THE STRATIGRAPHIC VALUE OF CERTAIN CRYPTOSTOMATOUS BRYOZOA OF THE TRAVERSE FORMATION, MIDDLE DEVONIAN AGE OF MICHIGAN

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This is to certify that the

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William A. Kelly.
Major professor

Date October 12, 1950

THE STRATIGRAPHIC VALUE OF CERTAIN CRYPTOSTOMATOUS BRYOZOA OF THE TRAVERSE FORMATION, MIDDLE DEVONIAN AGE OF MICHIGAN

by

Arthur Edwin Slaughter

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INTRODUCTION

Beginning with the Ordovician there are few formations of limestone, especially formations with shale alternations, that do not have a great abundance of fossil bryozoa. The seas of today as well, are rich in the modern orders of this animal.

Of the five separate orders of bryozoa only the Trepostomata and Cryptostomata are strictly Paleozoic forms. The Ctenostomata is rarely observed, the Cyclostomata is most abundant in the Mesozoic, and the Cheilostomata, sometimes regarded as the continuation of the Cryptostomata, includes Mesozoic and Recent forms. The trepostomatous forms are found most abundantly in late Ordovician sediments and subsequently wane in importance to become extinct in the Permian. The Cryptostomata were at their zenith during the Devonian and Mississippian periods and continue to be found in abundance until the Permian. Like the Trepostomata they become extinct at the close of the Paleozoic Era.

The culmination of the Paleozoic orders of bryozoa is regarded as being contemporaneous with the Hamilton stage, (Middle Devonian of New York). The Michigan counterpart of the Hamilton is the Traverse. The Traverse Formation selected for this study, like the Hamilton, is a prolific producer of bryozoan fossils and provides a good source of specimens.

The order Cryptosomata is more adaptable to study and identification than the Trepostomata in that most of the forms are identifiable from their external features thus recourse to thin section preparation and study are not strictly necessary.

Bryozoa found in Michigan have been used but little in stratigraphic work. Only recently through the endeavor of Deiss, Duncan, and McNair, have any extensive efforts been made to establish the identification of the faunal types encountered in the State. Previous to the work of these individuals bryozoa were only occasionly given enough attention for specific identification; usually noted as addenda at the end of faunal lists. Bassler (1922, p. 376) has stated that,

> "The use of fossil bryozoa in stratigraphic work has scarcely attained the importance it deserves. In American Paleozoic strata they are preeminently the fossil to be relied upon in correlation work. They are nearly always abundant and even when poorly preserved exteriorly can be identified by thin sections."

In the opinion of the writer Bassler is much too optimistic regarding the importance of employing bryozoa in correlation work. The difficulties encountered in identification and collection procedures, mentioned later, are to a considerable degree at variance with his opinion. The foregoing statement is not meant to imply that the bryozoa do not have any stratigraphic usefulness. To the contrary, they do have recognizable stratigraphic significance and an attempt will be made to point out a new method by which they may be used for correlation work.

OBJECTIVES OF THE STUDY

The primary importance of fossilized remains of animals lies in their use for stratigraphic correlation. This paper has been prepared for the purpose of determining the value of fragments of bryozoan colonies observed in cuttings taken from oil well drilling operations, especially those of the Traverse Formation. The addition of the types identified to the existing faunal lists will add one more bit to the knowledge of the subsurface expression of the Traverse in southeastern Michigan.

Bryozoa found in Michigan have had generally only a very secondary importance and those observed in well cuttings have been more or less ignored. Bryozoa could take a place of importance in subsurface stratigraphic work comparable to the Ostracoda, if specimens of adequate size and number could be obtained from well cuttings for unqualified identification. This paper will indicate the limitations and serve to verify the usefulness of this fauna in subsurface work.

STRATIGRAPHY OF THE TRAVERSE GROUP

Portions of the description of the Traverse stratigraphy taken from Oil and Gas Investigations, Preliminary Chart 28, prepared by G. V. Cohee, are reproduced below for descriptive information regarding the materials connected with this study.

> "The Traverse group and its correlative rocks are present over a large part of the Michigan basin, including the Southern Peninsula of Michigan, northern Indiana, northwestern Ohio, southwestern Ontario and eastern Wisconsin. They crop out at the surface in Alpena, Presque Isle, Cheboygan, Emmet and Charlevoix Counties in northern Michigan, near the village of Silica in Lucas County, Ohio and at various localities in Kent and Lambton Counties, Ontario, Canada. The rocks of this age crop out beneath glacial drift along the north flank of the Kankakee arch in Indiana and along the Findlay arch in northwestern Ohio and southeastern Michigan. They extend from the Michigan basin into the Appalachian basin, across southwestern Ontario in the vicinity of the Chatham sag in Essex, Kent, Lambton, Middlesex and Elgin Counties, where they are called Hamilton formation.

MAP I


MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION
ISLE ROYAL
LAKE SUPERIOR
KEWEENAW
KEWEENAW BAY
HOUGHTON
ONTONAGON
BARAGA
GOGEBIC
WISCONSIN
IRON
MARQUETTE
DICKINSON
ALGER
SCHOOLCRAFT
LUCE
CHIPPEWA
WHITEFISH BAY
DOMINION OF CANADA
NORTH CHANNEL
DELTA
MENOMINEE
MACKINAC
TO MACKINAC COUNTY
GREEN BAY
TO LEELANAU COUNTY
TO CHARLEVOIX COUNTY
EMMET
CHEBOYGAN
PRESQUE ISLE
LAKE HURON
CHARLEVOIX
ANTRIM
OTSEGO
MONTMORENCY
ALPENA
GRAND TRAVERSE
LEELANAU
BENZIE
GRAND TRAVERSE
KALKASKA
CRAWFORD
OSCODA
ALCONA
LAKE MICHIGAN
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
ARENAC
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
SAGINAW BAY
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
LAKE ST. CLAIR
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
CANADA
BERRIEN
CASS
ST JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
LAKE ERIE
INDIANA
OHIO

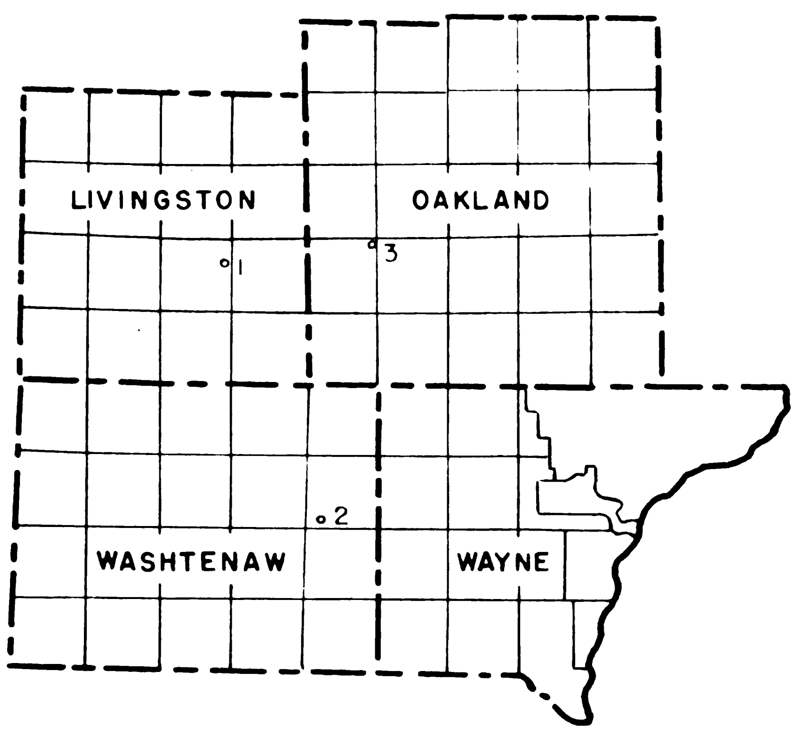
"The Traverse group in the eastern part of Michigan consists largely of argillaceous limestones and shales with some pure limestone. Westward the shales become more calcareous and the limestones purer, and in western Michigan the full thickness of the Traverse group, except the Bell shale at the base, is largely pure limestone with some dolomite and dolomitic and argillaceous limestones. Gypsum is found in the Ferron Point, Genshaw, Newton Creek and Potter Farm formations of the group in parts of northwestern and western Michigan. In southwestern Michigan lithographic limestones and some gypsum are present in the lower part of the Traverse. Chert is abundant in some of the pure limestones and occurs in argillaceous beds. It is particularly abundant in the upper part of the Traverse and also occurs in the lower part in southwestern Michigan. In the Thumb area of southeastern Michigan the Traverse is predominantly shale in the lower part with shale and some limestone in the upper part. Eastward into Ontario the Traverse consists of gray limestone and shale in the upper part with shale and a few limestone beds in the lower part. In the southern part of the Michigan basin in northern Indiana, the Traverse is light-gray, crystalline limestone. In Wisconsin the Traverse consists of gray limestones, dolomite and shale, with interbedded limestones and shales at the top.

"The Traverse group is thickest in the area of Saginaw Bay, where it has a maximum thickness of approximately 875 feet. In parts of Arenac, Ogemaw, Roscommon, Antrim and Otsego Counties the group is more than 800 feet thick. Southward from the areas of greatest thickness it thins to less than 100 feet in southwestern Berrien County and in southeastern Lenawee County. Part of this thinning is due to the absence of the Bell shale and the Squaw Bay limestone in Southwestern Michigan.

"The structure on the top of the Traverse group conforms to structure of the underlying Dundee-Rogers City sequence, and shows the dominant northwest-southeast anticlinal folds in the central basin area. The structural alinement in southwestern Michigan is likewise northwest-southeast, but some of the anticlines are alined in northeast-southwest and north-south directions."

The Traverse group has been divided into eleven formations based on material exposed in the northern part of the lower peninsula of Michigan. Although the Traverse is generally difficult to divide in its subsurface lithologic expression, Cohee does assign the pre-Antrim areal geology of Oakland and Washtenaw

SOURCES OF SAMPLES EXAMINED FOR BRYOZOA



WELL NO. 1: Pless No. 1, S.P. No. 15389
S.W. 1/4, Sec. 13, T.2N., R.5E.
Genoa Twp., Livingston County

WELL NO. 2: Voorhees No. 1, S.P. No. 3828
S.E. 1/4, Sec. 32, T.2S., R.7E.
Superior Twp., Washtenaw County

WELL NO. 3: Houghton No. 1, S.P. No. 1182
S.E. 1/4, Sec. 1, T.2N., R.7E.
Milford Twp., Oakland County

MAP 2

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

CHART I

counties to the Thunder Bay Limestone and that of Livingston County to the Squaw Bay Formation. The Squaw Bay is the highest member of the Traverse group and the Thunder Bay immediately precedes it in age.

SOURCE OF SPECIMENS

Three wells were selected at random, one from each of three counties in southeastern Michigan. The cuttings from these wells, the Voorhees #1, drilled by the Ypsilanti Development Company in Superior Township of Washtenaw County, the Houghton #1, drilled by the Milford Oil and Gas Syndicate in Milford Township of Oakland County, and the Pless #1, drilled by the Panhandle Eastern Pipe Line Company in Genoa Township of Livingston County, were examined from the base of the Antrim through the Traverse to the top of the Dundee Formation. All specimens of bryozoa found in the samples were removed for study. From the stratigraphic section of the three wells approximately 700 specimens were obtained. The exact location of the wells and their state drilling permit numbers are listed near the bottom of Map 2.

METHODS OF PREPARATION

All of the specimens collected were found free in the well cuttings. In some cases the cuttings, especially the shaly material, had to be washed with water on a small gauge screen to remove the fine powdery rock that concealed the fossils. In all cases, the specimens were subjected to the deliquescent action of potassium hydroxide tablets to loosen the material encrusting the preservations. Following the potassium hydroxide treatment the fossils were submerged in a bath of either dilute hydrochloric or dilute acetic acid to neutralize the activity of the previous process. A thorough washing in water followed the acid bath.

Considerable experimenting was done to determine the concentration and the length of time required for each treatment. If the specimens were left too long in the proximity of the potassium hydroxide tablets a white residue would accumulate and cover the specimen thus obscuring the structures of the animals. This residue is difficult to remove. If the specimens remained too long in the hydrochloric or acetic acid bath the superficial structures would be destroyed inasmuch as all fossilization was calcareous. Best results were obtained in cleaning the fossils by placing one or two or as many as could be handled without losing their stratigraphic position very close to three or four tablets of the potassium hydroxide on a watch glass. After a period of three or four minutes the fossils were removed and immersed for not more than thirty seconds in the dilute (4:1) acid and then washed with water. The acetic acid proved slightly more satisfactory than the hydrochloric acid. This method of cleaning was effective in removing the shaly material from around the specimens and thus making the detail of the external features visible.

The location and depth of each specimen was recorded on a data sheet and later transferred to Chart 3. Specimens were mounted on cardboard slides for detailed study and identification.

Those less than a millimeter in length were generally disregarded. Photographs were taken on 35 millimeter film with a camera mounted on a petrographic microscope.

CRITERIA USED IN DESCRIBING AND CLASSIFYING BRYOZOA

As previously mentioned, the Bryozoa are divided into five orders and of these only the Cryptostomata and the Trepostomata are definitely known from Michigan sediments. Both the Ctenostomata and the Cyclostomata are also Paleozoic forms but as yet have not been recognized in Michigan rocks. Although the Trepostomata were collected from the well cuttings, they were discarded as soon as their order became apparent, not being pertinent to this problem. The similarity in certain families of the orders Trepostomata and Cryptostomata presents a preliminary problem of separation that in many cases cannot be accomplished without the aid of thin sections. No difficulty is encountered in the bifoliate types, but those specimens that are cylindrical in shape show considerable external similarity. Internally the difference of structure is greater. Primary differences lie with the shortness of the primitive portion of the tube of the Cryptostomata and the abruptness of the passage to the mature region of the tube. This tube indicated by the opening on the surface of the zoaria, is the living chamber.

After the manner by which the Cryptostomata was named (Cryptos: hidden), the true apertures of the members of this order are deep-seated within the zooecial tube and ordinarily are marked by the occurrence of a hemiseptum. The hemisepta are partial plates projecting into the zooecium. If they project from the posterior wall they are termed superior; from the limited definition of the zoarium for no fragment exhibits more than a very small section of a colony.

The possibilities of erecting new species are considerable. In his work with the Cryptostomata McNair (1937) erected twenty-seven new species from the thirty-nine types that he found. Because of the limited number and size of the specimens taken from the well cuttings and the possibility that some types are only variations of the forms described by other investigators, no new species as such have been erected in this study. Instead, where a fragment or number of fragments cannot definitely be assigned to an existing species a separate and tentative classification has been used. This classification is referred to as species "A", species "B", or species "C" of a particular genera. It is not meant to be the erection of a new species although, with the initiation of further work, these classifications may be borne out and serve as a verification or foundation for new forms.

SYSTEMATIC DESCRIPTIONS OF BRYOZOA

Order Cryptostomata

"Zoaria compound, often highly complex, differing from Trepostomata in that the primitive part of the tube is usually much shorter and the passage to the mature region more abrupt, i.e., the zooecia have a short tubular primitive portion, above which the mature part is a tubular shaft or vestibule, often with hemisepta, and surrounded by vesicular or solid calcareous material; external aperture round; probably Paleozoic representatives of the Cheilostomata. Paleozoic." (Shimer and Shrock, 1943)

Bassler's (1922, pp. 363-364) informal description of the Cryptostomata is included here for further clarification of the order and for the comparisons that he makes with the other orders of the phylum.

"In this order the zooecia are usually short and have their orifice concealed (cryptos, hidden) at the bottom of a tubular shaft or vestibule which is surrounded by a solid or vesicular calcareous deposit. The primitive zooecium is short and quite regular in its outline, being pyriform to oblong, quadrate or hexagonal with the aperture anterior. This same characteristic is shared by the Cheilostomata also and it is probable that the Cryptostomata are nothing more than Paleozoic Cheilostomata. The Cryptostomata differ, however, from the typical members of the Cheilostomata, first in having neither ovicells nor avicularia, second in the much greater deposit of calcareous material upon the front of the zooecia, third in the frequent development of successive layers of polypides, one directly over the other, thus forming a continuous tube, and fourth, in that whenever a zoarium attains an uninterrupted width of more than 8millimeters it exhibits clusters of cells, differing more or less either in size or elevation from the average zooecia. The last two distinctions are suggestive of the Trepostomata, but the Cryptostomata differ chiefly in that the immature region (primitive cell) is usually much shorter and the passage to the mature region more abrupt, and that hemisepta occur at the bottom of the vestibule.

"Some of the Cryptostomata are ramose and have long thin-walled prisimatic tubes in the axial region, with or without diaphragms, precisely as in the ramose Trepostomata and Cyclostomata. They are distinguished from both these orders, however, by the presence of the hemiseptum, the incomplete plate which extends downward and forward from the posterior side of the base of the vestibule into the primitive cell. Sometimes a second hemiseptum is found springing from the bottom of the cell, in which case the latter is known as the inferior hemiseptum and the former as the superior one. The purpose of the hemisepta is unknown, although it is possible that they served as supports for a movable operculum.

"The relationship of the Cryptostomata to the Cheilostomata is further suggested in the zoarial forms they assume and in the beauty of the surface of the zooecia. In the typical Cryptostomata the zoarium consists of two thin layers of zooecia growing back to back into erect sword-shaped, ramose, ribbonlike or fan-shaped expansion. In other Cryptostomata the zoaria form lacelike expansions consisting of only a single layer of cells with the reverse side covered by a dense layer of striated or minutely granulose tissue. In the remaining sections of the order the zoaria are ramose with the zooecia arising from a real or imaginary axis and opening on all sides of the cylindrical stems. Usually the zoaria are continuous, but in some of the bifoliate and ramose forms they are divided into segments, articulating with each other.

"Most of the Cryptostomata can be identified from the zooecial surface characters, but in some of them, particularly the bifoliate and solid ramose species, thin sections of them are as necessary as in the Trepostomata. On account of their geometrical regularity of zooecial form, thin sections of the Cryptostomata are often most beautiful objects under the microscope.

"The order commences in Early Ordovician times, reaches its greatest development in the Devonian and Mississippian, and becomes extinct at the close of the Permian."

Genus EUSPILOPORA

Ulrich 1890

"Zoaria consisting of small, flattened, irregularly divided branches. Zooecial apertures subcircular or elliptical, arranged in four or more rows over the central portion of the branches between slightly elevated longitudinal ridges, bearing numerous, small nodes. At brief intervals, occurring alternately on each side of the branch, there are several short rows of apertures directed obliquely upward and outward from the central rows,

> extending nearly to the sharp margins. Between these lateral rows the margin of the frond is more or less indented, but a wide depressed non-poriferous space remains. This is covered with exceedingly fine granulose striae. Thin sections show that between the ends of the zooecia there is a vertical series of shallow lenticular vesicles, separated from each other by a thick layer of tissue. All the remaining interspaces are traversed vertically by exceedingly numerous minute tubuli." (Ulrich, 1890, page 389)

Euspilopora species "A" (plate 2 figure 7)

Zoarium ramose. Branches straight and flat. Edges serrate or smooth. Margin nonporiferous and narrow. Apertures elliptical or subcircular in outline; separated longitudinally by distances less than length of the apertures and separated transversely by distances approximately equal to the width of the apertures; arranged in regular longitudinal series. Zooecial tubes flattened for a short distance, then abruptly bent outward. Ridges are low and straight.

Specimens approximate the characters designated to *Euspilopora serrata* Ulrich but differ in the longitudinal spacing of the apertures.

Occurrence: Upper zone - Oakland County.

Genus ACANTHOCLEMA

Hall 1886

> "Zoarium ramose, solid. Cells arising from a filiform axis; apertures arranged in longitudinal rows separated by ridges. Usually with one or two nodes longitudinally between the cells, which are represented in the interior by short tubuli." (Hall, 1887, p. xv)

Acanthoclema species "A"

Zoarium composed of cylindrical branches. Apertures opening directly outward, elliptical in outline; separated longitudinally and transversely by a distance less than the length of the aperture; situated in longitudinal ranges, with apertures in adjacent ranges altenating.

Ridges between ranges sinuous and bear a single row of minute rounded nodes. No hemiseptum observed.

This variant is strikingly similiar to Trematopora (Orthopora) tortalinea, Hall, externally but has the filiform axis that characterizes the genus Acanthoclema. It differs from A. ohioense, McNair, in its distinctly sinuous ridges.

Occurrence: Upper and lower zone - Washtenaw County; upper zone - Oakland County.

Acanthoclema species "B" (plate 2, figure 3)

Zoarium composed of cylindrical branches. Apertures opening directly outward, elliptical outline; longitudinal separation less than the length of the apertures; transverse separation less than the width of the apertures. Peristomes low and inconspicuous.

Ridges are simuous and prominent. Two conspicuous nodes and sometimes a third inconspicuous node occur in the interapertural space in a linear series. Nodes connected to short tubules.

Species "B" is similiar to Trematopora bispinulata, Hall, but has the filiform axis characteristic of the genus Acanthopora.

Occurrence; Lower zone - Livingston County.

Acanthoclema species "C" (plate 2, figure 1)

Zoarium composed of cylindrical branches. Apertures opening directly outward, elliptical in outline; separated longitudinally by distances less than the length of the aperture; separated transversely by distances less than the width of the apertures. Apertures in adjacent ranges alternate in position.

Sinuous ridges between ranges. Peristomes are inconspicuous.

Apertural interspace is distinctive as one large pit. No nodes observed.

Occurrence: Lower zone - Livingston and Washtenaw counties.

<u>Acanthoclema</u> <u>hamiltonense</u> Hall (plate 2, figures 4 & 5)

Zoarium solid cylindrical branches. Apertures oblique to surface and slightly curved; arranged in longitudinal series; longitudinal separation less than the length of the apertures; transverse separation less than the width of the apertures. Apertures in adjacent ranges alternate in position.

Ridges between ranges are sinuous and prominent. Peristomes are inconspicuous.

Apertural interspace marked by two elliptical to quadrangular pits, one above the other. These pits are somewhat more elliptical than those diagrammed by Hall of his specimens. Occasionally a small node connected to a short tubule between the apertures.

Occurrence: Lower zone - Livingston and Washtenaw counties.

Genus STREBLOTRYPA

Ulrich 1890

"Zoaria ramose, solid. Zooecia radiating from an imaginary axis, their primitive portion long, tubular; or from a linear axis when they are somewhat shorter. Inferior hemisepta best developed, situated rather far down. Apertures regularly elliptical, or somewhat truncated at the posterior margin, surrounded by a slight peristome and, within this, sometimes a narrow sloping area; arranged usually in rather regular longitudinal series. Just back of the aperture, occupying the depressed front of the cell, there are from one to twelve or more small pits which, when numerous, are arranged in two or three rows. Very small acanthopores occasionally present." (Ulrich, 1890, page 403)

Streblotrypa anomala McNair

Zoarium cylindrical branches. Apertures open directly outward and are elliptical in outline; separated longitudinally by distance from one half to approximately entire length of aperture and transversely by distance less than width of aperture. Apertures are situated in a linear series and are separated by low sinuous or straight ridges. The apertures in the adjacent ranges alternate in position. Peristomes low, some of which cannot be distinguished from the ridges.

Small acanthopores present on most peristomes at ends of the apertures. One of five mesopores exist between most apertures.

Zooecial walls thin in axial region but thickened at periphery.

Occurrence: Upper and lower zones - Washtenaw County; lower zone - Livingston County.

Streblotrypa species "A" (plate 2, figure 6)

Zoarium composed of cylindrical branches. Apertures open directly outward; elliptical in outline; longitudinal separation variable, usually less than the length of the apertures; transverse separation less than the width of the apertures. Apertures in a linear series separated by sgraight or sinuous ridges. Adjacent series of apertures alternate in position. Peristomes low, difficult to distinguish from the ridges.

One or two acanthopores present. One to four mesopores in longitudinal series at the ends of the apertures.

Zooecial walls thin at the axial region thickening at the periphery. Hemisepta rarely observed.

Streblotrypa species "A" does not have as strong ridges as does S. anomala but are much more pronounced than those of Streblotrypa species "B".

Occurrence: Lower zone - Washtenaw County.

Streblotrypa species "B" (plate 1, figure 8)

Zoarium composed of cylindrical branches. Apertures are elliptical in outline; separated longitudinally by a distance from one half to approximately the entire length of the aperture and transversely by distance less than the width of the apertures; situated in linear series both longitudinally and obliquely; separated by faint sinuous ridges. Peristomes inconspicuous.

Single pit at the base of each aperture. Hemisepta not observed.

Ridges are not as pronounced as those of Streblotrypa species "A".

Occurrence: Upper and lower zones - Washtenaw, Livingston, and Oakland counties.

Genus INTRAPORA

Hall 1883

"Bryozoum growing as in Stictopora; stipe and branches broad, bifurcating at somewhat regular intervals. Both sides celluliferous, the intercellular spaces regularly punctured or pitted as if by numerous minute cell-apertures, entire intercellular space vesiculose." (Hall, 1883, p. 157)

Intrapora irregularis Stewart (plate 1, figure 7)

Zoarium consists of an irregular expanion. Apertures circular to subcircular in outline; arranged in an irregular linear series; ordinarily separated by one or more sub-angular mesopores. Peristomes low and sharp.

Mesopores of variable size abundant, sub-angular or polygonal in outline, small, in some places grouped in clusters; commonly appear to ring the apertures, common in space between four zooecia. No acanthopores observed.

Occurrence: Upper and lower zones - Washtenaw, Livingston, and Oakland counties.

Genus ACROGENIA

"Segmented, arising from cylindrical rootlets, two segments from truncated ends of preceding one, each obconical and striated 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)

Genus SULCORETEPORA

(D'Orbigny 1849)

Definition from Ulrich, 1890. - "Zoaria ramose, bifoliate, the branches acutely elliptical in cross section, with sub-parallel, sharp, non-poriferous, striated, granulose, or smooth margins. Zooecia apertures generally arranged in longitudinal series between ridges, sometimes in more pronounced oblique rows. Apertures sub-elliptical, partially closed in the fully matured condition with a more or less developed lunarium, that is always situated upon the side nearest to the margin of a branch. Interspaces finely striated, granulose, or smooth, and never with pits or cells, excepting when worn." (Ulrich, 1890, p. 385)

Sulcoretepora altenata McNair

Zoarium flat with alternately arranged branches. Margin nonporiferous. Edges round. Subcircular to elliptical apertures that open directly outward; those closest to the margin more rounded than those in the central portion. Apertures separated longitudinally by a distance less than the length of the openings and separated transversely by a distance less than the width of the apertures. Lunaria strong. Ridges are straight, prominent, and rounded.

This species has narrower and more prominent ridges, sharper peristomes, and more closely spaced and smaller branches than Sulcoretepora deissi. The latter qualification is undeterminable in fragmental specimens.

Occurrence: Lower zone - Washtenaw County.

Sulcoretepora deissi McNair (plate 1, figure 2)

Zoarium thick with alternately arranged branches. Margin nonporiferous with moderate width. Edges round. Apertures open directly outward; subcircular to elliptical with those closest to the margin more circular than those in the central portion. Apertures separated longitudinally by distances less than the length of the apertures and separated transversely by distances less than the widths of the openings. Peristomes are sharp and thin. Lunaria strong and thin. Ridges straight and not conspicuous on older portions of the colony.

This species is readily distinguished from the other species of Sulcoretepora by its greater relative thickness, weak ridges, and abrupt rounded edges.

Occurrence: Upper zones - Washtenaw and Oakland counties; lower zone - Livingston County.

Sulcoretepora incisurata (Hall) (plate 1, figure 4)

Zoarium consists of flat, dichotomizing branches. Margin nonporiferous and narrow. Edges are sharply angular. Apertures vary from nearly circular to elliptical in outline; those in the marginal rows larger than the others. Longitudinal and transverse separation of the apertures is variable. Peristomes are strong, equally or unequally elevated. Lunaria conspicuous. Ridges are prominent and broad.

Occurrence: Upper and lower zones - Washtenaw and Oakland counties; lower zone only - Livingston County.

Sulcoretepora lyrifica McNair (plate 1, figure 5)

Zoarium flat with dichotomizing branches. Margin nonporiferous, rounded and narrow. Apertures open directly outward; circular to elliptical in outline; those near the margin larger and more circular than those in the central portion. Apertures separated transversely by distances less than the widths of the openings and longitudinally by distances greater than the length of the apertures. Peristomes narrow and prominent. The lunaria project upward from the peristomes conspicuously. Ridges prominent and rounded.

Occurrence: Upper zone - Washtenaw County; lower zone only - Livingston and Oakland Counties.

Sulcoretepora lyrifica McNair variant "A" (plate 1, figure 1)

Zoarium flat with dichotomizing branches. Margin nonporiferous, rounded and narrow. Apertures open directly outward; circular to elliptical in outline; those near the margin larger and more circular than those in the central portion. Apertures separated longitudinally by distances less than the length of the apertures; separated transversely by distances less than the widths of the openings. Peristomes narrow and prominent. The lunaria project upward from the peristomes very conspicuously. Ridges prominent and rounded.

This variant differs from Sulcoretepora lyrifica only in the spacing of the apertures. All other characters are identical.

Occurrence: Lower zone - Washtenaw County.

Sulcoretepora obliqua McNair

Zoarium flat with bifurcating branches. Margin nonporiferous; width moderate; outer edge straight. Elliptical apertures open directly outward; those closest to the margin more rounded than those in the central portion. Apertures separated longitudinally by a distance greater than the length of the apertures; transverse separation less than the width of the apertures. Peristomes are broad and prominent. Lunaria absent. Ridges straight and prominent.

Occurrence: Upper and lower zones - Washtenaw County; lower zone only - Oakland County.

Sulcoretepora species "A" (plate 1, figure 3)

Zoarium flat and of slightly greater than average thickness. Margin nonporiferous. Edges round. Apertures elliptical; those closest to margin more circular than those in the central portion. Apertures separated longitudinally by a distance greater than the length of the openings; separated transversely by distances equal to the width of the openings. Lunaria rare, indicated by a weak fold when present. Peristomes are not present. Ridges absent.

Lack of peristomes and the spacing of the apertures differentiates this species from Sulcoretepora species "B"

Occurrence: Upper zone - Washtenaw County; lower zone - Livingston and Washtenaw counties.

Sulcoretepora species "B" (plate 1, figure 6)

Zoarium flat and of average thickness. Edges blunt and keeled. Apertures very close to edge leaving a very narrow margin. Apertures elliptical; those nearest the margin more rounded than those in the central portion. Apertures separated longitudinally by irregular distances; separated transversely by distances less than the width of the opening. Lunaria are common and prominent. Peristomes conspicuous. Ridges are broad and rounded; straight or sinuous.

This species is easily distinguished from Sulcoretepora species "A" by the conspicuous peristomes and spacing of apertures.

Occurrence: Upper zone - Oakland County.

Sulcoretepora sulcata (Winchell)

Zoarium consists of narrow, dichotomizing branches. Apertures open directly outward; elliptical in outline; those nearest the margin more circular than those in the central part of the branch. Apertures separated longitudinally by distances greater than the length of the openings and transversely by distances less than the width of the apertures. Peristomes sharp and elevated on the side closest to the margin. Lunaria numerous. Ridges between ranges of apertures low, narrow, and inconspicuous. Margin non-poriferous, narrow, and with sharply angular edges. Some of the apertures very close to the edge of the branch.

Occurrence: Upper and lower zones - Washtenaw and Livingston counties; upper zone only - Oakland County.

Chart 2

DISTRIBUTION OF BRYOZOA

Key
r - rare
c - common
a - abundant

	Livingston Co. Upper Zone	Washtenaw Co. Upper Zone	Oakland Co. Upper Zone	Livingston Co. Lower Zone	Washtenaw Co. Lower Zone	Oakland Co. Lower Zone
Acanthoclema hamiltonense				a	c	
Acanthoclema species "A"		r	r			
Acanthoclema species "B"				r		
Acanthoclema species "C"				c	c	
Acrogenia		r	r			
Euspilopora species "A"			r			
Fenestrate types	r	a	c	a		r
Intrapora irregularis	r	r	r	r	r	r
Streblotrypa anomala		r		c	r	
Streblotrypa species "A"					r	
Streblotrypa species "B"	a	a	a	a	a	a
Sulcoretepora alternata		r				
Sulcoretepora deissi		a	a	a		
Sulcoretepora incisurata		c	c	a	c	r
Sulcoretepora lyrifica		r		r		r
Sulcoretepora lyrifica var. "A"					r	
Sulcoretepora obliqua		r			r	r
Sulcoretepora species "A"		r		r	r	
Sulcoretepora species "B"			r			
Sulcoretepora sulcata	c	a	a	c	c	

DISCUSSION

Although no effort has been made for a precise tabulation, it is believed that as many as 40 percent of the specimens collected were unsuitable for use. Size, concealment by host rock, and poor preservation of the features were the prohibiting factors. Of the remaining specimens, approximately 40 percent were of the order Trepostomata, not pertinent to this thesis. Whenever possible, the remaining 300 odd specimens were identified to species. If not identified to species then the generic name was indicated; the fenestrate types excepted. Each cryptostomatous bryozoan identified is recorded on Chart 3 which appears at the end of the paper. On Chart 3 the fossil specimens are keyed by number and logged according to the depth from the top or height above the bottom of the Traverse Formation at which it was found. In addition the host rock type also is recorded.

The chart clearly pictures the occurrence of two separate zones in which the bryozoa are found. These zones have in each case a stratigraphic separation approximating 50 feet. The lower zone occurs in the bottom 40 to 60 feet of the formation and the higher zone is also upward of 60 feet in thickness.

Chart 2 is a composite record of the occurrence of the various types of fossils. This chart indicates only one significant difference apparent between the two faunal zones. The occurrence of Acanthoclema hamiltonense and Acanthoclema species "C" in the lower group distinguishes that zone from the higher zone. This observation, however, may not have significance after further investigations of the formation are made. Additional collection of specimens may show the occurrence of these two types in the higher, younger faunal group. Chart 2 shows a frequency rating of the individual types although the validity of such frequency is significant only to the extent of this particular study. Future work using more specimens may or may not verify the rating.

As can be observed in Chart 3 the bulk of the specimens were taken from the shaly limestones. A large portion of the stratigraphic section from Oakland County is shale and few fossils were found in it. The specimens collected from this shale are friable and easily destroyed in washing and cleaning processes. In some places the hard limestones seemed to yield the best specimens in that they were broken out of the host rock cleanly by the drilling process. None were found in the cherty or dolomitic zones.

Drilling methods made a noticeable difference in the size of the specimens available for collection. Cuttings from the wells drilled by the churn type method produced specimens that are larger and thus easier to work with than the cuttings from rotary type drilling operation. Size of the specimens recovered are an important consideration in the identification process. Zoarial fragments a millimeter or less in length do not exhibit enough of the structures of the colony or sufficient zooecia for purposes of satisfactory identification.

The unilaminate zoarial forms of the Cryptostomata such as

Fenestrellina and Polypora generally exhibit a fenestral structure. The lace-like construction of these types is very fragile. Though they may occur in abundance in southeastern Michigan the difficulty of recovery may prohibit their use to any significant degree. Because of their delicate construction they are easily ground up by the action of the drillers' bit. So few of this type of fossil were found and so poor was the preservation in the three wells investigated that no effort was made to establish their identity. Their occurrence has been listed in Chart 3 only as fenestrate types.

Problems encountered in the identification process were many and varied. Some of these are mentioned in the following six paragraphs for they bear directly on the evaluation of the usefulness of the fossils that could be taken from well cuttings and used in stratigraphic correlation.

Because of the pronounced morphological changes that have been observed in some types, for example, Sulcoretepora deissi, McNair, in the transition from younger branches to more mature regions of the colony, it is possible to mistake the identity of the fragments taken from the well cuttings. McNair (1937, p. 158) is quoted as follows:

> "Young branches of Sulcoretepora deissi are relatively narrow, with definite longitudinal ridges and prominent peristomes, usually without lunaria; the margins of the branches are angular in cross section. Older branches are wider; the margins are more rounded than those of young ones, the ridges lower and broader, and the peristomes less sharp, lunaria being strongly developed on the marginal ranges of the zooecia. Very old branches are wide and are two to three times as thick as the young branches. Most

> of the very old branches have lost the longitudinal ridges which are replaced by irregular striae. Many peristomes are much inflated and project above the surfaces of the branches. Lunaria are strongly developed. Many of the normal peristomes and some of the enlarged ones are covered by secondary sclerenchyma."

In the well cuttings the fragments of the colonies obtained are very small and contain but few zooecia. With such variation in the structure from the mature to younger portions of the zoarium as McNair has stated the true relationship may not be established.

Hall (1887, p. 242) made mention of this problem and regarding Sulcoretepora incisurata states:

> "The variations of this species are so great that where only the extremes are observed, they would naturally be regarded as belonging to different species."

Such mistaken identity may lead to the erection of either relatively few or many new species. The zoarial fragments are particularly adaptable to this and, as pointed out below, such establishment of new species would not be detrimental to stratigraphic correlation work if confined to the use of well cuttings.

Another difficulty involved in working with the well cuttings is the limited number of specimens that are available. If but one specimen of a particular type, especially the cylindrically shaped ones, is found, then the process of identification is limited to one of two procedures. Either the specimen must be defined from the superficial structure alone or from the internal construction by means of a thin section. If the thin section is made then the external features are destroyed and no further recourse may be made to them. Furthermore, unless the thin section is ground to a precise position, a meticulous and delicate process that often fails, it is valueless. The possibility of making a mold and cast of a fragment to preserve the external structures is remote because of the extremely small size of the fragments and of the minute detail of the individual zooecia. It is rare to find a specimen that is more than tree or four millimeters in length and in order to split satisfactorily a specimen into two parts saving one half and making a thin section of the other, a minimum length of five millimeters is necessary.

Some of the distinguishing characteristices of certain species are based on the angle at which the branches diverge from the main stems or by the presence of large primary and small secondary branches. Neither of these features can be determined from the small fragments.

The above mentioned classification problems are discouraging and all serve to lessen the value of the fossil fragments for stratigraphic purposes. However, if a number of new species whether artificial or not, are established as result of the peculiarities of portions of the zoaria, they may be used in correlation work. The stratigraphic range of these new species will vary no more than the range of true species. Contrarily, consideration should be made of the possibility of the fragments of two or more distinct species resembling each other and yet not having the same stratigraphic range.

No attempt has been made at this time to correlate the fauna described here with any definite stage or stages of the Traverse. However, it is noteworthy that the fossils identified compare favorably with the fauna described by McNair collected from the lower half of the Traverse, that is, below the Thunder Bay Stage and excluding the Bell Shale, in the northern part of the lower Peninsula and with those of the Silica Shale in Lucas County, Ohio.

The presence of Acanthoclema hamiltonense and Sulcoretepora incisurata, both described by Hall from the Hamilton of New York, bears out the Traverse correlation with subdivisions of that eastern formation.

CONCLUSIONS

It can be shown as result of this study that the Traverse of southeastern Michigan may be divided into four distinct parts. Chart 3 reveals an upper unfossiliferous zone, an upper fossiliferous zone, an intermediate barren zone, and a lower fossiliferous zone. These divisions can be shown without making any specific identification of the fossils found. Such zonal relationships may be as valuable in subsurface stratigraphic correlation as the listing of the particular faunal types. It should be noted that the lower fossiliferous zone closely parallels the Ostracoda zone in the Traverse found by Campau, (1950, p. 42).

There are shown here two species only that distinguish one fossiliferous zone from the other. It is possible that additional collecting will show more forms that are not common to both zones. Additional collection, however, also may reveal that all forms are common to both zones.

Certain limitations in the recovery of specimens of suitable size and number must be considered. Similiarly, problems in the identification procedures serve to lessen the reliability of some types of the bryozoa. There are, however, some individuals on which unqualified identification may be made. From these distinguishable forms stratigraphic relationships can be determined. It is the opinion of the writer that although there are readily distinguishable forms available for identification from the fragments that the difficulty and labor involved in making these identifications is not worthy of the effort. It is probable that the knowledge of the zonal occurrence of this fauna will be as valuable as knowledge of any specific types.

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EXPLANATION OF PLATE 1

Figure 1

Figure 2

Figure 3

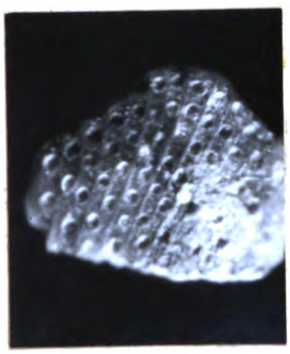

Figure 4

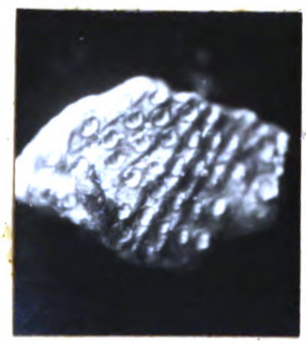

Figure 5

Figure 6

Figure 7

Figure 8

PLATE I

EXPLANATION OF PLATE 2

Figure 1

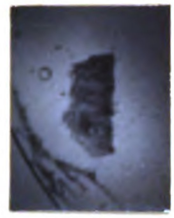

Figure 2

Figure 3

Figure 4

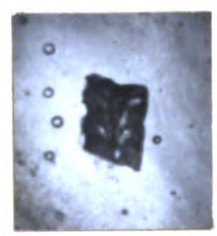

Figure 5

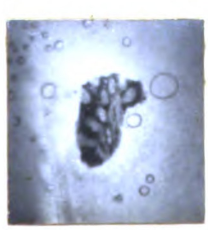

Figure 6

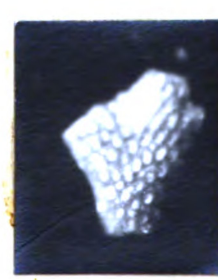

Figure 7

PLATE 2

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