THE STRATIGRAPHIC DISTRIBUTION OF OSTRACODA WITHIN THE TRAVERSE FORMATION OF THE MICHIGAN BASIN

Thesis for the Degree of M. S.

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Donald Edmund Campau

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This is to certify that the

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Major professor

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THE STRATIGRAPHIC DISTRIBUTION OF OSTRACODA WITHIN THE TRAVERSE FORMATION OF THE MICHIGAN BASIN

by

Donald Edmund Campau

A THESIS

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INTRODUCTION

Modern ostracoda are small bivalve crustaceans most of which live in the sea, although some live in fresh water. Their adaptability to changing environmental conditions makes them common today and probably explains the occurrence of fossil ostracoda in a variety of ancient sediments ranging in age from Ordovician to Recent. The fossil ostracoda as microfossils prove useful for correlation purposes because they have a relatively short geologic range, are abundant, wide spread and not readily destroyed by drilling operations.

Most of the specimens used in this study were found in well cuttings from the Middle Devonian Traverse Formation of Michigan (map 1 page 3, figure 1 page 4), or from equivalent strata, the Hamilton Shale of Ontario and the Silica Shale, of Ohio (figure 2 page 5). Microfossils were also collected at type localities of formations of the Traverse Group* because it was believed that those fossils might be of aid in the correlation of subsurface zones with those at the surface.

Approximately 2,000 microfossils, most of which were ostracoda, were studied. Microfossils other than ostracoda, which have proven significant in this study, include the bryozoan, Acrogenia, and the oogonia of the charophyte, Trocholodiscus.

*In this paper the Traverse will be referred to as a group when the individual lithological subdivisions are sufficiently defined to be represented as units which can be used in geological mapping. South of the outcrop area the distinctions between the subdivisions of the Traverse are difficult to make. The entire Traverse is therefore mapped as a single unit and is properly referred to as the Traverse Formation.

The ostracoda occurring in the Traverse Formation were classified into twenty-two genera. All the ostracoda obtained from well samples are concentrated in the lower half of the Traverse Formation. This vertical distribution does not agree with that from surface exposures, because ostracoda have been collected from the younger as well as from the older members of the exposed Traverse Group. This discrepancy may be explained by the presence of beds, near the center of the basin, younger than any occurring near the rim. Such an occurrence would suggest regressive overlap. It is worth noting that Hake and Maebius state that the Squaw Bay at the top of the Traverse is best represented towards the center of the Michigan Basin.

OBJECTIVES OF THE STUDY

The objective of this study is to determine the extent to which ostracoda can be used in zoning the Traverse Formation, either by showing restricted ranges for a few genera, or by establishing a common zone for the overlapping portions of relatively long ranges of common forms.

A. To investigate the distribution of ostracoda within the Traverse Formation.

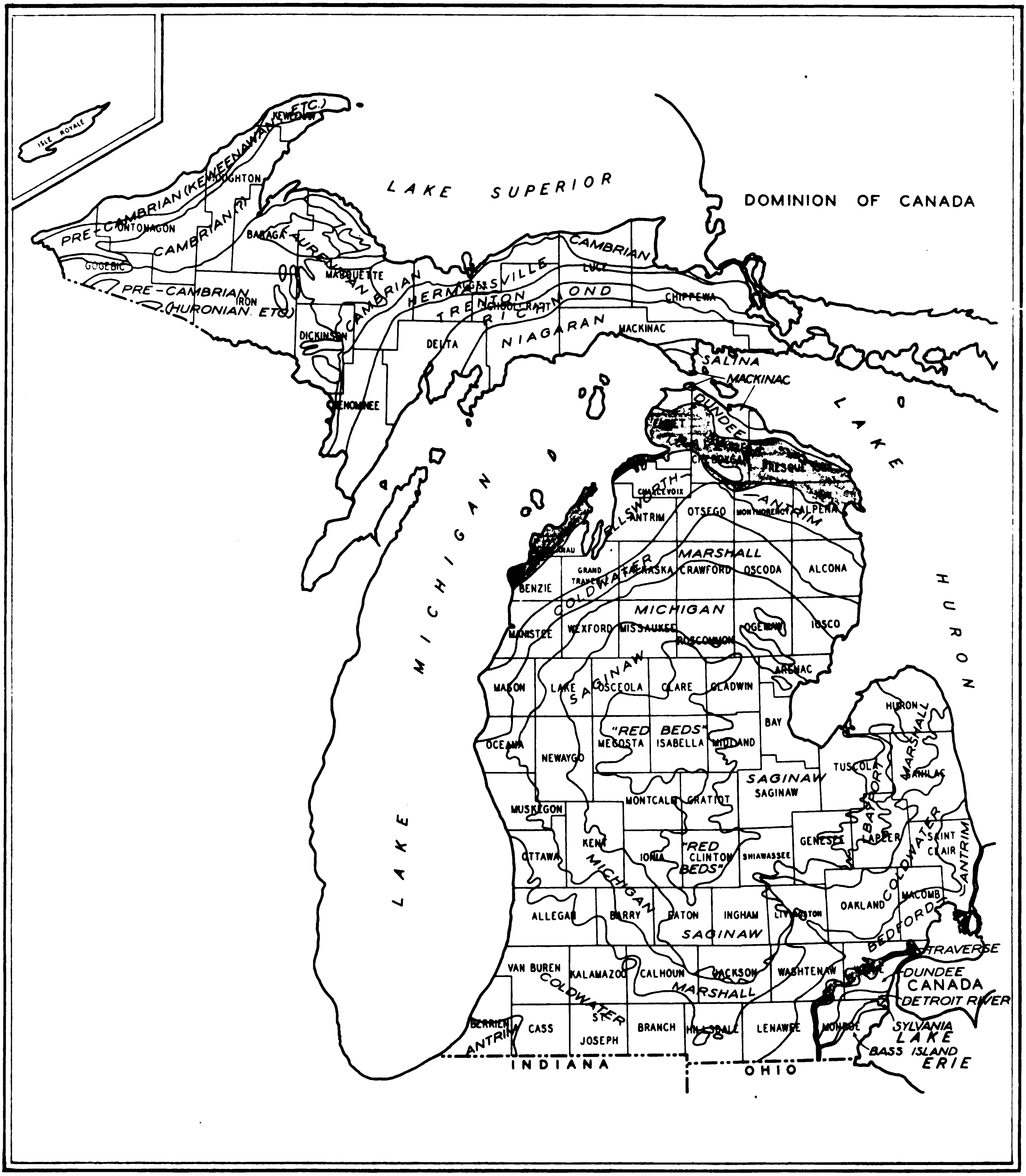
B. To determine if there is a single zone or a number of zones of ostracoda within the Traverse Formation.

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

D. To find out if the zone or zones pinch and swell within the Traverse Formation, and thus suggest the possibility that other formations, below or above, may also pinch and swell.

E. To make a faunal list of all ostracoda found in cuttings of certain wells drilled into the Traverse Formation.

F. Attempt to show the relation of the Silica shale of Ohio and the Hamilton shale of Ontario to the Traverse Formation of Michigan.


LAKE SUPERIOR
DOMINION OF CANADA
ISLE ROYALE
PRE-CAMBRIAN (KEWEENAWAN ETC.)
CAMBRIAN (?)
PRE-CAMBRIAN (HURONIAN ETC.)
CAMBRIAN
HERMANSVILLE
TRENTON
RICHMOND
NIAGARAN
SALINA
MACKINAC
DUNDEE
ELLSWORTH
ANTRIM
MARSHALL
COLDWATER
MICHIGAN
SAGINAW
"RED BEDS"
BAYPORT
BEDFORD
TRAVERSE
SYLVANIA
BASS ISLAND
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
CANADA
DETROIT RIVER
INDIANA
OHIO
KEWEENAW
HOUGHTON
ONTONAGON
GOGEBIC
BARAGA
MARQUETTE
IRON
DICKINSON
MENOMINEE
DELTA
ALGER
SCHOOLCRAFT
LUCE
CHIPPEWA
MACKINAC
CHEBOYGAN
PRESQUE ISLE
CHARLEVOIX
ANTRIM
OTSEGO
MONTMORENCY
ALPENA
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
ARENAC
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
BAY
HURON
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
TUSCOLA
SANILAC
SAGINAW
MUSKEGON
MONTCALM
GRATIOT
OTTAWA
KENT
IONIA
CLINTON
SHIAWASSEE
GENESEE
LAPEER
SAINT CLAIR
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
OAKLAND
MACOMB
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
BERRIEN
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE

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— I

GENERALIZED COLUMNAR SECTION

	NORTHWESTERN OHIO	MICHIGAN	SOUTHWESTERN ONTARIO
MISSISSIPPIAN	HURON SH.	ANTRIM SH.	HURON SH.
DEVONIAN	SILICA SH. DELAWARE LS.	TRAVERSE GROUP	HAMILTON GROUP
	COLUMBUS LS. West of Cincinatti arch	ROGER CITY–DUNDEE	DELAWARE "ONONDOGA"

D.E.Campau

FIGURE-2

CLASSIFICATION

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

The four superfamilies are listed below:

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

A total of twelve families belonging to the Leperditacea, Beyrichiacea and Cypridacea represented by twenty-two genera are known to occur. Most of these fall into the Beyrichiacea and Cypridacea. The most common genera are Ponderodictya and Quasillites which belong in the Cypridacea superfamily. The twenty-two genera are listed under both the superfamily and the family and will be described later (pages 17 to 35) in the order given in the list below.

Further references to the families are not made, but the genera will be listed under the superfamily to which they belong. In general, authorities agree on the major divisions to which the genera are assigned but not on the families. An example of disagreement is the genus Euglyphella which has been assigned by Bassler and Kellett to the family Thlipsuridae and by Coryell and Malkin to the family Ropolonellidae.

SYSTEMATIC CLASSIFICATION OF OSTRACODA

Superfamily Leperditacea
    Family Leperditellidae, Ulrich and Bassler
        Genus Aparchites

Superfamily Beyrichiacea
    Family Beyrichiidae, Jones
        Genus Ctenoloculina
            Ctenobolbina
            Richina
            Hollinella

    Family Kirkbyidae, Ulrich and Bassler
        Genus Amphissites
            Ulrichia

    Family Kloedenellidae, Ulrich and Bassler
        Genus Dizygopleura
            Poloniella

    Family Primitiidae, Ulrich and Bassler
        Genus Halliella

    Family Youngiellidae, Ulrich
        Genus Bufina

    Family Zygobolbidae, Ulrich and Bassler
        Genus Kloedenia

Superfamily Cypridacea
    Family Bairdiidae, Sars
        Genus Bairdia

    Family Barychilinidae, Ulrich
        Genus Barychilina

    Family Cytherellidae, Sars
        Genus Ponderodictya

    Family Quasillitidae, Coryell and Malkin
        Genus Jenningsina
            Quasillites
            Spinovina

    Family Thlipsuridae, Jones
        Genus Euglyphella
            Hyphasmaphora
            Octonaria
            Thlipsura

STRATIGRAPHY OF THE TRAVERSE GROUP

A very good summary of the Traverse stratigraphy as exposed in Michigan is given in an article by Swann (1947, pages 236 - 239) and is reproduced at length herewith (pages 8, 9).

"The Traverse Group is exposed in the northern part of the Lower Peninsula of Michigan in three areas, each separated from the other by moderate distances and each containing a rock section quite different from that of the others. The type area, the western one, borders Little Traverse Bay, Lake Michigan, in Emmet and Charlevoix counties. The stratigraphic terminology of Pohl (1930) is used for this western area, except that his 'stages' are recognized as formations. In ascending order these are the Gravel Point, the Charlevoix and the Petoskey formations. Although the western area contains the type Traverse section, only the upper part of the group is here represented in outcrop.

"The most complete section is exposed in the eastern area, in Alpena and Presque Isle counties, near Thunder Bay, Lake Huron. Warthin and Cooper (1935a, 1935b, 1943); Cooper and Warthin (1941, 1942) have described the section in detail and have kindly allowed the author to use material on the stratigraphic succession in this region previous to its publication. The sequence recognized here is that of their 1943 paper. In ascending order, the formations are Bell Shale, Rockport Quarry limestone, Ferron Point formation, Genshaw formation, including the Killians limestone member just above the middle, Newton Creek limestone, Alpena limestone, including the Dock Street clay lens at the top, Four Mile Dam limestone, Norway Point formation, Potter Farm formation, Thunder Bay limestone, and Squaw Bay limestone.

"The third area of outcrops of the Traverse Group occurs in Cheboygan County and at the western edge of Presque Isle County, about midway between the other two regions. This was named the Afton-Black Lake area by McNair (1937 pp. 105-107), who has published the only recent account of these outcrops. Dr. W. A. Kelly, who has done much field work in this area, generously allowed use of his notes on stratigraphy of the region. The section up to and including the Killians limestone member of the Genshaw formation is easily correlated with the Thunder Bay section, though the Ferron Point thins greatly to the west and is only four feet thick at Black Lake, whereas the Genshaw below the Killians is more than twice as thick in the Afton area as it is in the eastern area.

"Above the Killians limestone member correlation is much less secure. A covered interval of five or ten feet separates the Killians member from an unnamed light gray sparingly fossiliferous stylolitic limestone about thirty feet thick (since this article has been published this stylolitic limestone is now called the Koehler limestone by W. A. Kelly) which is best exposed in the abandoned Campbell Stone Company quarry north of Afton, Cheboygan County. Welleria aftonensis Warthin and a few cup corals are about the only fossils found in this limestone, which is stratigraphically equivalent but lithologically dissimiliar to the upper part of the Genshaw formation. (This limestone is now classified as Lower Gravel Point by W. A. Kelly.)

"Unconformably overlying this unnamed limestone is a very dark argillaceous limestone six to ten feet thick with numerous black shale partings. This dark limestone, which carries a poorly preserved coral-stromatoporoid fauna, can be considered the basal member in this region of the Gravel Point formation, although it is stratigraphically below the exposed base of the formation in the Traverse Bay region. Exposed portions of the Gravel Point formation above this member comprise chiefly gray limestones, some of which can be directly correlated with similiar beds in the type area. Long continuous sections are not known, and it seems certain from well records that shale beds are intercalated between the more resistent outcropping limestones and that the total thickness of the Gravel Point formation in this region is near eighty feet.

"Outcrops of beds above the Gravel Point formation occur only in one small area near Beebe School, one-half mile west and two and a half miles south of Afton, where about ninety feet of beds corresponding to the Norway Point formation and Potter Farm or equivalent Petoskey formation can be recognized. Several covered intervals and a dip unusually high for the Michigan basin make interpretation of this section difficult. The covered interval between the top bed, which carries a Potter Farm fauna, and the overlying Antrim shale appears to be no more than ten feet; this shows that the Thunder Bay limestone and Squaw Bay dolomite or their equivalents must be either lacking or extremely thin in the Afton region.

"The section here recognized in the Afton-Black Lake area comprises in ascending order, Bell shale (unexposed and known only from wells,) Rockport Quarry limestone, Ferron Point formation, Genshaw formation up to and including the Killians limestone member, a covered interval, unnamed stylolitic limestone, Gravel Point formation with dark argillaceous limestone member at the base, a covered interval, beds equivalent to the Norway Point formation, and the Potter Farm or Petoskey formation."

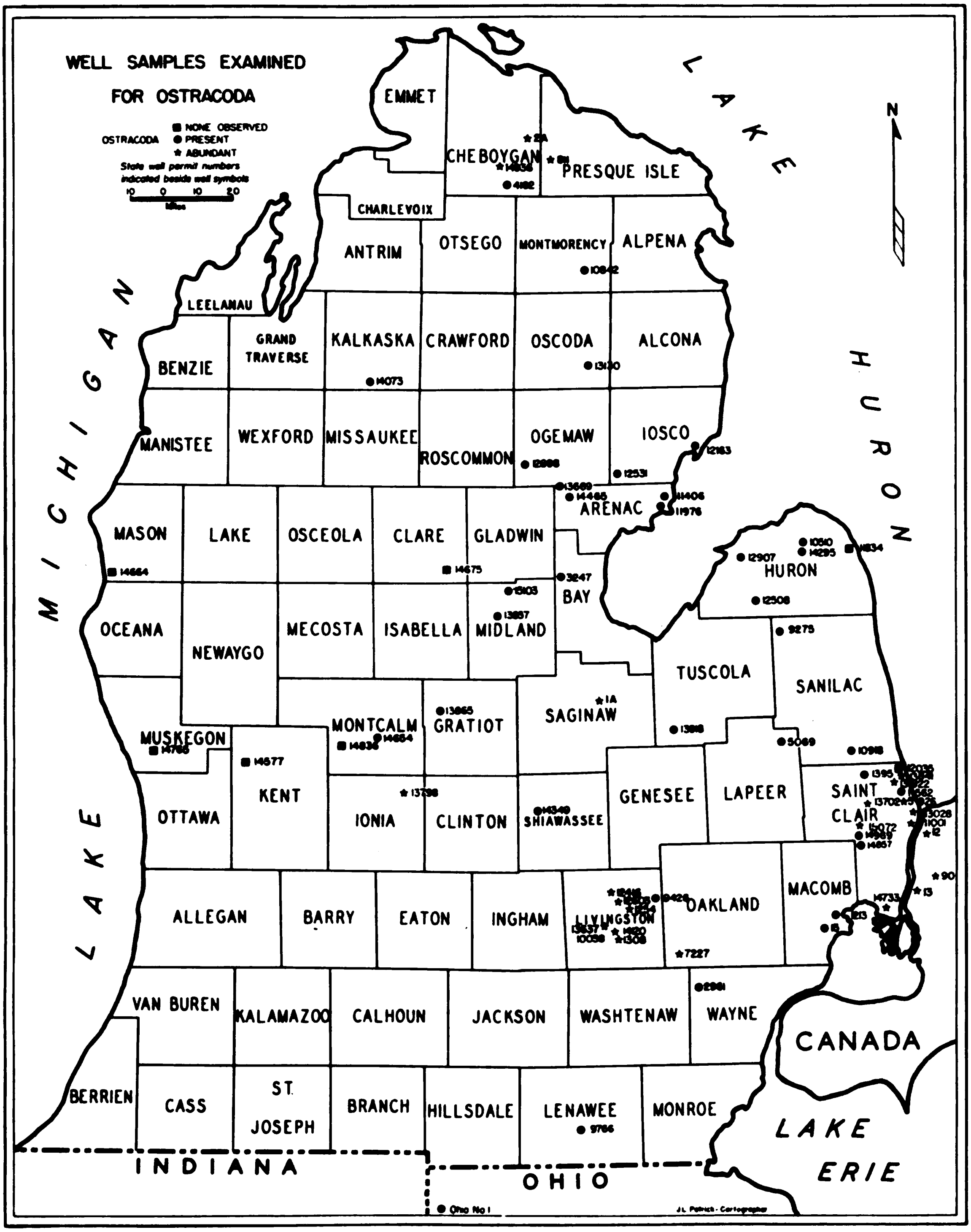
LOCATION OF WELLS USED IN THIS INVESTIGATION

The specific locations of wells in which fossil ostracoda, Charophyta, and the Bryozoan Acrogenia were found are given in the table which follows and also on map 2, page 12.

State Permit No.	Township	County
14	St. Clair	St. Clair
15	Clinton	Macomb
811	North Ellis	Presque Isle
1213	Chesterfield	Macomb
1254	Osceola	Livingston
1308	Genoa	Livingston
1395	Ft. Gratiot	St. Clair
1562	Clyde	St. Clair
2961	Canton	Wayne
3247	Garfield	Bay
4162	Walker	Cheboygan
5069	Burnside	Lapeer
5926	Ft. Gratiot	St. Clair
7227	Lyon	Oakland
9275	Greenleaf	Sanilac
9426	Hartland	Livingston
9766	Adrian	Lenawee
10038	Iosco	Livingston
10510	Bloomfield	Huron
10842	Avery	Montmorency
10918	Fremont	Sanilac
11001	Pt. Huron	St. Clair
11406	Whitney	Arenac
11834	Rubicon	Huron
11976	Sims	Arenac
12035	Burtchville	St. Clair
12163	Baldwin	Iosco
12416	Howell	Livingston
12508	Brookfield	Huron
12531	Burleigh	Iosco
12603	Howell	Livingston
12898	West Branch	Ogemaw
12907	Windsor	Huron
13028	Ft. Gratiot	St. Clair
13130	Oscoda	Oscoda
13637	Marion	Livingston
13669	Moffatt	Arenac
13702	Kenockwee	St. Clair
13798	North Plains	Ionia
13897	Jerome	Midland

State Permit No.	Township	County
13841	Ft. Gratiot	St. Clair
13865	Summer	Gratiot
13918	Arbela	Tuscola
13922	Clyde	St. Clair
14073	Garfield	Kalkaska
14120	Genoa	Livingston
14295	Bloomfield	Huron
14349	Owosso	Shiawassee
14465	Moffatt	Arenac
14577	Sparta	Kent
14654	Evergreen	Montcalm
14664	Summit	Mason
14675	Arthur	Clare
14733	Clay	St. Clair
14765	Muskegon	Muskegon
14836	Montcalm	Montcalm
14857	Wales	St. Clair
14936	Ellis	Cheboygan
14969	Wales	St. Clair
15072	Wales	St. Clair
15103	Edenville	Midland
1 A	Saginaw	Saginaw
2 A	Outcrop at Black Lake	Cheboygan
Canada #12	Moore	Lambton County Ontario
Canada #13	Zombra	Lambton County Ontario
Canada #90	Zone	Lambton County Ontario
Ohio #1	Adams	Defiance County Ohio

MAP 2


WELL SAMPLES EXAMINED
FOR OSTRACODA
OSTRACODA
NONE OBSERVED
PRESENT
ABUNDANT
State well permit numbers indicated beside well symbols
Miles
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
CANADA
INDIANA
OHIO
N
EMMET
CHEBOYGAN
PRESQUE ISLE
CHARLEVOIX
ANTRIM
OTSEGO
MONTMORENCY
ALPENA
LEELANAU
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
ARENAC
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
HURON
BAY
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
TUSCOLA
SANILAC
MUSKEGON
MONTCALM
GRATIOT
SAGINAW
OTTAWA
KENT
IONIA
CLINTON
SHIAWASSEE
GENESEE
LAPEER
SAINT CLAIR
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
OAKLAND
MACOMB
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
BERRIEN
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
Ohio No 1
J.L. Patrick - Cartographer

METHOD OF PREPARATION

Most of the ostracoda examined were found free in the samples obtained from well cuttings. In the wells from St. Clair County, Michigan, Defiance County, Ohio, and Lambton County, Ontario, concentration was necessary, because the Traverse Formation is a silty shale. Samples were washed and fine material decanted off several times, which left a concentration of fossils that could be examined under the microscope. Material from the outcrop area was treated the same as the well cuttings. No further preparation was necessary. The ostracoda then were mounted on slides, and the depth below the Antrim along with the state permit number was recorded. The photography was done with a Graflex Camera mounted on a Spencer binocular microscope. Some of the specimens were coated with ammonium chloride to bring out the details.

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 3, page 16) and conversely the posterior end will be at the right for a left valve.

For some ostracoda: eg; <u>Ponderodictya</u> and <u>Quasillites</u>, plenation is not marked and orientation by that method is not practical. Under these circumstances, orientation is determined by the position of such features as flanges and spines, the former being anterior and the latter, posterior. (figure 3, page 16)

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 the valves

G. Location of spines, nodes, and sulci

H. Surface ornamentation

I. Length and height of ostracoda in millimeters

Ostracoda, unlike Brachiopoda and Mollusca, 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.

Because many of the specimens found in this study do not completely satisfy the descriptions of species given by several paleontologists, the term "variant" has been introduced for those specimens which deviate in a minor degree from the described and illustrated species of various authors. These variations are not consistent in any one group and variants in species may be mutation in a single species or growth stages. As an example of the latter, one can cite <u>Ponderodictya bispinulata</u> variant "H" on 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.

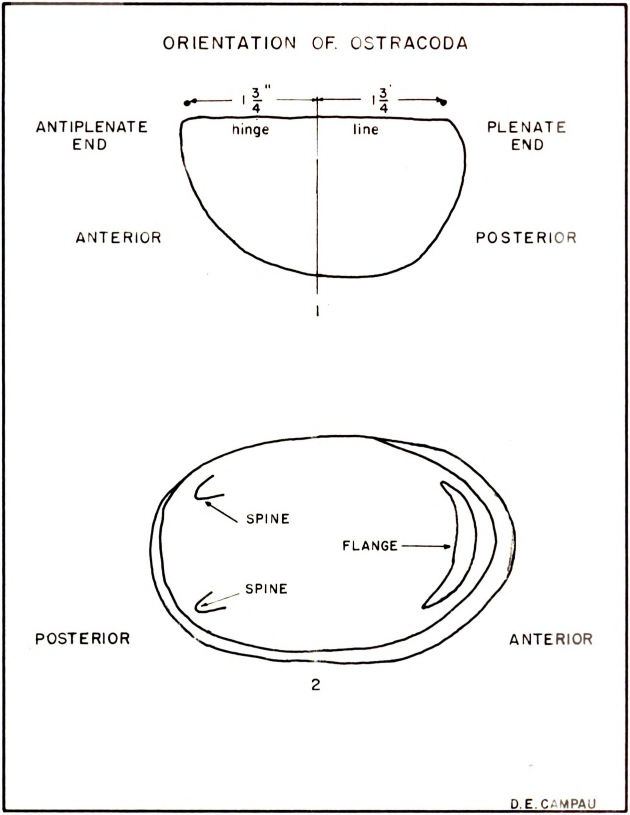

ORIENTATION OF OSTRACODA
1 3/4"
1 3/4'
ANTIPLENATE END
hinge
line
PLENATE END
ANTERIOR
POSTERIOR
1
SPINE
FLANGE
SPINE
POSTERIOR
ANTERIOR
2
D.E. CAMPAU

FIGURE 3

SYSTEMATIC DESCRIPTIONS OF OSTRACODA

Genus APARCHITES

Jones 1889

"Shell not over 3 mm. long, equivalve, subovate or oblong; hinge straight, ventral edge thickened, often beveled or channeled; surface convex, mostly in ventral half, smooth." (Shimer and Shrock, 1944, page 664)

Aparchites variant "A"

Carapace ovate; greatest height near center of the valve; greatest thickness posterior; straight hingeline, slight overlap of the valves, surface reticulated. Length, 0.70 mm., height, 0.50 mm. Rare in well cuttings.

Aparchites variant "B"

Carapace ovate in lateral view; greatest height near center of valve; greatest thickness near center; curved hinge line; valves nearly equal, surface granular. Length, 0.25 mm., height, 0.50 mm. Rare in well cuttings.

Genus CTENOLOCULINA

Bassler 1941

"Tetradella-like shells with valves crossed transversely by four flat-topped, finely reticulated ridges separated by narrow furrows, and with the margins surrounded by a false border, which in the female is swollen to form four to six loculi or brood chambers; right valve grooved on free margin to receive edge of left." (Shimer and Shrock, 1944, page 667)

Ctenoloculina cicatricosa (Warthin) (plate 3, figures 10-11)

Carapace semiovate in lateral view; greatest height in center of posterior half; anterior end sharper than blunt posterior; hinge line straight, valves equal; free margin surrounded by a narrow false border; posterior node near dorsum low and eliptical in shape, high lobe in center of posterior half slanting posteriorly; lobe just anterior of center of valve high and curving posteriorly; anterior node near dorsum low; surface very finely reticulated. Length 1.00 mm., height, 0.50 mm. Rare in well cuttings.

Ctenoloculina cicatricosa variant "A"

This variant differs from the description of the holotype in having brood pits. It resembles the form figured by Warthin (plate 1, figures 5-6) which he calls the female of the species. Rare in well cuttings.

Ctenoloculina cicatricosa and its variant have been compared with the description and plates by Warthin, 1934, page 209, (plate 1, figures 4-6) and agrees in all respects.

Genus CTENOBOLBINA

Ulrich 1890

"Straight-backed, typically with two, but in part with one, long subventral curving sulci dividing the surface into rather broadly convex lobes, and typically with rather inconspicuous submarginal frill along free edges." (Shimer and Shrock, 1944, page 669)

Ctenobolbina variant "A" (plate 2, figure 6)

Carapace semiovate; greatest height at posterior end; straight hinge line, valves are equal; posteriorly curving sulcus and a node in center of valve near hinge line; finely reticulated surface. Length, 0.70 mm., height 0.40 mm. Rare in well cuttings.

Ctenobolbina variant "B" (plate 2, figure 5)

Carapace semiovate; greatest height in posterior half; straight hinge line, valves equal; posterior sulcus, node in center of valve that projects above the hinge line, surface finely reticulated. Length, 0.70 mm., height 0.40 mm. Rare in well cuttings.

Ctenobolbina variant "C" (plate 2, figure 3)

Carapace semiovate; greatest height in posterior end; straight hinge line, valves equal; posteriorly curving sulcus, node located in center of valve; surface finely reticulated. Length, 0.80 mm., height 0.40 mm. Rare in well cuttings.

Ctenobolbina variant "D"

Variant "D" is like variant "A" except that the surface is granular. Length, 0.60 mm., height 0.35 mm. Rare in well cuttings.

Ctenobolbina variant "E" (plate 2, figure 2)

Carapace semiovate; greatest thickness in posterior end; straight hinge line; posteriorly curving sulcus near center of the valve; large anterior node and a small posterior node; small flange near the ventral edge at the anterior end. Length, 0.90 mm., height, 0.40 mm. Rare in well cuttings.

Ctenobolbina variant "F"

Carapace semiovate; greatest height in posterior end; greatest thickness in the anterior end; straight hinge line; right valve overlaps left; large anterior node, weak posteriorly curving sulcus, weak posterior node; anterior end is sharper. Length, 1.10 mm., height 0.50 mm. Rare in well cuttings.

Ctenobolbina variant "G"

Carapace semiovate; greatest height in posterior end; small anterior node, posteriorly curving sulcus; anterior end almost pointed; finely reticulated surface. Length, 0.60 mm., height 0.25 mm. Rare in well cuttings.

None of the Ctenobolbina forms found in this investigation resemble the described species.

Genus RICHINA

Coryell and Malkin 1936

"Carapace subovate; hinge line straight; ventral margin convex; ends rounded, anterior end with a backward swing. Right valve overlaps the left. A median sulcus is bounded by nodes, or blunt spines, or a node and a spine. Surface of valve smooth, or very finely punctate, or finely reticulated." (Coryell and Malkin, 1936, page 3)

Richina variant "A"

Carapace subovate in lateral view; greatest height in posterior end; greatest thickness in posterior end; anterior end sharp, posterior end blunt; straight hinge line; valves nearly equal; median sulcus curving posteriorly; surface finely reticulated. Length, 0.70 mm., height, 0.40 mm. Rare in well cuttings.

Genus HOLLINELLA

Coryell 1928

"Tapered edge of right valve fits into grooved hinge of left and protuberances near cardinal angles of right valve hinge with socket at their base, into which sockets corners of left valve fit; each species has three different forms: (1) with wide frill all along margin except at anterior; (2) with similar but narrower frill; and (3) with only a row of granules or spines representing frill." (Shimer and Shrock, 1944, page 669)

Hollinella tricollina Van Pelt (plate 2, figure 4)

Carapace semiovate in lateral view; greatest height in posterior end; greatest thickness in anterior end; anterior end is sharp, posterior end is blunt; straight hinge line; equal valves; large anterior node near dorsum; posteriorly curving sulcus near center of valve; posterior node near horizontal mid-line and a posterior node near dorsum; finely reticulated surface. Length, 0.70 mm., height, 0.40 mm.

This specimen has been compared with the description and plates by Warthin, 1945 (page 79) and agrees in every respect. Very rare in well cuttings.

Hellinella variant "A" (plate 2, figure 1)

Carapace semiovate in lateral view; greatest height at posterior end; anterior end is sharp, posterior end is blunt; straight hinge line; posteriorly curving sulcus; large posterior node, small anterior node; reticulated surface. Length, 0.90 mm., height, 0.60 mm. Very rare in well cuttings.

Genus AMPHISSITES

Girty 1910, emend Cooper 1941

> "Carapace with a single, centrally located node or swelling and two or more carinae or false keels, parallel or subparallel to free margins." (Shimer and Shrock, 1944, page 671)

Amphissites _subquadratus_ (Ulrich) (plate 3, figure 13)

Carapace subquadrate in lateral view; greatest height at posterior end, greatest thickness in center of posterior half; free margin is striated parallel to free edge; heavy carina around each valve, nearly paralleling the ventral border, but cutting sharply across both ends; kirkbyan pit just anterior to center of valve; surface coarsely reticulated, valves equal. Length, 0.65 mm., height, 0.40 mm. This specimen is very rare in well cuttings.

This specimen has been compared with the description and plates by Warthin 1934, page 214 (plate 1, figure 12) and agrees in every respect.

Amphissites variant "A" differs from _Amphissites_ _subquadratus_ (s.s.) by being ovate in lateral view; greatest thickness is in the anterior half, and the right valve overlaps the left. Length, 0.65 mm., height, 0.30 mm. This variant is rare in well cuttings.

Genus ULRICHIA

Jones 1890

"Like Primitia, but has sharply defined node on each side of sulcus, which in this case is scarcely impressed; occasionally other nodes are present on ventral half of surface in some of questionable members of genus." (Shimer and Shrock, 1944, page 667)

Ulrichia conradi Jones (plate 2, figure 7)

Carapace semioval in lateral view; greatest height in the center; straight hinge line, free margin surrounded by a false border; blunt node in center of posterior half near dorsal, sharper node in center of anterior; reticulated surface. Length, 0.65 mm., height, 0.40 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Warthin, 1934, page 213 (plate 1, figure 10) and agrees in every respect.

Ulrichia fragilis Warthin

Carapace semioval in lateral view; greatest height just posterior to the center; anterior end sharper and higher; hinge line straight; false border around free margin with a thin carina that forms a nearly perfect semicircle; two nodes near dorsal margin in the center of the valve; surface finely reticulated. Length, 0.55 mm., height 0.30 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Warthin 1934, page 213 (plate 1, figure 11) and agrees in every respect.

Genus DIZYGOPLEURA

Ulrich and Bassler 1923

"Differs from Kloedenella in having more or less distinct quadrilobation on valves, longer sulci, and prominent lobes at end bearing brood pouch (probably posterior); dimorphic." (Shimer and Shrock, 1944, page 679)

Disygopleura euglyphea Warthin (plate 2,figure 9)

Carapace subovate; greatest height near center of posterior half; greatest thickness in center of anterior half; anterior end pointed, posterior end more blunt; anterior and posterior sulci straight and equal in length; median sulcus curving slightly posteriorly, and dying out near mid-line; straight hinge line sloping anteriorly; right valve overlaps left; Length, 1.50 mm., height 0.70 mm. Common in well cuttings.

This specimen has been compared with the description and plates by Warthin 1934, page 210 (plate 1, figure 7) and agrees in every respect.

Disygopleura oblonga Warthin (plate 2, figure 8)

Carapace suboblong in lateral view; greatest height in center of posterior half; anterior and posterior ends equally rounded; posterior sulcus curving anteriorly; median sulcus broad dying out near mid-line; anterior sulcus curving posteriorly. Length, 0.80 mm., height, 0.50 mm. Common in well cuttings.

This specimen has been compared with the description and plates by Warthin 1934, page 211 (plate 1, figure 8) and agrees in every respect.

Disygopleura variant "A" (plate 2, figures 10-11)

Carapace subovate; greatest height near center of posterior half; greatest thickness in anterior half; anterior end pointed and posterior end more blunt. Anterior and posterior sulci straight but slightly slanting posteriorly; small anterior node and large posterior node; median sulcus deep and straight to mid-line then curved sharply posteriorly; straight hinge line with one posterior tooth; right valve slightly larger than left. Length, 0.70 mm., height, 0.30 mm. Rare in well cuttings.

Genus POLONIELLA

Gurich 1896

"Apparently similar to Octonaria, but the border of the valve also bears a ridge. A semicircular incision at the anterior end of the right valve, into which an extension of the left valve fits." (Bassler and Kellett, 1934, page 37)

Poloniella cingulata Warthin (plate 1, figure 3)

Carapace suboblong in lateral view; greatest height in center of posterior half; anterior end higher and sharper, posterior end broadly rounded; posterior sulcus is straight to the mid-line then curves anteriorly, and becomes narrow as it joins the anterior sulcus; median sulcus triangular ending about mid-line. Length, 0.90 mm., height, 0.50 mm. Common in well cuttings.

This specimen has been compared with the description and plates by Warthin, page 212 (plate 1, figure 9) and agrees in every respect.

Poloniella variant "A" (plate 1, figures 1-2)

This specimen is like Poloniella cingulata except that the anterior end is more rounded; the median sulcus extending below the mid-line swings posteriorly and has a rather large swelling anteriorly. Length, 1.40 mm., height, 0.80 mm. Common in well cuttings.

Genus HALLIELLA

Ulrich 1891

"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 bellipuncta Van Pelt

Carapace semioval in lateral view; greatest height is just posterior to center; ends smoothly rounded; subtriangular median sulcus; hinge line straight; surface coarsely reticulated; Length 0.65 mm., height 0.40 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Warthin, 1934, page 208 (plate 1, figure 2) and agrees in every respect.

Halliella variant "A"

Carapace semioval in lateral view; greatest height just posterior to center; ends smoothly rounded; weak sulcus just anterior to center; hinge line straight; blunt posterior spine just below mid-line; surface coarsely reticulated. Length, 0.85 mm., height, 0.50 mm. Rare in well cuttings.

Genus BUFINA

Coryell and Malkin 1936

"Carapace subovate; dorsal margin straight; ventral margin convex; ends rounded, anterior end with a backward swing. Surface is ornamented by two anterior spines and a posterior ridge, paralleling the posterior margin. Small papilla-like spines may or may not be present on the end margins. Contact of valves rabetted; right valve larger than left." (Coryell and Malkin, 1936, page 8)

Bufina elongata Coryell and Malkin (plate 3, figures 14-15)

Carapace subovate; greatest height and greatest thickness near center of valve; anterior end sharper than posterior end; straight hinge line sloping anteriorly; right valve overlaps left; two anterior spines and a high sharp posterior flange; surface very finely reticulated with a smooth muscle spot in center of valve. Length, 0.90 mm., height, 0.40 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Coryell and Malkin, 1936, page 9, and plate on page 13, figure 21, and agrees in every respect except for a prominent muscle scar in the center of the valve.

Bufina elongata variant "A"

This specimen is the same as Bufina elongata except that it is more ovate. Length, 0.85mm., height, 0.55 mm. Rare in well cuttings

Genus KLOEDENIA

Jones and Holl 1886

"Straight-backed, subovate, rather obese shells with two subventral to dorsal sulci inclosing a rounded median lobe; other lobes broadly convex; free margins with narrow border; dimorphic, with ventro-posterior, swollen, well defined brood pouches." (Shimer and Shrock, 1944, page 675)

Kloedenia sussexensis Jones and Holl (plate 3, figure 12)

Carapace subovate; greatest height near center; greatest thickness in the anterior end; anterior end sharper than the broadly rounded posterior end; hinge line is concave; fine carina around free margin; median sulcus curving posteriorly; surface finely reticulated; Length, 1.30 mm., height, 0.50 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Shimer and Shrock, page 675 (plate 283, figure 40) and agrees with their abbreviated description. However, Shimer and Shrock figure incomplete specimens and some doubt exists as to whether structures present in the Traverse specimens exist in the specimen of Jones and Holl. Furthermore the stratigraphic horizon for their specimens are from Lower Devonian beds.

Genus BAIRDIA

McCoy 1844

"Shell subtriangular or rhomboidal, with greatest height near middle; inequivalved; narrowly rounded anteriorly and pointed posteriorly; generally smooth; dorsal margin rather strongly convex; hingement formed by a groove in each of interlocking valves; over 200 species, some of which may belong to BAIRDOPPILATA Coryell, Sample and Jennings 1935." (Shimer and Shrock, 1944, page 683)

Bairdia variant "A" (plate 2, figure 12)

Carapace subtriangular; greatest height and greatest thickness near center of valve; anterior end sharper than posterior end; right valve overlaps left; surface smooth. Length, 1.30 mm., height, 0.80 mm. Rare in well cuttings.

Bairdia variant "B"

Carapace elongated; greatest height near center of valve; anterior end pointed, posterior end blunt; hinge line straight; right valve overlaps left; surface smooth. Length, 1.00 mm., height 0.60 mm. Rare in well cuttings.

Bairdia variant "C"

Carapace subtriangular; greatest height in center of valve; greatest thickness just posterior to center; posterior end pointed just above mid-line; surface smooth. Length, 1.50 mm., height, 1.00 mm. Rare in well cuttings.

Genus BARYCHILINA

Ulrich 1891

"Carapace small, rhomboidal; valves thick, right overlapping left except in posterior half of convex dorsal edge; surface of valves striate, except along edges where it is smooth; sharply defined narrow or rounded pit." (Shimer and Shrock, 1944, page 687)

Barychilina variant "A"

A single specimen was assigned to this genus Barychilina by a member of the staff of the U. S. National Museum, (personal communication). The specimen was found in the Campbell No. 1 well, 125 feet below the surface in the Killians member of the Traverse Formation.

Genus PONDERODICTYA

Coryell and Malkin 1936

The genotype of Ponderodictya bispinulata was erected on Cytherella bispinulatus Stewart, 1927, page 60, who obtained her material from the type locality of the Silica shale near Sylvania, Ohio. Coryell and Malkin later made the specie Cytherella bispinulata the genotype of Ponderodictya. Although we do not have any specimens of Ponderodictya bispinulata from the type locality we have specimens of that specie from a shale member in a well located in Wayne County, Michigan, which were studied and identified by Dr. Virginia Kline. Our specimens have been compared with these and are regarded as specifically identical.

> "Carapace ovate; dorsal margin convex; ventral margin straight with central sinuosity in ventral contact; convex at extremities. Posterior margin rounded; anterior margin broadly rounded with backward swing, and lower than posterior. Left valve overlaps right on all margins, with overlap most pronounced ventrally. A ridge near the margin of the right valve fits into a groove in the left. Surface of valve reticulate, with a less ornamented spot just anterior to the center of the valve. Anterior and posterior without reticulations. Two small nodes or spines, the ventral one more prominent, project near the posterior end from the surface of the convexity, at the crest of the posterior dorsal and posterior ventral slopes. Near the anterior end is a low, non-reticulate, curved ridge, more prominent in the right valve and in some specimens apparently lacking in the left. Greatest height is located about one third of the length from the posterior end, with convexity greatest near the center of the posterior half of the valve." (Coryell and Malkin, 1936, page 16)

The generic description applies to the specimens obtained from the Traverse Formation during the course of this investigation.

To the generic description the author would add the following remarks: Not having had the opportunity to study the type material of Ponderodictya bispinulata (Stewart), the identification is based entirely on descriptions and illustrations in the article by Coryell and Malkin, 1936. It is difficult to judge the general appearance of Coryell and Malkin's plesiotype Ponderodictya bispinulata from the illustrations. Such features as size, length of spines, and development of the flange can only be approximated. Judging alone from Coryell and Malkin's descriptions there seems to be little doubt that the genotype is represented in the Traverse Formation of Michigan.

The majority of the forms studied in this investigation do not completely satisfy this description. Variations from the normal, on the other hand, are abundant. Therefore, the writer has made up a preliminary series of groups which vary in minor characteristics from the genotype as well as from each other.

These variations from the type are described as variants. The variants differ chiefly in size, ornamentation, in development of the anterior flange and the posterior spines. All specimens have the same general outline, same reticulation, same muscle spot, but some lack almost entirely the posterior flange, or the anterior spines, or both. Typical examples of these variants are described below as variants "A" to "H".

Ponderodictya bispinulata (Stewart) variant "A" (plate 3, figures 1-2-3) is taken as identical with the plesiotype of Ponderodictya bispinulata described by Coryell and Malkin as well as the forms identified by Dr. Kline.

Ponderodictya bispinulata (Stewart) variant "B" differs from the variant "A" in the absence of a posterior spine. In other respects it agrees because there is a strong anterior flange and strong overlap of the valves. There is also an unornamented spot near the center of the valve.

Ponderodictya bispinulata (Stewart) variant "C" (plate 3, figures 4-5) resemble variant "B" in the presence of only one spine ventrally low on the posterior end, and a weak development of an anterior flange. In variant "C" the flange is reduced almost to an elliptical node.

Ponderodictya bispinulata (Stewart) variant "D" (plate 3, figure 8) differs from "A", "B" and "C" in the greatly reduced posterior spine and anterior flange. In this specimen there is a weak, narrow, semi-lunar ridge at the posterior end. This form is the most common of the variants and is found throughout the ostracode zone.

Ponderodictya bispinulata (Stewart) variant "E" (plate 3, figure 6) resembles "B" in the presence of a strong posterior spine near the venter, and a rounded node near the dorsum and a moderate, well-developed anterior flange. It differs markedly in the absence of characteristic reticulation and also in in the proportion of length to height of carapace, variant "B" being proportionately shorter. It is possible that these weak reticulated forms may be partially exfoliated specimens. These forms are common near the top of the Traverse ostracode zone and stratigraphically higher than those assigned to variant "B" which is more common near the base of the zone.

Ponderodictya bispinulata (Stewart) variant "F" (plate 3, figure 7) is the same as "E" except it has a small, sharp, posterior spine and no anterior flange.

Ponderodictya bispinulata (Stewart) variant "G" lacks all ornamentation except a low, rounded, anterior flange.

Ponderodictya bispinulata (Stewart) variant "H" (plate 3, figure 9) has a weakly developed spine and flange and is very small in size. It is probably a molt of a young ostracoda.

Genus JENNINGSINA

(Van Pelt 1933)

"Carapace subreniform; hinge line straight. Surface of valve covered with fine ridges diverging from a median line. These ridges are connected by cross bars at intervals slightly larger than the space between two ridges, thus producing in effect rows or elongate reticulations. In the center of the valve is a small circular pit. Right valve overlaps the left of free margins." (Coryell and Malkin, 1936, page 19)

Jenningsina catenulata (Van Pelt) (plate 1, figure 4)

Carapace subreniform; hinge line straight; surface covered with fine ridges which are connected by cross bars giving the effect of rows of elongated reticulations; a small circular pit in the center of the valve; right valve overlaps left. Length, 0.80 mm., height 0.35 mm. Rare in well cuttings, not found in outcrops.

This specimen has been compared with the description and plates by Coryell and Malkin, 1936, page 19 (plate on page 12, figure 35) and agrees in every respect.

Genus QUASILLITES

Coryell and Malkin 1936

"Carapace subovate to rhomboidal; hinge line straight. Ventral margin straight to gently convex. Right valve larger than left, with a grooved contact to receive the left valve. Surface of valves is marked by fine longitudinal ridges and grooves, bifurcating along a median line, and diverging slightly anteriorly. A less ornamented median spot is usually discernible. Posterior convexity is generally elevated into a ridge-like surface at the crest of the steep posterior slope. A spine projects forward from the anterior ventral region, at the crest of the anterior slope." (Coryell and Malkin, 1936, page 18)

Quasillites subobliquus Swartz and Oriel

Carapace subrhomboidal; greatest height in center of posterior half; greatest thickness in anterior half; anterior end is sharp and posterior end blunt; hinge line straight; right valve overlaps left; blunt antero-ventral spine; surface is covered with "fingerprint" ornamentation except for a smooth median spot. Length, 1.00 mm., height, 0.50 mm. Common in well cuttings.

Quasillites ornatus Swartz and Oriel

Carapace subovate; greatest height is anterior to center; anterior end blunt, posterior end sharp; hinge line slightly curved; right valve slightly larger than left valve; blunt antero-ventral spine; surface has "fingerprint" ornamentation except for smooth median spot. Length, 1.00 mm., height, 0.60 mm. Common in well cuttings.

Quasillites lobatus Swartz and Oriel

Carapace subrhomboidal; greatest height posterior to center; greatest thickness in the anterior half; anterior end sharp; posterior end blunt; hinge line straight sloping anteriorly; right valve overlaps left; blunt antero-ventral spine; surface ornamented with "fingerprint" ornamentation except for clear median spot. Length, 1.00 mm., height, 0.50 mm. Common in well cuttings.

In the writer's opinion, these three species differ only in minor details and should be given the rank of variants, because the variations between them are commensurate with the variations between forms of *Ponderodictya bispinulata* previously described on page 29.

Quasillites binodosus Swartz and Oriel (plate 1, figure 5)

Carapace subquadrate; greatest height just posterior of center; greatest thickness in anterior half; anterior end sharper; posterior end blunter; hinge line straight sloping anteriorly; right valve slightly overlapping the left; blunt antero-ventral spine; surface is covered with reticulations arranged in rows except for a smooth, median spot. Length, 0.80 mm., height, 0.35 mm. Common in well cuttings.

The above specimens have been compared with the descriptions and plates by Swartz and Oriel, 1948, pages 556 to 559 and agree in every respect.

Genus SPINOVINA

Coryell and Malkin, 1936

"Carapace cytherelloid; hinge straight, channeled. Right valve overlaps left, with grooved contact in right valve to receive the ridge of the smaller left valve. Surface marked by longitudinal ridges. An anterior ventral spine projects forward from the crest of the anterior slope of the convexity. A median spot free from ornamentation is present near the center of the valve." (Coryell and Malkin, 1936, page 17)

Spinovina distributa Coryell and Malkin

Carapace ovate; greatest height anterior half; greatest thickness in the anterior half; anterior end more bluntly rounded than posterior end; hinge line straight; right valve overlaps left valve; blunt anteroventral spine and a weak posterior flange; surface covered with "fingerprint" ornamentation. Length, 1.10 mm., height, 0.65 mm. Rare in well cuttings.

This specimen has been compared with descriptions and illustrations by Coryell and Malkin, 1936, page 17. The fine ornamentation, "fingerprint" feature, could not, however, be directly compared with their illustrations.

Genus EUGLYPHELLA

Warthin 1934

"Carapace subtriangular in lateral view, greatest height in posterior half; hinge line straight, inconspicuous; each valve bears a C-shaped carina opening anteriorly; anterior end spinose." (Shimer and Shrock, 1944, page 281)

Euglyphella sigmoidalis Warthin (plate 1, figure 6)

Carapace subtriangular; greatest height in center of posterior half; greatest thickness in center of valve; anterior end sharp and high; posterior end broadly rounded; hinge line straight; right valve slightly smaller than the left; each valve has sharp "C" shaped carina, the opening of the "C" is anterior; anterior end has small spines; Length, 0.90 mm., height, 0.60 mm. Rare in well cuttings.

This specimen has been compared with the description and plates by Warthin, 1934, page 220 (plate 1, figure 21) and agrees in every respect.

Euglyphella sigmoidalis Warthin variant "A"

This specimen differs from Euglyphella sigmoidalis (s.s.) in that the anterior end is more blunt and lacks spines. Length, 0.75 mm., height, 0.55 mm. Common in well cuttings throughout the ostracode zone.

Euglyphella sigmoidalis Warthin, variant "B"

This specimen differs from Euglyphella sigmoidalis (s.s.) in that it has a small projection anteriorly and lacks spines. Length, 1.00 mm., height, 0.50 mm. Rare in well cuttings.

Genus HYPHASMOPHORA

Van Pelt 1933

"Valve with reticulate surface and central pit, but lacks the marginal ridge of Amphissites." (Bassler and Kellett, 1934, page 37)

Hyphasmaphora textiligera

Carapace subovate; greatest height in center of posterior half; hinge line curving, ends smoothly rounded, posterior end lower and blunter; coarse irregular reticulation, with a deep pit near the center; right valve overlaps the left. Length, 0.50 mm., height 0.25 mm. Rare in well cuttings.

Genus OCTONARIA

Jones 1887

"Similar to Thlipsurella, but distinguished by tendency of left valve to overlap right, and by having surface of valves raised into a thin spiral or ringlike ridge, which in more typical forms resembles the figure "8". (Shimer and Shrock, 1944, page 682)

Octonaria variant "A" (plate 1, figures 7 and 11)

Carapace reniform; greatest height posterior to center; greatest thickness in center of anterior half; anterior end sharper than posterior; hinge line straight; surface ornamented with deep pits and fine longitudinal striations. Length, 1.00 mm., height 0.50 mm. Common in well cuttings.

A number of specimens that differ from variant "A" only in the amount of sculpturing on the valves were found in this investigation. Some specimens are sculptured only on one valve and others are weakly sculptured on both valves. (plate 1, figures 8-9-10 show these variations)

Genus THLIPSURA

Jones and Holl 1869

> "Valves convex with right overlapping left and with region bordering anterior margin depressed to form well defined sunken area with one to two furrows opening from this area and extending back for some distance." (Shimer and Shrock, 1944, page 681)

Carapace subovate; greatest height near center; greatest thickness near posterior; anterior end sharp, posterior blunt; hinge line straight; right valve overlaps left; small posterior flange. Length, 1.00 mm., height, 0.50 mm. Rare in well cuttings. (plate 1, figures 13-14)

PHYLUM BRYOZOA

Genus ACROGENIA

Hall 1883

> "Segmented, arising from cylindrical rootlets, two segments from truncated ends of preceding one, each obconical and striated at base, later becoming flattened and bearing apertures in linear series, separated by ridges, largest in marginal row; lunaria prominent." (Shimer and Shrock, 1944, page 270)

Bryozoan Acrogenia variant "A" is a tapered cylindrical form, that has long sigmoid striations which give an appearance of a rifled bullet. The smaller end averages .66 mm. in diameter and has a shallow conic projection.

The larger end averages .70 mm. in diameter and has a shallow conic depression. The average overall length of the specimen is 1.3 mm. (plate 1, figure 15). It is apparent that the conic projection of one unit fits into the conic depression of another unit in the growth of the animal. (plate 1, figure 16) On the projection and depression ends there are concentric growth rings and fine radial striae. Common in well cuttings.

CHAROPHYTA

Groves J., 1933

"Charophyta are small bushy plants ranging from about ten cm. to 60 cm. in height. They occur abundantly in quiet, clear, fresh-water bodies, like ponds, ditches, and lakes, and are distributed widely throughout the world. The outstanding characteristics of the group are the male and female reproductive organs, termed the antheridia and oogonia, respectively, and the whorled lateral branches on which the organs are borne. Some species secrete calcium carbonate and are large contributors to fresh water limestones.

Fossil Charophyta are exclusively oogonia. Vegetative parts are seldom preserved." (Shimer and Shrock, 1944, page 712)

Trochiliscus, Karpinsky variant "A" (plate 1, figure 12)

Calcified oogonia with nine spiralling striae beginning in a central pit. Diameter, 0.50 mm. Found only in wells and outcrops in Cheboygan County.

This specimen has been compared with the description given by Shimer and Shrock, 1944, on page 713.

The presence of Trochiliscus in the Traverse Formation, ordinarily regarded as exclusively marine, may be explained either by the possible proximity of these sediments to a shoreline, or by rafting far out to sea.

INTERPRETATION OF CROSS SECTIONS

Map 3, page 39, shows position of Cross Sections

A study of the cross section A-I from Defiance County, Ohio, northeast, to Lambton County, Ontario (figure 4, page 52), shows that the ostracod zone:

a. lies in the lower half of the Traverse Formation

b. reflects the Michigan basin structure

c. reflects the St. Clair structure

d. increases in thickness as it enters the deeper part of the Michigan basin

A study of the cross section A-B from Defiance County, Ohio, north, to Ferron Point Shale outcrop at Black Lake, Cheboygan County, Michigan (figure 5 in pocket) shows that the ostracod zone:

a. lies in the lower half of the Traverse Formation

b. reflects the Michigan basin structure

c. reflects the structure of the Howell anticline

d. reflects the West Branch structure

e. increases in thickness as it enters the deeper part of the Michigan basin

This cross section also shows that the Silica shale of northwest Ohio appears to be stratigraphically lower than the Ferron Point shale of the Black Lake locality.

A study of Cross Section C-D, Cheboygan County, Michigan, southeast to Lambton County, Ontario (figure 6, page 53) shows that the ostracod zone:

a. lies in the lower half of the Traverse Formation

b. reflects the Michigan Basin structure

c. reflects the St. Clair structure

d. increases in thickness as it enters the deeper part of the Michigan basin.

A study of Cross Section E-F from Wayne County, northwest to Montcalm County shows (figure 7, page 54) that the ostracod zone:

a. lies in the lower half of the Traverse Formation

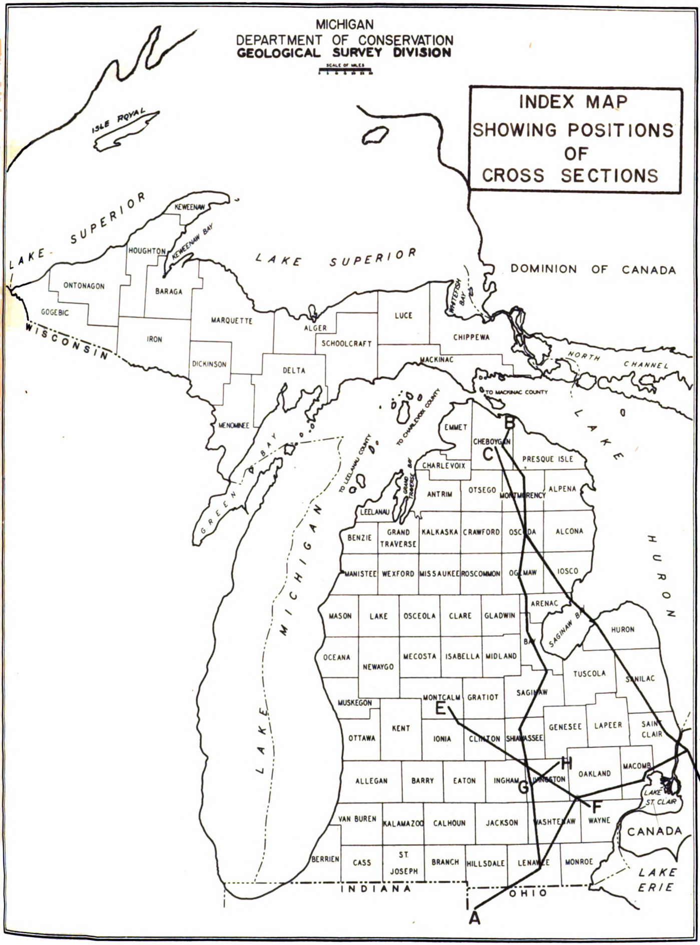
b. reflects the Michigan Basin structure

c. reflects the pitch of the Howell structure because it is approximately parallel to the axis.

A study of Cross Section G-H from Iosco Township, Livingston County, northeast to Hartland Township, Livingston County (figure 8, page 55) shows that the ostracod zone:

a. lies in the lower half of the Traverse Formation

b. reflects the reverse dip of the Howell Structure because it is taken approximately perpendicular to the strike.


MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION
INDEX MAP
SHOWING POSITIONS
OF
CROSS SECTIONS
ISLE ROYAL
LAKE SUPERIOR
LAKE SUPERIOR
DOMINION OF CANADA
WISCONSIN
KEWEENAW
KEWEENAW BAY
HOUGHTON
ONTONAGON
GOGEBIC
BARAGA
MARQUETTE
IRON
DICKINSON
ALGER
SCHOOLCRAFT
LUCE
WHITEFISH BAY
CHIPPEWA
MACKINAC
DELTA
MENOMINEE
NORTH CHANNEL
TO MACKINAC COUNTY
LAKE HURON
GREEN BAY
TO LEELANAU COUNTY
TO CHARLEVOIX COUNTY
GRAND TRAVERSE BAY
EMMET
CHEBOYGAN
PRESQUE ISLE
CHARLEVOIX
ANTRIM
OTSEGO
MONTMORENCY
ALPENA
LEELANAU
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
LAKE MICHIGAN
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
ARENAC
SAGINAW BAY
HURON
BAY
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
TUSCOLA
SANILAC
MUSKEGON
MONTCALM
GRATIOT
SAGINAW
GENESEE
LAPEER
SAINT CLAIR
OTTAWA
KENT
IONIA
CLINTON
SHIAWASSEE
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
OAKLAND
MACOMB
LAKE ST. CLAIR
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
CANADA
BERRIEN
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
LAKE ERIE
INDIANA
OHIO
A
B
C
D
E
F
G
H
I

DISTRIBUTION CHART OF OSTRACODA AND THE BRYOZOAN, ACROGENIA IN THE TRAVERSE FORMATION

This stratigraphic distribution chart (figure 9 in pocket) shows the vertical range and frequency of ostracoda and bryozoa within the Traverse Formation, from Black Lake outcrop, Cheboygan County, Michigan to well No. 13 in Lambton County, Ontario.

Twenty-two genera of ostracoda, one bryozoan genus and a single plant, were found and determined. Only the most abundant genera were used in as much as they give a true picture of the stratigraphic distribution. The genera are listed below:

Ostracoda -- Amphissites
Bairdia
Ctenobolbina
Ctenoloculina
Dizygopleura
Euglyphella
Jenningsina
Octonaria
Poloniella
Ponderodictya
Quasillites
Spinovina

Bryozoan -- Acrogenia

This chart shows a general restriction of genera to the lower half of the Traverse Formation. There is an exceptional occurrence of five ostracoda in the top fifty feet in well S.P. 10810, in Huron County. It is possible that the samples from this well may have been mis-labeled, as they represent the only case where ostracoda, collected from sixty-six wells, were found near the top of the Traverse Formation.

The distribution chart of ostracoda shows an increase in thickness of the zone as it enters the deeper part of the Michigan basin.

SUMMARY

Together, all cross sections show that the ostracod zone:

a. lies in the lower half of the Traverse Formation

b. reflects the Michigan basin structure

c. reflects structures in lower formations

d. increases in thickness as it enters the deeper part of the Michigan basin

e. the Silica shale of northwest Ohio appears to be stratigraphically lower than the Ferron Point shale of the Black Lake locality.

CONCLUSIONS

A. There is an ostracode zone within the Traverse Formation.

B. The ostracode zone lies in the lower half of the Traverse Formation.

C. The ostracode zone follows the synclinal Michigan basin and reflects structures in deeper formations.

D. This zone becomes thicker in the deeper parts of the basin.

E. Ponderodictya, Quasillites, Euglyphella, Dizygopleura, Poloniella, and Octonaria are abundant in this zone.

F. Ponderodictya has a long vertical range in this zone but is more abundant near the base. Quasillites, Euglyphella, Dizygopleura, Poloniella, and Octonaria are found throughout the zone but are more abundant just above the zone of concentration of Ponderodictya.

G. Bryozoan Acrogenia is common in this zone.

H. Tentaculites and crinoids are found along with the ostracoda.

I. Ponderodictya, Poloniella, Octonaria and Quasillites are common in the Upper Blue shale of the Gravel Point from the Bell quarry.

J. Ponderodictya, Poloniella, Octonaria, Euglyphella, Ctenobolbina, Ctenoloculina and Bryozoan Acrogenia are common in the Ferron Point shale from Black Lake locality.

K. Ostracoda are more abundant in shale than limestone. This could be due to mechanical concentration. In the harder material, ostracoda are broken into fragments, whereas in shale which is soft, the ostracoda are not broken and better specimens are obtained.

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EXPLANATION OF PLATE I

All specimens are magnified 18 diameters. Footage refers to the depth below Antrim-Traverse contact at which the fossil ostracoda was found.

		Page
Figure 1	*Poloniella* variant "A" . . . . Right valve S. P. No. 13922, 260 feet	24
Figure 2	*Poloniella* variant "A" . . . . Dorsal view S. P. No. 13922, 260 feet	24
Figure 3	*Poloniella cingulata* Warthin . . . . Right valve S. P. No. 13922, 270 feet	24
Figure 4	*Jenningsina catenulata* (Van Pelt). . . . . Right valve Canada No. 12, 200 feet	31
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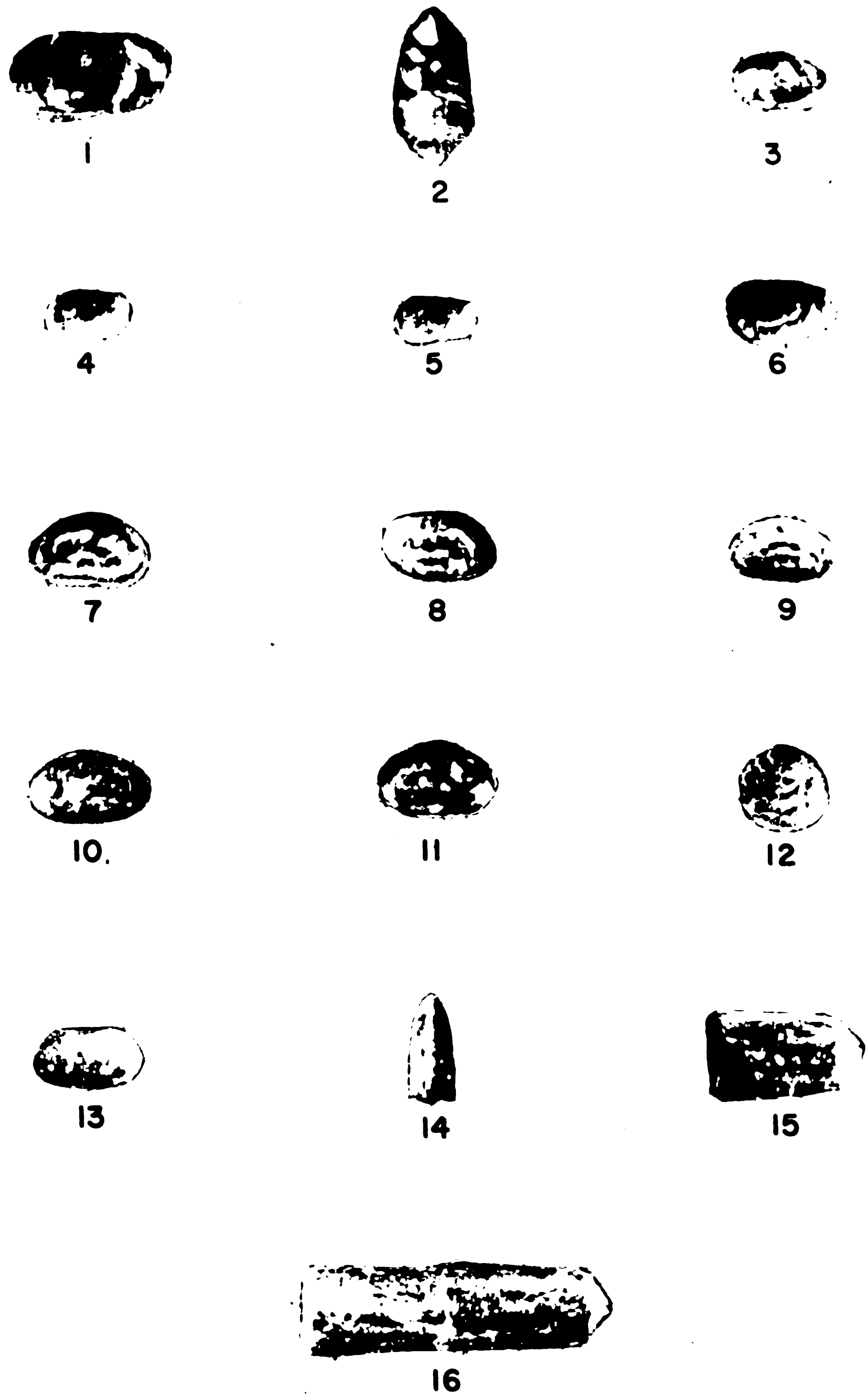
Figure 10	*Octonaria* variants from "A". . . . . Left valve Black Lake outcrop	35
Figure 11	*Octonaria* variant "A". . . . . Right valve Canada No. 12, 230 feet	34
Figure 12	*Charophyta Trochiliscus* Karpinsky. . . . . S. P. No. 14936, 75 feet	36

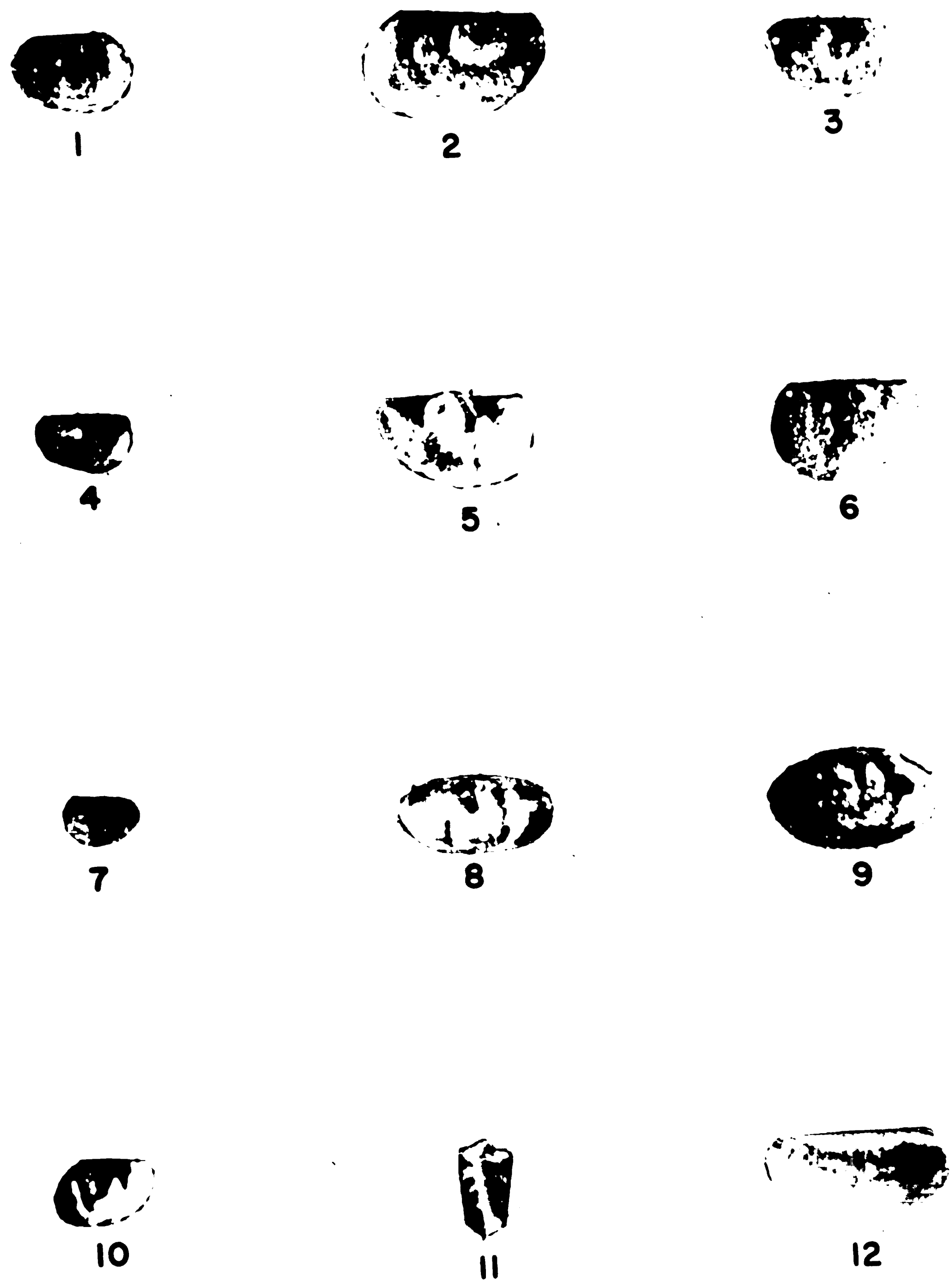
PLATE - I



EXPLANATION OF PLATE II

All specimens are magnified 18 diameters. Footage refers to the depth below Antrim-Traverse contact at which the fossil ostracoda was found.

PLATE - 2



EXPLANATION OF PLATE III

All specimens are magnified 18 diameters. Footage refers to the depth below Antrim-Traverse contact at which the fossil ostracoda was found.

Page

Figure 1 Ponderodictya bispinulata (Stewart) variant "A". 29
Right valve
S. P. No. 13841, 245 feet

Figure 2 Ponderodictya bispinulata (Stewart) variant "A". 29
Dorsal view
S. P. No. 13841, 245 feet

Figure 3 Ponderodictya bispinulata (Stewart) variant "A". 29
Left valve
S. P. No. 13841, 245 feet

Figure 4 Ponderodictya bispinulata (Stewart) variant "C". 29
Right valve
S. P. No. 13028, 275 feet

Figure 5 Ponderodictya bispinulata (Stewart) variant "C". 29
Dorsal view
S. P. No. 13028, 275 feet

Figure 6 Ponderodictya bispinulata (Stewart) variant "E". 30
Right valve
S. P. No. 13702, 215 feet

Figure 7 Ponderodictya bispinulata (Stewart) variant "F". 30
Right valve
S. P. No. 13702, 215 feet

Figure 8 Ponderodictya bispinulata (Stewart) variant "D". 30
Right valve
S. P. No. 11001, 280 feet

Figure 9 Ponderodictya bispinulata (Stewart) variant "H". 30
Left valve
Ohio No. 1, 40 feet

Figure 10 Ctenoloculina cicatricosa (Warthin). 17
Left valve
Canada No. 12, 210 feet

Figure 11 Ctenoloculina cicatricosa (Warthin) variant "A". 18
Ventral view
Canada No. 12, 150 feet

Figure 12 Kloedenia sussexensis? Jones and Holl. 26
Left valve
Black Lake outcrop

PLATE – 3

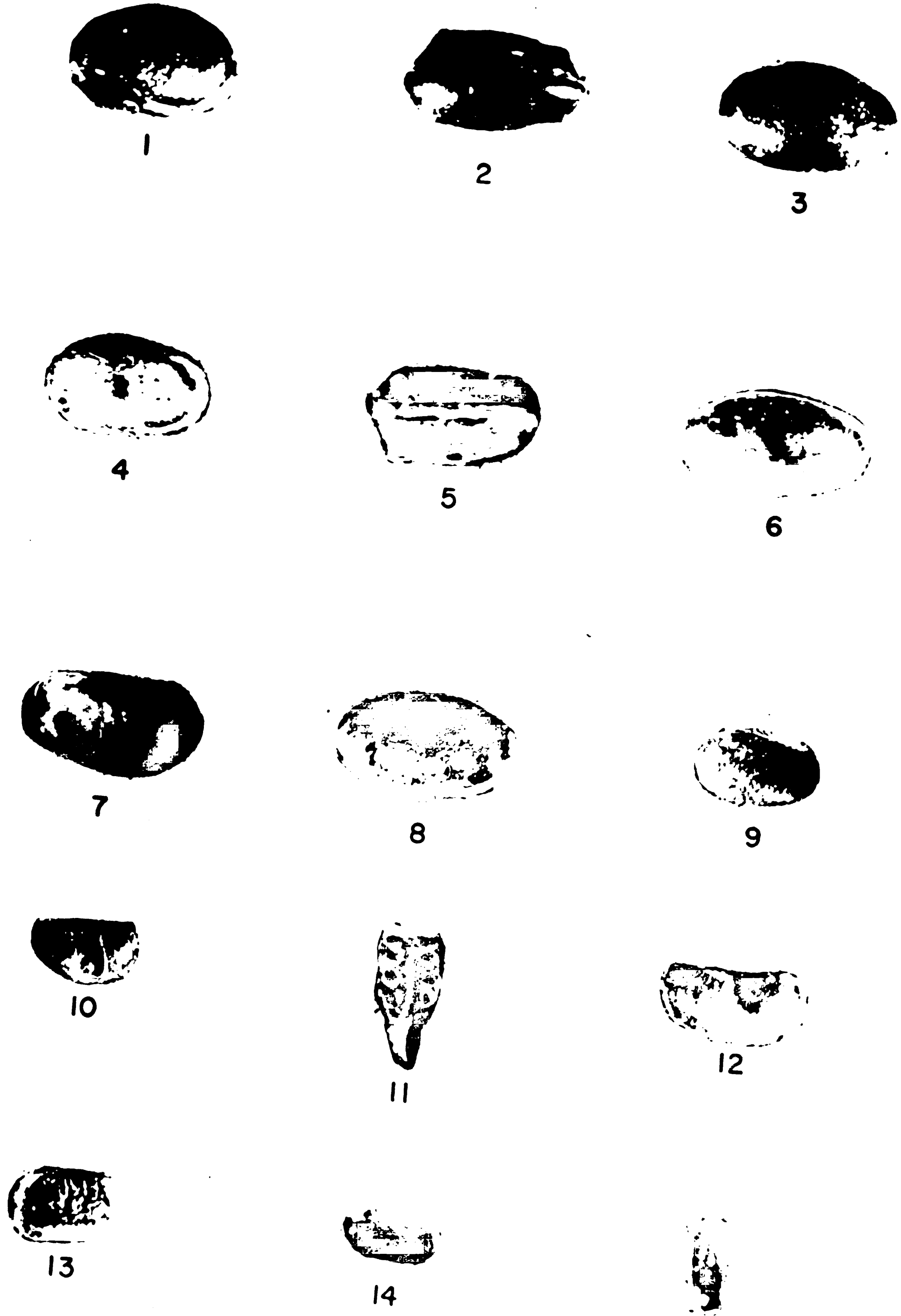


Figure 4

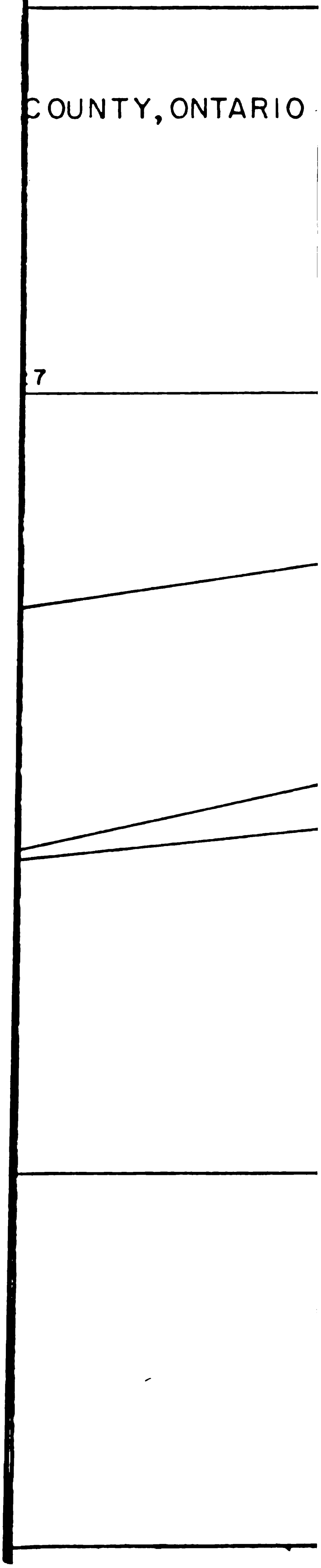


Figure 6

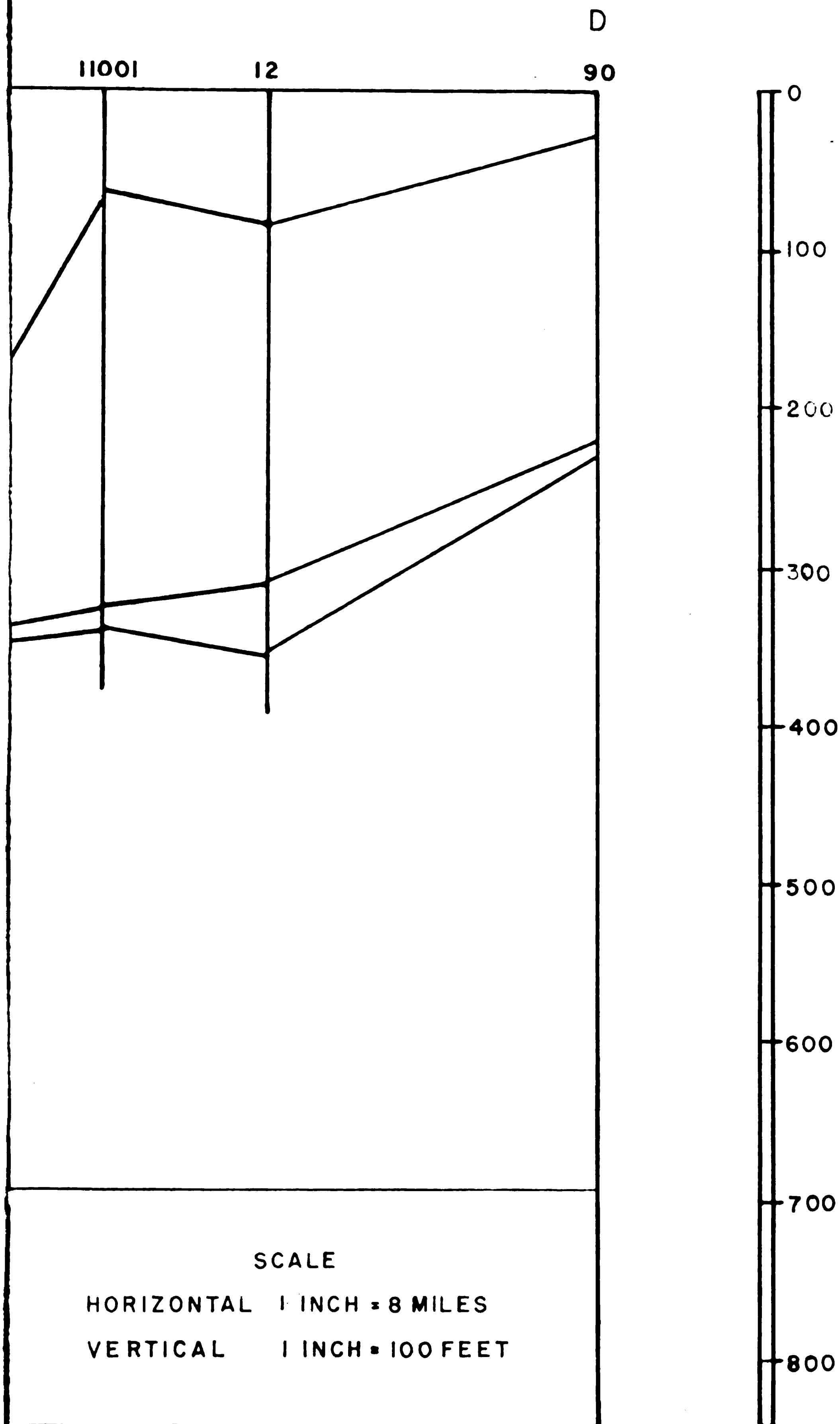


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Figure 7

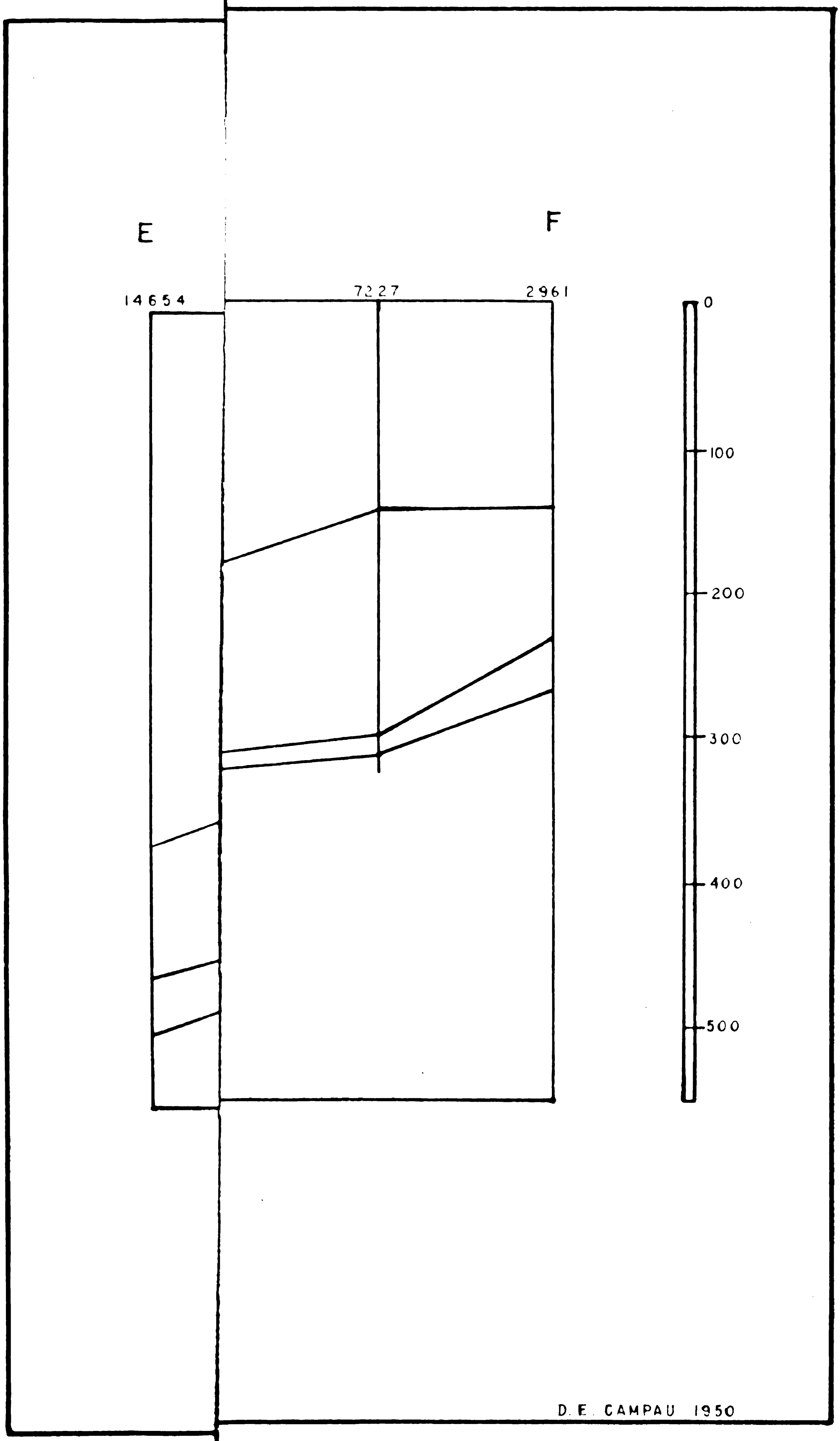
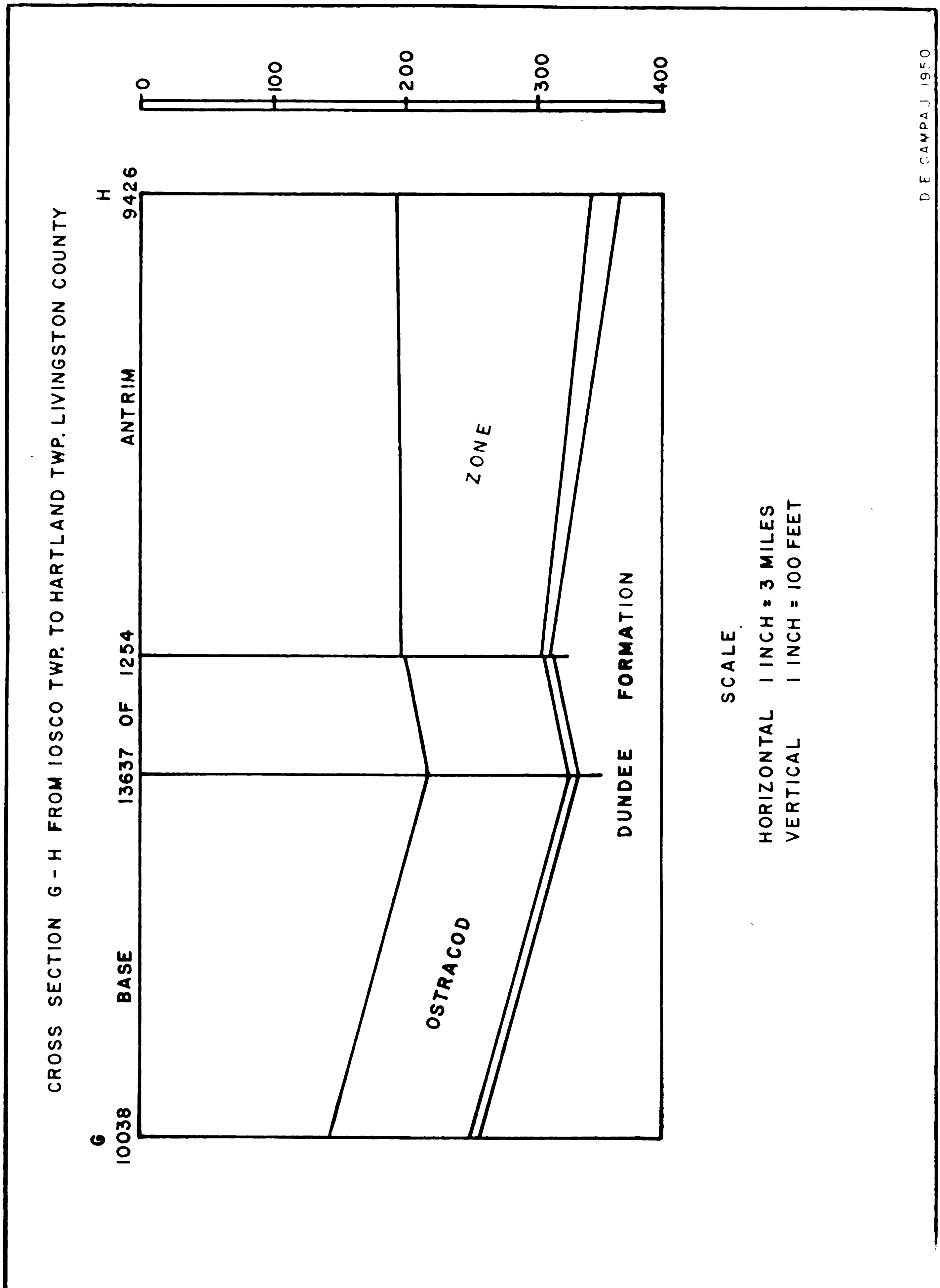


Figure 8


CROSS SECTION G - H FROM IOSCO TWP. TO HARTLAND TWP. LIVINGSTON COUNTY
G
10038
H
9426
13637 OF 1254
BASE
ANTRIM
OSTRACOD
ZONE
DUNDEE FORMATION
0
100
200
300
400
SCALE
HORIZONTAL 1 INCH = 3 MILES
VERTICAL 1 INCH = 100 FEET
D E CAMPAU 1950

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Pocket has: Fig. 5 & Fig. 9