MICROPALAEONTOLOGY OF THE MIDDLE AND UPPER DEVONIAN OF NORTHEASTERN ALBERTA, CANADA

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ABSTRACT

This thesis consists of a detailed study of the microfauna and associated megafossil material in the Middle and Upper Devonian sections from 10 boreholes in the McMurray area, Alberta, Canada.

The historical, geological, and palaeontological background of the area is reviewed and a synthesis of the regional setting and stratigraphy is presented. The rock type, grain size, chromal variation and organic content of samples is examined and used to deduct relative rates of deposition. Qualitative and quantitative aspects of the organic material falling within the 20-60 sieve sizes are shown on range charts and percentage distribution charts for each well and species. Identifications of 117 species belonging to 72 genera are listed of which, 36 species and 3 genera are described for the first time. Ecological data from literature and laboratory cultures is applied to the organic content of the McMurray boreholes for palaeoecological interpretation of each formational unit. A selected bibliography of references on ostracode ecology is included as an aid to future research and is followed by a list of over 600 cited references.

Delineation of Middle and Upper Devonian faunas suggests a transitional boundary related to two major biozones, of Givetian and Frasnian age respectively. This boundary is based on the evidence of several fossil groups, and can be correlated into the central Alberta plains by fossils or by associated electrolog characteristics. This is considerably higher in the stratigraphic column than has been suggested in previous publications. The shallow epicontinental seas in this area exhibit enough variation to be divided into supralittoral, littoral, sublittoral, arid lagoonal, humid lagoonal and epineritic environments. These environments and boundary between Middle and Upper Devonian are carried into western and central Alberta.

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CHAPTER I INTRODUCTION AND SCOPE

This thesis originated as an outcome of palaeontological work done while employed in the petroleum industry and the desire to investigate more fully the fauna present in Western Canada in proximity to adequate museum and library facilities. Since only one preliminary paper has been published on the Devonian microfaunas in this region it was evident that the initial stage would be identification and description of species by comparison to museum collections.

The present study was therefore undertaken with two principal objectives

(a) to identify Upper and Middle Devonian faunas in the selected area and to suggest a possible boundary between them

(b) to obtain a better understanding of palaeological conditions under which these forms lived.

An area was selected where adequate cored samples were available and known to contain well preserved, relatively unaltered and varied faunas that would lend themselves to qualitative and quantitative studies. The McMurray area of northeastern Alberta had been explored by the Bear Oil Company during the period 1948-50. This company had drilled a series of boreholes into the Devonian and had taken continuous or almost continuous cores throughout, thus providing an unequalled opportunity for the study of Middle and Upper sediments in this area. Geologically

the area is located on the flank of the Pre Cambrian Shield, normal to the Alberta shelf or borderland paralleling the deeper Devonian seas. Equally diverse faunas are present, in the deeper parts of the basin but metamorphism due to mountain building has had a pronounced effect on their preservation. Also, due to the greater drilling depths and prohibitive coring costs, little cored data is available.

The faunas obtained from these samples were compared to type collections and/or discussed with specialists at the British Museum (Natural History); Geological Survey of Great Britain; University of Glasgow; University of Exeter; Geological Institute, University of Stockholm; Palaeontological Institute, Uppsala; Palaeontological Institute, University of Oslo; Geological Institute and Senckenberg Museum, Frankfurt-Am-Main. The material was compared to previous collections made by the author and identified by comparison to the University of Illinois collection. The Middle/Upper Devonian boundary in England and Germany was compared to the borehole sections but proved to be somewhat disappointing, direct comparisons being impossible due to dissimilar biotas.

At the time this project was undertaken no extensive ecological ostracoda bibliography had appeared, such as are available for other orders, so that some time was devoted to the preparation of a list for immediate use. References which have not been specifically cited in the treatment of ostracoda have been placed in a supplementary list (Appendix D)

This investigation has shown a number of directions in which additional research can be directed. Additional samples, either from boreholes or outcrop, will be required to complete the palaeontological investigations started. It appears that study of faunas and their associated forms are more useful than relying on a specific group and also that the sediments associated with these biotas forms an intrinsic part of interpretive work. Apparently the shallow epicontinental seas in the McMurray area show enough variation to be subdivided into a number of environments and transitory phases. Careful study of the sediments and organic content yields information on the rate of deposition, increase of depth, turbidity and shoreline relationships.

CHAPTER II HISTORICAL BACKGROUND

The exploration history of northeastern Alberta is essentially one of geographic exploration; with concern in the beginning for the expansion of the fur trade, later with attention to mineral resources and suitable transportation routes to the Pacific. During the heroic age of Cuvier, Werner, Playfair, Hutton, Pallas, von Humboldt and de Saussure in the period 1820-40 some attempt was made to subdivide rock sections in eastern Canada following the sporadic attempts of pioneers such as l'Abbé Jean Etienne Guettard (1715-1786) (Parks 1922). Richardson, who had completed his degree after the battle of Waterloo, was appointed surgeon and naturalist to the first Franklin expedition and was the first to reach the Methy Portage area via the Clearwater in the McMurray area. He delineated the southern boundary of the Pre Cambrian in Saskatchewan but did not differentiate the overlying strata, as it was not until 1835 that Sedgewick and Murchison named the Silurian, and the Devonian in 1839. Richardson later used these terms and tried to correlate them with the stratigraphic sections in the British Isles. He applied the common stratigraphic terms, then in use, to the geologic section and used material from Lyell's Principles of Geology published in 1830 and monographs of Sedgewick and Murchison in the second Franklin report. He obtained salt from the Indians which had been collected near Cumberland House and sent it to England for chemical analysis. On this trip he

also collected important Silurian index fossils from the Interlake area in Manitoba (Richardson, 1858).

However, it was not until 1840-70 that the first substantial attempt was made by Buckland, Murchison and de la Beche to prepare a geological report on the province of Canada (Parks, 1922). Sir William Logan, the father of Canadian geology, founded the Geological Survey of Canada in 1842, which is the oldest scientific organisation in Canada with a continuous history. Unfortunately, or perhaps naturally, he confined his work to eastern Canada as did Elkanah Billings, the first palaeontologist added to the Survey staff in 1856, who produced a monumental 170 papers before his death in 1876. By 1851 Richardson was using the more recent stratigraphic terminology which had been adopted in England and he correctly assigned a Silurian age to the strata covering the flanks of the primary, i.e. the Pre Cambrian rocks from Lake Superior to Arctic Ocean. His correlation of the strata containing the salt springs to Devonian sections in the eastern United States is considered still valid (Kupsch, 1955, p.20).

In 1857 John Hector was appointed surgeon and geologist to the Palliser Expedition that had been commissioned to find a pass across the Rockies. Murchison himself had given him detailed instructions for sampling and labelling material which eventually was to be sent to England for comparison. The term Devonian was firmly established at this time but controversy still raged over the Cambrian and

the subdivision of the Silurian which at that time included Cambrian, Ordovician and Silurian. Hector noticed the Canadian prairies were divided into three levels or steppes and shows these in his report in Palliser's journals published in 1863. Shallow subsurface methods were employed by using gopher holes to examine the strata. Hector made the first attempt to subdivide the Cretaceous Bearpaw, a marine formation widely distributed in Saskatchewan and Alberta (Loranger and Gleddie, 1953). He made the trip to Fort Edmonton and the mission at Lac St. Anns, Alberta, and returned the following spring.

Hind was ordered by the Canadian Government in 1858 to prepare a geological report on western Canada. His investi g ations showed that a large area consisted of Pre Cambrian rocks surrounded by belts of Ordovician, Silurian and Devonian strata. Further south the plains area was covered by Cretaceous and a limited amount of Tertiary rocks. Fossil identifications established the age of his Palaeozoic and Cretaceous sections. He observed the absence of Carboniferous at the surface and the evident unconformity between the Devonian and the Cretaceous. Economic deposits of sodium sulphate, sodium chloride and coal were listed. He was accompanied by Humphrey Lloyd Hime, a photographer, and was able to bring back tangible proof of his observations (Kupsch, 1955).

During the remainder of the period 1840-70 Sir William Dawson wrote some 200 separate articles and is best known

for his work on Silurian, Devonian and Carboniferous plants and the discovery of amphipoids in the Palaeozoic (Parks, 1922). Geological progress in eastern Canada continued with emphasis on stratigraphy and developed independently in accordance with its own needs.

Concurrently, the western great plains were slowly being explored for their mineral resources. Coal had been discovered in the Edmonton area in 1841 and samples sent to Logan by Sir George Simpson. The first definite geological report was prepared by Dr. Hector of the Palliser expedition (1857-1860) which contained a map of the three prairie provinces, showing topography, pioneer settlements, fauna and flora, coal deposits and the different Cretaceous and Tertiary outcrops. This was particularly valuable as Logan's first geological map of Canada published in 1863 had left the entire western area blank.

Dawson examined fossils collected by Meek, Hayden and Bell and was able to apply the Meek and Hayden classification to rocks in southern Alberta. Dr. Robert Bell in 1874 traversed a section of country from Fort Garry to Fort Pelly, brought back evidence of Niobrara (Cretaceous) strata and noted the Devonian on Lake Winnipeg. J.B. Tyrrell worked in Manitoba in 1884-86 and recognized along the shore of the Interlake area Devonian sections which he subdivided into Upper Devonian or Manitoban, Middle Devonian, or Winnipegosan and Lower Devonian. Fossil collections were made by Tyrrell and Whiteaves which have laid the foundation.

for all subsequent work. Tyrrell and Dowling carried the classification into the Athabaska and Churchill River areas. In the Athabaska they recognized Devonian and the Athabaska sandstone of Cambrian age. Dowling classified Palaeozoic rocks of Manitoba and correlated them to sections in Minnesota. Tyrrell and Dowling carried these correlations into northern Saskatchewan and into the Canadian northwest. Hind had already recognized Devonian rocks on Lake Manitoba but nothing was done with his information until 1870-1900 when the Geological Survey, under the directorship of Selwyn and Dawson, became interested in reconnaissance work and the gigantic problem of mapping the entire country.

As the prairies were practically unknown Selwyn went to Fort Garry and as far west as the Rockies. Dawson found the Meek and Hayden classification could be used and prepared a report in 1875 on the geology and resources of the 49th parallel, which contained the first western stratigraphic table. Tyrrell was still active in western Canada and by now had introduced the use of roll film which saved much time previously devoted to sketching (Harrison, 1959).

Towards the close of 1900 McConnell was on the Mackenzie, Yukon, Peace and Liard rivers and Great Slave Lake and was able to prepare a table of formations for the Athabaska and Peace River areas. Increased specialization in the Survey and interest of American workers characterized the period 1900-1922. Major interest was in stratigraphic geology and other branches of geology were

almost ignored. Little actually had been added to the excellent work of Tyrrell and Dowling in the Palaeozoic of Manitoba Lakes area. Kindle in 1912 reviewed the geology, gave faunal lists, and separated out the lowest Devonian as a basal unit (Elm Point formation).

In the far north the Palaeozoic received more consideration due to interest in its petroleum resources. A well was drilled at Athabasca Landing about 100 miles north of Edmonton and 150 miles southeast of McMurray town site but did not peretrate the Devonian (Dawson, 1896). Bell in 1908 published one of the first detailed reports on the tar sands area giving their location, areal extent and stratigraphy. Further to the north Cameron in 1916-17 classified rocks in the Great Slave district and equated these to the Manitoba section (Cameron, 1922). The Palaeozoic section of the Rocky Mountains proper was established in outline chiefly by Dawson and McConnell. Then major advances due to Dowling, Allan, Slipper and Shimer were followed by an extensive petroleum search growing out of war time exigencies.

The McMurray area, which had been estimated by McConnell in 1891 as containing 6.50 cubic miles of bitumen, had received Ell's undivided attention in a series of 21 reports issued during 1914-1937. It was leased by the Abasand Oil Company, a wartime organization which aspired to produce these reserves. Unfortunately no commercial method had been devised to separate the oil from the sand

and the company was forced to cancel the project. The limited use for 7° gravity oil (Hodgson, 1954) and the discovery of the Leduc oil field in 1947, which touched off a frenetic rash of development drilling in the plains area, resulted in an abandonment of interest. It was not until shallower drilling on the plains had been completed, and exploratory drilling was forced into the difficult terraine and unprofitable thick strata of the foothills region, that interest was revived in the McMurray area. New production techniques of centrifuging the oil film from the sand encouraged another flurry of exploratory activity. At present the tar sand area covers an estimated 10,000 to 30,000 square miles, varies from a few feet to 225' in thickness with a probable volume of 35 to 100 cubic miles of saturated sand (A.S.P.G. 1951). It is believed that the bitumen content, by weight, which is capable of use as liquid fuel averages 18% (Warren and Bowles, 1947).

Little micropalaeontological work has been done in this area. Wickenden of the Geological Survey in 1948 published some sections on the Cretaceous beds overlying the Tar Sands and refers to the foraminifera of the Clearwater formation. This was followed by a paper by Martin (1954) referring to this fauna and then by another paper by Wall and Mellon (1955) describing a number of new species of foraminifera and correlating the section to bore holes in the Peace River area. Efforts to establish the age of the Tar Sands and show the relation to the Jurassic/Cretaceous

boundary and the facies changes to the southwest were attempted by Loranger (1951-60) using micro and megafossil data. The same author has delineated the extent of the Mississippean overlap in the area immediately to the west (1955) and has published microfaunal information enabling the Upper Devonian in the area to be correlated to the major petroleum producing areas in the southwest (1955).

Megafossil collections by Russell in 1922 from the Cretaceous were substantiated by the work of Warren (1933) and Crickmay (1955-60). The work of Warren and Crickmay in this area has been chiefly on the Devonian and has to a large extent overlapped, although working independently at the University of Alberta and Imperial Oil Limited respectively. Warren (1949) subdivided the Devonian into five zones using brachiopods and later with Stelck in 1958 subdivided the Alberta Devonian into 20 faunal zones based on outcrop and some subsurface data. Crickmay, working with large borehole and outcrop collections in the Northwest Territories and Alberta has published a series of papers describing the fauna and establishing formation names for the entire Middle Devonian in the McMurray area which he correlates over most of the Western Canada basin (1954-1960). Greiner (1956) made a detailed study of the lowermost member of the Devonian sequence for a master's thesis and has attempted to interpret the ecology of that particular section on the basis of petrographic and megafossil data.

In summary it can be stated that although considerable time has been given to the study of Devonian megafossil collections from the McMurray area, nothing has been done with the microfauna of the Middle Devonian and very little with the Upper Devonian.

No mention of the McMurray area is complete without reference to the work done on the origin of the Tar Sands. Sproule (1938, 1951) and Corbett (1955) have given excellent summaries of the various theories and clearly set forth evidence for in situ, residual or migrated oil. A complete bibliography of papers dealing with these theories has been prepared for the period 1891-1955 by the Alberta Society of Petroleum Geologists under the chairmanship of McCrossan (1957).

CHAPTER III MATERIAL & METHOD OF STUDY

The ten borcholes drilled by the Bear Oil Company provided sufficient cores for a fairly adequate study of the stratigraphic section in the McMurray area (Refer Plates 1 and 2 for localities). Samples were taken at the major changes of lithology but since core recovery is a variable factor and since it was not permissable to remove the entire core, the samples were of varying size. The weights of the samples, the percentages recovered after processing, and detailed lithological logs form Appendix A. A table summarizing the number of samples, average weight per sample, and average yield is also included in Appendix A.

The weighed samples were given standard laboratory treatment, i.e. if the matrix was predominantly shale, it was crushed in a mortar, soaked in water to which sodium hydroxide pellets had been added, and then boiled slowly for four to eight hours - the time dependant on the induratio When the material had been broken down to a fine sludge it was washed through a nest of screens (20, 40, 60, 80, 100 200 mesh), placed in a drying oven and the individual fractions placed into labelled coin envelopes. Samples of limestone or dolomite were crushed to a fine diameter (1/8" or less) and washed immediately through the screens, dried and placed into envelopes.

Separation of microfauna from the matrix followed standard laboratory techniques - the samples were spread on squared trays or saucers and the fossils removed by a

moistened sable brush. Four wells were completely picked over and the microfossils removed to slides for permanent collections. It was observed that little fossil material remained on the 20 mesh screen and that the 200 contained unidentifiable fragments. The 80 and 100 mesh screens contained some ostracode molts and fragments in about the same variety and proportion as that fraction of sample falling within the 20-60 mesh range. Therefore it was deemed practical to concentrate only on the organic matter falling into that category, the extra picking involved on the fractions above 20 and remaining on the 80,100 and 200 mesh not justifying the time involved.

The fossils were mounted on slides with gummed surfaces for permanence. Adhesive surfaces are not required in countries where the relative humidity is high but in semi arid areas this is an essential part of establishing permanent records. The easily prepared gum tragacanth solution is allowed to dry on the black matt surface of the slide where it forms a film from which fossils are easily removed or reoriented. Each fraction passing through the 20 mesh but retained on the 40 and 60 screens was counted separately and added together for total percentage distribution. Prevention of contamination through using the same screen for all the samples was accomplished by using an air blast to dry them after each sample had been processed.

The variable quantity of material presented some problem, for large samples where the counts reached 30,000 or more

individuals per sample it was impractical to examine everything in detail and so the quartering technique adopted by **Nyi Nyi** (1956) and based on Twenhofel and Tyler (1941) was adopted. The sample was built into flat topped cores and quartered by razor blades. The opposing quadrants were considered representative of half of the sample and the process was repeated until at least 250 specimens were recovered. It was found that 1/16th of a sample was the minimum size to which it could be reliably split. Authors are not in agreement as to what constitutes a reliable sample but 250 individuals seems to be as reliable as working with larger numbers. Greig-Smith (1957) and Dowdeswell (1959) apply correction factors to quantities of 20 or more. This is statistically sound but impractical to use on these particular samples. Many samples from the 337 examined had to be examined and picked over completely but did not yield the prerequisite 250 specimens. The quantitative aspectsof this investigation left much to be desired as it would be necessary to have considerably larger samples from these boreholes to obtain valid conclusions.

The sediments were examined for rock type, grain size, colour variation, mineral and organic content. The sieved fractions were examined under low magnification for lithology and the grain size was investigated by comparing the percentage of the various fractions against the total weight.

Variation in colour or chrome was examined by using a standard colour chart and referring the individual fragment representative of the sample to the coloured plates. The amount of organic material per gram of sample was related to the pyrite and glauconite present as well as the kind of organism present. The rate of deposition of these sediments was inferred from this data.

Ecological data from the literature and the observation of ostracode cultures in the laboratory provided the basic data for a palaeoecological interpretation of the formations which was a natural continuation of the systematic study of the faunas present in this area. These postulated environments are summarized in a series of palaeogeographic maps for the sediments present in the Mcmurray area.

Illustrative material is numbered in chronological sequence as the investigation progressed, with the exception of photographic plates prepared to illustrate previously undescribed forms. Emphasis throughout has been placed on new material, previously published material has not been duplicated. In the majority of cases it was considered advisable to obtain additional borehole material. Camera lucida drawings were prepared for each new or apparently new species. These line drawings were prepared at high magnifications and then photographically reduced.

CHAPTER IV REGIONAL SETTING & STRATIGRAPHY

Regional Setting

Devonian strata have the greatest areal extent of any remaining Palaeozoic deposition in the western Canadian basin. They extend from the Arctic circle of the North-west Territories, through the plains into the northern United States, a distance of about 2000 miles and from the Rocky Mountains of Alberta into central Manitoba, a distance of approximately 800 miles. These strata are exposed in discontinuous outcrop along both sides of this sedimentary belt (Baillie, 1953).

The northeastern part of Alberta forms a gently south-west dipping homocline adjacent to the Pre Cambrian shield (Plate 1). The area under consideration includes outcrops at Waterways, McMurray and the tributaries flowing into the Athabaska River in this vicinity. Beds dip southward and westward from the shield at 3-8 feet a mile. A broad north-south arch crossing one part of the area has a parallel shallow trough but dips only 3 or 4 feet to the mile. Struc-tural relief locally is less than 50' and widths are less than $\frac{1}{2}$ a mile, but occasionally near the Shield the relief may be as much as 200 feet and show 20° dips. Normal faults may show throws up to 50' (Alta.Soc.Pet.Geol.1951). The area, then, in spite of tectonic adjustment, is generally of low relief.

This homocline to the southwest dips into the western Canada sedimentary basin which has persisted throughout the

greater portion of geologic time. It extends northwards along the margins of the Shield to the Beaufort Sea and from northern Alberta southeastwards into the provinces of Saskatchewan and Alberta.

Stratigraphy

Pre Cambrian

Pre Cambrian rocks underlie northeastern Alberta, dipping to the southwest and striking approximately NW-SE, and emerging in the extreme northeastern part of the province as the Canadian Shield (Plate 3). Brown and Wright (1957) describe the section on the south shore of Lake Athabaska as mostly flat lying with initial dips of up to 10 degrees, due to deposition of sandstones, conglomerates and arkoses on an uneven floor. Along the north edge of the sandstone area the beds lie in minor folds and along the north shore of the lake dips of up to 75° and 80° may be found. However, most beds dip at less than 40°. The Athabaska series lies with pronounced angular unconformity on older Pre Cambrian rocks. The early Proterozoic rocks are folded, with related intrusions, deeply eroded, and conglomerates, sandstones, shales and some dolomites were laid down on this erosional surface to form the Athabaska series.

Wells penetrating the Athabaska section south of the outcrop areas encounter granodiorites with faint gneissic structure. The granodiorites are composed of medium to coarse crystals, feldspars, hornblendes and quartz. Bear Biltmore No.1 encountered pegmatitic biotite granite and some garnets in gray granite gneiss at 2849' (1404' below

the top of the Devonian). Burwash (1957), from petrographic analysis of cores, postulates that minor cataclastic metamorphism is confined to the southwest of the area.

The age of the Athabaska series is not known with any precision - McConnell assigned it to the Cambrian (1888); Dowling and Tyrrell to the Keweenawan (1897); Sproule to the early Palaeozoic and later as late Pre Cambrian (1938-9); Eckelman and Kulp to early Pre Cambrian (1952) and Gussow to Middle Devonian (1957).

However, since no fossil material, glauconite, or mica, have been found which might serve to date the series, dating and correlation with the subsurface must proceed by inference. The heavy minerals in the Athabaska sandstones are largely tourmaline, with minor amounts of zircon, rutile, garnet and magnetite (Gravenor, 1959). Garnets were found in Bear Biltmore No.1 at 2849' which suggests perhaps a similarity of environment or transportation. Eckelman and Kulp (1952) place it in early Pre Cambrian on the basis of uranium deposition. Gussow, on the other hand, correlates it to Elk Point (Middle Devonian), on the basis of a conformable contact described in an unpublished MS. (1957) and suggests this would support Mawdesley's postulation concerning the environment required by authigenic tourmaline (1947, 1952). The conformable contact quoted by Gussow is approximately 50 miles away from the Athabaska sandstone and could quite easily have resulted from reworked sandstones. The Athabaska has been postulated as a feature of long duration

and tremendous influence lasting into early Mesozoic time (Sproule, 1956). Since conclusions of early workers in the area have been based largely on stratigraphic succession and the evidence is meagre for Pre Cambrian or later, it is considered in this study as probably Pre Cambrian.

The background data on Pre Cambrian rocks is of interest in the interpretation of subsequent sediments since they indicate tectonic adjustment and have provided source material. McGehee (1949) suggested that the Pre Cambrian in well sections southeast of the McMurray area belongs to the Belt series. Burwash (1958), using potassium-argon dating of biotite, places the entire province of Alberta within the Churchill geologic province extending from the Rocky Mountains to Hudson Bay and dates this widespread orogeny of late Pre Cambrian time as occurring between 1.8 and 2.0 million years ago. The spread in age reflects variation in the purity of the biotite separates, analytical errors in potassium and radiogenic argon determinations, and variation in the crystallization time of biotite.

Cambrian

Although Cambrian rocks are widespread beneath the plains they are found in outcrop only along the edge of the Pre Cambrian Shield in the Great Slave Lake area. The Cambrian apparently rests unconformably on the Pre Cambrian basement complex of igneous and metamorphic rocks. This apparently had been reduced to a peneplain of low relief by long erosion. The plains Cambrian is a monotonous section

of interbedded green and maroon shales, light gray, calcareous, quartz siltstones and fine grained sandstone which are typically glauconitic and associated with glauconitic shales. Thin local conglomerates and limestone pebbles, weathered chert fragments, and well rounded, frosted quartz grains are present (Webb, 1951).

Cambrian sediments were present in the Angelus Ashmont No.1 well in the south eastern portion of the McMurray area (Plate 4). The section has been reduced to 454' ± and is chiefly fine grained varicoloured glauconitic sands and shales overlying a conglomeratic basal sandstone. Sediments undoubtedly extended farther to the east and northeast but were stripped back during the long erosional interval of Ordovician and Silurian times. Residual sands and weathered granitic material are present immediately overlying the Pre Cambrian in many wells penetrating this portion of the stratigraphic section, and may be of Cambrian age or younger.

South of Edmonton the Cambrian shows thicknesses exceeding 2000' but in northern Alberta well data shows a low upland extending westwards from the Shield. The thicker sections containing Upper Cambrian polyzoa (Fritz, 1948), are restricted to the Rockies and adjacent areas of the plains (North, 1953). Middle Cambrian brachiopods and trilobites found in the California Standard Parkland 4-12-15-27-4 (4-12-15-27 W4M) well were identified by Raasch and Campau (1957). The Glossopleura sp. present are considered zone fossils for early Middle Cambrian in east central

Alberta. Many pygidia of Glossopleura sp. were recorded by Hutchinson (1960) from the Rio Bravo Ronald No.1-6 (1-6-38-15 W4M) well and identified by the Geological Survey of Canada as Middle Cambrian in age. Lower Cambrian Hyolithes and a brachiopod were recorded by Howell (1952) but these have restricted distribution which does not extend to the McMurray area.

The Cambrian section in the southern part of the McMurray area is represented by basal sands resulting from erosion and eastward transgression (Raasch and Campau, 1957). Electrolog correlations show these sands to be correlative to the Middle Cambrian of the central Alberta plains.

Early Palaeozoic and Sub-Devonian Unconformity

Ordovician sediments, principally carbonate rocks first described by Dowling (1898) and Tyrrell (1900), are present in the vicinity of Great Slave Lake, the eastern Rocky Mountains and the Williston Basin, but are missing in northeastern Alberta.. Possibly one contiguous seaway joined the Great Slave area to the Williston Basin as conodont faunas similar to those present in the Decorah shales of Minnesota have been found in outcrop.*

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* J.E.Labrecque, Imperial Oil Limited geologist sampled Ordovician outcrops on Great Slave Lake which yielded conodonts similar to those obtained in core from Norcanols-Ogema No.1 (1-4-24-7-23-W2M) in Saskatchewan. Harker, Hutchinson and McLaren working with megafossil data correlate the eastern Rocky Mountains to the same well (1955).

The Silurian is somewhat better preserved in the Williston Basin and outcrops in the Interlake area of Manitoba (Kindle 1912, 1915; Tyrrell 1891, 1900; Whiteaves 1906; Jones 1891). The upper 200' contains the Leperditia hisingeri fauna which can be followed into the subsurface sections for a short distance. Silurian outliers have been recorded at Dubawnt Lake in the District of Franklin (Derry, 1950) and farther to the northwest at Norman Wells and in the Great Slave Lake areas. However, none has been found in northeastern Alberta that has been supported by fossil evidence.

No palaeontologically substantiated Lower Devonian rocks are found in Alberta although early work by Kindle (1912) suggested some Lower Devonian rocks were represented in Manitoba by the Elm Point formation. The original definition of the Elm Point has been used since that time although the tendency has been to assign it to Middle Devonian age. However, Hees(1956) has placed this Elm Point formation into the Lower Devonian on the basis of his work with well cuttings and electrologs. He suggests the possibility of the Pre Ashern Elk Point (i.e. lowermost Elk Point) of eastcentral Alberta and Meadow Lake areas belonging to Lower Devonian. However, he cites no definite palaeontological evidence but uses stratigraphic position and electrolog correlation. Wells examined through this section show the presence of Sporangites (Tasmanites) in local abundance. These rounded spores are present in the

basal Elk Point throughout the plains area and reappear in the Exshaw or what may be considered the Devonian/Mississippean transition zone. Ostracodes and charophytes present in the Elm Point and immediately above it, both from outcrop and borehole, yield genera with Middle Devonian affinities.[1]

In northeastern Alberta, then, no evidence for Ordovician Silurian or Lower Devonian rocks has been found, apparently subsequent erosion stripped back the sediments before the deposition of the Middle Devonian. The stratigraphic break at the base of the Middle Devonian was first recognized by Walcott (1921-28) in the Rocky Mountains in the vicinity of Bow River. The duration and extent of this unconformity was considered by Harker, Hutchinson and McLaren (1955) to have varied considerably from place to place. In central Saskatchewan Hees (1956) claims an unconformity is present as the Meadow Lake formation rests unconformably on middle Cambrian-Ordovician sands. The Peace River area, immediately west of the McMurray area has "granite wash"[2] lying between recognized Middle Devonian and Pre Cambrian.

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1. Ostracoda genera represented include Hogmochilina, Dizygopleura, Macrocypris, Isochilina, Elpe, Krausella, Thlipsurella, Jenningsina and **Halliella** These forms are dissimilar to Middle Devonian assemblages found in other portions of the Western Canada Basin but show relationship to the Middle Devonian faunae of Ohio described by Stewart (1950). The associated species of charophytes are confined in distribution to the Middle Devonian (see range charts). This undescribed fauna has been illustrated in an unpublished report in Imperial Oil Limited files (Loranger, 1952). The fauna may be indicative of a different geologic province.

2. A local term used in the petroleum industry to include arkose, granitic material, red beds and assorted detrital.

Possibly these basal sands and detrital materials are of varying ages in different places, since the unconformity shows little or no angular discordance in the Rocky Mountains section examined (Harker, Hutchinson and McLaren 1955), but shows marked discordance in the McMurray area. Gussow (1960) attempts to equate the disconformity to sections throughout North America, which suggests at least one author believes this unconformity to be almost continent-wide in magnitude.

Because an unconformity is recognised between recognised Middle Devonian and identified Cambrian and Pre Cambrian in northeastern Alberta, and because detrital beds of varying thicknesses and indeterminate age are present, these beds have been treated as a separate unit in cross section (Plates 33 and 34). A contour map on these beds shows gentle dips basinward (Plate 5). Isopach lines show thinning to the east and possibly to the southeast, and thickening to the southwest. Without faunal evidence it is impossible to assign these to any particular period although it would appear likely that they represent erosion immediately preceding Middle Devonian deposition in this area. Petroleum geologists tend to regard this as part of the overlying Methy Dolomite (Greiner 1956) or include it in the Elk Point group (Workman, 1953). For clarity in examining the Methy Dolomite it has been considered a separate unit of probable Devonian age.

Middle Devonian

Methy Dolomite

The Methy Dolomite was first observed by Richardson (1858) in early reconnaissance along the Clearwater River. Sproule (1930) assigned it to a doubtful Silurian age. Later in 1948 the Bear Oil Company geologist P.E.Côté used the term for the first dolomite formation overlying the basal detrital zone and used the historic Methy portage as type section. The term became well known in subsurface work although no adequate description of the lithology, contacts or type section had been formally recorded (Nauss, 1950). Greiner (1956) published the results of a Master's thesis and described the Bear Westmount No.2 well as the type section.

The dolomite is buff to grayish buff in type section, finely crystalline becoming dense and granular in part. Secondary calcite and calcite veining is common. The good intergranular porosity and vuggy recurrences suggest good resevoir properties and Greiner (1956) has described it as a biohermal dolomite.

Contours on the surface of this formation show the constant southwest dip and northwest-southeast strike (Plate 7). Thicknesses vary from 301' at Bear Vampire No.1 to 140' at Bear Rodeo No.1. Isopach contours suggest that the Methy Dolomite thickens in the northern and eastern portions of the McMurray area but thins to a probable edge zero in the southwest before plunging into the basin proper

(Plate 8). These areas of nondeposition may be contoured as one large sill or broken into individual areas suggestive of bioherms which has been done here. The Methy Dolomite can be correlated beyond the limits of the McMurray area in subsurface sections, according to Greiner (1956).

Elk Point Group

Originally the name Elk Point was assigned to a formation underlying the Waterways by McGehee in 1949 for a composite well section in townships 56 and 57, range 5 and 6, west of the 4th meridian. It was dated as Silurian with the possibility of some portion of the upper beds being Middle Devonian. Later he adjusted the age in favour of Middle Devonian (McGehee, 1955). Webb in 1951 shows the Elk Point as divided into an upper Middle Devonian section with the lower portion considered to be Silurian. Meanwhile in Saskatchewan, Manitoba and the Williston Basin, Andrichuk (1951), Powley (1951) and Mitchell (1951) carried correlations of the type section into wells as far south as North Dakota. Belyea (1952) raised the Elk Point to group status as it seemed to contain separately mappable units that were not necessarily coextensive. Webb (1951) suggested correlation with the problematical Ghost River section on the eastern edge of the Rockies. Crickmay in 1954 divided the Elk Point into a series of Middle Devonian members which he correlated with sections at Great Slave Lake and in Manitoba. Workman (1953) carried the evaporitic correlations, chiefly on the basis of lithology, into the Peace River area from

the central Alberta plains and divided the Elk Point into two main evaporitic cycles. Law (1955) working from Peace River into the Northwest Territories subdivided the Elk Point into four units. The Elk Point then, is widely distributed and can be subdivided in different ways depending on the area under consideration. In the McMurray area it has been thought advisable to use the term in a somewhat restricted sense by considering the Methy Dolomite and its underlying red beds and detritus as separate units and confining the name to the evaporitic beds.

The Elk Point (restricted) is generally evaporitic, the base conformable with the underlying Methy Dolomite and the top marked by red and green dolomitic shales. The intervening beds consist of halite and anhydrite. Detailed analysis of brines from drill stem tests (Bannatyne, 1960) in Manitoba show it to be largely sylvite, polyhalite, carnalite and anhydrite. The McMurray sections appear to be of similar composition.

Contours on the top of the Elk Point group follow regional dip and strike (Plate 9). Isopach maps of the Elk Point group, modified after Workman (1953) and Law (1955) as shown on Plate 10 indicate thinning to the east and thickening to the southwest. Similar thinning and thickening is shown on an isopach prepared for the Elk Point formation restricted to the evaporitic phase of deposition (Plate 11). Complete sections of the three salt beds are rarely found but Webb (1951) suggests a maximum of 1700 for 3 salt beds

approximately 450' thick, the total salt section being in the neighbourhood of 1200'. More recent drilling has suggested a maximum in excess of 2000' for the Elk Point group in the west central area near Dapp (Borden, 1956). In Manitoba and Saskatchewan it is of variable thickness, being in the magnitude of 500' in Williston Basin and becoming very thin in outcrop where it is frequently biohermal. Salt lakes occur along the outcrop sections of Manitoba and eastern Saskatchewan immediately adjacent to the Shield. In the west it overlaps onto the Peace River landmass and northwards into the Territories forming another salt basin (Plate 10) (Law, 1955, Workman 1953).

The McMurray area lies on the eastern edge of the salt basins, the thicknesses being reduced mainly due to non deposition rather than erosion. Angelus Ashmont, No.1, in the southern part of this area has two well developed salt sequences separated by associated anhydrites, dolomites and an occasional shale band. It was situated within the salt basin; the other wells examined lie on the saddle between the areas of maximum deposition or adjacent to the land mass.

Middle Devonian Unconformity

As Crickmay (1957) points out, sharply eroded contact at the top of the Elk Point is present in Bear Biltmore No.1 below the Slave Point. He takes this basal boundary as the principal break in this part of the Devonian since it is angularly discordant at Peace Point on the Peace River and the faunal sequence in both areas is similar. Warren

and Stelck (1949) place the late Middle Devonian unconformity at the top of the Slave Point where there is an abrupt discontinuity in the composition of the beds and sediments. Crickmay regards the erosion of the upper portion of the Slave Point to be of less magnitude than that at the base (1957). Warren and Stelck (1949) advocated the use of this disconformity for mapping purposes since they believed it divided the Middle and Upper Devonian. Megafossil evidence published by Crickmay (1957) and the data presented in this study suggest otherwise.

Slave Point

The Slave Point formation was described by Cameron in 1922 for a buff coloured, fine grained magnesian limestone on the shore of Great Slave Lake. The term is much used in the petroleum industry as thick equivalent beds are found in the Peace River area to the west of McMurray.

This limestone is sharply separated by disconformity from the overlying Waterways and the underlying Methy Dolomite and contains a distinctive fauna in the McMurray area. Variously it has been regarded as the basal member of the Waterways or the top of the Middle Devonian neither of which is accurate (Crickmay, 1957).

Crickmay describes the Slave Point at Bear Biltmore No.1 as 5½ feet thick, being a buff coloured, fine grained magnesian limestone containing

Atrypa aff. *independensis* Webster
Ambothyris sp.

Contours on the top of this unit show northwest southeast trend dipping into the southwest (Plate 12). The Slave Point is difficult to follow south of the Bear Westmount No.1 well as it interfingers with limy shales and the lithological characteristics become modified. The Christina River Hardy No.1 well cored 44' of these limestones and limy shales which contained the characteristic megafossils. Further south at Angelus Ashmont No. 1 the interbedded shale and limestone section contains 20% silt and is difficult to separate from the overlying Waterways.

An isopach map (Plate 13) on the Slave Point? suggests that deposition was limited to the north, east and south probably by shoreline or conditions of nondeposition. Thickening to the southwest probably indicates a major basin effect since Slave Point sediments are encountered in wells drilled in the Peace River area. Two localized areas of thickening appear to have been deposited in embayments of the shoreline or within topographical lows. Rapid rotary drilling methods and the subsequent contamination of cuttings suggest that it is quite possible to overlook such a thin unit.

Waterways Formation

The term Waterways was first given by Warren (1933) to a limestone and shale section on the Athabaska River at its confluence with the Clearwater in Township 89. The name was derived from the town of Waterways at the railway

terminal, 3 miles from McMurray townsite. Warren correlated this section with the Simpson shale on the Mackenzie and suggested a relationship to the Snider Creek shale of Missouri. Later in 1949 he correlated this to the Minnewanka section described by Shimer in the Banff area and placed the Waterways in the Upper Devonian.

Field work done by Crickmay for Imperial Oil in 1949 and subsequent work on well cores led to the usage of a number of formational terms in company reports. Some of this nomenclature has appeared without verification in various articles published by the Alberta Society of Petroleum Geologists and is in general use throughout the industry. Crickmay privately published (1957) an elucidation of some of these formation names. His subdivision of the Waterways is of interest since it is based on megafossil zones occurring in association with specific lithologies and consequently represents a biostratigraphic approach to the naming of units, a method long neglected in the petroleum industry. These units are difficult to trace into adjacent areas since they are thin and megapalaeontological data is scarce due to the paucity of coring. Generalized lithological descriptions of the type prepared by service companies or government agencies are often inadequate to prepare conclusive correlations. However, micropalaeontological relationships with these units suggest that the subdivisions established by Crickmay can be carried as equivalents beyond the limits of the McMurray area.

Crickmay's subdivision in ascending order is briefly

outlined as follows:-

Firebag member: defined as 170 feet or more of shales and argillaceous limestones with Lingula cf.spatulata Vanuxem, Atrypa cf. independensis Webster, Eleutherokomma impennis Crickmay, and Cyrtina billingsi Meek. Type sections are on Firebag River and in Bear Biltmore No.1, 1512 to - 1682.5'.

Calmut member: approximately 102 feet of resistant, fine grained clastic limestone with abundant Stropheodonta costata and Eleutherokomma cf. impennis shales above and below. The type locality is 3 miles downstream from the confluence of the Athabaska and Calmut Rivers. The type section is in Bear Biltmore No.1 from 1410 - 1512'.

Christina member is defined as 90' of argillaceous limestone and shales with small Eleutherokomma lying between the overlying limestone containing Allanaria allani and the underlying limestone containing Stropheodonta costata. Type sections are at Christina River and Bear Biltmore No.1 from 1320 - 1410'.

Moberly member is a dominantly limestone unit lying between the Eleutherokomma killeri zone and the argillaceous limestone and shales with small Eleutherokomma. The upper 80' contains E. hamiltoni and the lower 120' E. allani. The formation was named for a section at Moberly Rapid, 5 to 10 miles above McMurray on the Clearwater and found in Bear Biltmore 1120 - 1320'.

Mildred Lake member consists of 140' of argillaceous limestone beds with shales and E. killeri lying above the

E. hamiltoni subzone of the underlying **Moberly**. Outcrops are found on Mildred Lake and the type section is at Bear Biltmore No.1 980 - 1120'. The contact at Bear Biltmore No.1 is conformable with the overlying Woodbend group.

Contour lines drawn on the top of the Waterways **Formation** (Plate 23) or individual members Firebag* (Plate 15), Calmut (Plate 17), Christina (Plate 19), **Moberly** (Plate 21) and Mildred Lake (Plate 23) show essentially the same regional dip to the southwest and approximately the same strike, northwest-southeast. A suggested high area or nose appears in the lower four members which is partly exaggerated by the density of control in this area as opposed to the outer fringes of the McMurray area. This feature is observed in contour maps on the top of the pre-Methy detrital (Plate 5) the Methy Dolomite (Plate 7) and the Elk Point (Plate 9).

An isopach map of the Waterways **formation (Plate 14) shows** thickening to the west, southwest and south and suggests that a localized thickening occurred in the eastern portion of the McMurray area. The two areas of thicker deposition are separated by a rather broad saddle in the shape of an atoll.

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* Crickmay (1957) has not published a location map but implies thicknesses of his outcrop type sections are similar to his cored sections from wells. The elevations are unknown since detailed topographic maps have not been published. Therefore the outcrop sections are plotted as having the same thicknesses as the well type sections.

The individual members of the Waterways show variability of deposition in regard to the approximate limits of deposition and also in regard to the basinward thickening. Since these members exhibit conformable contacts in the type section and no evidence has been found to dispute the conformity of these contacts in the control points available, it suggests that the zero contour lines may represent hypothetical shorelines, areas above wave base, or areas of non deposition.

The most consistent of these zero isopach lines occurs in the Firebag (Plate 16), Calmut (Plate 18), Christina (Plate 20) members in the northeastern part of the McMurray area not far removed from the Canadian Shield. In the Moberly member (Plate 22) the limit of deposition appears to be in a more northerly sector and in the overlying Mildred Lake (Plate 24) it appears to be restricted to the east.

Nondeposition in the west appears in isopach maps of the Firebag (Plate 16) Christina (Plate 20) and Mildred Lake (Plate 24) members.

The thickest deposition appears to be in the south and southwest in all of the members of the Waterways formation.

The basinward thickening of the Waterways formation and the more localized and restricted areas of thickened deposition occurring within its members suggests a high area or sill present in the western part of the area under discussion. This high area may have been a sill, ridge or reef, and influenced the western limits of the individual members of

the Waterways group to a marked degree. It may have provided a western depositional limit for the Firebag and Christina members as well as the underlying Methy Dolomite and Slave Point. The eastern limit for the Firebag and Christina was provided by the Pre Cambrian Shield, suggesting very limited distribution in a west-east direction across the McMurray area.

Middle/Upper Devonian

Woodbend Group

On request from the petroleum industry the staff of Imperial Oil Limited in 1950 prepared a publication on the Devonian nomenclature in the Edmonton area, essentially a revision of Layer's 1949 paper, based primarily on data from well control (A.A.P.G. 1950). The group concerned with productive reefs was divided into an underlying Cooking Lake or first fragmental limestone, overlaid locally by a Devonian black shale, and topped by the green Ireton shales. The reef, originally designated D_3 in 1949 and then described as Leduc, corresponds to a facies change equivalent to part of the Woodbend (Belyea, 1955), although by definition it underlies the Ireton and overlies the Duvernay in the type section (Imperial Oil Limited Geological Staff 1950).

The formations are dealt with briefly as follows:

Cooking Lake formation which consists mainly of a buff fragmental, fossiliferous limestone with beds or zones of granular, oolitic and finely crystalline limestone. The upper part is interbedded with black calcareous shale and is considered by

Haugrud (1958) to be a partly reworked biostrome and away from the reef area is replaced by black shales carrying the same microfauna (Imperial Oil files). In the McMurray area it is biohermal throughout. Type section at Calmont Leduc No.3 (Lsd.4 Sec.14 Twp.51 Rge.21, W 4 M) has a section 248 feet thick occurring between 4990 - 5238 feet.

Duvernay formation was first applied by petroleum geologists to brown bituminous shale found in wells drilled in the Duvernay area and later defined in 1950 by Imperial Oil Limited Geological Staff. The type section consisted of a series of dark brown bituminous shales, dark brown, black and grey-green calcareous shales and dense argillaceous limestones. It is an offreef facies of the Leduc and is not present where reefs have been developed. Although well developed in the Edmonton oil field area it becomes indistinguishable from the lower Ireton and Cooking Lake in the west and south. The Duvernay has been correlated and carried into the Biltmore area on the basis of stratigraphic position, electrolog correlations and lithological similarities. The type section is 175 feet thick in Anglo-Canadian Beaverhill Lake No.2 well between 3863 - 4038' (Imperial Oil Limited Geological Staff 1950). The Ireton formation is composed of gray green to brown calcareous or dolomitic shales containing limestone bands, which are frequently fossiliferous, and carry occasional silt bands. At Imperial Ireton No.1 it is 262' thick but varies considerably throughout most of Alberta and Saskatchewan, being thin in reef areas and thick in shale basins (Taylor,

1954). It may be underlaid by Leduc, Duvernay, Cooking Lake or Beaverhill Lake and overlaid by a prominent widespread silt unit of the Nisku member of the Winterburn. In the McMurray area it is well distributed and forms the major portion of the Palaeozoic subcrop under a thin cover of Mesozoic sediments.

However Webb's map is contoured on the thickness of Woodbend sediments encountered by drilling and plotted without regard to the relationship of the top and bottom. Over simplified interpretation of the geology based on a few cross sections (e.g. Plates 33 and 34) suggested that the various formations had been deposited with uniform thinning to the northeast as the Pre Cambrian Shield was approached, and then uniformly eroded more or less parallel to the regional trend. Apparent support for this premise was given by geologists who had made cursory examination of outcrop sections in the immediate vicinity of McMurray and assumed lack of section was due to eastward thinning rather than westward pinchout.

Isopaching the Woodbend well data available in relationship to the contours of both top and bottom shows a deepening basinward to the southwest separated by a narrow area of restricted deposition from a somewhat thicker area on the east and northeast (Plate 26).

Isopach maps for the Cooking Lake (Plate 28) and the Ireton formations (Plate 31) of the Woodbend show a basinward thickening to the southwest and a corresponding thinning to

the east. The Duvernay (Plate 29) on the other hand, shows the reverse, with approach to edge zero on the west and thickening to the east. This may be explained by the inherent characteristics of the Duvernay which is an offreef facies of the Leduc (Belyea 1955). The zero isopach might well represent a change to reefal facies.

The general age assigned to the Woodbend is Upper Devonian although in the original usage the Cooking Lake was recognized as the first fragmental in a series which continued down to the top of the Elk Point and which is Middle Devonian in age. However, in the nomenclature published in 1950 (Imperial Oil Limited Geological Staff) the first unit of this series was placed into the Woodbend rather than the Beaverhill Lake. This point will be discussed further after the palaeontological evidence and palaeoecological interpretations are reviewed.

CHAPTER V SEDIMENTOLOGY

Lithology:

The dominant lithological features for the ten well sections, described in some detail in Appendix A, are indicated by conventional symbols in the first column of the well data charts(Plates 37-46). Variation of the section from sandstone, red or green shales through the evaporitic sequences of anhydrite, dolomite and limestone are indicated by pattern and colour as shown in the accompanying key. These lithologies are given in somewhat more detail in the appendix and were obtained from examination of cores under a microscope using low magnification of X15. These descriptions were further verified by examination of residues during the course of this study (Column 1).

Grain Size:

The original core sample was weighed, crushed and boiled with NaOH until an extremely fine sludge was formed. This sludge was washed through a nest of screens and the residue left on each screen (20, 40, 60, 80 and 100 mesh) dried and weighed. The portions of the samples falling into each of these sieve sizes were plotted on a graph (Column 2) as a percentage of the total sample.

This grain size analysis shows that the bulk of samples processed were fine enough to wash through the 100 mesh screen, i.e. the particles were in the order of 0.152-0.039 mm. in size, which is approaching clay in the scheme

advocated by Heinrich (1956). The most effective screenings for microfossil recovery were the 20, 40 and 60 mesh sizes, i.e. between 0.78 and 0.25 mm, although it was necessary to extend the examination of samples above and below this range to make adequate collections of instars. The smaller screens contained abundant fine fragments which could not be identified with confidence nor readily counted. Consequently fossil counts and population analyses were made only for the residues in the 20 to 60 mesh sizes which yielded maximum collections in a limited time.

The concentration of microfossils within a certain size may indicate transportation by currents (Carter, 1951) or preferential sorting due to swell (Powers and Kinsman, 1953). No consistent abrasion effects were noted so that it may be that winnowing and sorting took place in a low energy traction zone (Powers and Kinsman, 1953; Keller, 1954; Curtis, 1954). Sorting by grain size has been observed as best on the seaward side (Daltwyler, Kidwell and Hoskins, 1958). However, this analysis indicates very little difference in sorting and no particular trend is observed.

Chromal Variation:

Twanhofel (1939) concludes that the colours of sediments are due to several components, some of which are developed in diagenesis and others include organic matter of various kinds. The green shales common in the ten borehole section may arise from illite and montmorillonite clay minerals (Keller 1953) which is not contradicted by the fine

grain analysis results shown in Column 2 of the well data charts (Plates 37-46). There is, however, considerable variation in the green shales and they vary from green to grayish green and black suggesting that the colour is not entirely a matter of pigmentation (Pettijohn 1957). Trask and Patnode (1936) have investigated this in some detail and suggest that the darker the shale, the higher is the organic content. If colour in these samples is a function of organic content then it would appear that variations in colour would be reflected by variations in the abundance of organic material present (i.e. the richness) (Column 4); the darker the colour, the higher the organic content, and so on.

Studies of Carboniferous sediments in the Midlands by Broadhurst (1959) indicate that an increase of 0.3% of organic material is just visible to the unaided vision and that in samples of more than 4% organic carbon differences in colour can not be detected accurately by ordinary visual methods. He believes that there is a direct relationship between colour and carbon content which can be substantiated by chemical analysis. Zobell (1946) quotes Trask in regard to near shore sediments which contain an average 2.5% organic matter whereas oceanic deposits average something around 1%. From the work of these authors it would appear that variations in organic matter in near shore sediments could be visually measured or at least compared relatively. All the samples in this study were examined for colour variation under artificial light using a standard colour chart. The Cheskin Color Chart published by MacMillan (1954) was used throughout

since it readily lends itself to this type of study. Fragments of chips, representative of the rock section for each sample, were placed on the coded illustrations and direct comparisons were obtained against a standard scale. The Cheskin Chart is based on twelve hues (colours of pure pigment) to which are added equal amounts of white to give four tints and/or equal amounts of black to give four shades. When these are arranged in charts they form 12 charts with 25 combinations so that a possible 300 variations of chrome can be determined for any rock sample. Actually the choice was limited to buff or light brown dolomites (Cheskin Color Chart No.2) red shale (Chart No.3) green shales (Charts No.11 and 12). The variation in colour, as measured by the chart, proved to be a variation from pure hue in relatively rare samples of red shale to the darkest which is black shale. The majority of samples contained appreciable amounts of black pigment or organic matter and could be plotted in a simple scale of 1 to 5 representing the increase in shade or chromal variation towards the darker sediments (Column 3, well data charts).

Chromal variation towards the darker end of the scale is not consistently related to the abundance of organic remains unless these happen to be dark coloured carbonaceous fragments, scolecodonts, etc. Floods of planktonic pteropods such as occur in Bear Westmount No.1 (904-14; 991-98; 1039-49; 1251-62; 1429-39; 1668-79) are composed of light coloured Tentaculites sp. and are not necessarily consistent

with darker sediments (i.e. Value 5 on the scale, Column 3). The amount of organic material present does not appear to be related consistently to colour (Column 4). Barghorn (1952) has suggested that the bulk of plant remains recovered from sediments is non-cellulose in finely disseminated form. Foxe (1950) believes that an amount, probably considerably in excess of 1 ppm, is present in ocean water and represents organic matter produced by phytoplankton and sessile plants so that the sediments deposited may not yield a very accurate presentation of the total productivity of the area, no matter how accurately the measurements are made. It is suggested here that the darker chromes are partly due to finely disseminated organic material.

Another approach that should not be overlooked is that used by McCrossan (1957) in a study of bore hole sections from central Alberta. He has attempted to correlate chrome to depth of burial by arranging samples of essentially the same lithology in order of drilled depth across a basinal area. Depth increases and darker chromal values apparently coincided in these samples but he admits that no measurements were attempted for the organic content. It is probable that the samples he describes have acquired darker chromes as a result of pressure due to compaction from the weight of the overlying sediments, and influenced by lateral pressures exerted in the mountain building on the west. Metasomatic changes in ostracodes from the Aechmin-ella fribourgella biozone indicate that depth of burial

alone does not entirely account for increased chromal values* since no consistent relationship of depth and chrome were observed for a number of wells in central and northern Alberta.

The compaction due to overlying sediments should not be appreciable in the McMurray area since it is believed to have been on the edge of an intercratonic basin and total sedimentation is somewhat less than in central Alberta (Webb, 1951). Stylolitic markings throughout the cores may indicate that tectonic adjustment by faulting has been reflected in the sediments by changing chrome - if stylolites are indications of pressure, which has not been satisfactorily proven by students observing stylolitic phenomena (Stockdale, 1943; Prokovich, 1952; Shaub, 1955). However, the McMurray area is directly in line with some major fault trends on the PreCambrian Shield as shown by Derry (1950) and it is probable that these trends have continued as far south as the area in which these bore holes were drilled.

Pure hues were present in Angelus Ashmont No.1 at 5204-17' in red shales at the base of the Methy Dolomite. The complete lack of organic matter in the samples, both visible and identifiable species, and the apparent lack of finely comminuted carbonaceous material, suggest that a state of complete reduction had been attained for whatever organic matter might have been present originally.

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* Refer to Plate 87 which shows the variation within the fossil zone to be independant of depth of burial. The variation shown correspond's to Burwash's petrographic results (1957).

This brief investigation suggests that variations in ~~Chroma~~ for these samples is related to a number of factors:

(a) the amount and kind of organic material preserved - the darker organic material producing values at the darker end of the scale; the lighter and the planktonic influencing values in the middle scale,

(b) the present depth of burial does not influence the chrome in a consistent manner, i.e. darker chrome with increased depth. A theoretical consideration of sedimentary conditions for this area does not suggest that total deposition in the McMurray area exceeded that of central Alberta,

(c) the effects of overburden are masked by local or regional metamorphism which is suggested by extrapolation from tectonic trends on the PreCambrian Shield and may suggest an origin for stylolitic markings present.

Richness:

Richness is a measure of the organic material preserved in the samples. Values are obtained by totalling the visible organic content and dividing by the weight of the sample. Graphs were prepared from these values (Column 4) for each bore hole showing the amount of organic material preserved and identified within the 20-60 mesh range. A few samples contained finely disseminated plant fragments that could not be counted with any degree of accuracy and these were given arbitrary values of 100 + and are indicated on the scale. A scale was devised that would emphasize relatively low

values of 1.0 and yet show proportional increases up to 100 and yet remain compact enough to place in charts with related graphs (0; 1.0; 10.0; 50.0; 100.0; 100.0+).

The values were found to range from .0, i.e. barren, in the Methy Dolomite and lower Elk Point but reach a maximum of 286.2 in the Firebag at Bear Westmount No.1, 1251-61'. The dolomites proved to have uniformly low values as expected and the maximum values were present in mixed lithologies of 50% limestone, 45% shale and 5% silt.

No positive relationship between abundance of planktonic pteropods and the richness was observed that appeared consistently throughout the samples. The richness values were recalculated for benthonic species only but little variation in the averaged final values occurred (Refer Basic data Charts 35, 36) that were significant.

In order to observe the relationship between the richness and the formations under examination a series of maps was prepared, one for each formation showing the average richness of organic material (planktonic + benthonic) and the values contoured (Plates 47-56). Hoffmeister (1955*) has shown that the abundance of plant microfossils increases as a strand or shoreline is approached and a similar technique was considered applicable to these samples. Maps drawn for the Calmut and Moberley appeared to follow this pattern but those for the Methy Dolomite, Elk Point, Firebag

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* U.S.Pat.No. 2,686,108. Released to industry by Standard Oil of New Jersey.

and Christina indicated a concentration of organic matter such as might accumulate below the zone of active wave action, or the floor of shallow lagoons.

The same maps, with values plotted on them for benthonic forms only, showed very little change in the basic interpretation. It would appear that the values indicated that planktonic and benthonic material tended to accumulate in approximately the same places, i.e. parallel or near shore lines and below wave base in basin-like depressions. Presumably these areas would be those of rapid or more rapid subsidence that were not reworked by various scavengers. The accumulation of planktonic material near shore or parallel to a shoreline could be attributed in some measure to currents and sorting. Benthonic concentrations might be explained on the basis of proximity to food supply since scavengers (ostracodes) mud shovellers (worms) detritus feeders (molluscs) etc. tend to accumulate where adequate food supplies are available, and just off shore or the floor of a lagoonal area would fulfil these conditions.

Pyrite:

Pyrite is deposited in neutral or slightly acid environments by bacterial action (Twenhofel 1950). Becking Baas, Kaplan and Moore (1960) state that pyrite and sulphides are found in pH's ranging between 6-10.5. In the open California sea floor, black muds containing iron sulphide are found in shallow water environments with rapid deposition and H_2S alone in the deeper more slowly laid down deposits (Natland,

Revelle and Rittenberg, 1941). If deposition of pyrite is associated in open sea conditions with rapid deposition it might be useful as an indicator in determining relative rates of deposition or subsidence. Moretti (1957) has indicated that pyrite may be deposited at depths of 12 cm. although flourishing benthonic faunas are present in the overlying sediments, so it would appear that pyrite deposition is unrelated to benthonic faunas and may bear no relation to them. On the other hand it may be significant that the well containing the greatest amount of pyrite, i.e. most occurrences, Bear Westmount No.1, also exhibits the greatest percentage of planktonic organisms (Column 5). The conditions which favoured production of pyrite appear to have favoured the death and preservation of pteropods. There are, of course, samples in which pyrite occurs which have very low richness values and there are samples in which there are high planktonic richness values and no pyrite present.

The occurrence of pyrite in these samples is perhaps, indicative of an environment unfavourable to certain forms of life and may be used with other data to examine probable rates of deposition. With one exception (Bear Westmount No.1 941-51') it has not been found in association with glauconite. Recently Barghorn and Nichols (1961) have recorded sulphate-reducing bacteria and pyrite in black lacustrine and marine muds of McMurdo sound in the Antarctic. Pyrite apparently can be formed in cold or temperate climates.

Glauconite:

Glauconite occurs in some of the well cores abundantly enough to be recognized under low magnification but usually masked by the green sediments which predominate in the stratigraphic sections. More commonly it appears in disintegrated samples in association with ostracodes and other microfossils (Column 6). Twenhofel (1950) suggests that in modern seas glauconite occurs most abundantly in areas adjacent to the land where plutonic and metamorphic rocks are exposed and where reducing conditions are maintained by bacterial action. Galliher (1935) suggests glauconite is the end product of biotite destruction and found at depths of 5 to 10 fa. in areas of little agitation, black mud bottoms, anaerobic conditions, alkaline environments of up to 9 or 10 Ph under slow or negative depositional conditions. Burst (1958) refers glauconite to an inner or mid-neritic environment near shore but does not overlook the possibilities of production under marsh conditions. Pettijohn (1957) places depths of deposition between 10-400 fa. in areas of slow sedimentation in rich bottom muds with plentiful organic material.

Although variation of opinion on depth and origin is expressed by these and other authors, agreement is reached on environmental conditions and slow rate of deposition. An excellent summary of literature on glauconite and the application made to a palaeoecological study has been made by Lochman (1949). Emery (1960) has prepared a very det-

ailed study of the California area and has observed glauconite in abundance on bank tops where detritus accumulates very slowly or not at all. It is found in the most oxygenated portions of the sea floor in areas where there is some turbulence and flow from currents or the movements of organisms. Commonly the benthic population is not dense but consists of worms, seaurchins and brittle stars. P.h. is about 7.8 and Eh. about +300 mv., similar to the overlying seawaters.

Population Analysis:

Organic material present in these samples from the 20-60 mesh screenswas identified and counted, the values being recorded for each major group as a percentage of the total microfossil population on the basic data charts (Plates 35, 36). Since faunal analyses are more reliable if all groups represented in the collection are taken into consideration, every thing organic present was included, although many forms are not, strictly speaking, microfossils. Into this category fall the fragments and juvenile forms of crinoids, gastropods, echinoids, polyzoa, brachiopods and fish remains.

The general group classification used in these charts is as follows:

Column 1. Carbonaceous fragments, plant stems, wood, megaspores, fungi, Tasmanites, etc.

2. Charophyta.

3. Ostracoda valves.
4. Branchiopoda valves.
5. Foraminifera.
6. Conodonts.
7. Scolecodonts.
8. Coprolites.
9. Gastropods, juveniles.
10. Pelecypods, juveniles.
11. Crinoids, columnals, arms and calyx plates.
12. Polyzoa.
13. Echinoids, spines. Holothuroidian and Ophurian fragments.
14. Tentaculites.
15. Brachiopoda (unclassified) and Productid spines, and juveniles.
16. Fish remains, cartilage, phosphatic fragments.
17. Spines of indeterminate origin.
18. Total organic content expressed as number of individuals.
19. (a) Richness or organic content, per gram of sediment for planktonic and benthonic forms.
    (b) Richness of benthonic forms.

These groups are plotted in column 7 of the well data charts (Plates 37 - 46) with carbonaceous material and spores charophytes on the left, ostracode and crinoid material and representatives of other groups in the middle of the scale so that planktonic floods could be represented as originat-

ing on the right side of the chart. The arrangement serves to emphasise strand or shoreline deposition and gradual variations of depth in the section, as well as pteropod invasions. Variations of the fauna are discussed in a chapter dealing with the micropalaeontology of each formation.

The orders which could be worked beyond the wholesale grouping indicated were identified and the percentages plotted on a second set of basic data charts (Plates 67-70) with the species arranged in alphabetical order. This included the charophytes, foraminifera, conodonts, ostracodes, branchiopods, scolecodonts and polyzoa. These values were then plotted into range charts and formed the basis for subsequent distribution studies.

Rate of deposition:

Examination of these samples suggests that these sediments were deposited at different rates. The most rapid deposition took place in Elk Point time when thick salt beds were formed. Throughout the larger portion of the stratigraphic section, however, deposition, as indicated by fine grained sediments and selectively sorted fossils, proceeded slowly enough to permit winnowing and sorting. The presence of glauconite is taken as indicative of very slow deposition. Variation in the gradual subsidence is indicated by occasional floods of planktonic material or organic remains which were quickly buried and were not reworked or subjected to later removal by scavengers. Rapid deposition is also

suggested by the presence of coprolites and faecal débris in abundance.

An interpretation of the relative rates of deposition based on these conclusions is presented in Column 8 of Plates 37-46. The scale used is purely relative and has no quantitative value. It merely serves to differentiate between slow, rapid and normal (or average) deposition for this area.

CHAPTER VI. SYSTEMATIC PALAEONTOLOGY

Charophyta

Introduction:

Earliest report on Charophyta was made by Soldan in 1780, followed by Lamarck in 1804, both of whom regarded the oogonia as molluscan shells (Darrah, 1939).

Since 1849 certain small spherical bodies, generally called trochilisks have been recognized and assigned to primitive plants as lycopod spores, phyllopod eggs, fish eggs, echinoids and foraminifera (Peck 1934). They were first discovered in the northwestern Russian Devonian and later recognized in North America. Quenstadt first compared them to charophyte fruit in 1867 and this was followed by Meek's description of chara fruit in North America (1873).

Karpinsky's classic monograph of 1906 describing the morphology and affinities as well as the probable evolution of Sycidium and Trochiliscus gave sound reasons for inclusion in the charophyta. However, this was not generally accepted until Peck, working in Missouri, provided convincing evidence for the genus Trochiliscus belonging to the Charophyta. He reviewed previous literature and provided a range chart of formations which contained charophytes for Middle Devonian to Early Mississippian sections. Excellently preserved new material from Podolia, on the borders of Poland and Russia, has provided additional knowledge of the morphology and resulted in revision of the classification published by Peck (Croft, 1952). The first comprehensive study since 1934, giving annotated check lists, and an evaluation of the

affinities of related forms in North America and Europe was published by Horn Af Rantzien (1956). Mädler working in Germany has also provided a new classification (1955), evolutionary data (1957) and range charts for 44 genera (1958)

Morphology:

The descriptive terminology used in the following pages is essentially that presented by Peck (1934), with slight modification and simplification in view of Croft's contribution to the structural features of gyrogonites (1952)

Classification:

Karpinsky (1906) provides a key for the differentiation of Sycidium and Trochiliscus and evaluates both generic and specific characteristics. Members of the Sycidaciae are classified on outer form, size, convexity or concavity of the meridianal segments; the number of segments; the number of ribs and furrows; arrangement and/or alternation of ribs; contours and outlines of the areas formed; presence of tubercles and intersection of ribs. Peck (1934) admits that some variation of enveloping cells is possible in the Sycidiacea but bases a number of his Trochiliscus species on variations in number of enveloping cells. Karpinsky (1906) discusses the specific characteristics and lists form; size; number of spiral ribs, their configuration. He concludes that trochilisks are variable, particularly in regard to enveloping cells and ridges and presents a key based on the normal characteristics of the species. Croft (1952) supports this and cites several examples of variation in living

forms as well as referring to Groves (1933) and Harris (1939) who had similar conclusions after studying living species.

It would appear then, that variation in the number of cells and in the size of the gyrogonite is normal. This simplification applied to North America range charts shows that many species have considerably longer range than originally designated or cannot be used indiscriminately in stratigraphic work. This is substantiated by observation of similar forms in Western Canada and suggests some caution must be exercised in using this form, but does not detract in any way from their value as environmental indicators, provided they occur in place in the section and have not been transported.

The following descriptions follow Croft's treatment of the Trochiliscaccae, Karpinsky' of the Sycidaceae. Four genera and five species are listed, including a new genus believed to be ancestral to Paleochara Bell 1922 = Eochara Choquette 1956 and Trochiliscus Karpinsky 1906.

Family Trochiliscaccae

Trochiliscus Karpinsky 1906

Eutrochiliscus Croft 1952

Trochiliscus convolutus Peck 1936

Trochiliscus devonicus Peck 1934

Karpinskya Croft 1952

Trochiliscus bilineatus Peck 1934

Paleochara wickendeni (Choquette) 1956.

Family Sycidiaciae

Sycidium Sandberger 1849

Sycidium sp.

Prochara n.g.

Prochara symmetrica n.g., n.sp.

Descriptions

Trochiliscus (Eutrochiliscus) convolutus Peck

1936 Trochiliscus convolutus Peck, Jour.Palec., Vol.10, No.8, pp.764-68.

Trochiliscus minutus Peck, idem.

Trochiliscus multivolvis Peck, idem.

1952 T (Eutrochiliscus) convolutus Peck, Brit.Mus.Nat.Hist., Vol.1, No.7, p.209.

Types: University of Missouri, Nos.31011-13

Distribution: Onondaga limestone, Ralls county, Ms.; Ireton, Mildred Lake, Christina, Calmut and Firebag in McMurray area.*

Lithology: Gray argillaceous limestone with partings of limy green shale or in limy green shale.

Trochiliscus (Eutrochiliscus) devonicus (Wieland) Peck

1914 Chara devonica Wieland, Am.Mus.Nat.Hist., Bull., vol.33, p.245.

1934 Trochiliscus devonicus (Wieland) Peck, Jour.Paleo., Vol.8, No.2, pp.108-9,Pl.9, figs.14-21.

Trochiliscus rugulatus Peck, idem. p.108, Pl.13, figs.1-4.

1952 Trochiliscus (Eutrochiliscus) devonicus Peck, Bull. Brit.Mus.Nat.Hist., Vol.1, No.7, p.209.

* Detailed footages given in Appendix B.

Types: Topotype, U.S.Nat.Mus., Washington, No.39151.

Syntypes, Univ. Iowa Nos.691, 692.

Distribution: Jeffersonville limestone (Onondaga), Falls of the Ohio; Louisville, Kentucky; Snyder Creek shale, Snyder Creek, Calloway County, Missouri; Devonicidaris jacksoni zonule, Cerro Gordo member, Hackberry stage; Birds Hill, southwest of Rockford, Iowa; Moberly, Christina, Calmut and Firebag in McMurray area.

Lithology: Gray argillaceous limestone and/or limy gray green shale.

Remarks: These specimens agree in shape and convolution with Moellerina Greeni Ulrich, Falls of the Ohio (Brit.Mus.No.V13063). However, since T.devonicus is the accepted name for this form and M.Greeni is somewhat misleading, the former is used.

Trochiliscus (Karpinskya) bilineatus Peck

1934 Trochiliscus bilineatus Peck, Jour.Paleo, Vol.8, No.2, p.113, Pl.10, figs.25-30.

Trochiliscus meeki Peck, idem., p.112-3, Pl.10, figs.7-10.

Trochiliscus liratus Peck, idem., p.113-4, Pl.10, figs.1-6.

Trochiliscus raricostatus Peck, idem., p.114-5, Pl.12, figs.22-24.

Types: University of Iowa, Nos.693-699.

Distribution: Devonocidaris jacksoni zonule, Birds Hill, southwest of Rockford, Iowa; Snyder Creek shale, Calloway County, Mo; Columbus limestone, Sandusky, Ohio; Ireton, Mildred Lake, Calmut, Firebag in McMurray area and Beaverhill Lake in east central Alberta.

Lithology: Gray green limy shales with minor amounts of gray limestone. In Angelus Ashmont No. 1 this species occurred in a light buff limestone.

Paleochara wickendeni (Choquette)

1922 Paleochara Bell, Roy.Soc.Canada.Trans., ser.3, vol. 16, p.160 (non. Massalongo 1851. Piante foss.terr. terz.Vicentino, ossero, p.44).

1956 Eochara wickendeni Choquette, Jour.Paleo, vol.30, p.1373 text figure 1.

Types: Geological Survey, Ottawa.

Distribution: Found in the Elk Point, McMurray area.

Lithology: Buff, argillaceous dolomite with minor amounts of green dolomitic shale or in buff limestone.

Remarks: Eochara is placed in synonomy with Paleochara following the work of Croft. Specimens of E.wickendeni found with coronula cells which the original description does not describe, when these are considered the shape is that of Paleochara.

Sycidium sp.

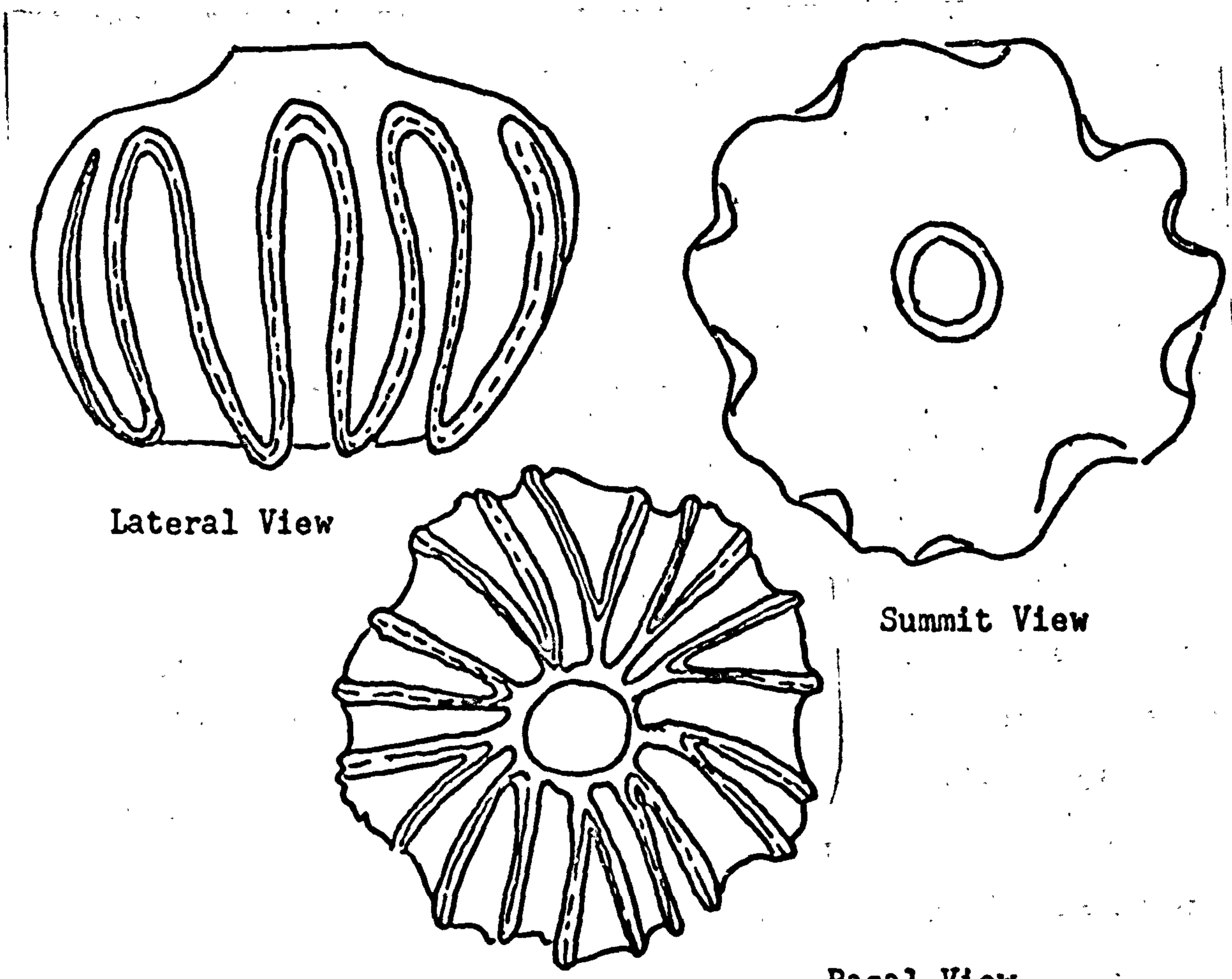
Poorly preserved specimens, unlike Upper Devonian forms present in western Alberta.* Additional material required before adequate description can be prepared.

Distribution: Moberly in McMurray area.

Lithology: Light green calcareous shale with some minor amounts of gray limestone.

Prochara n.gen.

Short cylindrical gyrogonites, ends evenly truncated,



x 140

text figure 1.

* Fina Cities Service Greencourt No.1, 6-7-58-9 W5M, 6690-6750'.

wider than high. Ornamented by vertical ribbing probably due to folding of one cell upon itself in the manner of a concertina. The ribs are narrow and have sharp margins which appear rounded in weathered specimens. Between the ribs are wide deep furrows. The narrow sharp rims or edges of the furrows are pinched together and join as they approach the raised rim surrounding the basal aperture. Sometimes the point of juncture forms a small projection which extends below the basal surface. These ribs are projected above the surface of the summit in a scalloped pattern and alternate with furrows which extend from the base. The flattened area around the summit aperture varies in width as does the height of the raised rim. The most common number of ribs counted is ten, although eight or nine are found.

Remarks: Short cylindrical shape and proportions separate this from the subcylindrical and ellipsoidal Choavanella described by Reitlanger and Jarszewa (1958) from the Upper Devonian of U.S.S.R.

The vertical ribbing without crossbars separates this genus from other charophyta. In the Vermillion Consolidated No. 15 well (6-12-41-6-W4M) specimens show the ribs beginning to twist to the left or right showing a possible trend towards the spiral development in the trochilisks.

It is anticipated that additional material from areas in the Northwest Territories where this form and/or Choavanella are known to be present will show many intermediate forms.

The characteristic scalloped summit has already been observed in rare specimens of "Paleochara". On the basis of shape, dimensional relationships, symmetrical ornamentation, stratigraphic position, this is regarded as a new genus.

Distribution: Restricted to Elk Point sediments immediately above Stringocephalus zone, McMurray area, Middle Devonian.

Genoholotype: Prochara symmetrica

Prochara symmetrica n.g., n.sp.

Photograph 1, figs., 1-3, text figure 1

Small, cylindrical gyrogonites with broadly truncated base and summit, about 13% wider than high in lateral view. Ornamentation consists of evenly spaced ribs separated by broad deep furrows. These lanceolate ribs extend below the basal area and form a series of projections before they join the basal apertural rim. The ribs are formed of two sharp narrow raised rims separated by a slight depression. These ribs are separated by the wide deep furrows extending upwards from the base and terminate above the surface of the summit in a series of scalloped ridges. The rim surrounding the apical opening is larger and more conspicuous than the basal aperture.

Dimensions: Height: 0.44 to 0.48 mm

Width: 0.52 to 0.68 mm

Figured specimen: Paratype, Christina R.Hardy No.1, 1860-67'

Height: 0.44 mm. Width: 0.52 mm.

Distribution: Above the Stringocephalus zone of the Elk Point group in McMurray area.

Lithology: Green shaly dolomite and green dolomitic shale.

Foraminifera

The history of Devonian foraminifera beginning with the earliest reference by John Phillips in 1849 in Yorkshire sediments and the subsequent discoveries by Ehrenberg near Leningrad, Terquem in the Eif el area, Germany and Chapman in the Stringocephalus limestone was reviewed by Miller and Carmer (1933).

Cushman's classification (1940) has been used for the 4 genera and 4 species present in the McMurray area.

Family Rhizamminidae

Bathysiphon M.Sars 1872

Bathysiphon sp.

Family Lituolidae

Endothyrinae

Endothyra Phillips 1846

Endothyra ? gallowayi Thomas 1931

Family Textulariidae

Semitextularia Miller and Carmer 1933

Semitextularia thomasi Miller and Carmer 1933

Textularia Defrance 1824

Textularia ? sp.

Bathysiphon sp.

Distribution: Present in Calmut, Firebag, and Elk Point in McMurray area.

Lithology: Limy or dolomitic gray green shale or in gray limestone.

Endothyra ? gallowayi Thomas

1921 Rotaline foraminifer Thomas, Geol.Soc.Am.Bull., vol.32, pl.131.

1930 Endothyra sp. Thomas, Iowa Acad.Sci.Proc., vol.36, pp.279-80.

1931 Endothyra gallowayi Thomas, Jour.Paleo, vol.5, pp.40-41, pl.7, figs. 1-9.

1933 Endothyra ? gallowayi Thomas, Jour.Paleo, vol.7, pp.427-8.

Types: Primary types, State University of Iowa, Nos.12-008, 12-010, 12-011, 12-012, 12-015, 12-017.

Distribution: Fairly common in Devonicidaris jacksoni zone near middle Cerro Gordo member Hackberry shale at Birds Hill. In upper Ireton of central Alberta. Ireton, Mildred Lake, Moberly and Calmut of McMurray area.

Lithology: Found in gray, buff or green limestones or in limy green shales, rarely in buff limestones.

Semitextularia thomasi Miller and Carmer

1933 Jour.Paleo, vol.7, No.3, pp.429-30, pl.50, figs.10a-e.

Types: Primary types State University of Iowa. No.12-018.

Distribution: Hackberry formation, Iowa.

Described from the Middle Devonian of Middle Moravia, Čelechovice, Czechoslovakia by Pokorný (1951).* Present in the Ireton, McMurray area.

Lithology: Limy gray green shale or gray or buff limestone.

* also identified from the Wanakah shale member, Ludlowville formation, Hamilton group, New York; Cerro Gordo and Independance formations, Iowa. (Copeland and Kesling, 1955).

Textularia ? sp.

Distribution: Poorly preserved forms present in the Ireton, Moberly and Calmut of McMurray area.

Lithology: Gray argillaceous limestone and/or gray green limy shale.

Ostracoda

Introduction:

The term Ostracoda was first used by P.A.Latreille in 1802 for small crustaceans from what is now recognized as a number of orders. Straus in 1821 first recognized the ostracodes as a distinct group and referred to them as "Ostrapodes" which is the correct name. However, the term Ostracoda has been universally accepted so that reversion to the proper name at this time is impractical.

The first ostracode fauna was described by Count von Münster in 1830. About twenty years later, Professor T. R. Jones and Kirkby and Brady began intensive studies in Great Britain. Jones published 116 ostracode papers on faunas from all over the world, a large percentage of them on Palaeozoic forms so that a basis was established for subsequent Palaeozoic studies. Jones applied his knowledge of ostracode faunas in identifying subsurface Jurassic sections in a Richmond borehole in 1884, thus showing that the ostracodes could be used in stratigraphic palaeontology.

At the end of the nineteenth century Ulrich began to investigate the Palaeozoic ostracode faunas in Ohio, Manitoba and Minnesota. In 1923 he and Bassler published the classic volume on the Silurian ostracodes of Maryland where nine persistent ostracode zones appeared. These zones were described and arranged in a classification which has formed the foundation for subsequent work.

During the last thirty years ostracodes have been used

extensively by the petroleum industry as an exploratory tool. Many papers were published on the stratigraphic occurrences of various fauna from different horizons so that new and more complete classifications were required. Bassler and Kellett in 1934 prepared an index of Palaeozoic ostracodes summarizing the literature then available and revising the 1923 classification of Ulrich and Bassler. This rapidly became the standard reference work for ostracode specialists. Two privately published classification keys were prepared, the one by Huffman (1942) based on taxonomic relationships within the genera of the ostracode families; the other by Wright (1948) based on surface ornamentation and characteristic hingeline overlap. These achieved a rather limited circulation within research groups in petroleum companies. In 1961 The Geological Society of America in cooperation with The Palaeontographical Society, The Palaeontological Society, and The Society of Economic Paleontologists and Mineralogists published a complete revision of all previous classifications and included a summary of classification from the U.S.S.R. Treatise of 1960. This work has proved to be very useful in this study and has been used in preference to Pokorný (1958).

In Canada the earliest ostracode studies were made by Ulrich (1889) for Cambro Silurian rocks in Manitoba. This was followed by Jones (1891) with a paper describing the ostracodes of the Interlake district and suggesting relationships to collections he had made in the Northwest Territories.

Nothing has been published on the Devonian ostracode

faunas of the McMurray area with the exception of an introductory paper which used specimens from the Bear Beaumont No.1 and Bear Biltmore No.1 wells to demonstrate correlation between central Alberta and the northeastern part of the province. The better preserved ostracodes from these wells were used to illustrate their distribution laterally and provided better material for photography (Loranger, 1954).

Morphology:

The descriptive terminology used in the following section is a simplification of Kesling's work at the University of Michigan (1951). His composite drawings, showing labeled areas, have been of particular use in adhering to standard descriptions. A new term 'inferior angle' has been introduced in the description of lateral outlines to denote the curvature of the carapace away from the venter; i.e., in opposition to the cardinal angles at the hingeline.

The orientation used is that which is primarily taught at the Universities of Illinois and Michigan. Three types of carapace structure are used:

1. muscle scars, representing the areas where the muscles close the valves or operate the appendages. These are considered anterior in Palaezoic ostracoda.
2. carapace proportions, particularly of greatest width and height, having definite relationship to the soft parts of living ostracodes. In living forms the greatest width is posterior and the greatest height anterior, particularly amongst the forms with straight dorsal borders. The

Leperditacea may be an exception since their greatest height is in opposition to the adductor muscle scars. The posterior is considered the widest part of the carapace (Bonnema, 1930; Geis, 1932; Swartz, 1933, 1936; Bold, 1946) and is blunt or wedgeshaped to permit easiest egress through the water or mud.

3. structural features consistently associated with muscle scars or proportions of the carapace.
   (a) major sulcus, associated with adductor muscle scars usually curves downward and forward but is just ahead of midcentral portion of the carapace.
   (b) major flaring structures or spines generally point backwards or are directed in such direction that swimming or burrowing is unimpeded.
   (c) frilled structures generally develop better anteriorly.
   (d) the most influential and largest lobes of trilobate valves are posteriorly situated.
   (e) channelled hingement generally widens posteriorly.
   (f) brood pouches considered posterior (Reuter 1885; Ulrich and Bassler 1908, 1923; Kummerow 1931; Warthin 1933; Bassler and Kellett 1934, Wright 1948). Another group (Keisow, 1888; Bonnema, 1932; Swartz, 1936, Hessland, 1949) believe brood pouches are anterior; i.e. associated with the muscle scar of the adductor muscles. Many of these pouched forms have runners or tracks

underneath which made it easier to burrow in the mud,* so it would appear that brood pouches in the posterior portion of the carapace could also serve the same purpose and probably were placed posteriorly.

The order in which the individual species is described places prime value on lateral and upper outline, hingeline overlap, proportions of carapace with consideration of these features as of generic import. Surface ornamentation has been used as a means of differentiating species. Wherever possible attempts have been made to collect the molts or instars and obtain data on size range of the individual species and the variation from juvenile to adult form. Descriptions are based on adults or the largest forms found and variations in height, width and length are indicated.

Abbreviated synonomies indicate homologous forms; if no fossil name is given the reference pertains to the original description and is therefore the type reference.

The descriptions are based primarily on external morphology due to the condition of preservation usually found in Devonian material. Wherever possible information on the type of hingement, muscle scars and instar variations has been included.

Distribution of each species is indicated briefly together with any published references that are pertinent or are useful in correlating the McMurray or adjacent area to other known sections.

*These tracks or runners only observed in living mud burrowers not in swimming forms.

Details of the lateral and vertical variation and abundance of these species in the McMurray boreholes have been placed in a separate appendix B. Abundances are indicated as the percentage of the entire fossil populations. All other occurrences listed in the appendix are rare; that is, less that 1%. Some indication has been obtained of the deposition of these forms in relation to the Middle/Upper Devonian contact in the McMurray area and in the northern United States. The "recurrence" of forms and their total stratigraphic ranges as they occur in central and northeastern Alberta is summarized in Plate 71. The implications of this "recurrence" are expoünded in the section dealing with the palaeontology of the formations and the Middle/Upper Devonian contact.

The lithology in which each occurrence was noted is summarized in the description and notations included on unusually large collections. Many of the ostracode species, either due to sampling techniques, natural range of tolerance or transportation were present in a variety of lithologies. Some species, however, displayed remarkable consistency and appeared only in one basic type of lithology; variation appearing sometimes within a genus. These results are indicated in summary form on Plate 72 and may be useful in ecological interpretation. Rare specimens, of which only a few occurrences have been noted, should be used with caution in this table, as the complete range of lithological variation may not be represented. The species which are considered reliable by reason of abundance, or occurrence in a consistent lithologic rock type are indicated by crosses.

Classification: Some attempt was made to use the Russian Treatise on Ostracoda which was published in 1960 but the classification of ostracodes was not broad enough in scope to be able to relate the McMurray fauna with any degree of nicety to the faunas described and classified for the Soviet Union. Pokorný's work (1958) has proved to be an invaluable tool in this study, incorporating as it does the best features of Swartz 1936, Henningsmoen 1953, Hessland 1949 and other authors. Some difficulty was experienced in using this classification as some of the genera common to North America has been excluded. The new Geological Society of America Treatise (Part Q Arthropoda 3) published in 1961 has attempted to include all published material in a concise form of classification. References listed pp. Q422-29 indicating Russian synomony have not been duplicated in this thesis. A summary of species identified and arranged in the same classification with the exception of Eridoconchinae appears on the following pages immediately preceding the descriptions. Remarks on the classification of the various genera are listed briefly at the beginning of the descriptions of the various species within that genus together with any observations on aberrant specimens.

The bore hole samples examined in this study yielded 68 species of ostracodes belonging to 41 genera and three orders. Two of the 41 genera are new and have been assigned the following classification:

Family Kloedenellidae Ulrich & Bassler 1908 - Westmountia

Family Pribylitidae Pokorný 1958 - Neopribylites

Out of the 68 species 25 have been described in the literature or reclassified:

Abursus beaumontensus

Abursus biltmorensus

Abursus duvernaius

Aechminella biltmorensa [Balantoides biltmorensus]

Aechminella fribourgella [Balantoides fribourgellus]

Amphissites albertensi

Amphissites beaumontensi

Amphizona pseudocarinata

Bairdia bartholomensis

Bairdia biltmorensa

Bairdia hypsoconcha

Bairdia leguminoides [B. summacuminata]

Bythocypris biltmorensis

Bythocypris mearnsa

Cavellina ovatiformis [Cytherella ovatiformis]

Cooperatia biltmorensa [Cooperia biltmorensa]

?Halliella bellipuncta [Amphissites bellipuncta]

[Kirkbyella bellipuncta]

Hypotetragona beaumontensa [Janetina beaumontensa]

Kirkbya biltmorensa

Knoxina kinsella [Kloedenia kinsella]

Macrocypris albertensis

Macronotella biltmorensa

Monoceratina albertensa

Plagionephrodes biltmorensus

Plagionephrodes spinosus

Six of these species have been described from Devonian sections in the United States.

Amphizona pseudocarinata

Bairdia bartholomensis

Bairdia hypsoconcha

Bairdia leguminoides

Cavellina ovatiformis

? Halliella bellipuncta

Four possible new species are present but are not in complete agreement with original descriptions; however, they are too closely allied to permit of separate descriptions:

Bairdia cf. pseudomagna

Bairdia cf. subtilla

Briartina cf. quenstedti

Winchellatia cf. deminuta

New species described which have sufficient range of molt stages available for study and with stratigraphic value include:

Abursus triangulensus

Acronotella keslingia

Aechmina vikingensa

Aechminella beaumontensa

Aechminella initialia

Aechminella trinodensa

Aechminella middevonica

Bairdia midconstricta

Hypotetragona albertensa

Kloedenella rodensa

Krausella albertensa

Limbinaria navicularia

Monoceratina scottia

Neopribylites albertensa

Plagionephrodes pseudomorpheus

Platyrhomboides albertensus

Rothella vampirensa

Thrallella reticulata

Westmountia mcmurraiensa

Youngiella devonicensa

Youngiella elongatensa

Seven species are described which are probably new species but whose size and stratigraphic range is not sufficiently known from the present material. It is anticipated that additional well cores will yield sufficient material to raise them to the status of the preceding group:

Aechmina sp. A.

Aechminella sp. A.

Bekena sp. A.

Mauryella sp. A.

Monoceratella sp. A.

Ponderodictya sp. A.

Roundyella sp. A.

Three questionable new forms were found that require better preserved specimens and larger collections to determine the variation within the species, as these may be aberrant representatives of previously described species:

Aparchites ? sp.

Cavellina ? sp.

Macrocypris ? sp.

Six genera are represented by poorly preserved and/or sparse material and were identified to generic level only:

Bairdia sp.

Bollia sp.

Eukloedenella sp.

Glyptopleura sp.

Krausella sp.

Phylictoscapha sp.

One species was dubiously assigned to Bicornellina ? sp. and one ostracode could not be assigned to any family, order or genus with confidence.

This collection was compared to type material in museums in London, Frankfort, Uppsala and Oslo, in addition to collections belonging to Imperial Oil Limited. Both the British Museum and the Senckenberg Museum have material from many localities in the United States. Problems of taxonomy were discussed with several palaeontologists in both Europe and North America. Additional collections are required to complete the classification of several of these forms which certainly suggests many problems for future work.

CLASSIFICATION SUMMARY - OSTRACODA

Subclass Ostracoda Latreille 1806

Order Leperditicopida Scott 1961

Family Leperditiidae Jones 1856

Genus Briartina Kegel 1932

Briartina cf. quenstedti (Gümbel) 1874

Order Palaeocopida Henningsmoen 1953

Suborder Beyrichicopina Scott 1961

Superfamily Beyrichiacea Matthew 1886

Family Beyrichiidae Matthew 1886

Genus ? Halliella Ulrich 1891

? Halliella bellipuncta (Van Pelt) 1933

Genus Phyctiscapha Kesling 1953

Phyctiscapha sp.

Superfamily Drepanellacea Ulrich & Bassler 1923

Family Aechminellidae Sohn 1961

Genus Aechminella Harlton 1933

Aechminella beaumontensa n. sp.

A. middevonica n. sp.

A. initialia n. sp.

A. trinodensa n. sp.

A. sp. A. n. sp.

A. biltmorensa (Loranger) 1954

A. fribourgella (Loranger) 1954

Genus Mauryella Ulrich & Bassler 1923

Mauryella sp. A. n. sp.

Family Aechminidae Bouček 1936

Genus Aechmina Jones & Holl 1869

A. vikingensa n. sp.

A. sp. A. n. sp.

Family Bolliidae Bouček 1936

Genus Bollia Jones & Holl 1886

Bollia sp.

? Family Eurychilinidae Ulrich & Bassler 1923

Genus Bicornellina Zaspelova 1952

Bicornellina ? sp. A n. sp.?

Family Sigmoopsidae Henningsmoen 1953

Genus Winchellatia Kay 1940

Winchellatia cf. deminuta Kesling & Tabor 1953

Superfamily Kirkbyacea Ulrich & Bassler 1906

Family Kirkbyidae Ulrich & Bassler 1906

Genus Kirkbya Jones 1859

Kirkbya biltmorensa Loranger 1954

Family Amphissitidae Knight 1928

Genus Amphissites Girty 1910

Amphissites albertensi Loranger 1954

A. beaumontensi Loranger 1954

Family Arcyzonidae Kesling 1961

Genus Amphizona Kesling & Copeland 1954

Amphizona pseudocarinata Smith 1956

? Family Scrobiculidae Posner 1951

Genus Roundyella Bradfield 1935

Roundyella sp. A. n. sp. ?

? Family Aparchitidae Jones 1901

Genus Aparchites Jones 1889

Aparchites ? sp.

Genus Macronotella Ulrich 1894

Macronotella biltmorensa Loranger 1954

Family Pribylitidae Pokorný 1958

Genus Neopribylites n. g.

Neopribylites albertensus n. g., n. sp.

Superfamily Primitiopsacea Swartz 1936

Family Primitiopsidae Swartz 1936

Genus Limbinaria Swartz 1956

Limbinaria navicularia n. sp.

? Superfamily Youngiellacea Kellett 1933

Family Youngiellidae Kellett 1933

Genus Youngiella Jones & Kirkby 1895

Youngiella devonicensa n. sp.

Y. elongatensa n. sp.

Suborder Kloedenellocopina Scott 1961

Superfamily Kloedenellacea Ulrich & Bassler 1908

Family Kloedenellidae Ulrich & Bassler 1908

Genus Kloedenella Ulrich & Bassler 1908

Kloedenella rodensa n. sp.

? Genus Eukloedenella Ulrich & Bassler 1923

Eukloedenella sp.

Family Geisinidae Sohn 1961

Genus Hypotetragona Morey 1935

Hypotetragona beaumontensa (Loranger) 1954

Hypotetragona albertensa n. sp.

Hypotetragona sp.

Genus Westmountia n. g.

Westmountia mcmurraiensa n. g., n. sp.

Family Glyptopleuridae Girty 1910

Genus Glyptopleura Girty 1910

Glyptopleura sp.

Family Beyrichiopsidae Henningsmoen 1953

Genus Knoxina Coryell & Rogatz 1932

Knoxina kinsella (Loranger) 1954

Order Podocopida Müller 1894

Suborder Podocopina Sars 1866

Superfamily Bairdiacea Sars 1888

Family Bairdiidae Sars 1888

Genus Bairdia McCoy 1844

Bairdia bartholomensis Stewart & Hendrix 1945

B. biltmorensa Loranger 1954

B. hypsoconcha Gibson 1955

B. leguminoides Ulrich 1891

B. midconstricta n. sp.

B. cf. pseudomagna Stewart & Hendrix 1945

B. cf. subtilla Gibson 1955

Bairdia sp.

Genus Bythocypris Brady 1880

Bythocypris biltmorensis Loranger 1954

B. mearnsa Loranger 1954

Family Macrocyprididae Müller 1912

Genus Macrocypris Brady 1867

Macrocypris albertensis Loranger 1954

Macrocypris ? sp. A.

? Family Acronotellidae Swartz 1936

Genus Acronotella Ulrich & Bassler 1923

Acronotella keslingia n. sp.

Family Bythocytheridae Sars 1926

Genus Monoceratina Roth 1928

Monoceratina albertensa Loranger 1954

Monoceratina scottia n. sp.

Superfamily Cytheracea Baird 1850

Incertae Sedis Monoceratella Teichert 1937

Genus Monoceratella sp. A., n. sp.

Suborder Metacopina Sylvester -Bradley 1961

Superfamily Healdiacea Harlton 1933

Family Bairdiocyprididae Shaver 1961

Genus Bekena Gibson 1955

Bekena sp. A., n. sp.

? Family Cavellinidae Egorov 1950

Genus Cavellina Coryell 1928

Cavellina ovatiformis (Ulrich) 1891

Cavellina sp.

? Family Krausellidae Berdan 1961.

Genus Krausella Ulrich 1894

Krausella albertensa n. sp.

Krausella sp.

? Genus Cooperatia Tolmachoff 1937

Cooperatia biltmorensa (Loranger) 1954

Superfamily Quasillitacea Coryell & Malkin 1936

Family Quasillitidae Coryell & Malkin 1936

Genus Abursus Loranger 1954

Abursus beaumontensus Loranger 1954

A. biltmorensus Loranger 1954

A. duvernaius Loranger 1954

A. triangulensus n. sp.

Genus Plagionephrodes Morey 1935

Plagionephrodes biltmorensus Loranger 1954

P. pseudomorpheus n. sp.

P. spinosus Loranger 1954

Family Thlipsuridae Ulrich 1894

? Genus Ponderodictya Coryell & Malkin 1936

Ponderodictya Sp. A

Genus Rothella Wilson 1935

Rothella vampirensa n. sp.

Genus Thrallella Stewart & Hendrix 1945

Thrallella reticulata n. sp.

Incertae Sedis

Genus Platyrhomboides Harris 1957

Platyrhomboides albertensus n. sp.

Genus and species unknown.

Ostracoda indet.

Order Leperditicopida Scott 1961

Leperditiidae Jones 1856

Briartina Kegel 1932

Briartina quenstedti (Gümbel) 1874

1852 Cytherina von Sotenick, Handbuch der Petrefaktenkunde, p.360, pl.29, fig.38.

1874 Leperditia quenstedti Gümbel, Neuse Jahrb, Min. Geol. Pal., Stuttgart, p.69.

1933 Leperditia (Briartina) quenstedti, Preuss. Geol. Landessart, Jahrb., vol. 53 (1932), pl.46, fig.14, p.925, ff.12.

Briartina cf. quenstedti (Gümbel) 1874

Types: Gümbel's and Quenstedt's specimens lost. Neotypes in Geologisches Landesmuseum, Berlin. Kegel's other specimens in Seckenberg Museum, Frankfurt on Main, Nrs.385n, 398a and 398b and 399a.

Distribution: Upper Middle Devonian; lower Givetian, lower Stringocephalus beds; near Sotenich, Eifel Mts., Rheinland; Pfaffrath in Eifel Mountains. Neotype from Urft Valley upstream from Sötenich. Specimens from Giessen, Hesse, Germany.

In McMurray area in Ireton formation.

Lithology: Kegel (1933) gives a description of marly limestone lithologic associations. In the McMurray well in argillaceous grayish green limestones.

Remarks: Specimens crushed and distorted so that lateral outline is not identical to that figured by Kegel (1933). The outline is closer to that figured by Quenstedt (1852). The characteristic depressed hinge area and eye tubercle are unmistakable.

Order Palaeocopida Henningsmoen 1953

Beyrichiidae Matthew 1886

? Halliella Ulrich 1891

? Halliella bellipuncta (Van Pelt) *

1933 Amphissites bellipuncta Van Pelt, Journ.of Paleo., Vol.7, No.3, p.332, Pl.39, figs.37-40.

1934 Halliella bellipuncta Warthin, Contrib.Mus.Paleo. Univ. Mich., Vol.4, No.12, p.208, Pl.1, fig.2.

1937 Kirkbyella bellipuncta Warthin, Wagner Free Institute, Sci., Card.80.

1939 Halliella bellipuncta Turner, Bull.Amer.Paleo., Vol.25, No.88, p.12, Pl.1, fig.3.

1944 Kirkbyella bellipuncta Shimer and Shrock, Index Fossils of North America, p.671, Pl.282, figs.43-44.

1952 Halliella bellipuncta (Van Pelt), Contrib.Univ.Mich., Vol.10, No.2, p.26, Pl.1, figs.16-25.

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* after this manuscript was typed an article by Sohn appeared (1961) which indicates he would place this in Kirkbyella (Kirkbyella) bellipuncta (Van Pelt);1933.

Types: Hypotypes, Univ.Michigan, Ann Arbor, Mich., Nos. 27581-27590. Depository not listed by author.

Remarks: Placed by Ulrich (1894) in Beyrichiidae; by Bassler and Kellett (1934) in Primitiidae-Primitiinae; by Kay (1940) Primitiidae-Eurychilininae; by Pokorný (1950) in Hollinidae; by Henningsmoen in Beyrichiacea of uncertain family (1953), by Pokorný (1958) in Eurychilinidae-Beyrichiidae; by Scott in Beyrichicopina-Beyrichiidae (1961).

Distribution: Present in Ireton, Cooking Lake, Mildred Lake, Moberly, Christina, Calmut and Firebag in McMurray area. Recorded from Ontario and Michigan.

Lithology: Occurs in light gray to buff limestones interbedded with grayish green or dark green shales. Maximum recovery from light green to buff argillaceous limestones.

Phlyctiscapha Kesling 1953

Phlyctiscapha sp.

Three poorly preserved specimens found, two molts, one adult. Precise identification impossible.

Distribution: Ireton formation in McMurray area.

Lithology: Greenish gray and fragmental gray limestone with limy greenish gray shale.

Drepanellacea Ulrich & Bassler 1923

Genus Aechminella Harlton 1933

Remarks: Harlton (1933) referred this genus to the Beyrichiidae; Swartz (1936) placed it in the Kirkbyidae; Kellett (1936) removed it to Drepanellidae; Zaspelova (1952) provisionally placed this in the Neodrepanellidae; Henningsmoen referred it to Kloedenellidae-Kloedenellinae in 1953; Pokorný (1958) has not dealt with this genus. Sohn (1961) has included Balantoides and Boursella in this genus. Balantoides was originally placed by Morey (1935) in Kirkbyidae; Agnew (1942) removed it to Beyrichiidae; Henningsmoen (1953) placed it in Kloedenellidae-Kloedenellinae; Pokorný (1958) assigned it to Beyrichiida-Neodrepanellidae. Boursella was placed in Beyrichiidae by Turner (1939), in Kloedenellidae-Kloedenellinae by Henningsmoen (1953), in Drepanellidae by Kesling (1953) and by Pokorný (1958) in Beyrichidae-Neodrepanellidae. Krommelbein* thinks this genus shows a remarkable amount of variation for a marine genus. Some of this variation is illustrated in sketches, page 92.

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* Personal Communication

Aechminella beaumontensa n.sp.

Photograph VI, figs., 23,24, text fig., 2

Carapace small, subquadrate in outline; long straight dorsum; left valve overlaps right along venter and posterior free margin; maximum length below midcentre, maximum height and width anterior to midcentre; anterior end broadly rounded, posterior and more sharply rounded; venter convex; obtuse anterior cardinal angle, and slightly more obtuse posterior cardinal angle; a ridge parallels the free margins and terminates in the cardinal angles; three spines present, the centroanterior spine arising just above midheight and directed anteriorly, being of small diameter approaches needle like proportions; the central dorsal spine is small, directed upwards and the small posterior dorsal spine is directed posteriorly.

Length: 0.48-0.52 mm. Height: 0.30-0.36 mm.

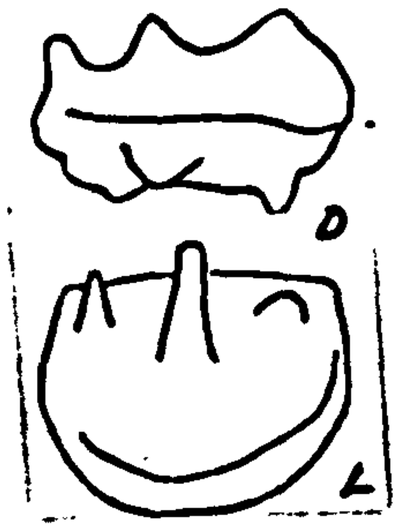
Width: 0.14-0.2 mm.

Figured specimen: Holotype, Ireton, Bear Beaumont No.1 1147-57'.

Length: 0.52 mm. Height: 0.36 mm. Width: 0.2 mm.

Aechminella fribourgella (Loranger) 1954

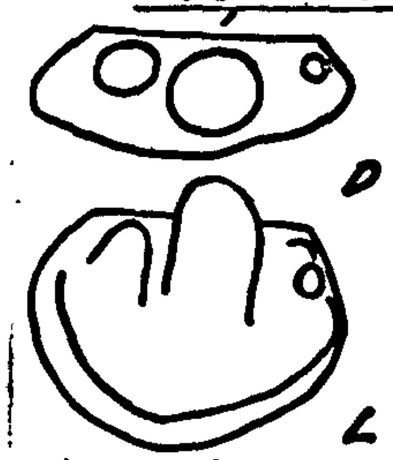
Aechminella beaumontensa
n. sp.



Text figure 4

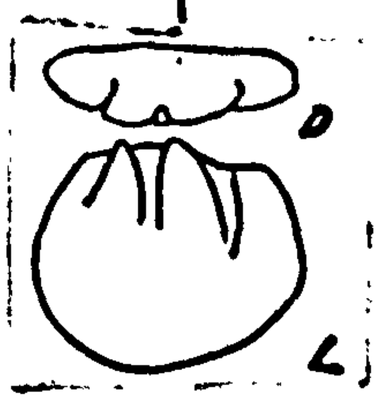
Text figure 2

Aechminella biltmorensa (Loranger) 1954

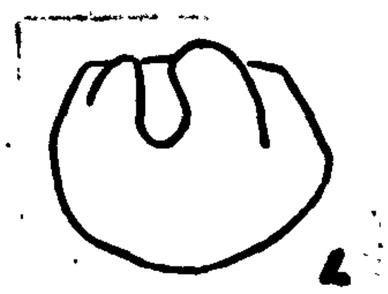


Text figure 5

Aechminella trinodensa
n. sp.

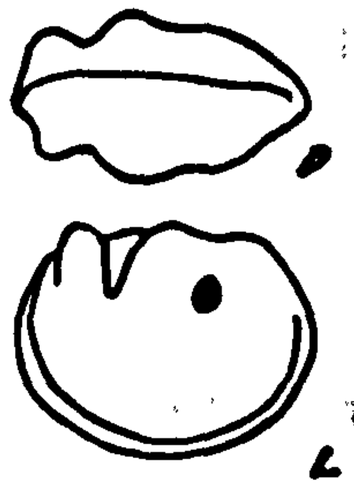


Aechminella
sp.A. n.sp.

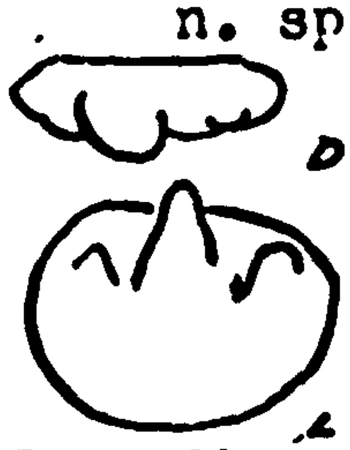


Text figure 6

Aechminella initialia n.sp.



Aechminella middevonica
n. sp.



Text figure 3

Text figure 7

Text figure8

X 20 (approx.)

VARIATIONS IN AECHMINELLA
text figures 2-8

Distinguishing characteristics: Absence of marginal ridge and weaker development of spines separates it from previously described species of Aechminella Harlton 1933. A. fimbriata Gibson 1955 can be differentiated by its fine reticulation, marginal ridge terminating in anterior and posterior margins and by the upward directed central spine. A.beaumontensa has all spines well separated and somewhat smaller. Distinguished from Neodrepanella tricornis (Batalina) which has a margin developed into a frill, spines directed upward and reticulate surface. Carapace outline is similar to some species of Aechminella but separated from them by development of central spine and suppression of the small spines. The weaker development of all three features distinguishes this from A. middevonicensa n.sp. which has a very stout dominant central spine.

Distribution: Present in the Ireton formation of the McMurray area.

Lithology: Grayish green limy shales. Rare interbeds of brown limestone.

Remarks: A. fimbriata Gibson 1955 is the first described species from the North American Devonian, Cerro Gordo formation. His description is based on one right valve so it would appear to be a rare form. His species shows that the hingement of the right valve consists of a thin groove and ridge with tear shaped sockets at the cardinal angles.

Aechminella middevonica n.sp.

Photograph II, figure 3,4, text figure 3

Carapace small, subquadrate outline, dorsum straight, valves probably inequal, single valves only observed; maximum length at midcentre, maximum height anterior to midcentre and maximum thickness at midcentre; anterior cardinal angle obtuse, with broadly rounded anterior end merging into convex venter and narrowly rounded posterior end terminating in a very obtuse posterior cardinal angle; anterior central node small, separated by broad shallow sulcus from stout long dorsocentral spine projecting well above hingeline; base of dorsocentral spine almost 1/3 length of carapace and about ½ shell height, separated from outward pointed posterodorsal spine by deep broad sulcus which is less than 1/3 carapace height and about ½ length S_1; hingement simple over lap as Aechminella; surface reticulate.

Length: 0.4-0.48 mm. Height: 0.28-0.32 mm. Width: 0.22-0.24 mm.

Figured specimen: Holotype, Moberly, Bear Beaumont No. 1 2130-44'. Length: 0.48 mm. Height: 0.34 mm. Width: 0.24 mm.

Distinguishing characteristics: Separated from A. beaumontensa by stout central dorsal spine and better development of posterior spine and anterior node. Separated from Boursella trilobata Turner 1939 by lack of granulose surface and distinctive dorsal spine lacking oblique posterior curvature, and trilobate dorsal area.

Distribution: Mildred Lake and Moberly members, Waterways formation, McMurray area.

Lithology: Buff dense limestone with bands of limy dark green shale.

Aechminella biltmorensa (Loranger)
Text figure 5

1954 Balantoides biltmorensus Loranger, Western Canada Sedimentary Basin pp. 197-8. Pl. I, figs. 9, 10.

Types: Primary types. Bear Biltmore No.1, 1010-20': in possession Imperial Oil Limited, Calgary, Alberta

Distribution: Lower Ireton of central and northeastern Alberta where it occurs in an important biozone. Mildred Lake and Moberly members of Waterways formation. McMurray area.

Lithology: In Mildred Lake member specimens are associated with a brownish gray limestone; in the Moberly they are in gray green limy shales and buff gray limestones; in the Christina in gray or brown limestones with shaly partings or in greenish gray shales.

Aechminella fribourgella (Loranger)
Text figure 4

1954 Balantoides fribourgellus Loranger, Western Canada Basin, p. 198, Pl. I, figs., 3,4.

Types: Primary types from Shell Fribourg No.1, 2369' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Lower Ireton formation of central and northeastern Alberta. Moberly, Christina and Calmut members, Waterways formation of McMurray area.

Lithology: Limy green shale with thin bands of gray limestone yield largest collections in Bear Beaumont No. 1, Bear Biltmore No.1 and Christina River Hardy No.1. Excellent collections of up to 12.5% of the total microfossil population found at Bear Rodeo No.1 in gray limestone.

Aechminella initialia n. sp.

Photograph II, figs., 5, 6, text fig., 7

Carapace small, subovate in outline; dorsum straight; overlap of left valve slightly along venter and in anterodorsal margin; maximum length at midcentre, maximum height at midcentre and maximum width above midcentre in posterior third of carapace; anterior cardinal angle very obtuse, broadly rounded above and below, convex venter becoming more sharply rounded in posterior end terminating in obtuse cardinal angle; maximum inflation above midcentre of carapace and dorsum extends well above hingeline; small sulcus in anterodorsal area separating large poorly developed node from anterior margin; this ill defined node joins a larger better defined elongate node in the central dorsal area, these nodes originate above midcentre of carapace and are separated by

a deep well marked pit in anterodorsal area, the shoulder or bridge joining these nodes extends above hingeline and is a characteristic feature of this species; this double node is separated in posterior quarter of carapace by a medium deep sulcus which extends downwards from the dorsum about ½ shell height; between this very pronounced sulcus and margin occurs an outwardly and upward pointed node which rises above the hingeline in the same plane to approximately the same height as the double node; hinge is simple groove and bar; surface finely reticulated.

Length: 0.44-0.48 mm. Height: 0.24-0.32 mm.
Width: 0.16-0.22 mm.

Figured specimen: Holotype, Moberly, Bear Beaumont No. 1 2130-44'.

Length: 0.48 mm. Height: 0.32 mm. Width: 0.22 mm.

Distinguishing characteristics: Shape, hingement and ornamentation show close relationship to other species of Aechminella found in McMurray area. The distinctive shoulder of bridge joining the two lobes and forming a pit differentiates this form from other members of the genus. Shape and hingement similar to Aechminella middevonicensa ornamentation in that genus consists of 2 minor nodes or spines and one central prominent spine. Aechminella sp.A which has a similar shape and hingement has only two nodes developed.

Distribution: Moberly in McMurray area.

Lithology: Buff dense limestone with bands of limy dark green shale.

Aechminella trinodensa n.sp.

Photograph I, figs. 10, 11, text fig., 6

Carapace small, subovate to subquadrate in outline; dorsum straight, slightly channelled; dorsum rises above hinge; valves equal except for left overlap on venter; maximum length at midcentre, maximum height in posterior half of carapace, maximum width posterior to midcentre; obtuse anterior cardinal angle, sharply rounded anterior end and venter convex; obtuse posterior cardinal angle broadly rounded to meet venter; maximum inflation above midcentral half of carapace; anterior lobe well defined, extending to midcentre of carapace, separated by broad shallow sulcus from a prominent central lobe arising in the central area and extending well above hingeline; separated by deep wide sulcus about a quarter carapace height from broad posterior lobe; posterior lobe evenly compressed towards margin; extending above hinge but shorter than central lobe.

Variation observed in development of lobes and sulci, however all three lobes are in the same plane, any or all of them may extend beyond hingeline, usually the central lobe is the largest, sometimes inclined towards posterior at a

slight angle; a marginal ridge is often developed parallel to venter; hingement groove and bar; surface finely reticulate.

Length: 0.44-0.46 mm. Height: 0.30-0.32 mm.

Width: 0.2-0.24 mm.

Figured specimen: Holotype, Calmut Bear Westmount No. 1 991-999'. Length: 0.46 mm. Height: 0.32 mm. Width 0.12 mm. (single valve).

Differentiating characteristics: Separated from A. biltmorensa (Loranger) 1954 which has large median lobe and poorly developed posterior node projecting outwards; the lobes do not slope outward at such an angle as A.biltmorensa nor does the marginal ridge assume such definition. More lobate than A. fribourgella (Loranger) 1954 which has one central node of importance and two smaller ones approaching spines or alar type development. Although the central lobe is predominant it does not assume the spine like quality of Aechminella middevonicensa or the needle-like definition of A. beaumontensa.

Distribution: Mildred Lake, Christina and Calmut in the McMurray area.

Lithology: Gray to buff gray limestone, argillaceous in Bear Rodeo No. 1 (269-280') and with limy dark green shaly bands in Bear Beaumont No. 1 (2130-2144').

Aechminella sp A., n.sp.

Photograph II, figs. 7, 8, text fig., 8

Carapace small, outline subquadrate; dorsum straight; valves equal or nearly so; maximum length at midcentre, maximum height at midcentre and maximum width above midcentre; anterior cardinal angle obtuse broadly rounded, venter broadly convex, posterior cardinal angle obtuse, posterior end sharply rounded; carapace inflated above midcentre of carapace; bar and groove hingement as Aechminella two sharp equally developed nodes arising in upper third of carapace and directed upwards above hingeline, in anterior 2/3 of carapace; suppression of nodal development in posterior of carapace; surface sometimes appears granular.

Length: 0.48 mm. Height: 0.28 mm. Width: 0.14 mm.

Figured specimen: Holotype, Moberly, Bear Vampire No. 2 92-102'; length: 0.48 mm, height: 0.28 mm, width: 0.14 mm.

Distribution: Moberly and Christina members in McMurray district.

Lithology: Green limy shale with dense gray or finely crystalline limestone bands.

Remarks: Distinguished by shape from Boursella trilobata Turner 1939 and by lack of granular surface. Kesling (1953) illustrates this species and comments that his specimens have the S_3 curved nearly parallel to

posterior border and not nearly as straight or vertical as the original description (p.197, Pl.1, figs. 11-16).

Mauryella Ulrich and Bassler 1923

Remarks: Ulrich and Bassler (1923) placed Mauryella in the family Kirkbyidae which is recognized as an artificial association of equivalved Beyrichiacea although it lacks a false border. Henningsmoen (1953) places this genus in Beyrichiacea of uncertain family connections. Although the pit, hingement, shape and ornamentation suggest closer affinities to the Kirkbyidae than the Beyrichiidae suggested by Pokorný (1958) it is now placed in the family Aechminellidae by Sohn (1961).

Mauryella sp A. n.sp.

Photograph II, figs. 9, 10, text figure 9.

Carapace small, subrectangular in outline, valves equal; long straight dorsum, maximum length at or above midcentre, maximum height posterior to midcentre, maximum width posterocentral; cardinal angles exceeding 90°; anterior end broadly rounded, posterior end broadly rounded postero-ventrally but sharply rounded in posterodorsal area; ventral margin may be slightly convex; seven nodes of various sizes arranged with four above midheight in a diagonal line and three below about equidistant to margin; anterodorsal and dorsal central nodes are anterior to a central pit which is just above midheight, the upper posterocentral area and

posterodorsal area have the nodes closer to the dorsum; lower three are variable and weathering of specimens or lack of reticulation tends to make them appear as elongate nodes, they are in anteroventral, central and posteroventral areas; fine irregular pentagonal and hexagonal reticulation on surface.

Length: 0.44-0.58 mm. Height: 0.24-0.36 mm.

Width: 0.14-0.16 mm.

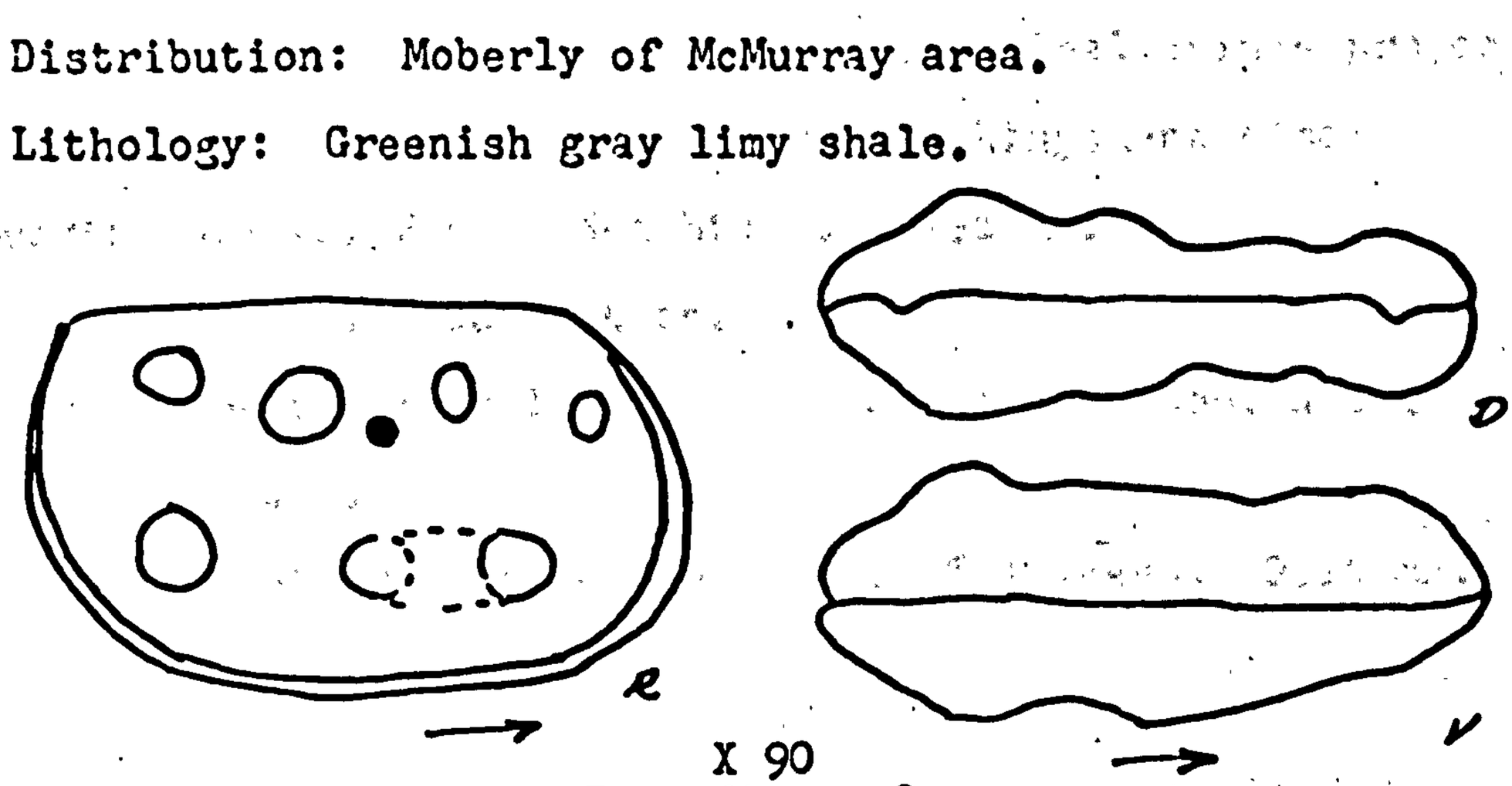
Figured specimen: Holotype, Moberly, Christina River Hardy No.1; 1249-59'. Length: 0.58 mm. Height: 0.36 mm.

Width: 0.16 mm.

Distinguishing characteristics: Superficial resemblance to M. mammillata Ulrich and Bassler 1923 in absence of false border, subcentral pit and reticulated surface with nodes. M. sp. A. has a more rectangular profile, less convex ventrally and a posterior cardinal angle close to 90 degrees.

Distribution: Moberly of McMurray area.

Lithology: Greenish gray limy shale.



X 90

Text figure 9

Aechmininidae Bouček 1936

Aechmina Jones and Holl 1869

Remarks: Aechmininae Bouček 1936 was considered a subfamily of the Primitiidae which included Aechmina, Paraechmina and Novakia; Levinson (1961) expanded and revised the family.

Aechmina vikingensa n.sp.

Photograph VI, figs., 13, 14, text fig., 10

Carapace small, outline subelliptical, truncated by long straight dorsum projected anteriorly as stout prow or beak; equivalved; maximum length just above midcentre and at hinge-line, maximum height at midcentre, maximum width well above and anterior to midcentre; anterior cardinal angle acute due to prow; broadly curved throughout venter and forming a more sharply rounded obtuse posterior cardinal angle; ventral half of carapace closely compressed; in addition to anterior cardinal prow, stout central dorsal nodes projecting outwards just anterior to midcentre, long cylindrical spines projecting slightly posterior in juvenile molts; hingement simple.

Length: 0.36-0.52 mm. Height: 0.2-0.36 mm.

Width: 0.12-to 0.14 mm.

Figured specimen: Holotype, Ireton Bear Beaumont No. 1 1334 -43'.

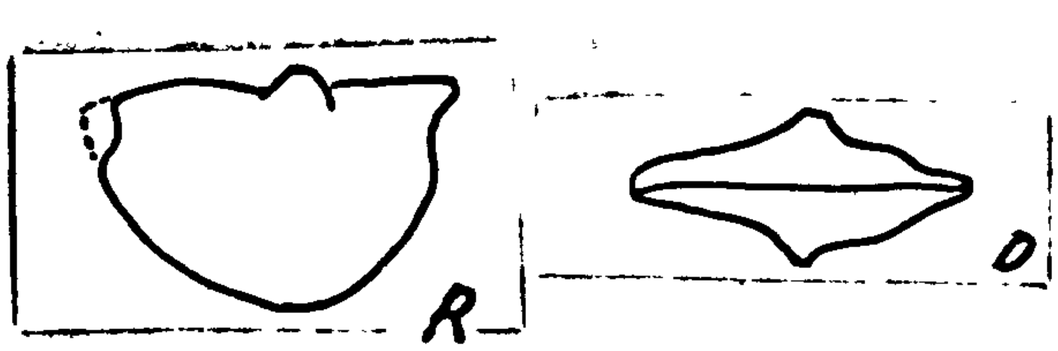
Length: 0.52 mm. Height: 0.36 mm. Thickness: 0.14 mm.

Distinguishing characteristics: Prominent prow or beak differentiates this from previously published species of Aechmina.

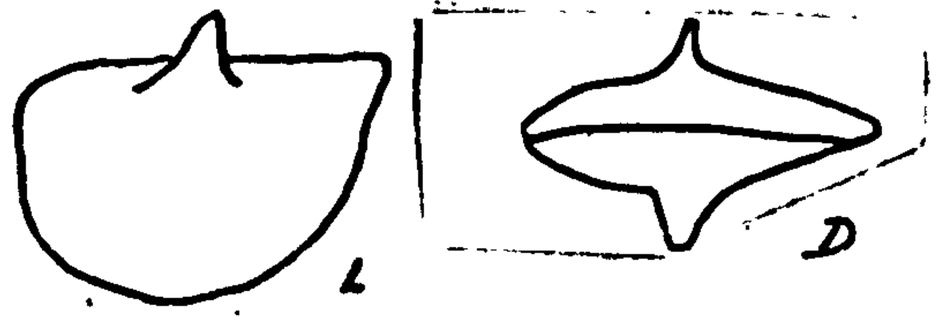
Distribution:

Ireton: Bear Beaumont No. 1 1312-25'; 1334-63'.

Lithology: Limy gray green shale.



X 25
Text figure 10



X 23
Text figure 11

Aechmina sp.A. n.sp.

Photograph VI, figures 15,16, text figure 11

Carapace small, compressed; dorsum straight; broadly rounded anterior margin and more sharply rounded posterior margin hence subovoid outline; hinge long almost maximum length, marginal overlap inconspicuous except anterior margin where right valve overlaps slightly; maximum length above mid-centre, maximum height anterior to midcentre, maximum width posterior to midcentre; anterior cardinal angle obtuse in molts and becoming almost 90^{o} in later forms; posterior cardinal angle very obtuse in adult; spindly antero-dorsal spine anterior to midcentre in adult; in molts midcentral or nearly so, and projecting outwards and slightly upwards at right angles to carapace; larger specimens have blunt spines which may be due to weathering; spines not diametrically

opposite on the valves; surface finely reticulate.

Length: 0.36-0.6 mm. Height: 0.16-0.36 mm.

Width: 0.12-0.20 mm.

Figured specimen: Paratype, Ireton. Bear Beaumont No. 1, 1334-43'. Length: 0.6 mm. Height: 0.36 mm.

Width: 0.20 mm.

Distinguishing characteristics: Acuminate posterior end weakly developed spine separates this from known Devonian and late Silurian forms.

Distribution: Ireton in McMurray area.

Lithology: Limy grey green shale.

Remarks: Spines more prominent in molt stages, appearing to be almost as long as carapace is high, and needlelike.

Bollidae Bouček 1936

Bollia Jones and Holl 1886

Remarks: Ulrich placed this genus in Beyrichiidae in 1894; Jones put it in Leperditiidae-Beyrichiinae in 1901; Bassler and Kellett revised the group and placed it in Primitiidae-Primitiinae in 1934; Swartz removed it in favor of Drepanellidae in 1936; Henningsmoen in 1953 referred it to Drepanellidae -? Bolliinae; Scott (1961) keeps it within the Superfamily Drepanellacea and Family Bollidae.

Bollia sp

Photograph VI, figures 9,10, text figure 12

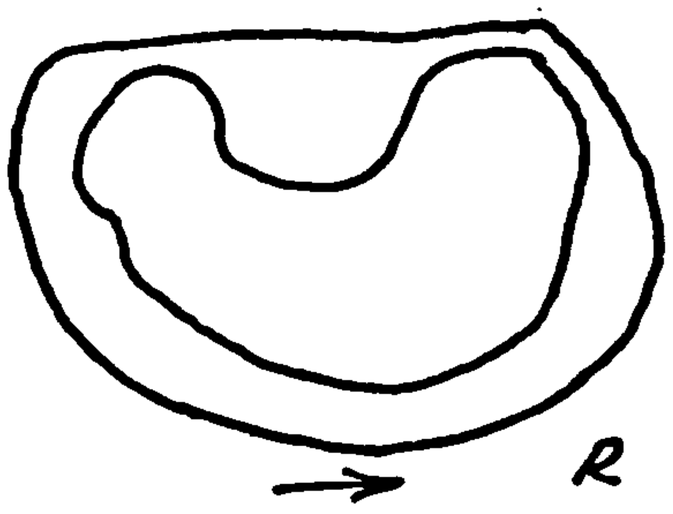
Small, incomplete specimens of Bollia with teeth along posterior and part of ventral margin. This is unlike other Bollias described with the exception of B.obesoides Bassler 1941 from the Upper Lower Devonian (Onondaga) of Benton County, Tennessee. However, these Ireton forms lack the rounded marginal ridge and well developed loop of that species. These specimens may represent molt stages.

Figured specimen: Ireton, Bear Biltmore, 568-78'.

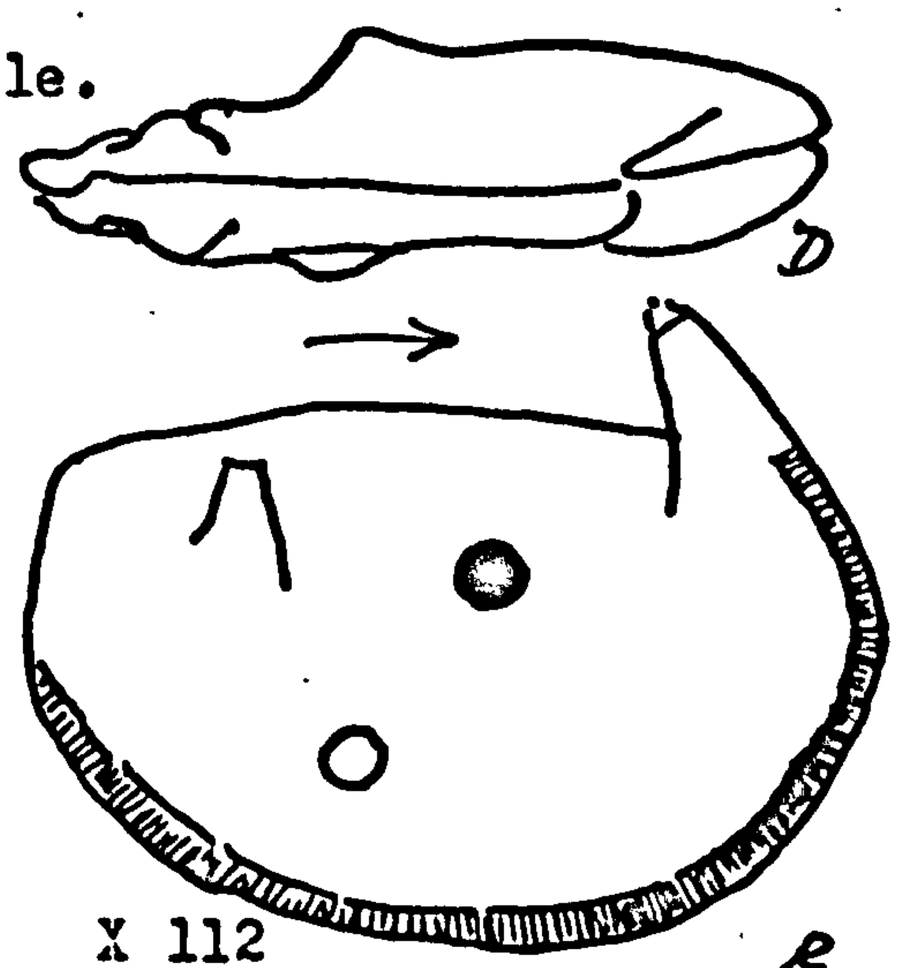
Length: 0.46 mm. Height: 0.36 mm. Width: 0.16 mm.

Distribution: Ireton formation in McMurray area.

Lithology: Greenish-gray limy shale.



X 100
Text figure 12



X 112
Text figure 13

? Eurychilinidae Ulrich & Bassler 1923

Bicornellina Zaspelova 1952

Remarks: Pokorný (1958) placed Bicornellina Zaspelova in Neodrepanellinae; Levinson and Moore in the G.S.A. Treatise place this in the ? Eurychilinidae.

Bicornellina ? sp., n.sp.?

Photograph VI, figures 25,26, text figure 13

Carapace small, subspherical, very compressed; dorsum straight or very slightly bowed; no apparent overlap; maximum length at midcentre, maximum height anterior to midcentre, maximum thickness at midcentre, anterior end broadly and evenly rounded forming obtuse cardinal angle, posterior end broadly rounded ventrally and more sharply rounded dorsally to form an acute dorsal cardinal angle; venter gently rounded; a small well defined frill begins in central posterior and extends around venter to anterodorsal angle where it is projected upwards and backward in a sharp blade; spines are present in posterodorsal and posterocentral areas; a pit appears anterior to midcentre and the surface is coarsely reticulated.

Length: 0.56 mm. Height: 0.36 mm. Width: 0.07 mm.

Figured specimen: Holotype, Ireton, Bear Beaumont No. 1 1334-63'.

Distinguishing characteristics: Coarse reticulated surface, prominent blade joined to striated frill, posterodorsal and posterocentral spines and median pit serve to differentiate this from described species of ? Eurychilinidae. It is similar to genus Bicornellina in having prominently upward directed spines in antero and posterodorsal regions, which may or may not be connected

to a complete, striated frill. However the surface is not smooth but reticulated and no muscle scar is present. In its place a small pit is present. Very few specimens were found in the McMurray area and until additional material is available for study it is proposed to provisionally refer this species, which is probably new, to the genus Bicornellina, since it has more features in common with this genus than anything else described.

Distribution: Present in the Ireton, McMurray area.

Lithology: Shaly gray green limestone.

Sigmoopsidae Henningsmoen 1953

Winchellatia Kay 1940

Winchellatia deminuta Kesling and Tabor

1953 Mus.Pal.Contr. Ann Arbor, Mich., vol.10, No.5, p.91 pl.2, figs. 20-23.

Types: Mus.Pal.Univ. Mich., Ann Arbor, Mich., holotype No.28077; paratype no.28078.

Remarks: The genus Winchellatia was originally assigned to Primitiidae-Eurychilininae by Kay (1940); later placed by Schmidt (1941) in Hollinidae-Ctenetominae and by Henningsmoen (1953) in Sigmoopsiidae? Sigmoopsinae.

Winchellatia cf. deminuta Kesling and Tabor

Photograph II, figs., 1,2.

Figured specimens: Christina River Hardy No.1 well, Moberly member, Waterways formation, 1339-49'

Length: 0.64 mm. Height: 0.36 mm. Width: 0.24 mm.

Distribution: Middle Devonian, lower Erian, upper Cazenovian, Genshaw formation below Killians black limestone member. Type locality in west half sec.32, T.33N., R 8 E., Presque Isle County, Mich. Present in the Moberly in McMurray area.

Lithology: From dark gray shale with abundant Cyrtina umbonata var. alpenensis Hall and Clarke in type locality. At McMurray in Christina River Hardy No. 1 well in gray buff, fragmental limestone.

Remarks: Variations from type description in ornamentation only, the S_2 being poorly developed and not extending under $L_1 \times L_3$, surface reticulate rather than granular and a small spine being prescnt on left valve in cardinal dorsal area. The figured specimen is apparently a molt. Krommelbein has observed that many adults possess better developed ornamentation than the molt stages.* This was also observed by Kesling (1954).

Kirkbyidae Ulrich and Bassler 1906

Kirkbya Jones 1859

1850 Dithyrocaris permiana Jones, Palaeont. Soc. London p. 58-66, Pls. 6, 17, 18.

*Personal communication

Remarks: Originally described by Jones in 1859 ; Bassler and Kellett (1934) give the synonomy up to 1934 and place it in the Kirkbyidae, a family erected by Ulrich and Bassler in 1906.

Kirkbya biltmorensa Loranger

1954 Western Canada Sedimentary Basin, p. 198, Pl. 2, figs., 27, 28.

Types: Primary types from Bear Biltmore No. 1, 1373-83' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Ireton, Macronotella biltmorensa biozone. Present in the Ireton, Duvernay, Mildred Lake, Moberly, Christina, Calmut, and Firebag members , McMurray area.

Lithology: Limy gray green shales and gray or buff limestones yield a few specimens throughout the intervals sampled.

Amphissitidae Knight 1928

Amphissites Girty 1910

Remarks: Placed in Kirkbyidae by Bassler and Kellett (1934), Henningsmoen (1953), and Pokorný (1958). The genus was redefined by Knight (1928).

Amphissites albertensi Loranger

1954 Western Canada Sedimentary Basin, p. 196, Pl.2, figs., 31-2.

Types: Primary types from Imperia l Duvernay No. 1, 2450-60' in possession of Imperial Oil Limited, Alberta.

Distribution: Lower Ireton of central and northeastern Alberta in Aechminella fribourgella biozone and in Ireton of McMurray area.

Lithology: Gray green limy shale.

Amphissites beaumontensi Loranger

1954 Western Canada Sedimentary Basin; p.196, Pl.2, figs. 31-2.

Types: Primary types from Bear Beaumont No.1 1373-83' in possession of Imperial Oil Limited, Alberta.

Distinguishing characteristics: Distinguished from A. duvernai Loranger 1954, A. shafferi Stewart and Hendrix 1945 and A. albertensi Loranger 1954 by frill like projections and carina.

Distribution: Upper Ireton in Macronotella biltmorensa biozone. Ireton, Mildred Lake and Moberly, McMurray area.

Lithology: Gray green limy shale, minor quantities brown or gray limestone.

Arcyzonidae Kesling 1961

Amphizona Kesling and Copeland 1954

Remarks: The authors originally placed this in the Kirkbyidae and this usage has been continued among authors.

The Geological Society of America in their treatise (196 consider this to have equal status with Kirkbyidae and have placed both within the Superfamily Kirkbyacea.

Amphizona pseudocarinata Smith

1956 Jour. Paleo., vol.30, No. 1, p.5, Pl.I, figs. 5-7.

Types: Holotype at New York State Museum, Albany, New York. No.10719.

Differentiating characteristics: Separated from A. asceta Kesling and Copeland 1954 by lack of central ridge, true carinae and frills.

Distribution: Middle Devonian, Middle Erian, lower Tioughniogan, upper Ludlowville, upper Wanakah shale; also Tichenor member Ludlowville formation; Ireton, McMurray area.

Lithology: Shaly limestone, gray green grading into a limy shale.

? Scrobiculidae Posner 1951

Roundyella Bradfield 1935

Remarks: Bradfield (1935) placed this in the Kirkbyidae, Sohn (1961) considers it Kirkbyacea-Scrobiculidae.

Roundyella sp. A. n.sp.?

Photograph VII, figures 1,2, text figure 14

Carapace medium size; subquadrate lateral view; dorsum long,

rises above hinge and is slightly convex; maximum length at midcentre, maximum height anterior to midcentre, maximum width at midcentre; anterior cardinal angle obtuse, broadly rounded with slightly less obtuse inferior angle, venter straight; posterior end symmetrically rounded above and below; poorly developed teeth and sockets; kirkbyan pit represented by nine or more small reticulations closely packed and slightly depressed below surface carapace, located just above midcentre; fine polygonal reticulations.

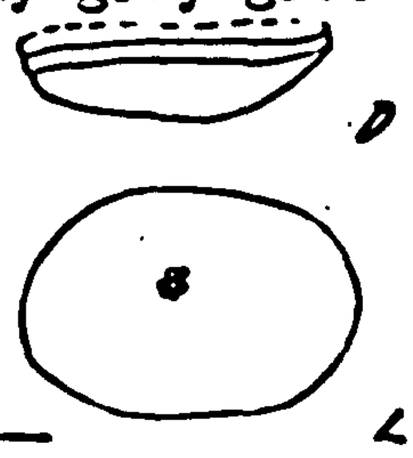
Length: 0.48-0.56 mm. Height: 0.26-0.32 mm. Width: 0.2-0.28mm

Figured specimen: Holotype, Bear Biltmore No.1, Ireton, 684-94'. Length: 0.56 mm. Height: 0.32 mm. Width: 0.28 mm.

Distinguishing characteristics: Separated from R.augustai Pokorný 1950 by finer reticulation and sculptured anterodorsal corner. Shape and lack of spinelets at points of pinetion between meshes of reticulation separate this from Amphissites simplicissimus Knight 1928.

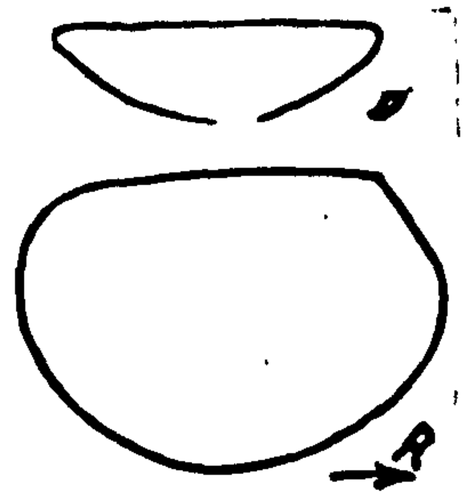
Distribution: Ireton in McMurray area.

Lithology: Occurs in gray limestones that grade into limy gray green shales.



X 46

Text figure 14



X 42

Text figure 15.

Aparchitidae Jones 1901

Aparchites Jones 1889

Remarks: Ulrich placed this in genus Leperditidae in 1894; Bassler and Kellett in 1934 included it in the Leperditellidae; Schmidt in 1941 raised this to Aparchitidae which has been continued by later workers.

Aparchites? sp.

Photograph I, figs., 12, 13, text figure 15

A few specimens found in the Calmut in Bear Vampire No.1 at 968-88' are tentatively identified as Aparchites? sp. Hingement details not observed due to adhering matrix.

Figured specimen: Holotype, Calmut, Bear Vampire, No.1 968-88'; length: 0.76 mm. height: 0.48 mm. width: 0.32 mm.

Distribution: Found in Ireton and Calmut in McMurray area.

Lithology: Buff, green to greenish gray limestone, argillaceous and shaly.

Macronotella Ulrich 1894

Remarks: The genus was placed in Beyrichiidae by Ulrich (1894); Kirkbyidae by Ulrich and Bassler (1923) and in Aparchitidae by Kay (1940) and Henningsmoen (1953).

Macronotella biltmorensa Loranger

1954 Western Canada Sedimentary Basin; p.199, Pl.2, fig. 13, 14.

Types: Primary types from Bear Biltmore No.1, 638-64' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Ireton of central and northeastern Alberta, Macronotella biltmorensa biozone.

Lithology: Best recovery from argillaceous greenish gray limestone in Bear Biltmore No.1, lesser numbers found in gray green limy shales in Bear Beaumont No.1 and in argillaceous grayish green limestone. The Duvernay equivalent in Bear Beaumont No.1 is chiefly gray green limy shale.

Remarks: Dorsum arched in posterodorsal area and in rare specimens forms a rounded shoulder well above hinge-line and is limited by a short deep sulcus. The areas adjacent to the cardinal angles have been compressed (Bear Biltmore No.1, 674-684').

Pribylitidae Pokorný 1958

Remarks: Pokorný (1950) placed Pribylites in superfamily Leperditiacea, family Aparchitidae, later (1958) created a new family to accommodate a number of forms. Due to similarity to Pribylites Pokorný 1950, this new genus is placed provisionally in the family Pribylitidae Pokorný 1958.

Neopribylites n.g.

Semiovoid to subovoid carapaces of medium size; hingement leperditoid; slight ventral overlap of right valve otherwise equal in size; cardinal nodes, formed at end of the hinge by subglobose swellings on both valves, develop outward or upward; ventral nodes project downwards.

Distinguishing characteristics: Recognized by sinuous dorsum terminating in upward or outward projecting nodes, stout anteroventral and posteroventral spines and inflated carapace below midcentre. Differentiated from Saffordella Ulrich and Bassler on basis of limited nodation and lack of long curved submarginal ridge; Paraparchites Ulrich and Bassler 1906 by lack of sansabelloid carapace and cardinal nodes; from Pseudoparaparchites Kellett 1933 by cardinal nodes; from Microparaparchites Croneis and Gale 1938 by cardinal nodes and spines on venter; from Eoleperditia sp. with notched cardinal angles described from Oklahoma by Harris (1957) by lack of eye tubercle and ventral marginal keels; separated from Pribylites Pokorný 1950 by lack of velate structure, ornamentation and having "tubercles" of the same material structurally as rest of carapace; from Parapribylites Pokorný 1950 by cardinal nodes.

Distribution: Late Middle Devonian. Rare.

Genoholotype: Neopribylites albertensus n.g. n.sp.

Neopribylites albertensus n.g., n.sp.

Photograph VI, figs. 3,4, text figure 16

Carapace medium size; outline semiovoid to subovoid; hinge concave at extremities due to rounded nodes developed in both valves and meeting in contact line to form a subglobose swelling at each end of hinge, in central portion may be straight or slightly convex; valves nearly equal with very slight overlap of right on venter; maximum length midcentre in adults or later molts, at hinge line in juveniles; maximum height anterior to midcentre; maximum width posterior to midcentre and/or below midcentre; apparent tendency for valves to be inflated, at least in juvenile molts below midcentre and then broadly rounded to form contact; anterior cardinal angle obtuse and broadly rounded so that the evenly convex venter continues into sharply defined posterior cardinal angle of just over 90°; marginal edges sometimes compressed to form narrow border extending from one cardinal angle to the other; prominent nodes or projections at cardinal angles project outward in juveniles, upward in adults; two stout spines situated anteroventrally and one posteroventrally, approximately opposed in each valve; hingement simple; surface finely reticulate.

Length: 0.44-0.88 mm. Height: 0.24-0.66 mm.

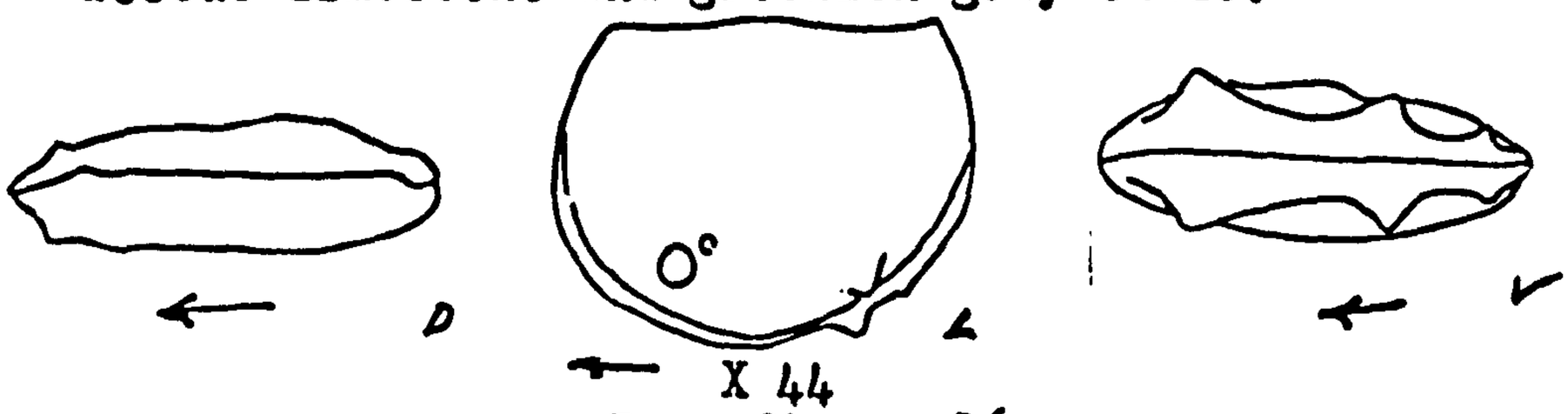
Width: 0.16-0.36 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore, No.1, 1064'-1074'; length, 0.88 mm., height 0.66 mm., width 0.36 mm.

Distinguishing characteristics: This species is similar to Pribylites Pokorný 1950 in having nodes and a tendency to have an inflated ventral section, however, the nodes in the juvenile molts are projected outwards and in more adult forms reduced to upward projecting features. No difference in preservation is noted and these projections are apparently mere extensions of shell rather than eye tubercles. None of the velate structure characteristic of Pribylites is present. Neopribylites albertensus is recognized by tumid carapace, nodes in cardinal and spines in ventral areas.

Distribution: Ireton, Mildred Lake and Moberly in the McMurray area.

Lithology: In Bear Beaumont No. 1 in a brown crystalline dolomite; in Bear Biltmore No.1 in a brown fragmental limestone, in Christina River Hardy No.1 in an argillaceous limestone and greenish gray shale.



Text figure 16

Primitiopsidae Swartz 1936

Limbinaria Swartz 1956

Limbinaria navicularia n.sp.

Photograph VI, figs., 11, 12, text figure 17 & 18

Carapace small, equivalved, semicircular in lateral view with exception of anterior projecting spine; dorsum straight and with spine exhibits maximum length which corresponds to length just above midcentre; maximum height anterior to midcentre, maximum width anterior of midcentre in anterodorsal and central dorsal areas; anterior cardinal angle projected as small stout spine; otherwise approximately 90°; posterior cardinal angle obtuse and broadly rounded to meet venter forming almost perfect semicircle; well defined thick ridge extends from anteroventral area parallels anterior margin and terminates in the mid posterodorsal area; it is broadly rounded above the dorsum and reaches maximum elevation at midcentre of hinge; above ridge in posterodorsal area carapace is compressed and this compression extends in diminishing value around the venter to the anteroventral area where it is much reduced and parallels the anterior margin to form base of spine; surface covered with small polygonal reticulations. Muscle scars observed in adult forms in submedian position. Shell compression and ridges more pronounced in molt stages.

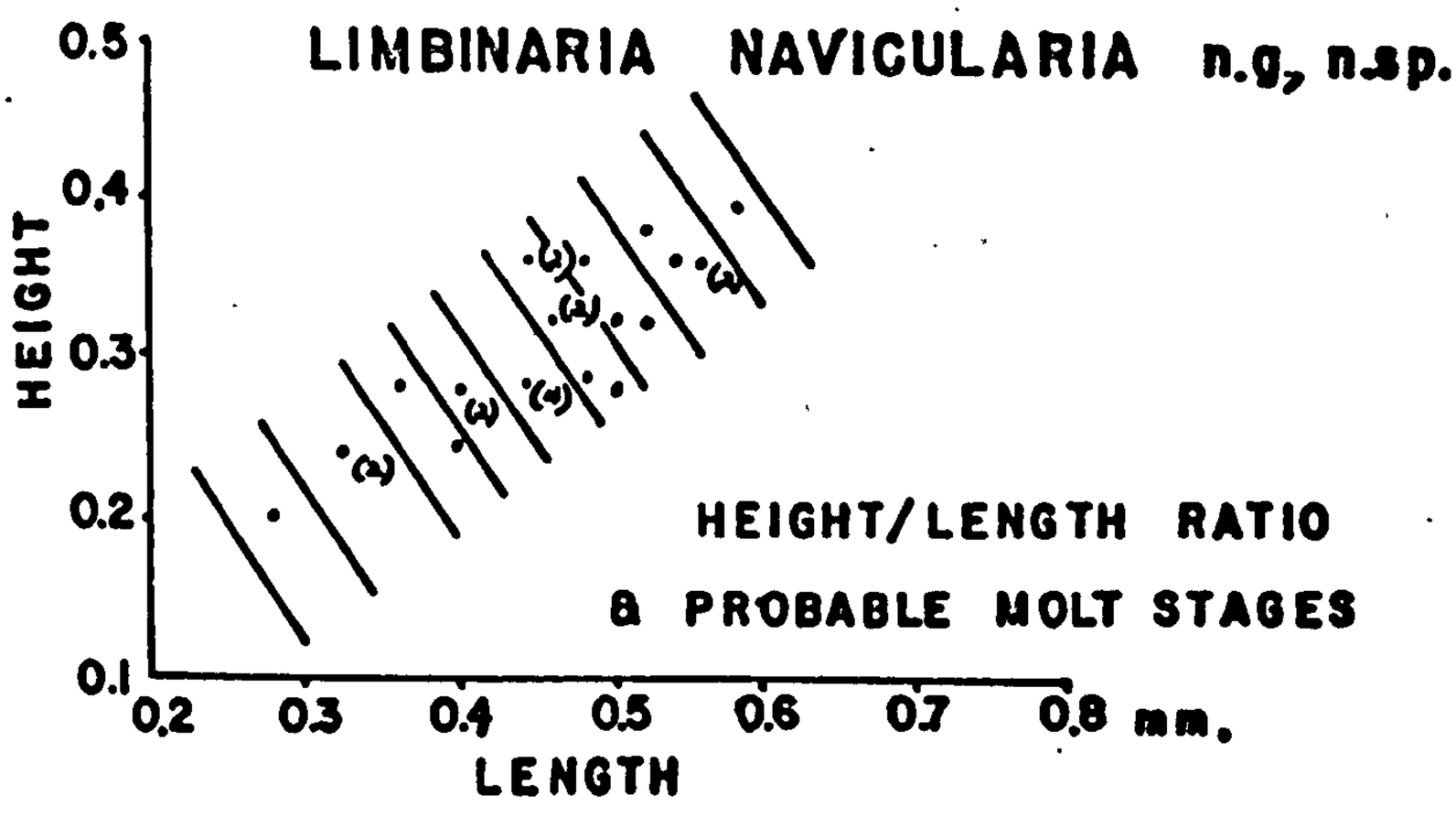
Length: 0.28 to 0.6 mm. Height: 0.2 mm. to 0.4 mm.

Width: 0.08 to 0.2 mm.

Figured specimen: Holotype, Ireton Bear Beaumont No.1 1334-44'. Length: 0.6 mm. Height: 0.4 mm.

Width: 0.2 mm.

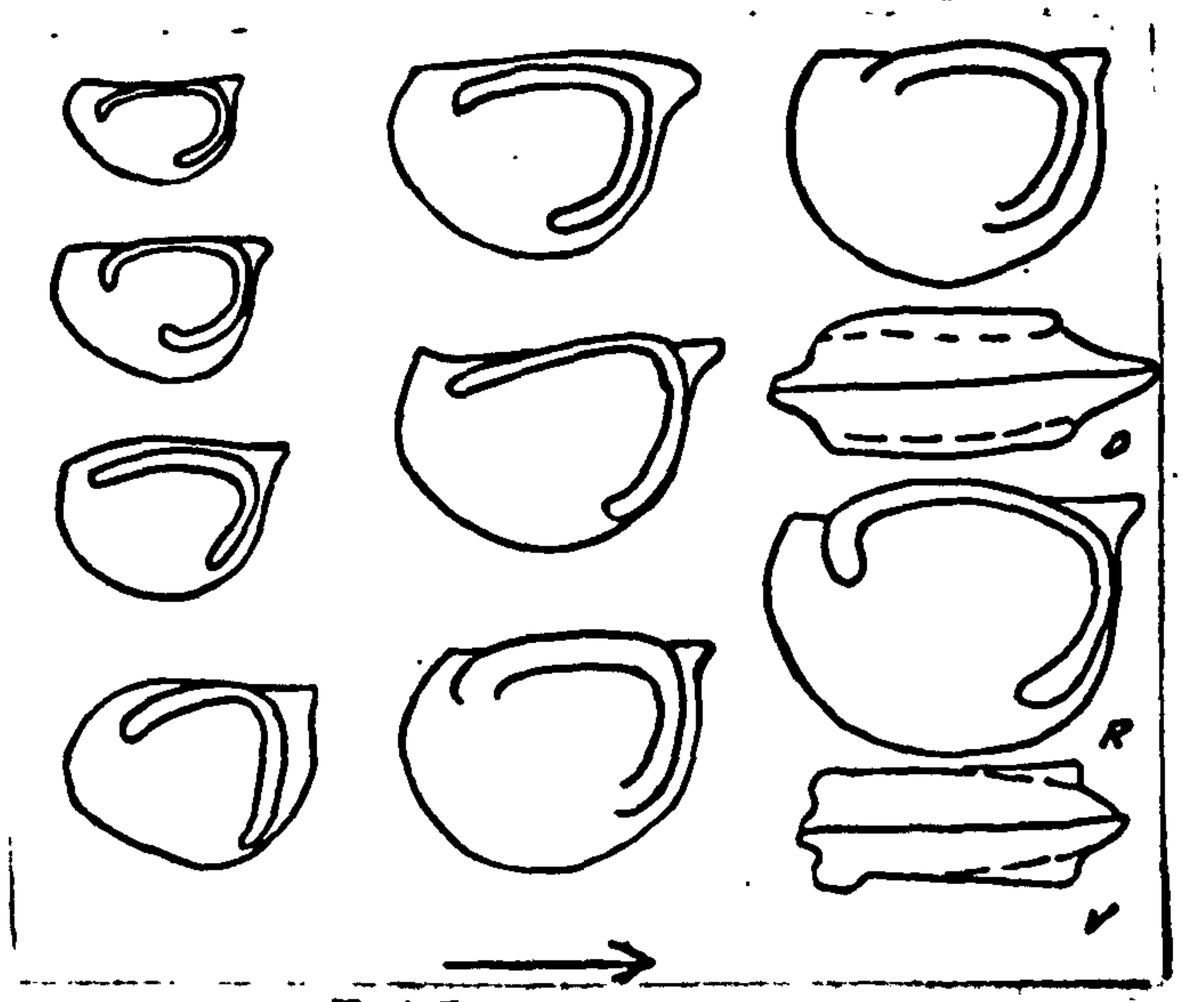
Distinguishing characteristics: Prominent anterior elongation of the hingeline, finer reticulation, and lack of deep submedian pit separate this from other Limbinarias.



Text figure 17

Distribution: Present in the Ireton, Moberly and Christina formations of the McMurray area.

Lithology: In the Ireton this species is found in a limy green shale; in the Moberly in a limy green shale which becomes dark green and associated with a buff limestone in the basal portion. In the Christina it is found in a gray green shale with some gray limestone.



X 45
Text figure 18

Remarks: Although deep submedian pit and dimorphism are characteristic of a number of species in this genus, Swartz finds a number which apparently do not exhibit dimorphism. L.navicularia did not show any dimorphic differences in the 25 specimens measured. The submedian pit is not present but the adult form of L.navicularia has a group of muscle scars in a submedian position. Pokorný (1950) has suggested that the elongation of the hinge line is a gerontic phase in the development of a species. It is also possible that the loss of ornamentation in the adult and later molt stages represent the same tendency.

Youngiellidae Kellett 1933

Youngiella Jones and Kirkby 1895 emend Wilson 1933

1886 Youngia Jones and Kirkby, Proc.Geol.Assoc., vol.9, p.515.

1895 Youngiella Jones and Kirkby, Ann.Mag.Nat.Hist., ser.6, vol. 16, p.456.

1932 Moorites Coryell and Billings, Amer.Midl., Nat., vol.13, No. 4, p.182.

Remarks: Jones and Kirkby placed this genus in the Cytheridae (1886), Ulrich and Bassler included this in the family Kirkbyidae (1923), Kellett in 1933 proposed to erect a new family for the genera Moorites and Youngiella - the diagnostic character of this family being a series of alternating teeth and sockets. Henningsmoen (1953) adds to the family Youngiellidae Kellett 1933 ? Moorea and ?Hardinia Pokorný (1958) includes in the Order Beyrichiida all of Ulrich and Bassler's Beyrichiacea plus the Aparchitidae and although he does not deal with the Youngiellidae in detail it appears that Youngiellidae should belong to the order Beyrichiida, on the basis of dentition and similarity to the other members of the subfamily erected by Ulrich and Bassler (1923). Sohn(1961) considers the family Youngiellidae to have the characters of the Superfamily Youngiellacea.

Youngiella devonicensa n.sp.

Photograph VI, figs., 19, 20, text figure 19

Carapace small, oblong in lateral view; equivalved; hingeline

long, dorsum slightly convex towards posterior end, depressed hinge forming narrow shallow channel; maximum length at midcentre, maximum height posterior to midcentre, maximum thickness midcentral; venter slightly convex, obtuse cardinal angles, the posterior being slightly smaller; anterior end more broadly rounded than posterior end; surface smooth. Length: 0.24-0.28 mm. Height: 0.1-0.22. Width: 0.04-0.14 mm.

Figured specimen: Holotype, Bear Biltmore No.1 539-549'.

Length: 0.28 mm. Height: 0.22 mm. Width: 0.14 mm.

Distinguishing characteristics: Lack of ornamentation differentiates this species from Y. spicifera Wilson 1933, Y. wapanuckensis Wilson 1935, and Y. puncta Wilson 1933. Oblong shape, slightly curved venter and less obtuse anterior cardinal angle separates this from Y. knighti Wilson 1933. No description of Y. rectidorsalis (Jones and Kirkby) [Youngia rectidorsalis 1886] exists and the published drawings are diagrammatic. Y. devonicensa n. sp. is recognized by its size, oblong shape, cardinal angles and slightly curved dorsum.

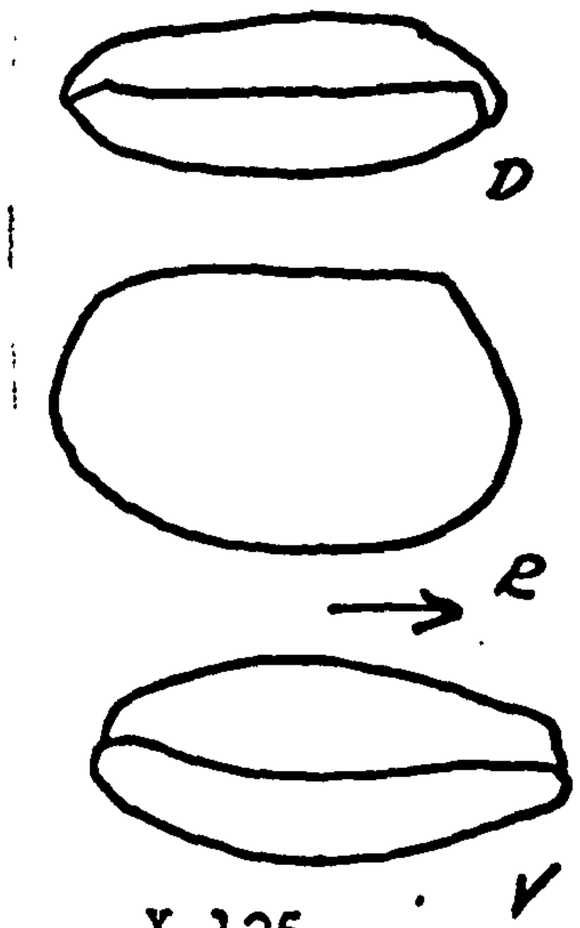
Distribution: Found in cores and cuttings in central Alberta.* Common in the Ireton, Cooking Lake, Mildred Lake, Moberly, Christina, Calmut, and Firebag in the McMurray area.

Lithology: Grayish green limy shales yield maximum numbers of specimens; argillaceous limestones yield fewer numbers; buff dense limestones rarely have more than

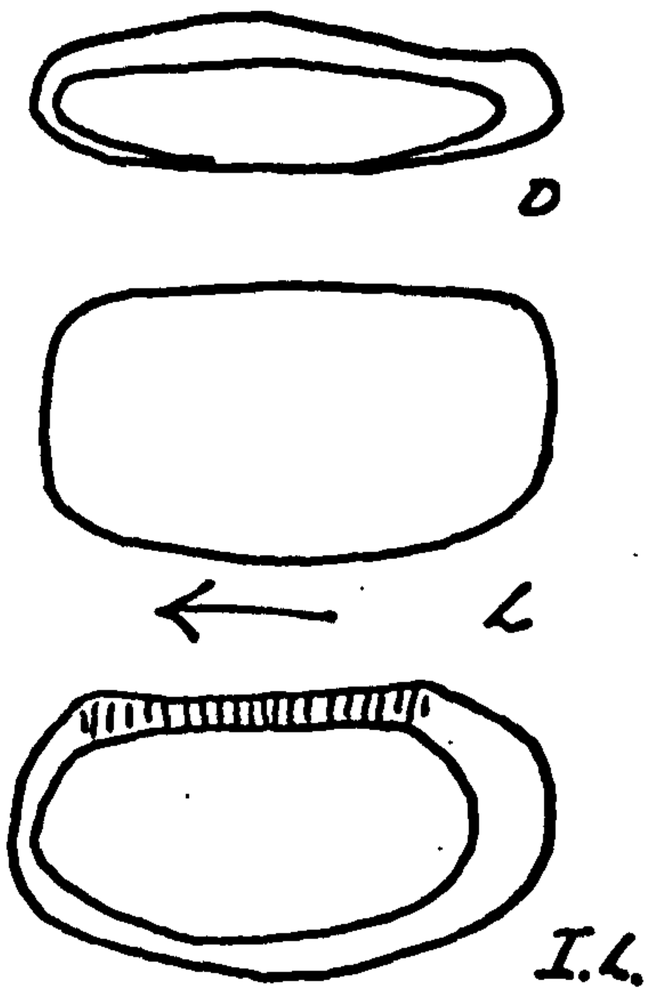
*Unpublished information

an occasional specimen.

Remarks: Orientation used here is similar to Jones and Kirkby 1886 rather than Wilson 1933. The pronounced swing of the carapace outline is considered indicative of the anterior end.



X 125
Text figure 19



X 125
Text figure 20

Youngiella elongatensa n.sp.

Photograph VI, figures 21, 22, text figure 20

Carapace small, subrectangular in lateral view; long straight dorsum; maximum length midcentre, maximum height anterior to midcentre, maximum width midcentral; dorsum and venter straight and parallel to each other; anterior cardinal angle very obtuse, less obtuse posterior cardinal angle; inferior ventral angle slightly less than posterior cardinal angle; anterior end broadly rounded at cardinal angle and sharply rounded below, posterior inferior angle broadly rounded below; two poorly defined ridges parallel anterior and posterior

margins present and faint surface pitting; dentition by alternating teeth and corresponding sockets along entire hinge length. Muscle spot not observed.

Length: 0.24-0.36 mm. Height: 0.14-0.16 mm. Width: 0.4-0.8 mm.

Figured specimen: Holotype, Bear Biltmore No.1, Ireton, 539-49'. Length: 0.36 mm. Height: 0.16 mm. Width: 0.8 mm.

Distinguishing characteristics: Ridges differentiate Y. elongatensa n. sp. from Y. spicifera Wilson 1933, Y. knighti Wilson 1933 and Y. rectidorsalis (Jones and Kirkby 1886). Poorly developed ridges and straight dorsum separate this from Y.wapanuckensis Harlton 1933. Lack of distinct orderly pitting prevents confusion with Y. puncta Wilson 1933. Ridges and elongate shape differentiate this from Y. devonicensa n. sp.

Distribution: Found in the Ireton, Moberly and Firebag of the McMurray area. Present in cores and cuttings in central Alberta.*

Lithology: Green gray limy shales in Bear Westmount No. 1 (1185-94') yielded maximum percentage but in remaining samples appear to be evenly distributed in mixed lithologies of gray buff limestones interbedded with or grading into limy gray green shales.

*Unpublished information

Kleodenellidae Ulrich & Bassler 1908

Kloedenella Ulrich and Bassler 1908

Remarks: Authors apparently have had no problem in classifying this as Kloedenellidae-Kloedenellidinae (Bassler and Kellett, 1934, Henningsmoen 1953).

Kloedenella rodensa n.sp.

Photograph I, figures 6,7, text figure 21

Carapace large in adult; subrhomboidal in lateral view, dorsum straight; hingement details and overlap not observed due to adhering matrix; maximum length just below midcentre, maximum height posterior to midcentre, maximum width posterior to midcentre; anterior cardinal angle obtuse, anterior end broadly rounded above and below midcentre, venter slightly convex, posterior end broadly rounded in inferior angle and sharply rounded to form posterior cardinal angle; carapace evenly inflated; narrow sharp edged marginal rim extending around both valves; ornamented by deep elongate sulcus anterior to midcentre of valve, about 1/3 carapace height which is slightly flared at lower extremity; reticulated surface which is arranged in fine longitudinal rows in posterior half of carapace.

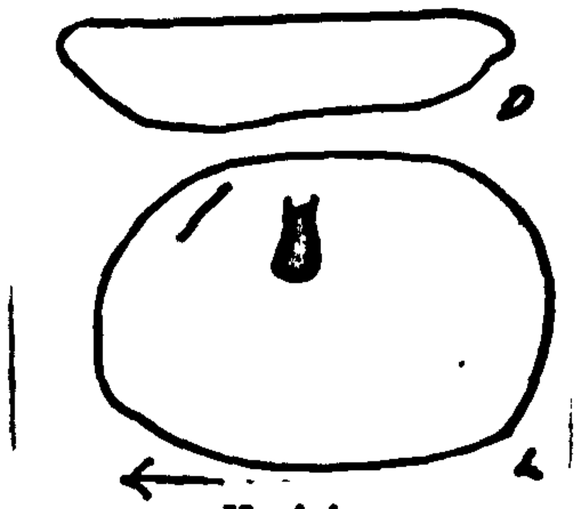
Length: 0.52-0.92 mm. Height: 0.36-0.48 mm.

Width: 0.14-0.16 mm. (1 valve)

Figured specimen: Holotype, Firebag, Bear Rodeo No. 1 321-31'. Length: 0.8 mm. Height: 0.48 mm. Width: 0.24mm.

Distinguishing characteristics: Separated from K. opisthorhysa Kesling and Kilgore 1952 by more rectangular shape and

reticulated ornamentation rather than punctate, striate; sulcus in the McMurray specimens is smaller, shallower and does not extend to midcentre of carapace.



X 44
Text figure 21

Distribution: Common in the Calmut and Firebag members of the McMurray area.

Lithology: More abundant in greenish gray limy shales and least abundant in gray buff limestones. Specimens are found in green limy shales and dark gray limy shales.

? Eukloedenella Ulrich and Bassler 1923

Remarks: This genus was placed in Kloedenellidae by Ulrich and Bassler 1923, in Kloedenellidae-Kloedenellinae by Henningsmoen in 1953 and in Kloedenellidae by Pokorný 1958.

? Eukloedenella sp.

Photograph VI, figs. 17, 18.

Single valves or molds found which resemble E. doverensis Turner 1939. However, the sulcus appears to be smaller, shallower and the posterior cardinal angle obtuse.

Figured specimen: Ireton, Bear Biltmore No. 1 638-48'.

Length: 0.82 mm. Height: 0.44 mm. Width: 0.2 mm.

Distribution: Found in the Ireton, Moberly, Calmut, and Firebag of the McMurray area.

Lithology: Maximum recovery in Bear Beaumont No. 1 1091-1116' in gray greenish brown limestone which is argillaceous. Of the remaining samples twice as many occurrences of this ostracode occur in gray argillaceous limestones as in gray green shales.

Geisinidae Sohn 1961

Hypotetragona Morey 1935

Remarks: Sohn (1961) places this genus in synonomy with ? Janetina Coryell & Malkin 1936, Kloedenellina, Gillina Coryell & Johnson 1939, Limnoprimitia Kummerow 1949, Knoxiella, ? Kuleschovkia Egorov 1950, Plavskella Samilova 1951.

Hypotetragona beaumontensa (Loranger)

1954 Janetina beaumontensa Loranger, Western Canada Basin, Amer. Assoc. Pet. Geol. pp. 199-200, Pl. 2, figs. 17,18.

Primary types: Imperial Oil Limited, Calgary, Alberta

Remarks: Sohn in the G. S. A. treatise (1961) suggests this is in synonomy with Hypotetragona Morey 1935.

Distribution: Upper Ireton in central and northeastern Alberta. Ireton in McMurray area.

Lithology: Limy gray green shale.

Hypotetragona albertensa n. sp.

Photograph III, figs.1-28, text figures 22, 23.

Carapace large, subrectangular; dorsum straight; valves inequal, slight overlap of right valve along hinge line, elsewhere left valve is inserted into a furrow present on the free margins of the right valve; maximum length at midcentre, maximum height posterior to midcentre, maximum width posterior to midcentre; anterior cardinal angle very obtuse, broadly rounded anterior end with anterior inferior angle slightly greater, venter gently rounded with an inferior angle greater than the anterior angles, sharply rounded posterior end forming an obtuse posterior cardinal angle; carapace inflated toward venter and in posterior half, slight tendency towards compression in the anterodorsal area; hingement appears to be simple groove and bar, maximum width of flange on venter of right valve; small 'ears' sometimes formed in posterior cardinal angle; broad shallow sulcus anterior to midcentre about 1/3 carapace height; poorly differentiated lobation; surface covered with polygonal reticulations. Carapace with maximum width in posterior half may be females; those with maximum width nearer midcentre males. Ornamentation in molts consists of large anterodorsal node, separated by short shallow sulcus from dorsocentral node, broad deeper central sulcus persists into adult stage,

INSTAR 1



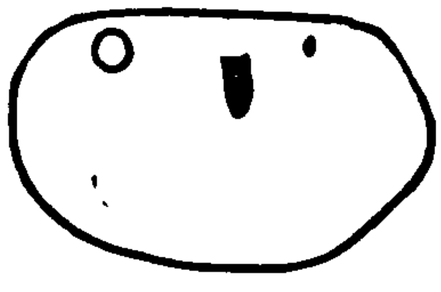
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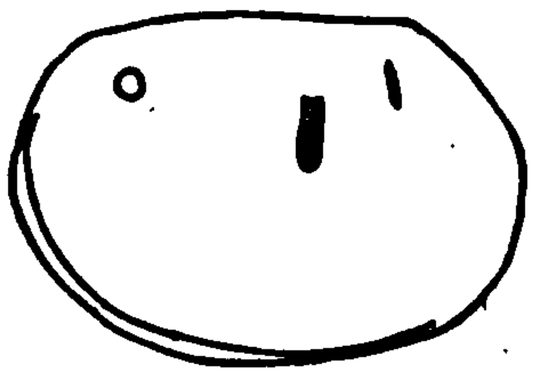
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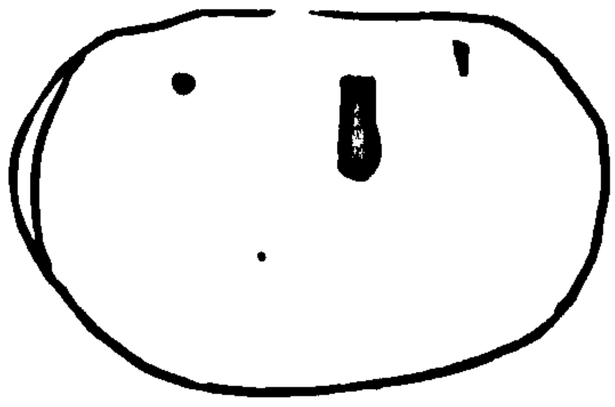
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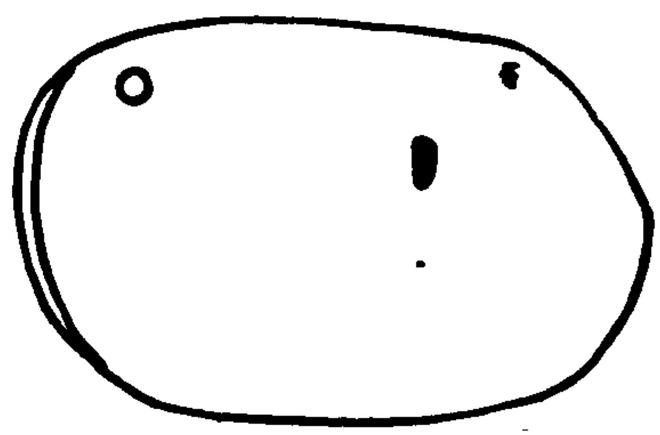
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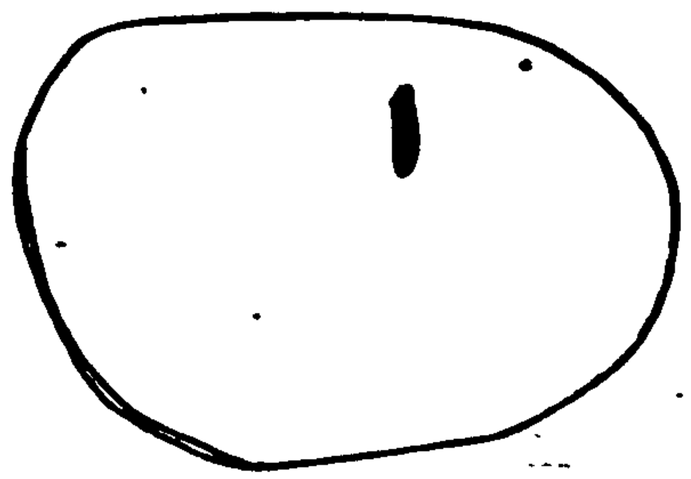
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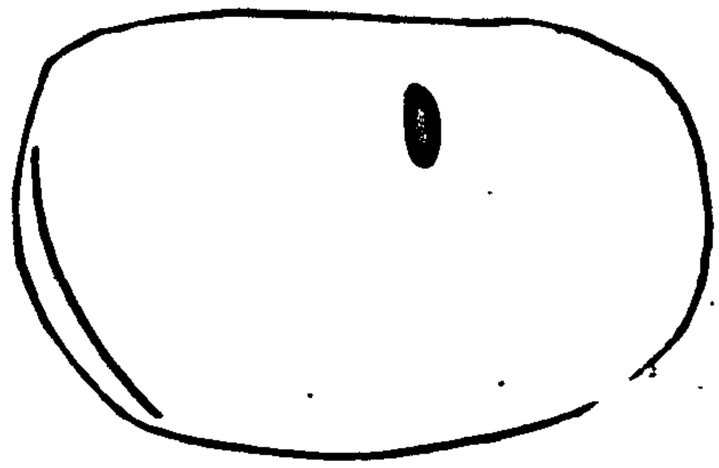
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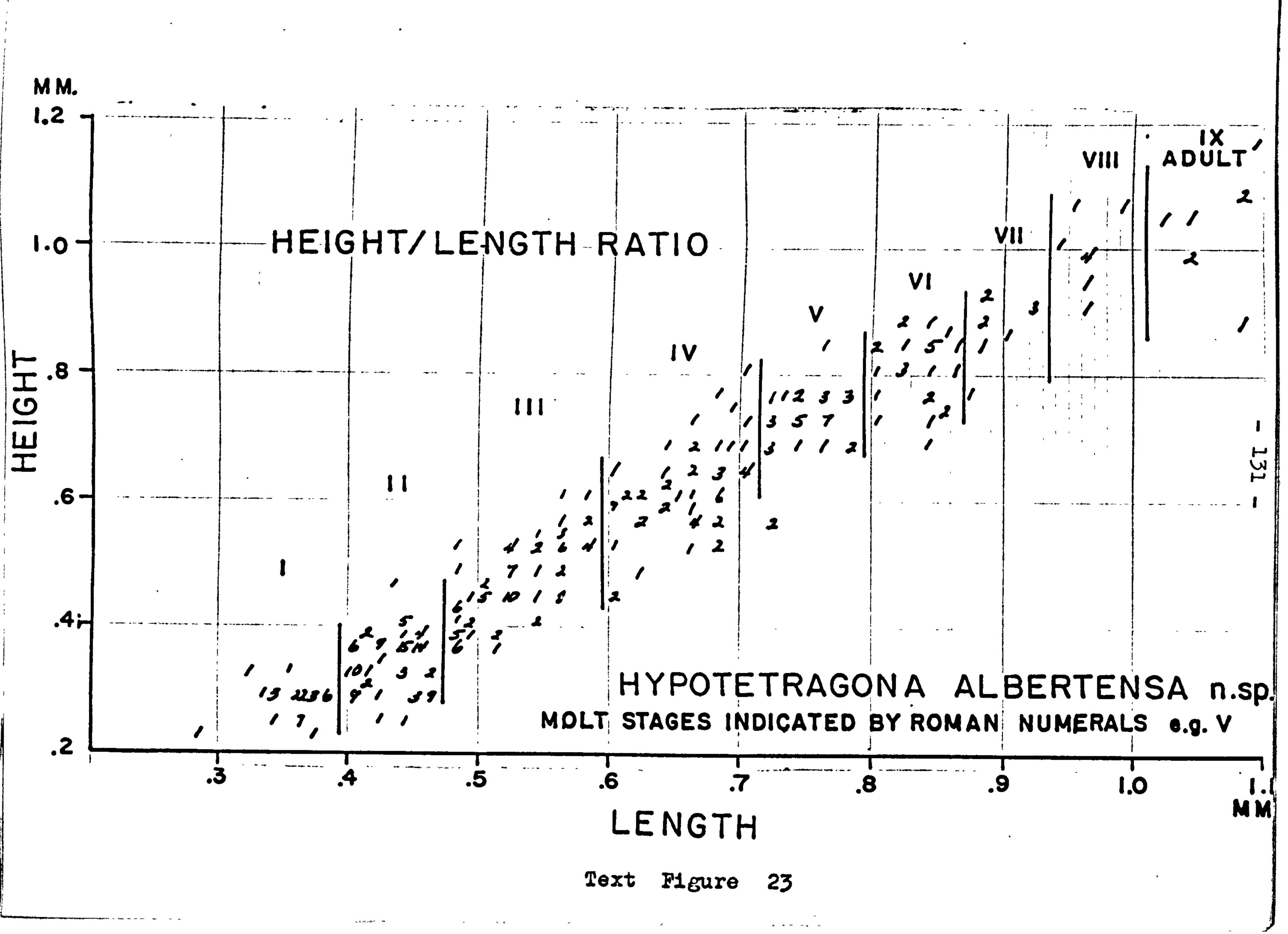


INSTAR 1X



X 57 approx.

Text Figure 22



Text Figure 23

a blunt posterodorsal spine projected outwards and a poorly developed posterocentral node. Molt stages are not clearly defined but there appear to be 9 (refer text figs. 22, 23).

Length: 0.28-1.08 mm. Height: 0.22-0.65 mm.

Width: 0.22-0.44 mm.

Dimensions:

Instar		Length	Height	Width
I.	figs. 1, 2	0.28 mm	0.22 mm	0.22 mm
II.	figs. 3, 4	0.30 mm	0.22 mm	0.23 mm
	figs. 5, 6	0.33 mm	0.25 mm	0.25 mm
III.	figs. 7, 8	0.40 mm	0.25 mm	0.27 mm
IV.	figs. 9, 10	0.45 mm	0.25 mm	0.27 mm
	figs. 11,12	0.50 mm	0.35 mm	0.29 mm
V.	figs. 13,14	0.52 mm	0.35 mm	0.29 mm
	figs. 15,16	0.55 mm	0.40 mm	0.31 mm
VI.	figs. 17,18	0.60 mm	0.40 mm	0.32 mm
	figs. 19,20	0.70 mm	0.45 mm	0.33 mm
VII.	figs. 21,22	0.75 mm	0.50 mm	0.35 mm
VIII.	figs. 23,24	0.85 mm	0.55 mm	0.38 mm
IX.	figs. 25,26	0.90 mm	0.55 mm	0.42 mm
	figs. 27,28	1.08	0.65 mm	0.44 mm

Figured specimens: Moberly, Bear Beaumont No. 1, 2130 - 2144'

Lithology: Gray or buff limestones with interbeds of limy green shale.

Distinguishing characteristics: The 'ears' present in the posterior cardinal angle and the molting variations in ornamentation separate this from other members of the genus. Some of the Russian Knoxiella apparently show this trend of complex ornamentation in the juveniles which becomes less well defined in the older molts and adults.

Distribution: Moberly, Christina and Calmut, McMurray area.

Westmountia n.g.

This includes subrectangular or suboblong species that have a sinuous dorsum rising well above the hingeline. The right valve overlaps the left at the hinge but elsewhere little overlap has been observed. The free margins form a thin frill-like projection, usually confined to the anterior half of the carapace. The shell is exceedingly thin and frequently the duplicature can be observed through the shell. The early molt stages are highly ornamented with nodes, sulci and reticulations. The Kloedenellid-like sulcus and reticulated surface persist into the adult form and the other ornamentation diminishes or dissapears.

Distinguishing characteristics: The sinuous dorsum and thin carapace differentiate this form from known Kloedenellids. It differs from Knoxites in having a subrectangular shape, anterior and posterior tubercles or nodes persisting into the adult form and projections of the margin along the free edges.

Distribution: Late Middle Devonian, McMurray are.

Genoholotype: Westmountia mcmurraiensa, n.g., n.sp.

Westmountia mcmurraiensa n.g., n.sp.

Photograph IV, figs.1-32 , text figs.24, 25

Carapace large, subrectangular to suboblong in outline; dorsum sinuous; right valve strongly overlaps left along hinge but elsewhere there is little overlap; very thin ridge developed on free margins of both valves sometimes forming a narrow frill; maximum length about midcentre; maximum height anterior to midcentre; maximum width posterior to midcentre; anterior cardinal angle just over 90°, bluntly rounded, venter sinuous with slight indentation in posterior third of carapace common; inferior posterior angle somewhat variable terminating in a posterior cardinal angle of about 90°; anterior cardinal angle often appears to have additional development above plane of the hinge due to sinuosity of dorsum; valves inflated posteriorly and in anteroventral area; hingement simple apparently, no definite teeth observed; in molts anterodorsal node elliptical, separated by broad shallow sulcus from broad node anterior to midcentral sulcus, which is deep in molts but restricted to shallow pit in mature forms, posterodorsal node often represented by slight inflation in adults. Number of molt stages not clearly defined but appear to be 9 (refer text figs.24, 25) In molts ornamentation consists of prominent elliptical

INSTAR 1



INSTAR 11



INSTAR 111



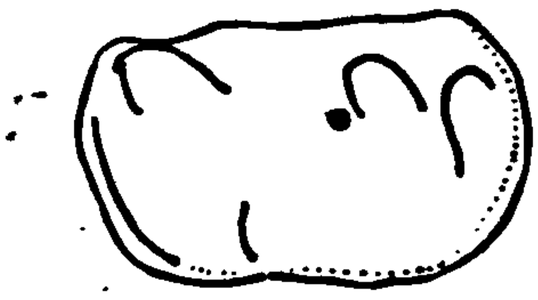
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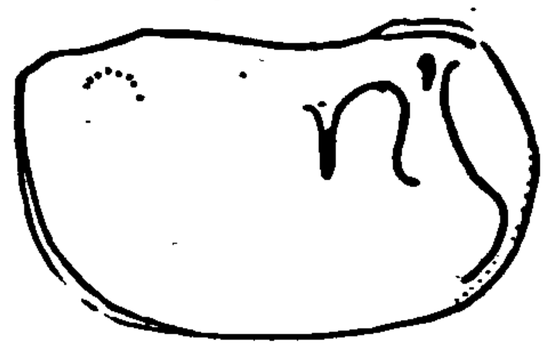
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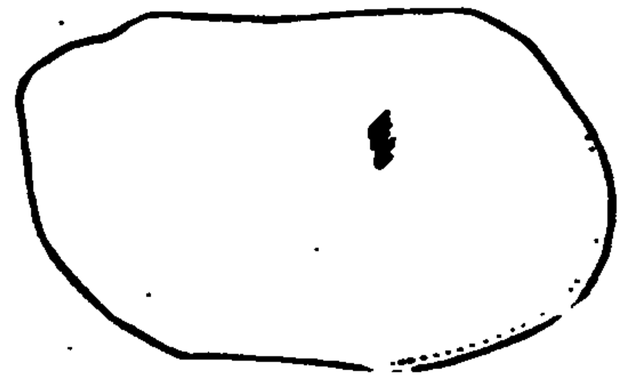
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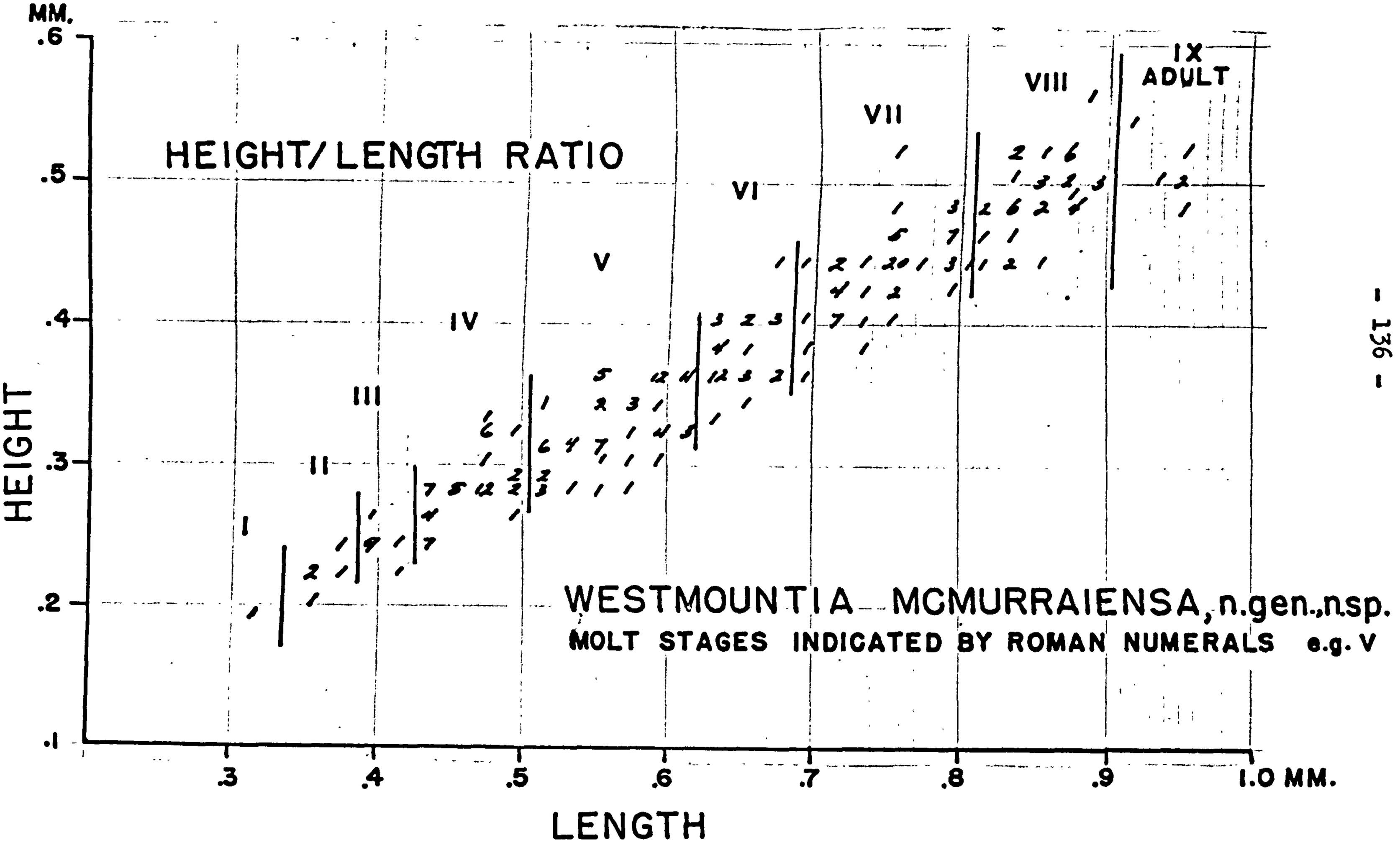


INSTAR 1X



X 46

Text Figure 24



Text Figure 25

anterodorsal node, large posterodorsal node which projects above hingeline in early molts, and an outwardly directed node in posteroventral area, a small node occurs anterior to major central sulcus; frill is better developed in the anterior portion of carapace (e.g., text fig.24,) which is seldom preserved.

Length: 0.32-0.95 mm. Height: 0.24-0.52 mm.

Width: 0.08-0.3 mm.

Figured specimens: Paratypes, Moberly, Bear Westmount No.2, 46-62'.

Dimension:

Photograph IV

Instar		Length	Height	Width
I.	figs.1,2	0.32mm	0.24mm	0.08mm
	figs.3,4	0.34mm	0.26mm	0.08mm
II.	figs.5,6	0.36mm	0.26mm	0.09mm
	figs.7,8	0.36mm	0.27mm	0.09mm
	figs.9,10	0.38mm	0.28mm	0.09mm
	figs.11,12	0.40mm	0.29mm	0.09mm
III.	figs.13,14	0.42mm	0.29mm	0.10mm
	figs.15,16	0.44mm	0.30mm	0.10mm
	figs.17,18	0.46mm	0.30mm	0.11mm
	figs.19,20	0.50mm	0.32mm	0.12mm
IV.	figs.21,22	0.52mm	0.32mm	0.14mm
V.	figs.23,24	0.54mm	0.33mm	0.16mm
	figs.25,26	0.56mm	0.34mm	0.17mm

	figs.27.28	0.59mm	0.34mm	0.18mm
	figs.29.30	0.62mm	0.35mm	0.19mm
VI.	figs.31.32	0.66mm	0.38mm	0.22mm
	figs.33.34	0.68mm	0.40mm	0.23mm

Photograph V

VI.	figs.1.2	0.76mm	0.43mm	0.24mm
VII.	figs.3.4	0.84mm	0.46mm	0.26mm
VIII.	figs.5.6	0.90mm	0.48mm	0.28mm
IX.	figs.7.8	0.95mm	0.52mm	0.3mm

Distribution: Moberly, Christina and Calmut, McMurray area.

Lithology: Maximum collection from a light gray and green calcareous shale at Bear Westmount No.2. Elsewhere found in shaly limestones grading into gray green shales.

Remarks: This delicate and unusual form is usually found as single valves.

Glyptopleuridae Girty 1910

Glyptopleura Girty 1910

Remarks: Girty (1910) proposed the family Glyptopleuridae for the genus Glyptopleura. Bassler and Kellett (1933) continued this classification and included Glyptopleurina Coryell 1928 in the family. Pokorný (1958) places them incertae ordinis possibly belonging to the Platycopa or Podocopida in the family Kloedenellidae. Poorly preserved specimens showing longitudinal ridges on carapace similar to G. cracens Kesling and Kilgore

1952 but more elongated carapace and flattened venter serve to place it in another species.

Distribution: Ireton and Moberly, McMurray area

Lithology: Gray and brown limestone, shaly partings of limy gray green shale.

Knoxina Coryell and Rogatz 1932

Remarks: Coryell and Rogatz (1932) place this in Kloedenellidae; Henningsmoen (1953) continues this usage by placing it in Kloedenellidae-Kloedenellinae.

Knoxina kinsella (Loranger)

text figure 26

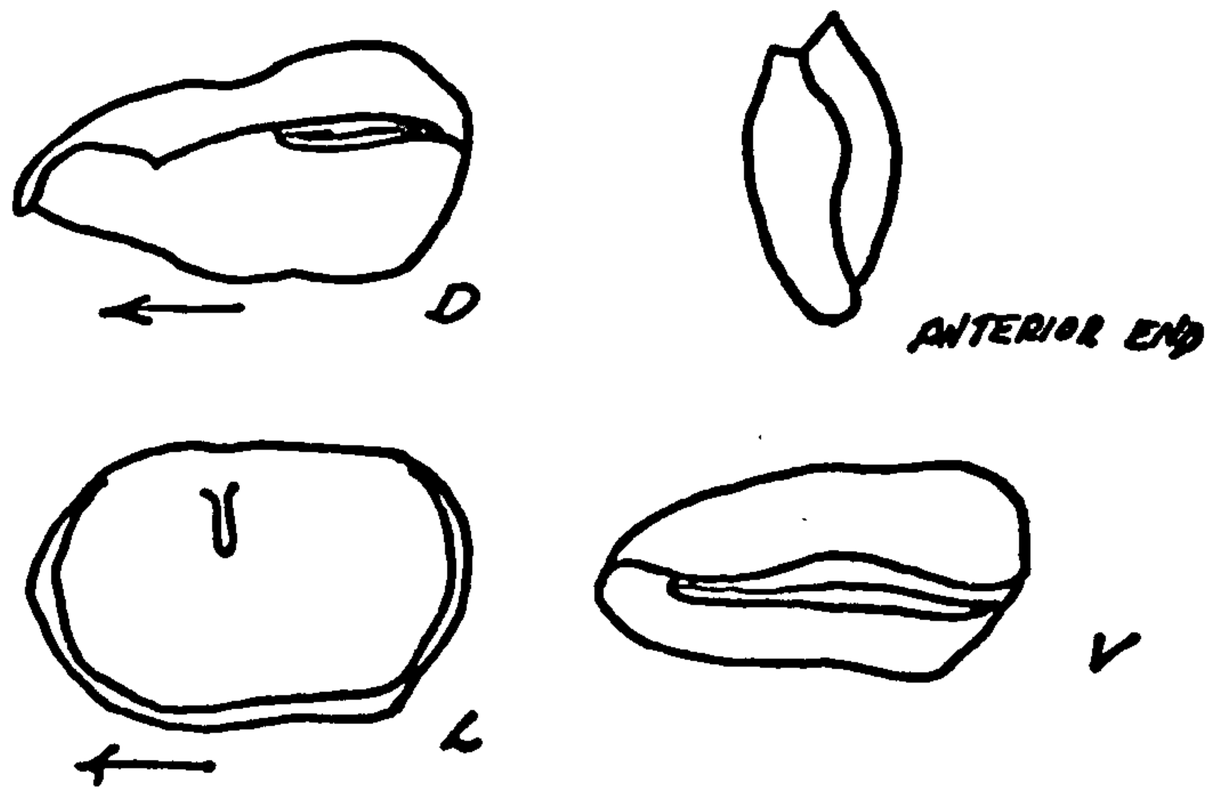
1954 Kloedenia kinsella Loranger, Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p.202, Pl.1, figs. 5,6, Pl.2, figs. 7,8.

Types: Primary types in possession of Imperial Oil Limited, Calgary, Alberta, Canada.

Remarks: This species was originally described as Kloedenia but the very youthful molt stages showing nodes and rib parallel to contact margin make it imperative to transfer this to Knoxina.

Distribution: Upper Ireton of central and northeastern Alberta; Ireton, Duvernay, Cooking Lake, Mildred Lake, Moberly and Christina in the McMurray area and Beaverhill Lake in east central Alberta.

Lithology: Occurs in both green gray or buff argillaceous limestones and in limy gray green shales and in samples grading from one to the other. Maximum percentages were obtained in gray argillaceous limestones in Bear Biltmore 954-984'.



X 44
Text figure 26

Order Podocopida Müller 1894

Bairdiidae G. O. Sars 1888

Bairdia McCoy 1844

Remarks: Sars (1888) placed this genus in Bairdiidae and this usage appears to be consistent. Sohn (1960) suggests this genus is restricted to marine sediments of unknown depths. Craig (1954) suggests Bairdia was a mud dweller in the Palaeozoic. Sohn's species occurred in shale, limestone and sandstone.

Bairdia bartholomensis Stewart and Hendrix

1945 Jour. Paleo. vol. 19, no. 2, p.109, Pl. 12, figs. 7,8.

Types: Primary types Ohio State Geol. Mus., Columbus, Ohio. No.18870.

Distribution: Olentangy shale, Rare. (Upper Devonian, lower Senecan, upper Fingerlakesian). Ireton and Cooking Lake formations of McMurray area.

Lithology: From a shale above base Olentangy formation which has bluish limestone layer at bottom and dark brown shale layer at top. In the Ireton in a greenish gray limy shale, in the Cooking Lake in a cream or light gray coloured limestone.

Remarks: Sohn (1960) rejected this name after a detailed punched card study of Palaeozoic Bairdia since the description was based on a poor specimen. However the form has not been redescribed and the specimens found in this study appear to be identical to Stewart and Hendrix' material.

Bairdia biltmorensa Loranger

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p.193, Pl.2, figs. 3,4.

Types: Primary types from Bear Biltmore No.1, 638-64', in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Ireton, Macronotella biltmorensa zone, central and northeastern Alberta; Ireton, Duvernay,

Cooking Lake, Mildred Lake and Moberly of McMurray area.

Lithology: Occurs in brown argillaceous limestones and in gray green limy shales.

Bairdia hypsoconcha Gibson

1955 Bull. Amer. Pal., vol. 35, no. 154, p. 14, Pl. 1, fig. 16.

Types: Primary types in U. S. Nat. Mus., Washington, D. C. No.123085.

Distribution: Upper Devonian, upper Senecan, upper Chemungian, upper Cerro Gordo formation. Rare Moberly, McMurray area.

Lithology: The type material came from a yellow fairly calcareous clay. Two samples from Bear Biltmore No. 1 contained these ostracodes in a gray, or green argillaceous limestone and one sample (1154-64') yielded forms from a gray green limy shale.

Bairdia leguminoides Ulrich

1891 Cincinnati Soc. Nat. Hist. Jour., vol. 13, p. 197, Pl. 17, figs. 5a-c.

1936 Bairdia summacuminata Coryell and Malkin, Am. Mus. Novitates, no. 891, p. 9, Pl. 12, fig. 23.

1952 Bairdia amplectens Kesling and Kilgore, Univ. Mich. Paleo. Contrib., Vol. 10, no. 1, p. 12, Pl. 4, figs. 1-3.

Types: Primary types U. S. Nat. Mus. Washington, No.41788. Originally described from Hamilton group, New York.

Distribution: Arkona, Lambton County, Ontario in Middle Devonian, middle Erian, lower Tioughniogan from "Coral"

zone of Widder Beds. Stover (1956) records it from two localities, one in abundance, one common, in Hamilton, N. Y. Kesling and Kilgore (1952) find it in the Grenshaw formation, Middle Devonian; Moberly in McMurray area.

Lithology: In "Coral zone" in bluish gray calcareous shale with abundant corals and other fossils. In Christina River Hardy No. 1 in greenish gray, limy shale.

Bairdia midconstricta n.sp.

Photograph VII, figs. 9,10, text figure 27.

Carapace small; triangular in lateral view; dorsum curved; left valve overlaps in anterior and posterior margins; maximum length below midcentre, maximum height anterior to midcentre, maximum width in posterior third of carapace; anterior end very broadly rounded and forms a small lip projected downwards; venter is broadly curved, posterior end sharply acuminate; carapace tumid, constricted at midcentre forming two pronounced bulges, the posterior being the more inflated; the extreme posterior end of the right valve projects outwards in a small spine.

Length: 0.64-0.77 mm. Height: 0.28-0.36 mm.

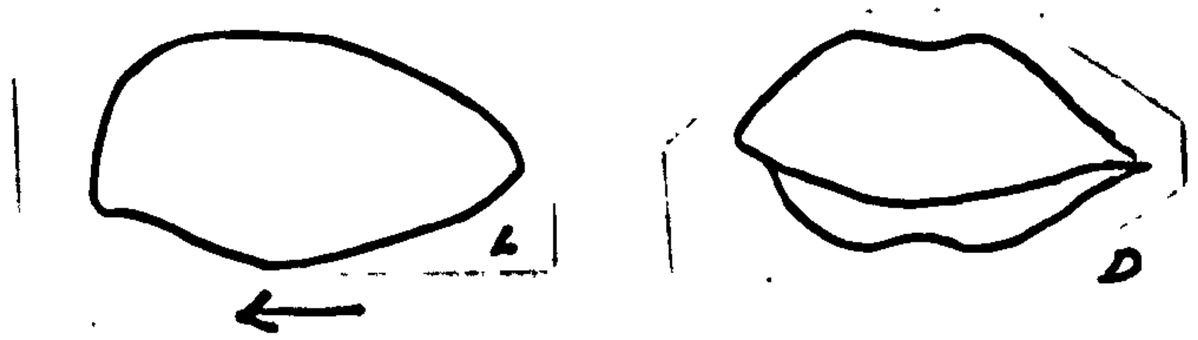
Width: 0.28-0.36 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore No. 1 588-98'. Length:0.68mm. Height:0.32mm. Width:0.32mm.

Distinguishing characteristics: The central constriction differentiates this species from other described Bairdia except B. notoconstricta Gibson 1955 (Cerro Gordo formation; Upper Devonian) and B.rostrata Péneau 1927 (Fammenian, northwestern France). The triangular shape of B.midconstricta in lateral view and the tumid carapace differentiate it from the subdeltoid B.notoconstricta Gibson. The acuminate oblong shape of B.rostrata Péneau and the upturned extremities serve to distinguish that form from B. midconstricta.

Distribution: Ireton and Moberly, McMurray area.

Lithology: Gray or greenish gray argillaceous limestone with some shale partings.



X 45
Text figure 27

Bairdia pseudomagna Stewart and Hendrix 1945

1945 Jour. Paleo., vol. 19, no. 2, p.110, Pl. 2, figs. 13,14.

Types: Syntypes in collections of Geological Museum Ohio State University, Columbus, Ohio, No.18868.

Distribution: 10-12 feet above base Olentangy formation. (Upper Devonian, lower Senecan).

Lithology: Bluish limestone grading into dark brown shale.

Bairdia cf. pseudomagna Stewart & Hendrix 1945

Photograph VII, figs. 17,18.

The chief characteristic of this form is the high arched dorsum which the authors compare to Cretaceous and Mississippian species. Unfortunately the species was erected on the basis of two internal casts and the description is inadequate.

Figured specimen: Holotype, Ireton, Bear Biltmore No. 1, 764-74'. Length: 0.66 mm. Height: 0.44 mm. Width: 0.28 mm.

Distribution: Ireton formation, McMurray area.

Lithology: Gray or brown limestone or limy gray green shale.

Bairdia subtilla Gibson

1955 Bull. Amer. Pal. vol. 35, no. 154, p. 16, fig. 14.

Types: Primary types in U. S. Nat. Mus. Washington, D. C. Nos.123089, 123090.

Distribution: Upper Devonian, upper Senecan, upper Chemungian, upper Cerro Gordo formation.

Lithology: Yellow, fairly calcareous clay. Rare.

Remarks: Sohn (1960) suggests this species may be homologous with B.hypsoconcha Gibson 1955 on the basis of a punched card study in which the majority of Bairdia and related genera in the Palaeozoic are broken down into a class-

ification key.

Bairdia cf. subtilla Gibson 1955

Photograph VII, figures 19, 20.

Reticulated surface quite distinctive on specimens found in Moberly, hence suggestive of a new variety. Material is scarce and further collections are required to identify the form with more precision.

Figured specimen: Holotype, Moberly, Bear Beaumont No. 1 1948-58'. Length: 0.8 mm. Height: 0.4 mm. Width: 0.36 mm.

Distribution: Moberly and Christina, McMurray area.

Lithology: Light gray or buff limestone.

Bairdia sp. indet.

Poorly preserved or weathered forms which lack diagnostic characteristics relating them to published literature, but lack sufficient features to consider them a new species.

Distribution: Mildred Lake, Moberly, Calmut, Firebag and Methy Dolomite in the McMurray area.

Lithology: Occurs in gray buff dense argillaceous limestone in top of Mildred Lake at Angelus Ashmont No. 1 up to 40% of total population and also in light to dark brown or gray brown argillaceous dolomite in Bear Vampire No. 1 in the Methy Dolomite. In the Moberly, Calmut and Firebag it is present in gray green limy shales.

Bythocypris Brady 1880

1866 Bairdia bosquetiana, Linnean Soc. London, Jour., vol. 19,

p. 364, Pl. 57.

1880 Rept., Sci., Results Voyage H.M.S. Challenger, Zoology, vol. 1, pt. 3, p. 45.

Remarks: Genus assigned by Brady to Cypridae (1880); by Müller to Nesideidae (1912); by Sars to Bairdiinae (1923); to Bairdiidae by most subsequent authors including Pokorný (1958).

Bythocypris biltmorensis Loranger

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p. 193, Pl. 2, figs. 3, 4.

Types: Primary types from Bear Biltmore No. 1, 638-64' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Devonian, Upper Ireton, Macronotella biltmorensa zone. Ireton, Mildred Lake, Moberly, Christina, and Firebag formations of the McMurray area.

Lithology: Occurs in gray, buff, or green limestones and limy green shales.

Bythocypris mearnsa Loranger

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol. p. 193, Pl. 2, figs. 37, 38.

Types: Primary types from Imperial Mearns No. 1 5250' in possession of Imperial Oil Limited, Calgary.

Distribution: Upper Devonian Macronotella biltmorensa zone of central and northeastern Alberta; Ireton and Moberly of McMurray area.

Lithology: Light gray or brown limestone, argillaceous or fragmental.

Macrocyprididae G.W.Müller 1912

Macrocypris G.S.Brady 1867

Remarks: Originally placed in Cypridae by Brady (1868); later in Bairdiidae by Brady and Norman (1889) in Cypridae-Macrocyprinae by G.W.Müller (1912); in Cypridae-Macrocypridae-Macrocyprinae by Alm (1915) Bairdiacea-Macrocypridae by Sylvester-Bradley (1948)

Macrocypris albertensis Loranger

1954 Western Canada Sedimentary Basin; Amer. Assoc. Pet. Geol. pp. 193-4, Pl. 1, figs. 19,20.

Types: Primary types from Imperial Duvernay No. 4, 3005-10' in possession of Imperial Oil Limited, Calgary, Alberta

Distribution: Lower Ireton of central and northeastern Alberta in Aechminella fribourgella biozone. Also in Ireton, Cooking Lake, Mildred Lake, Moberly, Christina, Calmut and Firebag of McMurray area.

Lithology: Approximately 60% of the occurrences were in brown or gray limestones, 31% in limy gray green shales and the remainder in interbedded limestone and shale samples. Maximum recovery of 16.6% was in shale in Bear Biltmore No. 1, 1524- 34'.

Macrocypris? sp.A n.sp?

Photograph VI, figs. 1, 2, text figure 28.

Carapace of medium size; subelliptical in outline; convex dorsum; right valve overlaps on all margins with maximum overlap along venter; maximum length well below midcentre, maximum height posterior to midcentre, maximum width posterior to midcentre; very obtuse anterior cardinal angle, sharply rounded to form an acute inferior angle, the contact margin is straight but the venter extends well below so that the cross-section is subtriangular through the centre of the carapace, the posterior end has two very obtuse angles above and below and meets at an angle of about 90° so that the prolonged posterior angle formed is below midcentre of the carapace; the carapace is tumid in the lower third in the later molt stages, more evenly inflated in earlier molts; the left valve fits neatly into the right and both terminate in acute posterior angle which has a tendency to become spine like.

Length: 0.52-0.88 mm. Height: 0.36-0.52 mm.

Width: 0.24-0.36 mm.

Figured specimen: Duvernay, Bear Beaumont No. 1, 1657-59'.

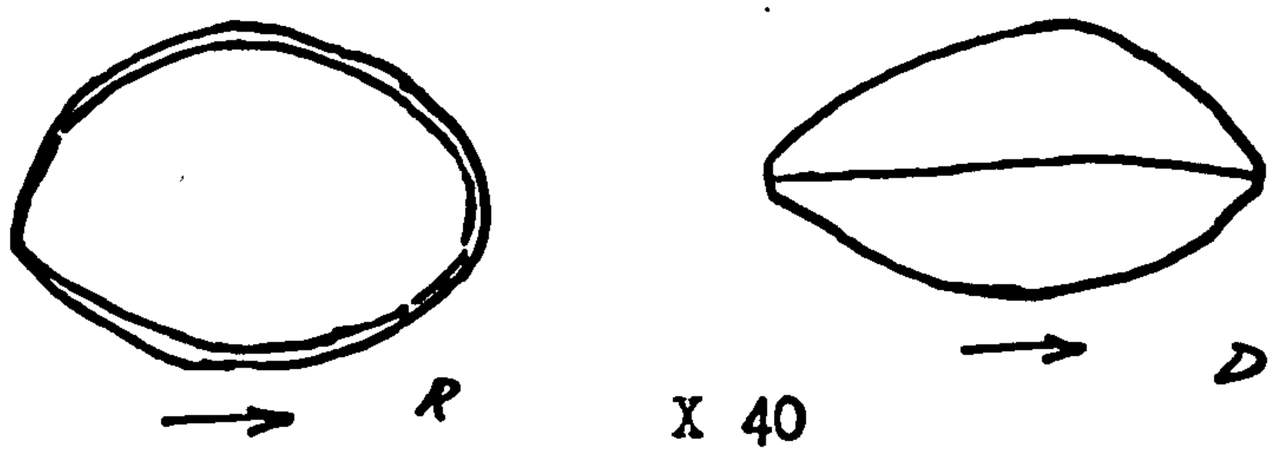
Length: 0.88mm. Height: 0.52mm. Width: 0.36mm.

Distribution: Ireton and Duvernay , McMurray area.

Lithology: Argillaceous limestone, gray green to brown with some limy shale bands.

Remarks: This tumid form has a more highly arched dorsum

than the commonly illustrated Macrocypris.



Text figure 28

? Acronotellidae Swartz 1936

Acronotella Ulrich and Bassler 1923

Remarks: Acronotella Ulrich and Bassler 1923 was originally placed in the family Primitiidae; later by Schmidt (1941) in Hollinidae-Ctenentominae and in Acronotellidae by Henningsmoen (1953).

Acronotella keslingia n.sp.

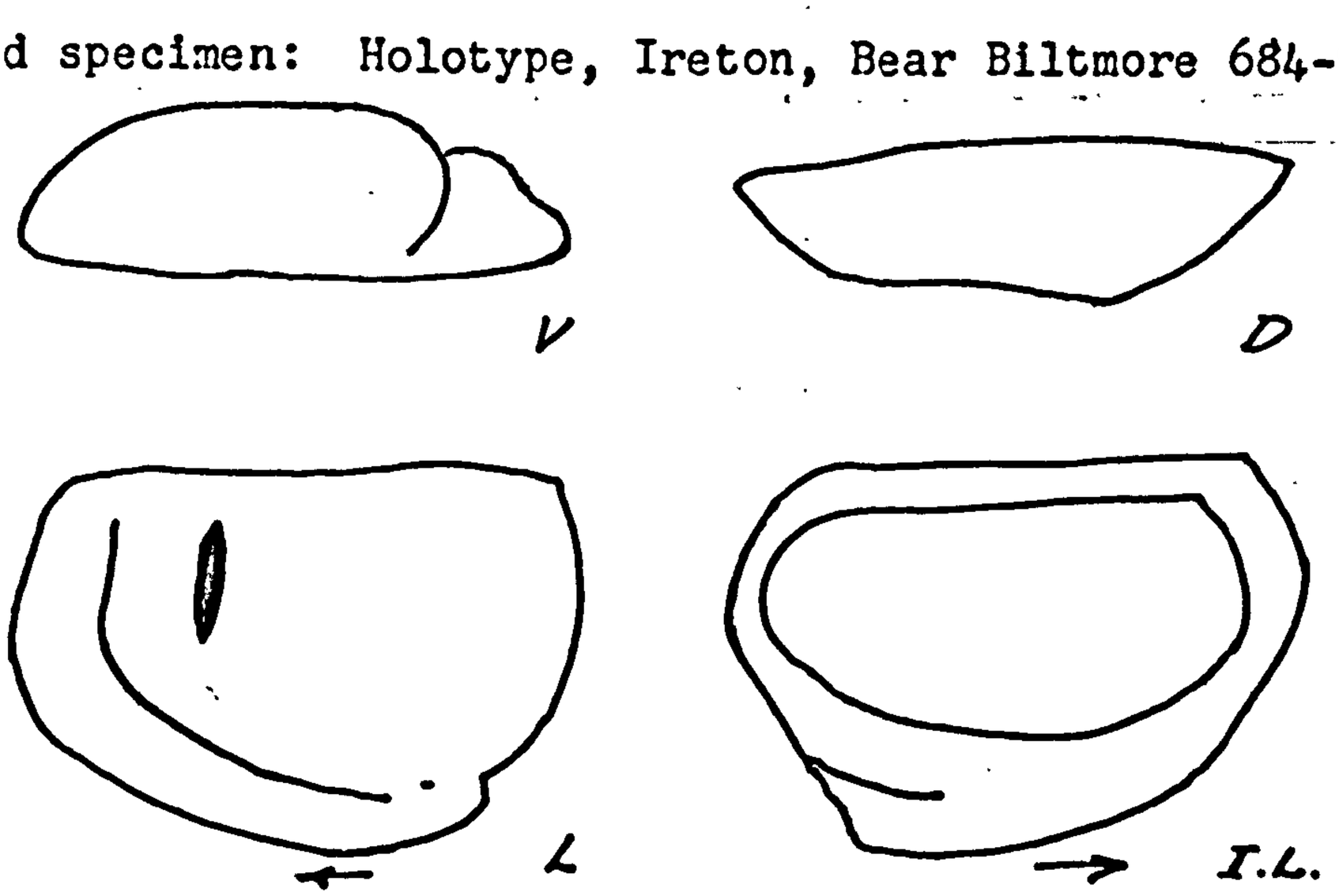
Photograph VI, figs. 5, 6, text fig., 29.

Carapace small, subrectangular outline obscured by thick well defined ala ; equivalved; dorsum straight, dorsum convex in posterior half; maximum length at midcentre, maximum height in central third of carapace; maximum thickness posterior of centre; anterior cardinal angle obtuse, broadly rounded below; venter parallel to hinge; posterior cardinal angle acute, broadly rounded into venter; anterior end sharply rounded above, broadly rounded below, posterior end acuminate above and very obtuse below; two sulci, poorly to well developed, at midcentre and anterior to midcentre; S_1 deep, broad becoming shallower near dorsum and paralleling ala

throughout part of its length; S_2 broad, shallow, and half of shell height; L_1 extended to form a broad rounded ala projecting outwards and posteriorly and extending below level of contact margin, forms acute angle with contact margin and extends below it; L_2 formed in anterocentral position; L_3 forms posterior half of carapace, evenly inflated for half its width and then broadly rounded to form acuminate posterior margin; hingement apparently simple; surface reticulate, irregularly ornamented except in flattened under side of ala parallel to the contact margin.

Length: 0.44-0.6 mm. Height: (not including ala.)
0.24-0.32 mm. Width: 0.2 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore 684-94'.



X 86
Text figure 29

Length: 0.6 mm. Height: 0.32mm. Width: 0.2 mm.

Distinguishing characteristics: Differs from the generic description in that an additional sulcus appears and that the major sulcus dividing the carapace in half is more or less vertical, and compression of the carapace is not restricted to the posterior half as designated. No description of the genotype A. shideleri Ulrich and Bassler (1923) is given.

Distribution: Ireton, Mildred Lake, and Moberly of McMurray area.

Lithology: In Bear Beaumont No. 1 found in greenish gray limy shale; in Bear Biltmore No. 1 in limy gray green shale and argillaceous gray green limestone.

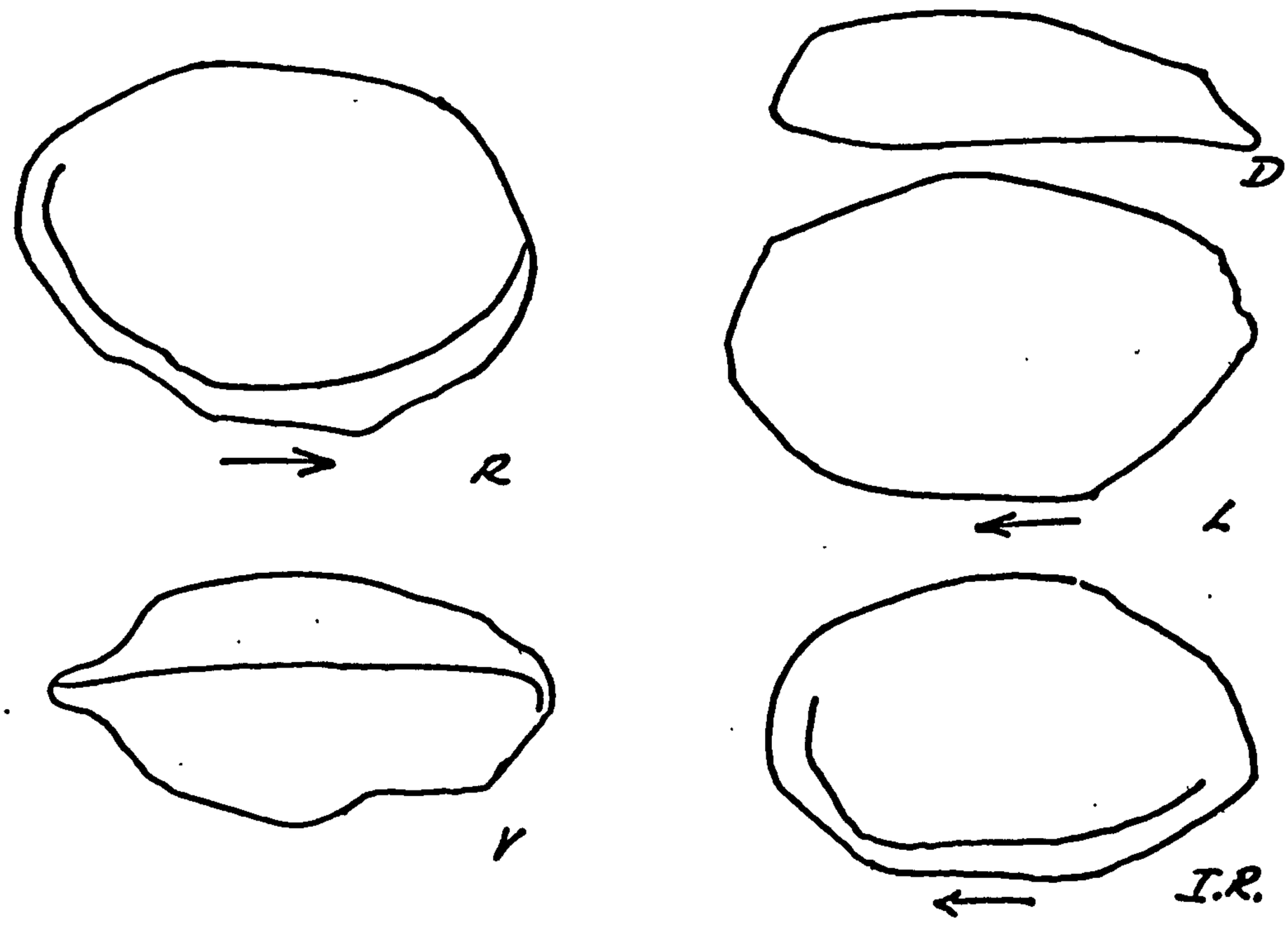
Remarks: Carapaces delicate and poorly preserved, usually found as single valves. The lobation and sulcation varies considerably on different specimens.

Bythocytheridae Sars 1926

Monoceratina Roth 1928

Remarks: This genus is badly in need of detailed revision, originally placed by Roth (1928) in Primitiidae; transferred to Beyrichiidae by Harlton 1933; removed to Cytheridae by Alexander on the basis of his Cretaceous studies in Texas (1934); Swartz (1936) assigned it to the Acronotellidae; Van den Bold (1946) transferred it to the Cytheridae-Bythocytherinae and

Pokorný dubiously includes it in the Kloedenellidae (1958). Sylvester-Bradley and Kesling (1961) place this in the Bythocytheridae.



X 120
Text figure 30

Monoceratina albertensa Loranger

1954 Western Canada Sedimentary Basin, p. 192, Pl. 2, figs. 35, 36.

Types: Primary types from Imperial Dapp No. 1 4500' in possession Imperial Oil Limited, Calgary, Alberta

Distinguishing characteristics: Differs from M? levinsoni Gibson 1955 by more elongate carapace, presence of tubercles on entire ventral margin rather than anterior and posterior, laterally projected spine originates in ventrocentral area rather than edge of venter. Tubercles are elongate and spinelike in rare specimens which are still embedded in the matrix.

Distribution: Macronotella biltmorensa biozone of Upper Ireton of central and northeastern Alberta, Ireton and Duvernay of McMurray area.

Lithology: Buff to brown limestone.

Monoceratina scottia n. sp.

Photograph II, figs. 13, 14, text figure 30

Carapace small, subrectangular outline; inequivalved, inflated; dorsum slightly bowed, left valve overlap in posterodorsal area; hinge incised maximum length about midcentre, maximum height and width posterior to midcentre; anterior cardinal angle obtuse, posterior cardinal angle acute; anterior end broadly and evenly rounded above and below; posterior end rounded below and forming thin accuminate process in posterodorsal area; venter curved and free margins compressed tightly to form thin frill in some specimens; carapace gradually inflated from anteroventral area to form an alar process extending below the contact margin and reaching maximum development in posteroventral area, where it abruptly

terminates; this ala. may be folded sharply and form a furrow parallel to the contact margin; poorly developed depressed area present anterior to midcentre, with circular spot over probable muscle scar; hingement simple; surface covered with coarse reticulations roughly parallel to margin and in furrows below alae .

Length: 0.36-0.46 mm. Height: 0.24-0.28 mm.

Width: 0.14-0.16 mm.

Figured specimen: Holotype, Moberly, Bear Beaumont No. 1 1948-58'. Length: 0.44 mm. Height: 0.28 mm.

Width: 0.16 mm.

Distinguishing characteristics: Differs from M. cooperi Swain 1953 by subrectangular outline, rounded spineless alae and reticulated surface. Separated from M. ventrale Roth 1928 by rounded hornless alae and prominent caudal process. Lack of pitting and horned ala at midcentre differentiates this from M. ventrale var. magnum Roth 1928.

Distribution: Ireton and Moberly of McMurray area.

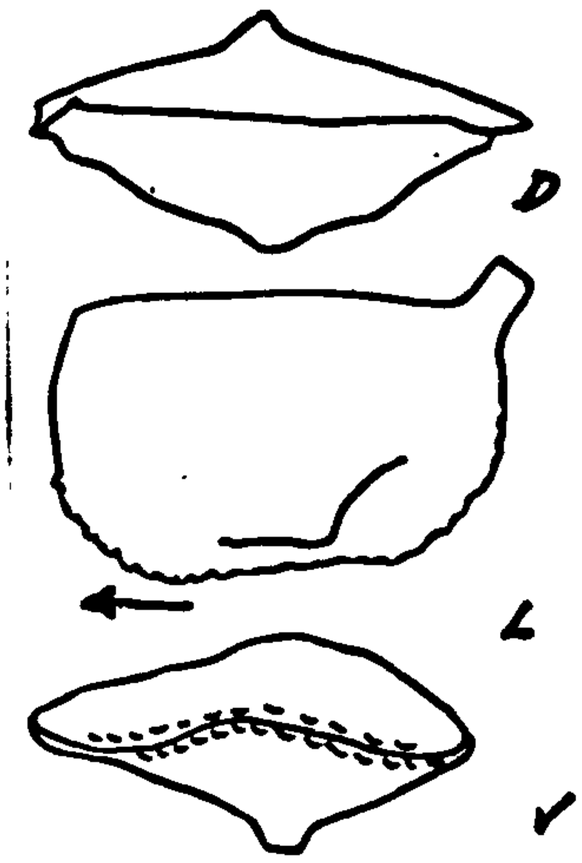
Lithology: Gray and light buff limestones with small percentage of interbedded gray green limy shales.

Remarks: Caudal process frequently broken in these delicate forms so measurement of length is subject to some variation in accuracy.

Family Uncertain

Monoceratella Teichert 1937

Remarks: Pokorný (1958) places this genus in the Acronotellidae, authors in the G.S.A. Treatise (1961) place it in Cytheracea- Family uncertain.



X 46
Text figure 31

Monoceratella sp.A. n.sp.

Photograph VI, figs. 7,8, text figure 31

Carapace medium size; subrectangular outline, dorsum slightly convex in posterior half; right valve overlaps on all margins and along dorsum is projected forward into a sharp anterior spine, at the posterior end projects upward and backwards in a blunt, flattened cylinder; maximum length in upper 1/3 carapace, maximum height posterior to midcentre, maximum thickness posterior to and below midcentre; anterior end over 90°, broadly rounded merging with broadly rounded venter, broadly rounded inferior posterior angle, terminates in posterior cardinal angle slightly less than anterior cardinal

angle; prominent central ventral spine projecting outwards and backwards on each valve; papillae on free margins.

Length: 0.72 mm. Height: 0.4 mm. Width: 0.24 mm.

Figured specimen: Holotype. Ireton, Bear Beaumont, No. 1 1147-1181'. Length: 0.72 mm. Height: 0.4 mm. Width: 0.24 mm.

Distinguishing Characteristics: Differs from Monoceratella Teichert 1937 and those described by Henningsmoen 1954 and from Tricornina Bouček 1936 which has a needlelike posterior. Absence of sulci separate Monoceratella sp.A from Acronotella Ulrich and Bassler 1923.

Distribution: Ireton in McMurray area.

Lithology: Gray and brown limestone with some gray green limy shale bands.

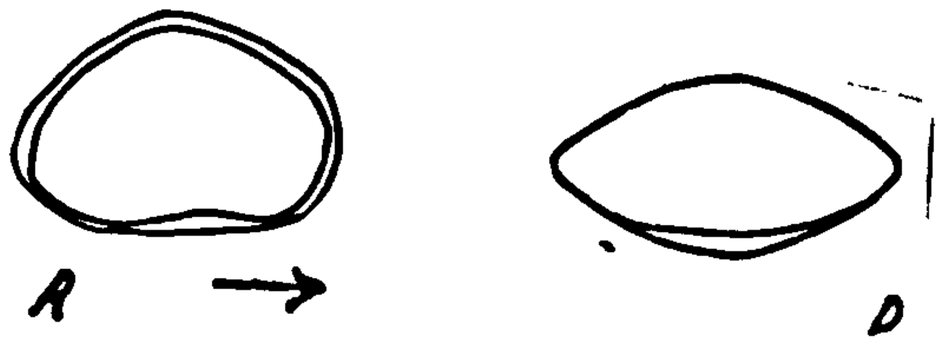
Bairdiocyprididae Shaver 1961

Bekena Gibson 1955

Bekena sp. A., n.sp.

Photograph VII, fig. 5, 6, text figure 32

Carapace large; subtriangular in lateral view; dorsum curved, dorsum highly arched; left valve overlaps right completely with minimum overlap on anterior end, maximum overlap about



X 14
Text figure 32

midcentre of dorsum; maximum length below midcentre, maximum height at midcentre, maximum width at midcentre; anterior end blunt, venter sinuous, posterior end more acutely rounded; compressed area paralleling anterior margins on both valves.

Length: 1.68 mm. Height: 1.08 mm. Width: 0.77 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore No.1 588-98'. Dimensions as above.

Distinguishing characteristics: Differs from Bairdiocypris rhenana (Kegel) [Bythocypris (Bairdiocypris) rhenana] 1932 B.üxheimensis (Kegel), [Bythocypris (Bairdiocypris) üxheimensis] 1932 which lack marginal flattening. Separated from Bairdiocypris prantli Pokorný 1950 by more rounded ends and by having flattened portion paralleling the ends rather than confined to the inferior angles. Comparison by Krommelbein of this species to type material places this in Bairdiocypris. However, revision of this genus by Shaver (1961) places this within the genus Bekena Gibson although the profile is that of Bairdiocypris. The compressed ends, by definition are characteristic of Bekena.

Distribution: Ireton and Moberly of the McMurray are.

Lithology: Maximum recovery from Bear Vampire No. 2 34-48' came in a gray buff argillaceous limestone that had a shaly base; found also in buff limestone; in limy gray green shales and in mixed lithologies of gray argillaceous limestone and limy greenish gray shales.

? Cavellinidae Egorov 1950

Cavellina Coryell 1928

Remarks: The genus Cavellina was originally placed in the Cytherellidae by Coryell (1928), in Healdiidae by Triebel 1950, in Cavellininae by Egorov (1950), Benson et al (1961) place it in the ?Family Cavellinidae Egorov 1950. Krommelbein* points out the inadequacy of referring this to Cytherella which has a Mesozoic genotype and agrees with Pokorný's (1958) restriction of the genus to the Palaeozoic. No evidence for sexual dimorphism observed in the collections made that substantiates Kellett's observations (1935).

Cavellina ovatiformis (Ulrich) 1891

1891 Cytherella ovatiformis Ulrich, Cincinnati Soc. Nat. Hist. Jour. Vol. 13, (1890-91), no. 4, p. 209. Pl. 17, figs. 3-4.

Types: Cotypes in U. S. Nat. Mus., Washington, D. C. No.41809.

Distribution: Originally described from Caldwell County, Kentucky from Upper Mississippian; top of the Chester group. (Exact locality not given). Ranges throughout the Middle and Upper Devonian in the McMurray area and is common throughout central Alberta. It is present in all wells examined in amount varying from 0 to 100% of the total microfossil population.

*Personal communication

Lithology: This species occurs in all lithologies sampled, the maximum in a slightly argillaceous gray limestone in Angelus Ashmont No. 1, 2620-23' (100%), also at 2782-2784' (100%) in a buff limestone.

Remarks: Devonian species differ from the original drawings and descriptions in lacking the muscle scar or impression on the valves which is insufficient variation for a separate description. Ulrich (1891) compares this with the Tertiary species C. compressa (Münster) Cythere compressa 1830. Appears to have eight or nine molt stages.

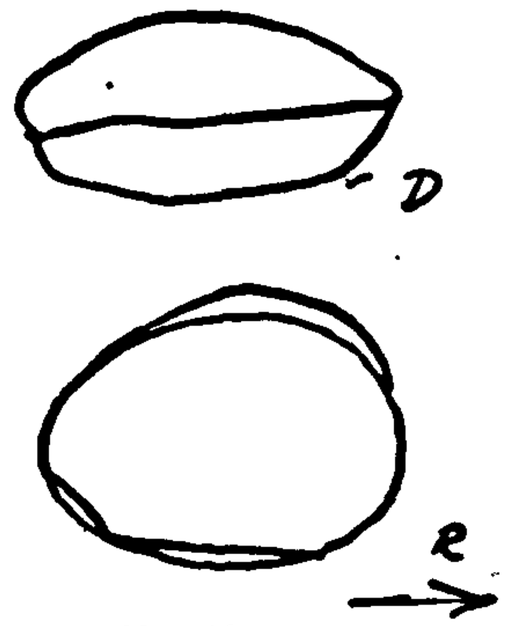
Cavellina? sp. n.sp.?

Photograph I, figs. 4,5, text figure 33

Carapace small suboval; dorsum curved, right valve overlaps; valves probably inequal but overlap uncertain due to preservation; maximum height at midcentre, maximum width just posterior or at midcentre; ends sharply rounded, venter slightly convex; hingement by overlap, no ornamentation; shell very delicate and invariably distorted, crushed.

Length: 0.40-0.50 mm. Height: 0.28-0.36 mm.
Width: 0.16-0.2 mm.

Figured specimen: Elk Point, Christina River Hardy No. 1 1860-67'. Length: 0.48 mm. Height: 0.36 mm.
Width: 0.18 mm.



X 54
Text figure 33

Distribution: Duvernay, Cooking Lake, Christina and Elk Point in McMurray area.

Lithology: Maximum occurrence in brown or gray limestones, and greenish gray limestones that grade into limy green shales; the next occurrence is found in gray brown limestones or gray green limestones which are argillaceous. It occurs rarely in green dolomitic shales, and interbedded limestones and limy green shales.

Remarks: This is included as a possible species of Cavellina as it appears to have some stratigraphic value although well preserved carapaces have not been encountered in the McMurray wells.

Krausellidae Berdan 1961

Krausella Ulrich 1894

Remarks: This genus originally placed by author in Beecherellidae, later by Den Bold (1946) in Cypridae-Cyprinae-Paracypridea; Berdan (1961) erected a new family to

include smooth asymmetric forms such as Janusella and Cooperatia. Synonyms include Rayella Teichert 1939, Basslerites Teichert (not Howe) 1937.

Krausella albertensa n.sp.

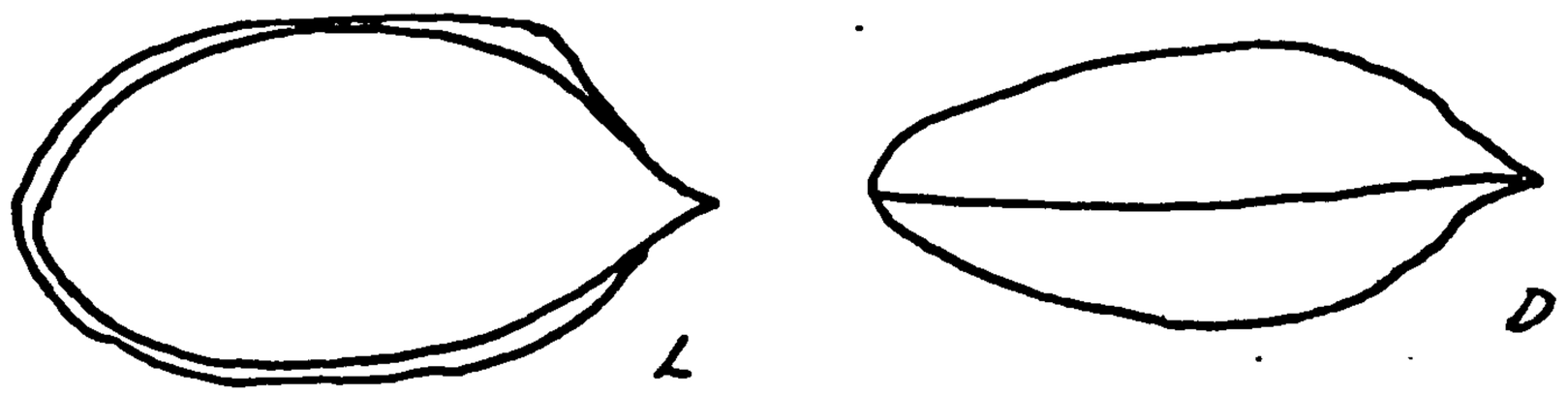
Photograph V, Figures 11, 12, text figure 34.

Carapace small; elongate oval in lateral view; dorsum slightly bowed, deeply channeled; left valve overlaps right in cardinal angles, ventrally and throughout the posterior margin; maximum overlap being at midcentre of venter; maximum length above midcentre, maximum height at midcentre or slightly posterior to midcentre; maximum width in posterior third of carapace; anterior cardinal angle very obtuse, narrowly rounded in anterior end, venter slightly convex, posterior cardinal angle obtuse, broadly rounded and projected posteriorly above mid height; carapace inflated, oval in cross-section.

Length: 0.48 mm. Height: 0.24 mm. Width: 0.2 mm.

Figured specimen: Holotype, Mildred Lake, Bear Biltmore No. 1, 1064-74'. Dimensions as above.

Differentiating characteristics: This species of Rayella is similar to the three Ordovician species in lateral profile but is differentiated from R.minuta Harris 1957 by having the posterior projection well above mid height in addition to a more pronounced ventral overlap; from R.calvini Kay and R.calvini Kay subsp. Harris 1957 by its oval cross-section.



X 110
Text figure 34

Distribution: Present in Ireton, Duvernay and Mildred Lake formations, McMurray area.

Lithology: In the Ireton in limy greenish gray shales with minor amounts of gray or buff limestones. In the Duvernay in gray green shale and cream limestone and in Mildred Lake in a buff brown limestone which is argillaceous in part and tends to become greenish gray.

Krausella sp.

Three small specimens present in Bear Biltmore No. 1 at 539-49' and 634-44'. Two molts and an adult but all broken or distorted.

Distribution: Present in Ireton formation, McMurray area.

Lithology: Limy greenish gray shale grading into shaly limestone, and in gray argillaceous shaly limestone.

Cooperatia Tolmachoff 1937

1926 Cooperia Tolmachoff, Rept. Second Norwegian Arctic Expedition in the "Fram" 1898-1902, No. 38, pp. 27-37, Pls. 1,2.

1937 Cooperatia Tolmachoff, Jour. Paleo., vol. 11, no. 1,

p. 78.

Remarks: Placed in Beecherellidae by Bassler and Kellett (1934); Berdan (1961) considers it representative of the new family ? Krausellidae.

Cooperatia biltmorensa (Loranger)

1954 Cooperia biltmorensa Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p. 194, Pl. 2, figs. 33,34.

Types: Primary types from Ireton, Bear Biltmore No. 1, 754-64', in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Ireton, Duvernay, Cooking Lake, Mildred Lake, Moberly, Calmut and Firebag, McMurray area.

Lithology: Just over half of occurrences were in limy gray green or green shales with a maximum of 21% being recovered from Bear Biltmore 1154-64', 42% were in gray or buff limestones including a maximum of 40% in Angelus Ashmont No. 1 2634-41'; the remaining 7% were in mixed lithologies of limestone and shale.

Quasillitidae Coryell & Malkin 1936

Abursus Loranger 1954

1954 Western Canada Sedimentary Basin: Amer. Assoc. Pet. Geol., pp. 194-5, Pl. I, figs. 21,22; Pl. II, figs. 1,2,5,6,9,10,23, and 24.

Remarks: Originally placed by author in the family Cytherellidae Sars; placed in Podocopida, suborder and family uncertain by Shaver (1961). Details of hingement suggest that it be placed in the Quasillitidae. Although slightly channelled hinge suggest affinity to Quasillites it differs by lacking a well developed ridge in front of posterior margin. It is differentiated from Graphiodactyllis by the lack of clearly defined marginal flanges, in Abursus a poorly developed flange has been observed in the anterior margin at midcentre, this occurs in a small percentage of valves examined. The ventral overlap is most pronounced at midcentre similar to Graphiodactyllis. Abursus appears to have the characteristics of both genera and is thought to be closely related (cf. text figures 35 - 40

Abursus beaumontensus Loranger

Text figure 36

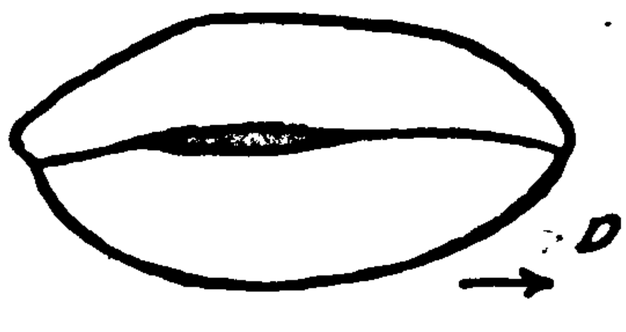
1954 Western Canada Sedimentary Basin; Amer. Assoc. Pet. Geol., p. 194, Pl. 2, figs. 5,6,9,10.

Types: Primary types from Bear Beaumont No. 1 1373-83' and Bear Biltmore No. 1 638-64' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Ireton Macronotella biltmorensa biozone, central and northeastern Alberta. Present in Ireton and Moberly, McMurray area.

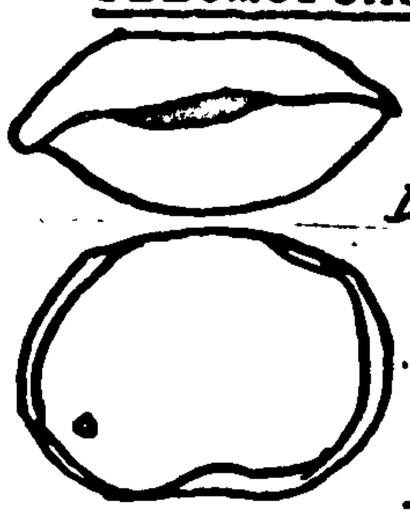
Lithology: Gray argillaceous limestones and limy gray green shales. Maximum occurrence of 3.6% in a mixed sample of gray buff limestone and greenish gray limy shale. (Bear Biltmore No. 1 502-18').

Graphiodactyllis sp.
Sohn and Stover 1961 Q381



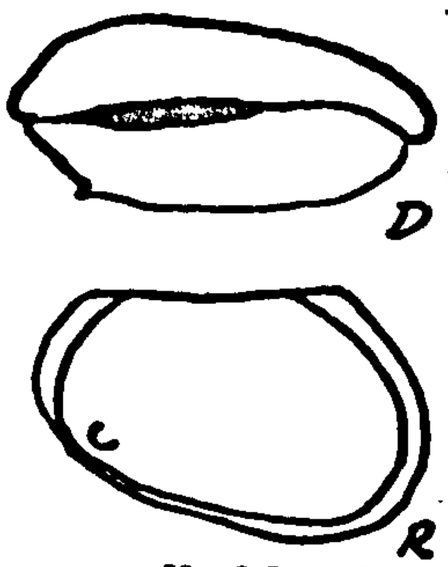
X 40
Text figure 37

Abursus biltmorensus



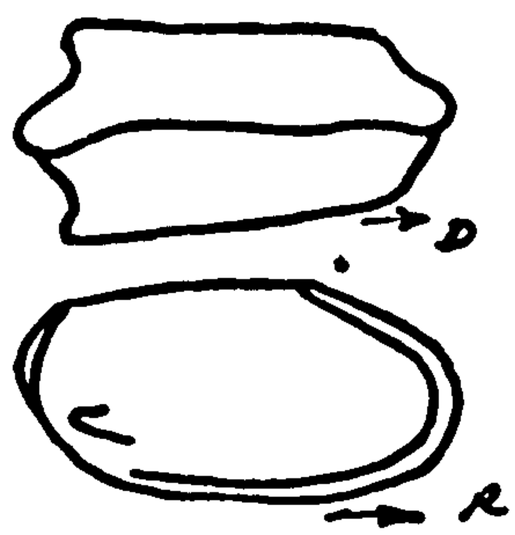
X 38
Text figure 35

Abursus beaumontensus



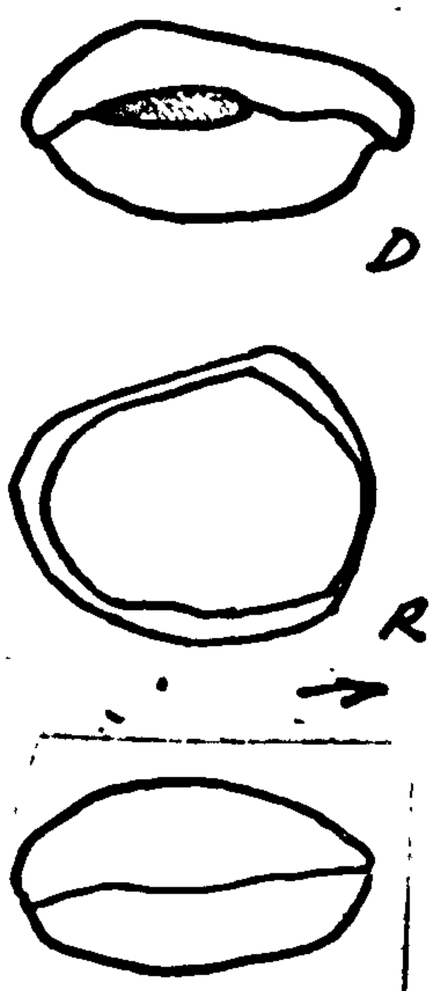
X 31
Text figure 36

Quasillites sp.
Sohn & Stover 1961
Q378



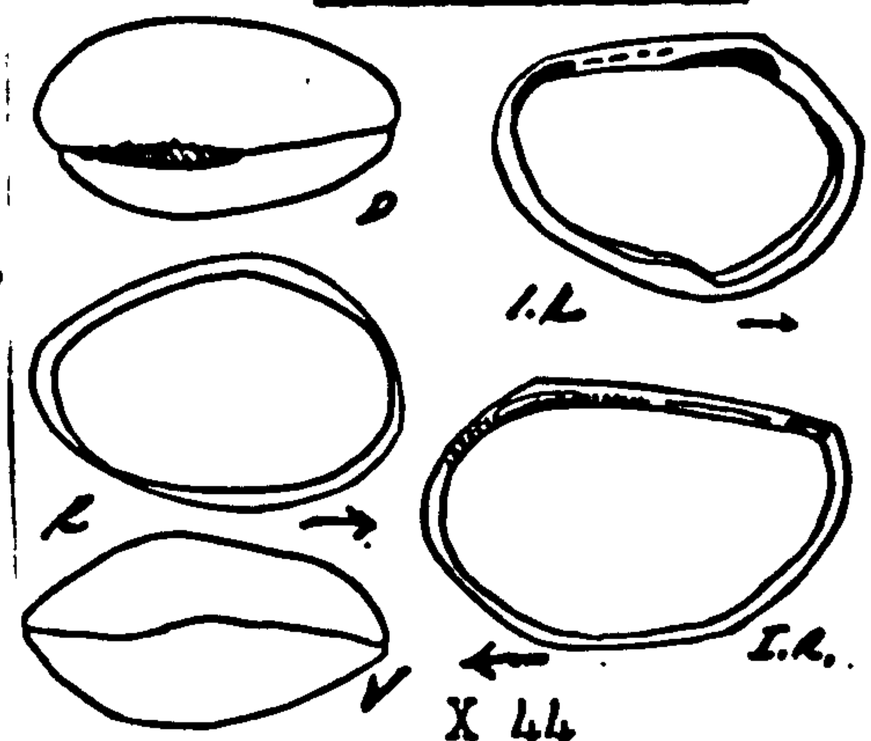
X 40
Text figure 38

Abursus duvernaius



X 38
Text figure 39

Abursus triangulensus



X 44
Text figure 40

Abursus biltmorensus Loranger

Text figure 35

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p. 194, Pl. 2, figs. 1,2,23,24.

1955 Quasillites beachi Gibson. Bull. Amer. Pal., Ithaca, N. Y., vol. 35, no. 154, p. 29.

Types: Primary types from Bear Biltmore No. 1 638-94', in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper Ireton Macronotella biltmorensa biozone central and northeastern Alberta; Ireton, Duvernay, Cooking Lake, Mildred Lake, Moberly, in McMurray area; Beaverhill Lake in central and east central Alberta.

Lithology: Sixty percent of occurrences observed occurred in brown or gray argillaceous limestones, five percent in interbedded limestone and shale samples and the remainder in limy gray green shale.

Abursus duvernaius Loranger

Text figure 39

1954 Western Canada Sedimentary Basin. Amer. Assoc. Pet. Geol., pp. 194-5, Pl. 1, figs. 21,22.

Types: Primary types from Imperial Duvernay No. 4 3005-10' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Lower Ireton, Aechminella fribourgella zone, central and northeastern Alberta; Ireton of McMurray area.

Lithology: Light gray or green gray argillaceous limestone.

Abursus triangulensus n.sp.

Photograph I, figures 16,17, text figure 40

Carapace medium sized, triangular in lateral view; dorsum straight or nearly so, channeled in posterior of carapace by short, deep, broad channel; valves inequal, the left overlapping on free margins and in the anterodorsal area, maximum overlap on venter; dorsum on right valves rises above hingeline in posterodorsal area; maximum length at midcentre, maximum height anterior to midcentre, maximum width in posterior third of carapace; anterior cardinal angle obtuse, anterior end broadly rounded above and below, venter convex, broadly rounded posterior end forming obtuse posterior cardinal angle; tumid form, evenly inflated with maximum in posterior third carapace; ornamented by fine reticulations which become striations along free margins and are parallel to them, in midcentre of carapace they are small, irregular and arranged over the muscle attachment in a compact group just above midcentre; ornamentation is well developed on both valves.

Length: 0.6-0.64 mm. Height: 0.36-0.44 mm.

Width: 0.32-0.4 mm.

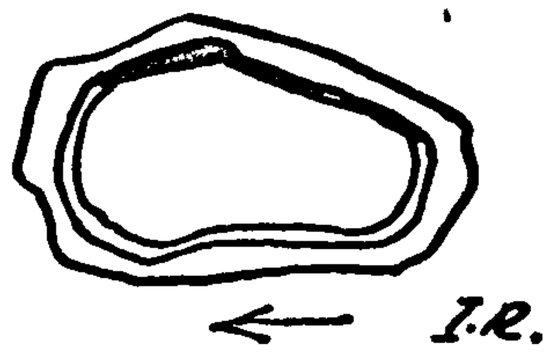
Figured specimen: Holotype Christina, Bear Vampire No. 1, 832-42'. Length: 0.64 mm. Height: 0.44 mm. Width: 0.4 mm.

Distinguishing characteristics: This tumid species with a triangular shape is easily differentiated from the more rounded A.biltmorensus, A.duvernaius and the more

rectangular A.beaumontensus.

Distribution: Found in Christina, Calmut and Firebag of McMurray area.

Lithology: This form occurs about twice as often in buff or gray argillaceous limestones than in gray green shales. Maximum yield of 100% in a shaly argillaceous limestone in Bear Westmount No. 1 at 951-61'.



X 40
Text figure 41

Ropolonellidae Coryell & Malkin 1936

Plagionephrodes Morey 1935

1935 Jour. Paleon., Vol. 9, No. 4, pp. 318-9.

Remarks: This was originally assigned to Thlipsuridae by Morey 1935; Henningsmoen placed it in the Quasillitidae-Ropolonellidae in 1935. Authors in the G. S. A. Treatise place it in nomina dubia as the types are apparently lost. There is however, no suitable synonym and since the genus is well established in the literature it appears advisable for the present at least to continue using this generic name. The hingement structure observed in a number of specimens of this genus consists of smooth

ridges fitting into elongated grooves in the left valve. This agrees with the hingement recorded by Sohn (1961) and is unlike merodont hingement observed in the Quasillitidae. Although profile resembles ? Euglypella Warthin 1934 it is placed in Roponellidae on the basis of hingement. (cf. text figure 41).

Plagionephrodes biltmorensus Loranger

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., pp. 200-1, Pl. 1, figs. 31,32; Pl. 2, figs. 19,20.

Types: Primary types from Bear Biltmore No. 1, 684-94' and Imperial Duvernay No. 4, 2855' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Upper and Lower Ireton, central and north-eastern Alberta; Ireton formation and Mildred Lake member McMurray area.

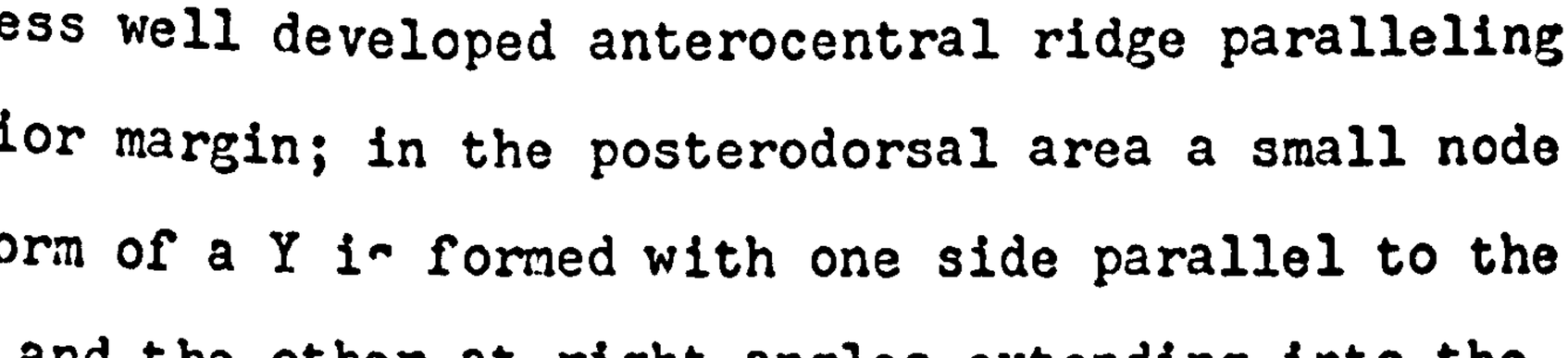
Lithology: Gray or brown limestones yield higher percentages; limy green shales yield specimens but only about half as often as limestones.

Plagionephrodes pseudomorpheus n.sp.

Photograph. I, figs. 8,9; text figure 42

Carapace large, subrhomboidal in lateral view; valves inequal, the left overlapping in anterodorsal area and on free margins; convex hinge, slightly channeled in posterior; maximum length above midcentre; maximum height in anterior quarter of carapace; maximum width at midcentre or just anterior to

midcentre; anterior end broadly rounded; posterior end blunt, anterior cardinal angle o"tuse but posterior cardinal angle acute; venter sinuous with maximum concavity at midcentre; hingement of left valve consists of a groove extending along dorsal margin, obscured anteriorly by fold in dorsum, ends beneath posterior cardinal angle in a semicircular or elliptical depression, right valve consists of ridge extending entire length of dorsum and terminating in broad semicircular cusps; on the left valve a flange in the anterodorsal area extends around the anterior end with maximum development in the anteroventral area and reappears in the posteroventral area as a small keel; on the right valve the striated flange is more prominent but confined to the anterior end; the overlapping valve shows less prominent surface irregularities and less well developed anterocentral ridge paralleling anterior margin; in the posterodorsal area a small node in the form of a Y is formed with one side parallel to the hinge and the other at right angles extending into the central posterior area, small spines are present in the posterior margin of equal size or one may predominate which appears to be a highly variable feature; surface very irregularly sculptured with irregular nodes.



X 46
Text figure 42

Length: 0.77-0.88 mm. Height: 0.48-0.56 mm.

Width: 0.2-0.32 mm.

Figured specimen: Paratype, Firebag, Bear Biltmore No. 1 1614-24'. Length: 0.84 mm. Height: 0.44 mm.

Width: 0.32 mm.

Distinguishing characteristics: The diagnostic Y node in posterodorsal area and elongate bar in anterocentral area distinguishes this from other Plagionephrodes. Left valve overlap is most commonly found although an occasional specimen shows reverse overlap and ornamentation.

Distribution: Moberly, Christina, Calmut and Firebag, McMurray area.

Lithology: Approximately 40% of the occurrences are in gray limestones, 60% in gray green or green shales and 20% in interbedded shales and limestones. Maximum percentage of 23.9% occurred in a limestone in Bear Rodeo No. 1 at 209-19'.

Plagionephrodes spinosus Loranger

1954 Western Canada Sedimentary Basin, Amer. Assoc. Pet. Geol., p. 201, Pl. 1, figs. 35,36.

Primary types: Shell Fribourg, No. 1 2369' in possession of Imperial Oil Limited, Calgary, Alberta.

Distribution: Lower Ireton. Aechminella fribourgella biozone central and northeastern Alberta. Mildred Lake, Moberly, and Christina, McMurray area.

Lithology: Approximately 54% of occurrences were in gray or grayish brown limestone, including the maximum percentage of 30 in Angelus Ashmont, (2995-3004'), about 36% occurred in grayish green or greenish gray shales and the remainder in interbedded limestones and shales or gradations between the two lithologies.

Thlipsuridae Ulrich 1894

? Ponderodictya Coryell and Malkin 1936

Leperditia (of authors) in part

Primitiopsis Jones (of authors) in part

Cytherella Jones (of authors) in part

Cytherellina Jones and Holl (of authors) in part

1936 Ponderodictya Coryell and Malkin, Amer. Mus. Nat. Hist., Amer. Mus. Novitates, New York, No. 891, p. 15.

1936 Hamiltonella Stewart, Jour. Paleo. Menasha, Mis., vol. 10, No. 8, p. 756.

Remarks: Coryell and Malkin (1936) assigned this genus to the Cytherellidae; later referred to the Healdiidae by Henningsmoen (1953). Pokorný (1958) places it with the Thlipsuridae. Stewart (1927) had previously identified this species as Cytherella bispinulatus

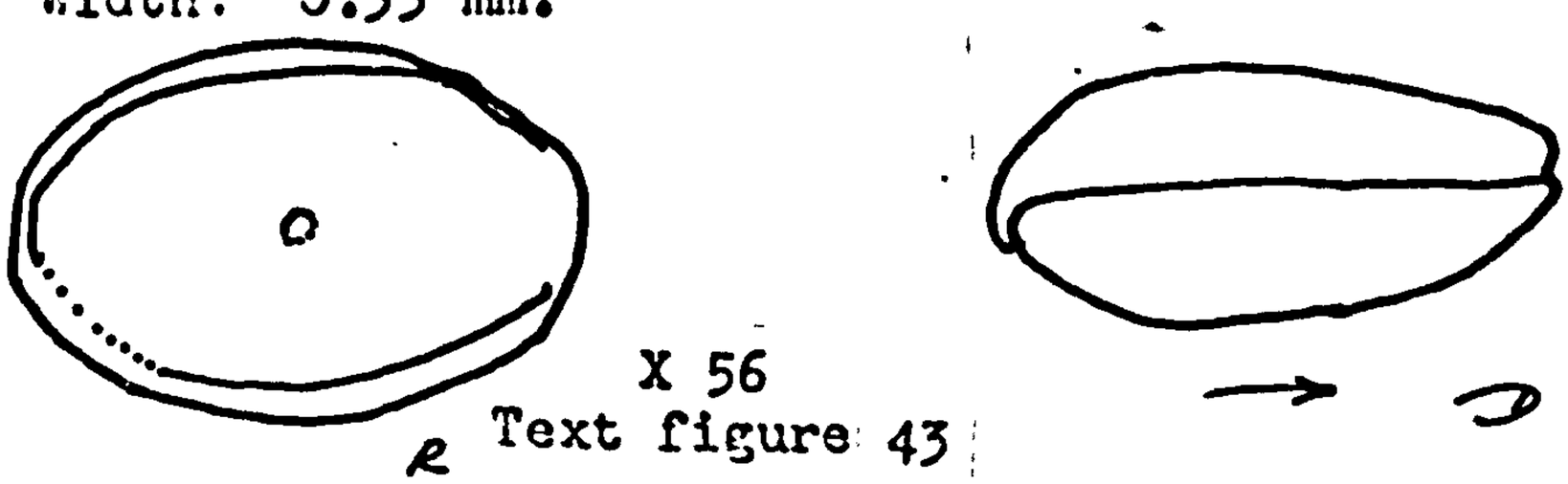
Stewart which was made the genotype of Ponderodictya Coryell and Malkin 1936; earlier in the same year Stewart published the description of Hamiltonella. Stewart (1936) assigned the cogeneric Hamiltonella to Bairdiidae which was later placed by Agnew in Cytherellidae (1942).

? Ponderodictya sp.A n.sp.

Photograph VII, figures 11,12, text figure 43.

Carapace large, outline ovate; arcuate dorsum; left valve overlaps right on hinge, posterior and ventral margins; dorsum rises well above hingeline; maximum length at midcentre, maximum height anterior to midcentre; maximum width posterior third of carapace; obtuse anterior cardinal angle forming sharply and evenly rounded anterior end, convex venter and sharply rounded posterior end terminating in posterior cardinal angle; carapace evenly inflated with maximum inflation in posterior third of carapace; hingement by overlap; ornamented by very fine polygonal reticulations.
Length: 0.64-0.8 mm. Height: 0.4-0.52 mm.
Width: 0.32-0.36 mm.

Figured specimen: Holotype, Ireton, Bear Beaumont No. 1 1334-63'. Length: 0.8 mm. Height: 0.32 mm.
Width: 0.33 mm.



X 56
Text figure 43

Distribution: Ireton and Moberly, McMurray area.

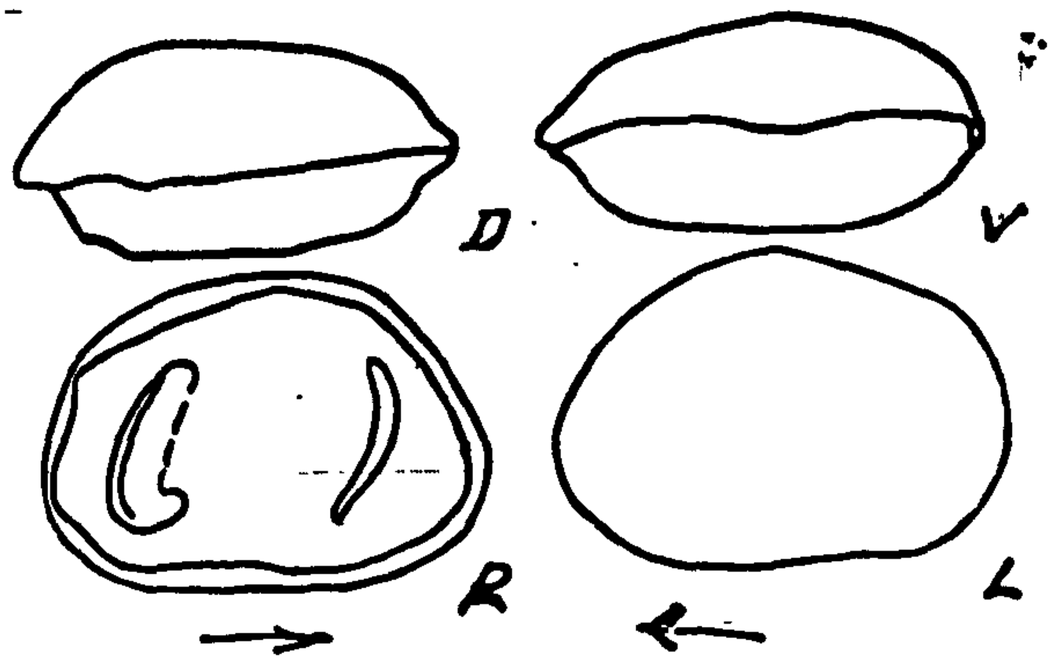
Lithology: Rare in gray, brown or grayish green limestones and gray green limy shales.

Rothella Wilson 1935

1939 Dizygopleura Roth (in part), Jour. Paleo, vol. 3, pp. 344-356.

1935 Rothella Wilson, Jour. Paleo., vol. 9, p. 643.

Remarks: Placed by Wilson in Thlipsuridae (1935).



X 45
Text figure 44

Rothella vampirensa n.sp.

Photograph I, figs. 14,15, text figure 44

Carapace medium sized, subreniform in outline; curved dorsum; right valve slightly flattened, small, fits into larger more convex left valve on all margins; maximum concavity of dorsum occurs anterior to midcentre; maximum length at midcentre, maximum height anterior to midcentre and maximum width posterior to midcentre; anterior end broadly rounded above, sharply rounded below; venter almost flat; sharply rounded

inferior angle and obtuse posterior cardinal angle; left valve unornamented except for short compressed areas at anterior and posterior margins; right valve has a C shaped depression in anterior end and one in posterior end paralleling margins; the depressions are ringed by slight ridge on the outer edge, the posterior being more pronounced.

Length: 0.68-0.74 mm. Height: 0.4-0.5 mm. Width: 0.3-0.32 mm.

Figured specimen: Holotype, Bear Vampire No. 2, Calmut formation, 212-22'; Length: 0.74 mm. Height: 0.50 mm. Width: 0.32 mm.

Differentiating characteristics: Differentiated from R.obtusa Wilson 1935 which has more elongate carapace and equal development of ornamentation; from R. birdsongia Wilson 1935 which has chunkier profile and lacks raised rim around craters. Distinguishing features are raised rim on outer margins of craters and inequal ornamentation.

Distribution: Calmut and Firebag members, McMurray area.

Lithology: Restricted to a gray green limestone.

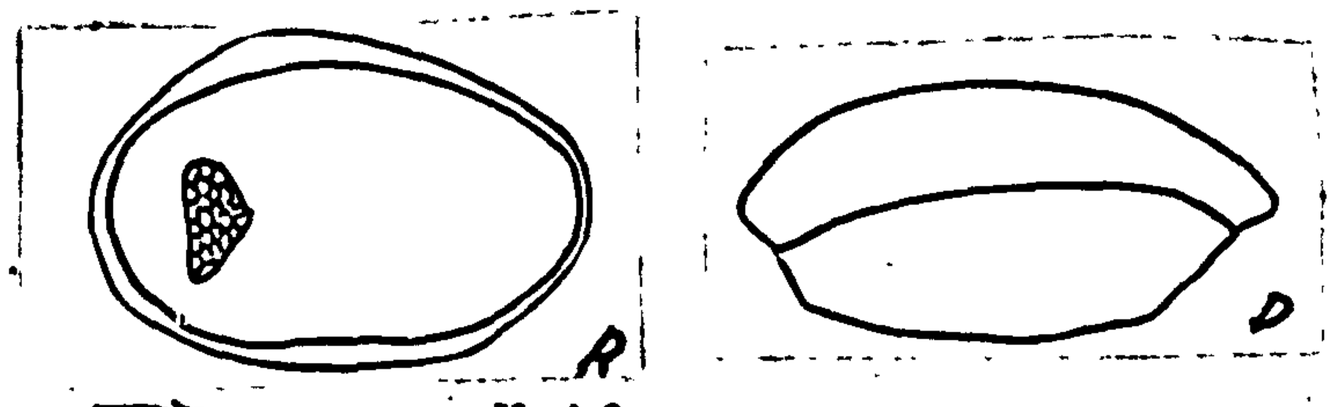
Thrallella Stewart and Hendrix 1945

Remarks: Originally placed in Cytherellidae by Stewart and Hendrix (1945); later put in Healdiidae Harlton 1953 by Pokorný (1958); revised by Kesling (1961) and placed in ? Thlipsuracea- Thlipsuridae.

Thrallella reticulata n.sp.

Photograph VII, figures 7,8, text figure 45

Carapace medium size; subovate in outline; dorsum short, channelled; dorsum shows maximum concavity posterior to midcentre; left valve overlaps all margins; maximum overlap occurs at midcentre of venter; maximum length at midcentre, maximum height and thickness posterior to midcentre; anterior end evenly and symmetrically rounded to form oval, venter evenly convex throughout, posterior end broadly curved; surface smooth except for triangular



X 43
Text figure 45

area on the posterior third of both valves which is covered by rows of irregular polygonal reticulations; approximately 50 fine reticulations in larger forms and somewhat less in molt stages.

Length: 0.67-0.84 mm. Height: 0.48-0.56 mm.

Width: 0.32-0.36 mm.

Figured specimen: Holotype, Bear Biltmore No. 1, Ireton 664-74'. Length: 0.82 mm. Height: 0.52 mm.

Width: 0.36 mm.

Distinguishing characteristics: Differs from Menoeidina arcuata Turner 1939, M. scopeli Coley 1954, T.mimica

Stewart and Hendrix 1945 and T.susanola Stewart and Hendrix 1945 by having oval shape, arched dorsum and lack of posterior ridge or shoulder. Numerous fine reticulations confined to limited area of valves is a most diagnostic feature.

Distribution: Ireton, McMurray area.

Lithology: In Bear Biltmore No. 1 664-74' it occurs in a mixed lithology of limy green shale grading in to a buff fragmental limestone; in the other samples occurs in an argillaceous gray green or greenish limestone.

Incertae Sedis

Platyrhomboides Harris 1957

Remarks: Author placed this in Beecherellidae; Moore (1961) in the G. S. A. Treatise places this in Ostracoda of uncertain suborder and family.

Platyrhomboides albertensus n.sp.

Photograph VII, figures 13-16, text figure 46

Carapace medium sized; trapezoidal in lateral outline, lanceolate in dorsal profile; dorsum straight, equivalved; maximum length below midcentre, maximum height at midcentre; maximum width anterior to midcentre; anterior cardinal angle very obtuse forming acute inferior angle in area of maximum width, venter convex extending in a broad arc to an acute posterior angle which is terminated by an obtuse posterior

cardinal angle; the carapace is evenly inflated; the left valve terminates in spines at both extremities, the right valve in molt stages has a distinctive posterior spine which has not been observed in the adult or later molt stages. Length: 0.67-0.88 mm. Height: 0.28-0.36 mm.

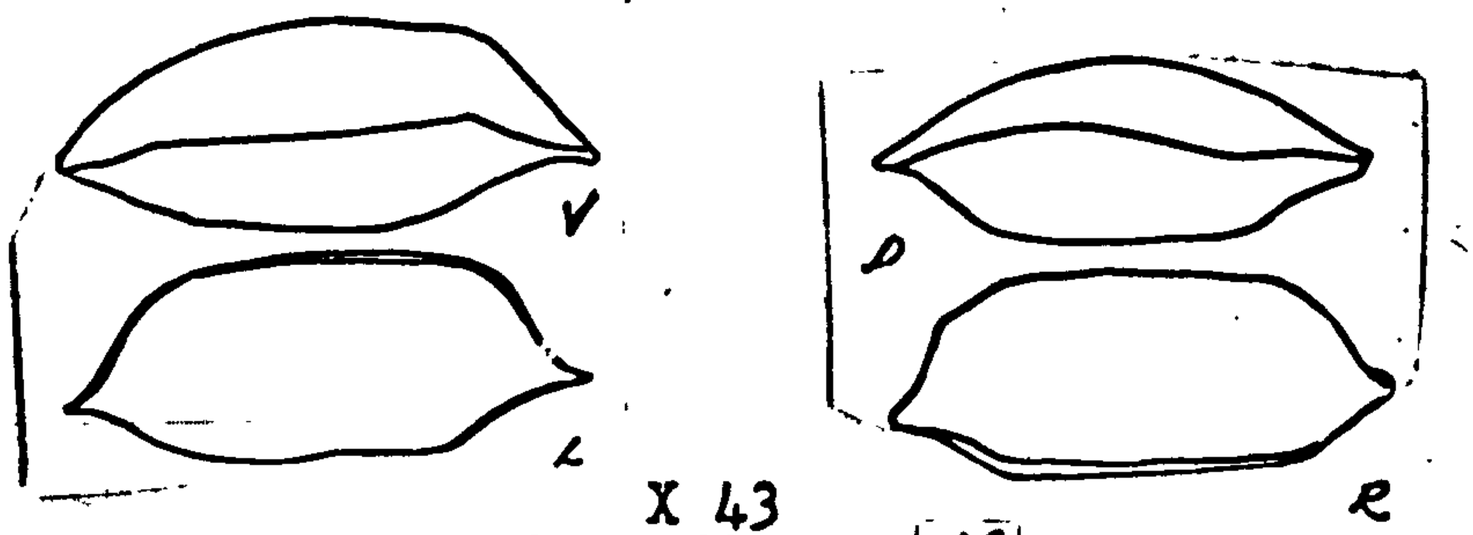
Width: 0.2-0.48 mm.

Figured specimens: Ireton, Bear Biltmore No. 1, 568-88';

Figs. 13,14 Length; 0.36 mm. Height: 0.28 mm.

Width: 0.24 mm. Figs. 15,16 Length: 0.88 mm.

Height: 0.68 mm. Width: 0.48 mm.



X 43

Text figure 46

Distinguishing characteristics: The trapezoidal lateral profile is similar to the genotype P.quadratus Harris 1957 but that species has a triangular cross-section and no spines. Pokorný (1958) has suggested that elongation of carapaces into spines occurs as an evolutionary tendency in many genera which is apparently what has happened to the Platyrhomboides described by Harris from the Middle Ordovician, Simpson formation of Oklahoma. However the species found in the Ireton lacks the triangular cross-section and flattened base.

Text cut off in original

The lateral outline is close to Beecherella trapezoides Gibson 1955 but lacks the triangular cross-section and ventral overlap.

Distribution: Ireton and Mildred Lake, McMurray area.

Lithology: Greenish gray limy shale and in shale and gray buff limestone samples.

Species indet.

Photograph VI, figures 27,28, text figure 47

Remarks: This form does not fit into published classifications with facility. It occurs very rarely and there is not enough material available at this time to prepare a complete description but for the sake of completeness it is included in this study. The following characteristics suggest some affinity to the family Bolliidae Bouček 1936: subquadrate carapace, long hinge, well defined dorsomedian lobes and distinct marginal rim. In contrast, there is a distinct central boss, anteroventral and dorsoventral nodes and no overlap of margins anywhere.

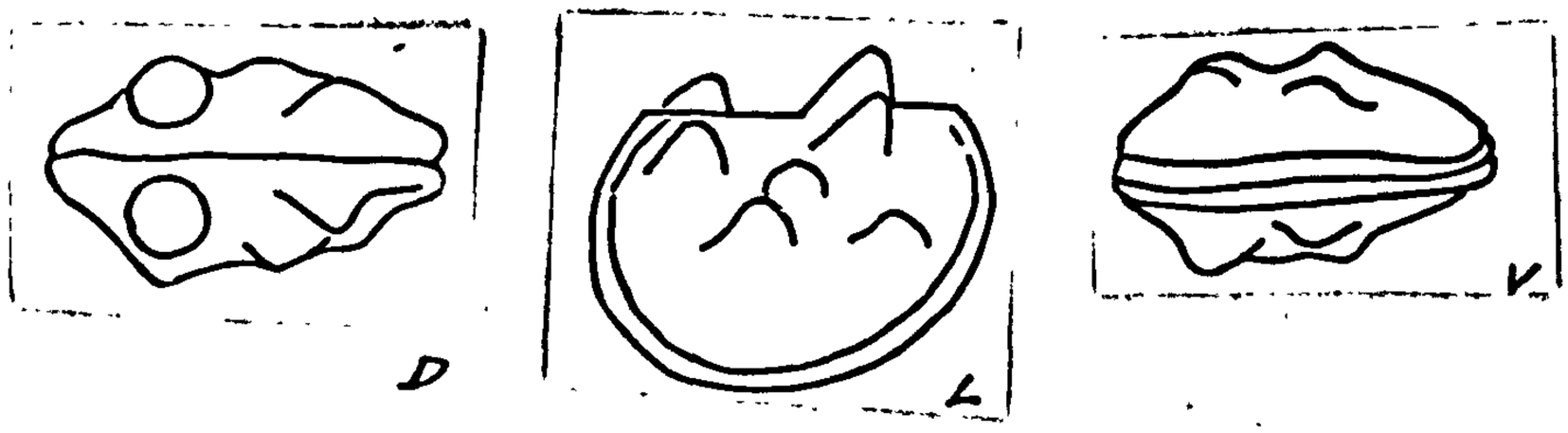
Description

Carapace medium size; subelliptical outline; straight dorsum equivalved except in anterior cardinal area where left overlaps right; maximum length at midcentre, maximum height anterior to midcentre and maximum thickness posterior to midcentre; anterior cardinal angle about 120° broadly rounded, broadly rounded venter and more sharply rounded anterior terminating in posterior cardinal angle of about 110°: a narrow but distinct ridge

parallels free margins, posteriorly directed anterodorsal spine and a larger outward and posteriorly directed spine in posterodorsal area, both extending above hingeline, a posteroventral node, an anterior dorsocentral node and a poorly developed anteroventral boss.

Length: 0.68-0.72 mm. Height: 0.38-0.42 mm. Thickness: 0.19-0.28 mm.

Figured specimen: Holotype, Ireton, Bear Bearmont No. 1 1147-81'. Length: 0.72 mm. Height: 0.42 mm. Thickness: 0.28 mm.



X 43
Text figure 47

Distribution: Ireton, Duvernay and Moberly in McMurray area. Rare.

Lithology: Rare in gray brown limestones or buff limestones grading into green or gray green shales.

Branchiopoda

Crustaceans which have multilamellar carapaces formed by the retention of molts have been included in the Ostracoda by Levinson (1951), Pokorný (1958) and Adamczak (1961). Adamczak concludes that these small pelecypod-like forms are an exceptional suborder of Ostracoda that retain their molts. However, Raymond (1946) described a genus of Rhabdostichus, which is similar in shape and shell material to Estheria, but lacks the small ornate ridges, which he assigned to Conchostraca (incertae sedis). He concluded that these forms belonged to a poorly known group of branchiopoda confined to the Middle Palaeozoic. This opinion is shared by Shrock and Twenhofel (1953, pp. 546-8) and by Krommelbein.*

Wilson (1956) followed Raymond's work and published illustrations of R.cf.pulex (Clarke) from the Williston Basin and western Alberta. However, he did not give detailed descriptions since this problematic group was to be treated by Tasch in the Treatise of Invertebrate Palaeontology, Part R. Estheria described by Lutkevich (1941) from the Permian of the U. S. S. R. are larger (up to 4.5 mm.) and have many growth lines.

The McMurray boreholes include R.cf.pulex (Clarke) and two forms that are provisionally placed in this genus. It is recognized that these may represent an undescribed group since

*Personal communication

there are marked differences from Rhabdostichus- consistent asymmetric shells, ornamented umbos and little variation in ridges and troughs. Additional research, particularly in respect to thin sections, is required to place these forms within their proper taxonomic position.

Branchiopoda Latreille 1817

Order Conchostraca

Rhabdostichus Raymond 1946

Rhabdostichus cf. pulex (Clarke)

Rhabdostichus ? reticulatus n.sp

R.? rugosus n.sp.

Rhabdostichus cf. pulex (Clarke) 1882

1882 Estheria pulex Clarke, Amer. Jour. Sci., ser. 3, vol. 23, p. 476, fig. 4.

1888 Estheria pulex Hall and Clarke, Palaeont. New York, vol. 7, p. 206, pl. 35, figs. 10,11.

1946 Rhabdostichus pulex Raymond, Bull. Mus. Comp. Zool., Harvard, vol. 96, No. 3, p. 276, pl. 5, fig. 4.

1956 Rhabdostichus cf. pulex (Clarke), Jour. Paleo., vol. 30, No. 4, pp. 959-80.

Types: Depository not listed by Clarke (1882).

Distribution: Woodbend and Beaverhill Lake, Western Alberta and Manitoba respectively. Ireton and Moberly in McMurray area.

Lithology: Green limy shales with bands of argillaceous gray limestone.

Remarks: This species has been misidentified as Aparchites canadensis Fritz (1940) or Eridoconcha sp. but is readily differentiated from A.canadensis by its troughs and ridges and from Eridoconcha by asymmetric shape. Clarke (1882) found these associated with undescribed Beyrichia, Leperditia, Entomis and Discina.

Rhabdostichus ? rugosus n.sp.

Photograph VII, figures 23,24.

Carapace small, subrectangular outline; hinge ¾ carapace length; equivalved; maximum length below midcentre, maximum height through central third of carapace (disregarding umbos), maximum width at midcentre, anterior cardinal angle about 150° broadly rounded with sharply rounded (almost 90°) inferior angle; venter broadly curved, posterior inferior and cardinal angles close to 90° giving a blunt profile; hingement appears to be of bar and groove type; ornamentation consists of a prominent umbo on posterodorsal area, and a series of seven thick rounded ridges commencing at the dorsum, parallelling the venter and converging in the posterior end at the contact margin; the troughs are U shaped, broad and deep; umbo may have fine pitted surface.

Length: 0.44-0.48 mm. Height: 0.24-0.28 mm.

Width: 0.24-0.26 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore No. 1 638-64'. Length: 0.44 mm. Height: 0.24 mm.

Width: 0.24 mm.

Distinguishing characteristics: Subrectangular shape separates this from R. cf. pulex (Clarke) and R.reticulatus n.sp.

Distribution: Ireton and Christina members, McMurray area.

Lithology: Gray or greenish gray argillaceous and shaly limestone.

Rhabdostichus ? reticulatus n.sp.

Photograph VII, figures 21,22

Carapace small, subquadrate in outline; straight hinge; equivalved; maximum length at midcentre, maximum height anterior to midcentre (disregarding umbos), maximum width above midcentre; anterior cardinal angle 160° or so, very broadly rounded in anterior end almost straight venter with an inferior angle of less than 90° terminating in obtuse posterior cardinal angle: umbo, more than half hinge length, confined to posterior half; separated by broad deep troughs from a series of thick rounded ridges paralleling the venter and diminishing in width and separation as they approach dorsum or posterior end; umbo coarsely reticulated.

Length: 0.36 mm. Height: 0.24 mm. Width: 0.16 mm.

Figured specimen: Holotype, Ireton, Bear Biltmore No. 1, 638-64'. Length: 0.36 mm. Height: 0.24 mm. Width: 0.16 mm.

Distinguishing characteristics: Subquadrate shape and coarsely reticulated umbo separate this from R.rugosus n.sp. and R.cf. pulex.

Distribution: Ireton, Mildred Lake, Moberly, Christina McMurray area.

Lithology: In gray green limy shales interbedded with gray limestones or in light gray dense limestones with shaly partings.

Phylum Annelida (Annulata)

Class Chaetopoda

Subclass Polychaeta

Hard parts of worms were present in a number of samples in rather small numbers and usually as incomplete specimens. This rather difficult group has been classified in accordance with Shimer and Shrock (1944). Representatives of five genera and species were identified:

Order Phanerocephala (Errantia)

Arabellites Hinde 1879

Arabellites comis Eller 1938

Arabellites pectinellus Stauffer 1939

Lumbriconereites Ehlers 1868

Lumbriconereites cooperi Eller 1938

Nereidavus Grennell 1877

Nereidavus ontarioensis Stauffer 1939

Staurocephalites Hinde 1879

Staurocephalites sp.

Order Cryptocephala (Sedentaria, Tubicola)

Spirorbis Lamarck 1801

Spirorbis sp.

Arabellites comis Eller

1938 Carnegie Mus., Ann. 27, p. 277, Pl. 28, fig. 9.

Types: Holotype Geological Museum, University of Minnesota, Nos. B5402, B5403, B5409.

Distribution: Potter Farm, Michigan; Olentangy shale and Widder Beds, Ontario; Ireton in McMurray area.

Lithology: Gray, brown or green limestone grading into limy green shale.

Arabellites pectinellus Stauffer

1939 Jour. Paleo. Vol. 13, No. 5, pp. 500-1, Pl. 58, fig. 7.

Types: Holotype, Geological Museum, University of Minnesota No. B5389.

Distribution: Ipperwash limestone, Ipperwash Beach, Ont.; Ireton, Moberly in McMurray area.

Lithology: Gray green limy shale with Lingula in the Ireton; argillaceous limestone in the Moberly.

Lumbriconereites cooperi Eller

1938 Carnegie Mus., Ann. 27, pp. 275-7, Pl. 28, figs. 1-8.

Types: Types in U. S. Nat. Mus. Washington and duplicates in Carnegie Museum.

Distribution: Potter Farm Formation, Michigan. Moberly, Calmut and Firebag, McMurray area.

Lithology: Gray green shale grading into argillaceous limestone.

Nereidavus ontarioensis Stauffer

1939 Jour. Paleo., Vol. 13, No. 5, p.507, Pl. 57, figs. 12,13, 15; Pl. 58, figs. 26, 32, 34.

Types: Geological Museum, University of Minnesota, syntypes nos. B5368, B5369, B5407, B5413, B5415 and figured specimen B5371.

Distribution: Olentangy shale, Widder Beds, Ipperwash limestone, Ontario. Ireton, Moberly and Christina, McMurray area.

Lithology: Gray limestone with green or brown shale partings.

Staurocephalites sp.

Distribution: Ireton in McMurray area.

Lithology: Greenish gray limy shale.

Spirorbis sp.

Distribution: Christina and Firebag members, Waterways, McMurray area.

Lithology: Gray limy shales or gray green shales grading into some gray argillaceous limestone.

Conodontophoridia

Historical summaries reviewing the early work by Pander in 1856 and later describing the classic localities in New York State have been published by Stauffer and Plummer (1932), Youngquist, Hibbard and Reimana (1948). Conodont morphology was examined in detail by Hass (1941) and revised partly by Müller (1957). The physical properties of conodonts and their chemical composition was described by Ellison (1944). Fay (1952) did much to stimulate research in this field by listing all references to the end of 1949 and provided a convenient identification key. Workers on both sides of the Atlantic published a series of descriptive papers which has provided a basis for correlation over large distances. A number of papers were prepared by Bishoff and Ziegler (1956), Bender (1959), Dengler (1959), Müller (1956) and Sannemann (1955), Germany; Branson and Mehl (1952), Cooper (1945), Stauffer (1940), Youngquist and Miller (1948) in the United States; Rhodes and Dineley (1957) in England. Rhodes and Dineley (1957) compared material from a borehole at Bishopsteighton in Devon to sections in Iowa and Müller has attempted to compare the Iowa sections to the German collections(1957). Ash (1961) has continued Fay's index and bibliographic lists which are now complete until the end of 1958.

As yet no satisfactory key has been found for the various genera. Scott's (1934) study of assemblages is enlightening

but such collections are exceedingly rare and not expected in borehole cores. The classification presented by Shimer and Shrock (1944) has been used as a basis in this study. Representations of five families, 16 genera and 24 species have been identified, and five new species are described.

Order Conodontidophoridia

Suborder Neurodontiformes Branson and Mehl 1942

Trucherognathidae

Curtognathus Branson and Mehl 1933

Curtognathus sp ?

Prioniodidae

Apatognathus Branson and Mehl 1934

Apatognathus sp.

Centrognathus Branson and Mehl 1942

Centrognathus sp.

Hindeodella Ulrich and Bassler 1926

Hindeodella lambdesta n.sp.

Hindeodella milleri Stauffer 1938

Hindeodella sp.

Lignodina Ulrich and Bassler 1926

Lignodina sp.

Prioniodinidae

Bryandotus Stauffer 1935

Bryandotus stratfordensis Stauffer 1938

Bryandotus sp. A. n.sp.

Ctenognathus Branson and Mehl 1942

Ctenognathus (Pandorinellina) insita (Stauffer 1940)

Leptochirognathus Branson and Mehl 1942

Leptochirognathus sp.

Neoprioniodus Müller 1956

Neoprioniodus sp.

Ozarkodina Branson and Mehl 1933

Ozarkodina regularis Branson and Mehl 1933

Prioniodus Pander 1856

Prioniodus cf. idoneus Stauffer 1938

Trichognathus Branson and Mehl 1933

Trichognathus blanda Stauffer 1940

Polygnathidae

Palmatolepis Ulrich and Bassler 1926

Palmatolepsis sp. A. n.sp.

Polygnathus Hinde 1879

Polygnathus stainbrooki Downs and Youngquist 1950

Polygnathus xylus Stauffer 1940

Polygnathus sp. A. n.sp.

Polygnathus sp. B. n.sp.

Gnathodidae

Icriodus Branson and Mehl 1934

Icriodus brevis Stauffer 1938

Icriodus cymbiformis Branson and Mehl 1938

Icriodus elegantulus Stauffer 1938

Icriodus cf. elegantulus Stauffer 1938

Icriodus expansus Branson and Mehl 1938

Taphrognathus Branson and Mehl 1940

Taphrognathus sp. ?

Descriptions

Curtognathus sp.

Distribution: Moberly member, McMurray area.

Lithology: Buff gray argillaceous limestone with some shaly partings.

Apatognathus sp.

Distribution: Ireton, Moberly and Firebag, McMurray area.

Lithology: Limy gray green shale grading into gray limestone.

Centrognathus sp.

Distribution: Mildred Lake :member, McMurray area.

Lithology: Limy gray green shale and gray fragmental limestone.

Hindeodella lambdesta n.sp.

Photograph VII, figure 25

Bar long, slightly bowed and tapering to posterior, maximum width at midcentre between cusp and posterior end; keeled with two faintly marked lateral carinae extending from below cusp to posterior end. Anterior limb not present. Posterior limb with large denticles at regular intervals inclined posteriorly at increasingly lower angle until they form the terminal denticle. Large denticles evenly spaced and alternate with two to four smaller denticles. All

denticles distinctly inserted in base.

Figured specimen: Holotype Ireton, Bear Biltmore No. 1 638-64'. Length of bar 1.44 mm.

Distinguishing characteristics: This species is similar to H.lambtonensis Stauffer 1938 in its lateral carinae and distinct insertion of denticles but differs in its terminal almost bifurcated dentition and its regularly spaced denticle series. The terminal dentition and angle of dentition are very similar to that found in H. modesta Stauffer 1938 but the cusp is not parallel to the adjacent denticles and the denticles are distinctly inserted. This posterior termination distinguishes it from H. milleri Stauffer 1938, H. plumatella Stauffer 1938, H. austinensis Stauffer 1940 and H.moweri Stauffer 1940. The species appears to be intermediate between H. lambtonensis Stauffer and H.modesta.

Distribution: Ireton and Moberly, McMurray area.

Lithology: Buff limestone and green limy shale.

Hindeodella milleri Stauffer

1938 Jour. Paleo., vol. 12, pp. 412,428, Pl. 50, figures 1,3a,3b,4,9-11.

Types: Geological Museum, University of Minnesota,, Nos.B4801, B4803, B4810, B4804, B4809, B4811.

Distribution: Olentangy shale, Ohio; Widder Beds, Ontario; Sweetland Creek, Iowa. Ireton, Mildred Lake and Firebag, McMurray area.

Lithology: Limy green shale and brown or green argillaceous limestone.

Lignodina sp.

Distribution: Ireton and Firebag McMurray area.

Lithology: Limy gray green shale and gray argillaceous limestone.

Bryandotus stratfordensis Stauffer

1938 Jour. Paleo., vol. 12, p. 423. Pl. 48, fig. 17; Pl. 49, fig. 6.

Types: Primary types, Geological Museum, University of Minnesota, B4757, B4780.

Distribution: Olentangy shale, Southwestern Ontario, central and northcentral Ohio. Ireton, Moberly, Calmut and Firebag, McMurray area.

Lithology: Greenish gray limy shale.

Bryandotus Sp. A.

Photograph I, figure 18

Base thick, broadly arched and slightly curved, with a prominent ridge or carina on the inner side below midcentre. The aboral keel continues beyond the escutcheon to the tip of the specimen, the carina or ridge paralleling the keel more or less throughout the length of the specimen. Anterior limb bears 6 or 7 discrete denticles, including a terminal denticle which is curved inwards. Beyond the thick main cusp the denticles are fused together. The denticles tend to angle

away from the main cusp and become almost horizontal in the anterior portion.

Figured specimen: Holotype, Firebag, Bear Rodeo No. 2 418-28'. Length: 0.96 mm.

Distinguishing characteristics: Some superficial resemblance to B.stratfordensis Stauffer 1938 is noted but this species is more strongly arched and curved, lacks the adequate number of denticles and has a distinctive terminal curve at tip.

Distribution: Firebag member, McMurray area.

Lithology: Limy green shale.

Ctenognathus (Pandorinella) insita (Stauffer).

1940 Pandorina insita Stauffer, Jour. Paleo., vol. 14, p. 429, Pl. 59, figs. 23,25.

1940 Pandorina gratiosa Stauffer, ibid. p. 428, Pl. 59, figs. 18-20,24.

1947 Spathognathudus gratiosus Youngquist, Jour. Paleo., vol. 21, p. 111, Pl. 26, fig. 1.

1957 Ctenognathus (Pandorinella) insita (Stauffer), ibid., vol. 31, p. 1083, Pl. 142, fig. 23.

Types: Lectotype designated by Müller (1957), State University of Iowa. Nos. S. U. I. 9976, 9977.

Distribution: Cedar Valley limestone, LeRoy, Minnesota, North Liberty beds, North Liberty, Iowa. Ireton, Moberly, Christina, Calmut and Firebag, McMurray area.

Lithology: In Ireton in gray argillaceous and shaly limestone, in other formations in gray green limy shale and/or interbedded gray limestone.

Leptochirognathus sp.

Distribution: Ireton, McMurray area.

Lithology: Greenish gray limy shale.

Neoprioniodus sp.

Distribution: Firebag, McMurray area.

Lithology: Limy green shale

Ozarkodina regularis Branson and Mehl

1933 Missouri Univ. Studies, vol. 8, no. 4, p. 287, Pl. 23, figs. 13,14.

Distribution: Ireton formation in McMurray area.

Lithology: Argillaceous gray or greenish gray limestone or greenish gray limy shale.

Prioniodus cf. idoneus Stauffer

1938 Prioniodus idoneus Stauffer, Jour. Paleo, vol. 12, p. 440, Pl. 49, fig. 19.

Type: Holotype, Geological Museum, University of Minnesota. No. B5093.

Distribution: P.idoneus in central Ohio, Olentangy shale. Ireton formation, McMurray area.

Lithology: Limy gray green shale or argillaceous gray green limestone.

Trichognathus blanda Stauffer

1940 Jour. Paleo., vol. 14, p. 434, Pl. 59, figs. 61,70.

Types: Syntypes, University of Minnesota, Geological Museum Nos. B5623, B5632.

Distribution: Cedar Valley limestone, Minn. Christina member, McMurray area.

Lithology: Limy gray green shale.

Palmatolepis sp.A. n.sp.

Photograph VII, figures 26,27.

Plate is small, short, sigmoidally curved. Posterior end slightly upturned. Outer part of the plate is larger than the inner part. Posteriorly the carina is high, consists of 4 large nodes almost the size of the azygous node and extends nearly to tip of plate. Anterior to azygous node the carina is deflected about 15° from the axis giving a gently curved pattern. Anteriorly the carina passes into a high blade as the nodes flatten into denticles. The denticles on the blade diminish in size and appear to merge into a well developed keel aborally. Blade short, abruptly terminated by passing into keel. Keel well developed in the anterior end and becomes restricted near the escutcheon although it continues to the tip and is slightly larger there than in the immediate vicinity of the escutcheon. Oral surface covered with nodes, one row marginal, the others less regularly arranged.

Figured specimen: Holotype, Ireton, Bear Biltmore No. 1 568-88'. Length: 0.64 mm.

Distinguishing characteristics: Better differentiated keel

and carina separate this from P.glabra Ulrich and Bassler. Leaf shape and short keel differentiate this from P(P) genioclymeniae Müller 1958. The oral nodes are similar to those occurring in various species of Ancyriodes Youngquist and Miller (1948).

Distribution: Ireton formation, McMurray area.

Lithology: Greenish gray limy shale.

Polygnathus stainbrooki Downs and Youngquist

1950 Jour. Paleo., Vol. 24, p. 671, Pl. 81, figs. 19,20.

Types: Holotype, State University of Iowa No.4184

Distribution: Cedar Valley limestone of Iowa. Mildred Lake member, McMurray area.

Lithology: Limy gray green shale with some gray limestone.

Polygnathus xylus Stauffer

1940 Jour. Paleo., vol. 14, pp. 430-1, Pl. 60, figs. 42,50, 54,65-67,69,72-74,79.

Types: Syntypes, Geological Museum, University of Minnesota B5680, B5687, B5691, B5699, B5700, B5701, B5703, B5705, B5706, B5707, B5709.

Distribution: Rapid member, Cedar Valley, Iowa and associated clays in southern Minnesota. Ireton and Elk Point formations, McMurray area.

Lithology: Gray argillaceous limestone grading into limy gray green shale.

Polygnathus sp. A.

Photograph I, figure 19

In profile this species is arched and the posterior end gently downcurved. The plate is nearly symmetrical and the carina slightly bowed throughout its length. The carina bears 4 or 5 nodes at the posterior end and then the nodes coalesce into a bar which is extended into the keel. The plate is smooth and troughs exist on both sides of the carina throughout its length. The troughs are sharp angled and formed by the edges of the plate being bent upwards sharply and on the outside parallel to the carinal bar the outer margin is turned broadly almost forming a fold. Aborally the keel extends the entire length of the specimen but in the central third of the specimen both sides are obscured by cartilaginous material.

Figured specimen: Firebag, Bear Westmount No. 2, 320-31'

Length: 1.12 mm. (broken).

Distribution: Firebag member, McMurray area.

Lithology: Gray green shale grading into argillaceous and shaly limestone.

Polygnathus sp. B.

Photograph I, figure 20

Species arched in profile with posterior end sharply downcurved. Asymmetrical plate curved at posterior approximately 15° to carinal axis. The carina has 12 or more nodes at posterior and then fuses into a bar, consisting of 12 or more compressed denticles. Troughs extend on both sides of carina and are covered with transverse ridges that extend to

the margins. Details of the aboral side are obscured by cartilaginous material. The keel extends the length of the specimen and has a small escutcheon midcentrally placed. A well marked carina is present on the aboral surface midway between keel and margin.

Figured specimen: Paratype, Firebag, Bear Vampire No. 2 272-81'. Length: 1.4 mm (broken).

Distinguishing characteristics: Differs from P.strongi Stauffer 1940 which has flattened plate covered by rows of nodes. Blade is not long and thin as in P.vareus Stauffer nor does the aboral side show keel variation at join of blade and carina as shown on Pl.60, figs. 53,55. Differs from P. wyomingensis Klapper 1958 by curved carina and asymmetrical plate. Separated from P.normalis Miller and Youngquist 1947 by backward swing of bar denticles and the flattened arch of carina and bar.

Distribution: Ireton and Firebag, McMurray area.

Lithology: Gray limestone, argillaceous, grading into limy green shales.

Icriodus brevis Stauffer

1940 Jour. Paleo. Vol. 14, p. 424, Pl. 60, figs. 36,43,44,52.

Types: Syntypes, Geological Museum, University of Minnesota Nos. B5674, B5681, B5682 and B5689.

Distribution: In clay at Austin, Minnesota and in Cedar Valley limestone. Firebag member, McMurray area.

Lithology: Limy green shale.

Icriodus cymbiformis Branson and Mehl

1938 Jour. Paleo., Vol. 12, No. 2, pp. 164-5, Pl. 26, figures 27-29.

Types: Syntypes, University of Missouri, No.C197-1.

Distribution: Southwestern Ontario above Encrinal limestone and Snyder Creek, Callaway limestone of Missouri. Ireton formation and Firebag member, McMurray area.

Lithology: Gray argillaceous limestone and/or limy green shale.

Icriodus elegantulus Stauffer

1938 Jour. Paleo. Vol. 12, p. 430, Pl. 52, figures 26,27.

Types: Holotype, Geological Museum, University of Minnesota No.B4947.

Distribution: Olentangy shale, southwestern Ontario, north central and central Iowa. Moberly and Firebag members, McMurray area.

Lithology: Argillaceous limestone and/or limy green shale.

Icriodus expansus Branson and Mehl

1938 Jour. Paleo. vol. 12, pp.156-158,160,161, Pl. 26, figs. 18-21.

Types: Syntypes, University of Missouri, No. C.249-3.

Distribution: Widespread in Mineola limestone, Snyder Creek shale, Mo.; Genundewah limestone, N.Y.; Silica shale, Ohio; New Albany shale, Ind.; Sycamore ss, Ark.; Alpina

limestone, Mich.; basal Widder Bed and Encrinal limestone of southwestern Ontario. Ireton, Christina and Firebag members, McMurray area.

Lithology: Limy green shale commonly; buff or argillaceous limestone rarely.

Taphrognathus sp.

Distribution: Firebag member in McMurray area.

Lithology: Gray green limy shale grading into argillaceous limestone.

Polyzoa (Bryozoa)

Two species of Polyzoa were present in Middle and Upper Devonian sediments. They have been temporarily referred to as Polyzoa A and B. Dr. Thomas has suggested that the first is a form of Rhombopora but that a series of cross sections on better preserved material would be required for specific identification. Polyzoa B is probably another species of the same genus.

Polyzoa (Bryozoa) A

Distribution: Ireton, Duvernay, Moberly, Christina, Calmut and Firebag, McMurray area.

Lithology: Gray argillaceous limestone or limy gray green shale predominantly. Rarely in dolomite. In Moberly and Christina predominantly limestone with minor shale content but in Firebag generally present in gray green limy shale.

Polyzoa (Bryozoa) B

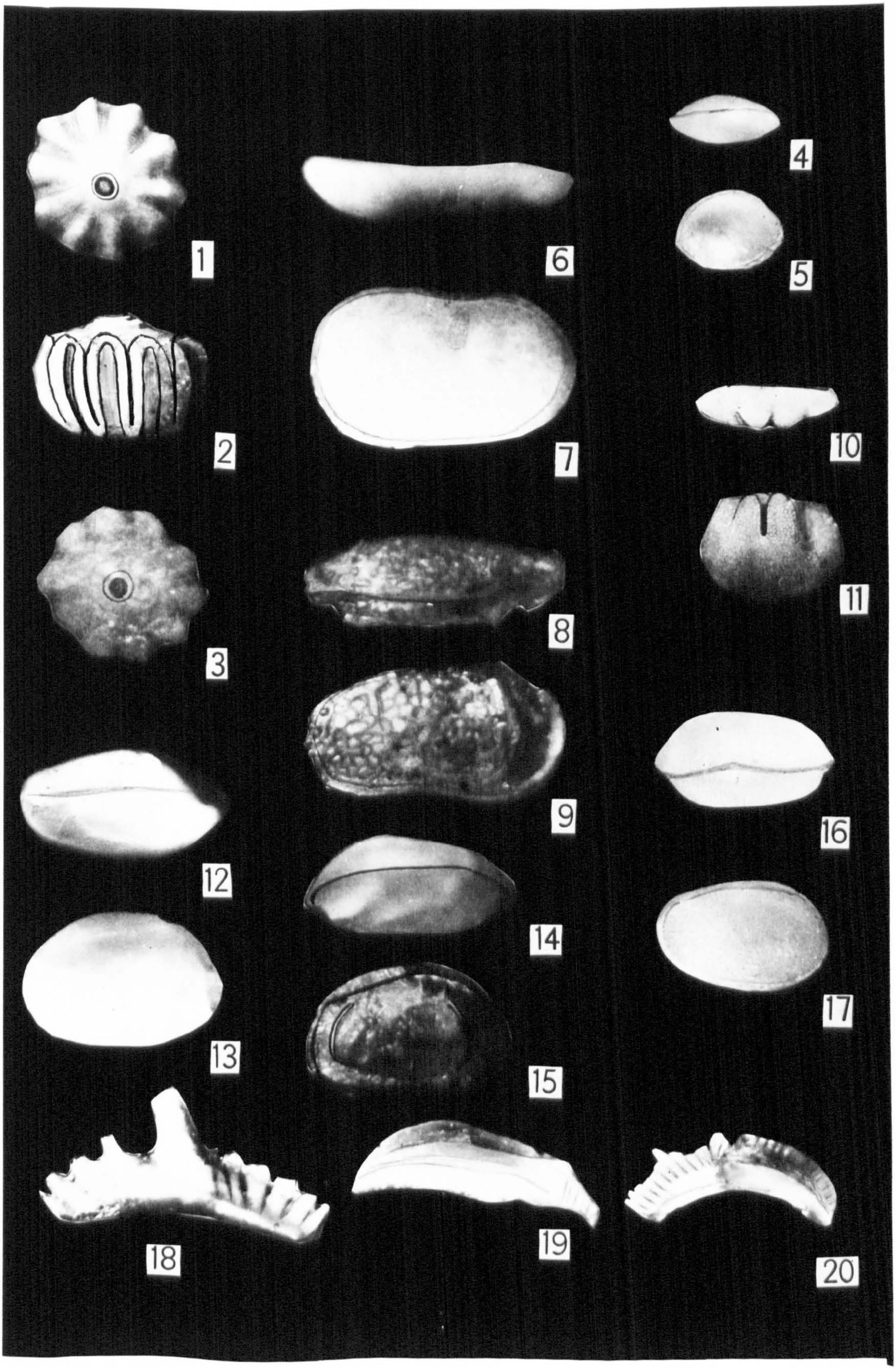
Distribution: Ireton, Moberly, Christina, Calmut and Firebag in McMurray area.

Lithology: Gray green limestone and/or grayish green or greenish gray limy shale.

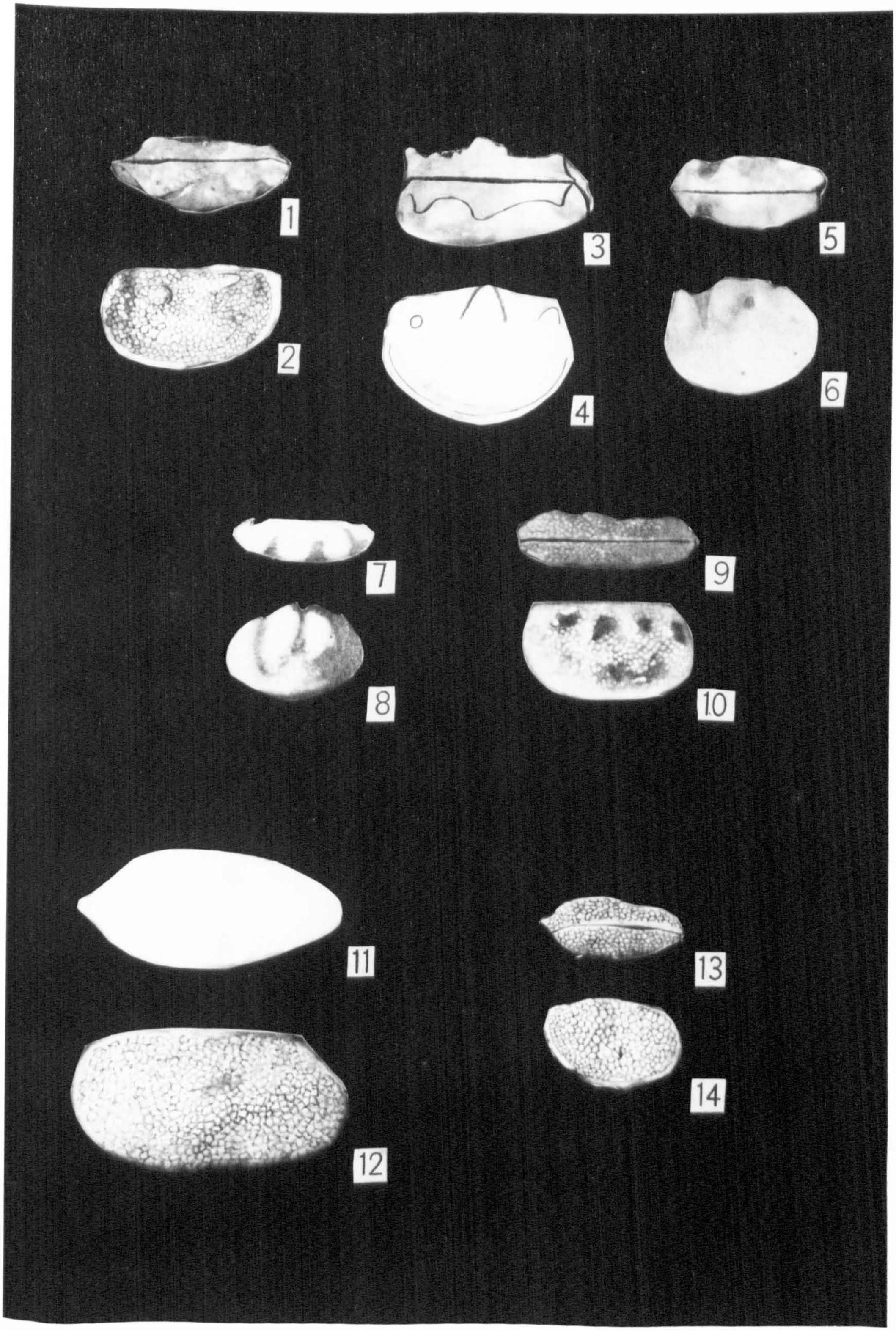
Miscellaneous Groups

The basic data chart 35 and 36 show that substantial percentages of the population are represented by the juvenile or fragmentary remains of brachiopoda, pelecypoda, gastropoda, echinoidea, holothuroidea, ophiuroidea, crinoidea and pteropoda. These groups are of use in the interpretation of environment but of little value in stratigraphic work in this area, since specific identifications are seldom possible. The planktonic pteropod Tentaculites sp. recurs in great numbers in some sections suggesting connections to the open sea.

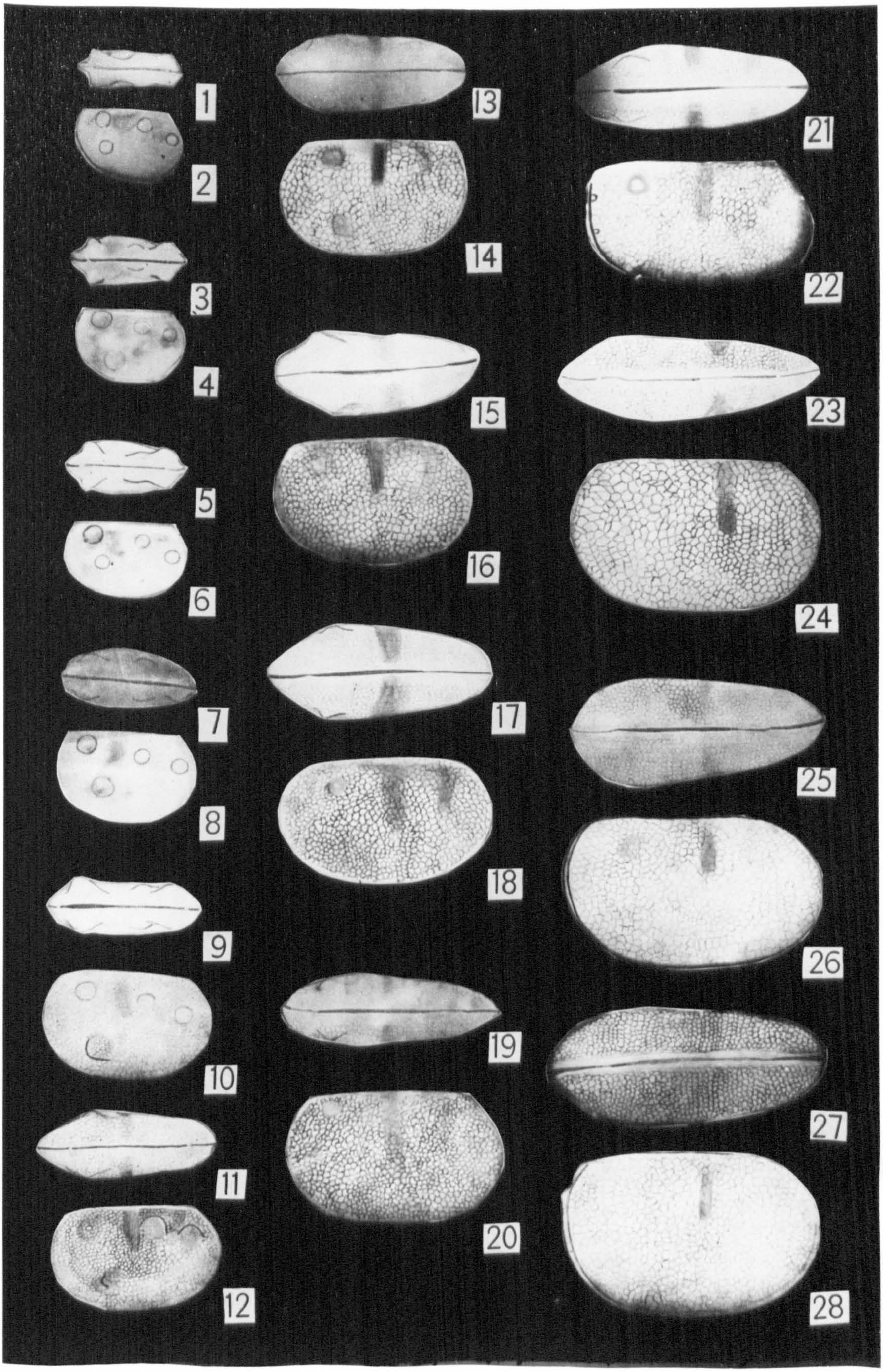
PHOTOGRAPH I



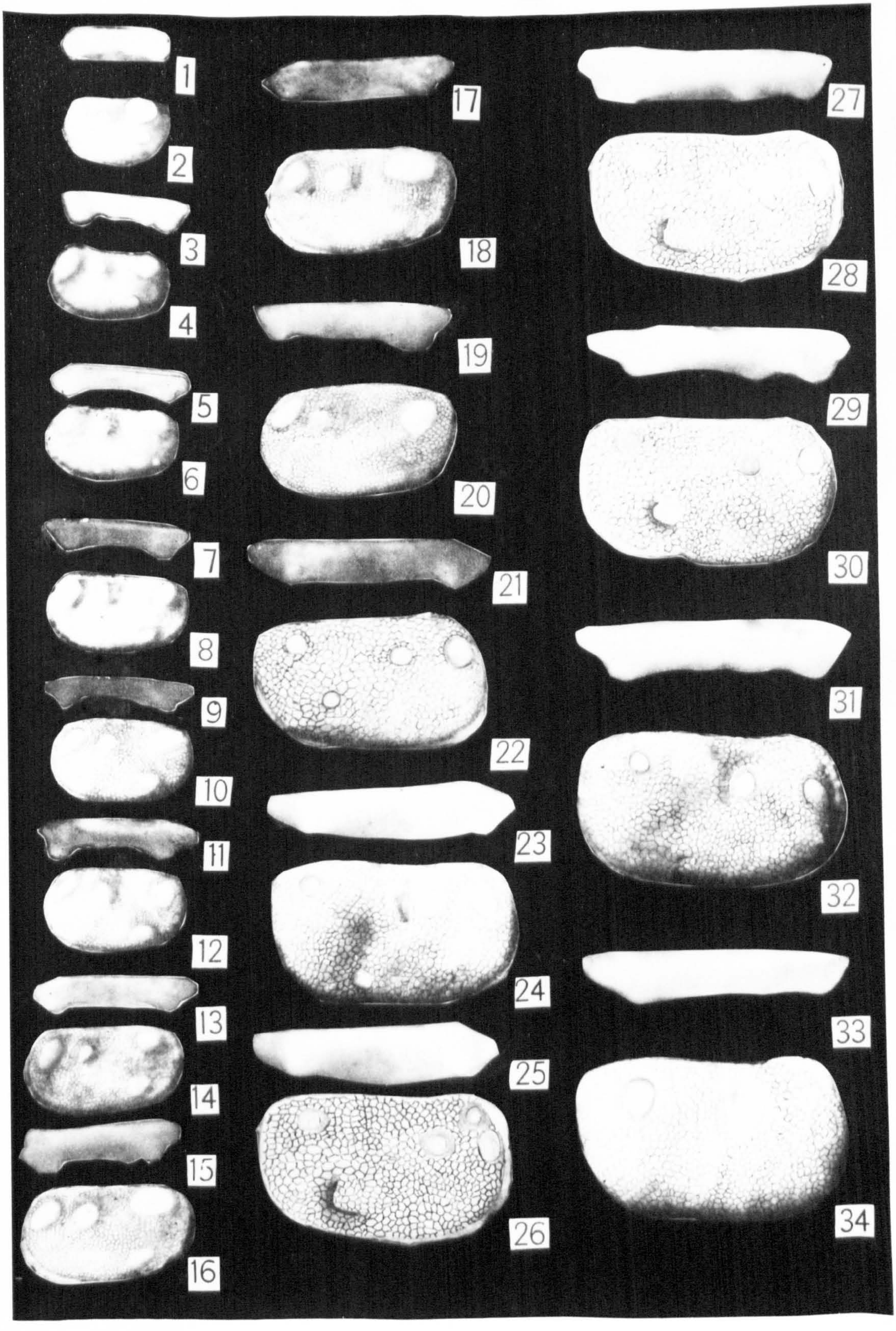
PHOTOGRAPH II



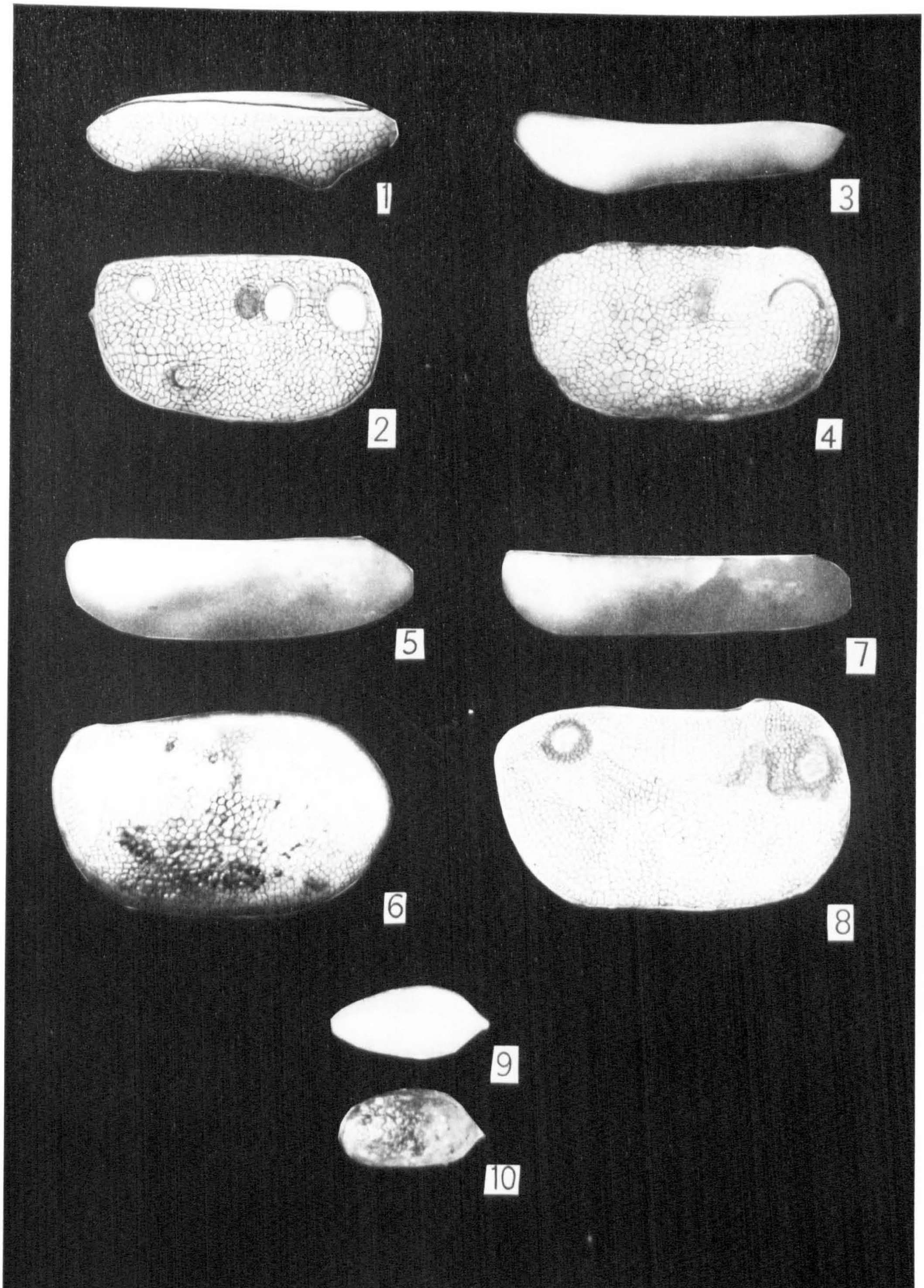
PHOTOGRAPH III



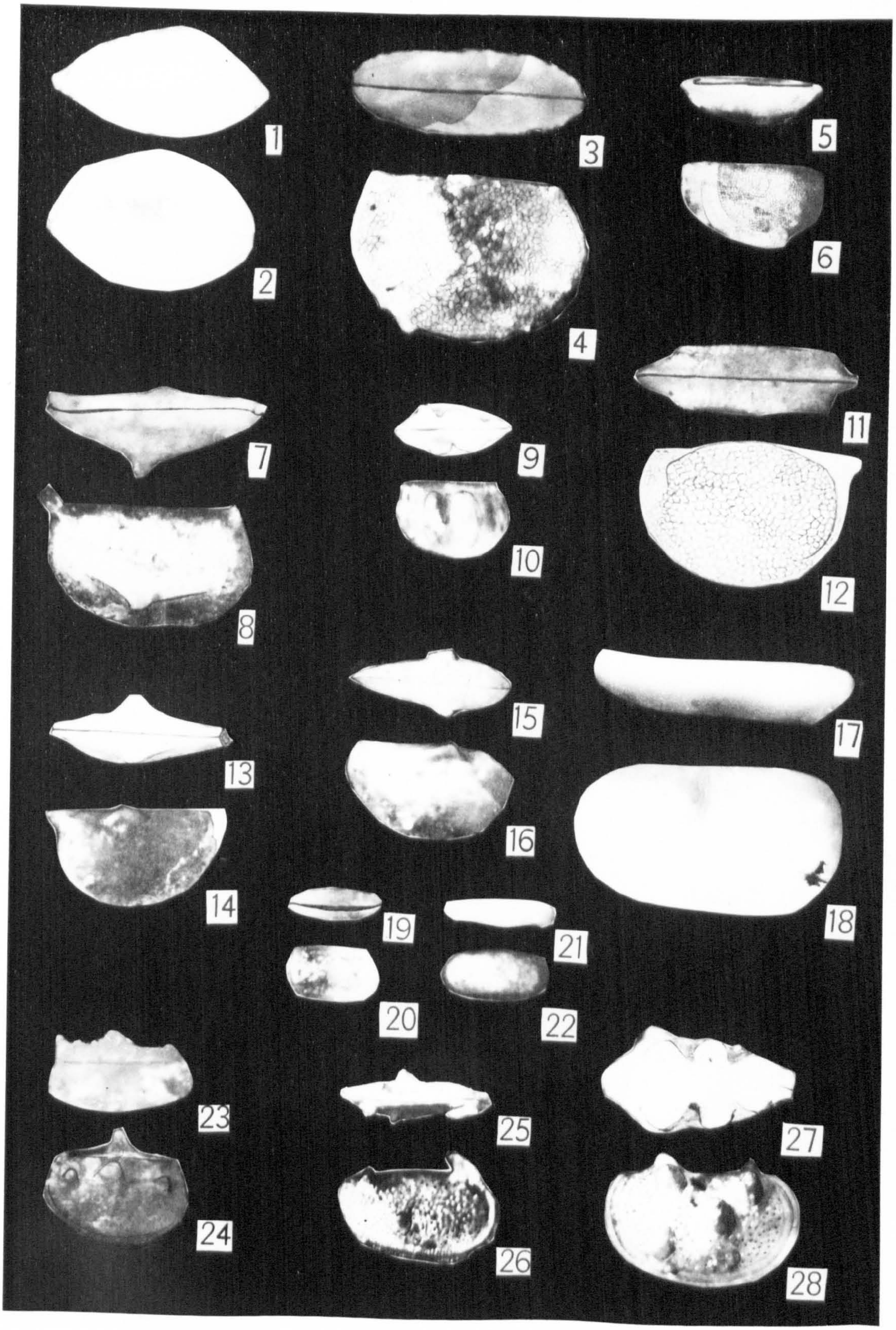
PHOTOGRAPH IV



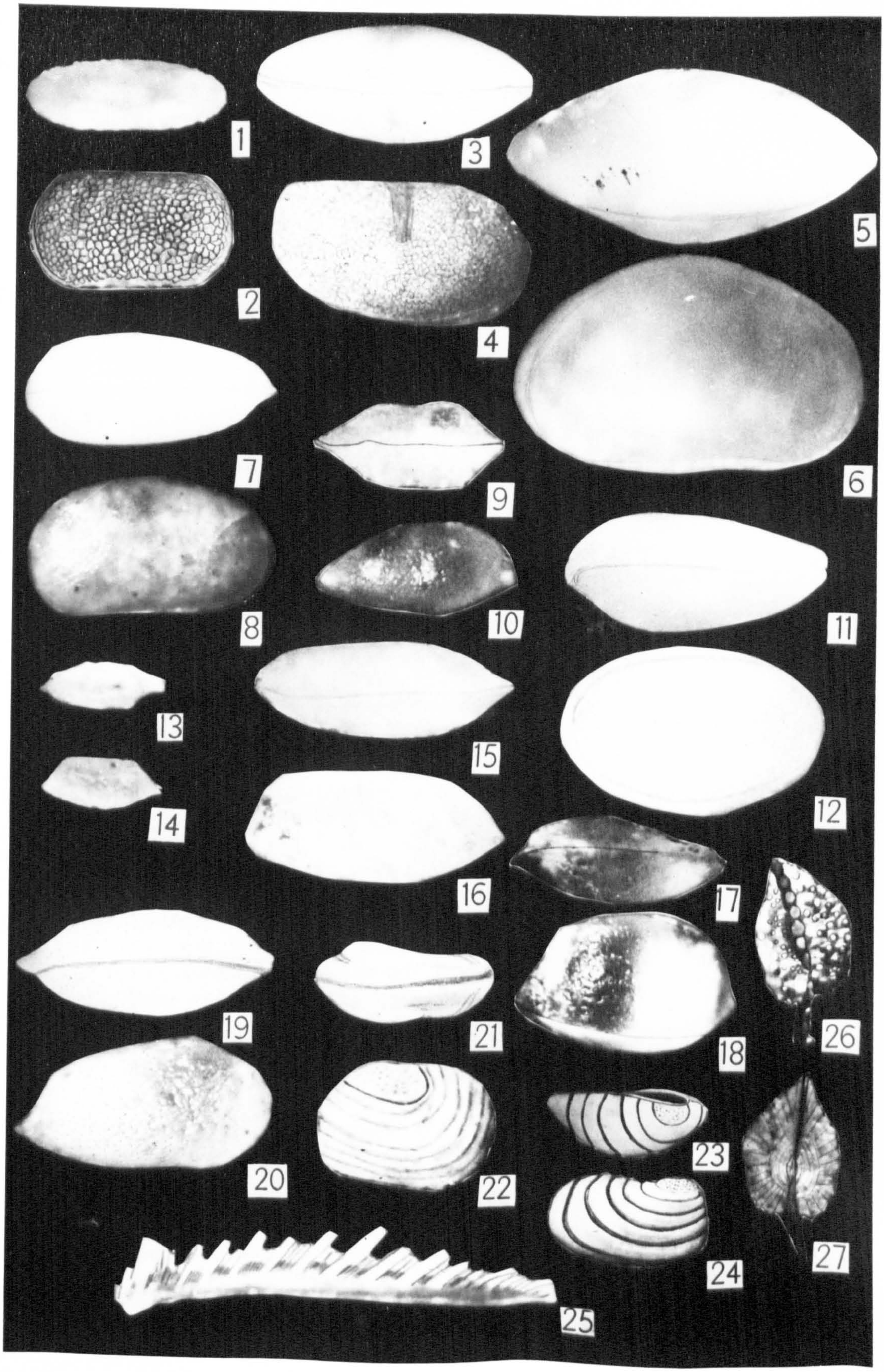
PHOTOGRAPH V



PHOTOGRAPH VI



PHOTOGRAPH VII



Photograph 1.

Elk Point Group - Elk Point Formation

Figs. 1, 2, 3, Prochara symmetrica, n.g., n.sp. x65*
Paratype, Christina River Hardy No. 1, 1860-67'.
Basal, lateral and apertural views.

4, 5, Cavellina ? sp., n.sp ? x39
Paratype, Christina River Hardy No. 1, 1860-67'
Dorsal and right lateral views.

Waterways Formation - Firebag

6, 7, Kloedenella rodensa, n. sp., x56.
Holotype, Bear Rodeo No. 1, 321-31'.
Dorsal and right lateral views, single valve.

8, 9, Plagionephrodes pseudomorpheus, n. sp., x51
Paratype, Bear Biltmore No. 1, 1614-24'.
Dorsal and right lateral views.

Calmut

10,11, Aechminella trinodensa, n.sp., x 52.
Holotype, Bear Westmount No. 1, 991-99'.
Dorsal and left lateral views, single valve.

12,13, Aparchites ? sp., x 40.
Holotype, Bear Vampire No. 2, 212-22'.
Dorsal and right lateral views.

14,15, Rothella vampirensa, n.sp., x 47.
Holotype, Bear Vampire No. 2, 212-22'.
Dorsal and right lateral views.

Christina

16,17, Abursus triangulensus, n.sp., x45.
Holotype, Bear Vampire No. 1, 832-42'.
Dorsal and right lateral views.

18, Bryandotus sp. A, n.sp., x 50.
Holotype, Bear Rodeo No. 2, 418-28'.
Lateral view.

19, Polygnathus sp. A, n.sp., x 37.
Paratype, Bear Westmount No. 2, 320-21'.
Oral view, slightly tilted.

20, Polygnathus sp. B, n.sp., x 24.
Holotype, Bear Vampire No. 2, 272-82'.
Oral view, slightly tilted.

Photograph 11.

Waterways Formation - Moberly

Figs. 1, 2, Winchellatia cf. deminuta, Kesling and Tabor x 47.
Christina River Hardy No. 1, 1339-49'.
Dorsal and left lateral views.

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* Magnifications are approximate.

3, 4, Aechminella middevonica, n.sp., x 70.
Holotype, Bear Beaumont No. 1, 2130-44'.
Dorsal and right lateral views.

5, 6, Aechminella initialia, n.sp., x 53.
Holotype, Bear Beaumont No. 1, 2130-44'.
Dorsal and right lateral views.

7, 8, Aechminella sp. A, n.sp. x 60.
Holotype, Bear Vampire No. 2, 92-102'.
Dorsal and right lateral views, single valve.

9,10, Mauryella sp. A, n.sp., x 50.
Holotype, Christina River Hardy No. 1, 1249-59'.
Dorsal and right lateral views.

11,12 Hypotetragona sp., x 50.
Christina River Hardy No. 1, 1239-49'.
Dorsal and right lateral views.

13,14 Monoceratina scottia n.sp., x 52.
Holotype, Bear Beaumont No. 1, 1948-59'.
Dorsal and right lateral views.

Photograph III.

Waterways Formation - Moberly

1-28 Hypotetragona albertensa n.sp., x 43.
Paratypes, Bear Beaumont No. 1, 2130-44'.
Instar I, figures 1-4.
Instar II, figures 5, 6.
Instar III, figures 7, 8.
Instar IV, figures 9-12.
Instar V, figures 13, 14.
Instar VI, figures 15, 16.
Instar VII, figures 17-22.
Instar VIII, figures 23, 24.
Instar IX, figures 25-28.
Dorsal views indicated by odd numbers;
right lateral views indicated by even numbers.

Photograph IV.

Waterways Formation - Moberly

1-34 Westmountia mcmurraiensa*, n.g., n.sp. x 57
Paratypes, Bear Westmount No. 2, 46-62'.
Instar I, figures 1-4.
Instar II, figures 5-12.
Instar III, figures 13-16.
Instar IV, figures 17-20.
Instar V, figures 21-26.
Instar VI, figures 27-30.

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* Dorsal views indicated by odd numbers; left lateral views single carapace up to figure 20; remainder of instars are right lateral views of single valve.

Instar VII, figures 31-34.

Photograph V.

Waterways Formation - Moberly

1-8 Westmountia mcmurraiensa*, n. g., n.sp.,
Instar VII, figures 1, 2.
Instar VIII, figures 3, 4, 5, 6.
Instar IX, figures 7, 8.

Mildred Lake

9,10, Krausella albertensa, n.sp., x 50
Holotype, Bear Biltmore No. 1, 1064-74'.
Dorsal and left lateral views.

Photograph VI.

Woodbend Group - Duvernay

1, 2, Macrocypris ? sp. A, n.sp. ? x 40.
Paratype, Bear Beaumont No. 1, 1657-59'.
Dorsal and right lateral views.

Ireton

3, 4, Neopribylites albertensus, n.g., n.sp., x 45.
Holotype, Bear Biltmore No. 1, 1064-74'.
Dorsal and right lateral views.

5, 6, Acronotella keslingia, n.sp., x 40.
Holotype, Bear Biltmore No. 1, 684-94'.
Dorsal and left lateral views, single carapace.

7, 8, Monoceratella sp. A, n.sp., x 48.
Holotype, Bear Beaumont No. 1, 1147-81'.
Dorsal and right lateral views.

9,10, Bollia sp., x 41.
Bear Biltmore No. 1, 568-78'.
Dorsal and right lateral views.

11,12, Limbinaria navicularia, n.sp., x 58.
Holotype, Bear Beaumont No. 1, 1334-43'.
Dorsal and right lateral views.

13,14, Aechmina vikingensa, n.sp., x 54.
Holotype, Bear Beaumont No. 1, 1334-43'.
Dorsal and left lateral views.

15,16, Aechmina sp. A, n.sp., x 48.
Paratype, Bear Beaumont No. 1, 1334-43'.
Dorsal and left lateral views.

17,18, ?Eukloedenella sp. x 55.
Bear Biltmore No. 1, 638-48'.
Dorsal and left lateral views, single valve.

19,20, Youngiella devonicensa, n.sp. x 57.
Holotype, Bear Biltmore No. 1, 539-49'.
Dorsal and right lateral views.

21,22, Youngiella elongatensa, n.sp., x 53.

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* Refer page 206.

Holotype, Bear Biltmore No. 1, 539-49'.
Dorsal and left lateral views, single valve.

23,24, Aechminella beaumontensa, n.sp., x 46.
Holotype, Bear Beaumont No. 1, 1147-57'.
Dorsal and right lateral views.

25,26, Bicornellina ? sp. A, n. sp. ? x 48.
Holotype, Bear Beaumont No. 1, 1334-63'.
Dorsal and right lateral views.

27,28 Ostracoda, sp. indet., x 46.
Holotype, Bear Beaumont No. 1, 1147-81'.
Dorsal and right lateral views.

Photograph VII.

Woodbend Group - Ireton

1, 2, Roundyella sp. A. n.sp.? x 16.
Holotype, Bear Biltmore No. 1, 684-94'.
Dorsal and right lateral views.

3, 4, Hypotetragona sp. x 50.
Bear Biltmore No. 1, 539-49'.
Dorsal and right lateral views.

5, 6, Bekena sp. A, n. sp., x 36.
Holotype, Bear Biltmore No. 1, 588-98'.
Dorsal and right lateral views.

7, 8, Thrallella reticulata n.sp., x 53.
Holotype, Bear Biltmore No. 1, 664-74'.
Dorsal and right lateral views.

9,10, Bairdia midconstricta, n.sp., x 53.
Holotype, Bear Biltmore No. 1, 588-98'.
Dorsal and right lateral views.

11,12, Ponderodictya sp. A, n.sp., x 57.
Holotype, Bear Beaumont No. 1, 1334-63'.
Dorsal and right lateral views.

13,14, Platyrhomboides albertensus, n.sp., x 40.
Paratypes, Bear Biltmore No. 1, 568-88'.
Dorsal and left lateral views of molt and adult.

17,18, Bairdia cf. pseudomagna Stewart and Hendrix x 50.
Bear Biltmore No. 1, 764-74'.
Dorsal and right lateral views.

19,20, Bairdia cf. subtilla Gibson 1955 x50.
Bear Beaumont No. 1, 1948-58'.
Dorsal and right lateral views.

21,22, Rhabdostichus ? reticulatus n.sp. x85.
Holotype, Bear Biltmore No. 1, 638-64'.
Dorsal and right lateral views.

23,24, Rhabdostichus ? rugosus n.sp., x 60.
Holotype, Bear Biltmore No. 1 638-64'.
Dorsal and left lateral views, single valve.

25, Hindeodella lambdesta n.sp., x 55.
Holotype, Bear Biltmore No. 1, 638-64'.
Lateral view.

26,27, Palmatolepis sp. A., n.sp., x 52.
Holotype, Bear Biltmore No. 1, 568-88'.
Oral and aboral views.

Chapter 7 MICROPALAEONTOLOGY

Although this study is primarily concerned with microfossils such as ostracodes, charophytes, etc., a more comprehensive interpretation can be made if associated macrofossil forms, juveniles or fragments are considered. Accordingly this section discusses the fossil content falling between the restricted range present on the 20-60 mesh screens although many of these forms are not normally considered as microfossils.

Cambrian: Four samples were taken in the basal sand section of Angelus Ashmont No. 1, 5536 to 5560', but proved to be devoid of organic matter.

Methy Dolomite: Although Greneir (1956) records corals, stromotoporoids, crinoids, brachiopods, polyzoa and sponge spicules from Bear Vampire No. 2, Bear Rodeo No. 2 and Bear Westmount No. 2, disintegrates yielded a very meagre collection of trochilisks (Bear Rodeo, No. 1, Bear Vampire No. 1), conodonts (Bear Rodeo No. 1, Bear Westmount No. 1) and pteropods (Bear Vampire No. 1, Bear Westmount No. 1). Plant material was present in Bear Vampire No. 1 and Bear Westmount No. 1. Ostracodes were represented by a few poorly preserved Bairdia sp. Five samples taken at 5187-5231' in the Angelus Ashmont No. 1 well were barren. These forms were poorly preserved and did not yield any conclusive information that would aid in correlation or in age determination of this part of the section.

Slave Point: No samples were taken in this interval from Bear Biltmore No. 1, the only borehole containing sediments is based on Crickmay's identifications of Atrypa aff. independensis Webster and Ambothysis sp. (1957).

Elk Point: Samples from the middle portion of the Elk Point at Angelus Ashmont No. 1, 3449-4182' and a single sample from Bear Biltmore No. 1, 2116-29' proved to be barren. Other sections taken at or just below the top of the formation yielded plant remains, charophytes, crinoids, conodonts, an occasional gastropod, and usually terminates in a flood of plankton. These pteropods apparently mark the top of the formation in Bear Rodeo No. 1, Bear Westmount No. 2, Christina River Hardy No. 1, and appear in considerably decreased numbers in Bear Vampire No. 1 but in Bear Westmount No. 1 are present in lower, middle and upper Elk Point. Plants and charophytes predominate in Bear Rodeo No. 1, Bear Rodeo No. 2, Bear Westmount No. 1. Elsewhere the crinoids are present in appreciable percentages. Conodonts are persistent in Bear Rodeo No. 1, Bear Rodeo No. 2 and Bear Westmount No. 2. From these forms the following specific identifications were made.

Charophyta	Sycidium sp.
	Prochara symmetrica
	Paleochara wickendeni
Ostracoda	Cavellina? sp.
Conodontophoroidea	Polygnathus xylus

With the exception of Prochara which has a restricted recurrence in a section a few feet above the Stringocephalus burtoni zone, none of these are useful marker fossils; Sycidium is not known to occur in any profusion in well cuttings; Paleochara occurs in at least three horizons according to Choquette (1956); Cavellina? sp. represents a rather fragile and easily crushed form belonging to an ubiquitous genus that is present throughout the stratigraphic section in variable amounts; and Polygnathus xylus occurs in both Middle and Upper Devonian in the McMurray areas as well as in Germany (Bishoff and Ziegler 1956). The presence of Stringocephalus in this formation (Crickmay 1957) places the age as Middle Devonian, Givetian.

Firebag: With the exception of Bear Beaumont No. 1 which did not penetrate this member and Angelus Ashmont No. 1 which was not sampled at this level, the Firebag contains an abundant biota. The basal portions contain appreciable percentages of conodonts, scolecodonts, faecal débris as well as juvenile Lingula. These persist through the formation but in diminishing numbers. Throughout the section numerous crinoid segments, brachiopod spines, echinoids, gastropods and miscellaneous shell fragments are found. Floods of plankton were present in the basal section at Bear Vampire No. 2 but elsewhere only a few forms were observed. Ostracodes were found in small numbers but did not predominate until the end of Firebag time in the Bear Biltmore No. 1 area.

The following specific identifications were made:

Charophyta	Trochiliscus (Eutrochiliscus) convolutus
	T. (E.) devonicus
	T. (Karpinskya) bilineatus
Foraminifera	Bathysiphon sp.
Ostracoda	Abursus triangulensus
	Bairdia sp.
	Bythocypris biltmorensis
	Cavellina ovatiformis
	Cooperatia biltmorensa
	Eukloedenella sp.
	? Halliella bellipuncta
	Kirkbya biltmorensa
	Kloedenella rodensa
	Macrocypris albertensis
	Plagionephrodes pseudomorpheus
	Rothella vampirensa
	Youngiella devonicensa
	Y. elongatensa
Annelida	Lumbriconerites cooperi
	Spirorbis sp.
Conodontophoridea	Apatognathus sp.
	Bryandotus stratfordensis
	Bryandotus sp. A.
	Ctenognathus (Pandorinella) insita
	Icriodus brevis

I. cymbiformis

I. elegantulus

I. cf. elegantulus

I. expansus

Lignodina sp.

Neoprioniodus sp.

Polygnathus sp. A.

Polygnathus sp. B.

Prioniodus cf. idoneus

Taphrognathus sp. ?

Restricted ranges are suggested for I. brevis, Neoprioniodus sp., Polygnathus sp. A. and Taphrognathus sp in these samples. I. brevis is recorded from the Cedar Valley limestones of Minnesota suggesting a Middle Devonian affinity. Other Middle Devonian forms common to this member and recorded in the literature are Trochiliscus (E.) convolutus, T. (E.) devonicus, T. (K.) bilineatus, Lumbriconerites cooperi, Bryandotus stratfordensis, Ctenognathus (Pandorinella) insita, Icriodus cymbiformis, I. elegantulus and I. expansus. The trochilisks and Icriodus species continue into Upper Devonian sediments. These forms suggest a Middle Devonian age rather than Upper but the distinction is very close, suggestive of late Middle Devonian. The Waterways formation has been placed in Middle Devonian on megafossil identifications by Warren and Stelck (1949).

The ostracodes from the Firebag are not closely allied to the zones illustrated from the Edmonton area although a number of long range forms are common in both the Edmonton as well as the McMurray wells. The examination of further material will be required to relate these Firebag sections to the fauna of the central Alberta plains.

Calmut: Ostracoda predominate in Bear Biltmore No. 1 and pteropods at Bear Westmount No. 1, elsewhere the formation is predominantly crinoidal. Minor percentages of ostracodes brachiopod fragments, gastropods, conodonts, scolecodonts, etc. appear. Charophytes are present in small percentages in the lower portion of the formation with the exception of Bear Westmount No. 1.

Specific identifications are as follows:

Charophyta	Trochiliscus (Eutrochiliscus) convolutus
	T. (E.) devonicus
	T. (Karpinskya) bilineatus
Foraminifera	Bathysiphon sp.
	Endothyra?gallowayi
	Textularia sp
Ostracoda	Abursus triangulensug
	Aechminella fribourgella
	Aparchites ? sp
	Bairdia sp.
	Cavellina ovatiformis
	Cooperatia biltmorensa

	Eukloedenella sp.
	? Halliella bellipuncta
	Hypotetragona albertensa
	Kirkbya biltmorensa
	Kloedenella rodensa
	Macrocypris albertensis
	Plagionephrodes pseudomorpheus
	Rothella vampirensa
	Westmountia mcmurraiensa
	Youngiella devonicensa
Annelida	Lumbriconereites cooperi
Conodontophoridea	Bryandotus stratfordensis
	Ctenognathus (Pandorinella) insita
Polyzoa	Polyzoa sp. A
	Polyzoa sp. B.

None of these forms are restricted to the Calmut. The trochilisks T. (E.) convolutus and T. (E.) devonicus range from late Middle into Upper Devonian time. The scolecodont Lumbriconereites cooperi from the Potter Farm formation, and the conodonts Bryandotus stratfordensis and Ctenognathus (Pandorinella) insita from the Olentangy shale of Ontario and Ohio, and the Cedar Valley formation of Minnesota and Iowa respectively, suggests that the Firebag belongs to the Middle Devonian. Increasing numbers of forms ranging into the Upper Devonian (refer Plate 82) indicate late Middle Devonian.

The ostracodes include Aechminella fribourgella which has a restricted range in the central Alberta plains and is confined to the lower Ireton in that area. Although it was believed to be of Upper Devonian age in that area originally it is suggested that this is no longer a valid assumption.

Christina: Ostracodes predominate in Bear Biltmore No. 1, Bear Vampire No. 2, Bear Westmount No. 1 and Christina River Hardy No. 1. Crinoids replace them as the dominant fauna in Bear Rodeo No. 1, Bear Vampire No. 1 and Bear Westmount No. 2. A few scolecodonts, conodonts and some faecal débris were found throughout the formation in Bear Vampire Nos. 1 and 2, and Christina River Hardy No. 1, restricted to the basal portion of the Bear Westmount Nos. 1 and 2 wells. Polyzoas are common in the middle of the formation in Bear Biltmore No. 1, also in Bear Vampire No. 1 and in Christina River Hardy No. 1. Planktonic invasions are evident in the basal section at Bear Rodeo No. 1 and in the middle of the formation at Bear Westmount No. 2.

The biota includes these forms:

Charophyta	Trochiliscus (Eutrochiliscus) convolutus
	T. (E.) devonicus
Ostracoda	Abursus triangulensus
	Aechminella fribourgella
	A. trinodensa
	Aechminella sp A.
	Bairdia pseudomagna

Bythocypris biltmorensis

Cavellina ovatiformis

Cavellina ? sp.

Cooperatia biltmorensa

? Halliella bellipuncta

Hypotetragona albertensa

Kirkbya biltmorensa

Limbinaria navicularia

Macrocypris albertensis

Plagionephrodes pseudomorpheus

P. spinosus

Westmountia mcmurraiensa

Youngiella devonicensa

Branchiopoda — Rhabdostichus ? rugosus

Annelida — Spirorbis sp.

Staurocephalites sp.

Conodontophoridea — Ctenognathus (Pandorinellina) insita

Icriodus expansus

Trichnognathus blanda

Polyzoa — Polyzoa sp. B

Two species - Rhabdostichus ? rugosus and Trichnognathus blanda appear to be restricted to the Christina member. The latter is known from Austin, Minnesota in Cedar Valley limestones of Middle Devonian age.

The trochilisks T. (E.) convolutus and T. (E.) devonicus have a long range in the Middle and Upper Devonian; the former appearing in the Onondaga limestone, the latter in the Jeffersonville limestone, Snyder Creek, Devonicidaris jacksoni zonule of Cerro Gordo member, Hackberry stage.

Ostracodes common to the lower Ireton of central Alberta, i.e., the Aechminella fribourgella biozone include, A.fribourgella, Cavellina ovatiformis,* Cooperatia biltmorensa, Macrocypris albertensis, Plagionephrodes spinosus and Youngiella devonicensa.* Ctenognathus (Pandorinellina) insita is found in the Cedar Valley limestone of Middle Devonian age. Icriodus expansus is widespread in Mineola limestone, Snyder Creek shale, Genundewah limestone, Silica shale, New Albany shale, Alpena limestone, basal Widder beds and Encrinal limestone of southwestern Ontario, which are of Middle Devonian age with the possible exception of the Snyder Creek shale (Cooper, 1942). Trichnognathus blanda is recorded from the Cedar Valley limestone of Middle Devonian age, probably very late Givetian.

Late Middle Devonian age of the Christina biota and correlation to the lower Ireton of the central Alberta plains is therefore indicated.

Moberly: Ostracodes predominate in Bear Beaumont No. 1, Bear Biltmore No. 1, Bear Vampire No. 2, Christina River Hardy No. 1 and in one sample from Angelus Ashmont No. 1, but are replaced by crinoids as the dominant population factor in

*unpublished well data

Bear Rodeo No. 1, Bear Rodeo No. 2, and Bear Vampire No. 1. Pteropod floods are present in the upper part of the section in Bear Biltmore No. 1, Bear Vampire No. 1 and in the upper half of Christina River Hardy No. 1. In Bear Westmount No. 1 they are more common in the basal portion. Conodonts and scolecodonts are common in the top of Bear Rodeo No. 2, and the base of Bear Vampire Nos. 1 and 2.

Specific identifications include:

Charophyta	Sycidium sp.
Foraminifera	Endothyra? gallowayi
	Textularia sp.
Ostracoda	Abursus beaumontensus
	A. biltmorensus
	Acronotella keslingia
	Aechminella biltmorensa
	Aechminella fribourgella
	Aechminella initialia
	Aechminella middevonicensa
	Aechminella trinodensa
	Aechminella sp. A.
	Amphissites beaumontensa
	Bairdia biltmorensa
	Bairdia hypsoconcha
	Bairdia leguminoides
	Bairdia cf. pseudomagna
	Bairdia cf. subtilla

Bairdia sp.

Bekena. sp.

Bythocypris biltmorensis

Bythocypris mearnsa

Cavellina ovatiformis

Cooperatia biltmorensa

Eukloedenella sp

Glyptopleura sp.

? Halliella bellipuncta

Hypotetragona albertensa

Kirkbya biltmorensa

Knoxina kinsella

Limbinaria navicularia

Macrocypris albertensis

Macronotella biltmorensa

Mauryella sp. A.

Monoceratina scottia

Neopribylites albertensa

Plagionephrodes pseudomorpheus

P. spinosus

Ponderodictya sp.A

Westmountia mcmurraiensa

Youngiella devonicensa

Y. elongatensa

Ostracode indet.

Branchiopoda	Rhabdostichus cf. pulex
	R. ? reticulatus
Annelida	Arabellites pectinellus
	Lumbriconerites cooperi
Conodontophoridea	Apatognathus sp.
	Bryandotus stratfordensis
	Ctenognathus (Pandorinella) insita
	Curtognathus ? sp.
	Hindeodella lambdesta
	Icriodus elegantulus
	Trichnognathus blanda
Polyzoa	Polyzoa A
	Polyzoa B

Only Sycidium sp., Curtognathus ? sp. and T. blanda are restricted to this member . Trichnognathus blanda is characteristic of the Cedar Valley formation, Middle Devonian, as is Bryandotus stratfordensis and Ctenognathus (Pandorinellina) insita, Icriodus elegantulus is present in the Olentangy shale, Ontario and Iowa, which is both Middle and Upper (Cooper, 1942). The Moberly appears then to be very late Middle Devonian.

Ostracodes from this member . contain the characteristic Aechminella fribourgella and A. biltmorensa of the lower Ireton of the central Edmonton area, also Macronotella biltmorensa which is restricted to the upper Ireton of that region. The ostracodes in the McMurray district are beginning to anticipate

the M. biltmorensa biozone but are still predominantly lower Ireton in aspect.

Mildred Lake: Ostracoda predominate in Bear Beaumont No. 1, are about equal in proportion to the crinoids in Bear Biltmore No. 1 and are reduced to minor proportions in Angelus Ashmont No. 1 (one sample only). Pteropods are common, especially near the top of this member and are associated with minor quantities of foraminifera, gastropods, scolecodonts, conodonts, etc. An abundant biota consisting of these forms is present.

Charophyta:

Trochiliscus (Eutrochiliscus) convolutus

T. (Karpinskya) bilineatus

Foraminifera:

Endothyra ? gallowayi

Ostracoda:

Abursus biltmorensus

Acronotella keslingia

Aechminella biltmorensa

A. trinodensa

Aechminella middevonicensa

Amphissites beaumontensi

Bairdia biltmorensa

Bairdia sp.

Bythocypris biltmorensis

Macrocypris albertensa

Mauryella sp. A

Neopribylites albertensis

Cavellina ovatiformis

Cooperatia biltmorensa

?Halliella bellipuncta

Kirkbya biltmorensa

Knoxina kinsella

Krausella albertensa

Youngiella devonicensa

Plagionephrodes biltmorensus

P. spinosus

Platyrhomboides albertensis

Branchiopoda:

Rhabdostichus ? reticulatus

Conodontophoridea:

Centrognathus sp.

Hindeodella milleri

Polygnathus stainbrooki

The only species restricted to the Mildred Lake and not terminating a range below or beginning one above are Centrognathus sp. and Polygnathus stainbrooki. The latter is associated with the Middle Devonian Cedar Valley limestone in Iowa. The trochilisks and Endothyra ? gallowayi are associated with Middle and Upper Devonian and Upper Devonian respectively. Endothyra ? gallowayi and Abursus biltmorensus, Amphissites beaumontensi, Bairdia biltmorensa, Bythocypris biltmorensis, Halliella bellipuncta, Kirkbya biltmorensa are common to the upper Ireton, Macronotella biltmorensa of the central Alberta plains; Aechminella biltmorensa, Cooperatia biltmorensa, Macrocypris albertensis and Plagionephrodes spinosus all present in the Aechminella

biltmorensa biozone of the lower Ireton; Knoxina kinsella and Plagionephrodes biltmorensus occur in both. The ostracodes then, show transition between the two biozones of the Edmonton area and the question of Middle or Upper Devonian is not clearly resolved. The Hindeodella milleri present could also be Middle or Upper as it occurs in the Middle Devonian Widder Beds, and Sweetland Creek as well as the Middle and Upper Devonian Olentangy shale. The Polygnathids would favour a choice of Middle Devonian, but the remaining microfauna could belong to Middle or Upper.

Cooking Lake: Bear Beaumont No. 1 is predominantly ostracodal changing to crinoidal at the top and showing some evidence for planktonic invasion. Bear Biltmore No. 1 on the south had some plant and charophytic remains near the base in small quantities with ostracodes and crinoids but yields primarily plant remains at the top. Angelus Ashmont No. 1 yielded ostracoda near the base; no samples were taken from the upper section.

A poorer fauna is represented in these few samples by:

Ostracoda
- Aboursus biltmorensus
- Bairdia bartholomensis
- Bairdia biltmorensa
- Cavellina ovatiformis
- Cavellina ? sp.
- Cooperatia biltmorensa
- ? Halliella bellipuncta
- Knoxina kinsella
- Macrocypris albertensis

Youngiella devonicensa

These forms are all present in the upper Ireton of the central Alberta plains with the exception of Bairdia bartholomensis and Cavellina ? sp. which have not been recognized from wells in that area. Cavellina ovatiformis and Youngiella devonicensa are commonly found but have not been recorded previously in the literature. B.bartholomensis is recorded from Upper Devonian by Stewart and Hendrix (1945). This formation appears to have closer affinities to the Upper Devonian than the Middle and has forms in common with the Macronotella biltmorensa zone of the upper Ireton in the central plains area.

Duvernay: Bear Biltmore No. 1 contains predominantly plant remains throughout with minor percentages of ostracodes, gastropods and brachiopods at the base. Bear Beaumont No. 1 is chiefly ostracodes with plant remains in minor quantities in the upper portion. The Angelus Ashmont No. 1 well was poorly sampled and yielded only brachiopod fragments.

The following species were present:

Ostracoda: Abursus biltmorensus

Bairdia biltmorensa

Cavellina ? sp.

Cooperatia biltmorensa

Knoxina kinsella

Krausella albertensa

Macrocypris ? sp. A

Mauryella sp. A.

Ostracoda indet.

Polyzoa: Polyzoa A.

None of these forms are restricted to the Duvernay formation, the majority belonging to forms with longer stratigraphic ranges. Species occurring in upper Ireton of central Alberta included Abursus biltmorensus, Bairdia biltmorensa and Cooperatia biltmorensa. Knoxina kinsella is present in the basal Aechminella fribourgella zone of the lower Ireton. This formation has more affinities to the upper Ireton than the lower, and unless the ostracoda present are controlled by lithology, it appears that this may represent a portion of the Macronotella biltmorensa zone.

Ireton: Predominantly plant material in the basal sections is represented in Bear Beaumont No. 1 and Bear Biltmore No. 1 with planktonic invasions occurring throughout the formation. The Bear Beaumont No. 1 and Bear Biltmore No. 1 wells have ostracodes for the major constituent of the population and show a wide range of genera and species; lesser amounts of crinoids and restricted numbers of conodonts, gastropods, scolecodonts, etc. are present. Polyzoa are common near the top of the section.

These specific identifications were made:

Charophyta:

Trochiliscus (Eutrochiliscus) convolutus

T. (Karpinskya) bilineatus

Foraminifera:

Endothyra ? gallowayi

Semitextularia thomasi

Ostracoda:

Abursus beaumontensus

Abursus biltmorensus

Abursus duvernaius

Acronotella keslingia

Aechmina vikingensa

Aechmina sp. A

Aechminella beaumontensa

Amphissites beaumontensis

Amphizona pseudocarinata

Aparchites ? sp.

Bairdia bartholomensis

Bairdia biltmorensa

Bairdia midconstricta

Bekena sp. A

Bicornellina sp. A

Bollia sp.

Briartina cf. quenstedti

Bythocypris biltmorensis

B. mearnsa

Cavellina ovatiformis

Cooperatia biltmorensa

Glyptopleura sp.

?Halliella bellipuncta

Hypotetragona sp.

Knoxina kinsella

Limbinaria havicularia

Macrocypris albertensis

Macrocypris ? sp. A

Macronotella biltmorensa

Maurvella sp. A

Monoceratella sp. A

Monoceratina albertensa

Monoceratina scottia

Neopribylites albertensa

Plagionephrodes biltmorensus

Platyrhomboides albertensis

Ponderodictya sp. A

Roundyella sp. A

Thrallella reticulata

Youngiella devonicensa

Y. elongatensa

Ostracoda indet

Branchiopoda:

Rhabdostichus cf. pulex

R. ? reticulatus

R. ? rugosus

Annelida:

Arabellites comis

A. pectinellus

Nereidavus ontarioensis

Staurocephalites sp.

Conodont:

Apatognathus sp.

Bryandotus stratfordensis

Ctenognathus (Pandorinellina) insita

Hindeodella lambdesta

H. milleri

Icriodus cymbiformis

I. expansus

Leptochirognathus sp. ?

Lignodina sp.

Ozarkodina regularis

Palmatolepis sp. A

Polygnathus xylus

Polygnathus sp. B

Prioniodus cf. idoneus

Polyzoa:

Polyzoa sp. A

Polyzoa sp. B

In the McMurray section the following species appear to be restricted to the Ireton - Semitextularia thomasi, Leptochirognathus sp. ?, Ozarkodina regularis, Palmatolepis sp. A, Prioniodus cf. idoneus, Abursus duvernaius, Aechmina vikingensa, Aechmina sp. A, Aechminella beaumontensa, Amphizona pseudocarinata, Bairdia midconstricta, Bicornellina sp. A, Bollia sp., Briartina cf. quenstedti, Hypotetragona beaumontensa, Knoxiella sp. A, Krausella sp., Monoceratella sp. A, Monoceratina albertensa, Phlyctiscapha sp., Roundyella sp. A, Thrallella reticulata, Nereidavus ontarioensis and Staurocephalites sp.

The upper Ireton in the central plains of Alberta contains the following common species: Endothyra ? gallowayi, Bairdia biltmorensa, Bythocypris biltmorensis,?Halliella bellipuncta, Kirkbya biltmorensa, Macronotella biltmorensa, Rhabdostichus cf. pulex* and the very short ranged Monoceratina albertensa, Hypotetragona beaumontensa, which suggests correlation to this biozone which is regarded as Upper Devonian in age (Layer, et al, 1949).

The age of this is probably very early Upper Devonian as many of the species present occur in both Middle and Upper Devonian sediments (Arabellites comis, A. pectinellus, Nereidavus ontarioensis, Ctenognathus (Pandorinella) insita, Hindeodella milleri, Icriodus cymbiformis, I.expansus, Polygnathus xylus, etc.).

*unpublished well data

Middle/Upper Devonian Boundary

Microfauna show that the Middle Devonian sediments in the McMurray area included the Methy Dolomite, Slave Point, Firebag, Calmut, Christina and Moberly members, and possibly the Mildred Lake, which contains both the upper range of Middle Devonian forms and the beginning of Upper Devonian biozones. If Polygnathus stainbrooki is restricted to the Middle Devonian, as it appears to be, this would provide some evidence for keeping the Mildred Lake entirely within the Middle Devonian. Otherwise the Mildred Lake could be considered transitional as the fauna suggest the last of a marine sequence and the gradual transition to forms of decided Upper Devonian aspect.

The overlying Cooking Lake has close affinities with the Upper Devonian faunas and the Duvernay has a decided Upper Devonian character except in Bear Biltmore No. 1 where it might be partly non-marine. The Ireton in this area, although it contains a number of forms ranging into Middle Devonian sediments is correlated to the Macronotella biltmorensa zone in the Edmonton area which has evoked little controversy concerning its Upper Devonian age. (Layer 1949). The lower Ireton containing the Aechminella fribourgella zone correlates to the Christina and Moberly of the McMurray area and should therefore be regarded as Middle Devonian. This would also be in close agreement with the distribution of the Entomozoidae in Middle Devonian sediments both in the

Northwest Territories (Kindle, 1918) and in Germany (Rabien, 1954). No representatives were present in these McMurray samples but they are well represented in the Edmonton area in the A. fribourgella zone. No close correlation on the basis of ostracodes can be made between the English, German, or McMurray Devonian across the Middle/Upper boundary as the faunas are quite dissimilar in each place; although members of the Entomozoidae occur in the Middle Devonian in England and in Germany in such abundance as to form the basis of micropalaeontological subdivisions. It appears, therefore, that the sediments below the top of A. fribourgella belong to the Middle Devonian and those occurring above the base of M. biltmorensa belong to the Upper Devonian. The Mildred Lake member is present between the two zones in the McMurray area and is represented by a green shale section in the central Alberta plains, which can be considered as the transitional contact between Middle/Upper Devonian sediments. This correlation of the McMurray and Edmonton sections is summarized on Plate 73. Additional work is required on the microfauna of the Beaverhill Lake which has not yet been described.

The two biozones, A. fribourgella and M. biltmorensa, do not represent true time lines, since they are based almost entirely on benthonic forms. Furthermore, being small, and easily dispersed by currents, they tend to migrate at a different rate than megafossils. Any boundary selected between Middle and Upper Devonian on the basis of microfossils can then be expected to differ from that selected by megafossil data. If A. fribourgella represents the last transgressive phase of Givetian time, and M. biltmorensa indicates the initial stage of the regressive Frasnian, a line drawn between the two zones might approx-

evidence to the megafossil data available, agreeing as it does with Warren's age designation of the upper part of the Waterways, and with Crickmay's work on the lower part of the section, but it does suggest a contact higher in the stratigraphic section than has been previously published.

CHAPTER VIII PALAEOECOLOGY

Palaeoecology is the study of past organisms in relation to their environment as physical, chemical and biological factors. Depth range, salinity, temperature, turbidity, water circulation, substrate, p.H., oxygenation and the interaction of plants and animals are factors of vital consideration in any interpretation of ancient sediments and their organic remains. During the last decade substantial progress has been made in collecting data on living forms and applying these observations to ancient sediments. The development of ecologic thought from observations made by Aristotle, Leonardo and other philosophers has never been the prerogative of any one group as authors have explained in detail (Hesse, Allee, Schmidt, 1951; Hedgpeth, 1957; Hecker, 1960). Advanced thinking in one country has often been parallelled in another so that it is not possible often to credit those responsible for present ecologic thinking or technicological advancement. One of the most lucid outlines of recent years was given in an address by Harper in 1958. This paper, together with the previously mentioned authors, presents a reasonably complete development of the modern approach to the study of ancient organisms and the various methods used to interpret them within geologic and biologic dimensions.

Preparatory to any application of ecological technique is the literature search which provides the necessary data for interpretation. The observations and conclusions

of many authors with different experience, working in different areas, have been reduced to tables, evaluated and then applied to the McMurray faunas. This method of multiple observations expresses more clearly the environmental limits which govern the life processes of these organisms.

PROTISTA AND PLANTS

During Devonian time it has been suggested (Walton 1940 that Bacteria, Myxophyceae, Chlorophyceae, Charophycacae, Fungi, Psilophytales, Filicales, Lycopodiales, Articulales and possibly the Pteridospermae were already flourishing and that lush vegetation already existed on the land, along the shore and in the surface waters of the seas.

The primary emphasis in this study is, of course, on the marine and any discussion on ecology of marine bacteria would have to consider the factors controlling their relative abundance. Zobell (1946) has covered in detail, supported by adequate bibliographical references, the factors of water depth, distance from shore, substrate, abundance of plankton and water movement. Bacteria are the initial force and building blocks on which all other forms of life depend directly or indirectly. They are responsible for the decomposition of complex animal and plant residues, the liberation of nitrogen, phosphorus and other elements as nutrients, for the oxidation of ammonia to nitrates, the denitrification of materials, the oxidation of sulphur, and the reduction of sulphates and therefore play an essential rôle in

organic production, not only as food for protozoa but in symbiosis with other forms of life. They influence the H^{ion} concentration and oxygen reduction potential of bottom sediments thus affecting the chemical composition of the sea water itself and the deposits which are precipitated as $CaCO_3$ or complex Fe silicates.

Bacteria are present at all oceanic depths but optimum conditions are shallower than 200 m. with optimum conditions lower than 25°C and in maximum numbers in coastal waters or where currents converge. Salinities vary from 33 to 37‰. During settling and burial of organic matter the abundance of bacteria determines the vertical distribution of the proteins, chitins, lipids and the amount and kind which are left to become a permanent deposit. Buried organic matter serves as a source of energy for the sulphate bacteria which are important in pyrite deposition (Zobell, 1946).

Land floras had already evolved so that the major groups were well established, and in areas where preservation is adequate, evidence for Psilophytales, Filicales, Lycopodiales, Articulatales and possibly the Pteridospermae have been described (Walton, 1940). Since the pteridophytes were dominant in the Devonian (Alden)* it is likely that some of the fragmentary stems with well developed tracheids and xylem belonged to that group. Walton (1940) further considers that cutile, stomata or lignified vascular tissue is good

* Talk given to the De La Beche Club on Pre Carboniferous Land Plants, February 21, 1961.

evidence of land plants. The abundance of such tracheids, xylem and woody fibres in borehole sections such as Bear Biltmore No.1 (784-86') might well be interpreted as terrestrial or at least near shore. Supporting evidence from conodonts, scolecodonts or forms of phosphatic brachiopods might suggest an approach to lagoonal conditions. Den Bold (1947) has interpreted such fragments as indicative of land proximity in borehole samples.

Charophyta

A survey of charophyte literature summarizing the observations and conclusions of various authors is shown on Table 1 (Appendix C). From this it is concluded that recent charophytes are found in shallow depths varying from the surface to thirty metres in fresh, brackish or marine conditions. Optimum temperature in warm temperate zones, where water has normal circulation and is free from mud are favoured There is a close association with limestone deposition and accumulation into reeflike deposits. The majority of authors favour a marine habitat for fossil faunas, but a wide range of salinities through normal marine to salt lagoonal is indicated. This may be on the basis of associated fossil material of a predominantly marine nature. The late Horn Af Rantzen* had a manuscript in preparation outlining the results of experimental work on the temperature and salinity ranges of living forms.

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* Personal communication.

Fungi

The remains of fungal filaments were observed on crinoid stems in Bear Rodeo No.1, 219-29' and Bear Biltmore No.1 at 674-84'. Similar filaments have been found in northwestern Alberta by Fry and McLaren in calcareous mud associated with biostromal banks (1959). These authors consider these as belonging to the phycomycetes and from the associated sediments suggest that oxidizing conditions were at a minimum.

Foraminifera

A few references were selected from the many papers on foraminiferal ecology to outline the limiting factors for benthonic marine species. Few papers made specific reference to the ecology of the four Devonian genera which occurred in these borehole cores. Authors consider the substrate of considerable influence in determining outline, cross-section, ornamentation and test thickness. Of lesser importance are temperature, depth, salinity, oxygenation and the presence of toxic substances. Bathysiphon sp. occurs in shallow to deep sediments; the other genera are apparently associated with shallow water limestones and shales (Table 2).

BRACHIOPODA

Brachiopoda live in normal marine habitats in depths from high tide to 2900 fathoms. About 60% of living forms for which information is available, can live in shallow water although only 33% are actually restricted to shallow depths.

The notable exceptions are Lingula and Glottidia which are known to be confined to shallow depths. Consequently generalizations on bathymetric distribution cannot be safely made for the brachiopods. Generalizations on temperature are also suspect since the order has world wide distribution, in both polar regions and in equatorial waters. Some forms have reflected environmental conditions by shell shape and ornamentation, the short rotund shells having been developed where waters are the roughest and the elongate spirifer-like forms in quieter waters. Spines are thought to have been developed as an aid in keeping the front margin of the brachiopod out of the mud. (Table 3).

Lingula due to its long geologic but restricted depth range, which the majority of authors agree is 23 fathoms or less, is one of the best forms for ecological study. Apparently preferring warm temperate zones and able to withstand foul, stagnant waters by burrowing into muddy or sandy substrates, it is considered to be an excellent indicator of shoreline conditions. (Table 4).

MOLLUSCA

Pelecypoda-

The pelecypods are commonly found in a wide range of environments varying from freshwater to marine, in cold or warm waters in all types of substrate due to pelagic larval forms. They apparently are more common in shallow depths and may form reefs. (Table 5).

Gastropoda and Pteropoda

Gastropoda are adapted to a wide range of environmental conditions of temperature, depth and salinities. The presence of lime and water aire apparently more important than temperature in effecting distribution (Table 6).

Modern pteropods may have no connection with Palaeozoic forms (Theile, 1931) but some interesting parallels are made by Blankenhorn in the comparisons of Recent and Cretaceous forms (1889). The theory he advanced was that the apical ends of Tentaculites were identified as Vaginella sp. Similar 'ends' have been called Cleodora, Cuverina or Stylolina. The McMurray samples show large numbers of Cleodora and Cuverina not only associated with Tentaculites (Bear Westmount No.1, 14061 Cleodora, 8994 Cuverina and 8762 Tentaculites) but frequently forming the apical end of the Tentaculites. Selective sorting might explain the concentration of 'ends' in relation to the Tentaculites found in some samples. (Bear Westmount, No.1, 905 Tentaculites found in association with 19,472 ends at 1252-62'). The relationship to pyrite occurrence is briefly mentioned under the discussion of pyrite in the Sedimentology section. Authors agree that these are pelagic forms and therefore of little use in ecologic interpretation (Table 7).

ANNELIDA

The hard parts of Annelids are preserved as 'scolecodonts' from deposits primarily originating in shallow environments,

in a variety of substrates in localities that vary from temperate to subtropical climates. They may be representative of pelagic, sedentary or benthonic genera and occasionally form reefs (Table 8).

ARTHROPODA

Branchiopoda

The subclass Branchiopoda has not been studied adequately and little information on ecology is available although authors agree the forms are aquatic (Lankaster, 1909) Shimer and Shrock (1944) Shrock and Twenhofel (1953). Clarke (1882) favours a brackish environment.

Ostracoda

The majority of authors consider these crustaceans as shallow water forms, probably occurring in abundance at depths of less than 500'. They tolerate a wide range of salinities and are present in cool and warm climates. Many genera show preference for certain types of substrate, others apparently can tolerate a wide variety of bottom conditions. Structural adaptations are present in planktonic and benthonic forms. Those variations may be in elongation of the carapace into spines, flaring structures, runners or development of asymmetric shape to facilitate swimming and/or burrowing through the substrate. They exhibit sensitivity to light and toxic substances in solution (such as Fe, H_2S and S_2). Salinity and current velocity are important factors in their distribution (Table 9).

A survey of ostracode literature on living and fossil forms and observations on living forms grown under laboratory conditions suggests that these crustaceans have become

adapted to such a variety of depths, salinities, temperatures and substrates that investigation is warranted at the specific level for more refined ecological interpretation.

ECHINODERMA

Crinoidea-

The stalked crinoids are consistently marine in habitat and flourish on hard uneven substrate, where support is available for the cirri, or in deeper water in mud or surrounded by mud. They are found through a wide depth range in the present oceans wherever clear, well aerated waters with adequate food supplies are available. During the Palaeozoic they are considered to be reef builders of considerable importance (Table 11).

Echinoidea, Holothuroidea, Ophuroidea,

The echinoids are aquatic forms, present at all depths, in normal or subnormal salinities in a wide variety of substrates. They appear to be more abundant at shallow depths and are influenced by temperature.

The majority of holothuroidians occur at variable depths, in various salinities in soft, muddy substrata.

Ophuroids are entirely marine benthonic forms living on soft or hard substrates, depending on plankton or detritus for food.

POLYZOA. (BRYOZOA,)

Polyzoa are present in a wide range of depths and temperatures, apparently preferring hard substrates in clear

quiet waters of normal circulation. They may accumulate as reefs and are associated with a number of other macrofossils. They are not commonly found in association with conodonts or in stagnant foul waters (Table 14).

CONODONTOPHORIDEA

Conodonts are regarded by the majority of authors as indicative of shallow waters, and variable salinities, in calm undisturbed waters overlying stagnant black muds often rich in phosphorus. Although the origin is not known with certainty they are regarded as free swimming and are recorded as occurring in a variety of environments in association with a wide variety of other forms (Table 15). Dental parts of the sharks and rays* as displayed in the British Museum show a similarity of shape to some of the bar shaped conodonts.

COPROLITES

Coprolites or faecal débris have been variously assigned to pelecypods, gastropods, holothurians, crustaceans or worms. They may serve as marker fossils if they occur in a definite geological horizon. Ecologically they imply rapid deposition and are not destroyed immediately as they generally are loosely cemented by mucoid material (Table 16).

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* families Carcharinidae, Squalidae, Squatinidae

CHAPTER IX: POSTULATED ENVIRONMENT

Application of the palaeoecological material reviewed in the previous chapter to the ten boreholes used in this study has been attempted using a modification of the tecto-environmental classification originally suggested by Krumbein, Sloss and Dapples (1949). The following environments and the transitional phases between them are recognized in these samples.

(1) supralittoral, grading into terrestrial. Samples with fine grained sediments, low richness and plant fragments representing the only type of organic matter present. Van den Bold (1947) considers plant fragments indicative of proximity to land areas.

(2) littoral or shoreline characterized by substantial percentages of species in place that are restricted to a particular milieu.

(3) sublittoral or offshore, deeper than littoral and containing mixed faunas.

(4) lagoonal (humid), dark coloured, fine grained sediments with benthonic faunas predisposed to burrowing in the muddy bottoms, crinoids often occurring in patches in the deeper portions of the lagoon. This varies from marine lagoonal, with apparently adequate circulation of the upper waters and the lower depths probably cut off by a sill (Fleming and Revelle, 1955), to salt marsh or swampy areas. where high percentages of plant material are found and the faunas are impoverished.

(5) lagoonal (arid), saltpans or basins where a high rate of deposition prevails, evaporation is rapid and temperatures are possibly above normal (Krumbein and Garrels 1952) in semi arid or arid climates (Green 1961).

(6) epineritic, faunas of the channels leading to the open sea or outer and therefore deeper portions of the epicontinental sea. These inner shelf faunas approach those found in the clear, open, unmuddied waters of the deeper portions of the adjacent sea.

These inferred environments are plotted on Column 9 of th the well data charts (Plates 37-46). If these interpretations, based only on ecological data are valid, they should show a positive relationship to isopach maps for the same intervals, particularly those formations which have transitional contacts and are therefore uncomplicated by loss of sections. Although control points are few, the inferred environments appear to correspond reasonably well to the isopach maps. The postulated environments have been superimposed on the isopach maps for the ten formations in this study in Plates 74 to 83. The palaeogeography of these formations can therefore be read directly from these sketches. During Methy Dolomite deposition bioherms developed along the margins of the land area. The succeeding Elk Point was characterized by rapid subsidence, arid or semiarid conditions and possibly with higher temperatures. Presumably the land area was of very low relief and the lagoonal Firebag developed behind some barrier island or reef, separated

from the main Devonian sea. The seas deepened and freshened in Calmut, Christina, Moberley and Mildred Lake time so that normal marine conditions were restored over most of the area. Cooking Lake time showed a withdrawal of the sea, and emergence of the land over most of the McMurray area. The seas apparently returned during Duvernay time and by the late Ireton the McMurray area was inundated.

Interpretation of the depth of deposition has been limited in this study by the type of material sampled, most of the forms having similar depth ranges. Although deposition took place in a shallow epicontinental sea some indication of depth variation is shown by the Population Analysis graphs (Column 7, Plates 37-46) where supralittoral, littoral and sublittoral groups have been arranged on the left of the graph. The arrangement of plankton on the right suggests periods when connections to the open sea permitted the invasion of appreciable percentages of pteropods. The rate of deposition has been inferred from a study of the gross organic and mineral content and the physical characteristics of the sediments.

No positive evidence has been suggested by this study to indicate the seas in this area were above average temperature for temperate zones, since the majority of descendent or related forms tend to favour a temperate climate although a wide range of temperature can be tolerated (Refer Ecological Tables 1-15). No assurance of a radically different climate than is found in present marine areas of the same

latitude was found with the possible exception of the Elk Point which could have been formed at higher temperatures although agreement on this has not been reached by all workers in this field (Green 1961). The popular myth equating reefs with tropical or subtropical climates was exploded by Tasch (1958). The reefs in Alberta which have been considered indicative of balmy, warm climates are non-coral, i.e. algal, stromatoporoidal or polyzoan which are more in keeping with the temperate climate suggested by the rest of the contemporaneous fossil biotas.

The relation of size to temperature, small size being indicative of colder, large of warmer climates has been put forward as a hypothesis but has not generally been accepted in discussion groups.* The microfaunas in Western Canada are unusually small throughout the stratigraphic sequences, with minor exceptions in early Silurian and late Carboniferous time. Living forms today which are conspecific with larger forms of the same species living in more equitable climates tend to be consistently smaller. Ostracodes and associated forms from cold temperate climates in the same latitudes as temperate maritime climates have been observed to be smaller in laboratory cultures (Ecological Table 10).

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* Ecological Conference, Palaeontological Society, held in Glasgow, December 1960.

CHAPTER X CONCLUSIONS

A survey of geological and palaeontological work done in the McMurray area indicates that a great deal of research can still be done, particularly in the realm of micropalaeontology. Discussion of the formations present in this area tends to confirm the accepted geological opinion that it was a borderland adjacent to the Pre Cambrian Shield in Devonian time. Greater precision in mapping by using the thicknesses of formations in relation to sediments above and below has made more detailed interpretation possible for this area than has appeared in the literature.

The sediments were examined for rock type, grain size, colour variation, mineral and organic content, primarily by visual methods. The quantitative analysis attempted was not satisfactory as the borehole samples were insufficient in the majority of cases to provide large numbers of fossils for statistical treatment. The application of correction factors and other analytical techniques is considered too laborious and time consuming for these particular samples. The best microfossil recovery was obtained from material passing through the 20 mesh screen and retained by the 60 mesh, i.e., within 0.78mm. to 0.25mm. size limits. The sediments were very fine grained and the majority fell within the clay particle range. Variation in colour or chrome appeared due partly to the amount and type of organic material preserved. The present depth of burial did not

seem to have a consistent relationship and the effects of overburden were masked by local or regional metamorphism.

Richness or relative abundance per unit weight of sample indicated that planktonic and benthonic material tended to accumulate in approximately the same places, i.e. parallel or near shorelines, or in depressions below wave base.

The presence of pyrite and glauconite together with a population analysis based on gross percentage of the fauna present in relation to the total population were used to interpret the relative rate of deposition. Variation in the depth of deposition is indicated by charting the variation from supralittoral, littoral, sublittoral to epineritic. Connections to the open sea are suggested by periodic invasions of planktonic organisms.

Systematic study of the fauna and flora and comparison to museum collections indicate that no close comparison can be made to established sections outside of the western Canada basin. The biota has been identified and described and a grading system introduced to indicate which species require supplementary material. Two families of the Charophyta represented by three genera and six species were recorded, of these one genus and species has not been previously described. Four species belonging to four genera and three families of the Foraminifera were identified. The Branchiopoda were represented by one genus and three species, two of which are provisionally referred to the

Rhabdostichus sp.Ostracoda from 68 different species, 41 genera, and three orders were identified. Twenty-eight new species were described and two new genera suggested. Some gerontic features of elongated carapace, reduction in size of ornamentation, and decrease in ornamentation in older instars and adults were observed in Limbinaria navicularia, Hypotetragona albertensa, and Westmountia mcmurraiensa.This has not been recorded by previous workers in this field. The Annelida are represented by two orders, five genera and six species, none of them new. The Conodontophoridea are represented by five families, sixteen genera and twenty-four species, of which four are newly described. One genus and two species of polyzoa is recognized.

Detailed examination of the micropalaeontology of each formation and comparison to the central Alberta plains indicates that correlation can be readily made by using ostracode zones. Study of the Middle/Upper Devonian faunas elsewhere suggests that a transitional contact also occurs in northeastern and central Alberta. The top of the Aechminella fribourgella zone probably marks the end of the clearly defined Givetian forms. The Macronotella biltmorensa biozone indicates the beginning of definite Frasnian time. Separating the two biozones is a transitional unit containing forms from both below and above. If a choice had to be made the base of the Macronotella biltmorensa zone would be favoured, pending substantiation of additional evidence.

Palaeoecological data from the literature and observations of laboratory cultures has suggested that six environments and their transitional phases can be recognized in this epicontinental area. These range from supralittoral, which is probably terrestrial, through littoral and sublittoral, to epineritic conditions approaching the open sea. Lagoonal area vary from salt basins to salt marshes or swamps, and biohermal areas are found in close proximity to the shorelines.

Palaeogeographic interpretation suggests that after extensive weathering and erosion prior to early Middle Devonian time

there was a period of biohermal development (Methy Dolomite), followed by elevation of the land, resulting in rapid salt deposition, arid conditions, and possibly higher temperatures of Elk Point time. The shallow lagoonal Firebag developed after erosion of the Slave Point and the seas deepened throughout the remainder of Waterways time until normal marine conditions prevailed over most of the area. The transgressive Cooking Lake was briefly interrupted by a withdrawal of the sea. The seas returned and the Duvernay was deposited in the lagoon before the first green shales of the Ireton marked the complete invasion of the Frasnian faunas. By late Ireton time the entire area had been inundated, although further to the south biostromal reefs, such as the Nisku, were growing in the regressive seas. The fossil biotas suggest temperate rather than semitropical or tropical temperatures, but no definite conclusion can be made from the evidence available at this time.

It is concluded that the McMurray boreholes contain adequate, diverse, and varied faunas which can be correlated to the central Alberta plains. A transitional Middle/Upper Devonian boundary is advocated using two widely distributed microfossil zones. Palaeoecological conditions for each formation can be deduced and more detailed palaeographic maps drawn if sufficient material is available.

APPENDIX A

LITHOLOGICAL DESCRIPTIONS AND SAMPLE SUMMARY TABLE

Angelus Ashmont No. 1

2165-2168 (40.0-38%)* Limestone, buff, dense, argillaceous. Numerous Lingula.

2168-2172 (40.0-36%) Limestone, buff, dense, argillaceous. Traces pyrite. Brachiopod fragments.

2172-2176 (40.0-38%) Limestone, buff, finely crystalline to dense. Traces pyrite. Fossil fragments and impressions.

2178-2182 (40.0-34.32) Limestone, buff to gray buff, dense, argillaceous. Trace pyrite. Fossil traces.

2282-2285 (40.0-81.5%) Limestone, buff, argillaceous, trace green calcareous shale. Trace pyrite.

2403-2405 (255.0-8.7%) Shale, green to grayish-green, very limy. Traces pyrite.

2602-2623 (40.0-8.7%) Limestone, gray, dense, slightly argillaceous and/or silty. Traces pyrite, calcite. Fossil traces.

2624-2632 (40.0-90.3%) Limestone, light buff, dense. Traces pyrite, calcite veining.

2634-2637 (40.0-88.8%) Limestone, light buff, fragmental, dense. Traces pyrite, secondary calcite. Fossil fragments throughout.

2641-2642 (40.0-81.3%) Limestone, buff, dense, argillaceous. Traces calcite veining.

2782-2784 (40.0-82.3%) Limestone, buff to brown, dense or finely crystalline with limy green shale and bitumen partings. Trace finely disseminated pyrite. Crinoid stems.

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* Original weight of sample = 40.0 grams. Weight of residue recovered for grain size analysis and fossil content = 38% of original.

2995-2997 (40.0-73.2%) Limestone, buff, finely crystalline to finely fragmental. Brachiopods, crinoid stems.

3200-3205 (40.0-80.5%) Limestone, buff, dense, fragmental. Trace pyrite, calcite.

3205-3207 (40.0-80.6%) Limestone, buff to brown, dense, slightly argillaceous. Fossil impressions.

3213-3215 (40.0-67.2%) Limestone, buff to brown, dense, slightly argillaceous. Traces pyrite, secondary calcite. Brachiopod.

3217-3222.6 (40.0-76%) Limestone, buff to brown, dense, slightly argillaceous. Traces pyrite. Trochilisks in abundance.

3449-3451 (241.0-3.6%) Dolomite, light brown, dense; anhydrite and salt along planes; scattered reddish anhydrite stringers (65%)½
Dolomite, gray to grayish green, dense, argillaceous. Traces salt in pores (35%).

3458-3460 (344.0-11.4%) Dolomite, brick red with green patches, dense, argillaceous and/or shaly. Trace anhydrite.

3466-3475 (88.0-8.3%) Dolomite, reddish brown to grayish green, dense or finely crystalline; argillaceous in part. Anhydrite and salt along bedding.

4136-4138 (40.0-93.5%) Dolomite, brown to dark brown, dense, argillaceous. Anhydrite and gypsum traces.

4143-4145 (40.0-88.8%) Ditto. Pink salt inclusions.

4147-4151 (40.0-88.8%) Ditto.

4151-4155 (40.0-88.5%) Dolomite, buff to brown, slightly argillaceous and calcareous. Scattered pink salt inclusions.

4160-4163 (40.0-90.5%) Dolomite as above.

4166-4169 (40.0-88.5%) Dolomite, buff to grayish buff, dense, slightly argillaceous. Scattered salt inclusions.

4174-4177 (40.0-92.5%) Dolomite, grayish buff to reddish brown, becoming shaly (80%).
Dolomite, brick red, dense, very argillaceous to shaly (20%).

5187-5189 (142.0-13.2%) Shale, brick red, dolomitic, slightly calcareous.

5194.5-5199 (22[illegible].0-6.[illegible]%) Dolomite, red to brick red, green shale mottling, medium to coarse quartz grains.

5204-5207 (195.0-12.4%) Dolomite as above (15%).
Shale, brick red, dolomitic. Traces glauconite and rounded quartz pebbles. Scattered silt patches (50%).
Limestone, green to brownish green, dense to finely crystalline, silty and sandy, rounded quartz, chert pebbles (35%).

5212-5217 (251.0-15.7%) Shale, brick red, limy to dolomitic, very silty, micro micaceous. Scattered quartz pebbles.

5220-5224 (156.0-8.5%) Dolomite, brick red to green, dense, argillaceous to shaly, very silty, quartz pebbles scattered throughout.

5536-5537 (110.0-27.3%) Siltstone to sandstone, brick red, micaceous, poorly sorted, coarse rounded and angular quartz pebbles.
Glauconitic, micaceous siltstone.

5540-5543 (278.0-38.0%) Sandstone, gray green to green, fine to coarse grained, unsorted, argillaceous and becoming conglomeritic towards base.

5548-5551 (46.0-33.0%) Sandstone, grayish green, fine to coarse grained, unsorted, conglomeratic in part, argillaceous in part. Friable. Trace good porosity.

5558-5560 (40.0-54.2%) Sandstone, greenish gray, in part reddish, medium grained, poorly sorted, slightly friable. Poor to fair porosity.

Bear Beaumont No. 1

1091-1116 (296.0-8.7%) Dolomite, gray to brownish gray, finely granular, argillaceous, some dark brown carbonaccous and bituminous specks. Trace fossils. Oil staining (25%). Limestone, cream, brown to greenish gray, dense, argillaceous and fragmental bands. Bands of reworked fragmental limestones. Brachiopods and Ostracods (75%).

1139-1147 (299.0-7.4%) Limestone, grayish brown, finely crystalline. Calcite inclusions and some dolomitization. Black stylolitic shale partings. Traces of fossils. Oil staining upper 2" and isolated vugs (36%)
Limestone, argillaceous; gray to green gray, dense, gray green limy shale and gray fossiliferous limestone partings (14%).
Shale, limy, gray green (50%).

1147-1181 (93.0-3.9%) Shale, as above (35%)
Limestone, brown or gray, dense to finely crystalline, numerous fossil fragments. Stylolitic shale partings.

1313-1323 (115.0-1.9%) Shale, gray green, limy, dense. Scattered Brachiopods and Ostracods.

1334-1363 (142.0-1.8%) Shale as above.

1363-1371 (100.0-9.5%) Shale as above.

1373-1383 (63.0-4.6%) Shale as above. Lower 3' with numerous fossiliferous bands and inclusions.

1413-1423 (396.0-4.7%) Limestone, gray, dense to finely crystalline, irregular dark greenish to brownish gray limy shale partings (90%).
Shale, limy gray green (10%).

1492-1502 (185.0-6.9%) Limestone, light gray, dense to very finely crystalline; argillaceous, grading into patches of greenish gray, silty limy shale. Scattered brachiopods.

1542-1552 (185.0-4.1%) Shale, gray green, limy, grading into argillaceous limestone. Traces pyrite.

1582-1593 (73.0-10.9%) Limestone, gray green argillaceous, grading to limy shale; bands of gray brown dense limestone near base. Brachiopods.

1632-1652 (156.0-6.7%) Limestone, gray brown to gray green; argillaceous bands; thin dark brown shaly partings. Pyritized plant remains?

1657-1659 (96.0-10.1%) Limestone, argillaceous, gray green to dark brown, banded, dense, some dark brown limy shale bands, some fossiliferous bands. Traces pyrite, carbonaceous and bituminous material. Brachiopods and spicules.

1699-1703 (129.0-5.5%) Shale, gray green, limy. Crinoids and brachiopods.

1808-1815 (198.0-10.4%) Limestone, light gray, dense, abundant dark brown and dark greenish gray shale partings. Brachiopods, crinoid stems, microfossils.

1838-1843 (135.0-7.8) Limestone, dark greenish gray, dense and shaly in lower part (20%).
Shale, limy gray green to greenish gray, dense.

Scattered brachiopods, crinoids (60%).
Limestone, light gray, dense, with dark gray argillaceous limestone and limy shale bands (20%).

1843-1848 (192.0-6.2%) Shale, limy as above (35%)
Limestone, gray, dense. Numerous dark gray stylolitic shale partings. Brachiopods. Ostracods (65%).

1898-1902 (182.0-9.4) Limestone, light gray, dense, some dark gray shaly partings. Abundant fossil fragments.

1902-1908 (159.0-11.9%) Limestone, light gray, dense. Numerous stylolitic shale partings. Fossil fragments numerous. Brachiopods, Crinoids, Ostracods.

1938-o942 (85.0-9.9%) Limestone, gray, dense; abundant irregular gray green shale partings. Numerous fossil fragments.

1948-1958 (121.0-8.0%) Limestone, gray to light brown, dense; finely granular in part. Numerous black and dark brown stylolitic shale partings and patches of dark greenish gray shale.

1988-1998 (47.0-12.1) Limestone, gray, dense to very finely crystalline and abundant irregular dark gray to greenish gray shale partings. Grades in part to an argillaceous limestone. Brachiopod and crinoid fragments.

2013-2021 (73.0-13.6%) Limestone as above (75%)
Shale, limy gray green, dense. Fossiliferous limy patches (25%).

2023-2033 (139.0-1.1%) Shale, limy, gray green, dense, grading into green gray argillaceous limestone and gray limestone. Scattered brachiopods.

2108-2118 (148.0-4.1%) Limestone, gray, dense, argillaceous in part, bands brown, dense limestone. Abundant

shale partings (30%)
Limestone, brown, dense to crystalline partly fragmental and fossiliferous. Abundant shale partings in base. Some stylolitic shale (70%).

2130-2144 (374.0-0.2%) Limestone, buff, dense with numerous bands of limy dark green shale (30%)
Shale, dark green, slightly limy, some thin bands gray fossiliferous limestone in basal 1' which are brecciated and pyritic (30%)
Shale, dark green, slightly limy (40%).

Bear Biltmore No. 1

502-518 (241.0-6.1%) Limestone, gray buff to brown, dense to crystalline, fragmental. Basal 3" very argillaceous. Crinoids, brachiopods in abundance (40%)
Shale, greenish gray, limy, fissile. (60%).

518-529 (101.0-0.4%) Shale, greenish gray, limy, fissile. Traces pyrite.

529-539 (80.0-0.2%) Shale, greenish gray, dolomitic, fissile. Traces pyrite. Basal 6" gray to greenish gray, argillaceous limestone. Brachiopods. Crinoids.

539-549 (80.0-0.2%) Shale, greenish gray, limy, grading into shaly limestones. Thin fossiliferous bands.

549-558 (131.0-2.0%) Shale, greenish gray, limy (60%)
Limestone, gray, dense. Fragmental and fossiliferous (40%).

558-568 (262.0-3.8%) Shale, greenish gray, limy. Trace pyrite.

568-588 (373.0-1.7%) Shale as above grading into argillaceous fossiliferous limestone at base. Brachiopods.

588-598 (384-2.4%) Limestone, gray, dense, irregular bands of limy green shale. Fossiliferous.

598-608 (460.0-1.1%) Shale, gray green, limy, some irregular bands of limestone as above.

608-618 (243.0-1.0%) Shale, gray green, limy grading into shaly limestone.

618-628 (117.0-0.02%) Shale, gray green, limy, fissile. A few bands of shaly limestone.

628-638 (238.0-o.1%) Shale as above. Some Lingulas.

638-664 (184.0-7.2%) Limestone, gray, dense to granular, argillaceous to shaly, fossiliferous.

664-674 (299-0.7%) Shale, limy, gray green, dense, grades into gray argillaceous fossiliferous limestone and then into buff limestone, dense, finely crystalline and fragmental. Brachiopods, ostracods, crinoids, stromatoporoids, brown stylolitic shale partings.

674-684 (174-9.2%) Limestone as above with 6" interbed gray green fossiliferous limy shale (50%)
Limestone argillaceous, gray green, dense, fossiliferous grades into a shale (50%).

684-694 (426-4.3%) Limestone, gray, dense to very finely crystalline, with abundant fossils, partly fragmental. Irregular gray green limy shale patches and interbeds of dense argillaceous limestone (75%)
Limestone, argillaceous, gray green, dense, fossiliferous grades into a basal shale (25%).

694-704 (81.0-6.1%) Limestone, argillaceous, gray green, dense, fossiliferous, irregular partings of limy shale grading into light gray limestone.

704-714 (69.0-5.7%) Limestone, argillaceous, as above.

714-724 (293.0-3.1%) Limestone, gray green, shaly grading into limy shale.

724-734 (234.0-2.7%) Shale, gray green, limy, dense, grading into shaly limestone.

734-744 (165.0-7.6%) Limestone, argillaceous, gray to greenish gray, dense, shaly in part. Brachiopods.

744-754 (245.0-0.3%) Shale, gray green, limy, dense, grades into gray argillaceous limestone. Scattered Lingulas (60%)
Limestone, buff to light brown, dense to finely crystalline, abundant brachiopods, ostracods, crinoid fragments.

754-764 (352.0-0.8) Shale, gray green, limy, dense, Scattered Lingulas. Conodonts.

764-774 (278.0-1.4%) Shale as above.

774-786 (272.0-1.8%) Limestone, argillaceous, green to brownish gray, dense. Scattered fossils.

786-797 (469.0-7.6%) Limestone, as above.

797-807 (383.0-13.1%) Limestone, as above.

807-819 (303.0-20%) Limestone, as above.

819-829 (339.0-16.7%) Shale, gray green, limy, dense. Few fossils.

829-839 (431.0-18.9%) Shale, limy,; partings light gray limestone (87%)
Limestone, gray and brown, finely crystalline, calcite inclusions and thick partings of brown limy shale.

839-849 (363.0-8.9%) Limestone, light gray and brown, very finely crystalline interbedded with dark brown, green and black limy shale, carbonaceous-like inclusions. Fossil fragments in limestone.

849-859 (170.0-10.5%) Limestone, as above, thick partings dark brownish black petroliferous like limy shale (10%)

Limestone, buff to brown fragmental, dense, oolitic in part. Stromatoporoid inclusions, stylolitic partings of black and brown shale.

915-925 (40.0-80.7%) Limestone, cream coloured, dense (68%). Limestone, light gray, dense to finely crystalline, some bands argillaceous limestone (32%).

935-945 (40.0-90.7%) Limestone, cream coloured to light gray, dense to finely crystalline, some patches of fine granular limestone. Ostracods.

954-964 (40.0-83.3%) Limestone, as above, scattered crinoids.

974-984 (40.0-62.5%) Limestone, light gray becoming more argillaceous and fossiliferous at base. Cephalopod ? near base (68%).
Limestone, greenish gray, finely granular, argillaceous. Crinoids, brachiopods (32%).

984-994 (37.0-18.4%) Limestone, argillaceous as above grading into shaly limestone. Scattered brachiopods.

994-1002 (18.0-16.8%) Shale, gray green, limy. Brachiopods.

1002-1010 (203.0-4.2%) Shale as above, some bands shaly limestone.

1010-1020 (62.0-1.6%) As above (30%).
Limestone, brownish green, argillaceous, dense, fossiliferous and fragmental. Irregular bands of shaly limestone. Brachiopods, crinoids.

1032-1044 (207.0-5.1%) Limestone, gray green, dense, argillaceous. Brachiopod bands.

1064-1074 (351.0-11.1%) Limestone, brown to greenish gray, argillaceous in part. Charophyta (12%).
Limestone, buff, dense, fossiliferous and fragmental. Crinoids abundant (78%).

1074-1084 (272.0-14.6%) Limestone, fragmental as above.

1084-1094 (303.0-4.2%) Shale, green, limy, fissile (25%).
Limestone, gray green becoming brown at base.
Crinoids, brachiopods (75%).

1094-1104 (274.0-7.2%) Shale, green, limy, fissile.
Limestone, gray green, dense, argillaceous to shaly.
Scattered crinoids.

1114-1124 (176.0-14%) Shale, gray green, limy, grading in part to shaly limestone. Brachiopods.

1124-1134 (160.0-3.8%) Limestone, gray green, argillaceous to shaly. Brachiopods including Lingula (45%).
Limestone, buff to gray, some bands argillaceous limestone, some green shale partings. Crinoids.

1134-1144 (72.0-3.8%) Limestone as above, some brachiopods.

1154-1164 (383.0-5.7%) Shale, gray green, limy.

1184-1194 (67.0-10.6%) Shale, as above.

1254-1264 (101.0-5.9%) Limestone, buff, fossiliferous and fragmental, black and shale stylolitic partings (65%). Limestone, light gray, dense, abundant irregular partings of limy green shale, fossiliferous (35%).

1304-1314 (25.0-11.6%) Limestone, light gray, finely crystalline, abundant thick partings, gray green limy shale. Brachiopod and crinoid fragments (76%).
Shale, gray green, limy (24%).

1314-1324 (192.0-4.1%) Limestone as above (45%).
Shale as above (55%).

1324-1334 (161.0-2.4%) Shale as above (25%).
Limestone, gray, buff and gray green, shaly in base.
Stylolitic shale partings. Brachiopods.

1334-1344 (129.0-6.5%) Limestone, gray green, shaly, dense grading into limy shale. Scattered brachiopods and crinoid stems.

1344-1354 (151.0-35.8%) Limestone as above.

1354-1364 (86.0-3.5%) Shale, limy as above (25%). Limestone, gray green to gray in base, fragmental, limy partings. Crinoids (75%).

1364-1374 (75.0-4%) Shale, gray green, limy. Scattered fossils.

1394-1404 (339.0-5.8%) Shale, as above.

1404-1414 (48.0-37.6%) Shale, as above (63%) Limestone, buff, dense to finely crystalline, stylolitic shale partings. Coquina of brachiopods, crinoids (37%).

1414-1424 (233.0-37.6%) Limestone as above (75%) Limestone, gray green, dense (25%).

1454-1464 (279.0-3.2%) Limestone, light gray to buff, dense to finely crystalline, irregular greenish brown shale partings. Scattered fossils. Base becomes argillaceous, greenish gray. Brachiopods, crinoids.

1464-1474 (114.0-5.7%) Limestone as above, stylolitic shale partings. Fossil fragments abundant.

1484-1494 (98.0-3.1%) Interbedded gray green limy shale and limestone as above. Fossiliferous in part.

1504-1514 (153.0-2.9%) As above.

1514-1524 (228.0-3.2%) As above, some silty shaly limestone.

1524-1534 (125.0-6.4%) Shale, gray green, limy.

1534-1544 (224.0-0.4%) Shale, green, limy. Brachiopods, pyritized plant (?) remains.

1544-1554 (163.0-1.8%) Shale, green, limy.

1554-1574 (100.0-.08%) Shale as above, grading into green shaly limestone, finely silty. Brachiopod bands.

1574-1584 (190.0-2.9%) Limestone, greenish gray, argillaceous. Brachiopods.

1584-1594 (92.0-5.6%) Limestone as above (70%)
Shale, green, limy. Brachiopods.

1604-1614 (77.0-7.6%) Limestone green and gray, interbeds limy shale.

1614-1624 (32.0-17%) Limestone, gray green, argillaceous grading into limy shale. Brachiopods.

1634-1644 (167.0-9%) Shale, green, limy, interbeds limestone near base. Lingulas.

1658-1668 (189.0-15.6%) Shale, green to dark green, limy, platy, some Lingulas.

1668-1678 (215.0-6.2%) Shale as above. Lingulas.

1678-1688 (435.0-10.3%) Limestone, gray with partings of black shale, dolomitic and bituminous. (12½%)
Limestone, brown to gray, fragmental, fossiliferous. Crystalline anhydrite veins. Brachiopods, crinoids, Coral (87½%).

2116-2129 (228.0-39%) Shale, greenish gray (30%).
Remaining 70% of core consisted of halite and not sampled.

2660-2670 (262.0-17.3%) Dolomite, dark gray, anhydritic.
Band of black shale, with traces pyrite (13%).
Anhydrite, brown to dark gray with partings of material described in upper part of core (87%).

2670-2680 (37.0-24%) Anhydrite as above (60%) but not sampled. Shale, dark gray (40%).

2680-2690 (95.0-30.7%) Shale, olive green to dark gray, anhydrite veins.

2690-2699 (166.0-16.9%) Shale, as above (30%).
Shale, dark gray, dark brown and black with brown dolomite (70%).

2764-2774 (84.0-20.8%) Shale, maroon to green, dolomitic, bands of white anhydrite and poorly sorted medium to coarse rounded and frosted quartz, chert and glauconite.

Bear Rodeo No. 1.

103'3"-109 (40.0-1.9%) Limestone, gray and buff, dense to finely crystalline.

119-129 (119.0-19.7%) As above, interbedded with argillaceous limestone. Fossiliferous (68%).
Shale, greenish gray and gray argillaceous limestone slickensiding. Devoid of fossils (32%).

129-139 (187.0-5.0%) Interbedded argillaceous limestone and limy shale.

139-149 (92.0-12.2%) As above. Crinoid band.

149-159 (179.0-7.4%) Shale, green gray; limy to argillaceous limestone. Fossiliferous band.

209-219 (40.0-77.0%) Limestone, gray, argillaceous.
Pyrite crystals. Fossiliferous.

219-229 (120.0-1.4%) Limestone, gray, fossiliferous.

269-280 (206.0-2.5%) Limestone, gray, argillaceous.
Pelecypods, brachiopods.

280-291 (159.0-18.1%) As above.

311-321 (73.0-24.5%) Shale, greenish gray, limy. Few crystalline calcite nodules.

321-331 (109.0-10.1%) As above.

331-341 (148.0-1.0%) Shale as above.

341-351 (57.0-0.7%) Shale as above, interbedded with gray argillaceous limestone which is very fossiliferOous. Brachiopods, pelecypods.

361-372 (110.0-6.2%) Shale as above.

372-381 (178.0-8.1%) As above. Pyrite nodules.

411-422 (116.0-4.5%) Interbedded argillaceous limestone and limy shale as above. Lingulas. Fossiliferous at base.

422-430 (124.0-5.6%) As above.

471-481 (45.0-3.6%) Shale, gray green, limy with interbedded dark gray shale (53%)
Limestone, light gray, dense, carbonaceous (?) flakes disseminated throughout, argillaceous. Pelecypod, brachiopod. Slickensided surfaces (47%).

481-491 (40.0-22.3%) Shale, dark gray; gray limestone bands (10%).
Limestone, buff gray. Vertical fractures, small, calcite filled (40%).
Anhydrite, white to brown, bands fibrous gypsum (50%).

520'5" -530 (43.4-12.6%) Shale, grayish green anhydritic, stringers gray to pink anhydrite (33%).
Shale, green, brick red, anhydritic (10%).
Interbedded green shale and anhydrite (57%).

889-899 (73.0-0.2%). Limestone, light buff gray to dark brown. Brecciated. Petroliferous shale partings. Fossiliferous.

Bear Rodeo No. 2

35-42 (151.0-0.13%) Shale, green limy; interbedded with gray, green shaly limestone.

118-128 (100.0-7.5%) Shale gray green limy (80%) interbedded with gray argillaceous limestone (20%).

228-238 (187.0-9.7%) Limestone, gray, dense, argillaceous to shaly. Trace pyrite. Fossil fragments.

248-259 (232.0-10.9%) Shale, gray green, limy and gray green shaly limestone. Fossil fragments.

308-318 (159.0-7.5%) Shale, green, limy (85%) Limestone, gray, dense, argillaceous and fossiliferous (15%).

388-398 (77.0-0.7%) Variable gray green to gray limestone and gray green limy shale. Pyrite. Fossil fragments.

398-408 (170.0-5.0%) Limestone, gray, dense, argillaceous (25%) Fossiliferous. Shale, gray green, limy. Fossiliferous (75%).

418-428 (94.0-.43%) Shale, green, limy. Nodular pyrite. Fossiliferous.

513-523 (229-4.5%) Shale, green, dolomitic with bands gypsum, dolomite. 1" band dark brown petroliferous band at 515'2".

523-535 (464.0-27.3%) Shale, green, dolomitic and gypsiferous (12%) Dolomite, buff to brown, dense, argillaceous; partings of shale in upper partion core, stringers gypsum in base (86%).

892-902 (199.0-12.3%) Shale, gray green, dolomitic, interbeds of gypsum.

Bear Vampire No. 1

642-652 (287.0-7.1%) Limestone, gray to gray brown becoming argillaceous at base. Pyrite in upper part. Traces fossils and slickensiding.

657-667 (225.0-7.6%) Limestone, gray to gray green, argillaceous. Slickensiding. Fossils.

677-687 (326.0-4.1%) Limestone, gray to gray brown, dense, argillaceous. Fossil fragments.

725-732 (207.0-5.9%) Limestone, gray green, argillaceous.

792-802 (398.0-4.2%) Limestone, buff, finely crystalline to dense, with numerous gray shaly partings. Fossil fragments.

812-822'2" (414.0-1.9%) Limestone gray to buff, dense with gray green limy shale. Fossiliferous.

832'2"-842'2" (134.0-8.1%) Shale, gray green, limy. Fossiliferous limestone bands.

852-862 (169.0-11.2%) Shale, as above (55%). Limestone, gray, argillaceous to shaly. Irregular green shale partings. Fossiliferous (45%).

918-928 (103.0-13.7%) Limestone, gray to greenish gray, dense. Fossiliferous.

958-968 (101.0-17.2%) Limestone, buff to gray buff, dense. Traces pyrite, secondary calcite. Fossil fragments.

968-978 (114.0-11.6%) Limestone, buff to greenish gray, dense. Fossil fragments.

978-988 (99.0-9.4%) Limestone, gray to gray green, dense, some limy shale in middle of core. Fossiliferous.

988-998 (103.0-10.4%) Limestone, gray green, shaly to limy green shale.

1008-1018 (79.0-2.6%) Shale, greenish gray, limy. Fossiliferous lime bands.

1018-1028 (190.0-6.3%) Shale, green, limy, .4" band green argillaceous limestone with Brachiopods.

1028-1038 (279.0-2.7%) Shale as above.

1038-1048 (200.0-3.2%) Shale as above (83%). Limestone, green, argillaceous. Fossiliferous (17%).

1048-1058 (259.0-3.1%) Shale, green limy.

1058-1068 (159.0-10.8%) As above. Brachiopod bands.

1088-1098 (92.0-1.9%) As above, grading into argillaceous and shaly limestone. Brachiopods.

1098-1108 (286.0-4.6%) Shale, gray green, limy, fissile (28%). Limestone, gray to gray green, dense,

argillaceous to shaly. Slickensiding (72%).

1118-1128 (54.0-5.2%) Shale gray green, limy. Brachiopod. bands.

1128-1138 (74.0-4.5%) Shale, greenish gray, limy. Some gray to greenish gray limestone. Brachiopods and pelecypods.

1138-1148 (57.0-18.0%) As above.

1148-1158 (211.0-4.4%) Shale as above (90%).
Limestone, gray to gray green, argillaceous to shaly. Fossiliferous. (10%).

1158-1168 (270.0-1.6%) Shale as above.

1168-1178 (282.0-31.3%) Shale as above. Limestone, brown, argillaceous at base.

1230-1243 (57.0-19.0%) Dolomite, buff and green shale.

1253-1263 (40.0-91.3%) Dolomite, gray to gray green, anhydritic.

1273-1304 (99.0-18.4%) Dolomite, red and green mottled, finely crystalline to dense argillaceous with anhydrite stringers (78%).
Dolomite, gray, anhydritic (12%).

1917-1927 (40.0-100.0%) Dolomite, buff to brown, dense, anhydritic.

1957-1958 (40.0-68.2%) Dolomite, brown, finely crystalline, anhydritic. External mold Brachiopod.

2105-2115 (40.0-90.3%) Dolomite, light to dark brown finely crystalline to dense, argillaceous in part. Replaced fossils (Crinoids?).

2115-2125 (124.0-20.3%) Dolomite, brown to brownish black, argillaceous and slightly anhydritic. Brachiopod mold.

2125-2135 (40.0-78.3%) Dolomite, brown to gray, crystalline at top becoming argillaceous and anhydritic. Partings brown petroliferous shale.

2145-2155 (302.0-30.7%) Dolomite, gray, argillaceous to shaly. Slickensiding. Salt veins.

2155-2165 (268.0-32.2%) As above.

2175-2185 (435.0-18.1%) Dolomite gray to gray green, argillaceous gypsum and salt band (50%). Dolomite, gray green and maroon, argillaceous. Salt veins.

2185-2195 (72.0-15.3%) Dolomite, gray to gray green, and maroon dolomitic shale. Salt veins.

Bear Vampire No. 2.

11-15 (40.0-87.2%) Limestone, buff, dense, secondary calcite traces. Fossil fragments. Tar in fractures.

29-38 (63.0-4.4%) Limestone, gray to gray buff, dense, argillaceous to shaly. Fossil fragments.

38-45 (65.0-13.2%) Shale, gray green, limy (60%). Limestone, gray buff, dense, argillaceous. Fossiliferous. Fracturing and oil staining (40%).

45-48 (40.0-93.7%) Limestone, buff, dense, interbedded light green limy shale. Traces fossils. Oil staining on fracture planes (45%). Limestone, buff to brown. Fragmental. Fossil fragments (55%).

58-68 (184.0-8.9%) Shale, gray green, limy, small fossiliferous limestone bands. Pyrite.

82-92 (97.0-8.8%) Shale, greenish gray, limy with gray fossiliferous limestone at base.

92-102 (79.0-4.8%) Shale, green limy (85%) and gray limestone (15%).

112-122 (106.0-3.0%) Shale as above.

122-132 (57.0-1.4%) Shale as above. Pyrite.

132-142 (40.0-97.0%) Shale as above. Pyrite (90%)
Limestone, brown, dense. Fossil fragments. (10%).

162-172 (109.0-11.6%) Limestone, gray, dense, argillaceous. Irregular shaly partings. Fossil fragments. Pyrite traces.

172-182 (106.0-12.7%) Limestone, gray, dense, becoming shaly at base.

182-192 (42.0-17.8%) Shale, green, limy. Fossil fragments.

192-202 (96.0-12.9%) Shale as above. Pyrite.

202-212 (101.0-14.3%) Interbedded shale, green, limy and limestone, gray, dense, argillaceous. Fossiliferous.

212-222 (110.0-2.6%) As above.

222-232 (95.0-4.9%) As above.

232-242 (80.2-14.2%) As above.

262-272 (86.0-15.4%) Shale, green, limy, almost fissile.

272-281 (91.0-21.2%) Shale, green, limy interbedded with limestone, gray, dense. Fossiliferous.

281-286 (69.0-2.2%) Shale, green, limy. Pyrite.
Fossil band.

304-308 (47.0-4.9%) Shale as above. Pyrite inclusions.

308-312 (72.0-7.0%) As above.

312-322 (135.0-3.9%) Shale, green, limy. Some shaly limestone.

322-332 (115.0-14.5%) Shale, green, limy (30%)
Limestone, gray to gray green (70%).

342-352 (159.0-9.5%) Shale and limestone as above.

367-377 (54.0-0.7%) Shale, greenish gray, limy (55%).
Limestone, gray, dense. Fossiliferous. (45%).

377-387 34.0-0.5%) Shale, green, limy. Interbedded gray limestone. Fossiliferous.

389-393 (87.0-0.1%) Shale, green, limy, fossiliferous.

393-403 (112.0-0.4%) Shale as above. Slickensiding. Interbedded gray limestone.

403-413 (113.0-0.8%) As above.

413-419 (119.0-0.7%) As above. Slickensiding.

419-429 (95.0-4.2%) Shale, dark gray, limy. Slickensiding. Carbonaceous and fossil material.

436-446 (128.0-7.0%) Limestone, as above (28%)
Limestone, gray to buff, dense (40%).
Shale, green, limy. Slickensiding (32%).

817-827 (751.0-34.2%) Dolomite, gray to brown, becoming greenish, argillaceous and shaly at base. Gypsum band.

Bear Westmount No. 1

904-911 (180.0-18.5%) Limestone, greenish gray, argillaceous and shaly. Pyrite. Carbonaceous fragments. Fossiliferous in upper foot.

921-931 (269.0-0.9%) As above.

941-951 (324.0-0.3%) As above.

951-961 (245.0-7.8%) As above.

971-931 (393.0-7.8%) Limestone as above.

991-999 (137.0-12.6%) Limestone, buff gray to gray, becoming shaly towards base. Fragmental.

1004-1114½ (43.0-53.3%) Limestone gray buff to buff, argillaceous, fragmental. Fossiliferous.

1039½-1049 (119.0-12.2%) Limestone, gray buff to gray. Shaly in parts.

1049-1059 (36.0-1.6%) Limestone as above. Slightly silty.

1059-1069 (99.0-10.7%) As above. Pyrite crystals. Calcite stringers. Pelecypods, crinoids in base

1079-1089 (106.0-8.0%) Shale, greenish gray, limy and gray argillaceous limestone.

1098-1104 (61.0-9.1%) Shale, greenish gray, argillaceous.

1124½-1135 (89.0-13.3%) As above.

1165-1175 (90.0-12.6%) Shale, greenish gray, limy. Slickensided surface. Pyrite crystals.

1185-1194 (130.0-4.6%) As above.

1194-1206 (59.0-2.5%) Shale, pyrite as above. Brachiopods, pelecypods.

1206-1216 (140.0-3.3%) As above.

1221-1231 (56.0-0.7%) As above.

1251-1262 (73.0-3.6%) As above. Tentaculites.

1429-1439 (40.0-77.7%) Dolomite, buff gray, slightly argillaceous.

1439-1449 (58.0-27.8%) As above.

1658-1668 (40.0-86.2%) Shale, gray to dark gray, stringers of fibrous gypsum, some brown dolomitic shale.

1668-1679 (45.0-22.5%) Shale as above.

Bear Westmount No. 2.

46-62 (236.0-6.1%) Shale, light green, calcareous interbedded with fossiliferous limestone in upper 4".

62-75 (128.0-11.4%) Shale, gray green, limy (45%). Limestone, gray green, argillaceous, shaly partings. Pyrite (55%).

75-78 (103.0-7.7%) Shale, green, limy. Lime bands.

190-200 (84.0-13.6%) Limestone, buff to gray, dense, argillaceous. Fragmental. Fossil fragments. Trace pyrite.

210-220 (127.0-15.6%) Limestone, gray buff to gray green, argillaceous becoming shaly. Fossil fragments.

240-251 (81.0-14.7%) Shale, gray green to green, limy (70%) Limestone, gray dense, argillaceous. Slickensiding (30%)

251-262 (85.0-13.8%) Shale as above.

320-331 (328.0-4.7%) Shale, gray green, argillaceous, limy.

331-341 (105.0-5.9%) Shale, gray green. Fossiliferous.

341-352 (518.0-3.1%) Limestone, gray, with shale break (45%). Shale as above (55%). Fossiliferous.

382'6"-393' (94.0-2.4%) Interbedded green shale and gray argillaceous limestone.

393-403 (94.0-2.5%) Shale, green, limy (50%). Shale, brown, green mottling. Iron pyrite, slickensiding (10%). Limestone, gray, dense, fossiliferous grading into dolomitic green shale (40%).

429-439 (99.0-2.0%) Anhydrite band at top. Shale, green limy and dolomitic alternately.

449-459 (121.0-14.1%) As above. Anhydrite (65%) at base.

574-584 (51.0-53.8%) Dolomite, buff to gray buff, granular to crystalline. Secondary calcite in small vugs. Some fine intergranular and vuggy porosity.

758-768 (51.0-31.0%) Dolomite, buff to brown, granular to crystalline. Pinpoint porosity. Greenish gray shale band at base.

790-800 (357.0-11.0%) Shale, gray, brown and grayish green interbedded with gypsum. Pyrite and small quartz grains.

Christina River Hardy No. 1

1239-1249 (231.0-32.6%) Shale, greenish gray, limy, pyritic.

1249-1259 (248.0-25.2%) Limestone, gray, to buff, crystalline.

1259-1269 (218.0-2.2%) Shale, greenish gray grading into gray buff limestone as above.

1269-1280 (326.0-4.4%) As above.

1280-1290 (127.0-5.0%) As above.

1290-1300 (207.0-3.2%) As above.

1332-1338 (106.0-5.1%) Limestone, gray buff to brown, dense, crystalline.

1339-1349 (201.0-4.5%) As above, becoming dolomitic towards base.

1434-1444 (49.0-12.6%) Limestone, argillaceous, greenish gray to brownish gray, dense to finely crystalline.

1444-1454 (84.0-9.3%) Limestone, greenish gray.

1454-1464 (146.0-1.5%) Limestone as above (50%) with limy shale (50%).

1464-1470 (140.0-6.0%) Limestone as above.

1470-1480 (312.0-4.5%) As above.

1480-1490 (192.0-6.2%) Shale, limy, green.

1490-1500 (144.0-16.1%) Limestone, greenish gray, finely crystalline.

1500-1510 (55.0-20.3%) Shale, green, limy.

1510-1520 (147.0-8.4%) Limestone, greenish gray, argillaceous becoming fragmental.

1540-1550 (40.0-80.8%) Limestone, brownish gray, crystalline.

1550-1560 (40.0-42.5%) Limestone, greenish gray, argillaceous.

1590-1600 (274.0-7.8%) As above.

1600-1610 (92.0-14.2%) As above.

1620-1630 (160.0-9.9%) Shale, brownish gray to greenish gray, limy and argillaceous limestone interbedded. Fragmental bands. Pyrite.

1630-1640 (240.0-8.4%) As above.

1650-1660 (138.0-8.9%) As above.

1660-1667 (121.0-6.9%) As above.

1667-1677 (170.0-7.5%) Shale, brownish gray with limestone as above.

1687-1700 (161.0-0.2%) Shale, brownish gray to greenish gray and argillaceous limestone.

1700-1710 (162.0-0.1%) As above.

1710-1720 (89.0-0.1%) As above.

1730-1740 (72.0-7.2%) As above.

1740-1750 (56.0-0.1%) As above.

1750-1760 (106.0-13.4%) As above, shale becoming darker. Plant remains.

1770-1780 (75.0-3.6%) As above.

1780-1790 (112.0-1.9%) Shale as above.

1790-1800 (166.0-4.6%) As above.

1800-1810 (76.0-7.9%) Shale, dark gray. Pyrite.

1810-1820 (103.0-18.6%) As above.

1820-1830 (112.0-14.6%) As above. Tentaculites. sp.

1830-1840 (155.0-8.4%) Dolomite, gray to brownish gray, sometimes greenish, crystalline to dense, argillaceous Gypsum inclusions. Anhydrite interbeds.

1850-1860 (68.0-16.8%) Dolomite as above, minor amount shale.

1860-1867 (120.6-10.3%) Shale, dark brown to green, dolomitic to limy, some dolomite and anhydrite inclusions. Trochelisks.

Well name	Total number microfossils A	Original Wt. samples B	No. of samples C	Average yield D	Average wt. per sample E	Average richness per sample F
				$\frac{A}{C}$	$\frac{A}{C}$	$\frac{A}{B}$
Angelus Ashmont 1	1,475	3,409.24	38	38.81	89.72	.433
Bear Beaumont 1	59,996	4,153.02	27	2220.9	153.8	14.438
Bear Biltmore 1	147,263	15,627.64	84	1753.1	186.04	9.423
Bear Rodeo 1	29,644	2,259.09	21	1411.6	107.57	13.122
Bear Rodeo 2	33,515	2523.81	12	2792.9	210.25	13.283
Bear Vampire 1	34,936	6729.79	40	8732.5	168.24	5.191
Bear Vampire 2	20,579	3486.78	35	587.9	99.62	5.902
Bear Westmount 1	94,317	2733.21	23	4100.7	118.83	34.507
Bear Westmount 2	39,098	2660.37	17	2299.7	156.49	14.696
Christina River Hardy 1	17,321	6310.58	40	435.7	157.7	2.76
Totals:	478,224	49,893.53	337	2437.391	130.63	9.584
		49.89 Kg = 109.995 lb.				

<u>Arabellites comis</u> Eller		
Ireton	Bear Beaumont No. 1	1147 - 1181'*
	Bear Biltmore No. 1	694 - 704'
<u>Arabellites pectinellus</u> Stauffer		
Ireton	Bear Biltmore No. 1	628 - 638' 664 - 674'
Moberly	Angelus Ashmont No. 1	3205 - 3215'
<u>Lumbriconerites cooperi</u> Eller		
Moberly	Christina River Hardy No. 1	1259 - 1269' 1280 - 1290'
Calmut	Bear Westmount No. 1	991 - 999'
Firebag	Bear Westmount No. 2	320 - 331'
<u>Nereidavus ontarioensis</u> Stauffer		
Ireton	Bear Beaumont No. 1	1413 - 1423'
Moberly	Bear Beaumont No. 1	1948 - 1958'
Christina	Bear Vampire No. 1	832½- 842½'
<u>Staurocephalites sp.</u>		
Ireton	Bear Biltmore No. 1	568 - 588'
<u>Spirorbis sp.</u>		
Christina	Bear Biltmore No. 1	1334 - 1344'
Firebag	Bear Vampire No. 2	419 - 429'
	Bear Westmount No. 2	320 - 331'

* All occurrences are rare, less than 1% unless given in parenthesis following footage.

APPENDIX B DISTRIBUTION OF MICROFAUNA IN THE MCMURRAY AREA

ANNELIDA (ANNULATA)

Arabellites comis Eller			
	Ireton	Bear Beaumont No. 1	1147 - 1181'*
		Bear Biltmore No. 1	694 - 704'
Arabellites pectinellus Stauffer			
	Ireton	Bear Biltmore No. 1	628 - 638'
			664 - 674'
	Moberly	Angelus Ashmont No. 1	3205 - 3215'
Lumbriconerites cooperi Eller			
	Moberly	Christina River	
		Hardy No. 1	1259 - 1269'
			1280 - 1290'
	Calmut	Bear Westmount No. 1	991 - 999'
	Firebag	Bear Westmount No. 2	320 - 331'
Nereidavus ontarioensis Stauffer			
	Ireton	Bear Beaumont No. 1	1413 - 1423'
	Moberly	Bear Beaumont No. 1	1948 - 1958'
	Christina	Bear Vampire No. 1	832½ - 842½'
Staurocephalites sp.			
	Ireton	Bear Biltmore No. 1	568 - 588'
Spirorbis sp.			
	Christina	Bear Biltmore No. 1	1334 - 1344'
	Firebag	Bear Vampire No. 2	419 - 429'
		Bear Westmount No. 2	320 - 331'

* All occurrences are rare, less than 1% unless given in parenthesis following footage.

BRANCHIOPODA

Rhabdostichus cf. pulex

Ireton	Bear Biltmore No. 1	598 - 628' 684 - 694' 754 - 764'
Moberly	Bear Biltmore No. 1	1154 - 1164'
	Bear Vampire No. 2	82 - 92'

Rhabdostichus?reticulatus n.sp.

Ireton	Bear Beaumont No. 1	1312 - 1335' 1373 - 1383' 1413 - 1423'
	Bear Biltmore No. 1	598 - 608' 638 - 664' 774 - 786'
Mildred Lake	Bear Beaumont No. 1	1902 - 1908'
Moberly	Christina River Hardy No. 1	1239 - 1259' 1269 - 1280'
Christina	Bear Biltmore No. 1	1404 - 1414'

Rhabdostichus?rugosus n.sp.

Ireton	Bear Biltmore No. 1	638 - 664' 684 - 694' 714 - 724'
Christina	Bear Biltmore No. 1	1394 - 1404'
	Bear Westmount No. 1	921 - 931'
	Bear Beaumont No. 1	1888 - 1898'

CHAROPHYTA

Trochiliscus (Eutrochiliscus) convolutus Peck

Ireton	Bear Biltmore No. 1	588 - 598'
		704 - 714'
		734 - 754'
Mildred Lake	Bear Biltmore No. 1	1064 - 1074'
Christina	Bear Biltmore No. 1	1364 - 1374'
	Bear Westmount No. 1	921 - 931'
	Christina River Hardy No. 1	1490 - 1500'
Calmut	Bear Vampire No. 1	978 - 988'
	Bear Vampire No. 2	182 - 192'
		212 - 222'
	Bear Westmount No. 2	190 - 262'
Firebag	Bear Vampire No. 1	1038 - 1048'

Trochiliscus (Eutrochiliscus) devonicus (Wieland)

Moberly	Bear Westmount No. 2	62 - 78'
Christina	Bear Westmount No. 1	921 - 931'
	Christina River Hardy No. 1	1480 - 1490'
Calmut	Bear Biltmore No. 1	1454 - 1464'
	Bear Rodeo No. 2	249 - 259'
	Bear Vampire No. 1	988 - 998'
	Bear Vampire No. 2	202 - 212'
Firebag	Bear Biltmore No. 1	1484 - 1494'
	Bear Vampire No. 1	1038 - 1048'

Trochiliscus (Karpinskya) bilineatus Peck

Ireton	Bear Beaumont No. 1	1147 - 1167'
	Bear Biltmore No. 1	568 - 588'
Mildred Lake	Angelus Ashmont No. 1	2634 - 2644'
Calmut	Bear Vampire No. 2	212 - 222'
Firebag	Bear Rodeo No. 2	308 - 318'
	Christina River Hardy No. 1	1630 - 1660'
Beaverhill Lake	Angelus Ashmont No. 1	3217 - 3222'

Paleochara wickendeni (Choquette)

Elk Point	Bear Vampire No. 1	1230 - 1243'
	Christina River Hardy No. 1	1860 - 1867'

Prochara symmetrica n.g., n.sp.

Elk Point	Bear Vampire No. 1	1230 - 1243'
	Bear Westmount No. 2	449 - 459'
	Christina River Hardy No. 1	1860 - 1867'

Sycidium sp.

Moberly	Bear Westmount No. 2	62 - 75'

CONODONTIDOPHORIDIA

Apatognathus sp.

Ireton	Bear Biltmore No. 1	558 - 568' 638 - 664'
Moberly	Bear Beaumont No. 1	1938 - 1948'
Firebag	Bear Rodeo No. 2	418 - 428'
	Bear Vampire No. 2	377 - 387'

Bryandotus stratfordensis Stauffer		
Ireton	Bear Biltmore No. 1	558 - 568'
Moberly	Christina River Hardy No. 1	1249 - 1259'
Calmut	Christina River Hardy No. 1	1590 - 1600'
Firebag	Bear Westmount No. 1	1124½- 1135'
Bryandotus sp. A.		
Firebag	Bear Rodeo No. 2	418 - 428'
Centrognathus sp.		
Mildred Lake	Bear Beaumont No. 1	1898 - 1902'
Ctenognathus (Pandorinellina) insita (Stauffer)		
Ireton	Bear Biltmore No. 1	638 - 664' 674 - 684'
Moberly	Bear Beaumont No. 1	1938 - 1958'
	Bear Vampire No. 1	792 - 802'
	Christina River Hardy No. 1	1249 - 1259'
Christina	Bear Westmount No. 2	62 - 75'
Calmut	Bear Rodeo No. 2	249 - 259'
	Bear Vampire No. 1	978 - 988'
	Bear Vampire No. 2	202 - 212'
	Bear Westmount No. 1	1004 - 1114½' 1206 - 1216'
	Christina River Hardy No. 1	1590 - 1600'
Firebag	Bear Biltmore No. 1	1544 - 1554'
	Bear Vampire No. 1	1058 - 1068'

	Bear Vampire No. 2	272 - 281'
	Christina River	
	Hardy No. 1	1710 - 1720'
		1810 - 1820'

Curtognathus sp.

Moberly	Bear Biltmore No. 1	1134 - 1144'

Hindeodella lambdesta n.sp.

Ireton	Bear Biltmore No. 1	638 - 664'
Moberly	Bear Beaumont No. 1	2130 - 2144'
	Bear Vampire No. 1	677 - 687'
	Bear Vampire No. 2	202 - 212'

Hindeodella milleri Stauffer

Ireton	Bear Biltmore No. 1	674 - 684'
Mildred Lake	Bear Biltmore No. 1	1084 - 1094'
Firebag	Bear Vampire No. 2	403 - 413'

Hindeodella sp.

Firebag	Bear Rodeo No. 1	311 - 321'
	Bear Vampire No. 2	304 - 308'

Icriodus brevis Stauffer

Firebag	Bear Rodeo No. 1	321? - 331?'
	Bear Vampire No. 2	304 - 308'

Icriodus cymbiformis Branson and Mehl

Ireton	Bear Biltmore No. 1	588 - 598'
Firebag	Bear Rodeo No. 2	418 - 428'
	Bear Westmount No. 2	393 - 403'

Icriodus elegantulus Stauffer		
Moberly	Bear Beaumont	2130 - 2144'
	Bear Rodeo No. 1	129 - 139'
Firebag	Bear Biltmore No. 1	1524 - 1534'
	Bear Rodeo No. 2	418 - 428'
Icriodus cf. elegantulus Stauffer		
Moberly	Bear Beaumont No. 1	2130 - 2144'
Firebag	Bear Rodeo No. 2	418 - 428'
Icriodus expansus Branson and Mehl		
Ireton	Bear Biltmore	664 - 674' 744 - 754'
Christina	Bear Westmount No. 2	46 - 62'
Firebag	Bear Rodeo No. 1	422 - 430'
	Bear Rodeo No. 2	418 - 428'
	Bear Vampire No. 1	1148 - 1158'
	Bear Westmount No. 1	1124½- 1135' 1185 - 1194' 1251 - 1262'
	Bear Westmount No. 2	320 - 331' 382½- 393'
Leptochirognathus sp.		
Ireton	Bear Biltmore	518 - 529'
Lignodina sp.		
Ireton	Bear Beaumont No. 1	1147 - 1181'
Firebag	Bear Westmount No. 1	1221 - 1231'
	Bear Westmount No. 2	320 - 331'

Neoprioniodus sp.		
Firebag	Bear Vampire No. 2	403 - 413'
Ozarkodina regularis Branson and Mehl		
Ireton	Bear Beaumont No. 1	1492 - 1502'
	Bear Biltmore No. 1	518 - 529'
Palmatolepis sp. A		
Ireton	Bear Biltmore No. 1	568 - 588'
Polygnathus stainbrooki Downs and Youngquist		
Mildred Lake	Bear Beaumont No. 1	1898 - 1902'
Polygnathus xylus Stauffer		
Ireton	Bear Biltmore No. 1	638 - 664' 744 - 784'
Elk Point	Bear Rodeo No. 1	481 - 491'
Polygnathus sp. A		
Firebag	Bear Westmount No. 2	320 - 331'
Polygnathus sp. B		
Ireton	Bear Biltmore No. 1	638 - 664'
Firebag	Bear Vampire No. 2	272 - 281'
Prioniodus cf. idoneus Stauffer		
Ireton	Bear Biltmore No. 1	568 - 588'
Taphrognathus sp. ?		
Firebag	Bear Vampire No. 1	1088 - 1098'
Trichnognathus blanda Stauffer		
Christina	Bear Biltmore No. 1	1394 - 1304'

FORAMINIFERA

Bathysiphon sp.

Calmut	Bear Westmount No. 1	991 - 999'
Firebag	Bear Westmount No. 1	1185 - 1194'
Elk Point	Bear Westmount No. 2	449 - 459?'

Endothyra ? gallowayi Thomas

Ireton	Angelus Ashmont No. 1	2165 - 2172'	(3.4%)
	Bear Beaumont No. 1	1091½- 1116'	
		1147 - 1181'	
		1368 - 1371'	
		1373 - 1383'	
	Bear Biltmore No. 1	502 - 518'	
		588 - 598'	(6.2%)
		638 - 664'	
		674 - 694'	
Mildred Lake	Bear Biltmore No. 1	1064 - 1074'	
Moberly	Bear Biltmore No. 1	1154 - 1164'	
		1156 - 1168'	
	Bear Rodeo No. 2	60 - 70'	
		118 - 128'	
	Bear Westmount No. 1	904 - 911'	
	Bear Westmount No. 2	62 - 75'	
	Christina River Hardy	1290 - 1300'	
Calmut	Bear Westmount No. 1	991 - 999'	

Semitextularia thomasi Miller and Carmer

Ireton	Bear Beaumont No. 1	1147 - 1181'
		1373 - 1383'
	Bear Biltmore No. 1	539 - 549'
		558 - 568'
		628 - 664'

Textularia ? sp.

Ireton	Angelus Ashmont No. 1	2634 - 2644'	
		3205 - 3215'	
	Bear Biltmore No. 1	502 - 518'	(6.2%)
		588 - 598'	
		628 - 638'	
		638 - 664'	(1.6%)
		674 - 684'	(1.6%)
		684 - 694'	
		774 - 786'	
Moberly	Bear Biltmore No. 1	1124 - 1134'	
	Bear Westmount No. 1	921 - 931'	
	Christina River Hardy No. 1	1249 - 1269'	
		1280 - 1300'	
Calmut	Bear Vampire No. 2	212 - 222'	

OSTRACODA

Abursus beaumontensus Loranger

Ireton	Bear Beaumont No. 1	1373 - 1383'	
		1413 - 1423'	
		1492 - 1502'	
	Bear Biltmore No. 1	502 - 518'	(3.6%)
		529 - 568'	
		568 - 588'	(1.9%)
		588 - 598'	(1.7%)
		638 - 664'	(1.3%)
		664 - 674'	(1.6%)
Moberly	Bear Vampire No. 2	58 - 68'	
		92 - 102'	(1.2%)

Abursus biltmorensus Loranger

Ireton	Angelus Ashmont No. 1	2165 - 2176'	
		2276 - 2282'	(4.4%)

		Bear Beaumont No. 1	1139 - 1147'
			1147 - 1181' (40.8%)
			1312 - 1325' (10.0%)
			1368 - 1371' (1.6%)
			1413 - 1423' (9.6%)
			1492 - 1502' (24.6%)
		Bear Biltmore No. 1	518 - 529'
			549 - 558'
			558 - 588' (2.0%)
			588 - 598' (13.5%)
			608 - 618' (2.0%)
			638 - 664'
			664 - 674' (5.1%)
			674 - 684' (2.3%)
			684 - 694' (6.0%)
			694 - 704' (2.1%)
			704 - 714' (5.6%)
			764 - 774' (4.1%)
			774 - 784' (1.9%)
	Duvernay	Bear Beaumont No. 1	1699 - 1703' (21.2%)
	Cooking Lake	Angelus Ashmont No. 1	2624 - 2634'
	Mildred Lake	Angelus Ashmont No. 1	2634 - 2641' (10.0%)
		Bear Beaumont No. 1	1808 - 1818' (7.3%)
		Bear Biltmore	994 - 1002' (1.1%)
			1002 - 1010' (2.4%)
			1010 - 1020'
	Moberly	Bear Beaumont No. 1	1948 - 1958'
			2023 - 2033'
		Bear Biltmore No. 1	1084 - 1094' (1.0%)
			1094 - 1104' (30.0%)
			1114 - 1124' (1.8%)
			1134 - 1144' (1.9%)
		Bear Rodeo No. 1	119 - 129'
			139 - 149'
		Bear Vampire No. 1	832 - 842' (1.3%)

	Bear Vampire No. 2	58 - 68'	
		82 - 92'	
		92 - 102'	(36.3%)
	Christina River		
	Hardy No. 1	1239 - 1249'	
		1259 - 1269'	(1.7%)
		1269 - 1280'	
Beaverhill Lake	Angelus Ashmont No. 1	3213 - 3222'	(1.5%)

Abursus duvernaius Loranger

Ireton	Bear Biltmore No. 1	684 - 694'	

Abursus triangulensus n.sp.

Christina	Bear Biltmore No. 1	1304 - 1314'	(1.9%)
		1314 - 1324'	(2.9%)
		1324 - 1334'	(55.9%)
		1334 - 1344'	
		1344 - 1354'	(2.6%)
		1394 - 1404'	(3.2%)
	Bear Rodeo No. 1	209 - 219'	(1.29%)
		219 - 229'	
	Bear Vampire No. 1	832 - 842'	
	Bear Westmount No. 1	921 - 931'	(12.0%)
		951 - 961'	(100%)
		971 - 981'	(51.0%)
		991 - 999'	
		1039½- 1049'	
	Bear Westmount No. 2	46 - 61'	
	Christina River		
	Hardy No. 1	1470 - 1480'	(5.8%)
		1490 - 1500'	(10.8%)
		1500 - 1510'	(14.2%)
Calmut	Bear Westmount No. 1	190 - 200'	
		210 - 220'	
Firebag	Bear Rodeo No. 1	311 - 321'	(5.9%)
		361 - 372'	

Acronotella keslingia n.sp.

Ireton	Bear Beaumont No. 1	1312 - 1363'
		1373 - 1383' (1.2%)
	Bear Biltmore No. 1	568 - 598'
		674 - 694'
		704 - 714'
		774 - 784'
		786 - 797'
Mildred Lake	Bear Biltmore No. 1	1010 - 1020'
		1084 - 1094'
Moberly	Bear Biltmore No. 1	1084 - 1094'
		1124 - 1134' (4.6%)

Aechmina vikingensa n.sp.

Ireton	Bear Beaumont No. 1	1312 - 1325'
		1334 - 1363'

Aechmina sp. A n.sp.

Ireton	Bear Beaumont No. 1	1334 - 1363'
		1368 - 1371'

Aechminella beaumontensa n.sp.

Ireton	Bear Beaumont No. 1	1147 - 1181'
		1334 - 1363'
		1373 - 1383'
	Bear Biltmore No. 1	502 - 518'
		529 - 539'
		558 - 588'

Aechminella biltmorensa (Loranger)

Mildred Lake	Bear Beaumont No. 1	1838 - 1843'
		1843 - 1848' (1.8%)
		1898 - 1902'
		1902 - 1908' (1.5%)
		1938 - 1948'
		1948 - 1958'
		1988 - 1998'

	Bear Biltmore No. 1	1002 - 1010'	(5.9%)
		1010 - 1020'	
		1032 - 1044'	
		1064 - 1074'	
		1084 - 1094'	(4.0%)
Moberly	Bear Biltmore No. 1	1114 - 1144'	
	Bear Rodeo No. 1	129 - 139'	
	Bear Vampire No. 1	812 - 822'	(1.1%)
	Bear Vampire No. 2	82 - 92'	
		92 - 102'	(9.0%)
	Christina River Hardy No. 1	1239 - 1249'	(5.8%)
		1249 - 1259'	(10.2%)
		1259 - 1269'	

Aechminella fribourgella (Loranger)

Moberly	Bear Beaumont No. 1	1938 - 1942'	
		1948 - 1958'	
		1988 - 1998'	
		2130 - 2144'	
	Bear Rodeo No. 1	129 - 139'	
	Christina River Hardy No. 1	1239 - 1269'	
		1269 - 1280'	(2.3%)
		1280 - 1290'	
		1290 - 1300'	(2.5%)
Christina	Bear Biltmore No. 1	1324 - 1334'	(3.2%)
		1334 - 1344'	(2.9%)
		1394 - 1404'	(9.2%)
		1404 - 1414'	(7.0%)
	Bear Rodeo No. 1	209 - 219'	(12.5%)
		219 - 229'	
	Bear Westmount No. 1	904 - 911'	
		971 - 981'	(2.9%)
	Bear Westmount No. 2	46 - 62'	
		62 - 75'	

Calmut	Bear Biltmore No. 1	1414 - 1424' (4.6%)
	Bear Rodeo No. 1	269 - 280'
	Bear Rodeo No. 2	248 - 258' (4.2%)
	Bear Vampire No. 1	918 - 928'
	Bear Vampire No. 2	172 - 192'
		192 - 202' (4.3%)
		202 - 212' (2.1%)
		212 - 222' (4.0%)
		262 - 272'
	Bear Westmount No. 1	991 - 999'
		1039½- 1049'
Christina River		
Hardy No. 1		1510 - 1520' (8.6%)

Aechminella initialia n.sp.

Moberly	Bear Beaumont No. 1	2130 - 2144'

Aechminella middevonica n.sp.

Mildred Lake	Bear Beaumont No. 1	1843 - 1848'
		1898 - 1902'
Moberly	Bear Beaumont No. 1	2023 - 2033'
		2108 - 2118'
		2130 - 2144'

Aechminella trinodensa n.sp.

Mildred Lake	Bear Beaumont No. 1	1902 - 1908'
		1938 - 1942'
		2023 - 2033'
		2130 - 2144'
Christina	Bear Rodeo No. 1	209 - 219'
		269 - 280'
Calmut	Bear Vampire No. 1	918 - 928' (1.2%)
	Bear Westmount No. 1	991 - 999'

<u>Aechminella sp. A</u>, n.sp.			
	Moberly	Bear Vampire No. 2	92 - 102'
	Christina	Bear Westmount No. 2	75 - 78'
<u>Amphissites albertensi</u>	Loranger		
	Ireton	Bear Beaumont No. 1	1368 - 1383'
		Bear Biltmore No. 1	1114 - 1124'
<u>Amphissites beaumontensi</u>	Loranger		
	Ireton	Bear Beaumont No. 1	1147 - 1181' 1312 - 1325' 1368 - 1371' 1373 - 1383' 1413 - 1423'
		Bear Biltmore No. 1	539 - 549' 684 - 694'
	Mildred Lake	Bear Biltmore No. 1	1114 - 1124'
	Moberly	Bear Beaumont No. 1	1988 - 1998'
<u>Amphizona pseudocarinata</u>	Smith		
	Ireton	Bear Biltmore No. 1	502 - 518' 704 - 714'
<u>Aparchites</u> ? sp.			
	Ireton	Bear Beaumont	1139 - 1147' 954 - 964' (2.7%)
		Bear Biltmore No. 1	974 - 984' (1.3%)
	Calmut	Bear Vampire No. 1	968 - 988'
<u>Bairdia bartholomensis</u>	Stewart and Hendrix		
	Ireton	Bear Biltmore No. 1	568 - 598'
	Cooking Lake	Bear Biltmore No. 1	954 - 964'

Bairdia biltmorensa Loranger

Ireton	Angelus Ashmont No. 1	2165 - 2176' (1.9%)
	Bear Beaumont No. 1	1147 - 1181'
		1312 - 1325'
		1368 - 1371'
		1413 - 1423'
		1492 - 1502' (1.5%)
	Bear Biltmore No. 1	528 - 608'
		638 - 664'
		734 - 744' (2.9%)
		744 - 754' (15.4%)
		1074 - 1084'
		1094 - 1104' (3.0%)
Duvernay	Bear Beaumont No. 1	1699 - 1703'
Cooking Lake	Angelus Ashmont No. 1	2624 - 2634' (20.0%)
Mildred Lake	Bear Beaumont No. 1	1843 - 1848'
		1898 - 1902'
		1938 - 1942'
Moberly	Bear Westmount No. 1	904 - 911'
	Christina River Hardy No. 1	1239 - 1249' (1.9%)
		1249 - 1259'
		1280 - 1290'

Bairdia hypsoconcha Gibson

Moberly	Bear Biltmore No. 1	1032 - 1044'
		1064 - 1104'
		1154 - 1164'

Bairdia leguminoides Ulrich

Moberly	Christina River Hardy No. 1	1269 - 1280'

Bairdia midconstricta n.sp.

Ireton	Bear Beaumont No. 1	1147 - 1181'
	Bear Biltmore No. 1	549 - 598'

Moberly	Christina River Hardy No. 1	1239 - 1249'	
<u>Bairdia cf. pseudomagna</u> Stewart and Hendrix			
Ireton	Bear Beaumont No. 1	1147 - 1171'	
	Bear Biltmore No. 1	764 - 774'	
<u>Bairdia cf. subtilla</u> Gibson			
Moberly	Bear Beaumont No. 1	1948 - 1958'	
	Bear Biltmore No. 1	1304 - 1334'	
Christina	Bear Biltmore No. 1	1454 - 1464'	
<u>Bairdia</u> sp.			
Mildred Lake	Angelus Ashmont No. 1	2641 - 2645' 2995 - 3004'	(40.0%) (16.0%)
Moberly	Bear Biltmore No. 1	1134 - 1144' 1154 - 1164'	
	Bear Vampire No. 2	11 - 15' 39 - 48'	
Calmut	Bear Rodeo No. 1	269 - 280'	
Firebag	Bear Vampire No. 2	281 - 286' 312 - 322' 377 - 387' 419 - 429'	(3.6%) (2.8%) (5.4%) (5.9%)
	Bear Westmount No. 1	1206 - 1216'	
Methy Dolomite	Bear Vampire No. 1	2105 - 2115' 2125 - 2135'	(40.0%) (4.4%)
<u>Bekena sp. A</u>, n.sp.			
Ireton	Bear Beaumont No. 1	1368 - 1371' 1373 - 1383' 1699 - 1703'	
	Bear Biltmore No. 1	588 - 598' 618 - 628'	

Moberly	Bear Vampire No. 2	34 - 48' (3.2%)

Bicornellina ? sp. A, n.sp.

Ireton	Bear Beaumont No. 1	1334 - 1363'

Bollia sp.

Ireton	Bear Beaumont No. 1	1147 - 1181'
	Bear Biltmore No. 1	568 - 588'
		638 - 664'
		724 - 734'

Briartina cf. quenstedti (Gümbel)

Ireton	Bear Biltmore No. 1	694 - 704'

Bythocypris biltmorensis Loranger

Ireton	Bear Beaumont No. 1	1368 - 1371'
	Bear Biltmore No. 1	558 - 568'
		638 - 648'
		664 - 674'
Mildred Lake	Bear Biltmore No. 1	1064 - 1074'
Moberly	Bear Biltmore No. 1	1134 - 1144'
Christina	Bear Vampire No. 1	832 - 842'
Firebag	Bear Westmount No. 2	320 - 331'

Bythocypris mearnsa Loranger

Ireton	Bear Beaumont No. 1	1492 - 1502'
Moberly	Bear Beaumont No. 1	1948 - 1958'

Cavellina ovatiformis (Ulrich)

Ireton	Angelus Ashmont No. 1	2165 - 2178' (8.0%)
		2276 - 2282' (60.5%)

	Bear Beaumont No. 1	1091 - 1116' (40.7%)
		1139 - 1147' (78.8%)
		1147 - 1181'
		1312 - 1325' (24.9%)
		1334 - 1363' (76.3%)
		1371 - 1368' (87.7%)
		1373 - 1383' (47.08%)
		1413 - 1423' (59.9%)
		1492 - 1502' (44.0%)
		1542 - 1552' (41.1%)
		1582 - 1592' (50.0%)
		1632 - 1642' (40.5%)
	Bear Biltmore No. 1	502 - 518' (47.4%)
		518 - 529' (84.5%)
		529 - 539' (78.8%)
		539 - 549' (44.5%)
		549 - 558' (51.6%)
		558 - 568' (60.7%)
		568 - 588' (80.06%)
		588 - 598' (34.4%)
		598 - 608' (79.4%)
		608 - 618' (92.7%)
		618 - 628' (43.3%)
		628 - 638' (61.6%)
		664 - 674' (67.2%)
		674 - 684' (17.38%)
		684 - 694' (61.7%)
		694 - 704' (69.4%)
		704 - 714' (80.7%)
		714 - 724' (31.3%)
		724 - 734' (18.1%)
		734 - 744' (26.1%)
		744 - 754' (7.06%)
		754 - 764' (15.2%)
		764 - 774' (36.6%)
		774 - 784' (82.4%)
Duvernay	Bear Beaumont No. 1	1657 - 1659' (99.0%)
		1699 - 1703' (65.3%)
	Bear Biltmore No. 1	839 - 849' (10.0%)
Cooking Lake	Angelus Ashmont No. 1	2620 - 2623' (100%)
		2624 - 2634' (42.0%)

	Bear Biltmore No. 1	849 - 859' (53.7%)
		935 - 945' (29.4%)
		954 - 964' (35.0%)
Mildred Lake	Angelus Ashmont No. 1	2634 - 2641' (41.0%)
		2641 - 2645' (60.0%)
		2782 - 2784' (2.6%)
	Bear Beaumont No. 1	1808 - 1818' (29.4%)
		1838 - 1843' (38.6%)
		1843 - 1848' (15.2%)
		1898 - 1902' (3.7%)
		1902 - 1908' (36.2%)
	Bear Biltmore No. 1	984 - 994' (2.5%)
		994 - 1002' (3.4%)
		1002 - 1010' (25.3%)
		1010 - 1020'
		1032 - 1044' (22.2%)
		1064 - 1074' (2.8%)
		1084 - 1094' (52.6%)
		1094 - 1114' (33.0%)
		1114 - 1124' (82.6%)
Moberly	Bear Beaumont No. 1	1938 - 1942' (54.2%)
		1948 - 1958' (40.03%)
		1988 - 1998' (32.5%)
		2013 - 2021' (43.5%)
		2023 - 2033' (48.1%)
		2108 - 2118' (2.0%)
		2130 - 2144' (18.4%)
	Bear Biltmore No. 1	1124 - 1134' (31.4%)
		1134 - 1144' (26.5%)
		1154 - 1184' (30.3%)
		1184 - 1194' (23.9%)
		1254 - 1264'
		1304 - 1314' (97.1%)
		1314 - 1324' (69.1%)
	Bear Rodeo No. 1	103 - 109' (3.9%)
		119 - 129' (8.2%)
		129 - 139' (2.8%)
	Bear Rodeo No. 2	118 - 128' (15.4%)

		Bear Vampire No. 1	642 - 652' (2.5%)
			657 - 667'
			677 - 687' (1.9%)
			725 - 732' (34.2%)
		Bear Vampire No. 2	132 - 142' (40.9%)
		Christina River Hardy No. 1	1239 - 1249' (66.0%)
			1249 - 1259'
			1259 - 1269' (59.7%)
			1269 - 1280' (43.7%)
			1280 - 1290' (6.6%)
			1332 - 1338' (32.1%)
			1339 - 1349' (32.0%)
			1434 - 1444'
	Christina	Bear Biltmore No. 1	1324 - 1334' (5.1%)
			1334 - 1344' (6.0%)
			1344 - 1354' (26.3%)
			1354 - 1364'
			1364 - 1374' (79.0%)
		Bear Rodeo No. 1	139 - 149' (4.7%)
			149 - 159' (6.2%)
			209 - 219' (8.4%)
			219 - 229' (3.2%)
		Bear Vampire No. 1	832 - 842' (7.7%)
			852 - 862' (1.8%)
		Bear Vampire No. 2	162 - 172' (76.3%)
		Christina River Hardy No. 1	1444 - 1454' (20.0%)
			1454 - 1464' (71.0%)
			1464 - 1470' (41.7%)
			1470 - 1480' (3.8%)
			1480 - 1490' (37.3%)
			1490 - 1500' (13.4%)
			1500 - 1510' (75.0%)
	Calmut	Bear Biltmore No. 1	1404 - 1414' (73.4%)
			1414 - 1424' (23.6%)
			1484 - 1494' (69.1%)
			1504 - 1514' (60.0%)
		Bear Rodeo No. 1	269 - 280' (33.8%)
			280 - 291' (2.9%)

	Bear Rodeo No. 2	228 - 238' (10.0%)
	Bear Vampire No. 1	918 - 928' (1.2%) 958 - 968' (16.9%) 968 - 978' (11.0%) 978 - 988' (14.5%) 988 - 998' (11.4%)
	Bear Vampire No. 2	172 - 182' (58.7%) 182 - 192' (2.9%) 192 - 202' (70.0%) 202 - 212' (1.3%) 212 - 222' (6.4%) 222 - 232' (74.0%) 232 - 242'
	Bear Westmount No. 1	1004 - 1014½' 1039½- 1049' (4.0%) 1049 - 1059' (1.09%) 1059 - 1067' (1.77%)
	Bear Westmount No. 2	190 - 200' (1.4%) 210 - 220' (5.6%)
	Christina River	
	Hardy No. 1	1510 - 1520' (2.4%) 1540 - 1550' (3.7%) 1550 - 1560' (18.6%) 1590 - 1600' (1.9%)
Firebag	Bear Biltmore No. 1	1524 - 1534' (14.0%) 1534 - 1544' (20.4%) 1544 - 1554' (7.7%) 1554 - 1574' (50.5%) 1574 - 1584' (88.0%) 1584 - 1594' (15.7%) 1614 - 1624' (2.3%) 1624 - 1634' (4.1%)
	Bear Rodeo No. 1	311 - 321' (14.0%) 341 - 351' 361 - 372' (21.3%) 372 - 381' (5.3%) 422 - 430'

Bear Rodeo No. 2	388 - 398'	(3.8%)
	399 - 408'	(1.1%)
	418 - 428'	(29.4%)
Bear Vampire No. 1	1000 - 1010'	(9.4%)
	1018 - 1028'	(2.3%)
	1028 - 1038'	(20.0%)
	1038 - 1048'	(1.96%)
	1048 - 1058'	(3.1%)
	1088 - 1098'	
	1098 - 1108'	(1.1%)
	1118 - 1128'	(12.5%)
	1128 - 1138'	
	1148 - 1158'	(9.5%)
	1158 - 1168'	(93.3%)
Bear Vampire No. 2	262 - 272'	(17.7%)
	272 - 281'	(2.6%)
	281 - 286'	(3.4%)
	304 - 308'	
	308 - 312'	
	312 - 322'	(1.2%)
	342 - 352'	(22.0%)
	367 - 372'	(2.9%)
	377 - 387'	(9.2%)
Bear Westmount No. 1	1079 - 1089'	(6.3%)
	1098 - 1104'	(18.5%)
	1124½- 1135'	(53.5%)
	1194 - 1206'	(73.0%)
	1221 - 1231'	(1.4%)
	1251 - 1262'	(6.4%)
Christina River		
Hardy No. 1	1600 - 1610'	(1.2%)
	1620 - 1630'	
	1630 - 1640'	(1.5%)
	1650 - 1660'	(3.0%)
	1660 - 1667'	(17.3%)
	1687 - 1700'	(6.1%)
	1700 - 1710'	(4.3%)
	1710 - 1720'	(14.8%)
	1730 - 1740'	(2.9%)
	1750 - 1760'	(20.0%)
	1770 - 1780'	(79.0%)
	1790 - 1800'	(1.9%)

Elk Point	Angelus Ashmont No. 1	2995 - 3004'	(34.7%)
		3200 - 3205'	(12.5%)
		3213 - 3222'	(4.0%)
	Bear Vampire No. 2	436 - 446'	(25.0%)
	Bear Westmount No. 2	429 - 439'	
	Christina River Hardy No. 1	1820 - 1830'	(100%)
Methy Dolomite	Bear Vampire No. 1	2105 - 2115'	(10.77%)
		2125 - 2135'	(15.6%)
	Bear Vampire No. 2	817 - 829'	(13.4%)
	Bear Westmount No. 1	1429 - 1439'	
<u>Cavellina</u> sp. n.sp.			
Duvernay	Bear Beaumont No. 1	1657 - 1659'	(99.0%)
		1692 - 1703'	
Cooking Lake	Bear Beaumont No. 1	1808 - 1818'	
Christina	Bear Biltmore No. 1	1404 - 1414'	
	Bear Westmount No. 1	1251 - 1262'	
	Bear Westmount No. 2	382½- 393'	(2.0%)
	Christina River Hardy No. 1	1770 - 1780'	(5.2%)
		1790 - 1800'	(3.7%)
Elk Point	Bear Westmount No. 2	429 - 439'	
		449 - 459'	
	Christina River Hardy No. 1	1860 - 1867'	
<u>Cooperatia biltmorensa</u> (Loranger)			
Ireton	Bear Beaumont No. 1	1147 - 1148'	(1.2%)
		1312 - 1334'	(1.4%)
		1334 - 1363'	
		1373 - 1383'	(1.3%)
		1413 - 1423'	
		1492 - 1502'	

	Bear Biltmore No. 1	518 - 528'	(3.5%)
		529 - 539'	(5.8%)
		539 - 549'	(6.4%)
		549 - 558'	(9.9%)
		558 - 568'	(7.7%)
		568 - 588'	(2.5%)
		588 - 598'	(2.9%)
		598 - 608'	(3.6%)
		608 - 618'	
		618 - 628'	(7.2%)
		628 - 638'	(2.6%)
		638 - 664'	(1.1%)
		664 - 674'	(1.03%)
		674 - 684'	(1.08%)
		684 - 694'	
		704 - 724'	
		724 - 734'	(6.4%)
		734 - 744'	(1.4%)
		744 - 754'	(30.8%)
		754 - 764'	(21.4%)
		774 - 784'	(1.2%)
Duvernay	Angelus Ashmont No. 1	2403 - 2416'	
	Bear Beaumont No. 1	1699 - 1703'	
Cooking Lake	Bear Beaumont No. 1	1808 - 1818'	(2.0%)
	Bear Biltmore No. 1	915 - 925'	(13.5%)
Mildred Lake	Angelus Ashmont No. 1	2634 - 2641'	(40.0%)
	Bear Beaumont No. 1	1843 - 1848'	
		1898 - 1902'	
	Bear Biltmore No. 1	1032 - 1044'	
		1084 - 1094'	
		1114 - 1124'	(1.8%)
		1124 - 1134'	(7.6%)
		1134 - 1144'	
		1154 - 1164'	(21.0%)
Moberly	Bear Beaumont	1938 - 1942'	
		1988 - 1998'	(9.0%)
		2023 - 2033'	

		Bear Vampire No. 1	642 - 652' (1.7%) 725 - 732'
		Bear Westmount No. 1	904 - 914'
		Christina River Hardy No. 1	1239 - 1249' (6.5%) 1249 - 1259' (1.1%) 1259 - 1269' 1269 - 1280' (4.3%) 1280 - 1290' 1290 - 1300'
	Calmut	Bear Biltmore No. 1	1484 - 1494' (4.2%)
		Bear Vampire No. 1	978 - 988'
	Firebag	Bear Biltmore No. 1	1584 - 1594'
		Bear Westmount No. 1	1098 - 1104' 1185 - 1194' 1206 - 1216' (1.4%)
		Christina River Hardy No. 1	1790 - 1800'
<u>Eukloedenella</u> sp.			
	Ireton	Bear Beaumont No. 1	1091 - 1116' (4.1%)
		Bear Biltmore No. 1	568 - 598' 628 - 664' 704 - 714' 734 - 744' 984 - 994'
	Moberly	Bear Beaumont No. 1	1988 - 1998'
		Bear Biltmore No. 1	1114 - 1128'
	Calmut	Bear Vampire No. 1	918 - 928'
	Firebag	Bear Rodeo No. 1	331 - 341'
		Christina River Hardy No. 1	1790 - 1800'

<u>Glyptopleura sp.</u>			
	Ireton	Bear Beaumont No. 1	1147 - 1181'
	Moberly	Bear Beaumont No. 1	1938 - 1942'
<u>Halliella bellipuncta</u>	(Van Pelt)		
	Ireton	Bear Beaumont No. 1	1312 - 1325'
			1334 - 1363'
			1368 - 1371'
			1373 - 1383'
		Bear Biltmore No. 1	502 - 518'
			558 - 588'
			598 - 618'
			674 - 694'
			694 - 704' (1.8%)
	Cocking Lake	Bear Beaumont No. 1	1808 - 1815' (1.2%)
	Mildred Lake	Bear Beaumont No. 1	1843 - 1848'
			1902 - 1908'
		Bear Biltmore No. 1	994 - 1002'
			1064 - 1074'
	Moberly	Bear Beaumont No. 1	1938 - 1942'
			1948 - 1958'
		Bear Rodeo No. 1	129 - 139'
		Bear Vampire No. 1	812 - 822' (1.3%)
		Christina River Hardy No. 1	1239 - 1280'
	Christina	Bear Biltmore No. 1	1354 - 1364'
		Bear Rodeo No. 1	209 - 219' (9.8%)
			219 - 229'
		Bear Westmount No. 2	46 - 75'

Calmut	Bear Biltmore No. 1	1504 - 1514'	
	Bear Rodeo No. 1	269 - 280'	
	Bear Rodeo No. 2	248 - 259'	(2.3%)
	Bear Vampire No. 1	918 - 928'	
		978 - 988'	
	Bear Vampire No. 2	212 - 222'	(6.0%)
		232 - 242'	
	Bear Westmount No. 1	1049 - 1059'	
	Christina River		
	Hardy No. 1	1510 - 1520'	
		1590 - 1600'	(1.7%)
Firebag	Bear Biltmore No. 1	1554 - 1574'	
	Bear Vampire No. 1	1088 - 1098'	
	Bear Vampire No. 2	436 - 446'	(1.4%)
	Christina River		
	Hardy No. 1	1660 - 1667'	
		1710 - 1720'	

<u>Hypotetragona albertensa n.sp.</u>

Moberly	Bear Beaumont No. 1	2023 - 2033'	(11.5%)
		2130 - 2144'	(70.0%)
	Bear Biltmore No. 1	1304 - 1314'	(1.0%)
		1314 - 1324'	(2.8%)
	Bear Rodeo No. 1	129 - 139'	
	Christina River		
	Hardy No. 1	1332 - 1338'	(4.9%)
		1434 - 1444'	(2.6%)
Christina	Bear Biltmore No. 1	1324 - 1334'	(1.9%)
		1344 - 1354'	(1.2%)
		1354 - 1364'	(1.7%)
		1404 - 1414'	

	Bear Westmount No. 1	971 - 981'	(2.9%)
	Christina River Hardy No. 1	1480 - 1490'	(9.2%)
Calmut	Bear Westmount No. 1	1039½- 1049'	
	Christina River Hardy No. 1	1510 - 1520'	(43.0%)

Hypotetragona beaumontensa (Loranger)

Ireton	Bear Beaumont No. 1	1373 - 1383'	
	Bear Biltmore No. 1	1154 - 1164'	

Hypotetragona sp.

Ireton	Bear Beaumont No. 1	1334 - 1363'	
	Bear Biltmore No. 1	539 - 549'	
Moberly	Bear Biltmore No. 1	1154 - 1164'	
Firebag	Bear Biltmore No. 1	1524 - 1534'	(26.0%)
	Bear Westmount No. 1	1098 - 1104'	
		1124½- 1135'	

Kirkbya biltmorensa Loranger

Ireton	Bear Beaumont No. 1	1147 - 1181'	
		(Broken specimens)	
		1312 - 1363'	
		1373 - 1383'	
		1413 - 1423'	
	Bear Biltmore No. 1	539 - 549'	
		558 - 568'	(6.6%)
		568 - 588'	
		588 - 598'	
		628 - 664'	
		684 - 694'	
		694 - 704'	(1.8%)
		704 - 714'	

	Duvernay	Bear Beaumont No. 1	1699 - 1703'
	Mildred Lake	Bear Beaumont No. 1	1808 - 1818' (2.4%) 1843 - 1848' 1898 - 1902' 1902 - 1908' (1.8%)
		Bear Biltmore No. 1	1032 - 1044' 1064 - 1074'
	Moberly	Bear Beaumont No. 1	1938 - 1942' 1948 - 1958' 1988 - 1998'
		Bear Biltmore No. 1	1114 - 1124' 1124 - 1134' (7.8%) 1134 - 1144'
		Bear Rodeo No. 1	129 - 139'
		Bear Vampire No. 1	812 - 822'
		Christina River	
		Hardy No. 1	1239 - 1249' 1269 - 1280' 1290 - 1300'
	Christina	Bear Biltmore No. 1	1314 - 1324' (5.9%) 1324 - 1334' 1334 - 1344' 1364 - 1374' (13.2%)
		Bear Rodeo No. 1	209 - 219' (9.02%) 219 - 229'
	Calmut	Bear Rodeo No. 2	249 - 259'
		Bear Vampire No. 1	1018 - 1028'
	Firebag	Bear Vampire No. 2	304 - 312'
		Bear Westmount No. 1	1098 - 1104' 1185 - 1194' (1.9%) 1221 - 1231'
		Bear Westmount No. 2	240 - 251'

Kloedenella rodensa n.sp.

Calmut	Bear Rodeo No. 1	280 - 291'
	Bear Vampire No. 1	918 - 928'
		978 - 988'
		988 - 998' (7.9%)
	Bear Vampire No. 2	182 - 192'
		192 - 202' (3.2%)
Firebag	Bear Biltmore No. 1	1544 - 1554' (4.6%)
		1554 - 1574' (43.8%)
		1574 - 1584' (7.8%)
		1584 - 1594'
	Bear Rodeo No. 1	321 - 331'
		331 - 341' (12.2%)
		341 - 351'
		361 - 372'
		411 - 422' (5.6%)
		422 - 430'
	Bear Vampire No. 1	1008 - 1018'
		1018 - 1028' (2.2%)
		1028 - 1038' (1.6%)
		1038 - 1058'
		1088 - 1098'
		1098 - 1108' (3.3%)
		1148 - 1158' (3.1%)
	Bear Vampire No. 2	262 - 281'
		312 - 322' (2.5%)
		377 - 387' (5.4%)
		419 - 429' (1.5%)
		436 - 446' (6.8%)
	Bear Westmount No. 1	1039 - 1049'
		1124½- 1135'
		1185 - 1194'
Christina River		
Hardy No. 1		1620 - 1630'
		1667 - 1677'
		1820 - 1830' (2.3%)

Knoxina kinsella (Loranger)

Ireton	Angelus Ashmont No. 1	2165 - 2176'	
	Bear Beaumont No. 1	1091 - 1116'	
		1147 - 1181'	(2.8%)
		1312 - 1325'	(1.6%)
		1368 - 1371'	
		1373 - 1383'	
		1413 - 1423'	(4.5%)
		1542 - 1552'	(35.3%)
	Bear Biltmore No. 1	502 - 529'	
		529 - 539'	(6.4%)
		539 - 549'	(3.5%)
		549 - 558'	(1.7%)
		558 - 568'	(9.6%)
		568 - 588'	(1.0%)
		588 - 598'	(2.9%)
		598 - 608'	(3.6%)
		608 - 618'	
		618 - 628'	(7.2%)
		628 - 638'	(2.6%)
		638 - 664'	(1.6%)
		664 - 674'	(3.5%)
		674 - 684'	
		684 - 694'	
		694 - 704'	(9.5%)
		704 - 714'	(1.06%)
		714 - 724'	(31.2%)
		724 - 734'	(6.4%)
		734 - 744'	(5.8%)
		754 - 764'	(21.0%)
		764 - 774'	(28.6%)
		774 - 784'	
Duvernay	Bear Beaumont No. 1	1699 - 1703'	(4.5%)
Cooking Lake	Bear Beaumont No. 1	1808 - 1818'	(7.3%)
	Bear Biltmore No. 1	915 - 925'	(22.5%)
		954 - 964'	(58.1%)
		974 - 984'	(45.5%)

	Mildred Lake	Bear Beaumont No. 1	1843 - 1848' (38.2%) 1898 - 1902'
		Bear Biltmore No. 1	984 - 994' (5.5%) 994 - 1002' 1002 - 1010' 1010 - 1020'
	Moberly	Bear Beaumont No. 1	1938 - 1942' 1948 - 1958'
		Bear Biltmore No. 1	1124 - 1134' (1.3%) 1154 - 1164' (7.0%) 1184 - 1194'
		Bear Rodeo No. 1	119 - 129'
		Bear Vampire No. 2	38 - 48' (1.6%) 82 - 92' (1.7%)
	Christina River Hardy No. 1		1239 - 1249' (5.4%) 1249 - 1259' (9.5%) 1259 - 1269' 1269 - 1280' (6.8%) 1280 - 1290' 1290 - 1300' (22.3%)
	Beaverhill Lake	Angelus Ashmont	2995 - 3004' 3205 - 3213' (1.0%)
	Christina	Bear Westmount No. 1	904 - 911'
<u>Krausella albertensa</u> n.sp.			
	Ireton	Bear Beaumont No. 1	1373 - 1383'
		Bear Biltmore No. 1	558 - 598' 598 - 608' 638 - 664' 664 - 684'
	Duvernay	Bear Beaumont No. 1	1699 - 1703'
	Mildred Lake	Bear Biltmore No. 1	1064 - 1074'

<u>Krausella</u> sp.

Ireton	Bear Biltmore No. 1	539 - 549'
		638 - 664'
		724 - 734'

<u>Limbinaria navicularia</u> n.sp.

Ireton	Bear Beaumont No. 1	1334 - 1344'
Moberly	Bear Beaumont No. 1	2023 - 2033'
		2130 - 2144'
Christina	Bear Westmount No. 2	62 - 75'

<u>Macrocypris albertensis</u> (Loranger)

Ireton	Angelus Ashmont No. 1	2165 - 2176'
	Bear Beaumont No. 1	1091 - 1112'
		1147 - 1181'
		1334 - 1363'
	Bear Biltmore No. 1	518 - 558'
		638 - 664'
		664 - 674'
		684 - 694'
		724 - 734'
		774 - 784' (3.1%)
Cooking Lake	Bear Biltmore No. 1	915 - 925' (1.2%)
Mildred Lake	Bear Beaumont No. 1	1902 - 1908'
		1948 - 1958'
		1988 - 1998'
	Bear Biltmore No. 1	1032 - 1044'
		1064 - 1074'
		1114 - 1124'
Moberly	Bear Biltmore No. 1	1124 - 1134'
		1154 - 1164'
	Bear Rodeo No. 1	119 - 129' (1.7%)

	Bear Vampire No. 1	725 - 732'	
		812 - 822'	
	Christina River Hardy No. 1	1259 - 1269'	
Christina	Bear Biltmore No. 1	1334 - 1354'	
	Bear Westmount No. 1	921 - 931'	(1.4%)
Calmut	Christina River Hardy No. 1	1590 - 1600'	(1.7%)
Firebag	Bear Biltmore No. 1	1524 - 1534'	(16.6%)
	Bear Vampire No. 1	1028 - 1038'	
	Bear Westmount No. 2	320 - 331'	

Macrocypris ? sp. A, n.sp.?

Ireton	Bear Biltmore No. 1	714 - 724'	
Duvernay	Bear Beaumont No. 1	1657 - 1659'	

Macronotella biltmorensa Loranger

Ireton	Bear Beaumont No. 1	1368 - 1383'	
		1413 - 1423'	
		1492 - 1502'	
	Bear Biltmore No. 1	502 - 518'	(1.9% pyritized)
		674 - 684'	(2.0%)
		684 - 694'	(1.7%)
		694 - 704'	(2.4%)
		704 - 714'	
		774 - 784'	
		786 - 797'	
Duvernay	Bear Beaumont No. 1	1699 - 1703'	
		1808 - 1818'	(3.7%)
		1898 - 1908'	
		1948 - 1958'	

Mauryella sp. A., n.sp.

Duvernay	Bear Beaumont No. 1	1699 - 1702'
Mildred Lake	Bear Beaumont No. 1	1843 - 1848'
Moberly	Christina River Hardy No. 1	1239 - 1259' 1269 - 1280' 1290 - 1300'

Monoceratella sp. A, n.sp.

Ireton	Bear Beaumont No. 1	1147 - 1181'

Monoceratina albertensa n.sp.

Ireton	Angelus Ashmont No. 1	2165 - 2176'
	Bear Biltmore No. 1	638 - 664'

Monoceratina scottia n.sp.

Moberly	Bear Beaumont No. 1	1948 - 1958'
	Bear Biltmore No. 1	1084 - 1094' 1124 - 1134'
	Christina River Hardy No. 1	1259 - 1269'

Neopribylites albertensis Loranger

Ireton	Bear Beaumont No. 1	1147 - 1181'
Mildred Lake	Bear Biltmore No. 1	1064 - 1084' 1134 - 1140'
Moberly	Christina River Hardy No. 1	1249 - 1259'

Phlyctiscapha sp.

Ireton	Bear Biltmore No. 1	549 - 558'

<u>Plagionephrodes biltmorensus</u> Loranger

Ireton	Angelus Ashmont No. 1	2995 - 3004' (2.4%)
	Bear Beaumont No. 1	1147 - 1181'
		1368 - 1371'
		1492 - 1502' (4.0%)
		1632 - 1642' (22.0%)
	Bear Biltmore No. 1	502 - 518'
		588 - 598'
		598 - 618'
		638 - 664' (1.5%)
		664 - 674'
		674 - 684' (4.2%)
		704 - 714' (2.4%)
		774 - 784'
Mildred Lake	Bear Beaumont No. 1	2023 - 2033'
	Bear Westmount No. 1	904 - 910'
	Bear Westmount No. 2	46 - 62' (6.0%)
		62 - 75' (2.5%)
		75 - 78' (3.7%)
	Christina River Hardy No. 1	1239 - 1269' (1.0%)
		1290 - 1300' (1.3%)
		1470 - 1510' (1.2%)

<u>Plagionephrodes pseudomorpheus</u> n.sp.

Moberly	Bear Vampire No. 2	58 - 68' (2.2%)
		82 - 92' (7.2%)
Christina	Bear Biltmore No. 1	1334 - 1354'
		1354 - 1364' (6.1%)
		1364 - 1374' (6.4%)
		1374 - 1404' (6.6%)
	Bear Rodeo No. 1	209 - 219' (23.9%)
		219 - 229'

	Bear Vampire No. 1	832 - 842' (2.8%)
		852 - 862' (1.4%)
		918 - 928' (1.4%)
	Christina River Hardy No. 1	1480 - 1490' (1.5%)
		1490 - 1500' (8.7%)
Calmut	Bear Biltmore No. 1	1414 - 1424' (1.7%)
	Bear Rodeo No. 1	269 - 291'
	Bear Rodeo No. 2	249 - 259' (3.9%)
		269 - 280'
	Bear Vampire No. 1	958 - 968' (2.7%)
		968 - 978' (1.7%)
		978 - 988'
	Bear Vampire No. 2	182 - 192' (2.2%)
		212 - 222'
		222 - 232' (4.0%)
		232 - 242'
	Bear Westmount No. 1	991 - 999'
		1039½- 1069'
	Bear Westmount No. 2	190 - 200' (1.3%)
		210 - 220'
	Christina River Hardy No. 1	1510 - 1520' (2.2%)
		1590 - 1600' (1.7%)
Firebag	Bear Biltmore No. 1	1544 - 1554' (7.7%)
		1554 - 1574' (6.3%)
		1574 - 1584' (9.8%)
		1584 - 1594' (2.8%)
		1614 - 1624' (2.5%)
	Bear Rodeo No. 1	311 - 327' (5.9%)
		321 - 331' (1.5%)
		331 - 341'
		341 - 351' (1.2%)
		361 - 372' (1.7%)

	Bear Vampire No. 1	988 - 998' (3.9%) 1008 - 1018' (1.6%) 1038 - 1048' 1088 - 1098'
	Bear Vampire No. 2	262 - 272' 281 - 286' (8.0%) 304 - 308' 312 - 322' (2.5%)
	Bear Westmount No. 1	1124 - 1134'
	Bear Westmount No. 2	240 - 262' 320 - 331'
Christina	Christina River Hardy No. 1	1620 - 1630' 1650 - 1660' 1660 - 1670' (20.0%) 1687 - 1700' (3.2%) 1710 - 1720' (5.3%)

Plagionephrodes spinosus n.sp.

Mildred Lake	Bear Beaumont No. 1	1843 - 1848' 1898 - 1902' (9.8%) 1902 - 1908' (4.0%)
	Bear Biltmore No. 1	1032 - 1044' 1064 - 1074' (4.1%) 1074 - 1094'
Moberly	Bear Beaumont No. 1	1938 - 1942' (5.7%) 1948 - 1958' (4.4%) 1988 - 1998' 2023 - 2033'
	Bear Biltmore No. 1	1124 - 1134' (2.5%) 1134 - 1144' (1.5%) 1254 - 1264' (8.0%)
	Bear Rodeo No. 1	119 - 129' (4.1%) 129 - 139'

		Bear Vampire No. 1	642 - 652' (2.4%)
			657 - 667'
			725 - 732'
			812 - 822' (1.3%)
		Bear Vampire No. 2	38 - 45'
			58 - 68' (1.9%)
			82 - 92' (7.2%)
		Bear Westmount No. 1	904 - 911'
		Christina River Hardy No. 1	1239 - 1249' (3.7%)
			1249 - 1259' (1.4%)
			1259 - 1269' (3.4%)
			1269 - 1280' (2.1%)
			1290 - 1300'
	Christina	Bear Biltmore No. 1	1354 - 1364'
		Bear Rodeo No. 1	139 - 149' (1.6%)
			149 - 159' (4.8%)
		Bear Westmount No. 2	46 - 62' (4.0%)
			62 - 75' (4.0%)
	Beaverhill Lake	Angelus Ashmont No. 1	2995 - 3004' (30.0%)
<u>Platyrhomboides albertensus</u> n.sp.			
	Ireton	Bear Biltmore No. 1	502 - 518'
			529 - 588'
	Mildred Lake	Bear Biltmore No. 1	114 - 124'
<u>Ponderodictya sp. A</u>, n.sp.			
	Ireton	Bear Beaumont No. 1	1139 - 1142'
			1334 - 1363'
	Moberly	Bear Biltmore No. 1	1124 - 1134'
		Christina River Hardy No. 1	1239 - 1249'

<u>Rothella vampirensa</u> n.sp.			
Calmut member	Bear Biltmore No. 1	1484 - 1494'	(2.0%)
	Bear Rodoe No. 1	280 - 290'	
	Bear Vampire No. 1	988 - 998'	
	Bear Vampire No. 2	172 - 192'	
		192 - 202'	(1.0%)
		212 - 222'	
	Bear Westmount No. 1	1039½- 1049'	
	Bear Westmount No. 2	240 - 251'	
Firebag	Bear Vampire No. 1	1008 - 1018'	
<u>Roundyella sp. A</u>, n.sp.			
Ireton	Bear Biltmore No. 1	588 - 598'	
		684 - 694'	
<u>Thrallella reticulata</u> n.sp.			
Ireton	Bear Biltmore No. 1	664 - 674'	
		674 - 714'	
		774 - 784'	
		786 - 797'	
<u>Westmountia mcmurraiensa</u> n.g., n.sp.			
Moberly	Bear Beaumont No. 1	2130 - 2144'	(6.93%)
	Bear Rodeo No. 1	119 - 129'	
	Christina River Hardy No. 1	1239 - 1249'	
Christina	Bear Biltmore No. 1	1334 - 1354'	
	Bear Westmount No. 2	46 - 62'	(37.0%)
Calmut	Bear Biltmore No. 1	1414 - 1424'	(1.4%)

Winchellatia cf. deminuta Kesling and Tabor

	Moberly	Christina River Hardy No. 1	1339 - 1349'

Youngiella devonica n.sp.

	Ireton	Angelus Ashmont No. 1	2165 - 2175'
		Bear Beaumont No. 1	1147 - 1181'
			1312 - 1325'
			1334 - 1363'
			1368 - 1371'
		Bear Biltmore No. 1	539 - 588'
			588 - 608'
			618 - 664'
			664 - 674' (1.5%)
			674 - 684'
			704 - 724'
			764 - 774' (4.1%)
			774 - 784'
	Cooking Lake	Bear Beaumont No. 1	1413 - 1423'
		Bear Biltmore No. 1	915 - 925' (1.01%)
	Mildred Lake	Bear Beaumont No. 1	1902 - 1908'
		Bear Biltmore No. 1	994 - 1002' (1.05%)
			1032 - 1044'
			1114 - 1124'
	Moberly	Bear Beaumont No. 1	1938 - 1942'
			1948 - 1958'
			1988 - 1998'
			2023 - 2033'
		Bear Rodeo No. 1	119 - 139'
			209 - 219'. (1.9%)
		Bear Vampire No. 1	812 - 822' (3.3%)
		Bear Westmount No. 1	904 - 911'

	Christina River		
	Hardy No. 1	1239 - 1259'	
		1259 - 1269'	(1.1%)
		1269 - 1280'	
		1280 - 1300'	
Christina	Bear Biltmore No. 1	1314 - 1324'	(2.9%)
		1324 - 1334'	(1.9%)
	Bear Westmount No. 1	941 - 951'	(9.0%)
		971 - 981'	(55.7%)
	Bear Westmount No. 2	46 - 62'	
	Christina River		
	Hardy No. 1	1454 - 1464'	(15.7%)
		1464 - 1470'	(8.3%)
Calmut	Angelus Ashmont No. 1	3213 - 3222'	(1.9%)
	Bear Biltmore No. 1	1464 - 1474'	(50.0%)
	Bear Rodeo No. 1	269 - 280'	
	Bear Rodeo No. 2	249 - 259'	
	Bear Vampire No. 1	978 - 988'	
	Bear Vampire No. 2	212 - 222'	(4.9%)
		232 - 242'	
	Bear Westmount No. 1	991 - 999'	
		1039½- 1049'	
		1049 - 1059'	
	Bear Westmount No. 2	190 - 200'	
Firebag	Bear Biltmore No. 1	1524 - 1534'	(5.5%)
		1614 - 1624'	(1.5%)
	Bear Rodeo No. 1	341 - 351'	(4.3%)
		361 - 372'	(1.8%)
		372 - 381'	(62.0%)
		411 - 422'	(7.0%)
	Bear Rodeo No. 2	388 - 398'	
		398 - 403'	(13.5%)

	Bear Vampire No. 1	1008 - 1018'	
		1018 - 1028'	(1.7%)
		1028 - 1038'	
		1058 - 1068'	
		1098 - 1108'	(9.2%)
		1118 - 1128'	
	Bear Vampire No. 2	262 - 272'	
		272 - 281'	
		281 - 286'	(1.0%)
		304 - 308'	
	Bear Westmount No. 1	1098 - 1104'	
		1124½- 1135'	
		1185 - 1194'	(9.0%)
		1251 - 1262'	
	Bear Westmount No. 2	240 - 251'	
		251 - 262'	
		320 - 331'	
		341 - 352'	(37.0%)

Youngiella elongatensa n.sp.

Ireton	Bear Biltmore No. 1	549 - 568'	
		618 - 638'	
Moberly	Bear Biltmore No. 1	1304 - 1314'	
	Bear Rodeo No. 1	103 - 109'	(1.2%)
		119 - 129'	(1.2%)
Firebag	Bear Rodeo No. 1	372 - 381'	
		411 - 422'	
	Bear Vampire No. 1	1118 - 1128'	
	Bear Westmount No. 1	1039½- 1049'	
		1049 - 1059'	
		1124½- 1135'	
		1185 - 1194'	(2.1%)
	Bear Westmount No. 2	320 - 330'	

POLYZOA (BRYOZOA)

Polyzoa sp. A

Ireton	Bear Beaumont No. 1	1091½- 1116' (21.0%)
		1139 - 1147' (1.1%)
		1312 - 1325'
		1368 - 1371'
		1373 - 1383'
	Bear Biltmore No. 1	502 - 518' (5.6%)
		568 - 588'
		588 - 598'
		608 - 618'
		674 - 684'
		684 - 694'
		714 - 724'
		774 - 786'
Duvernay	Bear Beaumont No. 1	1699 - 1703'
Moberly	Bear Rodeo No. 2	118 - 128' (4.97%)
	Bear Beaumont No. 1	1948 - 1958'
	Bear Westmount No. 2	46 - 62' (4.1%)
		62 - 75'
		75 - 78' (1.7%)
	Christina River Hardy No. 1	1269 - 1280' (5.4%)
Christina	Bear Rodeo No. 1	139 - 149'
		209 - 219' (5.4%)
		219 - 229'
		280 - 291'
	Bear Vampire No. 1	852 - 862' (14.3%)
	Christina River Hardy No. 1	1470 - 1490'
Calmut	Bear Rodeo No. 2	248 - 259'
	Bear Westmount No. 1	991 - 999'

		Christina River Hardy No. 1	1510 - 1520'
	Firebag	Bear Rodeo No. 1	361 - 372'
		Bear Westmount No. 2	240 - 251'
<u>Polyzoa sp. B</u>			
	Ireton	Bear Biltmore No. 1	502 - 518'
			568 - 588'
			588 - 598'
			608 - 618'
			674 - 684'
			684 - 694'
			714 - 724'
			774 - 786'
	Moberly	Bear Rodeo No. 1	129 - 139'
		Bear Rodeo No. 2	118 - 128'
		Bear Vampire No. 1	812 - 822'
		Christina River Hardy No. 1	1259 - 1269'
	Christina	Christina River Hardy No. 1	1470 - 1490'
	Calmut	Bear Rodeo No. 2	249 - 259'
		Bear Vampire No. 2	212 - 222' (8.9%)
		Christina River Hardy No. 1	1510 - 1520'
	Firebag	Bear Vampire No. 2	262 - 272'

TABLE 1 SUMMARY CHAROPHYTA ECOLOGY

* R= Rarely
C= Common
A= Abundant

	Andrews 1947	Branson 1922, 1944	Chapman 1941	Chapman 1960	Conard 1951	Croft 1952	Cummings 1932	Fassett 1940	Fenton 1919	Groves Bullock Webster 1920	Hecker 1935	Hecker 1941	Hesse, Allee, Schmidt 1949	Karpinsky 1906	Johnson 1945	Johnson 1957	Jones 1956	Leroy 1951	Lu 1948	Pearse 1939	Peck 1934	Pia 1937	Schemper 1903	Sewart 1931	Shimer & Shrock 1944
Depth at surface					X					6 35' Var.															
Salinity Estuarine										X															
Ponds, lakes											X	X													
Fresh		X		X		X					X	X													
Brackish		X		?		?				<1%															
Marine		X		0.5%		?							X	R											
Shallow	X	X						X						X		X									
Littoral	X	X		p				X									X	X							
Near shore	X			0.																					
Salt lagoon										X	X														
Temperature Arctic										L															
Cool temperate										C															
Warm "										A															
Turbidity Pronounced																									
Calm, undisturbed		X								X						X									
Warer circulation																									
Running		X				X				x	X														
Normal										X						X									
Stagnant																									
Substrate SD SDST		X												X		X									
Mud SH		X												X											
Limestone, marl									X																
Basal deposits advancing or retreating seas																									
Forms Limestone																									
Reefs	X						X									X									
Living	X		X	X	X	X				X						X									
Fossil Fossil		X				X			X		X	X		X											
Trochiliscus		X				X			X			X		X											
Sycidium		X				X								X											
Associated forms																									
1) Ostracodes						X						X													
2) Fish remains						X						Y													
3) Vascular land plants																									
4) Corals																									
5) Chlorophyta (green algae)																									
6) Endothy 7) Crinoids																									
8) Brachiopods																									

* provides food for animals
* photic limit

TABLE 3

BRACHIOPODA
(General)
ECOLOGY

	Ager 1956	Cooper 1937	Cooper 1957	Dubois 1916	Fenton 1932	Greiner 1957	Helmcke 1939	Johnson & Snook 1927	Jones 1956	Lamont 1934	Moore, Lalicker, Fischer, 1952	Muir-Wood & Cooper 1960	Ruedemann 1934	Shrock & Twenhofel 1953	Sverdrup 1942	Twenhofel 1950	Yakelova 1926
Environmental factors																	
Littoral						X											
Sublittoral						X											
Depth Shallow	X						to 5000 m.	X			100 ft.		X	60% shallow.	40 m		
Near shore	X													H.T. to 20 mfs.			
Brackish *																	
Salinity Marine	X	X		X	X	X	X	X	X		X		X	X X	X	X	X
Not influential						X	X		X								
Temperature																	
Arctic														X X			
Temperate											X X						
Tropical											X			X			
Not influential							X										
Sedimentation																	
Substrate Sd	X						X		X					X			
Muds	X								X			X		X			
Lime									X								
Habitat																	
Free moving														X			
Burrowing							X							X			
Sessile								X						X			
Pelagic (larvae)							X							X			
Benthonic								X						X			
Influence shell form	X	X	X		X				X								
Symbiotic																	X
Parasitic				X													
Associated																	
1. Aulopora																	X
2. Gastropod				X													

* less than normal marine salinities

TABLE 4

SUMMARY

LINGULA

ECOLOGY

	Allan 1936	Ashworth 1918	Burton 1954	Chuang 1956	Cook 1957	Cooper 1936-7	Cooper 1957	Elias 1937	Foreman 1959	Hall & Sardeson 1892	Helmcke 1939	Morse 1903	Nomura & Hatai 1936	Pearse 1939	Ruedemann 1934	Schuchert 1911	Shimakura & Matai 1939	Shrock & Twenhofel 1953	Thomas 1937	Twenhofel 1950
Intertidal flats																				
Depth Low tide mark	↓	X																		
Shallow	10fa.	7m.			4 to 117fa	30fa		X	X		X			X		X	X	X→ 10 fa	47m	X
Littoral						31fa						X	X		X		X			
Shoreline indicators					X											X				
Deep water																				
Salinity fresh																				
Brackish																				X
Marine																				
Temperature																				
Cool																				
Warm temperate	X											X				X	X			
Tropical	X																			
Turbidity Clear water													X							
Turbid																				
Water circulation																				
Normal							X													X
Foul, stagnant										X				X	X		X			
Substrate Sands, silts										X	X						X			
Black muds											X						X			
" shale																				
Mud beaches														\						
Coarse & fine textures												X								
Habitat Mobile																				
Burrowing			X								X	X								X
Pelagic						X														
Near surface						X														
Nekton																				
Benthos																				
Ciliary feeding				X																
Detritus "			X																	
Associated forms																				
Plant remains															X					
Conodonts															X					
Scolithus										X										
Fucoid																				
Radiolaria										X	X									
Living																				
Fossil										X	X				X					

* exception: 1 larvae found 200 mi from coast at 2200 fa.

TABLE 5 SUMMARY PELECYPODA ECOLOGY

	Coe & Fox 1942	Davis 1958	de Buen 1957	Fraser, McLean & Smith 1928	Grant & Gale 1931	Grave 1901	Gunter 1942	Huntsman 1921	McMaster 1958	Menzel & Nichy 1958	Nelson 1926	Nelson 1943	Nelson 1947	Nichol 1958	Priddy & Cresler 1953	Ranson 1926	Rodina 1948	Smith 1928	Shrock & Twenhofel 1953	Stewart & Stewart 1949	Swan 1952	Thorson 1946	Urey, Lowenstam, Epstein McKinney 1951
Depth Littoral																			X				
Shallow										X									X				
Deep																			X				
Salinity Fresh																							
Brackish																							
Salt marsh		16								X													
Marine		25 ppt. X										X							Y				
Size control																					X	X	X
Temperature Boreal																					X	X	X
Warm										20 ↓ 31°C	X				30.5 ↓ 34.5°C Lethal								X
Controls growth	X				X																		
										2.5°C var.													
Turbidity - pronounced																							
quiet				X																			
Water circulation																							
Normal				X																			
Stagnant																							
Light - shape effect									X														
Substrate Silts															X	X							
Clay, muds															X								
Sands																X							
Effects growth																					X	X	X
Habitat Pelagic larvae																							
Swimmers																			X				
Boring																			X			X	
Burrowing										X									X				
Predators										X	X												
Binding agent										X													
Reef builders							X	X															
Controlled by food supply	X																						
Detritus																							
Bacteria																	X						
Plankton																		X					
Associated with diatoms													X										
Reefs										X													
Foraminifera																							
Ostracodes																			X				
																			X				

Thin shell

Thick shell

TABLE 6 SUMMARY GASTROPODA ECOLOGY

	Anon 1958	Clench 1957	Durham 1947	Elias 1937	Fischer 1956	Ostergaard 1950	Shrock & Twenhofel 1953	Uhl 1927
Depth Shallow			<200 m major	12 ↓ 500'			-5400 ↓ -5500 m.	
Littoral					X			
Deep	3 mi.	3590 m.	> 7000 m.					
Salinity Terrestrial							X	X
Fresh							X	X
Brackish							X	
Marine	X	X				X	X	
Temperature								
Zoned by temp.			X	X				
Temperate			X	X				
Tropical			X	X				
Arctic				X				
Secondary							X	
Dependent on								
Water							X	
Lime							X	
Habitat								
Pelagic larvae						X		
Plankton							X	
Benthos							X	
Habit Herbiverous							X	
Boring					X		X	
Predators							X	
Commensal							X	
Associated with								
Chitons	X							
Pelecypoda	X							
"Trails"							X	
Crinoids							X	

TABLE 7 SUMMARY PTEROPOD ECOLOGY

F = FOSSIL

	Avnimelech 1945	Blanckenhorn 1889	Boas 1886	Grabau 1917	Thompson 1942	Shimer & Shrock 1944	Shrock & Twenhofel 1953
	F	F				F	F
Depth Shallow	100						
Deep	400 m.						
Salinity							
Marine				X			
Turbidity							
Circulation by currents				X			
Substrate							
Habitat							
Plankton	X						
Pelagic	X			X			X
Worm tube						?	
Identified as							
Stylolina	X			X		X	X
Tentaculites	X	X				X	X
Cleodora			X		X		
Cuverina			X		X		
Vaginella		X					

TABLE 8 SUMMARY ANNELID ECOLOGY

		Abe 1943	Allen 1959	Beckmann 1954	Berkeley 1958	Bowden 1951	Bucher 1928	Brady 1943	Crossland 1924	Dales 1956	Eller 1942	Flatteley & Walton 1922	Hartman 1951	Hazell 1965
Depth	Tidal pools	X				F								
	Intertidal	X	X					X	X		X	X		
	Near shore								X				X	
	Littoral										X		X	
	Shallow										X			
	Deep													
Salinity														
Distribution effect														
	Marine												X	X
Temperature antarctic														
	Temperate													
Warm, subtropical											X			
Turbidity														
Water														
Substrate	Hard							X				X		
	Sand							X	X					
	Organic muds							X						
	Muds					X			X					
	Limestone													
Habitat	Plankton													
	Pelagic				X					X				
	Sedentary													
	Gregarious													
	Reef builders						X							
Food	Protozoa	X												
	Diatoms	X												
Data on young														
	Arabella													
	Nereidavus					X								
	Nereis				X			X						
	Sabellaria						X							
	Serpula												X	
	Spirorbis	X		X								X		
Associated Reefs									X					
	Lamellibraichs								X					
	Corals								X					
	Sponge								X					
	Oysters													X
	Coprolites													
	Conodonts													

TABLE 9 SUMMARY OSTRACODA ECOLOGY I

F = Fossil Faunas

		Agnew 1942	Apstein 1910	Araki 1955	Bailey 1935	Bassler 1911	Benson 1959	Chave 1954	Cooper 1942	Crouch 1954	Curtis 1954	Davidson 1924	Deschiens, Lamy & Lamy 1953	Decker 1915	Dubovsky 1960	Elofson 1941	Fage 1933	Fage 1934	Fisher 1951	Fryer 1955	Funtos 1956
Depth	Near Shore													F		x					
	Littoral						0 ↓ 215 fa			<200 mg/.											
	Neritic																				
	Strand													x							
	Shallow													x							
	Deep																				
Salinity	Fresh							x			x								x	x	
	Brackish							x			x										
	Marine						x	x								x					
	Abnormal						0.37 ppt.														
Control, Tolerance																x					
Temperature	Boreal						50 ↓ 85 °F	0 / 26 °C								x					
	Underice																				
	Temperate																				
Turbidity	Calm													x							
Light Sensitivity				x							x										
Sensitivity to S_2, H_2S., Fe.																			x		
Oxygenation																					
Substrate																					
	Sandstone					x	x		x												
	Lt.col.Sh.				x																
	Muds																		x		
	Calc. Seds.																				
	Oolitic																				
	Control						x							x	x						
Habitat	Planktonic	x																x			
	Benthonic	x				x											x	x	x		
	Nektonic	x				x											x				
	Pelagic		x														x				
	Predator												x								
	Parasitic																				
Environment																					
	Salt Lagoon						x														
	Estuary						x														
	Open Bays						x														
	Marsh										x										
	Terrestrial																				
Associated																					
	(1) Spirobis						7		1/2				1								
	(2) Plants, spores																				

TABLE 9 (contd.) SUMMARY OSTRACODA ECOLOGY II

F = Fossil Faunas

		F	Gillette 1947	Glaessner 1947	Gutschick 1941	Harding 1955, 1965	Hardy & Gunther 1935	Hastings 1952	Hazel & Shidley 1969	Hartley 1969	Harman 1953 (2 refs)	Hecht 1939	Hiscock 1965	Hoes 1955	Holt 1962	Kesling 1946-1949	Kornicker 1964
Depth	Near Shore				X						X						
	Littoral																
	Neritic																
	Strand																
	Shallow																
	Deep																
Salinity	Fresh									X					X	X	X
	Brackish																
	Marine			X						X							
	Abnormal											X					
	Tolerance																
Temperature																	
	Boreal																
	Underice						X									X	
	Neartic																
	Control														X		
Light Sensitivity																	
Oxygenation							X										
	H+ concentration														X		
Substrate																	
	Sandstone		X								X	X					
	Lt.col.Sh.		X														
	Muds																
	Calc. Seds.		X														
	Oolitic																
	Control												X				
Habitat	Planktonic						X										
	Benthonic																
	Nektonic																
	Pelagic								X								
	Predator																
	Parasitic									X			X				
	Epizoic																
	Commensal																
Environment	Salt Lagoon																
	Estuary																
	Open Bays																
	Marsh																
	Terrestrial					X											
Associated																	
	(3) Organic content			3													
	(4) Crayfish												X		4		

TABLE 9 (contd.) SUMMARY OSTRADOCA ECOLOGY III

F = Fossil Faunas

	Holland 1934	Howe 1952	Hulings 1958	Johnson & Snook 1927	Kelj 1957	Kesling 1951	Kle 1929 (2 refs)	Kle 1956 (2 refs)	Kle 1957 (2 refs)	Kle 1958	Klekowski 1952	Komicker 1957	Komicker 1958	Komicker 1961	Komicker & Wise 1960	
Depth Neartic			X	X	X											
Depth Shallow				X	X											
Depth Deep				X	X											
Salinity Fresh	X				X											
Salinity Brackish						X										
Salinity Marine				X	X											
Control, Tolerance		X	X						X		X			X		
Temperature Undericc														X	10°C	
Temperature Tolerance			X											X		
Circulation														X		
Light Sensitivity											X					
Sensitivity S_2, H_2S etc						X										
Oxygenation																
Substrate Sandstone					X		X	X	X							
Substrate Lt.col. Sh.							X									
Substrate Muds																
Substrate Calc. Seds.							X				X					
Substrate Oolitic																
Substrate Control																
Habitat Planktonic																
Habitat Benthonic				X												
Habitat Nektonic																
Habitat Pelagic																
Habitat Predator																
Habitat Parasitic																
Habitat Epizoic, Commensal							X									
Habitat Food for fish																
Environment Lagoonal			X		X											
Associated Strand.																
(5) Fish scales, teeth																
(6) Gastropoda	1				20	7										
(7) Algae	5				21											
(8) Worm trails	6															

TABLE 9 (contd.) SUMMARY OSTRACODA ECOLOGY IV

F = Fossil faunas

		Kozloff & Whitman 1954	Kummerow 1939	Lankester 1909	Leutze 1956	Lint 1923	Loomis 1903	Mason 1939	Marshall 1903	Merrett 1924	Moore, Lalicker Fisher 1952	Monahan 1951	Muller 1893	Muller 1908	Muller 1912	
			F	F						F		F				
Depth	Shallow															
	Deep															
Salinity																
	Fresh		X					?		X						
	Brackish			X												
	Marine		X							X		X	X	X	X	
	Salt Marsh															
	Tolerance							3‰							X	under 12‰
Temperature								1								
Material	Suspended							5/5°C								
Turbidity																
	Quiet															
Circulation			X				X									
	Current		X													
	Stagnant															
	Control															
Substrate	Sand															
	Mud															
	Control		X													
Habitat																
	Planktonic			X												
	Pelagic		X													
	Benthonic		X	X						X						
	Commensal		X							X						
	Food									X						
Environment				?												
Associated					X											
(9)	Nematodes															
(10)	Diatoms															
(11)	Radiolaria															
(12)	Copepods															
(13)	Pteropods				8											
(14)	Rhizopods															

TABLE 9 (contd.) SUMMARY OSTRACODA ECOLOGY V

F = Fossil faunas

	Needham 1938	Laris 1916	Pearse 1939	Pokorny 1958	Kolenova 1953	Rabien 1956	Redeke 1936	Robertson 1876	Rome 1947	Rome 1953	Rothwell 1947	Rothwell 1949	Rose 1926	Ruedemann 1918	Sars 1928	Schafer 1952	Schmidt 1936
				F		F								F			F
Depth																	
Shallow			X								1/2 200 fa	X					
Deeper															X		
Salinity Fresh	X						X		?						X		
Brackish							X										
Marine, Salt marsh											X				X		
Control, Tolerance				X			X				X					X	
Temperature																	
Cold									7°								
Warm*									bpc								
Control																	
Material suspended Circulation	X	X				X											
PH -									7.4								
Sensitivity H_2S_1 etc.																	
Oxygenation, Current						X											
Substrate																	
Hard																	
Sandstone	X			X													
Muds				X							X						
Calc.Seds.																	
Limestone																	
Control															X	X	
Habitat																	
Planktonic				X									X				X
Benthonic				X											X		
Swimmers				X											X		
Environment																	
Terrestrial																	
Associated Commensal		X							X	?							
(15) Pelecypods														10			
(16) Forams														11			
(17) Sponges														12			
(18) Echinoids														13	T		
(19) Annelids														14			
(20) Glauconite																	
(21) Pyrite																	

1. concentrated between 50 – 150 m.

TABLE 9 (contd.) SUMMARY OSTRACODA ECOLOGY VI

F = Fossil faunas

	Scott 1944	Scott 1948	Scott & Summerson 1943	Shepard 1953	Skogsberg 1920	Skogsberg 1950	Sylvester-Bradley 1941	Sverdrup et al 1942	Swain 1952	Swartz 1942	Thorslund 1940	Tressler 1941	Tressler & Smith 1948	Tressler 1956	Tressler 1957	Triebel 1958	Ulrich 1927	Ulrich & Bassler 1923	Zenkevich 1954
			F				F			F	F								
Depth																			
Shallow			x							x	x	xx							
Deeper																			
Salinity Fresh	x	x	x											x	x		x		
Brackish										?			x	x	x	x			
Marine					x	x				x	x		x	x	x	x	x	x	
Control, Tolerance		x		x									x						
Temperature																			
Cold												x		x	x				
Warm												x	x	x	x				
Control																x			
Circulation	x		x																
Ph -		x																	
Sensitivity H_2S, etc.		x														x			
Oxygenation													x						
Substrate																			
Hard													x						
Sandstone														x		x			
Muds	x													x		x			
Calc. Seds.	x										x								
Limestone																x			
Control			x						x					x					
Habitat																			
Planktonic		x						x											
Benthonic	x													x		x			
Swimmers																x			
Environment																			
Terrestrial													x						
Associated																			
(15) Pelecypods	1		1	15															
(16) Forams	1		15	16	7														
(17) Sponges																			
(18) Echinoids																			
(19) Annelids																			
(20) Glauconite																			
(21) Pyrite																			

TABLE 10 SUMMARY EXPERIMENTAL DATA ON OSTRACODA

	Kesling 1951	Kornicker & Wise 1960	Wise 1960		
Species	Cypridopsis vidua O.F.Muller	Hemicythere conradi Howe & McGiart		Cypridopsis vidua O.F.Muller	Philomeme sp.
Location	Illinois	Laguna Madre and Bays along Texas coast		(a)Calgary (b)Chorley Wood (c)Uxbridge (d)Kent	
Environment	Ponds, lakes	Shallow marine separated by long shore sand bars from Gulf		(a)slough, seasonal droughts, fresh to brackish water (b)(c)(d) ponds	Same as (a)
Temperature range		2-35°C 6-36°C		-30° to 70°F optimum 68° ± F	-30° to 60°F
Salinity	Wide range	6-65 ppt. min - max		Varies from fresh to highly brackish seas SaH content increases 10X after 19 generations in (a) Less variation in (b) (c) (d)	
Light	Preference	Preference		Preference	Preference
Size variations	Consistent within limits		Varies in laboratory cultures	In (a) (continental temperate) about 80% of (b)(c)(d)consistently, but varies within (a)	No comparative material

	Kesling 1951	Kornicker & Wise 1960	
Generations	-	-	- 2 crops a year May & September in field (a)Continuing generations in (b)(c)(d) Same as (a)
Substrate	Muds, sands	Poorly sorted preferred to well sorted	Black organic muds preferred to poorly sorted sand Black muds preferred to sand
	Commensal rather than parasitic	Experimental data similar to observed field data	Associated with Branchiopods, Copepods, Daphnia, Insects, etc.

TABLE 11 SUMMARY CRINOID ECOLOGY

	Clark 1946	Clark 1950	Clark 1957	Ladd 1944	Moore, Lalicker Fischer 1952	Pearse 1939	Shimer & Shrock 1944	Shrock & Twenhofel 1953	Stockdale 1931	Sverdrup 1942	Twenhofel 1950
Depth											
shallow	90 ↓ 200	2925m.			x ↓ 400m	60 fm	x ↓ 3 fm		x		
Intermediate		x									
Bathyal		12 x							x		
Salinity Marine	x	x		x	x	x	x	x			x
Temperature		1.2 ↓ 22.6			x						
Arctic					x						
Temperate					x						
Tropical											
Turbidity											
None, clear waters											x
Well aerated		x									
Substrate											
Hard, uneven		x									
Mud		x			x				x		
Surrounded					x						
Habitat											
Free swimming			x					x			
Sessile								x			
Gregarious								x			
Reef builders			x					x	x		
Associated											
Reefs	x		x								
Sponges			x								
Algae			x								

㊥ comatlids

TABLE 12 SUMMARY ECHINOID ECOLOGY

		Clarke 1937	Clarke 1939	Clarke 1946	Cloud 1949	Cooke 1957	D'iakonov 1955	Flattely & Walton 1922	Galtsoff 1933	Johnson & Snook 1927	Koehler, 1927	Lankaster 1900	Moore 1934	Moore, Lalicker, & Fischer 1953	Pearse 1939	Shimer & Shrock 1944	Shock & Twenhofel 1953	Sverdrup 1942	Twenhofel 1926	Yonge 1951
Depth	Low water mark			x																
	Near shore		>50% <10%			x							>37 fm	x		1-7 fm		x		Varies
	Shallow			x							x						x			
	Littoral												x	x						
	Deep					x				x		x		x	x			x		
Salinity																				
	Fresh						below normal													
	Brackish																			
	Marine					x														
	Lagoons					x														
	Estuaries					x														
Temperature																				
	Controls distribution					x														
	Cold					surface depth				x										
	Warm, tropical																			
Turbidity																				
	Pronounced											x								
	Calm																			x
Water Circulation						x														
	Normal					x														
	Stagnant																			
Substrate	All types	x																		
	Sand		x			x							x							
	Mud, SH		x			x					x	x	x							
	Limy					x														
	Hard substrate										x									
	Red clays									x										
Habitat	Burrowing		x			x														
	Boring																			x
	Shell thick in turbulend areas												x							
	Similar																			
	Holothurians								x											
Food	Seaweeds							x	x											
	Barnacles							x												
Associated Corals			x																	
	Crinoids			x						x	x	x		x						
	Fringing reef,			x		x														
	Reefs					x														
	Siliceous sponges									x		x								

TABLE 13 SUMMARY HOLOTHUROIDEA AND OPHUROIDEA ECOLOGY

F = Fossil faunas
R = Recre

	Bather 1928	Clark 1907	Deichmann 1957	Elton 1927	Hampton 1958	Fearse 1939	Fetterson 1949	Summerow & Campbel 1958	Yamanouti 1939	Clark 1949	Deichmann 1957	Shrock & Twenhofel 1953
Depth												
Littoral												
Neritic												
Shallow												
Deep												
Salinity												
Brackish												
Marine												
Temperature												
Warm												
Tropical												
Turbidity												
Water circulation												
Substrate												
Hard												
Mud												
Habitat												
Burrowing												
Pelagic												
Benthonic												
Food												
Detritus & plankton												
Living												
Fossil												
Associated with												
Reefs												
Crinoids												
Forams												
Polyzoa												
Pelecypoda												
Gastropods												
Echinoids												

X checks growth

TABLE I4

SUMMARY POLYZOA (BRYOZOA)

ECOLOGY	Androsova 1958	Bassler in Sheppard & Cohee 1936	Borg 1947	Canu & Bassler 1929	Crespin 1926	Elias 1949	Gautier 1953	George 1959	Johnson & Snook 1927	Marcus 1938	McDougall 1943	Moore, Lalicker, & Fischer 1952	Pray 1958	Pufter 1952	Rigby 1957	Rogick & Croasdale 1949	Ruedemann 1934	Shrock & Twenhofel 1953	Vigeland 1958	U.S.G.S. Pap. 196 3	Warthin 1910
Depth Littoral			x	10															0	↓	125
Shallow				↓	x		x	x				x x					x	x x x	60 m.	1800 m?	↓
Deep				1118 m																	240 ft.
Salinity Fresh																					
Brackish			X			x															
Marine																		x			
Temperature																					
Artic-boreal	x		X						x												
Boreal	x																				
Temperate												x									
Subtropical	x								x			x									
Tropical																					
Turbidity Pronounced																					
Quiet																		x			
Destroyed by moving sand		x				x	x														
Water circulation																					
Normal			X			x															
Stagnent																					
Controlled by wave action			x																		
Substrate Hard																		x			
Sand				x		x	x											x			
Shale				x	x		x											x			
Limestone																x					
Habitat Encrusting					x		x				x		x								
Sossile											x										
Gregarious										x											
Reef builders					x		x											x			x
Boring																					
Symbiotic																					
Associated with Forams																					
Calcareous algae						x															
Brachiopods																					x
Ostracods							x														x
Radiolaria							x					x									
Molluscs							x					x									
Sponges							x				x										
Crinoids							x					x									

TABLE 15 SUMMARY CONODONT OPHOROIDEA ECOLOGY

	Bailey 1935	Branson 1942	Branson 1944	Branson & Mehl 1933	-ditto-1934	-ditto-1938	-ditto-1940	-ditto-1944	Bryant 1921	Dengler 1959	Dubois 1946	Ellison 1944	Fay 1943	Gunnell 1931	Hass 1941	Macfarlane 1931	Moore 1929	Moore 1936	Muller 1956	Muller & Muller 1957	Rexroad 1958	Rhodes & Wingard 1957	Ruedemann 1934	Scott 1942	Smith 1907	Smith & Whitlock 1940	Shrock & Twenhofel 1953	Stauffer 1938	Stauffer 1940	Tasch 1958	Youngquist & Miller 1948
Depth Near Shore				X				X	X				X			X															
Shallow								X	X								X	X								X	X				
Abyssal																			?												
Salinity Fresh				X	X			X																	X						
Brackish	X			X	X												X		X												
Marine	X							X							X		X		X								X				
Temperature Cool																															
Subtropical																	X														
Turbidity																															
Calm, undisturbed						X					X								X				X								
Water circulation																															
Normal																X															
Stagnant	X																X														
Sedimentation																															
Substrate Clays					X		X																								
Sands, silts					X		X			X		X						X	X				X								
Shale, black							X			X								X													
blue																								X		X		X			
red																								X		X					
green																								X		X					
gray																										X		X			
Shale												X																			
Limestone												X							X												
Phosphatic											X																				
Chert												X																			
Facies Changes -																															
Not related										X																					
Related																															
Environment Lagoonal																															
Deeper Littoral																X															
Habitat Plankton																															
Free swimming	X	X										X		X		X			X												
Nekton																															
Benthos																															
Associated Forms																															
(1)Brachiopoda (11)Lingula																															
(2)Crinoids (12)Orbiculoidea																															
(3)Cephalopoda (13)Worm traces										11		11							13	7							10				10
(4)Gastropods (14)Fish										12									9	5											
(5)Scolecodonts (15)Forams										13									8	4											
(6)Trilobites (16)Ostracodoid																			1	3											
(7)Ostracods (17)Algae																															
(8)Corals (18)Tentaculites																															
(9)Sponges (19)Holothurian spicules																															
(10)Sporansites (20)Polyzoa																															

PELLET FORMATION

TABLE 16 SUMMARY COPROLITE ECOLOGY

	Amstutz 1958	Dapples 1942	Fenton & Fenton, 1934	Kornicker & Purdy 1957	Illing 1954	Manning 1959	Schäfer 1956	Shrock & Twenhofel 1953	Johnson 1934
			F					F	
Depth									
Intertidal				X					
Shallow				X					
Salinity									
Above normal to 45%				X					
Substrate									
Soft	X								
Sand		X			X				
Mud		X		X					
Calcareous					X				
Deposition									
Rapid		X							
Habitat									
Benthos		X							
Burrowing		X							
Lagoonal				X					
From									
Pelecypods		X				X			
Gastropods		X				X		X	
Holothurians		X							
Worms			?						
Crustaceans						X		X	
Associated									
Algae				X					X
Fish									X

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Variable print quality

Selected Bibliography for Ostracoda Ecology

Factual data on the distribution, abundance, depth and associated sediments of recent ostracoda can be found in the reports of the Discovery, Challenger and other marine expeditions. The classic works of Brady, Jones, Norman, Elie, Sars, Brogoberg, etc. are fundamental to an understanding of ostracode environments. Many publications worthy of attention appear in the Fisheries Board research reports of the United Kingdom. A short selected list of authors not referred to above or cited elsewhere in this thesis are therefore included as an aid to further research.

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