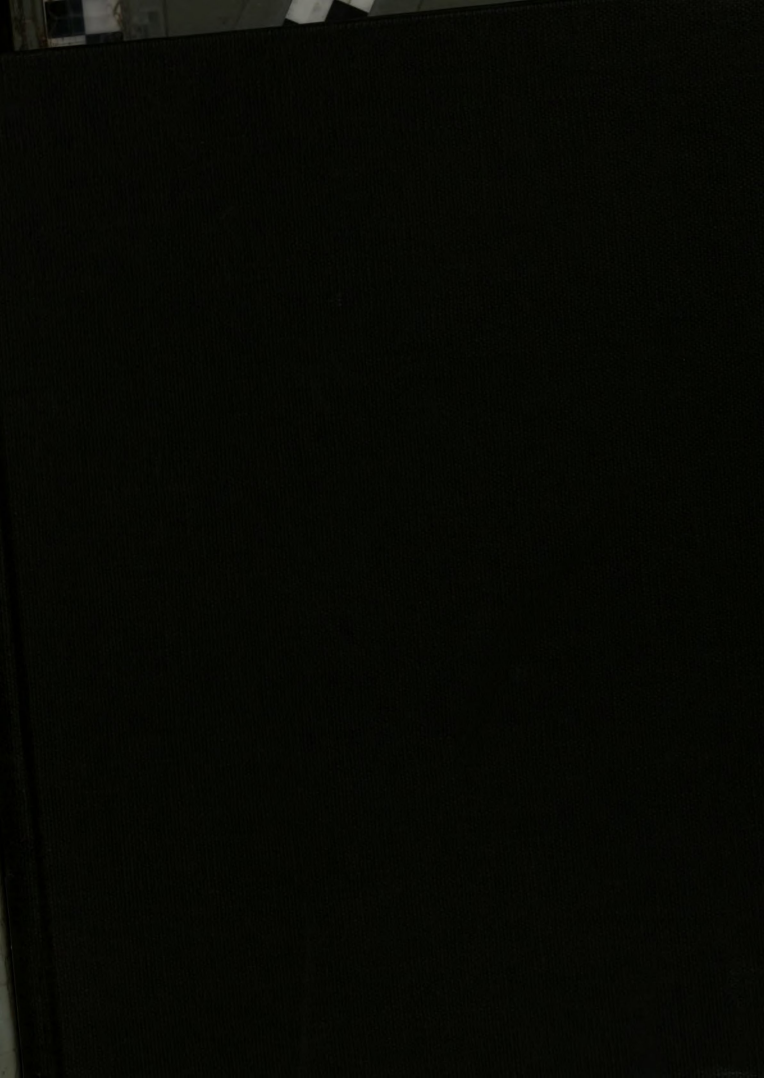
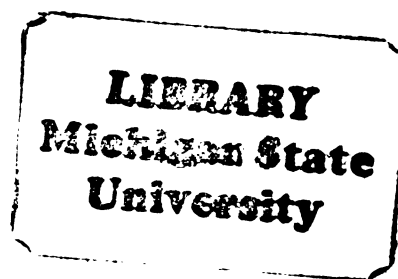






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F-SALTS OF THE SALINA GROUP  
OF THE MICHIGAN BASIN

presented by

Burrell Peter Shirey

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Masters degree in Geological Sciences

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**F-SALTS OF THE SALINA GROUP  
OF THE MICHIGAN BASIN**

**By**

**Burrell Peter Shirey**

**A THESIS**

**Submitted to  
Michigan State University  
in partial fulfillment of the requirements  
for the degree of**

**MASTER OF SCIENCE**

**Department of Geological Sciences**

**1983**

**ABSTRACT**  
**F-SALTS OF THE SALINA GROUP**  
**OF THE MICHIGAN BASIN**

**By**

**Burrell Peter Shirey**

Previous studies on the Salina have been on a Group basis, resulting in lack of data on the F-salts. Therefore, the F-salts were studied on a basin-wide scale to determine lithology and depositional history.

Results indicate the F-salts are a typical basin marine evaporite sequence. Units F-1 through F-3 were deposited in a stable basin, connected to exterior marine environments by channels across the shelf zone. At the midpoint of F-salt deposition, the Basin experienced tectonic movement, reflected in changes in lithology and deposition. For units F-4 and F-5, depocenter and hinge lines moved northeast; clastic shales dominated the shelf; channels across the shelf ceased to exist, isolating the Basin; units became progressively thicker. Possible causes are: external stress acting on the Basin basement and frame complex, resulting in tectonic activity; basin subsidence; uplift of exterior features and/or sea level changes, before returning to a more normal marine basin environment of unit F-6.

**DEDICATION**

**IN MEMORY**

**to my Uncle Fred and his two Bachelors degrees.**

## ACKNOWLEDGEMENTS

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A very special and loving thanks is given to my parents for all their love and support and for putting up with my procrastinating these past years. This is for you, Mom and Dad, you worked for this as much as I did, and you certainly earned it.

## TABLE OF CONTENTS

|                                                                  |     |
|------------------------------------------------------------------|-----|
| ACKNOWLEDGEMENTS . . . . .                                       | iii |
| LIST OF FIGURES . . . . .                                        | vi  |
| LIST OF MAPS . . . . .                                           | vii |
| INTRODUCTION . . . . .                                           | 1   |
| STRUCTURAL SETTING OF THE MICHIGAN BASIN. . . . .                | 2   |
| PREVIOUS WORK. . . . .                                           | 5   |
| Regional Geology . . . . .                                       | 5   |
| Geology of the Basin . . . . .                                   | 6   |
| Origin, Occurrence and Deposition of Evaporites . . . . .        | 8   |
| SILURIAN HISTORY OF THE MICHIGAN BASIN . . . . .                 | 15  |
| MATERIALS AND METHODS OF INVESTIGATION . . . . .                 | 17  |
| Formation Tops and Elevations. . . . .                           | 17  |
| Determination of Lithology . . . . .                             | 18  |
| Comparison of Geophysical Curve Responses to Lithology . . . . . | 27  |
| RESULTS AND DISCUSSION . . . . .                                 | 31  |
| F-1 Unit . . . . .                                               | 31  |
| F-2 Unit . . . . .                                               | 34  |
| F-3 Unit . . . . .                                               | 37  |
| F-4 Unit . . . . .                                               | 40  |
| F-5 Unit . . . . .                                               | 43  |
| F-6 Unit . . . . .                                               | 43  |
| Observations on F-Salt Unit Maps . . . . .                       | 49  |
| Possible Explanations of Observations. . . . .                   | 50  |
| Isopach Map - Total F-salt . . . . .                             | 52  |
| Structure Contour on Top of the F-Salts Unit . . . . .           | 55  |
| Chart of Depocenter Thickness . . . . .                          | 55  |
| Lithologic Cross-Section Through Time . . . . .                  | 58  |
| Depocenter and Hinge Line Map . . . . .                          | 60  |
| Depocenters . . . . .                                            | 60  |
| Hinge Line . . . . .                                             | 62  |
| CONCLUSIONS. . . . .                                             | 63  |

**TABLE OF CONTENTS (continued)**

|                                                      |           |
|------------------------------------------------------|-----------|
| <b>RECOMMENDED AREAS FOR FURTHER STUDY . . . . .</b> | <b>66</b> |
| <b>REFERENCES . . . . .</b>                          | <b>67</b> |
| <b>APPENDIX . . . . .</b>                            | <b>70</b> |

## LIST OF FIGURES

|            |                                                                                                                            |    |
|------------|----------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1.  | General tectonic map of the Michigan Basin . . . . .                                                                       | 3  |
| Figure 2.  | Idealized evaporite cycle. . . . .                                                                                         | 12 |
| Figure 3.  | Comparison of gamma-ray log, descriptive log and sample analysis - Well 2 - Emery-1 PN23849. . . . .                       | 19 |
| Figure 4.  | Comparison of lithologies of the F-salt section from Ells, and descriptive log - well 4 - State-Foster-1 PN25099. . . . .  | 20 |
| Figure 5.  | Stratigraphic succession in Michigan . . . . .                                                                             | 22 |
| Figure 6.  | Shale reference - Bell Shale - Well 147 - Brandt 1-34 PN34790 . . . . .                                                    | 24 |
| Figure 7.  | Evaporite and carbonate reference: A-2 evaporite - A-2 carbonate - B evaporite - Well 147 - Brandt 1-34 PN34790. . . . .   | 25 |
| Figure 8.  | Comparison of sample log and interpretation based on geophysical curve analysis - Well 147 - Brandt 1-34 PN34790 . . . . . | 26 |
| Figure 9.  | General ranges of data for evaporites, carbonates and shales - Well 147 - Brandt 1-34 PN34790 . . . . .                    | 28 |
| Figure 10. | Arch-shelf channels . . . . .                                                                                              | 51 |
| Figure 11. | Depocenter thickness of F-salts . . . . .                                                                                  | 57 |
| Figure 12. | Lithologic cross-section through time . . . . .                                                                            | 59 |

## LIST OF MAPS

|          |                                                                  |      |
|----------|------------------------------------------------------------------|------|
| Map A.   | Index map with well locations and data<br>index number . . . . . | 29   |
| Map B.   | County map of Michigan . . . . .                                 | 30   |
| Map 1-1. | Isopach Unit F-1 . . . . .                                       | 32   |
| Map 1-2. | Clastic ratio Unit F-1 . . . . .                                 | 33   |
| Map 2-1. | Isopach Unit F-2 . . . . .                                       | 35   |
| Map 2-2. | Clastic ratio Unit F-2 . . . . .                                 | 36   |
| Map 3-1. | Isopach Unit F-3 . . . . .                                       | 38   |
| Map 3-2. | Clastic ratio Unit F-3 . . . . .                                 | 39   |
| Map 4-1. | Isopach Unit F-4 . . . . .                                       | 41   |
| Map 4-2. | Clastic ratio Unit F-4 . . . . .                                 | 42   |
| Map 5-1. | Isopach Unit F-5 . . . . .                                       | 44   |
| Map 5-2. | Clastic ratio Unit F-5. . . . .                                  | 45   |
| Map 6-1. | Isopach Unit F-6 . . . . .                                       | 46   |
| Map 6-2. | Clastic ratio Unit F-6. . . . .                                  | 47   |
| Map 7.   | Isopach total F-salt . . . . .                                   | 53   |
| Map 8.   | Structure-contour top of E unit . . . . .                        | 54   |
| Map 9.   | Structure-contour top of F-salt section . . . . .                | 56   |
| Map 10.  | Depocenter and hinge line of F-salt section. . . . .             | 61   |
| Map 11.  | Geophysical cross-section . . . . .                              | back |

## INTRODUCTION

The F-salts of the Late Silurian Salina Group in Southern Michigan are the last of several evaporite formations that were deposited in the Silurian of the Michigan Basin. While many authors have studied the Salina Group, their studies have been for the most part on a group-wide basis, overshadowing the F-salts in favor of the older and more extensive A-Evaporites. This has resulted in a relative scarcity of information on the F-salts alone. Therefore, the purpose of this study is a regional study of the F-salts, to determine the varying lithology of the formation from the Basin interior to the rim with an eye toward any changes in the normally accepted sequence of evaporite interior to a shale and carbonate rim. Additional goals are to develop any data that may show possible effects of basin subsidence; transgressive-regressive sea level effects; and extrabasinal influences during the relatively brief period of the F-salt deposition.

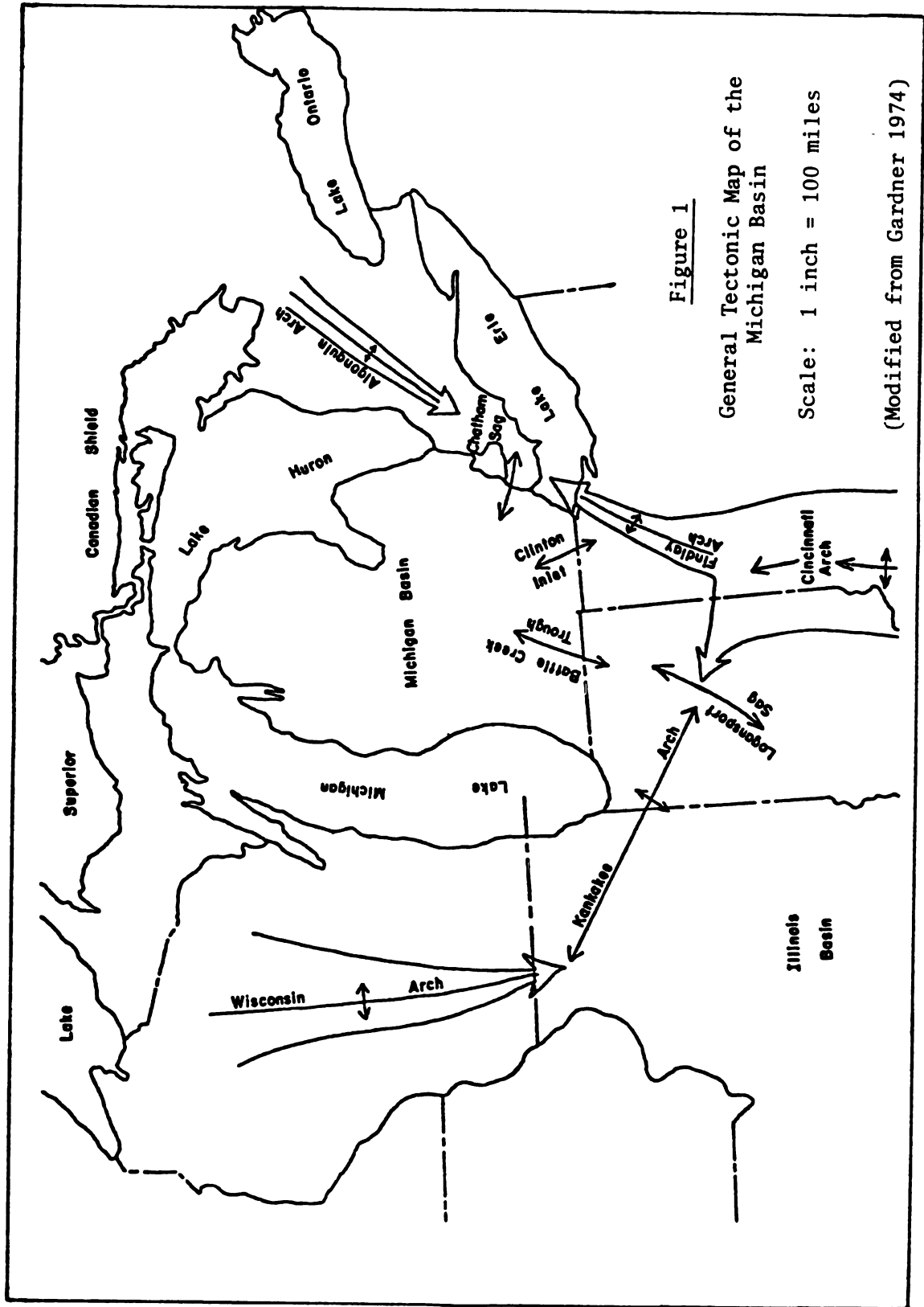
The F-salts are divisible into six units throughout most of the Michigan Basin (Ells, 1967; Lilianthal, 1978). The ability to subdivide and study zones of geologically brief episodes makes it possible to restore the developmental history of the F-salts.

## STRUCTURAL SETTING OF THE MICHIGAN BASIN

Tectonic features surrounding the Michigan Basin during the Late Silurian time consisted of the Canadian Shield to the north; the Algonquin Arch to the east; the Findlay Arch to the southeast; the Cincinnati Arch to the south; the Kankakee Arch to the southwest; and the Wisconsin Arch to the west. Other features present at various times include the Battle Creek Trough in the south-southwest connecting the Michigan Basin with the Illinois Basin; and the Clinton Inlet and the Chatham Sag in the southeast connecting the Michigan Basin with marine environments to the east (Figure 1).

Fettke (1948) showed the Chatham Sag to have been present in Ordovician time. Melhorn (1958) thought the Kankakee and Findlay Arches became important in their influence on the Michigan Basin during the Ordovician. One of the major inlets for marine waters into the Michigan Basin was through the Chatham Sag (Burns, 1962). Burns indicated this by his Salina isopach map showing extensive thickening of sediments in the Chatham Sag area. Dellwig (1954) considered ripple marks, poor bedding development and fragmentation of halite crystals as being due to turbulent seawaters from currents flowing through the Chatham Sag area.

Melhorn (1958) believed a link between the Michigan and Illinois basins existed from Early to Middle Silurian and became inoperative by the start of Salina time because of the growth of reefs or arch uplift to the south. He called this link the Battle Creek Trough. He based his idea on the sand-shale and clastic ratio maps he constructed in which the latter showed carbonates dominant along a narrow belt extending south from Eaton and Hillsdale counties into northern Indiana, connecting with the Logansport Sag.



Briggs, Gill, Briggs and Elmore (1980) in mapping the thickness of the Lockport-Guelph rocks in southeast Michigan and northern Ohio, detected the presence of a deep inlet between Ohio and Michigan they called the Clinton Inlet. They believed the Clinton Inlet was present during the Late Silurian and was a major inlet for marine waters into the Michigan Basin. Alling and Briggs (1961) earlier had noted evidence of this feature using the distribution of evaporite facies of the Salina Group in the Michigan Basin.

## PREVIOUS WORK

Previous studies of the Salina Group of the Michigan Basin area can be separated into three areas. The regional geology, exterior to the Basin; the geology of the Basin; and the origin, occurrence and deposition of evaporite formations within the Basin.

### Regional Geology

Some of the earlier studies on the Michigan Basin were of a regional nature, encompassing the Basin and its relation to surrounding tectonic features. Among these are Pirtle (1932), Newcombe (1933), Lockett (1947), Krumbein, Sloss and Dapples (1949), Kay (1951), Sloss and Krumbein (1955), Hinze and Merritt (1969), and Prouty (1970, 1972, 1976), as well as others.

Pirtle (1932) studied the regional geology of the Michigan Basin and the surrounding areas in regards to anticlinal fold patterns present within the Basin. He attributed the fold patterns to trends of structural weaknesses in the Precambrian basement rocks of the Basin.

Newcombe (1933) further elaborated on the work done by Pirtle and stated that deep-seated basement faults were the source of the anticlinal fold patterns (apparently assuming vertical movement along the faults).

Lockett (1947) concluded that the dominant positive structures of the area are the cores of old Precambrian mountains and that principal movement in the area was the subsidence of the Michigan Basin.

Krumbein, Sloss and Dapples (1949) indicated that sediments deposited within an intracratonic basin are mainly comprised of clastics derived from a distant source or are carbonate rocks in association with evaporite formations

that originated within the basin. They also state that there are intervals during the development of a basin when that basin is connected with surrounding seaways, allowing for normal marine water circulation to occur and produce a marine deposit sequence. Other intervals in the development of a basin, where normal seawater circulation is restricted possibly owing to development of reef banks or low water levels or surrounding positive features, leads to the deposition of an evaporite sequence.

Kay (1951) and Sloss and Krumbein (1955), in their work on geosynclines, stated that the Michigan Basin is the prototype of the autogeosyncline or intracratonic basin, where the basin shape is generally oval and rates of subsidence in the Basin are greatest in the Basin center and decrease as one moves outward from the interior to the Basin rim.

Hinze and Merritt (1969) attributed the formation of the Michigan Basin to isostatic sinking as the crust adjusted to added mass of basic material in the basement complex. Their work was based on regional gravity and magnetic surveys of the lower peninsula of Michigan.

Prouty (1970, 1972, 1976) attributed the origin of most of the Michigan Basin's faulted and folded structures to extrabasinal shearing stresses carried in the Precambrian basement rocks from the southeast, presumably from the Appalachians. It is further suggested that these stresses were instrumental in developing the oblate form of the Basin through the simple shear stresses as well as having a part in the shifting of depocenters through the Paleozoic.

### Geology of the Basin

Studies on the geology of the Michigan Basin during the Late Silurian Salina time include works done by Landes (1945), Evans (1950), Melhorn (1958), Cohee and Landes (1958), Burns (1962), Ells (1967), Lilienthal (1978), and Paris (1977) and many more.

Much of the initial work on the Salina Group of the Michigan Basin can be accredited to Landes (1945) who divided the Salina into eight separate formations labelled A through H. These labels, with minor changes, are still in use.

Evans (1950) studied the Salina and further divided the "A" formation of Landes' into four units, the A-1 and A-2 Carbonate and Evaporite sequences.

Melhorn (1958) studied the Silurian and chemically analyzed 35 core samples obtained from oil and gas wells and mapped the Silurian both stratigraphically and lithologically. His data showed the presence of a southwest clastic belt and a structural hinge line that separated the dominant interior evaporites of the Basin from the carbonates and shales of the Basin rim. On a regional basis, Melhorn also noted the influence of the Wisconsin and Kankakee Arches and attributed an increase in his clastics maps on the west and southwest edge of the Basin as due to regional positive influences and erosion from these features.

Cohee and Landes (1958) believed the Michigan Basin underwent its greatest period of subsidence during Late Silurian with downwarping during the Salina, Bass Islands and Detroit River times.

Burns (1962) examined the Upper Silurian Salina A-H groups. He noted the importance of the Chatham Sag as a major inlet of normal marine water to the Michigan Basin. He also noted that the deepest part of the Basin was in eastern Michigan near Saginaw Bay.

Ells (1967) conducted studies of the Salina formation, making stratigraphic analyses and correlations based on sample cuttings and geophysical records of oil and gas wells. Based on his correlations and interpretations he was able to subdivide the F-salts into six separate units and trace each unit across most of the Basin.

Lilienthal (1978) correlated stratigraphic cross sections for the complete geologic column for the Michigan Basin using geophysical records of oil wells. He was able to divide the F-salts into six units and trace each unit across the Basin, the same as Ells.

Paris (1977), in his study of the Howell Anticline, states that the greatest episode of subsidence along the northeast flank of the Howell Fault was contemporaneous with F-salts deposition.

#### Origin, Occurrence and Deposition of Evaporites

Studies and papers on the deposition of evaporites in various basins are numerous, and include King (1947), Kaufman and Slawson (1950), Scruton (1953), Dellwig (1954), Briggs and Lucas (1954), Briggs (1957), Pannekoek (1965), Briggs and Pollack (1967), Rickard (1970), Matthews and Egleson (1974), Mesollela (1974), Droste and Shaver (1977), Johnson and Gonzales (1978) and Briggs et al. (1980).

King (1947) in his study of the Permian Castile beds of the Permian-Delaware Basin in West Texas and New Mexico, proposed the theory of reflux to explain evaporite composition and deposition in the Basin. He concluded the evaporation rate in the Basin exceeded both the rate of influx of local terrestrial water and the influx of normal marine waters. He states that the waters trapped in the Basin (waters below average wavebase) consisted of a brine formed by evaporation and which was recharged intermittently by normal marine water influx through a restricted connecting channel. He accredited a constant flow of dense, hypersaline brines at depth out of the basin to compensate for the volume of new sinking brines accumulating in the Basin. This theory of dense brine flow out of the Basin at depth he termed "reflux" to explain the lack of halite in the evaporite sequence in the Basin.

Scruton (1953) in a similar theory, states that high brine concentrations are associated with a strong salinity gradient which produces segregation of the various precipitated salts. The escaping deep, dense brines return to the marine environment those salts that were not precipitated. His theory proposed the initial idea of a "brine body" migrating across a basin. The mechanics of migration are due to changes in influx of normal marine waters, rates of evaporation and changes in connecting channels. Scruton noted that the order in which evaporites are precipitated vertically cannot only be predicted from lagoonal studies but agree with the vertical series of sequences found in several formations. Scruton's vertical sequence includes a basal carbonate, then anhydrite, anhydrite and halite and finally halite. Some of his conclusions on deposition of evaporites are:

1. Evaporites are deposited in restricted areas of the sea in which evaporation exceeds precipitation.
2. Circulation in the basin is established similar to that of a continuous influx of surface current of partly concentrated solution, counterbalanced by a continuous return flow at depth of concentrated brines to the sea.
3. High salinity is developed because of restrictions to brine escape. Under established equilibrium conditions, escaping brines return to the sea those salts that were not precipitated.
4. Restrictions to escape of the brine at depth are in part static (as physical barriers) and in part dynamic (as relationships between pressures due to hydrostatic head and density distribution, friction between opposite flowing currents and friction between the current and the channel bottom). Basin equilibrium is

dynamic and is sensitive to fluctuations of excessive evaporation and amount of channel restriction.

5. The vertical sequence of beds which results from the salinity changes can be predicted approximately from experiments in seawater evaporation.

Briggs and Lucas (1954), in comparing texture and mineralogy of a core section of Salina salt decided the salt was deposited in annual cyclic layers, stating the deposition of separate anhydrite and halite laminae probably resulted from periodic influxes of seawater.

Dellwig (1954) studied the Salina salt to determine the manner of deposition, including the temperature of deposition of the salts and the origin of dolomite-anhydrite laminae. He determined the temperature of deposition of the salts was between 32-48° Centigrade. Alternating bands of clear and cloudy salts he attributed to temperature changes due to seasonal variations, and the dolomite-anhydrite laminae to be the result of the influx of normal marine waters.

Rickard (1966) researched hundreds of samples and gamma-ray logs of the Upper Silurian Salina Group in New York, Pennsylvania, Ohio and Ontario for stratigraphic relationships. He concluded that thick halite beds formed rapidly relative to the deposition of intervening rock layers, supporting the proposition that Basin floor subsidence occurs before the deposition of salt beds, to provide the storage capacity for thick beds of salt. His hypothetical depositional model suggests that salts formed in both shallow and deep water at rates 100 times faster than the rates of the intervening sediments.

Matthews and Egleson (1974) in a study of Potash salts in the Salina salt of the Michigan Basin, concluded that sea level fluctuation was the principal factor in controlling the evaporite megacycles; periods of lowest water over the basin

rims are marked by widespread clastics within the evaporite sequences and that the thickness and relative purity of the lower A-1, A-2 and B salts are best explained by the inertia of a large brine mass found only in deep basins.

Matthews and Egleson's theory on evaporite deposition encompasses several points. The first point is that evaporite deposition is cyclic (Figure 2). They state that the early stages of a cycle are dominated by factors leading to an increase in salt concentration, while final stages are dominated by factors causing increasing dilution. The peak of the cycle is when salt concentration is at its highest and the most soluble mineral in an evaporite cycle is deposited.

Their second point is the theory of a transgressive/regressive brine body. They claim that minerals deposited in the early stages of an evaporite cycle are the result of a transgressing brine body, where increasing concentration gradients transgress the ocean floor. These early cycle minerals are usually well preserved as they are covered by higher concentrations of brine. Minerals of the later cycle are the result of a regressing brine body and are often poorly preserved as they tend to be covered by brines capable of redissolving the bottom sediments.

Third, Matthews and Egleson state that reversals or dynamic equilibrium conditions can occur at any point in an evaporite cycle only if reflux to open seas is present. In the absence of reflux, and if conditions of increasing concentration are maintained, the evaporite cycle must reach the eventual point of deposition of bitterns, regardless of basin depth.

Fourth, they conclude that radial or convergent inflow existed in the Michigan Basin (Briggs and Pollack, 1967). With convergent inflow, the densest brines occur at basin center. With radial flow, the densest brine will sink at the Basin center and transgress the ocean floor from the center outward to the rim. As concentration continues, these dense brine bodies will transgress across the

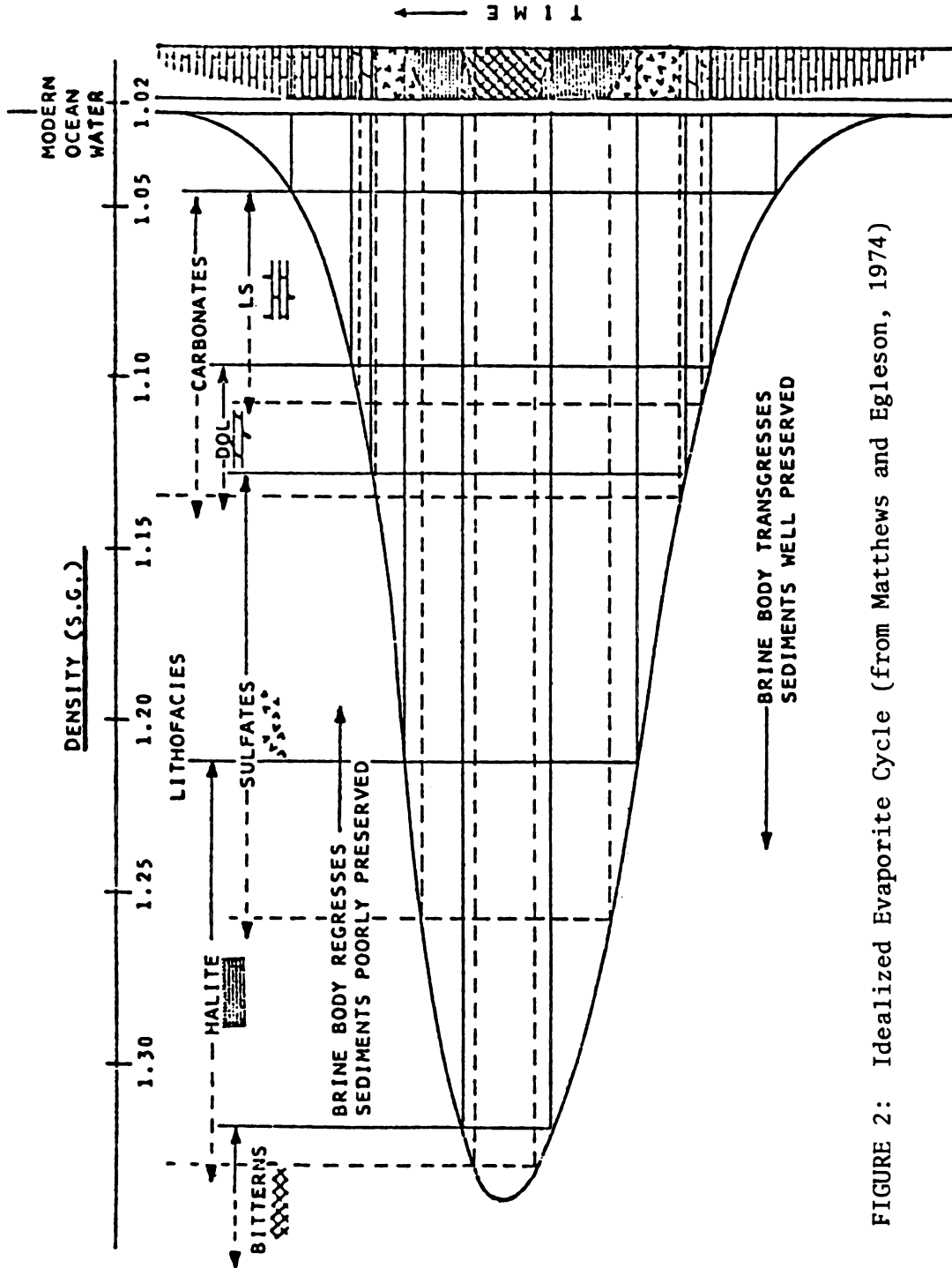


FIGURE 2: Idealized Evaporite Cycle (from Matthews and Egleson, 1974)

Basin floor from the center. As dilution conditions prevailed, as in the later stages of the evaporite cycle, the dense brine body would regress back across the Basin floor to the Basin center.

As a fifth point, they state that the midpoint of the evaporite cycle is likely to coincide with the lowest water stage over the Basin rim, providing clastics from exposed reef complexes and shelf areas to the evaporite sequence deposited.

For a sixth and final point, Matthews and Egleson state the degree of restriction in the Michigan Basin was controlled by eustatic changes in sea level. They claim a slight rise in sea level increased the influx of marine waters and permitted reflux currents to move out of the Basin during the time of the A-1 salt formation. This reflux of bittern brines out of the Basin caused the evaporite megacycle of the A-1 salt to reverse slowly to the point of halite deposition where it was trapped due to a rise in sea level that cut off the brine body from surface evaporation and isolated it, causing deposition to change from the A-1 salt to the A-1 carbonate. A lowering of sea level to that level that prevailed during the A-1 salt deposition ended the A-1 carbonate deposition as the body of trapped brine was again exposed to surface evaporation, resulting in deposition of the A-2 salts. Deposition of the A-2 carbonate followed under the same conditions as the A-1 carbonate, while the B salts began with trapped brines left over from earlier cycles, as did the A-2 salts.

Matthews and Egleson believe the trapped brines received considerable volumes of re-dissolved salts as the Basin subsided and salt beds around the rim were exposed to less concentrated surface waters and re-dissolved. They concluded the younger A-2, B, D and F salts contain a substantial portion of re-dissolved, second-generation halite, showing a slightly different chemical makeup by containing lesser levels of bromine.

Matthews and Egleson interpret their data to indicate a deep water origin of the A-1 salts, A-2 and B salts. They believed the Basin was at its deepest at the close of the Niagaran and became progressively shallower with the end of each evaporite cycle so that the D and F salts were basically deposited in a "filled" basin. They believed the thickness and relative purity of the halites in the lower salts suggest the slow, regular change of a large brine body while the evaporite megacycles younger than the A-1; the A-2, B, D and F salts, are represented by progressively thinner sequences; they appear to have cycled more quickly as the Basin filled and as the brine involved in each megacycle became smaller in volume.

## SILURIAN HISTORY OF THE MICHIGAN BASIN

Early Silurian in the Michigan Basin began with a marine transgression from the north that deposited the Manitoulin Formation (Newcombe, 1933). Melhorn (1958) states that parts of the Basin underwent slight subsidence with the Battle Creek Trough connecting the Michigan Basin to the Illinois Basin across the southern shelf area through the Logansport Sag, while the Kankakee and Findlay Arches already existed as slightly positive elements that controlled and restricted circulation to the basin (Figure 1).

The Cabot Head Shale possibly originated from red and green muds that washed into the Michigan Basin from eastern sources through the Chatham Sag, or originated as detritus from uplift and erosion of Ordovician shales that were deposited along the axis of the Cincinnati Arch (Melhorn, 1958).

Middle Silurian Clinton Shales resulted when a slight increase in subsidence rates and deepening of marine waters over the southeast part of the shelf permitted influx of clay muds from the east (Melhorn, 1958).

The Niagaran began with deepening of the Basin and resubmergence of positive areas that had contributed to the Cabot Head Shale and Clinton Shales. The Battle Creek Trough was present as a link between the Michigan Basin and Illinois Basin, allowing water circulation. Light colored, fine textured fossilized carbonates indicate a normal marine environment. Small reef structures began to become more extensive and widespread on the Basin edges (Melhorn, 1958). As the Niagaran progressed, better development of reefal structures and shallowing of the seas occurred (Mesoella, 1975; Briggs et al., 1980). The shallowing seas were perhaps coincident with uplift of arches to the south. Marginal uplifts, reef growth, lowering sea levels and severance of the Battle

Creek Trough connection to the Illinois Basin marked the end of the Niagaran epoch and the resulting isolation and restriction of circulating seas set the stage for the deposition of the Salina Evaporites (Melhorn, 1958; Nurmi and Friedman, 1975; Briggs et al., 1980).

Upper Silurian Salina and Bass Islands deposition began with the deposition of carbonate muds and anhydrites in a gradually subsiding Basin (Dellwig, 1955). Periodic influxes of seawater occurred into the Basin from the east and northeast. Basin subsidence and isolation continued and saline conditions increased to the point where evaporite sequences were laid down, interrupted by periodic influx of normal marine waters causing deposition of carbonates in dominantly salt sections of the Salina Formation. Reef growth on Basin margins eventually ceased as conditions became too saline for reef growth and survival (Mesolella, 1975).

The close of the Salina deposition is marked by the cessation of subsidence and reinvasion of normal marine waters that led to the deposition of gray muds over the Basin, forming the G-unit shale. Final stabilization of the Basin is noted by the return to normal marine carbonates of the Bass Islands Formation (Melhorn, 1958).

## MATERIALS AND METHODS OF INVESTIGATION

Materials used in the study consisted of oil and gas well sample cuttings, descriptive records and geophysical well records available from the Michigan Geological Survey.

Over 150 oil and gas wells were researched for this study. The oldest record analyzed was a well drilled in 1962 while the remaining wells all date from the late 1960's to 1982, providing new data that was not available to earlier researchers.

The method of investigation for this study can be separated into two areas: geophysical log "picks" for formation tops and elevations, and determination of lithology.

### Formation Tops and Elevations

The choice of formation tops is that of the author but basically follow those choices commonly accepted and used by the Michigan Geological Survey. These tops also generally correspond to those picks used by Ells (1967) and Lilienthal (1978). Constant cross-checking and cross-correlation of tops from one well to another allowed for consistency in picks across the Basin. Areas of difficulty in formation picks were encountered, especially in the shelf area and to the southwest of the Basin where the Salina truncates very abruptly.

Once formation tops were determined, elevations and thickness of each unit of the F-salts were calculated for structure and isopach maps. Elevations were corrected to sea level as sea level was used for the common reference datum.

### Determination of Lithology

The second area of analysis, that of determining lithology, was not as straightforward. The original research plan called for a comparison of some gamma-ray-neutron logs with any available core/cutting samples and descriptive logs to help determine the meaning of mechanical log deflections and reinforce generally accepted log interpretations.

The initial step in this phase of the study consisted of an examination of well cuttings and descriptive log comparisons. Cutting samples of three wells were obtained from the Michigan State University Geology Department. These cuttings of the F-salt sequence were from well #2 (Emery #1 PN23849), well #57 (Zischke #1 PN22348) and well #66 (Sattelberg #1 PN23890). These rotary cuttings were examined under the microscope and compared with the descriptive logs of each well. Initial comparison of the examined cuttings and the descriptive logs of the three wells show a very close correlation between the author's analysis and descriptive logs. The degree of correlation can be seen in Figure 3 which graphically compares the two analyses for well #2, the Emery #1. The comparison of the two remaining wells, well #57 and #66, are not shown as they essentially are the same as the comparison for well #2. However, as also can be seen, the descriptions, while in agreement, are not detailed enough to correlate with available geophysical logs with any great amount of confidence.

The second step was a comparison of lithologies for well #4 (State-Foster #1 PN25099). This well was lithologically analyzed by Ells (1967), based mainly on geophysical log curves. Ells' interpretation was compared with the descriptive log for the well (Figure 4). In this instance, while close correlation was found in the two wells, Ells' interpretation showed much more accurate detail than the descriptive log for the well. It should be kept in mind that in the results shown in Figures 3 and 4 specifically, and as a rule generally, cable tool

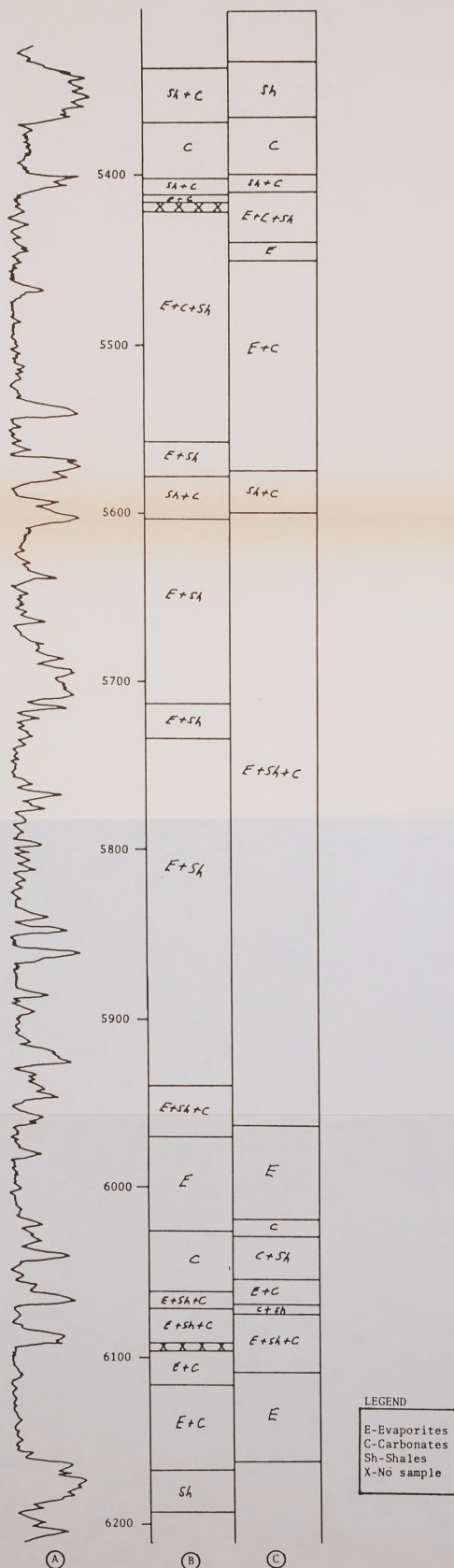


FIGURE 3: Comparison of (A) - Gamma-Ray Curve, (B) - Descriptive log and (C) - Sample analysis by B. Shirey from microscope examination Well 2-Emery 1 (PN23849) Salina F-salt Section

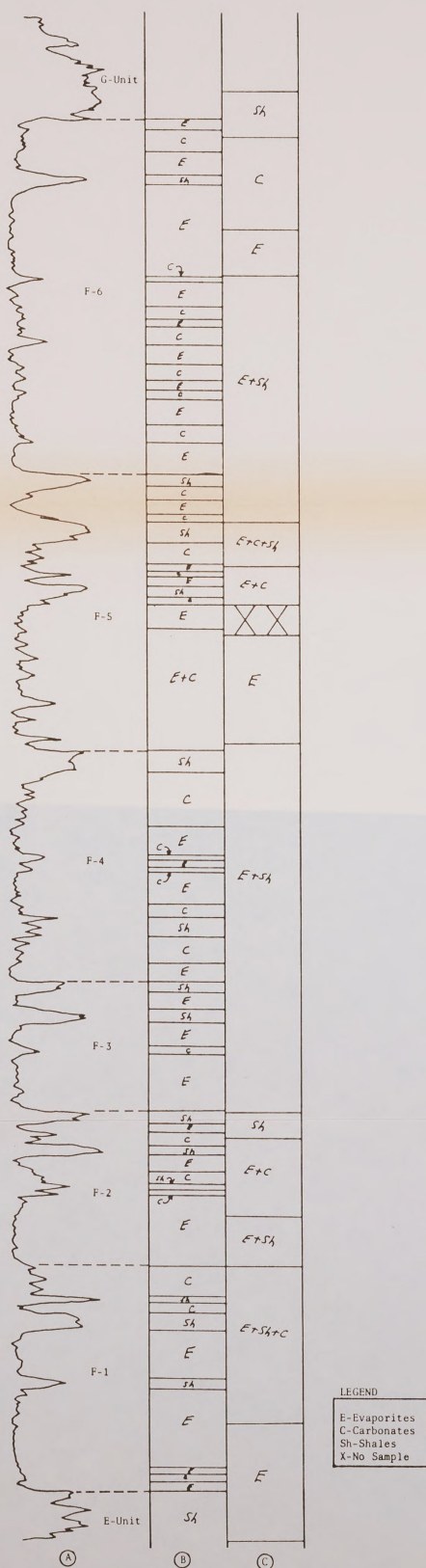


FIGURE 4: Comparison of (A) Gamma-Ray Curve, (B) Ells' (1967) lithologic interpretation based on Geophysical Curve Analysis and (C) Descriptive Log

Well 4-St.-Foster 1 (PN25099)  
Salina F-salt Section

samples are usually more accurate than rotary samples because of greater down-hole contamination in the latter. The final phase consisted of an analysis of various kinds of geophysical logs that would help determine lithology. In this phase, it was determined that the best interpretation could be based on a combination of the Compensated Neutron-Litho-Density Log which contains the Gamma-Ray, Bulk Density and Neutron Porosity Curves and the Borehole Compensated Sonic Log, which contains the Gamma-Ray and Sonic Curves. In determining this, the various curves were interpreted for their responses in areas of definitely known lithology for evaporites, shales and carbonates. Areas chosen in the stratigraphic column for the desired lithology were the Bell Shale of the basal Traverse of the Middle Devonian for shales and the Upper A-2 Evaporite-A-2 Carbonate-lower B Evaporite segment of the basal Salina-Niagaran of the Middle Silurian for the evaporite and carbonate sequences (Figure 5).

The Bell Shale was chosen for its consistent lithology, as described by Lilienthal (1978):

"The Bell Shale...is consistently a shale where present...is widespread...it is generally 60-70 feet thick in the central basin area but thins to the north where it eventually pinches out."

The upper A-2 Evaporite - A-2 Carbonate - B Evaporite segment was also chosen for its consistent lithology, which is described by Ells (1967):

"The A-2 Evaporite...is nearly a pure salt more than 475 feet thick in the deeper part of the basin...the A-2 Carbonate is a widespread formation whose lithologic characteristics...are composed of dark to light-colored limestone, dolomite or both. The B Evaporite is a widespread formation...the unit is over 475 feet thick in the deeper part of the basin...the lower part of the B Evaporite is a clean salt, confined to the inner part of the reef complex."

These two sequences, the Bell Shale and the A-2 Evaporite through B Evaporite section, were analyzed in well #147 (Brandt #1-34 PN34790) and displayed in Figures 6 and 7. The Brandt #1-34 was chosen because of the

| ERA      | SYSTEM     | PRESTOCENE NOMENCLATURE |             |
|----------|------------|-------------------------|-------------|
|          |            | SERIES                  | STAGE       |
| CENOZOIC | QUATERNARY | Recent                  | Present     |
|          |            | Prehistoric             | Prehistoric |

## STRATIGRAPHIC SUCCESSION IN MICHIGAN

PALEOZOIC THROUGH RECENT



MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Edward A. Tanner, Director

Geological Survey Division

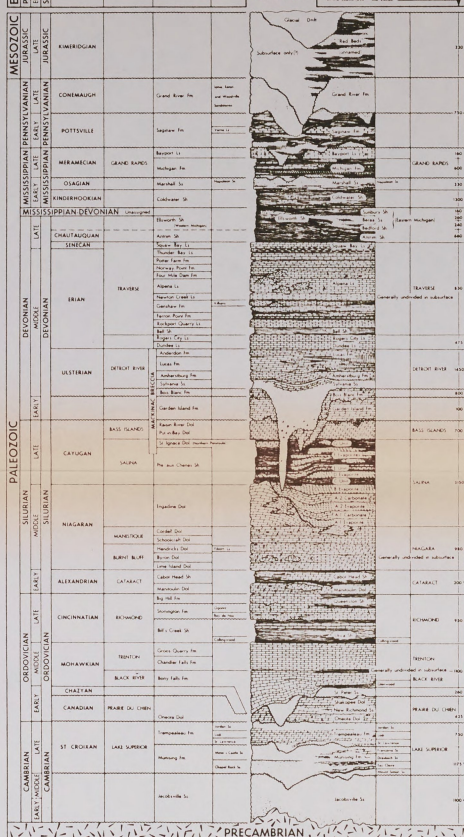
Survey of Stratigraphy and Paleontology

### OUTCROP NOMENCLATURE

| ERA | TIME SYSTEM | ROCK STRATIGRAPHIC |       |
|-----|-------------|--------------------|-------|
|     |             | SERIES             | GROUP |

### SUBSURFACE NOMENCLATURE

| ROCK STRATIGRAPHIC |        |       |
|--------------------|--------|-------|
| FORMATION          | MEMBER | GROUP |



| STRATIGRAPHIC POSITION |  | FORMAL TERMS    | FAULT |
|------------------------|--|-----------------|-------|
| Base of section of     |  | Base of section |       |
| Top of section of      |  | Top of section  |       |
| Base of member of      |  | Base of member  |       |
| Top of member of       |  | Top of member   |       |
| Base of bed of         |  | Base of bed     |       |
| Top of bed of          |  | Top of bed      |       |
| Base of layer of       |  | Base of layer   |       |
| Top of layer of        |  | Top of layer    |       |
| Base of zone of        |  | Base of zone    |       |
| Top of zone of         |  | Top of zone     |       |
| Base of unit of        |  | Base of unit    |       |
| Top of unit of         |  | Top of unit     |       |
| Base of group of       |  | Base of group   |       |
| Top of group of        |  | Top of group    |       |
| Base of system of      |  | Base of system  |       |
| Top of system of       |  | Top of system   |       |
| Base of period of      |  | Base of period  |       |
| Top of period of       |  | Top of period   |       |
| Base of epoch of       |  | Base of epoch   |       |
| Top of epoch of        |  | Top of epoch    |       |
| Base of era of         |  | Base of era     |       |
| Top of era of          |  | Top of era      |       |
| Base of eon of         |  | Base of eon     |       |
| Top of eon of          |  | Top of eon      |       |

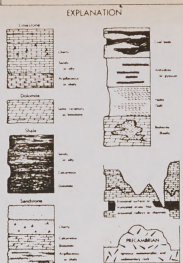


CHART 1

Figure 5

Stratigraphic Succession in Michigan

completeness of the geophysical logs that were run on the well. Not only are a Compensated Neutron-Litho-Density Log and Sonic Log available, but also a Sample Log and a Descriptive Log, allowing a thorough and complete analysis of not only the Bell Shale and the A-2 Evaporite through B Evaporite sections, but the F-salts as well.

The Bell Shale and A-2 Evaporite through B Evaporite sequence in the Brandt #1-34 show very distinct log curve responses that can be used in other wells to determine lithology (Figures 6 and 7). Once the geophysical log curves were analyzed for the Brandt #1-34, the lithology of the F-salts was compared with the Sample Log of the Brandt #1-34 which was prepared by a professional logging company (Figure 8). The lithologic analysis, based on geophysical curve interpretations, compares very closely to the actual Sample Log, with only minor areas of differing lithologic interpretation.

To summarize, in comparison of the geophysical log interpretation to the professional sample interpretation, the geophysical log analysis for lithology shows relatively good comparison with the sample log except for one anomalous situation in the column (Figure 8). This anomaly could be due to separation and partial settling of the cuttings during transport to the surface; possible human error in sample collection, bagging or due to possible contamination of samples while down-hole. In all other respects, in even the most optimum conditions of sample description, geophysical log interpretation for lithology would appear to be as good as, if not more satisfactory for, lithologic interpretations. This is not to say that geophysical logs should entirely replace sample logs, but in view of the difficulty in obtaining accurate and true samples as well as the time to run samples, it has been shown that geophysical log interpretation without samples can result in just as accurate a lithologic description as using a sample log.

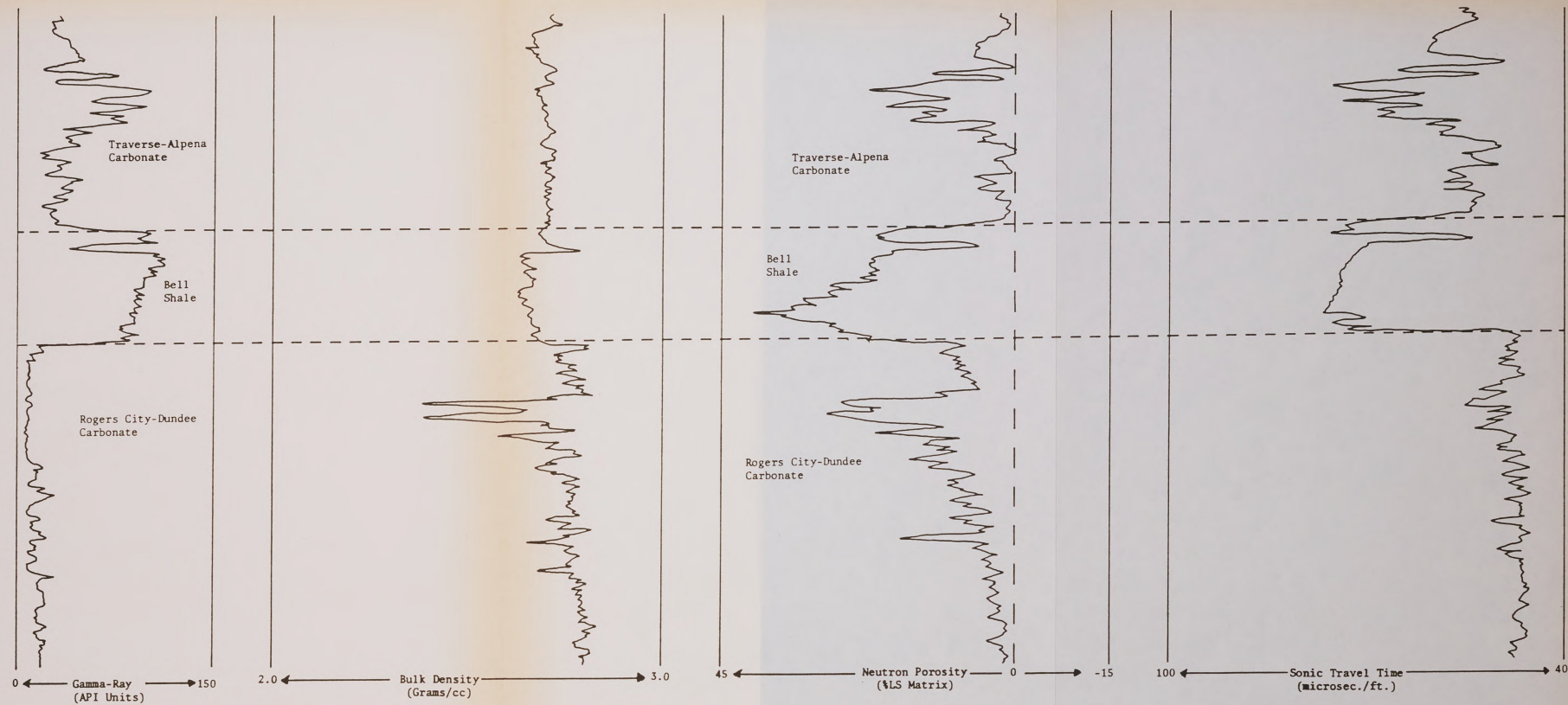


FIGURE 6: Shale Reference  
 Bell Shale  
 Well 147 - Brandt 1-34 (PN34790)

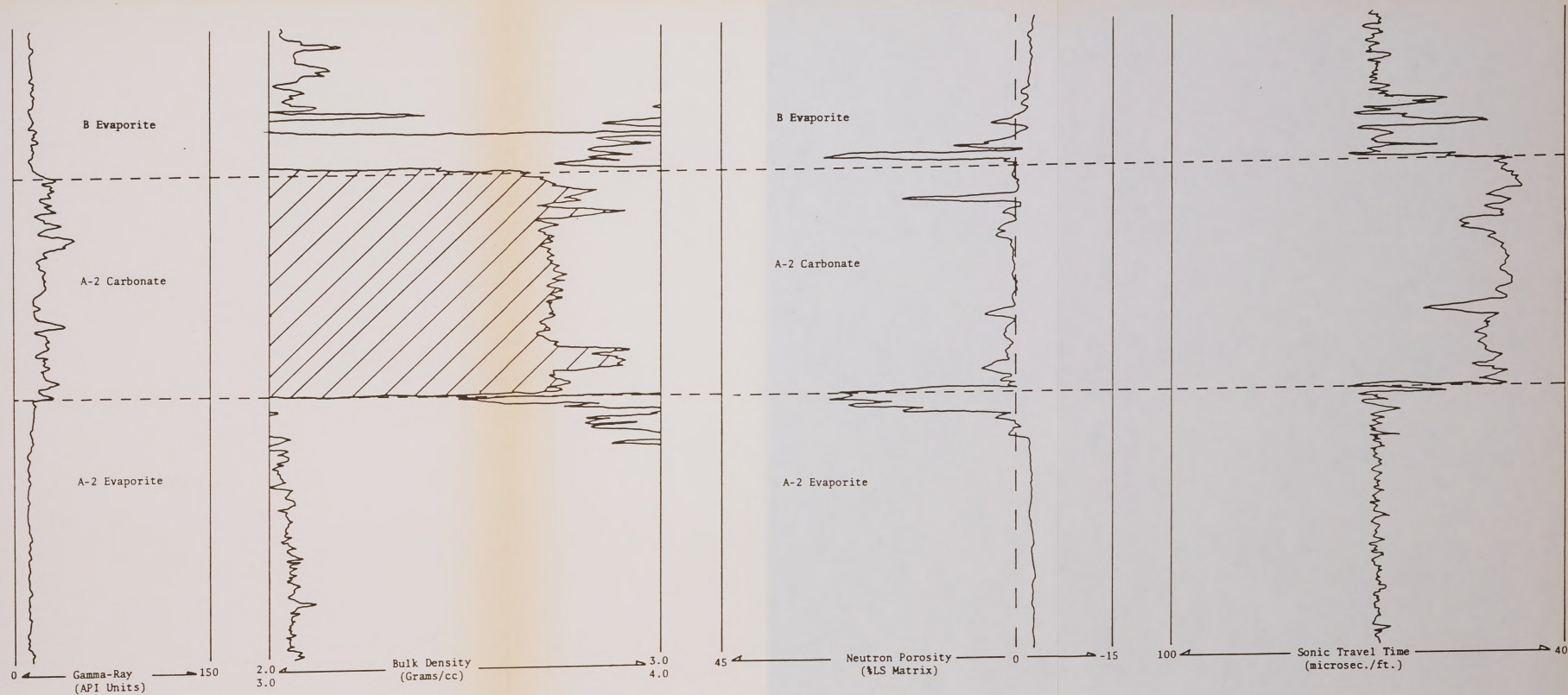


FIGURE 7: Evaporite-Carbonate Reference  
 A-2 Evaporite-A-2 Carbonate-B Evaporite  
 Well 147 - Brandt 1-34 (PN34790)

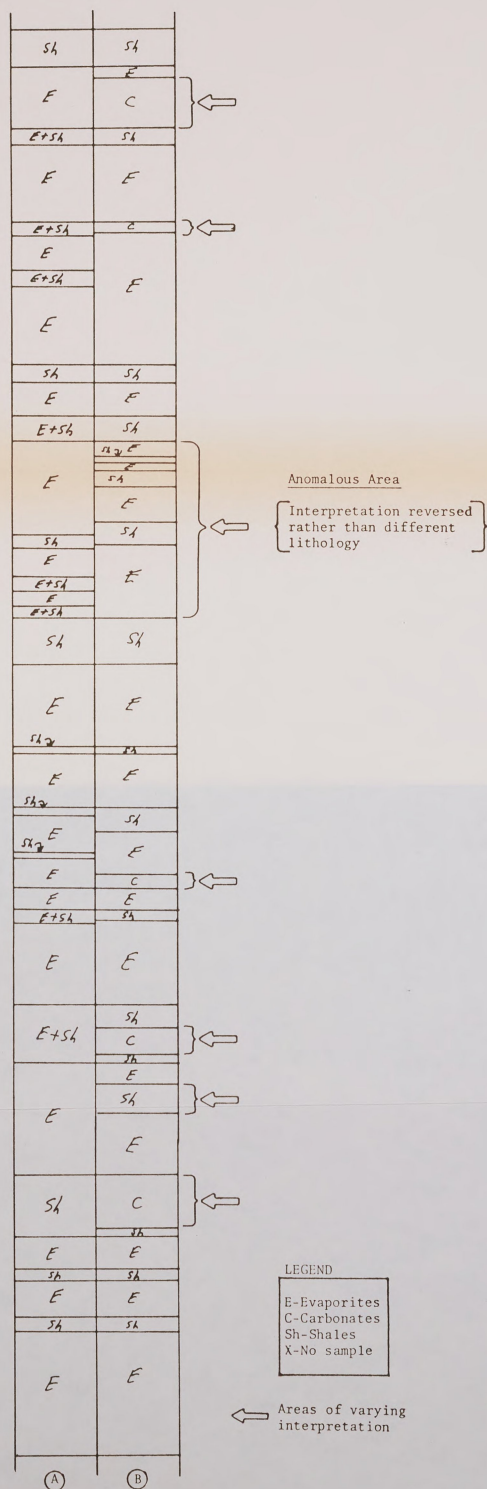


FIGURE 8: Comparison of (A)-Sample Log prepared by Professional Logging Company and (B)-Interpretation by B. Shirey based on Geophysical Log curve analysis

### Comparison of Geophysical Curve Responses to Lithology

The various geophysical logs of the Brandt #1-34 were analyzed for their responses, with Figure 9 summing up the curve characteristics for evaporites, carbonates and shales. From these data, it can be seen that the use of the Gamma-Ray, Bulk Density and Sonic Curves usually was enough to identify the lithology of the formation, because the responses of the three curves were usually quite different enough in their reaction to the three different lithologies to clearly show a change in lithology from evaporites, shales and carbonates. Use of the Neutron Porosity curve was not as helpful as the other curves, perhaps because the Neutron Porosity Curve is not designed to detect inherent properties of the different lithologies like the other three curves are designed to do.

Once the geophysical logs were interpreted as to their various lithologies, each unit of the F-salts was analyzed as to the total amounts of evaporites, carbonates and shales present. Once this was completed, clastic ratio maps were prepared for each of the six units of the F-salts (the amounts of shales compared to the amounts of evaporites plus carbonates). These data may be compared to an isopach map prepared for each of the F-salt units.

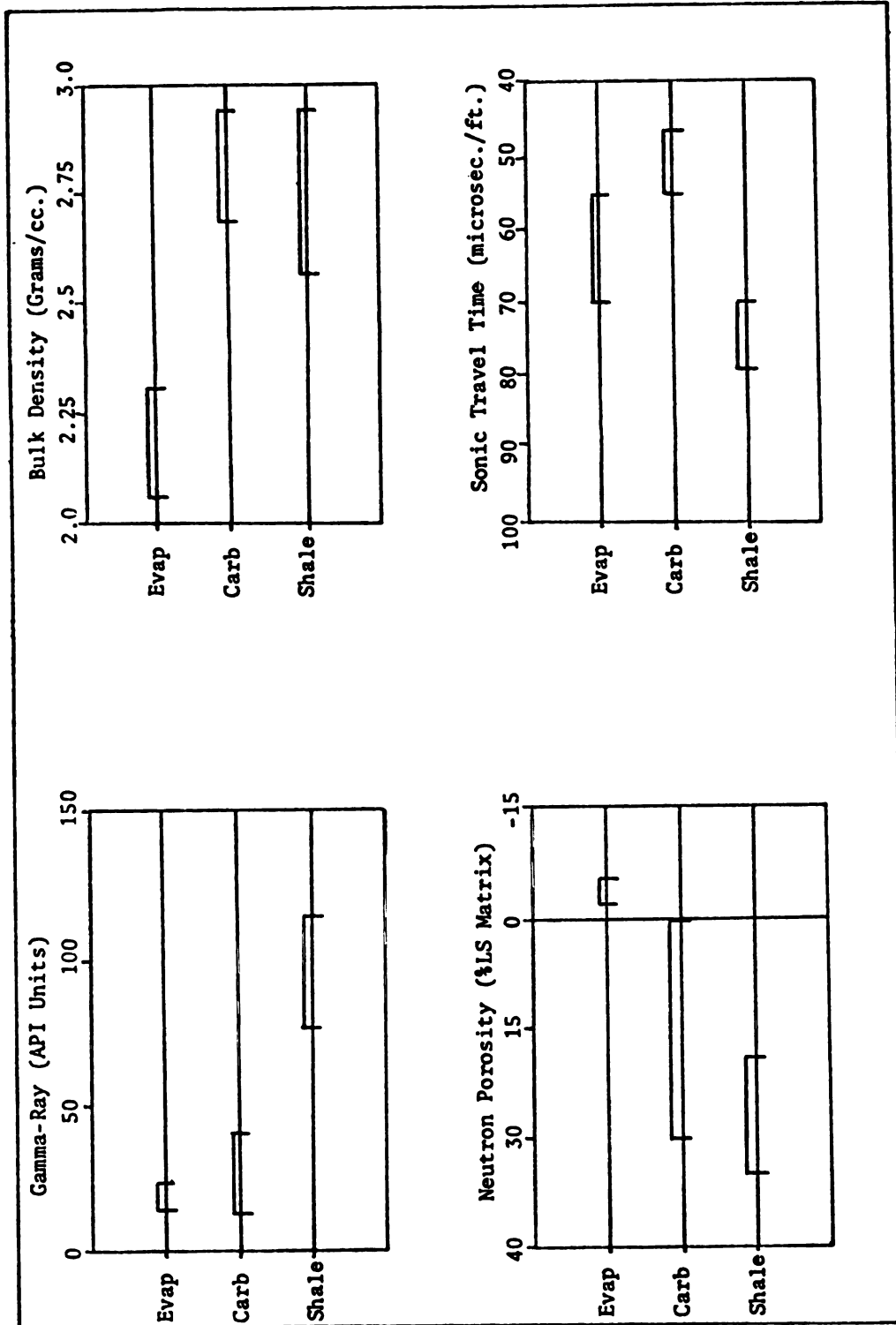
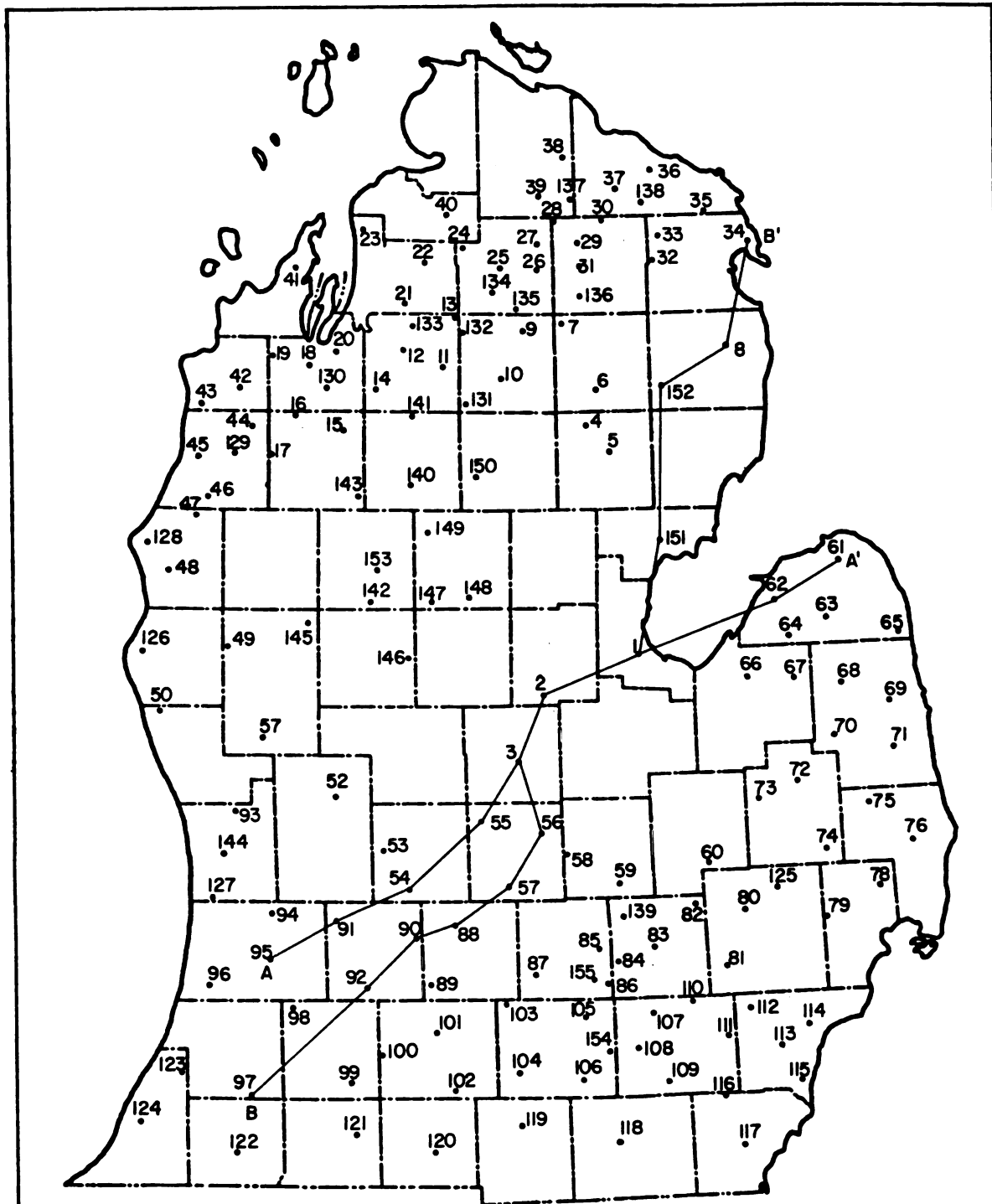


FIGURE 9: Graphic comparison of ranges of values for Evaporites, Carbonates and Shales curve responses for various geophysical logs for well 147.



Map A

Index Map With Well Locations  
and Data Index Number

A-A': See Figure 12: Lithologic Cross-section  
B-B': See Map 11: Geophysical Cross-section



Map B

County Map of Michigan

## RESULTS AND DISCUSSION

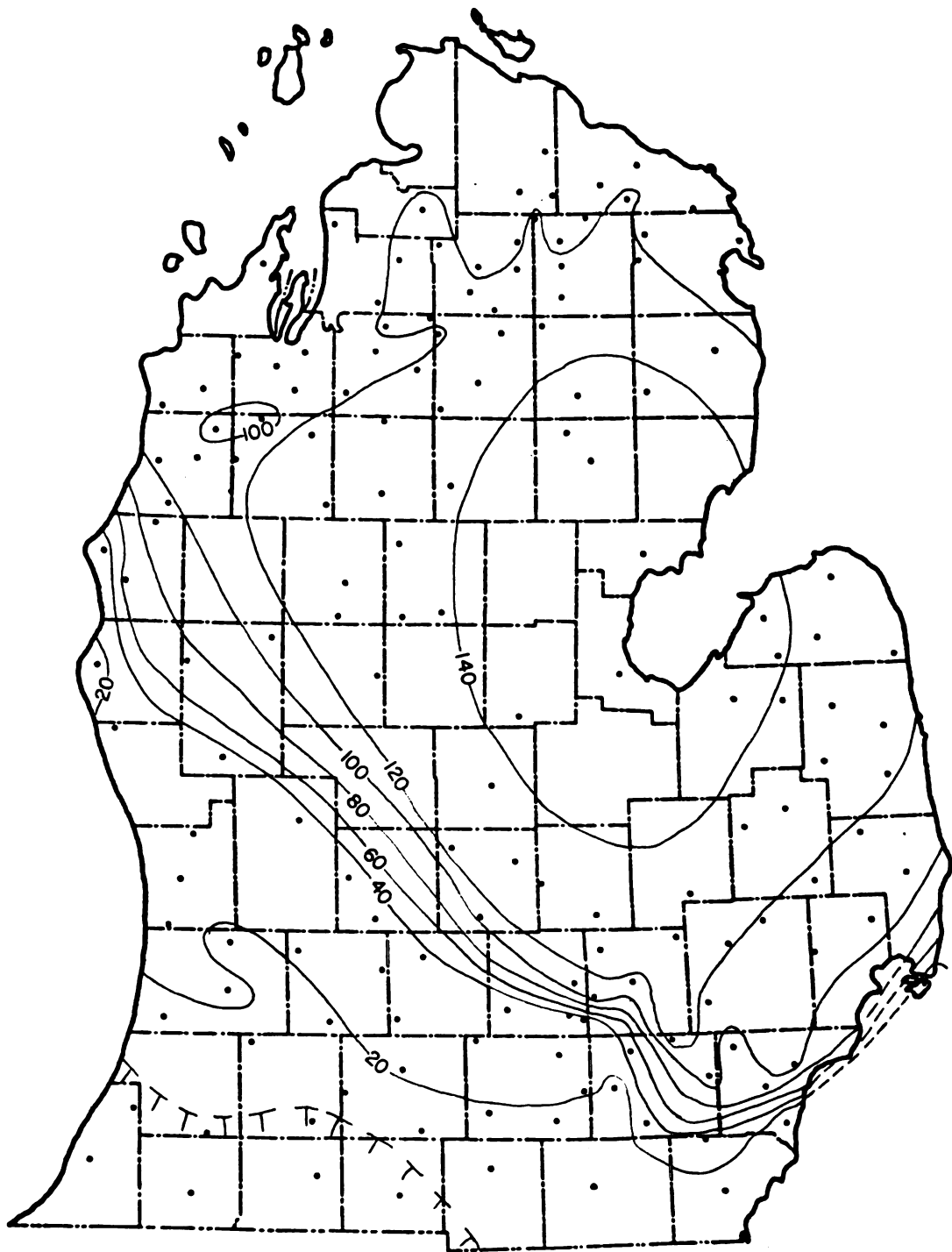
### F-1 Unit

The F-1 Unit (Map 1) is the basal sequence of evaporite deposition of the F-salts. In the depocenter area, the F-1 Unit is composed of two thick evaporite beds separated by a carbonate bed. The upper evaporite bed grades into thin carbonate and shale beds before encountering the basal evaporite bed of the F-2 Unit.

The F-1 Unit is comprised of dominant non-clastic evaporites in the Basin interior and grades to the southwest into a dominant clastic shale and non-clastic carbonate shelf zone before ending in the southwest corner of the state.

The depocenter of the F-1 Unit is located in the area of Arenac County where 159 feet of the Unit are recorded in well #151. Moving southwest from the depocenter, the F-1 Unit thins abruptly from 120 feet to 40 feet, marking the location of a hinge line trending in a southeast direction from Mason County to Wayne County. Coinciding with the hinge line, the lithology of the F-1 Unit changes from a non-clastic evaporite interior to a clastic shale and non-clastic carbonate "shelf" zone directly southwest of the hinge line. This shelf area is continuous to the southwest until the F-1 Unit ends abruptly in the southwest corner of the state.

The clastic ratio map of the F-1 Unit appears to indicate the presence of a possible channel across the shelf zone in the area of Hillsdale, Jackson, Lenawee and Ingham counties, where a zone of low-clastic sediments is present. This channel possibly provided a connection to marine areas exterior to the Basin and allowed an exchange of marine waters between the Basin and other marine environments.



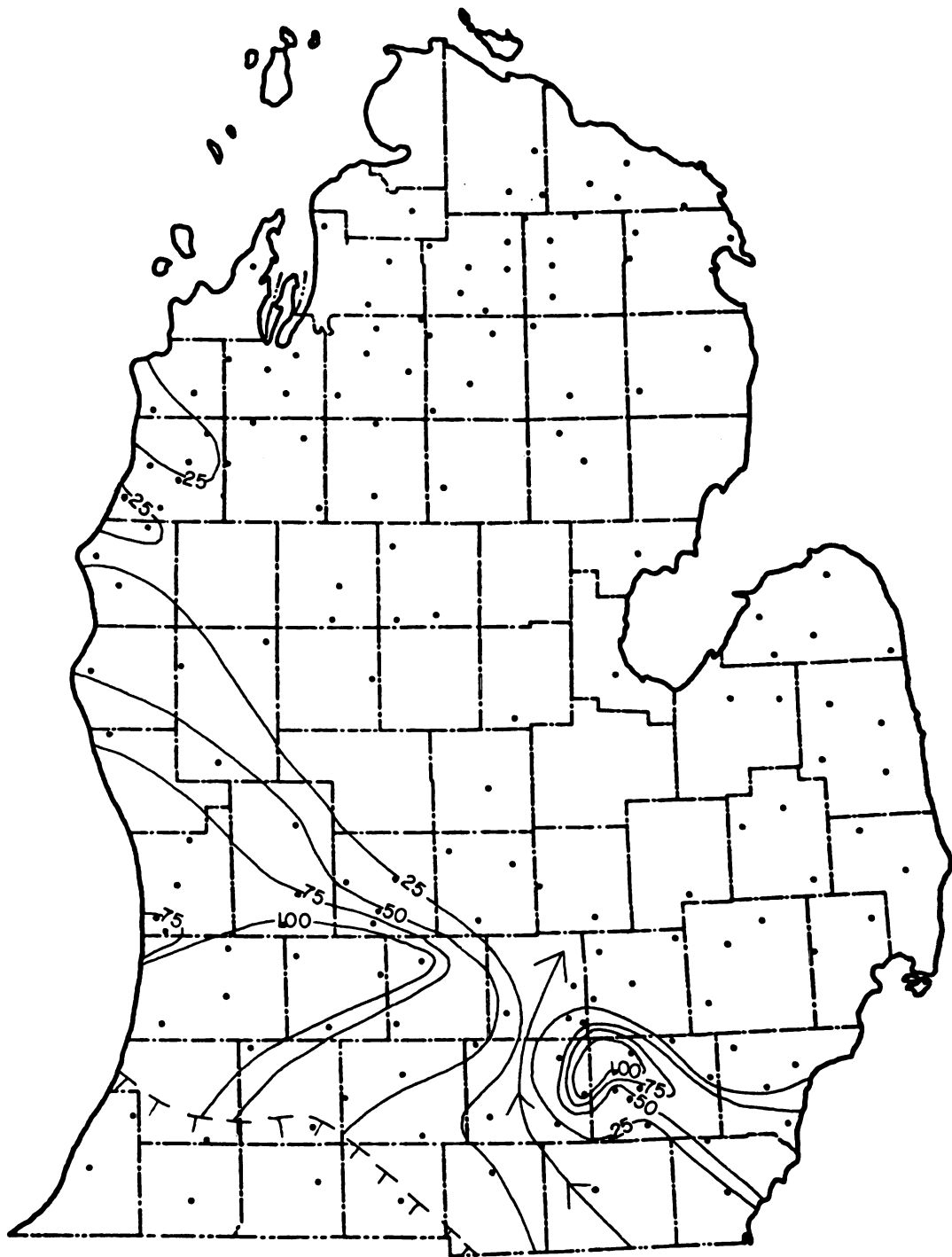
Map 1-1

Isopach Unit F-1

Contour Interval: 20 feet  
Scale: 1 inch=40 miles

Truncated Area: TTT

Shirey 83



Map 1-2

Clastic Ratio Unit F-1

Contour Interval: 0.25  
 Scale: 1 inch = 40 miles

Possible Channel: → → →  
 Truncated Area: T T T

Shirey 83

Zones of high-clastic shale are present in the southeast area of the Basin in Wayne and Washtenaw counties and also in the southwest of the Basin in the areas of Allegan and Barry counties, possibly indicating influence from the Findlay and Kankakee Arch systems.

Possible sources across the surrounding Basin frame complex may be distant sources such as the Appalachians, with shales brought into the Michigan Basin through various sags and inlets present in the frame complexes.

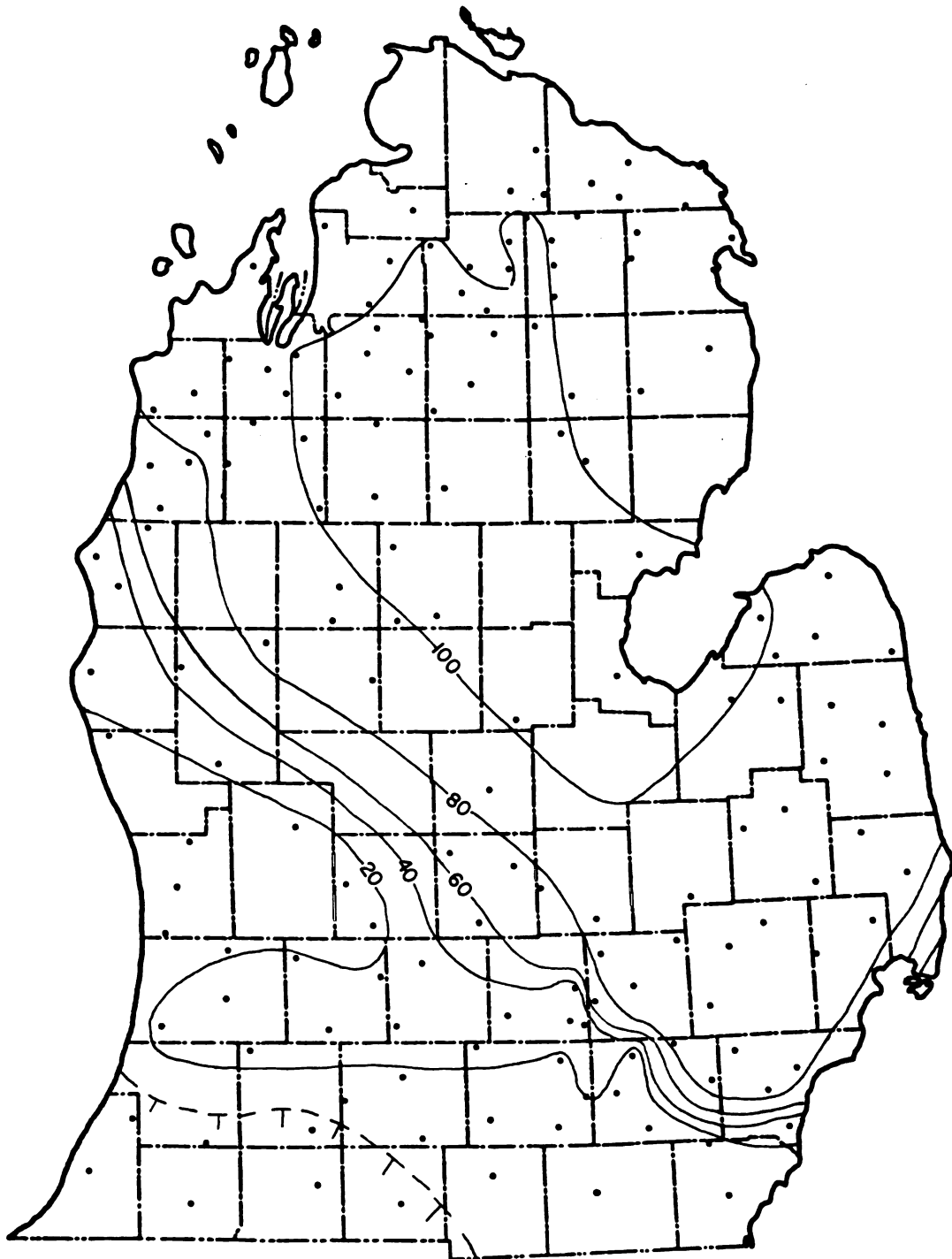
### F-2 Unit

The F-2 Unit (Map 2) is the second sequence of evaporites among the F-salts. In the depocenter area, the F-2 Unit is comprised of a major basal evaporite sequence that grades into a shale and carbonate series of beds toward the top of the unit before grading into the basal evaporite of the F-3 Unit.

The F-2 Unit, like the F-1 Unit, is comprised of dominant non-clastic evaporites in the Basin interior and grades to the southwest into a dominant clastic shale and non-clastic carbonate shelf zone before ending in the southwest area of the state.

The depocenter of the F-2 Unit is located in the area of Bay County where 110 feet of the formation is present in well #1. Moving southwest from the Basin center, the F-2 Unit thins sharply from 80 feet to 20 feet, delineating a hinge line located in the same area as the hinge line for the F-1 Unit. This hinge line again denotes a change in lithology, showing an increase in clastics onto the shelf area from the dominant non-clastic evaporites of the Basin interior.

The clastic ratio map of the F-2 Unit appears to indicate possible channels across the shelf area, possibly providing a connection to marine areas outside the Basin for exchange of water into and out of the Basin. Zones of high shale content, as denoted by the high value of the clastic ratio, are present in the southeast corner of the shelf area in Monroe, Washtenaw and Jackson counties.



Map 2-1

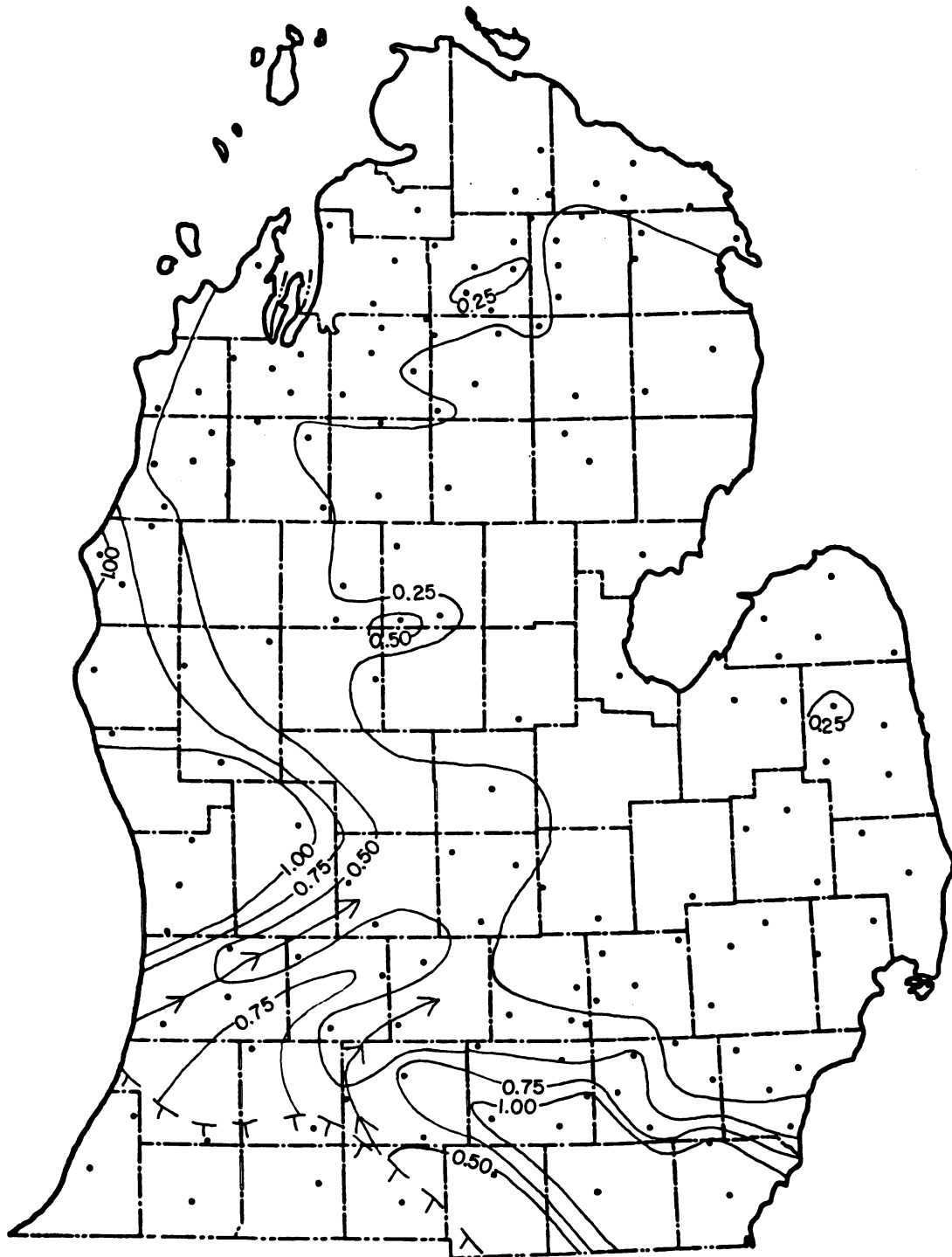
Isopach Unit F-2

Contour Interval: 20 feet

Scale: 1 inch = 40 miles

Truncated Area: T T T

Shirey 83



Map 2-2

Clastic Ratio Unit F-2

Contour Interval: 0.25  
 Scale: 1 inch = 40 miles

Possible Channels: → → →  
 Truncated Area: T T T

Shirey 83

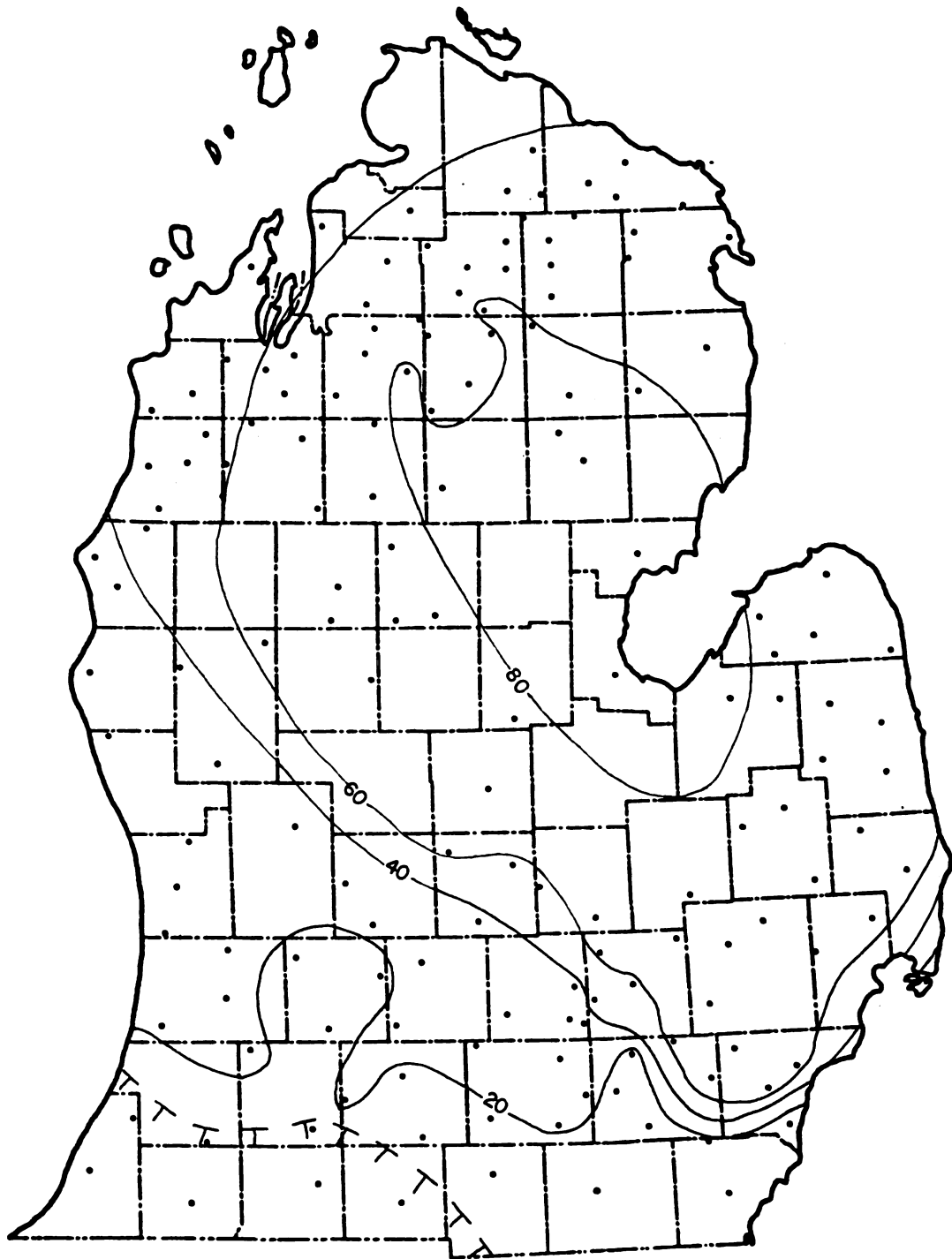
These shale areas may indicate an influence off the Findlay Arch and/or the Clinton Inlet and Chatham Sag (Figure 1), which might have introduced fine clastics from the Appalachians. Another area of clastic shales is present in the west edge of Michigan in the Muskegon, Ottawa and Kent county area, possibly indicating influence of the Wisconsin and Kankakee Arch complex to the west and southwest of the Basin.

### F-3 Unit

The F-3 Unit (Map 3) is the third sequence in the F-salt formation. As in the two previous units, the F-3 Unit in the Basin center is composed of a thick basal evaporite bed, grading upward into beds of carbonates and shales before encountering the basal evaporite of the F-4 Unit.

The depocenter of the F-3 Unit is centered in the area of Arenac County where 90 feet of the F-3 Unit is recorded in well #151. Moving to the southwest from the Basin center, the F-3 Unit grades into a shelf area of clastic shales and non-clastic carbonates. The hinge line of the F-3 Unit is located in the same area as the hinge line of the previous units. However, the abrupt thinning of the F-3 Unit is not as noticeable because the F-3 Unit comprises the thinnest sequence of the F-salts and the location of the hinge line is denoted only by the thinning of the Unit from a thickness of 60 feet to 40 feet. As in units F-1 and F-2, the hinge line denotes a change in lithology from the evaporites of the interior to a shelf lithology of shales and carbonates.

The clastic ratio map of the F-3 Unit appears to delineate a possible channel across the shelf area in the area of Ionia, Barry, Kalamazoo and Calhoun counties, where a low-clastic zone is outlined. As in previous units, high clastic shale zones are present in the southeast and southwest areas of the Basin, possibly indicating an influence from the Findlay and Wisconsin-Kankakee Arch complexes.



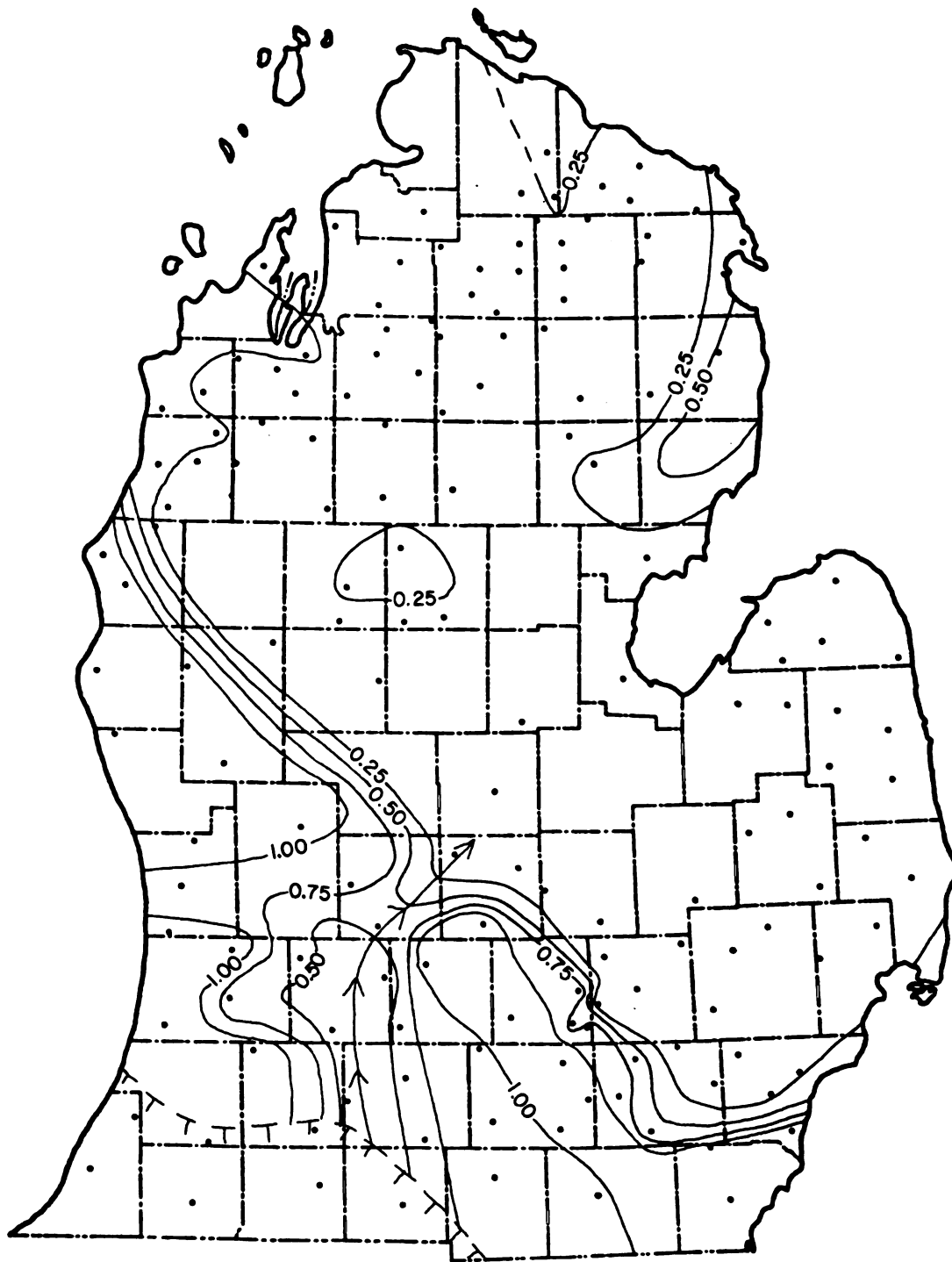
Map 3-1

Isopach Unit F-3

Contour Interval: 20 feet  
Scale: 1 inch = 40 miles

Truncated Area: TTT

Shirey 83



Map 3-2

Clastic Ratio Unit F-3

Contour Interval: 0.25  
 Scale: 1 inch = 40 miles

Possible Channels: →→→  
 Truncated Area: T T T

Shirey 83

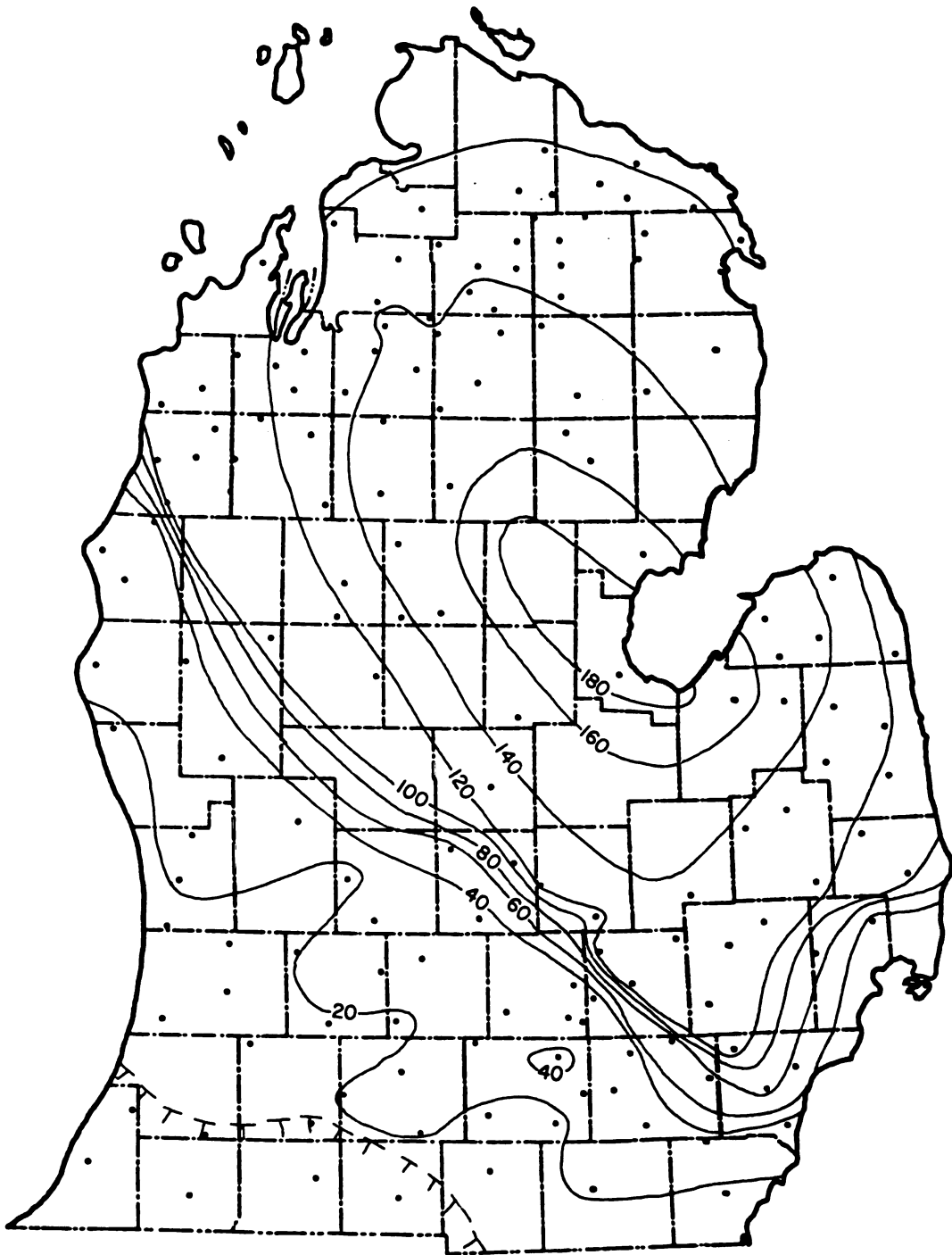
#### F-4 Unit

The F-4 Unit (Map 4) is the fourth Unit of the F-salts. In the Basin center, the F-4 Unit is a sequence of two major evaporite beds, separated by carbonates. The lower half of the F-4 Unit is comprised of alternating zones of thick evaporites and thin carbonates. The upper half of the F-4 Unit is comprised of a thick bed of evaporite which grades into carbonates and shales before encountering the basal evaporite of the F-5 Unit.

The depocenter of the F-4 Unit is located in the area of Bay County where 193 feet are found in well #1. Moving southwest from the Basin interior the F-4 Unit thins from 120 feet to 40 feet, over the hinge line, which lies slightly more to the northeast than the hinge lines of the previous units. Again, the hinge line marks a change in lithology from the interior non-clastics (evaporites) to the shelf clastics. In the case of the F-4 Unit, the shelf lithology is one of dominant shales, as can be seen in the clastic ratios.

The clastic ratio map of the F-4 Unit fails to indicate any channels present across the shelf area as in the previous units, indicating that possibly no channel connections were present during this time. In the F-4 Unit, the area of clastic shale zones encompasses the entire shelf area, denoting massive widespread shales all through the shelf. This change to a massive shale shelf environment could possibly be due to a change in tectonic activity along the Findlay-Kankakee-Wisconsin Arch complex with increased erosion to provide increased shale content; or a lowering of sea level resulting in exposure and erosion of outlying areas.

The massive shales on the shelf area and apparent lack of any channels across the shelf may be indicative of a lower sea level and an increasingly isolated depositional environment which may account for the increased thickness of deposition as compared to the previous three units (Figure 11).



Map 4-1

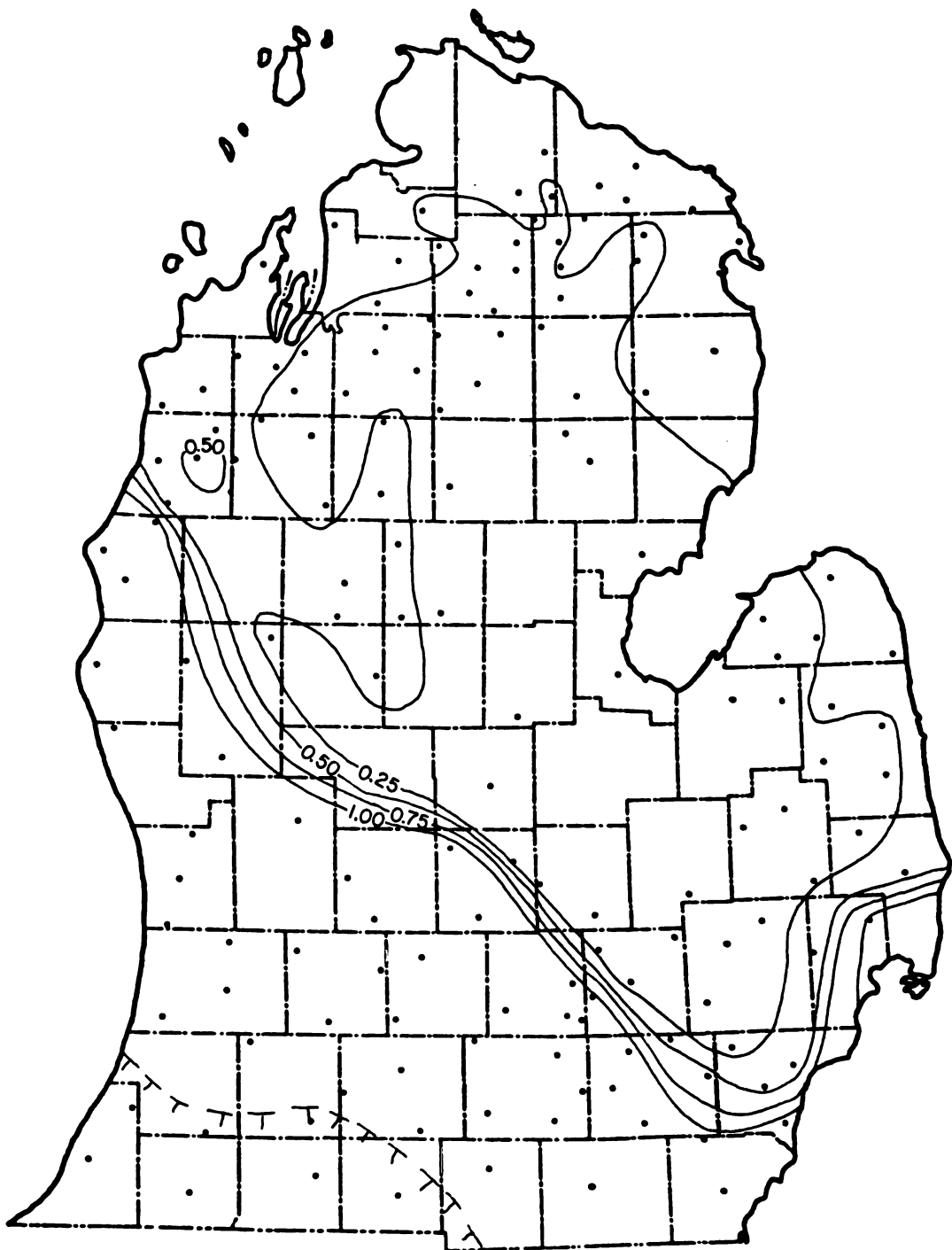
Isopach Unit F-4

Contour Interval: 20 feet

Scale: 1 inch = 40 miles

Truncated Area: TTT

Shirey 83



Map 4-2

Clastic Ratio Unit F-4

Contour Interval: 0.25  
 Scale: 1 inch = 40 miles

Possible Channels: → → →  
 Truncated Area: T T T

Shirey 83

### F-5 Unit

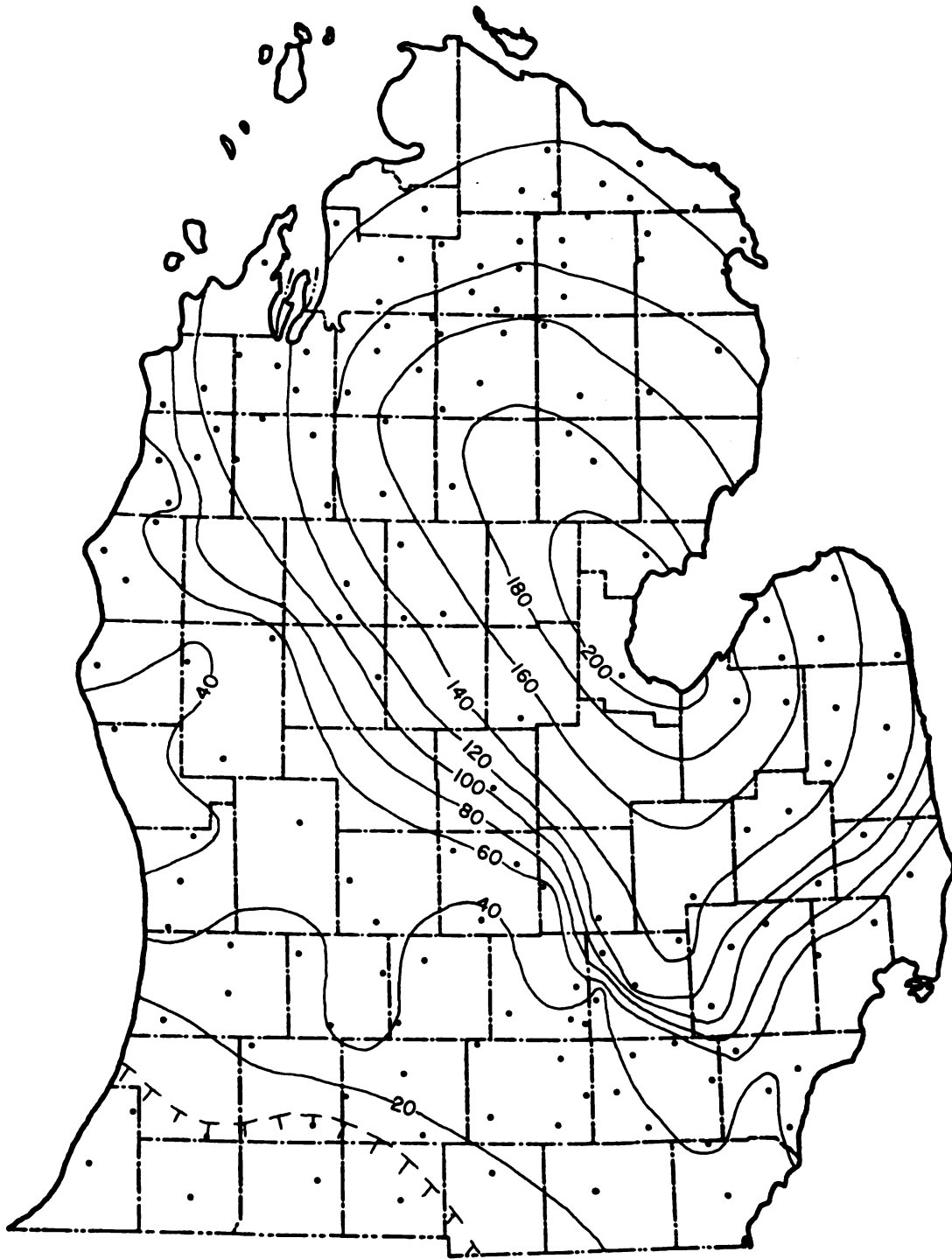
The F-5 Unit (Map 5) is the fifth and next-to-last sequence of the F-salts. The F-5 Unit in the depocenter area is composed of a thick basal evaporite sequence that contains several thin streaks of carbonates and grades upward into thinner evaporites, carbonates and shales before encountering the basal evaporite of the F-6 Unit.

The depocenter of the F-5 Unit is located in the area of Arenac County where it attains a thickness of 206 feet in well #151. Moving to the southwest from the Basin center the F-5 Unit thins gradually from 206 feet to 140 feet before thinning abruptly to 60 feet, indicating a hinge line located even farther to the northeast than any previous unit. The hinge line again separates the evaporites of the Basin interior from the clastic shelf sediments. As in the F-4 Unit, the clastic ratio indicates the shelf area to be a widespread shale lithology.

The clastic ratio map of the F-5 Unit, as was the case in the F-4 Unit, fails to indicate the presence of any likely channels across the shelf area. The re-entrants along the 40 foot isopach pose a question regarding the possibility of channel development. It should be noted, however, that the 20 foot isopach does not reflect the same re-entrants. As in the F-4 Unit, the area of clastic shale zones encompass the entire shelf area. This massive shale, like the F-4 Unit, may be indicative of the same conditions and depositional environment as existed during the F-4 Unit.

### F-6 Unit

The F-6 Unit (Map 6) comprises the uppermost and last unit of the evaporites of the Salina Group. In the Basin interior, the F-6 Unit is composed of two extremely thick evaporite beds separated by a thin shaly bed. The upper evaporite bed is topped by a thin shale that separates the upper evaporite bed



Map 5-1

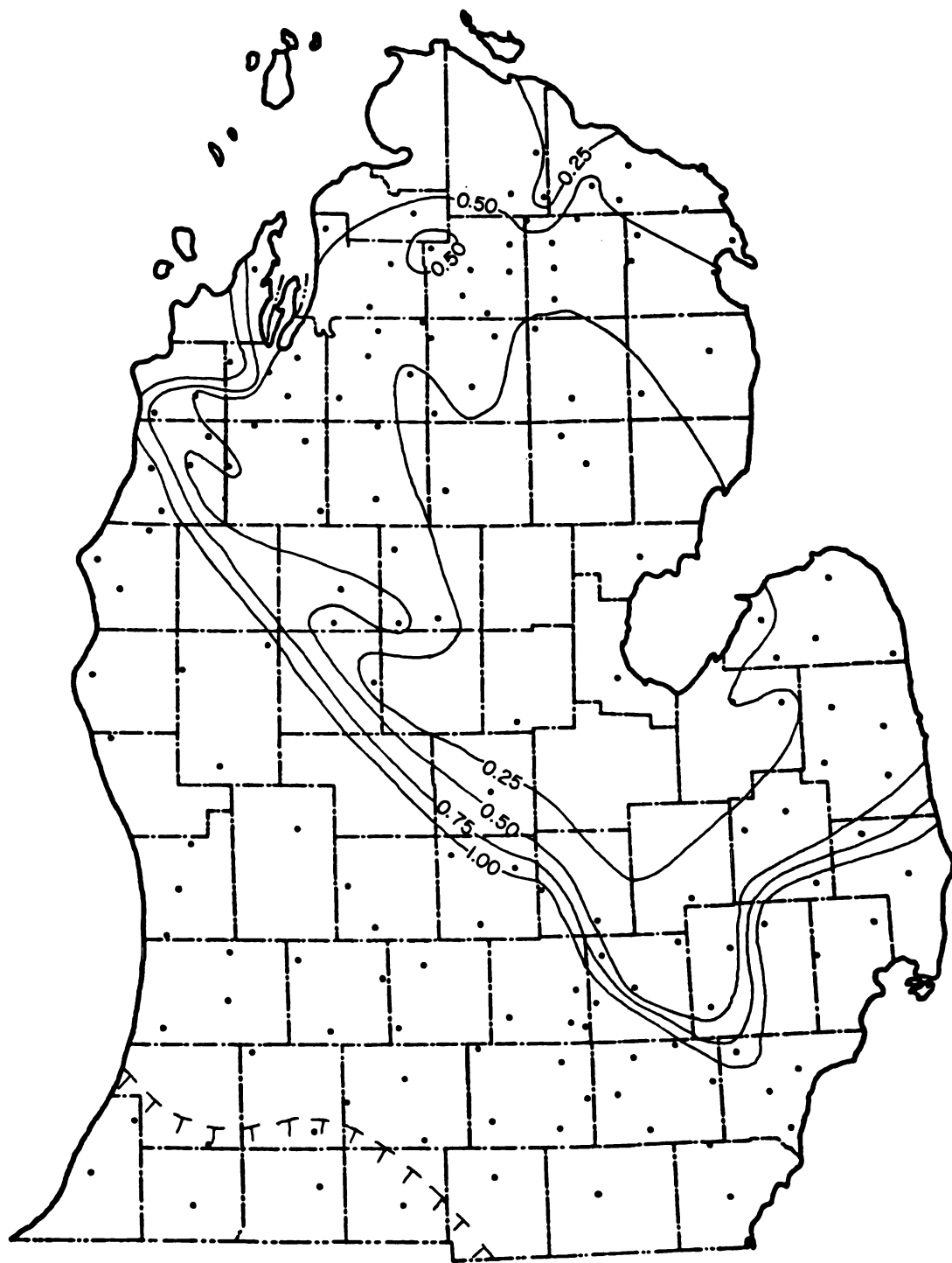
Isopach Unit F-5

Contour Interval: 20 feet

Scale: 1 inch = 40 miles

Truncated Area: T T T

Shirey 83



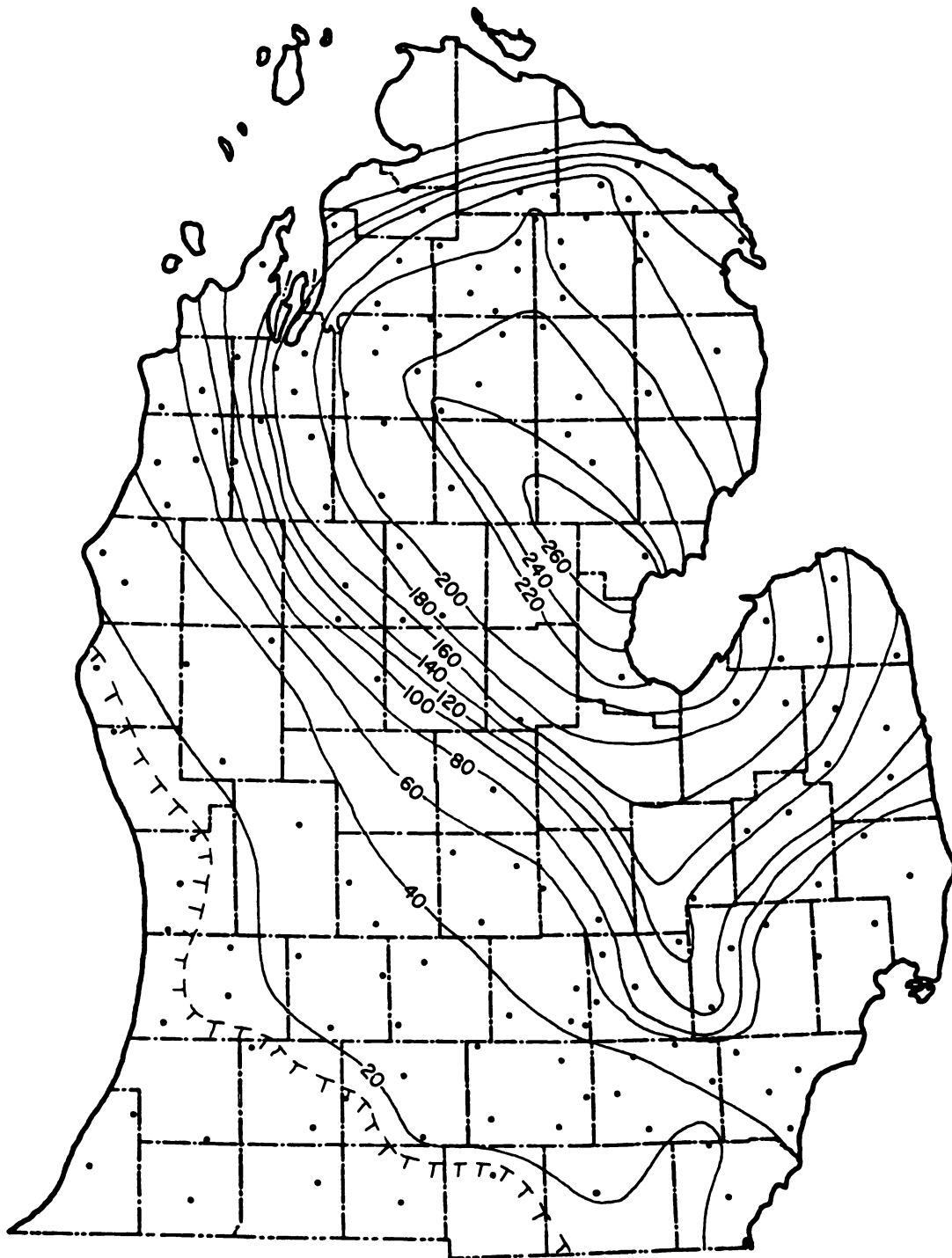
Map 5-2

Clastic Ratio Unit F-5

Contour Interval: 0.25  
Scale: 1 inch = 40 miles

Possible Channels: → → →  
Truncated Area: T T T

Shirey 83



Map 6-1

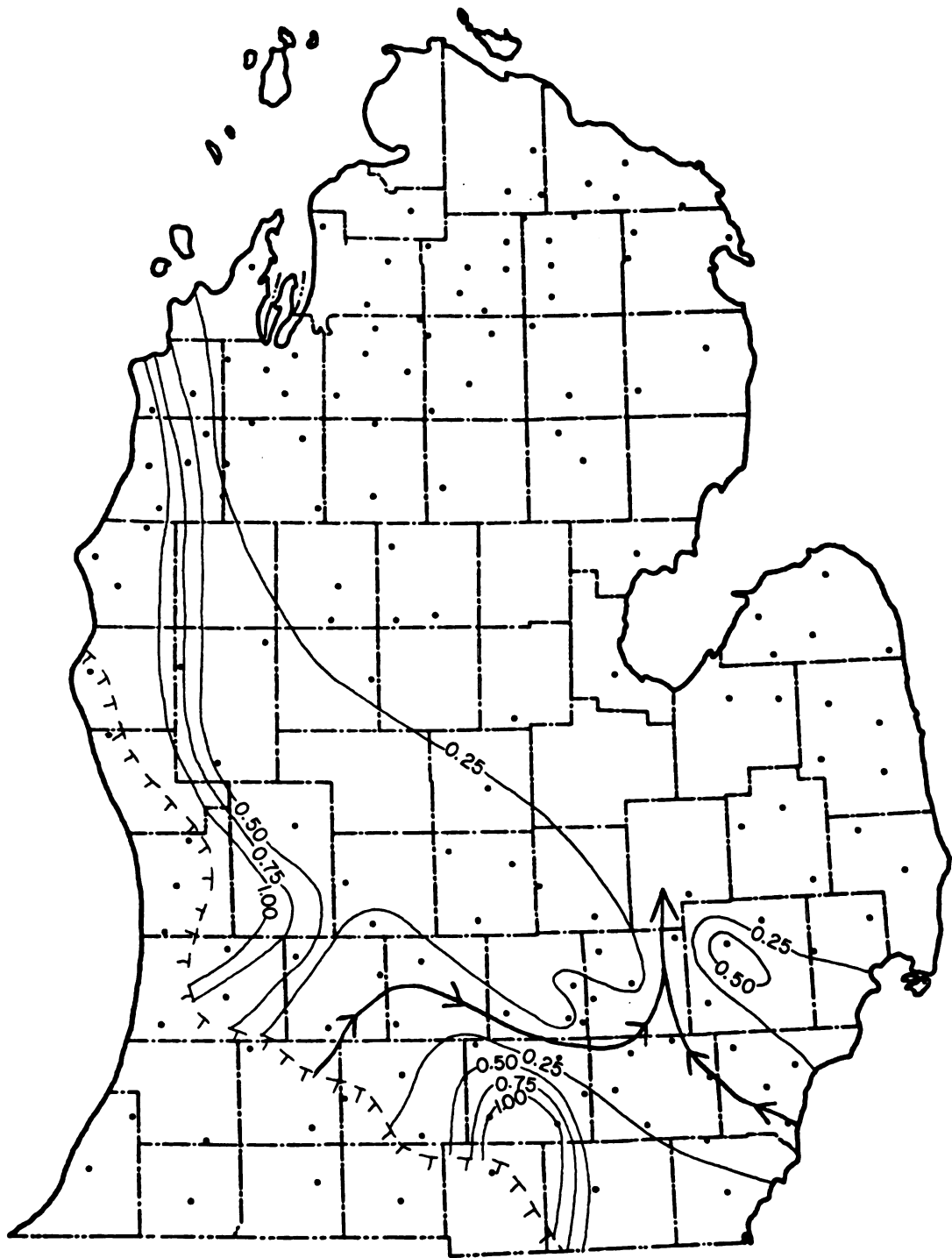
Isopach Unit F-6

Contour Interval: 20 feet

Scale: 1 inch = 40 miles

Truncated Area: TTT

Shirey 83



Map 6-2

Clastic Ratio Unit F-6

Contour Interval: 0.25  
 Scale: 1 inch = 40 miles

Possible Channels:   
 Truncated Area:   

Shirey 83

from an overlying carbonate bed, which in turn is topped by a thin anhydrite bed before yielding to the shales of the G-Unit.

The depocenter of the F-6 Unit is located in the Arenac County area where the F-6 Unit attained a recorded thickness of 266 feet in well #151. This sequence is by far the thickest unit of all the F-salt Units. Moving to the southwest from the depocenter, the F-6 Unit thins gradually from 266 feet to 140 feet before thinning to 80 feet in a short distance, denoting the hinge line, which is located even farther to the northeast than the previous units. Again the hinge line denotes a change in lithology from the evaporites of the Basin interior and the shelf sediments. However, in the case of the F-6 Unit, the shelf lithology is not one of massive and widespread clastic shales like units F-4 and F-5, but is more like the shelf lithology of units F-1 through F-3, with a mixture of clastic shales and non-clastic carbonates.

The Clastic Ratio Map of the F-6 Unit appears to delineate a possible channel or channels across the shelf zone in the areas of Wayne, Washtenaw and Livingston counties as well as in the areas of Jackson, Eaton, Barry and Calhoun counties, where a trend of low-clastic (high carbonate) is present, providing for influx of marine waters from outside the Basin. Again it is possible that the "trough" shown on the isopach map in Washtenaw and Livingston counties may indicate the presence of a scour channel. High levels of shale are present in the shelf area, being mainly in the Lenawee, Hillsdale and Jackson county areas in the south and along the western shoreline of Michigan ranging northward from Ottawa County to Benzie County. Again, these shale zones may indicate influence from the Kankakee and Wisconsin Arch complex, respectively.

Also of note is the expanded area of the southwest part of the state where the F-salts have been eroded. This area extends up the western side of the state and into Oceana County.

A note of interest in the F-6 Unit is the presence of a widespread and consistent thin anhydrite that tops the F-6 Unit. This anhydrite is present in all the wells used in the study that encompasses the Basin interior, except for well #151. This well is the closest to the depocenter of the Salina Basin and has the deepest and thickest column of recorded F-salts. The thin zone of anhydrite that normally tops the F-6 Unit is not present in the well, but is replaced by a 25 foot thick zone of salt. This salt zone is areally restricted to the depocenter and probably is evidence of a last remnant brine body that was confined to the deepest part of the Basin, before a return to a more normal marine depositional environment of the G-Shale and Bass Islands carbonates.

#### Observations on F-Salt Unit Maps

Review of the F-salt unit maps leads to several observations regarding the Basin shelf area and possible channels.

1. Low clastic, pronounced channel ways across the shelf area and into the Basin interior.
2. High clastic areas in the southwest and southeast, possibly indicating effects of channels leading into the shelf areas but not necessarily into the Basin interior. This could possibly represent influence of inlets/sags through the surrounding frame structure, carrying eroded frame structure clastics into and onto the shelf areas.
3. Thick isopach zone in Livingston and Oakland County area possibly reflects affects of the Chatham Sag.
4. Some isopach reflections in the southwest possibly reflect channel ways from surrounding frame structure.
5. In the scientific literature, some channel sag structures are indicated by high clastics (Kempany, 1976; Burns, 1962, on the

Chatham Sag) while other channels are indicated by low clastic sediments (Melhorn, 1968, for the Battle Creek Trough; Briggs et al., 1980, for the Clinton Inlet).

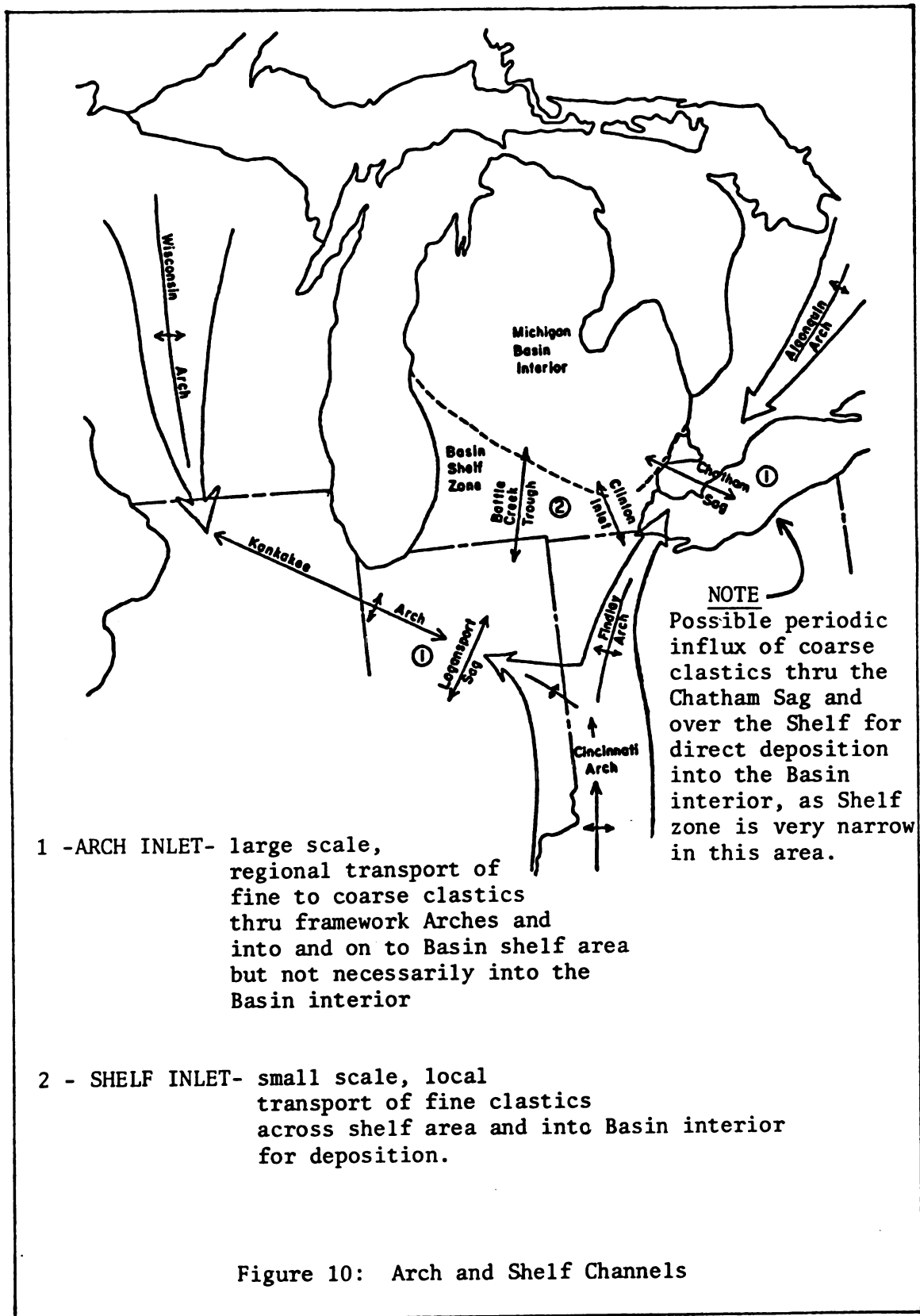
#### Possible Explanations of Observations

A review of the preceeding observations leads to the speculation on the possibility of two different types of inlets into the Michigan Basin area (Figure 10).

The first type of inlet is called the "Arch Inlet". This type of inlet is represented by such structures as the Chatham Sag and Logansport Sag and is represented in some studies by the presence of high clastics (Kembany, 1976; Burns, 1962; Gardner, 1974). These Arch Inlets connect the Michigan Basin to exterior environments by sags through the surrounding Arch complex, providing areas for clastics to cross the Arches and enter the Basin. These inlets are of a large scale, long-lasting existence, structurally evident and long lasting in their effects and influence.

The other type of inlet is called the "Shelf Inlet". This type of inlet is represented by the Battle Creek Trough (Melhorn, 1958) and the Clinton Inlet (Briggs and Gill et al., 1980) and are characterized by the presence of low clastic sediments. These inlets are of a smaller scale than the Arch Inlets and are confined to the Basin shelf areas, not extending through the surrounding Arch system. The affects and influences on the Basin are much less and smaller scale. These channels are shallower than Arch Inlets, are not as long lived or structurally as evident. These channels provide access across the shelf and into the Basin interior, unlike Arch Inlets which may not provide access directly into the Basin interior but only onto the Basin edge (Figure 10).

It is evident that more data is necessary before any opinions more definite than speculation can be made.



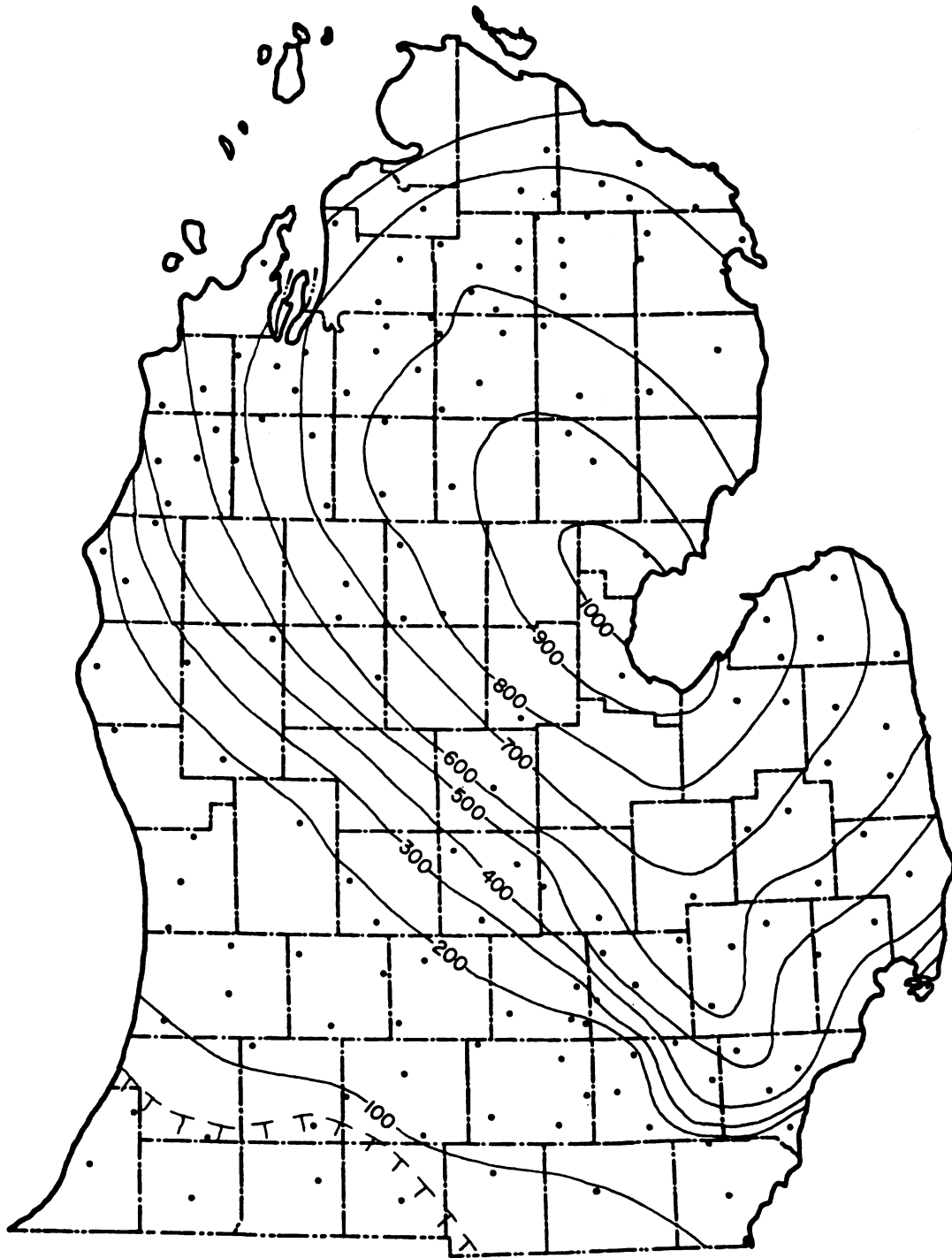
### Isopach Map - Total F-salt

Map 7 represents the total combined thickness of the entire F-salt section, comprising all six of the units that make up the F-salt section.

The map indicates an elongate, northwest-southeast trending depression, ranging from a thickness of 0 feet in the southwest to 1000 feet located in the area of Arenac County where the depocenter of the F-salts is located. Other features of the map are a flat wide area in the southwest of the Basin, between the 100 and 200 foot contours that represents the shelf platform area of the Basin. Another area is the zone of thickening sediments in the southeast area of the Basin, centered in the area of Livingston County and trending in a south-southeast direction, possibly indicating influence from the Chatham Sag. In all respects, the map indicates a depositional and structural pattern considered typical for a basinal structure. In the extreme southwest area of the basin, in the areas of Van Buren, Cass, Kalamazoo and St. Joseph counties, the F-salt formation disappears completely and abruptly upon truncation and erosion of the F-salt formation. This area was studied by Ells (1958) who concluded that the Salina F-salt section in this area was truncated due to post-depositional erosion of sediments. Ells believed the causes of the erosion could have been due to lower sea levels after the sediments were deposited or movement of the beds and possible uplift due to movement in the basement structure of the area.

### Structure Contour on Top of the E-Unit

The structure contour map on top of the E-Unit (Map 8) indicates the Michigan Basin to be a slightly elongate, northwest to southeast trending depression, centered in the Arenac-Bay County area. Relief on the Basin ranges from a high of +351 feet above sea level to a low of -6549 feet below sea level in the basin depocenter, representing a slope of about one-half a degree.



Map 7

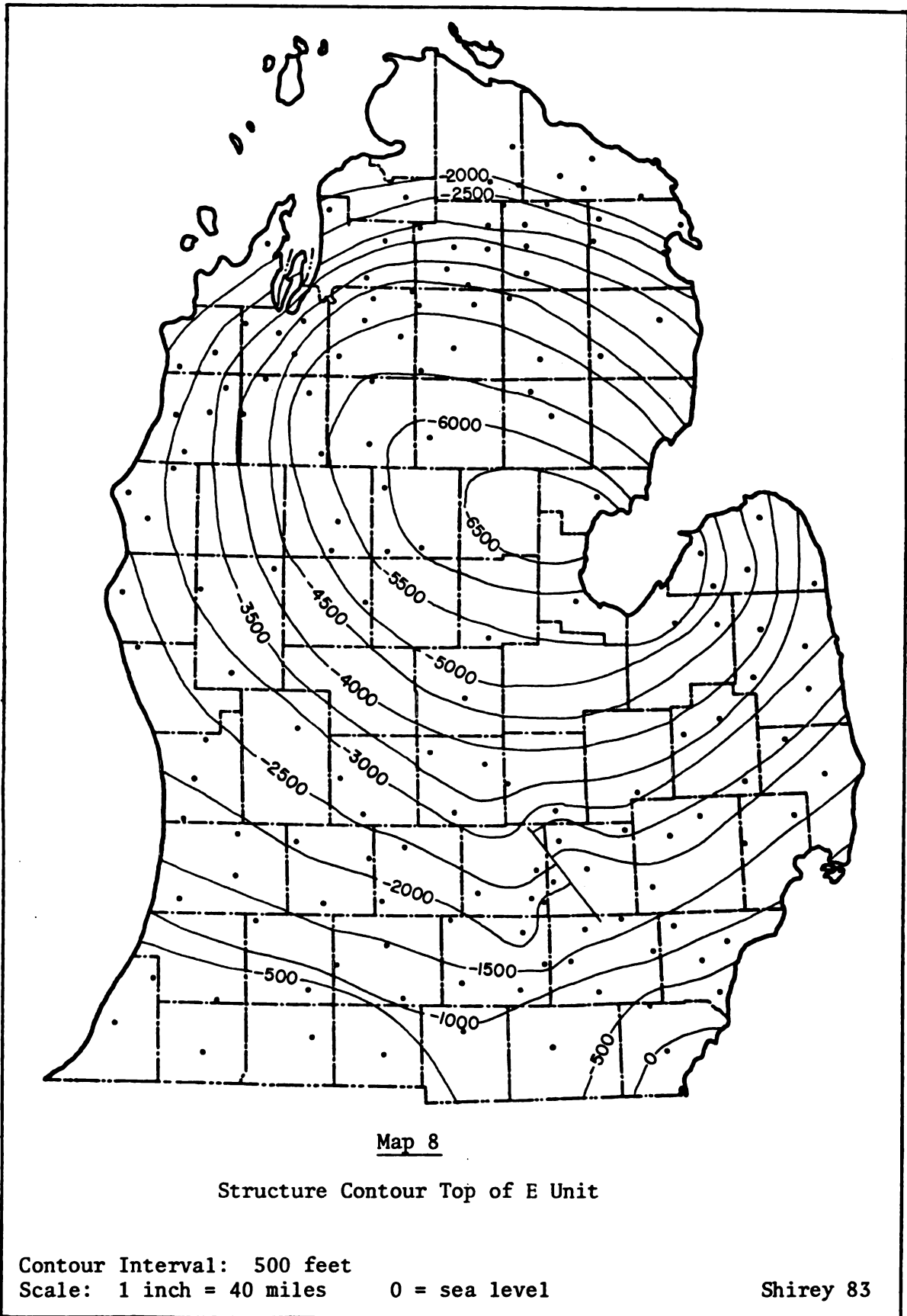
Isopach Total F-salts

Contour Interval: 100 feet

Scale: 1 inch = 40 miles

Truncated Area: T T T

Shirey 83



The only structure that shows a departure from the elongate basinal shape of F-salt time is the presence of the Howell and Lucas-Monroe Anticlines in the Livingston County area. Local study of this feature has been done (Paris, 1977) showing the relationship of the structures to the Basin sediments.

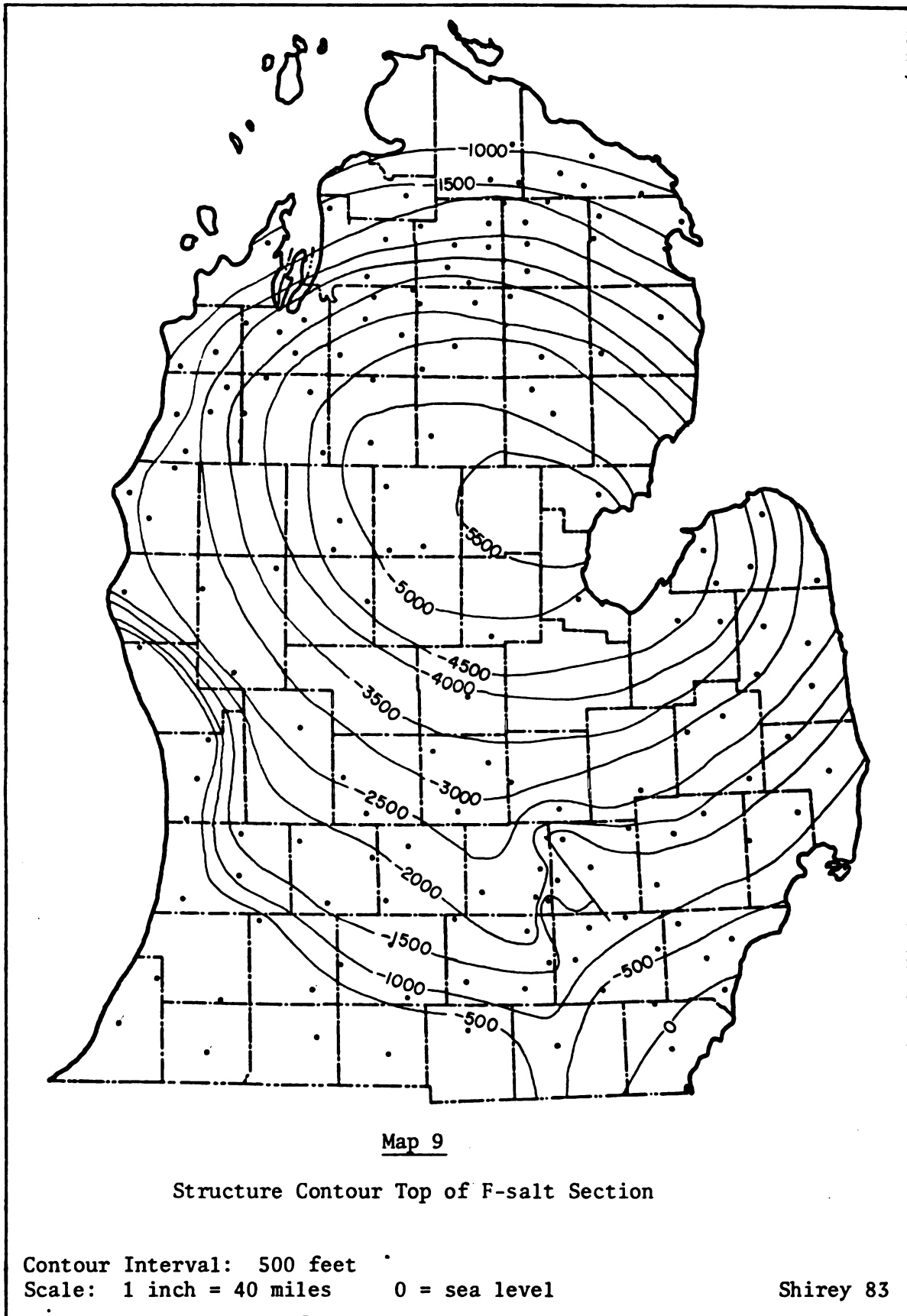
#### Structure Contour on Top of the F-Salts Unit

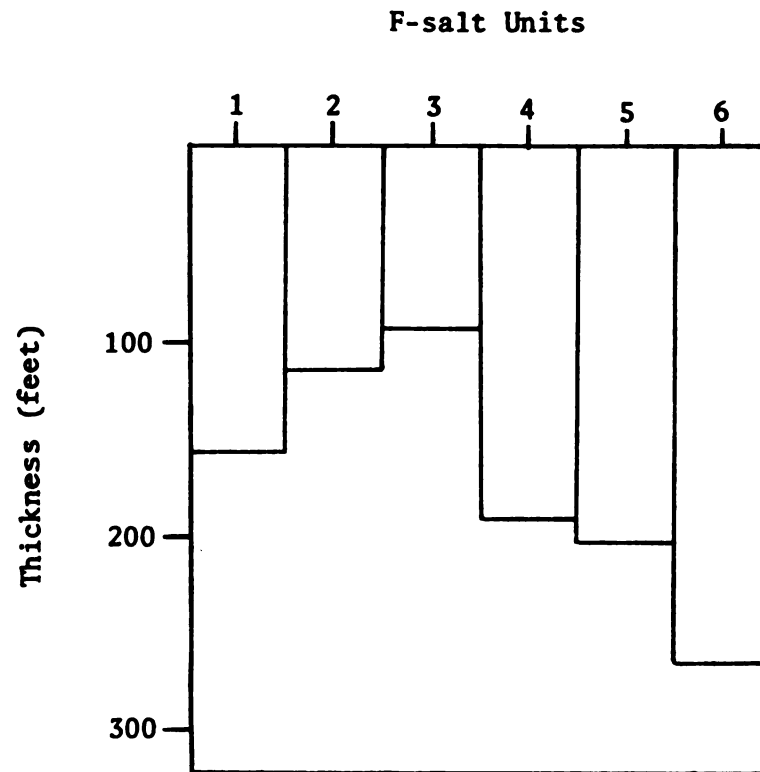
The structure contour map on top of the F-salt Unit (Map 9) shows very little change in the basin structure as represented by the E-Unit structure contour map. The structure of the Basin is still an elongate depression, trending northwest to southeast. The Howell and Lucas-Monroe Anticlinal features are still present. Relief on the F-salt Unit top ranges between +485 feet above sea level to -5549 feet below sea level in the depocenter, giving a slope of one-half a degree.

#### Chart of Depocenter Thickness

A chart of depocenter thicknesses (Figure 11) was constructed to help in further analysis of the Basin. This chart indicates continually thinner sequences of deposition for the F-salt units F-1 through F-3, then abruptly reverses and indicates continually thicker sequences of deposition for the units F-4 through F-6.

If one agrees with the theory supported by Rickard (1966) that Basin subsidence preceeds deposition in order to provide the necessary storage space for the rapidly deposited evaporites, then Figure 11 seems to indicate that for the F-salt units F-1 through F-3, the Michigan Basin was a relatively stable basin, slowly filling as the progressively thinner deposits of the early F units indicate. Approximately at the mid-point of F-salt deposition, between the F-3 and F-4 units, the Basin entered a period of subsidence as the progressively thicker beds of the F-4 through F-6 units may indicate.





**FIGURE 11: Thickness of F-salt Units at Depocenter**

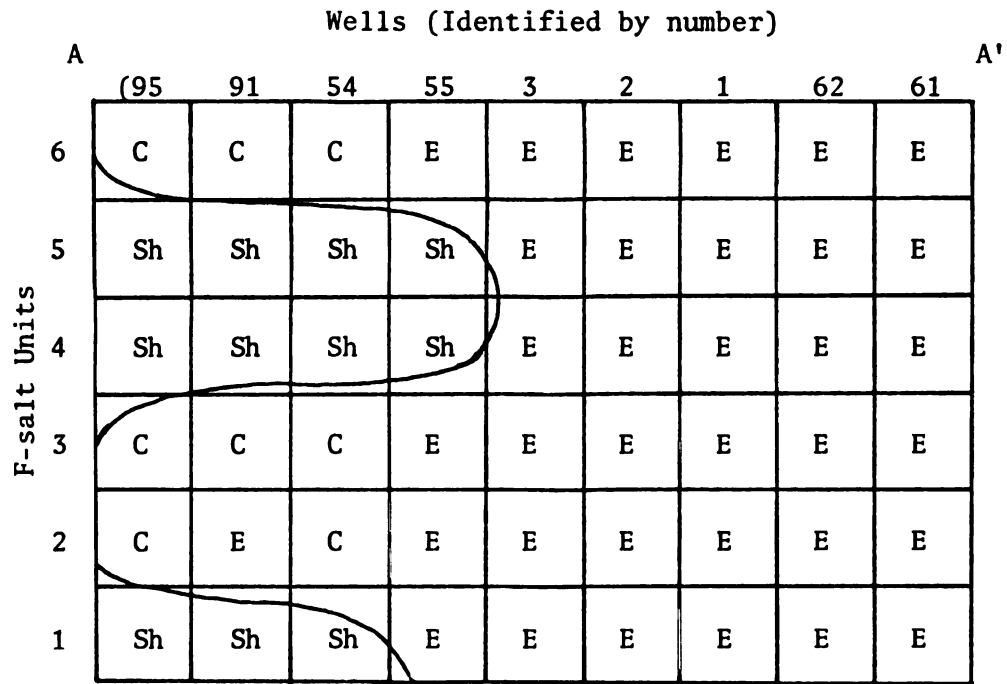
An alternative theory may be one that is more in line with the ideas set forth by Matthews and Egleson (1974). In this case, the early F-salt units, F-1 through F-3, may represent an environment of a "sediment-starved" Basin. In this case, while subsidence continued, maximum deposition was never obtained, possibly due to excessive water influx into the Basin and a lack of hypersaline conditions, resulting in the deposition of the carbonates of the early formations and less deposition of salts. This depositional environment may have resulted in a deepening Basin, providing the depth needed for future deposition and storage of the later F-salts.

Approximately midway in the F-salt deposition (F-3 to F-4), some geologic event occurred, as seems to be supported by the change in rim lithology and movement of the hinge line and depocenters. This would seem to indicate movement of the basement complex which may have resulted in the Basin becoming more isolated and restricted, leading to the development of more hypersaline conditions and deposition of more salts in the deepening Basin. This environment may have continued to the point where the depositing sediments eventually "caught up" with the subsiding Basin and finally filled the Basin.

#### Lithologic Cross-Section Through Time

A lithological cross-sectional chart was constructed (Figure 12), extending from the shelf into the center of the Basin (Map A, Index Map, cross-section A-A' for well locations). This cross-section indicates a dominant evaporite sequence for the Basin interior for all six of the F-salt units. The sequence for the shelf shows some interesting differences in lithology.

The dominant lithology of the shelf for F-salt unit F-1 is a mix of shales and carbonates. This lithology is also true for F-salt units F-2 and F-3. However, for F-salt units F-4 and F-5 the dominant shelf lithology has changed to a widespread shale that covers the entire shelf area. F-salt unit F-6 shows a



**FIGURE 12: Lithologic Cross-Section Through F-salt Time Cross-Section A-A'**  
(see Index Map for locations)

return to the shale and carbonate mix similar to the lithology of units F-1 through F-3.

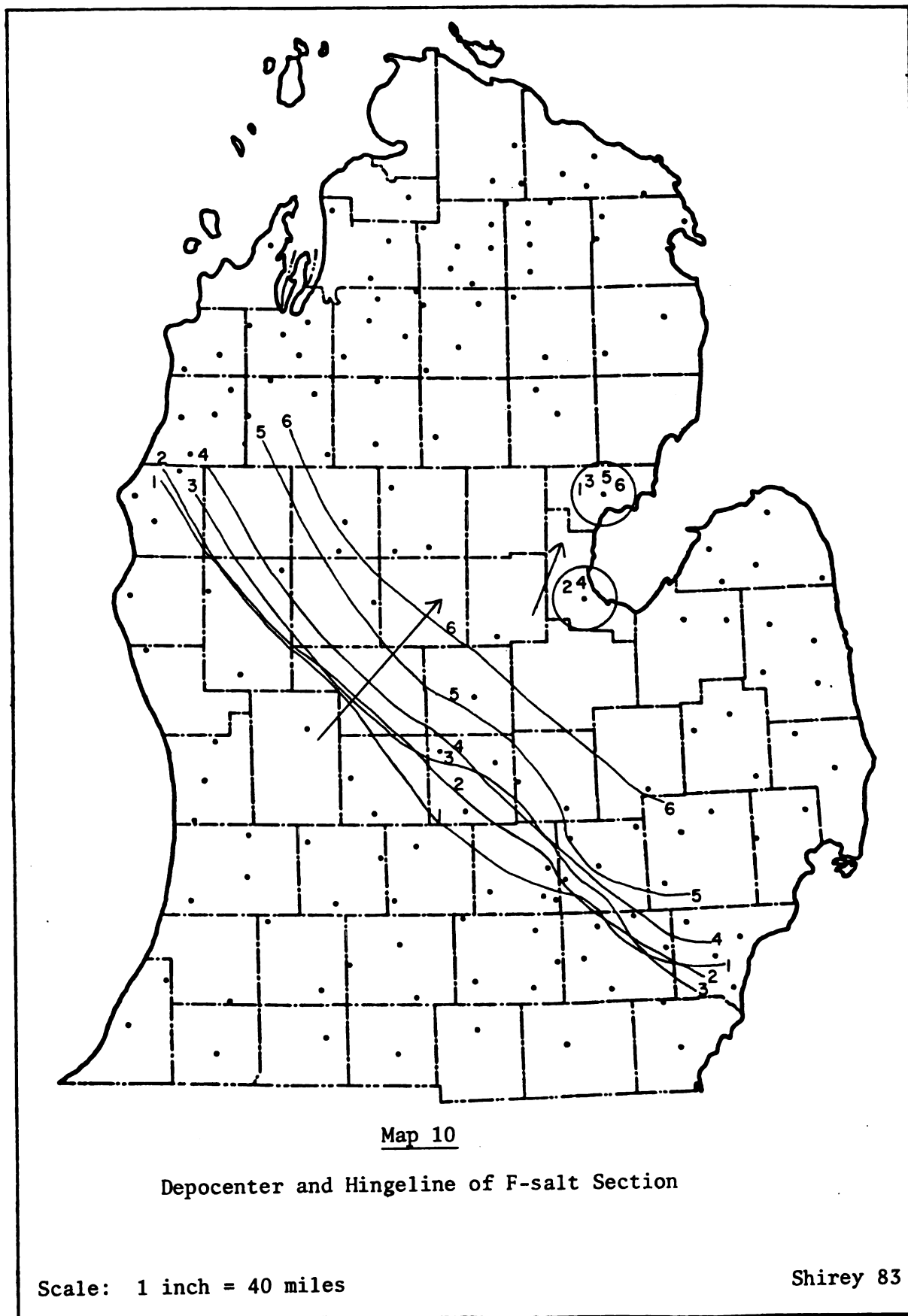
This variation in shelf lithology, from a mix of shale and carbonate to a shale, coincides with the possible Basin subsidence or tectonic activity which began at the time of the F-4 deposition. The increase in shale during F-4 and F-5 could be due to several possible occurrences: 1) The possible emergence of positive features such as surrounding arches, due to basement movement from external stresses; 2) basement movement resulting in subsidence and 3) low sea levels resulting in exposure of surrounding areas to erosion and deposition of reworked sediments.

#### Depocenter and Hinge Line Map

The depocenter and hinge line map (Map 10) comprises the depocenter locations where the thickest deposits of each of the six units was found. The map also shows the locations of the hinge line for each of the six units. The hinge line is where the unit thins abruptly and the lithology changes from the dominant evaporites of the Basin interior to the lithology of the shelf areas.

Depocenters. The depocenters of each of the six units of the F-salts has remained relatively steady in the Arenac-Bay county areas. However, individual analysis of each unit depocenter does indicate variations of the depocenters within the area as follows:

- F-1: centered in Arenac County
- F-2: centered in Bay County
- F-3: centered in Arenac County
- F-4: centered in Bay County
- F-5: centered in Arenac County
- F-6: centered in Arenac County



This map indicates general shifting back and forth of depocenters between Arenac and Bay counties for F-salt units 1 through 4, before a trend to the northeast, from Bay County to Arenac County, is noted for F-salt units 5 and 6. This shift of depocenters generally coincides with the time of basin subsidence and change in platform lithology.

Hinge Line. The depocenter-hinge line map also shows the locations of the structural and lithological hinge lines for each of the six units of the F-salts. The approximate location of the hinge lines, which separates the basin interior from the platform shelf areas, trends in a general northwest to southeast direction, starting in the area of Mason County and trending southeast into Washtenaw and Wayne counties. This hinge line remained relatively stable through units F-1 through F-3 then began moving to the northeast for units F-4 through F-6. The location for the hinge line was taken as the line that represents the midpoint of the area of abrupt thinning for each unit.

This shift of the hinge line for F-salts units 4 through 6 toward the northeast coincides with the time of basin subsidence and movement of the depocenters to the northeast and the influx of shales into the platform areas.

## CONCLUSIONS

The F-salt sequence of the Michigan Basin represents the last evaporite environment of the Salina Group in Michigan. Previous studies have shown that at the beginning of F-salt deposition, the Michigan Basin was already established as an isolated to semi-isolated basin, connected by channels to marine environments exterior to the Basin. Massive evaporites of the A and B salts had already been deposited and with units C, D and E had essentially filled the Basin by F-salt time. By the time of the F-salt episode, the Basin was for all practical purposes a stable, filled Basin, with the interior dominated by evaporites and the rim areas consisting of a mixture of shales and carbonates.

The results of this study on the period of F-salt deposition indicate that for the beginning and early part of F-salt deposition (F-salt units F-1 to F-3), this lithology held true for both the interior and the shelf area. The shelf zone was composed of a mix of shales and carbonates. Connecting channels were present across the shelf zone to join the Michigan Basin with exterior marine environments, allowing exchange and interaction of marine waters. Progressively thinner beds of units F-1 through F-3 may be indicative of either a less than hypersaline depositional environment partly due to the connecting channels or indications of a stable, filling Basin, allowing progressively less area for deposition and storage of evaporites.

A definite change occurred approximately midway through the F-salt period (F-salt units F-3 to F-4). Evidence seems to indicate possibly some extra-basinal stress was brought to bear on the basement complex, reactivating the frame structure of the Basin and surrounding area and affecting the

conditions of deposition within the Basin. The evidence consists of the following, derived from this study.

An abrupt increase in deposition of the later F-salt units F-4 through unit F-6, represented by the thicker beds of these units as compared to the progressively thinner beds of the early F-salt units. This change may also be indicative of a period of subsidence occurring within the Basin, possibly activated by basement stresses.

A slight but noticable shift of both the Basin-shelf hinge line and the depocenters of each F-salt unit to the northeast for the units F-4 through F-6, possibly due to basement activity.

Widespread clastic shales over the shelf area for F-salt units F-4 and F-5 may be indicative of either lower sea levels exposing outlying areas to erosion or tectonic reactivation of the basement complex may have led to uplift and exposure of once positive structures, providing a shale source to the Basin shelf.

The apparent lack of connecting channels across the shelf area of the Basin may have lead to increased restriction of the Basin waters as they had no means of mixing with marine waters exterior to the Basin, leading to increased deposition and therefore thicker beds of the F-salt units F-4 through F-6.

These changes in Basin lithology were persistent for units F-4 and F-5. By the time of unit F-6 deposition, the lithology had returned to a depositional environment similar to the environment of the early F-salt units F-1 through F-3, namely an environment of mixed clastic shales and non-clastic carbonates in the shelf area, with a connecting channel across the shelf zone allowing exchange of waters into and out of the Basin. Deposition within the Basin eventually "caught up" with subsidence; or subsidence ceased, allowing deposition to catch up, as the depositional environment toward the end of F-6 deposition approached a more normal marine situation, with widespread carbonates across

the entire Basin and a limited remnant brine body confined to the depocenter area of the Basin.

Further study is needed, both on a smaller, local scale and on a larger, regional scale as more data becomes available to further tie in the Salina F-salts with other events at this time. This study, being of a Basin-wide scale, of necessity could not go into smaller details of deposition or more detailed study in a given area of the Basin, precluding any extensive work on areas of salt dissolution and collapse features. The scale and density used in this study did not reveal any such features as the above, which are known to exist and would possibly appear in areas where more detailed study could be made.

While studies of a Group-wide nature reveal much information, studies of a much smaller, briefer period, such as this study, can also reveal much information that may be overlooked or overshadowed in a larger-scale study. This information may fill in some areas that are lacking or provide more detail on areas that are only touched briefly in larger studies of a Group-wide nature and may be correlated with events that have been documented as occurring on a Group-wide basis.

## RECOMMENDED AREAS FOR FURTHER STUDY

Further areas for study that became evident from this study include the following:

1. More detailed work on the Chatham Sag area and its influence on the Michigan Basin during F-salt time.
2. Extended work to the north and northeast, possibly into Canada for influences to the Basin from this direction, as seemed to be hinted in this study.
3. Study to the south, southwest and southeast in the shelf areas and adjoining states to determine if the speculations concerning the shelf inlets can be better documented.
4. Study to the west, possibly into Wisconsin, to determine more data on the clastics that seem to have originated from this direction and are present on the west side of the Basin.
5. Detailed study in the area of the Basin-shelf hinge line to determine more exactly what influence the hinge had on the lithology of the shelf and Basin interior.
6. More detailed study on the F-salts in relation to Matthews and Egleson's (1974) theory on migrating and cyclic brine bodies and various cycles that may be present within the F-salts.

## BIBLIOGRAPHY

## BIBLIOGRAPHY

- Alling, H. L. and Briggs, L. I., 1961. Stratigraphy of Upper Silurian Cayugan Evaporites. AAPG Bull., v. 45, no. 4, p. 515-547.
- Briggs, L. I. and Lucas, P. T., 1954. Mechanism of Salina Salt Deposition in the Michigan Basin. Geol. Soc. Am. Bull., v. 65, no. 12, p. 1233.
- Briggs, L. I., 1957. Quantitative Aspects of Evaporite Deposition. Mich. Acad. Sci., Arts and Letters, v. XLII, p. 115-123.
- Briggs, L. I. and Pollack, H. N., 1967. Digital Model of Evaporite Sedimentation. Science, v. 55, no. 3761, p. 453-456.
- Briggs, Gill, Briggs and Elmore, 1980. Transition from Open Marine to Evaporite Deposition in the Silurian Michigan Basin, in "Hypersaline Brines and Evaporite Environments". Elsevier Scientific Publishing Company, Amsterdam.
- Burns, J. W., 1962. Regional Study of the Upper Silurian Salina Evaporites in the Michigan Basin. M.S. Thesis, Michigan State University.
- Cohee, G. V. and Landes, K. K., 1958. Oil in the Michigan Basin, in Habitat of Oil. AAPG Symposium, p. 413-493.
- Dellwig, L. F., 1954. Origin of the Salina Salt of Michigan. Jour. Sed. Petrology, v. 25, no. 2, p. 83-110.
- Dresser-Atlas Logging Systems Manuals, 1) Log Review I, 1974; 2) Log Interpretation Fundamentals, 1975.
- Droste, J. B. and Shaver, R. H., 1977. Synchronization of Deposition: Silurian Reef-bearing Rocks on the Wabash Platform with Cyclic Evaporites of the Michigan Basin. Studies in Geology, no. 5, AAPG, p. 93-109.
- Ells, G. D., 1967. Michigan's Silurian Oil and Gas Pools. Rept. Invest. #2, Mich. Geol. Surv. Publ.
- \_\_\_\_\_, 1958. Notes on the Devonian in the Subsurface of Southwestern Michigan. Mich. Geol. Surv. Prog. Rept. #18.
- Evans, C. S., 1950. Underground Hunting in the Silurian of Southwestern Ontario. Proc. Geol. Assoc. Canada, v. 3, p. 55-85.
- Fettke, C. R., 1948. Subsurface Trenton and Sub-Trenton Rocks in Ohio, New York, Pennsylvania and West Virginia. AAPG Bull., v. 72, no. 8, p. 1457-1492.

- Fisher, J. H., 1969. Early Paleozoic History of the Michigan Basin. Mich. Basin Geol. Soc. Ann. Field Excursion, p. 89-95.
- Fisher, 1969. Stratigraphic Cross-Sections of the Michigan Basin. Mich. Basin Geol. Soc. Spec. Publ.
- Gardner, 1974. Devonian Sediments of the Michigan Basin. Mich. Basin Geol. Soc. Spec. Publ.
- Hinze and Merritt, 1969. Basement Rocks of the Southern Peninsula of Michigan. Mich. Basin Geol. Soc. Ann. Field Excursion, p. 28-59.
- Johnson, K. S. and Gonzales, S., 1978. Salt Deposits in the U.S. and Regional Geologic Characteristics Important for Storage of Radioactive Waste. Rept. for Union Carbide Corp., Nuclear Division, U.S. Dept. of Energy, p. 13-38.
- Kaufmann, D. W. and Slawson, C. B., 1950. Ripple Mark in Rock Salt of the Salina Formation. Jour. Geology, v. 58, p. 24-29.
- Kay, M., 1951. North American Geosynclines. Geol. Soc. Amer., Mem. #8.
- Kempany, R. G., 1976. Subsurface Analysis of the Middle Devonian Sylvania Sandstone in the Michigan Basin. M.S. Thesis, Michigan State University.
- King, R. H., 1947. Sedimentation in Permian Castile Sea. AAPG Bull., v. 31, p. 470-477.
- Krumbein, Sloss, and Dapples, 1949. Sedimentary Tectonics and Sedimentary Environments. AAPG, v. 33, p. 1859-1891.
- Landes, K. K., 1945. Salina and Bass Islands Rocks in the Michigan Basin. U.S.G.S. Oil and Gas Invest., Prelim. Map 40.
- Lilianthal, R. T., 1978. Stratigraphic Cross-Sections of the Michigan Basin. Rept. Invest. 19, Mich. Geol. Surv. Publ.
- Lockett, J. R., 1947. Development of Structures in Basin Areas of Northeast United States. AAPG Bull., v. 31, p. 429-446.
- Matthews and Egleson, 1974. Origin and Implications of a Mid-Basin Potash Facies in the Salina Salt of Michigan. 4th Intl. Symposium on Salt, p. 15-34.
- Melhorn, W. N., 1958. Stratigraphic Analysis of Silurian Rocks in the Michigan Basin. AAPG Bull., v. 42, no. 4, p. 816-838.
- Mesollela, et al., 1974. Cyclic Deposition of Silurian Carbonates and Evaporites in the Michigan Basin. AAPG Bull., v. 58, p. 34-62.
- Newcombe, R. B., 1933. Oil and Gas Fields of Michigan. Mich. Geol. Surv. Div. Publ. 38.

- Nurmi, R. D. and Friedman, G. M., 1975. Sedimentology and Diagenesis of Lower Salina Group (Upper Silurian) Evaporites in Michigan Basin. AAPG, v. 59, no. 9, p. 1738.
- Pannekoek, A. J., 1965. Shallow Water and Deep Water Evaporite Deposition - a discussion. Amer. Jour. Sci., v. 263, p. 284-285.
- Paris, R. M., 1977. Developmental History of the Howell Anticline. M.S. Thesis, Michigan State University.
- Pirtle, G. W., 1932. Michigan Structural Basin and its Relationship to Surrounding Areas. AAPG Bull., v. 16, p. 145-152.
- Prouty, C. E., 1970, 1972, 1976. Personal communication.
- Rickard, L. V., 1966. Gamma-Ray Logs and the Origin of Salt. 3rd Symposium on Salt, N. Ohio Geol. Soc., p. 34-39.
- Schlumberger Logging Manuals. 1) Production Log Interpretation, 1973; 2) Log Interpretation Charts, 1977; 3) Log Interpretation Vol. II -Applications, 1974.
- Scruton, P. C., 1953. Deposition of Evaporites. AAPG Bull., v. 37, p. 2498-2512.
- Sloss, L. L. and Krumbein, W. D., 1955. Stratigraphy and Sedimentation. W. H. Freeman and Company, San Francisco, California.

## **APPENDIX**

# DATA

|       | Elev. | Thick. | %Sh             | %E | %C | Clastic Ratio |       |
|-------|-------|--------|-----------------|----|----|---------------|-------|
| 31386 |       |        | Bay 14N4E2      |    |    |               | #1    |
| KB    | 607   |        |                 |    |    |               |       |
| E     | 5808  |        |                 |    |    |               |       |
| F     |       | 980    |                 |    |    |               |       |
| 6     | 4828  | 234    | 4               | 87 | 9  | 10/224        | .0446 |
| 5     | 5062  | 201    | 18              | 61 | 4  | 37/164        | .2256 |
| 4     | 5263  | 193    | 12              | 63 | 25 | 24/169        | .1420 |
| 3     | 5456  | 85     | 18              | 74 | 8  | 15/70         | .2142 |
| 2     | 5541  | 110    | 22              | 72 | 6  | 24/86         | .2790 |
| 1     | 5651  | 157    | 13              | 77 | 10 | 21/136        | .1544 |
| 23849 |       |        | Midland 13N1W21 |    |    |               | #2    |
| KB    | 695   |        |                 |    |    |               |       |
| E     | 5468  |        |                 |    |    |               |       |
| F     |       | 794    |                 |    |    |               |       |
| 6     | 4674  | 168    | 6               | 70 | 24 | 10/158        | .0632 |
| 5     | 4842  | 151    | 19              | 52 | 29 | 30/127        | .2362 |
| 4     | 4999  | 154    | 15              | 47 | 38 | 24/130        | .1846 |
| 3     | 5153  | 71     | 14              | 68 | 18 | 10/61         | .1639 |
| 2     | 5224  | 103    | 14              | 61 | 25 | 14/89         | .1573 |
| 1     | 5327  | 141    | 12              | 71 | 17 | 17/124        | .1370 |
| 29739 |       |        | Gratiot 10N2W8  |    |    |               | #3    |
| KB    | 761   |        |                 |    |    |               |       |
| E     | 4504  |        |                 |    |    |               |       |
| F     |       | 611    |                 |    |    |               |       |
| 6     | 3893  | 66     | 24              | 58 | 18 | 16/50         | .3200 |
| 5     | 3959  | 131    | 27              | 40 | 33 | 36/95         | .3789 |
| 4     | 4090  | 127    | 19              | 48 | 33 | 24/103        | .2330 |
| 3     | 4217  | 66     | 8               | 77 | 15 | 5/61          | .0819 |
| 2     | 4283  | 87     | 24              | 67 | 9  | 21/66         | .3181 |
| 1     | 4370  | 134    | 14              | 74 | 12 | 19/115        | .1652 |
| 25099 |       |        | Ogemaw 24N2E28  |    |    |               | #4    |
| KB    | 1477  |        |                 |    |    |               |       |
| E     | 5289  |        |                 |    |    |               |       |
| F     |       | 901    |                 |    |    |               |       |
| 6     | 4388  | 233    | 4               | 67 | 19 | 9/224         | .0401 |
| 5     | 4621  | 181    | 15              | 41 | 44 | 27/154        | .1753 |
| 4     | 4802  | 153    | 19              | 40 | 41 | 29/124        | .2338 |
| 3     | 4955  | 86     | 9               | 66 | 25 | 8/78          | .1025 |
| 2     | 5041  | 102    | 16              | 62 | 22 | 16/86         | .1860 |
| 1     | 5143  | 146    | 14              | 56 | 30 | 21/125        | .1680 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh            | %E | %C | Clastic Ratio |       |
|-------|-------|--------|----------------|----|----|---------------|-------|
| 28456 |       |        | Ogemaw 23N3E28 |    |    |               | #5    |
| KB    | 878   |        |                |    |    |               |       |
| E     | 5653  |        |                |    |    |               |       |
| F     |       | 918    |                |    |    |               |       |
| 6     | 4735  | 235    | 3              | 72 | 25 | 8/227         | .0352 |
| 5     | 4970  | 188    | 14             | 39 | 47 | 27/161        | .1677 |
| 4     | 5258  | 157    | 12             | 44 | 44 | 17/140        | .1214 |
| 3     | 5316  | 87     | 21             | 52 | 27 | 18/69         | .2608 |
| 2     | 5402  | 93     | 25             | 48 | 27 | 23/70         | .3285 |
| 1     | 5495  | 158    | 14             | 64 | 22 | 21/137        | .1532 |
| 28294 |       |        | Oscoda 25N2E12 |    |    |               | #6    |
| KB    | 1145  |        |                |    |    |               |       |
| E     | 5463  |        |                |    |    |               |       |
| F     |       | 878    |                |    |    |               |       |
| 6     | 4585  | 229    | 4              | 81 | 15 |               | .0456 |
| 5     | 4814  | 171    | 18             | 40 | 41 |               | .2127 |
| 4     | 4985  | 150    | 13             | 66 | 21 |               | .1538 |
| 3     | 5135  | 85     | 17             | 73 | 10 |               | .2083 |
| 2     | 5220  | 95     | 16             | 44 | 40 |               | .1875 |
| 1     | 5315  | 148    | 13             | 68 | 19 |               | .1562 |
| 28546 |       |        | Oscoda 28N1E16 |    |    |               | #7    |
| KB    | 1243  |        |                |    |    |               |       |
| E     | 4752  |        |                |    |    |               |       |
| F     |       | 856    |                |    |    |               |       |
| 6     | 3896  | 234    | 3              | 60 | 37 | 7/227         | .0308 |
| 5     | 4130  | 162    | 15             | 42 | 43 | 25/137        | .1824 |
| 4     | 4292  | 145    | 14             | 72 | 14 | 21/124        | .1693 |
| 3     | 4437  | 80     | 10             | 73 | 17 | 8/72          | .1111 |
| 2     | 4517  | 105    | 20             | 51 | 29 | 21/84         | .2500 |
| 1     | 4622  | 130    | 13             | 74 | 13 | 17/113        | .1504 |
| 24359 |       |        | Alcona 27N8E20 |    |    |               | #8    |
| KB    | 912   |        |                |    |    |               |       |
| E     | 3599  |        |                |    |    |               |       |
| F     |       | 763    |                |    |    |               |       |
| 6     | 2836  | 178    | 5              | 57 | 38 | 9/169         | .0532 |
| 5     | 3014  | 144    | 22             | 45 | 33 | 31/113        | .2743 |
| 4     | 3158  | 138    | 21             | 35 | 44 | 29/109        | .2660 |
| 3     | 3296  | 77     | 34             | 57 | 9  | 26/51         | .5098 |
| 2     | 3373  | 87     | 15             | 72 | 13 | 13/74         | .1756 |
| 1     | 3460  | 139    | 12             | 71 | 17 | 17/122        | .1393 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio |
|-------|-------|--------|------------------|----|----|---------|-------|
| 29036 |       |        | Crawford 28N2W26 |    |    |         | #9    |
| KB    | 1293  |        |                  |    |    |         |       |
| E     | 4721  |        |                  |    |    |         |       |
| F     |       | 839    |                  |    |    |         |       |
| 6     | 3882  | 225    | 3                | 72 | 25 | 7/218   | .0321 |
| 5     | 4107  | 160    | 25               | 46 | 29 | 40/120  | .3333 |
| 4     | 4267  | 143    | 14               | 43 | 43 | 21/122  | .1721 |
| 3     | 4410  | 70     | 9                | 38 | 53 | 6/64    | .0937 |
| 2     | 4480  | 113    | 18               | 55 | 27 | 21/92   | .2282 |
| 1     | 4593  | 128    | 12               | 76 | 12 | 15/113  | .1327 |
| 28862 |       |        | Crawford 26N3W36 |    |    |         | #10   |
| KB    | 1242  |        |                  |    |    |         |       |
| E     | 5398  |        |                  |    |    |         |       |
| F     |       | 844    |                  |    |    |         |       |
| 6     | 4554  | 221    | 4                | 66 | 30 | 9/212   | .0424 |
| 5     | 4775  | 167    | 26               | 40 | 34 | 43/124  | .3467 |
| 4     | 4942  | 144    | 12               | 63 | 25 | 17/127  | .1338 |
| 3     | 5086  | 77     | 18               | 60 | 22 | 14/63   | .2222 |
| 2     | 5163  | 105    | 15               | 44 | 41 | 16/89   | .1797 |
| 1     | 5268  | 130    | 13               | 72 | 15 | 17/113  | .1504 |
| 28187 |       |        | Kalkaska 26N5W16 |    |    |         | #11   |
| KB    | 1124  |        |                  |    |    |         |       |
| E     | 5193  |        |                  |    |    |         |       |
| F     |       | 879    |                  |    |    |         |       |
| 6     | 4314  | 239    | 3                | 62 | 35 | 8/231   | .0346 |
| 5     | 4553  | 167    | 18               | 38 | 44 | 30/137  | .2189 |
| 4     | 4720  | 144    | 14               | 38 | 48 | 20/124  | .1612 |
| 3     | 4864  | 84     | 10               | 45 | 45 | 8/76    | .1052 |
| 2     | 4948  | 111    | 18               | 38 | 44 | 20/91   | .2197 |
| 1     | 5059  | 134    | 13               | 67 | 20 | 17/117  | .1452 |
| 31656 |       |        | Kalkaska 27N7W23 |    |    |         | #12   |
| KB    | 1093  |        |                  |    |    |         |       |
| E     | 4731  |        |                  |    |    |         |       |
| F     |       | 779    |                  |    |    |         |       |
| 6     | 3952  | 205    | 5                | 61 | 34 | 10/195  | .0512 |
| 5     | 4157  | 143    | 29               | 34 | 37 | 42/101  | .4258 |
| 4     | 4300  | 138    | 19               | 27 | 54 | 26/112  | .2321 |
| 3     | 4438  | 73     | 11               | 41 | 48 | 8/65    | .1230 |
| 2     | 4511  | 104    | 25               | 44 | 31 | 26/78   | .3333 |
| 1     | 4615  | 116    | 17               | 65 | 18 | 20/96   | .2083 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio |
|-------|-------|--------|------------------|----|----|---------|-------|
| 28325 |       |        | Kalkaska 28N5W1  |    |    |         | #13   |
| lg    | 1211  |        |                  |    |    |         |       |
| E     | 4433  |        |                  |    |    |         |       |
| F     |       | 781    |                  |    |    |         |       |
| 6     | 3652  | 207    | 5                | 74 | 21 | 10/197  | .0507 |
| 5     | 3859  | 146    | 30               | 40 | 30 | 44/102  | .4313 |
| 4     | 4005  | 131    | 13               | 59 | 28 | 17/114  | .1491 |
| 3     | 4136  | 73     | 14               | 55 | 31 | 10/63   | .1587 |
| 2     | 4209  | 101    | 26               | 35 | 39 | 27/74   | .3648 |
| 1     | 4310  | 123    | 13               | 61 | 26 | 16/107  | .1495 |
| 24543 |       |        | Kalkaska 25N8W10 |    |    |         | #14   |
| KB    | 1135  |        |                  |    |    |         |       |
| E     | 5148  |        |                  |    |    |         |       |
| F     |       | 778    |                  |    |    |         |       |
| 6     | 4370  | 200    | 5                | 59 | 36 | 10/190  | .0526 |
| 5     | 4570  | 146    | 27               | 24 | 49 | 40/106  | .3773 |
| 4     | 4716  | 135    | 17               | 44 | 39 | 23/112  | .2053 |
| 3     | 4851  | 76     | 12               | 53 | 35 | 9/67    | .1343 |
| 2     | 4929  | 106    | 24               | 54 | 22 | 26/80   | .3250 |
| 1     | 5063  | 115    | 15               | 70 | 15 | 18/97   | .1855 |
| 28535 |       |        | Wexford 24N9W31  |    |    |         | #15   |
| KB    | 1160  |        |                  |    |    |         |       |
| E     | 5111  |        |                  |    |    |         |       |
| F     |       | 726    |                  |    |    |         |       |
| 6     | 4385  | 170    | 6                | 78 | 16 | 10/160  | .0625 |
| 5     | 4555  | 128    | 29               | 44 | 27 | 37/91   | .4065 |
| 4     | 4683  | 131    | 16               | 66 | 18 | 21/110  | .1909 |
| 3     | 4814  | 72     | 11               | 54 | 35 | 8/64    | .1250 |
| 2     | 4886  | 102    | 16               | 56 | 28 | 16/86   | .1860 |
| 1     | 4988  | 123    | 14               | 68 | 18 | 17/106  | .1603 |
| 31221 |       |        | Wexford 24N11W6  |    |    |         | #16   |
| KB    | 1071  |        |                  |    |    |         |       |
| E     | 4252  |        |                  |    |    |         |       |
| F     |       | 617    |                  |    |    |         |       |
| 6     | 3635  | 130    | 11               | 60 | 29 | 15/115  | .1304 |
| 5     | 3765  | 112    | 30               | 63 | 7  | 33/79   | .4177 |
| 4     | 3877  | 119    | 18               | 44 | 38 | 22/97   | .2268 |
| 3     | 3996  | 63     | 11               | 40 | 49 | 7/56    | .1250 |
| 2     | 4059  | 93     | 28               | 49 | 23 | 26/67   | .3880 |
| 1     | 4152  | 100    | 19               | 63 | 18 | 19/81   | .2345 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                     | %E | %C | Clastic Ratio |        |
|-------|-------|--------|-------------------------|----|----|---------------|--------|
| 29037 |       |        | Wexford 23N12W31        |    |    |               | #17    |
| KB    | 911   |        |                         |    |    |               |        |
| E     | 4055  |        |                         |    |    |               |        |
| F     |       | 551    |                         |    |    |               |        |
| 6     | 3504  | 83     | 20                      | 43 | 37 | 16/67         | .2388  |
| 5     | 3587  | 102    | 36                      | 35 | 29 | 27/65         | .5692  |
| 4     | 3689  | 115    | 21                      | 49 | 30 | 24/91         | .2637  |
| 3     | 3804  | 60     | 16                      | 42 | 42 | 10/50         | .2000  |
| 2     | 3864  | 88     | 26                      | 53 | 21 | 23/65         | .3538  |
| 1     | 3952  | 103    | 15                      | 55 | 30 | 16/87         | .1839  |
| 28564 |       |        | Grand Traverse 26N11W11 |    |    |               | #18    |
| KB    | 772   |        |                         |    |    |               |        |
| E     | 3871  |        |                         |    |    |               |        |
| F     |       | 671    |                         |    |    |               |        |
| 6     | 3200  | 165    | 8                       | 65 | 27 | 14/151        | .0927  |
| 5     | 3365  | 109    | 32                      | 39 | 29 | 35/74         | .4729  |
| 4     | 3474  | 127    | 24                      | 39 | 37 | 30/97         | .3092  |
| 3     | 3601  | 69     | 13                      | 48 | 39 | 9/60          | .1500  |
| 2     | 3670  | 93     | 27                      | 62 | 11 | 25/68         | .3676  |
| 1     | 3763  | 108    | 19                      | 60 | 21 | 20/88         | .2272  |
| 28041 |       |        | Grand Traverse 27N12W32 |    |    |               | #19    |
| KB    | 886   |        |                         |    |    |               |        |
| E     | 3311  |        |                         |    |    |               |        |
| F     |       | 589    |                         |    |    |               |        |
| 6     | 2722  | 112    | 15                      | 62 | 23 | 17/95         | .1789  |
| 5     | 2834  | 108    | 51                      | 45 | 4  | 55/53         | 1.0377 |
| 4     | 2942  | 117    | 20                      | 48 | 32 | 24/93         | .2580  |
| 3     | 3059  | 58     | 19                      | 50 | 31 | 11/47         | .2340  |
| 2     | 3117  | 87     | 20                      | 60 | 20 | 18/69         | .2608  |
| 1     | 3204  | 107    | 17                      | 67 | 16 | 18/89         | .2022  |
| 29494 |       |        | Grand Traverse 27N10W25 |    |    |               | #20    |
| El.   | 973   |        |                         |    |    |               |        |
| E     | 4169  |        |                         |    |    |               |        |
| F     |       | 727    |                         |    |    |               |        |
| 6     | 3442  | 178    | 8                       | 62 | 30 | 14/164        | .0853  |
| 5     | 3620  | 127    | 26                      | 59 | 15 | 37/94         | .3510  |
| 4     | 3747  | 137    | 18                      | 47 | 35 | 25/112        | .2232  |
| 3     | 3884  | 68     | 22                      | 41 | 37 | 15/53         | .2830  |
| 2     | 3952  | 100    | 24                      | 53 | 23 | 24/76         | .3157  |
| 1     | 4052  | 117    | 16                      | 69 | 15 | 19/98         | .1938  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh            | %E | %C | Clastic | Ratio |
|-------|-------|--------|----------------|----|----|---------|-------|
| 27483 |       |        | Antrim 29N7W24 |    |    |         | #21   |
| lg    | 1113  |        |                |    |    |         |       |
| E     | 4097  |        |                |    |    |         |       |
| F     |       | 772    |                |    |    |         |       |
| 6     | 3325  | 209    | 4              | 56 | 40 | 8/201   | .0398 |
| 5     | 3534  | 137    | 29             | 50 | 21 | 40/97   | .4123 |
| 4     | 3671  | 140    | 19             | 44 | 37 | 26/114  | .2280 |
| 3     | 3811  | 69     | 14             | 51 | 35 | 10/59   | .1694 |
| 2     | 3880  | 98     | 21             | 44 | 35 | 21/77   | .2727 |
| 1     | 3978  | 119    | 10             | 73 | 17 | 12/107  | .1121 |
| 29058 |       |        | Antrim 31N6W35 |    |    |         | #22   |
| log   | 1042  |        |                |    |    |         |       |
| E     | 3244  |        |                |    |    |         |       |
| F     |       | 751    |                |    |    |         |       |
| 6     | 2493  | 189    | 6              | 59 | 35 | 12/177  | .0677 |
| 5     | 2682  | 131    | 29             | 38 | 33 | 38/93   | .4086 |
| 4     | 2813  | 137    | 20             | 50 | 30 | 28/109  | .2568 |
| 3     | 2950  | 72     | 14             | 42 | 44 | 10/62   | .1612 |
| 2     | 3022  | 99     | 22             | 25 | 53 | 22/77   | .2857 |
| 1     | 3121  | 123    | 6              | 61 | 33 | 7/116   | .0603 |
| 22639 |       |        | Antrim 32N8W19 |    |    |         | #23   |
| KB    | 878   |        |                |    |    |         |       |
| E     | 2328  |        |                |    |    |         |       |
| F     |       | 618    |                |    |    |         |       |
| 6     | 1710  | 129    | 12             | 74 | 14 | 15/114  | .1315 |
| 5     | 1839  | 108    | 37             | 32 | 31 | 40/68   | .5882 |
| 4     | 1947  | 123    | 23             | 53 | 24 | 28/95   | .2947 |
| 3     | 2070  | 56     | 13             | 39 | 48 | 7/49    | .1428 |
| 2     | 2126  | 85     | 26             | 45 | 29 | 22/63   | .3492 |
| 1     | 2211  | 117    | 15             | 77 | 8  | 17/100  | .1700 |
| 29572 |       |        | Otsego 31N4W9  |    |    |         | #24   |
| log   | 1374  |        |                |    |    |         |       |
| E     | 3038  |        |                |    |    |         |       |
| F     |       | 749    |                |    |    |         |       |
| 6     | 2289  | 190    | 6              | 54 | 40 | 11/179  | .0614 |
| 5     | 2479  | 129    | 38             | 44 | 18 | 49/80   | .6125 |
| 4     | 2608  | 136    | 26             | 35 | 39 | 35/101  | .3465 |
| 3     | 2744  | 71     | 13             | 27 | 60 | 9/62    | .1451 |
| 2     | 2815  | 101    | 22             | 32 | 46 | 22/79   | .2784 |
| 1     | 2916  | 122    | 16             | 72 | 12 | 20/102  | .1960 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                | %E | %C | Clastic | Ratio |
|-------|-------|--------|--------------------|----|----|---------|-------|
| 29986 |       |        | Otsego 30N3W1      |    |    |         | #25   |
| log   | 1371  |        |                    |    |    |         |       |
| E     | 3559  |        |                    |    |    |         |       |
| F     |       | 769    |                    |    |    |         |       |
| 6     | 2790  | 207    | 5                  | 60 | 75 | 11/196  | .0561 |
| 5     | 2997  | 135    | 30                 | 40 | 30 | 40/95   | .4210 |
| 4     | 3132  | 135    | 19                 | 36 | 45 | 26/109  | .2385 |
| 3     | 3267  | 74     | 11                 | 53 | 36 | 8/66    | .1272 |
| 2     | 3341  | 99     | 20                 | 30 | 50 | 20/79   | .2533 |
| 1     | 3440  | 119    | 16                 | 74 | 10 | 19/100  | .1900 |
| 29612 |       |        | Otsego 30N1W16     |    |    |         | #26   |
| KB    | 1383  |        |                    |    |    |         |       |
| E     | 3551  |        |                    |    |    |         |       |
| F     |       | 767    |                    |    |    |         |       |
| 6     | 2784  | 204    | 5                  | 70 | 25 | 10/194  | .0515 |
| 5     | 2998  | 142    | 25                 | 47 | 28 | 36/106  | .3396 |
| 4     | 3130  | 129    | 14                 | 53 | 33 | 18/111  | .1621 |
| 3     | 3259  | 72     | 8                  | 68 | 24 | 6/66    | .0909 |
| 2     | 3331  | 99     | 16                 | 52 | 32 | 16/83   | .1927 |
| 1     | 3430  | 14     | 15                 | 74 | 11 | 18/103  | .1747 |
| 28898 |       |        | Otsego 31N1W4      |    |    |         | #27   |
| log   | 1070  |        |                    |    |    |         |       |
| E     | 2996  |        |                    |    |    |         |       |
| F     |       | 749    |                    |    |    |         |       |
| 6     | 2247  | 200    | 6                  | 57 | 37 | 12/188  | .0638 |
| 5     | 2447  | 128    | 29                 | 38 | 33 | 37/91   | .4065 |
| 4     | 2575  | 128    | 19                 | 51 | 30 | 25/103  | .2427 |
| 3     | 2703  | 73     | 8                  | 54 | 38 | 6/67    | .0895 |
| 2     | 2776  | 101    | 21                 | 44 | 35 | 21/80   | .2625 |
| 1     | 2877  | 119    | 14                 | 59 | 27 | 17/102  | .1666 |
| 30528 |       |        | Montmorency 32N1E7 |    |    |         | #28   |
| KB    | 929   |        |                    |    |    |         |       |
| E     | 2776  |        |                    |    |    |         |       |
| F     |       | 770    |                    |    |    |         |       |
| 6     | 2006  | 205    | 6                  | 71 | 23 | 13/92   | .0677 |
| 5     | 2211  | 131    | 34                 | 45 | 21 | 45/86   | .5232 |
| 4     | 2342  | 136    | 22                 | 35 | 43 | 30/106  | .2830 |
| 3     | 2478  | 74     | 18                 | 43 | 39 | 13/61   | .2131 |
| 2     | 2552  | 101    | 24                 | 32 | 44 | 24/77   | .3116 |
| 1     | 2653  | 123    | 13                 | 64 | 23 | 16/107  | .1495 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                | %E | %C | Clastic Ratio |       |
|-------|-------|--------|--------------------|----|----|---------------|-------|
| 30619 |       |        | Montmorency 31N2E6 |    |    |               | #29   |
| KB    | 915   |        |                    |    |    |               |       |
| E     | 2945  |        |                    |    |    |               |       |
| F     |       | 752    |                    |    |    |               |       |
| 6     | 2193  | 198    | 6                  | 55 | 39 | 11/187        | .0588 |
| 5     | 2191  | 133    | 32                 | 36 | 32 | 42/91         | .4615 |
| 4     | 2524  | 134    | 18                 | 48 | 34 | 24/110        | .2181 |
| 3     | 2658  | 71     | 7                  | 39 | 54 | 5/66          | .0757 |
| 2     | 2729  | 98     | 17                 | 32 | 51 | 17/81         | .2098 |
| 1     | 2827  | 118    | 14                 | 76 | 10 | 16/102        | .1568 |
| 32575 |       |        | Montmorency 32N3E5 |    |    |               | #30   |
| KB    | 893   |        |                    |    |    |               |       |
| E     | 2173  |        |                    |    |    |               |       |
| F     |       | 741    |                    |    |    |               |       |
| 6     | 1432  | 190    | 8                  | 53 | 39 | 15/175        | .0857 |
| 5     | 1622  | 130    | 28                 | 43 | 29 | 36/94         | .3829 |
| 4     | 1752  | 135    | 20                 | 44 | 36 | 27/108        | .2500 |
| 3     | 1887  | 70     | 10                 | 46 | 44 | 7/63          | .1111 |
| 2     | 1957  | 97     | 18                 | 33 | 49 | 17/80         | .2125 |
| 1     | 2054  | 119    | 9                  | 64 | 27 | 11/108        | .1018 |
| 30393 |       |        | Montmorency 30N2E5 |    |    |               | #31   |
| KB    | 1229  |        |                    |    |    |               |       |
| E     | 3267  |        |                    |    |    |               |       |
| F     |       | 764    |                    |    |    |               |       |
| 6     | 2503  | 192    | 5                  | 59 | 36 | 10/182        | .0549 |
| 5     | 2695  | 137    | 22                 | 39 | 39 | 30/107        | .2803 |
| 4     | 2832  | 134    | 21                 | 43 | 36 | 28/106        | .2641 |
| 3     | 2966  | 75     | 11                 | 40 | 49 | 8/67          | .1194 |
| 2     | 3041  | 100    | 20                 | 58 | 22 | 20/80         | .2500 |
| 1     | 3141  | 126    | 8                  | 61 | 31 | 10/116        | .0862 |
| 28583 |       |        | Alpena 31N5E32     |    |    |               | #32   |
| lg    | 784   |        |                    |    |    |               |       |
| E     | 2956  |        |                    |    |    |               |       |
| F     |       | 746    |                    |    |    |               |       |
| 6     | 2210  | 190    | 5                  | 57 | 38 | 10/180        | .0555 |
| 5     | 2400  | 137    | 23                 | 54 | 23 | 32/105        | .3047 |
| 4     | 2537  | 131    | 18                 | 55 | 27 | 23/108        | .2129 |
| 3     | 2668  | 72     | 7                  | 63 | 90 | 5/67          | .0746 |
| 2     | 2740  | 94     | 17                 | 46 | 37 | 16/78         | .2051 |
| 1     | 2834  | 122    | 6                  | 65 | 29 | 7/115         | .0608 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                  | %E | %C | Clastic | Ratio |
|-------|-------|--------|----------------------|----|----|---------|-------|
| 29571 |       |        | Alpena 32N5E34       |    |    |         | #33   |
| Lg    | 756   |        |                      |    |    |         |       |
| E     | 2259  |        |                      |    |    |         |       |
| F     |       | 718    |                      |    |    |         |       |
| 6     | 1541  | 173    | 7                    | 58 | 35 | 12/161  | .0745 |
| 5     | 1714  | 130    | 24                   | 45 | 31 | 31/99   | .3131 |
| 4     | 1844  | 133    | 16                   | 32 | 52 | 21/112  | .1875 |
| 3     | 1977  | 69     | 7                    | 71 | 22 | 5/64    | .0781 |
| 2     | 2046  | 98     | 13                   | 57 | 30 | 13/85   | .1529 |
| 1     | 2144  | 115    | 12                   | 77 | 11 | 14/101  | .1386 |
| 25690 |       |        | Alpena 31N9E5        |    |    |         | #34   |
| Gl    | 684   |        |                      |    |    |         |       |
| E     | 1834  |        |                      |    |    |         |       |
| F     |       | 660    |                      |    |    |         |       |
| 6     | 1174  | 148    | 9                    | 55 | 36 | 13/135  | .0962 |
| 5     | 1322  | 117    | 36                   | 36 | 28 | 42/75   | .5600 |
| 4     | 1439  | 119    | 26                   | 34 | 40 | 31/88   | .3522 |
| 3     | 1558  | 69     | 25                   | 54 | 21 | 17/52   | .3269 |
| 2     | 1627  | 95     | 28                   | 36 | 36 | 27/68   | .3970 |
| 1     | 1722  | 112    | 15                   | 72 | 13 | 17/95   | .1789 |
| 24999 |       |        | Presque Isle 33N7E33 |    |    |         | #35   |
| KB    | 815   |        |                      |    |    |         |       |
| E     | 1712  |        |                      |    |    |         |       |
| F     |       | 662    |                      |    |    |         |       |
| 6     | 1050  | 149    | 9                    | 64 | 27 | 13/136  | .0955 |
| 5     | 1199  | 119    | 35                   | 56 | 9  | 42/77   | .5454 |
| 4     | 1318  | 123    | 21                   | 64 | 15 | 26/97   | .2680 |
| 3     | 1441  | 65     | 9                    | 58 | 33 | 6/59    | .1016 |
| 2     | 1506  | 97     | 24                   | 38 | 38 | 23/74   | .3108 |
| 1     | 1603  | 109    | 13                   | 79 | 8  | 14/95   | .1473 |
| 28337 |       |        | Presque Isle 34N5E5  |    |    |         | #36   |
| KB    | 785   |        |                      |    |    |         |       |
| E     | 1340  |        |                      |    |    |         |       |
| F     |       | 654    |                      |    |    |         |       |
| 6     | 686   | 150    | 0                    | 33 | 67 | 1/99    | .0067 |
| 5     | 836   | 116    | 34                   | 45 | 21 | 40/76   | .5263 |
| 4     | 952   | 117    | 25                   | 47 | 28 | 29/88   | .3295 |
| 3     | 1069  | 64     | 0                    | 55 | 45 | 1/63    | .0158 |
| 2     | 1133  | 93     | 22                   | 60 | 18 | 20/73   | .2739 |
| 1     | 1226  | 114    | 9                    | 71 | 20 | 10/104  | .0961 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                  | %E | %C | Clastic | Ratio |
|-------|-------|--------|----------------------|----|----|---------|-------|
| 32255 |       |        | Presque Isle 34N3E36 |    |    |         | #37   |
| KB    | 894   |        |                      |    |    |         |       |
| E     | 1781  |        |                      |    |    |         |       |
| F     |       | 722    |                      |    |    |         |       |
| 6     | 1059  | 189    | 5                    | 55 | 40 | 10/179  | .0558 |
| 5     | 1248  | 128    | 33                   | 46 | 21 | 42/86   | .4883 |
| 4     | 1376  | 125    | 22                   | 31 | 47 | 28/97   | .2886 |
| 3     | 1501  | 68     | 0                    | 43 | 57 | 1/68    | .0149 |
| 2     | 1569  | 95     | 29                   | 55 | 16 | 28/67   | .4179 |
| 1     | 1664  | 117    | 15                   | 76 | 9  | 18/99   | .1818 |
| 24918 |       |        | Cheboygan 35N1E22    |    |    |         | #38   |
| KB    | 789   |        |                      |    |    |         |       |
| E     | 1279  |        |                      |    |    |         |       |
| F     |       | 616    |                      |    |    |         |       |
| 6     | 663   | 107    | 15                   | 62 | 23 | 16/91   | .1758 |
| 5     | 770   | 121    | 35                   | 43 | 22 | 42/79   | .5316 |
| 4     | 891   | 124    | 20                   | 27 | 53 | 25/99   | .2525 |
| 3     | 1015  | 66     | 18                   | 46 | 36 | 12/45   | .2666 |
| 2     | 1081  | 91     | 24                   | 46 | 30 | 22/69   | .3188 |
| 1     | 1172  | 107    | 5                    | 54 | 51 | 5/102   | .0490 |
| 27976 |       |        | Cheboygan 33N1W3     |    |    |         | #39   |
| KB    | 909   |        |                      |    |    |         |       |
| E     | 2194  |        |                      |    |    |         |       |
| F     |       | 723    |                      |    |    |         |       |
| 6     | 1471  | 183    | 9                    | 77 | 14 | 16/107  | .0958 |
| 5     | 1654  | 125    | 36                   | 55 | 9  | 45/80   | .5625 |
| 4     | 1779  | 134    | 20                   | 58 | 22 | 27/107  | .2523 |
| 3     | 1913  | 65     | 14                   | 66 | 20 | 9/56    | .1607 |
| 2     | 1978  | 99     | 23                   | 48 | 29 | 23/76   | .3026 |
| 1     | 2077  | 117    | 14                   | 82 | 4  | 16/101  | .1584 |
| 28474 |       |        | Charlevoix 33N5W35   |    |    |         | #40   |
| KB    | 825   |        |                      |    |    |         |       |
| E     | 2417  |        |                      |    |    |         |       |
| F     |       | 708    |                      |    |    |         |       |
| 6     | 1709  | 163    | 8                    | 75 | 17 | 13/150  | .0866 |
| 5     | 1872  | 121    | 32                   | 45 | 23 | 39/82   | .4756 |
| 4     | 1993  | 135    | 18                   | 49 | 33 | 24/111  | .2162 |
| 3     | 2128  | 71     | 15                   | 47 | 38 | 11/60   | .1833 |
| 2     | 2199  | 93     | 24                   | 40 | 36 | 22/71   | .3098 |
| 1     | 2292  | 125    | 9                    | 72 | 19 | 11/114  | .0964 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic | Ratio  |
|-------|-------|--------|-------------------|----|----|---------|--------|
| 22627 |       |        | Leelanaw 30N11W6  |    |    |         | #41    |
| KB    | 925   |        |                   |    |    |         |        |
| E     | 2329  |        |                   |    |    |         |        |
| F     |       | 582    |                   |    |    |         |        |
| 6     | 1747  | 108    | 15                | 63 | 22 | 16/92   | .1739  |
| 5     | 1855  | 103    | 42                | 31 | 27 | 43/60   | .7166  |
| 4     | 1958  | 114    | 24                | 61 | 15 | 27/87   | .3103  |
| 3     | 2072  | 54     | 13                | 37 | 50 | 7/47    | .1489  |
| 2     | 2126  | 84     | 29                | 39 | 32 | 24/60   | .4000  |
| 1     | 2210  | 119    | 10                | 76 | 14 | 12/107  | .1121  |
| 28109 |       |        | Benzie 25N14W1    |    |    |         | #42    |
| KB    | 832   |        |                   |    |    |         |        |
| E     | 3222  |        |                   |    |    |         |        |
| F     |       | 527    |                   |    |    |         |        |
| 6     | 2695  | 62     | 32                | 45 | 23 | 20/42   | .4761  |
| 5     | 2757  | 102    | 33                | 36 | 31 | 34/68   | .5000  |
| 4     | 2859  | 115    | 21                | 39 | 40 | 24/91   | .2637  |
| 3     | 2974  | 56     | 11                | 34 | 55 | 6/50    | .1200  |
| 2     | 3030  | 85     | 27                | 47 | 26 | 23/62   | .3709  |
| 1     | 3115  | 107    | 13                | 60 | 27 | 14/93   | .1505  |
| 29711 |       |        | Benzie 25N15W29   |    |    |         | #43    |
| KB    | 717   |        |                   |    |    |         |        |
| E     | 2742  |        |                   |    |    |         |        |
| F     |       | 483    |                   |    |    |         |        |
| 6     | 2259  | 52     | 52                | 40 | 8  | 27/25   | 1.0800 |
| 5     | 2311  | 75     | 37                | 26 | 37 | 28/47   | .5957  |
| 4     | 2386  | 111    | 24                | 41 | 35 | 27/84   | .3214  |
| 3     | 2497  | 53     | 23                | 47 | 30 | 12/41   | .2926  |
| 2     | 2550  | 83     | 36                | 38 | 26 | 30/53   | .5660  |
| 1     | 2633  | 109    | 22                | 66 | 12 | 24/85   | .2823  |
| 31980 |       |        | Manistee 24N13W28 |    |    |         | #44    |
| KB    | 904   |        |                   |    |    |         |        |
| E     | 3616  |        |                   |    |    |         |        |
| F     |       | 515    |                   |    |    |         |        |
| 6     | 3101  | 69     | 30                | 48 | 22 | 21/48   | .4375  |
| 5     | 3170  | 100    | 41                | 39 | 20 | 41/59   | .6949  |
| 4     | 3270  | 113    | 25                | 56 | 19 | 28/85   | .3294  |
| 3     | 3383  | 55     | 24                | 27 | 49 | 13/42   | .3095  |
| 2     | 3438  | 88     | 30                | 42 | 28 | 26/62   | .4193  |
| 1     | 3526  | 90     | 20                | 60 | 20 | 18/72   | .2500  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic | Ratio   |
|-------|-------|--------|-------------------|----|----|---------|---------|
| 29681 |       |        | Manistee 23N15W31 |    |    |         | #45     |
| KB    | 678   |        |                   |    |    |         |         |
| E     | 2859  |        |                   |    |    |         |         |
| F     |       | 424    |                   |    |    |         |         |
| 6     | 2435  | 51     | 63                | 31 | 6  | 32/19   | 1.6842  |
| 5     | 2486  | 43     | 63                | 14 | 23 | 27/16   | 1.6875  |
| 4     | 2529  | 101    | 24                | 51 | 25 | 24/77   | .3116   |
| 3     | 2630  | 51     | 22                | 51 | 27 | 11/40   | .2750   |
| 2     | 2681  | 77     | 32                | 52 | 16 | 25/52   | .4807   |
| 1     | 2758  | 101    | 18                | 65 | 17 | 18/83   | .2168   |
| 29966 |       |        | Manistee 21N15W15 |    |    |         | #46     |
| KB    | 739   |        |                   |    |    |         |         |
| E     | 3208  |        |                   |    |    |         |         |
| F     |       | 423    |                   |    |    |         |         |
| 6     | 2785  | 55     | 55                | 18 | 27 | 30/25   | 1.2000  |
| 5     | 2840  | 41     | 58                | 17 | 25 | 24/17   | 1.4117  |
| 4     | 2881  | 100    | 27                | 43 | 30 | 27/73   | .3698   |
| 3     | 2981  | 50     | 14                | 0  | 86 | 7/43    | .1627   |
| 2     | 3031  | 79     | 35                | 35 | 30 | 28/51   | .5490   |
| 1     | 3110  | 98     | 17                | 58 | 25 | 17/81   | .2098   |
| 29370 |       |        | Mason 20N16W11    |    |    |         | #47     |
| lg    | 702   |        |                   |    |    |         |         |
| E     | 3022  |        |                   |    |    |         |         |
| F     |       | 344    |                   |    |    |         |         |
| 6     | 2678  | 28     | 50                | 28 | 22 | 14/41   | 1.0000  |
| 5     | 2706  | 62     | 90                | 0  | 10 | 56/6    | 9.3333  |
| 4     | 2768  | 37     | 59                | 41 | 0  | 22/15   | 1.4666  |
| 3     | 2805  | 50     | 16                | 14 | 70 | 8/42    | .1904   |
| 2     | 2855  | 73     | 34                | 45 | 21 | 25/48   | .5208   |
| 1     | 2928  | 94     | 25                | 49 | 26 | 24/70   | .3428   |
| 25053 |       |        | Mason 18N17W14    |    |    |         | #48     |
| lb    | 708   |        |                   |    |    |         |         |
| E     | 2843  |        |                   |    |    |         |         |
| F     |       | 214    |                   |    |    |         |         |
| 6     | 2629  | 29     | 52                | 0  | 48 | 15/14   | 1.0714  |
| 5     | 2658  | 36     | 100               | 0  | 0  | 35/1    | 35.0000 |
| 4     | 2694  | 23     | 100               | 0  | 0  | 22/1    | 22.0000 |
| 3     | 2717  | 39     | 77                | 0  | 23 | 30/9    | 3.3333  |
| 2     | 2756  | 24     | 46                | 0  | 54 | 11/13   | .8461   |
| 1     | 2780  | 63     | 29                | 46 | 25 | 18/45   | .4000   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio   |
|-------|-------|--------|------------------|----|----|---------|---------|
| 26662 |       |        | Newaygo 15N14W20 |    |    |         | #49     |
| KB    | 829   |        |                  |    |    |         |         |
| E     | 3088  |        |                  |    |    |         |         |
| F     |       | 250    |                  |    |    |         |         |
| 6     | 2838  | 35     | 49               | 0  | 51 | 17/18   | .9444   |
| 5     | 2873  | 37     | 100              | 0  | 0  | 36/1    | 36.0000 |
| 4     | 2910  | 31     | 100              | 0  | 0  | 30/1    | 30.0000 |
| 3     | 2941  | 33     | 73               | 0  | 27 | 24/9    | 2.6666  |
| 2     | 2974  | 45     | 38               | 35 | 27 | 17/28   | .6071   |
| 1     | 3019  | 69     | 26               | 65 | 9  | 18/51   | .3529   |
| 28931 |       |        | Muskegon 12N17W8 |    |    |         | #50     |
| KB    | 754   |        |                  |    |    |         |         |
| E     | 2068  |        |                  |    |    |         |         |
| F     |       | 122    |                  |    |    |         |         |
| 6     |       |        |                  |    |    |         |         |
| 5     | 1946  | 29     | 100              | 0  | 0  | 28/1    | 28.0000 |
| 4     | 1975  | 18     | 78               | 0  | 22 | 14/4    | 3.5000  |
| 3     | 1993  | 23     | 56               | 35 | 9  | 13/10   | 1.3000  |
| 2     | 2016  | 19     | 47               | 37 | 16 | 9/10    | .9000   |
| 1     | 2035  | 33     | 39               | 0  | 61 | 13/20   | .6500   |
| 28137 |       |        | Newaygo 11N13W11 |    |    |         | #51     |
| KB    | 888   |        |                  |    |    |         |         |
| E     | 2946  |        |                  |    |    |         |         |
| F     |       | 194    |                  |    |    |         |         |
| 6     | 2752  | 34     | 21               | 26 | 53 | 7/27    | .2592   |
| 5     | 2786  | 52     | 92               | 0  | 8  | 48/4    | 12.0000 |
| 4     | 2838  | 28     | 89               | 0  | 11 | 25/3    | 8.3333  |
| 3     | 2866  | 26     | 62               | 27 | 11 | 16/10   | 1.6000  |
| 2     | 2892  | 20     | 50               | 25 | 25 | 10/10   | 1.0000  |
| 1     | 2912  | 34     | 38               | 15 | 47 | 13/21   | .6190   |
| 20103 |       |        | Kent 9N10W27     |    |    |         | #52     |
| DF    | 903   |        |                  |    |    |         |         |
| E     | 2986  |        |                  |    |    |         |         |
| F     |       | 178    |                  |    |    |         |         |
| 6     | 2808  | 29     | 24               | 11 | 65 | 7/22    | .3181   |
| 5     | 2837  | 52     | 90               | 0  | 10 | 47/5    | 9.4000  |
| 4     | 2889  | 28     | 71               | 18 | 11 | 20/8    | 2.5000  |
| 3     | 2917  | 26     | 70               | 15 | 15 | 18/8    | 2.2500  |
| 2     | 2943  | 15     | 53               | 0  | 47 | 8/7     | 1.1428  |
| 1     | 2958  | 28     | 36               | 36 | 28 | 10/18   | .5555   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh            | %E | %C | Clastic | Ratio   |
|-------|-------|--------|----------------|----|----|---------|---------|
| 24619 |       |        | Ionia 7N8W34   |    |    |         | #53     |
| KB    | 775   |        |                |    |    |         |         |
| E     | 2789  |        |                |    |    |         |         |
| F     |       | 174    |                |    |    |         |         |
| 6     | 2615  | 32     | 31             | 13 | 56 | 10/22   | .4545   |
| 5     | 2647  | 46     | 95             | 0  | 5  | 53/3    | 17.6666 |
| 4     | 2703  | 17     | 100            | 0  | 0  | 16/1    | 16.0000 |
| 3     | 2720  | 28     | 46             | 32 | 22 | 13/15   | .8666   |
| 2     | 2748  | 15     | 33             | 27 | 40 | 5/10    | .5000   |
| 1     | 2763  | 26     | 31             | 23 | 46 | 8/18    | .4444   |
| 23574 |       |        | Ionia 5N7W15   |    |    |         | #54     |
| KB    | 870   |        |                |    |    |         |         |
| E     | 2559  |        |                |    |    |         |         |
| F     |       | 176    |                |    |    |         |         |
| 6     | 2383  | 32     | 13             | 0  | 87 | 4/28    | .1428   |
| 5     | 2415  | 51     | 90             | 0  | 10 | 46/5    | 9.2000  |
| 4     | 2466  | 21     | 100            | 0  | 0  | 20/1    | 20.0000 |
| 3     | 2487  | 26     | 38             | 16 | 46 | 10/16   | .6250   |
| 2     | 2513  | 20     | 40             | 15 | 45 | 8/12    | .6666   |
| 1     | 2533  | 26     | 46             | 12 | 42 | 12/14   | .8571   |
| 22399 |       |        | Clinton 8N4W27 |    |    |         | #55     |
| KB    | 754   |        |                |    |    |         |         |
| E     | 3705  |        |                |    |    |         |         |
| F     |       | 384    |                |    |    |         |         |
| 6     | 3321  | 43     | 30             | 47 | 23 | 13/30   | .4333   |
| 5     | 3364  | 47     | 92             | 0  | 8  | 43/4    | 10.7500 |
| 4     | 3411  | 49     | 84             | 16 | 0  | 41/8    | 5.1250  |
| 3     | 3460  | 61     | 16             | 49 | 35 | 10/51   | .1960   |
| 2     | 354   | 63     | 25             | 51 | 24 | 16/47   | .3404   |
| 2     | 3584  | 121    | 15             | 79 | 6  | 18/103  | .1747   |
| 27811 |       |        | Clinton 7W1W6  |    |    |         | #56     |
| KB    | 772   |        |                |    |    |         |         |
| E     | 3728  |        |                |    |    |         |         |
| F     |       | 487    |                |    |    |         |         |
| 6     | 3241  | 44     | 27             | 50 | 23 | 12/32   | .3750   |
| 5     | 3285  | 63     | 46             | 21 | 33 | 29/34   | .8529   |
| 4     | 3348  | 110    | 16             | 39 | 45 | 18/92   | .1956   |
| 3     | 3458  | 58     | 7              | 74 | 19 | 4/54    | .0740   |
| 2     | 3516  | 75     | 27             | 69 | 4  | 20/55   | .3636   |
| 1     | 3591  | 137    | 14             | 73 | 13 | 19/118  | .1610   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic Ratio |
|-------|-------|--------|-------------------|----|----|---------------|
| 22348 |       |        | Clinton 5N3W14    |    |    | #57           |
| KB    | 835   |        |                   |    |    |               |
| E     | 3125  |        |                   |    |    |               |
| F     |       | 296    |                   |    |    |               |
| 6     | 2829  | 42     | 24                | 36 | 40 | 10/32 .3125   |
| 5     | 2871  | 30     | 83                | 0  | 17 | 25/5 5.0000   |
| 4     | 2901  | 27     | 100               | 0  | 0  | 27/1 27.0000  |
| 3     | 2928  | 28     | 64                | 0  | 36 | 18/10 1.8000  |
| 2     | 2956  | 55     | 24                | 52 | 24 | 13/42 .3096   |
| 1     | 3011  | 114    | 17                | 61 | 22 | 19/95 .2000   |
| 30727 |       |        | Shiawassee 6N1E5  |    |    | #58           |
| KB    | 783   |        |                   |    |    |               |
| E     | 2610  |        |                   |    |    |               |
| F     |       | 493    |                   |    |    |               |
| 6     | 3117  | 46     | 22                | 33 | 45 | 10/36 .2777   |
| 5     | 3163  | 59     | 75                | 0  | 25 | 44/15 2.9333  |
| 4     | 3222  | 125    | 17                | 51 | 32 | 21/104 .2019  |
| 3     | 3347  | 57     | 7                 | 68 | 25 | 4/53 .0754    |
| 2     | 3404  | 80     | 19                | 59 | 22 | 15/65 .2307   |
| 1     | 3484  | 126    | 13                | 74 | 13 | 16/110 .1454  |
| 23375 |       |        | Shiawassee 5N3E15 |    |    | #59           |
| KB    | 885   |        |                   |    |    |               |
| E     | 2884  |        |                   |    |    |               |
| F     |       | 586    |                   |    |    |               |
| 6     | 2298  | 74     | 24                | 61 | 15 | 18/56 .3214   |
| 5     | 2372  | 121    | 33                | 25 | 42 | 40/81 .4938   |
| 4     | 2493  | 118    | 13                | 30 | 57 | 15/103 .1456  |
| 3     | 2611  | 62     | 6                 | 50 | 44 | 4/58 .0689    |
| 2     | 2673  | 86     | 21                | 66 | 13 | 18/68 .2647   |
| 1     | 2759  | 125    | 10                | 78 | 12 | 13/112 .1180  |
| 23948 |       |        | Genessee 6N7E29   |    |    | #60           |
| Gl.   | 850   |        |                   |    |    |               |
| E     | 3278  |        |                   |    |    |               |
| F     |       | 676    |                   |    |    |               |
| 6     | 2602  | 112    | 16                | 73 | 11 | 18/94 .1914   |
| 5     | 2714  | 143    | 29                | 27 | 44 | 41/102 .4019  |
| 4     | 2857  | 135    | 19                | 41 | 40 | 26/109 .2385  |
| 3     | 2992  | 68     | 19                | 66 | 15 | 13/55 .2363   |
| 2     | 3060  | 93     | 18                | 74 | 8  | 17/76 .2236   |
| 1     | 3153  | 125    | 12                | 71 | 17 | 15/110 .1363  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh            | %E | %C | Clastic | Ratio |
|-------|-------|--------|----------------|----|----|---------|-------|
| 23899 |       |        | Huron 18N13E21 |    |    |         | #61   |
| KB    | 692   |        |                |    |    |         |       |
| E     | 4340  |        |                |    |    |         |       |
| F     |       | 704    |                |    |    |         |       |
| 6     | 3636  | 144    | 10             | 78 | 12 | 14/130  | .1076 |
| 5     | 3780  | 141    | 25             | 39 | 36 | 36/105  | .3428 |
| 4     | 3921  | 137    | 21             | 47 | 32 | 29/108  | .2685 |
| 3     | 4058  | 69     | 10             | 58 | 32 | 7/62    | .1129 |
| 2     | 4127  | 89     | 16             | 54 | 30 | 14/75   | .1866 |
| 1     | 4216  | 124    | 18             | 63 | 19 | 22/102  | .2156 |
| 24040 |       |        | Huron 17N10E36 |    |    |         | #62   |
| KB    | 636   |        |                |    |    |         |       |
| E     | 5676  |        |                |    |    |         |       |
| F     |       | 834    |                |    |    |         |       |
| 6     | 4842  | 190    | 5              | 92 | 3  | 10/180  | .0555 |
| 5     | 5032  | 170    | 19             | 57 | 24 | 32/138  | .2318 |
| 4     | 5202  | 156    | 11             | 47 | 42 | 17/139  | .1223 |
| 3     | 5358  | 74     | 8              | 51 | 41 | 6/68    | .0882 |
| 2     | 5432  | 103    | 15             | 63 | 22 | 15/88   | .1704 |
| 1     | 5535  | 141    | 16             | 69 | 5  | 22/119  | .1848 |
| 24789 |       |        | Huron 16N12E36 |    |    |         | #63   |
| KB    | 764   |        |                |    |    |         |       |
| E     | 4796  |        |                |    |    |         |       |
| F     |       | 751    |                |    |    |         |       |
| 6     | 4045  | 161    | 6              | 76 | 18 | 10/151  | .0662 |
| 5     | 4206  | 155    | 23             | 34 | 43 | 35/120  | .2916 |
| 4     | 4361  | 142    | 13             | 37 | 50 | 19/123  | .1544 |
| 3     | 4503  | 67     | 9              | 54 | 37 | 6/61    | .0983 |
| 2     | 4570  | 88     | 15             | 52 | 33 | 13/75   | .1733 |
| 1     | 4658  | 138    | 14             | 66 | 20 | 20/118  | .1694 |
| 28772 |       |        | Huron 15N11E20 |    |    |         | #64   |
| lg    | 709   |        |                |    |    |         |       |
| E     | 5311  |        |                |    |    |         |       |
| F     |       | 813    |                |    |    |         |       |
| 6     | 4498  | 179    | 7              | 72 | 21 | 13/166  | .0783 |
| 5     | 4677  | 169    | 22             | 47 | 31 | 38/131  | .2900 |
| 4     | 4846  | 150    | 14             | 43 | 43 | 22/128  | .1718 |
| 3     | 4996  | 75     | 9              | 71 | 20 | 7/68    | .1029 |
| 2     | 5071  | 94     | 14             | 56 | 30 | 13/81   | .1604 |
| 1     | 5165  | 146    | 12             | 72 | 16 | 17/129  | .1317 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio |
|-------|-------|--------|------------------|----|----|---------|-------|
| 29191 |       |        | Huron 15N15E26   |    |    |         | #65   |
| lg    | 711   |        |                  |    |    |         |       |
| E     | 3319  |        |                  |    |    |         |       |
| F     |       | 631    |                  |    |    |         |       |
| 6     | 2688  | 117    | 9                | 66 | 26 | 10/107  | .0934 |
| 5     | 2805  | 122    | 28               | 37 | 35 | 34/88   | .3863 |
| 4     | 2927  | 115    | 23               | 39 | 38 | 26/89   | .2921 |
| 3     | 3042  | 68     | 10               | 69 | 21 | 7/61    | .1147 |
| 2     | 3110  | 81     | 16               | 63 | 21 | 13/68   | .1911 |
| 1     | 3191  | 128    | 15               | 77 | 8  | 20/108  | .1851 |
| 23890 |       |        | Tuscola 13N9E8   |    |    |         | #66   |
| KB    | 678   |        |                  |    |    |         |       |
| E     | 5507  |        |                  |    |    |         |       |
| F     |       | 871    |                  |    |    |         |       |
| 6     | 4636  | 193    | 5                | 76 | 19 | 10/183  | .0546 |
| 5     | 4829  | 188    | 20               | 42 | 38 | 38/150  | .2533 |
| 4     | 5017  | 162    | 11               | 44 | 45 | 18/144  | .1250 |
| 3     | 5179  | 80     | 7                | 79 | 14 | 6/74    | .0810 |
| 2     | 5259  | 100    | 14               | 61 | 25 | 14/86   | .1627 |
| 1     | 5359  | 148    | 13               | 78 | 9  | 19/129  | .1472 |
| 25609 |       |        | Tuscola 13N11E16 |    |    |         | #67   |
| KB    | 737   |        |                  |    |    |         |       |
| E     | 4867  |        |                  |    |    |         |       |
| F     |       | 772    |                  |    |    |         |       |
| 6     | 4095  | 163    | 4                | 69 | 27 | 7/156   | .0448 |
| 5     | 4258  | 164    | 19               | 34 | 47 | 31/133  | .2330 |
| 4     | 4422  | 144    | 16               | 38 | 46 | 23/121  | .1900 |
| 3     | 4566  | 73     | 8                | 78 | 14 | 6/67    | .0895 |
| 2     | 4639  | 89     | 17               | 51 | 32 | 15/74   | .2027 |
| 1     | 4728  | 139    | 13               | 69 | 18 | 18/121  | .1487 |
| 23500 |       |        | Sanilac 13N13E20 |    |    |         | #68   |
| KB    | 770   |        |                  |    |    |         |       |
| E     | 4082  |        |                  |    |    |         |       |
| F     |       | 713    |                  |    |    |         |       |
| 6     | 3369  | 144    | 9                | 77 | 14 | 13/131  | .0992 |
| 5     | 3513  | 149    | 25               | 43 | 32 | 38/111  | .3423 |
| 4     | 3662  | 131    | 24               | 37 | 39 | 31/100  | .3100 |
| 3     | 3793  | 70     | 16               | 61 | 23 | 11/59   | .1864 |
| 2     | 3863  | 89     | 26               | 56 | 18 | 23/66   | .3484 |
| 1     | 3952  | 130    | 16               | 66 | 18 | 21/109  | .1926 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio  |
|-------|-------|--------|------------------|----|----|---------|--------|
| 24254 |       |        | Sanilac 12N15E5  |    |    |         | #69    |
| KB    | 812   |        |                  |    |    |         |        |
| E     | 3347  |        |                  |    |    |         |        |
| F     |       | 655    |                  |    |    |         |        |
| 6     | 2692  | 118    | 6                | 73 | 21 | 7/111   | .0630  |
| 5     | 2810  | 131    | 25               | 22 | 53 | 33/98   | .3367  |
| 4     | 2941  | 121    | 19               | 31 | 50 | 23/98   | .2346  |
| 3     | 3062  | 72     | 10               | 68 | 22 | 7/65    | .1076  |
| 2     | 3134  | 88     | 17               | 57 | 26 | 15/73   | .2054  |
| 1     | 3222  | 125    | 14               | 80 | 6  | 17/109  | .1574  |
| 22856 |       |        | Sanilac 11N12E25 |    |    |         | #70    |
| KB    | 784   |        |                  |    |    |         |        |
| E     | 3956  |        |                  |    |    |         |        |
| F     |       | 681    |                  |    |    |         |        |
| 6     | 3275  | 128    | 4                | 70 | 26 | 5/123   | .0406  |
| 5     | 3403  | 143    | 21               | 36 | 43 | 30/113  | .2654  |
| 4     | 3546  | 130    | 17               | 28 | 55 | 22/108  | .2037  |
| 3     | 3676  | 67     | 7                | 52 | 41 | 5/62    | .0806  |
| 2     | 3743  | 92     | 13               | 60 | 27 | 12/80   | .1500  |
| 1     | 3835  | 121    | 16               | 70 | 14 | 19/102  | .1862  |
| 25939 |       |        | Sanilac 10N15E9  |    |    |         | #71    |
| KB    | 775   |        |                  |    |    |         |        |
| E     | 2676  |        |                  |    |    |         |        |
| F     |       | 640    |                  |    |    |         |        |
| 6     | 2036  | 94     | 19               | 61 | 20 | 18/76   | .2368  |
| 5     | 2130  | 138    | 25               | 33 | 42 | 34/104  | .7269  |
| 4     | 2268  | 120    | 18               | 50 | 32 | 22/98   | .2244  |
| 3     | 2388  | 71     | 8                | 71 | 21 | 6/65    | .0923  |
| 2     | 2459  | 90     | 14               | 62 | 24 | 13/77   | .1688  |
| 1     | 2549  | 127    | 9                | 70 | 21 | 11/116  | 1.0948 |
| 24142 |       |        | Lapeer 9N11E21   |    |    |         | #72    |
| KB    | 836   |        |                  |    |    |         |        |
| E     | 3619  |        |                  |    |    |         |        |
| F     |       | 678    |                  |    |    |         |        |
| 6     | 2941  | 119    | 11               | 80 | 9  | 13/106  | .1226  |
| 5     | 3060  | 141    | 21               | 45 | 34 | 29/112  | .2589  |
| 4     | 3201  | 133    | 12               | 44 | 44 | 16/117  | .1367  |
| 3     | 3334  | 68     | 7                | 60 | 33 | 5/63    | .0793  |
| 2     | 3402  | 94     | 13               | 67 | 20 | 12/82   | .1463  |
| 1     | 3496  | 123    | 14               | 70 | 16 | 17/106  | .1603  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic | Ratio  |
|-------|-------|--------|-------------------|----|----|---------|--------|
| 23946 |       |        | Lapeer 8N9E10     |    |    |         | #73    |
| KB    | 801   |        |                   |    |    |         |        |
| E     | 3704  |        |                   |    |    |         |        |
| F     |       | 705    |                   |    |    |         |        |
| 6     | 2999  | 137    | 12                | 70 | 18 | 16/121  | .1322  |
| 5     | 3136  | 144    | 22                | 44 | 34 | 31/113  | .2743  |
| 4     | 3280  | 139    | 15                | 45 | 50 | 21/118  | .1779  |
| 3     | 3419  | 70     | 11                | 73 | 16 | 8/62    | .1290  |
| 2     | 3489  | 88     | 11                | 56 | 33 | 10/78   | .1282  |
| 1     | 3577  | 127    | 13                | 72 | 15 | 16/111  | .1444  |
| 24010 |       |        | Lapeer 6N12E17    |    |    |         | #74    |
| KB    | 925   |        |                   |    |    |         |        |
| E     | 2400  |        |                   |    |    |         |        |
| F     |       | 534    |                   |    |    |         |        |
| 6     | 1866  | 44     | 27                | 45 | 28 | 12/32   | .3750  |
| 5     | 1910  | 97     | 51                | 27 | 22 | 49/48   | 1.0208 |
| 4     | 2007  | 121    | 16                | 55 | 29 | 20/101  | .1980  |
| 3     | 2128  | 64     | 15                | 70 | 15 | 10/54   | .1851  |
| 2     | 2192  | 89     | 20                | 65 | 15 | 18/71   | .2535  |
| 1     | 2281  | 119    | 8                 | 75 | 17 | 10/109  | .0917  |
| 25859 |       |        | St. Clair 8N14E19 |    |    |         | #75    |
| lg    | 820   |        |                   |    |    |         |        |
| E     | 2635  |        |                   |    |    |         |        |
| F     |       | 544    |                   |    |    |         |        |
| 6     | 2091  | 49     | 14                | 49 | 32 | 7/42    | .1666  |
| 5     | 2140  | 107    | 34                | 23 | 43 | 36/71   | .5070  |
| 4     | 2247  | 118    | 14                | 54 | 32 | 17/101  | .1683  |
| 3     | 2365  | 64     | 17                | 70 | 13 | 11/53   | .2075  |
| 2     | 2429  | 89     | 16                | 55 | 29 | 14/75   | .1866  |
| 1     | 2518  | 117    | 9                 | 69 | 22 | 10/107  | .0934  |
| 26086 |       |        | St. Clair 6N15E1  |    |    |         | #76    |
| lg    | 709   |        |                   |    |    |         |        |
| E     | 1615  |        |                   |    |    |         |        |
| F     |       | 468    |                   |    |    |         |        |
| 6     | 1147  | 49     | 8                 | 51 | 41 | 4/45    | .0888  |
| 5     | 1196  | 50     | 90                | 0  | 10 | 45/5    | 9.0000 |
| 4     | 1246  | 102    | 22                | 56 | 22 | 22/80   | .2750  |
| 3     | 1348  | 67     | 9                 | 76 | 15 | 6/61    | .0983  |
| 2     | 1415  | 91     | 13                | 63 | 24 | 12/78   | .1518  |
| 1     | 1506  | 109    | 4                 | 70 | 26 | 5/104   | .0480  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic | Ratio   |
|-------|-------|--------|-------------------|----|----|---------|---------|
| 25780 |       |        | St. Clair 2N16E17 |    |    |         | #77     |
| lg    | 581   |        |                   |    |    |         |         |
| E     | 799   |        |                   |    |    |         |         |
| F     |       | 183    |                   |    |    |         |         |
| 6     | 616   | 47     | 23                | 66 | 11 | 11/36   | .3055   |
| 5     | 663   | 43     | 67                | 0  | 33 | 29/14   | 2.0714  |
| 4     | 706   | 28     | 89                | 0  | 11 | 25/3    | 8.3333  |
| 3     | 734   | 13     | 23                | 0  | 77 | 3/10    | .3000   |
| 2     | 747   | 26     | 27                | 27 | 46 | 7/19    | .3684   |
| 1     | 773   | 26     | 0                 | 1  | 10 | 0/6     | .0400   |
| 31301 |       |        | Macomb 4N14E4     |    |    |         | #78     |
| KB    | 713   |        |                   |    |    |         |         |
| E     | 1525  |        |                   |    |    |         |         |
| F     |       | 404    |                   |    |    |         |         |
| 6     | 1121  | 43     | 19                | 49 | 32 | 8/35    | .2285   |
| 5     | 1164  | 50     | 80                | 0  | 20 | 40/10   | 4.0000  |
| 4     | 1214  | 53     | 58                | 40 | 2  | 29/24   | 1.2083  |
| 3     | 1267  | 61     | 16                | 64 | 20 | 10/51   | .1960   |
| 2     | 1328  | 92     | 13                | 63 | 24 | 12/80   | .1500   |
| 1     | 1420  | 105    | 7                 | 69 | 24 | 8/97    | .0824   |
| 31333 |       |        | Macomb 3N12E7     |    |    |         | #79     |
| KB    | 772   |        |                   |    |    |         |         |
| E     | 1544  |        |                   |    |    |         |         |
| F     |       | 456    |                   |    |    |         |         |
| 6     | 1088  | 45     | 6                 | 47 | 47 | 3/42    | .0714   |
| 5     | 1133  | 46     | 91                | 0  | 9  | 42/4    | 10.5000 |
| 4     | 1179  | 97     | 24                | 45 | 31 | 23/74   | .3108   |
| 3     | 1276  | 62     | 8                 | 74 | 18 | 5/57    | .0877   |
| 2     | 1338  | 93     | 11                | 66 | 23 | 10/83   | .1204   |
| 1     | 1431  | 113    | 5                 | 60 | 35 | 6/107   | .0560   |
| 28258 |       |        | Oakland 4N8E35    |    |    |         | #80     |
| KB    | 1048  |        |                   |    |    |         |         |
| E     | 2320  |        |                   |    |    |         |         |
| F     |       | 611    |                   |    |    |         |         |
| 6     | 1709  | 83     | 36                | 46 | 18 | 30/53   | .5660   |
| 5     | 1792  | 117    | 23                | 36 | 41 | 27/90   | .3000   |
| 4     | 1909  | 128    | 12                | 45 | 43 | 16/112  | .1428   |
| 3     | 2037  | 65     | 11                | 63 | 26 | 7/58    | .1206   |
| 2     | 2102  | 94     | 13                | 67 | 20 | 12/82   | .1463   |
| 1     | 2196  | 124    | 12                | 69 | 19 | 15/109  | .1376   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic Ratio |        |
|-------|-------|--------|-------------------|----|----|---------------|--------|
| 31372 |       |        | Oakland 2N7E25    |    |    |               | #81    |
| KB    | 963   |        |                   |    |    |               |        |
| E     | 1887  |        |                   |    |    |               |        |
| F     |       | 624    |                   |    |    |               |        |
| 6     | 1263  | 108    | 19                | 65 | 15 | 20/88         | .2272  |
| 5     | 1371  | 111    | 29                | 33 | 38 | 32/79         | .4050  |
| 4     | 1482  | 130    | 12                | 60 | 28 | 15/115        | .1304  |
| 3     | 1612  | 65     | 9                 | 77 | 14 | 6/59          | .1016  |
| 2     | 1677  | 97     | 16                | 62 | 22 | 16/81         | .1975  |
| 1     | 1774  | 113    | 6                 | 69 | 25 | 7/106         | .0660  |
| 23426 |       |        | Livingston 4N6E22 |    |    |               | #82    |
| KB    | 1062  |        |                   |    |    |               |        |
| E     | 2647  |        |                   |    |    |               |        |
| F     |       | 685    |                   |    |    |               |        |
| 6     | 1962  | 126    | 11                | 75 | 14 | 14/112        | .1250  |
| 5     | 2088  | 144    | 30                | 35 | 35 | 42/102        | .4117  |
| 4     | 2232  | 133    | 11                | 53 | 36 | 15/118        | .1271  |
| 3     | 2365  | 65     | 9                 | 82 | 9  | 6/59          | .1016  |
| 2     | 2430  | 96     | 16                | 76 | 8  | 15/81         | .1851  |
| 1     | 2526  | 121    | 15                | 71 | 14 | 18/103        | .1747  |
| 12766 |       |        | Livingston 2N4E1  |    |    |               | #83    |
| DF    | 905   |        |                   |    |    |               |        |
| E     | 1908  |        |                   |    |    |               |        |
| F     |       | 599    |                   |    |    |               |        |
| 6     | 1309  | 95     | 22                | 63 | 15 | 21/74         | .2837  |
| 5     | 1404  | 124    | 33                | 36 | 31 | 41/83         | .4939  |
| 4     | 1528  | 122    | 16                | 40 | 44 | 20/102        | .1960  |
| 3     | 1650  | 58     | 9                 | 31 | 60 | 5/53          | .0943  |
| 2     | 1708  | 85     | 18                | 15 | 67 | 15/70         | .2142  |
| 1     | 1793  | 115    | 4                 | 20 | 76 | 5/110         | .0454  |
| 28752 |       |        | Livingston 2N3E17 |    |    |               | #84    |
| KB    | 960   |        |                   |    |    |               |        |
| E     | 2175  |        |                   |    |    |               |        |
| F     |       | 365    |                   |    |    |               |        |
| 6     | 1810  | 50     | 8                 | 26 | 66 | 4/46          | .0869  |
| 5     | 1860  | 39     | 74                | 0  | 26 | 29/10         | 2.9000 |
| 4     | 1899  | 34     | 88                | 0  | 12 | 30/4          | 7.5000 |
| 3     | 1933  | 54     | 17                | 39 | 44 | 9/45          | .2000  |
| 2     | 1987  | 75     | 17                | 68 | 15 | 13/62         | .2096  |
| 1     | 2062  | 113    | 13                | 65 | 22 | 15/98         | .1530  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh           | %E | %C | Clastic | Ratio   |
|-------|-------|--------|---------------|----|----|---------|---------|
| 30134 |       |        | Ingham 2N2E3  |    |    |         | #85     |
| KB    | 944   |        |               |    |    |         |         |
| E     | 2670  |        |               |    |    |         |         |
| F     |       | 284    |               |    |    |         |         |
| 6     | 2386  | 44     | 18            | 55 | 27 | 8/36    | .2222   |
| 5     | 2430  | 45     | 84            | 0  | 16 | 38/7    | 5.4285  |
| 4     | 2475  | 33     | 88            | 12 | 0  | 29/4    | 7.2500  |
| 3     | 2508  | 23     | 48            | 22 | 30 | 11/12   | .9166   |
| 2     | 2531  | 32     | 19            | 19 | 62 | 6/26    | .2307   |
| 1     | 2563  | 107    | 12            | 69 | 19 | 13/94   | .1382   |
| 22607 |       |        | Ingham 1N2E13 |    |    |         | #86     |
| RT    | 972   |        |               |    |    |         |         |
| E     | 1728  |        |               |    |    |         |         |
| F     |       | 194    |               |    |    |         |         |
| 6     | 1534  | 49     | 6             | 24 | 70 | 3/46    | .0652   |
| 5     | 1583  | 38     | 100           | 0  | 0  | 38/1    | 38.0000 |
| 4     | 1621  | 34     | 91            | 0  | 9  | 31/3    | 10.3333 |
| 3     | 1655  | 23     | 48            | 22 | 30 | 11/12   | .9166   |
| 2     | 1678  | 23     | 26            | 17 | 57 | 6/17    | .3529   |
| 1     | 1701  | 27     | 22            | 15 | 63 | 6/21    | .2857   |
| 29498 |       |        | Ingham 1N2W1  |    |    |         | #87     |
| KB    | 1003  |        |               |    |    |         |         |
| E     | 2355  |        |               |    |    |         |         |
| F     |       | 182    |               |    |    |         |         |
| 6     | 2173  | 38     | 13            | 24 | 63 | 5/33    | .1515   |
| 5     | 2211  | 36     | 78            | 0  | 22 | 28/8    | 3.5000  |
| 4     | 2247  | 34     | 85            | 6  | 9  | 29/5    | 5.8000  |
| 3     | 3381  | 22     | 59            | 23 | 18 | 13/9    | 1.4444  |
| 2     | 2303  | 23     | 26            | 26 | 48 | 6/17    | .3529   |
| 1     | 2326  | 29     | 28            | 17 | 55 | 8/21    | .3809   |
| 30432 |       |        | Eaton 3N5W10  |    |    |         | #88     |
| KB    | 866   |        |               |    |    |         |         |
| E     | 2380  |        |               |    |    |         |         |
| F     |       | 153    |               |    |    |         |         |
| 6     | 2227  | 18     | 0             | 22 | 78 | 1/17    | .0588   |
| 5     | 2245  | 26     | 100           | 0  | 0  | 26/1    | 26.0000 |
| 4     | 2271  | 37     | 70            | 8  | 22 | 26/11   | 2.3636  |
| 3     | 2308  | 26     | 54            | 31 | 15 | 14/12   | 1.1666  |
| 2     | 2334  | 30     | 40            | 10 | 50 | 12/18   | .6666   |
| 1     | 2364  | 16     | 56            | 0  | 44 | 9/7     | 1.2857  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh           | %E | %C | Clastic | Ratio   |
|-------|-------|--------|---------------|----|----|---------|---------|
| 22541 |       |        | Eaton 1N6W17  |    |    |         | #89     |
|       | 954   |        |               |    |    |         |         |
| E     | 1830  |        |               |    |    |         |         |
| F     |       | 159    |               |    |    |         |         |
| 6     | 1671  | 29     | 17            | 0  | 83 | 5/24    | .2083   |
| 5     | 1700  | 40     | 100           | 0  | 0  | 40/1    | 40.0000 |
| 4     | 1740  | 18     | 61            | 0  | 39 | 11/7    | 1.5714  |
| 3     | 1758  | 24     | 38            | 33 | 29 | 9/15    | .6000   |
| 2     | 1782  | 26     | 19            | 23 | 58 | 5/21    | .2380   |
| 1     | 1808  | 22     | 41            | 0  | 59 | 9/13    | .6923   |
| 28802 |       |        | Barry 3N7W23  |    |    |         | #90     |
|       | 949   |        |               |    |    |         |         |
| E     | 2124  |        |               |    |    |         |         |
| F     |       | 165    |               |    |    |         |         |
| 6     | 1959  | 31     | 19            | 23 | 58 | 6/25    | .2400   |
| 5     | 1990  | 44     | 91            | 0  | 9  | 40/4    | 10.0000 |
| 4     | 2034  | 30     | 80            | 20 | 0  | 24/6    | 4.0000  |
| 3     | 2064  | 19     | 32            | 32 | 36 | 6/13    | .4615   |
| 2     | 2083  | 20     | 40            | 0  | 60 | 8/12    | .6666   |
| 1     | 2103  | 21     | 57            | 0  | 43 | 12/9    | 1.3333  |
| 26182 |       |        | Barry 4N10W34 |    |    |         | #91     |
|       | 790   |        |               |    |    |         |         |
| E     | 2030  |        |               |    |    |         |         |
| F     |       | 133    |               |    |    |         |         |
| 6     | 1897  | 21     | 28            | 24 | 48 | 6/15    | .4000   |
| 5     | 1918  | 34     | 100           | 0  | 0  | 34/1    | 34.0000 |
| 4     | 1952  | 20     | 100           | 0  | 0  | 20/1    | 20.0000 |
| 3     | 1972  | 17     | 35            | 30 | 35 | 6/11    | .5454   |
| 2     | 1989  | 21     | 24            | 43 | 33 | 5/16    | .3125   |
| 1     | 2010  | 20     | 60            | 25 | 15 | 12/8    | 1.5000  |
| 30764 |       |        | Barry 1N9W14  |    |    |         | #92     |
|       | 940   |        |               |    |    |         |         |
| E     | 1837  |        |               |    |    |         |         |
| F     |       | 144    |               |    |    |         |         |
| 6     | 1693  | 31     | 16            | 0  | 84 | 5/26    | .1923   |
| 5     | 1724  | 40     | 100           | 0  | 0  | 40/1    | 40.0000 |
| 4     | 1764  | 13     | 77            | 0  | 23 | 10/3    | 3.3333  |
| 3     | 1777  | 18     | 33            | 0  | 67 | 6/12    | .5000   |
| 2     | 1795  | 22     | 32            | 0  | 68 | 7/15    | .4666   |
| 1     | 1817  | 20     | 50            | 0  | 50 | 10/10   | 1.0000  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh             | %E | %C | Clastic | Ratio   |
|-------|-------|--------|-----------------|----|----|---------|---------|
| 22852 |       |        | Ottawa 8N14W9   |    |    |         | #93     |
|       | 695   |        |                 |    |    |         |         |
| E     | 2170  |        |                 |    |    |         |         |
| F     |       | 122    |                 |    |    |         |         |
| 6     |       |        |                 |    |    |         |         |
| 5     | 2048  | 33     | 100             | 0  | 0  | 33/0    | 33.0000 |
| 4     | 2081  | 24     | 88              | 12 | 0  | 21/3    | 7.0000  |
| 3     | 2105  | 22     | 54              | 23 | 23 | 12/10   | 1.2000  |
| 2     | 2127  | 19     | 58              | 21 | 21 | 11/8    | 1.3750  |
| 1     | 2146  | 24     | 46              | 33 | 21 | 11/13   | .8461   |
| 25519 |       |        | Allegan 4N13W23 |    |    |         | #94     |
|       | 690   |        |                 |    |    |         |         |
| E     | 1812  |        |                 |    |    |         |         |
| F     |       | 108    |                 |    |    |         |         |
| 6     | 1704  | 10     | 70              | 0  | 30 | 7/3     | 2.3333  |
| 5     | 1714  | 23     | 100             | 0  | 0  | 23/1    | 23.0000 |
| 4     | 1737  | 10     | 100             | 0  | 0  | 10/1    | 10.0000 |
| 3     | 1747  | 28     | 57              | 0  | 43 | 16/12   | 1.3333  |
| 2     | 1775  | 19     | 32              | 0  | 68 | 6/13    | .4615   |
| 1     | 1794  | 18     | 55              | 0  | 45 | 10/8    | 1.2500  |
| 22959 |       |        | Allegan 2N13W15 |    |    |         | #95     |
|       | 748   |        |                 |    |    |         |         |
| E     | 1566  |        |                 |    |    |         |         |
| F     |       | 133    |                 |    |    |         |         |
| 6     | 1433  | 19     | 42              | 0  | 58 | 8/11    | .7272   |
| 5     | 1452  | 29     | 90              | 0  | 10 | 26/3    | 8.6666  |
| 4     | 1481  | 12     | 100             | 0  | 0  | 11/1    | 11.0000 |
| 3     | 1493  | 28     | 36              | 0  | 64 | 10/18   | .5555   |
| 2     | 1521  | 24     | 42              | 0  | 58 | 10/14   | .7142   |
| 1     | 1545  | 21     | 52              | 0  | 48 | 11/10   | 1.1000  |
| 24016 |       |        | Allegan 1N15W18 |    |    |         | #96     |
|       | 652   |        |                 |    |    |         |         |
| E     | 1096  |        |                 |    |    |         |         |
| F     |       | 100    |                 |    |    |         |         |
| 6     |       |        |                 |    |    |         |         |
| 5     | 996   | 13     | 100             | 0  | 0  | 13/1    | 13.0000 |
| 4     | 1009  | 16     | 69              | 0  | 31 | 11/5    | 2.2000  |
| 3     | 1025  | 32     | 53              | 0  | 47 | 17/15   | 1.1333  |
| 2     | 1057  | 22     | 41              | 0  | 59 | 9/13    | .6923   |
| 1     | 1079  | 17     | 53              | 0  | 47 | 9/8     | 1.1250  |

## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic Ratio |         |
|-------|-------|--------|-------------------|----|----|---------------|---------|
| 23524 |       |        | Van Buren 4S14W34 |    |    |               | #97     |
| E     |       |        |                   |    |    |               |         |
| F     |       |        |                   |    |    |               |         |
| 6     |       |        |                   |    |    |               |         |
| 5     |       |        |                   |    |    |               |         |
| 4     |       |        |                   |    |    |               |         |
| 3     |       |        |                   |    |    |               |         |
| 2     |       |        |                   |    |    |               |         |
| 1     |       |        |                   |    |    |               |         |
| 23035 |       |        | Kalamazoo 1S12W10 |    |    |               | #98     |
|       | 789   |        |                   |    |    |               |         |
| E     | 1346  |        |                   |    |    |               |         |
| F     |       | 105    |                   |    |    |               |         |
| 6     |       |        |                   |    |    |               |         |
| 5     | 1241  | 23     | 100               | 0  | 0  | 23/1          | 23.0000 |
| 4     | 1264  | 17     | 100               | 0  | 0  | 17/1          | 17.0000 |
| 3     | 1281  | 30     | 73                | 0  | 27 | 22/8          | 2.7500  |
| 2     | 1311  | 22     | 45                | 0  | 55 | 10/12         | .8333   |
| 1     | 1333  | 13     | 61                | 0  | 39 | 8/5           | 1.6000  |
| 23004 |       |        | Kalamazoo 4S10W11 |    |    |               | #99     |
|       | 892   |        |                   |    |    |               |         |
| E     |       |        |                   |    |    |               |         |
| F     |       |        |                   |    |    |               |         |
| 6     |       |        |                   |    |    |               |         |
| 5     |       |        |                   |    |    |               |         |
| 4     |       |        |                   |    |    |               |         |
| 3     |       |        |                   |    |    |               |         |
| 2     |       |        |                   |    |    |               |         |
| 1     |       |        |                   |    |    |               |         |
| 27862 |       |        | Calhoun 3S8W7     |    |    |               | #100    |
|       | 982   |        |                   |    |    |               |         |
| E     | 1064  |        |                   |    |    |               |         |
| F     |       | 91     |                   |    |    |               |         |
| 6     |       |        |                   |    |    |               |         |
| 5     | 973   | 10     | 100               | 0  | 0  | 10/1          | 10.0000 |
| 4     | 983   | 27     | 89                | 0  | 11 | 24/1          | 8.0000  |
| 3     | 1010  | 22     | 18                | 0  | 82 | 4/18          | .2222   |
| 2     | 1032  | 16     | 38                | 0  | 62 | 6/10          | .6000   |
| 1     | 1048  | 16     | 38                | 0  | 62 | 6/10          | .6000   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh            | %E | %C  | Clastic | Ratio   |
|-------|-------|--------|----------------|----|-----|---------|---------|
| 30339 |       |        | Calhoun 2S6W10 |    |     |         | #101    |
|       | 956   |        |                |    |     |         |         |
| E     | 1440  |        |                |    |     |         |         |
| F     |       | 129    |                |    |     |         |         |
| 6     | 1311  | 28     | 18             | 0  | 82  | 5/23    | .2173   |
| 5     | 1339  | 22     | 82             | 0  | 18  | 18/4    | 4.5000  |
| 4     | 1361  | 23     | 100            | 0  | 0   | 23/1    | 23.0000 |
| 3     | 1384  | 19     | 42             | 0  | 58  | 8/11    | .7272   |
| 2     | 1403  | 16     | 44             | 0  | 56  | 7/9     | .7777   |
| 1     | 1419  | 21     | 38             | 0  | 62  | 8/13    | .6153   |
| 24556 |       |        | Calhoun 4S5W20 |    |     |         | #102    |
|       | 1018  |        |                |    |     |         |         |
| E     | 1041  |        |                |    |     |         |         |
| F     |       | 117    |                |    |     |         |         |
| 6     | 924   | 28     | 25             | 0  | 75  | 7/21    | .3333   |
| 5     | 952   | 20     | 80             | 0  | 20  | 16/4    | 4.0000  |
| 4     | 972   | 23     | 87             | 0  | 13  | 20/3    | 6.6666  |
| 3     | 995   | 17     | 41             | 0  | 59  | 7/10    | .7000   |
| 2     | 1012  | 17     | 41             | 0  | 59  | 7/10    | .7000   |
| 1     | 1029  | 12     | 25             | 0  | 75  | 3/9     | .3333   |
| 26481 |       |        | Jackson 1S3W4  |    |     |         | #103    |
|       | 946   |        |                |    |     |         |         |
| E     | 1898  |        |                |    |     |         |         |
| F     |       | 170    |                |    |     |         |         |
| 6     | 1728  | 26     | 23             | 0  | 77  | 6/20    | .3000   |
| 5     | 1754  | 37     | 89             | 0  | 1   | 33/4    | 8.2500  |
| 4     | 1791  | 31     | 90             | 0  | 10  | 28/3    | 9.3333  |
| 3     | 1822  | 23     | 48             | 0  | 52  | 11/12   | .9166   |
| 2     | 1845  | 22     | 32             | 0  | 68  | 7/15    | .4666   |
| 1     | 1867  | 31     | 36             | 0  | 64  | 11/20   | .5500   |
| 22950 |       |        | Jackson        |    |     |         | #104    |
|       | 1044  |        |                |    |     |         |         |
| E     | 1288  |        |                |    |     |         |         |
| F     |       | 121    |                |    |     |         |         |
| 6     | 1167  | 26     | 50             | 0  | 50  | 13/13   | 1.0000  |
| 5     | 1193  | 33     | 100            | 0  | 0   | 33/1    | 33.0000 |
| 4     | 1226  | 13     | 100            | 0  | 0   | 13/1    | 13.0000 |
| 3     | 1239  | 16     | 44             | 0  | 56  | 7/9     | .7777   |
| 2     | 1255  | 14     | 57             | 0  | 43  | 8/6     | 1.3333  |
| 1     | 1269  | 19     | 0              | 0  | 100 | 1/19    | .0526   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C  | Clastic | Ratio   |
|-------|-------|--------|------------------|----|-----|---------|---------|
| 21992 |       |        | Jackson 1S1E26   |    |     |         | #105    |
|       | 924   |        |                  |    |     |         |         |
| E     | 2233  |        |                  |    |     |         |         |
| F     |       | 170    |                  |    |     |         |         |
| 6     | 2063  | 36     | 17               | 0  | 83  | 6/30    | .2000   |
| 5     | 2099  | 27     | 81               | 0  | 19  | 22/5    | 4.4000  |
| 4     | 2126  | 43     | 100              | 0  | 0   | 43/1    | 43.0000 |
| 3     | 2169  | 21     | 52               | 0  | 48  | 11/10   | 1.1000  |
| 2     | 2190  | 18     | 33               | 0  | 67  | 6/12    | .5000   |
| 1     | 2208  | 25     | 32               | 0  | 68  | 8/17    | .4705   |
| 28665 |       |        | Jackson 4S1E10   |    |     |         | #106    |
|       | 995   |        |                  |    |     |         |         |
| E     | 1356  |        |                  |    |     |         |         |
| F     |       | 128    |                  |    |     |         |         |
| 6     | 1228  | 34     | 50               | 0  | 50  | 17/17   | 1.0000  |
| 5     | 1262  | 25     | 100              | 0  | 0   | 25/1    | 25.0000 |
| 4     | 1287  | 16     | 100              | 0  | 0   | 16/1    | 16.0000 |
| 3     | 1303  | 21     | 57               | 0  | 43  | 12/9    | 1.3333  |
| 2     | 1324  | 14     | 57               | 0  | 43  | 8/6     | 1.3333  |
| 1     | 1338  | 18     | 0                | 0  | 100 | 1/18    | .0555   |
| ?     |       |        | Washtenaw 1S4E26 |    |     |         | #107    |
|       | 916   |        |                  |    |     |         |         |
| E     | 1633  |        |                  |    |     |         |         |
| F     |       | 193    |                  |    |     |         |         |
| 6     | 1440  | 40     | 10               | 12 | 78  | 4/36    | .1111   |
| 5     | 1480  | 41     | 90               | 0  | 10  | 37/4    | 9.2500  |
| 4     | 1521  | 32     | 81               | 19 | 0   | 26/6    | 4.3333  |
| 3     | 1553  | 19     | 42               | 21 | 37  | 8/11    | .7300   |
| 2     | 1572  | 18     | 39               | 50 | 11  | 7/11    | .6400   |
| 1     | 1590  | 43     | 79               | 9  | 12  | 34/9    | 3.7800  |
| 27472 |       |        | Washtenaw 3S4E8  |    |     |         | #108    |
|       | 957   |        |                  |    |     |         |         |
| E     | 1273  |        |                  |    |     |         |         |
| F     |       | 165    |                  |    |     |         |         |
| 6     | 1108  | 37     | 8                | 27 | 65  | 3/34    | .0900   |
| 5     | 1145  | 38     | 89               | 0  | 11  | 34/4    | 8.5000  |
| 4     | 1183  | 36     | 75               | 8  | 17  | 27/9    | 3.0000  |
| 3     | 1219  | 19     | 48               | 6  | 26  | 9/10    | .9000   |
| 2     | 1238  | 16     | 37               | 26 | 37  | 6/10    | .6000   |
| 1     | 1254  | 19     | 32               | 0  | 68  | 6/13    | .4600   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C  | Clastic | Ratio   |
|-------|-------|--------|------------------|----|-----|---------|---------|
| 26856 |       |        | Washtenaw 4S5E17 |    |     |         | #109    |
|       | 860   |        |                  |    |     |         |         |
| E     | 642   |        |                  |    |     |         |         |
| F     |       | 159    |                  |    |     |         |         |
| 6     | 483   | 28     | 0                | 21 | 79  | 0/28    | .0400   |
| 5     | 511   | 38     | 100              | 0  | 0   | 38/1    | 38.0000 |
| 4     | 549   | 31     | 64               | 0  | 36  | 20/11   | 1.8200  |
| 3     | 580   | 19     | 37               | 26 | 37  | 7/12    | .5800   |
| 2     | 599   | 15     | 40               | 20 | 40  | 6/9     | .6700   |
| 1     | 614   | 28     | 0                | 0  | 100 | 2/17    | .0400   |
| 32734 |       |        | Washtenaw 1S6E8  |    |     |         | #110    |
|       | 922   |        |                  |    |     |         |         |
| E     | 1616  |        |                  |    |     |         |         |
| F     |       | 445    |                  |    |     |         |         |
| 6     | 1171  | 45     | 11               | 25 | 64  | 5/40    | .1250   |
| 5     | 1216  | 55     | 95               | 0  | 5   | 52/3    | 17.3333 |
| 4     | 1271  | 72     | 32               | 42 | 26  | 23/49   | .4695   |
| 3     | 1343  | 61     | 10               | 67 | 23  | 6/55    | .1090   |
| 2     | 1404  | 89     | 13               | 66 | 21  | 12/77   | .1558   |
| 1     | 1493  | 123    | 10               | 64 | 26  | 13/110  | .1181   |
| 25714 |       |        | Washtenaw 2S7#26 |    |     |         | #111    |
|       | 782   |        |                  |    |     |         |         |
| E     | 1095  |        |                  |    |     |         |         |
| F     |       | 439    |                  |    |     |         |         |
| 6     | 656   | 51     | 9                | 20 | 72  | 5/46    | .1086   |
| 5     | 707   | 42     | 78               | 0  | 22  | 33/9    | 3.6666  |
| 4     | 749   | 72     | 43               | 30 | 27  | 31/41   | .7560   |
| 3     | 821   | 61     | 0                | 82 | 18  | 1/60    | .0166   |
| 2     | 882   | 94     | 0                | 64 | 36  | 1/93    | .0107   |
| 1     | 976   | 119    | 0                | 66 | 34  | 1/118   | .0084   |
| 25860 |       |        | Wayne 1S8E25     |    |     |         | #112    |
|       | 724   |        |                  |    |     |         |         |
| E     | 1210  |        |                  |    |     |         |         |
| F     |       | 524    |                  |    |     |         |         |
| 6     | 686   | 43     | 7                | 44 | 49  | 3/40    | .0750   |
| 5     | 729   | 75     | 48               | 13 | 99  | 36/39   | .9230   |
| 4     | 804   | 131    | 11               | 63 | 26  | 14/117  | .1196   |
| 3     | 935   | 64     | 10               | 64 | 26  | 6/58    | .1034   |
| 2     | 999   | 102    | 15               | 70 | 15  | 15/87   | .1724   |
| 1     | 1101  | 109    | 17               | 70 | 13  | 19/90   | .2111   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh           | %E | %C  | Clastic | Ratio   |
|-------|-------|--------|---------------|----|-----|---------|---------|
| 26443 |       |        | Wayne 3S9E12  |    |     |         | #113    |
|       | 633   |        |               |    |     |         |         |
| E     | 646   |        |               |    |     |         |         |
| F     |       | 471    |               |    |     |         |         |
| 6     | 175   | 56     | 0             | 30 | 70  | 1/55    | .0181   |
| 5     | 231   | 38     | 87            | 0  | 13  | 33/5    | 6.6000  |
| 4     | 269   | 91     | 26            | 46 | 28  | 24/67   | .3582   |
| 3     | 360   | 71     | 7             | 56 | 37  | 5/66    | .0757   |
| 2     | 431   | 106    | 12            | 64 | 24  | 13/93   | .1397   |
| 1     | 537   | 109    | 18            | 69 | 13  | 20/89   | .2247   |
| 25560 |       |        | Wayne 2S11E19 |    |     |         | #114    |
|       | 588   |        |               |    |     |         |         |
| E     | 693   |        |               |    |     |         |         |
| F     |       | 448    |               |    |     |         |         |
| 6     | 245   | 48     | 6             | 52 | 42  | 3/45    | .0666   |
| 5     | 293   | 42     | 81            | 0  | 19  | 34/8    | 4.2500  |
| 4     | 335   | 75     | 27            | 48 | 25  | 20/55   | .3636   |
| 3     | 410   | 71     | 7             | 75 | 18  | 5/66    | .0757   |
| 2     | 481   | 99     | 15            | 71 | 14  | 15/84   | .1785   |
| 1     | 580   | 113    | 17            | 70 | 13  | 19/94   | .2021   |
| 23775 |       |        | Wayne 4S10E22 |    |     |         | #115    |
|       | 610   |        |               |    |     |         |         |
| E     | 164   |        |               |    |     |         |         |
| F     |       | 184    |               |    |     |         |         |
| 6     | +20   | 46     | 9             | 30 | 61  | 4/42    | .0952   |
| 5     | 26    | 41     | 93            | 0  | 7   | 38/3    | 12.6666 |
| 4     | 67    | 40     | 68            | 22 | 10  | 27/13   | 2.0769  |
| 3     | 107   | 16     | 62            | 38 | 0   | 10/6    | 1.6666  |
| 2     | 123   | 25     | 28            | 32 | 40  | 7/18    | .3888   |
| 1     | 148   | 16     | 37            | 26 | 37  | 6/10    | .6000   |
| 23531 |       |        | Monroe 5S7E4  |    |     |         | #116    |
|       | 658   |        |               |    |     |         |         |
| E     | 400   |        |               |    |     |         |         |
| F     |       | 161    |               |    |     |         |         |
| 6     | 239   | 20     | 0             | 0  | 100 | 1/19    | .0526   |
| 5     | 259   | 41     | 80            | 0  | 20  | 33/8    | 4.1250  |
| 4     | 300   | 32     | 56            | 0  | 44  | 18/14   | 1.2857  |
| 3     | 332   | 20     | 70            | 0  | 30  | 14/6    | 2.3333  |
| 2     | 352   | 12     | 58            | 0  | 42  | 7/5     | 1.4000  |
| 1     | 364   | 36     | 36            | 0  | 64  | 13/23   | .5652   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C  | Clastic Ratio |         |
|-------|-------|--------|------------------|----|-----|---------------|---------|
| 23356 |       |        | Monroe 7S8E6     |    |     |               | #117    |
|       | 640   |        |                  |    |     |               |         |
| E     | +351  |        |                  |    |     |               |         |
| F     |       | 134    |                  |    |     |               |         |
| 6     | +485  | 37     | 24               | 0  | 76  | 9/28          | .3214   |
| 5     | +448  | 36     | 86               | 0  | 14  | 31/5          | 6.2000  |
| 4     | +412  | 15     | 73               | 0  | 27  | 11/4          | 2.7500  |
| 3     | +397  | 19     | 68               | 0  | 32  | 13/6          | 2.1666  |
| 2     | +378  | 8      | 100              | 0  | 0   | 8/1           | 8.0000  |
| 1     | +370  | 19     | 0                | 0  | 100 | 1/18          | .0555   |
| 24515 |       |        | Lenawee 6S3E30   |    |     |               | #118    |
|       | 872   |        |                  |    |     |               |         |
| E     | 635   |        |                  |    |     |               |         |
| F     |       | 98     |                  |    |     |               |         |
| 6     | 537   | 21     | 29               | 0  | 71  | 6/15          | .4000   |
| 5     | 558   | 21     | 81               | 0  | 19  | 17/4          | 4.2500  |
| 4     | 579   | 22     | 73               | 0  | 27  | 16/6          | 2.6666  |
| 3     | 601   | 13     | 46               | 0  | 54  | 6/7           | .8571   |
| 2     | 614   | 12     | 58               | 0  | 42  | 7/5           | 1.4000  |
| 1     | 626   | 9      | 0                | 0  | 100 | 1/8           | .1250   |
| 23079 |       |        | Hillsdale 6S3W12 |    |     |               | #119    |
|       | 1121  |        |                  |    |     |               |         |
| E     | 711   |        |                  |    |     |               |         |
| F     |       | 77     |                  |    |     |               |         |
| 6     |       |        |                  |    |     |               |         |
| 5     | 634   | 19     | 100              | 0  | 0   | 19/1          | 19.0000 |
| 4     | 653   | 12     | 67               | 0  | 33  | 8/4           | 2.0000  |
| 3     | 665   | 14     | 43               | 0  | 57  | 6/8           | .7500   |
| 2     | 679   | 18     | 28               | 0  | 72  | 5/13          | .3846   |
| 1     | 697   | 14     | 29               | 0  | 71  | 4/10          | .4000   |
| 25853 |       |        | Branch 7S6W8     |    |     |               | #120    |
|       | 988   |        |                  |    |     |               |         |
| E     |       |        |                  |    |     |               |         |
| F     |       |        |                  |    |     |               |         |
| 6     |       |        |                  |    |     |               |         |
| 5     |       |        |                  |    |     |               |         |
| 4     |       |        |                  |    |     |               |         |
| 3     |       |        |                  |    |     |               |         |
| 2     |       |        |                  |    |     |               |         |
| 1     |       |        |                  |    |     |               |         |

## DATA (Continued)

|       | Elev. | Thick. | %Sh             | %E | %C | Clastic Ratio |
|-------|-------|--------|-----------------|----|----|---------------|
| 24183 | 862   |        | St. Joe 6S9W29  |    |    | #121          |
| E     |       |        |                 |    |    |               |
| F     |       |        |                 |    |    |               |
| 6     |       |        |                 |    |    |               |
| 5     |       |        |                 |    |    |               |
| 4     |       |        |                 |    |    |               |
| 3     |       |        |                 |    |    |               |
| 2     |       |        |                 |    |    |               |
| 1     |       |        |                 |    |    |               |
| 23289 | 865   |        | Cass 7S14W8     |    |    | #122          |
| E     |       |        |                 |    |    |               |
| F     |       |        |                 |    |    |               |
| 6     |       |        |                 |    |    |               |
| 5     |       |        |                 |    |    |               |
| 4     |       |        |                 |    |    |               |
| 3     |       |        |                 |    |    |               |
| 2     |       |        |                 |    |    |               |
| 1     |       |        |                 |    |    |               |
| 23130 | 667   |        | Berrien 3S17W34 |    |    | #123          |
| E     |       |        |                 |    |    |               |
| F     |       |        |                 |    |    |               |
| 6     |       |        |                 |    |    |               |
| 5     |       |        |                 |    |    |               |
| 4     |       |        |                 |    |    |               |
| 3     |       |        |                 |    |    |               |
| 2     |       |        |                 |    |    |               |
| 1     |       |        |                 |    |    |               |
| 24369 | 654   |        | Berrien 6S19W1  |    |    | #124          |
| E     |       |        |                 |    |    |               |
| F     |       |        |                 |    |    |               |
| 6     |       |        |                 |    |    |               |
| 5     |       |        |                 |    |    |               |
| 4     |       |        |                 |    |    |               |
| 3     |       |        |                 |    |    |               |
| 2     |       |        |                 |    |    |               |
| 1     |       |        |                 |    |    |               |

## DATA (Continued)

|             | Elev. | Thick. | %Sh             | %E | %C | Clastic | Ratio   |
|-------------|-------|--------|-----------------|----|----|---------|---------|
| 30777       |       |        | Oakland 5N10E31 |    |    |         | #125    |
|             | 1052  |        |                 |    |    |         |         |
| E           | 2358  |        |                 |    |    |         |         |
| F           |       | 532    |                 |    |    |         |         |
| 6           | 1826  | 46     | 6               | 40 | 54 | 3/43    | .0697   |
| 5           | 1872  | 93     | 51              | 38 | 11 | 47/46   | 1.0217  |
| 4           | 1965  | 123    | 12              | 70 | 18 | 15/108  | .1388   |
| 3           | 2088  | 61     | 8               | 88 | 4  | 5/56    | .0892   |
| 2           | 2149  | 95     | 18              | 63 | 19 | 17/78   | .2179   |
| 1           | 2244  | 114    | 6               | 68 | 26 | 6/108   | .0555   |
| 30169       |       |        | Oceana 15N18W27 |    |    |         | #126    |
| KB          | 762   |        |                 |    |    |         |         |
| E           | 2175  |        |                 |    |    |         |         |
| F           |       | 151    |                 |    |    |         |         |
| 6           |       |        |                 |    |    |         |         |
| 5           | 2033  | 53     | 89              | 0  | 11 | 47/6    | 7.8333  |
| 4           | 2086  | 26     | 73              | 0  | 27 | 19/7    | 2.7142  |
| 3           | 2112  | 23     | 65              | 0  | 35 | 15/8    | 1.8750  |
| 2           | 2135  | 24     | 46              | 0  | 54 | 11/13   | .8461   |
| 1           | 2159  | 16     | 31              | 0  | 69 | 5/11    | .4545   |
| 129-744-870 |       |        | Ottawa 5N15W20  |    |    |         | #127    |
| KB          | 604   |        |                 |    |    |         |         |
| E           | 1829  |        |                 |    |    |         |         |
| F           |       | 124    |                 |    |    |         |         |
| 6           |       |        |                 |    |    |         |         |
| 5           | 1705  | 43     | 93              | 0  | 7  | 40/3    | 13.3333 |
| 4           | 1748  | 18     | 67              | 0  | 33 | 12/6    | 2.0000  |
| 3           | 1766  | 22     | 54              | 0  | 46 | 12/10   | 1.2000  |
| 2           | 1788  | 13     | 69              | 0  | 31 | 9/4     | 2.2500  |
| 1           | 1801  | 28     | 39              | 0  | 61 | 11/17   | .6470   |
| 28865       |       |        | Mason 19N18W13  |    |    |         | #128    |
| lg          | 646   |        |                 |    |    |         |         |
| E           | 2610  |        |                 |    |    |         |         |
| F           |       | 171    |                 |    |    |         |         |
| 6           | 2439  | 28     | 50              | 36 | 14 | 14/14   | 1.0000  |
| 5           | 2467  | 41     | 90              | 0  | 10 | 37/4    | 9.2500  |
| 4           | 2508  | 23     | 100             | 0  | 0  | 23/1    | 23.0000 |
| 3           | 2531  | 35     | 83              | 0  | 17 | 29/6    | 4.8333  |
| 2           | 2566  | 23     | 52              | 18 | 30 | 12/11   | 1.0909  |
| 1           | 2589  | 21     | 14              | 24 | 62 | 3/18    | .1666   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                    | %E | %C | Clastic | Ratio |
|-------|-------|--------|------------------------|----|----|---------|-------|
| 28825 |       |        | Manistee 23N14W27      |    |    |         | #129  |
| KB    | 772   |        |                        |    |    |         |       |
| E     | 3477  |        |                        |    |    |         |       |
| F     |       | 420    |                        |    |    |         |       |
| 6     | 3057  | 55     | 40                     | 49 | 11 | 22/33   | .6666 |
| 5     | 3112  | 96     | 32                     | 32 | 36 | 31/65   | .4769 |
| 4     | 3208  | 55     | 38                     | 38 | 24 | 21/34   | .6176 |
| 3     | 3263  | 52     | 10                     | 40 | 50 | 5/47    | .1063 |
| 2     | 3315  | 56     | 28                     | 34 | 38 | 16/40   | .4000 |
| 1     | 3371  | 106    | 24                     | 38 | 38 | 26/80   | .3250 |
| 30520 |       |        | Grand Traverse 25N10W3 |    |    |         | #130  |
| lg    | 1044  |        |                        |    |    |         |       |
| E     | 4501  |        |                        |    |    |         |       |
| F     |       | 691    |                        |    |    |         |       |
| 6     | 3810  | 168    | 7                      | 63 | 30 | 12/156  | .0769 |
| 5     | 3978  | 121    | 30                     | 40 | 30 | 37/84   | .4404 |
| 4     | 4099  | 129    | 17                     | 36 | 47 | 22/107  | .2056 |
| 3     | 4228  | 68     | 9                      | 37 | 54 | 6/62    | .0967 |
| 2     | 4296  | 98     | 24                     | 37 | 39 | 24/74   | .3243 |
| 1     | 4394  | 107    | 16                     | 62 | 22 | 17/90   | .1888 |
| 28110 |       |        | Crawford 25N4W21       |    |    |         | #131  |
| KB    | 1239  |        |                        |    |    |         |       |
| E     | 5231  |        |                        |    |    |         |       |
| F     |       | 881    |                        |    |    |         |       |
| 6     | 4350  | 243    | 3                      | 72 | 25 | 8/235   | .0340 |
| 5     | 4593  | 173    | 18                     | 44 | 38 | 32/141  | .2269 |
| 4     | 4766  | 151    | 13                     | 76 | 11 | 19/132  | .1439 |
| 3     | 4917  | 76     | 8                      | 87 | 5  | 6/70    | .0857 |
| 2     | 4993  | 111    | 21                     | 53 | 26 | 23/88   | .2613 |
| 1     | 5104  | 127    | 13                     | 65 | 22 | 17/110  | .1545 |
| 29001 |       |        | Crawford 28N4W29       |    |    |         | #132  |
| KB    | 1359  |        |                        |    |    |         |       |
| E     | 4727  |        |                        |    |    |         |       |
| F     |       | 798    |                        |    |    |         |       |
| 6     | 3929  | 210    | 4                      | 77 | 19 | 8/202   | .0396 |
| 5     | 4139  | 147    | 21                     | 37 | 42 | 31/116  | .2672 |
| 4     | 4286  | 141    | 18                     | 45 | 37 | 26/115  | .2260 |
| 3     | 4427  | 76     | 9                      | 41 | 50 | 7/69    | .1014 |
| 2     | 4503  | 106    | 24                     | 44 | 32 | 25/81   | .3086 |
| 1     | 4609  | 118    | 11                     | 63 | 26 | 13/105  | .1238 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                | %E | %C | Clastic | Ratio |
|-------|-------|--------|--------------------|----|----|---------|-------|
| 28479 |       |        | Kalkaska 28N6W19   |    |    |         | #133  |
| lg    | 1112  |        |                    |    |    |         |       |
| E     | 4518  |        |                    |    |    |         |       |
| F     |       | 788    |                    |    |    |         |       |
| 6     | 3730  | 218    | 4                  | 68 | 28 | 9/209   | .0430 |
| 5     | 3948  | 140    | 26                 | 48 | 26 | 37/103  | .3592 |
| 4     | 4088  | 142    | 18                 | 54 | 28 | 25/117  | .2136 |
| 3     | 4230  | 64     | 11                 | 45 | 44 | 7/57    | .1228 |
| 2     | 4294  | 104    | 29                 | 49 | 22 | 30/74   | .4054 |
| 1     | 4398  | 120    | 12                 | 72 | 16 | 14/106  | .1320 |
| 30848 |       |        | Otsego 29N3W2      |    |    |         | #134  |
| lg    | 1282  |        |                    |    |    |         |       |
| E     | 4058  |        |                    |    |    |         |       |
| F     |       | 819    |                    |    |    |         |       |
| 6     | 3239  | 216    | 5                  | 65 | 30 | 10/206  | .0485 |
| 5     | 3455  | 145    | 27                 | 46 | 27 | 40/105  | .3809 |
| 4     | 3600  | 146    | 16                 | 30 | 54 | 23/123  | .1869 |
| 3     | 3746  | 77     | 8                  | 45 | 47 | 6/71    | .0845 |
| 2     | 3823  | 105    | 17                 | 54 | 29 | 18/87   | .2068 |
| 1     | 3928  | 130    | 16                 | 57 | 27 | 21/109  | .1926 |
| 31255 |       |        | Otsego 29N2W27     |    |    |         | #135  |
| lg    | 1234  |        |                    |    |    |         |       |
| E     | 4274  |        |                    |    |    |         |       |
| F     |       | 844    |                    |    |    |         |       |
| 6     | 3430  | 216    | 5                  | 63 | 32 | 10/206  | .0485 |
| 5     | 3646  | 155    | 28                 | 41 | 31 | 43/112  | .3839 |
| 4     | 3801  | 142    | 15                 | 51 | 34 | 21/121  | .1735 |
| 3     | 3943  | 86     | 9                  | 67 | 24 | 8/78    | .1025 |
| 2     | 4029  | 112    | 22                 | 38 | 40 | 25/87   | .2873 |
| 1     | 4141  | 133    | 16                 | 75 | 9  | 21/112  | .1875 |
| 30184 |       |        | Montmorency 29N2E7 |    |    |         | #136  |
| KB    | 1192  |        |                    |    |    |         |       |
| E     | 3953  |        |                    |    |    |         |       |
| F     |       | 790    |                    |    |    |         |       |
| 6     | 3163  | 207    | 4                  | 65 | 31 | 9/198   | .0454 |
| 5     | 3370  | 151    | 26                 | 38 | 36 | 40/111  | .3603 |
| 4     | 3521  | 133    | 13                 | 68 | 19 | 18/115  | .1565 |
| 3     | 3654  | 78     | 6                  | 77 | 17 | 5/73    | .0684 |
| 2     | 3732  | 100    | 19                 | 31 | 50 | 19/81   | .2345 |
| 1     | 3832  | 121    | 13                 | 74 | 13 | 16/105  | .1523 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh                  | %E | %C | Clastic | Ratio |
|-------|-------|--------|----------------------|----|----|---------|-------|
| 32319 |       |        | Cheboygan 33N1E12    |    |    |         | #137  |
| KB    | 794   |        |                      |    |    |         |       |
| E     | 1957  |        |                      |    |    |         |       |
| F     |       | 727    |                      |    |    |         |       |
| 6     | 1230  | 184    | 7                    | 53 | 40 | 13/171  | .0760 |
| 5     | 1414  | 130    | 45                   | 24 | 31 | 58/72   | .8055 |
| 4     | 1544  | 130    | 19                   | 17 | 64 | 25/105  | .2380 |
| 3     | 1674  | 70     | 27                   | 34 | 39 | 19/51   | .3725 |
| 2     | 1744  | 96     | 24                   | 44 | 32 | 23/73   | .3150 |
| 1     | 1840  | 117    | 12                   | 56 | 32 | 14/103  | .1359 |
| 28856 |       |        | Presque Isle 33N4E12 |    |    |         | #138  |
| KB    | 874   |        |                      |    |    |         |       |
| E     | 1778  |        |                      |    |    |         |       |
| F     |       | 712    |                      |    |    |         |       |
| 6     | 1066  | 175    | 6                    | 54 | 40 | 11/164  | .0670 |
| 5     | 1241  | 126    | 34                   | 43 | 23 | 43/83   | .5180 |
| 4     | 1367  | 128    | 22                   | 16 | 62 | 29/99   | .2929 |
| 3     | 1495  | 68     | 7                    | 49 | 44 | 5/63    | .0793 |
| 2     | 1563  | 93     | 24                   | 24 | 52 | 22/71   | .3098 |
| 1     | 1656  | 122    | 11                   | 69 | 20 | 14/108  | .1296 |
| 24324 |       |        | Livingston 4N3E35    |    |    |         | #139  |
| KB    | 906   |        |                      |    |    |         |       |
| E     | 2034  |        |                      |    |    |         |       |
| F     |       | 589    |                      |    |    |         |       |
| 6     | 1445  | 63     | 22                   | 57 | 21 | 14/49   | .2857 |
| 5     | 1508  | 118    | 36                   | 20 | 44 | 43/75   | .5733 |
| 4     | 1626  | 121    | 16                   | 35 | 49 | 19/102  | .1862 |
| 3     | 1747  | 64     | 8                    | 64 | 28 | 5/59    | .0847 |
| 2     | 1811  | 89     | 18                   | 67 | 15 | 16/73   | .2191 |
| 1     | 1900  | 134    | 18                   | 64 | 18 | 24/110  | .2181 |
| 34357 |       |        | Missaukee 22N6W31    |    |    |         | #140  |
| KB    | 1206  |        |                      |    |    |         |       |
| E     | 5980  |        |                      |    |    |         |       |
| F     |       | 819    |                      |    |    |         |       |
| 6     | 5161  | 205    | 4                    | 89 | 7  | 8/197   | .0406 |
| 5     | 5366  | 147    | 28                   | 36 | 36 | 42/105  | .4000 |
| 4     | 5513  | 146    | 21                   | 53 | 26 | 31/115  | .2695 |
| 3     | 5659  | 79     | 15                   | 61 | 24 | 12/67   | .1791 |
| 2     | 5738  | 115    | 17                   | 60 | 23 | 20/95   | .2105 |
| 1     | 5853  | 127    | 12                   | 76 | 12 | 15/112  | .1339 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic Ratio |         |
|-------|-------|--------|------------------|----|----|---------------|---------|
| 34078 |       |        | Missaukee 24N6W7 |    |    |               | #141    |
| KB    | 1288  |        |                  |    |    |               |         |
| E     | 5554  |        |                  |    |    |               |         |
| F     |       | 830    |                  |    |    |               |         |
| 6     | 4724  | 211    | 5                | 56 | 39 | 10/201        | .0497   |
| 5     | 5935  | 161    | 23               | 38 | 39 | 37/124        | .2983   |
| 4     | 5096  | 150    | 22               | 49 | 29 | 33/117        | .2820   |
| 3     | 5246  | 73     | 11               | 59 | 30 | 8/65          | .1230   |
| 2     | 5319  | 111    | 22               | 51 | 27 | 24/87         | .2758   |
| 1     | 5430  | 124    | 14               | 72 | 14 | 17/107        | .1588   |
| 34558 |       |        | Osceola 17N8W31  |    |    |               | #142    |
| KB    | 1117  |        |                  |    |    |               |         |
| E     | 5256  |        |                  |    |    |               |         |
| F     |       | 629    |                  |    |    |               |         |
| 6     | 4627  | 114    | 11               | 75 | 14 | 12/102        | .1176   |
| 5     | 4741  | 109    | 31               | 40 | 29 | 34/75         | .4533   |
| 4     | 4850  | 115    | 22               | 64 | 14 | 25/90         | .2777   |
| 3     | 4965  | 78     | 8                | 55 | 37 | 6/72          | .0833   |
| 2     | 5043  | 86     | 23               | 71 | 6  | 20/66         | .3030   |
| 1     | 5129  | 127    | 16               | 66 | 18 | 10/107        | .1869   |
| 34612 |       |        | Wexford 21N9W14  |    |    |               | #143    |
| KB    | 1412  |        |                  |    |    |               |         |
| E     | 5486  |        |                  |    |    |               |         |
| F     |       | 716    |                  |    |    |               |         |
| 6     | 4770  | 162    | 6                | 78 | 16 | 10/152        | .0657   |
| 5     | 4932  | 128    | 25               | 58 | 17 | 32/96         | .3333   |
| 4     | 5060  | 130    | 15               | 60 | 25 | 20/110        | .1818   |
| 3     | 5190  | 67     | 9                | 36 | 55 | 6/61          | .0983   |
| 2     | 5257  | 102    | 25               | 56 | 19 | 25/77         | .3246   |
| 1     | 5359  | 127    | 15               | 68 | 17 | 19/108        | .1759   |
| 34268 |       |        | Ottawa 6N15W1    |    |    |               | #144    |
| KB    | 638   |        |                  |    |    |               |         |
| E     | 2146  |        |                  |    |    |               |         |
| F     |       | 111    |                  |    |    |               |         |
| 6     |       |        |                  |    |    |               |         |
| 5     | 2035  | 43     | 100              | 0  | 0  | 42/1          | 42.0000 |
| 4     | 2078  | 16     | 100              | 0  | 0  | 15/1          | 15.0000 |
| 3     | 2094  | 15     | 48               | 27 | 25 | 7/8           | .8750   |
| 2     | 2109  | 6      | 100              | 0  | 0  | 5/1           | 5.0000  |
| 1     | 2115  | 31     | 45               | 55 | 0  | 14/17         | .8235   |

## DATA (Continued)

|       | Elev. | Thick. | %Sh              | %E | %C | Clastic | Ratio   |
|-------|-------|--------|------------------|----|----|---------|---------|
| 35311 |       |        | Newaygo 16N11W28 |    |    |         | #145    |
| KB    | 1078  |        |                  |    |    |         |         |
| E     | 4358  |        |                  |    |    |         |         |
| F     |       | 440    |                  |    |    |         |         |
| 6     | 3918  | 39     | 26               | 10 | 64 | 10/29   | .3448   |
| 5     | 3957  | 52     | 100              | 0  | 0  | 51/1    | 51.0000 |
| 4     | 4009  | 101    | 1                | 70 | 29 | 1/1000  | .0100   |
| 3     | 4110  | 61     | 0                | 69 | 31 | 1/60    | .0166   |
| 2     | 4171  | 83     | 24               | 45 | 31 | 20/63   | .3174   |
| 1     | 4254  | 104    | 4                | 62 | 34 | 4/100   | .0400   |
| 35259 |       |        | Mecosta 14N7W12  |    |    |         | #146    |
| KB    | 1052  |        |                  |    |    |         |         |
| E     | 5135  |        |                  |    |    |         |         |
| F     |       | 619    |                  |    |    |         |         |
| 6     | 4516  | 97     | 4                | 59 | 37 | 4/93    | .0430   |
| 5     | 4613  | 109    | 10               | 65 | 25 | 11/98   | .1122   |
| 4     | 4722  | 118    | 22               | 78 | 0  | 26/92   | .2826   |
| 3     | 4840  | 61     | 0                | 80 | 20 | 1/66    | .0151   |
| 2     | 4907  | 92     | 15               | 67 | 18 | 14/77   | .1818   |
| 1     | 4998  | 137    | 8                | 66 | 26 | 11/126  | .0873   |
| 34790 |       |        | Clare 17N6W34    |    |    |         | #147    |
| KB    | 1121  |        |                  |    |    |         |         |
| E     | 5765  |        |                  |    |    |         |         |
| F     |       | 730    |                  |    |    |         |         |
| 6     | 5035  | 155    | 9                | 75 | 16 | 14/141  | .0992   |
| 5     | 5190  | 133    | 34               | 66 | 0  | 45/88   | .5113   |
| 4     | 5323  | 136    | 31               | 69 | 0  | 42/94   | .4468   |
| 3     | 5459  | 69     | 7                | 81 | 12 | 5/64    | .0781   |
| 2     | 5528  | 90     | 35               | 48 | 17 | 32/58   | .5517   |
| 1     | 5618  | 147    | 11               | 72 | 17 | 17/130  | .1307   |
| 34611 |       |        | Clare 17N4W7     |    |    |         | #148    |
| KB    | 1004  |        |                  |    |    |         |         |
| E     | 6130  |        |                  |    |    |         |         |
| F     |       | 812    |                  |    |    |         |         |
| 6     | 5318  | 190    | 4                | 78 | 18 | 7/183   | .0382   |
| 5     | 5508  | 158    | 29               | 64 | 7  | 46/112  | .4107   |
| 4     | 5666  | 152    | 17               | 80 | 3  | 26/126  | .2063   |
| 3     | 5818  | 77     | 19               | 67 | 14 | 15/62   | .2419   |
| 2     | 5895  | 99     | 23               | 63 | 14 | 23/78   | .2948   |
| 1     | 5994  | 136    | 4                | 63 | 33 | 5/131   | .0381   |

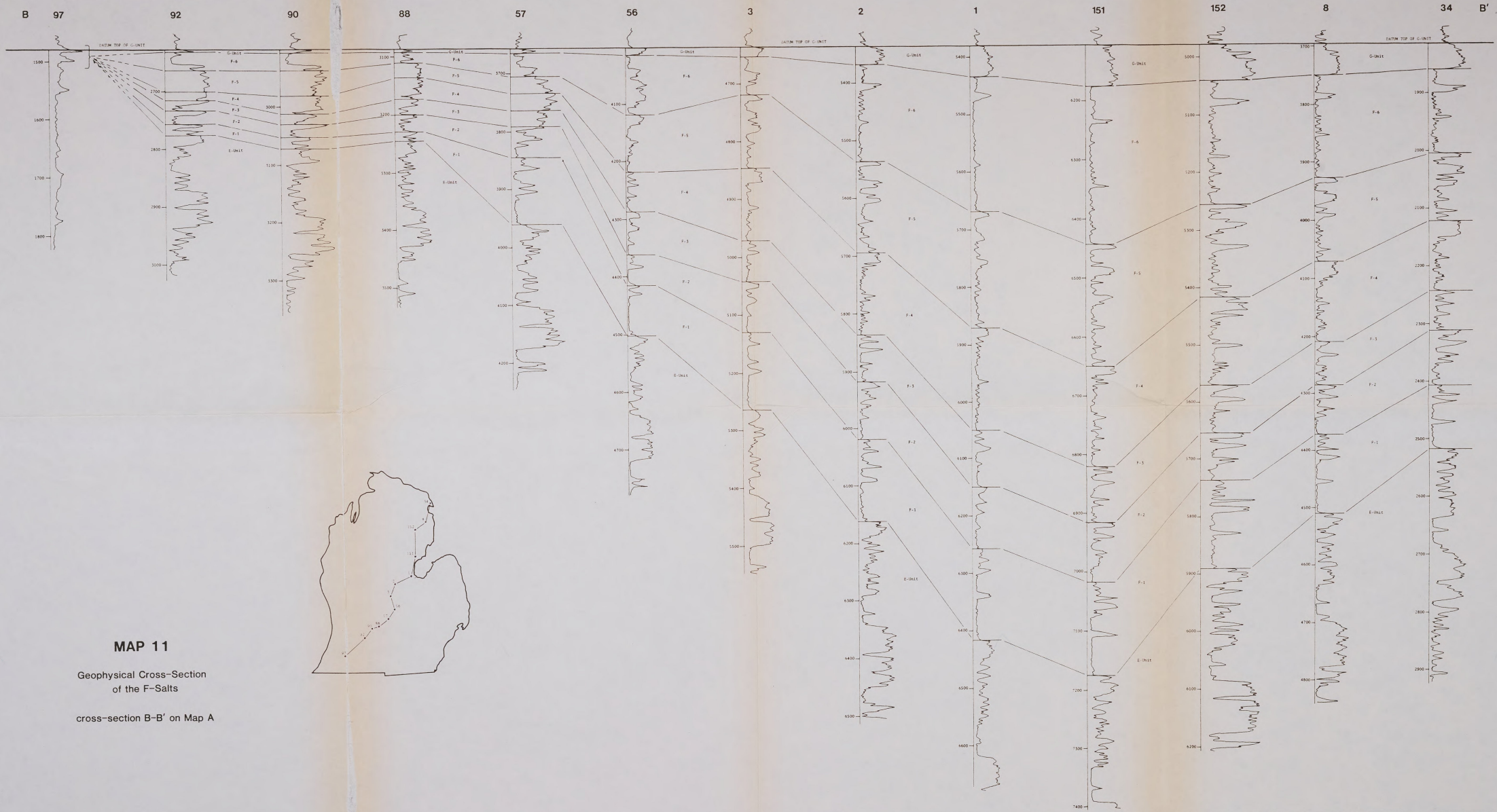
## DATA (Continued)

|       | Elev. | Thick. | %Sh               | %E | %C | Clastic | Ratio |
|-------|-------|--------|-------------------|----|----|---------|-------|
| 33680 |       |        | Clare 20N6W30     |    |    |         | #149  |
| KB    | 1157  |        |                   |    |    |         |       |
| E     | 5843  |        |                   |    |    |         |       |
| F     |       | 788    |                   |    |    |         |       |
| 6     | 5055  | 182    | 5                 | 75 | 20 | 9/172   | .0523 |
| 5     | 5237  | 145    | 26                | 74 | 0  | 38/106  | .3584 |
| 4     | 5382  | 148    | 24                | 58 | 18 | 35/112  | .3125 |
| 3     | 5530  | 76     | 24                | 68 | 8  | 18/57   | .3157 |
| 2     | 5606  | 105    | 19                | 63 | 18 | 20/84   | .2380 |
| 1     | 5711  | 132    | 5                 | 70 | 25 | 7/124   | .0564 |
| 34537 |       |        | Roscommon 22N4W16 |    |    |         | #150  |
| KB    | 1141  |        |                   |    |    |         |       |
| E     | 6174  |        |                   |    |    |         |       |
| F     |       | 866    |                   |    |    |         |       |
| 6     | 5308  | 217    | 3                 | 83 | 14 | 7/210   | .0333 |
| 5     | 5525  | 173    | 19                | 65 | 16 | 33/140  | .2357 |
| 4     | 5698  | 148    | 11                | 82 | 7  | 16/132  | .1212 |
| 3     | 5846  | 81     | 10                | 81 | 9  | 8/73    | .1095 |
| 2     | 5927  | 110    | 5                 | 81 | 14 | 6/104   | .0576 |
| 1     | 6037  | 137    | 10                | 64 | 26 | 14/123  | .1138 |
| 34973 |       |        | Arenac 19N5E21    |    |    |         | #151  |
| KB    | 629   |        |                   |    |    |         |       |
| E     | 6549  |        |                   |    |    |         |       |
| F     |       | 1000   |                   |    |    |         |       |
| 6     | 5549  | 266    | 4                 | 81 | 15 | 11/255  | .0431 |
| 5     | 5815  | 206    | 14                | 78 | 8  | 28/178  | .1573 |
| 4     | 6021  | 171    | 8                 | 71 | 21 | 14/157  | .0891 |
| 3     | 6192  | 95     | 14                | 77 | 9  | 13/82   | .1585 |
| 2     | 6287  | 103    | 16                | 61 | 23 | 16/87   | .1839 |
| 1     | 6390  | 159    | 9                 | 64 | 27 | 14/145  | .0965 |
| 34931 |       |        | Alcona 26N5E31    |    |    |         | #152  |
| KB    | 986   |        |                   |    |    |         |       |
| E     | 4903  |        |                   |    |    |         |       |
| F     |       | 850    |                   |    |    |         |       |
| 6     | 4053  | 216    | 7                 | 73 | 20 | 15/201  | .0746 |
| 5     | 4269  | 160    | 17                | 67 | 16 | 28/132  | .2121 |
| 4     | 4429  | 154    | 22                | 78 | 0  | 33/121  | .2727 |
| 3     | 4583  | 85     | 12                | 78 | 10 | 10/75   | .1333 |
| 2     | 4668  | 83     | 18                | 60 | 22 | 15/68   | .2205 |
| 1     | 4751  | 152    | 7                 | 71 | 22 | 11/141  | .0780 |

## DATA (Continued)

|       | Elev. | Thick. | %Sh             | %E | %C | Clastic Ratio |         |
|-------|-------|--------|-----------------|----|----|---------------|---------|
| 34536 |       |        | Osceola 18N8W27 |    |    |               | #153    |
| KB    | 1055  |        |                 |    |    |               |         |
| E     | 5412  |        |                 |    |    |               |         |
| F     |       | 674    |                 |    |    |               |         |
| 6     | 4738  | 141    | 8               | 69 | 23 | 11/130        | .0846   |
| 5     | 4879  | 122    | 39              | 61 | 0  | 47/75         | .6266   |
| 4     | 5001  | 127    | 24              | 76 | 0  | 31/96         | .3229   |
| 3     | 5128  | 66     | 23              | 67 | 10 | 15/51         | .2941   |
| 2     | 5194  | 90     | 12              | 67 | 21 | 11/79         | .1392   |
| 1     | 5284  | 128    | 9               | 61 | 30 | 12/116        | .1034   |
| 35153 |       |        | Jackson 3S2E1   |    |    |               | #154    |
| KB    | 1041  |        |                 |    |    |               |         |
| E     | 1662  |        |                 |    |    |               |         |
| F     |       | 149    |                 |    |    |               |         |
| 6     | 1513  | 27     | 26              | 0  | 74 | 7/10          | .3500   |
| 5     | 1540  | 19     | 100             | 0  | 0  | 18/1          | 18.0000 |
| 4     | 1559  | 33     | 100             | 0  | 0  | 32/1          | 32.0000 |
| 3     | 1592  | 24     | 62              | 0  | 38 | 15/9          | 1.6670  |
| 2     | 1616  | 22     | 73              | 0  | 27 | 16/6          | 2.6670  |
| 1     | 1638  | 24     | 75              | 0  | 25 | 18/6          | 3.0000  |
| 29158 |       |        | Ingham 2N2E32   |    |    |               | #155    |
| KB    | 963   |        |                 |    |    |               |         |
| E     | 2386  |        |                 |    |    |               |         |
| F     |       | 196    |                 |    |    |               |         |
| 6     | 2190  | 47     | 29              | 17 | 54 | 14/34         | .4242   |
| 5     | 2237  | 38     | 89              | 0  | 11 | 34/4          | 8.5000  |
| 4     | 2275  | 32     | 94              | 0  | 6  | 30/2          | 15.0000 |
| 3     | 2307  | 30     | 33              | 0  | 67 | 10/20         | .5000   |
| 2     | 2337  | 22     | 27              | 0  | 73 | 6/16          | .3750   |
| 1     | 2359  | 27     | 22              | 0  | 78 | 6/21          | .2857   |



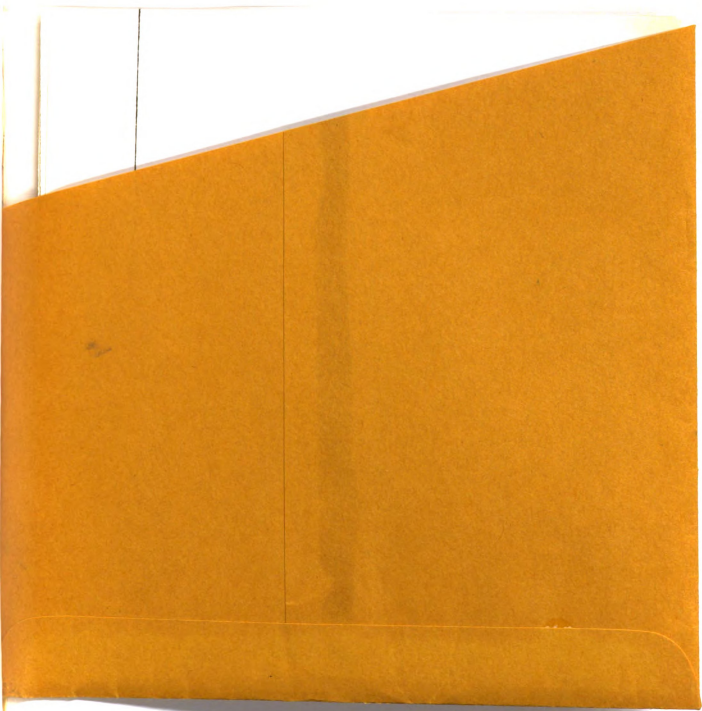


MAP 11

Geophysical Cross-Section  
of the F-Salts

cross-section B-B' on Map A







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