BIOSERIES OF THE OSTRACODE <u>PONDERODICTYA</u> IN THE TRAVERSE GROUP OF MICHIGAN

Thesis for the Degree of M. S.

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Arthur Emil Wuckert

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This is to certify that the

thesis entitled

"Bioseries of the Ostracode Ponderodictya in the Traverse Group of Michigan."

presented by

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William A. Kelly
Major professor

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BIOSERIES OF THE OSTRACODE *PONDERODICTYA*

IN THE TRAVERSE GROUP OF MICHIGAN

by

Arthur Emil Wuckert

A THESIS

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THESIS

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INTRODUCTION

Microfossils have been used for several years as a means of subsurface correlation with special emphasis on the foraminifera; however, the Michigan basin has very few of these. Many ostracodes are found in the oil well cuttings as well as at outcrop locations in Michigan. They are rated second only to the foraminifera in stratigraphic value.

Glaessner* states:

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*Glaessner, M.F., Principles of Micropaleontology, Melbourne University Press, Melbourne, Australia, 1945, p. 17.

> "Locally ostracodes are of greater value than foraminifera, because of their greater adaptability to a variety of environmental conditions, including brackish and fresh water habitat, as well as to the conditions leading to deposition of dark shales. Micropaleontologists are inclined to place the ostracodes second in stratigraphic value, after the foraminifera."

Ostracodes are an important group of microfossils in the Paleozoic era.*

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*Kelly, W.A., Personal communication.

Of the many genera found in the Devonian formations of Michigan, Ponderodictya appeared to be the most abundant; therefore, it was chosen for this bioseries or phylomorphogenetic study. According to Glaessner,*

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*Glaessner, M.F., op. cit., 1945, p. 81.

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the sequence of evolutionary stages of each morphologic character or feature is a bioseries. Any subdivisions or zones of a stratigraphic column based on the evidence of bioseries are known as biozones.

This research method has been and is now employed by several workers in paleontology. After citing several examples of such work Jeletzky* says:

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*Jeletzky, J.A., "Some Nomenclatorial and Taxonomic Problems in Paleozoology," Journal of Paleontology, Vol. 24, No. 1, 1950, p. 27.

> "The tendency to discard specimens as a foundation of paleozoological species and to use fossil populations (i.e. series of specimens assumingly representing these) contributes considrably to the phylogenetical method and makes it much more exact. It seems to be sufficiently evident that the old phylogenetical concept of 'phylogenetic lines' did not represent the true character of paleozoological evolution. The fact that in all numerous cases when paleozoological material is more or less plentiful and evolutionary series continuous we observe not 'lines', but 'phylogenetical fields' or 'plexus' is very significant. It may be safely assumed that these concepts reflect much more correctly the character and course of evolutionary processes than the concept of 'phylogenetical lines'."

In accord with the above, the writer has employed the subspecies, or variants, as a basis for classification rather than the conventional and empirical catagorizing of the species into specific geologic time spans. This method embraces the 'phylogenetical field' concept referred to by Jeletzky above. Furthermore this method testifies to the contemporaneity and ancestry of the several variants of Ponderodictya which comprise its populations manifested in the Traverse formation.

OBJECT OF STUDY

The object of this study is determine whether there is evidence of one or more bioseries in the single ostracode genus, *Ponderodictya*, and with the evidence obtained for such bioseries, to subdivide the Traverse ostracode zone into as many biozones as may be distinguished.

TERMINOLOGY

Carapace is the entire shell or fossil composed of two halves, a right valve and left valve; often referred to as the test.

Flanges are located in the anterior region of Ponderodictya, being linear ridges, often arcuate. Some may appear merely as nodose structures. (Pl. I, Fig. 1,2; Pl. 2, Fig. 1,3.)

Hingement. In Ponderodictya the valves articulated about an axis directed through the more convex dorsal margin. The interlocking of the valves at this position is a rabbeted contact of the ridge and groove type.* (Pl. I, Fig. 1,6.)

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*Shimer, H.W., & Shrock, R.R., Index Fossils of North America, J. Wiley & Sons, Inc., New York, 1947. p. 685.

Mamelons are intermediate between nodes and monticules.

Marginal overlap is a feature where one valve overlaps the other along the free margins, the larger one may have a groove for receiving the edge of the smaller. (Pl. I, Fig. 2,4,8; Pl. 2. Fig. 2,3.)

Monticules are of lower relief than nodes, having a large diameter and very little height. This term differs from the general usage and is here initiated with the above definition. (Pl. I, Fig. 2.)

Muscle scar is usually located in the central region on the side of the valve of Ponderodictya, it has much the appearance of an old vaccine scar. (Pl. I, Fig. 2,7; Pl.2, Fig. 1,2,3.)

Nodes are a variation from the spines; being broader and of lower relief than the spines. The height is about equal to the diameter. (Pl. 2, Fig. 3.)

Pitting is a type of ornamentaion of the surface of the carapace. It is used in this paper to describe a condition where the area of the pits is smaller than the space between them. (Pl. 2, Fig. 3,4.)

Plenation. The plenate end is the end toward which the swing of the shell is directed, and which tends to be full because of the greater area of the region extending beyond the hinge. The degree of plenation is a composite effect of relative height of the ends, relative projection beyond the limits of the hinge, and relative fullness of the ventro-adplenate, as compared to the ventro-antiplenate portions of the shell.* (Pl. I, Fig. 1,3,13; Pl. 2, Fig. 1,2,3.)

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*Swartz, F.M., & Oriel, S.S., Journal of Paleontology, Vol.22, No. 5, 1948, p. 546.

Reticulation is the opposite of the condition for pitting, i.e., the pits are broader than the intervening spaces, which may be only ridges separating the pits. (Pl I, Fig. 1, 2.)

Shoulders may take the place of flanges, where the sides of the valves converge abruptly toward the margins. Some specimens even lack the abrupt shoulder. (Pl. I, Fig. 6,12.)

Spines are structures that appear normally in the posterior region of Ponderodictya and have a length greater than the diameter normal to the length. (Pl. 2, Fig. 2.)

DISCUSSION

Ostracodes comprise a subclass of bivalved marine crustacea, which average from 0.5 m.m to 4 m.m in length. One group, the Leperditacea, not used in this study, attain a length of some 25 m.m. The two valves of the carapace are joined at a dorsal hingement, about which they articulate in life. As the writer will demonstrate in this study, the external surface of the valves may have various types of morphologic features and degrees thereof; or the sufface may be void of superficial ornamentation.

These variations in expression of morphological characteristics are the criteria with which the biozones are delineated. According to Glaessner:*

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*Glaessner, M.F., op. cit., 1945, p. 225.

> "When it is found that the stages in the progressive structural development of morphological characters follow each other in numbers of individuals taken from successive beds in a stratigraphic sequence, then their order of appearance supports the phylogenetic interpretation of these stages while, concurrently, the possibility of establishing phylogenetic relations between them supports the classification of the stratigraphic sequence of biozones."

In this present study it is not claimed that the aurorae of the several bioseries are complete within the Traverse group, but the statistical examination of the frequency of occurrence of mutations should indicate the existence of at least one hemera or point of peak development in the stratigraphic column.

An aurora is the geologic time interval from the actual appearance of a mutant in a bioseries to its subsequent disappearance or replacement by a successive mutant. An aurora is not necessarily completed within the short interval of geologic time as represented in the Traverse formation.

Further studies on the formations directly above and below the Traverse group might easily discover biostratigraphic divisions that integrate perfectly with the divisions that are evident from this study. As Tan Sin Hok* states:

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*Tan Sin Hok, "The Results of Phylomorphogenetic Studies of Some Larger Foraminifera", De Mg. in Ned. Indie, 6, (IV), 1939, p. 93.

> "The biostratigraphic value of phylomorphogenetic researches is that they mean a methodical search for index fossils, and that they also enable us to establish a series of time markers in which the geologic time is recorded in a gapless manner, as the consecutive terms of the same bioseries represent a rational and continuous sequence. Such a paleontological chronometer is of utmost improtance, as by means of it, other forms can be dated independently."

The biozones, representing a continuous series of stratigraphic units in the Michigan synclinorial basin, may be correlated by further work in some other region that has a similar and fairly continuous section of Paleozoic formations. This would be limited to sediments of marine origin such as the section in New York or Illinois.

The question has been asked whether or not a geographically restricted environment could be a dominant factor affecting the variations and mutations that give rise to the bioseries. For example, if a stratigraphically continuous series of ostracodes in the Illinois basin had been subjected to a much different environment than a series in the Michigan basin, the two faunal series may by assumption be highly different in types of ornamentation, in degrees of expression, and in time interval of occurrence; morphologic features typical in the series of one basin for a definite time interval or biozone may never occur or at least be much different in the faunal series of the other basin. Furthermore, in harmony with the assumption, the same set of features may occur in a time interval other than that of the first found series. If this assumption were the case, then the projected correlation over the continent would not be a reliable method even if there were any hints of correlation trends that appeared to corroborate the empirical method. The latter method is that of arbitrarily chosen ranges for species which is and has been relied upon quite heavily by geologists for many years.

According to Glaessner,*

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*Glaessner, M.F., op. cit., 1945, p. 226.

"The stratigraphic value of morphogenetic stages would be very limited if the rate of change from one stage in a bioseries ot the next depended largely on local environmental factors. Tan Sin Hok has considered this possibility and has found indications that the effect of such influences is rather limited. For example the stages of evolution of nepionic characters in some foraminifera were reached in Southern Europe and in the Indo-Pacific region at the same time."

For an illustration in the ostracodes, the co-existing faunal series of the Illinios and Michigan basins will suffice. If the two series of fossils from these two basins or any other two or more basins of marine sediments of similar age were compared on the basis of bioseries and biozoning, it is highly probable that the same combinations of morphologic features will be present in each of the faunal series in every basin in similar geologic time intervals. These morphologic features should invariably show the same frequency of occurrence in all basins.

This discussion is summarized very well in Glaessner's* words,

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*Glaessner, M.F., op. cit., 1945, p. 226.

"Since it is improbable that evolutionary changes varying inspeed under the influence of environment can produce, under different circumstances and in different regions, the same combinations of bioserial stages in a number of co-existing species (populations), the actual occurrence of such combinations would strengthen the case for the stratigraphic application of the morphogenetic method."

METHOD OF PREPARATION

Practically all of the well cuttings examined in this study are the washed and bottled sets of the Michigan Geological Survey. Most of the rock samples were suitable for study under the binocular microscope, but occasionally it was necessary to crush the larger rock pieces or to wash away excess drilling muds in order to recover any specimens otherwise undetectable.

The contents of all the bottles covering the Traverse formation in all the wells were examined to pick out the ostracode genus Ponderodictya for mounting in stratigraphic type slides. The state well-permit numbers and depths were recorded on each slide immediately.

After all of the available wells in the St. Clair area had been checked, the mounted specimens were again examined to obtain a control set of type specimens which exemplified the sundry morphologic structures and their variations necessary for the bioseries study.

STRATIGRAPHY

The writer here presents the Traverse* section as described in a well log from the St. Clair area. The lithology recorded in this log is typical of the well cuttings examined in this study. In many wells the footage intervals were somewhat more constant than the record below would indicate; so that, for example, thirty feet of shale as seen in this type of log, may be represented by three or four samples in the bottled sets.

Devonian, Traverse:	Thickness in Feet	Total Thickness
Limestone, black, hard	2	2
Limestone	8	10
Limestone, gray black	6	16
Shale, black	12	28
Limestone, buff and gray, fossiliferous; some gray limy shale	20	48
Shale, black	10	58
Chert, limestone, gray	1½	59½
" " "	½	60
Shale, gray	8	68
Limestone, gray brown	10	78
Shale and limestone, gray	10	88
Limestone, gray, brown, dense,fossiliferous, some shale, chert, and secondary calcite	15	103
Shale, gray, soft	6	109
Shale, and limestone	3	112
Shale, gray and soft	1	113
Limestone, brown, buff, dense; secondary calcite	7	120
Limestone, brownish-gray, dense, shaly; gray shale	10	130
Limestone, gray-brown, dense, fossiliferous	4	134
Shale, gray, flakey and muddy, limy	19	153
Limestone, gray-brown, dense, fossiliferous; some shale and seconday calcite	15	168

*See Columnar Section, Figure I

Devonian, Traverse cont'd	Thickness in Feet	Total Thickness
Shale, soft, gray, limy	55	223
Limestone, gray-brown, fossiliferous, gray shale	10	233
Limestone, gray, fossiliferous, gray muddy shale	15	248
Limestone, brown, fossiliferous	5	253
Limestone, gray and buff, some gray shale	5	258
Shale, gray, soft	5	263
Limestone, brown, fossiliferous	5	268
Shale, light gray, soft	10	278
Limestone, brown, fossiliferous; pyrite, brown flaky shale	35	313
Shale, gray, flaky, soft, limy; pyrite	5	318
Shale, light gray, soft and powdery	5	323
Shale, gray, flaky, limy; pyrite	30	353
Shale, gray, flaky, limy, fossils pyrite	5	358
Limestone, gray, many fossils, a little gray shale; pyrite	10	368

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

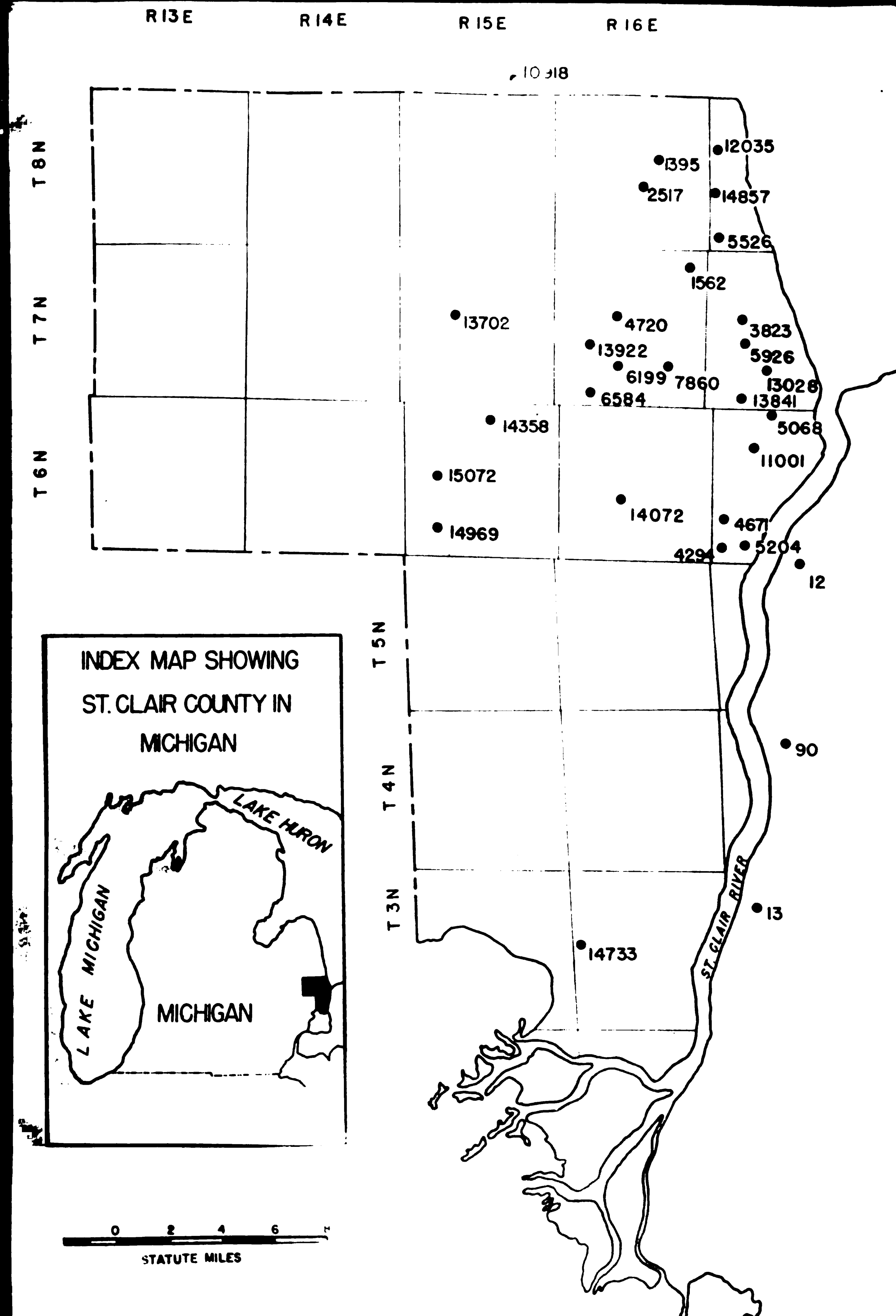
WELLS EXAMINED IN THE STUDY

County	Township	State Permit Number
St. Clair	Ft. Gratiot	13841
"	Clyde	13922
"	Pt. Huron	11001
"	Grant	1395
"	Clyde	1562
"	Wales	15072
"	Cottrelville	14733
"	Burchville	14847
"	Ft. Gratiot	13028
"	Burchville	12035
"	Wales	14969
"	Ft. Gratiot	5926
"	Kenockee	13702
"	Kimball	14072
"	Wales	14358
"	Pt. Huron	5068
"	Burchville	5526
"	Clyde	6199
"	Clyde	7860
"	Ft. Gratiot	8990
"	St. Clare	9271
"	Pt. Huron	M.S.11*
"	Clyde	4720
"	Ft. Gratiot	3833
"	Clyde	6584
"	Pt. Huron	4671
"	Pt. Huron	5204
"	Pt. Huron	4294
"	Grant	2517
"	Grant	1395
Sanilac	Fremont	10918

Ontario Wells:

Lambton	Moore	12
"	Zombra	13
"	Zone	90

*Morton's Salt #11, no state permit number.



WELLS EXAMINED FOR PONDERODICTYA IN THE ST. CLAIR COUNTY AREA

JOE LONG

ORIENTATION OF OSTRACODES

Glaessner*

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*Glaessner, M.F., op. cit., 1945, p. 13.

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outlines the problem that exists on the subject of orienting ostracodes.

> "As there is no obvious relation between the shape of the test (fossil) and the internal anatomy of living ostracodes, the characters considered as distinguishing the anterior and posterior ends of the shell are not genreally accepted in the same sense by all students of Palaeozoic ostracodes."

For the specimens examined in this study it was decided to designate the relatively more bulbous end as the posterior, (see Plate 2.) which usage is widely employed. This is often referred to as the plenate end. The more pointed, streamlined is the anterior or antiplenate. The portion of the margin which is more convex, and which also lacks overlap in several of the varieties, is the hinge area as well as the dorsum. The relatively straight portion of the margin opposite the dorsum is the venter. If the observer tips the specimen up on its venter with the pointed anterior end facing away, the valve on the observer's left is the left valve, and the one on his right becomes the right valve. This latter valve is smaller and is overlapped by the left valve along the margins as described for each type in the control set.

DESCRIPTIONS OF THE TYPE SPECIMENS

SPECIMEN 1 (Fig. 5)*

Carapace oblong-ovate; left valve overlaps right on entire margin except at the posterodorsal portion; dorsal margin arched, ventral nearly straight; indistinct anterior flange on right valve; muscle scar not very pronounced; surface of right valve quite reticulate; left valve smoother than right valve; no evidence of spines on either valve.

SPECIMEN 2 (Fig. 3)

Carapace subquadrate in outline; pitting on entire surface very fine; left valve slightly larger than right valve, overlapping the latter rather weakly on the entire margin except on the posterodorsal portion where there is no overlap; a very indistinct ridge or shoulder on the anterior portion of the right valve; muscle scar weakly expressed; one nodose spine present on lower left portion of right valve.

SPECIMEN 3 (Fig. 6)

Carapace subquadrate in outline much like "2"; this specimen is shorter and wider, also has a straighter ventral line than "2"; left valve only slightly larger, overlaps right valve weakly; no overlap on the posterodorsal or anterior margins; line of juncture forms a projecting prow

*The pictures appear on Plate I.

at the anterior (antiplenate) end; anterior shoulders of both valves converge abruptly to the anterior margin; the muscle scar is very indistinct; pitting appears quite fine; two tiny nodose mamelons in the posterodorsal and posteroventral quadrants of the right valve; a very weak anterior flange is present on right valve.

SPECIMEN 4 (Fig. 8)

Carapace similar to "1", oblong-ovate, but on this specimen the anterior flange ofthe right valve is a low linear ridge rather than a spinose structure; one postterior mamelon is prominent on the lower portion of the bulge of plenation of the right valve; left valve reticulate but has no other structures; overlap not prominent, entirely lacking along the posterodorsal portion of the margin; muscle scar is only moderately expressed.

SPECIMEN 5 (Fig. 2)

Carapace much like "4", subquadrate; conspicuous overlap of left valve over right valve, except within the posterodorsal portion of the margin; muscle scar smooth and distinct, anterior flange on right valve very prominent, somewhat lunar; two distinct posterior monticules; both valves reticulate; dorsal margin somewhat less arched than that of "4"; ventral margin nearly straight.

SPECIMEN 6 (Fig. 12)

Carapace larger than, but similar to "3"; left valve moderately overlaps right except on the posterodorsal slope; dorsal margin arcuate; ventral nearly straight; anterior shoulder of right valve bold, but not expressed as a flange; one nodose spine on the lower left portion of the right valve; muscle scar indistinct and shallow; left valve smoother than the right which is moderately reticulate.

SPECIMEN 7 (Fig. 4)

Carapace sub-elliptical; dorsal margin arcuate, ventral nearly straight; left valve larger than right, overlapping the latter strongly along the margin except in the posterodorsal portion; muscle scar very shallow and indistict; pitting quite weak over entire carapace; no spines present; the anterior half of right valve slopes gently down from the center to the anterior margin; no flanges or bold shoulders present.

SPECIMEN 8 (Fig. 14)

Carapace like "4", oblong-ovate, though more elliptical; left valve larger, overlaps right valve along entire margin except on the posterodorsal slope; lacks any anterior flange or shoulder; one monticule on the lower left portion of the right valve; distinct reticulation on both valves; muscle scar smooth and very distinct.

SPECIMEN 9 (Fig. 11)

Carapace similar to "2", subquadrate in outline; overlap very prominent and evident along entire margin; one very prominent mamelon in the posteroventral region of the right valve; the anterior ridge is bold and slightly pointed; muscle scar smooth and indistinct; reticulation well expressed over entire carapace.

SPECIMEN 10 (Fig. 9)

Carapace oblong-ovate with left valve overlapping right very markedly except on the posterodorsal portion; dorsal margin arched; ventral margin nearly straight; muscle scar extremely weak; two rather indistinct posterior monticules and a much depressed anterior ridge on the right valve; surface only moderately pitted.

SPECIMEN 11 (Fig. 13)

Carapace outline much like "10", oblong-ovate; left valve larger than and overlapping right valve except on the posterodorsal portion; dorsal margin arched, ventral margin nearly straight; two posterior mamelons on right valve; the right valve lacks the anterior shoulder and slopes gently down to the anterior margin; a spinose ridge is located on this anterior slope of the right valve; muscle scar smooth and rather weakly developed; fairly well-pitted surface.

SPECIMEN 12 (Fig. 7)

Carapace subquadrate similar to "5"; left valve larger than right with overlap on all margins except along the posterodorsal portion; dorsal margin moderately arched; ventral margin straighter than in "10"; one monticule in the center of the lower left quadrant of right valve; the anterior flange is rather weakly developed; the muscle scar is quite smooth and shallow; surface moderately pitted.

SPECIMEN 13 (Fig. 1)

Carapace subquadrate in outline more like "12" than "5"; left valve larger than right with prominent overlap on entire margin except along the posterodorsal portion; dorsal margin moderately arcuate; ventral margin nearly straight; a posterior monticule present on the right valve; a very bold anterior flange on right valve and an indistinct anterior ridge on left valve; muscle scar distinct and smooth; reticulation distinct on both valves.

PLATE I

Fig. 1. Dorsal view;* anterior flanges on both valves, reticulation, relative fulness or planation of the posterior half.

Fig. 2. Reticulation, muscle scar, anterior flange, two monticules, distinct overlap.

Fig. 3. Pitted; indistinct muscle scar, flange and spine; weak overlap.

Fig. 4. Pitted, prominent overlap, sloping right valve, indistinct muscle scar.

Fig. 5. Reticulation, indistinct muscle scar, weak flange, moderate overlap.

Fig. 6. Dorsal view, fine pitting, weak overlap and flange, projecting anterior prow.

Fig. 7. Prominent overlap, weak anterior flange, 1 monticule, distinct muscle scar.

Fig. 8. Indistinct muscle scar, linear flange, prominent overlap.

Fig. 9. Pitted, prominent overlap, anterior shoulder, 2 monticules, weak muscle scar.

Fig. 10. Left valve, reticulation, absence of other features.

Fig. 11. Reticulation, prominent anterior flange, posterior mamelon, weak muscle scar.

Fig. 12. Reticulation, overlap, anterior shoulder, shallow muscle scar.

Fig. 13. Reticulation, 2 mamelons, spinose ridge, shallow muscle scar.

Fig. 14. Reticulation, moderate overlap, anterior shoulder, indistinct muscle scar.

*All views are right valves unless otherwise stated.

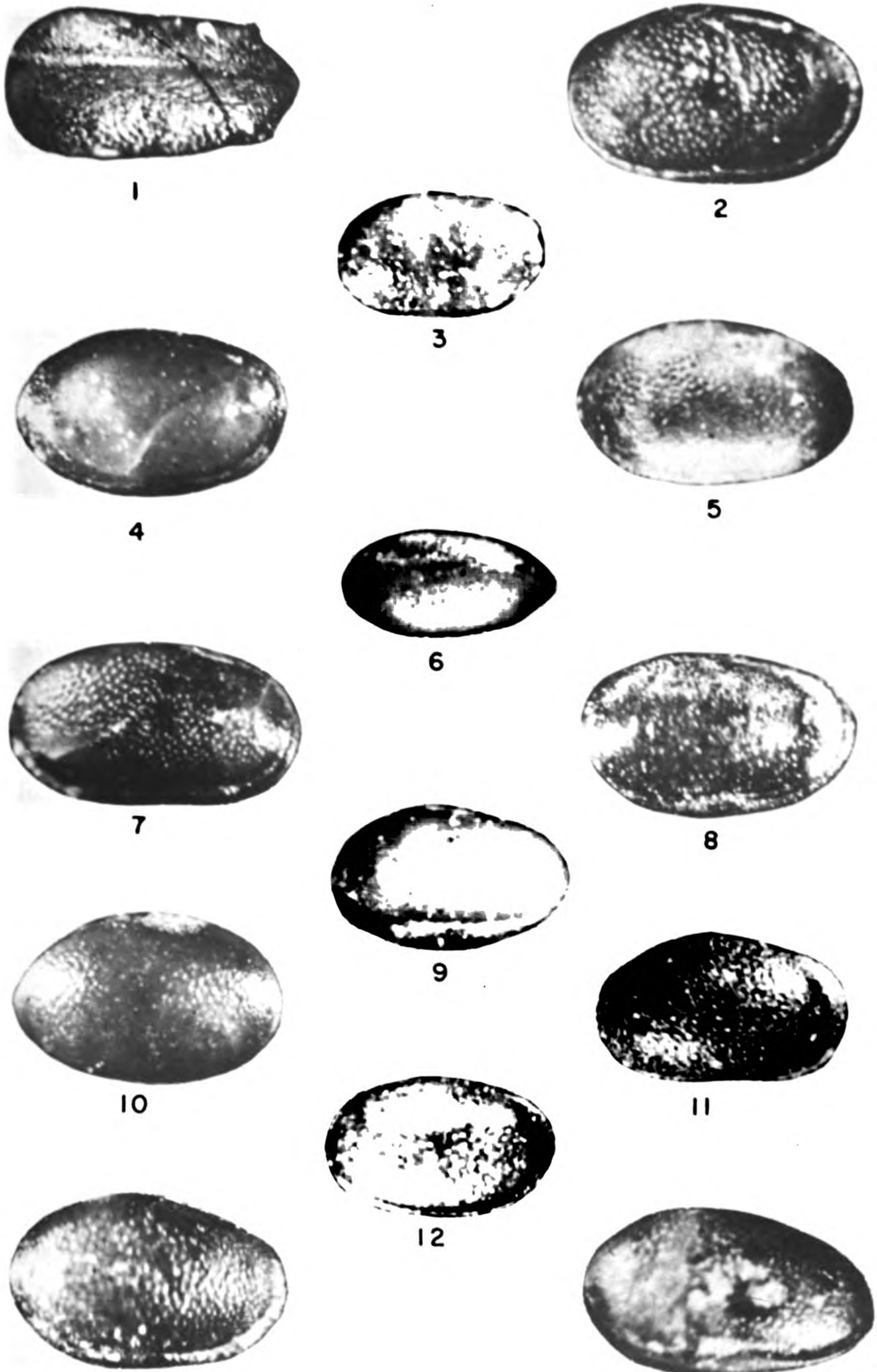


PLATE I

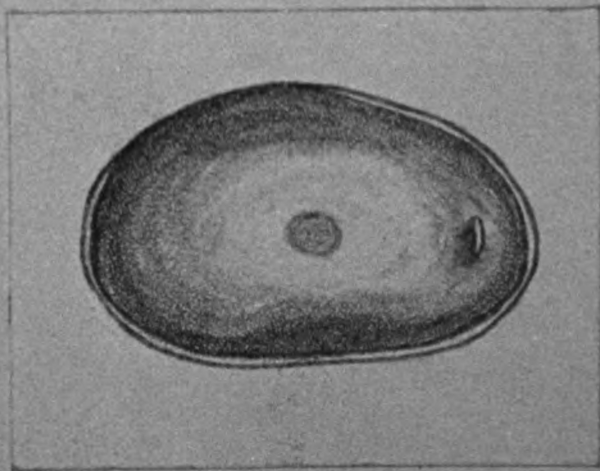
PLATE II

All three sketches exhibit a definite swing or plenation to the left or posterior. They may be reticulate or pitted; nodes may be replaced by monticular mounds.

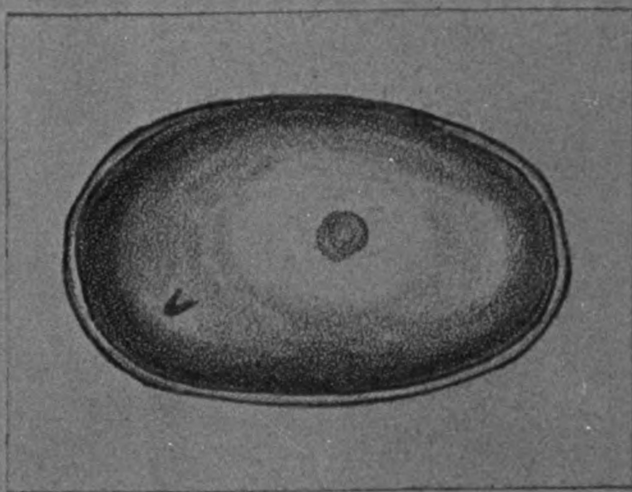
Fig. 1. Right valve; anterior ridge, moderate overlap, distinct central muscle scar, no posterior spines, convex dorsal margin, straight ventral margin.

Fig. 2. Right valve; prominent anterior shoulder, no flange, 1 posterior spine, muscle scar, distinct overlap, arcuate dorsal and ventral margins.

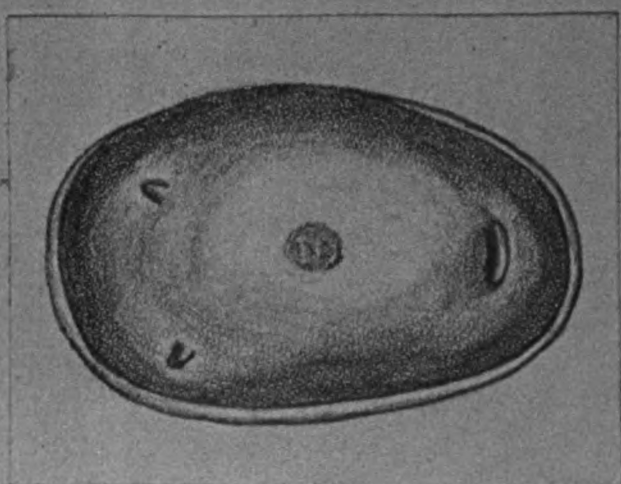
Fig. 3. Right valve; prominent overlap, lunar anterior ridge, 2 nodose posterior spines, muscle scar, dorsal margin much more arched than ventral.



1



2



3

PLATE 2

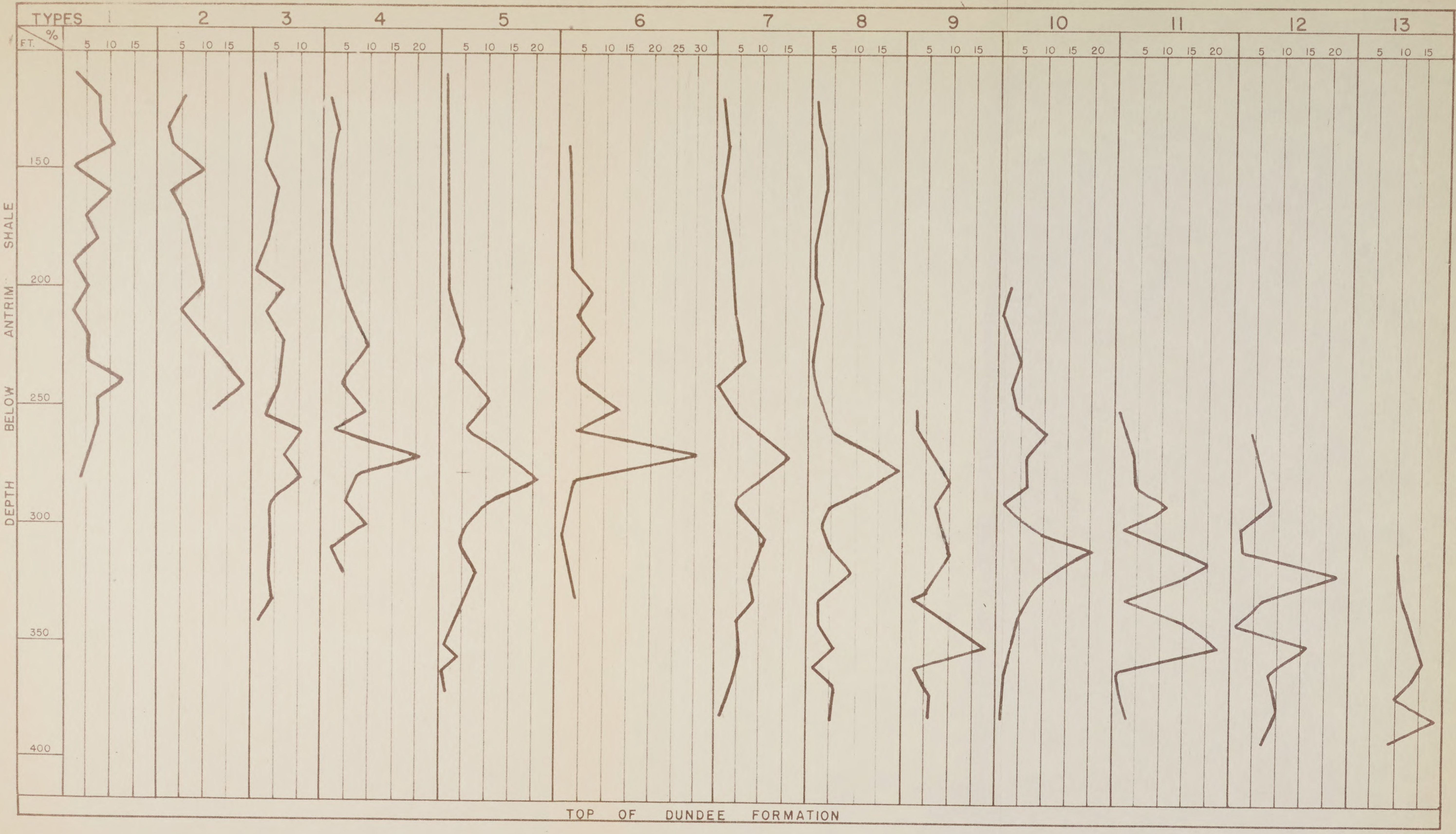
INTRODUCTION TO THE GRAPHS

Of all the wells examined in the study the twenty one that had a minimum of poor features, as missing intervals, were graphed to illustrate the distribution of the type variants counted. The base of the Antrim shale is the top of the Traverse formation, which is used in this study as the marker horizon below which the depths in feet ar in negative elevations. This feature is recorded on all three graphs on the extreme left, and it also serves as the vertical or stratigraphic scale on the graphs. The same portion of the Traverse formation is shown on all the graphs, to preclude any confusion when the graphs are compared. Since there is no appreciable variation in the thickness of the Traverse formation in the small area studied, it was possible to draw an approximately straight base for this formation, which line also serves as the top of the Dundee formation. (See Fig. I, p. 15.) The Bell formation shown on figure I has been included as part of the Traverse formational group, because the two are not easily differentiated. This is shown to be true also by the absence of the Bell on the driller's log.

Graph I (in pocket) shows the frequency in numbers of the variants throughout their vertical extent in twenty on e wells. As indicated in the legend each type variant has a different color, but the size of the geometric symbol expresses an absolute number of the specimens at the proper elevations. At the extreme right on graph I are the conventional zones based on the various combinations of faunal assemblages throughout the column examined. The length of the vertical line for each type variant expresses the upper and lower limits of the respective type.

Graph 2 (p. 30.) is not a group ofwells but rather the thirteen type variants of Ponderodictya plotted to show the percentage of the total number of each type that occurs at any given elevation. The points of highest percentages as well as the second highest points for each type variant have been plotted stratigraphically on graph 3 (p. 31.) as major and minor highs. They appear as large and small circles, from which horizontal lines are shown projected to the right side. The lines projected from the large circles limit the major zones which are lettered; the small circles or minor highs subdivide the major zones into minor zones which are numbered.

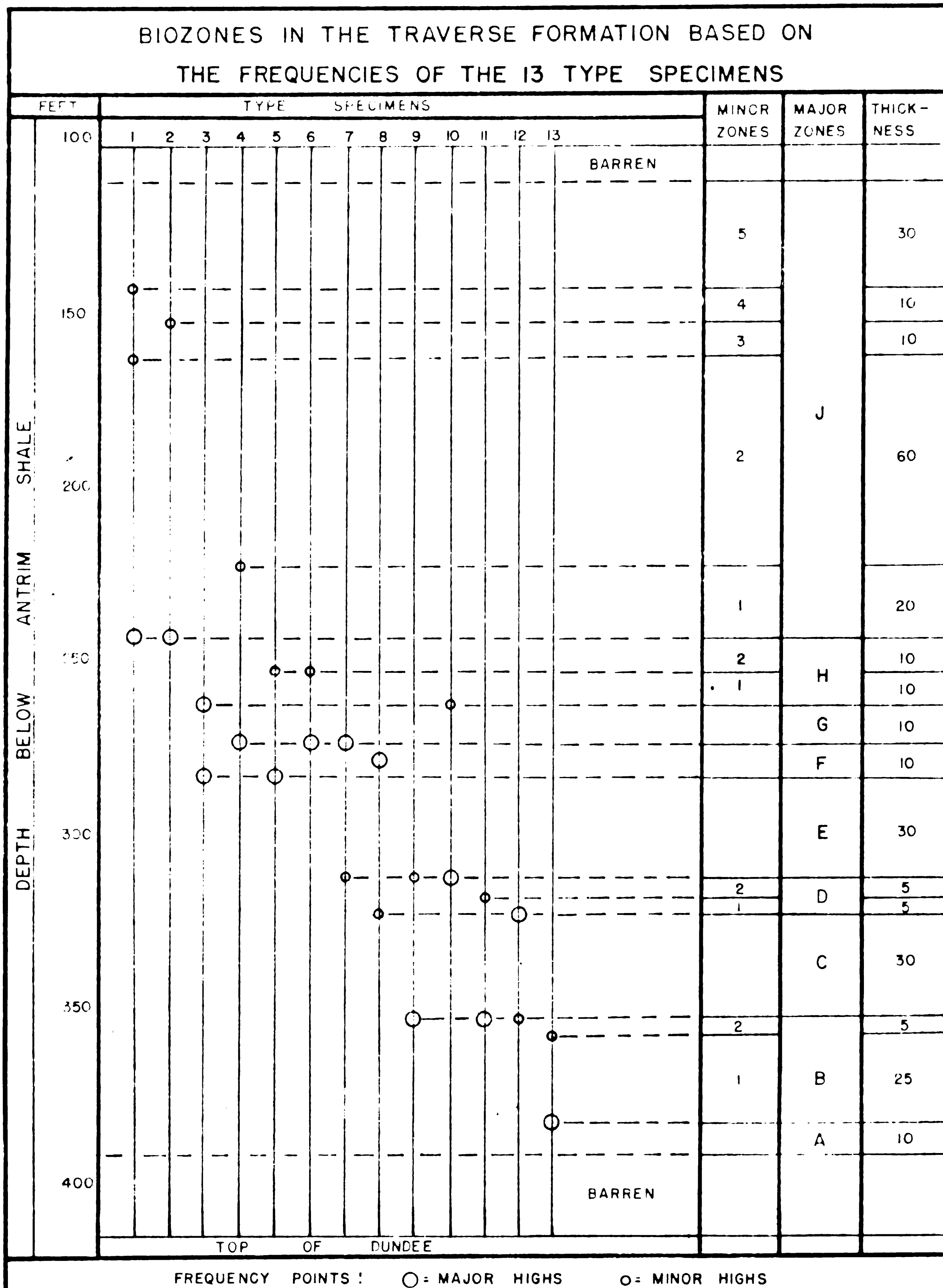
In summary, Graph 3 illustrates the biozones previously defined in contrast to the stratigraphic range zones shown on graph I.



A STRATIGRAPHIC SECTION SHOWING FREQUENCY IN PERCENT OF THE 13 TYPES OF PONDERODICTYA

FROM 21 WELLS IN THE ST. CLAIR COUNTY AREA

GRAPH 2


BIOZONES IN THE TRAVERSE FORMATION BASED ON
THE FREQUENCIES OF THE 13 TYPE SPECIMENS
FEET
TYPE SPECIMENS
MINOR ZONES
MAJOR ZONES
THICK-NESS
DEPTH BELOW ANTRIM SHALE
100
150
200
250
300
350
400
1 2 3 4 5 6 7 8 9 10 11 12 13
BARREN
5
4
3
2
1
2
1
2
1
2
1
J
H
G
F
E
D
C
B
A
30
10
10
60
20
10
10
10
10
30
5
5
30
5
25
10
BARREN
TOP OF DUNDEE
FREQUENCY POINTS : ◯ = MAJOR HIGHS o = MINOR HIGHS

GRAPH 3

RESULTS AND INTERPRETAIONS OF THE STUDY

The graphic illustrations of the counts on the different variants of Ponderodictya show that their individual peak developments did not maintain within the same short stratigraphic interval, but rather, there is indicated a phylomorphogenetic succession through much of the Traverse formation. Some of the types show considerable overlapping of their time periods or zones, which indicates transitional periods in which the younger groups of variant morphologic structures were gradually replacing the preceeding ancestral groups. (Graph 2.)

The thirteen type specimens were graphed in descending order with respect ot their hemerae, (Graph 2 and 3.) but the writer is not able to account for the succession of the various groups of taxonomic features, although an ample amount of projection has been done by students of paleozoology to explain such occurrences.

For example; the posterior structures vary in number as well as expression from spinose to monticular; the flanges vary in degree of development, even being replaced by a shoulder or lack of either feature at the anterior or antiplenate end. Similar discussion is applicable to the other features as the overlap, muscle scar, reticulation, pitting, and general outline of the carapace. These morphologic structures are variations within the genus, so that we may expect the types to be generally similar. A greater variation of these features or subsequent replacement by some other features would cross the generic boundary. From an examination of the zones on graph I, the reader may see the long contemporaneous life spans of various types. Specimens 7 and 10 exhibit much overlap of life span. They have some common morphologic features, so that one may be more closely related to the other than either is with a more dissimilar form such as number 13. It is evident from graph 3 that the peak development of 7 is forty feet stratigraphically higher or later than that of 10. These two types may be very close variants of a common ancestral form. Further investigation of the formations stratigraphically lower than the Traverse group may disclose variants of Ponderodictya that are similar and ancestral to these. Such studies need not be confined to the Michigan Basin alone; for in harmony with the bioseries concept, the development of the phylomorphogenetic series was similar over the entire world within the same geologic time interval even though breaks in sedimentation took place at different times in different basins of deposition.

Another point necessary for clarification is that the stratigraphic points of peak development or hemerae do not express the same stratigraphic terminal points that limit the life span or stratigraphic range of each type specimen; therefore, the biozones made evident on their respective graphs (1 and 3) are different with respect to the number of zones and their vertical distribution. The zones shown on graph 3 are not proposed to be the same zones or even a similar expression of the zones shown on graph I. Since the hemeral peaks or major and minor highs on graph 3 are the points of highest frequencies of the individual variant types, then the peak point of each type must fall within the stratigraphic range of that respective type on graph I.

From the nature of the two kinds of zones as shown on graphs 1 and 3, it appears faster and easier to locate and define a zone stratigraphically accurate by the high frequency points (hemerae) than by the conventional life span or stratigraphic range of a type. It would be necessary to check several of the type variants by the old method of graph I in order to find the various assemblages of those types that define any one zone of graph I. On the other hand, if a student were reasonably sure he had located two hemeral or major points as those of types 10 and 12 (graph 3), then he will have limited the horizon to approximately ten feet. The top of this horizon is 310 feet stratigraphically below the base of the Antrim shale or its equivalent. (See graph 3, major zone D.)

The frequency-biozones (graph 3) are further preferred to those of the conventional zones based on the stratigraphic range of individuals (graph I) because the missing of one or more type specimens for some footage interval will result in an erroneous faunal assemblage. Even some of the zones shown on graph I may be in error because of this. Where small footage (5-20 feet) intervals are missing from the well samples, the range of the type specimen may not be determined correctly to its true upper or lower extent if the missing interval is at such a critical stratigraphic position. It is true that where such an interval is missing, the frequency or statistical methods will have no specimens either, but if the student has sufficient well samples to locate the high points or hemerae, then he has the biozones (graph 3) located stratigraphically in spite of the missing intervals. It may be argued that the use of samples from several wells would increase the accuracy of determining the zones of graph I. This may be very true; but that same number of wells will locate the hemerae much better, so that the zones of graph 3 become more accurate than those of graph I. by so doing.

Since the study was made from well samples in a relatively sámll area (See map.) it was possible to obviate the possible arguments of environmental differences and extreme variations of thickness of the Traverse formation. The absence of specimens for different intevals as evidenced by graph I is not due to contemporaneous environmental differences within the area, but this absence is often due to a break in well samples for several feet.

It is also caused by poor sampling; for example, several of the wells examined were not used in the count because entire trays of 25 bottles each, may have had little besides the drilling muds, which washed away readily to reveal a paucity of rock fragments and fossils.

The variation in thickness of the formation over some thirty miles approximates sixty to seventy feet, the slightly thicker portion is toward the basin itself. Accordingly, if any area with a thicker or thinner section is studied for comparison, then its hemerae points and their respective biozones must be compared on a stratigraphically proportional basis with the zones outlined in this study. (Graph 3)

CONCLUSIONS

On the basis of the hemerae of the respective variant types of *Ponderodictya* there is a definite zoning in the lower three fourths of the Traverse formation. This zoning or subdividing of a formational group is not only possible with the frequency method, but such zones are also more accurately located stratigraphically than the zones defined by the conventional method of vertical ranges of species.

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DISTRIBUTION CHART OF THE 13 TYPES OF PONDERODICTYA IN THE TRAVERSE FORMATION IN THE ST. CLAIR COUNTY AREA
LEGEND
TYPE SPECIMENS
= 1
= 2
= 3
= 4
= 5
= 6
= 7
= 8
= 9
= 10
= 11
= 12
= 13
FREQUENCY SYMBOLS
= 0-1
= 2-3
= 4-5
= 6->
13841
5526
13922
5926
13028
5068
11001
5204
4294
4671
CANADA 12
14072
13702
6584
4720
6199
7860
CANADA 90
CANADA 13
14733
14358
TYPE SPECIMENS
1 2 3 4 5 6 7 8 9 10 11 12 13
ZONE
DEPTH BELOW ANTRIM SHALE
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
TOP OF DUNDEE
1 2 3 4 5 6 7 8 9 10 11 12 13

GRAPH I

Pocket has: 1 Chart