MICROFOSSILS OF THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS IN DEEP WELLS OF ALPENA, OGEMAW, BAY, AND INGHAM COUNTIES OF MICHIGAN

by

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A THESIS

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INTRODUCTION

Microfossils examined in this study include brachiopoda, bryozoa, crinoidea, gastropoda, and ostracoda. Among these, bryozoa, crinoidea and ostracoda are the most abundant. However, only brachiopoda, gastropoda and ostracoda are identified in this work.

The ostracoda are small crustaceans with bivalve shells measuring typically between 0.5 mm. and 0.4 mm. in length though some range up to 30 mm. long. Most of the living ostracoda are marine organisms, but some occur in freshwater. They are found in great numbers and occasionally constitute the bulk of the sediment. Fossil ostracoda have been found in a great variety of sedimentary rock of all ages from the Ordovician onwards.

Agnew, in his article "Annotated Bibliography of Paleoecology of Paleozoic Ostracods", National Research Council, pages 58-67, 1946-1947, reports:

> "Although more abundant in the calcareous shales, particularly immediately above or below limestones, Paleozoic ostracods have been reported and described from argillaceous limestone, "pure" limestone, siliceous limestone, chert, dolomitic limestone, bituminous limestone, arenaceous limestone, sandstone, argillaceous sandstone, arenaceous shale, and clay shale. Paleozoic ostracods have been described from calcareous lenses in diabases and tuffs, and red shales of freshwater origin, but are reportedly not present in black, fissile shales. Siliceous rocks seem to be among the less suitable host rocks. However, silicified and cherty rocks contain ostracod carapaces, as these rocks are for the most part secondary; this is true also of the iron ores which contain ostracods. Furthermore, ostracods have been recorded from beds which were formed under conditions so unfavorable to other forms of invertebrate life as to cause the latter to be dwarfed (Loomis, 1903). The ease of extracting ostracods from the rock for study accounts, in part, for their relative abundance in certain types

> of sediments, for example, calcareous shales. On the other hand, it is very difficult and sometimes impossible to extract calcareous shells from pure limestone. Furthermore, in dolomitic rocks the granular molds and casts of the original shells can be prepared for study only with difficulty. This is true also of silicified shells in a siliceous matrix."
>
> "The abundance of ostracods in certain types of sediments may not mean that these particular rocks record the optimum environments, but rather that the environment became so unfavorable that the animals were unable to live and died in great numbers."
>
> "Furthermore, inasmuch as ostracod carapaces are of low specific gravity and small size, they were probably amenable to transportation, both by waves and currents of air and water, to regions not all conducive to ostracod life and growth."
>
> "Ostracods in the Paleozoic were associated with almost all types of invertebrates; in particular they occured with brachiopods, gastropods, pelecypods, bryozoans, pteropods, trilobites, cephalopods, crinoids, foraminifers, and, except in black shales, with conodonts."

In supporting Agnew's statement the writer found that fossil ostracoda are more abundant in the Richmond formation which consists largely of gray to dark gray shale, partly calcareous, interbedded with thin argillaceous limestone and dolomite beds.

In the case of the fossils in the Trenton and Black River formations which are made up of limestone and dolomite, the writer agrees entirely with Agnew that fossil specimens are very difficult and sometimes impossible to extract and most of them have to be discarded. In contradiction to his statement a few ostracoda were found in Utica black fissile shales in Reinhardt Well No. 1. They were found free which might be due to caving in of the overlying formation. A few fossils were also found in the St. Peter sandstone possibly for the same reason given above.

Although foraminifera are ranked as the bext index microfossils, ostracoda are regarded second in importance due to the frequency of occurrence, their wide geographic distribution and short geologic ranges.

Most of the specimens in this study were found in well cuttings from the Middle and Upper Ordovician series of Michigan and were furnished through the courtesy of the State Geological Survey of Michigan. The specimens are from four different counties; Alpena, Ogemaw, Bay and Ingham. (Map 1, page 7)

The ostracoda are represented by twenty-eight genera, the brachiopoda by one genus, and the gastropoda by three genera. All these fossils show that there are definite major and minor zones in all the Middle and Upper Ordovician series. (Charts 1,2,3,4,5,6)

OBJECTIVES OF THE STUDY

A. To investigate the distribution of microfossils in the Middle and Upper Ordovician series of Michigan.

B. To determine the possibility of distinguishing the boundary between the systems of the Silurian and the Ordovician.

C. To investigate the possibility of differentiating the Middle and Upper Ordovician series by means of microfossils.

D. To search for evidence of possible correlation between the different wells by microfossils.

E. To determine if there is a single zone, or a number of microfossil zones in the Middle and Upper Ordovician series.

F. To determine if the zone or zones follow the Michigan basin structure and reflect subsurface structure in upper and lower horizons.

G. To find out if the zone or zones pinch and swell suggesting the possibility that other formations, above or below, may also pinch and swell.

STRATIGRAPHY OF THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS IN MICHIGAN

Dr. Cohee, (1945, Chart No. 11 and 1948, Chart No. 33) has written concise descriptions of the Middle and Upper Ordovician series in Michigan and adjacent areas. (Figure 1 , page 6) Portions of his descriptions of subsurface formations are quoted below:

> (Middle Ordovician) "In the Southern Peninsula the lithology of the Black River limestone, which is 150 to 517 feet thick, is very similar to that of the Trenton limestone. The uppermost beds here included in the Black River limestones are believed by Kay to be of Rockland (Trenton) age."
>
> "Like the Trenton limestone, the basal part of the Black River limestone may consist in places of a fine-grained, dark-gray to black argillaceous limestone or may consist of limestone and shale. The top of the limestone in Kent County, Mich., contains some chert fragments."
>
> "In the Southern Peninsula the Trenton limestone is 203 to 479 feet thick and consists of light-brown to brown and gray fossiliferous fine-grained to crystalline limestone and dolomite except in the central part of the Michigan basin where available drill cuttings indicate that it is entirely limestone. The basal part of the Trenton is a 20-to-40-foot bed consisting in places of dark-gray to black somewhat argillaceous fine-grained limestone and in others of limestone and shale. The base of the Trenton could be determined with little difficulty except in Berrien County, Mich., where both it and the Black River are largely dolomite. In the Northern Peninsula the Trenton is 175 to 206 feet thick and consists of buff to brown crystalline limestone with some dolomite and gray to dark-gray argillaceous limestone. A greater thickness of argillaceous limestone is in the western part of the Northern Peninsula than in the eastern part."

(Upper Ordovician) "Southern Peninsula of Michigan. In the subsurface of southeastern Michigan the Upper Ordovician rocks are approximately 750 feet thick. They are divided on the basis of their lithologic characteristics into 3 units identified as the Utica, Lorraine, and Queenston shales. The Utica shale is dark gray to black and is 150 to 200 feet thick. It thins northward and in the Northern Penninsula, the Bruce Peninsula, and on Manitoulin and adjacent islands, it is represented in part by the Collingwood formation. In the subsurface it is about 10 to 20 feet thick in the Northern Peninsula. The Collingwood formation was identified in a well in Door County, Wis., but could not be identified farther south. The Utica shale grades laterally into light-gray shale and cannot be separated from the overlying Lorraine shale west of Washtenaw and Lenawee Counties. The shale thins westward from southeastern Michigan and is absent in southeastern Wisconsin and northeastern Illinois. In the southern part of the Michigan Basin the Utica shale thins from 175 feet in northwestern Ohio to 50 feet in Jasper County, Ind. However, two wells, one in Wabash County and another in Wells County, Ind., penetrated from 200 to more than 300 feet of dark gray to black shale in the lower part of the Upper Ordovician sequence. This shale is mainly Utica in age, but the upper part may be of Lorraine age. In southeastern Michigan the Lorraine consists of about 250 feet of gray to dark gray shale containing a few thin beds of limestone and dolomite. The overlying Queenston shale, about 200 feet thick, is similar to the Lorraine, but contains also some red shale. Westward across Michigan most of the red shale grades laterally into gray shale, and in western Michigan little red shale is present. The thin beds of limestone and dolomite in both the Lorraine and Queenston shales thicken toward the west and become more abundant particularly west of Eaton County, and north toward the Northern Peninsula."

"The total thickness of the Upper Ordovician strata ranges from 277 feet in southwestern Michigan to 812 feet in eastern Michigan. The area of greatest thickness is in Saginaw and Genesee Counties. Some thinning occurs in southeastern Michigan in the area of the Findlay arch and on the Howell anticline suggesting slight elevation of these folds during deposition of Upper Ordovician rocks."

GENERALIZED COLUMNAR SECTION OF MICHIGAN

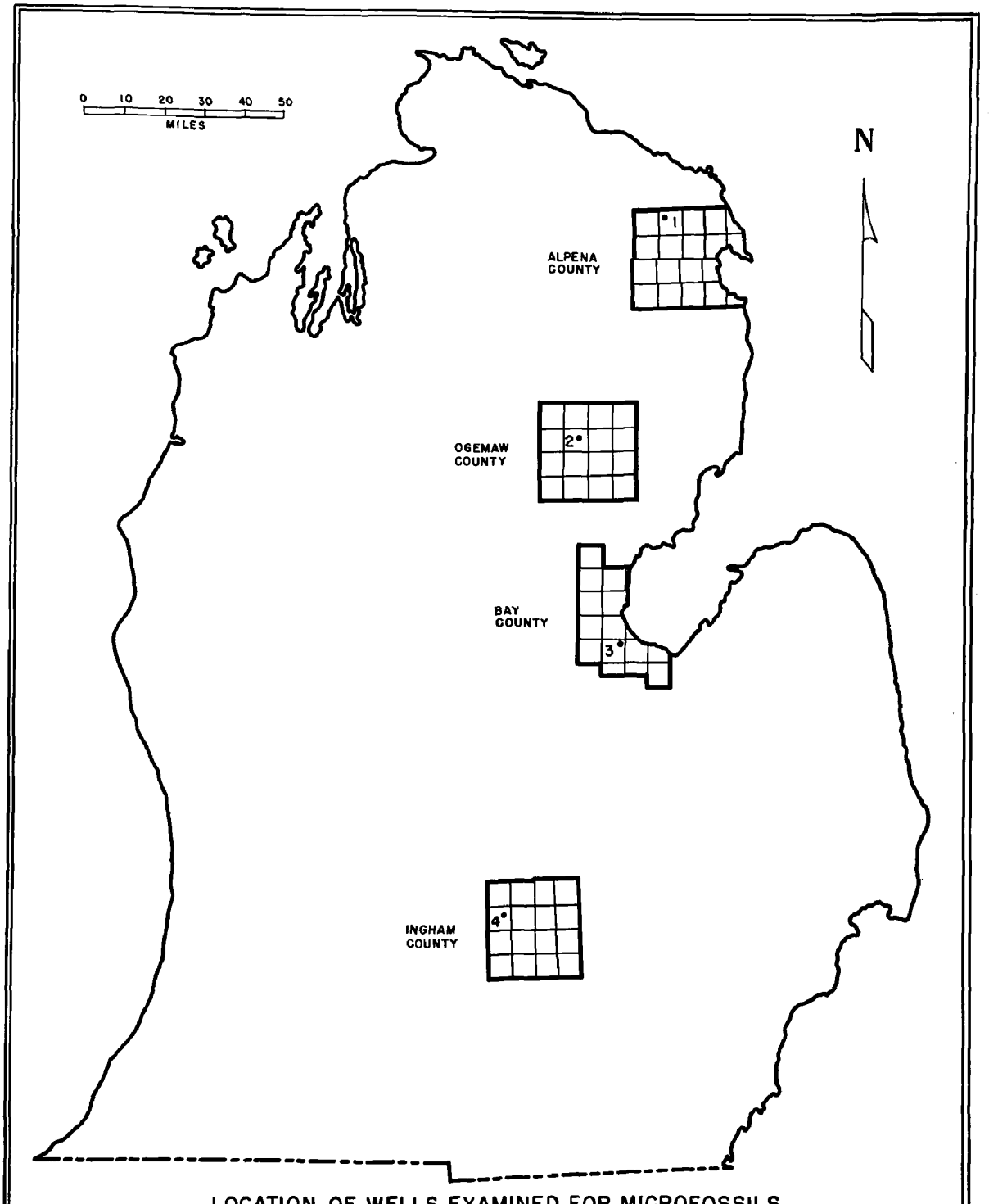
MICHIGAN GEOLOGICAL SURVEY DIVISION

1949

SYSTEM, SERIES	FORMATION, GROUP	LITHOLOGY	THICKNESS	ECONOMIC PRODUCTS
RECENT				
PLEISTOCENE	GLACIAL DRIFT	SAND, GRAVEL, CLAY, boulders, marl	0-1000	SAND, GRAVEL, PEAT, MARL, FRESH WATER
"PERMO-CARBONIFEROUS"	"RED-BEDS"	SHALE, CLAY, SANDY SHALE, gypsum		
PENNSYLVANIAN	GRAND RIVER	SANDSTONE, sandy shale	80-95	BUILDING STONE, FRESH WATER
	SAGINAW	SHALE, SANDSTONE, limestone, coal	20-535	SHALE, COAL, FRESH WATER, BRINE, GAS
MISSISSIPPIAN	BAY PORT	LIMESTONE, SANDY OR CHERTY LIMESTONE, SANDSTONE	2-100	LIMESTONE, FRESH WATER
	MICHIGAN	SHALE, gypsum, anhydrite, sandstone	0-500	GYPSUM
	"MICHIGAN STRAY"	SANDSTONE	0-80	GAS
	MARSHALL	SANDSTONE, sandy shale	100-400	FRESH WATER, BRINE BUILDING STONE
	COLDWATER	SHALE, sandstone, limestone	500-1100	SHALE, FRESH WATER
	SUNBURY	SHALE	0-140	
	BEREA-BEDFORD	SANDSTONE, SHALE	0-325	GAS, OIL
	ELLSWORTH-ANTRIM	SHALE, limestone	100-950	SHALE, GAS
DEVONIAN	TRAVERSE	LIMESTONE, SHALE	100-800	LIMESTONE, OIL, GAS, FRESH WATER
	BELL	SHALE, Limestone	0-80	SHALE
	ROGERS CITY-DUNDEE	LIMESTONE	0-475	LIMESTONE, OIL, GAS, FRESH WATER
	DETROIT RIVER	DOLOMITE, limestone, salt anhydrite	150-1400	LIMESTONE, DOLOMITE, OIL, GAS, SALT, BRINE, FRESH WATER
	SYLVANIA	SANDSTONE, SANDY DOLOMITE	0-550	GLASS SAND, FRESH WATER
	BOIS BLANC	DOLOMITE, CHERTY DOLOMITE	0-1000	
SILURIAN	BASS ISLAND	DOLOMITE	50-570	DOLOMITE, FRESH WATER
	SALINA	SALT, DOLOMITE, Shale, anhydrite	50-4000	SALT, GAS, OIL
	NIAGARAN (Guelph-Lockport-Engadine) (Manistique-Burnt Bluff) (Cataract)	DOLOMITE, Limestone, shale	150-800	LIMESTONE, DOLOMITE, OIL, GAS, FRESH WATER
ORDOVICIAN	CINCINNATIAN (Richmond) (Maysville-Eden)	SHALE, LIMESTONE	250-800	
	TRENTON-BLACK RIVER	LIMESTONE, DOLOMITE	200-1000	OIL, GAS, LIMESTONE, FRESH WATER
	ST. PETER	SANDSTONE	0-150	FRESH WATER
OZARKIAN OR CANADIAN	PRAIRIE DU CHIEN	DOLOMITE, Shale	0-410	
	HERMANSVILLE	DOLOMITE, SANDY DOLOMITE, sandstone	15-500	
CAMBRIAN	LAKE SUPERIOR (Munising) (Jacobsville)	SANDSTONE	500-2000	BUILDING STONE FRESH WATER
ALGONKIAN	KEWEENAW (Copper formations)	LAVA FLOWS, conglomerate, shale, sandstone	9800-35000	COPPER, SILVER, ROAD METAL, SEMI-PRECIOUS GEM STONES
	KILLARNEY GRANITE	GRANITE, GNEISS, diorite, syenite		
	HURONIAN (Iron formations)	SLATES, HEMATITE, SCHIST, QUARTZITE, GRANITE, marble, dolomite	2000+	IRON ORE, ROOFING SLATE, ROAD METAL, GRAPHITE MARBLE
ARCHEAN	LAURENTIAN	SCHIST, GNEISS, GRANITE		ROAD METAL, BUILDING STONE, VERDE ANTIQUE, TALC, GOLD
	KEEWATIN	SCHIST, GREENSTONE, SLATE		ROAD METAL

FIGURE— 1

Map 1



LOCATION OF WELLS EXAMINED FOR MICROFOSSILS

WELL NO.1: Nevins No.1, S.P. No.2960
T. 32 N., R. 6 E., Sec. 18
Long Rapids Twp., N.W.1/4, N.W.1/4, N.E.1/4

WELL NO.2: Reinhardt Consolidated No.1, S.P.No.12898
T.22N., R.2 E., Sec. 35
West Branch Twp., S.E. 1/4, N.W.1/4, N.W.1/2

WELL NO.3: William Bateson No.1, S.P. No.5441
T.14 N., R.4 E., Sec.2
Monitor Twp., S.1/2, S.E.1/4, S.E.1/4

WELL NO.4: Glaser No.1, S.P. No. 10011
T.3 N., R.1 E., Sec.14
Wheatfield Twp., S.E. 1/4, S.E.1/4, S.E.1/4

E.K. LUCAS - CARTOGRAPHER

LOCATION OF WELLS USED IN THIS INVESTIGATION

A total of four deep wells were selected. These wells are located along an approximate north-south line, beginning in Alpena County at the north, and extending through Ogemaw and Bay Counties, to Ingham County at the south.

This line corresponds approximately to a chord through the eastern half of the Michigan synclinarial basin. The chord is approximately parallel to the long axis of the Michigan basin. Thus the distance of the sections in Bay County from the center will be less than for the others.

There may be a correlation between the fact that the most abundant fauna came from the Bateson Well.

The specific location of wells in which microfossils were found appear on Map 1, page 7.

METHODS OF PREPARATION

The microfossils examined were found in the well cutting samples which were taken approximately at 5 foot intervals. Most of the fossils were found free, but some were enclosed in matrix particularly in the limestones of Trenton and Black River formations of the Middle Ordovician age. The matrix was broken by means of a vise in order to free the fossils. Shale samples were washed to clear the particles from the specimens. For refractory shale the disintegration method was used. This method is briefly described below:

> "First heat the sample on a gas plate or in an oven sufficiently to drive out the interstitial moisture. After it has cooled, pour gasoline over it and allow to stand for about half an hour. Next decant the gasoline and cover the sample with water. It will be found that in a few minutes the shales will have been broken down to a fine mud which can be handled in the customary manner." (Layne, Jr., 1950, page 21)

The microfossils were mounted on the slides with the well location and the horizon noted on each for reference. The mounting medium employed was gum tragacanth dissolved in hot water.

CRITERIA USED IN DESCRIBING OSTRACODA

A. Shape of carapace

B. Position of greatest height

C. Position of greatest thickness

D. Relative sharpness of anterior and posterior ends

E. Character of the hinge line

F. Overlap of valves

G. Location of spines, nodes and sulci

H. Surface ornamentation

I. Length and height of ostracoda in millimeters

Ostracoda, unlike other bivalves such as brachiopoda and pelecypoda, have no part of the carapace that can be classified as a protoconch and therefore developmental stages can not be made out in a single individual.

Some of the specimens found could not be referred to described species because sufficient literature on the ostracoda is not available in our library. Other specimens could not be positively identified because of imperfect preservation, or because of minor variation from the holotype. In such instances the writer is following the precedent established by Campau (1950, pages 14-15) by referring to these as variants. Variant is defined by Campau:

> "The variations are not consistent in any one group and variants in species may be mutations in a single species or growth stages. As an example of the latter,

> one can site Ponderodictya bispinulata variant "H" (page 30) the weak ornamentation, small carapace suggests a young specimen rather than a new species. The significance of variations cannot be evaluated. As a result the term 'variant' is used to imply variation from a form arbitrarily taken as type or norm."

ORIENTATION TERMINOLOGY

In this study the orientation is taken from the Journal of Paleontology, 1948, Volume 22, No. 5, "Ostracoda from the Middle Devonian Windon Beds in western New York", by Swartz and Oriel, who state:

> "The term, plenate end, was proposed for the end of the ostracoda shell towards which the swing is directed, because this end tends to be relatively 'full' either in height, or in extension beyond the hinge, or in both respects. The opposing end can then be termed 'the antiplenate end'; features toward the one or other end are 'adplenate' or 'antiplenate'."

The adplenate end in this study will be referred to as posterior and the antiplenate will be anterior.

If the determination of a right valve is made from a lateral view, the posterior end will be at the left, (Figure 2 , page 11) and conversely the posterior end will be at the right for a left valve.

For some ostracoda: eg; Ceratopsis, plenation is not marked and orientation is determined by the position of such features as flanges and spines, the former being anterior and the latter, posterior. (Figure 2, page 11)

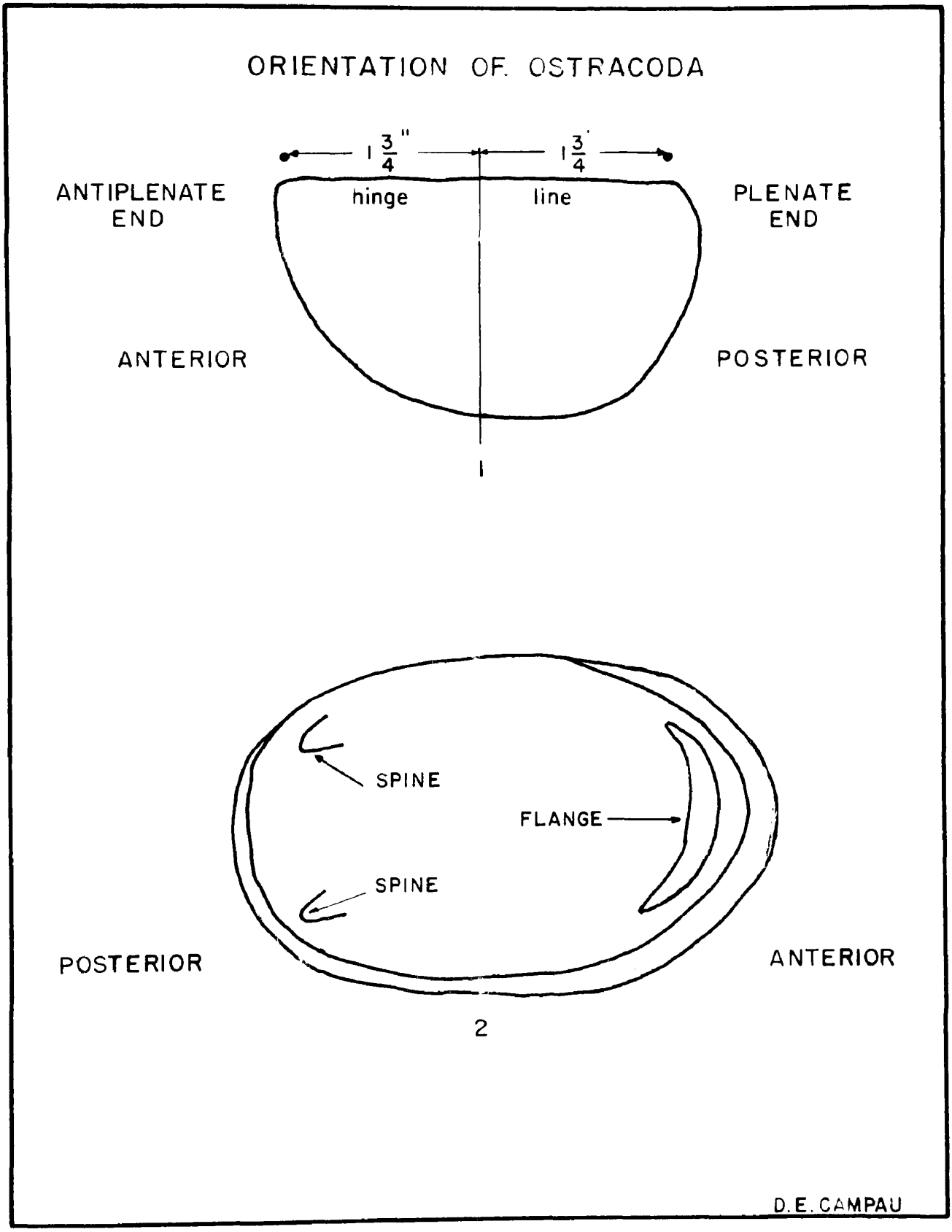

ORIENTATION OF OSTRACODA
1 3/4"
1 3/4"
ANTIPLENATE END
hinge
line
PLENATE END
ANTERIOR
POSTERIOR
1
SPINE
FLANGE
SPINE
POSTERIOR
ANTERIOR
2
D.E. CAMPAU

Figure 2

CLASSIFICATION

Bassler and Kellett (1934) divided the ostracoda into four superfamilies and nineteen families, with about 170 Paleozoic genera. Twelve new families and 167 new genera have since been proposed (Agnew, 1942) and the number of Paleozoic species alone is estimated at 3400 (Cooper, 1942). Not all the new families are generally accepted.

The four superfamilies are:

1. Leperditacea
2. Beyrichiacea
3. Cypridacea
4. Cytheracea

A total of six families belonging to the Leperditacea, Beyrichiacea, and Cypridacea represented by twenty-eight genera are known to occur in the Middle and Upper Ordovician series of Michigan. The most abundant are from the Leperditacea and Beyrichiacea. The most common genera are Bythocypris, Ceratopsis, Eridoconcha, Leperditia, Leperditella, Macrocypris, Milleratia, and Schmidtella. The twenty-eight genera are listed under both the superfamily and the family and their descriptions are given on page 14 to 46 in the order given below.

SYSTEMATIC CLASSIFICATION OF OSTRACODA

Superfamily Leperditacea
- Family Leperditiidae, Jones
  - Genus Leperditia
- Family Leperditellidae, Ulrich and Bassler
  - Genus Aparchites
  - Eridoconcha
  - Leperditella

Macronotella
Paraschmidtella
Saccelatia
Schmidtella

Superfamily Beyrichiacea
Family Beyrichiacea, Jones
Genus Beyrichia
Ctenobolbina
Ceratopsis
Opikatia
Tetradella

Family Primitidae, Ulrich and Bassler
Genus Bollia
Dilobella
Primitia
Haploprimitia
Laccoprimitia
Euprimitia
Milleratia
Halliella
Eurychilina
Coelochilina
Chilobolbina
Winchellatia

Superfamily Cypridacea
Family Bairdiidae, Lienenklaus
Genus Bythocypris
Macrocypris

Family Beecherellidae, Ulrich
Genus Krausella

BRACHIOPODA

Genus Zygospira

GASTROPODA

Genus Cyclora
Hormotoma
Maclurites

SYSTEMATIC DESCRIPTIONS OF MICROFOSSILS

OSTRACODA

Genus LEPERDITIA

Renault 1851

Genotype Leperditia brittinica Renault

> "Shell suboblong with an oblique backward swing; comparatively large, commonly exceeding 8 mm. in length; dorsal edge straight, generally angular at the extremities; ventral outline rounded, greatest thickness in ventral half, lower edge usually also blunt; valves unequal, right larger and overlapping ventral edge of left; hinge simple; surface frequently horny in appearance, smooth and glossy in most cases, granulose or minutely punctate in others; a small tubercle or eye-spot generally present on anterodorsal fourth, while a large rounded, subcentrally situated muscular imprint is a well marked feature of the interior and sometimes distinguishable even on the exterior." (Shimer and Shrock, 1944, page 664)

Leperditia variant "A"

Carapace suboval in lateral view; greatest height and thickness in posterior end; anterior sharp, posterior end blunt, straight and depressed hinge line. Valves unequal, right larger and overlapping ventral edge of left. Surface smooth. Length 0.8 mm., height 0.5 mm.

Occurrence: Rare in both Richmond and Trenton of Bateson Well No. 1; frequent in Richmond of Nevins Well No. 1 and rare in Richmond of Reinhardt Well No. 1.

Leperditia variant "B"

Carapace semicircular in lateral view; greatest height in the middle; greatest thickness in ventral half; anterior and posterior ends equal; hinge straight but not depressed. In other characters it closely resembles variant "A". Length 0.7 mm., height 0.5 mm.

Occurrence: Rare in Trenton of Bateson Well No. 1.

Leperditia variant "C"

Greatest height in posterior end; greatest thickness in antero-ventral half; anterior end slightly sharper than the posterior; hinge straight but not depressed. In other characters it closely resembles variant "A". Length 0.3 mm., height 0.1 mm.

Occurrence: Rare in both Richmond and Trenton of Bateson Well No. 1 and Nevins Well No. 1.

Leperditia variant "D"

Greatest height in the middle; greatest thickness in the center. In other characters it closely resembles variant "C". Length 1.5 mm., height 0.8 mm.

Occurrence: Frequent in Richmond of Bateson Well No. 1; rare in Richmond of Reinhardt Well No. 1 and Trenton of Bateson Well No. 1.

Leperditia variant "E"

Right valve larger and overlapping all around on the left. In other characters it closely resembles variant "A". Length 0.8 mm., height 0.5 mm.

Occurrence: Abundant in Richmond of Bateson Well No. 1.

Leperditia variant "F"

Surface minutely punctate. In other characters it closely resembles variant "B". Length 1.2 mm., height 0.7 mm.

Occurrence: Rare in Trenton of Reinhardt Well No. 1.

Genus ARARCHITES

Jones 1889

Genotype Aparchites whiteavesii Jones

> "Carapace subovate, oblong or somewhat rounded, with a straight hinge of variable length; valves subequal; edges thickened, never overlapping, often beveled or channeled, in other cases simple, and rarely with a narrow flattened border. Surface more or less convex, usually smooth, without sulcus, tubercles or lobes." (Ulrich, 1894, page 643)

Aparchites ellipticus Ulrich 1894

Carapace elliptical in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends blunt and equally rounded; hinge straight. Valves unequal, dorsal margin of left valve more arcuate and projecting above that of right. Edges beveled all around but in the lower part the bevel is turned into a groove by thickening of the contact edges. Surface smooth. Length 1.0 mm., height 0.8 mm.

This species has been compared with the description and plates by Ulrich, 1894, page 644 (Plate XLIII, Figures 15-17, Volume III), and agrees in every respect except that it is about 0.97 mm. less in length and about 0.15 mm. less in height.

Occurrence: Very rare in Richmond of Nevins Well No. 1.

Aparchites millepunctatus Ulrich 1892

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the ventral half; anterior and posterior ends equal; hinge straight and long. Valves equal, no overlapping or dorsal margin of left projecting above that of right. Ventral edge beveled. Surface finely punctate. Length 1.5 mm., height 0.6 mm.

This species is questionably represented by one specimen and has been compared with the description and plates by Ulrich, 1894, page 645 (Plate XLV, figures 16-18, Volume III), and agrees in every respect

except that it is about 0.4 mm. less in height.

Occurrence: Very rare in both Richmond and Trenton of Nevins Well No. 1.

Aparchites variant "A"

Greatest thickness in the dorsal half; ventral edge thickened but not beveled. Surface granulose. In other characters it closely resembles Aparchites millepunctatus. Length 0.6 mm., height 0.25 mm.

Occurrence: Very rare in Trenton of Bateson Well No. 1.

Genus ERIDOCONCHA

Ulrich and Bassler 1923

Genotype Eridoconcha rugosa Ulrich and Bassler

> "Small, apparently unequivalved carapaces with concentric, simple or rugose bands or rows of punctae, resembling an equilateral pelecypod or a brachiopod in shape and marking." (Ulrich and Bassler, 1923, page 297)

Eridoconcha oboloides Ulrich and Bassler variant "A"

Carapace trigonal in lateral view; greatest height in the middle; greatest thickness in the dorsal region; anterior and posterior ends almost equal; hinge straight and short. Valves equal; surface quite convex, rising gently from free margins to dorsal umbo; having three arcuate belts defined by centrally facing low shoulders, giving the valve the aspect of a pelecypod having prominent growth lines. Has an apical sulcus. Length 0.8 mm., height 0.5 mm.

This specimen has been compared with the description and plates by Kay, 1940, page 247 (Plate 29, Figures 34-35), and agrees in every respect except that it is about 0.17 mm. less in height than the holotype.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and very rare in Trenton of Nevins Well No. 1.

Eridoconcho oboloides Ulrich and Bassler variant "B"

Has only one broad concentric band with low shoulder along the free margins. In other characters it closely resembles Eridoconcha oboloides. Length 1.0 mm., height 0.6 mm.

Occurrence: Rare in Richmond of Glaser Well No. 1; rare in Trenton of Nevins Well No. 1 and Bateson Well No. 1.

Eridoconcha rugosa Ulrich variant "A"

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the dorsal region; anterior and posterior ends almost equal; hinge straight and short. Valves equal, inflated dorsally. Surface quite convex with a prominent umbo slightly anterior to center; channel above hinge line wide and U-shaped; surface marked by four prominent narrow growth rings separated by deep narrow depressions. Has an apical sulcus. Length 0.6 mm., height 0.4 mm.

This specimen has been compared with the description and plates by Ulrich and Bassler, 1923, page 297 (Figure 14, No. 9, page 296), and seems to agree in every respect though it is 0.1 mm. less in length and 0.1 mm. less in height and one concentric ring less than the holotype.

Occurrence: Rare in Richmond of Bateson Well No. 1.

Eridoconcha rugosa Ulrich and Bassler variant "B" (Plate 1, Figure 5)

Carapace oval in lateral view. Has only three prominent narrow growth rings separated by deep narrow depressions. In other characters it closely resembles Eridoconcha rugosa. Length 0.6 mm., height 0.3 mm.

Occurrence: Rare in Richmond of Nevins Well No. 1, Reinhardt Well No. 1, and Glaser Well No. 1.

Genus LEPERDITELLA

Ulrich 1894

Genotype Leperditia inflata Ulrich

> "Carapace leperditoid, ovate or oblong, with a straight back; surface of valves without eye tubercle or distinguishable muscle spot, but a more or less obscure broad depression is generally present in the central part of the dorsal half; left valve a little larger than the other, the free edges of the latter fitting into a groove. Length 1 to 3 mm. long." (Shimer and Shrock, 1944, page 664)

Leperditella variant "A"

Carapace oval in lateral view; greatest height and greatest thickness in posterior end; anterior end sharp, posterior end blunt; straight, short, and depressed hinge line. Valves unequal, left larger and overlapping ventral edge of right. Surface smooth with an obscure broad depression in the central part of the dorsal half. Dorsal view shows wedge-shape. Length 0.8 mm., height 0.4 mm.

Occurrence: Common in Richmond and rare in Trenton of Nevins Well No. 1, Bateson Well No. 1, and Reinhardt Well No. 1.

Leperditella variant "B"

Greatest height and greatest thickness in anterior end; hinge straight and long but not depressed. Valves unequal, left larger and overlapping all around on the right. In other characters it closely resembles variant "A". Length 1.3 mm., height 0.7 mm.

Occurrence: Frequent in Richmond and rare in Trenton of Nevins Well No. 1 and Bateson Well No. 1.

Leperditella variant "C"

Hinge straight and long but not depressed. In other characters it closely resembles variant "A". Length 0.8 mm., height 0.3 mm.

Occurrence: Rare in Richmond of Bateson Well No. 1 and Reinhardt Well No. 1; rare in Trenton of Bateson Well No. 1.

Genus MACRONOTELLA

Ulrich 1894

Genotype Macronotella scofieldi Ulrich

> "Shell semicircular or semiovate with a long, nearly straight hinge line; valves equal, inflated centrodorsally, without ridges or sulcus but exhibiting a smooth, subcentral spot where reticular ornamentation is lacking." (Shimer and Shrock, 1944, page 664)

Macronotella scofieldi Ulrich variant "A"

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends equal; straight and long hinge line. Valves equal; with a sharply impressed furrow along free edges forming a beveled border. Surface distinctly punctate except for subcircular smooth "muscle spot" in the center. Height 0.7 mm., length 0.3 mm.

This species has been compared with the descriptions and plates by Ulrich, 1894, page 684 (Plate XLIII, Figures 30-34), and agrees in every respect except it is about one half the size of the holotype.

Occurrence: Very rare in Richmond of Glaser Well No. 1.

Macronotella scofieldi variant "B"

This variant is doubtfully represented by one valve.

Carapace suboval in lateral view; greatest height and greatest thickness in posterior end; anterior sharper than posterior end; straight and short hinge line. Surface distinctly punctate except central area of the body. Length 2.0 mm., height 0.1 mm.

Occurrence: Very rare in Trenton of Bateson Well No. 1.

Genus PARASCHMIDTELLA

Swartz 1936

Genotype Paraschmidtella dorsopunctata Swartz

> "Small, straight-hinged, elliptical to subquadrate Ostracoda, with broad thickened dorsal umbos, which generally project beyond the hinge, and thus modify the dorsal margin. Surface marked by deep, distinct, rounded punctae. Hingement and overlap not well known." (Kay, 1940, page 245)

Paraschmidtella variant "A"

Carapace oval in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends equal; hinge straight and depressed. Valves unequal, right overlapping on the posterior end of left; left overlapping on the ventral edge and anterior end of right. Surface with 30 to 40 distinct punctae irregularly distributed over all but borders of the valve. In other characters it closely resembles the genotype though the dimensions of the genotype could not be found in the literature. Length 0.5 mm., height 0.3 mm.

Occurrence: Frequent in Trenton of Bateson Well No. 1 and very rare in Trenton of Reinhardt Well No. 1 and Glaser Well No. 1.

Genus SACCELATIA

Kay 1940

Genotype Aparchites arrectus Ulrich

> "Valves small, similar; outline deeply truncate elliptical; hinge straight, relatively long; ends subequal. Valves quite convex, surface rising gently from dorsal margin to greatest thickness ventral to midheight; surface smooth or with fine reticulation, having ventral swellings, flanges and projections in some species. Contact with left valve overlapping; bordered by marginal granules in some species." (Kay, 1940, page 424)

Saccelatia arrecta Ulrich variant "A"

This species is doubtfully represented by one valve. Carapace suboval in lateral view; greatest height in the middle; greatest thickness ventral to center; anterior and posterior ends nearly equal; straight and long hinge line. Surface smooth; free margins granulose. Length 0.4 mm., height 0.2 mm.

This specimen has been compared with the description and plates by Kay, 1940 page 243 (Plates 29, Figures 12-16) and seems to agree in every respect except it is 0.31 mm. less in length and 0.23 mm. less in height than the holotype.

Occurrence: Very rare in Trenton of Bateson Well No. 1 and Reinhardt Well No. 1.

Saccelatia arrecta Ulrich variant "B"

Valves unequal, left larger and overlapping on free margins. Free margins not granulose. In other characters it closely resembles Saccelatia arrecta. Length 0.6 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Saccelatia arrecta Ulrich variant "C"

Carapace truncate suboval in lateral view; free margins granulose, separated from contact by shallow channel. In other characters it closely resembles Saccelatia arrecta. Length 1 mm., height 0.6 mm.

Occurrence: Very rare in Rochmond of Bateson Well No. 1.

Genus SCHMIDTELLA

Ulrich 1892

Genotype Schmidtella crassimarginata Ulrich

> "Carapace small (2 mm. or less in length), short, rounded or subovate, moderately convex, more or less inflated in the dorsal region, this part being the thickest and appearing generally (in an end view), as projecting shoulder-like over and out from the straight hinge line; right valve slightly larger than the left and overlapping it along the ventral margin. No eye tubercle nor sulcus, but a faint central pit and elevation occasionally present." (Shimer and Shrock, 1944, page 664)

Schmidtella incompta Ulrich variant "A"

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the dorsal half; anterior and posterior ends nearly equal; straight and depressed hinge line. Valves unequal; right larger and overlapping the ventral edge. Surface smooth. Length, 1.0 mm., height 0.7 mm.

This specimen has been compared with the description and plates by Ulrich, 1894, page 642 (Plate XLV and Figures 27, 32, and 33, Volume III), and agrees in every respect except that it is slightly smaller than the holotype.

Occurrence: Rare in Richmond of Bateson Well No. 1 and frequent in Nevins Well No. 1; rare in Trenton of Bateson Well No. 1 and Nevins Well No. 1.

Schmidtella umbonata Ulrich variant "A"

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the dorsal region; posterior sharper than anterior end; straight and short hinge line. Valves unequal, right larger and overlapping on the ventral edge of left; an umbo-like structure at the dorsal margin. Surface smooth. Length, 0.9 mm., height 0.6 mm.

This specimen has been compared with the description and plates by Kay, 1940, page 242 (Plate 29, Figures 9,11), and agrees in every respect except that it is slightly larger than the holotype.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and Reinhardt Well No. 1; very rare in Trenton of Nevins Well No. 1 and Bateson Well No. 1.

Schmidtella umbonata Ulrich variant "B"

Anterior and posterior ends equal. Valves unequal; inflated in dorsal region with a distinct umbo-like shape over and out from the hinge line. In other characters it closely resembles Schmidtella umbonata. Length 0.4 mm., width, 0.2 mm.

Occurrence: Frequent in Richmond of Bateson Well No. 1 and rare in Richmond of Reinhardt Well No. 1.

Schmidtella variant "C" (Plate 1 , Figure 2).

Right valve larger and overlapping all around the ventral edge of left. Grooves all along the free margins of left valve. In other characters it closely resembles variant "B". Length 1.0 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Glaser Well No. 1, Reinhardt Well No. 1, and Nevins Well No. 1; frequent in Richmond of Bateson Well No. 1.

Genus BEYRICHIA

McCoy 1844

Genotype Beyrichia kloedeni McCoy

> "Straight-backed, distinctly trilobate; middle lobe smallest, rounded and commonly isolated, posterior longer but also detached; brood pouch subglobular or ovate, ventroposterior or in

Bonnema's opinion ventroanterior; many species."
(Shimer and Shrock, 1944 page 675)

Beyrichia variant "A" (Plate 2 , Figure 3)

This specimen is represented by one left valve only. Carapace suboval in lateral view; greatest height in the middle; greatest thickness at the posterior half, posterior end slightly sharper than anterior; straight hinge line. Surface smooth, distinctly trilobate; middle lobe smallest, rounded and isolated. Length 0.8 mm., height 0.3 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and rare in Reinhardt Well No. 1.

Beyrichia variant "B"

This specimen is represented by one left valve only. The posterior lobes are very pronounced and projected like a node; thick marginal ridge at ventral edge. In other characters it closely resembles variant "A". Length 0.5 mm., height 0.2 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and rare in Reinhardt Well No. 1.

Genus CTENOBOLBINA

Ulrich 1890

Genotype Ctenobolbina (Beyrichia) ciliata Emmons

"Carapace small, elongate-suboval, strongly convex, the posterior two-fifths more or less decidedly bulbous or subglobular, and separated from the remainder by a deep, narrow and more or less oblique sulcus extending with a gentle curve from the dorsal margin more than half the distance across the valves toward the posteroventral border. The anterior three-fifths often with another oblique but less impressed sulcus. Valves equal, the dorsal margin straight, hingement simple, the ventral edge thick, and the true contact margins generally concealed, in a lateral view, by a 'frill' or flattened false border; surface granulose, smooth, or punctate." (Ulrich, 1894, page 673)

Ctenobolbina ciliata Ulrich variant "A"

Greatest height and greatest thickness in the posterior end; anterior end sharp, posterior end blunt. Surface granulose bearing two sulci, posterior sulcus crescentic, narrow and deep; anterior shallow and narrower ventral edge with a flattened false border. In other characters it closely resembles the genotype.
Length 1.0 mm., height 0.5 mm.

Occurrence: Very rare in the Richmond of Bateson Well No. 1.

Ctenobolbina hammelli Miller and Faber variant "A"

Carapace semicircular in lateral view; greatest height in the middle; greatest thickness in the posterior; anterior and posterior ends nearly equal; straight and long hinge line. Surface smooth bearing two deep oblique sulci, one at the anterior and the other at the posterior, dividing the body into three distinct lobes. The median and anterior lobes are united just below the anterodorsal margin; the posterior, round in shape, separated from the other two entirely. The posterior sulcus extending from the dorsal margin across the body to the postero-ventral margin; the anterior sulcus extending from just below the antero-dorsal margin across the body to the mid-ventral margin parallel with the posterior one. Length 0.7 mm., height 0.4 mm.

This species is represented by one perfectly preserved valve and has been compared with Shimer and Shrock, 1944, page 669 (Plate 281, Figure 66). The actual descriptions of this speices is not given by Shimer and Shrock but the figure closely resembles the figured specimen. The dimensions of the holotype could not be found in the literature.

Occurrence: Very rare in the Richmond of Bateson Well No. 1.

Genus CERATOPSIS

Ulrich 1894

Genotype Beyrichia chambersi Miller

> "Valves somewhat obliquely subovate, widest posteriorly, straight dorsally, with a thick rounded semicircular marginal ridge, and two submedian ridges extending obliquely upward from the marginal ridge, the anterior one reaching the dorsal edge, the other shorter and smaller; post-dorsal end of marginal ridge raised into a strong spine-like, or a mushroom-shaped process, beaded or fimbriated along one edge or around the flattened top. Free edges of carapace as in Ctenobolbina, being thick, and having "false borders"." (Ulrich, 1894, page 675)

Ceratopsis variant "A"

Carapace obliquely suboval in lateral view; greatest height in the posterior end; greatest thickness in the ventral half; anterior pointed, posterior end blunt; straight and long hinge line. Anterior sulcus short and not well defined; short and small spine partly broken. Surface smooth with a thick rounded semicircular marginal ridge. Length 0.8 mm., height 0.4 mm.

Occurence: Rare in the Richmond of Bateson Well No. 1; very rare in Nevins Well No. 1 and Glaser Well No. 1.

Ceratopsis variant "B"

Carapace suboval in lateral view; anterior end sharp but not pointed, anterior sulcus well defined, deep and as long as the median sulcus. Both sulci nearly vertical. Free edges having 'false borders' and ventral margin beveled. Short and stout spine partly broken. In other characters it closely resembles variant "A". Length 1.2 mm., height, 0.6 mm.

Occurrence: Frequent in the Richmond of Nevins Well No. 1; rare in Bateson Well No. 1.

Ceratopsis variant "C"

Carapace semicircular in lateral view; greatest height in the middle; anterior and posterior ends nearly equal. Anterior sulcus well defined, deep and as long as the median sulcus. Both sulci distinctly concave posteriorly. Ventral margin flattened out. In other characters it closely resembles variant "A". Length 1.0 mm., height 0.6 mm.

Occurrence: Very rare in the Richmond of Nevins Well No. 1; rare in Bateson Well No. 1.

Ceratopsis variant "D"

Mushroom-shaped process instead of a spine. Free edges with a thick rounded semicircular marginal ridge. In other characters it closely resembles variant "C". Length 1.4 mm., height 0.8 mm.

Occurrence: Frequent in the Richmond of Nevins Well No. 1; very rare in Reinhardt Well No. 1; very rare in Trenton of Bateson Well No. 1.

Ceratopsis variant "E"

Anterior sulcus short, shallow but well defined. Spine short, straight and node-like. In other characters it closely resembles variant "A". Length 1.2 mm., height 0.6 mm.

Ceratopsis variant "F" (Plate 1 , Figure 1)

Greatest thickness in the posterior end. Spine short, stout, gently curved. Free edges without false borders; ventral margin beveled. In other characters it closely resembles variant "B". Length 1.4 mm., height 0.7 mm.

Occurrence: Very rare in the Richmond of Nevins Well No. 1.

Genus OPIKATIA

Kay 1940

Genotype Opikatia emaciata Kay

> "Valves medium in size, similar. Dimorphic, valves similar in outline in two forms; truncate oval; hinge rather long; dorsal margin slightly sinuous; free margins regularly curved; ends subequal. Surface of male valve bearing median sulcus or pit, with distinct lobe to posterior; low node within dorsal margin anterior to midlength; linear lobe anteroventral to sulcus, thickest point on valve; female dimorph with three distinct rounded nodes within posterodorsal, midposterior, and posteroventral margins, with corresponding internal brood pouches; surface smooth or slightly pitted. Contact simple." (Kay, 1940, page 264)

Opikatia rotunda Kay variant "A" (Plate 2, Figure 1)

Greatest height and greatest thickness in the posterior end; anterior sharp, posterior end blunt. Surface pitted. Length 0.7 mm., height 0.50 mm. In other characters it closely resembles Opikatia rotunda described by Kay, 1940, page 264, (Plate 34, Figures 1-6) except that its height is 0,10 mm. greater than the holotype.

This variant is represented by one perfectly preserved left valve and the only one found in this study.

Occurrence: Very rare in the Richmond of Nevins Well No. 1.

Genus TETRADELLA

Ulrich 1890

Genotype Beyrichia quadrilirata Hall and Whitfield

> "Valves marked by four or less curved vertical ridges ventrally united; one or both inner ridges sometimes duplex; loculi or partitions usually project from posterior and posteroventral marginal ridge." (Shimer and Shrock, 1944, page 667)

Tetradella ulrichi Kay variant "A" (Plate 1 , Figure 4)

Carapace suboval in lateral view; greatest height and greatest thickness in the posterior end; anterior end sharp, posterior end blunt; straight and long hinge line. Surface with six distinct ridges, two of this number produced by division of the posterior and antero-median ridges. Both the posterior pair and the anterior-median pair are united above and below forming a crescent-shaped hollow space facing inwards. Ventral edge relatively thick bearing three brood pouches at the posteroventral margin. These pouches are rather obscure due to filling up of the matrix. Length 1.2 mm., height 0.50 mm.

This variant is represented by one perfectly preserved left valve and the only one found in this study. It has been compared with the descriptions by Kay, 1934, page 339, (Plate 45, Figures 16-19) and agrees in every respect except the presence of three brood pouches, stating that this variant is a female and its length 0.33 mm. longer and its height 0.08 mm. less than the holotype.

Occurrence: Very rare in the Richmond of Bateson Well No. 1.

Genus BOLLIA

Jones and Holl 1886

Genotype Bollia bicollina Jones and Holl

> "Valves subequal, oblong or somewhat rounded, with rounded and nearly equal ends and a straight hinge line; surface punctate or smooth, and bearing a large loop-like or more or less horse-shoe-shaped ridge in central area; from the edges the surface rises into a more or less well-developed, angular or rounded marginal ridge; the outer and inner ridge often come close together ventrally, but rarely, if ever, coalesce; horseshoe ridge of nearly equal strength throughout, or the ends may be bulbous and the connecting bent portion relatively very thin and low." (Ulrich, 1894, Page 668)

Bollia subaequata Ulrich variant "A"

Carapace suboval in lateral view. Greatest height in posterior; greatest thickness in the center. Straight hinge line; surface smooth bearing a U-shaped ridge closer on the mid-dorsal half. Length, 1.25 mm., height, 0.8 mm.

This species is questionably represented by one poorly preserved valve and has been compared with the descriptions and plates by Kay, 1934, page 336 (Plate 4 and Figures 6-16) and agrees in every respect except it is twice in length and height of the holotype.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Bollia subaequata Ulrich variant "B"

This variant is represented by one left valve only. Anterior slightly sharper than posterior end; straight and long hinge line. Surface punctate bearing a small U-shaped ridge in the central area. In other characters it closely resembles Bollia subaequata variant "A". Length 1.0 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Bollia regularis Emmons variant "A" (Plate 2 , Figure 5)

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends almost equal, straight and short hinge line. Surface smooth bearing a highly elevated horse-shoe-shaped ridge of equal strength in the center. Length 1.0 mm., height 0.5 mm.

This species is questionably represented due to the lack of adequate descriptions in Shimer and Shrock, 1944, page 667. (Plate 281, Figures 27-28) though it resembles the figured specimen.

The dimensions of the holotype could not be found in the literature.

Occurrence: Rare in Richmond of Reinhardt Well No. 1; very rare in Richmond of Bateson Well No. 1.

Genus DILOBELLA

Ulrich 1894

Genotype Dilobella typa Ulrich 1894

> "Carapace small, equivalved, subovate or somewhat reniform in outline, the back straight or faintly concave; valves bilobed, the lobes subequal, very large, and almost completely separated by a deep subcentral vertical sulcus; edges thin, simple; surface smooth." (Ulrich, 1894, page 672)

Dilobella simplex Kay 1940 variant "A"

Carapace truncate suboval in lateral view; greatest height in the middle; greatest thickness in the ventral half; anterior and posterior ends almost equal; straight and fairly long hinge line. Valves equal; surface smooth and distinctly bilobed bearing a distinct arcuate sulcus extending from midventral to middle of dorsal margin, concave posteriorly. Lobes same elevation. Contact of valves with slightly thickened border. Length 1.1 mm., height 0.5 mm.

The specimen has been compared with the above description by Kay, 1940, page 257, (Plates 33, Figures 17-19), and agrees in every respect except that it is twice as large as the holotype.

Occurrence: Very rare in Trenton of Bateson Well No. 1 and rare in Richmond of Nevins Well No. 1.

Dilobella simplex Kay variant "B"

Anterior much sharper than posterior end; surface papillose with low rounded node on the posterior side of sulcus; in other characters it closely resembles Dilobella simplex variant "A".

Length 1.0 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and rare in Nevins Well No. 1.

Dilobella simplex Kay variant "C"

Surface smooth with a broad deep sulcus vertically extending from mid-ventral to dorsal margin. Posterior lobe more elevated than anterior. In other characters it closely resembles Dilobella simplex variant "A". Length 1.4 mm., height 0.6 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Genus PRIMITIA

Jones and Holl 1865

Genotype Beyrichia mandula Jones

> "Straight-backed; dorsally truncated suboval or subovate; valve surface rather regularly convex, with rather well marked but small vertical dorsomedian furrow without distinct nodes; contact without appreciable overlap; hinge relatively simple, though it may be a little thickened, with faint longitudinal grooves and ridges; no dimorphism known; many species." (Shimer and Shrock, 1944, page 665)

Primitia mammata Ulrich variant "A"

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in centro-dorsal half, anterior and posterior ends equal; straight and short hinge line. Valves equal; surface smooth bearing a dorsally extending, well-defined sulcus posterior to mid-height, margined by poorly defined swellings. Length 0.6 mm., height, 0.25 mm.

This specimen has been compared with the description and plates by Kay, 1940, page 248 (Plate 30, Figure 22) and agrees in every respect except it is slightly larger than the holotype.

Occurrence: Very rare in Richmond of Reinhardt Well No. 1.

Primitia variant "B"

Greatest height in the middle; greatest thickness in the center. Surface smooth with rather well marked small vertical dorsomedian furrow. In other characters it closely resembles Primitia mammata variant "A". Length 0.7 mm., width 0.3 mm., thickness 0.15 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1, and rare in Nevins Well No. 1.

Primitia variant "C"

Anterior sharper than posterior end; surface smooth with a well marked vertical dorsomedian sulci with rather distinct node to the anterior. In other characters it closely resembles Primitia mammata variant "A". Length 1.0 mm., height 0.1 mm.

Occurrence: Very rare in Trenton of Bateson Well No. 1 and rare in Richmond of Nevins Well No. 1.

Primitia variant "D"

Greatest height in posterior; greatest thickness in the anterior; anterior end sharp; posterior end blunt. Valves unequal, right larger and overlapping in the ventral edge of left. Flange-like structure on the anterior half. In other characters it closely resembles the genotype. Length 1.0 mm., height 0.6 mm.

Occurrence: Abundant in Richmond of Nevins Well No. 1. Very rare in Bateson Well No. 1, Reinhardt Well No. 1 and Glaser Well No. 1.

Primitia variant "E"

Greatest height in the middle; greatest thickness in the center; anterior and posterior ends equal. Valves equal; surface

smooth bearing a deep and wide dorsomedian sulcus. In other characters it closely resembles the genotype. Length 1.3 mm., height 0.6 mm.

Occurrence: Rare in Richmond of Bateson Well No. 1.

Genus HAPLOPRIMITIA

Ulrich and Bassler, 1923

Genotype Haploprimitia(Primitia) minutissima Ulrich & Bassler

> "Distinguished from Primitia by the absense of a border along the free edge of valves and by the occurrence of a simple slit-like furrow in the dorsal half." (Ulrich and Bassler, 1923, page 297)

Haploprimitia variant "A"

Carapace suboval in lateral view; greatest height in the middle and greatest thickness in the center; anterior and posterior ends equal; straight hinge line. Valves equal without a border along the free edge. Surface finely reticulated, with slit-like furrow in the dorsal half. Length, 1.0 mm., height 0.3 mm., thickness 0.3 mm.

Occurrence: Very rare in Richmond of Bateson and Reinhardt Wells No. 1., and very rare in Trenton of Bateson and Reinhardt in Wells No. 1.

Genus LACCOPRIMITIA

Ulrich and Bassler 1923

Genotype Laccoprimitia (Primitia) centralis Ulrich and Bassler

> "Valves with a border along the free edge, a single, simple, subcircular pit a little above the mid-height and without surface nodes. Otherwise as in Primitia." (Ulrich and Bassler, 1923, page 300)

Laccoprimitia variant "A"

Carapace suboval in lateral view; greatest height in the middle and greatest thickness in the center; anterior and posterior ends equal; straight hinge line. Valves equal with a border along the free edge. Surface smooth, with a subcircular pit above center and without surface nodes. Length, 0.4 mm., height 0.2 mm.

Occurrence: Very rare in Richmond of Nevins Well No. 1, and Reinhardt Well No. 1; very rare in Trenton of Nevins, Bateson and Reinhardt, Wells No. 1.

Genus EUPRIMITIA

Ulrich and Bassler 1923

Genotype Primitia sanctipauli Ulrich 1894

> "Like typical Primitia except that the carapace has a simple sulcus, reticulate ornamentation, and an elevated false border around the free edge of the valve, making a bicanaliculate edge in the entire closed carapace." (Ulrich and Bassler, 1923, page 299)

Euprimitia variant "A"

Carapace reniform in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends equal; straight and depressed hinge line. Valves equal; surface finely reticulated and with a primitian sulcus extending from just center of the valve to mid dorsal. False borders along the free margins. Length 0.5 mm., height 0.2 mm., thickness 0.1 mm.

Occurrence: Very rare in Richmond of Reinhardt Well No. 1.

Genus MILLERATIA

Swartz 1936

Genotype Beyrichia cincinnatiensis Miller

> "Small, strongly unisulcate, essentially equivalved shells like Primitia, but differing in development of strong asymmetrical dorsal umbos." (Shimer and Shrock, 1944, page 665)

Milleratia cincinnateinsis Miller variant "A"

Carapace oval in lateral view; greatest height in the anterior; greatest thickness in the center; posterior end sharp, anterior end blunt; straight, short and depressed hinge line. Valves equal with an umbonal extension in the dorsal region. Surface finely granulose bearing a deep sulcus in the dorsal half of the valve, widest at ventral end, not extending to ventral border. A rounded node on the anterior side of the sulcus. Length 0.6 mm., height 0.3 mm.

This species has been compared with the description and plates by Spivey, 1939, page 167, (Plate 21, Figures 18,19, page 170) and agrees in every respect except that it is 0.13 mm. less in length and 0.2 mm. less in height of the hypotype.

Occurrence: Abundant in Richmond of Nevins Well No. 1 and Bateson Well No. 1; common in Reinhardt Well No. 1 and Glaser Well No. 1; and very rare in Trenton of Nevins Well No. 1 and Bateson Well No. 1.

Genus HALLIELLA

Ulrich 1890

Genotype Halliella (Primitia and

Halliella retifera Ulrich

> "Carapace with broad sulcus and very coarsely reticulate surface which rises to greatest height in anterodorsal quarter; thick double border." (Shimer and Shrock, 1944, page 665)

Halliella labiosa Ulrich variant "A"

Carapace suboval in lateral view; greatest height in anterodorsal half; greatest thickness in the posterior end; anterior slightly sharper than posterior; straight and long hinge line. Valves equal with a false border on free margins. Surface coarsely reticulated with a posteriorly arcuate sulcus extending from center to mid-dorsal. Length 0.6 mm., height 0.3 mm.

This species has been compared with the description and plates by Kay, 1934, page 332 (Plate 44, Figures 17,18) and agrees in every respect except that it is 0.22 mm. less in length and 0.30 mm. less in height than the holotype.

Occurrence: Rare in Trenton of Bateson Well No. 1. Very rare in Black River of Reinhardt Well No. 1.

Genus EURYCHILINA

Ulrich 1889

Genotype Eurychilina reticulata Ulrich

> "Oblong or semielliptical, long-hinged shells with a subcentral primitian sulcus, the posterior edge of which is often raised into a small, rounded node; free margins provided with a wide, usually radiately plicated, frill-like border curved on its under side so as to form a concave area around the true contact edge of valves." (Shimer and Shrock, 1944, page 673)

Eurychilina reticulata Ulrich variant "A" (Plate 2 , Figure 4)

Greatest height and greatest thickness in the posterior end. Surface coarsely reticulated without frill-like border on the free margins. In other characters it closely resembles the genotype.

Length, 1.1 mm., height 0.5 mm.

Occurrence: Very rare in Richmond of Nevins Well No. 1 and Bateson Well No. 1.

Eurychilina aequalis Ulrich variant "A" (Plate 1 , Figure 3)

Carapace suboval in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends equal; straight and long hinge line. Surface smooth with a narrow and shallow central sulcus not extending to the dorsal margin. Free margins with a radiately-plicated, frill-like border. Length 2.0 mm., height 1.0 mm.

This species is represented by one perfectly preserved valve out of six specimens found. It has been compared with the descriptions and plates by Ulrich, 1890, page 129 (Plate 9, Figures 5-8) and agrees in every respect except that the frill-like border is not wide and the length is 0.46 mm. longer and the height is 0.15 mm. less than the holotype.

Occurrence: Frequent in Richmond of Nevins Well No. 1; rare in Bateson Well No. 1; very rare in Reinhardt Well No. 1; very rare in Trenton of Reinhardt Well No. 1.

Eurychilina aequalis Ulrich variant "B"

Surface smooth with a narrow and deep central sulcus not extending to the dorsal margin which is slightly depressed. Free margins without a distinct radiately-plicated, frill-like border. In other characters it closely resembles Eurychilina aequalis variant "A". Length 1.0 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Eurychilina aequalis Ulrich variant "C" (Plate 2 , Figure 2)

Surface coarsely reticulated bearing a long arcuate sulcus extending from the mid-ventral half to the dorsal margin. Dorsal portion of the sulcus widened out and connected at the posterior by a shallow depression. Free edges of the valve with a thick rounded ridge and also at the dorsal margin. In other characters it closely resembles Eurychilina aequalis variant "B". Length 1.5 mm., height 0.9 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Eurychilina granosa Ulrich variant "A"

Carapace semicircular in lateral view; greatest height in the middle; greatest thickness in the anterior half; anterior and posterior ends equal; straight and long hinge line. Surface finely granulose with a subcentral primitian sulcus having a small rounded node posteriorly. Free margins without frill-like border. Length 0.8 mm., height 0.4 mm.

This species is doubtfully represented due to lack of a perfect specimen though five specimens in total were found. It has been compared with the descriptions and plates by Ulrich, 1890, page 128 (Plate 29, Figures 9-12) and agrees in every respect except that the frill-like border is lacking and the length is 0.8 mm. less than the height which is 0.8mm. less than the holotype.

Occurrence: Rare in Richmond of Nevins Well No. 1.

Eurychilina granosa Ulrich variant "B"

Surface smooth instead of granulose. In other characters it closely resembles Eurychilina granosa variant "A". Length 0.8 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Genus COELOCHILINA

Ulrich and Bassler 1923

Genotype Coelochilina (Eurychilina) aequalis Ulrich

> "Straight-hinged with primitian sulcus and free margins bordered by wide, convex frill." (Shimer and Shrock, 1944, page 673)

Coelochilina variant "A"

Carapace semicircular in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends nearly equal; straight and long hinge line. Surface smooth. In other characters it closely resembles the genotype except that the frill of this variant is broken off and a small portion left along the ventral margin. Length 1.0 mm., height 0.7 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Genus CHILOBOLBINA

Ulrich and Bassler 1923

Genotype Primitia dentifera Bonnema

> "Like Coelochilina, but differing in having a long, ovate brood pouch developed in posterior three-fifths of ventral part of frill." (Shimer and Shrock, 1944, page 675)

Chilobolbina billingsi Jones variant "A"

Carapace suboval in lateral view; greatest height in the posterior end; greatest thickness in the anteroventral half; anterior end sharper than posterior; straight and long hinge line. Surface coarsely reticulated with a well outlined median pit. Most of the frill is broken off except a small portion left at the posteroventral edge. Length 1.25 mm., height 0.6 mm.

This species is represented by a poorly preserved left valve. It has been compared with the description and plates by Ulrich and Bassler, 1923, page 518 (Plate XXXVII, Figures 4-6) and found to be half as large as the holotype.

Occurrence: Very rare in Trenton of Bateson Well No. 1.

Genus WINCHELLATIA

Kay 1940

Genotype Winchellatia longispina Kay 1940

> "Valves medium in size, similar. Outline truncate oval; hinge straight, quite long. Valves irregularly convex, bearing distinct posteriorly concave sulcus posterior to valve center, extending to dorsal margin; margined by rounded node on posterior lobe; dimorphic, posteroventral margin in female form bearing flange, typically striate; surface smooth, having nodes or spines on anterior lobe. Contact seems plane." (Kay, 1940, page 253)

Winchellatia variant "A"

Free edges with a sharply impressed furrow, forming a beveled border. In other characters it closely resembles Winchellatia longispina. Length 0.8 mm., height 0.5 mm., thickness 0.15 mm.

Occurrence: Common in Richmond of Bateson Well No. 1.

Genus BYTHOCYPRIS

Brady 1880

Genotype Bythocypris reniforms Brady 1880

> "Shell smooth, reniform, ovate or elliptical; left valve larger than right, overlapping it usually on both dorsal and ventral margins; dorsal margin convex, ventral edge straighter, sometimes slightly convex." (Shimer and Shrock, 1944, page 683)

Bythocypris batesi Spivey variant "A"

Carapace suboval in lateral view; greatest height in posterior

end; greatest thickness in the center; anterior end sharper than posterior. Valves unequal, left larger and overlapping on ventral and dorsal edge of right. Surface smooth with shallow circular pit near the center of the body. Length 0.7 mm., height 0.2 mm.

This species has been compared with the description and plates by Spivey, 1939, page 173 (Plate 21, Figures 51-54) and agrees in every respect except that it is 0.15 mm. less in height than the holotype.

Occurrence: Very rare in Richmond of Nevins Well No. 1.

Bythocypris granti Ulrich variant "A"

Carapace truncated suboval in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior end nearly equal. Valves unequal, left larger and overlapping on ventral edge of right. Surface smooth. Length 1.2 mm., height 0.5 mm.

This species has been compared with the descriptions and plates by Ulrich, 1894, page 689 (Plate XLIV, Figures 39-42) and agrees in every respect except that it is 0.20 mm. less in length and 0.18 mm. less in height than the holotype.

Occurrence: Very rare in Richmond of Nevins Well No. 1 and Bateson Well No. 1. Very rare in Trenton of Bateson Well No. 1. Very rare in Black River of Reinhardt Well No. 1.

Bythocypris variant "A"

Greatest height and greatest thickness in posterior end; anterior distinctly sharper than posterior end. Valves unequal, left large and overlapping with dorsal and ventral margins of right. In other characters it closely resembles Bythocypris granti. Length 1.0 mm., Height 0.8 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Bythocypris variant "B"

Carapace uniform in lateral view; greatest thickness in center; anterior slightly sharper than posterior end; in other characters it closely resembles variant "A". Length 0.4 mm., height 0.3 mm.

Occurrence: Very rare in Richmond of Reinhardt Well No. 1.

Bythocypris variant "C"

Greatest height in the middle; anterior and posterior ends equal; left valve larger and overlapping all around the edge of right. In other characters it closely resembles variant "B". Length 1.0 mm., height 0.4 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1 and Reinhardt Well No. 1.

Bythocypris variant "D"

Greatest height in the middle; greatest thickness in the center; anterior and posterior end almost equal. In other characters it closely resembles variant "A". Length 0.9 mm., height 0.3 mm.

Occurrence: Rare in Richmond of Bateson Well No. 1 and very rare in Glaser Well No. 1 and abundant in Nevins Well No. 1. Very rare in Trenton of Nevins Well No. 1, Reinhardt Well No. 1, Bateson Well No. 1 and Glaser Well No. 1.

Bythocypris variant "E"

Carapace cylindrical in lateral view. Left valve overlapping along the ventral margin. In other characters it closely resembles variant "D". Length 1.0 mm., height 0.4 mm. Very similar to Bythocypris cylindrica.

Occurrence: Abundant in Richmond of Nevins Well No. 1; rare in Reinhardt Well No. 1 and Glaser No. 1; very rare in Bateson Well No. 1. Very rare in Trenton of Reinhardt Well No. 1 and Bateson Well No. 1.

Bythocypris variant "F"

Carapace truncated suboval in lateral view; greatest height and greatest thickness in the posterior; anterior slightly sharper than posterior. Left valve larger and overlapping on dorsal margin. In other characters it closely resembles variant "A". Length 1.0 mm., height 0.6 mm.

Occurrence: Very rare in Richmond and Trenton of Bateson Well No. 1.

Genus MACROCYPRIS

Brady 1867

Genotype Cythere minna Baird

> "Carapace more elongate than Bythocypris and with right instead of left valve the larger, and overlapping along dorsal margin; surface smooth; hinge structure simple, hinge teeth lacking." (Shimer and Shrock, 1944, page 683)

Macrocypris variant "A"

Carapace reniform in lateral view; greatest height in the middle; greatest thickness in the center; anterior and posterior ends nearly equal; valves unequal, left larger and overlapping on the dorsal and ventral margins of right. In other characters it closely resembles the genotype. Length 0.7 mm., height 0.3 mm.

Occurrence: Abundant in Richmond of Nevins Well No. 1 and

Bateson Well No. 1; common in Reinhardt Well No. 1; rare in Glaser Well No. 1; and very rare in Trenton of Nevins Well No. 1.

Genus KRAUSELLA

Ulrich 1894

Genotype Krausella inaequalis Ulrich 1894

> "Carapace small (1.5 to 2.5 mm.) in length, somewhat elongate, subelliptical, obscurely triangular or semiovate in outline, the dorsal margin more convex than the ventral, the latter straight or but gently convex; with moderately thick and unequal valves; right valve the smaller, drawn out posteriorly into a strong spine-like process; left valve overlapping the right all around." (Ulrich, 1894, page 691)

Krausella variant "A"

This specimen is questionably represented by one broken valve.

Carapace suboval in lateral view; greatest height and greatest thickness in posterior half; anterior end sharper than posterior. Has a drawn-out spine-like process posteriorly. Surface smooth. Length 1.5 mm., height 0.3 mm.

Occurrence: Very rare in Richmond of Nevins and Bateson Wells No. 1, very rare in Trenton of Nevins and Bateson Wells No. 1.

BRACHIOPODA

Genus ZYGOSPIRA

Hall 1862

Genotype Atrypa modesta Say

> "Externally like Protozyga with ventral fold and dorsal sulcus but with numerous strong costae; hinge plate divided, supporting spire with widely divergent descending lamellae and

several coils directed medially; jugum simple, its position variable." (Shimer and Shrock, 1944, page 317)

Zygospira variant "A"

Shell small in size. Outline longitudinally suboval. Surface of both valves marked by 13 to 14 weak radiating plications. Greatest thickness in pedicle valve in the posterior region. Beak small and pointed. Median fold not very distinct. Brachial valve less convex than the other, marked by a rather broad, shallow median sinus or sulcus which corresponds with the fold of the pedicle valve and which reaches nearly to the beak. Length 2.0 mm., height 1.0 mm., thickness 0.5 mm.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Zygospira variant "B"

Shell rather large; outline semicircular. Surface of both valves marked by 12 distinct and strong radiating plications. Greatest elevation near the center of the pedicle valve. Distinct crenulation along the line of commissure. In other characters it closely resembles variant "A". Length, 3.0 mm., height 3.0 mm., thickness 1.0 mm.

Occurrence: Very rare in the Richmond of Reinhardt Well No. 1 and the Bateson Well No. 1.

Zygospira variant "C"

This variant is doubtfully represented by two poor specimens. Shell small in size; outline not determinable. Surface of both valves marked by at least 16 weak radiating plications. Beak is broken off.

Crenulation not well pronounced. In other characters it closely resembles variant "A". Length 1.0 mm., height 1.0 mm., thickness 0.45 mm.

Occurrence: Very rare in the Richmond of Nevins Well No. 1.

GASTROPODA

Genus CYCLORA

Hall 1845

Genotype Cyclora minuta Hall 1845

> "Shell small, averaging 1.0 mm. in height, smooth, consisting of about three volutions which rapidly expand toward the mouth and form a moderately elevated spire. The upper two whorls are quite small and the shell is formed in large part by the third whorl. The aperture is round and well defined." (Cambrian and Ordovician, 1919, page 316)

Cyclora variant "A"

This species has been compared with the description and plates of the genotype in Cambrian and Ordovician, 1919, Maryland Geological Survey, page 316, (Plate I, Figures 23-26; Plate III) and agrees in every respect. Height about 1.0 mm.

Occurrence: Very rare in the Richmond of Reinhardt Well No. 1 and Glaser Well No. 1.

Genus HORMOTOMA

Salter 1859

Genotype Hormotoma (Murchisonia) gracilis

> "High spired shells with many rounded whorls and a sinus in outer lip culminating in a short, notch-like slit that generates a flat or gently concave selenizone; base rounded, without an umbilicus; ornamentation, other than selenizone, growth lines alone. (Shimer and Shrock, 1944, page 457)

Hormotoma gracilis Hall variant "A"

This species is questionably represented by one specimen. The shell is exfoliated except near the aperture. Only four volutions are exemplified in a length of 3.0 mm. The aperture is angular, notches, and produced anteriorly. In other characters it closely resembles the genotype.

Occurrence: Very rare in Richmond of Glaser Well No. 1.

Genus MACLURITES

Lesueur 1818

Genotype Maclurites magnus Lesueur

> "Large, hyperstrophic (pseudosinistral) shells with all whorls visible on flat lower side and a deep, often wide umbilicus on convex upper side; operculum a heavy, horn-shaped or flattened plate which if horn-shaped has rugose projections on inner side for muscle attachment; ornamentation, growth lines and in some species revolving straie or grooves." (Shimer and Shrock, 1944, page 467.)

Maclurites magnus Lesueur

This species is questionably represented by two specimens. The shell smooth without ornamentation, growth lines, striae or grooves. Only three volutions are exemplified in a breadth of 0.4 mm. and height of 0.2 mm. It is discoidal in shape with all the volutions visible on flat side; volutions gradually increasing from the apex, and a deep wide umbilicus of convex upper side. The shape of the aperture is somewhat trigonal.

Occurrence: Very rare in Richmond of Bateson Well No. 1.

Table 1

COMPOSITE OCCURRENCE OF MICROFOSSILS

Genera	Well No. 1	Well No. 2	Well No. 3	Well No. 4
OSTRACODA				
Leperditia A	c.	v.r.	f.	
Leperditia B			v.r.	
Leperditia C	r.		v.r.	
Leperditia D	f.	c.	r.	
Leperditia E			a.	
Leperditia F		r.		
Aparchites ellipticus	v.r.			
Aparchites millepunctatus	v.r.			
Aparchites A			v.r.	
Eridoconcha oboloides	v.r.		v.r.	
Eridoconcha oboloides A	r.		r.	r.
Eridoconcha rugosa			r.	
Eridoconcha rugosa A	r.	r.		r.
Leperditella A	c.	r.	r.	
Leperditella B	f.		f.	
Leperditella C		r.	r.	
Macronotella Scofieldi				v.r.
Macronotella scofieldi A			v.r.	
Paraschimidtella				v.r.
Saccelatia arrecta A		v.r.	v.r.	
Saccelatia B			v.r.	
Saccelatia C			v.r.	
Schmidtella incompta A	f.		r.	

Genera	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Schmidtella umbonata A	v.r.	v.r.	v.r.	
Schmidtella umbonata B		r.	f.	
Schmidtella umbonata C	v.r.	v.r.	f.	v.r.
Beyrichia A		r.	v.r.	
Beyrichia B		r.	v.r.	
Ctenobolbina ciliata A			v.r.	
Ctenobolbina hamelli			v.r.	
Ceratopsis A	v.r.		r.	v.r.
Ceratopsis B	f.		r.	
Ceratopsis C	v.r.		r.	
Ceratopsis D	f.	v.r.	v.r.	
Ceratopsis E	v.r.			
Ceratopsis F	v.r.			
Opikatia A			v.r.	
Tetradella ulrichi A			v.r.	
Bollia subaequata A			v.r.	
Bollia subaequata B			v.r.	
Bollia regularis A		r.	v.r.	
Dilobella simplex A	r.		v.r.	
Dilobella simplex B	r.		v.r.	
Dilobella simplex C			v.r.	
Primitia mammata A		v.r.		
Primitia mammata B	r.	v.r.	v.r.	
Primitia C	r.		v.r.	
Primitia D	a.	v.r.	v.r.	v.r.

Genera	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Primitia E			r.	
Haploprimitia A		v.r.	v.r.	
Laccoprimitia A	v.r.	v.r.	v.r.	
Euprimitia A		v.r.		
Milleratia cincinnatiensis	a.	a.	a.	v.r.
Halliella labiosa A		v.r.	v.r.	
Eurychilina reticulata A	v.r.		v.r.	
Eurychilina aequalis A	f.	v.r.	r.	
Eurychilina aequalis B			v.r.	
Eurychilina aequalis C			v.r.	
Eurychilina granosa A	r.			
Eurychilina granosa B			v.r.	
Chilobolbina billingsi A			v.r.	
Coelochilina A			v.r.	
Winchellatia A			c.	
Bythocypris batesi A	v.r.			
Bythocypris granti A	v.r.	v.r.	v.r.	
Bythocypris A			v.r.	
Bythocypris B		v.r.		
Bythocypris D	v.r.	v.r.	r.	v.r.
Bythocypris E	a.	r.	v.r.	r.
Bythocypris F			v.r.	
Macrocypris A	a.	c.	a.	r.
Krausella A	v.r.		v.r.	

Genera	Well No. 1	Well No. 2	Well No. 3	Well No. 4
BRACHIOPODA				
Zygospira A			v.r.	
Zygospira B		v.r.	v.r.	
Zygospira C	v.r.			
GASTROPODA				
Cyclora A		v.r.		v.r.
Hormotoma gracilis				v.r.
Maclurites magnus			v.r.	

Explanation

v.r. - very rare

r. - - rare

f. - - frequent

c. - - common

a. - - abundant

CONCLUSIONS

A.

1. There is a wide distribution of microfossils in the Middle and Upper Ordovician series on the eastern side of Michigan.
2. The microfossils include brachiopoda, bryozoa, crinoidea, gastropoda and ostracoda. Ostracoda are the most common and bryozoa and crinoidal columnals are next in order.
3. Microfossils occur at interrupted intervals within the Trenton and Richmond groups.
4. Ostracoda are abundant in both Middle and Upper Ordovician series.
5. Ostracoda are more abundant in the Richmond shale than the Trenton limestone.
6. Bryozoa are not found in Glaser well No. 1, Ingham County.
7. Nevins Well No. 1 and Bateson Well No. 1 have the widest distribution of microfossils.
8. Glaser Well No. 1 has the least distribution of microfossils.

B.

1. There is a distinct possibility that the boundary between the Silurian and Ordovician Age may be distinguished by microfossils.
2. There is a distinct bryozoan zone just below the Cataract formation of the Silurian Age. This is found in three wells, namely Nevins, Reinhardt and Bateson and is missing in Glaser, probably because of pinching out before reaching the Glaser well area. Below the bryozoan concentration is the distinct ostracoda zone found in all the four wells. Hence, the boundary between Ordovician and Silurian could be drawn on the basis of the bryozoan zone in the case of the three

wells (Nevins, Reinhardt and Bateson) and the ostracoda zone in Glaser.

C.

1. There is a possibility of differentiating between the Upper and Middle Ordovician series by microfossils. In this case, by using Bateson Well No. 1 (Chart No. 3 and 6) the Upper Ordovician beds could be differentiated into zones or formations according to the frequency of the ostracoda. The same method could be applied to the Middle Ordovician series.
2. The Upper Ordovician could be divided into two major zones and four minor zones. From top to bottom the zones could be differentiated in the following manner: (Chart No. 3 and 6)
   a. Bryozoan zone (major zone)
   b. Schmidtella umbonata zone
   c. Eridoconcha aboloides zone
   d. Ceratopsis, Eridoconcha rugosa and Tetradella ulrichi zone (major zone)
   e. Eurychilina aequalis zone
   f. Bolliø regularis zone
3. The Middle Ordovician could be divided into two major zones and two minor zones. From top to bottom the zones could be differentiated in the following manner: (Chart No. 3 and 6)
   a. Leperditella "A" zone
   b. Paraschmidtella zone (major zone)
   c. Macronotella, Chilobolbina billingsi zone (major zone)
   d. Dilobella simplex zone

D.

1. There is a definite correlation between different wells by microfossils (Table 1, Page 50 to 53)

E.

1. The zones follow the synclinal Michigan Basin and reflect structures in Upper formations. (Chart No. 5)

F.

1. The zones become thicker in the deeper parts of the Michigan Basin (Chart No. 5).

G.

1. The zones pinch and swell and suggest that the other formations above or below may also pinch and swell. (Chart No. 5)

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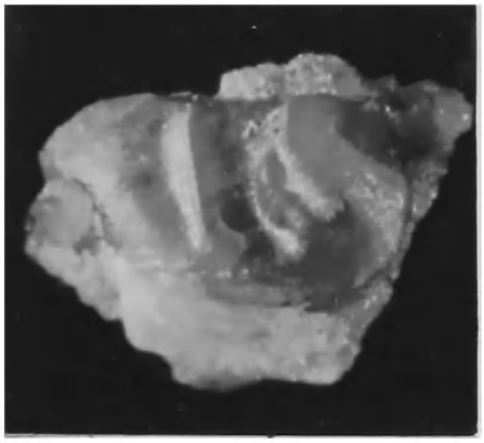
EXPLANATION OF PLATE 1



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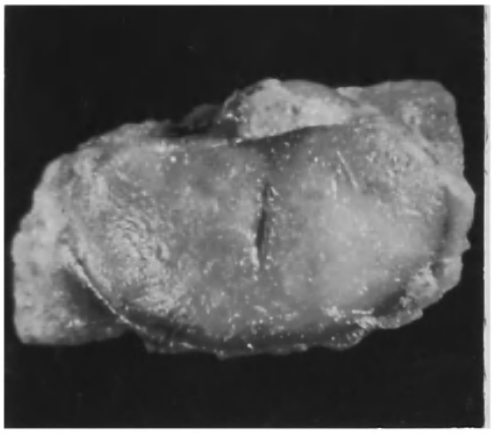

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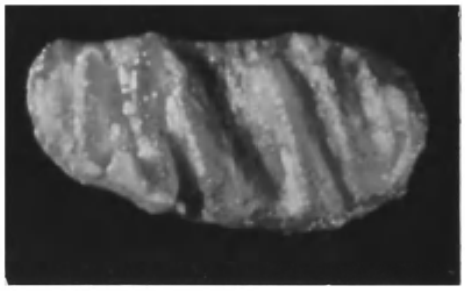

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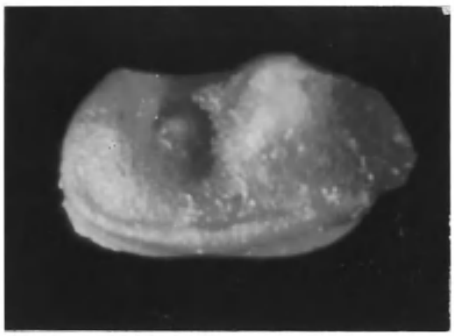
PLATE 1.

EXPLANATION OF PLATE 2

1

2



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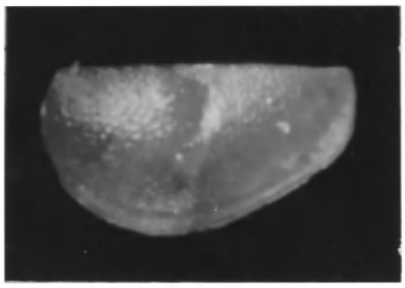

4

5

PLATE 2.

REINHARDT CONSOLIDATED NO. I
OGEMAW COUNTY
WEST BRANCH TOWNSHIP
S.P. NO. 12898 — ELEV. 903.4'

GENERA	8920'-8945'	8945'-8970'	8970'-8995'	8995'-9020'	9020'-9045'	9045'-9070'	9070'-9095'	9095'-9120'	9120'-9145'	9145'-9170'	9170'-9195'	9195'-9220'	9220'-9245'	9245'-9270'	9270'-9295'	9295'-9320'
				100'				200'				300'				400'
	0	1	0	2	0	1	0	0	0	1	4	2	4	0	2	0
OSTRACODA																
BOLLIA REGULARIS											▭					
BYTHOCYPRIS B		▭											▭			
BYTHOCYPRIS C																
BYTHOCYPRIS D																
BYTHOCYPRIS E															▭	
BYTHOCYPRIS GRANTI																
CERATOPSIS D															▭	
ERIDOCONCHA B																
EUPRIMITIA A											▭					
EURYCHILINA AEQUALIS ?																
HALLIELLA LABIOSA ?																
HAPLOPRIMITIA ?																
LACCOPRIMITIA												▭				
LEPERDITIA A											▭		▭			
LEPERDITIA F																
LEPERDITELLA A																
LEPERDITELLA C						▭										
MACROCYPRIS KAYI ?																
MILLERATIA CINCINNATIENSIS											▭					
PRIMITIA C																
PARASCHMIDTELLA PLANILATERALIS																
PRIMITIA MAMMATA																
SACCELATIA ARRECTA																
SCHMIDTELLA UMBONATA				▭												
SCHMIDTELLA A													▭			
SCHMIDTELLA B													▭			
BEYRICHIA																
BRACHIOPODA																
ZYGOSPIRA A																
ZYGOSPIRA B				▭												
GASTROPODA																
CYCLORA										▭						

GENERA	9320'-9345'	9345'-9370'	9370'-9395'	9395'-9420'	9420'-9445'	9445'-9470'	9470'-9495'	9495'-9520'	9520'-9545'	9545'-9570'	9570'-9595'	9595'-9620'	9620'-9645'	9645'-9670'	9670'-9695'	9695'-9720'
				500'				600'				700'				800'
	2	3	2	0	4	3	4	2	6	2	3	1	1	0	1	3
OSTRACODA																
BOLLIA REGULARIS																✚
BYTHOCYPRIS B																
BYTHOCYPRIS C						▭										
BYTHOCYPRIS D		▭			▭				✚		▭					
BYTHOCYPRIS E	✚															
BYTHOCYPRIS GRANTI																
CERATOPSIS D																
ERIDOCONCHA B							▭									
EUPRIMITIA A					▭											
EURYCHILINA AEQUALIS ?															▭	
HALLIELLA LABIOSA ?																
HAPLOPRIMITIA ?																
LACCOPRIMITIA																
LEPERDITIA A																
LEPERDITIA F																
LEPERDITELLA A	▭		▭		▭				✚	▭		▭				
LEPERDITELLA C																
MACROCYPRIS KAYI ?			▭		▭	▭			▭							▭
MILLERATIA CINCINNATIENSIS		▭					▭		▭	▭	✚					▭
PRIMITIA C		✚														
PARASCHMIDTELLA PLANILATERALIS																
PRIMITIA MAMMATA								▭			▭					
SACCELATIA ARRECTA																
SCHMIDTELLA UMBONATA																
SCHMIDTELLA A						▭	▭	✚	▭							
SCHMIDTELLA B							▭		▭							
BEYRICHIA													▭			
BRACHIOPODA																
ZYGOSPIRA A																
ZYGOSPIRA B																
GASTROPODA																
CYCLORA																

GENERA	9720'-9745'	9745'-9770'	9770'-9795'	9795'-9820'	9820'-9845'	9845'-9870'	9870'-9895'	9895'-9920'	9920'-9945'	9945'-9970'	9970'-9995'	9995'-10,020'	10,020'-10,045'	10,045'-10,070'	10,070'-10,095'	10,095'-10,120'
				900'				1000'				1100'				1200'
	0	0	0													
OSTRACODA																
BOLLIA REGULARIS																
BYTHOCYPRIS B																
BYTHOCYPRIS C																
BYTHOCYPRIS D																
BYTHOCYPRIS E												▭				
BYTHOCYPRIS GRANTI																
CERATOPSIS D																
ERIDOCONCHA B																
EUPRIMITIA A																
EURYCHILINA AEQUALIS ?																
HALLIELLA LABIOSA ?																
HAPLOPRIMITIA ?																
LACCOPRIMITIA																
LEPERDITIA A																
LEPERDITIA F																
LEPERDITELLA A																
LEPERDITELLA C																
MACROCYPRIS KAYI ?																
MILLERATIA CINCINNATIENSIS																
PRIMITIA C																
PARASCHMIDTELLA PLANILATERALIS												▭				
PRIMITIA MAMMATA																
SACCELATIA ARRECTA																
SCHMIDTELLA UMBONATA																
SCHMIDTELLA A																
SCHMIDTELLA B																
BEYRICHIA																
BRACHIOPODA																
ZYGOSPIRA A																
ZYGOSPIRA B					▭											
GASTROPODA																
CYCLORA																

GENERA	10,120'-10145'	10,145'-10,170'	10,170'-10,195'	10,195'-10,220'	10,220'-10,245'	10,245'-10,270'	10,270'-10,295'	10,295'-10,320'	10,320'-10,345'	10,345'-10,370'	10,370'-10,395'	10,395'-10,420'	10,420'-10,445'	10,445'-10,470'	10,470'-10,490'	10,490'-10,520'
				1300'				1400'				1500'				1600'
OSTRACODA																
BOLLIA REGULARIS																
BYTHOCYPRIS B																
BYTHOCYPRIS C																
BYTHOCYPRIS D										▭					▭	
BYTHOCYPRIS E						▭										
BYTHOCYPRIS GRANTI													✚		▭	
CERATOPSIS D																
ERIDOCONCHA B																
EUPRIMITIA A																
EURYCHILINA AEQUALIS ?										▭						
HALLIELLA LABIOSA ?												▭				
HAPLOPRIMITIA ?												▭				
LACCOPRIMITIA												▭				
LEPERDITIA A																
LEPERDITIA F														▭	✚	
LEPERDITELLA A														▭	▭	
LEPERDITELLA C																
MACROCYPRIS KAYI ?																
MILLERATIA CINCINNATIENSIS																
PRIMITIA C																
PARASCHMIDTELLA PLANILATERALIS																
PRIMITIA MAMMATA																
SACCELATIA ARRECTA			▭													
SCHMIDTELLA UMBONATA																
SCHMIDTELLA A																
SCHMIDTELLA B																
BEYRICHIA																
BRACHIOPODA																
ZYGOSPIRA A																
ZYGOSPIRA B																
GASTROPODA																
CYCLORA																

CHART NO. 2

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS IN THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS

Ogemaw

EXPLANATION

FREQUENCY SYMBOLS

▭	0 - 1	VERY RARE
✚	2 - 4	RARE
△	5 - 7	FREQUENT
○	8 - 10	COMMON
□	11 - >	ABUNDANT

FORMATION TOPS

QUEENSTON - LORRAINE	8932'
UTICA	9640'
TRENTON	9779'
BLACK RIVER	10,036'
ST. PETER	10,475'

AGE	FORMATION	DESCRIPTION	THICKNESS	LOG	
SILURIAN ?	NIAGARAN GROUP	Limestone	180'		
	CABOT HEAD	Red shale	35'		
	MANITOULIN	Cherty limestone	99'	8500'-	
ORDOVICIAN	RICHMOND GROUP	Sand Shale Shaly limestone			Schmidtella umbonata
		Limestone	558'		Bythocypris granti and "F", Eridoconcha oboloides.
				9000'-	Maclurites magnus?
					Bollia subequata?, Bythocypris cylindrica and "E", Ceratopsis "C", Dilobella "E". Eridoconcha "A", Leperditia "A", Zygospira "A",
					Eridoconcha "A", Macrocypris kayi?, Milleratia cincinnatiensis, Maclurites.
					Ceratopsis "B" and "C", PRIMITIA D, Eridoconcha oboloides, Milleratia cincinnatiensis.
					Bythocypris 4 species, Ceratopsis 3 species, Coelochilina, Ctenobolbina ciliata,
					Dilobella "B", Eridoconcha rugosa, Eurychilina 2 species, Haploprimitia, Krausella,
					Leperditia 3 species, Leperditella 3 species, Macrocypris kayi?, Milleratia cincinnatiensis,
					PRIMITIA C, Primitia "B", Saccelatia 2 species, Schmidtella 3 species,
					Tetradella ulrichi, BEYRICHIA, Winchellatia, Zygospira "A".
	CINCINNATIAN	Gray shale	258'		Eurychilina aequalis, Leperditella "B", Schmidtella "B", Schmidtella incompta. Eurychilina C Bythocypris "A", Macrocypris kayi?, Milleratia cincinnatiensis. Primitia "A", Winchellatia. Ctenobolbina hamelli, Leperditella "A".
					Bollia regularis, Leperditia "C".
	TRENTON	Limestone	961'	9500'-	Leperditella "A".
		Cherty limestone			
		Shaly limestone			Ceratopsis "D", Eridoconcha "A",
					Bythocypris cylindrica, Schmidtella icompta.
					Paraschmidtella planilateralis.
					Paraschmidtella planilateralis.
					Haploprimitia, Paraschmidtella planilateralis.
					Bythocypris granti, Leperditella "A", Milleratia cincinnatiensis.
				10,000'-	Leperditia "A",
		Limestone			Macronotella.
					Macronotella, Primitia "B",
					Chilobolbina billingsi, Leperditella "A".
					Chilobolbina billingsi, Schmidtella incompta
					Bythocypris "E", Krausella, Leperditia "A",
					Bythocypris granti.
					Leperditia "B".
					Halliella labiosa?, Laccoprimitia, Schmidtella incompta.
					Bythocypris "E".
					Halliella labiosa?, Leperditia "D".
	ST. PETER	Green shaly sand Dolomite Sand (water 10414)	86'	W	Aparchites?, Eridoconcha "A", Haploprimitia, Leperditia "C" and "D", Leperditella "B". Saccelatia arrecta. Dilobella simplex.
				T.D. 10,447'	

LOG OF GULF NO.1 BATESON, BAY CO., MICHIGAN.

ORDOVICIAN SECTION.

CHART NO. 6

Well log after J.B. Maebius.

WM. BATESON NO.1
BAY COUNTY
MONITOR TOWNSHIP
S.P. NO. 5441 — ELEV. 599'

GENERA	8580'-8605'	8605'-8630'	8630'-8655'	8655'-8680'	8680'-8705'	8705'-8730'	8730'-8755'	8755'-8780'	8780'-8805'	8805'-8830'	8830'-8855'	8855'-8880'	8880'-8905'	8905'-8930'	8930'-8955'	8955'-8980'	8980'-9005'	9005'-9030'	9030'-9055'	9055'-9080'
				100'				200'				300'				400'				500'
		1	0	0	0	3	16	6	0	8	4	0	5	0	19	18	15	8	6	2
OSTRACODA																				
APARCHITES ?																				
BOLLIA A																▭				
BOLLIA REGULARIS																				
BOLLIA SUBAEQUATA										▭										
BYTHOCYPRIS A																				
BYTHOCYPRIS C															▭					
BYTHOCYPRIS CYLINDRICA										▭					✚		✚			
BYTHOCYPRIS E										▭										
BYTHOCYPRIS F						▭									▭					
BYTHOCYPRIS GRANTI						▭									▭					
CERATOPSIS A																▭	▭			
CERATOPSIS B													▭			▭		✚		
CERATOPSIS C										✚			▭					✚		
CERATOPSIS D																				
CHILOBOLBINA BILLINGSI																				
COELOCHILINA															▭					
PRIMITIA D													✚		▭					
CTENOBOLBINA CILIATA																		▭		
CTENOBOLBINA HAMMELLI																				
DILOBELLA SIMPLEX																				
DILOBELLA A										▭									▭	
DILOBELLA B															▭					
ERIDOCONCHA OBOLOIDES						▭							▭							
ERIDOCONCHA RUGOSA															▭	▭				
ERIDOCONCHA A										▭	▭									
EURYCHILINA AEQUALIS ?																				
EURYCHILINA RETICULATA ?																▭	▭			
EURYCHILINA C																				
EURYCHILINA B																▭				
HALLIELLA LABIOSA ?																				
HAPLOPRIMITIA															▭					
KRAUSELLA															▭					
LACCOPRIMITIA																				
LEPERDITIA A										▭						▭			▭	
LEPERDITIA B																				
LEPERDITIA C																				
LEPERDITIA E															□	▭				
LEPERDITELLA A															✚	✚	△	▭	✚	▭
LEPERDITELLA B															✚	✚	✚	✚		
LEPERDITELLA C															✚	▭		▭		
MACRONOTELLA																				
MACROCYPRIS KAYI ?											✚				△	○	✚	▭		
MILLERATIA CINCINNATIENSIS											✚		▭		△	✚	✚		▭	
PRIMITIA C															▭		▭			
PARASCHMIDTELLA PLANILATERALIS																				
PRIMITIA A															▭					
PRIMITIA B																				
SACCELATIA ARRECTA																				
SACCELATIA A															▭		▭			
SACCELATIA B																▭				
SCHMIDTELLA INCOMPTA																				
SCHMIDTELLA UMBONATA		▭															▭			
SCHMIDTELLA A																✚	▭		▭	✚
SCHMIDTELLA B																✚	✚	▭		
TETRADELLA ULRICHI																	▭			
BEYRICHIA																	▭			
WINCHELLATIA																✚	✚		▭	
BRACHIOPODA																				
ZYGOSPIRA A										▭										
ZYGOSPIRA B																▭				
GASTROPODA																				
MACLURITES MAGNUS ?							▭				▭									

GENERA	9080'-9105'	9105'-9130'	9130'-9155'	9155'-9180'	9180'-9205'	9205'-9230'	9230'-9255'	9255'-9280'	9280'-9305'	9305'-9330'	9330'-9355'	9355'-9380'	9380'-9405'	9405'-9430'	9430'-9455'	9455'-9480'	9480'-9505'	9505'-9530'	9530'-9555'	9555'-9580'
				600'				700'				800'				900'				1000'
	0	0	0	4	6	2	0	0	0	2	0	0	0	0	0	0	0	1		
OSTRACODA																				
APARCHITES ?																				
BOLLIA A																				
BOLLIA REGULARIS										▭										
BOLLIA SUBAEQUATA																				
BYTHOCYPRIS A					▭															
BYTHOCYPRIS C																				
BYTHOCYPRIS CYLINDRICA																				
BYTHOCYPRIS E																				
BYTHOCYPRIS F																				
BYTHOCYPRIS GRANTI																				
CERATOPSIS A																				
CERATOPSIS B																				
CERATOPSIS C																				
CERATOPSIS D																				
CHILOBOLBINA BILLINGSI																				
COELOCHILINA																				
PRIMITIA D																				
CTENOBOLBINA CILIATA																				
CTENOBOLBINA HAMMELLI						▭														
DILOBELLA SIMPLEX																				
DILOBELLA A																				
DILOBELLA B																				
ERIDOCONCHA OBOLOIDES																				
ERIDOCONCHA RUGOSA																				
ERIDOCONCHA A																				
EURYCHILINA AEQUALIS ?				▭																
EURYCHILINA RETICULATA ?																				
EURYCHILINA C					▭															
EURYCHILINA B																				
HALLIELLA LABIOSA ?																				
HAPLOPRIMITIA																				
KRAUSELLA																				
LACCOPRIMITIA																				
LEPERDITIA A																				
LEPERDITIA B																				
LEPERDITIA C										▭										
LEPERDITIA E																				
LEPERDITELLA A						▭												▭		
LEPERDITELLA B				▭																
LEPERDITELLA C																				
MACRONOTELLA																				
MACROCYPRIS KAYI ?					▭															
MILLERATIA CINCINNATIENSIS					▭															
PRIMITIA C																				
PARASCHMIDTELLA PLANILATERALIS																				
PRIMITIA A					▭															
PRIMITIA B																				
SACCELATIA ARRECTA																				
SACCELATIA A																				
SACCELATIA B																				
SCHMIDTELLA INCOMPTA				▭																
SCHMIDTELLA UMBONATA																				
SCHMIDTELLA A																				
SCHMIDTELLA B				▭																
TETRADELLA ULRICHI																				
BEYRICHIA																				
WINCHELLATIA					▭															
BRACHIOPODA																				
ZYGOSPIRA A																				
ZYGOSPIRA B																				
GASTROPODA																				
MACLURITES MAGNUS ?																				

GENERA	9580'-9605'	9605'-9630'	9630'-9655'	9655'-9680'	9680'-9705'	9705'-9730'	9730'-9755'	9755'-9780'	9780'-9805'	9805'-9830'	9830'-9855'	9855'-9880'	9880'-9905'	9905'-9930'	9930'-9955'	9955'-9980'	9980'-10,005'	10,005'-10,030'	10,030'-10,055'	10,055'-10,080'
				1100'				1200'				1300'				1400'				1500'
OSTRACODA																				
APARCHITES ?																				
BOLLIA A																				
BOLLIA REGULARIS																				
BOLLIA SUBAEQUATA																				
BYTHOCYPRIS A																				
BYTHOCYPRIS C																				
BYTHOCYPRIS CYLINDRICA								▭												
BYTHOCYPRIS E																				
BYTHOCYPRIS F																				
BYTHOCYPRIS GRANTI												▭								
CERATOPSIS A																				
CERATOPSIS B																				
CERATOPSIS C																				
CERATOPSIS D							▭													
CHILOBOLBINA BILLINGSI																				
COELOCHILINA																				
PRIMITIA D																				
CTENOBOLBINA CILIATA																				
CTENOBOLBINA HAMMELLI																				
DILOBELLA SIMPLEX																				
DILOBELLA A																				
DILOBELLA B																				
ERIDOCONCHA OBOLOIDES																				
ERIDOCONCHA RUGOSA																				
ERIDOCONCHA A							▭													
EURYCHILINA AEQUALIS ?																				
EURYCHILINA RETICULATA ?																				
EURYCHILINA C																				
EURYCHILINA B																				
HALLIELLA LABIOSA ?																				
HAPLOPRIMITIA											▭									
KRAUSELLA																				
LACCOPRIMITIA																				
LEPERDITIA A													▭							
LEPERDITIA B																				
LEPERDITIA C																				
LEPERDITIA E																				
LEPERDITELLA A												▭								
LEPERDITELLA B																				
LEPERDITELLA C																				
MACRONOTELLA																				▭
MACROCYPRIS KAYI ?																				
MILLERATIA CINCINNATIENSIS												▭								
PRIMITIA C																				
PARASCHMIDTELLA PLANILATERALIS									▭	✚	▭									
PRIMITIA A																				
PRIMITIA B																				
SACCELATIA ARRECTA																				
SACCELATIA A																				
SACCELATIA B																				
SCHMIDTELLA INCOMPTA																				
SCHMIDTELLA UMBONATA								▭												
SCHMIDTELLA A																				
SCHMIDTELLA B																				
TETRADELLA ULRICHI																				
BEYRICHIA																				
WINCHELLATIA																				
BRACHIOPODA																				
ZYGOSPIRA A																▭				
ZYGOSPIRA B																				
GASTROPODA																				
MACLURITES MAGNUS ?																				

GENERA	10,080'-10,105'	10,105'-10,130'	10,130'-10,155'	10,155'-10,180'	10,180'-10,205'	10,205'-10,230'	10,230'-10,255'	10,255'-10,280'	10,280'-10,305'	10,305'-10,330'	10,330'-10,355'	10,355'-10,380'	10,380'-10,405'	10,405'-10,430'	10,430'-10,455'	10,455'-10,480'	10,480'-10,505'
				1600'				1700'				1800'				1900'	
OSTRACODA																	
APARCHITES ?											▭						
BOLLIA A																	
BOLLIA REGULARIS																	
BOLLIA SUBAEQUATA																	
BYTHOCYPRIS A																	
BYTHOCYPRIS C																	
BYTHOCYPRIS CYLINDRICA																	
BYTHOCYPRIS E				▭		▭											
BYTHOCYPRIS F					▭												
BYTHOCYPRIS GRANTI																	
CERATOPSIS A																	
CERATOPSIS B																	
CERATOPSIS C																	
CERATOPSIS D																	
CHILOBOLBINA BILLINGSI		▭	▭														
COELOCHILINA																	
PRIMITIA D																	
CTENOBOLBINA CILIATA																	
CTENOBOLBINA HAMMELLI																	
DILOBELLA SIMPLEX													▭				
DILOBELLA A																	
DILOBELLA B																	
ERIDOCONCHA OBOLOIDES																	
ERIDOCONCHA RUGOSA																	
ERIDOCONCHA A											▭						
EURYCHILINA AEQUALIS ?																	
EURYCHILINA RETICULATA ?																	
EURYCHILINA C																	
EURYCHILINA B																	
HALLIELLA LABIOSA ?								✚		▭							
HAPLOPRIMITIA											▭						
KRAUSELLA				▭													
LACCOPRIMITIA								▭									
LEPERDITIA A				▭													
LEPERDITIA B							▭										
LEPERDITIA C											▭						
LEPERDITIA E																	
LEPERDITELLA A		▭															
LEPERDITELLA B											▭						
LEPERDITELLA C																	
MACRONOTELLA	▭																
MACROCYPRIS KAYI ?																	
MILLERATIA CINCINNATIENSIS																	
PRIMITIA C																	
PARASCHMIDTELLA PLANILATERALIS																	
PRIMITIA A																	
PRIMITIA B	▭																
SACCELATIA ARRECTA												▭					
SACCELATIA A																	
SACCELATIA B																	
SCHMIDTELLA INCOMPTA			▭					▭									
SCHMIDTELLA UMBONATA																	
SCHMIDTELLA A																	
SCHMIDTELLA B																	
TETRADELLA ULRICHI																	
BEYRICHIA																	
WINCHELLATIA																	
BRACHIOPODA																	
ZYGOSPIRA A																	
ZYGOSPIRA B																	
GASTROPODA																	
MACLURITES MAGNUS ?																	

CHART NO. 3

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS IN THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS

EXPLANATION

FREQUENCY SYMBOLS

▭	0 - 1	VERY RARE
✚	2 - 4	RARE
△	5 - 7	FREQUENT
○	8 - 10	COMMON
□	11 - >	ABUNDANT

FORMATION TOPS

RICHMOND	8584'
CINCINNATIAN	9142'
TRENTON	9400'
ST. PETER	10,361'

GLASER NO. 1
INGHAM COUNTY
WHEATFIELD TOWNSHIP
S.P. NO. 10011 — ELEV. 908'

GENERA	5180'-5205'	5205'-5230'	5230'-5255'	5255'-5280'	5280'-5305'	5305'-5330'	5330'-5355'	5355'-5380'	5380'-5405'	5405'-5430'	5430'-5455'	5455'-5480'	5480'-5505'	5505'-5530'	5530'-5555'	5555'-5580'	5580'-5605'	5605'-5630'	5630'-5655'	5655'-5680'	5680'-5705'	5705'-5730'	5730'-5755'	5755'-5780'	5780'-5805'	5805'-5830'	5830'-5855'	5855'-5880'	5880'-5905'	5905'-5930'	5930'-5955'	5955'-5980'	5980'-6005'	6005'-6030'	6030'-6055'	6055'-6080'	6080'-6105'	6105'-6130'	6130'-6155'	6155'-6180'	6180'-6205'	6205'-6230'	6230'-6255'	6255'-6280'	6280'-6305'	6305'-6330'	6330'-6355'	6355'-6380'	6380'-6405'	6405'-6430'	6430'-6455'	6455'-6480'	6480'-6505'	6505'-6530'	6530'-6555'	6555'-6580'	6580'-6605'
100'																																																										
200'																																																												
300'																																																											
400'																																																											
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MACROCYPRIS KAYI ?	✣			▭																																																								
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MILLERATIA CINCINNATIENSIS	▭	△		▭						▭																																																				
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PARASCHMIDTELLA PLANILATERALIS																																																											
SCHMIDTELLA B				▭																																																								
GASTROPODA																																																																
CYCLORA										▭																																																			
HORMOTOMA		▭																																																											

CHART NO. 4

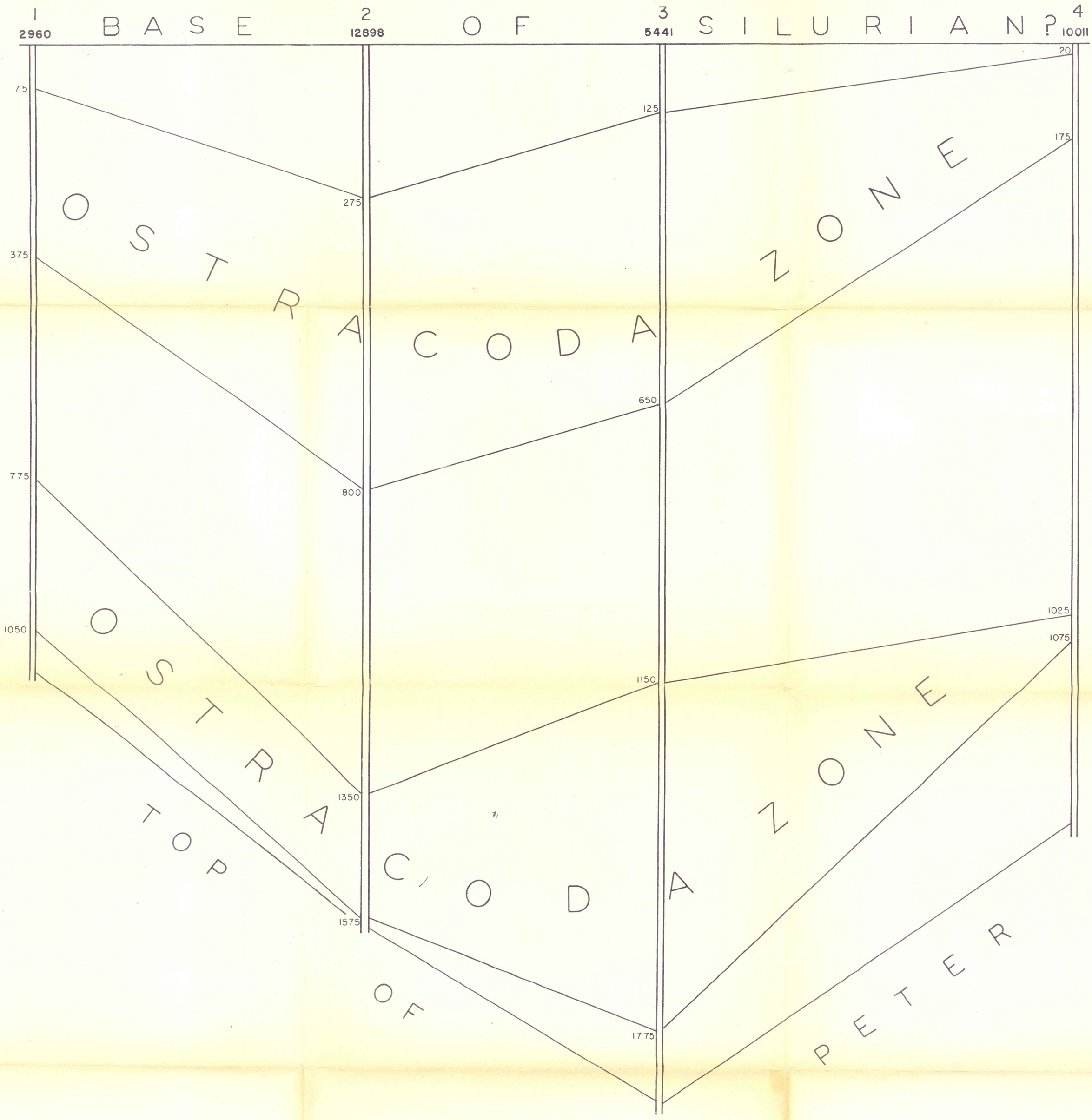
EXPLANATION

FREQUENCY	SYMBOLS	
▭	0 - 1	VERY RARE
✣	2 - 4	RARE
△	5 - 7	FREQUENT
○	8 - 10	COMMON
□	11 - >	ABUNDANT

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS IN THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS

Ingham Ostrac

FORMATION	TOPS
CINCINNATIAN	5180'
TRENTON	5752'
ST. PETER	6553'



CROSS SECTION 1-4 ALPENA COUNTY TO INGHAM COUNTY

SCALE

HORIZONTAL 1 INCH = 10 MILES
VERTICAL 1 INCH = 100 FEET

Cross-section

CHART NO. 5

NEVINS NO. 1
ALPENA COUNTY
LONG RAPIDS TOWNSHIP
S.P. NO. 2960 — ELEV. 803'

GENERA	100'				200'				300'				400'				500'				600'				700'				800'				900'				1000'				1100'		
	4535'-4560'	4560'-4585'	4585'-4610'	4610'-4635'	4635'-4660'	4660'-4685'	4685'-4710'	4710'-4735'	4735'-4760'	4760'-4785'	4785'-4810'	4810'-4835'	4835'-4860'	4860'-4885'	4885'-4910'	4910'-4935'	4935'-4960'	4960'-4985'	4985'-5010'	5010'-5035'	5035'-5060'	5060'-5085'	5085'-5110'	5110'-5135'	5135'-5160'	5160'-5185'	5185'-5210'	5210'-5235'	5235'-5260'	5260'-5285'	5285'-5310'	5310'-5335'	5335'-5360'	5360'-5385'	5385'-5410'	5410'-5435'	5435'-5460'	5460'-5485'	5485'-5510'	5510'-5535'	5535'-5560'	5560'-5585'	5585'-5610'	5610'-5635'	5635'-5660'	5660'-5685'
OSTRACODA																																											
APARCHITES ELLIPTICUS											▭																																
APARCHITES MILLIPUNCTATUS											▭																					▭											
BYTHOCYPRIS D				✣	✣	✣	▭	△	✣	▭	△	▭	△	✣	△																							▭	▭				
BYTHOCYPRIS E				✣	△	△		△	✣	▭	△	△	✣	▭	▭																												
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BYTHOCYPRIS BATESI						▭																																					
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CERATOPSIS A						▭				▭	▭																																
CERATOPSIS B						▭	▭		✣	✣	✣																																
CERATOPSIS C									✣																																		
CERATOPSIS D				▭			✣			▭	▭																																
CERATOPSIS E							✣																																				
CERATOPSIS F									▭	▭																																	
DILOBELLA SIMPLEX					▭	✣				▭	▭																																
ERIDOCONCHA OBOLOIDES																																							▭				
ERIDOCONCHA A																																							▭				
ERIDOCONCHA B										▭																																	
EURYCHILINA AEQUALIS					✣		▭	▭			✣	▭																															
EURYCHILINA GRANOSA					✣		▭	▭		▭																																	
EURYCHILINA RETICULATA ?									▭																																	
KRAUSELLA													▭																											▭				
LACCOPRIMITIA					▭																												▭									
LEPERDITIA A				▭	▭			▭		✣		▭	▭	✣									▭																				
LEPERDITIA C						▭					✣																															▭			
LEPERDITELLA A										✣	✣	✣	▭	▭																									▭	▭				
LEPERDITELLA B						▭			✣	△	✣	○		△																									▭				
MACROCYPRIS KAYI ?					✣	▭		✣	△	△	□	○		△														▭			▭											
MILLERATIA CINCINNATIENSIS					□	△	○	○	✣	□	□																								▭								
PRIMITIA C											□	□		✣																													
OPIKATIA											▭																																	
PRIMITIA A					▭	△								▭																													
PRIMITIA B					✣																																						
SCHMIDTELLA INCOMPTA								▭	▭	✣	✣																						▭										
SCHMIDTELLA UMBONATA																																						▭					
SCHMIDTELLA B										▭																																	
BEYRICHIA						▭			▭		✣																																	
BRACHIOPODA																																											
ZYGOSPIRA C										✣																																	

CHART NO. 1

EXPLANATION

FREQUENCY	SYMBOLS	
0 - 1	▭	VERY RARE
2 - 4	✣	RARE
5 - 7	△	FREQUENT
8 - 10	○	COMMON
11 - >	□	ABUNDANT

STRATIGRAPHIC DISTRIBUTION OF MICROFOSSILS IN THE MIDDLE AND UPPER ORDOVICIAN FORMATIONS

alpena

FORMATION	TOPS
CINCINNATIAN	4535'
TRENTON	5145'
ST. PETER	5630'