface ornamented by two ridges: an anterior ridge paralleling the anterior border, and a posterior ridge extending almost vertically from the posterior end of the dorsal border to near the ventral border. A shallow depression situated on the inner side of each ridge, the posterior depression being the wider. A row of regularly to irregularly spaced pits lying in each depression adjacent to each ridge. More pits forming the row in the right valve (5 to 6 pits) than in the left valve (about 4 pits). A few scattered pits present in some specimens on the anterior slope of the posterior depression. In the right valve one or two pits may lie on the anterior ridge towards its base. A sharp, thin submarginal ridge paralleling the free margins in the right valve, delimiting the extent of overlap. Ridge extending forward mid-anteriorly and forming a small subtriangular angulation, separated

from the main portion of the valve by a distinct groove. A narrow marginal ridge present anteriorly and posteriorly in the left valve.

Lateral surface smooth.

Description of instars: Instar A—1. Differing from adult in being relatively shorter. In the right valve a complete row of pits paralleling both the anterior and posterior ridges. In the left valve only the dorsal half of the anterior ridge developed; one pit behind this ridge. The posterior ridge less strongly developed than in the adult, and flanked anteriorly by up to two pits.

Instar A—2. Differing from instar A—1 in being somewhat more ovate. In the right valve the anterior ridge more faintly developed and only one pit on its posterior flank. Posterior ridge bordered anteriorly by about three pits. Submarginal ridge developed only anteriorly. The anterior ridge in the left valve a barely distinguishable flexure in the anterodorsal area. Posterior ridge remaining distinct, and may have a pit on its anterior flank. Anterior marginal ridge still present.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0191	0.57	0.34	0.23
Paratype PO. 0192	0.46	0.27	—
Paratype PO. 0193	0.49	0.30	—
Paratype PO. 0194	0.34	0.23	—

Remarks: This species differs from other described species of *Seminolites* in having the pits in two groups, inside the anterior and posterior ridges. The almost regular row of pits on the ridge flanks is a distinctive feature. *S. nelsoni* is also differentiated from most other Mississippian species by its possession of a large number of pits; from many Pennsylvanian species it differs in having the anterodorsal and posterodorsal flanks almost equal in length.

The species is named in honor of Dr. S. J. Nelson, who donated the material containing this ostracode.

Occurrence: Forest Shell Peace River No. 14-29 well, 2,530 feet, 2,540 feet, 2,550 feet.

Types: Holotype, a complete carapace, No. PO. 0191 (2,550 feet); paratypes, two right valves and one left valve, Nos. PO. 0192-0194 (2,540 feet).

SEMINOLITES STELCKI, n. sp.

Plate 13, figures 27-32

Diagnosis: *Seminolites* species with pits set in a row paralleling the anterior and posterior ridges and also extending across the dorsal central area.

Description of adult: Carapace inequivalved, elongate subovate in lateral view. Greatest height anterior, greatest width posterior; greatest length close to midheight. Left valve overlapping right conspicuously around free margins. Hinge depressed on posterior half of dorsal border. Dorsal border arched; anterior and posterior borders rounded; ventral border slightly concave to slightly convex.

Surface ornamented by two ridges: an anterior ridge paralleling the valve border, and a posterior ridge extending almost vertically across the posterior end of the valve.

Posterior ridge in the right valve a distinct elevation on the valve surface; anterior ridge almost wholly defined by the shallow depression parallel to its posterior side. A row of 4 to 5 pits in the anterior depression; this row extending regularly and continuously, or discontinuously, across the dorsal central area into a row of 6 to 7 closely spaced pits in the depression bordering the posterior ridge. In some specimens other pits scattered in the anterocentral and posterocentral areas, most being in the latter area. Pits absent in the central area of the valve.

Anterior ridge in the left valve faintly developed or present only dorsally. Row of pits paralleling the posterior ridge, and extending across the dorsal central area into the anterodorsal area where anterior ridge present only dorsally, and into the anterocentral area where anterior ridge wholly present. Other scattered pits confined mainly to the posterocentral area.

Sharp, thin submarginal ridge paralleling the anterior and posterior margins in the right valve, and a marginal ridge paralleling the anterior margin in the left valve. Ridge extending forward mid-anteriorly in the right valve to form a small angulation, separated from the main part of the valve by a narrow groove.

Lateral surface smooth.

Description of instars: Instar A—1. Differing from adult in being more ovate. Anterior ridge faintly developed in the right valve and absent in the left valve. Up to three pits present anterior to the

posterior ridge, and up to two pits posterior to the anterior ridge in the left valve.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0195	0.46	0.27	0.24
Paratype PO. 0196	0.46	0.23	0.16
Paratype PO. 0197	0.49	0.27	—
Paratype PO. 0198	0.47	0.32	0.22
Paratype PO. 0199	0.38	0.27	—

Remarks: This species differs from other described species of *Seminolites* in the tendency towards reduction of the anterior ridge in the left valve, and in possessing, especially in the left valve, a row of pits extending from the dorsal central to the posterocentral area.

S. stelcki has a distinctive feature of the Devonian Thlipsuridae, which is that of difference in ornament of the two valves. In many genera of the Thlipsuridae the left valve may be unornamented or only poorly ornamented, whilst the right valve is strongly ornamented. The difference between ornament of opposite valves is greater in *S. stelcki* than in the stratigraphically higher species *S. nelsoni*. *S. stelcki* shows several basic features in common with *Octonaria laevilatata* Kesling and Kilgore, 1952, such as the presence of a marginal flange, pits arranged in rows, possession of a posterior ridge, and difference in ornament between valves. The successive changes in form of *Seminolites* as traced back through earlier species, suggest that the genus developed from *Octonaria*.

The species is named in honor of Dr. C. R. Stelck, who donated the fossil material from Canadian Petroleums No. 2 well.

Occurrence: Canadian Petroleums No. 2 well, 1,959-60 feet, 2,060-65 feet, 2,065-70 feet, 2,085-90 feet.

Types: Holotype, a complete carapace, No. PO. 0195 (1,959-60 feet); paratypes, a complete carapace, No. PO. 0196 (2,065-70 feet), a left valve, No. PO. 0197 (2,085-90 feet), a complete carapace, No. PO. 0198 (2,060-65 feet), and a left valve, No. PO. 0199 (1,959-60 feet).

SEMINOLITES? sp.

Plate 13, figure 16

Remarks: One right valve was obtained of a species possibly referable to *Seminolites*. The valve is ornamented by a posterior ridge, flanked anteriorly by a deep groove which apparently contains

closely spaced pits. Other pits are scattered over the lateral surface. A marginal flange lies on the anterior border.

It is questionable whether this form should be referred to *Seminolites*, as it apparently lacks the anterior ridge and possesses a deep groove posteriorly. It appears to have relationships to *Octonaria* Jones. The specimen may not be mature, is not ideally preserved, and thus the question of generic assignment cannot yet be solved.

Occurrence: RG 56-1-42.

Specimen: A right valve, No. PO. 0200.

Genus WAYLANDELLA Coryell and Billings, 1932

WAYLANDELLA? PUNCTATA, n. sp.

Plate 14, figures 1-6

Diagnosis: *Waylandella*? species with a posterior shoulder and a posteroventral spine on each valve, and with scattered punctae in front of the spine.

Description: Carapace inequivalved, subovate in lateral view, sublanceolate in dorsal view. Left valve overlapping right all around, overlap very slight along hinge. Greatest overlap mid-dorsally and ventrally. Hinge gently convex, depressed in a short canoe-shaped channel. Anterodorsal border gently convex, anterior border evenly rounded. Ventral border long, gently convex; posterior border rounded, truncate ventrally. Posterodorsal border gently convex, cardinal angles rounded. Greatest height central; greatest width close to posterior end; greatest length close to midheight.

Distinct shoulder, visible in dorsal view, present close to the posterior end, passing ventrally into a low inflation; a small spine situated at the posteroventral tip of the inflation. The posteroventral area of the valve in front of the shoulder and spine ornamented by scattered punctae, the number of punctae ranging from three to fourteen. A narrow ridge paralleling the anterior margin of each valve.

Lateral surface otherwise smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0179	1.03	0.61	0.53
Paratype PO. 0180	0.95	0.53	—
Paratype PO. 0181	1.01	0.57	0.49
Paratype PO. 0182	1.25	0.72	0.61

Remarks: *Waylandella*? *punctata*, n. sp., differs from other species of *Waylandella* in its possession of punctae and of narrow anterior ridges, and in having the hinge depressed. *Waylandella*? *punctata* is closely related to, but shorter than *Waylandella*? sp. of Copeland (1960); it is also similar to *W. perplexa* Morey, from which it differs in being larger and more elongate-quadrate in lateral view.

This species is close to *Healdioides* but lacks the posterior ridge and depression of that genus. It differs from species of *Menoeidina* in possessing anterior marginal ridges and in having reduced posterodorsal overlap of the valves. Its features fit the generic description of *Thrallella*, but its size and overall proportions differ from those of described species. It differs from *Lucasella* in size, in its highly arched dorsum, and in possessing punctae and anterior ridges.

This species is placed, with question, in *Waylandella* on the basis of its overall shape, possession of a posteroventral spine and general nature of the overlap.

Occurrence: RG 56-3-51; RG 56-4-26A, 58, 64, 75; RG 57-11-1, 2; Shell Cadotte No. 1 well, 2,770-800 feet; Forest Shell Peace River No. 14-29 well, 2,540 feet; H. B. Union Salt Creek No. 1 well, 2,950 feet.

Types: Holotype, a complete carapace, No. PO. 0179 (Forest Shell well); paratypes, a right valve, No. PO. 0180, and two complete carapaces, Nos. PO. 0181 (H. B. Union well), 0182.

Family CAVELLINIDAE Egorov, 1950
Genus PARACAVELLINA Cooper, 1941

PARACAVELLINA INDISTINCTA, n. sp.

Plate 13, figures 33-36

Diagnosis: *Paracavellina* species with an indistinct posterior ridge and surface partly finely reticulate.

Description: Carapace inequivalved, ovate in lateral view, subelliptical in dorsal view. Right valve overlapping left all around. Overlap greatest dorsally and midventrally, and slight posteroventrally. Greatest height slightly in front of midlength; greatest width posterior; greatest length at midheight. Dorsal border convex, with moderately flattened anterodorsal and posterodorsal slopes; ends evenly rounded; ventral border gently concave centrally.

A distinct marginal ridge present anteriorly on the right valve extending farther anteroventrally than anterodorsally; a similar but much narrower ridge present in the left valve. Marginal ridge dis-

tinguishable posteroventrally in the left valve, in some specimens extending to midheight.

Marginal areas of each valve and the central area smooth. Remainder of valve faintly reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0202	0.80	0.53	0.34
Paratype PO. 0203	0.57	0.42	0.27
Paratype PO. 0204	0.46	0.34	0.20

Remarks: *P. indistincta*, n. sp., is distinguished from other species of *Paracavellina*, all from the Chester strata of Illinois, by its much reduced posterior marginal ridge. Its smooth lateral outline is similar to that of *P. elliptica* Cooper, from which it also differs in possessing a flatter ventral border.

The specific name, derived from the Latin "*in*" (not) and "*distinctus*" (distinct) refers to the indistinct nature of the posterior marginal ridge.

Occurrence: Canadian Petroleums Peace River No. 2 well, 1,959-60 feet.

Types: Holotype, a complete carapace, No. PO. 0202; paratypes, two complete carapaces, Nos. PO. 0203, 0204.

Genus SULCELLA Coryell and Sample, 1932

SULCELLA sp.

Plate 14, figures 7, 8

Remarks: A single carapace was collected of a subovate species of *Sulcella* with a faint sulcus and no pit.

Occurrence: Canadian Petroleums Peace River No. 2 well, 1,959-60 feet.

Specimen: A complete carapace, No. PO. 0201.

Family BUFINIDAE Sohn and Stover, 1961

?Genus BYTHOCYPROIDEA Stewart and Hendrix, 1945

BYTHOCYPROIDEA PUNCTATA, n. sp.

Plate 8, figures 26-28

Diagnosis: *Bythocyproidea* species having a posterior shoulder instead of a ridge and depression.

Description: Carapace inequivalved, elongate subovate in lateral view. Left valve overlapping right all around, overlap almost even. Greatest height and width posterior, greatest length below midheight. Dorsal border convex, with long, gently convex anterodorsal slope. Ends rounded, anterior more sharply than posterior. Posterior border moderately truncate ventrally. Ventral border straight to gently concave centrally.

Left valve in dorsal view smoothly curved; right valve convex anteriorly, flattened centrally with a sharp posterior shoulder, and convex behind the shoulder. Flattened area in front of the shoulder ornamented by scattered coarse punctae, in part roughly arranged in a row in some specimens, the row convex posteriorly, parallel to the line of the shoulder. Posterocentral area in the left valve also typically punctate, but with less punctae than the right valve.

Lateral surface otherwise smooth.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0308	0.58	0.35	0.28
Paratype PO. 0309	0.49	0.30	—

Remarks: *Bythocyproidea punctata*, n. sp., differs from the other described species—both from the Middle Devonian—in lacking the posterior ridge and depression. Instead it possesses a flattened lateral surface on the right valve and a distinct posterior shoulder.

Occurrence: Canadian Petroleums Peace River No. 2 well, 1,959-60 feet, 2,085-90 feet.

Types: Holotype, a complete carapace, No. PO. 0308; paratype, a left valve, No. PO. 0309.

Superfamily QUASILLITACEA Coryell and Malkin, 1936
Family QUASILLITIDAE Coryell and Malkin, 1936

Generic differentiation within the family Quasillitidae was in part emended by Sohn and Stover (in Moore, 1961) in an attempt to establish a more consistent form of classification.

Their diagnoses of the more important genera in this family are presented in table 12. A number of described species referred by various authors to *Graphiadactyllis*, but possessing both well-developed marginal flanges and posteroventral spines, and lacking posterior shoulders, still cannot be fitted into this classification. Also, those species referred to *Quasillites* by Gibson (1955) have poorly

Table 12. Present Classification of North American Quasillitid Genera

Marginal flanges	Posterior ridge or shoulder	Postero-ventral spine	Rim around muscle-scar pit	GENUS
Well developed	Absent	Absent	Absent	*Graphiadactyllis*
Poorly developed to vestigial	Present	Present	Absent	*Quasillites*
		Absent	Present	*Jenningsina*
			Absent	*Scalptina*
	Absent	Present	Absent	*Eriella*

developed flanges and lack posterior shoulders and posteroventral spines; again these do not fit satisfactorily into this classification. In addition the large numbers of quasillitid ostracodes from Alberta Lower Mississippian rocks include a number of species that cannot be referred to described genera.

Thus it is considered that a reclassification of genera in this family is desirable. Present classification is based primarily on the presence or absence of three basic morphologic features; consideration of the presence or absence of any one of these is subject to the personal opinions of the taxonomist involved, as each feature may grade from vestigial to well developed. However, objectively, on the basis of these three features, eight genera theoretically exist in the Quasillitidae (Table 13); four of these genera have been named (*Graphiadactyllis, Quasillites, Scalptina, Eriella*) and two others[1] (*Jenningsina, Costatia*) have been established by use of other morphologic features.

In the proposed revision of the Quasillitidae (Table 13) two new genera are established: *Graphiadactylloides* and *Craspedographylus.* The primary morphologic features of generic value are considered to be: (1) presence or absence of well-developed anterior marginal

1 The genus *Euglyphella* was questionably referred to the Quasillitidae by Sohn and Stover. It is considered herein, however, to belong to a separate family in which also is placed *Plagionephrodes* Morey.

Table 13. Proposed Classification of North American Quasillitid Genera

Anterior marginal flange	Posterior shoulder	Postero-ventral spines	Other criteria	GENUS
Poorly developed to vestigial	Absent	Absent	—	*"Quasillites"* of Gibson (1955)
		Present	—	*Eriella* + *Abursus*
	Present	Absent	Raised rim around muscle scar	*Jenningsina*
			No raised rim around muscle scar	*Scalptina*
		Present	—	*Quasillites*
Well developed	Absent	Absent	—	*Graphiadactyllis*
		Present	Flange expressed externally as strong ridge-like or frill-like structure	*Craspedographylus*
			No strong ridge-like or frill-like flange development	*Graphiadactylloides*
	Present	Absent	—	(theoretical)
		Present	—	(theoretical)

flanges, (2) presence or absence of a posterior shoulder, (3) presence or absence of posteroventral spines. Criteria of secondary generic value are considered to be: (1) presence or absence of a raised rim around the muscle scar, (2) nature of hinge structure, (3) nature of external expression of the flange on the carapace surface.

The nature of surface ornament has been used by some workers as a generic criterion in this family. While this is valid to a limited extent, it is a feature that should be used with caution. The genus *Costatia* Polenova is stated to be characterized by the vertical trend of ornamental ribs; the type species, *C. posneri* Polenova, is distinctive in this feature, but *C. cavernosa* Polenova has much less

definitive vertical ribbing. Also, the change in form of the ribbed ornament is shown below, in species of *Graphiadactylloides*, to be gradual and to be a feature of probable specific significance. Ribbed and reticulate ornaments are both present on the same specimens in *Craspedographylus comptilimbus* (Pl. 15, Figs. 24, 25); specimens of *C. acrolimbus* (Pl. 15, Fig. 6) and of *Eriella*? *cribraria* (Pl. 14, Figs. 9-20) are partially smooth and partially reticulate; specimens of *Graphiadactylloides moreyi* (Pl. 16, Figs. 7-11) are partially ribbed and partially smooth.

The proposed classification is not wholly satisfactory because of the nature of the morphologic criteria used. Some species will necessarily have intermediate characteristics and will be referable to a particular genus only with question. A case in point is that of *Eriella*? *cribraria* (Pl. 14, Figs. 9-20), in which most adults have a small posteroventral spine only on the left valve (Pl. 14, Figs. 11, 12); the species is referred to *Eriella* with question rather than to a new genus with question, because partial presence of a feature is considered more important than partial absence.

Also, *Craspedographylus*? *inornatus* is referred with question to that genus because it lacks posteroventral spines. Logically a new genus should be established to contain this species, but this has not been done as only very few specimens of this form are available and limits of variation are not known.

It should be stressed that the classification is applicable primarily to adult instars because of the morphologic changes that may take place during growth (see for instance Pl. 15, Figs. 9, 8, 4 and 2).

Genus GRAPHIADACTYLLIS Roth, 1929, emend.

Type species: *Kirkbya lindahli arkansana* Girty, 1910.

Kirkbya Jones—Girty, 1910 (part), Ann. New York Acad. Sci., vol. 20, no. 3, pt. 2, p. 234; Roundy, 1926, U.S. Geol. Surv. Prof. Paper 146, p. 7.

Graphiadactyllis Roth, 1929, Wagner Free Inst. Publ., vol. 1, p. 10; Cooper, 1941, Illinois Geol. Surv. Rept. Invest. No. 77, p. 45; Benson and Collinson, 1958 (part), Illinois Geol. Surv. Circ. 255, p. 19.

Graphiodactylus Roth, 1929, Jour. Paleont., vol. 3, p. 292-3; Bassler and Kellett, 1934 (part), Bibl. Index Paleozoic Ostracoda, p. 34; Kellett, 1936 (part), Jour. Paleont., vol. 10, p. 773; Benson, 1955 (part), Jour. Paleont., vol. 29, p. 1033.

Bassleria Harlton, 1929, Am. Jour. Sci., ser. 5, vol. 18, p. 255.

Paracythere Ulrich and Bassler, in Bassler, 1932 (part), Tennessee Dept. Educ., Div. Geol. Bull. 38, pl. 27, fig. 13; Bassler, 1935 (part), Jour. Washington Acad. Sci., vol. 25, p. 409.

Diagnosis: Quasillitid ostracodes with well-developed anterior marginal flanges, lacking a posterior shoulder and posteroventral spines.

Discussion: With the absence of a posterior shoulder or ridge, species of this genus are subovate in dorsal view. The carapace surface is typically ornamented with a fingerprint pattern of inosculating riblets; the ornament may also range to reticulate. A posterodorsal spine is developed in a number of species.

The following species are retained in the genus: *G. arkansana* (Girty), *G. cornutus* (Ulrich and Bassler), and *G. fayettevillensis* (Harlton).

Geologic range: Mississippian-Pennsylvanian.

Lithology: Limestone-calcareous shale.

Habitat: Marine.

GRAPHIADACTYLLIS SUBRHOMBOIDALIS, n. sp.

Plate 16, figures 20-23

Diagnosis: Subrhomboidal *Graphiadactyllis* species with subreticulate ornament predominantly parallel to the anterodorsal and ventral borders.

Description: Carapace inequivalved, subrhomboidal in lateral view, subpyriform in dorsal view. Greatest height close to anterior cardinal angle; greatest width close to posterior cardinal angle; greatest length at midheight. Left valve larger, overlapping right around free margins and at cardinal angles. In lateral view, left valve projecting strongly beyond right on anterodorsal, posterodorsal and ventral margins. Hinge long, straight, depressed in canoe-shaped channel for most of its length. Dorsal border straight to gently convex, with rounded hump at anterior end where border of left valve rises strongly above anterior cardinal angle. Anterodorsal slope long, straight in right valve, gently convex in left valve. Anteroventral border rounded; posterior border evenly rounded in right valve, rounded and truncate ventrally in left valve. Ventral border slightly concave to straight, converging posteriorly towards dorsal border.

Anterior cardinal angle distinct, 135 degrees; posterior cardinal angle subrounded, 125 to 130 degrees.

A slight break in the anterior border of the left valve in lateral view, slightly above midheight, marking the position of the anterior spine, not developed in this species. A slightly raised spot situated centrally, ornamented by a subdued reticulation. Most of the

remainder of the lateral surface ornamented by rarely inosculating riblets, joined by smaller riblets, giving an overall impression of a subreticulate ornament. In an area defined by the dorsal margin, a line drawn parallel to the dorsal margin through the base of the raised spot, and a line drawn vertically through the posterior cardinal angle, the main riblets roughly parallel the anterodorsal slope. The riblets in the anteroventral, ventral and posterior areas parallel the valve borders. The main riblets of the posterior and the central areas thus appear to converge at an acute angle towards the posterior cardinal angle—a distinctive feature of this species. In much of the submarginal area, and particularly that adjacent to the hinge, the subreticulate ornament of the lateral surface grades into a finely striate ornament, the striations lying parallel to the valve borders.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0251	0.84	0.46	0.42
Paratype PO. 0252	0.74	0.41	0.30

Remarks: *G. subrhomboidalis* is similar in overall proportions to *Eriella*? *subquadratus* (Morey), but is less quadrate in dorsal view, and has the central lateral ornament converging towards the posterior cardinal angle rather than towards the central dorsal area.

G. subrhomboidalis is differentiated from other species of *Graphiadactyllis* by its lack of spines and by having a convergence of lateral ornament towards the posterior cardinal angle.

Occurrence: Forest Shell Peace River No. 14-29 well, 2,560-70 feet: Shell Cadotte No. 1 well, 3,400-10 feet.

Types: Holotype, a complete carapace, No. PO. 0251 (Forest Shell well); paratype, a complete carapace, No. PO. 0252 (Shell Cadotte well).

GRAPHIADACTYLLIS sp. A

Plate 16, figures 18, 19, 24-26

Diagnosis: *Graphiadactyllis* species suboval in lateral view, without spines, and with riblets of the fingerprint mainly lying parallel to the valve borders; central spot represented by a small reticulate area.

Description: Carapace inequivalved, suboval in lateral view, elongate oval in dorsal view. Greatest height close to, but behind, anterior cardinal angle. Greatest width posterior, about two-thirds of length from anterior end. Greatest length at midheight. Left

valve larger, overlapping right moderately on free margins, and at cardinal angles and possibly slightly along the hinge line. Hinge long, straight, depressed in a shallow canoe-shaped channel in some specimens; hinge probably slightly depressed in all mature individuals, but in some subsequent distortion has eliminated this channel. Dorsal border straight to gently convex. Anterodorsal slope short, almost straight, and passing smoothly into evenly rounded anteroventral border. Posterior border rounded, somewhat truncate ventrally. Ventral border almost straight, slightly concave centrally.

Anterior cardinal angle distinct, 135 degrees; posterior cardinal angle less distinct, 120 degrees.

A distinct spot situated centrally, ornamented by fine, irregular reticulations. Remainder of lateral surface ornamented by riblets, joined by slightly subdued cross-riblets. Riblets smoothly parallel to the valve borders, except in the central and posterocentral areas where the riblets are more undulating in form. Riblets tending to inosculate towards the valve margins, becoming finer and more closely spaced, and the cross-riblets tending to disappear.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0227	0.87	0.48	0.40
Specimen PO. 0228	0.72	0.38	0.30

Remarks: This species is closely similar to *Eriella*? *lineata* (Ulrich and Bassler) in the type of ornament—riblets with minor cross-riblets. The Alberta species differs, however, in having the riblets more irregular in form centrally, in possessing a central reticulate spot and in differing in shape. It is closely similar to *G. subrhomboidalis,* but is thinner and has a different distribution of surface riblets.

Occurrence: Hudson's Bay Union Salt Creek No. 1 well, 2,950 feet.

Specimens: Two complete carapaces, Nos. PO. 0227, 0228.

GRAPHIADACTYLLIS sp. B

Plate 17, figure 7

Diagnosis: Subrhomboidal *Graphiadactyllis* species with reticulate surface ornament, strong anterior horn, and a posterodorsal spine.

Remarks: Some specimens of this species possess a slight central to centrodorsal depression. The flange area is flattened somewhat anteroventrally, and may bear a few scattered tubercles.

Occurrence: RG 57-11-1, 2.

Specimen: A complete carapace, No. PO. 0240.

GRAPHIADACTYLLIS sp. C

Plate 17, figure 8

Remarks: One sample from the upper member of the Banff Formation contains specimens similar in shape and outline to *Graphiadactylloides unionensis* (Benson and Collinson) and possessing a reticulate surface ornament similar to that of *G.* sp. B, but lacking both posterior spines and surface tubercles.

Occurrence: RG 56-4-26A.

Specimens. A left valve, No. PO. 0244.

Genus ERIELLA Stewart and Hendrix, 1945

Type species: *Eriella robusta* Stewart and Hendrix, 1945.

Eriella Stewart and Hendrix, 1945, Jour. Paleont., vol. 19, p. 95.

Barychilina Ulrich—Ulrich and Bassler, in Bassler, 1932, Tennessee Dept. Educ., Div. Geol., Bull. 38, pl. 27, figs. 2, 3; Bassler, 1935, Jour. Washington Acad. Sci., vol. 25, p. 409.

?*Graphiodactylus* Roth—Morey, 1935 (part), Jour. Paleont., vol. 9, p. 321; Branson, 1944, Univ. Missouri Studies, vol. 19, no. 3, pl. 24, figs. 31-34.

Graphiadactyllis Roth—Swain, 1953, Jour. Paleont., vol. 27, p. 270.

Abursus Loranger, 1954, Am. Assoc. Petroleum Geol., Rutherford Memorial Volume, p. 194.

Diagnosis: Quasillitid ostracodes with poorly developed to vestigial marginal flanges, lacking posterior shoulders and possessing posteroventral spines.

Remarks: Species of this genus have a surface ornament of concentrically arranged riblets, of reticulae, or have reticulate surface ornament with smooth marginal areas.

The genus *Abursus* Loranger apparently is referable to *Eriella* (P. C. McGill, pers. comm.), as are a number of species previously referred to *Graphiadactyllis*. *G. lineatus* (Ulrich and Bassler), if—as illustrated—it lacks a well-developed flange, is referable to *Eriella;*

the species *G. subquadratus* Morey, *G. tumidus* Morey and *G. walteri* Morey, are referable to *Eriella* if they are based on adult instars, or if the characters of the immature instars persist into the adult stage. *G. minutus* Morey is based on an immature instar, the generic characteristics of which are indeterminate.

The range of *Eriella* is somewhat uncertain: species are known from Middle and Upper Devonian strata, but Mississippian records are all doubtful. If, as suggested by Branson and Mehl (1941), much of Morey's (1935) material from the basal Mississippian of Missouri was reworked from earlier strata, then many of his species probably were derived from the Snyder Creek Formation (see Branson, 1944, Pl. 24) of Late Devonian age. *Barychilina lineata* Ulrich and Bassler, from the Lower Mississippian of Tennessee, at present is only questionably referred to *Eriella*. Specimens considered comparable with this species by Benson (1955) and Benson and Collinson (1958) all possess well-developed flanges and thus do not belong in the genus *Eriella*. Alberta Mississippian records of the genus (see below) are also questionable.

The generic range is thus from Middle to Upper Devonian, and questionably to Lower Mississippian.

ERIELLA? CRIBRARIA, n. sp.

Plate 14, figures 9-20

Diagnosis: *Eriella*? species with a surface ornament of closely spaced pits approaching reticulation, a smooth submarginal area, and one posteroventral spine in adult instars.

Description: Carapace inequivalved, suboval to subquadrate in lateral view. Greatest height close to anterior cardinal angle. Greatest width close to posterior cardinal angle. Greatest length at midheight. Left valve larger, overlapping right around free margins. In lateral view left valve projecting considerably beyond right except in central part of hinge. Hinge straight, depressed below dorsal border in a V-shaped channel. Dorsal border gently convex in right valve, almost straight in left valve. Anterior and posterior borders rounded. Ventral border straight to slightly concave centrally, almost parallel to dorsal border of left valve.

Cardinal angles rounded.

A small anterior spine situated submarginally at midheight in mature specimens. A narrow, frill-like flange extension present ventral to the spine, extending parallel to the anteroventral margin,

and dying out before reaching the central ventral area. A portion of this "frill" also extending dorsally from the spine, and dying out before reaching the anterior cardinal angle. A rudimentary posteroventral spine present in the left valve in well-preserved adult specimens.

A smooth spot, situated centrally, level with the lateral surface, or slightly raised or slightly depressed. V-shaped channel containing the hinge also smooth in the posterior part; smooth area widening anteriorly, more so in the left valve than in the right, and extending as a smooth band around the submarginal area as far as the posteroventral area. Remainder of the lateral surface coarsely reticulate, the pits commonly being irregular in size. Reticulation tending to show a subradial distribution about the muscle spot.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0259	1.24	0.68	0.57
Paratype PO. 0260	1.29	0.68	0.59
Paratype PO. 0261	0.95	0.59	0.46
Paratype PO. 0262	0.76	0.49	0.38
Paratype PO. 0263	0.57	0.40	0.29
Paratype PO. 0063	1.10	0.68	0.55

Remarks: *E.? cribraria* differs from described species of *Eriella* in possessing a single posteroventral spine. It is considerably larger than other described species, but is similar in ornament to Upper Devonian species of the genus from Alberta rocks (Loranger, 1954).

A closely similar, if not conspecific, form with a somewhat more finely reticulate surface ornament is present in the Big Valley Formation in southeastern Alberta.

The specific name is derived from the Latin "*cribrarius*" (sieve-like) and refers to the mesh-like appearance of the deeply and coarsely reticulate surface ornament.

Occurrence: Bear Villa No. 1 well, 4,125-39 feet; Hudson's Bay Union Salt Creek No. 1 well, 3,900 feet.

Types: Holotype, a complete carapace, No. PO. 0259; paratypes, five complete carapaces, Nos. PO. 0260-0263, 0063; Nos. PO. 0259-0263 from Bear Villa No. 1 well; No. PO. 0063 from H. B. Union Salt Creek No. 1 well.

ERIELLA? sp. cf. E.? LINEATA (Ulrich and Bassler)

Plate 16, figure 27

?*Barychilina lineata* Ulrich and Bassler, in Bassler, 1932, Tennessee Dept. Educ., Div. Geol., Bull. 38, pl. 27, figs. 2, 3; Bassler, 1935, Jour. Washington Acad. Sci., vol. 25, p. 409.

?*Graphiadactyllis* sp. aff. *G. lineatus* (Ulrich and Bassler)—Swain, 1953, Jour. Paleont., vol 27, p. 270, pl. 38, figs. 11a-e.

Remarks: Two specimens have been recovered that are very close in shape and in ornament to *E.? lineata* (Ulrich and Bassler). The preservation is incomplete, however, and until completely preserved material is obtained these individuals are placed in *Eriella* and *E.? lineata* with reservation.

Occurrence: RG 56-4-26A.

Specimen: A complete carapace, No. PO. 0226.

ERIELLA? sp.

Plate 14, figure 21

Diagnosis: *Eriella*? species with strongly granulose surface ornament, narrow, even marginal flange, and probably a small posteroventral spine.

Occurrence: RG 57-10-1.

Specimen: A right valve, No. PO. 0222.

Genus GRAPHIADACTYLLOIDES, n. gen.

Type species: *Graphiadactylloides moreyi*, n. sp.

Graphiodactylus Roth—Morey, 1935 (part), Jour. Paleont., vol. 9, p. 321; Morey, 1936 (part), Jour. Paleont., vol. 10, p. 116; Benson, 1955 (part), Jour. Paleont., vol. 29, p. 1033.

Graphiadactyllis Roth—Brayer, 1952, Jour. Paleont., vol. 26, p. 169; Benson and Collinson, 1958 (part), Illinois Geol. Surv. Circ. 255, p. 19; Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, ser. 3, sec. 4, pl. 1, figs. 12-17.

?*Paracythere* Ulrich and Bassler, in Bassler, 1932 (part), Tennessee Dept. Educ., Div. Geol., Bull. 38, pl. 27, fig. 4; Bassler, 1935 (part), Jour. Washington Acad. Sci., vol. 25, p. 409.

?*Allostracites* Pribyl, 1953 (part), Ustr. Ust. Geol. Sbornik, fasc. 20, Sect. Pal., p. 109.

Diagnosis: Quasillitid ostracodes with well-developed marginal flanges, posteroventral spines, and lacking posterior shoulders.

Discussion: The genus *Graphiadactylloides* is intermediate between *Quasillites* and *Graphiadactyllis* and contains essentially

those species with posteroventral spines and well-developed marginal flanges that were formerly placed in *Graphiadactyllis*.

The following species are referred to this genus: *Graphiadactyllis axea* Brayer, *G. cornutus* (Ulrich and Bassler) of Morey (1936) (*not Paracythere cornuta* Ulrich and Bassler), *G. moridgei* Benson, and *G. spinosus* Morey. If the type of *Paracythere granopunctata* Ulrich and Bassler possesses a well-developed flange and posteroventral spine, as have specimens illustrated by Morey (1936, Pl. 17, Figs. 20, 21, 24, 27), then it also is referable to *Graphiadactylloides*.

Geologic range: Lower to Upper Mississippian.

Lithology: Limestone-calcareous shale.

Habitat: Marine.

GRAPHIADACTYLLOIDES MOREYI, n. sp.

Plate 16, figures 7-10, 12

Graphiadactyllis moridgei Benson—Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 15.

?*Graphiodactylus cornutus* (Ulrich and Bassler)—Morey, 1936, Jour. Paleont., vol. 10, p. 117, pl. 17, fig. 22.

Diagnosis: *Graphiadactylloides* species with distinctive fingerprint pattern on the posterior half of the carapace and with well-developed posteroventral and anterior spines.

Description: Carapace small, subrhomboidal in lateral view. Greatest height slightly behind anterodorsal angle; greatest width approximately two-thirds of length from anterior; greatest length at midheight. Length approximately 1.6 times height.

Dorsal border gently convex, approximately two-thirds of length. Ventral border evenly convex anteroventrally, straight to very slightly concave centroventrally, convex posteroventrally. Anterodorsal slope slightly convex, anterior slope rounded ventrally. Posterior slope straight centrally, otherwise rounded.

Cardinal angles distinct in left valve. Anterior cardinal angle 130 degrees, posterior cardinal angle 120 degrees.

Smooth spot situated centrally.

Lateral surface ornamented in posterior one-half to two-thirds by rarely inosculating fine ribs, arranged in a fingerprint pattern about the centre of the posterior area. Posterior and ventral ribs parallel to the margins; dorsal ribs diverging anteriorly from the

margin at 10 to 20 degrees. Anterior one-half to one-third of carapace smooth, with ornament extending farthest anteriorly in central area. Strong spine developed at posteroventral corner. Narrow marginal flange arising on the anteroventral margin and extending anteriorly to midheight where flange development culminates in a strong dorsolaterally directed spine.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0229	0.86	0.48	0.40
Paratype PO. 0230	0.95	0.51	0.49
Paratype PO. 0231	0.87	0.49	0.44
Paratype PO. 0232	0.85	0.42	—

Remarks: This species characterizes the lower part of the upper member of the Banff Formation and was recorded also by Copeland (1960) from the Exshaw Formation in the Crowsnest Pass. The absence of ribbed ornament in the anterior part of the carapace apparently is not a function of preservation, as it is characteristic of all specimens, and also as other quasillitid species present in the same beds are fully ornamented.

The species is similar in its partial absence of ornament to *G. moridgei* (Benson), but differs somewhat in shape, in the area from which ornament is absent and in the form of the ornament. It is similar in shape to *Graphiadactyllis* sp. aff. *G. lineatus* (Ulrich and Bassler) of Benson and Collinson (1958), (= *Graphiadactylloides* sp. aff. *Eriella*? *lineata* (Ulrich and Bassler)).

G. moreyi, n. sp., appears to be very close to *Graphiodactylus cornutus* (Ulrich and Bassler) of Morey (1936) (= *Graphiadactylloides*). Comparison of type material is not possible, however, as Dr. R. E. Peck states (pers. comm.) that Morey's specimens of this species are not present in the University of Missouri collections. Benson and Collinson (1958, p. 20) consider that Morey's specimens of "*G. cornutus*" are referable to a new species.

As Morey's specimens are missing, the writer is establishing the holotype for *G. moreyi* from the Banff material rather than from Morey's Chouteau specimens.

Occurrence: RG 56-4-26A, 43; ?RG 56-3-51.

Types: Holotype, a complete carapace, No. PO. 0229; paratypes, two complete carapaces and a left valve, Nos. PO. 0230-0232.

GRAPHIADACTYLLOIDES sp. cf. G. MOREYI, n. sp.

Plate 16, figure 11

Remarks: This form differs from *G. moreyi* in that the posterocentral riblets are not looped, but abut directly against the posterior riblets that parallel the posterior margin. With this modification, the surface ornament approaches that of *G. moridgei* (Benson); the lateral outline, however, differs.

Occurrence: RG 56-4-75.

Specimen: A left valve, No. PO. 0233.

GRAPHIADACTYLLOIDES sp. aff. G. MOREYI, n. sp.

Plate 16, figure 14

Remarks: Certain specimens from the upper part of the upper member of the Banff Formation resemble *G. moreyi* in lateral outline. They differ in possessing complete surface ornament of riblets, but as much of the detail of this is obscured by adventitious silica, their exact affinities cannot be determined.

Occurrence: RG 56-4-72, 75.

Specimen: A right valve, No. PO. 0234.

GRAPHIADACTYLLOIDES MORIDGEI (Benson)

Plate 16, figure 15

Graphiadactyllis moridgei Benson, 1955, Jour. Paleont., vol. 29, p. 1035, pl. 108, figs. 1, 2.

Graphiadactyllis moridgei Benson—Benson and Collinson, 1958, Illinois Geol. Surv. Circ. 255, p. 21, pl. 2, figs. 1-4, pl. 3, fig. 5.

not *Graphiadactyllis moridgei* Benson—Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 15.

Remarks: One specimen resembling *G. moridgei* (Benson) in all respects was obtained from the upper part of the upper member of the Banff Formation.

Occurrence: RG 56-4-75.

Hypotype: A right valve, No. PO. 0235.

GRAPHIADACTYLLOIDES sp. aff. G. MORIDGEI (Benson)

Plate 16, figures 16, 17

Remarks: Two immature instars have been recovered that appear to be similar in general form to *G. moridgei* (Benson), although differing in detail of surface ornament.

Occurrence: RG 56-4-75; RG 57-11-1.

Specimen: Two right valves, Nos. PO. 0236, 0254.

GRAPHIADACTYLLOIDES PAUCITUBERCULATUS, n. sp.

Plate 17, figures 1-5

Graphiadactyllis fernglenensis Benson—Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, figs. 12, 13.

Diagnosis: A species with small posteroventral spine, reticulate surface ornament with scattered small tubercles. Tubercles most dense in the posterodorsal and anteroventral areas.

Description: Carapace inequivalved, subrhomboidal in lateral view. Greatest height close to anterior cardinal angle; greatest width a short distance behind midlength; greatest length slightly above midheight. Left valve larger, overlapping right at cardinal angles and around free margins. Hinge long, straight, moderately depressed below dorsal border. Dorsal border gently convex; anterodorsal border straight; anteroventral border convex, rounding smoothly into ventral border. Ventral border slightly concave centrally; posterior border convex, strongly truncate ventrally.

Cardinal angles distinct; anterior cardinal angle 130 degrees; posterior cardinal angle 115 to 120 degrees.

A poorly to moderately developed submarginal "frill" commonly present on the flange anteroventrally, extending from the base of the anterior spine into the anterior portion of the ventral border. A long, dorsolaterally directed, anterior horn present in well-preserved specimens, the base being situated at or slightly above midheight. Lateral surface reticulate, except for the central smooth spot; small tubercles scattered over the reticulate surface. Tubercles more closely spaced towards the posterodorsal and anteroventral areas, and tending to be arranged in rows close to the valve borders in these areas, and to

develop the form of fine spines. Posteroventral spine distinguishable in most specimens, small and difficult to differentiate from the tubercles.

Dimensions:

	Length (mm.)	Height (mm.)
Holotype PO. 0237	0.84	0.40
Paratype PO. 0238	0.73	0.35
Paratype PO. 0239	0.68	0.38
Paratype PO. 0241	0.76	0.47

Remarks: This species differs from most previously described quasillitid ostracodes in having a reticulate surface ornament upon which are scattered tubercles. *Graphiadactyllis*? *fernglenensis* (Benson) has a similar surface ornament, but is less elongate, has more convex dorsal and ventral margins, is of larger size, and lacks a posteroventral spine.

Occurrence: RG 56-4-26A, 49, 75.

Types: Holotype, a right valve, No. PO. 0237; paratypes, three right valves, and a left valve, Nos. PO. 0238, 0239, 0241, 0334.

GRAPHIADACTYLLOIDES sp. cf. G. PAUCITUBERCULATUS, n. sp.

Plate 17, figure 6

Remarks: Immature instars of a species recovered from several samples are considered probably referable to *G. paucituberculatus*, n. sp. In addition to the reticulate ornament, scattered tubercles, and shape characteristic of *G. paucituberculatus*, these specimens possess a strong anterior spine and narrow anteroventral frill-like flange extension.

Occurrence: RG 56-1-42, 46, 62, 70, 71; RG 56-3-2, 10, 16, 18, 22.

Specimen: A left valve, No. PO. 0253.

GRAPHIADACTYLLOIDES STRIATORETICULATUS, n. sp.

Plate 16, figures 1-6

Graphiadactyllis cf. *G. lineatus* (Ulrich and Bassler)—Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 14.

Graphiadactyllis sp. Copeland, 1960, Trans. Roy. Soc. Can., vol. 54, pl. 1, fig. 17.

Diagnosis: Subrhomboidal *Graphiadactylloides* species with anterior spines, anteroventral flange, and striate-reticulate surface ornament centred about the central smooth spot.

Description: Carapace inequivalved, rounded subrhomboidal in lateral view, suboval in dorsal view. Greatest height at anterior cardinal angle; greatest width a short distance in front of posterior cardinal angle; greatest length at or slightly above midheight. Left valve larger, overlapping right moderately at cardinal angles, slightly on anterodorsal margin, and moderately on remainder of free margin. Hinge long, straight, slightly depressed below dorsal border. Dorsal border straight; anterodorsal border gently convex; anterodorsal slope extending to or below midheight. Anteroventral border convex, rounding smoothly into ventral border; ventral border slightly concave centrally, not parallel to dorsal border. Posterior border rounded, truncate ventrally.

Cardinal angles subrounded; anterior cardinal angle about 130 to 135 degrees; posterior cardinal angle 120 to 125 degrees.

A thin frill-like flange arising in the anterior portion of the ventral border, extending anteriorly, and passing into the base of the anterior horn situated at or slightly below midheight. In some instars a poorly developed flange extending from the spine base part way up the anterodorsal slope. A small, posterolaterally directed spine situated posteroventrally. Central smooth spot generally distinct, and in most specimens slightly depressed below the level of the ribbed ornament.

Lateral surface ornamented by rarely inosculating riblets, commonly joined by small cross-riblets, giving the ornament an overall striate-reticulate appearance. Riblets predominantly lying roughly parallel to the valve borders with the number of riblets parallel to any one margin being approximately equal; the riblets paralleling the anterodorsal and anteroventral borders commonly joining at acute angles, with those paralleling the other borders rounding smoothly into one another. Ornament thus of the "loop" type in fingerprint nomenclature, the base of the loop being directed towards the anteroventral area, and the centre of the loop lying slightly posterior to the central smooth spot.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0245	0.60	0.34	—
Paratype PO. 0246	0.61	0.34	—
Paratype PO. 0247	0.61	0.35	—
Paratype PO. 0248	0.72	0.38	0.36
Paratype PO. 0249	0.65	0.34	—
Paratype PO. 0250	0.67	0.36	—

Remarks: This species differs from *E.*? *lineata* (Ulrich and Bassler) in having a concave ventral border, a less ventrally truncate posterior border, as well as in possessing an anterior flange and spine. In *E.*? *lineata* the riblets nowhere join at acute angles, the central smooth spot apparently is lacking, and the posteroventral spine is ventrally directed. *G. striatoreticulatus* differs from "*G.* sp. aff. *G. lineatus* (Ulrich and Bassler)" of Benson and Collinson (1958) mainly in the form of the ornament; cross-riblets apparently are lacking in the Illinois species, which also does not have a broad zone of riblets parallel to the posterior border. It differs from *G. moreyi*, n. sp., in having complete surface ornament, and in having the posterior vertical riblets occupying a zone the width of which is equal to one-third to one-quarter of the total length; the equivalent zone in *G. moreyi* occupies a width of one-fifth to one-sixth of the length. *G. moridgei* (Benson) differs in the pattern of ribbed ornament.

Although this species is probably based on immature instars, the pattern of ribbed ornament is so distinctive that it must persist into adult instars—as apparently indicated in Copeland's (1960) larger specimens.

Occurrence: RG 56-1-4, 5, 33, 41, 42, 43, 61, 70; RG 56-3-2; RG 57-10-1.

Types: Holotype, an instar right valve, No. PO. 0245; paratypes, a complete carapace, two left and two right valves, Nos. PO. 0246-0250.

GRAPHIADACTYLLOIDES sp. cf. G. STRIATORETICULATUS, n. sp.

Remarks: Specimens from three samples are closely similar to *G. striatoreticulatus*, n. sp., but are included in it with reservations because of imperfect preservation.

Occurrence: RG 56-1-74; RG 56-3-2, 16.

GRAPHIADACTYLLOIDES sp. A

Plate 16, figure 13

Remarks: One specimen was obtained of a form similar in general distribution of lateral ornament to *Graphiadactyllis subrhomboidalis*, n. sp. It differs in lacking cross-riblets, in being more elongate, and in possessing a subdued posteroventral spine.

Occurrence: RG 56-4-83.

Specimen: A complete carapace, No. PO. 0255.

GRAPHIADACTYLLOIDES sp. B

Plate 17, figures 11, 13

Remarks: Some specimens associated with *Craspedographylus comptilimbus*, n. sp., possess much coarser ribbed ornament, cross-riblets, and are more oval in lateral outline. As the submarginal ridge is extremely subdued, these specimens probably do not belong in *Craspedographylus*, and at present they are referred to *Graphiadactylloides* under an open name.

Occurrence: RG 56-4-26A.

Specimens: Two right valves, Nos. PO. 0219, 0220.

GRAPHIADACTYLLOIDES sp. C

Plate 17, figures 9, 12

Remarks: Specimens from the Moose Mountain section are similar in surface ornament to some specimens of *G. paucituberculatus*, n. sp. They differ in shape, in possessing a stronger posteroventral spine than in most specimens, and—possibly as a consequence of preservation—show no tubercles.

Occurrence: RG 57-9-5.

Specimens: Two complete carapaces, Nos. PO. 0242, 0243.

GRAPHIADACTYLLOIDES sp. D

Plate 17, figure 10

Diagnosis: Subovate *Graphiadactylloides* species with fairly coarse reticulate surface ornament. Anterior and subdued posterodorsal spines present, and scattered tubercles close to the posterodorsal and anteroventral margins.

Remarks: Only imperfectly preserved specimens of this form have been obtained.

Occurrence: RG 56-4-26A.

Specimen: A right valve, No. PO. 0256.

GRAPHIADACTYLLOIDES? sp. E

Plate 17, figure 15

Diagnosis: *Graphiadactylloides*? species with anterior spines, anteroventral frill-like flange extension, and lateral ornament of un-

dulating and commonly inosculating riblets, mostly lying parallel to the dorsal and ventral margins.

Remarks: Only immature instars of this species have been found.

Occurrence: RG 56-1-42, 71; ?RG 56-3-22.

Specimen: A right valve, No. PO. 0258.

Genus CRASPEDOGRAPHYLUS, n. gen.

Type species: *Craspedographylus acrolimbus*, n. sp.

Diagnosis: Quasillitid ostracodes with well-developed marginal flanges expressed externally as strong ridge-like or frill-like structures adjacent to the free margins, lacking posterior shoulders, and typically possessing posteroventral spines.

Discussion: This genus is erected to contain a new group of quasillitid ostracodes obtained from Alberta Lower Mississippian rocks. These ostracodes possess the basic *Bufina* pattern (Henningsmoen, 1953) and also display, particularly in *C. comptilimbus*, features indicating a close relationship to *Graphiadactylloides* and *Graphiadactyllis*.

The generic name is derived from the Greek "*craspedo*" (border, hem) and "*grapho*" (drawing, writing) and refers to the basic features of the genus.

Geologic range: Lower Mississippian.

Lithology: Impure limestone-calcareous shale.

Habitat: Marine.

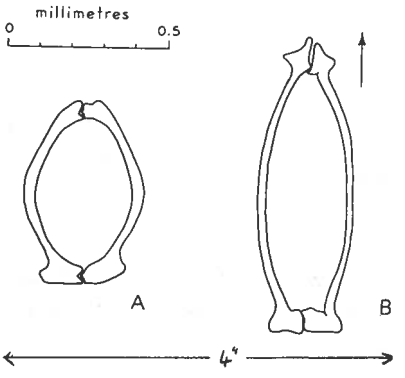

FIGURE 23. Sections through carapaces of Craspedographylus acrolimbus, *n. gen., n. sp.: A. vertical transverse section, anterior view; B. horizontal longitudinal section, dorsal view.*

CRASPEDOGRAPHYLUS ACROLIMBUS, n. sp.

Plate 15, figures 1-9, 11, 12

Diagnosis: *Craspedographylus* species with strongly developed posterodorsal spine, peaked flange ridge, and mainly smooth lateral surface.

Description: Carapace inequivalved, almost kite-shaped in lateral view. Greatest height anterior, a short distance behind the anterior cardinal angle; greatest width close to midlength; greatest length at about midheight. Left valve larger, overlapping right on free margins and on anterior portion of hinge line. Anterodorsal border of left valve projecting beyond border of right valve in lateral view. Hinge long, straight, strongly depressed below dorsal border in a V-shaped channel in its posterior two-thirds. Dorsal border straight; anterodorsal border straight to gently convex; anteroventral border evenly convex. Ventral border straight to slightly concave centrally; posterior border rounded.

Anterior cardinal angle distinct, 130 degrees in left valve, rounded in right valve; posterior cardinal angle rounded.

Strong submarginal flange ridge arising on the flange (Fig. 23) from the base of the dorsally directed anterior horn, extending posteriorly parallel to the valve border, and passing into the posteroventral spine. Area between the sharp crest of the ridge and the valve border flat, and grading imperceptibly to the ridge crest. Ridge separated from main portion of the valve by a groove, V-shaped in cross section (Fig. 23). A strong blunt spine situated in the posterodorsal area, the ventral portion of the spine extending anteroventrally as a low swelling dying out at about midlength.

Main part of lateral surface apparently smooth. In well-preserved specimens the area immediately dorsal, anterior and ventral to the posterodorsal spine may be reticulate. Area between the flange-ridge crest and the valve borders finely striate to elongate reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0205	0.99	0.53	0.34
Paratype PO. 0206	0.95	0.50	0.35
Paratype PO. 0207	0.95	0.49	0.38
Paratype PO. 0208	0.91	0.49	0.38
Paratype PO. 0209	0.76	0.40	0.27
Paratype PO. 0210	0.65	0.30	0.25
Paratype PO. 0211	0.87	0.53	—

Remarks: This species differs from other species of *Craspedographylus* in its exaggerated development of the posterodorsal spine, in its predominantly smooth surface, and in its strongly developed, continuous, submarginal, ridged flange.

The name of this species is derived from the Greek "*acro*" (peak, pointed) and "*limbus*" (border, edge), and refers to the cross-sectional shape of the strong flange.

In immature instars of this form the anteroventral and midventral portions of the flange ridge are not developed; a ridge extends anteriorly from the posteroventral spine almost to midlength.

Occurrence: RG 56-4-26A, 75; RG 57-11-1, 2.

Types: Holotype, a complete carapace, No. PO. 0205; paratypes, five complete carapaces and a right valve, Nos. PO. 0206-0211.

CRASPEDOGRAPHYLUS COMPTILIMBUS, n. sp.

Plate 15, figures 23-26

Diagnosis: *Craspedographylus* species with elongate ribbed to subreticulate ornament and strong, rounded, ornamented submarginal flange ridge.

Description: Carapace slightly inequivalved, elongate subpyriform in lateral view. Greatest height anterior, at anterior cardinal angle; greatest width midposterior; greatest length slightly above midheight. Hinge long, straight, slightly depressed. Dorsal border very gently convex. Anterodorsal border straight, anteroventral border evenly convex. Posterior border convex. Ventral border straight to slightly concave centrally.

Anterior cardinal angle 130 to 140 degrees; posterior cardinal angle rounded.

Rounded, submarginal flange ridge extending from the posterior cardinal angle around the free margin, becoming indistinct midventrally, and strongly developed anteroventrally, broadening as far as a short distance above midheight; a low narrower continuation of the ridge extending to the anterior cardinal angle and the main part of the ridge culminating in a dorsally directed horn. The crest of the ridge on the anteroventral margin becoming sharp dorsally, and the anterior border becoming flat. A poorly developed node present on the ridge posterodorsally, and a posteriorly directed, short spine posteroventrally.

A broad shallow depression separating the flange ridge from the remainder of the valve in the anterior and posterior areas.

A smooth spot situated centrally; the remainder of the lateral surface ornamented by gently inosculating subdued riblets lying parallel to the dorsal and ventral margins in the central two-thirds of the valve, and paralleling the anterior and posterior margins in the anterior and posterior areas. Cross-riblets present, but subdued in the stratigraphically lower specimens; cross-riblets becoming stronger in the stratigraphically higher specimens, the ornament thus becoming in part reticulate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0216	0.91	0.38	—
Paratype PO. 0217	0.78	0.38	—
Paratype PO. 0218	1.06	0.48	0.38

Remarks: *C. comptilimbus* differs from other species of *Craspedographylus* in its possession of a broad flange ridge ending in a node-like form close to the posterior cardinal angle, and in possessing a reticulate ornament. The surface ornament in the earlier forms is closely similar to that of *Graphiadactylloides moridgei* (Benson).

Occurrence: RG 56-4-26A, 73, 75.

Types: Holotype, a right valve, No. PO. 0216; paratypes, a right valve and a complete carapace, Nos. PO. 0217, 0218.

CRASPEDOGRAPHYLUS? INORNATUS, n. sp.

Plate 15, figures 13-15

Diagnosis: Smooth *Craspedographylus*? species with strong flange ridge and no posterior spines.

Description: Carapace inequivalved, subrhomboidal in lateral view. Greatest height anterior, close to anterior cardinal angle; greatest width in posterior quarter; greatest length slightly above midheight. Left valve larger, overlapping right slightly at anterior cardinal angle and around free margins. Anterodorsal margin of left valve projecting slightly beyond right in lateral view. Hinge long, straight, strongly depressed below dorsal border in a V-shaped channel. Dorsal border straight anteriorly, slightly convex posteriorly. Anterodorsal border gently convex, anteroventral border evenly rounded. Posterior border rounded. Ventral border straight posteriorly, convex anteriorly, not parallel to dorsal border.

Anterior cardinal angle distinct, 130 degrees; posterior cardinal angle rounded.

A sharp flange ridge arising anteriorly at midheight, and paralleling the valve borders ventrally into the posteroventral area. Ridge separated from the main portion of the valve by a groove, V-shaped in cross-section, and somewhat shorter than the ridge itself. Ridge passing midanteriorly into a very short, blunt anterior horn.

Lateral surface smooth, except for the area between the crest of the flange ridge and the valve border, which is finely striate.

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Holotype PO. 0223	0.89	0.50	0.38

Remarks: This species is closely related to *C. acrolimbus*, n. sp., from which it differs in being more quadrate in lateral view, in having more extensive channelling along the hinge, and in lacking posterodorsal and posteroventral spines. From other species, *C.? inornatus* is easily differentiated by its almost complete lack of surface ornament, and by its lack of spines.

Because of its lack of posteroventral spines, this species is referred with question to *Craspedographylus*. From the dichotomous generic classification used for the Quasillitidae (Table 13) this species should probably form the basis for a new genus. This is not, however, warranted at present as insufficient material is available.

The specific name is derived from the Latin *"inornatus"* (unadorned) and refers to the absence of surface ornament.

Occurrence: Forest Shell Peace River No. 14-29 well, 2,560-70 feet.

Type: Holotype, a complete carapace, No. PO. 0223.

CRASPEDOGRAPHYLUS sp. A

Plate 15, figures 19, 20

Diagnosis: *Craspedographylus* species with broad, corrugated flange frill, large anterior horn, and very large posteroventral spine.

Remarks: A number of specimens, of adult size, from the upper member of the Banff Formation are closely similar in form to immature instars of *C. acrolimbus*. They possess a broad, corrugated, anterior, frill-like flange extension which bears a large anterior horn

extending close to or above the dorsal margin. The posteroventral spine also shows extreme development, being half as long as the carapace, and bearing a narrow ridge that arises at midlength. The posterodorsal spine is reduced to a small node. The valve surfaces apparently are smooth.

Insufficient material is available to permit adequate description of the species.

Occurrence: RG 56-4-75.

Specimens: Two left valves, Nos. PO. 0212, 0213.

CRASPEDOGRAPHYLUS sp. B

Plate 15, figures 21, 22

Diagnosis: *Craspedographylus* species with narrow, continuous flange ridge, small posteroventral spine, anterior horn, and apparently with smooth lateral surface.

Remarks: Specimens apparently constituting a distinct species of *Craspedographylus* were obtained from two localities. Preservation is, however, not ideal.

Occurrence: RG 56-3-38, 51.

Specimens: Two left valves, Nos. PO. 0224, 0225.

CRASPEDOGRAPHYLUS sp. C

Plate 15, figures 10, 18

Diagnosis: A species with a moderately developed, striate flange frill arising in the anterior portion of the ventral margin and extending to the base of the hook-shaped anterior horn. Inflation or shoulder extending from the small posterodorsal spine anteroventrally to in front of the posteroventral spine. Surface finely striate to reticulate in the posterior one-quarter of the valve.

Remarks: Only immature instars of this distinctive species have been found. In its posterodorsal inflation, this species is considered to have affinities to *C. acrolimbus*, and possibly to *C.* sp. A.

Occurrence: RG 56-1-2, 34, 42, 43; RG 57-10-1; ?RG 56-3-41.

Specimens: A right valve and a left valve, Nos. PO. 0214, 0215.

CRASPEDOGRAPHYLUS sp. D

Plate 15, figures 16, 17

Remarks: Immature instars were collected of a species with an anteroventral flange frill, a partial flange ridge, anterior horn and posteroventral spines. The shape and ribbed ornament are similar to those of *C. comptilimbus*. If the flange frill does not persist into adult instars, then this form may well be conspecific with *C. comptilimbus*.

Occurrence: RG 56-1-42.

Specimens: Two right valves, Nos. PO. 0015, 0221.

CRASPEDOGRAPHYLUS? sp. E

Plate 17, figure 14

Diagnosis: *Craspedographylus*? species possessing lateral outline similar to *C. acrolimbus* but with surface ornament of riblets and cross-riblets, and with very subdued anteroventral flange ridge.

Occurrence: RG 56-4-26A, 75.

Specimen: A left valve, No. PO. 0257.

Order PODOCOPIDA, suborder and family UNCERTAIN
Genus MICROCHEILINELLA Geis, 1933

MICROCHEILINELLA sp. aff. M.SPINOSA (Geis)

Plate 17, figures 18, 20- 22

Dimensions:

	Length (mm.)	Height (mm.)	Width (mm.)
Specimen PO. 0184	0.49	0.31	0.36
Specimen PO. 0185	0.46	0.30	0.29
Specimen PO. 0186	0.76	0.44	0.46

Remarks: A species similar to *M. spinosa* (Geis) is present in the upper member of the Banff Formation. It differs from the Salem species in lacking the posteroventral spine in the right valve, and in being larger.

Occurrence: RG 56-3-52; RG 56-4-26A, 76.

Specimens: Three complete carapaces, Nos. PO. 0184-0186.

MICROCHEILINELLA sp.

Plate 17, figures 19, 23

Remarks: A quadrate species of *Microcheilinella* from the basal unit of the Banff Formation bears an outward resemblance to

Tubulibairdia amaliae (Kummerow). In addition to lacking pores in the wall, the specimens from the Banff Formation differ from Kummerow's species in having a more unequal extension of the left valve beyond the right in lateral view, and in having a less pronounced ventral overlap.

Occurrence: RG 57-10-1.

Specimen: A complete carapace, No. PO. 0183.

Genus SILENITES Coryell and Booth, 1933

SILENITES sp. cf. S. WAREI Morey

Plate 17, figures 24-28

?*Silenites warei* Morey, 1936, Jour. Paleont., vol. 10, p. 121, pl. 17, figs. 12, 14.

?*Silenites marginiferus* (Geis)—Morey, 1936, Jour. Paleont., vol. 10, p. 121, pl. 17, figs. 23, 25.

?*Silenites warei* Morey—Sohn, 1960, U.S. Geol. Surv. Prof. Paper 330-A, p. 74.

Remarks: It was suggested by Sohn (1960) that *Silenites warei* Morey and *Silenites marginiferus* (Geis) of Morey (1936) were the same species. The species so delimited is relatively broad in concept and includes a group of forms in which the dorsoanterior margin extends to half or close to half of the total length of the valve, and which possess a dorsal commissure that is angular at the junction with each end margin.

The species from the Banff Formation is closely similar to *S. warei* in possessing angularity of the dorsal commissure, and a relatively long dorsoanterior margin which, however, does not quite extend to midlength. The Banff species also has a more evenly rounded dorsal margin than does *S. warei,* and thus is interpreted as being a slightly later form showing development towards the more symmetrical species *S. marginiferus* (Geis).

Occurrence: RG 56-3-51; RG 56-4-26A, 75; RG 57-11-1.

Specimens: Three complete carapaces, Nos. PO. 0305-0307.

Order MYODOCOPIDA Sars, 1866

Suborder MYODOCOPINA Sars, 1866

?Superfamily ENTOMOZOACEA (Jones, 1873) Pribyl, 1951

Family ENTOMOZOIDAE Pribyl, 1951

Subfamily RICHTERININAE Sylvester-Bradley, 1961

Genus RICHTERINA Gurich, 1896

RICHTERINA sp. aff. FOSSIRICHTERINA INTERCOSTATA (Matern) 1929

Plate 17, figures 29-32

Remarks: Young instars of this species were collected from the base and the middle of the Banff Formation. The specimens are similar to *F. intercostata* (Matern) in having major ribs with minor ribs between, but they differ in lacking a pit, in having more strongly raised ribs, and in being less symmetrical in lateral view. The Banff species thus belongs to the genus *Richterina* and not to *Fossirichterina.*

Occurrence: RG 57-10-1; RG 56-3-48.

Specimens: Four single valves Nos. PO. 0001-0004.

Suborder CLADOCOPINA Sars, 1866
Family UNCERTAIN
Genus DISCOIDELLA Croneis and Gale, 1939

DISCOIDELLA sp. aff. D. AMPLA Cooper, 1941

Plate 17, figures 16, 17

Description: Relationship of valves unknown. Valves small, subcircular in lateral view, greatest thickness above midheight. Hinge short, depressed below dorsal border. A narrow, obliquely striate, marginal ridge present anteroventrally and ventrally. Lateral surface ornamented by striae with cross-reticulations, the major striae lying subparallel to the ventral border. Striae are irregular and anastomosing in the central dorsal area.

Dimensions:

	Length (mm.)	Height (mm.)
Specimen PO. 0165	0.35	0.34
Specimen PO. 0166	0.40	0.38

Remarks: This species differs from *D. ampla* Cooper in its more irregular surface ornament and in its possession of a marginal ridge. It is more elongate than *D. pendens* Croneis and Gutke and *D. costata* Samoilova and Smirnova, and possesses somewhat different surface ornament and a marginal ridge.

Only single valves of this species were obtained.

Occurrence: RG 56-1-42; RG 56-3-50; RG 56-4-49.

Specimens: A right valve and a left valve, Nos. PO. 0165, 0166.

DISCOIDELLA sp.

Occurrence: RG 56-3-16, 40.

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EXPLANATION OF PLATE 1

Banff Formation

Banff, Jasper and Sunwapta Pass

Magnifications about X30, except where noted

Figures 1, 3: *Halliella*? sp.; 1—left valve, figured specimen PO. 0167, RG 56-3-52, Banff; 3—left valve, figured specimen PO. 0168, RG 57-10-1, Jasper ..... (p. 71)

Figures 2, 4-7, 11: *Mammoides longispinosa*, n. sp.; 2—right valve X40, paratype PO. 0073, RG 56-1-42, Banff; 4—right valve X40, paratype PO. 0071, RG 56-1-42, Banff; 5—left valve X40, paratype PO. 0072, RG 56-1-42, Banff; 6—left valve X40, paratype PO. 0074, RG 56-1-42, Banff; 7, 11—left and dorsal views of carapace, holotype PO. 0070, RG 56-3-16, Banff ..... (p. 72)

Figures 8-10: *Cornigella* sp. cf. *C. golcondensis* (Croneis and Gale); 8—left valve X40, figured specimen PO. 0077; 9—right valve X40, figured specimen PO. 0076; 10—right valve X40, figured specimen PO. 0075; all specimens from RG 56-1-42, Banff ..... (p. 76)

Figures 12, 13, 19-23: *Kirkbyella (Berdanella) reticulata*, n. sp.; 12, 19—outside and dorsal views of right valve, holotype PO. 0083; 13—right valve, paratype PO. 0085; 20—left valve, paratype PO. 0087; 21—left valve, paratype PO. 0088; 22—right valve, paratype PO. 0084; 23—right valve, paratype PO. 0086; all specimens from RG 56-4-75, Banff ..... (p. 78)

Figures 14-18: *Kirkbyella (Berdanella) bowensis*, n. sp.; 14, 15—outside and dorsal views of right valve, holotype PO. 0079; 16—right valve, paratype PO. 0081; 17—right valve, paratype PO. 0080; 18—right valve, paratype PO.0082; all specimens from RG 56-4-75, Banff. (p. 77)

Figure 24: *Kirkbyella (Berdanella)* sp. aff. *K. reticulata*, n. sp.; left valve, figured specimen PO. 0089, RG 56-1-42, Banff ..... (p. 80)

Figures 25, 26: *Kirkbyella (Berdanella) annensis* (Benson and Collinson); right and dorsal views of complete carapace, hypotype PO. 0078, RG 57-11-1, Sunwapta Pass ..... (p. 77)

PLATE 1

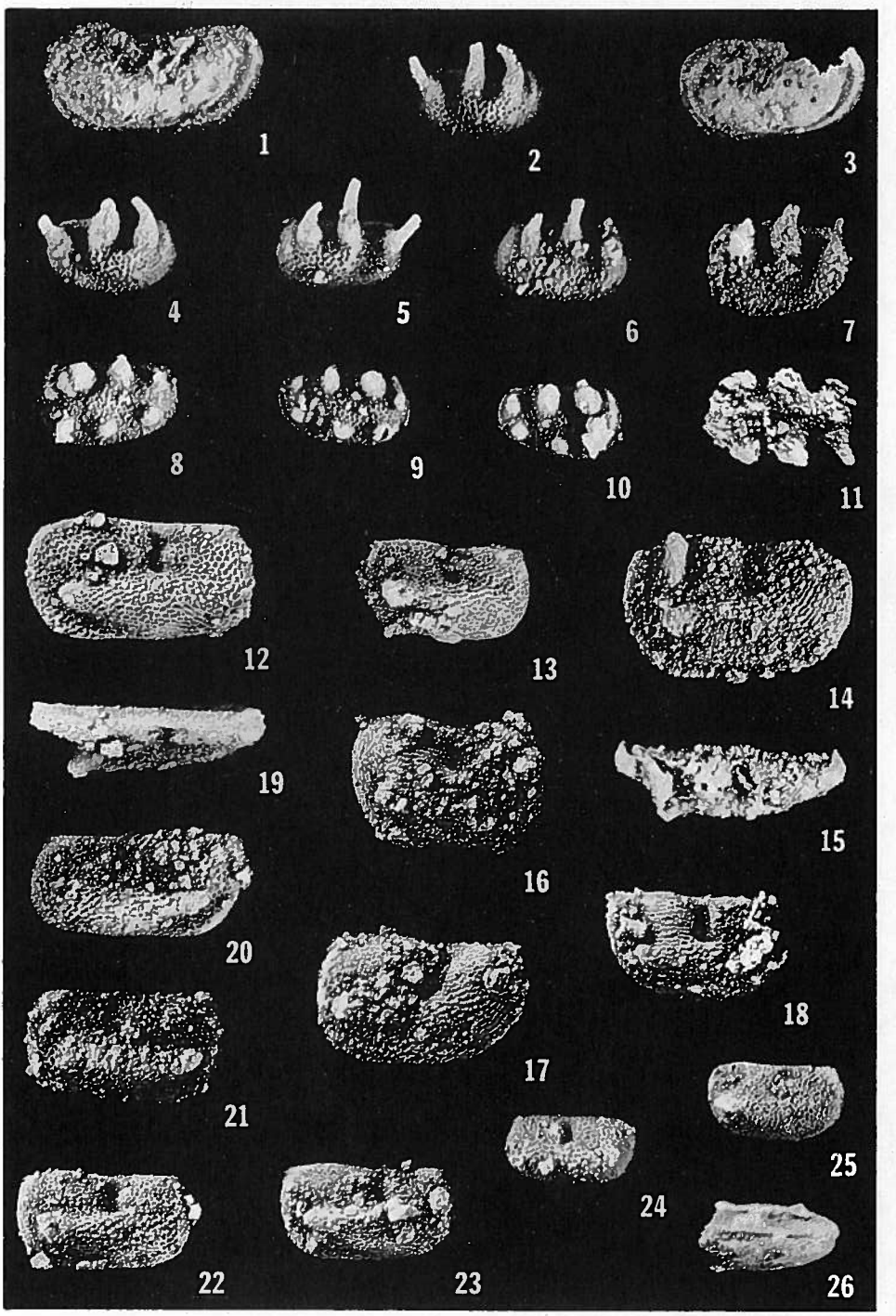
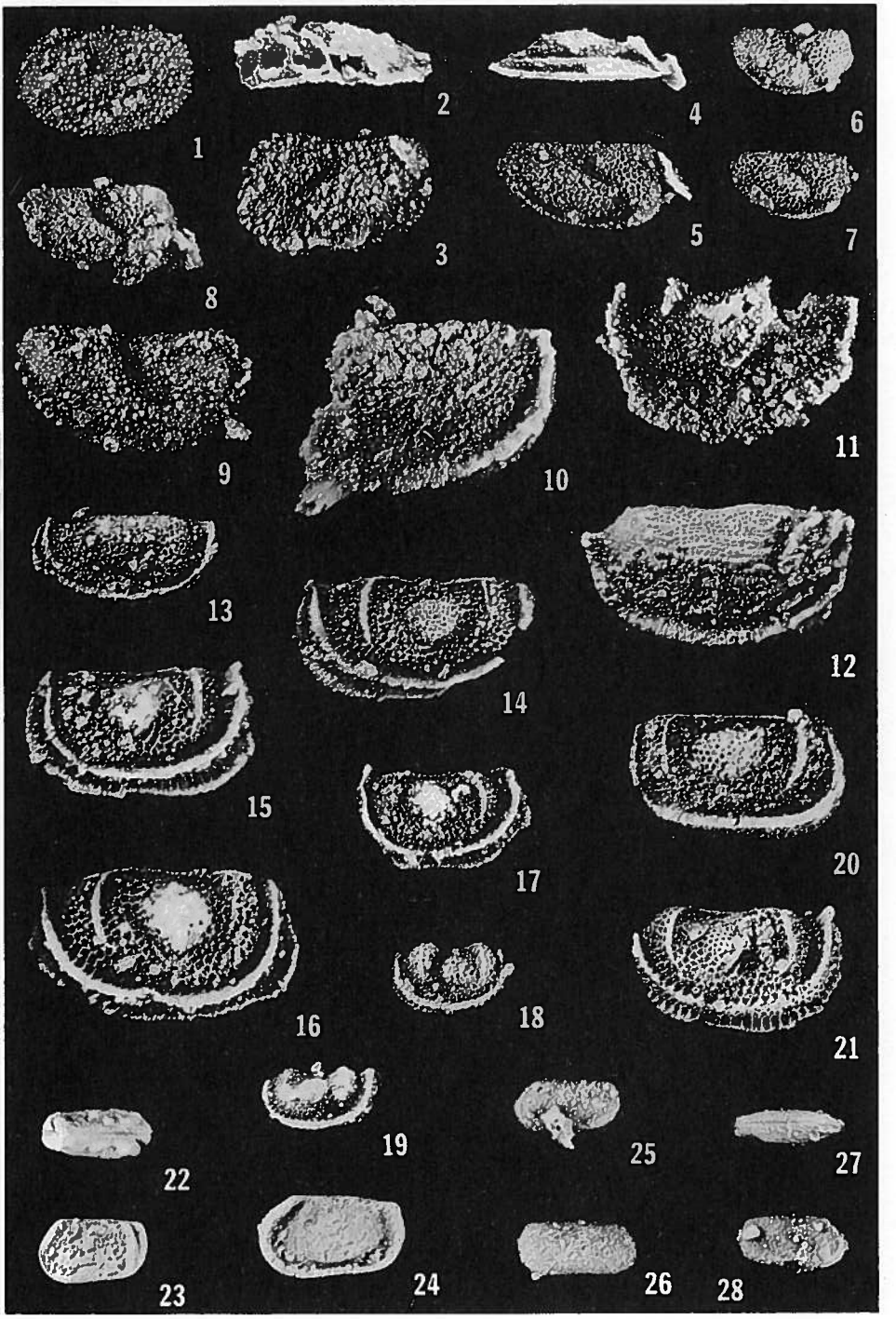


PLATE 2



EXPLANATION OF PLATE 2

Banff Formation

Banff, Jasper, and Peace River region

Magnifications about X30, except where noted

Figure 1: *Hollinella* sp.; immature left valve, figured specimen PO. 0023, RG 57-10-1, Jasper ..... (p. 80)

Figures 2-9: *Tetrasacculus calcaratus*, n. sp.; 2, 3—ventral and outside views of adult female left valve, paratype PO. 0025, RG 56-4-75, Banff; 4, 5—ventral and outside views of immature male right valve, paratype PO. 0027, RG 56-4-75, Banff; 6, 7—immature right valves, paratypes PO. 0028, 0029, respectively, RG 56-1-42, Banff; 8—immature female right valve, paratype PO. 0026, RG 56-4-75, Banff; 9—adult male right valve, holotype PO. 0024, RG 56-4-75, Banff ..... (p. 80)

Figures 10, 11: *Kirkbya* sp. cf. *K. keiferi* Benson; 10—left valve, figured specimen PO. 0150; 11—right valve, figured specimen PO. 0149; both specimens from RG 56-3-52, Banff ..... (p. 83)

Figure 12: *Kirkbya* sp.; right valve, figured specimen PO. 0151, RG 60-1-12, Jasper ..... (p. 84)

Figure 13: *Kirkbya* sp.; left valve, figured specimen PO. 0152, RG 56-4-75, Banff ..... (p. 84)

Figures 14-18: *Amphissites similaris* Morey; 14—right valve, hypotype PO. 0153; 15—left valve, hypotype PO. 0155; 16—right valve, hypotype PO. 0154; 17—left valve, hypotype PO. 0156; 18—right valve, hypotype PO. 0157; all specimens from RG 56-4-75, Banff ..... (p. 84)

Figure 19: *Amphissites* sp. cf. *A. similaris* Morey; left valve, figured specimen PO. 0158, RG 56-1-42, Banff ..... (p. 86)

Figures 20, 21: *Amphissites* sp. aff. *A. similaris* Morey; 20—left valve, figured specimen PO. 0159; 21—left valve, figured specimen PO. 0160; both specimens from RG 57-10-1, Jasper ..... (p. 87)

Figures 22, 23: *Glyptopleuroides*, sp. aff. *G. girtyi* Croneis and Gale; 22, 23—dorsal and left views of carapace X40, figured specimen PO. 0069, Peace River region ..... (p. 87)

Figure 24: *Moorites* sp.; left view of carapace X40, figured specimen PO. 0164, Peace River region ..... (p. 88)

Figures 25-28: *Moorites calvatus*, n. sp.; 25—left valve, X40, paratype PO. 0163; 26—right valve X40, paratype PO. 0162; 27, 28—dorsal and right views of carapace X40, holotype PO. 0161; all specimens from RG 56-1-42, Banff ..... (p. 87)

EXPLANATION OF PLATE 3

Banff Formation

Banff, Sunwapta Pass and Peace River region

Magnifications about X30, except where noted

Figures 1-3: *Glyptopleura primitiva*, n. sp.; 1—left valve, holotype PO. 0064; 2—right valve, paratype PO. 0065; 3—right valve, paratype PO. 0066; all specimens from RG 56-1-42, Banff ..... (p. 89)

Figures 4, 5: *Glyptopleura* sp. cf. *G. belphegora* Brayer; 4—right valve, figured specimen PO. 0068, RG 56-4-75, Banff; 5—right valve, figured specimen PO. 0067, RG 56-3-40, Banff ..... (p. 90)

Figures 6-12: *Beyrichiopsis banffensis*, n. sp.; 6, 7—dorsal and left views of complete carapace, paratype PO. 0032; 8—right valve, paratype PO. 0033; 9, 10—dorsal and left views of carapace, paratype PO. 0031; 11, 12—dorsal and left views of carapace, holotype PO. 0030; all specimens from RG 56-4-49, Banff ..... (p. 91)

Figure 13: *Beyrichiopsis bicarinata*, n. sp.; right valve, holotype PO. 0050, RG 56-4-26A, Banff ..... (p. 93)

Figures 14-20: *Beyrichiopsis bispinosa*, n. sp.; 14, 15—dorsal and left views of female carapace, holotype PO. 0034; 16, 17—dorsal and right views of female carapace, paratype PO. 0036; 18—right view of instar carapace, paratype PO. 0037; 19, 20—dorsal and left views of male carapace, paratype PO. 0035; all specimens from RG-57-11-2, Sunwapta Pass ..... (p. 94)

Figures 21-23: *Beyrichiopsis carinata carinata*, n. sp., n. ssp.; 21, 22—dorsal and left views of female carapace, holotype PO. 0038; 23—left view of female carapace, paratype PO. 0039. Both specimens from Peace River region ..... (p. 95)

Figures 24-29: *Beyrichiopsis carinata nigelensis*, n. ssp.; 24, 25—dorsal and left views of female carapace, holotype PO. 0040, RG 57-11-2, Sunwapta Pass; 26—left view of carapace, paratype PO. 0041, RG 57-11-2, Sunwapta Pass; 27, 28—dorsal and left views of carapace, paratype PO. 0042, RG 56-4-49, Banff; 29—left valve, paratype PO. 0043, RG 56-4-49, Banff ..... (p. 98)

PLATE 3

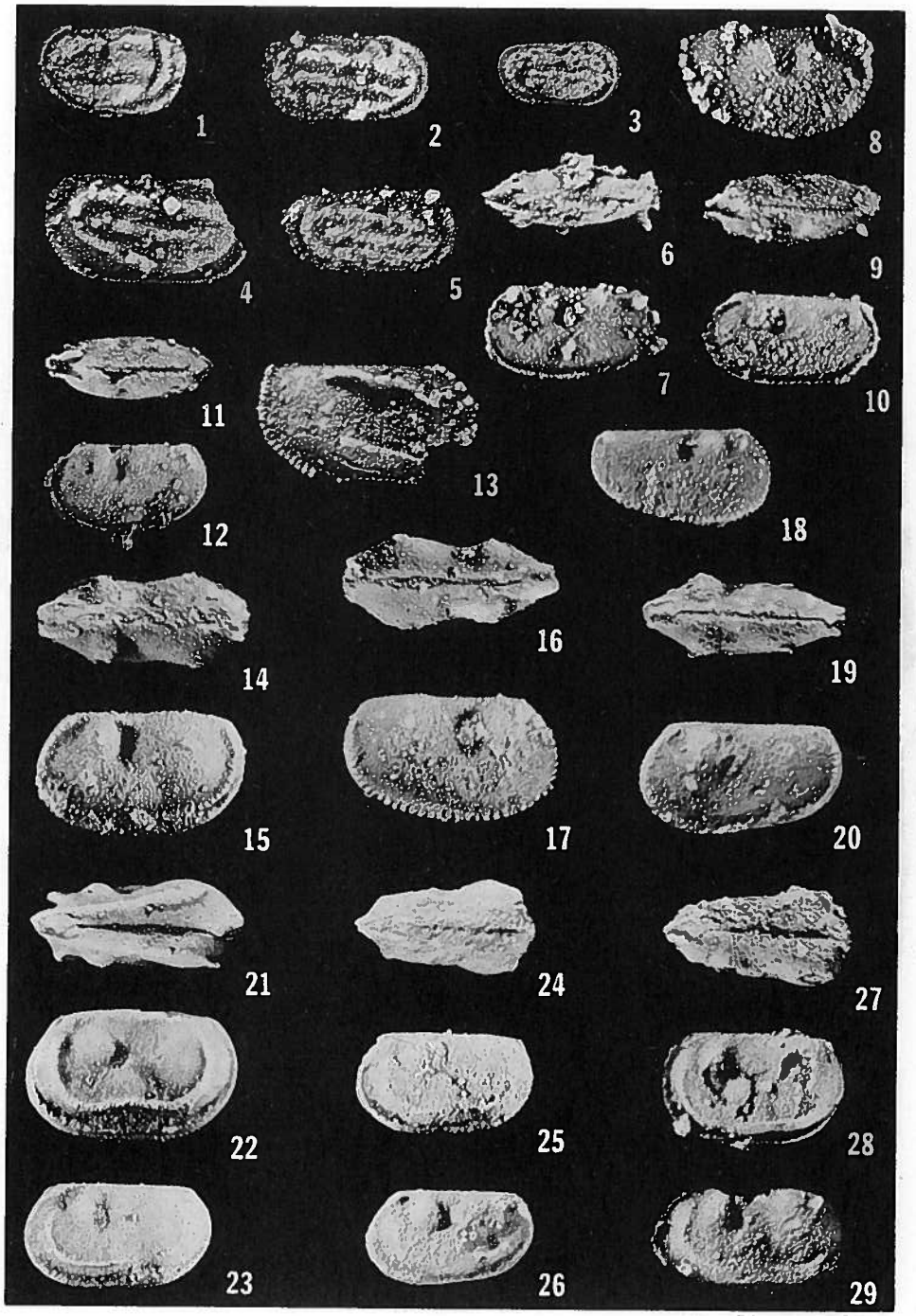
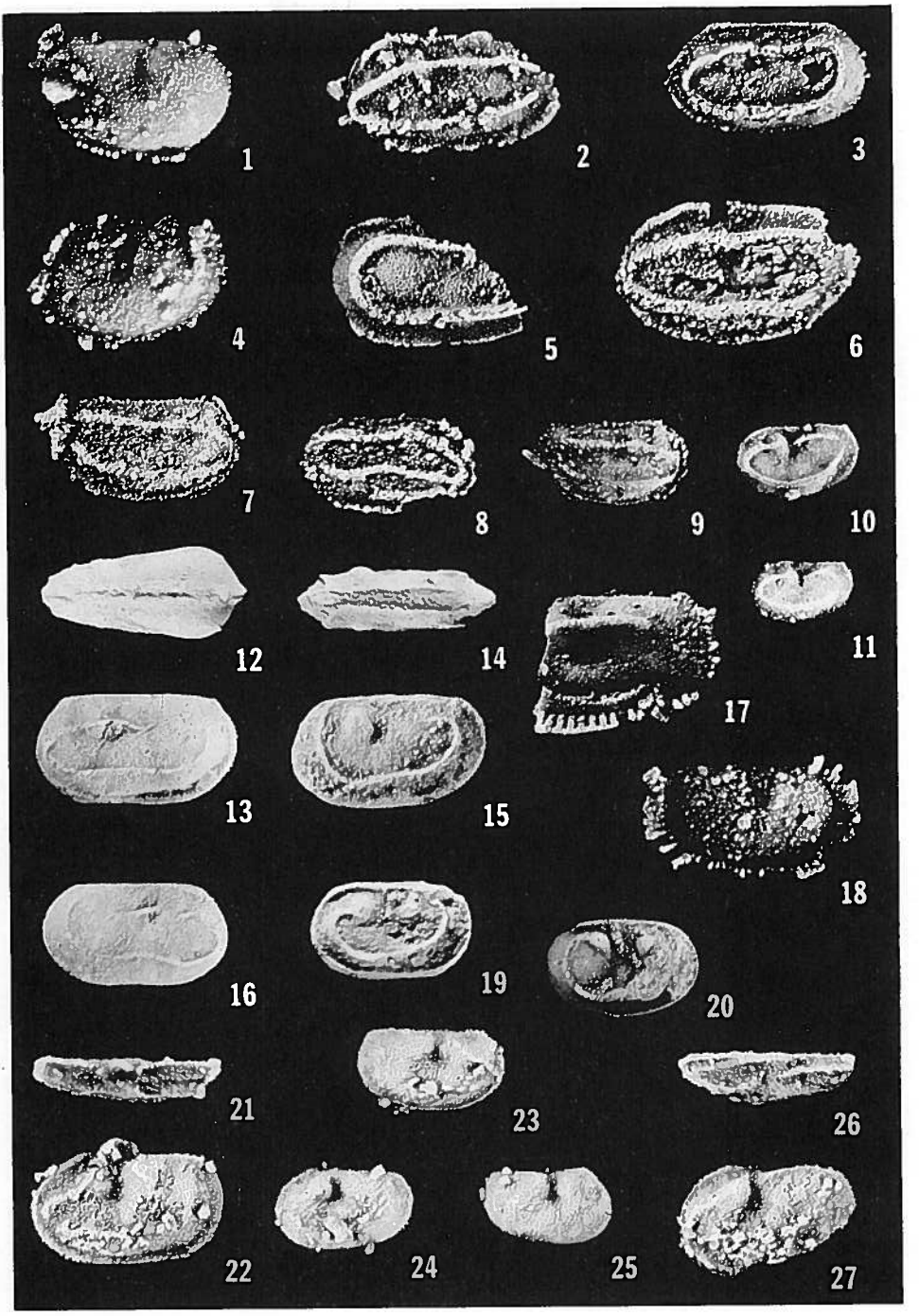


PLATE 4



EXPLANATION OF PLATE 4

Banff Formation

Banff, Jasper and Peace River region

Magnifications about X30

Figures 1, 4: *Beyrichiopsis curta*, n. sp.; 1—right valve, holotype PO. 0047, RG 56-1-42, Banff; 4—left valve, paratype PO. 0048, RG 56-1-42, Banff ..... (p. 98)

Figures 2, 3, 5-11: *Beyrichiopsis glyptopleuroides*, n. sp.; 2—male left valve, holotype PO. 0052, RG 57-10-1, Jasper; 3—female left valve, paratype PO. 0058, RG 56-4-26A, Banff; 5—female right valve, paratype PO. 0053, RG 57-10-1, Jasper; 6—male left valve, paratype PO. 0059, RG 56-4-26A, Banff; 7—immature right valve, paratype PO. 0057, RG 56-3-43, Banff; 8—immature right valve, paratype PO. 0060, RG 56-4-26A, Banff; 9—immature right valve, paratype PO. 0056, RG 56-3-43, Banff; 10—immature left valve, paratype PO. 0055, RG 57-10-1, Jasper; 11—immature left valve, paratype PO. 0054, RG 57-10-1, Jasper ..... (p. 99)

Figures 12, 13, 16: *Beyrichiopsis* sp. aff. *B. glyptopleuroides*, n. sp.; 12, 13—dorsal and left views of complete carapace, figured specimen PO. 0061; 16—right view of complete carapace, figured specimen PO. 0062; both specimens from Peace River region ..... (p. 102)

Figures 14, 15: *Beyrichiopsis* sp. A; 14, 15—dorsal and left views of complete carapace, figured specimen PO. 0044, Peace River region ..... (p. 103)

Figure 17: *Beyrichiopsis* sp. D; left valve, figured specimen PO. 0051, RG 57-10-1, Jasper ..... (p. 105)

Figure 18: *Beyrichiopsis* sp. C; right valve, figured specimen PO. 0049, RG 56-4-26A, Banff ..... (p. 105)

Figures 19, 20: *Beyrichiopsis* sp. B; 19—left view of complete male carapace, figured specimen PO. 0045; 20—female right valve, figured specimen PO. 0046; both specimens from Peace River region. (p. 104)

Figures 21-27: *Knoxina costata*, n. sp.; 21, 22—dorsal and outside views of left valve, holotype PO. 0119; 23—right valve, paratype PO. 0122; 24—left valve, paratype PO. 0123; 25—right valve, paratype PO. 0121; 26, 27—dorsal and outside views of left valve, paratype PO. 0120; all specimens from RG 56-1-42, Banff ..... (p. 106)

Explanation of Plate 5

Banff Formation

Banff and Sunwapta Pass

Magnifications about X30

Figures 1-6: *Knoxina marginata*, n. sp.; 1, 2—dorsal and right views of complete carapace, holotype PO. 0124; 3—left valve, paratype PO. 0126; 4, 5, 6—inside, ventral and outside views of left valve, paratype PO. 0125; all specimens from RG 56-4-26A, Banff ..... (p. 107)

Figures 7-15: *Geffenina? aspinifera*, n. sp.; 7—dorsal view of complete female carapace, paratype PO. 0129, RG 56-4-79, Banff; 8, 9—left and dorsal views of complete female carapace, holotype PO. 0127, RG 56-4-75, Banff; 10—left view of complete female carapace, paratype PO. 0128, RG 56-4-79, Banff; 11—right valve, paratype PO. 0130, RG 56-3-51, Banff; 12, 13—dorsal and left views of complete carapace, paratype PO. 0131, RG 56-3-51, Banff; 14—left valve, paratype PO. 0132, RG 56-3-51, Banff; 15—left view of complete carapace, paratype PO. 0133, RG 56-3-51, Banff ..... (p. 109)

Figures 16-24: *Geffenina nigelensis*, n. sp.; 16, 17—dorsal and left views of complete female carapace, paratype PO. 0135; 18, 19—dorsal and left views of complete male carapace, holotype PO. 0134; 20—left view of complete male carapace, paratype PO. 0136; 21—left view of complete carapace, paratype PO. 0137; 22—left view of complete carapace, paratype PO. 0138; 23—left view of complete carapace, paratype PO. 0139; 24—left view of complete carapace, paratype PO. 0140; all specimens from RG 57-11-2, Sunwapta Pass ..... (p. 111)

PLATE 5

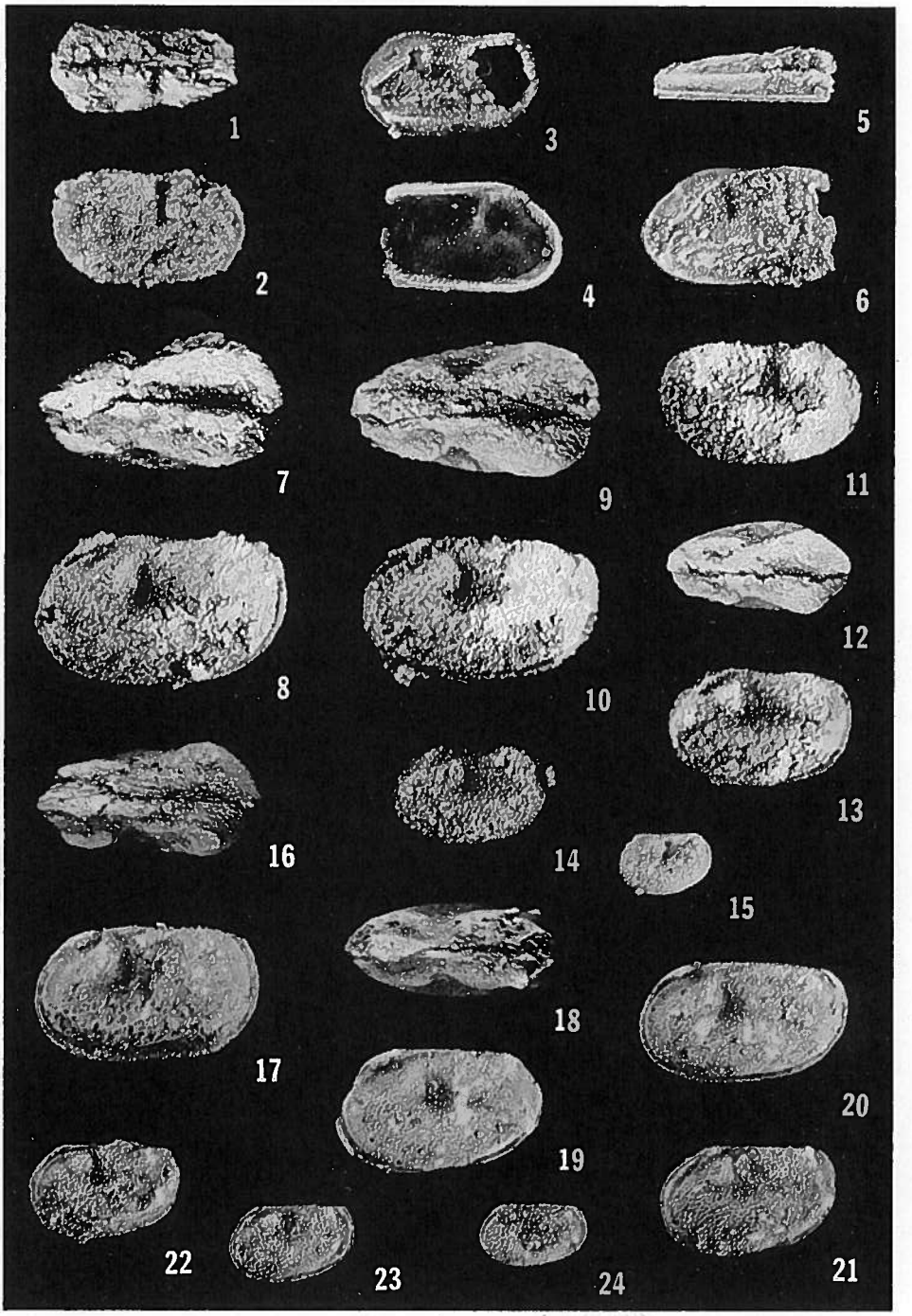
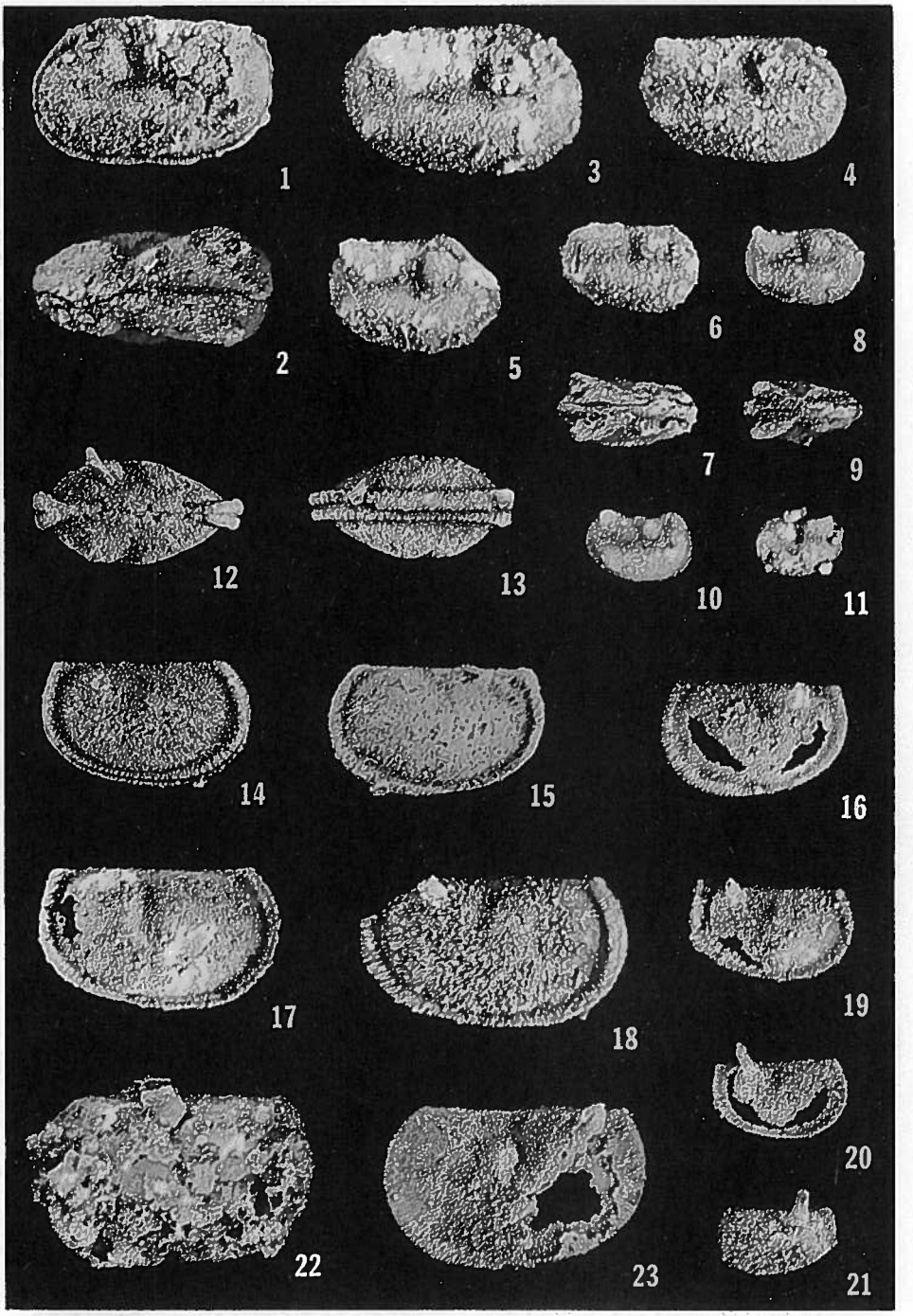


PLATE 6



EXPLANATION OF PLATE 6

Banff Formation

Banff and Jasper

Magnifications about X30, except where noted

Figures 1-11: *Geffenina warreni*, n. sp.; 1, 2—left and dorsal views of complete female carapace, holotype PO. 0141, RG 56-3-51, Banff; 3—male right valve, paratype PO. 0142, RG 56-3-51, Banff; 4—right valve, paratype PO. 0143, RG 56-3-51, Banff; 5—right valve, paratype PO. 0144, RG 56-3-51, Banff; 6, 7—right and dorsal views of complete carapace, paratype PO. 0145, RG 56-3-51, Banff; 8, 9—right and dorsal views of complete carapace, paratype PO. 0146, RG 56-3-51, Banff; 10—right valve, paratype PO. 0147, RG 56-1-42, Banff; 11—left valve, paratype PO. 0148, RG 56-1-42, Banff ..... (p. 114)

Figures 12-21: *Pseudochilina marginata*, n. gen., n. sp.; 12, 13, 14, 15—dorsal, ventral, right and left views of complete carapace X10, holotype PO. 0169; 16—left valve X15, paratype PO. 0172; 17—right valve X15, paratype PO. 0170; 18—right valve X15, paratype PO. 0171; 19—right valve X15, paratype PO. 0173; 20—right valve X15, paratype PO. 0174; 21—left valve X15, paratype PO. 0175; all specimens from RG 56-3-51, Banff ..... (p. 118)

Figures 22, 23: *Pseudochilina* sp.; 22—left valve X10, figured specimen PO. 0177, RG 60-1-9, Jasper; adventitious silicified fragments obscuring most of exterior; 23—left valve X15, figured specimen PO. 0178, RG 60-1-9, Jasper ..... (p. 119)

EXPLANATION OF PLATE 7

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X30, except where noted

Figures 1-9: *Libumella athabascensis*, n. sp.; 1, 2—left and dorsal views of complete carapace X20, holotype PO. 0005, RG 60-1-9, Jasper; 3—right valve X20, paratype PO. 0007, RG 57-10-1, Jasper; 4—right valve X20, paratype PO. 0006, RG 57-10-1, Jasper; 5—left valve X20, paratype PO. 0011, RG 57-10-1, Jasper; 6—right valve X20, paratype PO. 0008, RG 57-10-1, Jasper; 7—right valve X20, paratype PO. 0009, RG 57-10-1, Jasper; 8—left valve X20, paratype PO. 0012, RG 57-10-1, Jasper; 9—right valve X20, paratype PO. 0010, RG 57-10-1, Jasper ..... (p. 120)

Figures 10-13: *Namaia reticulata*, n. gen., n. sp.; 10—right valve, paratype PO. 0014, RG 56-3-40, Banff; 11, 12, 13—dorsal, right and ventral views of complete carapace, holotype PO. 0013, RG 56-3-51, Banff ..... (p. 122)

Figures 14-19: *Coryellina obesa*, n. sp.; 14, 15—right and ventral views of complete carapace, paratype PO. 0096, Peace River region; 16, 17, 19—posterior, left and dorsal views of complete carapace, holotype PO. 0095, Peace River region; 18—left view of complete carapace, paratype PO. 0097, RG 57-11-1, Sunwapta Pass ..... (p. 123)

Figures 20-25: *Coryellina spinosa*, n. sp.; 20—left valve, paratype PO. 0102, RG 56-3-51, Banff; 21, 22—outside and dorsal views of left valve, holotype PO. 0098, RG 56-4-75, Banff; 23—left valve, paratype PO. 0099, RG 56-4-75, Banff; 24—right valve, paratype PO. 0101, RG 56-4-75, Banff; 25—right valve, paratype PO. 0100, RG 56-4-75, Banff ..... (p. 124)

Figures 26-29: *Pseudoparaparchites montis*, n. sp.; 26, 27—dorsal and left views of a complete carapace, holotype PO. 0090, RG 57-11-1, Sunwapta Pass; 28—left valve, paratype PO. 0091, RG 56-4-75, Banff; 29—right valve, paratype PO. 0092, RG 56-4-75, Banff ..... (p. 129)

PLATE 7

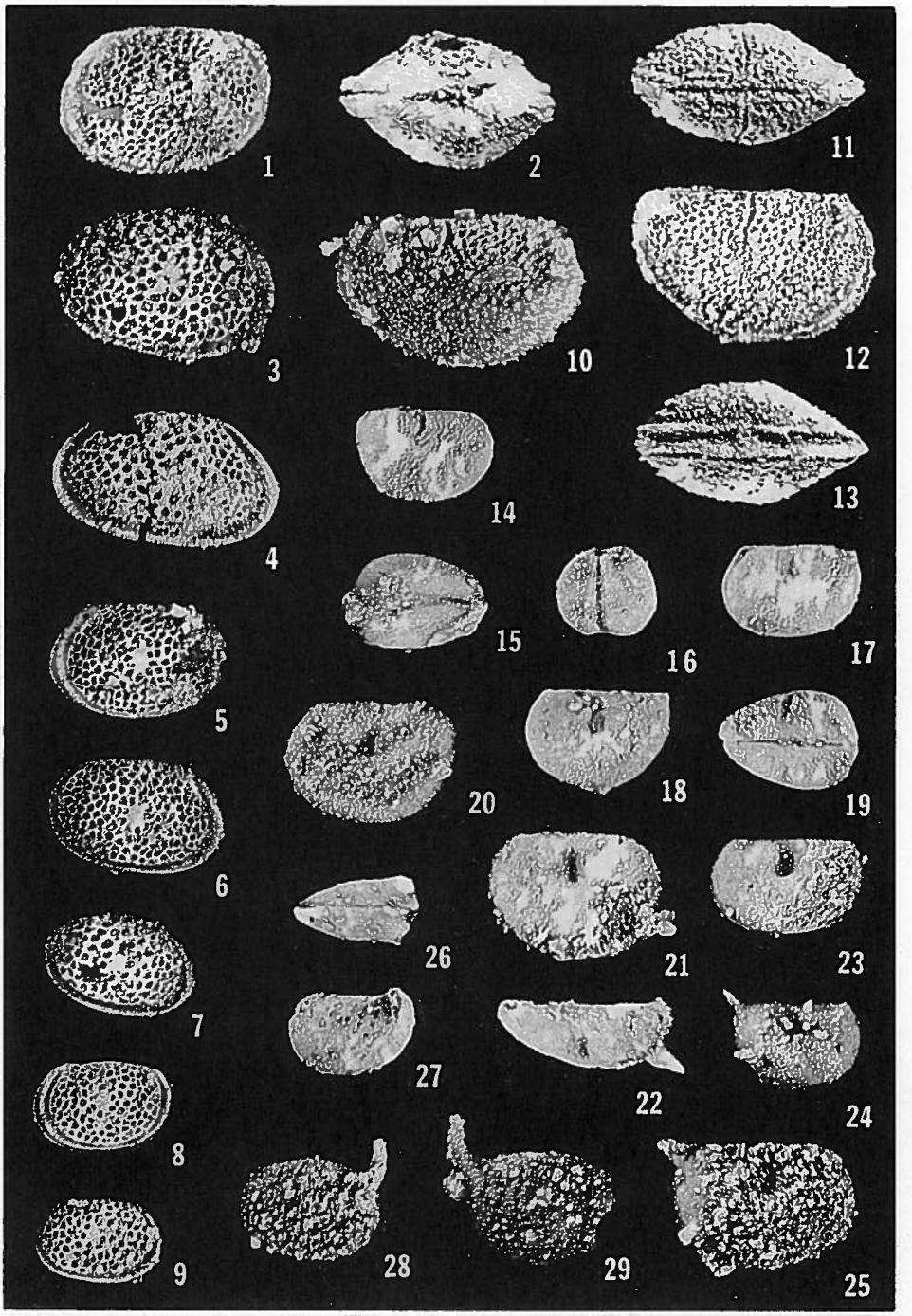
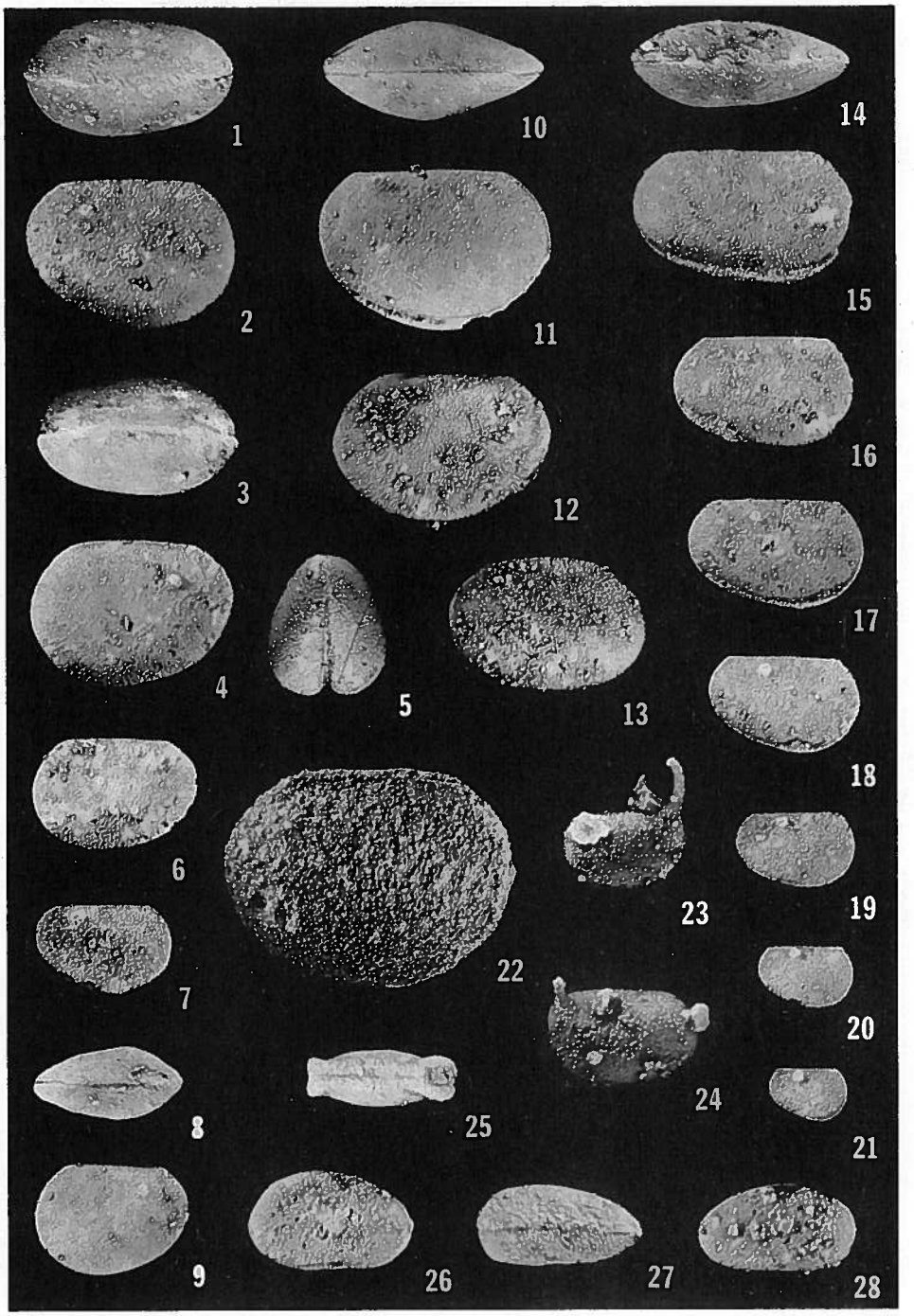


PLATE 8



EXPLANATION OF PLATE 8

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X15, except where noted

Figures 1-7: *Paraparchites pinguis*, n. sp.; 1, 2—dorsal and right views of complete carapace, holotype PO. 0110; 3, 4, 5—dorsal, left and end views of complete carapace, paratype PO. 0111; 6—left view of complete carapace, paratype PO. 0112; 7—right view of complete carapace X20, paratype PO. 0113; all specimens from RG-57-11-2, Sunwapta Pass ..... (p. 126)

Figures 8, 9: *Paraparchites* sp. cf. *P. pinguis*, n. sp.; 8—dorsal view of complete carapace X20, figured specimen PO. 0114; 9—left view of complete carapace X20, figured specimen PO. 0115; both specimens from Peace River region ..... (p. 127)

Figures 10, 11: *Paraparchites nicklesi* (Ulrich); 10, 11—dorsal and right views of complete carapace X20, hypotype PO. 0116, Peace River region ..... (p. 127)

Figures 12, 13: *Paraparchites* sp. aff. *P. nicklesi* (Ulrich); 12—left valve, figured specimen PO. 0117; 13—right valve, figured specimen PO. 0118; both specimens from RG 57-10-1, Jasper ..... (p. 128)

Figures 14-21: *Paraparchites productus*, n. sp.; 14, 15—dorsal and right views of complete carapace, holotype PO. 0103; 16—right view of complete carapace, paratype PO. 0104; 17—right view of complete carapace X20, paratype PO. 0105; 18—right view of complete carapace X20, paratype PO. 0106; 19—right view of complete carapace X20, paratype PO. 0107; 20—right view of complete carapace X20, paratype PO. 0108; 21—right view of complete carapace X20, paratype PO. 0109; all specimens from RG 57-11-2, Sunwapta Pass. (p. 125)

Figure 22: *Paraparchites* sp. cf. *P. nicklesi* (Ulrich); left view of complete carapace, figured specimen PO. 0176, RG 56-3-51, Banff ..... (p. 128)

Figures 23, 24: *Pseudoparaparchites* sp. cf. *P. montis*, n. sp.; 23—left valve X30, figured specimen PO. 0093; 24—right valve X40, figured specimen PO. 0094; both specimens from RG 56-1-42, Banff ..... (p. 130)

Figure 25: *Moorites* sp.; dorsal view of carapace X40, figured specimen PO. 0164, Peace River region ..... (p. 88)

Figures 26-28: *Bythocyproidea punctata*, n. sp.; 26, 27—right and dorsal views of complete carapace X40, holotype PO. 0308; 28—left valve X40, paratype PO. 0309; both specimens from Peace River region ..... (p. 168)

Explanation of Plate 9

Banff Formation

Banff, Jasper and Peace River region

Magnifications about X40, except where noted

Figures 1-6: *Editia albertensis*, n. sp.; 1, 2, 3—left, dorsal and end views of complete carapace, holotype PO. 0016, Peace River region; 4—right valve, paratype PO. 0018, Peace River region; 5—right valve, paratype PO. 0017, Peace River region; 6—left valve, paratype PO. 0019, RG 56-4-75, Banff ..... (p. 131)

Figures 7-9: *Editia brayeri*, n. sp.; 7—left valve, paratype PO. 0022, RG 56-3-43, Banff; 8—right valve, paratype PO. 0021, RG 56-3-43, Banff; 9—right valve, holotype PO. 0020, RG 56-3-40, Banff. (p. 132)

Figures 10, 11: *Bairdia* sp. aff. *B. egorovi* Sohn; 10, 11—right and dorsal views of complete carapace X15, figured specimen PO. 0271, RG 56-4-75, Banff ..... (p. 135)

Figures 12-14: *Bairdia* sp. aff. *B. grahamensis* Harlton; 12—right valve X15, figured specimen PO. 0273; 13, 14—outside and inside views of left valve X15, figured specimen PO. 0272; specimens belong to the same carapace, from RG 56-3-51, Banff ..... (p. 136)

Figures 15, 16: *Bairdia kinderhookensis* Morey; 15, 16—right and dorsal views of complete carapace X20, hypotype PO. 0274, RG 57-10-1, Jasper ..... (p. 137)

Figure 17: *Bairdia* sp. aff. *B. kinderhookensis* Morey; right view of complete carapace X20, figured specimen PO. 0275, RG 57-10-1, Jasper ..... (p. 137)

Figures 18, 19: *Bairdia* sp. aff. *B. whitesidei* Bradfield; 18, 19—right and dorsal views of complete carapace X20, figured specimen PO. 0276, RG 57-10-1, Jasper ..... (p. 137)

Figure 20: *Bairdia* sp. A; right view of complete carapace X15, figured specimen PO. 0277, RG 56-4-79, Banff ..... (p. 138)

Figure 21: *Bairdia* (*?Rectobairdia*) sp. C; right view of complete carapace X20, figured specimen PO. 0279, RG 56-3-51, Banff ..... (p. 139)

Figure 22: *Bairdia* sp. B; right view of complete carapace X30, figured specimen PO. 0278, Peace River region ..... (p. 138)

Figures 23, 24: *Bairdia* sp. D; 23, 24—right and dorsal views of complete carapace X15, figured specimen PO. 0280, RG-56-4-75, Banff. (p. 140)

PLATE 9

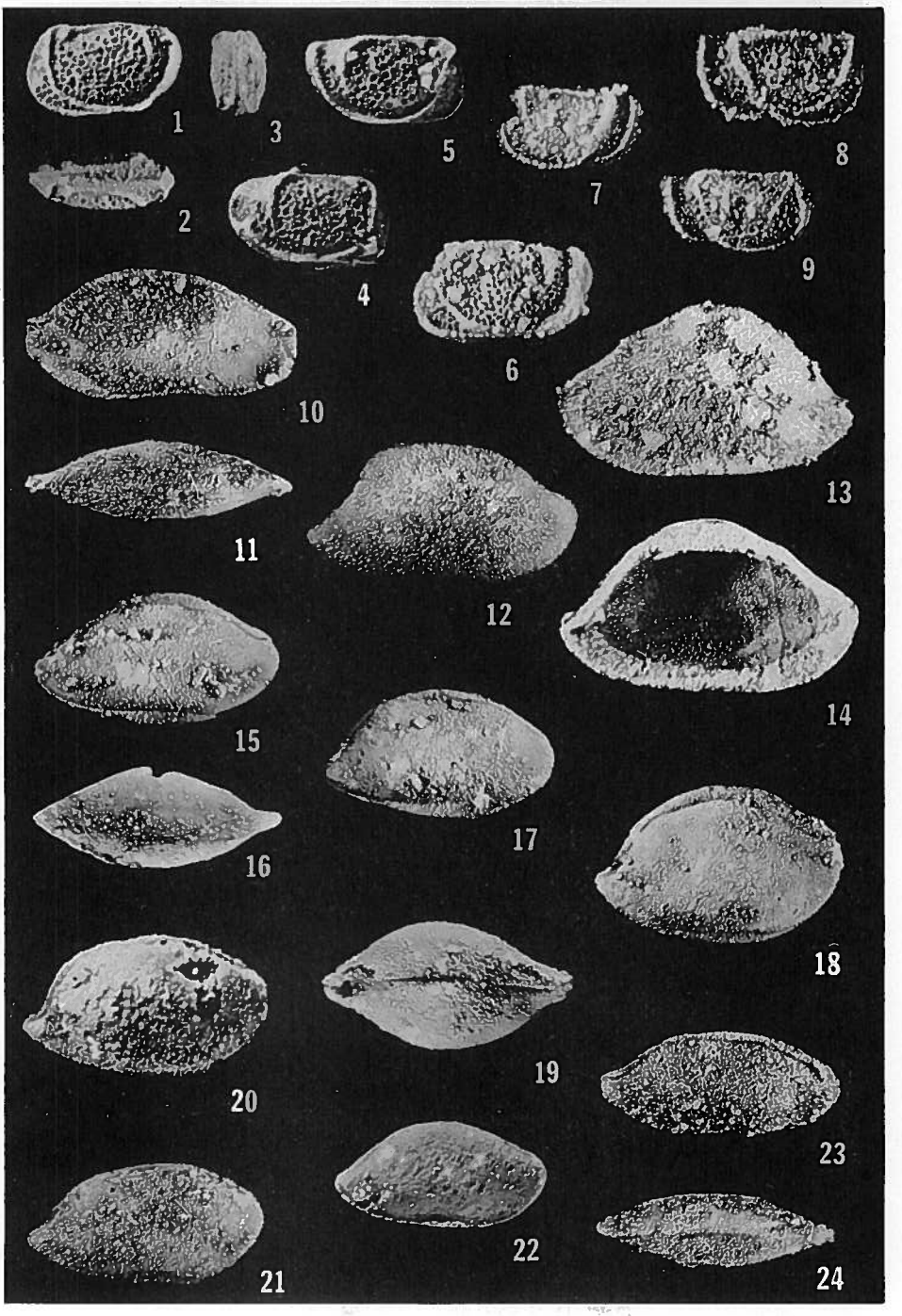
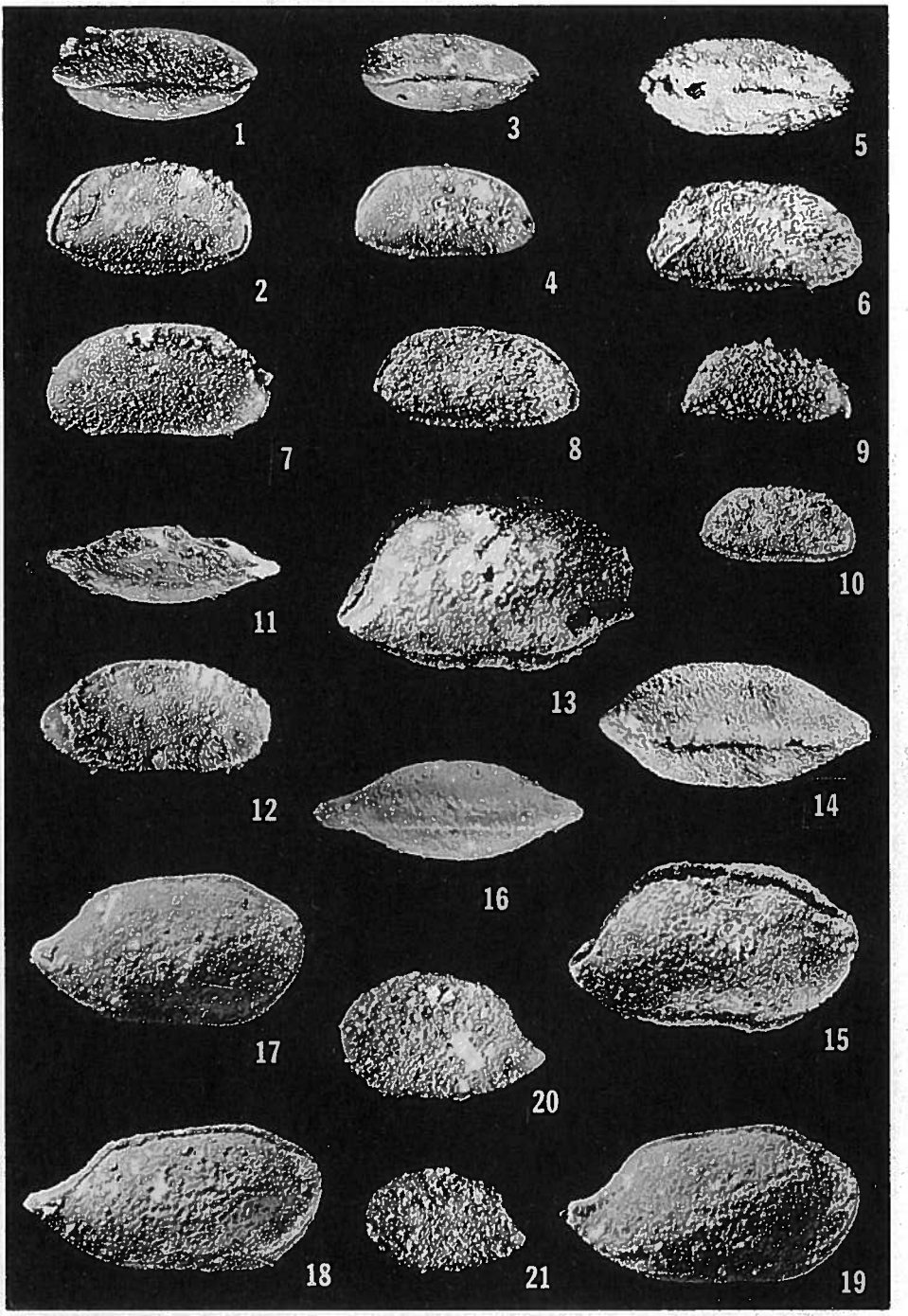


PLATE 10



Explanation of Plate 10

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X20, except where noted

Figures 1-4, 7: *Acratia fabaeformis*, n. sp.; 1, 2—dorsal and right views of complete carapace, holotype PO. 0264, RG 56-4-75, Banff; 3, 4—dorsal and right views of complete carapace, paratype PO. 0265, RG 57-11-1, Sunwapta Pass; 7—left valve, paratype PO. 0266, RG 56-4-75, Banff ..... (p. 141)

Figures 5, 6, 8: *Acratia* sp. cf. *A. similaris* Morey; 5, 6—dorsal and right views of complete carapace, figured specimen PO. 0268; 8—right view of complete carapace, figured specimen PO. 0269; both specimens from RG 56-3-51, Banff ..... (p. 142)

Figure 9: *Acratia similaris* Morey; right valve, hypotype PO. 0267, RG 56-4-26A, Banff ..... (p. 142)

Figure 10: *Acratia* sp.; right view of complete carapace, figured specimen PO. 0270, RG 57-10-1, Jasper ..... (p. 142)

Figures 11, 12: *Bairdiacypris*? sp.; 11, 12—dorsal and right views of complete carapace X15, figured specimen PO. 0304, RG 60-1-12, Jasper ..... (p. 143)

Figures 13-15: *Orthobairdia* sp.; 13, 14—right and dorsal views of complete carapace X15, figured specimen PO. 0302; 15—right view of complete carapace X15, figured specimen PO. 0303; both specimens from RG 56-4-73, Banff ..... (p. 144)

Figures 16-19: *Rectobairdia confragosa*, n. sp.; 16, 17—dorsal and right views of complete carapace X30, holotype PO. 0283; 18—right view of complete carapace X30, paratype PO. 0285; 19—right view of complete carapace X30, paratype PO. 0284; all specimens from RG 57-11-1, Sunwapta Pass ..... (p. 145)

Figures 20, 21: *Cryptobairdia* sp. aff. *C. compacta* (Geis); 20—left valve X30, figured specimen PO. 0281; 21—left valve X30, figured specimen PO. 0282; both specimens from Peace River region ..... (p. 143)

EXPLANATION OF PLATE 11

Banff Formation

Jasper, Sunwapta Pass and Peace River region

Magnifications about X20, except where noted

Figures 1-6: *Rectobairdia* sp. aff. *R. fragosa* (Morey); 1, 2—right and dorsal views of complete carapace, figured specimen PO. 0288; 3—right view of complete carapace, figured specimen PO. 0287; 4, 5—right and dorsal views of complete carapace, figured specimen PO. 0289; 6—right view of complete carapace, figured specimen PO. 0290; all specimens from RG 57-11-1, Sunwapta Pass ..... (p. 146)

Figures 7, 8: *Rectobairdia* sp. cf. *R. distressa* (Geis); 7, 8—right and dorsal views of complete carapace X30, figured specimen PO. 0286, RG 57-10-1, Jasper ..... (p. 146)

Figures 9-12: *Rectobairdia subparallela* (Morey); 9, 10—right and dorsal views of complete carapace X15, hypotype PO. 0297, RG 57-11-1, Sunwapta Pass; 11, 12—right and dorsal views of complete carapace X15, hypotype PO. 0298, Peace River region ..... (p. 150)

Figures 13-16: *Rectobairdia morroensis*, n. sp.; 13—right view of complete carapace, paratype PO. 0292, RG 60-1-12, Jasper; 14—right view of complete carapace, paratype PO. 0293, RG 57-10-1, Jasper; 15, 16—right and dorsal views of complete carapace, holotype PO. 0291, RG 60-1-12, Jasper ..... (p. 148)

Figures 17-21: *Rectobairdia* sp. cf. *R. sinuosa* (Morey); 17—right view of complete carapace, figured specimen PO. 0295; 18, 19—right and dorsal views of complete carapace, figured specimen PO. 0294; 20, 21—right and dorsal views of complete carapace, figured specimen PO. 0296; all specimens from Peace River region ..... (p. 148)

PLATE 11

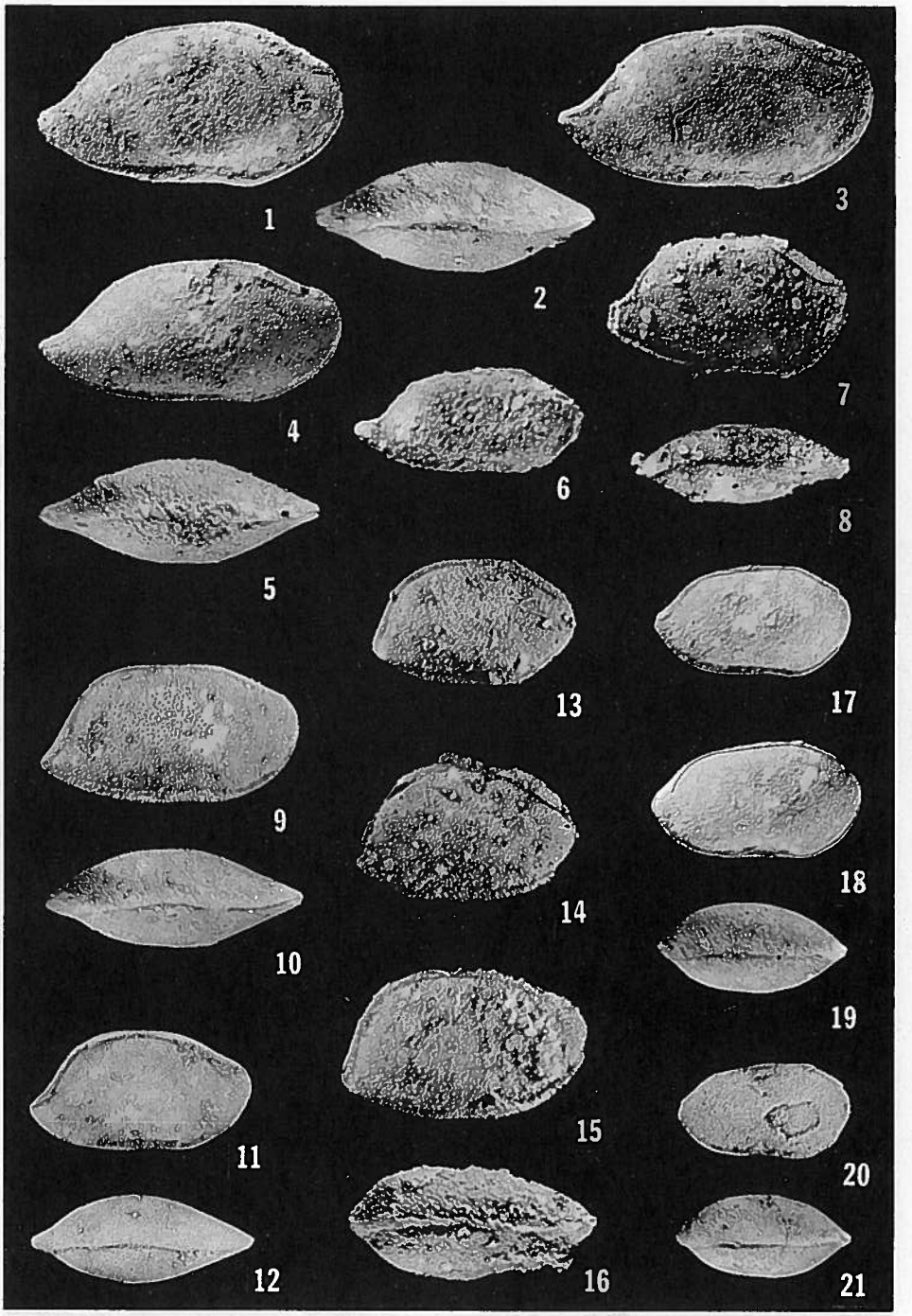
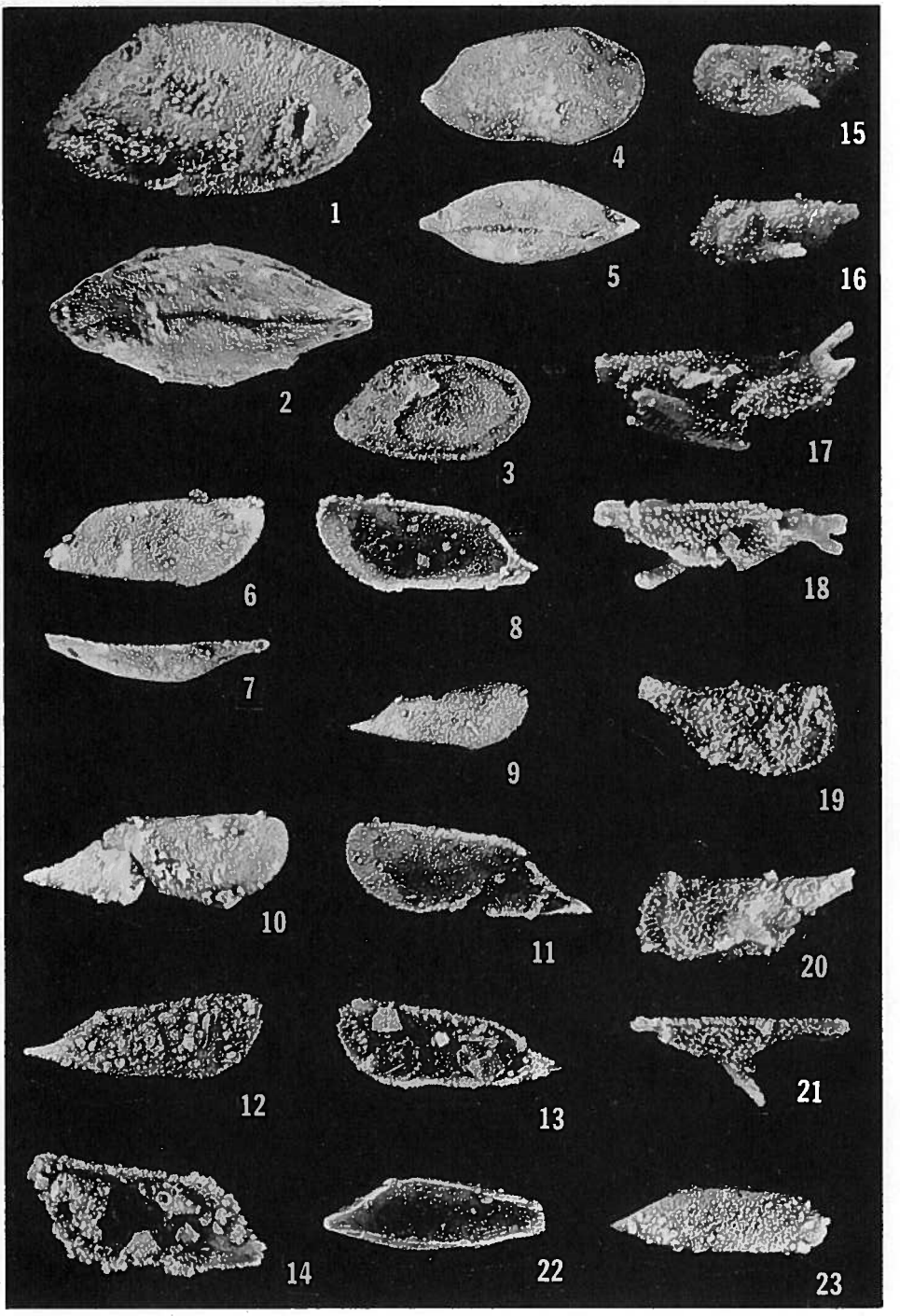


PLATE 12



EXPLANATION OF PLATE 12

Banff Formation

Banff, Jasper and Peace River region

Magnifications about X30, except where noted

Figures 1-3: *Rectobairdia* sp. A; 1, 2—right and dorsal views of complete carapace X20, figured specimen PO. 0299; 3—right view of carapace with part of right valve missing X20, figured specimen PO. 0300; both specimens from RG 60-1-12, Jasper ..... (p. 150)

Figures 4, 5: *Rectobairdia* sp. B; 4, 5—right and dorsal views of complete carapace, figured specimen PO. 0301, Peace River region ..... (p. 151)

Figures 6-14: *Acanthoscapha*? *banffensis*, n. sp.; 6, 7, 8—outside, dorsal and inside views of right valve, holotype PO. 0312, RG 56-1-42, Banff; 9—right valve, paratype PO. 0315, RG 56-1-42, Banff; 10, 11—outside and inside views of right valve, paratype PO. 0316, RG 56-4-75, Banff; 12, 13—outside and inside views of right valve, paratype PO. 0314, RG 56-1-42, Banff; 14—inside view of right valve, paratype PO. 0313, RG 56-1-42, Banff ..... (p. 152)

Figures 15-18: *Kirkbyellina* sp. A; 15—left valve X40, figured specimen PO. 0318; 16—left valve X40, figured specimen PO. 0319; 17, 18—outside and dorsal views of incomplete right valve X40, figured specimen PO. 0317; all specimens from RG 56-1-42, Banff ..... (p. 154)

Figures 19-21: *Kirkbyellina* sp. B; 19—right valve X40, figured specimen PO. 0321; 20, 21—outside and dorsal views of left valve X40, figured specimen PO. 0320; both specimens from RG 56-3-40, Banff. (p. 155)

Figures 22, 23: *Hastacypris* sp.; 22—inside view of left valve, figured specimen PO. 0310; 23—right valve, figured specimen PO. 0311; both specimens from RG 56-4-26A, Banff ..... (p. 154)

EXPLANATION OF PLATE 13

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X40, except where noted

Figures 1-3: *Monoceratina* sp. cf. *M. tennesseensis* (Ulrich and Bassler); 1, 2—outside and dorsal views of left valve X30, figured specimen PO. 0322; 3—incomplete right valve X30, figured specimen PO. 0323; both specimens from RG 56-4-75, Banff ..... (p. 155)

Figures 4-6: *Monoceratina tricostata*, n. sp.; 4—left valve, paratype PO. 0325; 5, 6—outside and dorsal views of right valve, holotype PO. 0324; both specimens from RG 57-10-1, Jasper ..... (p. 156)

Figures 7, 8: *Monoceratina* sp. A; 7—left valve, figured specimen PO. 0330; 8—left valve, figured specimen PO. 0331; both specimens from RG 57-10-1, Jasper ..... (p. 159)

Figures 9-12: *Monoceratina virgata*, n. sp.; 9—right valve, holotype PO. 0326, RG 57-10-1, Jasper; 10—dorsal view of complete carapace, paratype PO. 0329, RG 56-3-41, Banff; 11—right valve, paratype PO. 0327, RG 57-10-1, Jasper; 12—left valve, paratype PO. 0328, RG 56-1-42, Banff ..... (p. 158)

Figure 13: *Monoceratina* sp. B; right valve, figured specimen PO. 0332, RG 57-10-1, Jasper ..... (p. 160)

Figure 14: *Monoceratina* sp. C; right valve, figured specimen PO. 0333, RG 57-10-1, Jasper ..... (p. 160)

Figure 15: *Healdia* sp.; right valve, figured specimen PO. 0190, RG 56-4-26A, Banff ..... (p. 160)

Figure 16: *Seminolites*? sp.; right valve, figured specimen PO. 0200, RG 56-1-42, Banff ..... (p. 165)

Figures 17-20: *Cribroconcha triquetra*, n. sp.; 17, 18—right and dorsal views of complete carapace, holotype PO. 0187, RG 57-11-1, Sunwapta Pass; 19—right view of complete carapace, paratype PO. 0189, RG 60-1-12, Jasper; 20—left valve, paratype PO. 0188, RG 56-4-75, Banff ..... (p. 161)

Figures 21-26: *Seminolites nelsoni*, n. sp.; 21, 22, 23—right, left and dorsal views of complete carapace, holotype PO. 0191; 24—incomplete right valve, paratype PO. 0192; 25—left valve, paratype PO. 0193; 26—right valve, paratype PO. 0194; all specimens from Peace River region ..... (p. 162)

Figures 27-32: *Seminolites stelcki*, n. sp.; 27, 28—dorsal and right views of complete carapace, holotype PO. 0195; 29—right view of complete carapace, paratype PO. 0196; 30—incomplete left valve, paratype PO. 0197; 31—left valve, paratype PO. 0199; 32—left view of complete carapace, paratype PO. 0198; all specimens from Peace River region ..... (p. 164)

Figures 33-36: *Paracavellina indistincta*, n. sp.; 33, 34—dorsal and left views of complete carapace X30, holotype PO. 0202; 35—left view of complete carapace X30, paratype PO. 0203; 36—left view of complete carapace X30, paratype PO. 0204; all specimens from Peace River region ..... (p. 167)

PLATE 13

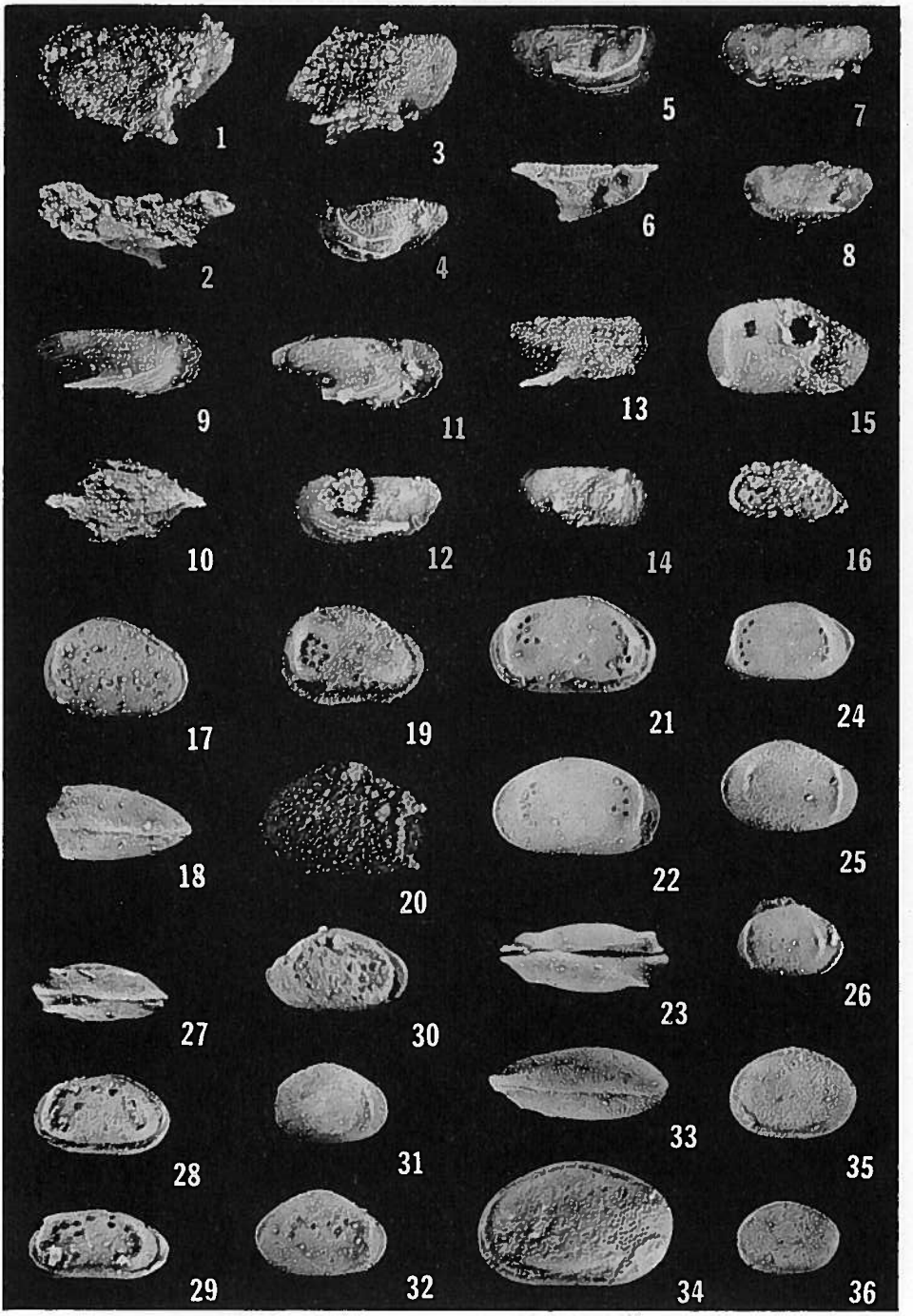

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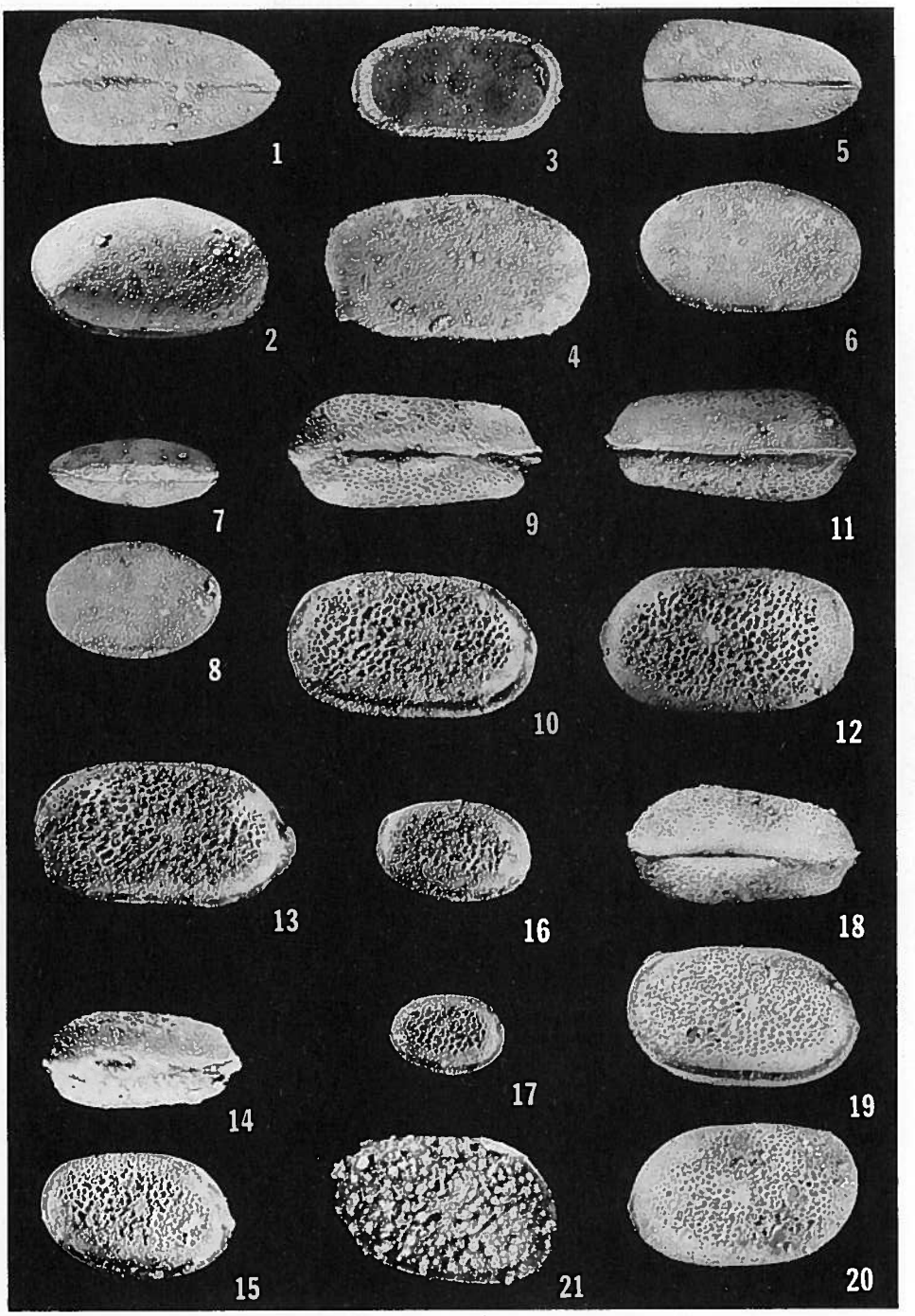
PLATE 14



EXPLANATION OF PLATE 14

Banff and Exshaw Formations

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X30, except where noted

Figures 1-6: *Waylandella*? *punctata*, n. sp.; 1, 2—dorsal and right views of complete carapace, holotype PO. 0179, Peace River region; 3—inside of right valve, paratype PO. 0180, RG 56-4-26A, Banff; 4—right view of carapace, paratype PO. 0182, RG 57-11-1, Sunwapta Pass; 5, 6—dorsal and right views of complete carapace, paratype PO. 0181, Peace River region ..... (p. 166)

Figures 7, 8: *Sulcella* sp.; 7, 8—dorsal and left views of complete carapace, figured specimen PO. 0201, Peace River region ..... (p. 168)

Figures 9-20: *Eriella*? *cribraria*, n. sp.; 9, 10, 11, 12—dorsal, right, ventral and left views of complete carapace, holotype PO. 0259; 13—right view of complete carapace, paratype PO. 0260; 14, 15—dorsal and right views of complete carapace, paratype PO. 0261; 16—right view of complete carapace, paratype PO. 0262; 17—right view of complete carapace, paratype PO. 0263; 18, 19, 20—dorsal, right and left views of complete carapace, paratype PO. 0063; all specimens from Peace River region ..... (p. 177)

Figure 21: *Eriella*? sp.; right valve, figured specimen PO. 0222, RG 57-10-1, Jasper ..... (p. 179)

Explanation of Plate 15

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X30, except where noted

Figures 1-9, 11, 12: *Craspedographylus acrolimbus*, n. gen., n. sp.; 1, 2, 4—dorsal, left and right views of complete carapace, holotype PO. 0205; 3—ventral view of complete carapace, paratype PO. 0208; 5—dorsal view of complete carapace, paratype PO. 0207; 6—left view of carapace lacking anterior horn, paratype PO. 0206; 7, 8—dorsal and left views of complete carapace, paratype PO. 0209; 9—right view of complete carapace, paratype PO. 0210; 11, 12—outside and inside views of right valve, paratype PO. 0211; types PO. 0205-10 from RG 57-11-2, Sunwapta Pass, type PO. 0211 from RG 56-4-26A, Banff ..... (p. 189)

Figures 10, 18: *Craspedographylus* sp. C; 10—right valve, figured specimen PO. 0215; 18—left valve X40, figured specimen PO. 0214; both specimens from RG 56-1-42, Banff ..... (p. 193)

Figures 13-15: *Craspedographylus*? *inornatus*, n. sp.; 13, 14, 15—right, dorsal and left views of complete carapace, holotype PO. 0223, Peace River region ..... (p. 191)

Figures 16, 17: *Craspedographylus* sp. D; 16—right valve X40, figured specimen PO. 0015; 17—right valve X40, figured specimen PO. 0221; both specimens from RG 56-1-42, Banff ..... (p. 194)

Figures 19, 20: *Craspedographylus* sp. A; 19—left valve, figured specimen PO. 0212; 20—left valve, figured specimen PO. 0213; both specimens from RG 56-4-75, Banff ..... (p. 192)

Figures 21, 22: *Craspedographylus* sp. B; 21—left valve, figured specimen PO. 0224; 22—left valve, figured specimen PO. 0225; both specimens from RG 56-3-51, Banff ..... (p. 193)

Figures 23-26: *Craspedographylus comptilimbus*, n. gen., n. sp.; 23—right valve, paratype PO. 0217, RG 56-4-26A, Banff; 24—right valve, holotype PO. 0216, RG 56-4-26A, Banff; 25, 26—right and dorsal views of complete carapace, paratype PO. 0218, RG 56-4-75, Banff ..... (p. 190)

PLATE 15

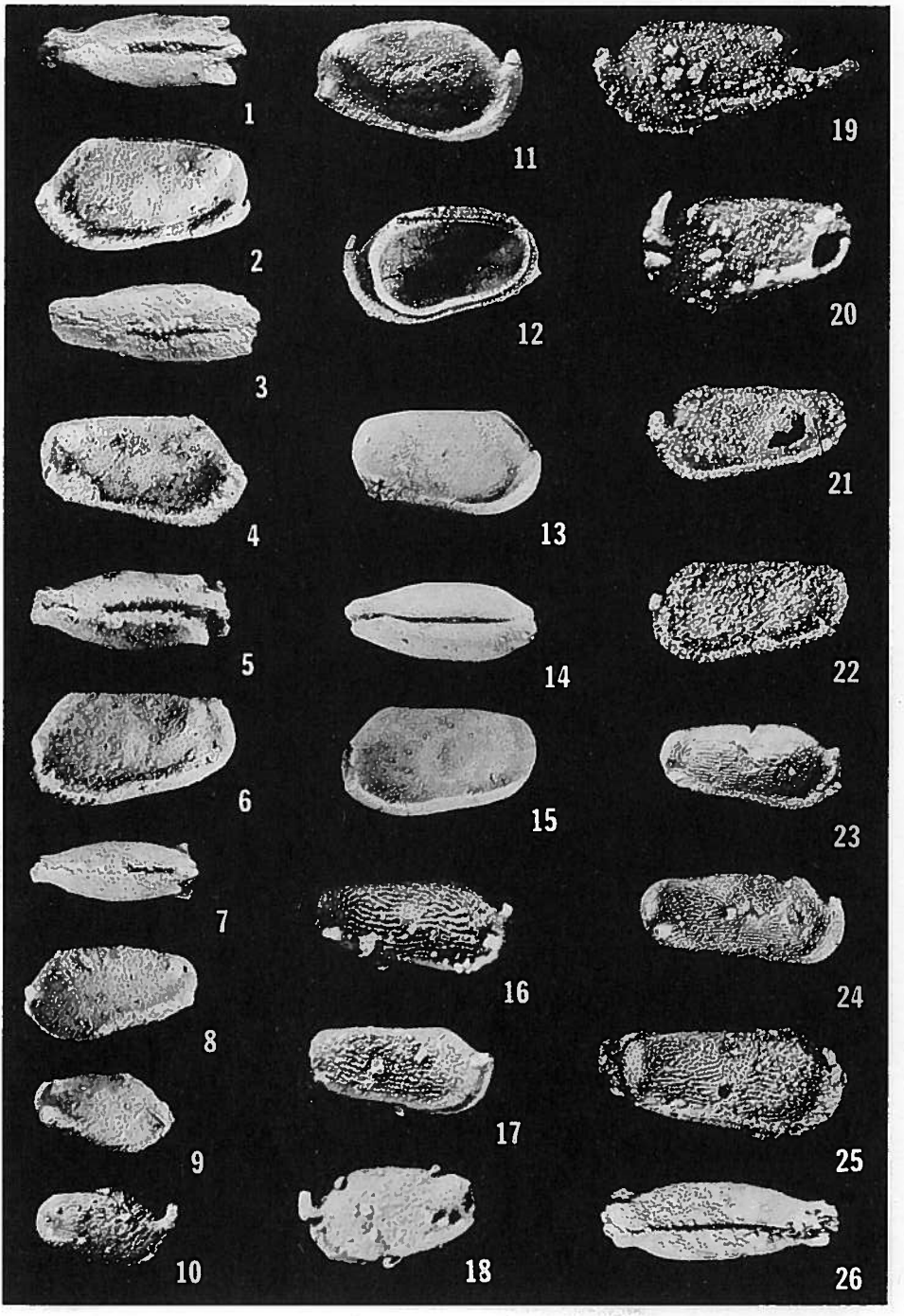
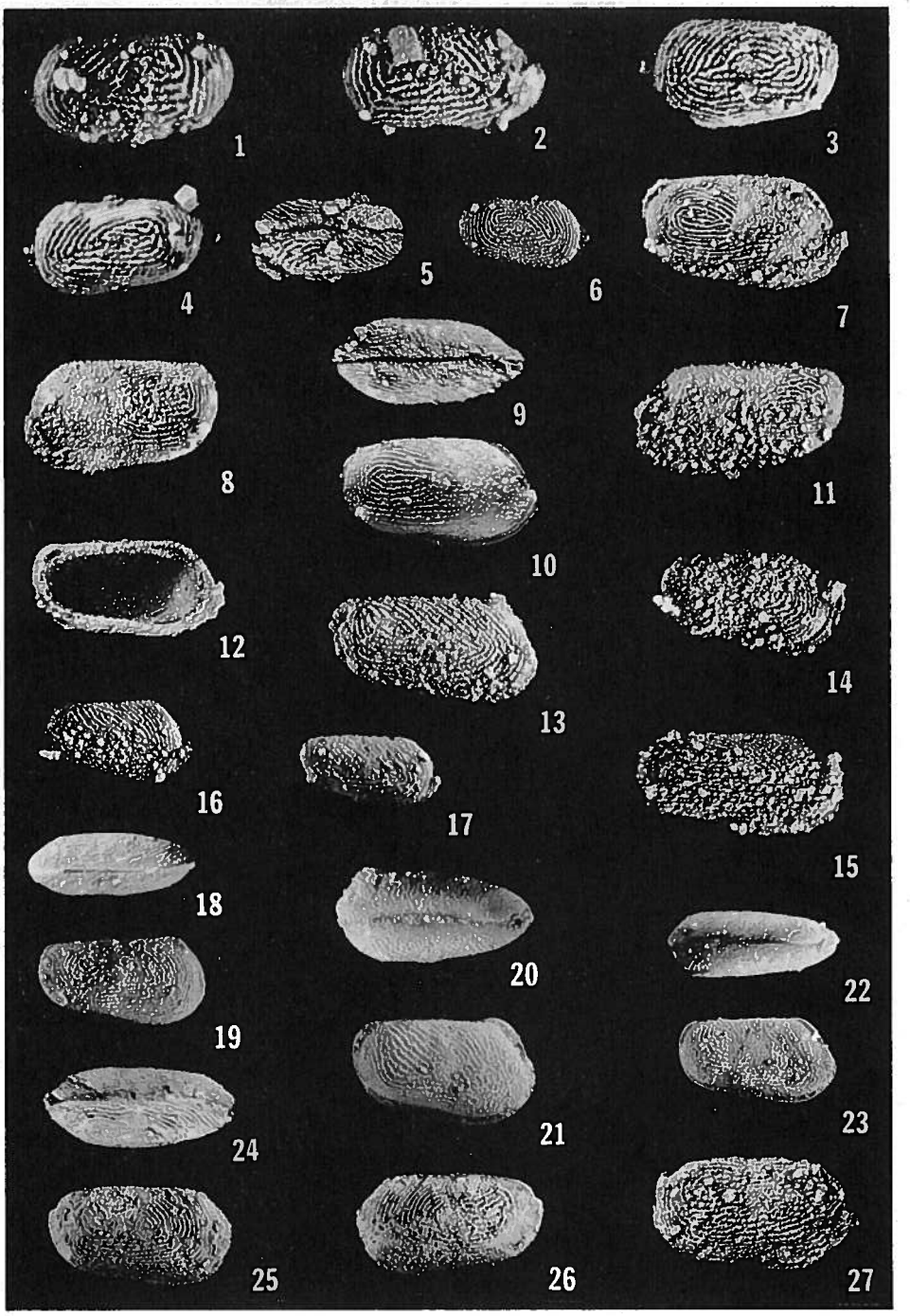


PLATE 16



EXPLANATION OF PLATE 16

Banff Formation

Banff, Jasper, Sunwapta Pass and Peace River region

Magnifications about X30, except where noted

Figures 1-6: *Graphiadactylloides striatoreticulatus*, n. sp.; 1—left valve X40, paratype PO. 0250, RG 57-10-1, Jasper; 2—right valve X40, paratype PO. 0249, RG 57-10-1, Jasper; 3—incomplete left valve X40, paratype PO. 0247, RG 56-1-42, Banff; 4—left valve X40, paratype PO. 0246, RG 56-1-42, Banff; 5—dorsal view of incomplete carapace, paratype PO. 0248, RG 56-1-42, Banff; 6—right valve, holotype PO. 0245, RG 56-1-42, Banff ..... (p. 184)

Figures 7-10, 12: *Graphiadactylloides moreyi*, n. sp.; 7—right view of complete carapace, paratype PO. 0230; 8—left view of complete carapace, paratype PO. 0232; 9, 10—dorsal and right views of complete carapace, holotype PO. 0229; 12—inside view of left valve, paratype PO. 0231; all specimens from RG 56-4-26A, Banff ..... (p. 180)

Figure 11: *Graphiadactylloides* sp. cf. *G. moreyi*, n. sp.; left valve, figured specimen PO. 0233, RG 56-4-75, Banff ..... (p. 182)

Figure 13: *Graphiadactylloides* sp. A; right view of complete carapace, figured specimen PO. 0255, RG 56-4-83, Banff ..... (p. 186)

Figure 14: *Graphiadactylloides* sp. aff. *G. moreyi*, n. sp.; right valve, figured specimen PO. 0234, RG 56-4-75, Banff ..... (p. 182)

Figure 15: *Graphiadactylloides moridgei* (Benson); right valve, hypotype PO. 0235, RG 56-4-75, Banff ..... (p. 182)

Figures 16, 17: *Graphiadactylloides* sp. aff. *G. moridgei* (Benson); 16—right valve, figured specimen PO. 0254, RG 56-4-75, Banff; 17—right valve, figured specimen PO. 0236, RG 57-11-1, Sunwapta Pass. (p. 183)

Figures 18, 19, 24-26: *Graphiadactyllis* sp. A; 18, 19—dorsal and right views of complete carapace, figured specimen PO. 0228; 24, 25, 26—dorsal, right and left views of complete carapace, figured specimen PO. 0227; both specimens from Peace River region ..... (p. 174)

Figures 20-23: *Graphiadactyllis subrhomboidalis*, n. sp.; 20, 21—dorsal and right views of complete carapace, holotype PO. 0251; 22, 23—dorsal and right views of complete carapace, paratype PO. 0252; both specimens from Peace River region ..... (p. 173)

Figure 27: *Eriella*? sp. cf. *E.*? *lineata* (Ulrich and Bassler); right view of incomplete carapace, figured specimen PO. 0226, RG 56-4-26A, Banff ..... (p. 179)

Explanation of Plate 17

Banff Formation

Banff, Jasper, Sunwapta Pass and Moose Mountain

Magnifications about X30, except where noted

Figures 1-5: *Graphiadactylloides paucituberculatus*, n. sp.; 1—right valve, holotype PO. 0237, RG 56-4-49, Banff; 2—right valve, paratype PO. 0238, RG 56-4-49, Banff; 3—right valve, paratype PO. 0239, RG 56-4-75, Banff; 4—left valve, paratype PO. 0334, RG 56-4-26A, Banff; 5—right valve, paratype PO. 0241, RG 56-4-26A, Banff ..... (p. 183)

Figure 6: *Graphiadactylloides* sp. cf. *G. paucituberculatus*, n. sp.; left valve, figured specimen PO. 0253, RG 56-1-42, Banff ..... (p. 184)

Figure 7: *Graphiadactyllis* sp. B; right view of complete carapace, paratype PO. 0240, RG 57-11-2, Sunwapta Pass ..... (p. 175)

Figure 8: *Graphiadactyllis* sp. C; left valve, figured specimen PO. 0244, RG 56-4-26A, Banff ..... (p. 176)

Figures 9, 12: *Graphiadactylloides* sp. C; 9—right view of a complete carapace, figured specimen PO. 0242; 12—right view of a complete carapace, mashed dorsally, figured specimen PO. 0243; both specimens from RG 57-9-5, Moose Mountain ..... (p. 187)

Figure 10: *Graphiadactylloides* sp. D; incomplete right valve, figured specimen PO. 0256, RG 56-4-26A, Banff ..... (p. 187)

Figures 11, 13: *Graphiadactylloides* sp. B; 11—right valve, figured specimen PO. 0219; 13—right valve, figured specimen PO. 0220; both specimens from RG 56-4-26A, Banff ..... (p. 187)

Figure 14: *Craspedographylus*? sp. E; left valve, figured specimen PO. 0257, RG 56-4-26A, Banff ..... (p. 194)

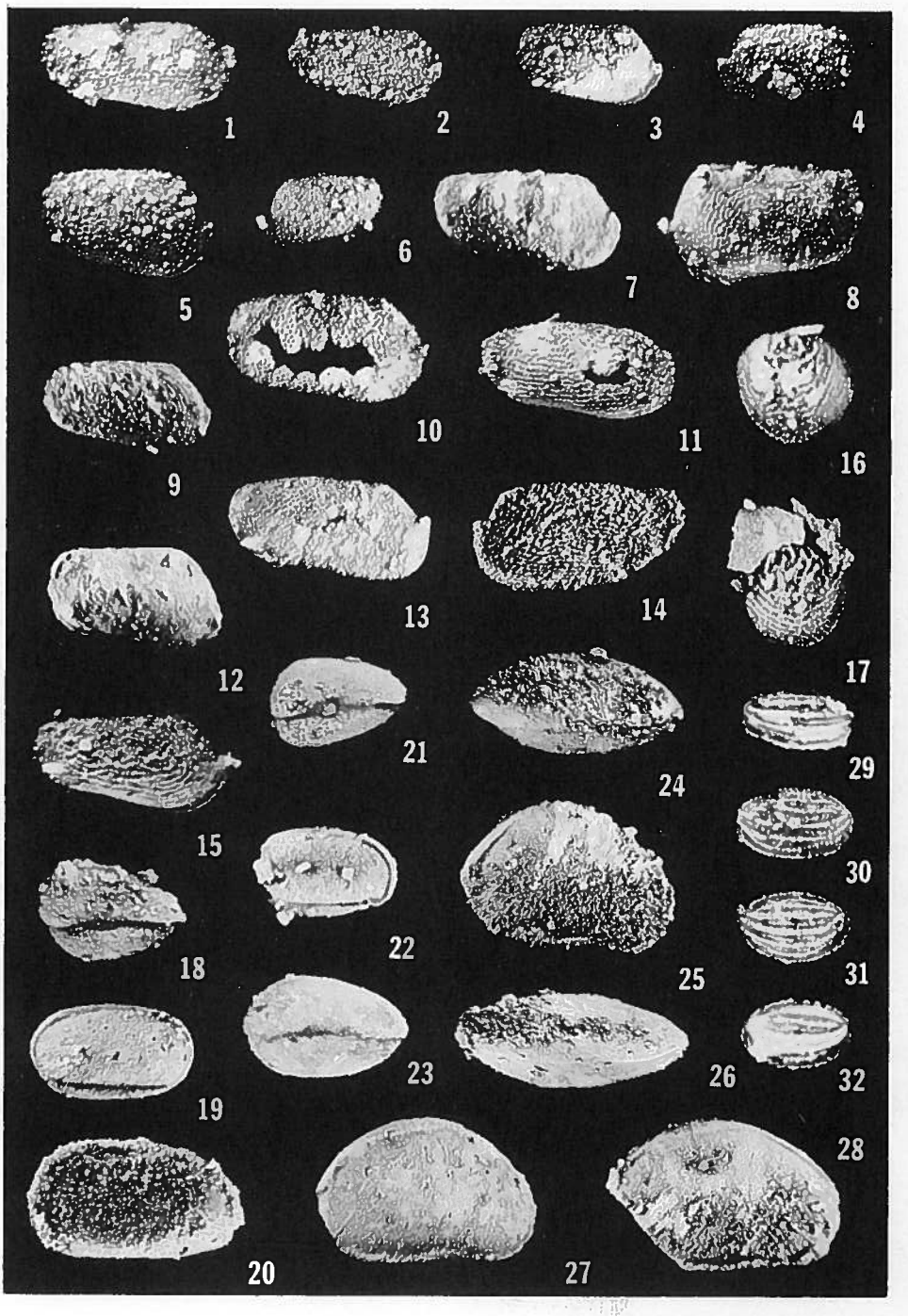
Figure 15: *Graphiadactylloides*? sp. E; right valve X40, figured specimen PO. 0258, RG 56-1-42, Banff ..... (p. 187)

Figures 16, 17: *Discoidella* sp. aff. *D. ampla* Cooper; 16—left valve X40, figured specimen PO. 0165; 17—right valve X40, figured specimen PO. 0166; both specimens from RG 56-1-42, Banff ..... (p. 196)

Figures 18, 20-22: *Microcheilinella* sp. aff. *M. spinosa* (Geis); 18—dorsal view of complete carapace X40, figured specimen PO. 0185, RG 56-4-26A, Banff; 20—right view of complete carapace X40, figured specimen PO. 0186, RG 56-3-52, Banff; 21, 22—dorsal and right views of complete carapace X40, figured specimen PO. 0184, RG 56-4-26A, Banff ..... (p. 194)

Figures 19, 23: *Microcheilinella* sp.; 19, 23—right and dorsal views of complete carapace X40, figured specimen PO. 0183, RG 57-10-1, Jasper ..... (p. 194)

PLATE 17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Figures 24-28: *Silenites* sp. cf. *S. warei* Morey; 24, 25—dorsal and right views of complete carapace X15, figured specimen PO. 0305, RG 56-4-75, Banff; 26, 28—dorsal and right views of incomplete carapace X15, figured specimen PO. 0306, RG 56-4-75, Banff; 27—right view of complete carapace X20, figured specimen PO. 0307, RG 57-11-1, Sunwapta Pass ..... (p. 195)

Figures 29-32: *Richterina* sp. aff. *Fossirichterina intercostata* (Matern); 29—single valve X50, figured specimen PO. 0003, RG 56-3-48, Banff; 30—single valve X50, figured specimen PO. 0001, RG 57-10-1, Jasper; 31—single valve X50, figured specimen PO. 0004, RG 56-3-48, Banff; 32—single valve X50, figured specimen PO. 0002, RG 56-3-48, Banff ..... (p. 195)

AGE | ROCK UNIT | FEET | LITHOLOGY | SAMPLE NUMBER | SECTION NUMBER | ORGANIC REMAINS

KINDERHOOKIAN

BANFF FORMATION

Lower member

Unit 1

Unit 2

Middle member

Unit 3

Unit 4

Upper member

Unit 5

Unit 6

RUNDLE FORMATION

?

RG 56-4

RG 56-3

RG 56-1

Ostracodes

Crinoid fragments

Brachiopod fragments

Hollow spines

Bryozoans

Sponge spicules

Gastropods

Pelecypods

Corals

Fish fragments

Holothurian fragments

Echinoid fragments

LEGEND

Shale, mudstone

Calcareous shale, mudstone

Dolomitic shale, mudstone

Limestone

Limestone, dolomitic

Dolomite

Silt

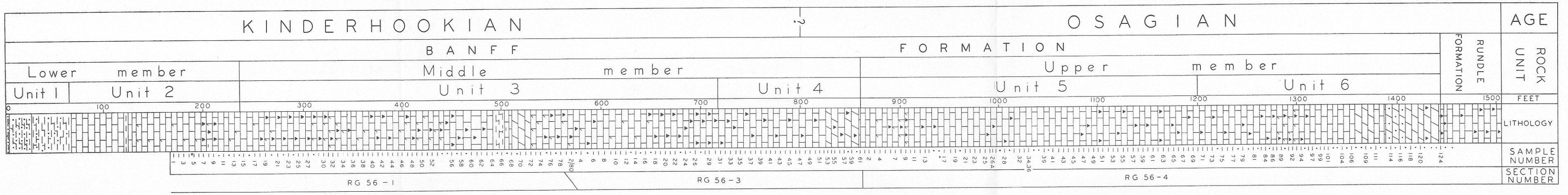
Chert

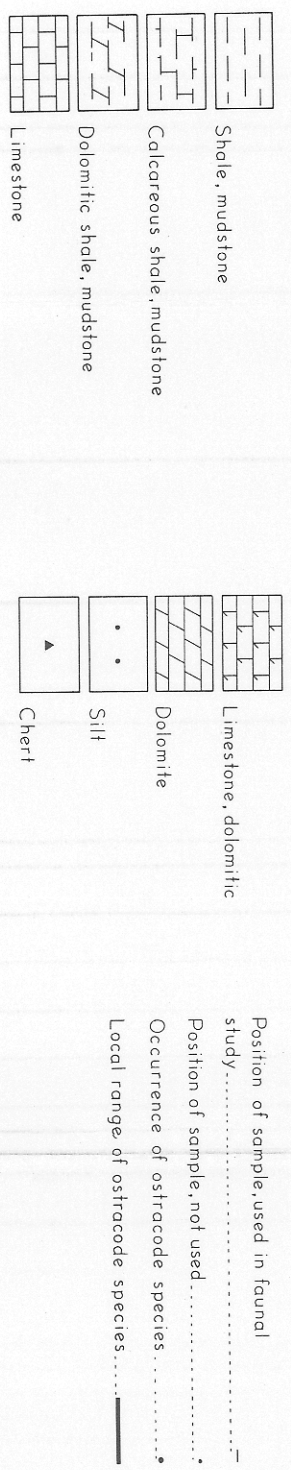
Position of sample, used in faunal study

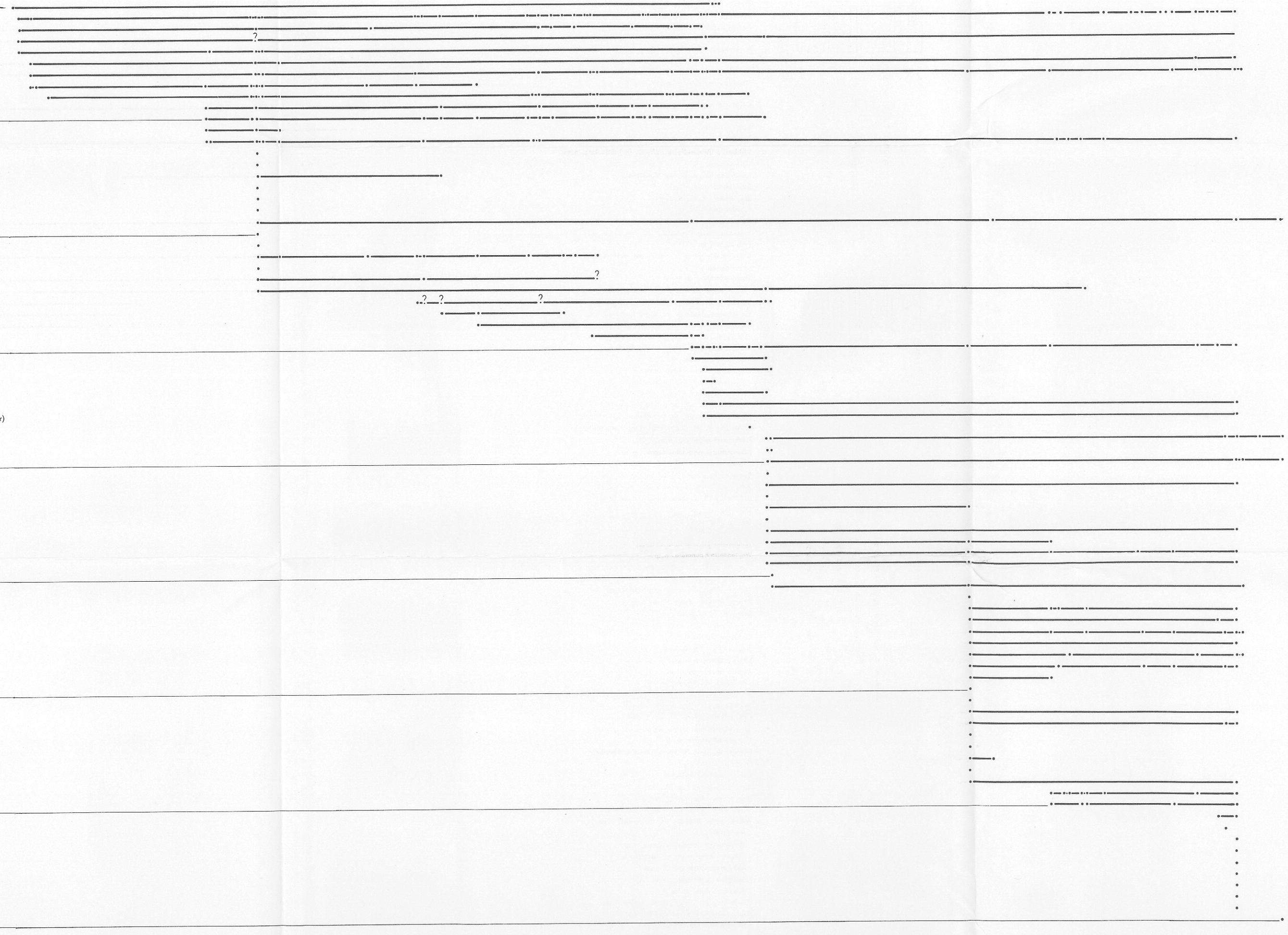
Position of sample, not used

Ostracodes No. of valves	Other fossils
>60	abundant
30-60	common
8-30	occasional
4-8	rare
1-4	very rare

FIGURE 5. STRATIGRAPHIC VARIATION IN TYPES AND ABUNDANCE OF SILICIFIED ORGANIC REMAINS IN THE BANFF FORMATION







SPECIES OCCURRENCES

FIGURE 12. RECORDED RANGES OF OSTRACODE SPECIES IN THE TYPE BANFF FORMATION

FIGURE 13. OSTRACODE SPECIES OF PROBABLE ZONAL AND ECOLOGIC SIGNIFICANCE