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OF MICHIGAN.

Michigan State University, Ph.D., 1972  
Geology

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CAMBRIAN STRATIGRAPHY OF THE LOWER  
PENINSULA OF MICHIGAN

By

Paul Anthony Catacosinos

A THESIS

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

DOCTOR OF PHILOSOPHY

Department of Geology

1972

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## ABSTRACT

### CAMBRIAN STRATIGRAPHY OF THE LOWER PENINSULA OF MICHIGAN

By

Paul Anthony Catacosinos

The Cambrian rocks of Michigan have heretofore been an enigma to geologists because of a lack of drilling information and outcrops available for study. When viewed against the broad, regional stratigraphic framework, and defined rigorously in terms of lithology, they are clearly identified as representing facies present in or near the margins of a transgressive-regressive sea.

A composite vertical sequence establishes the following ascending order: the Mt. Simon Sandstone; the Eau Claire Formation, Galesville Sandstone, and Franconia Formation (all three members of the Munising Group); the St. Lawrence Formation; "Lodi" (a minor unit); and Jordan Sandstone. This vertical sequence, however, is facies related as these rocks are lateral equivalents of one another, at least in part. They form an essentially unbroken sequence of deposition beginning with marine transgression during Late Cambrian time and ending with regression of the sea in probable Early Ordovician.

Paul Anthony Catacosinos

The Mt. Simon represents the shoreline facies of the transgressing sea. The Eau Claire and Franconia Formations indicate nearshore marine environments. These two units can be distinguished from one another only when separated by the Galesville Sandstone; otherwise this sequence is known as the Munising Group. The Galesville Sandstone represents a regression of the sea, most evident in southern Michigan. Outside the depositional limits of the Galesville Sandstone, there is present an interval of interbedded sandstone, dolomite, shale, and nodular anhydrite within the Munising Group which strongly suggests a shallow to supra-tidal environment of deposition. Known to occur only in central Michigan, the areal extent of this facies is yet unknown.

The St. Lawrence Formation consists of dolomite and interbedded dolomite and sandstone, a series which includes the Trempealeau and Prairie Du Chien Group of previous investigations. The St. Lawrence grades upward into the Jordan Sandstone, a regressive sandstone unit which documents the retreat of the sea and gradual infilling of the Michigan Basin area. This unit has been erroneously identified in prior reports as the St. Peter Sandstone of the Mid-Continent region; however, St. Peter rocks were not recognized anywhere within the Michigan area.

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There is an erosional unconformity found everywhere along the top of the Cambrian (and Cambro-Ordovician) rocks on which the beds of the "Glenwood" Formation (Middle Ordovician) were deposited.

This record of marine invasion and subsequent retreat clearly places the presence of a precursor of the present-day structural Michigan Basin back at least to Late Cambrian time.

Dedicated to my Wife, Children, and Parents.

## ACKNOWLEDGMENTS

The writer wishes to express his deep appreciation to Dr. James H. Fisher, his thesis chairman, for his constant guidance and encouragement throughout the writer's doctoral program. Special thanks should go to Dr. Robert Ehrlich for his excellent advice and interest, and to Drs. Harold W. Scott and Sam B. Upchurch for their valuable editing and criticism of the dissertation.

The writer gratefully acknowledges his colleagues Robert F. Barbour and William Mantek, and the staff of the Michigan Geological Survey, who graciously made available well data and other information necessary to this study, and Dr. H. B. Stonehouse and Mr. Roy W. Nurmi for many stimulating discussions.

Finally, the writer would be remiss if he did not acknowledge the patience, love, and encouragement provided him by his wife and children, without which this labor would never have been started, or completed.

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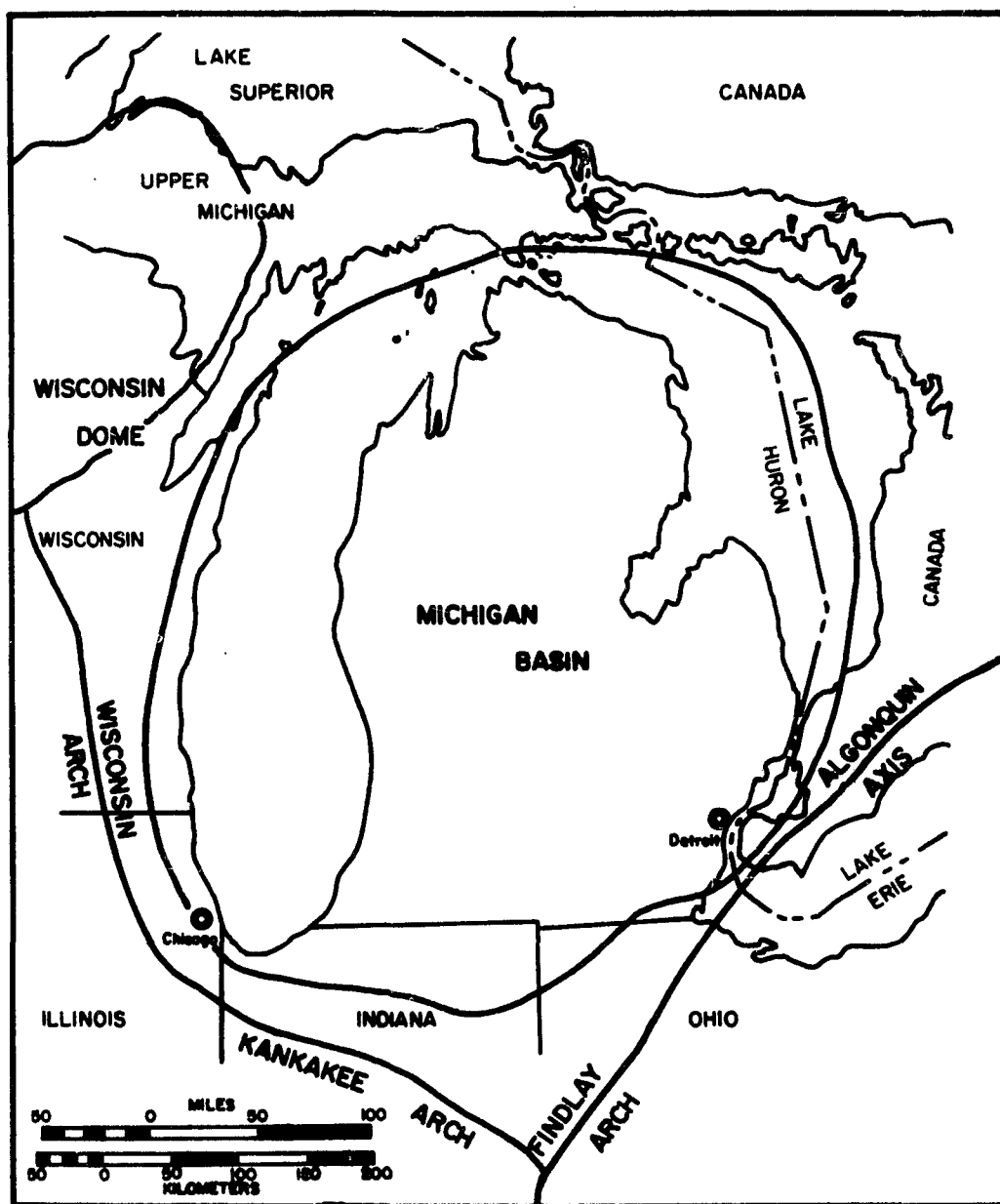
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## INTRODUCTION

The Michigan Basin encompasses an area of some 122,000 square miles (Ells, 1969, p. 63). The Basin includes eastern Wisconsin, northeastern Illinois, northern Indiana, northwestern Ohio, the extreme western and southwestern portions of Ontario, the eastern half of the Upper Peninsula and the entire Lower Peninsula of Michigan (Figure 1). Within Michigan, Cambrian rocks crop out only in the Upper Peninsula where they were studied comprehensively by Hamblin (1958). The present study deals with the subsurface Cambrian sequence of the Lower Peninsula, an area of about 60,000 square miles, and the regional stratigraphic relationships to the adjoining areas.

There are no published, comprehensive studies dealing with the Cambrian rocks of the Lower Peninsula, and indeed, only a few, broad, regional studies have been attempted. Of these, the most notable are those of Cohee (1945, 1947, 1948), Ells (1967, 1969), Fisher (1969), and the Michigan Basin Geological Society Stratigraphic Committee (1969).



**FIGURE 1**  
**REGIONAL INDEX MAP**  
**OF**  
**MICHIGAN AND ENVIRONS**

The Cambrian of the Lower Peninsula has remained an enigma for four reasons: (1) Of approximately 30,000 wells drilled in Michigan, only some 140 have been drilled to the Cambrian, something under 0.5 per cent. Of these, only 20 have reached the Precambrian and these have been confined mainly to the southern third of the Lower Peninsula (Plate 10). (2) There are no outcrops available for study in the area; (3) complex facies changes within and between the Cambrian formations which are present but not clearly defined; and (4) perhaps most important, the improper stratigraphic terminology employed by geologists in dealing with these rocks. This improper usage includes the introduction of terms from different geographical areas, the application of different names for the same rocks, using the same names for different rocks, and finally, the mixing of rock-stratigraphic and time-stratigraphic terminology, an undesirable practice that has further obscured the rock relationships.

The lithostratigraphic approach employed in this report is considered fundamental toward the understanding of stratigraphic relationships in any geological setting. First, from regional considerations, the probability of certain rock units occurring in the area of study was determined. These units were defined in terms of lithology and stratigraphic position. All the available cuttings and cores from Michigan wells that were considered

to have reached the Cambrian were examined by the writer, and sample tops established. These sample tops were then reconciled with the available geophysical logs (gamma ray-neutron logs in most cases). In a few cases, drilling tops were utilized where no other information could be obtained, and these were modified slightly to reflect modern terminology, but, only where control was adequate to do so. Appendix A lists all wells and tops utilized in this study; Plate 1 shows their location.

The descriptive clastic terms follow that of Wentworth (1922); rock colors were established using the Munsel Rock Color Chart distributed by the Geological Society of America. In the carbonate units, distinction between dolomite and limestone was made by observing the sample reaction to a 10 per cent solution of hydrochloric acid.

In establishing the stratigraphic terminology for this report two guidelines were followed: (1) all formations are rock-stratigraphic units. No time-stratigraphic units are used as the formations are considered to be time transgressive. (2) No new terms are introduced; instead there is a return to older, clearer terminology. Where informal units are utilized they are clearly recognizable as part of a particular formation. The use of gross lithology has made it possible to trace the larger units present with considerable reliability.

This in turn has allowed the formulation of a reasonable stratigraphic framework. As new data become available, this framework will be modified and adjusted. The terms used are given in Table 1.

Unless otherwise stated, the ages of the formations studied are considered to be Late Cambrian. The St. Lawrence, "Lodi," and Jordan Formations are Late Cambrian to Early Ordovician in age. The "Glenwood" Formation is Middle Ordovician in age. Presumably, Precambrian rocks immediately underlie the Late Cambrian sedimentary sequence in the Michigan Basin, though Early and Middle Cambrian rocks may be present.

TABLE 1. Stratigraphic Terminology.

|                   |                |                                                                                              |
|-------------------|----------------|----------------------------------------------------------------------------------------------|
| Middle Ordovician |                | "Glenwood" Formation                                                                         |
|                   | Unconformity   |                                                                                              |
| Cambro-Ordovician |                | Jordan Sandstone<br>"Lodi" Formation<br>St. Lawrence Formation                               |
|                   | Conformable    |                                                                                              |
| Late Cambrian     |                | { Franconia Formation<br>Galesville Sandstone<br>Eau Claire Formation<br>Mt. Simon Sandstone |
|                   | Munising Group |                                                                                              |
|                   | Unconformity   |                                                                                              |
| Precambrian (?)   |                | Pre-Mt. Simon section<br>or Basement Complex                                                 |
| Precambrian       |                |                                                                                              |

## STRATIGRAPHY

### Precambrian Basement Complex

Our present knowledge of the basement rocks of the Lower Peninsula is gleaned directly from only some 20 deep tests, and indirectly by geophysical methods. Also contributing are subsurface and outcrop extrapolations from areas immediately adjacent to the Basin. The most recent work on this subject is that of Hinze and Merritt (1969), and Stonehouse (1969a, 1969b). These writers have summarized the data, and have classified the lithologies encountered with regard to the Precambrian Basement Provinces of the Great Lakes region. The Precambrian of the Lower Peninsula consists, with few exceptions, of granitic rock and high-grade gneiss and schist.

There are at present 18 accepted Precambrian tests in the Lower Peninsula, plus two other tests that may fall into this category (Plate 10). Of the latter two, one is the McClure, Beaver Island #1 (Well #15) which bottomed in pre-Mt. Simon (Precambrian (?)) sedimentary rock. This well is discussed in detail in the next

section. The other well is the Mobil, Kranz #1 in Ingham County (Well #30) which is reported to have bottomed in the Precambrian. Information on this well is not available at this time.

As part of the Precambrian System, the writer has included a section of granite wash which varies from 0-30 feet in thickness (but generally less than 10 feet). The granite wash is not always present. With few exceptions the Precambrian is overlain unconformably by the Mt. Simon Sandstone.

Two recently drilled Precambrian tests require special mention in that both lack the Mt. Simon Sandstone. These are the Mobil, Messmore #1 in Livingston County (Well #51) and the Pan-Am Drasey #1 in Presque Isle County (Well #88). Both wells are interpreted as having been drilled on basement highs which were present as positive areas during Mt. Simon deposition (Plate 2). The Messmore, Well #51, penetrated some reported "quartzite" or "feldspathic sandstone" at 7146 feet (treated as a probable granite wash zone of 11 feet) and then into definitely acidic igneous rock at 7157 which continued to a total depth of 7589.

In the north, the Drasey test (Well #88) passed through 168 feet of quartzite of uncertain age into basalt flows of Keweenawan type (Bass, 1968).



Isotopic age dates from five wells in the Lower Peninsula (Hinze and Merritt, 1969, p. 39) fall within a range of 840 m.y. to 1090 m.y. A K/Ar date of  $382 \pm 18$  m.y. has been determined for the Drasey basalts, which would make them no older than Silurian. Bass (1968), however, refers to weathering zones in the basalt flows and this may have produced the anomalous results. The writer agrees with Benson (1968) that this date is only minimal. The overlying metaquartzite in this well is of uncertain age. It is referred to the Precambrian (?) by the writer, but may be younger.

#### Pre-Mt. Simon Section

To date, this section of rock has been found in only one well, the McClure, Beaver Island #1 (Charlevoix County, Well #15). It consists of pale reddish purple (5RP6/2) sandstone, siltstone, and some shale. The grains are generally quartz, coarse grained, and silica cemented. There is a high feldspar content, some glauconite, and much hematitic staining. Well #15 cut 813 feet of this sequence and bottomed within it. Overlying this unit is 256 feet of white Mt. Simon Sandstone. Six miles away, Well #14 (McClure, Beaver Island #2) cut 282 feet of Mt. Simon and passed directly into 73 feet plus of granite. On the base of the Mt. Simon, the structural difference between Wells 14 and 15 is only 96 feet; the difference in Mt. Simon thickness is a scant 26 feet over the six

miles. This points to a relatively flat surface of deposition for the Mt. Simon in this area. The presence of over 800 feet of sedimentary rock in Well #15 and none in Well #14 indicates a fault relationship between the two wells with the Pre-Mt. Simon section preserved in the downthrown block (Plates 10, 12, and 13). In a geophysical study, Oray (1971, p. 71) also suggested the presence of faults in the area of Beaver Island, thus substantially strengthening the structural analysis presented above.

The age of the Pre-Mt. Simon sequence is not known. These rocks are herein referred to the Precambrian (?), but may be Cambrian in age.

The stratigraphic position of this unit, below the Mt. Simon Sandstone and above crystalline basement rocks, suggests a possible correlation with the Jacobsville Formation of the Upper Peninsula. Lithologically the two units bear a superficial resemblance to one another; their stratigraphic relationships to surrounding rocks are similar; and the age of both units is uncertain. The Jacobsville, however, is terrestrial in origin (Hamblin, 1958) whereas the Pre-Mt. Simon rocks contain abundant glauconite indicating a marine origin of deposition. The Pre-Mt. Simon may represent a marine facies of the Jacobsville Formation, but all that can definitely be stated at this time is that correlation of the Pre-Mt. Simon is uncertain.

Mt. Simon Sandstone

The Mt. Simon was named by Ulrich (in Walcott, 1914, p. 354) for exposures on Mt. Simon at Eau Claire, Wisconsin. It is considered the basal Cambrian unit of the Lower Peninsula, and is characterized by sub-rounded to rounded quartz grains; generally coarse but ranging from medium to very coarse in size; dominantly silica cemented; little or no glauconite; light coloration towards the top but somewhat "pinkish" towards the base which reflect an increase in hematite content; and an increase in feldspar content towards the base. Occasionally, minor amounts of glauconite, anhydrite, green shale, and dolomite cement are present.

The Mt. Simon of Michigan is probably correlative, in northern Ohio, to the combined Mt. Simon and Jacobsville of Fettke (1948) and the Mt. Simon and Basal Arkose of Calvert (1963; 1964). There are problems, however, since Calvert (1963, Plate 2), following convention, placed the basal sandstones of his Michigan well (the Collins and Black, Dancer #1, Jackson Co.) (Well #34) in the Mt. Simon. These sandstones are referred herein to the overlying Eau Claire Formation. This correlation is based on a consideration of the regional stratigraphic relationships between the Mt. Simon Sandstone and the Eau Claire Formation, and on lithologic criteria.

The Mt. Simon lies unconformably on the Precambrian granite wash and basement complex, and is probably unconformable with the Pre-Mt. Simon section of Beaver Island. It grades into and interfingers with the overlying Eau Claire Formation. This interfingering contact is best displayed in the Security, Thalmann #1 (Well #3, Plate 15) and consists of non-glauconitic, silica cemented sandstones of the Mt. Simon interbedded with the glauconitic, dolomite cemented sandstones present in the lower portion of the Eau Claire. The contact between the two stratigraphic units is an arbitrary one, in the sense of Wheeler and Mallory (1953), and accounts for the various Mt. Simon tops selected by others, for example Ellis (1967, p. 48); Yettaw (1967); and the Michigan Basin Geological Society Stratigraphic Committee (1969, Plate B). As shown on Plate 15, this interfingering zone has consistently been placed within the Eau Claire, restricting the Mt. Simon terminology to the dominantly silica cemented, non-glauconitic sandstones. The Dancer #1 (Well #34) is not shown on Plate 15, but does correlate on the basis of gamma ray log characteristics, with the Nanco, Smith #2 (Well #33, Jackson Co.) which is present on Plate 15. Using these criteria, Well #33 (and by inference, Well #34) has bottomed in the Eau Claire.

Other correlations of the Mt. Simon have been made. It has been suggested that the Mt. Simon is correlative with the Jacobsville Formation and some of the criteria have been discussed (Ostrom and Slaughter, 1967). In the Upper Peninsula of Michigan, the Michigan Geological Survey sample descriptions indicate the presence of an unnamed basal sandstone which may be the Mt. Simon Sandstone. The probable presence of the Mt. Simon in the Upper Peninsula has been mentioned by Conee (1945). Driscoll (1959, p. 8) states:

A pure white, well sorted, and poorly consolidated sandstone sporadically occurs below the conglomerate and above the Jacobsville sandstone. The sandstone has a thickness of 4 feet in the cliffs of Grand Island where it shows prominent cross-bedding.

The conglomerate referred to is the unnamed basal conglomerate member of the Munising Formation defined by Hamblin (1958). This white sandstone is interpreted as representing the approximate edge of the Mt. Simon (see Plate 2). If this is the correct interpretation, then the Jacobsville-Mt. Simon correlation is doubtful. The evidence is far from conclusive for either correlation at this time.

The age span of the Mt. Simon Sandstone is not clearly known. Buschbach (1964, p. 29) states:

No fossils have been found in the Mt. Simon of the Upper Mississippi Valley, but the conformably overlying Eau Claire Formation contains fossils of late Cambrian age. . . . There is no basis for a formational break within the Mt. Simon sequence in northeastern Illinois, and the Mt. Simon is therefore retained in the Croixan Series.

In a recent summary, Lochman-Balk (1971, p. 104) reports tracks and trails (Climactichnites) in the upper part of the Mt. Simon which are, again, not definitive. Lacking evidence to the contrary, the Mt. Simon is considered to be Late Cambrian though an older age is possible.

#### Munising Group

Lane and Seaman (1907, p. 692) originally described this formation from outcrops in the Upper Peninsula of Michigan, near Munising. The terminology for this unit is quite involved, and has been summarized by Hamblin (1958). Hamblin formally defined this formation, in terms of lithology, as consisting of three members. In ascending order these are an unnamed basal conglomerate member, the Chapel Rock member, and the Miner's Castle member. These members are recognized only in the Upper Peninsula.

In the Lower Peninsula, following Cohee's 1945 usage, the Munising has been considered to include (in ascending order) the Mt. Simon, Eau Claire, Dresbach (Galesville of this report), Franconia, and a part of the St. Lawrence. Modern usage has dropped the St. Lawrence from the Munising as is shown on Chart 1 of the Michigan Geological Survey (1964); see also Briggs (1968, p. 139).

The meaning of the term Munising is further restricted in the Lower Peninsula, as follows. Because the Mt. Simon is present, generally, throughout the Lower Peninsula, and would appear to underlie the

Munising Formation in the Upper Peninsula, the Mt. Simon is treated as a distinct unit apart from the Munising. The Eau Claire, Galesville, and Franconia Formations of the Lower Peninsula are considered to be lateral equivalents of Hamblin's Munising Formation. Further, the Eau Claire and Franconia, as they are defined in this study, can only be distinguished from one another when they are separated by the Galesville Sandstone. Therefore, outside the depositional limits of the Galesville Sandstone, the term Munising Group is used, as shown on Plates 3, 4, 5, and 6. The relationships between the Upper and Lower Peninsulas and among the stratigraphic units is depicted schematically in Figure 2.

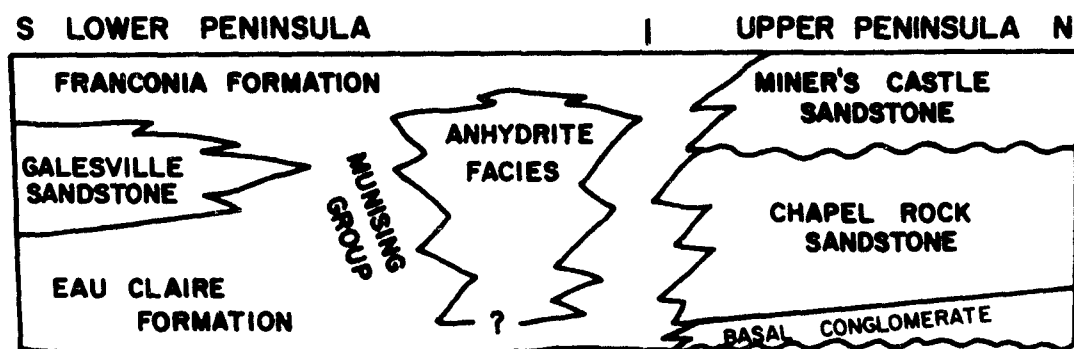


Figure 2. Munising Stratigraphic Relationships; Diagrammatic.

A comparison of the Mt. Simon isopach map (Plate 2) with the Munising Group isopach map (Plate 3) shows the Mt. Simon to have the form of an embayment with its depocenter located in northeastern Illinois. On the other hand, the Munising Group clearly displays a basinal configuration. This firmly establishes a precursor to the present-day structural Michigan Basin as definitely present in Late Cambrian time. A basinal configuration for the Mt. Simon rocks in the Lower Peninsula of Michigan may be obtained when further data become available.

Plates 12 and 13, as well as Figure 2 above show the writer's correlation of the highly controversial section of rocks present in the lower portion of the Brazos, State Foster #1 deep test, Ogemaw County (Well #80). Below the dolomitic sandstone facies of the St. Lawrence Formation there occurs an atypical non-glaucconitic dark shale, 101 feet thick. Below this is a sequence of interbedded anhydrite, dolomite, sandstone, and shale, some 1417 feet thick in which the well bottomed at a Michigan record depth of 12,996 feet. Slabbed cores of this sequence have been examined by the writer. The anhydrite occurs generally as nodules, and occasionally as thin beds (lenses?). The sandstones are dolomite cemented; many of the dolomite beds are pelletal, and stromatolites are present. The rocks in this well are singular in character in that they have not been observed



in any other well in the Lower Peninsula to date. Both the overlying dark shale and the interbedded sequence (informally called the Anhydrite Facies) are referred to the Munising Group. The extent of the facies is not known at this time. The presence of nodular anhydrite, pelltal dolomites, and stromatolites suggests that the sequence represents a very shallow marine or lagoonal to supra-tidal environment of deposition (peritidal of Folk, 1970).

The age of this sequence is also controversial. Fisher (1969, p. 91) pointed out that there were rumors of Ordovician ostracodes well within what is considered to be Cambrian age rocks. All parties responsible for issuing this report have been contacted, and the core from which ostracodes and graptolites have been reported has been examined. One gastropod of undeterminable age was found at 11,710 feet, but not the reported ostracodes. It would appear, lacking any other firm evidence, that the reported Ordovician age is in error.

The maximum thickness of this unit is probably on the order of 1700 feet, based on geophysical considerations, and is so shown on Plate 3. The Munising Group records the presence of the embryonic Michigan Basin. The zero thickness line of the Munising Group on Plate 3 should be taken to indicate a facies change to the north, and thinning by erosion or non-deposition to the east.

### Eau Claire Formation

The unit was named by Ulrich (in Walcott, 1914, p. 354) for the sequence of rocks exposed near Eau Claire, Wisconsin. In the Lower Peninsula, the Eau Claire Formation is the lowermost member of the Munising Group and probably comprises the bulk of that unit. The Eau Claire typically displays a bi-partite character. The lower portion consists of a sandy zone often confused with the Mt. Simon Sandstone, and an upper zone of thinly bedded siltstones, shales, and sandy dolomites. Both zones are characterized by an abundance of glauconite. The lower sandy zone is generally finer-grained than the underlying Mt. Simon, and is cemented by dolomite. The color is often light gray (N7), but does vary. The upper zone is quite variable in lithology: the sandstones are dolomitic; the dolomites are sandy and silty; and the shale dark gray (N3).

The Eau Claire is conformable with the underlying Mt. Simon, and apparently also with the overlying Galesville Sandstone. Where the Galesville is absent, the Eau Claire is indistinguishable from the Franconia Formation, hence its identification is controlled by the distribution of the Galesville. Because of this, Plate 4 shows the Eau Claire to be confined to the lower third of the state. The unit varies in thickness, but seems to be thickest in a small basinal area centered in the

vicinity of Calhoun and Kalamazoo counties. The maximum thickness to date is in Well #3 (Security, Thalmann #1, Berrien Co.), where it is some 590 feet.

The Eau Claire Formation exhibits complex facies changes both within Michigan and in adjoining areas. The regional facies have been worked out in detail for Illinois by Workman and Bell (1948), Buschbach (1964, 1965); in Indiana by Gutstadt (1958), Dawson (1960); in Ohio by Fettke (1948), Woodward (1961), Calvert (1963, 1964); and most recently in Wisconsin by Ostrom (1970).

Generally speaking, the facies described in Lower Michigan are present in those states immediately to the south. Toward the west, and in Wisconsin, the rocks change character and become dominantly sandstone. Further to the south, dolomite predominates and the Eau Claire has been correlated with the Bonterre Dolomite of Missouri by Workman and Bell (1948, p. 2049).

In Michigan, Cohee (1945, 1947, 1948) clearly recognized the variable nature of the Eau Claire and noted its northward change to sandstone equivalents in the Upper Peninsula. As indicated on Plates 4 and 14, somewhere north of Well #56 (Dow-Brazos, Taggert #1, Mason Co.), the depositional limits of the overlying Galesville Sandstone are reached which limits the discernible Eau Claire province in the Lower Peninsula. The correlative section of the Munising Group in the Beaver Island wells

clearly shows the northerly transition to a sandier facies. Further, the transitional nature of the Eau Claire-Mt. Simon contact is also demonstrated in these wells.

Late Cambrian (Dresbachian) trilobite zones (Cedaria-lowermost, Crepicephalus-uppermost) have been reported for the Eau Claire of western Wisconsin (Twenhofel, et al., 1935, pp. 1694-1696). The Wisconsin section displays a two-fold character as does the Michigan sequence. Because the Wisconsin rocks are a sandstone facies of the Michigan section, the ages of the two are equivalent.

#### Galesville Sandstone

The name Galesville was introduced by Trowbridge and Atwater (1934) to replace the time term Dresbach. The type section is at Galesville, Wisconsin and has recently been revised by Emrich (1966). As used in this study, the Galesville of Michigan includes the Dresbach Sandstone and a part of the Franconia Sandstone of earlier reports. Cohee (1945) evidently considered the Franconia of Michigan equivalent to the Ironston of Wisconsin, which overlies the Galesville there. It is not possible to differentiate these units away from the outcrop, so both are included in Michigan's Galesville Sandstone.

The Galesville is typically light olive gray (5Y6/1) but includes some pale red purple (5RP6/2) sandstone. It is medium grained, often subangular, and though the cement type varies, silica predominates. The unit is occasionally limonite stained. The upper 10 feet or so of the Galesville is commonly a glauconitic, dolomitic sandstone (Franconia of earlier writers and possible Ironston equivalent), but in the main body of the unit, Glauconite is usually absent. There are some siltstone and shale interbeds; and in Jackson County, a red, silty, micaceous shale occurs in the middle of the section (Plate 15, Well #33). The extent of this middle shale is not known.

The maximum thicknesses recorded to date are 180 feet in the Security, Thalmann #1 (Well #3, Berrien Co.) and 179 feet in the Nanco, Smith #2 (Well #33, Jackson Co.). The basinal area in Calhoun-Kalamazoo counties is again reflected (Plate 5). The Galesville thins to zero in the vicinity of Detroit, and to the north. The geometry of the body strongly resembles a tongue projecting from the Wisconsin source area.

Regionally, the Galesville is present in northwestern Indiana (Emrich, 1966) and in northern and northwestern Ohio (Dresbach or Franconia Sandstones of Cohee, 1948, pp. 1419-1425; Fettke, 1948; Calvert, 1963). There is a problem, however, in northeastern Indiana

where the Galesville appears to be absent (Gutstadt, 1958). In southern Michigan, the Horwath well drilled in 1967 (Well #16, Hillsdale Co.) encountered 92 feet of Galesville Sandstone (Plate 5). Some 78 feet of Galesville is also present in the Eckert, Taylor #1 (Well #37, Lenawee Co.). The unit can be traced with assurance in the southern third of Michigan (Plate 15), and along the western margin of the Lower Peninsula (Plates 13 and 14). This distribution requires the contours to be drawn as shown on Plate 5 and this in turn suggests the presence of Galesville in northeastern Indiana. It is possible that the Galesville rapidly changes facies to a dolomite lithology in this area of Indiana, as suggested by Emrich (1966, Figure 10). The problem needs to be resolved.

In Michigan, the Galesville appears to be conformable with both the underlying Eau Claire and overlying Franconia Formations. The contact with the Franconia is gradational and is picked with some difficulty as the unit grades upward into glauconitic dolomitic sandstone and then passes into glauconitic sandy dolomites (see Plate 14, Well #56). The downward transition with the Eau Claire is gradually into more glauconitic siltstone and dolomitic sandstone.

### Franconia Formation

Berkey (1897, p. 373) named the unit for sandstone exposures near Franconia, Minnesota. The unit has undergone considerable revision and study and has been treated most thoroughly in a regional sense by Berg (1954), and most recently by Buschbach (1964, 1965) for Illinois. In Michigan, the term Franconia has generally been applied to a thin, glauconitic sandstone which possibly correlates with the Ironston Sandstone (Cohee, 1945). That sandstone is now included herein with the Galesville Sandstone, and the Franconia redefined for the state.

The Franconia of this report is defined as a highly variable zone of dolomitic sandstone, shale, and sandy dolomite, generally quite glauconitic. It can only be distinguished as a distinct unit when the underlying Galesville Sandstone is present (Plate 6). When the Galesville is absent, the Franconia merges with the Eau Claire to form the Munising Group of the Lower Peninsula (Plate 3).

In the areas where the Franconia can be identified, the formation appears to thicken westward with the thickest section documented to date in the Holland-Suco, Waste Disposal well #1 (Well #83, Ottawa Co., 95 feet), as shown on Plates 6 and 14.

The Franconia is conformable with the underlying Galesville Sandstone, and with the overlying St. Lawrence

Formation. In the southern portion of the Lower Peninsula, in the vicinity of Detroit, it is difficult to distinguish the upper part of the Franconia from the basal portion of the overlying St. Lawrence Formation because of the transitional character of the rocks (Plate 15, east side). Along the eastern side of Michigan and to the north, the Franconia cannot be separated from the Eau Claire Formation. To the south, in Ohio and Indiana, the unit changes facies and becomes the lower part of the Knox Dolomite (Gutstadt, 1958, Table 3).

#### St. Lawrence Formation

This formation was originally named the St. Lawrence Limestone by A. Winchell (1872) but was later redefined by N. H. Winchell (1874, pp. 152-155) as a glauconitic, sandy dolomite exposed in a 14.5 foot section near St. Lawrence, Minnesota. As defined in this report for Michigan, it is predominantly a medium dark gray (N4), generally finely crystalline to dense, dolomite. Occasionally towards the top, minor amounts of glauconite, dark shale, and some sandstone are present. In south central and southeastern Michigan (Plate 15), the shale content increases towards the base and the unit is distinguished, with difficulty, from the underlying Franconia (or Munising Group) only by the presence of glauconite. Towards the west and southwest, pink dolomite occurs in the middle portion of the unit, and the section



becomes increasingly cherty towards the top. The thickest section of dolomite is 713 feet (Plate 7), in the Ambassador, Schlautmann #1 (Well #4, Branch Co.). Towards the north central and west central parts of the Lower Peninsula, the upper section of the St. Lawrence consists of interbeds of dolomite and sandstone. In the Mobil, Messmore #1 (Livingston Co., Well #51) 760 feet of St. Lawrence are present and 729 feet in Well #83 in Ottawa County (Holland-Suco, Waste Disposal #1). Plate 7 clearly outlines a large, basinal area over most of the Lower Peninsula.

The St. Lawrence Formation changes facies toward the central part of the Lower Peninsula, as documented by the section in the Brazos, State-Foster #1 (Ogemaw Co., Well #80). In this well the St. Lawrence is represented by 623 feet of dolomitic sandstone, the top of which is marked by a zone of characteristic dolomite. Thin dolomite interbeds are present throughout this section (Plates 12 and 13). Toward the northwest, near Beaver Island, the St. Lawrence consists of interbedded sandstone and dolomite but towards the northeast (to Alpena Co.), the section is more dolomitic, though much sandstone is still present. The interbedded nature of the top of the St. Lawrence is portrayed in various wells on Plates 11 through 14.

This interbedded sandstone-dolomite section is interpreted as a transition zone between the St. Lawrence and the overlying Jordan Sandstone. The Brazos, State-Foster #1 (Well #80) is interpreted as being located on a positive area. This concept has also been applied in preparing Plates 8 and 9, isopach maps of the Jordan, and the combined St. Lawrence-"Lodi"-Jordan Formations, respectively.

The St. Lawrence thins toward the Upper Peninsula (Plate 7) where it is indistinguishable from the sandy dolomites of the lower Au Train of Hamblin (1958). The distribution of this unit in Ontario (Mapped as Trempealeau) has been outlined by Sanford and Quillian (1959). The various facies of the St. Lawrence are shown on Figure 3.

In Wells #55 and #56 (Superior, Sippy #17; Dow-Brazos-Taggart #1) in Mason County, a distinctive unit of apparently restricted distribution occurs between the St. Lawrence and Jordan Formations (Plates 10, 13, and 14). This is the "Lodi" of this report. In southwestern Michigan the Jordan Sandstone is absent and the St. Lawrence is unconformably overlain by the "Glenwood" unit (Plate 14).

The St. Lawrence terminology of this report replaces the Trempealeau of older studies, and also includes those cherty dolomites and minor sandstone

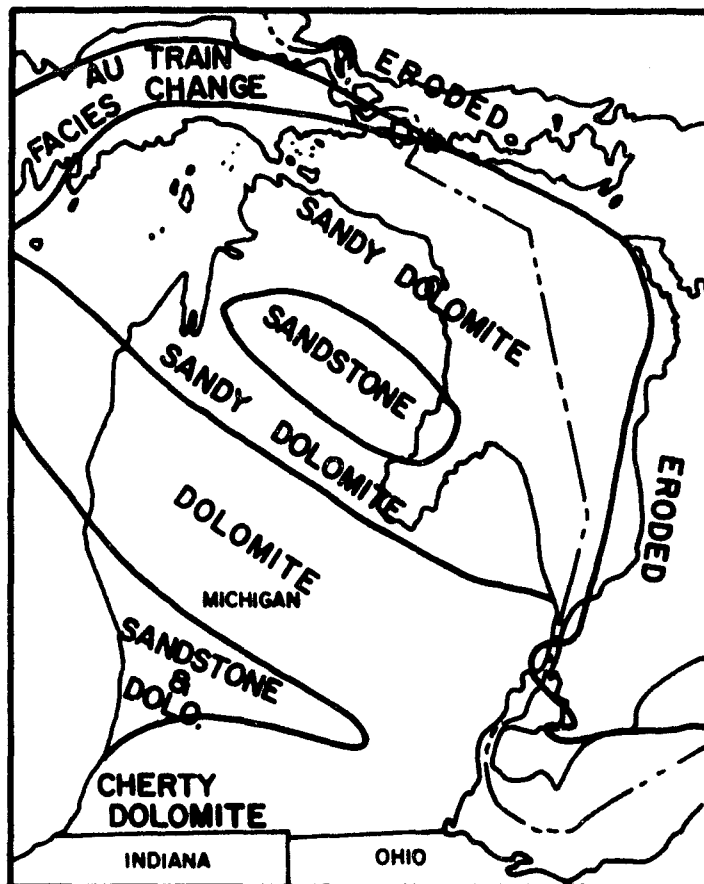


FIGURE 3

FACIES WITHIN ST LAWRENCE FORMATION

interbeds present in southwestern Michigan commonly referred to the Prairie Du Chien. Trempealeau is a time term and is therefore abandoned as a formational term as recommended by Nelson (1956, p. 170).

The Prairie Du Chien Group is a complex assemblage of cherty dolomites and sandstones whose exact facies relationships and distribution is not clearly known within Michigan. Customarily, the presence of chert has been used to distinguish this group (Early Ordovician) from the underlying Trempealeau Dolomite (Late Cambrian), particularly in southwestern and western Michigan. In this sense, the lithostratigraphic term Prairie Du Chien is being used, incorrectly, as a time term. Chert has been found to be unreliable as a stratigraphic marker as it is distributed throughout the entire dolomite section, sparsely at the base and more abundant towards the top. Further, there is no reliable geophysical marker that is consistent throughout the region. Because the chert is significant as an environmental indicator only, and since the dolomite cannot be clearly separated on lithologic grounds, and as the dolomite probably represents essentially continuous depositional conditions from latest Cambrian to earliest Ordovician time, the terms Prairie Du Chien and Trempealeau have not been used. The entire dolomite sequence is referred to and identified as a single rock stratigraphic unit, the St. Lawrence

Formation. Davis (1970, p. 35) is undertaking a detailed lithologic study of the Prairie Du Chien, the results of which are to appear in a future paper (Davis, in press).

To summarize, the St. Lawrence is correlative with the Trempealeau of Sanford and Quillian (1959) in southwestern Ontario; it forms a part of the Knox Dolomite of northern Ohio and Indiana; is probably equivalent to the Potosi, Eminence and possibly a part of the Prairie Du Chien of Illinois, though the exact relationships remain to be worked out; and is probably correlative, at least in part, to the Black Earth Dolomite member of the St. Lawrence Formation in Wisconsin (Nelson, 1956; Ostrom, 1966, 1970). The unit is correlated with the lower Au Train Formation of Hamblin (1958) in the Upper Peninsula of Michigan.

Since the writer has included elements of the Prairie Du Chien Group in his St. Lawrence concept, the unit is time transgressive embracing both the Late Cambrian and Early Ordovician. That the lower Au Train has a facies relationship with the St. Lawrence is further substantiated by a consideration of the time element. Hamblin (1958) considered the Au Train to be Middle Ordovician in age on the basis of fossils. Recently, however, Ostrom and Slaughter (1967, p. 26) have presented compelling evidence for a Late Cambrian-maximum Early Ordovician age for the Au Train.

Additionally, Guldenzoph (1967), on the basis of conodont studies, concurs in a Canadian (Early Ordovician) age for the Au Train.

### "Lodi"

The "Lodi" of this report is a term used for stratigraphic convenience. It has been recognized in only three wells in Michigan (#55, #56, and #77) and its apparently limited distribution is shown on Plate 10. The unit consists of grayish red (5R4/2) to light brownish gray (5YR6/1) dolomitic, micaceous siltstone and medium dark gray (N4) shale. The sequence becomes somewhat glauconitic and more of a dolomite towards the base. In the above wells (Plates 13 and 14), the unit separates the St. Lawrence and Jordan Formations. Its stratigraphic relationships with these units in Michigan is not clearly known, but does appear to be gradational. Its correlation with the Lodi of Wisconsin cannot be established at this time. The Michigan "Lodi" reaches a thickness of 170 feet in Well #77 (Thunder Hollow, Thompson #1, Newaygo Co.). The unit has been included with the St. Lawrence and Jordan in the construction of Plate 9.

### Jordan Sandstone

N. H. Winchell (1874, pp. 147-152) named the unit for exposures at Jordan, Minnesota. The Jordan Sandstone, along with the St. Lawrence and Lodi units, has been discussed thoroughly by Nelson (1956).

The Jordan Sandstone of the Lower Peninsula is made up of sub-angular to sub-rounded quartz grains, fine-medium in size, and generally grayish (N7-N8), sometimes grayish orange pink (10R8/2) in color. The unit is silica cemented towards the top, but has more dolomite cement in the lower portion of the formation. Occasionally, particles in the size range of 1 mm are present, and traces of anhydrite are not uncommon. The Jordan is somewhat redder in color in the western portion of the Lower Peninsula.

The formation is present over the northern two-thirds of the area of study (Plate 8) and has a maximum recorded thickness of 580 feet, in Well #56 (Dow, Brazos-Taggart #1, Mason Co.). The Jordan appears to thin to the north and northwest, and, through non-deposition or erosion, to the east. To the south and southwest, thinning was most likely accomplished by erosion. Plate 8 suggests a thinning of the unit toward Wisconsin.

Plates 11 through 14 indicate the Jordan to be transitional with the underlying St. Lawrence Formation. The Jordan is unconformably overlain by the "Glenwood" of this report. The writer considers it to be the lateral equivalent of the dolomitic sandstones of the upper Au Train Formation of the Upper Peninsula (Hamblin, 1958).

The regional correlation of this unit is uncertain to date because of the appearance of numerous sandstone bodies within the St. Lawrence equivalents lying to the southwest and south. Before firm regional correlations can be attempted, studies of the Prairie Du Chien Group, the St. Peter Sandstone, and the Glenwood Formation must be made.

The identification of this unit in Michigan as the Jordan, rather than the St. Peter Sandstone requires some amplification. Traditionally, any sandstone body found above the St. Lawrence (Trempealeau-Prairie Du Chien of prior studies) and below the limestones of the Black River Formation was referred to as St. Peter. This was the basis of Cohee's usage in 1945, 1947, and 1948 papers, and subsequent geologists have simply followed his lead. The usage was further entrenched in Michigan by the excellent regional study of the St. Peter by Dapples (1955). Dapples shows the limits of the St. Peter Sandstone to extend into southern and western Michigan (Figure 2, p. 451 and subsequent figures). However, Dapples' data were obtained from Kistler (1952). While Kistler's work has not been examined in this study, it is readily apparent that Kistler's St. Peter limits in Michigan (Dapples, 1955, Figure 2) are identical to those presented by Cohee in 1945. The work by Dapples



is now a standard and basic reference for the lithology and distribution of the St. Peter.

Clearly, re-evaluation of this sandstone unit in Michigan is in order. The basis for the writer's use of the term Jordan as opposed to St. Peter is based on five criteria: (1) According to Dapples (1955), the St. Peter in Michigan should be 50 feet thick or less, and not present on the east side of the state. Plates 11 through 14 and Plate 8, however, clearly show the sandstone body to be in excess of 100 feet as a rule and present in east central and north central Michigan. (2) The distribution of the St. Peter should be restricted to western and southwestern Michigan, and it should be expected in northeastern Indiana. Again, Plate 8 shows the sandstone configuration to be widespread throughout the northern two-thirds of the Lower Peninsula, and not present in southwestern Michigan. Further, according to Gutstadt (1958, Figure 10), little or no St. Peter is present in northeastern Indiana. (3) In the Upper Peninsula of Michigan, Cohee (1945) specifically identifies 5-30 feet of Jordan, not St. Peter, Sandstone. (4) As shown on Plates 11 through 14, the stratigraphic relationship of the sandstone body with the underlying St. Lawrence Formation is gradational, not unconformable. This is based on the fact that the transition zone between the two units (assigned to the

St. Lawrence) is composed of interbedded sandstones and dolomites whose sandstones lithologically resemble the overlying unit and the dolomites are similar to the underlying St. Lawrence dolomites. This stratigraphic relationship is significant because the Jordan is regionally conformable with the St. Lawrence (Lochman-Balk, 1971, p. 106). Stratigraphically, the St. Peter should be unconformable. (5) The sandstone is thick where overlain by the "Glenwood" (those rocks below the Black River limestones and above the dolomites and sandstones of the St. Lawrence or Jordan are herein referred to as the "Glenwood Formation"); or thick where directly overlain by the distinctive limestones of the Black River Formation. The sandstone is thin or absent when only the thin green shale called Glenwood shale is present. Further, the "Glenwood," as described above, occurs stratigraphically above the sandstone, the transition zone, and the dolomites of the St. Lawrence, thus substantiating the placement of the regional unconformity at the base of the "Glenwood" (or base of the Black River in the absence of "Glenwood"), as shown on Plates 11 through 15. Figure 4 contrasts the previous and present interpretation of the unit's stratigraphic relations.

Though the evidence listed above is not conclusive, it strongly suggests that assignment of the

observed sandstone to the St. Peter would be incorrect. The writer therefore assigns the unit to the Jordan Sandstone.

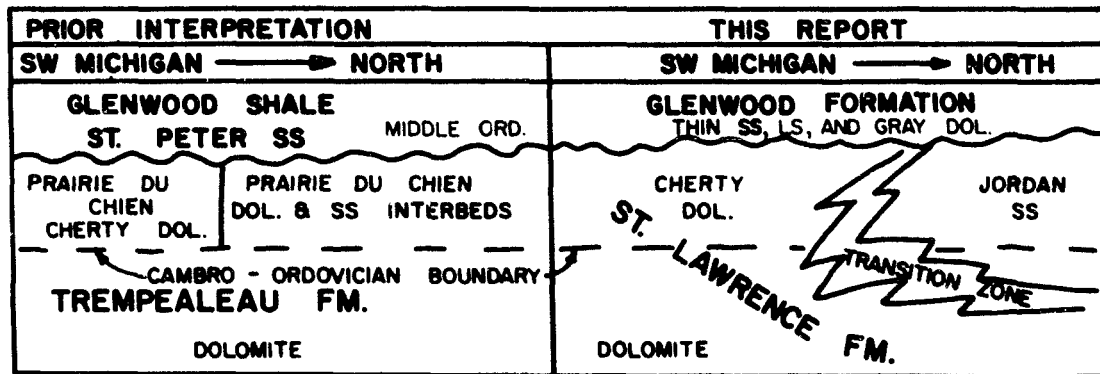


Figure 4. Stratigraphic Interpretations of the Rocks Beneath the "Glenwood" in Western Michigan.

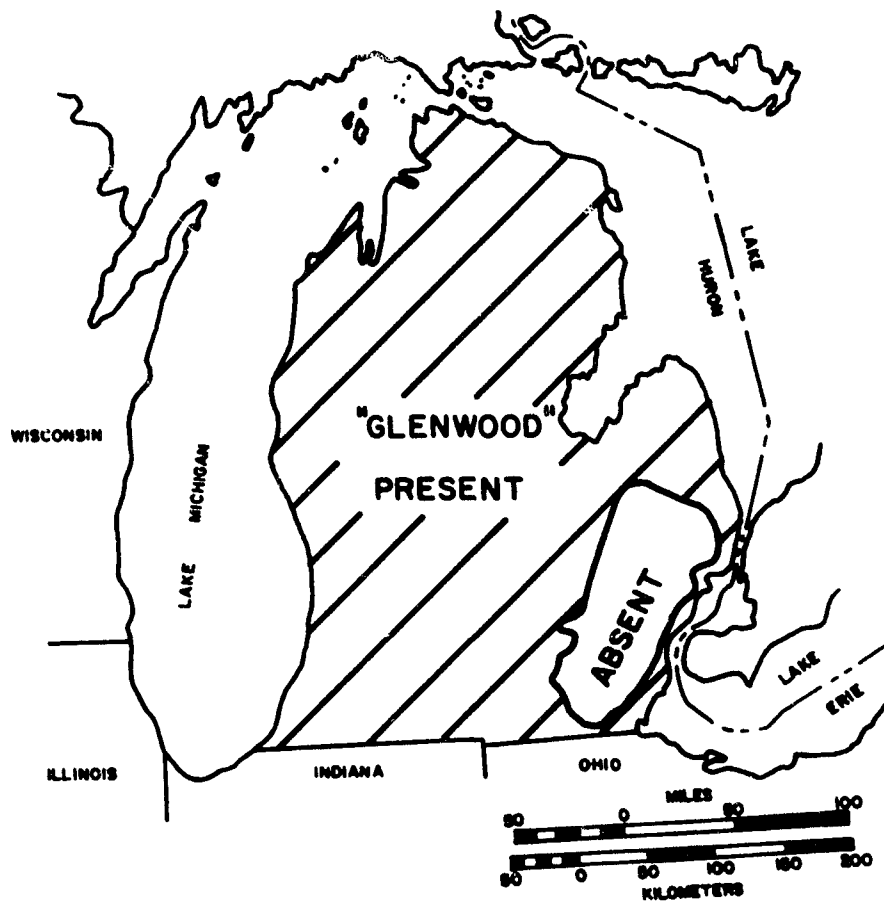
Plate 9, the isopach map of the combined St. Lawrence-"Lodi"-Jordan interval documents the continued presence of the basinal precursor of the modern day Michigan Basin.

#### "Glenwood" Formation and the Extra Section

The "Glenwood" of this report refers to the interbedded sequence of green shale, gray dolomite, thin sandstone, and limestone which unconformably overlies the St. Lawrence-Jordan units, or the Munising Group (Plate 11). The approximate distribution of the

unit is shown in Figure 5. In southern Michigan, the unit is typically a thin green shale, sometimes interbedded with thin sandstones traditionally (but incorrectly) called St. Peter. The "Glenwood" is overlain by the limestones of the Black River Formation.

The Extra Section is a part of the Black River Formation and is an informal term applied to the basal limestones of the Black River Formation in the eastern portion of the Lower Peninsula (Plate 10). Normally, the lithologic base of the Black River coincides with a characteristic gamma ray response on geophysical logs. This is not the case, however, where the Extra Section is present as the lithologic base of the Black River then occurs below this characteristic gamma-ray response. The gamma-ray signature is identifiable throughout Michigan, and is therefore utilized on the cross-sections as a reliable stratigraphic marker.



**FIGURE 5. DISTRIBUTION OF THE "GLENWOOD" FORMATION IN MICHIGAN.**

## STRATIGRAPHIC ANALYSIS

The lithologic units described above represent environments of deposition within an embayment of the Cambrian sea. The geometry of the units is portrayed on Figure 6. Because of the extent of the Lower Peninsula, different areas of the Peninsula will exhibit somewhat different vertical sequences in the section. In order to relate the units to one another in a meaningful way, an arbitrary reference area located about in T. 5 N., R. 1 W. will be used to discuss the vertical and lateral facies relationships.

Prior to the Cambrian invasion of the sea in this area, the Lower Peninsula was apparently a land area. That a sea had been present formerly is documented by the Beaver Island section, but its distribution and timing are unknown. Bordering the region on the west was the Wisconsin Highlands. To the north and northwest lay the Northern Michigan Highlands of the Upper Peninsula (Hamblin, 1958, 1961). On the southeast, in Ontario, the Algonquin Highland area was also present.

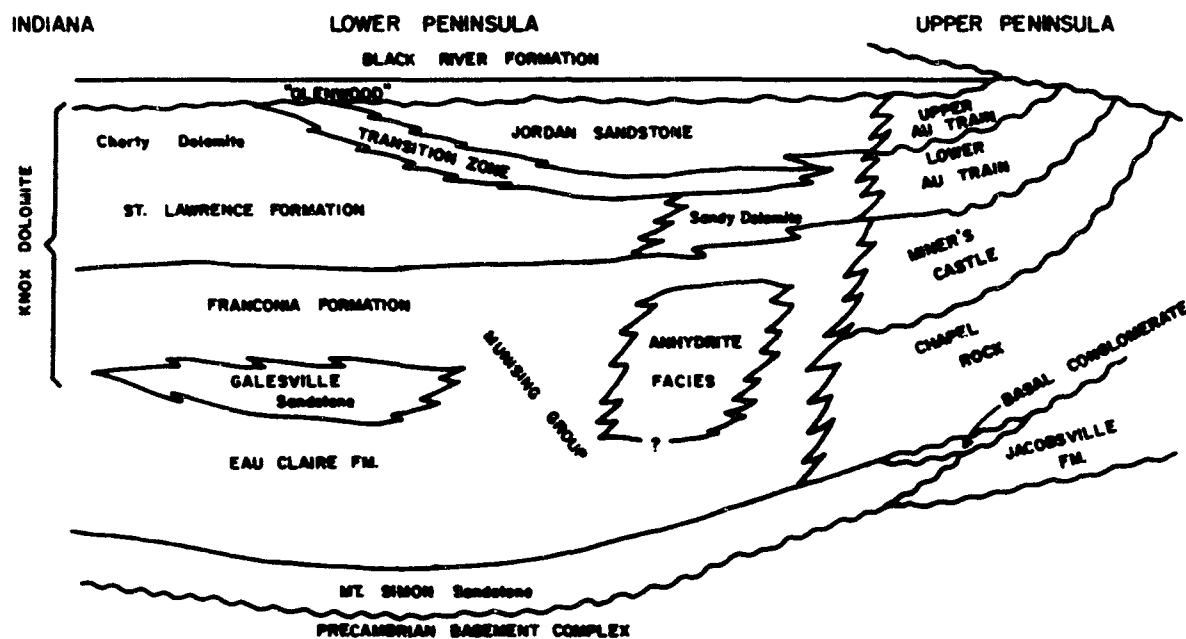


FIGURE 6. CAMBRIAN GEOMETRY OF THE MICHIGAN BASIN.  
SOUTH-NORTH ORIENTATION, NOT TO SCALE.

On this surface of generally low relief, the sea transgressed to the north, approaching the reference area. The lower Mt. Simon Sandstone which is characterized by relatively coarse-grain size, silica cement, and little glauconite represents the near-shore and shoreline deposits. As the sea moved further northward, the shallow off-shore environment migrated into the area. This is reflected in the vertical sequence by the presence of the fine-grained, glauconitic, dolomitic cemented basal sandstones of Eau Claire or Munising Group, which then gradually pass upward into thin interbeds of sandstone, siltstone, shale, and dolomite. This interplay of lithology which characterizes the Munising Group suggests that water depth was quite shallow, probably less than 100 feet, so that shifting marine currents and local source areas exerted maximum effect on sedimentation. The apparent depocenter of the Munising Group seems to be located somewhat south and west of the Brazos, State-Foster #1 (Well #80) near the border of Ogemaw and Roscommon Counties, and north of the reference area. The anhydritic facies present in Well #80 is interpreted as a very shallow sub-tidal to supra-tidal environment.

South and west of the reference area, clastic sedimentation took place as represented by the Galesville Sandstone. The depositional environment of this unit



is uncertain, but probably reflects areally localized regressive-transgressive conditions within the Munising Group.

The vertical change to carbonates in the sequence, the St. Lawrence Formation, indicates the migration of somewhat deeper water in the reference area. It should be borne in mind, however, that a lack of clastic material combined with climatic conditions could result in near-shore deposition of carbonate (see, for example, Laporte, 1969). Further, recent work by Folk and Pittman (1971) on chert nodules may also have a bearing on water depth as certain kinds of chert replace evaporites of sabkha (supratidal) origin, and cherty dolomite is present in this section, particularly in the southwestern Lower Peninsula.

Gradual infilling of the basin and retreat of the sea is indicated by the interbedded sandstone and dolomite transition zone between the St. Lawrence and Jordan formations. The upward lithologic change in the Jordan from dolomite cemented sandstone to silica cemented sandstone associated with anhydrite, suggests an extremely shallow, regressive sea.

Further interpretation of the sedimentary facies is precluded by the presence in the sequence of the regional unconformity found at the base of the "Glenwood" interval.

## SUMMARY AND CONCLUSIONS

Application of the basic principles of lithostratigraphy has allowed the construction of a reasonable stratigraphic framework for the Cambrian rocks of the Lower Peninsula of Michigan. This framework is the geometric reconstruction of the area in terms of the distribution of discrete rock units, and this in turn provides insight into the timing of tectonic and sedimentary events in this area.

The Mount Simon to Jordan sequence has been defined in terms of lithology and shown to be a complex of marine rocks which are facies related. The Mt. Simon Sandstone was deposited in a northerly transgressing Late Cambrian sea taking the form of an embayment over a region of relatively low topographic relief. The area was bounded by regions of high relief in Wisconsin, northern Michigan, and southwestern Ontario. Prior to "Glenwood" deposition, regional uplift and erosion of the Late Cambrian-Early Ordovician sequence took place.

Though some light has been shed on the early sedimentary history of the area, many problems remain

to be investigated. Some of the more important of these are as follows: (1) though the gross interformational relationships of the units has been established, the highly complex intra-formational facies that are present have yet to be outlined. (2) Lithologic differentiation of the Prairie Du Chien (Early Ordovician) dolomite from the Late Cambrian carbonate sequence could not be made on a regional scale, but such differentiation might be possible if a detailed petrographic study of these rocks were made. (3) A study of the regional relationships of the Prairie Du Chien Group from the Upper Mississippi Valley into the Michigan Basin is necessary. (4) The presence or absence of the St. Peter Sandstone in Michigan should be readily determinable from existing data and an investigation should be undertaken. (5) The geometry, lithology, and distribution of the "Glenwood" Formation are in need of clarification.

In the course of this study, some 140 wells have been shown to have penetrated Cambrian and Cambro-Ordovician rocks. Re-evaluation of the other deep tests (now called St. Peter-Prairie Du Chien) in the Michigan Basin in terms of the formational units defined in this report will undoubtedly result in the reclassification and identification of more wells in Michigan as Cambrian. Finally, it is hoped that the

stratigraphic model presented here will provide some incentive for the testing of deeper drilling objectives within the Cambrian of the Lower Peninsula of Michigan.

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## APPENDIX

## APPENDIX A

### CATALOG OF CAMBRIAN WELLS IN THE LOWER PENINSULA OF MICHIGAN

The wells are arranged alphabetically by county. The index number refers to well locations on Plate 1. Tops were determined by a study of all available samples, state survey (log) descriptions, and geo-physical logs. Unless otherwise stated, all tops reported are Gamma Ray-Neutron log tops. Information includes Principal Operator, Farm Name; Permit #; Location; Elevation; and Total Depth.

#### Formation Abbreviations

|     |                        |     |                        |
|-----|------------------------|-----|------------------------|
| BBR | - Base Black River Fm. | F   | - Franconia Fm.        |
| X   | - Extra Section        | G   | - Galesville Sandstone |
| GW  | - "Glenwood" Fm.       | EC  | - Eau Claire Fm.       |
| J   | - Jordan Sandstone     | MS  | - Mt. Simon Sandstone  |
| L   | - "Lodi" Fm.           | PMS | - Pre-Mt. Simon        |
| SL  | - St. Lawrence Fm.     | PC  | - Precambrian Basement |
| M   | - Munising Group       |     | Complex                |

#### Index Number

##### Alpena County

- 1 Panhandle Eastern Pipeline, Ford Motor #1-5; #25690; Sec. 5, T31N, R9E; El. 684 GR; TD 6380; BBR 5297; X 5297; GW 5370; J 5388; SL 5800.

##### Berrien County

- 2 Leighton, Anstiss #1-A; #23545; Sec. 14, T6S, R17W; EL. 783; TD 2970; (Sample Tops); BBR 2312; GW 2312; SL 2377; M 2886; F 2886.

Index  
NumberBerrien County (continued)

- 3 Security O & G, Thalmann #1; #26112; Sec. 10, T6S, R17W; El. 804 KB; TD 5647; BBR 2413; GW 2413; SL 2430; M 2882; F 2882; G 2958; EC 3138; MS 3728; PC 4605.

Branch County

- 4 Ambassador Oil, Schlautmann #1; #20685; Sec. 15, T7S, R8W; El. 910 RB; TD 3990; (Electric log); BBR 3196; GW 3196; SL 3202; M 3915; F 3915; G 3972.
- 5 Bell and Gault, Anspaugh and Lowther #1; #26296; Sec. 21, T7S, R5W, El. 1025 RF; TD 3776; (State log, modified); BBR 3495; GW 3495; SL 3533.
- 6 Houseknecht Oil, Liskey #1; #26719; Sec. 5, T6S, R5W; El. 1032; TD 4100; BBR 3808; GW 3808; SL 3842.

Calhoun County

- 7 Trenton Petrol., Bernloehr et al #1; #22352; Sec. 13, T3S, R8W; El. 951 KB; TD 4739; BBR 4048; GW 4048; SL 4051.
- 8 Petrosonic, Maynard #1; #23389; Sec. 15, T3S, R6W; El. 963 KB; TD 4646; (Samples & GR log available to 4408 only); BBR 4260; GW 4260; SL 4285.
- 9 Trenton Petrol., Wood #1; #22397; Sec. 9, T1S, R5W; El. 949 KB; TD 5098; BBR 4962; GW 4962; SL 4970.
- 10 B. Hensley, Hensley #1; #26737; Sec. 5, T1S, R5W; El. 944 KB; TD 5082; BBR 4948; GW 4948; SL 5032.

Cass County

- 11 Spiller Oil, Andresen #1; #22913; Sec. 16, T8S, R14W; El. 848 GR; TD 3300; (Sample Tops); BBR 2505; GW 2505; SL 2555; M 3100; F3100; G 3175.
- 12 Perry & Son, Wooden #1; #23289; Sec. 8, T7S, R14W; El. 864 KB; TD 3950; BBR 2641; GW 2641; SL 2677; M 3222; F 3222; G 3274; EC 3444.

Index  
Number

Charlevoix County

- 13 McClure Oil, Goddard et al #1; #23681; Sec. 19, T37N, R10W; El. 660 KB; TD 3950; BBR 3364; GW 3364; J 3380; SL 3620.
- 14 McClure Oil, State Beaver Island #2; #23478; Sec. 6, T37N, R10W; El. 743 KB; TD 4803; BBR 3310; GW 3310; J 3326; SL 3528; M 4074; MS 4448; PC 4730.
- 15 McClure Oil, State Beaver Island #1; #23435; Sec. 27, T38N, R10W; El. 679 KB; TD 5383; BBR 3185; GW 3185; J 3194; SL 3350; M 3945; MS 4314; PMS 4570.

Hillsdale County

- 16 Liberty Petrol., Horwath #1; #27024; Sec. 3, T9S, R1W; El. 882 KB; TD 3977; BBR 3225; GW 3225; SL 3265; M 3760; F 3760; G 3825; EC 3917.
- 17 Liberty Petrol., Fellows #1; #26655; Sec. 3, T9S, R1W; El. 886 KB; TD 3403; BBR 3222; GW 3222; SL 3263.
- 18 B. B. & C. Oil, Crall #1; #27045; Sec. 32, T8S, R4W; El. 1011 RB; TD 3463; BBR 3268; GW 3268; SL 3304.
- 19 Morris, Zeiter #1; #12307; Sec. 24, T8S, R4W; El. 1061RF; TD 3765; BBR, GW, & SL Sample Top Intervals Missing; SL Dolomite from 3430 to TD indicated on State log; No logs run.
- 20 Liberty Petrol., VanLandel #1; #26488; Sec. 20, T8S, R1W; El. 893 RF; TD 3463; BBR 3326; GW 3326; SL 3360.
- 21 Bell & Gault, Laser #1; #27349; Sec. 15, T8S, R1W; El. 916 RF; TD 3603; BBR 3467; GW 3467; SL 3500.
- 22 Bell & Gault, H. Young #1; #22536; Sec. 11, T8S, R1W; El. 920 RF; TD 3729; BBR 3436; GW 3436; SL 3440.
- 23 Trolz & McInally, C. Young #1; #22729; Sec. 2, T8S, R1W; El. 914 RF; TD 3692; (Sample Tops); BBR 3479; GW?; SL 3470.

Index  
Number

Hillsdale County (continued)

- 24 Perry & Son, Rymal #1; #25508; Sec. 15, T7S, R1W; El. 1027 RB; TD 4210; BBR 3732; GW 3732; SL 3770; M 4190; F 4190.
- 25 Houseknecht Oil, Price-Stafford #1; #26500; Sec. 20, T6S, R4W; El. 1062 RB; TD 4088; BBR 3732; GW 3732; SL 3768.
- 26 Houseknecht Oil, Ebel #1; #26252; Sec. 18, T6S, R2W; El. 1174 RB; TD 4207; BBR 4018; GW 4018; SL 4056.

Ingham County

- 27 Pure Oil, F. W. Harkness #1; #24518; Sec. 16, T2N, R2W; El. 916 KB; TD 6077; BBR 5911; GW 5911; SL 5931.
- 28 Colvin & Assoc., Glasser #1; #10011; Sec. 14, T3N, R1E; El. 908 RF; TD 6599; (Sample Tops); BBR 6553; GW?; SL 6553.
- 29 Ambassador Oil, F. Wild et al #1; #24470; Sec. 31, T1N, R2E; El. 944 KB; TD 5830; BBR 5770; GW 5770; SL 5812.
- 30 Mobil Oil, W. Kranz #1; #28607; Sec. 29, T2N, R1W; El. 939 KB; TD 7866; Information not available at this time.

Jackson County

- 31 Taggart, Watkins Farms #1; #19444; Sec. 13, T4S, R2E; El. 1013 RB; TD 4700; BBR, GW, & SL top intervals missing; in SL by 4576 to TD; no logs run.
- 32 Rovsek, McFarlane #1, #24840; Sec. 35, T3S, R3W; El. 1078 RB; TD 5199; BBR 4550; GW 4550; SL 4556.
- 33 Nanco, A. Smith #2; #27137; Sec. 30, T3S, R3W; El. 1018 KB; TD 5936; BBR 4472; GW 4472; SL 4515; M 5135; F 5135; G 5221; EC 5400.
- 34 Collin & Black, Dancer #1; #22275; Sec. 29, T3S, R1W; El. 997; TD 6088; BBR 4646; GW 4646; SL 4661; M 5283; F 5283; G 5353; EC 5517.

Index  
Number

Lenawee County

- 35 Bauer Bros. & Basin Oil, Beal #3; #27046; Sec. 4, T8S, R1E; El. 867 RB; TD 3773; BBR 3390; GW 3390; SL 3426; M 3749; F 3749.
- 36 Bauer Bros., Moore #1; #25307; Sec. 3, T8S, R1E; El. 858 RF; TD 3550; (State log, modified); BBR 3417; GW? SL 3417.
- 37 Eckert, Taylor #1; #10448; Sec. 32, T8S, R5E; El. 714 RF; TD 3902; (Sample Tops, some intervals missing); BBR 2905; GW 2905; SL 2930?; M3264; F3264; G 3275; EC 3353; MS3611; PC 3865.
- 38 Ashland Oil, Muck #1; #26411; Sec. 13, T7S, R2E; El. 840 KB; TD 3800; BBR 3536; GW 3536; SL 3575.
- 39 Bernhardt, O & G, Gerber Est. #1; #25016; Sec. 25, T7S, R5E; El. 687 RF; TD 2901; (State log, modified); BBR 2691; GW 2691; SL 2726.
- 40 MVOC, Yape #1; #24554; Sec. 14, T7S, R5E; El. 681 RF; TD 3112; (State log, modified); BBR 3065; GW?; SL 3065?.
- 41 B.U.B. Oil, Seidel #1; #23667; Sec. 5, T7S, R5E; El. 683 RF; TD 3251; BBR 3206; GW 3206; SL 3213.
- 42 Bell & Gault, Wahl #1; #25556; Sec. 5, T7S, R5E; El. 688 RF; TD 3250; (State log, modified and samples); BBR 3206; GW 3206; SL 3208.
- 43 B.U.B. Oil. Vanhaerents #1; #23979; Sec. 4, T7S, R5E; El. 682 RF; TD 3246; (State log, modified); BBR 3221?; GW 3221?; SL 3221.
- 44 California Co., Mohr et al #1; #24515; Sec. 30, T6S, R3E; El. 871 RB; TD 3768; BBR 3736; GW 3736; SL 3740.
- 45 Seven Seas Co., Francouer #1; #22112; Sec. 18, T6S, R3E; El. 888 RB; TD 3900; BBR 3793; GW 3793; SL 3812.
- 46 Socony-Vacuum, Downing Est. #1; #3353; Sec. 36, T5S, R5E; El. 697 DF; TD 3457; (State log, modified and samples); BBR 3103; GW 3103; SL 3133.



Index  
NumberLenawee County (continued)

- 47 Bell & Marks, Earhart #1; #22517; Sec. 17, T5S, R5E; El. 798 RF; TD 3645; (State log, modified and samples); BBR 3583; GW 3583; SL 3592.
- 48 Good & Good, DeLodder #GG-1; #24304; Sec. 3, T5S, R5E; El. 760 RF; TD 3555; BBR 3470; GW 3470; SL 3476.

Livingston County

- 49 Brazos O & G, Kizer #1; #25868; Sec. 14, T2N, R4E; El. 938 KB; TD 7205; BBR 6222; GW 6222; SL 6246; M 6938; F 6938; G 6997; EC 7031.
- 50 Panhandle Eastern Pipeline, Wilson Bush Comm. #1; #16067; Sec. 12, T2N, R4E, El. 935 RB; TD 5752; (Sample Tops); BBR 5730; GW?; SL 5730.
- 51 Mobil Oil, Messmore #1; #27986; Sec. 11, T3N, R5E; El. 980 KB; TD 7589; BBR 6201; GW 6201; SL 6229; M 6989; PC 7146.

Macomb County

- 52 Michigan Con. Gas, Hyland and Ciaramitaro #1; #22825; Sec. 34, T3N, R13E; El. 600 RF; TD 4695; (State log, modified); BBR 4536; X?; SL 4536; M 4674.
- 53 Consumers Power, Halmich #3-1; #26214; Sec. 1, T4N, R13E; El. 692 RF; TD 5214; BBR 5120; X 5120; SL 5168.
- 54 Panhandle Eastern Pipeline, Heide #1; #22439; Sec. 7, T5N, R13E; El. 785 KB; TD 5721; BBR 5636; X 5636; SL 5692.

Mason County

- 55 Superior Oil, Mabel Sippy #17; #18905; Sec. 25, T17N, R16W; El. 726 KB; TD 7249; (Laterolog); BBR 5942; GW 5942; J 5996; L 6490; SL 6577; M 6935; F 6935; G 6984; EC 7070.
- 56 Dow Chem., Dow-Brazos-Taggart #1; #17789; Sec. 27, T19N, R18W; El. 647 RB; TD 6617; BBR 5340; GW 5340; J 5348; L 5928; SL 5945; M 6158; F 6158; G 6212; EC 6255; MS 6602.

Index  
NumberMonroe County

- 57 Ashland Oil, Nichols #1; #26224; Sec. 5, T8S, R6E; El. 693 KB; TD 2777; BBR 2512; X 2512; GW 2568; SL 2574.
- 58 Norton and Tuttle, Schultz #1; #22117; Sec. 1, T8S, R7E; El. 636 DF; TD 2531; (State log, modified); BBR 2477; GW 2477; SL 2500.
- 59 Bernhardt O & G, Allen #2; #25378; Sec. 19, T7S, R6E; El. 687 RF; TD 2762; (State log, modified and samples); BBR 2650; GW 2650; SL 2669.
- 60 Ferguson & Garrison, Shimp #1; #25494; Sec. 16, T7S, R6E; El. 685 RF; TD 3671; (Sample Tops and State log); BBR 2710; X 2710; SL 2725; M 3007; F 3007; G 3039; EC 3103; MS 3355; PC 3634.
- 61 Beck, Sancrant #1; #7702; Sec. 19, T7S, R7E; El. 669 DF; TD 5495; (No record, Cambrian samples missing, samples start in granite wash); PC 3595?.
- 62 Basin Oil, Metz Comm. #1; #23024; Sec. 12, T7S, R7E; El. 627 RF; TD 2659; BBR 2614; X 2614; SL 2636.
- 63 McClure Oil, Stotz-Williams #1; #25062; Sec. 10, T7S, R7E; El. 650 KB; TD 2989; BBR 2876; X 2876; SL 2904.
- 64 Hack Drilling, Weeman #1; #23356; Sec. 6 (Proj.), T7S, R8E; El. 640 RB; TD 2711; BBR 2656; X 2656; SL 2684.
- 65 Consolidated Develop., Bragg #B-2; #8449; Sec. 30, T6S, R6E; El. 676 DF; TD 3250; (Sample Tops); BBR 2810; GW?; X?; SL 2810; M 3085; (F, G, & EC could not be determined).
- 66 Good & Good, Montry #5; #9257; Sec. 30, T6S, R6E; El. 677 DF; TD 2874; (State log, modified); BBR 2770; GW 2770; SL 2785.
- 67 Parkinson, VanDevelde #1; #17187; Sec. 29, T6S, R9E; El. 602 DF; TD 2681; (Sample Tops); BBR 2610; X?; GW? SL 2610; M 2630; F 2630; G 2666.

Index  
NumberMonroe County (continued)

- 68 Morriss, Compau #1; #13867; Sec. 12, T6S, R9E; El. 592 DF; TD 2910; (Sample Tops to 2841 and State log); BBR 2745; X?; GW?; SL 2745; M 2770; F 2770; G 2777; EC 2841?.
- 69 Bell & Marks, Lennard #1; #23659; Sec. 15, T5S, R6E; El. 681 DF; TD 3313; BBR 3284; GW 3284; SL 3289.
- 70 Basin Oil, Kanitz et al #1; #22092; Sec. 13, T5S, R6E; El. 676 RF; TD 3343; BBR 3254; GW 3254; SL 3258.
- 71 Simpson, Jennings #GG-1; #23532; Sec. 22, T5S, R7E; El. 662 RF; TD 3280; BBR 3174; X 3174; SL 3202.
- 72 Humble Oil, Oger #1; #24405; Sec. 15, T5S, R7E; El. 676 RB; TD 3260; BBR 3216; X 3216; SL 3232.
- 73 Dow Chem., Grassley #1; #17767; Sec. 7, T5S, R7E; El. 679 DF; TD 3325; (Sample Tops); BBR 3261; X?; GW?; SL 3261.
- 74 Bell & Marks, Heath #GG-1; #23531; Sec. 4, T5S, R7E; El. 658 DF; TD 3398; BBR 3334; X 3334; SL 3354.
- 75 Sturman, Chapman #1; #11221; Sec. 29, T5S, R10E; El. 596 DF; TD 3377; (Sample Tops); BBR 2854; X?; GW?; SL 2854; M 2963; (F, G, and EC could not be determined); MS 3204; PC 3375.

Muskegon County

- 76 DuPont, DuPont #1; Brine Disposal; Sec. 36, T12N, R18W; El. 655 KB; TD 6512; BBR 4598; GW 4598; J 4625; L?; SL 4908; M 5505; F 5505; G 5570; EC 5683; MS 5820.

Newaygo County

- 77 Thunderhollow O & G, Thompson #1; #26662; Sec. 20, T15N, R14W; El. 829 RB; TD 8215; (Log to J and Sample Tops); BBR 6432; GW 6432; J 6486; L 6970; SL 7140; M 7755.

Index  
NumberOakland County

- 78 Collin, Gowan et al #1; #19055; Sec. 35, T1N, R7E;  
El. 1020 DF; TD 5850; (Sample Tops); BBR 5328;  
X?; GW?; SL 5328.

Ogemaw County

- 79 Ohio Oil, Reinhardt #1; #12896; Sec. 35, T22N,  
R2E; El. 903 DF; TD 11012; (Sample Tops); BBR  
10475; X?; GW?; J 10475; SL 10785.
- 80 Brazos O & G, State-Foster #1; #25099; Sec. 28,  
T24N, R2E; El. 1477 KB; TD 12996; BBR 10412;  
GW 10412; J 10506; SL 10855; M 11478.

Osceola County

- 81 Michigan Con. Gas, Stedman #3; #12802; Sec. 29,  
T18N, R10W; El. 1133 DF; TD 8917; (State log,  
modified); BBR 8817; GW 8817; J 8857.

Otsego County

- 82 Simpson, Lake Horicon #1; #25873; Sec. 2, T29N  
R4W; El. 1412 KB; TD 8372; BBR 8108; GW 8108;  
J 8136.

Ottawa County

- 83 Holland Suco, Disposal Well #1; None; Sec. 30,  
T5N, R15W; El. 623 RB; TD 5894; BBR 3909; GW 3909;  
SL 3936; M 4659; F 4659; G 4754; EC 4835; MS 5226.
- 84 Holland Suco, Disposal Well #2; None; Sec. 30,  
T5N, R15W; El. 620 KB; TD 5910; BBR 3902; GW 3902;  
SL 3922; M 4652; F 4652; G 4700; EC 4832; MS 5221.
- 85 Michigan Petrol., Moe #1; #537; Sec. 6, T9N, R13W;  
El. 704 DF; TD 6310; (Sample Tops and State log);  
BBR 5465; GW?; J 5465; SL 5661.

Presque Isle County

- 86 Fain-Porter, Weide #1; #24999; Sec. 33, T33N,  
R7E; El. 816 KB; TD 5458; BBR 5310; X 5310; GW  
5337; J 5358.

Index  
NumberPresque Isle County (continued)

- 87 Lindsay, Sellke #1; #22638; Sec. 20, T34N, R5E; El. 844 KB; TD 5137; BBR 5044; X 5044; GW 5064; J 5089.
- 88 Pan-Am, Drasey #1; #27199; Sec. 29, T35N, R2E; El. 808 KB; TD 5940; BBR 4649; X 4649; J 4684; SL 5162; PC? Quartzite 5714; PC 5882.
- 89 McClure Oil, State-Ocqueoc #1; #27725; Sec. 24, T35N, R3E; El. 730 KB; TD 4737; BBR 4583; X 4583; GW 4600; J 4616.
- 90 Mich. Limestone Div., U.S. Steel #1; #20194; Sec. 31, T35N, R6E; El. 668 RB; TD 4463; (Sample Tops); BBR 4355; X?; GW 4355; J 4385.

Sanilac County

- 91 Hallwell G & O, Spencer #1; #26480; Sec. 27, T9N, R15E; El. 759 RB; TD 6289; BBR 6194; X 6194; GW 6236; J 6280.
- 92 Humble Oil, Hoppinthal #1; #25357; Sec. 16, T9N, R15E; El. 768 RB; TD 6784; BBR 6614; X 6614; GW 6669; J 6692.
- 93 Simpson, Hontar #1; #25939; Sec. 9, T10N, R15E; El. 775 KB; TD 6793; BBR 6606; X 6606; GW 6650; J 6736.
- 94 Phillips Petrol., Long #1; #24441; Sec. 27, T10N, R16E; El. 770 KB; TD 6503; BBR 6240; X 6240; GW 6291; J 6321; SL 6485.

Shiawassee County

- 95 Hadson O & G, Dysinger #1; #23376; Sec. 22, T5N, R2E; El. 905 RB; TD 7310; BBR 7227; GW 7227; J 7262.
- 96 Mobil Oil, Jelinek-Ferris #1; #27907; Sec. 5, T5N, R2E; El. 843 KB; TD 7056; BBR 6953; GW 6953; J?; SL 7005.
- 97 Lee, Ferris #1; #22379; Sec. 5, T5N, R2E; El. 856 KB; TD 6815; BBR 6718; GW 6718; J?; SL 6785.

Index  
NumberSt. Clair County

- 98 Bernhardt O & G, Puzzuoli #1; #25780; Sec. 17, T2N, R16E (Proj.), PC #3; El. 581 DF; TD 4186; BBR 3945; X 3945; GW 3995; M 3999; MS 4074; PC 4145.
- 99 Collin, Bidal-Laucher-Levraw #1; #23796; Sec. 10, T3N, R15E; El. 595 RF; TD 4494; BBR 4397; X 4397; GW 4446; M 4448.
- 100 Consumers Power, Brine Disposal #1; #BD 139; Sec. 31, T4N, R15E; El. 615 KB; TD 4627; BBR 4434; X 4434; GW 4486; M 4489; MS 4563; PC 4611.
- 101 St. Clair O & G, Hurst #1; #196; Sec. 26, T5N, R16E; El. 620 DF; TD 4770; (Sample Tops); BBR 4590; X?; GW?; M 4590; MS 4675; PC 4740.
- 102 Panhandle Eastern Pipeline, Roney #1; #22002; Sec. 11, T5N, R16E; El. 628 RF; TD 4824; BBR 4642; X 4642; GW 4688; M 4694; MS 4815.
- 103 Consumers Power, CP CO 2-7 BDW; #BD 152; Sec. 7, T5N, R17E; El. 631 KB; TD 4700; BBR 4514; X 4514; GW 4561; M 4564; MS 4654; PC 4684.
- 104 Consumers Power, CP CO 1-7 BDW; #BD 151; Sec. 7, T5N, R17E; El. 637 KB; TD 4733; BBR 4532; X 4532; GW 4579; M 4582; MS 4674; PC 4710.
- 105 Nadco, Conrad #1; #26086; Sec. 1, T6N, R15E; El. 709 RB; TD 5498; BBR 5250; X 5250; GW 5298; SL 5302; M 5430.
- 106 Goll, Graves & Mechling, Baldwin et al #1; #25024; Sec. 6, T6N, R16E; El. 681 KB; TD 5492; BBR 5224; X 5224; GW 5272; SL 5276; M 5400.
- 107 Goll, Graves & Mechling, Sumrack #1; #24722; Sec. 6, T6N, R16E; El. 676 RF; TD 5391; (Sample Tops); BBR 5351; X?; GW?; M 5351.
- 108 Mueller Brass, Van Antwerp #1; #11001; Sec. 9, T6N R17E; El. 608 DF; TD 4948; (State log, modified and samples); BBR 4893; GW 4893; SL 4898; M 4919.

Index  
NumberSt. Clair County (continued)

- 109 Lanphar O & G, Lyle et al #1; #25632; Sec. 28,  
T7N, R13E; El. 813 KB; TD 6337; BBR 6234; X 6234;  
J 6293.

St. Joseph County

- 110 Mahnke, Mahnke #1; #1244; Sec. 2, T6S, R11W; El.  
833 RF; TD 3520; (Sample Tops); BBR 3035; GW  
3035; SL 3065.

Tuscola County

- 111 Rayburn, Watchern & Wells #1; #20209; Sec. 5,  
T10N, R9E; El. 873 RB; TD 9128; (Sample Tops);  
BBR 8910; X?; GW?; J 8910.
- 112 Simpson & Sun, Sattelberg #1; #23890; Sec. 8,  
T13N, R9E; El. 678 KB; TD 10130; BBR 9858; X 9858;  
GW 9914; J 9934.
- 113 Simpson, Novesta Twp. et al #1; #25609; Sec. 16,  
T13N, R11E; El. 737 KB; TD 9296; BBR 9089;  
X 9089; GW 9140, J 9164.

Van Buren County

- 114 Tri-County Develop., Reed #1; #25706; Sec. 35,  
T3S, R14W; El. 747 RF; TD 3628; (State log,  
modified); BBR 3020?; GW?; SL 3020?.

Washtenaw County

- 115 Good & Good, Marion GG-1; #23921; Sec. 14, T4S,  
R5E; El. 794 RF; TD 3868; BBR 3758; GW 3758;  
SL 3764.
- 116 Trolz, Trolz #1; #25950; Sec. 20, T4S, R3E; El.  
1024 RB; TD 4640; BBR 4562; GW 4562; SL 4568.
- 117 Peake Petrol., Bonhenstiehl #1; #23380; Sec. 34,  
T4S, R4E; El. 919 RF; TD 3951; BBR 3873; GW  
3873; SL 3878.
- 118 Leonard Oil, Schwocho #1; #26856; Sec. 17, T4S,  
R5E; El. 861 RF; TD 3934; BBR 3797; GW 3797;  
SL 3802.

Index  
NumberWashtenaw County (continued)

- 119 Good & Good, Schowacko #GG-1; #24714; Sec. 16, T4S, R5E; El. 864 RF; TD 3940; BBR 3778; GW 3778; SL 3783.
- 120 Basin Oil & G. G. & M, Wanty & Edwards #1; #22292; Sec. 28, T4S, R6E; El. 721 RF; TD 3637; BBR 3575; GW 3575; SL 3584.
- 121 Sun Oil, Meyer #1; #25607; Sec. 16, T3S, R4E; El. 974 RB; TD 4524; BBR 4457; GW 4457; SL 4466.
- 122 Sun Oil, Buss & Haab Unit #1; #19231; Sec. 8, T3S, R4E; El. 963 DF; TD 4691; BBR 4532; GW 4532; SL 4536.
- 123 Rovsek, Grau #1; #27472; Sec. 8, T3S, R4E; El. 957 RB; TD 4628; BBR 4555; GW 4555; SL 4564.
- 124 Rovsek, Wabash R.R. #1; #25482; Sec. 24, T3S, R7E; El. 693 RF; TD 3973; BBR 3880; GW 3880; SL 3886.
- 125 Peake Petrol., Goers #1; #24396; Sec. 25, T2S, R3E; El. 939 DF; TD 4758; BBR 4699; GW 4699; SL 4718.
- 126 Degenther, Wenk #1; #19891; Sec. 33, T2S, R4E; El. 918 DF; TD 4758; (Sample Tops); BBR 4615; X?; GW?; SL 4615.
- 127 Rovsek, Jorgensen #1; #25714; Sec. 26, T2S, R7E; El. 782 RB; TD 5002; BBR 4868; GW 4868; SL 4880 (Sample).
- 128 Colvin et al, Meinzinger #1; #11341; Sec. 12, T2S, R7E; El. 818 DF; TD 5692; (Sample Tops); BBR 4696; X?; GW?; SL 4696; M 5059; F 5059; G 5075; EC 5160; MS 5357; PC 5663.
- 129 Simpson et al, Wagner & Slocum #1; #24161; Sec. 22, T1S, R3E; El. 960 KB; TD 5159; BBR 5086; GW 5086; SL 5094.
- 130 Ohio Oil, Cooper #1; #19384; Sec. 7, T1S, R3E; El. 939 RT; TD 5156; BBR 5044; GW 5044; SL 5052.



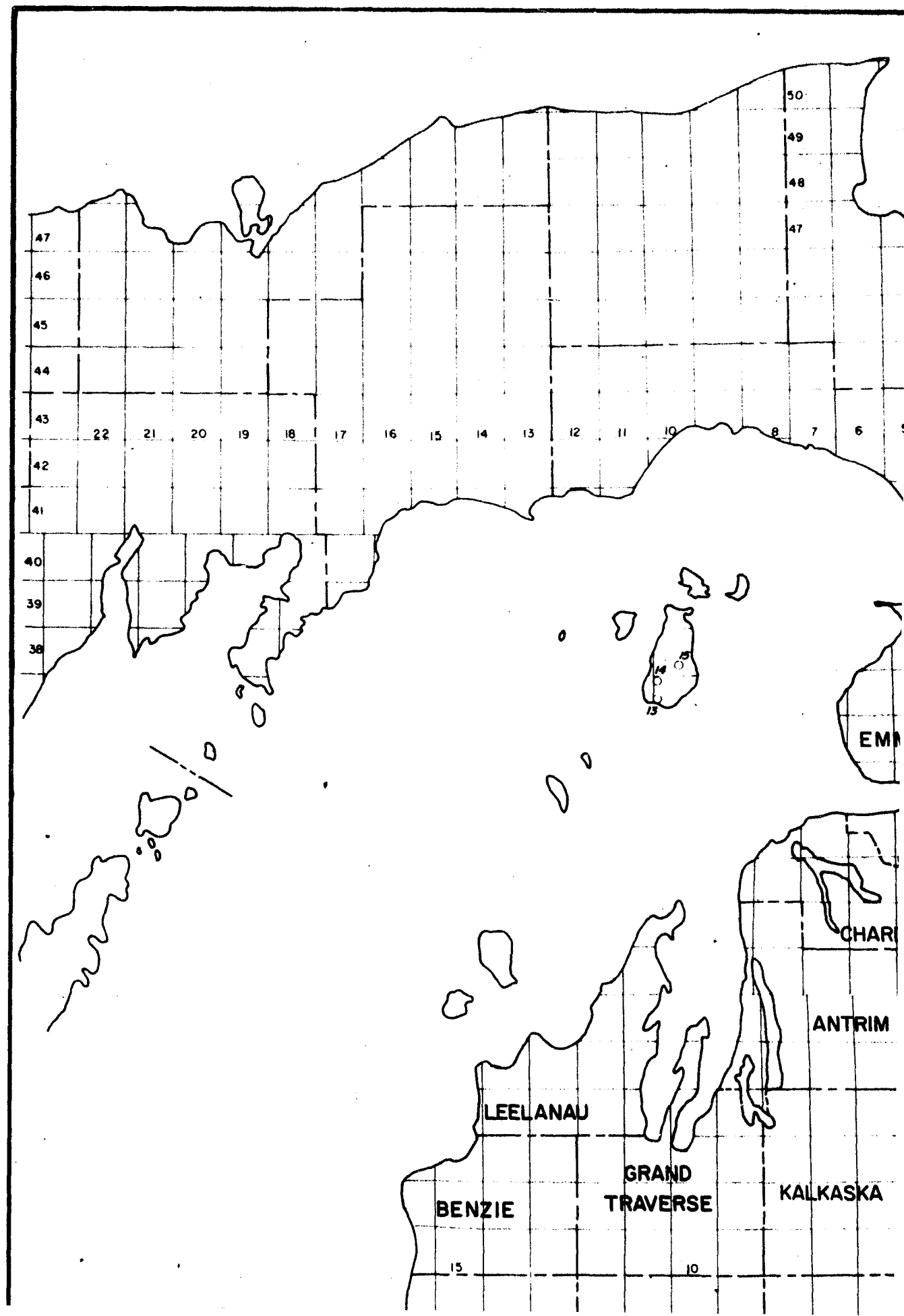
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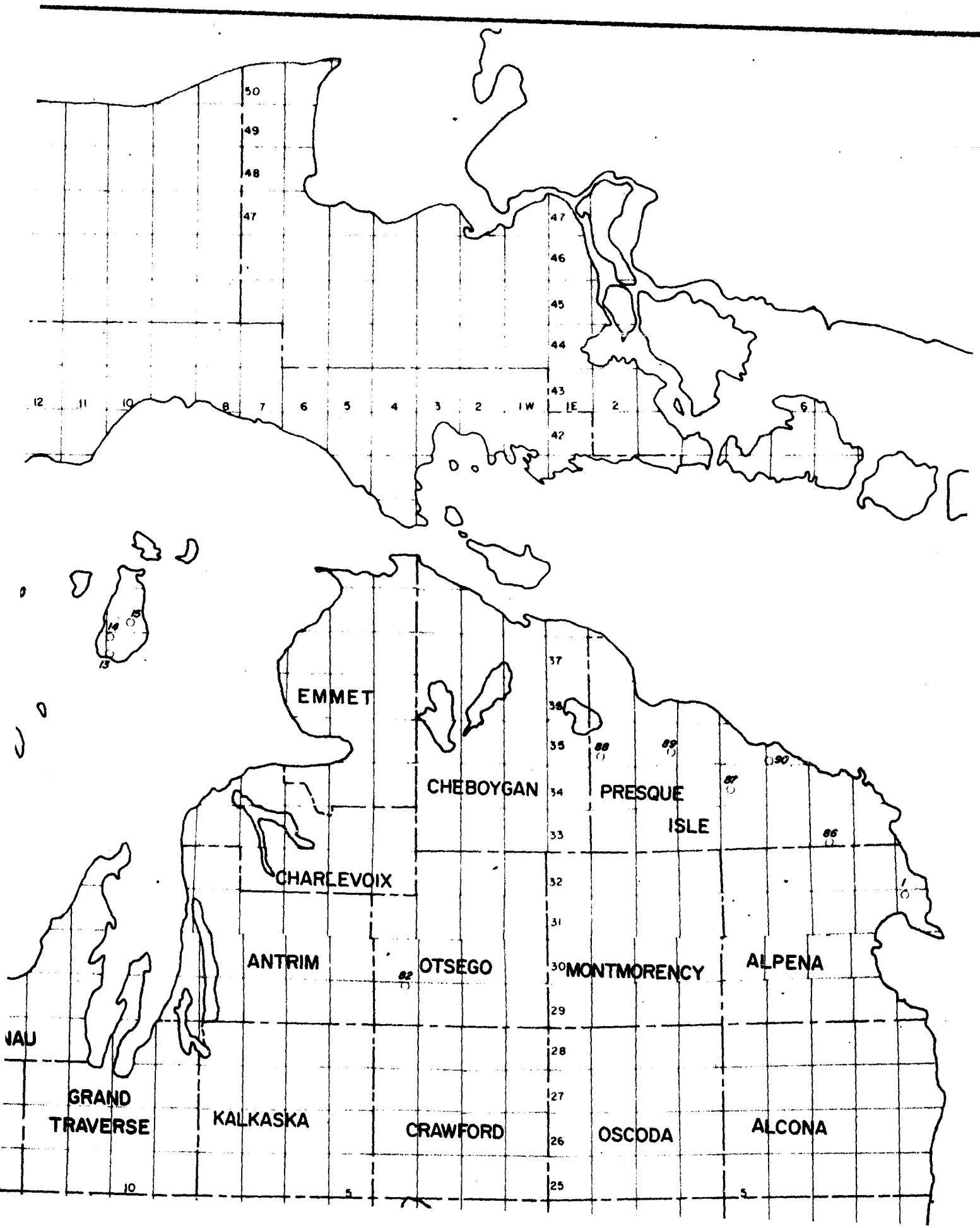
Washtenaw County (continued)

- 131 Chamness, Troy-Roddenberry Comm. #1; #10792; Sec. 27, T1S, R7E; El. 885 DF; TD 6094; (Electric Log and Samples); BBR 5019; X?; GW?; SL 5019; M 5403; F 5403; G 5435; EC 5528; MS 5827; PC 6062.
- 132 Colvin et al, Voss Comm. #1; #10141; Sec. 16, T1S, R7E; El. 915 DF; TD 6410; (Sample Tops); BBR 5210; X?; GW?; SL 5210; M 5735; F 5735; G 5758; EC 5848; MS 5992; PC 6368.
- 133 Rovsek, Bulman #1; #25759; Sec. 2, T1S, R7E; El. 996 KB; TD 5377; BBR 5254; GW 5254; SL 5260.

Wayne County

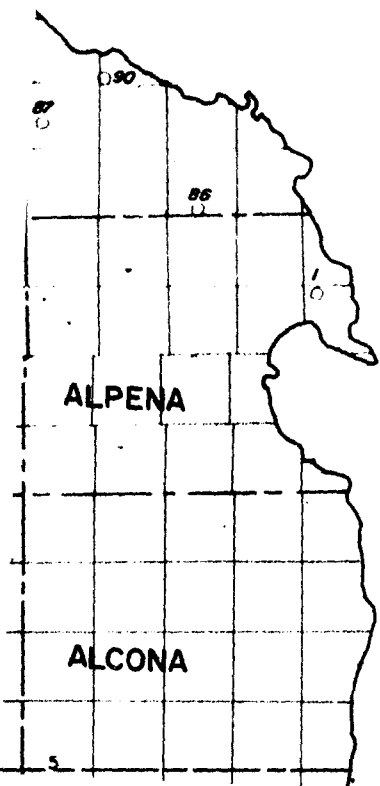
- 134 Colvin et al, Theisen Est. #1; #10430; Sec. 16 T4S, R9E; El. 624 DF; TD 4046; (State log, modified); BBR 3340; X?; GW?; SL 3340; M 3450; F 3450; G 3460; EC 3527; MS 3774; PC 3980.
- 135 Marathon Oil, Woodhaven BD #1; BD 146; Sec. 22, T4S, R10E; El. 609 KB; TD 3752; BBR 3195; GW 3195; SL 3241; M 3338; F 3338; G 3343; EC 3412; MS 3505; PC 3705.
- 136 None, H. R. Ford Well; None; Sec. 22, T2S, R10E; El. 612 DF; TD 4050; (Sample Tops); BBR 3920; X?; GW?; SL 3920; M 4025.
- 137 Semet Solvay Div., Allied Chem. #1 Waste Disposal; None; Sec. 26 Ext, T2S, R11E; El. 599 KB; TD 4110; (Laterolog); BBR 3778; GW 3778; SL 3790; M 3832; MS 4042.
- 138 Panhandle Eastern Pipeline, Ford Motor #1; #25560; P.C. 33, Proj. Sec. 19, T2S, R11E; El. 587 KB; TD 3917; BBR 3824; X 3824; GW 3872; SL 3875; M 3898.
- 139 Taggart, George et al #1; #19329; Sec. 18, T1S, R8E; El. 860 RF; TD 5130; (Sample Tops); BBR 4825; X?; GW?; SL 4825.
- 140 Woodson (CP Co), DeHoCo #3; #19496; Sec. 17, T1S, R8E; El. 900 RB; TD 5483; BBR 4744; X 4744; SL 4788; M 5228; F 5228; G 5270; EC 5356.





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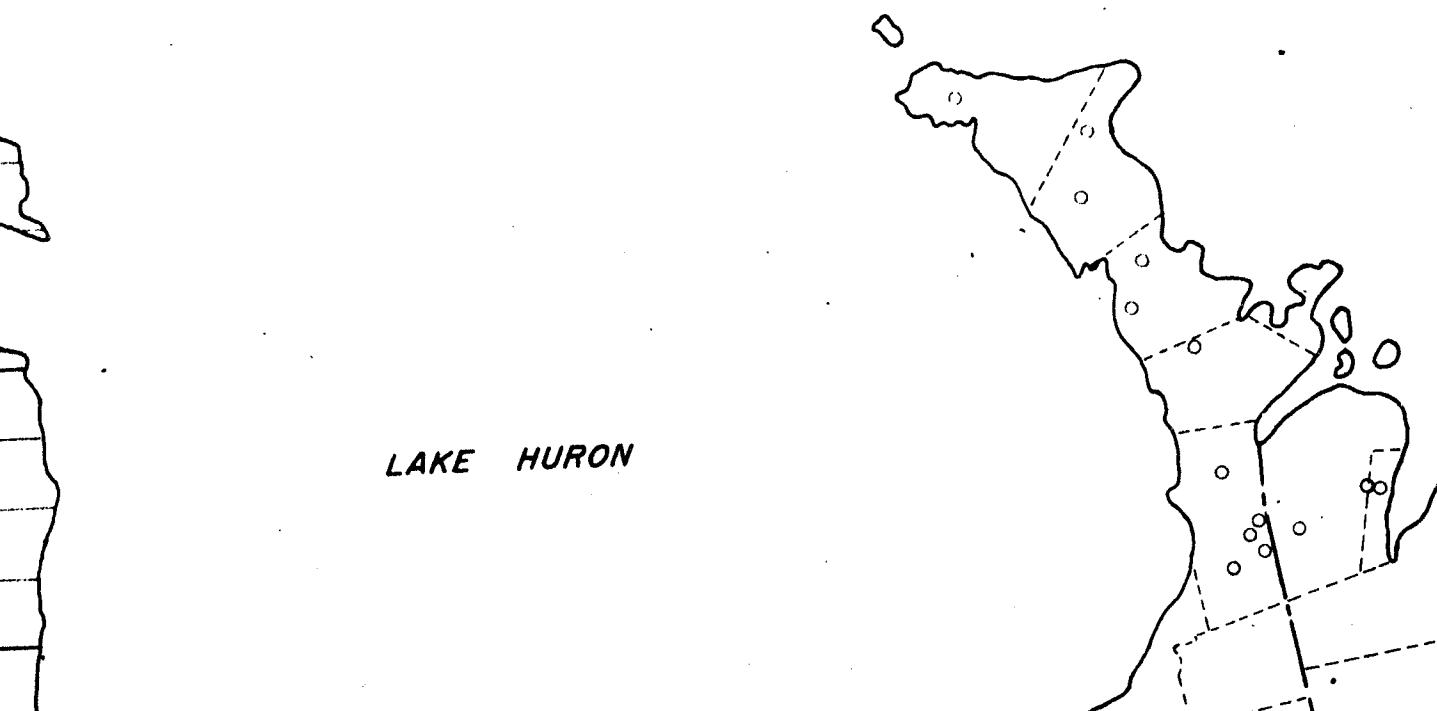
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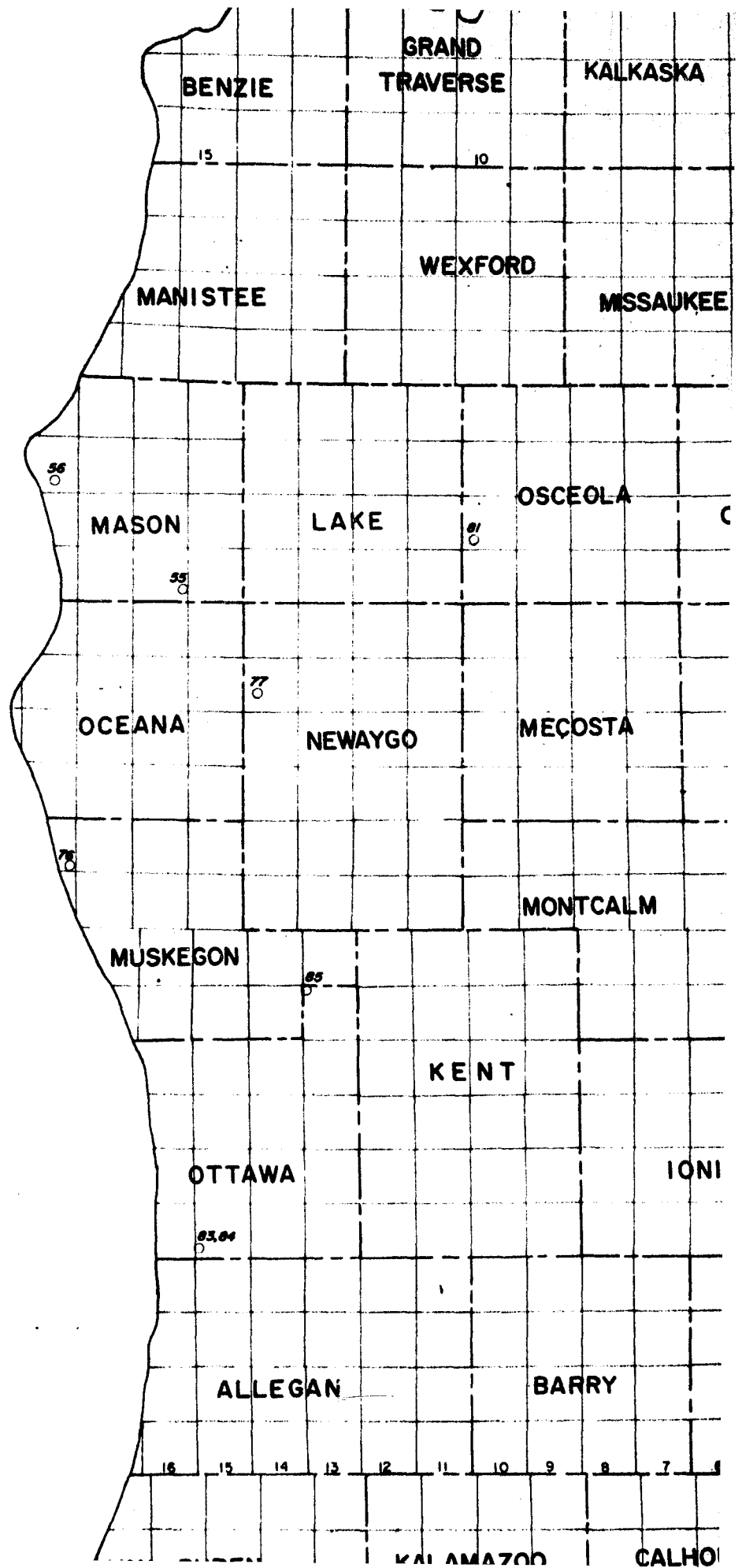
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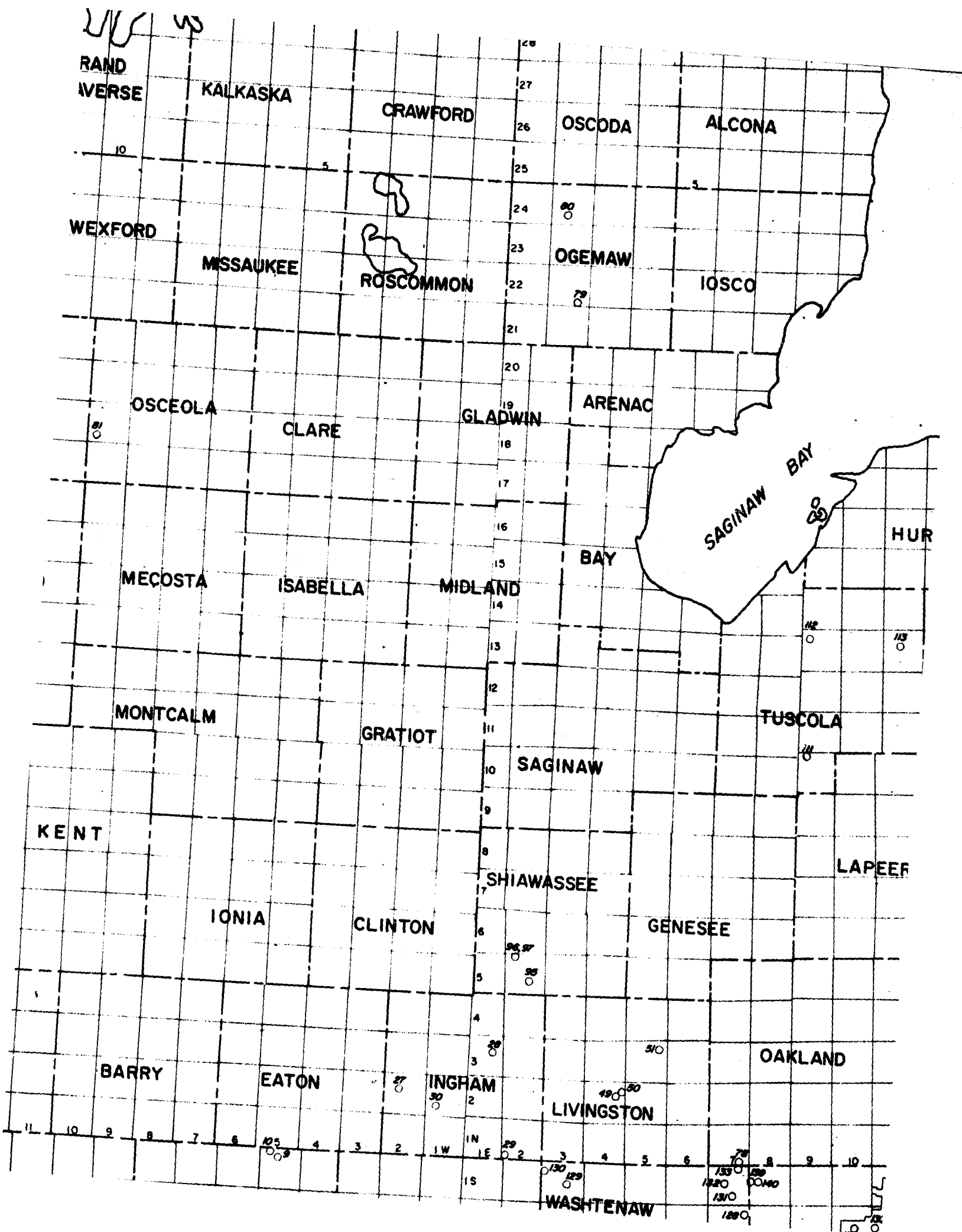


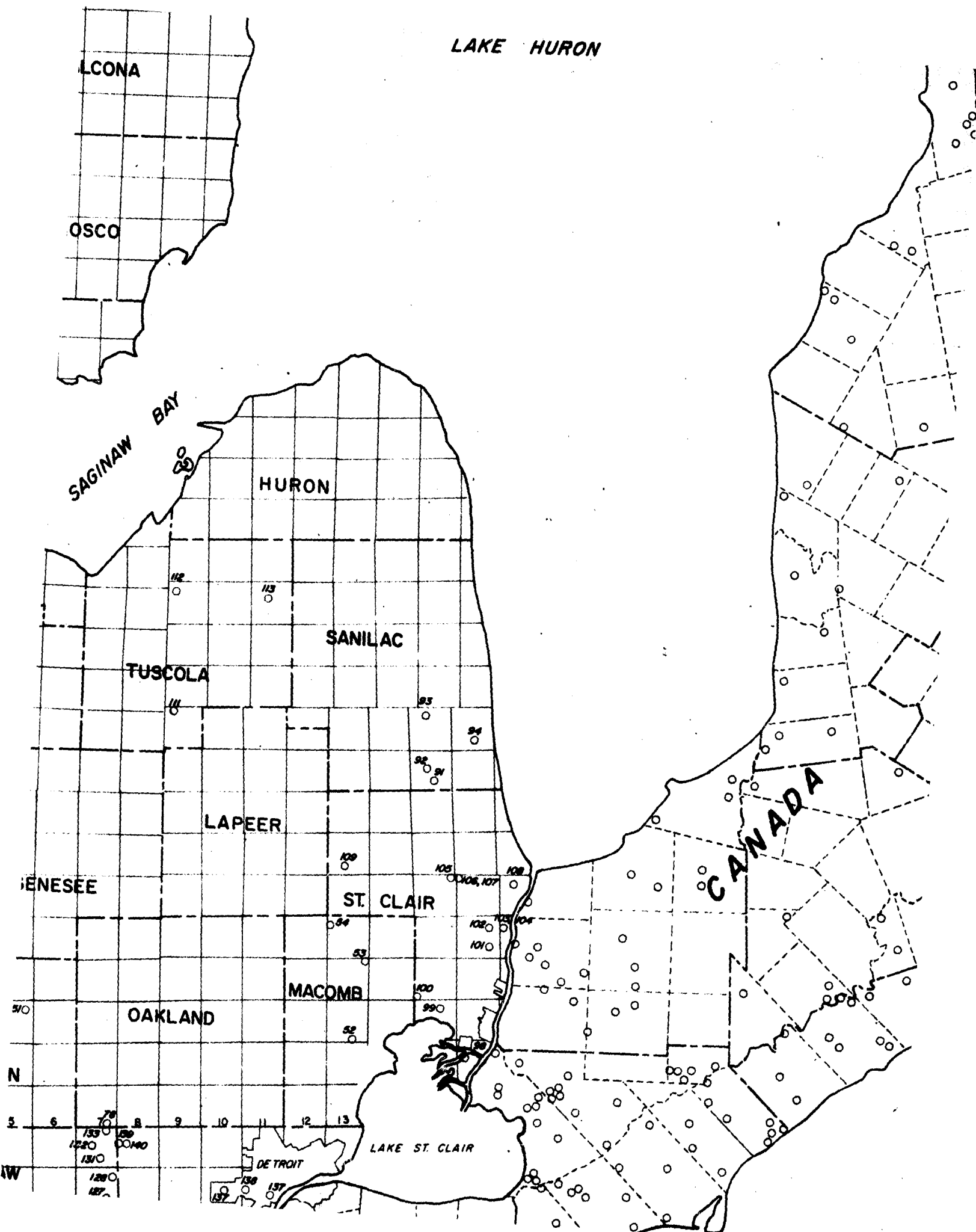
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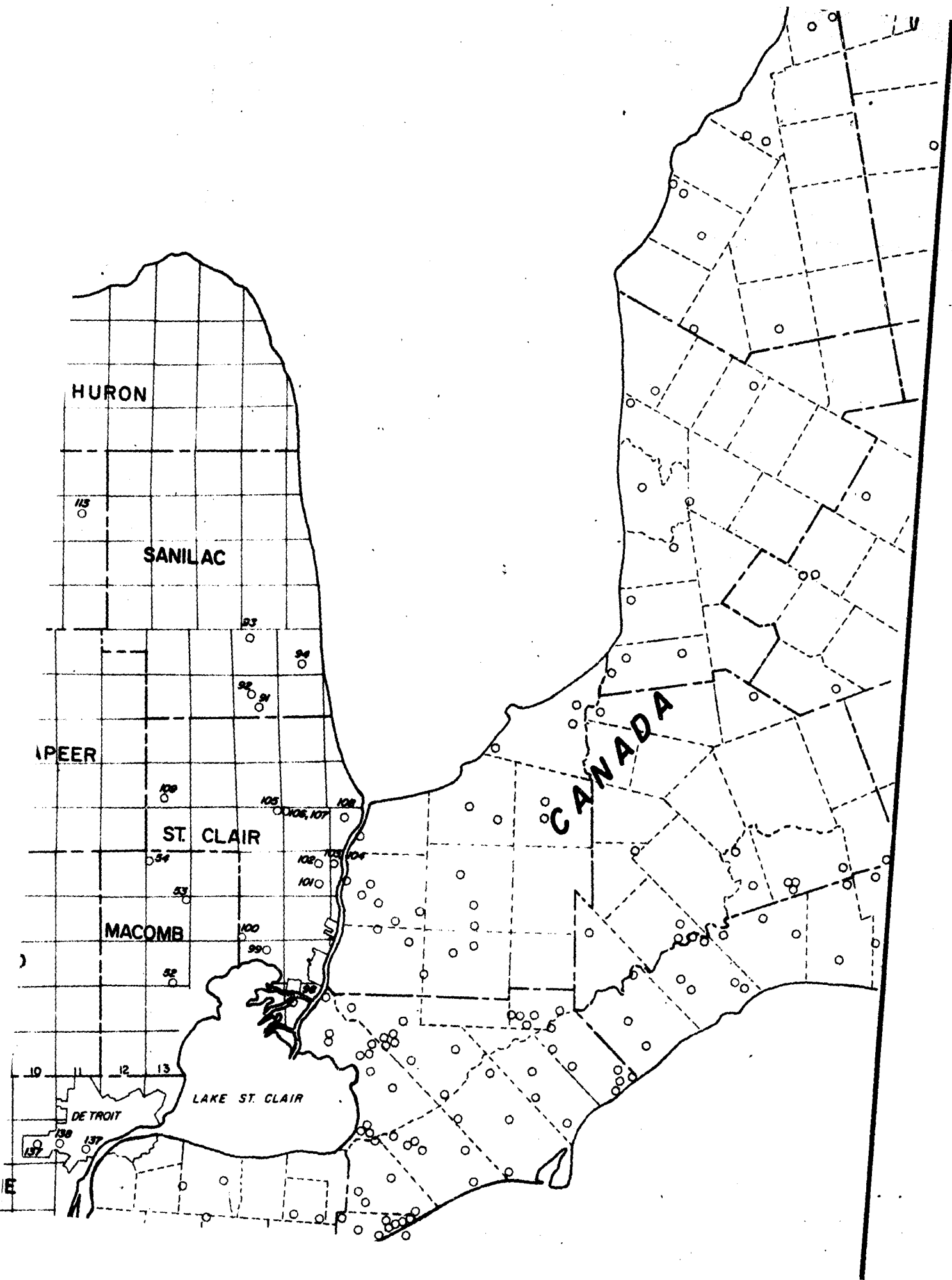
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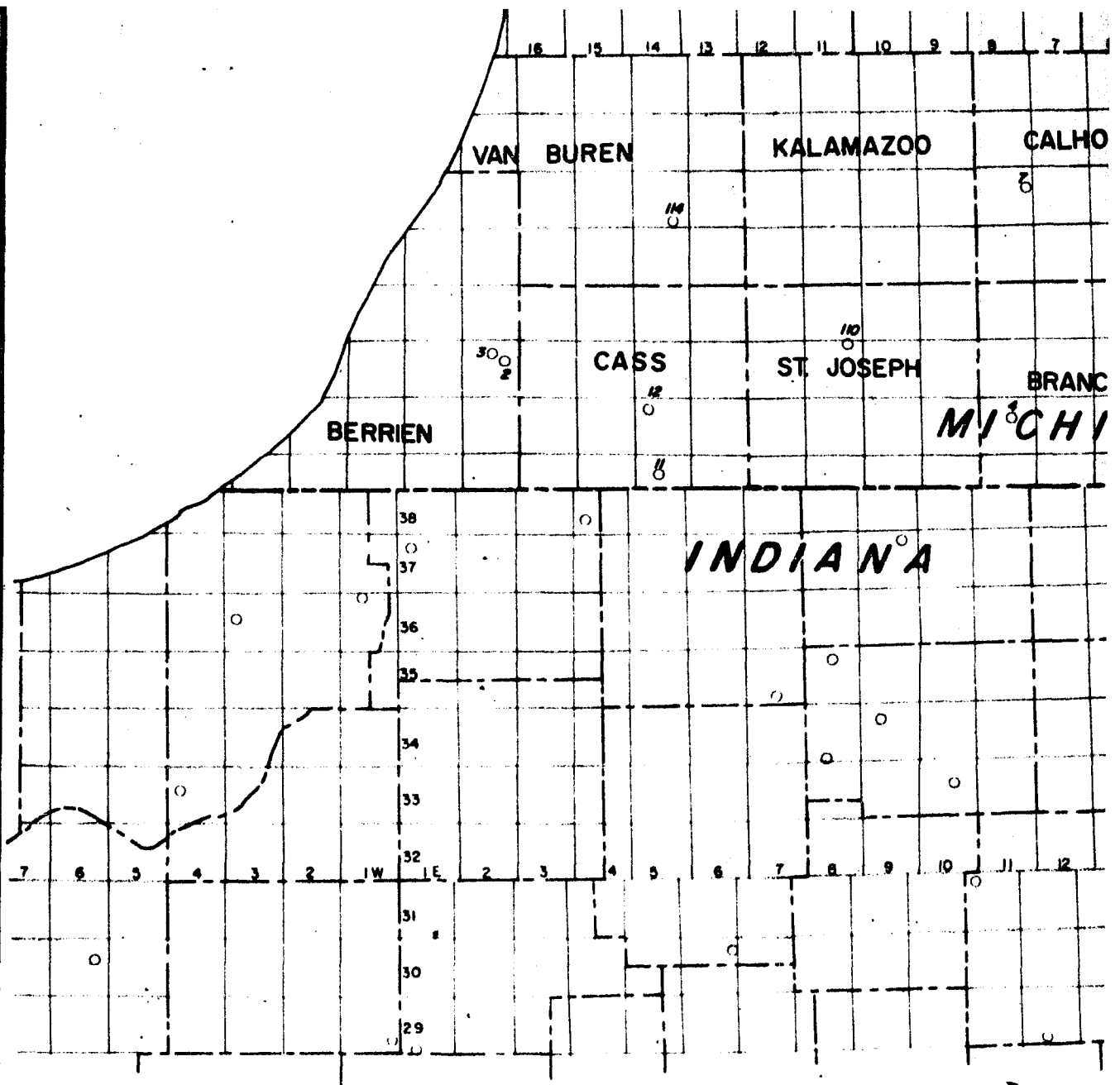












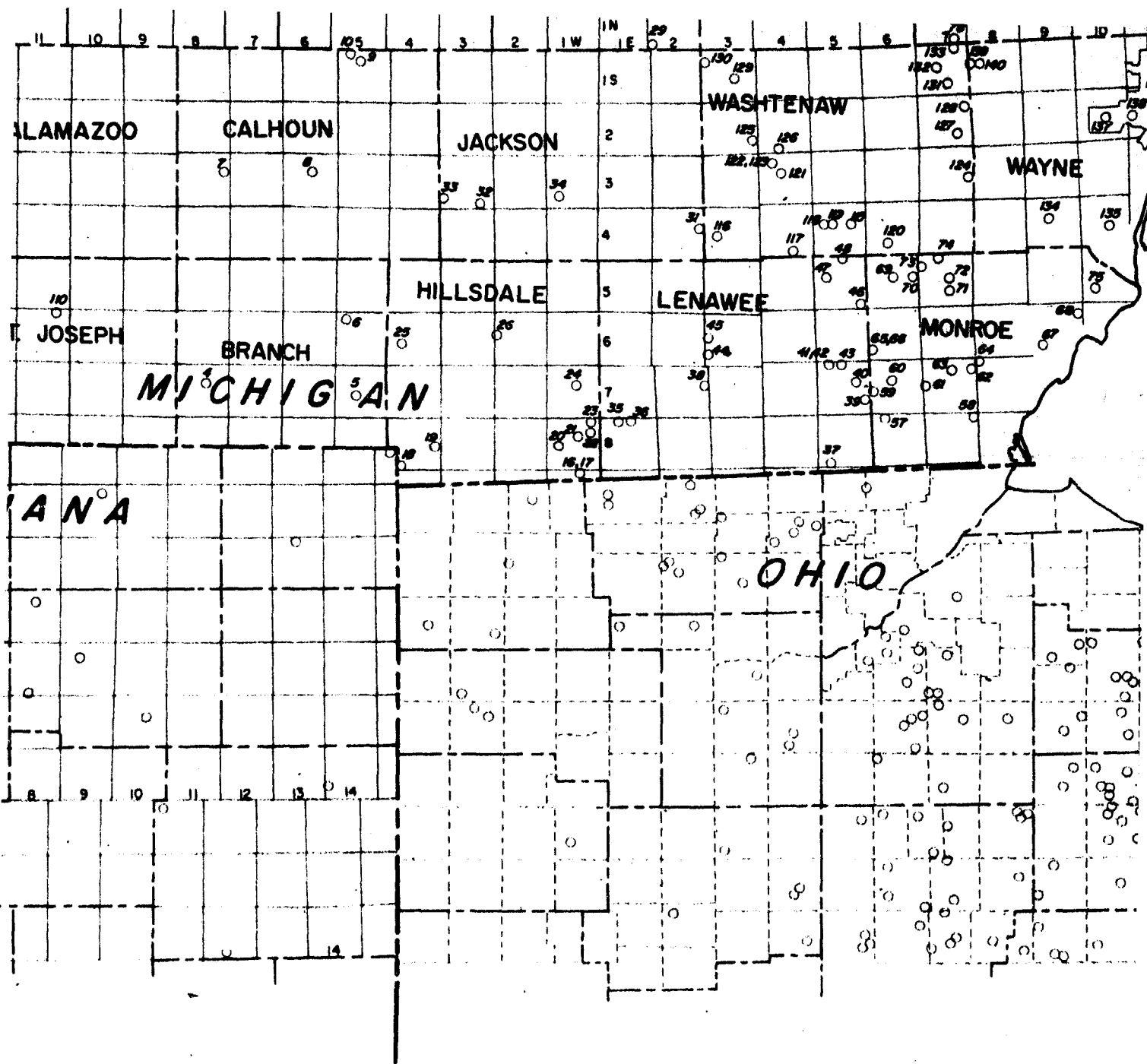
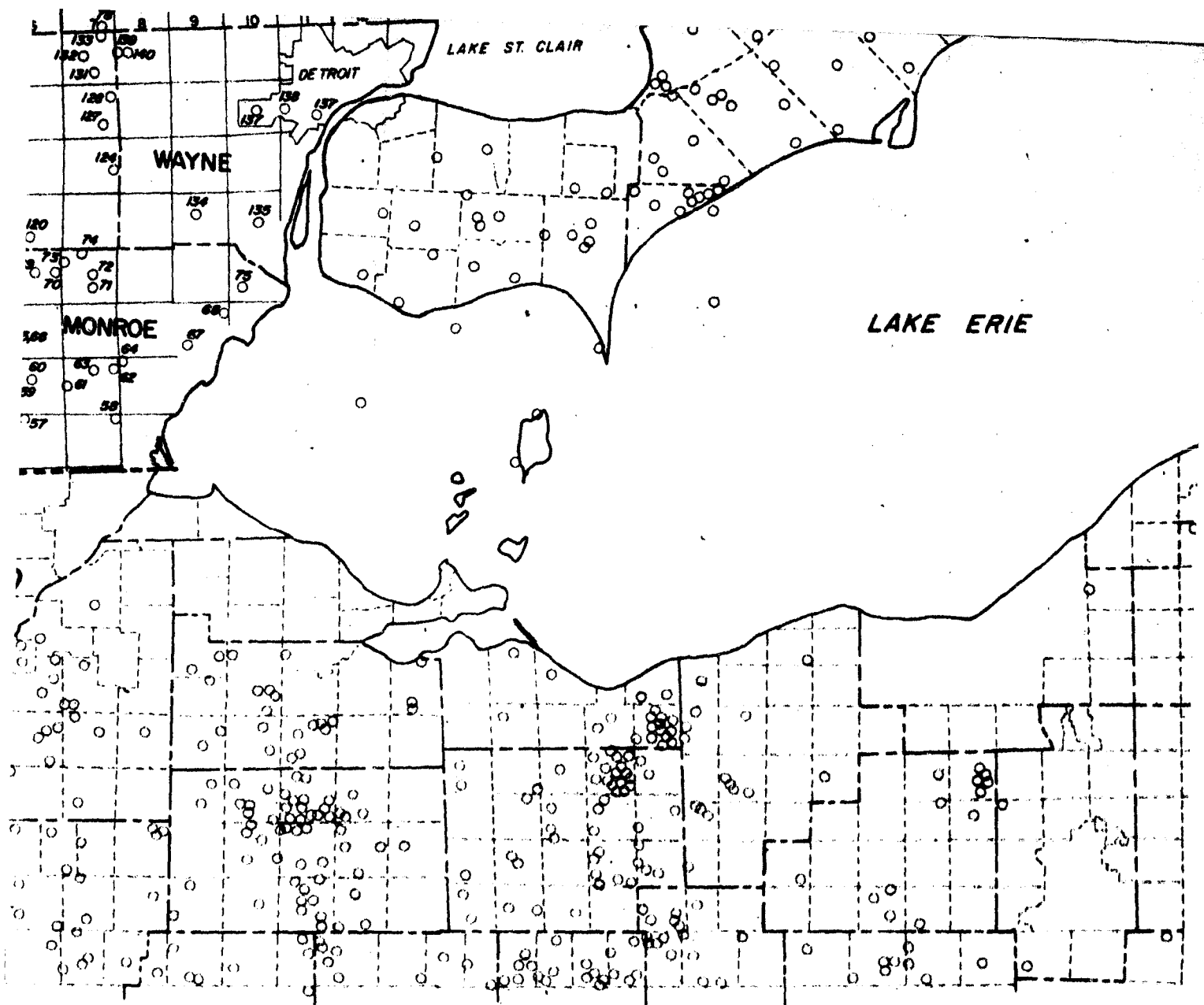


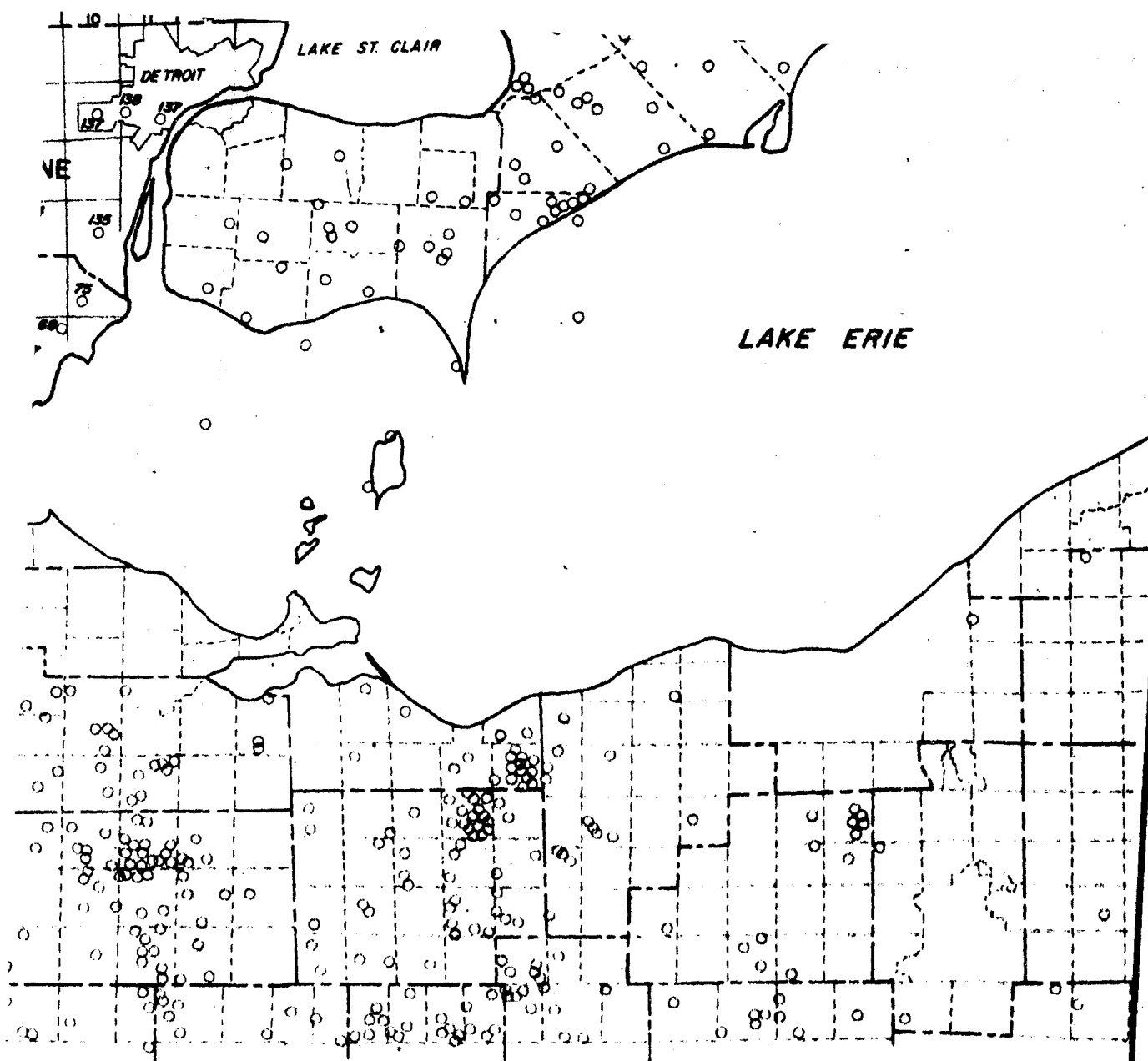
PLATE I

WELL DATA LOCATION MAP



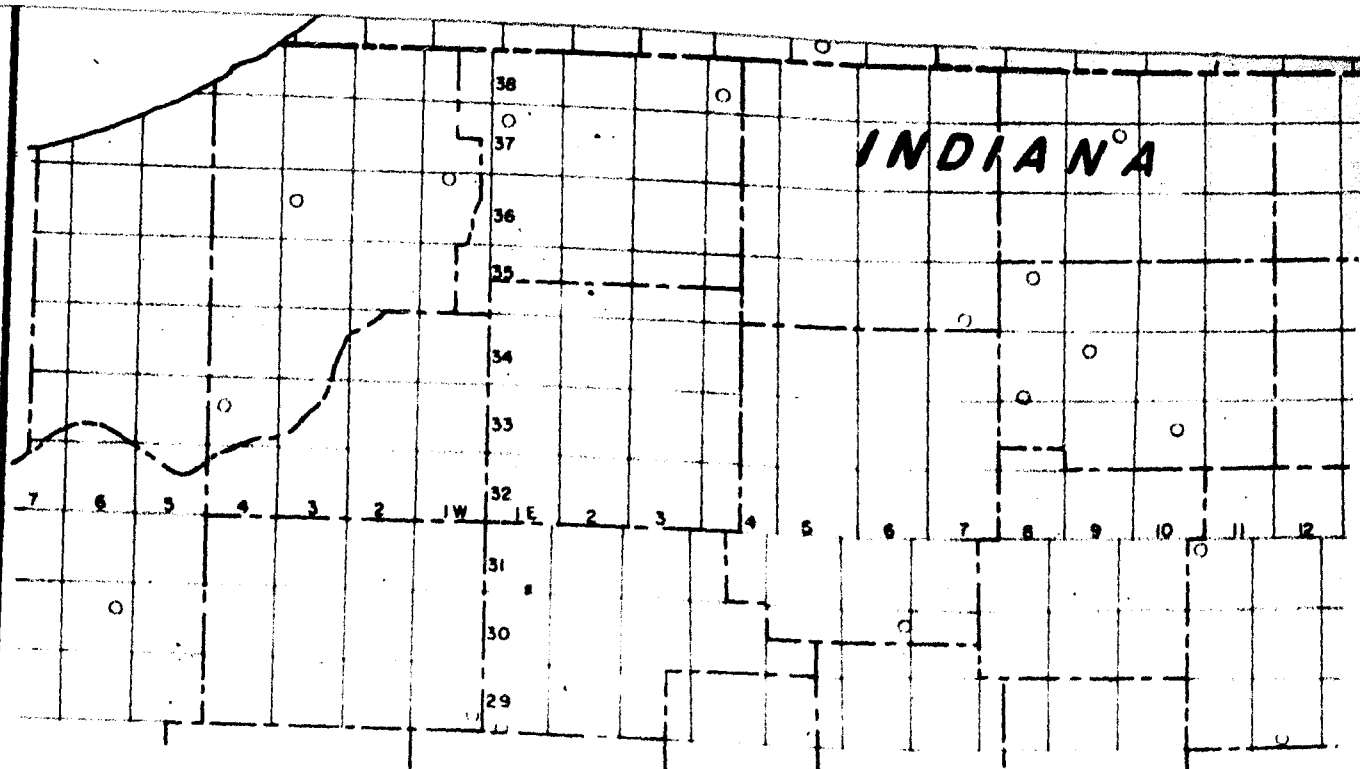
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 INDIANA.....Gutstadt (1958)  
                     Dawson (1960)  
 OHIO.....J.H. Fisher (Unpublished)  
 ILLINOIS.....Buschbach (1964)  
                     Emrich (1966)



### SOURCES OF DATA

- CANADA.....Sanford and Quillian (1959)
- UPPER  
PENINSULA .....Hamblin (1953)
- INDIANA.....Gutstadt (1958)  
Dawson (1960)
- OHIO.....J.H. Fisher (Unpublished)
- ILLINOIS.....Buschbach (1964)  
Emrich (1966)



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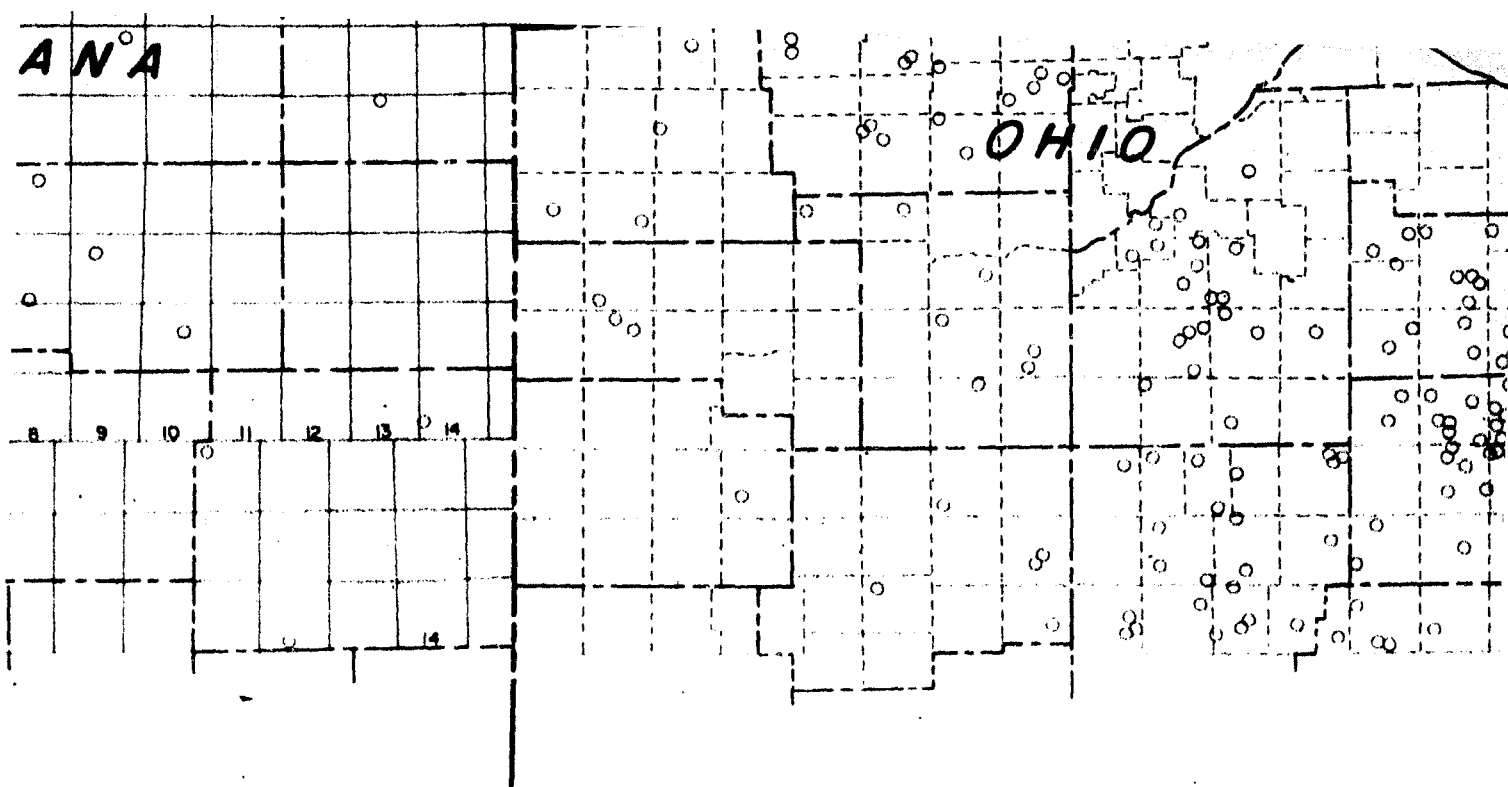
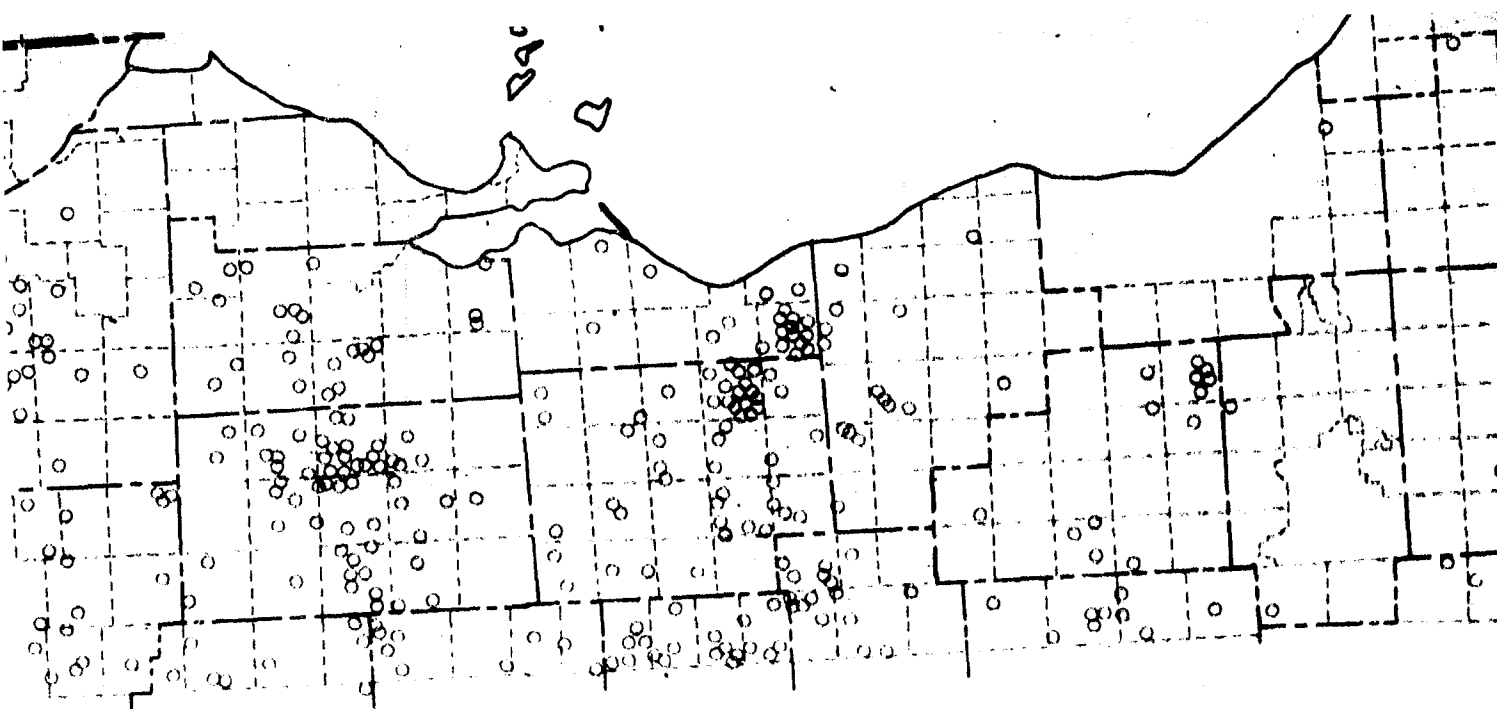


PLATE I

WELL DATA LOCATION MAP



### SOURCES OF DATA

CANADA.....Sanford and Quillian (1959)

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PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
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OHIO.....J.H. Fisher (Unpublished)

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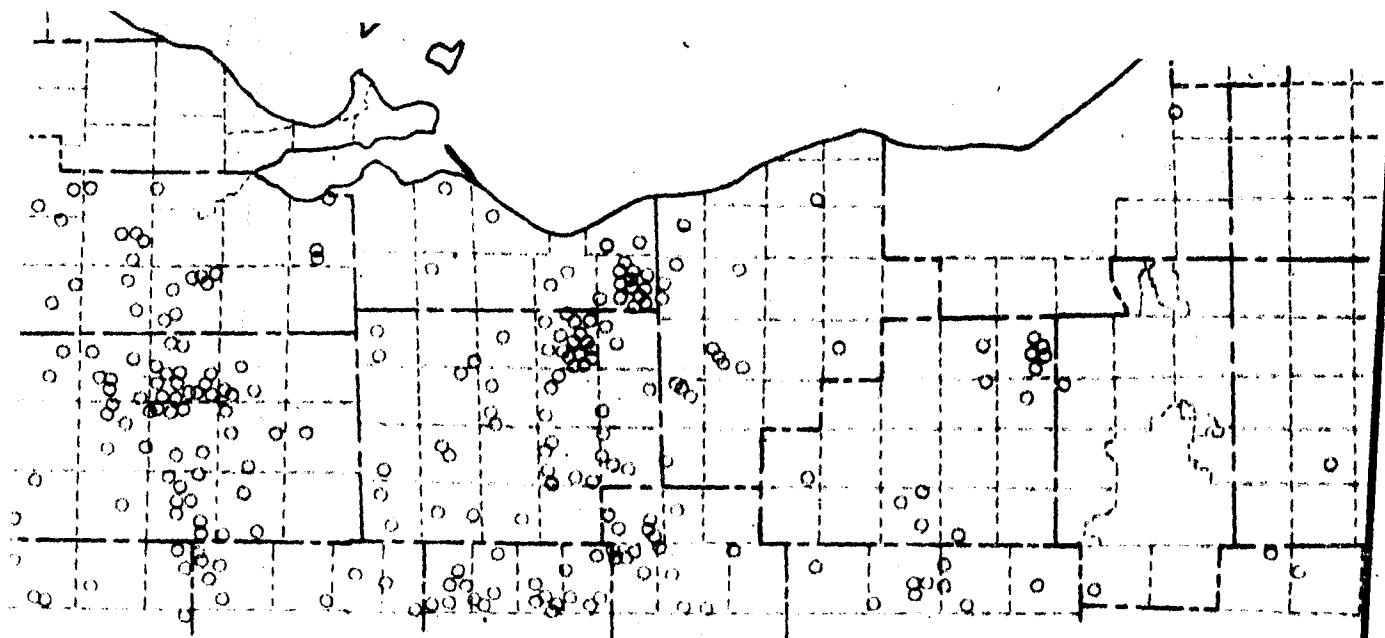
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### SOURCES OF DATA

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 INDIANA.....Gutstadt (1958)  
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 OHIO.....J.H. Fisher (Unpublished)  
 ILLINOIS.....Buschbach (1964)  
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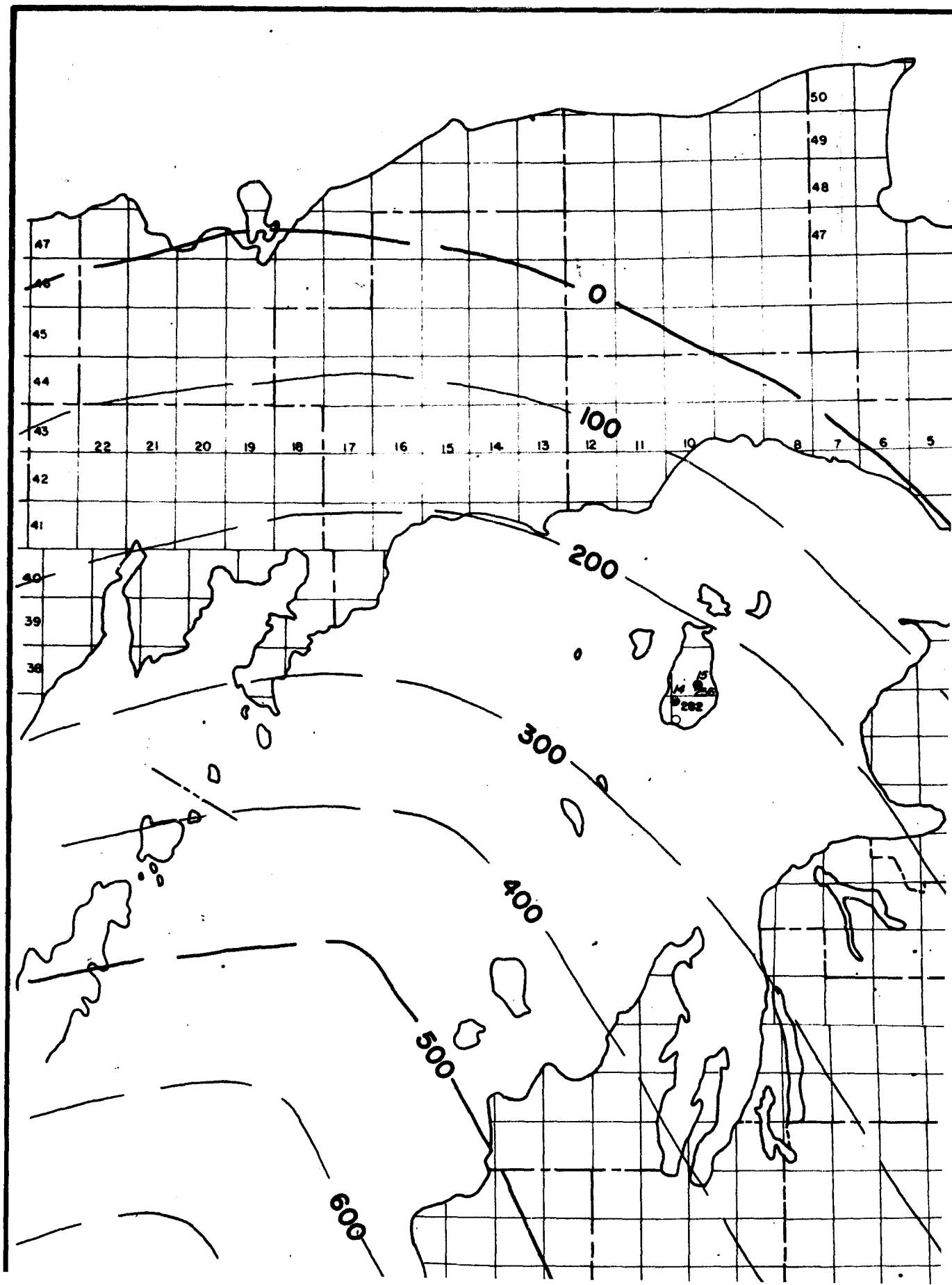
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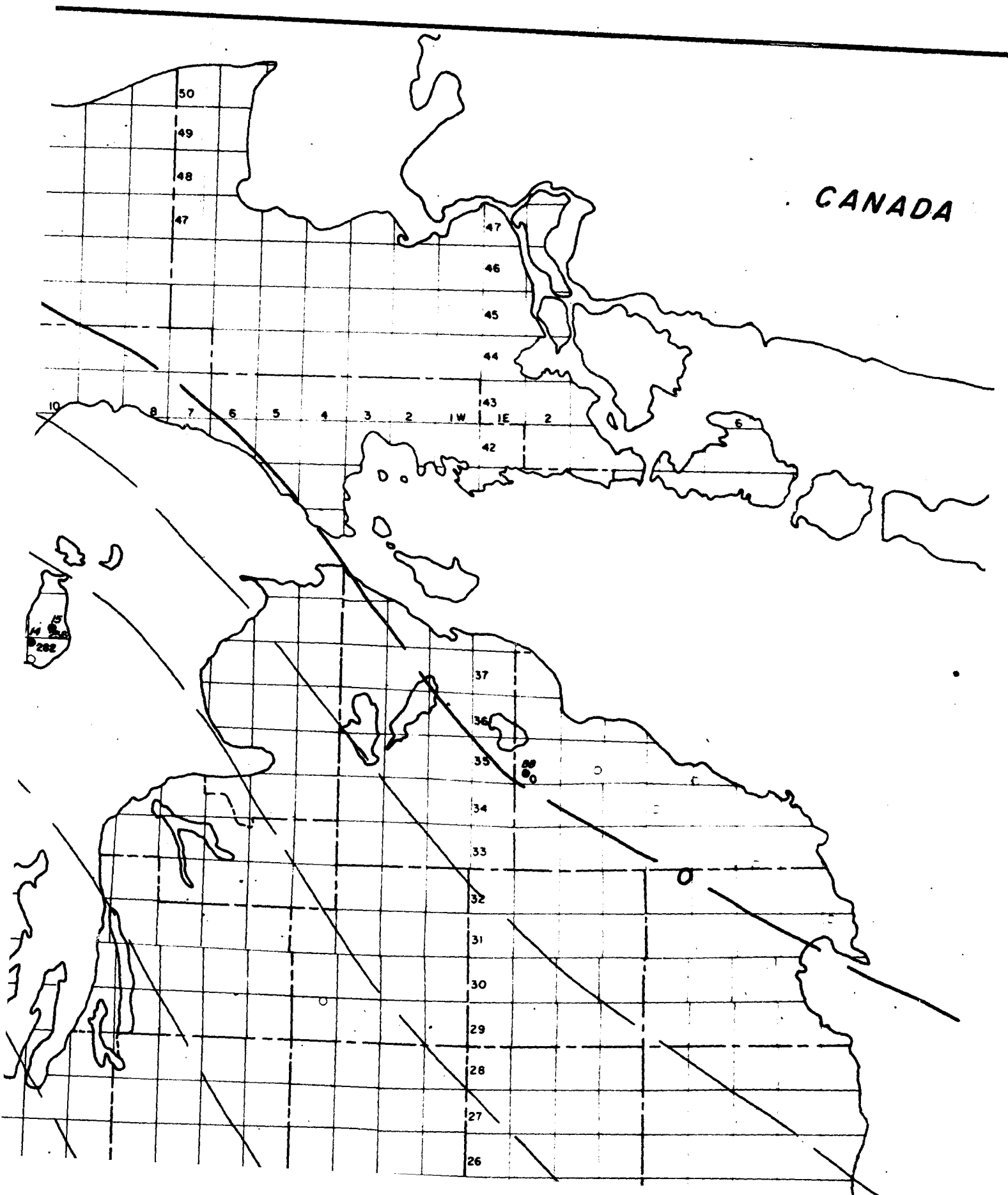


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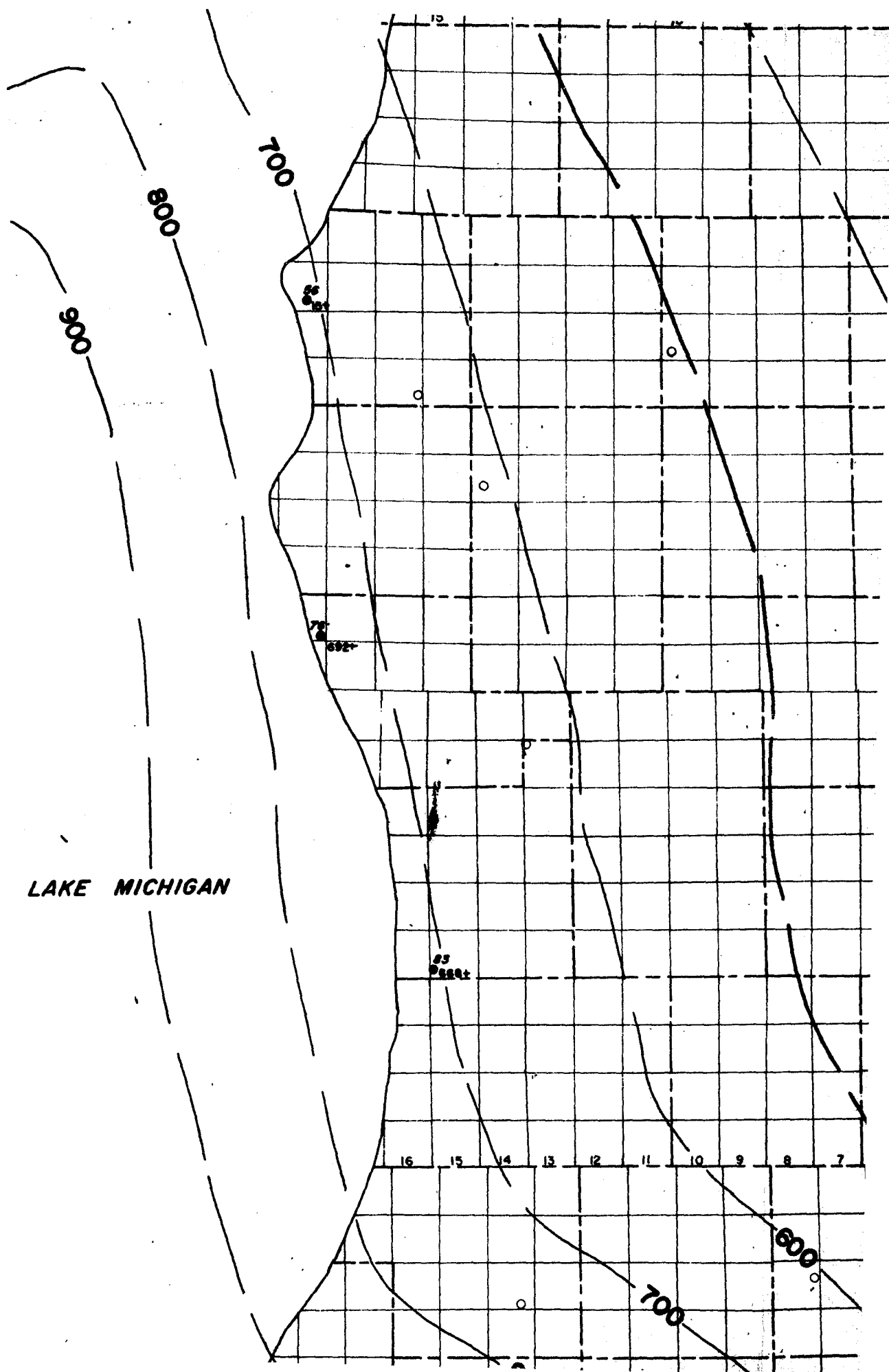
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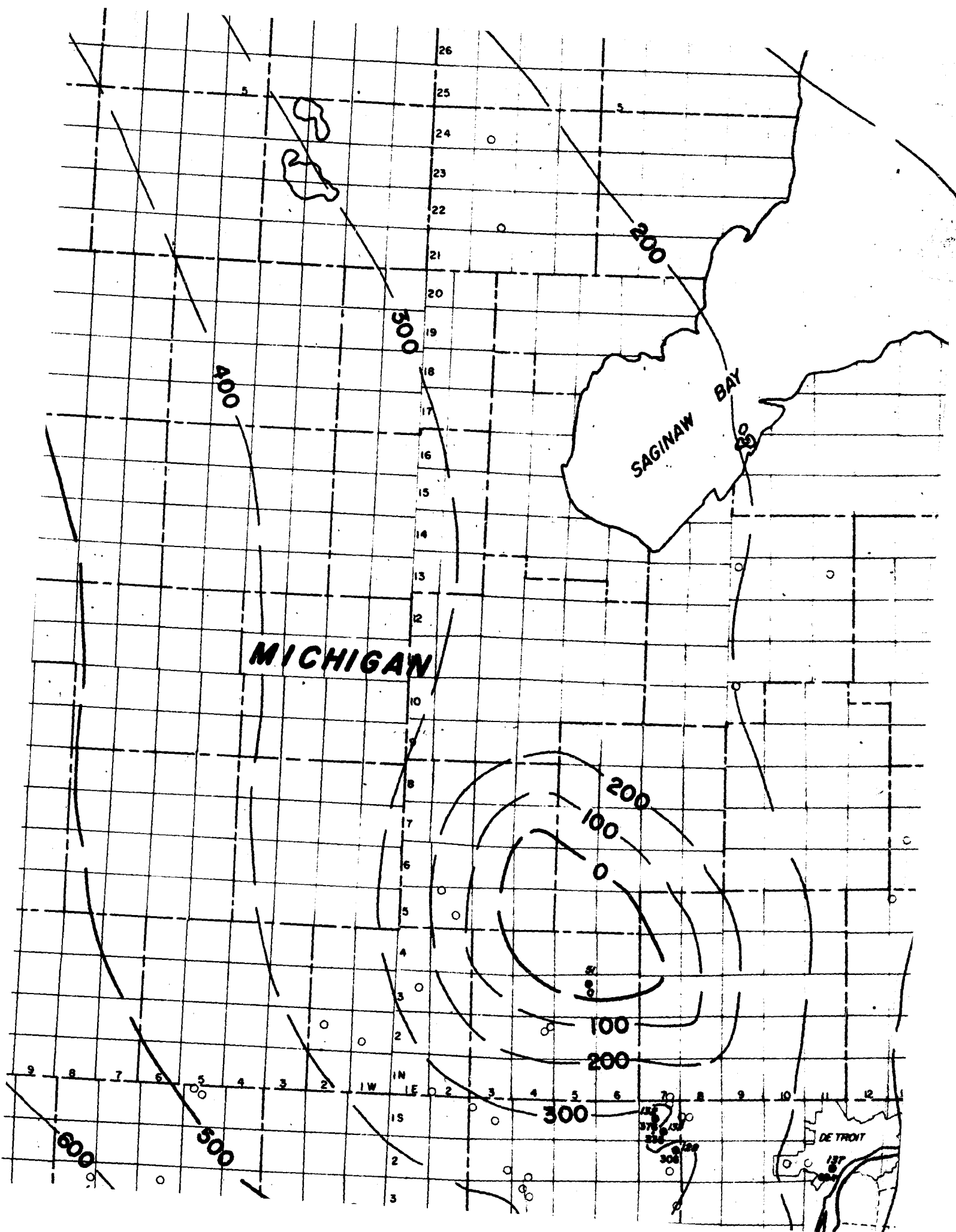


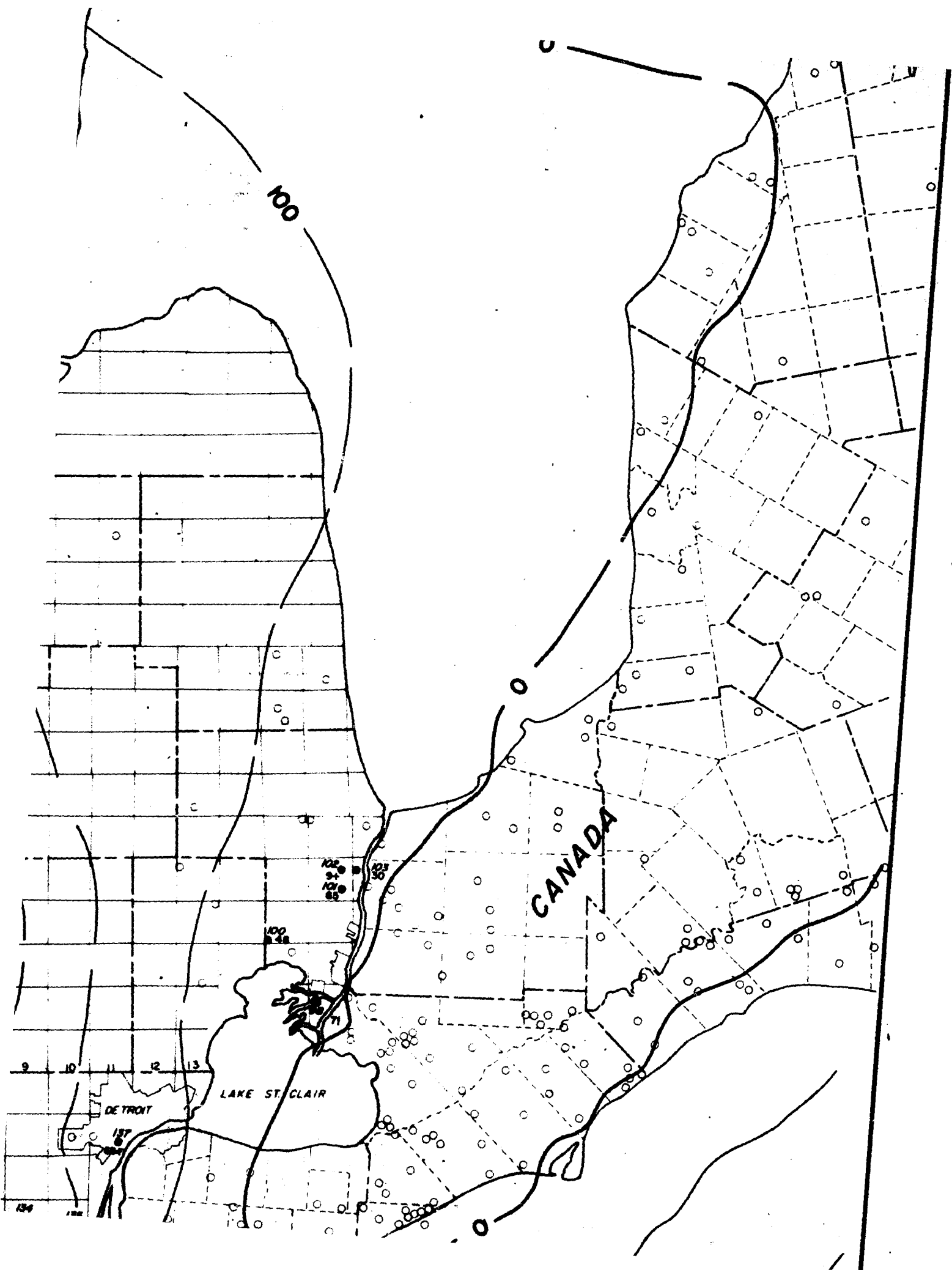
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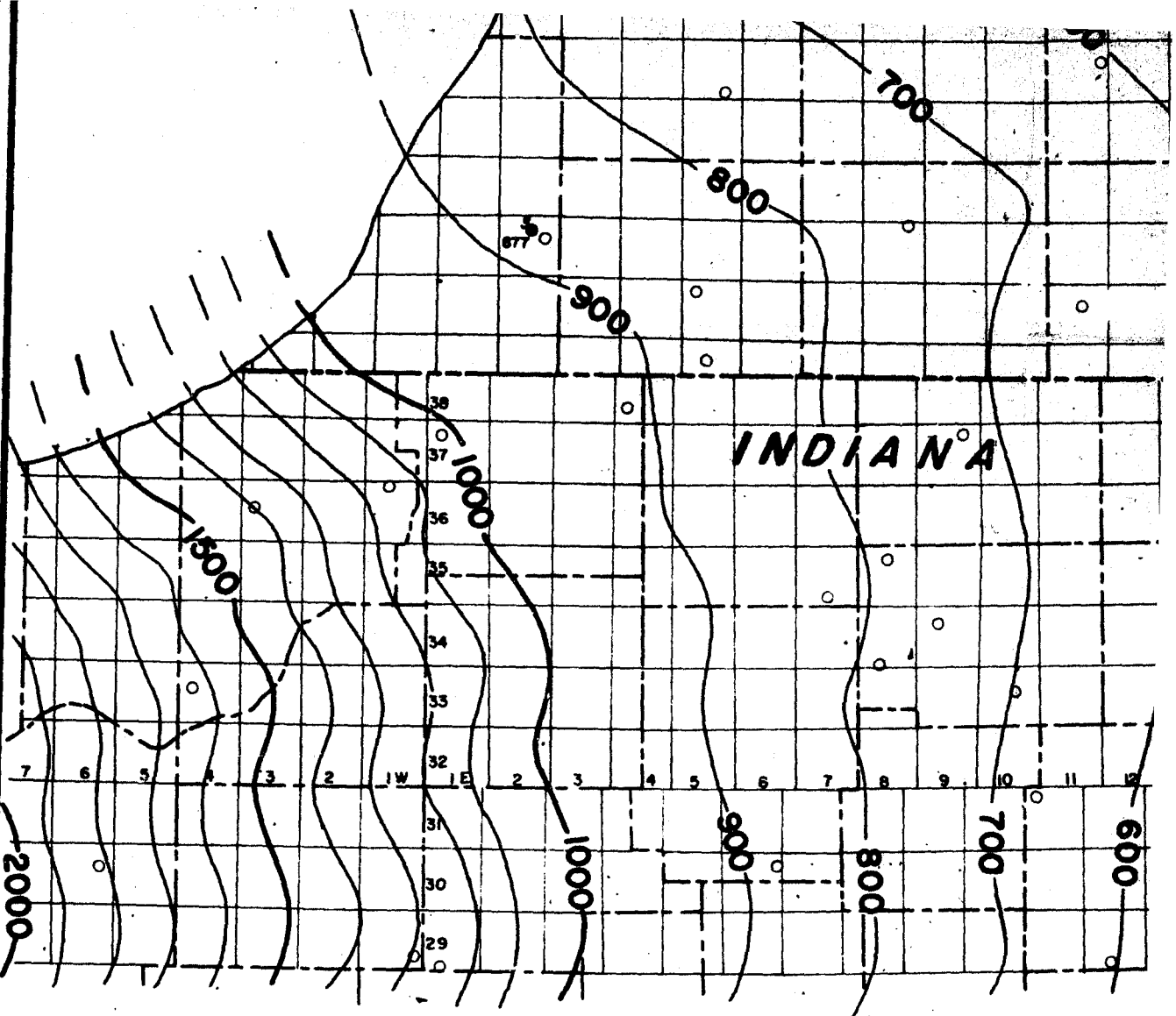
LAKE MICHIGAN











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1972

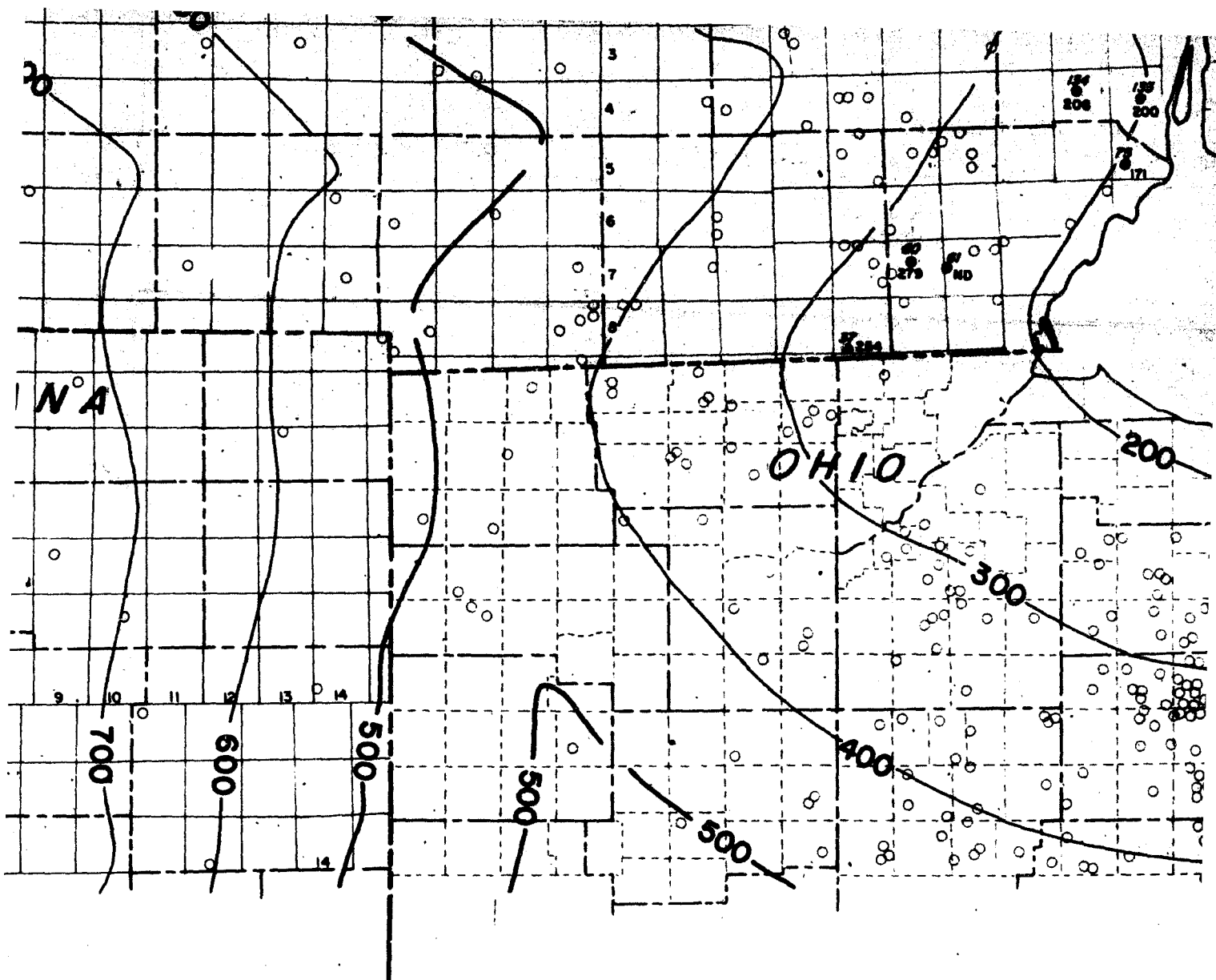
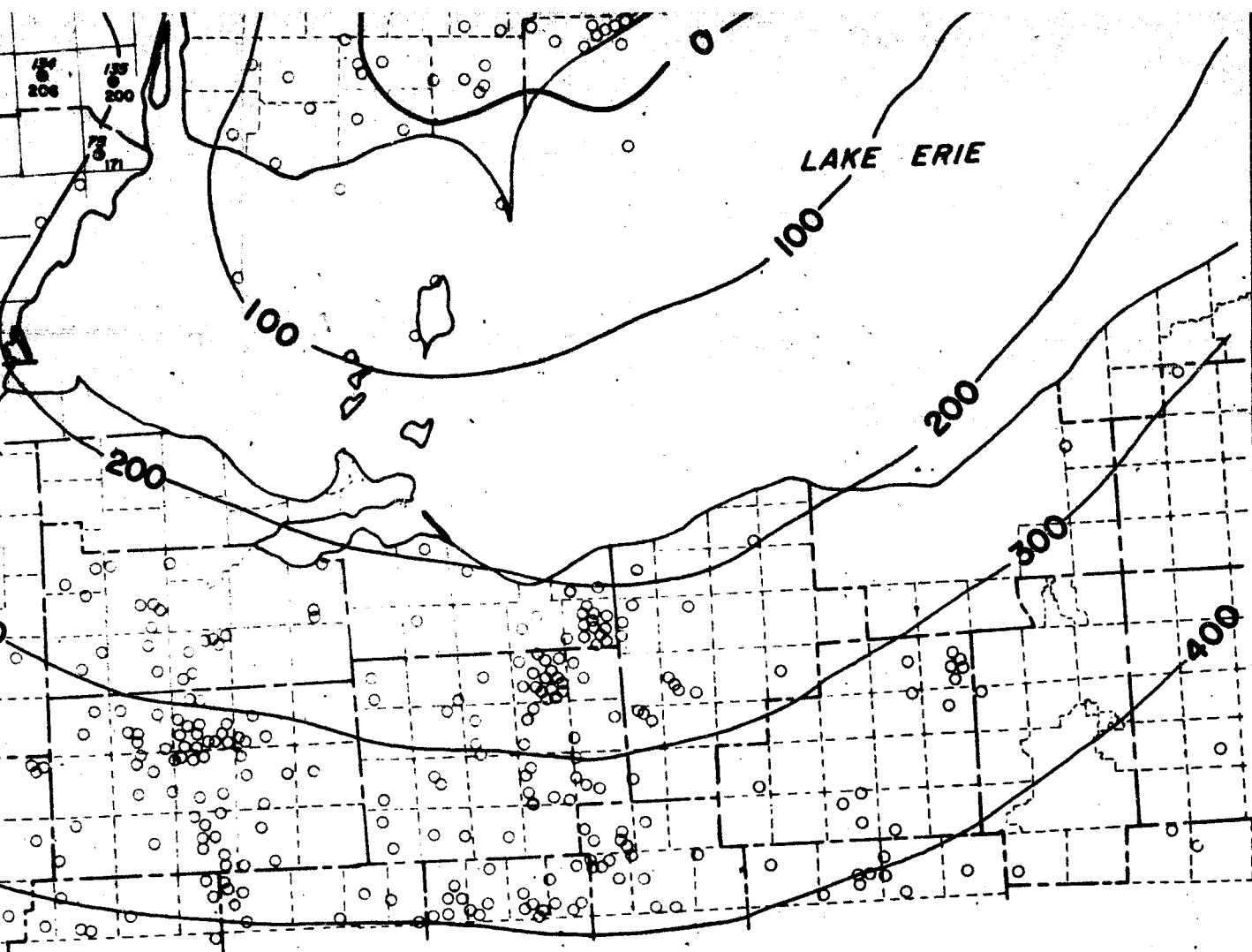


PLATE 2

ISOPACH MAP OF THE  
MT. SIMON SANDSTONE



### SOURCES OF DATA

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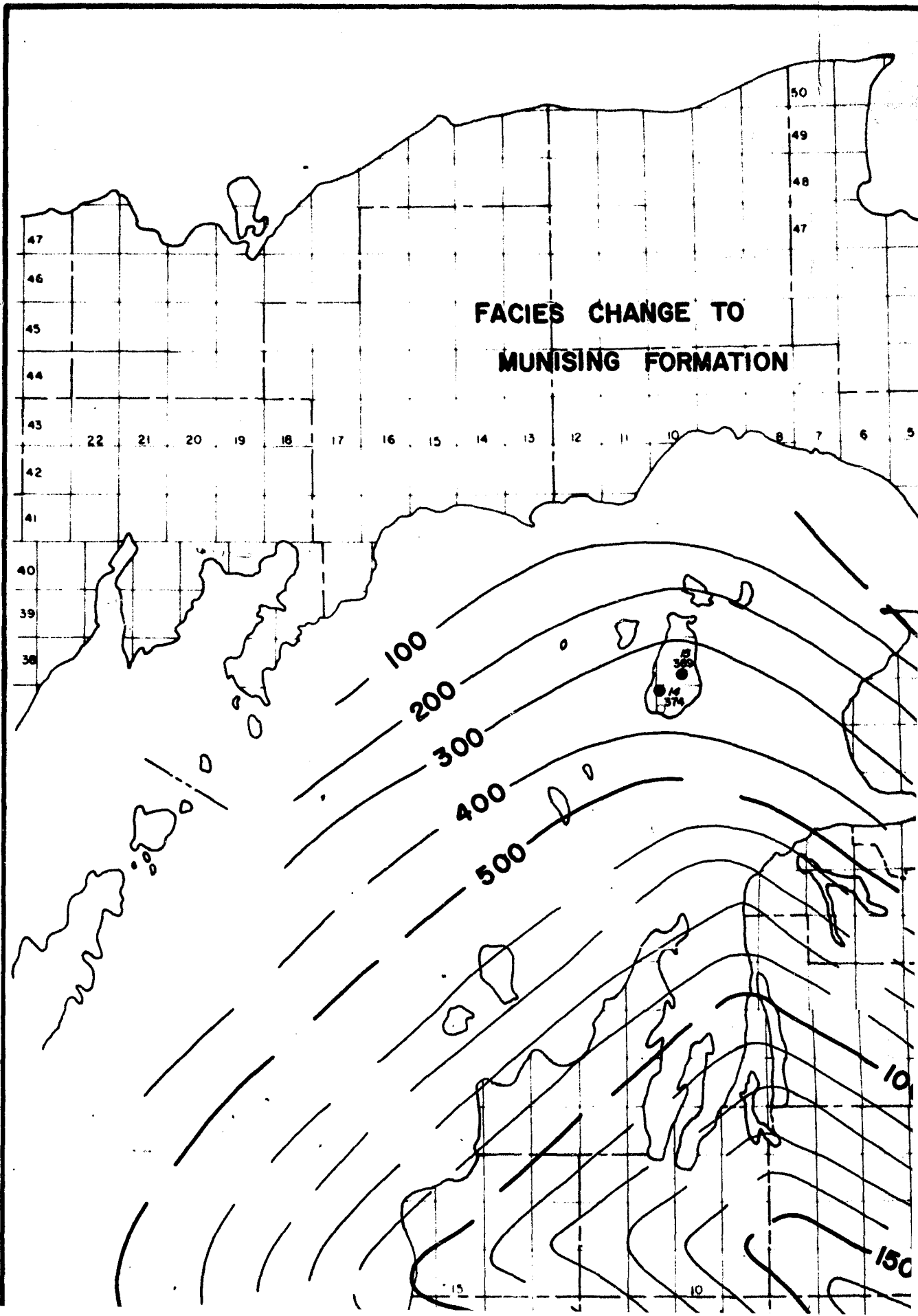
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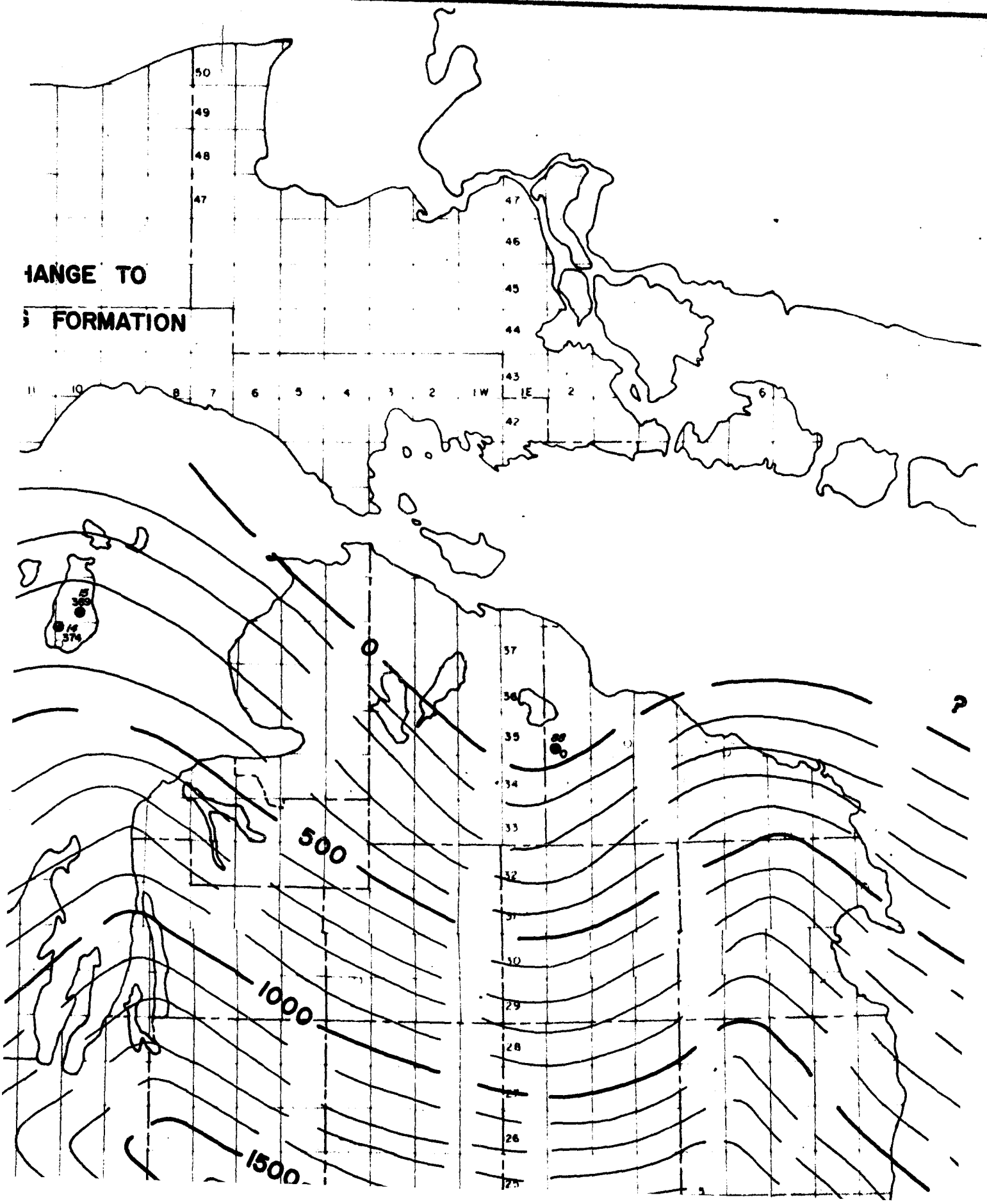
OHIO.....J.H.Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
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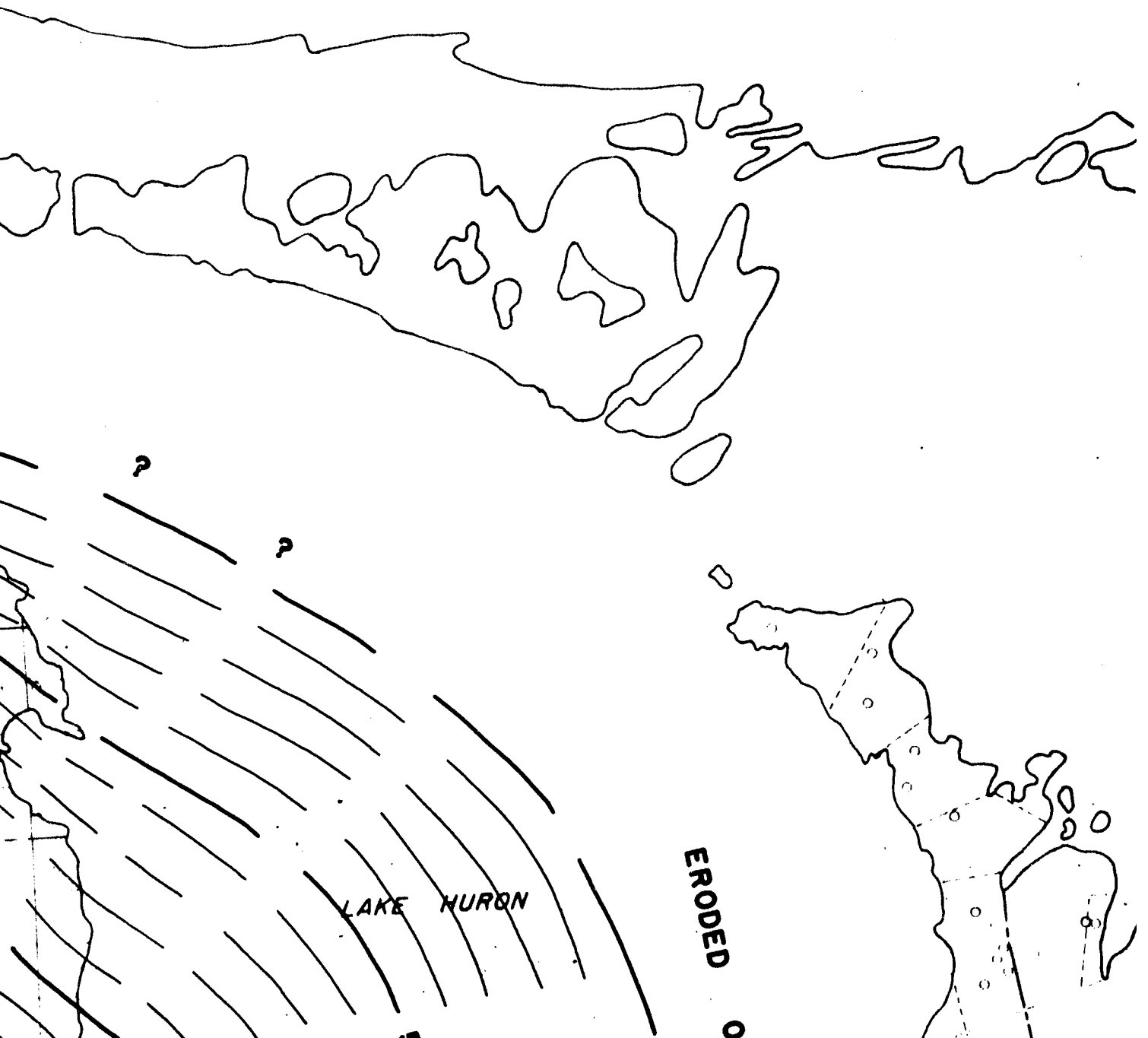
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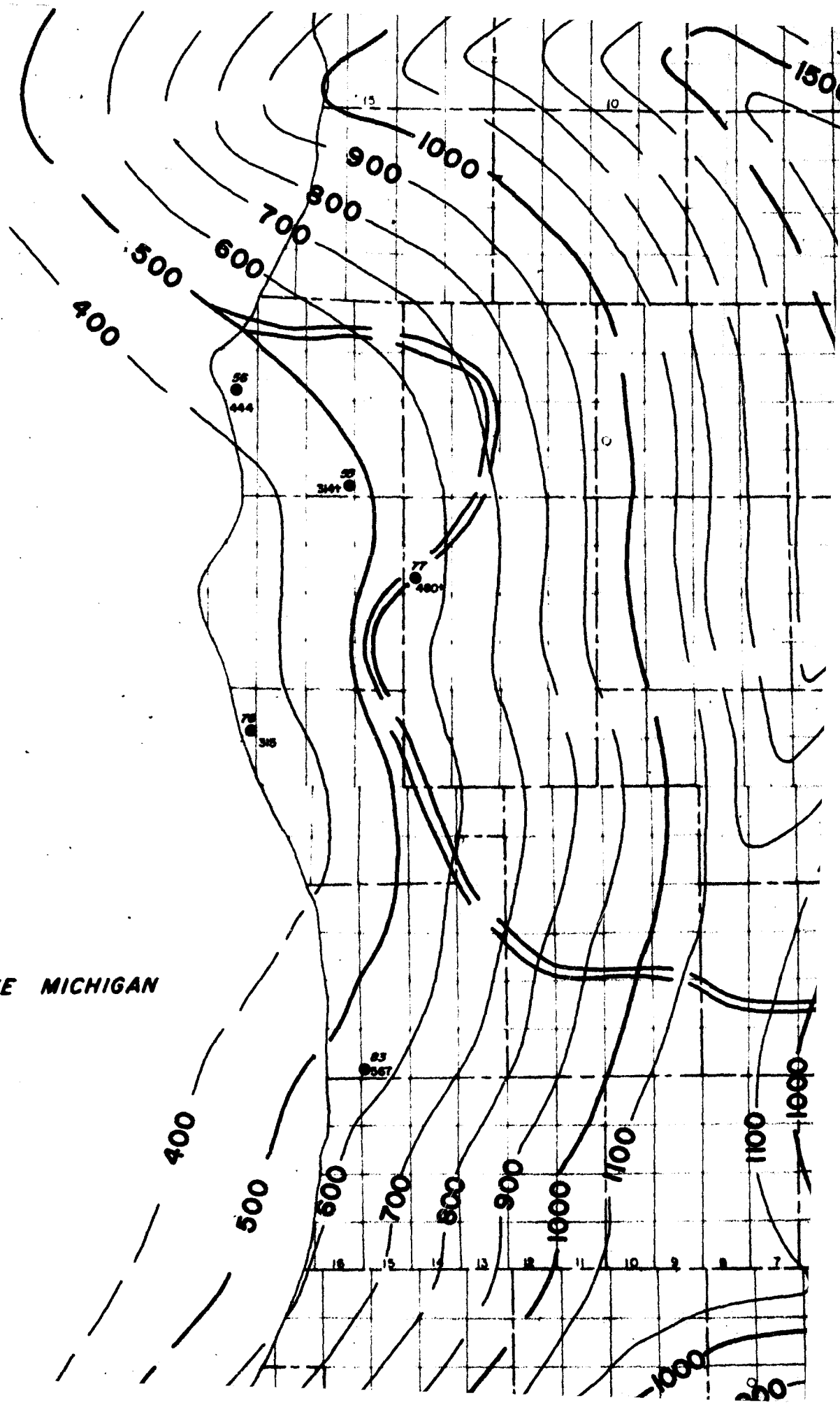
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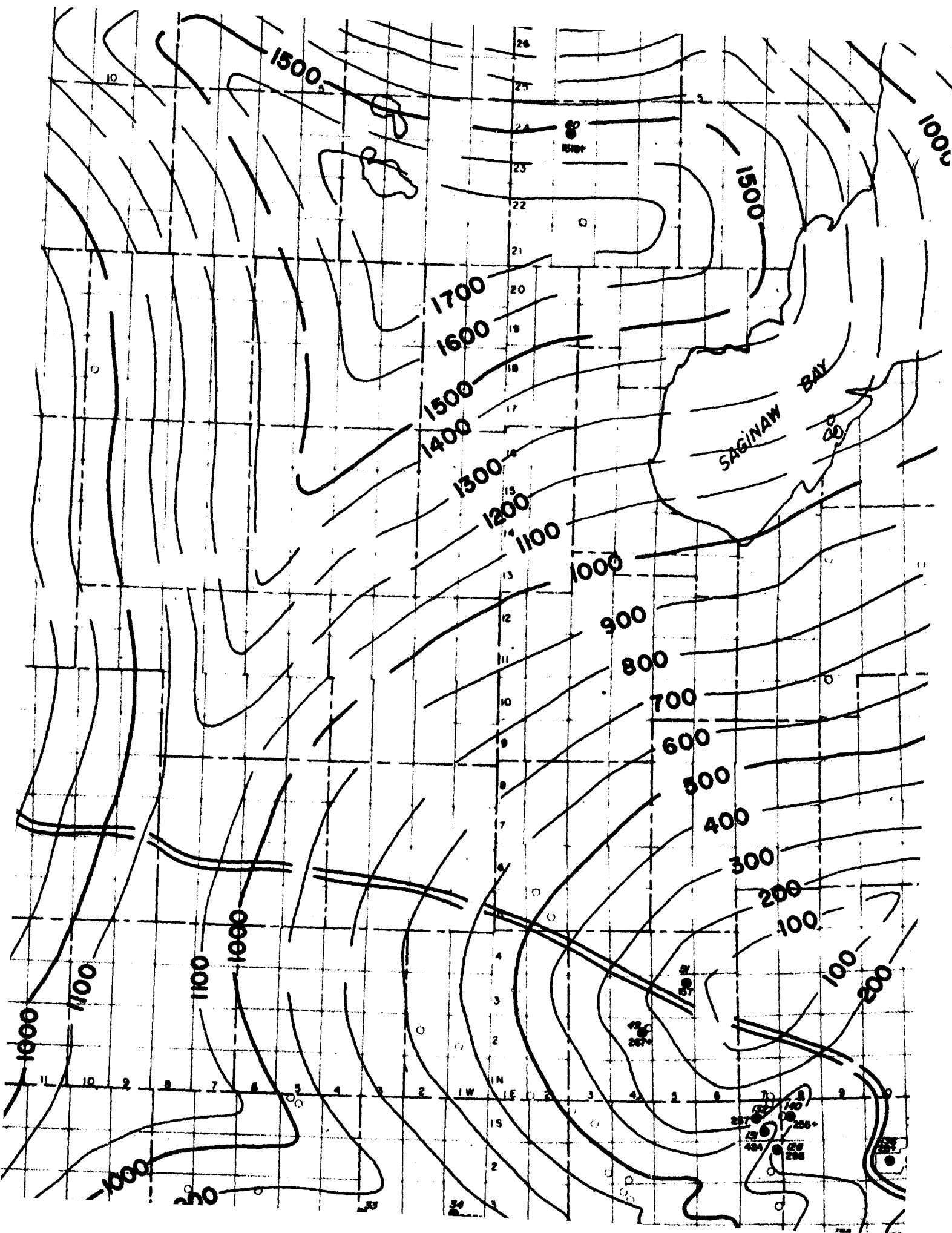


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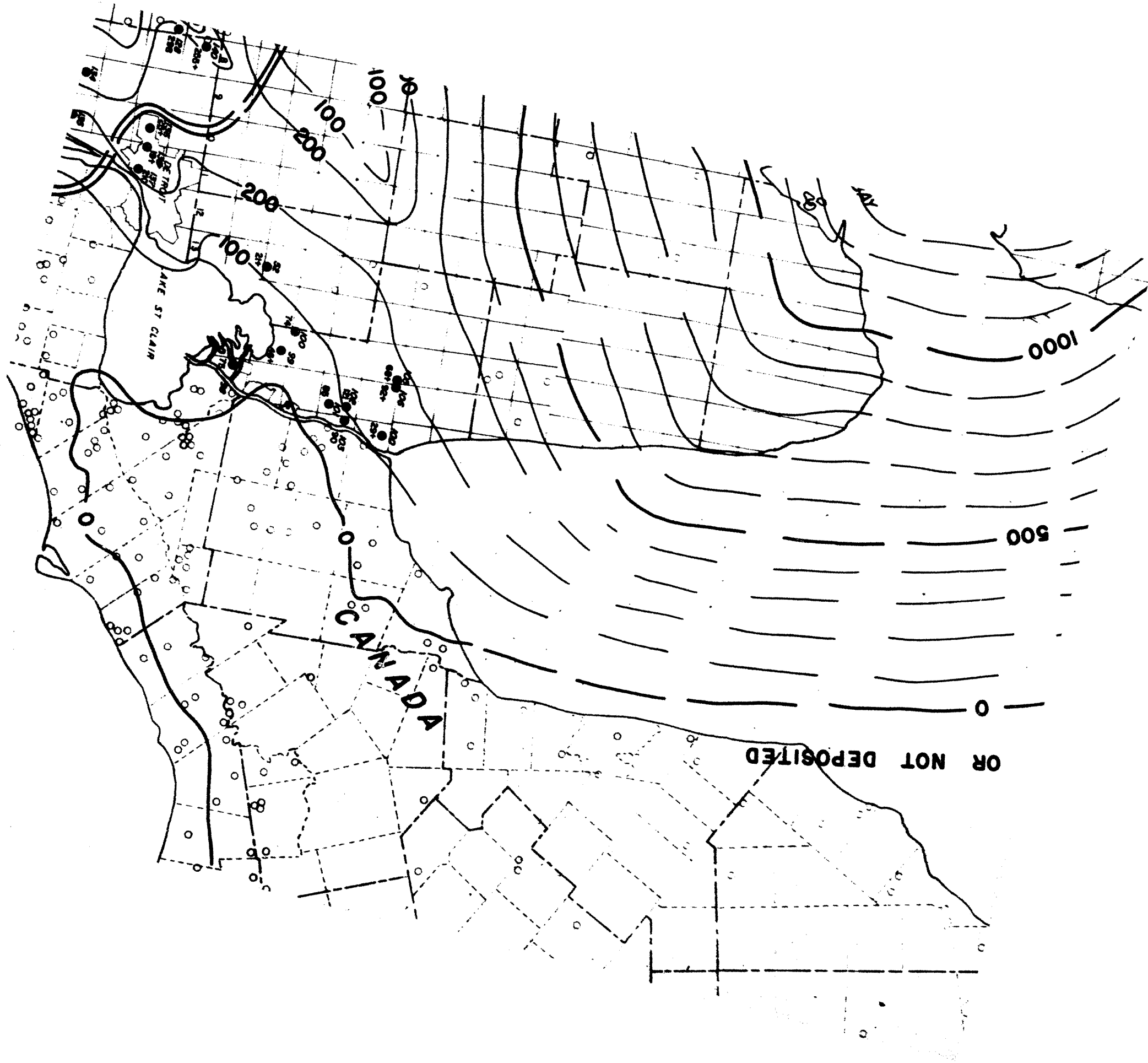


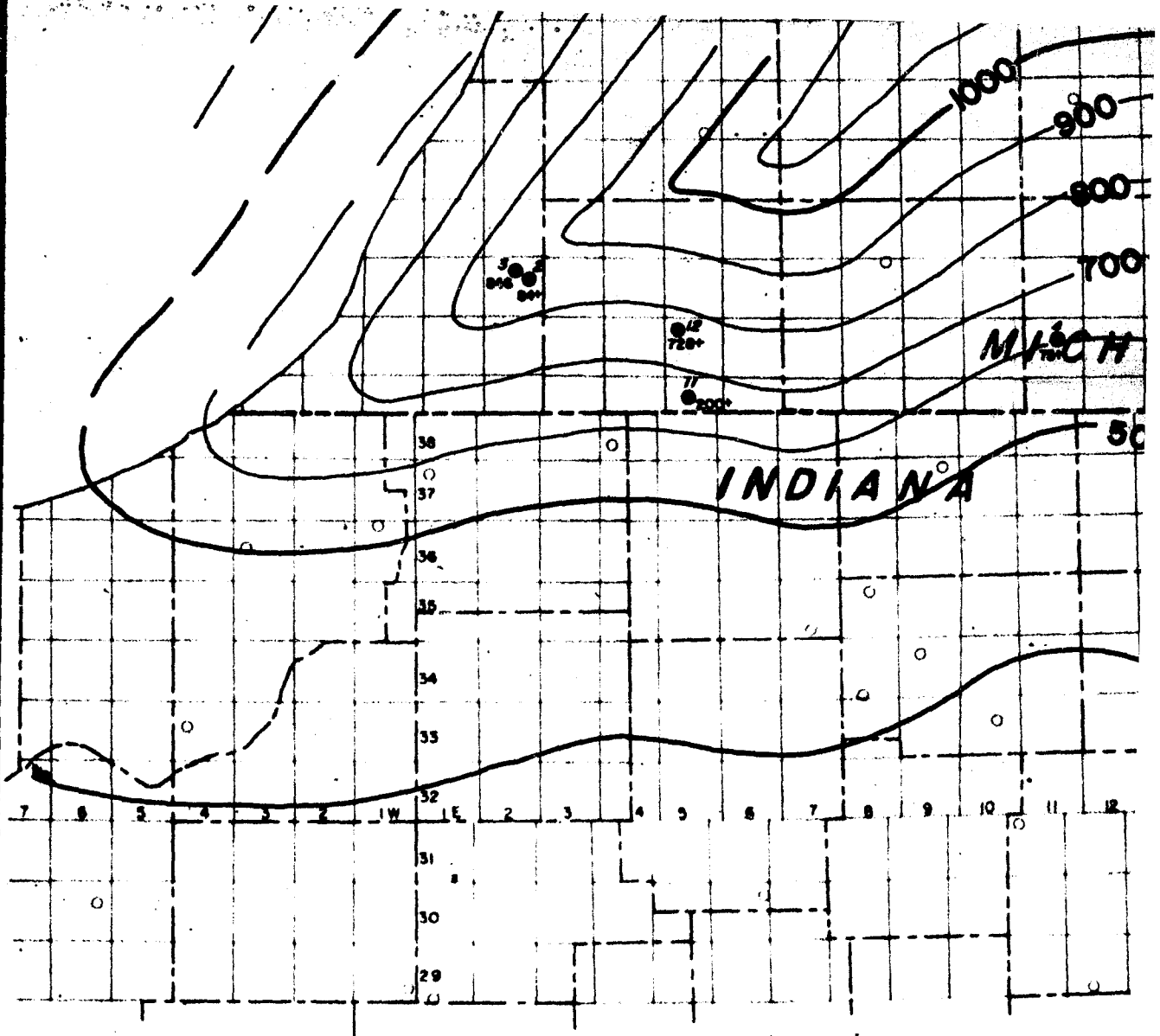
LAKE MICHIGAN











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1972

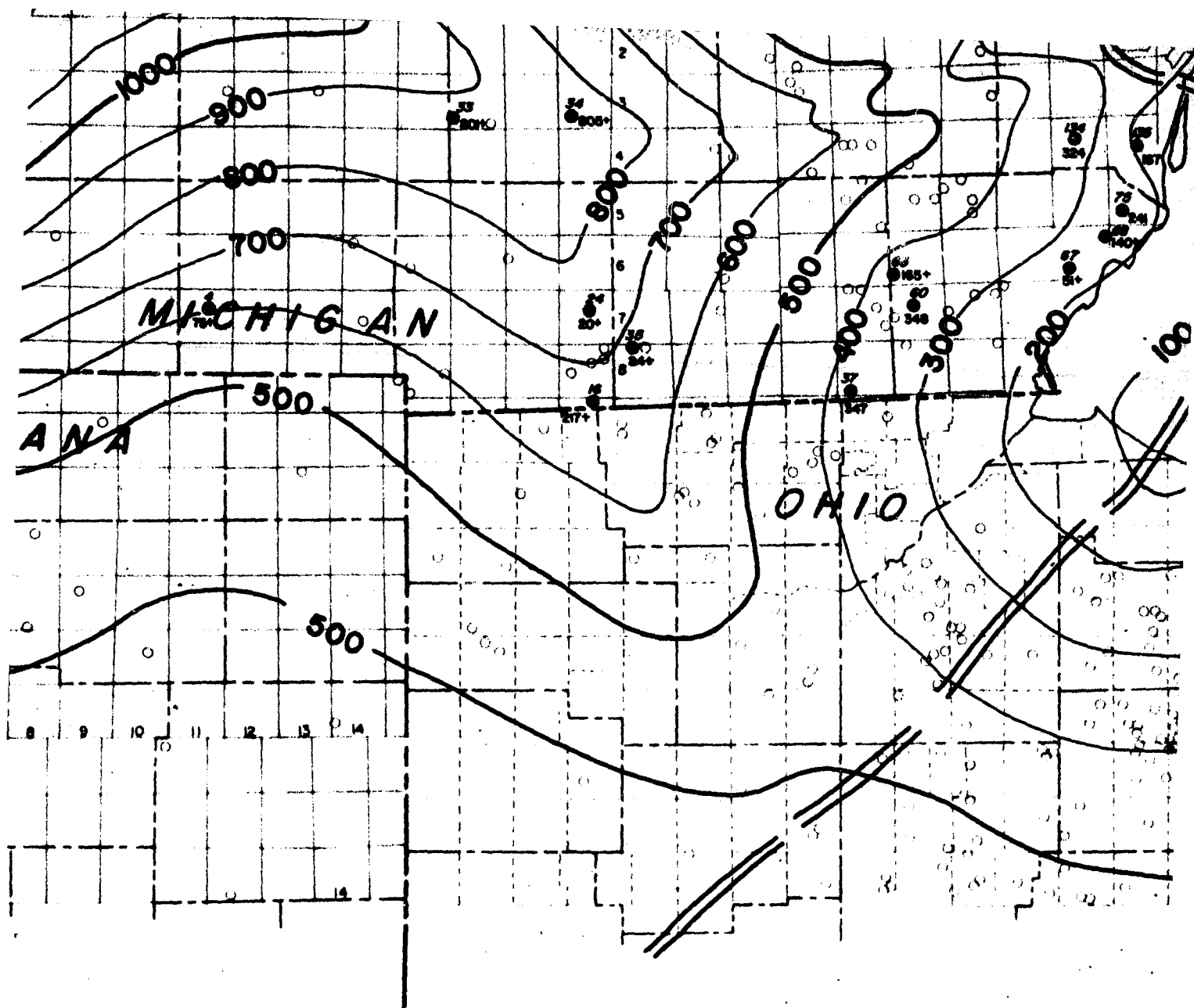
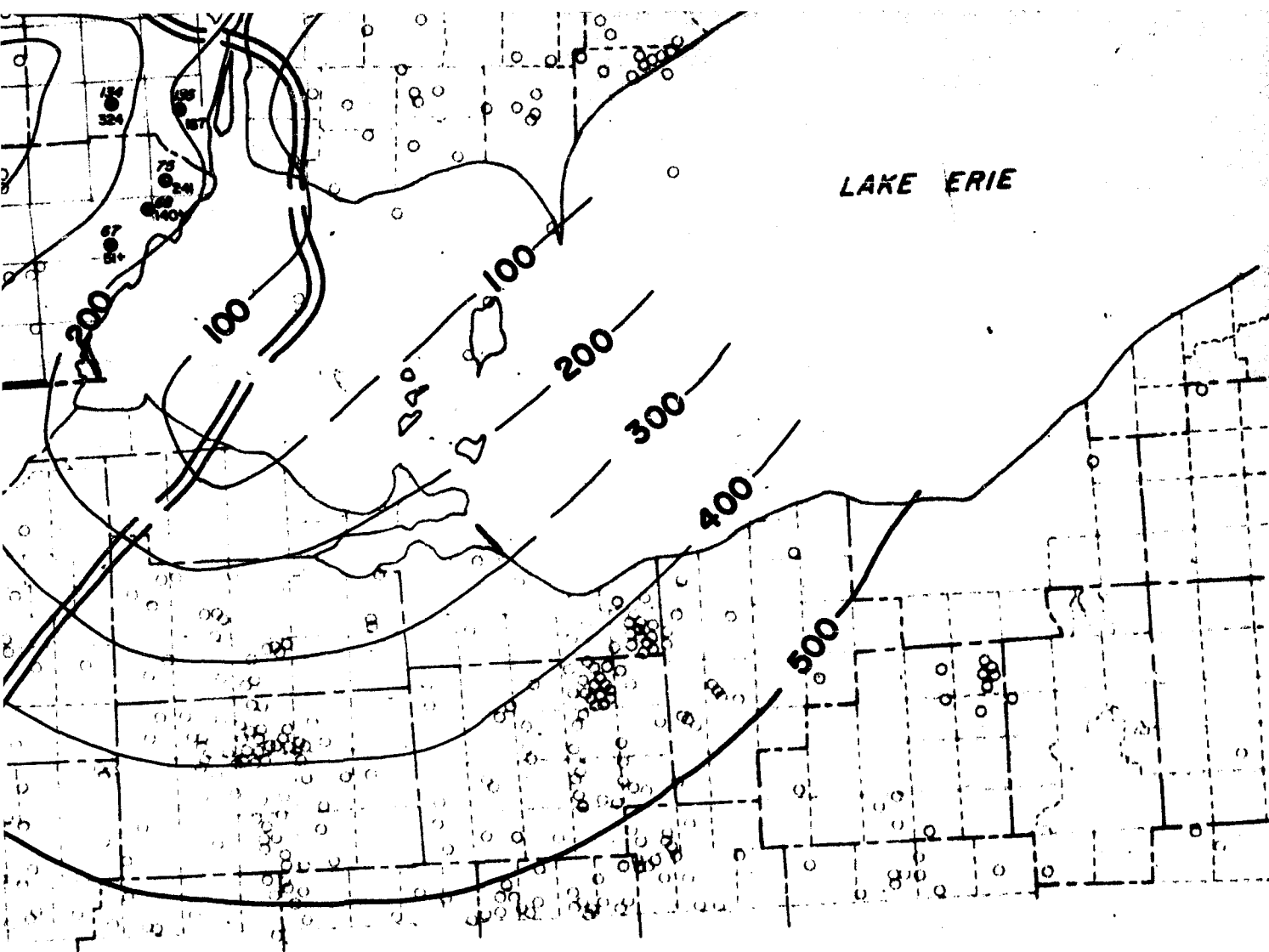


PLATE 3'

ISOPACH MAP OF THE  
MUNISING GROUP



LAKE ERIE

### SOURCES OF DATA

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PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

OHIO.....J.H. Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
Emrich (1966)

**Edge of Galesville Sandstone**



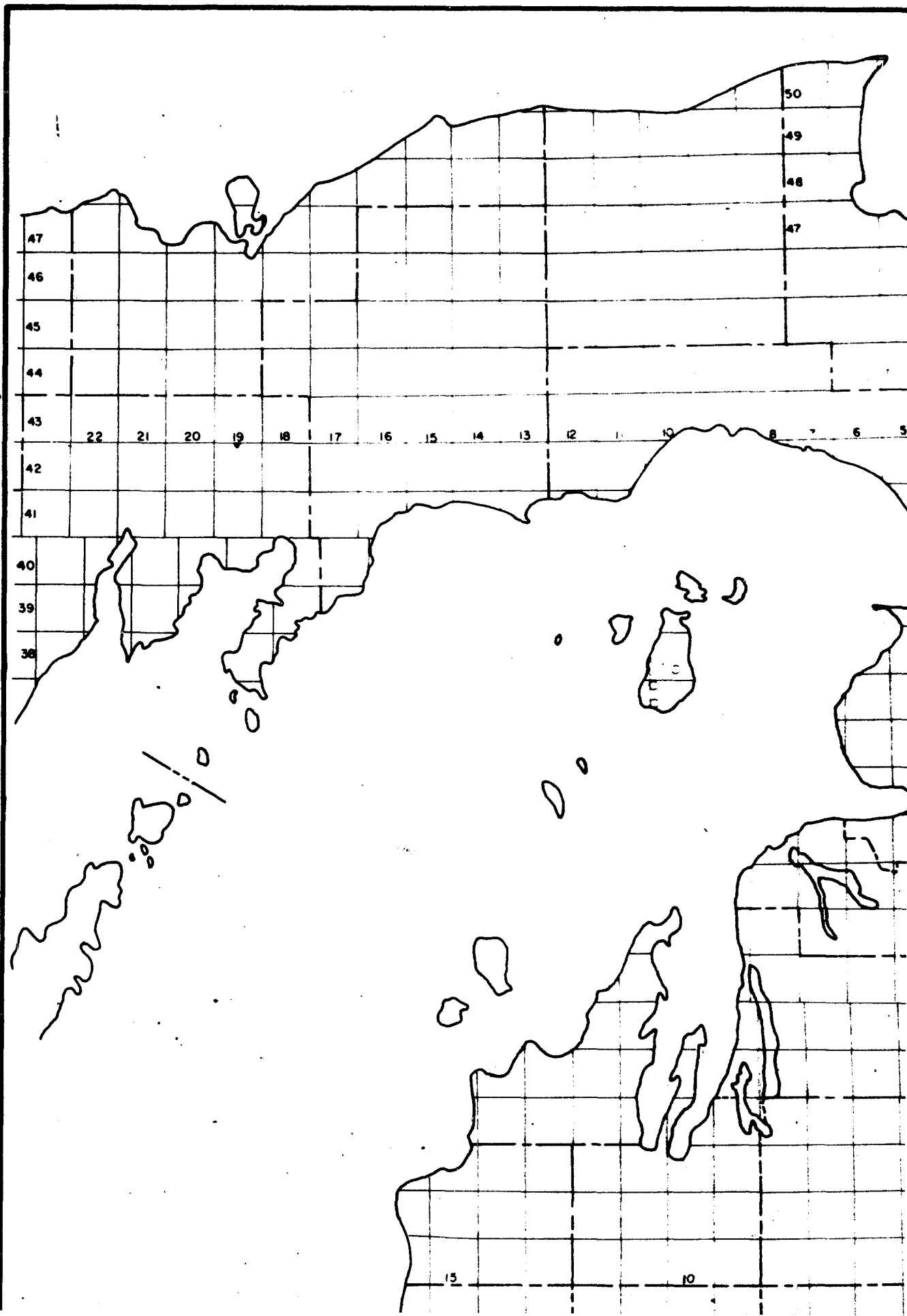
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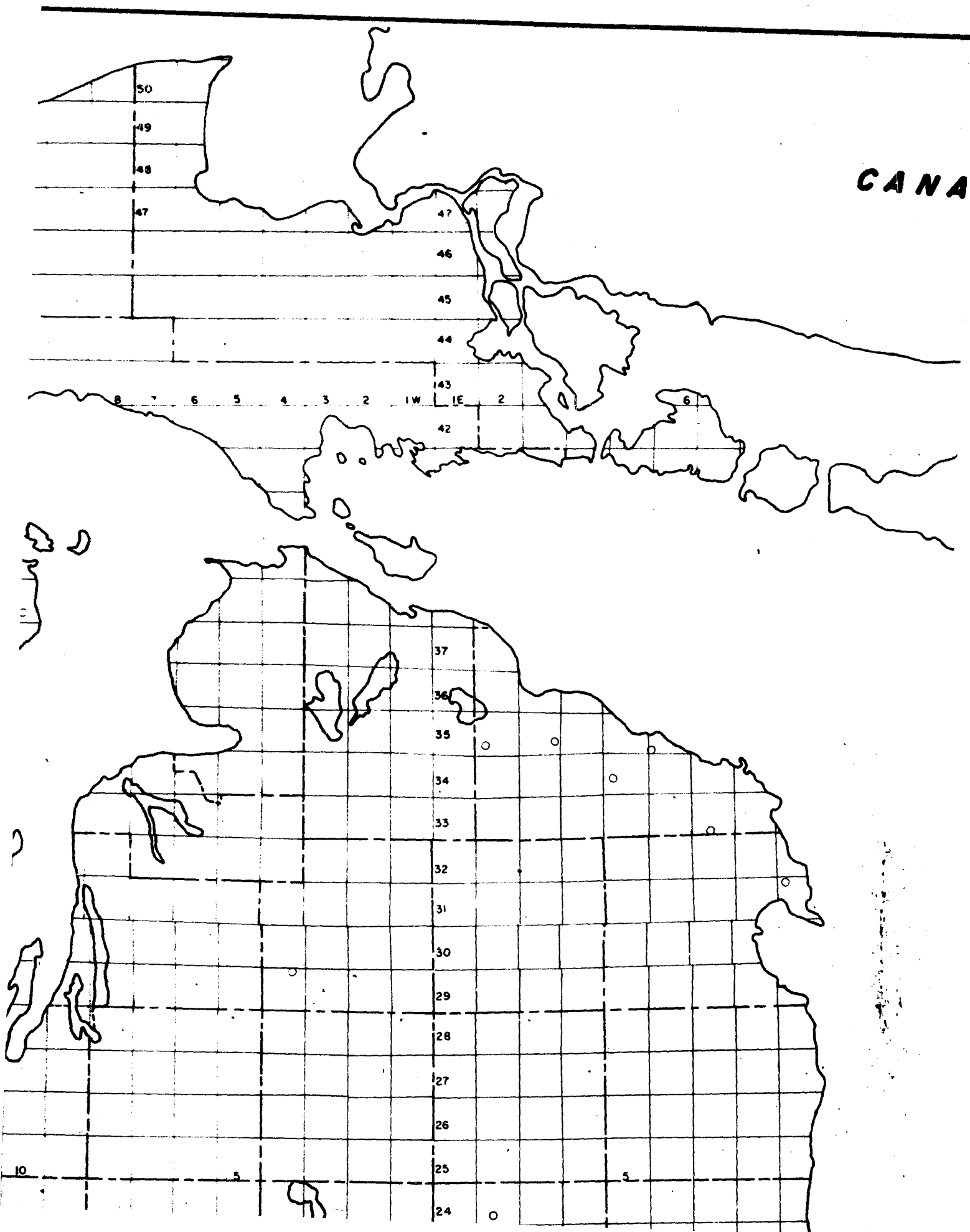
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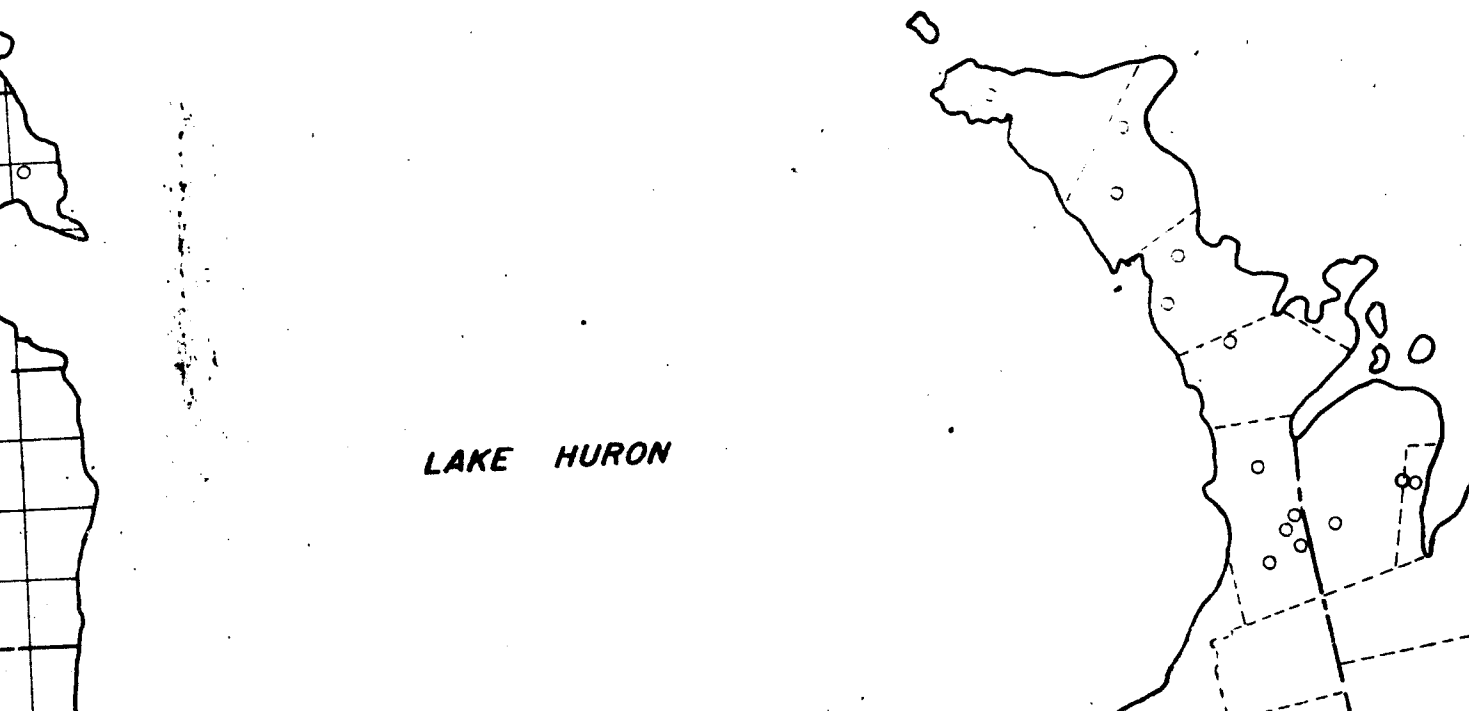


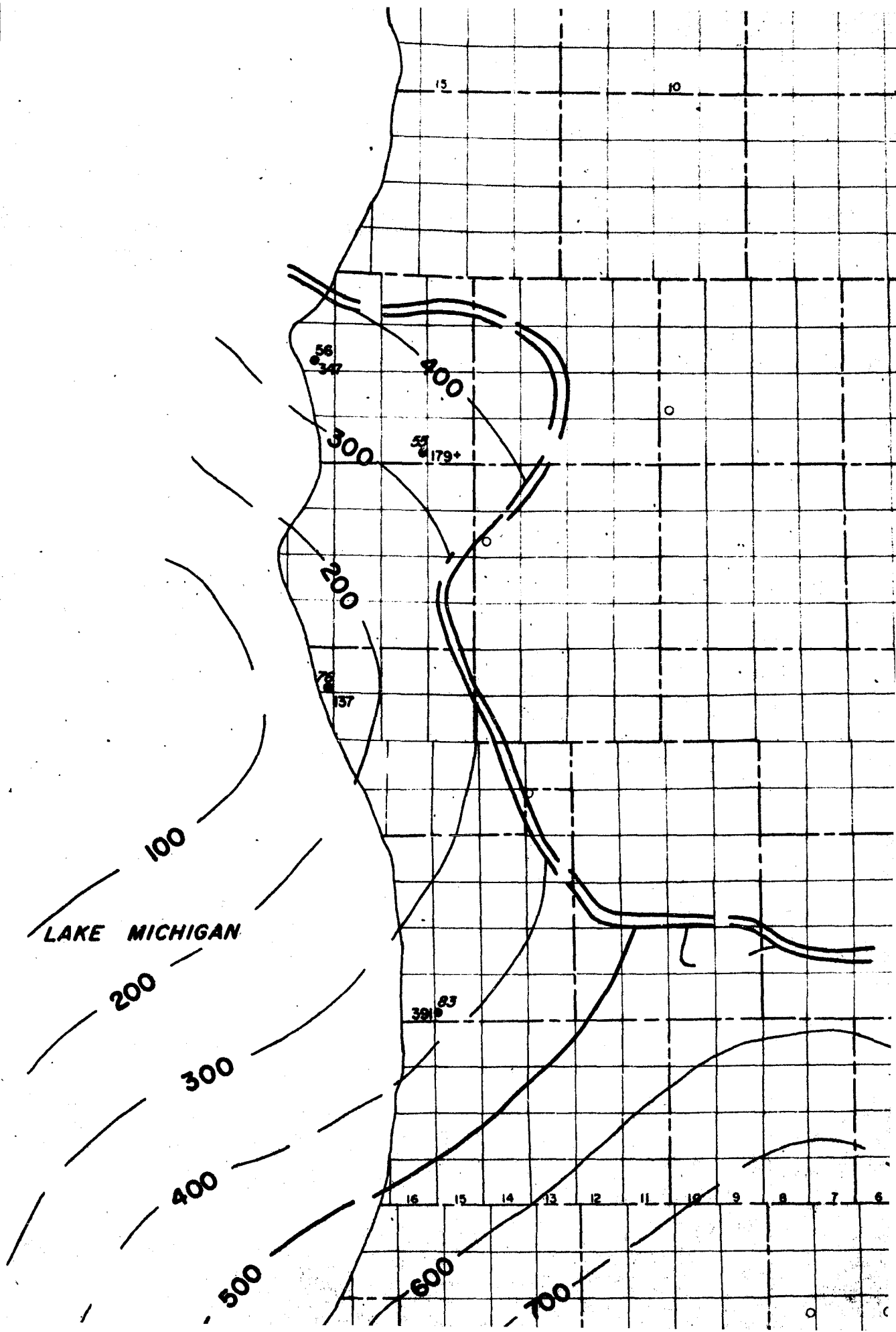


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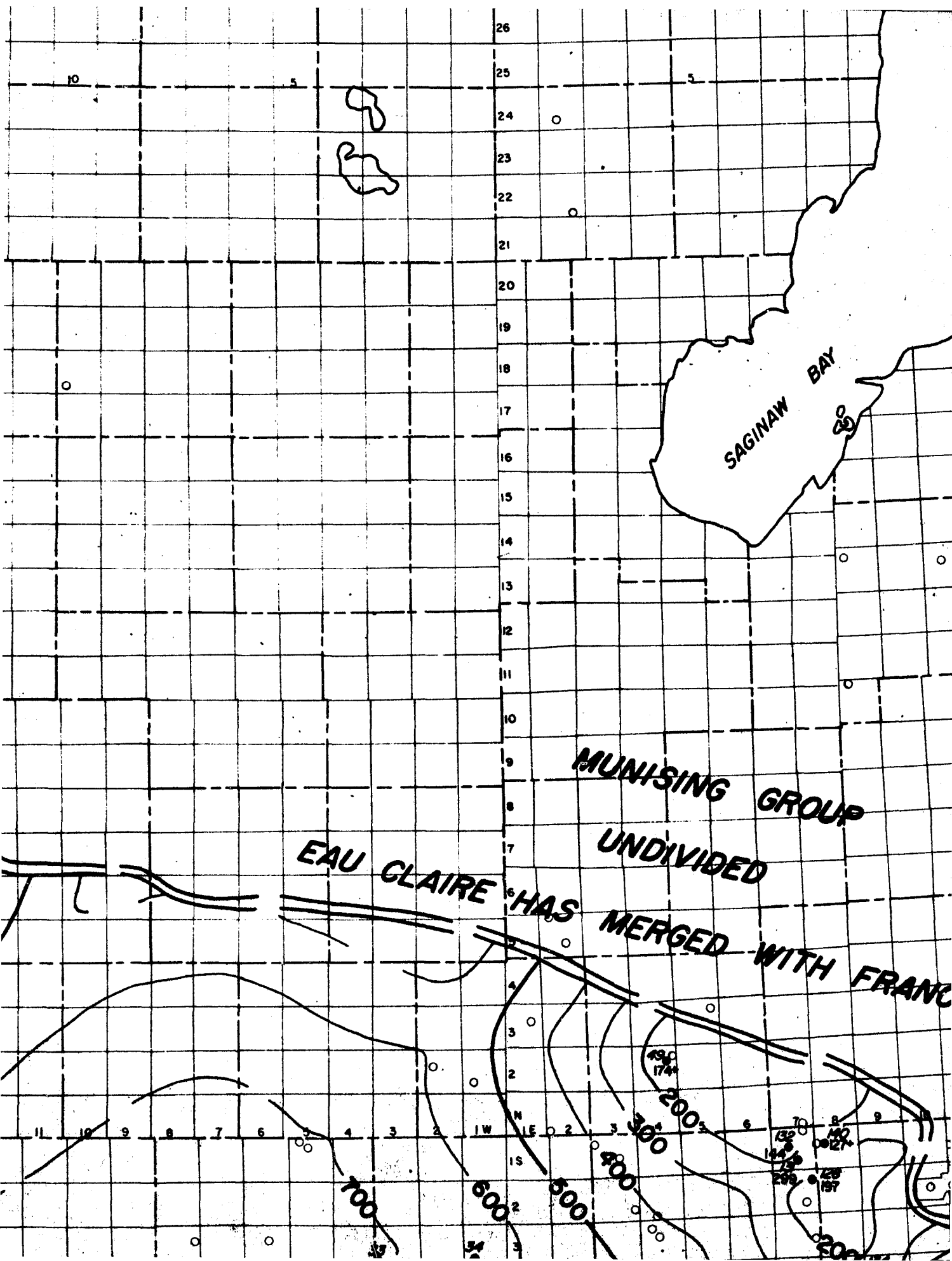


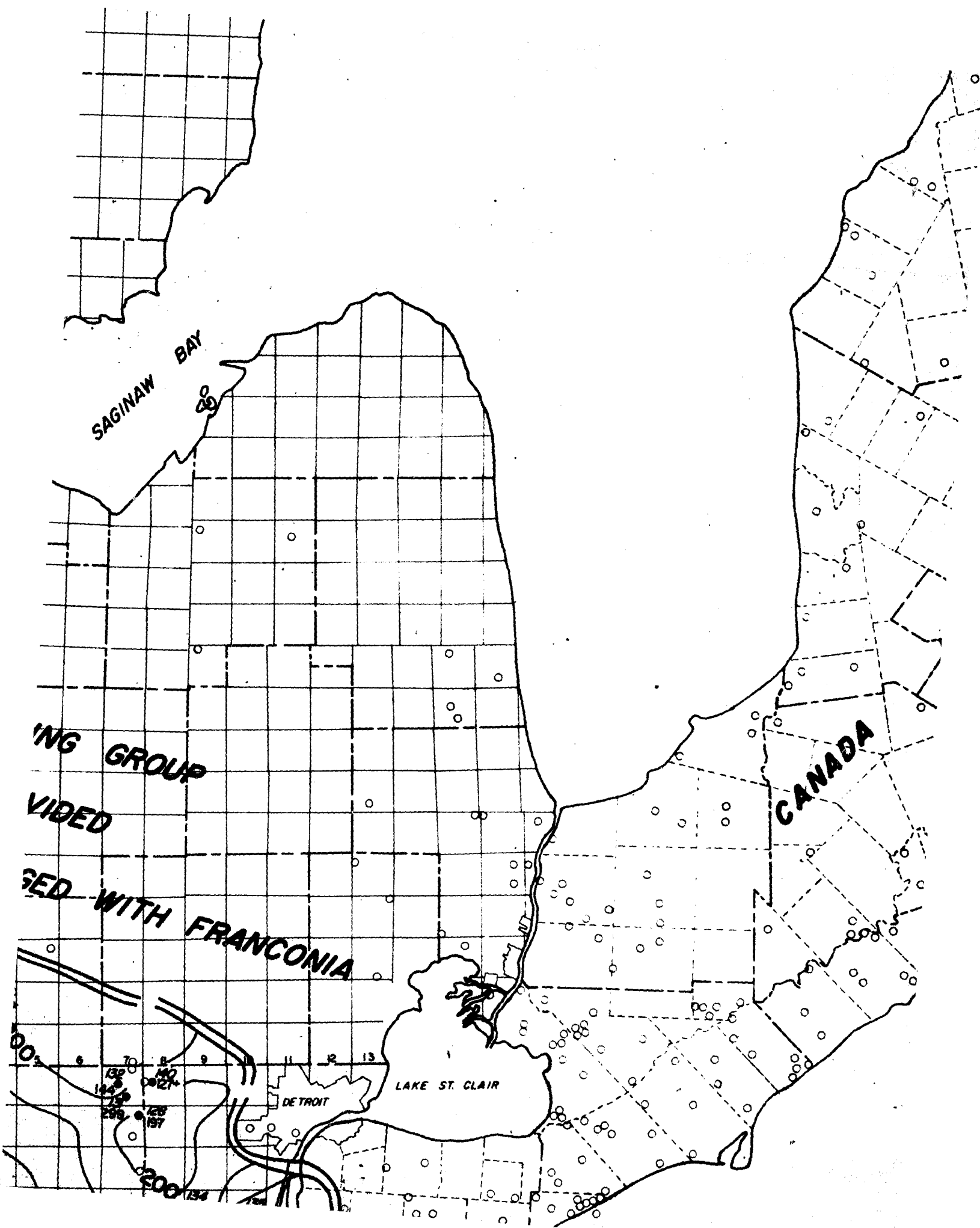
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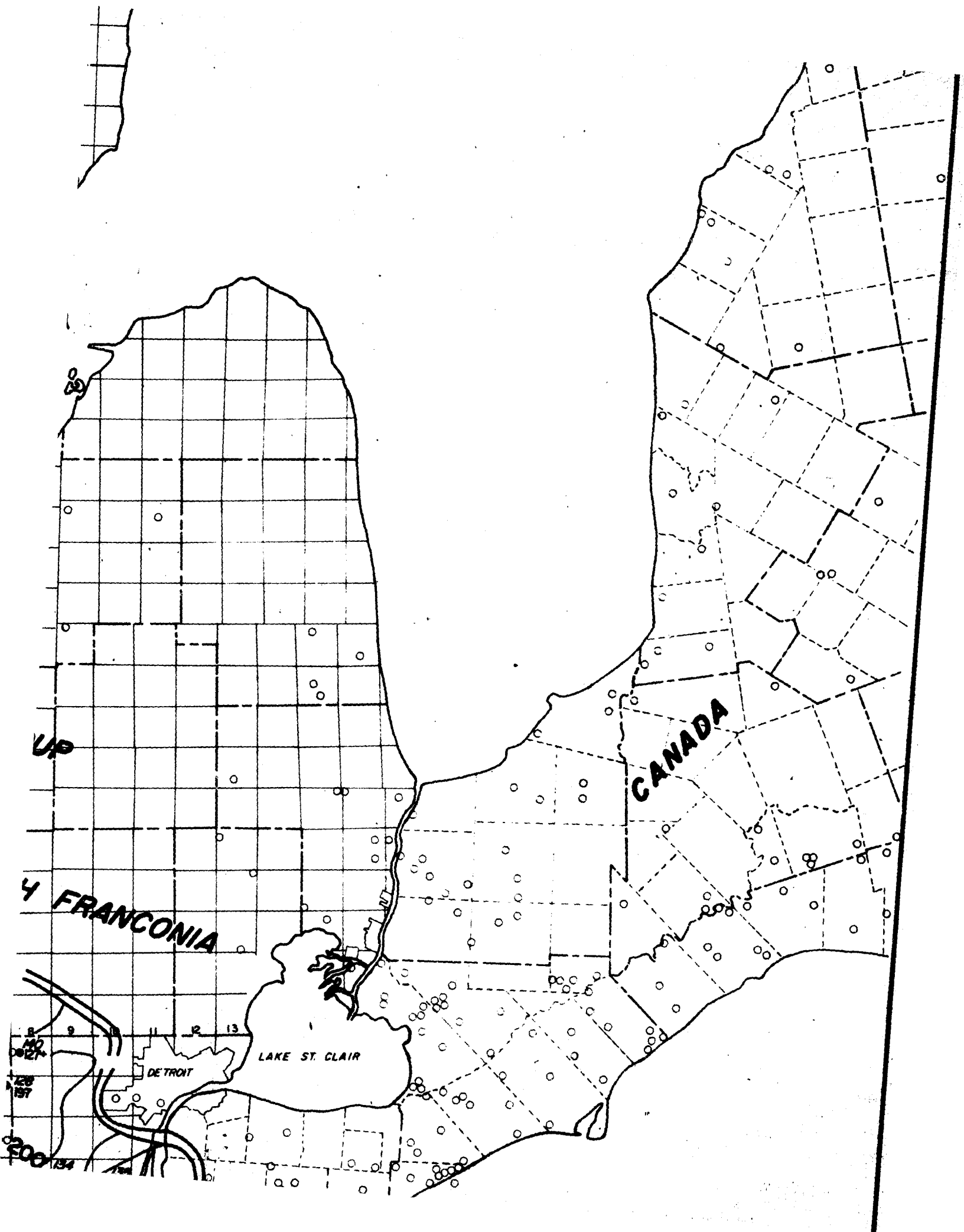














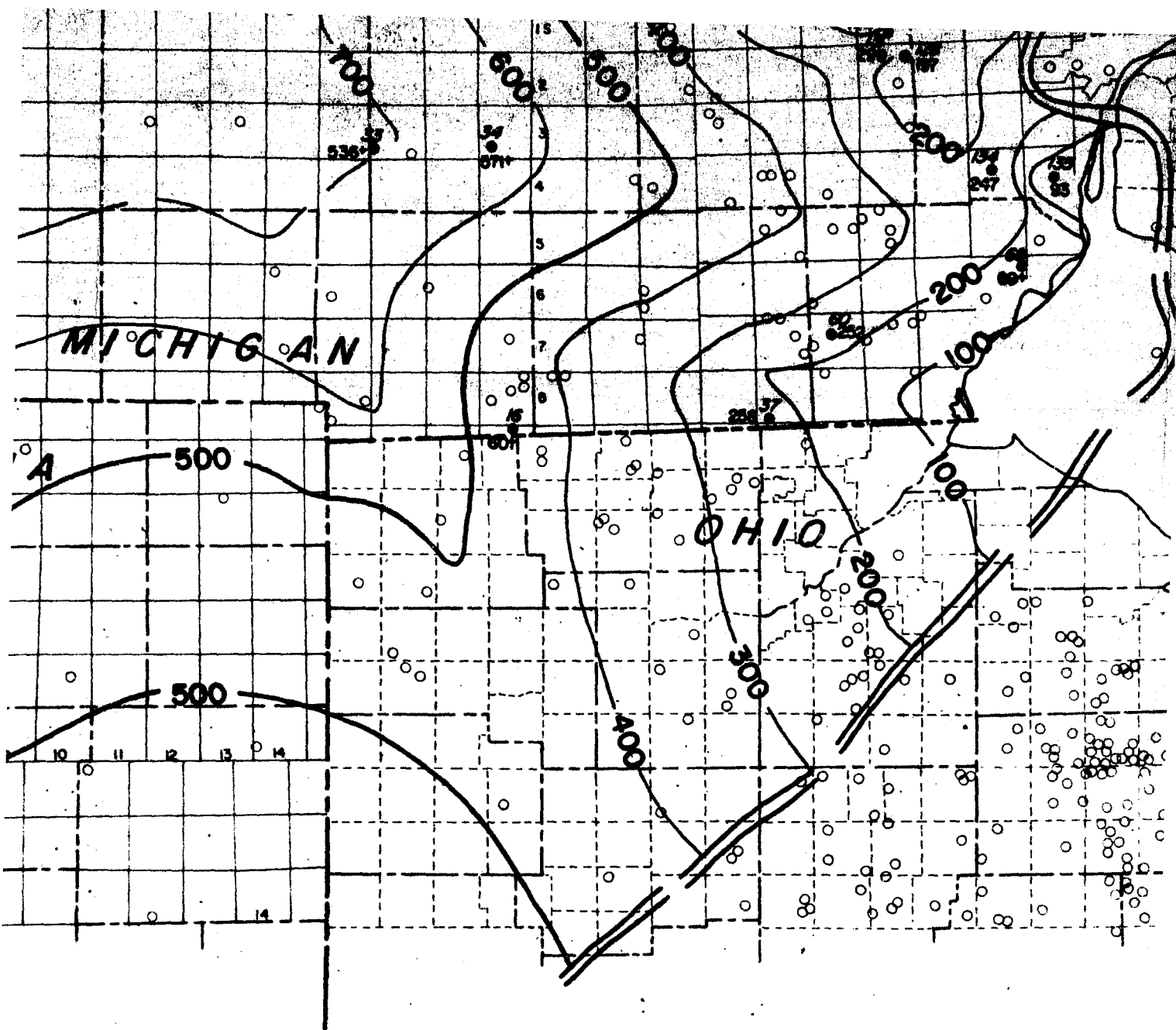
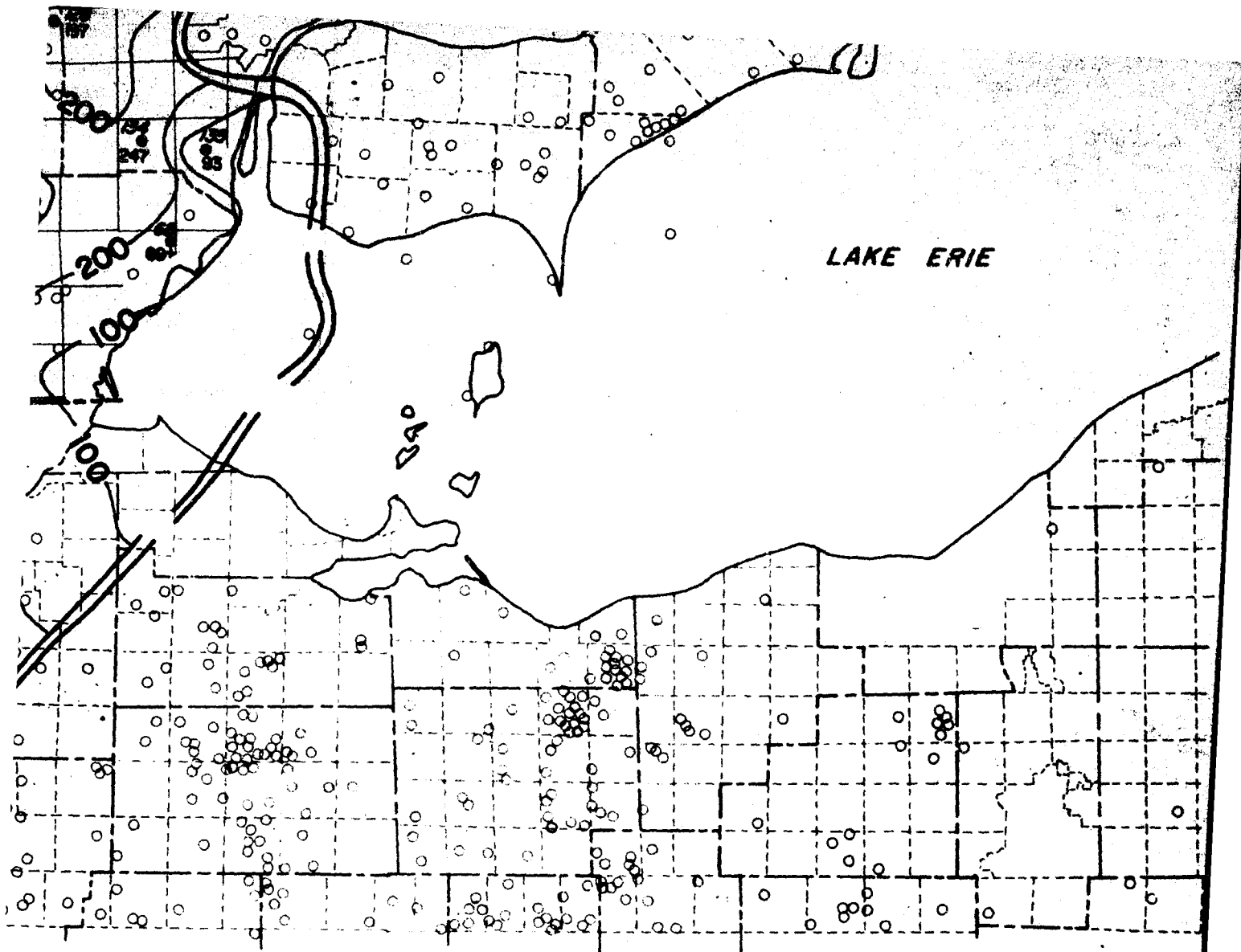


PLATE 4

ISOPACH MAP OF THE

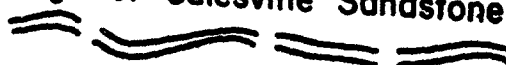
EAU CLAIRE FORMATION



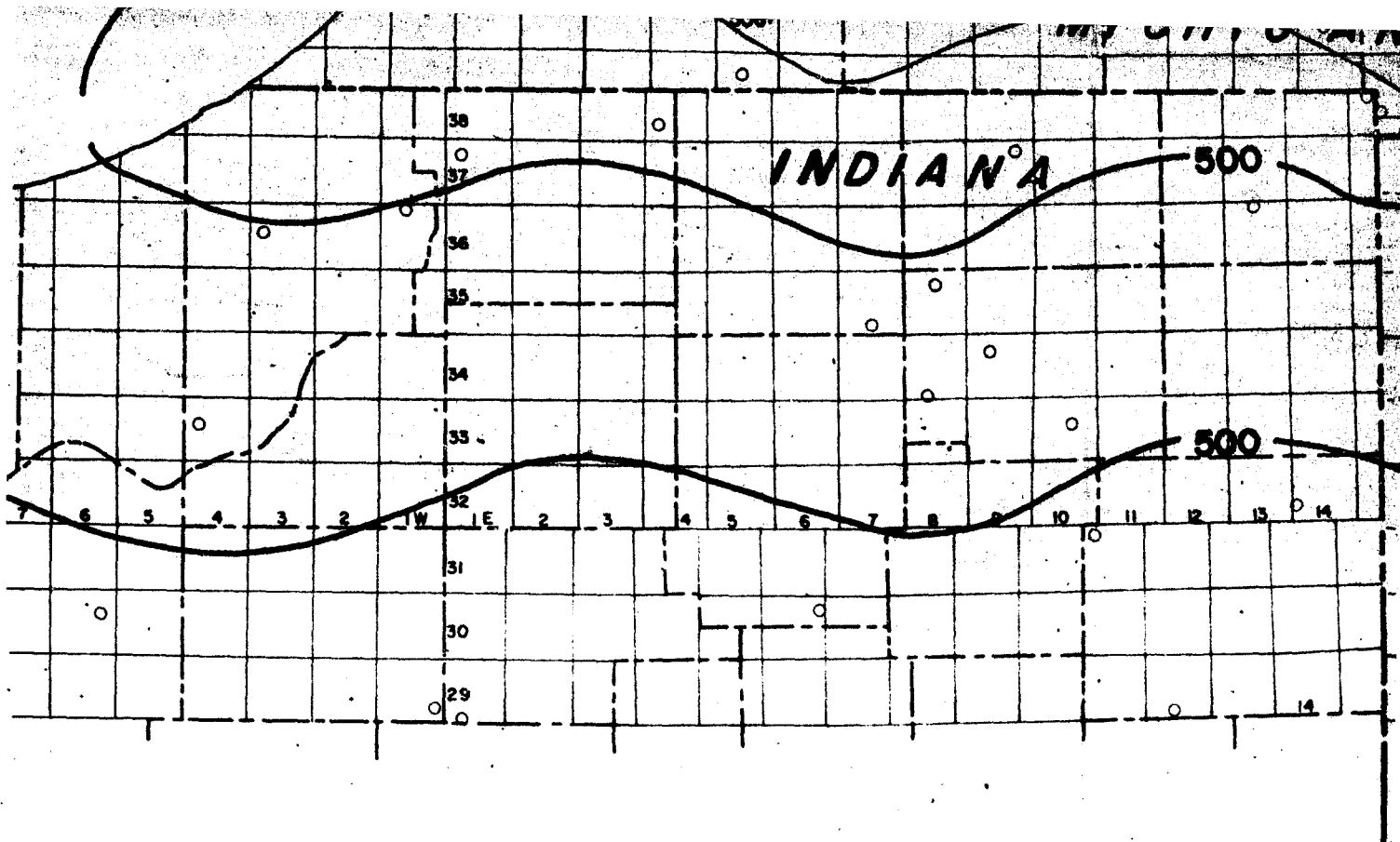
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                   Dawson (1960)  
 OHIO.....J.H. Fisher (Unpublished)  
 ILLINOIS.....Buschbach (1964)  
                   Emrich (1966)

Edge of Galesville Sandstone



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 CONTOUR INTERVAL = 100 FEET



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1972

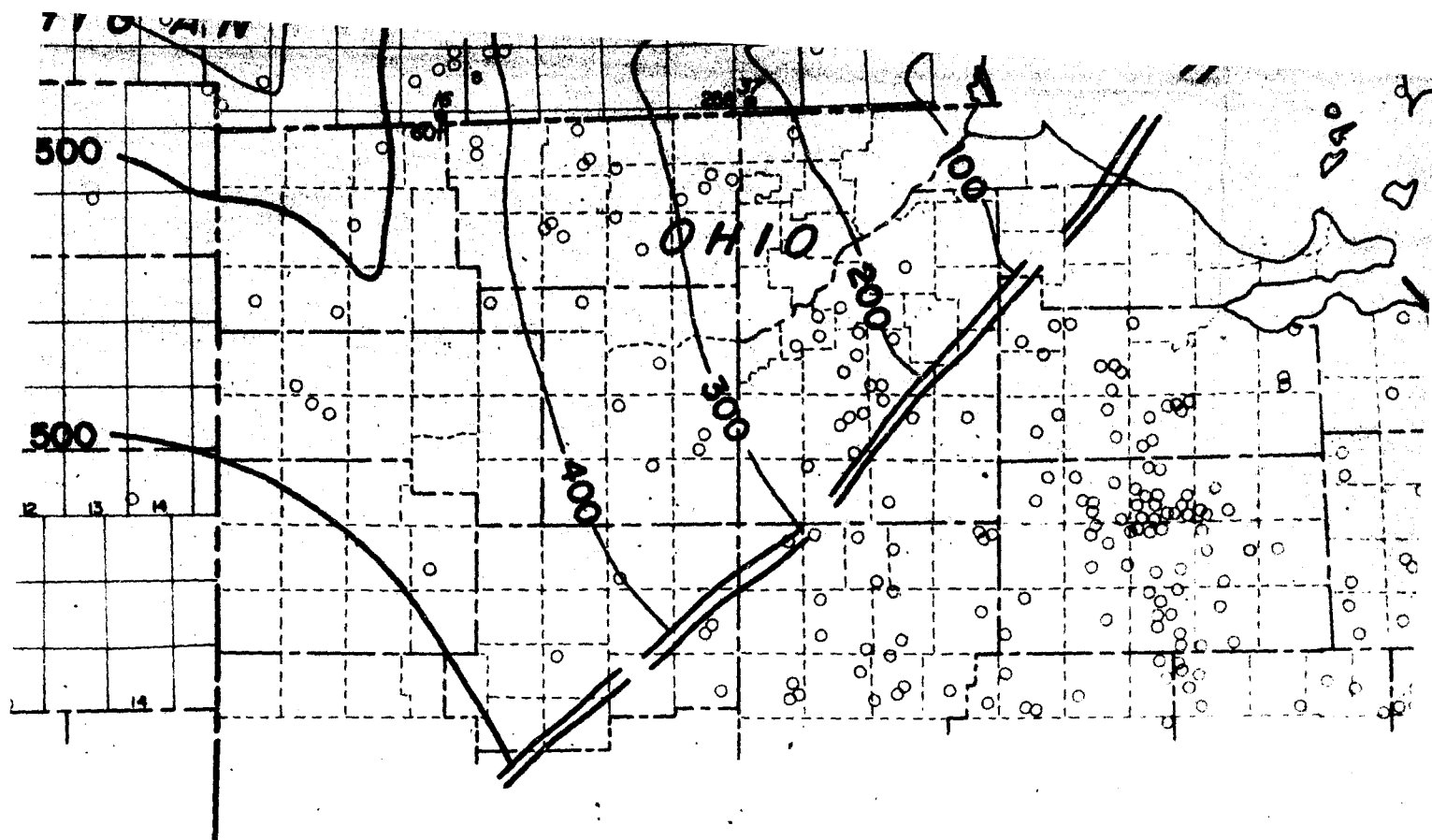
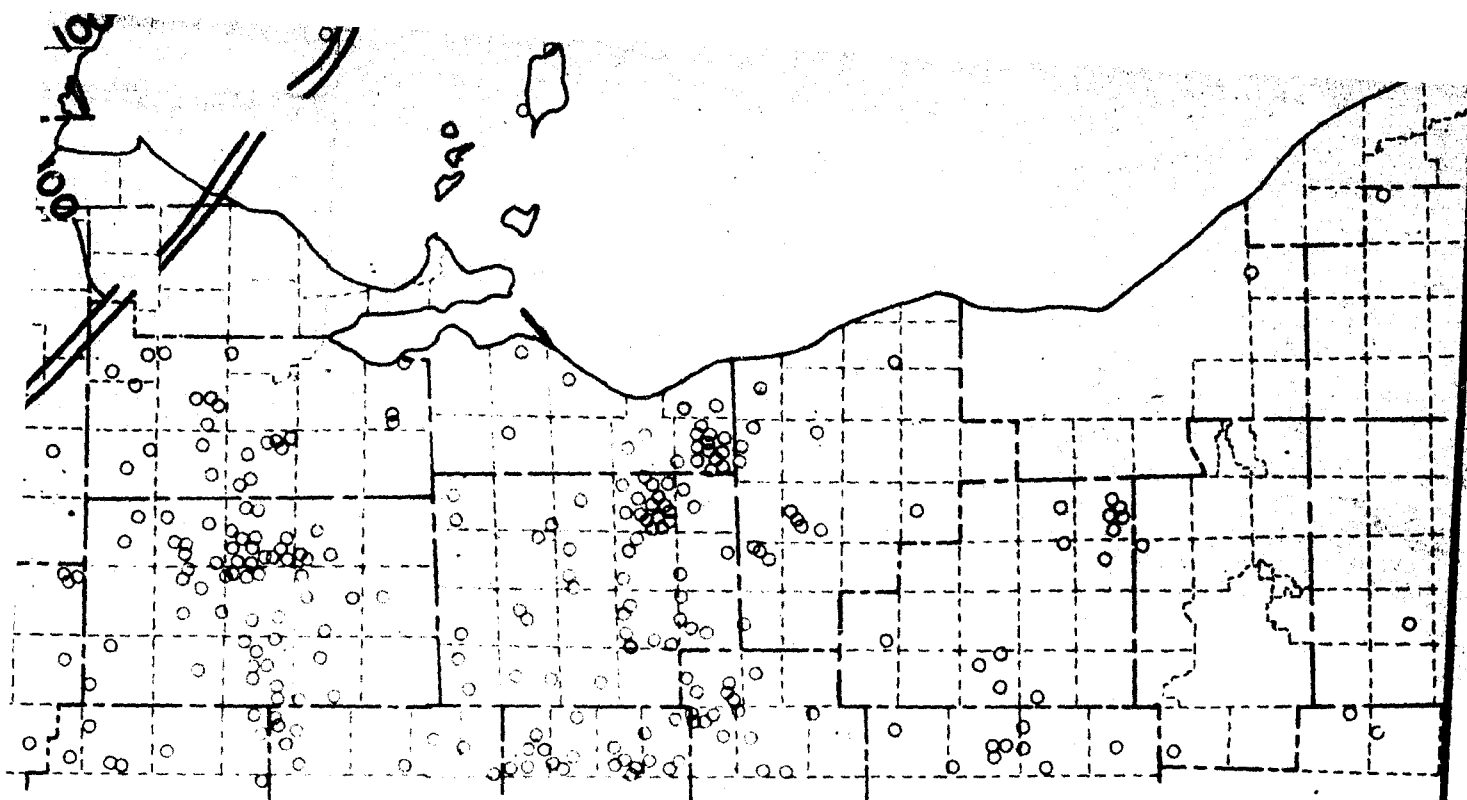


PLATE 4

ISOPACH MAP OF THE  
EAU CLAIRE FORMATION

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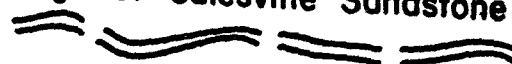
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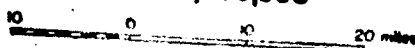
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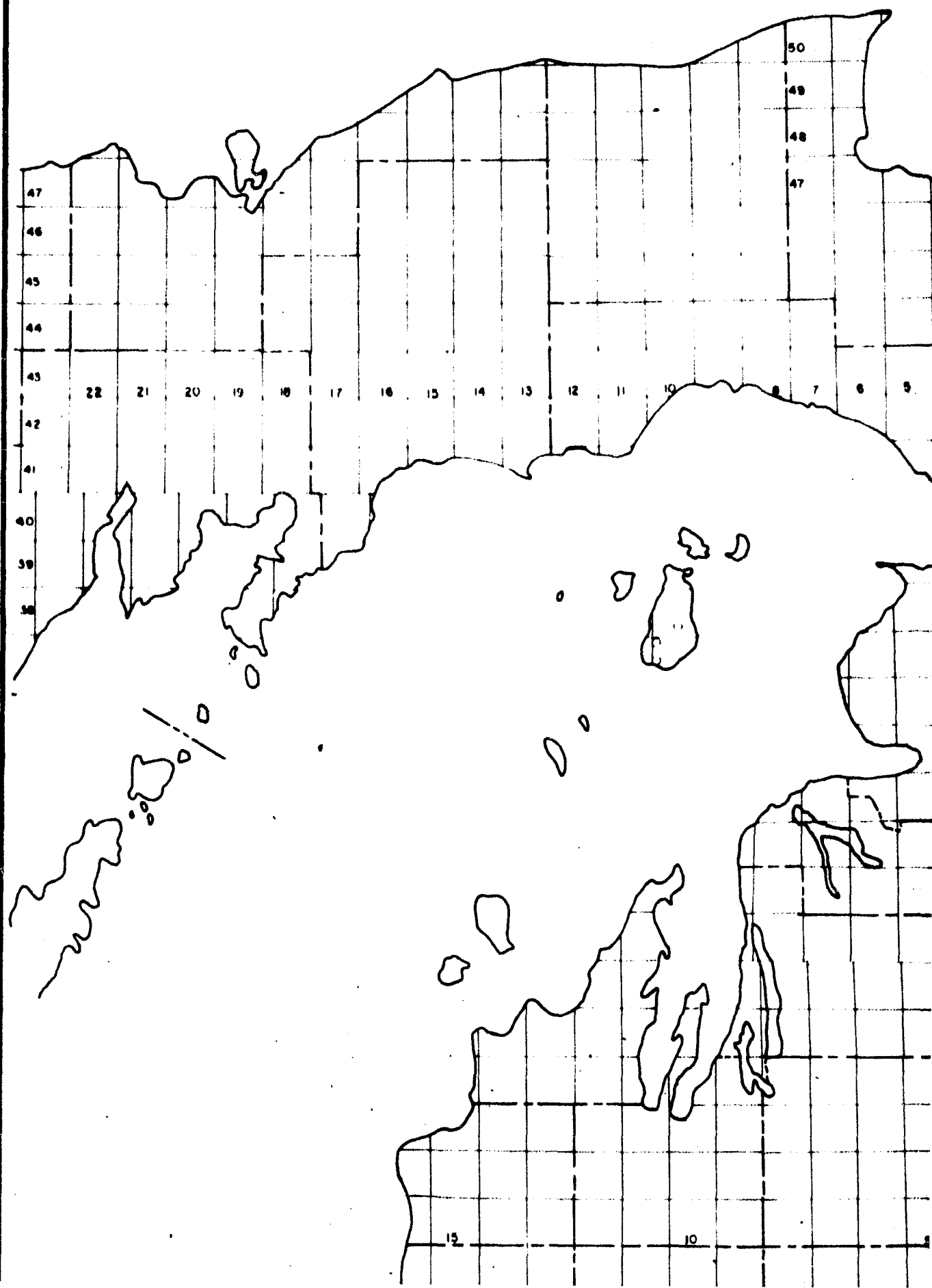
Edge of Galesville Sandstone

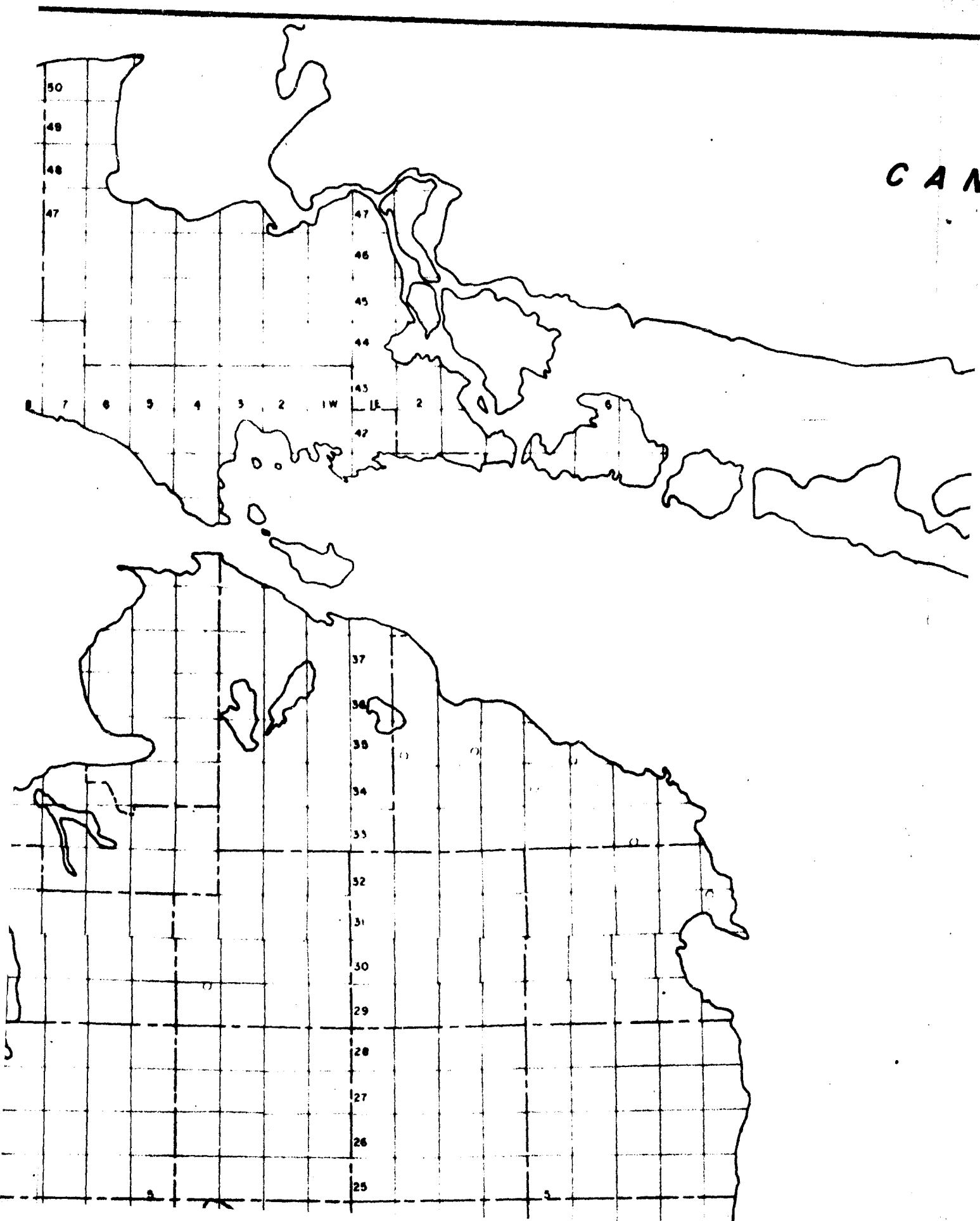


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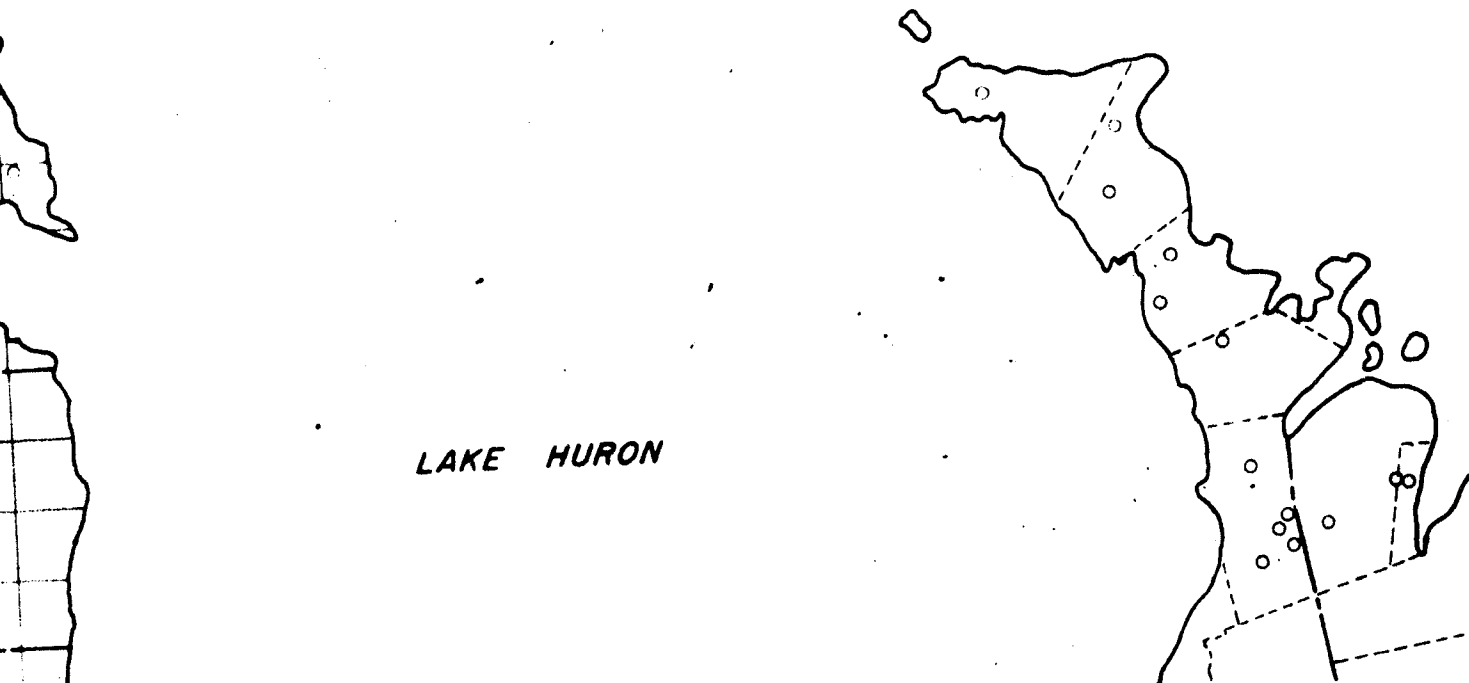


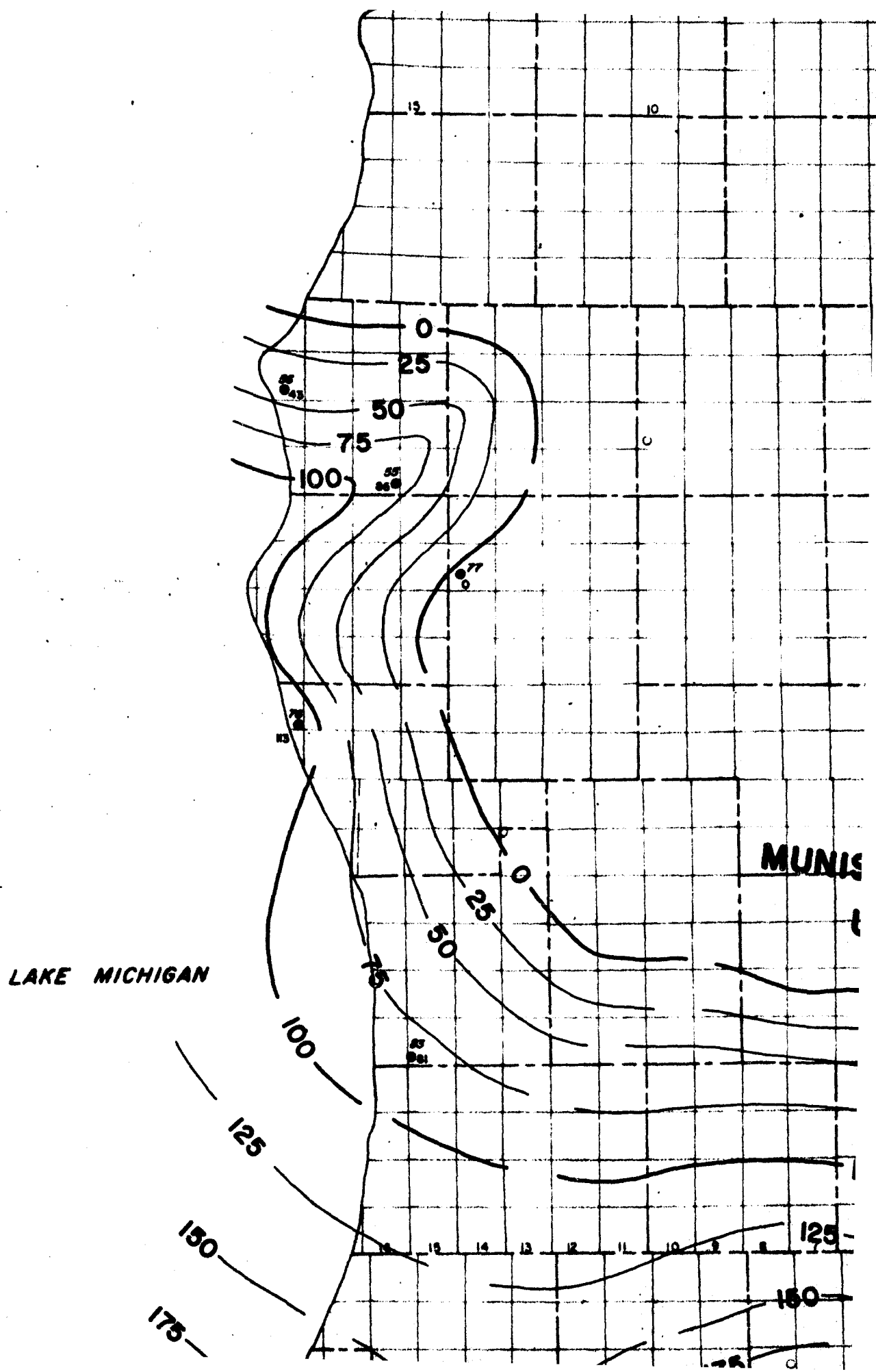


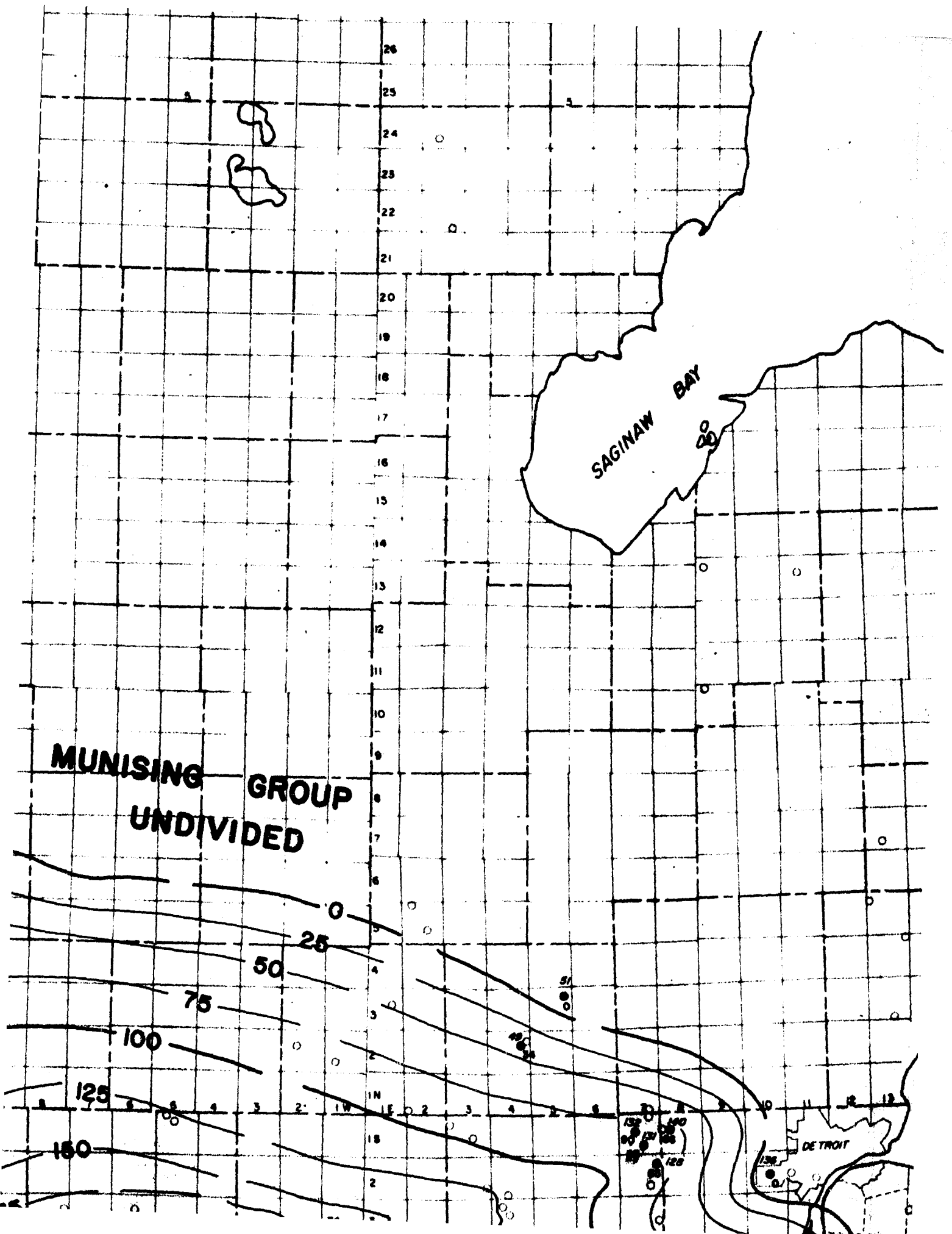
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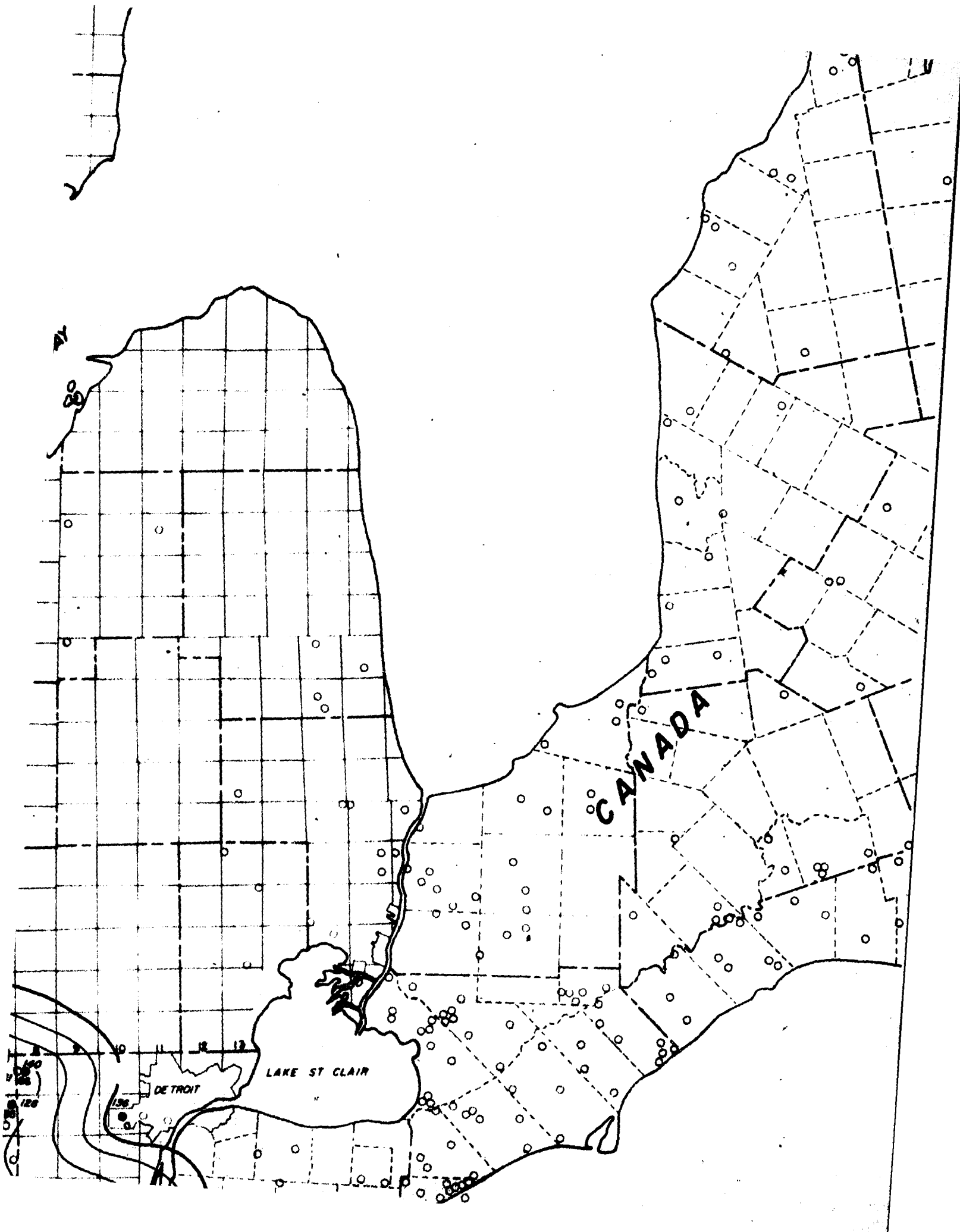


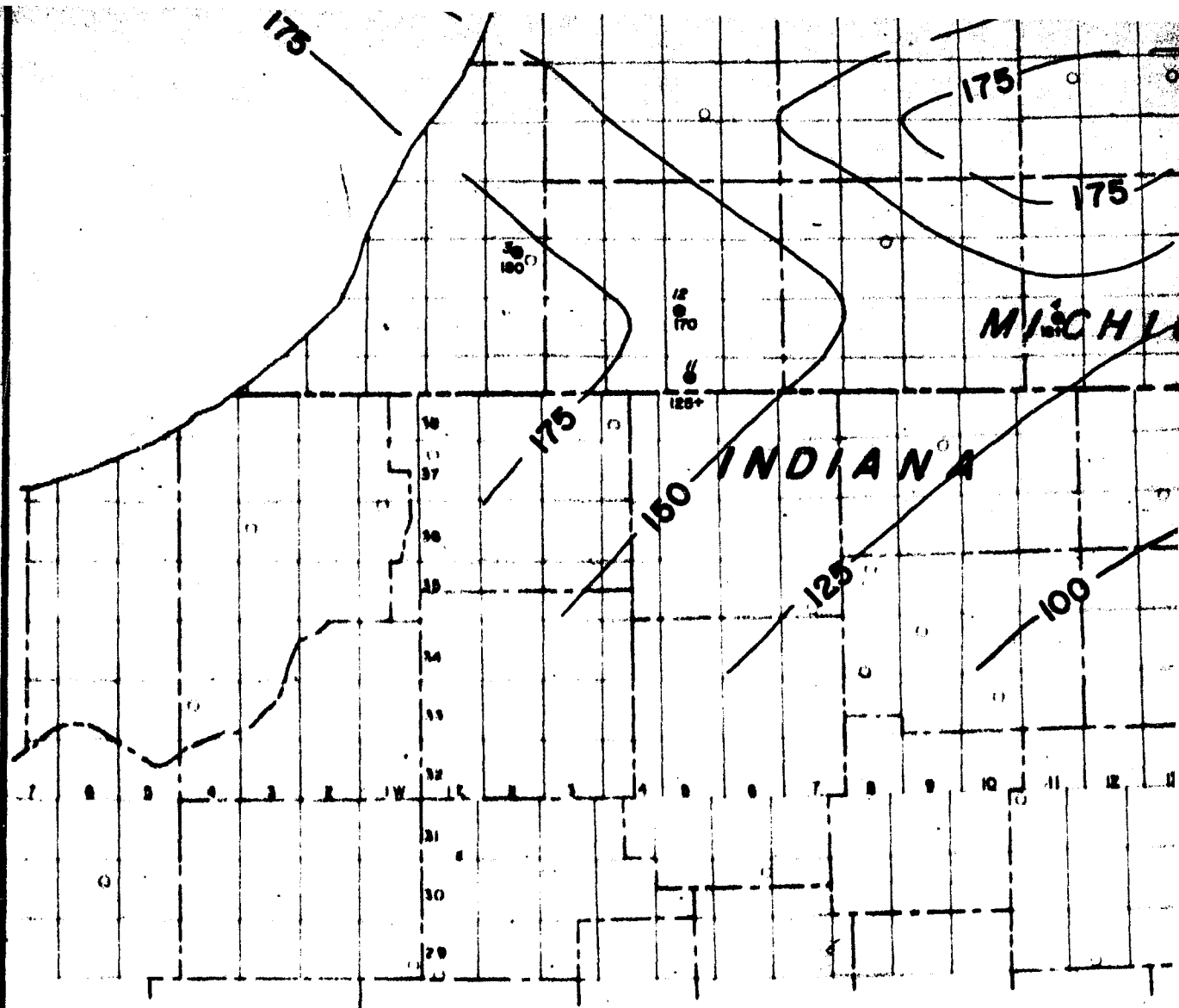
**LAKE HURON**





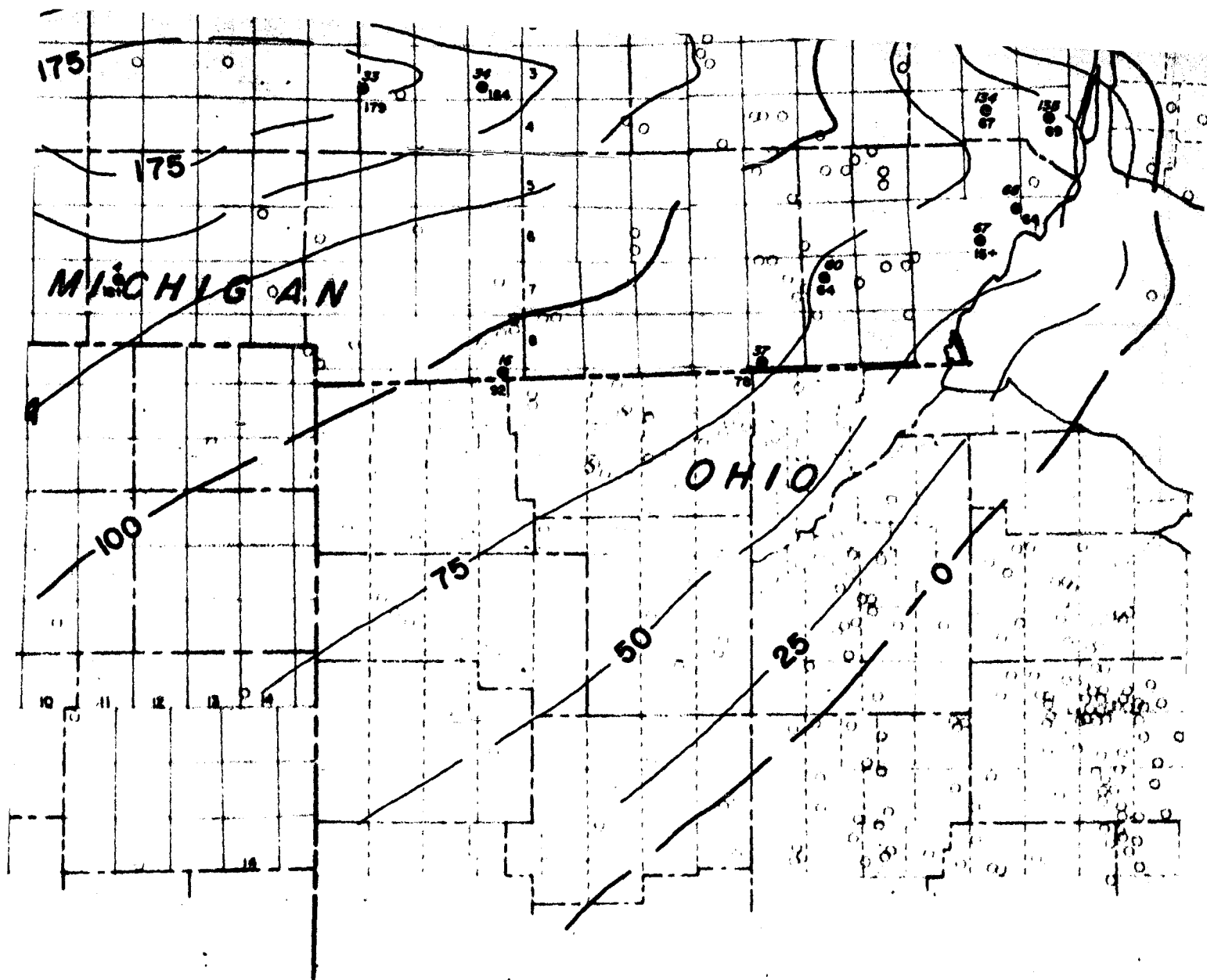






PAUL A CATACOSINOS  
1972

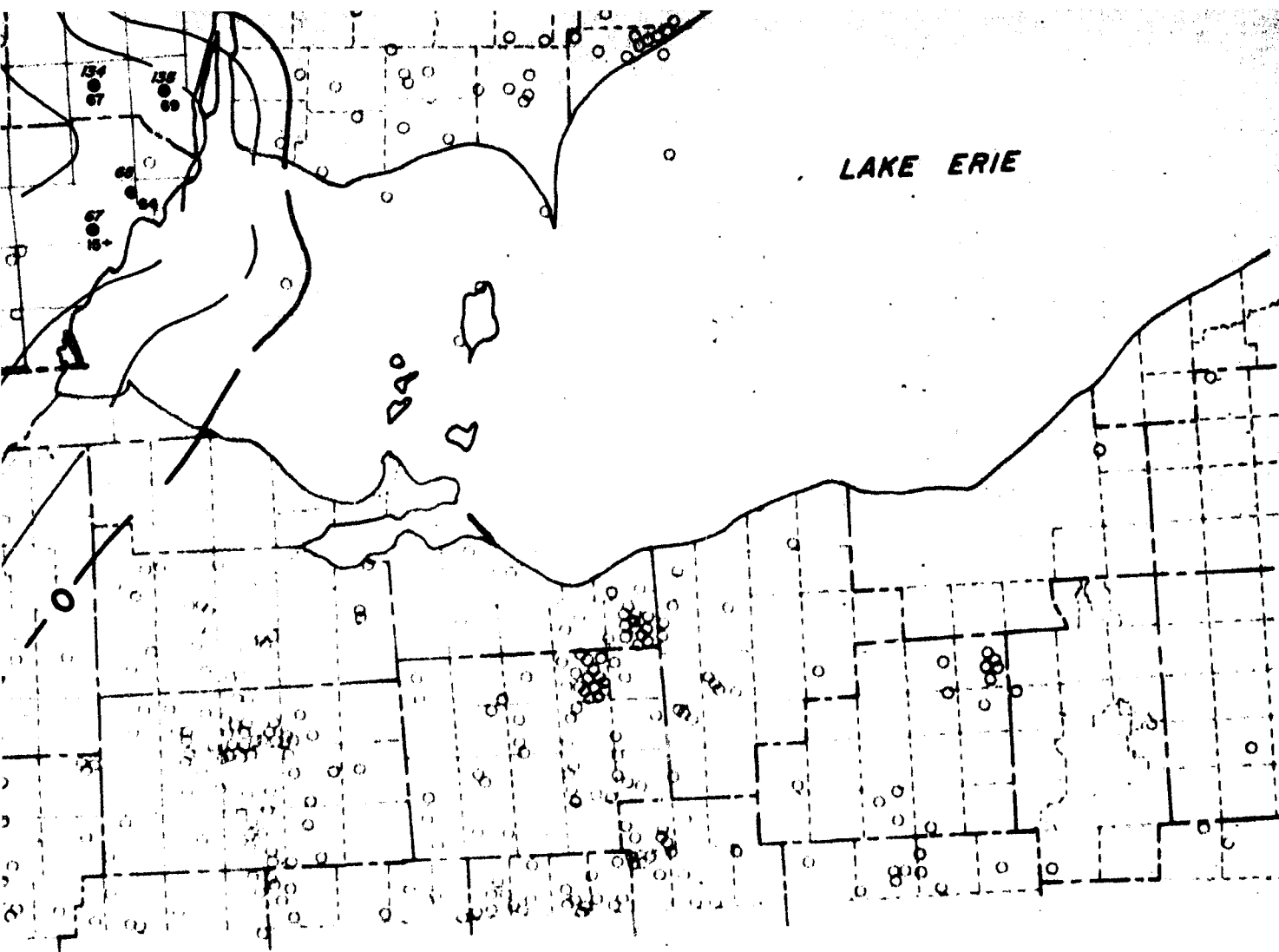




**PLATE 5**

**ISOPACH MAP OF THE**

**GALESVILLE SANDSTONE**



### SOURCES OF DATA

CANADA.....Sanford and Quillian (1959)

UPPER  
PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

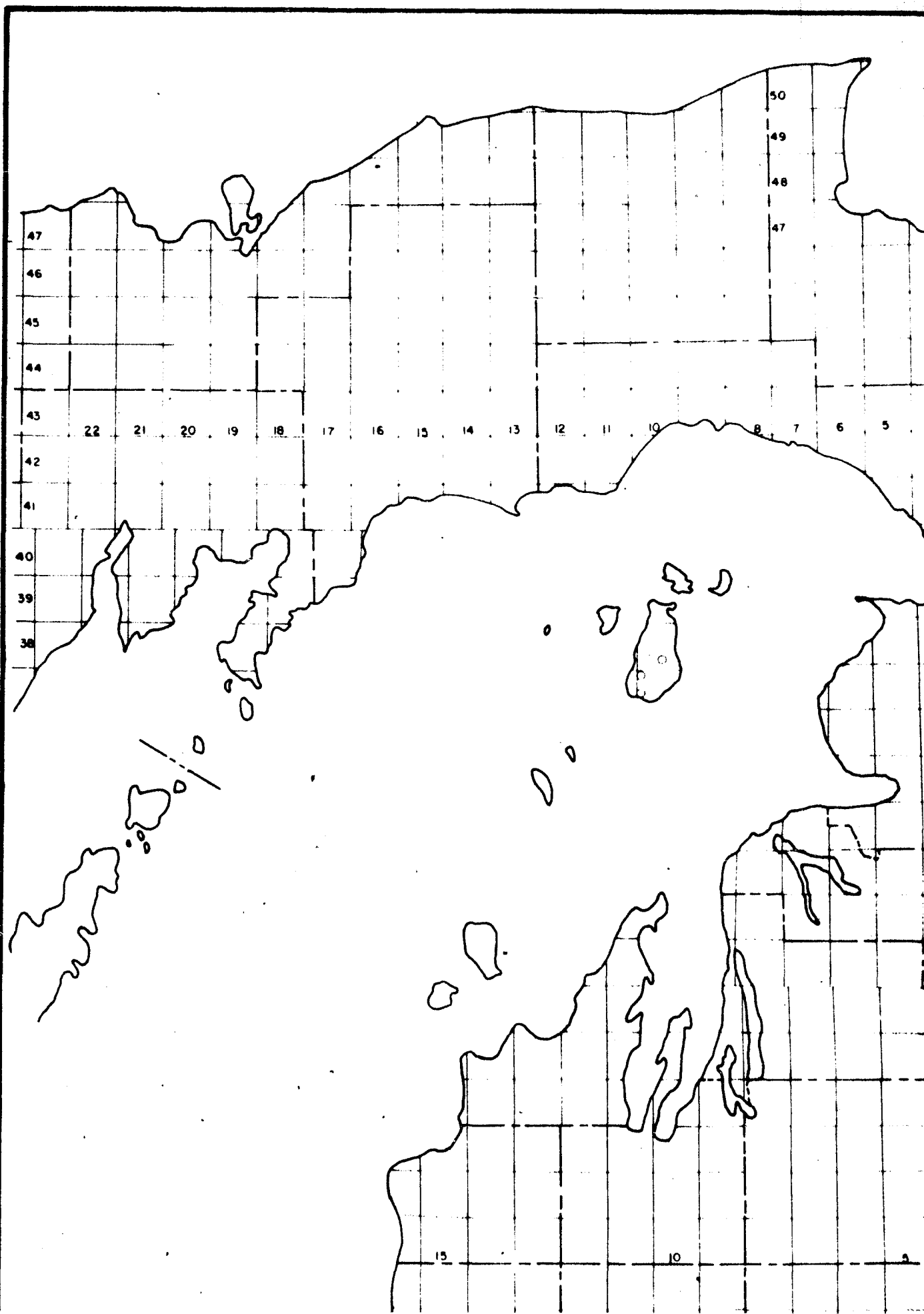
OHIO.....J.H. Fisher (Unpublished)

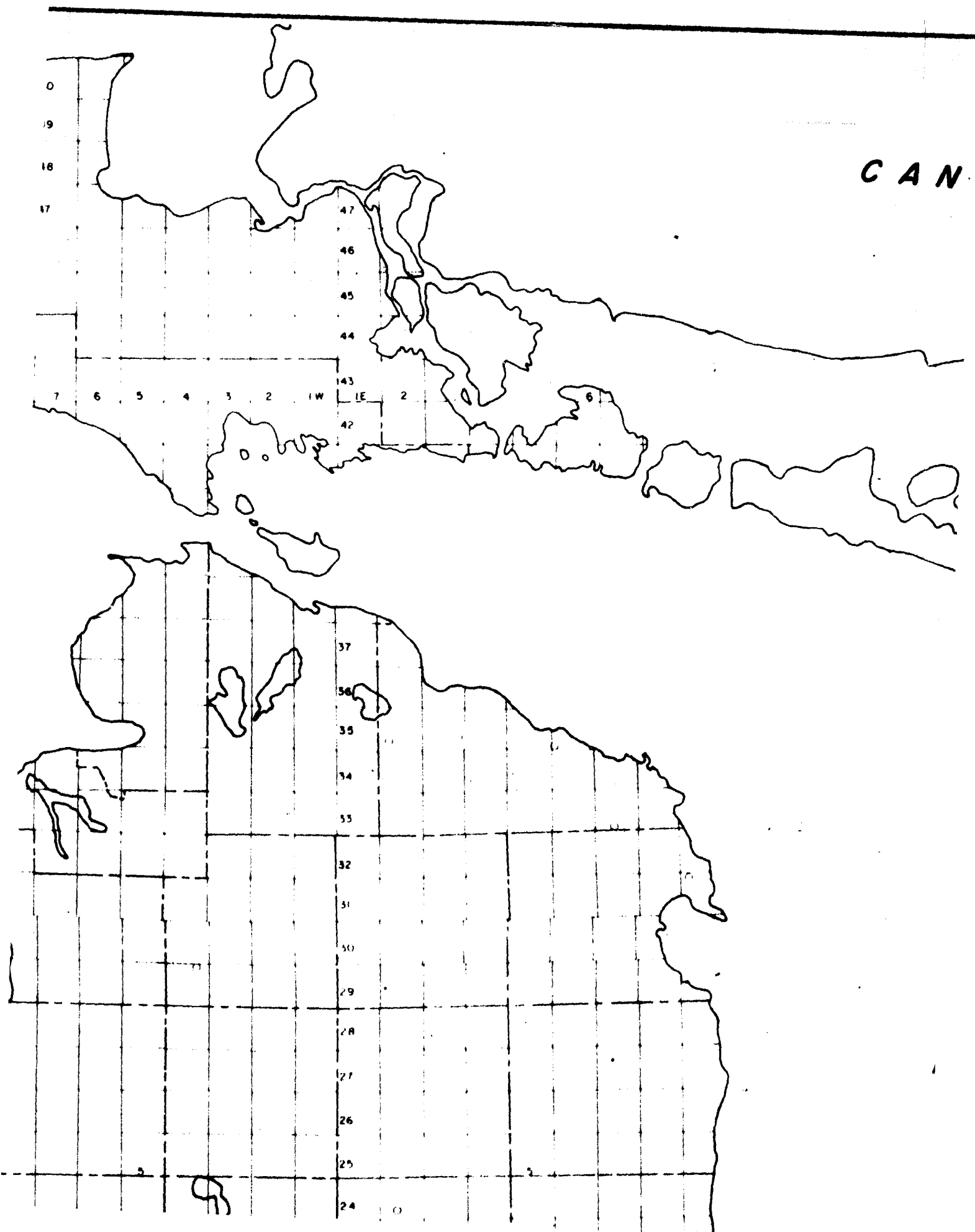
ILLINOIS.....Buschbach (1964)  
Emrich (1966)

 WELL DATA POINT  
 CONTOUR INTERVAL = 25 FEET

Scale 1:1,000,000

10 0 10 20 miles

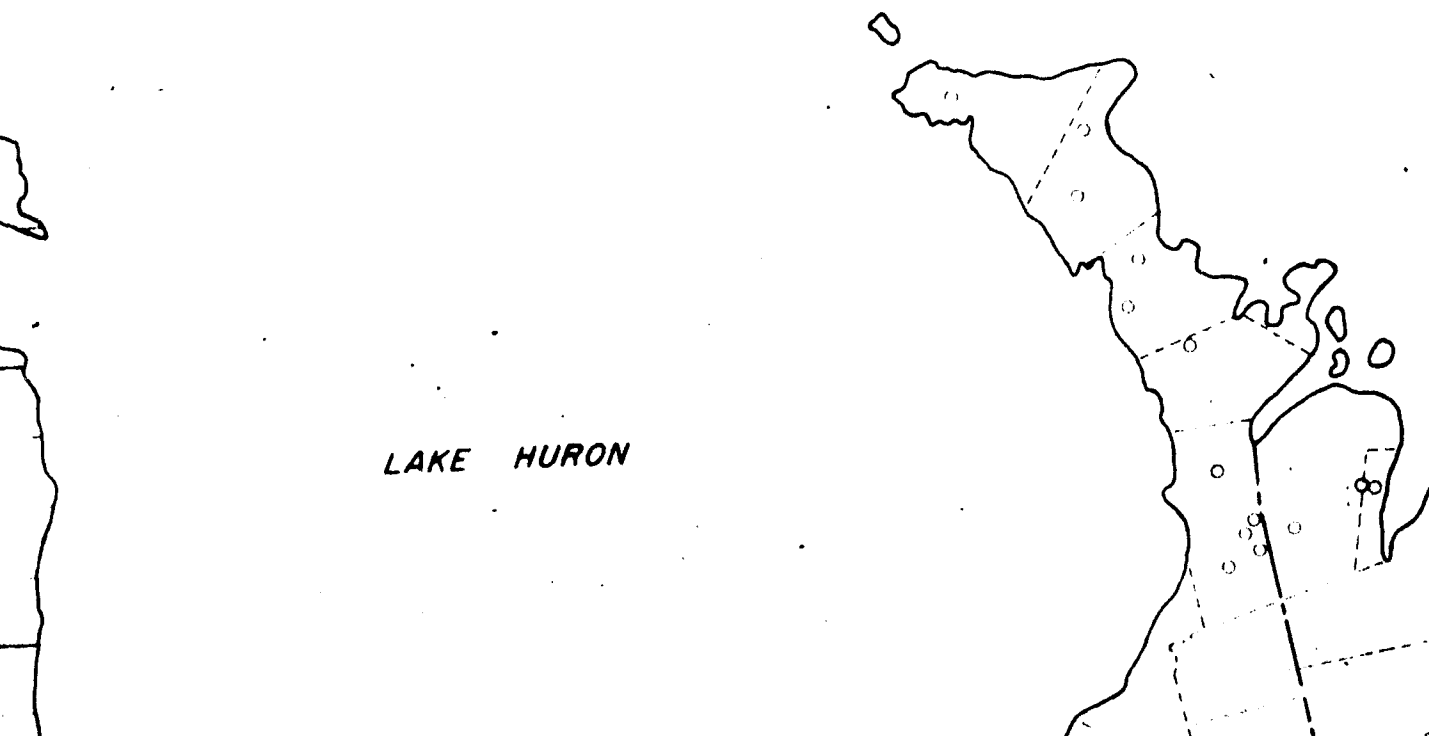




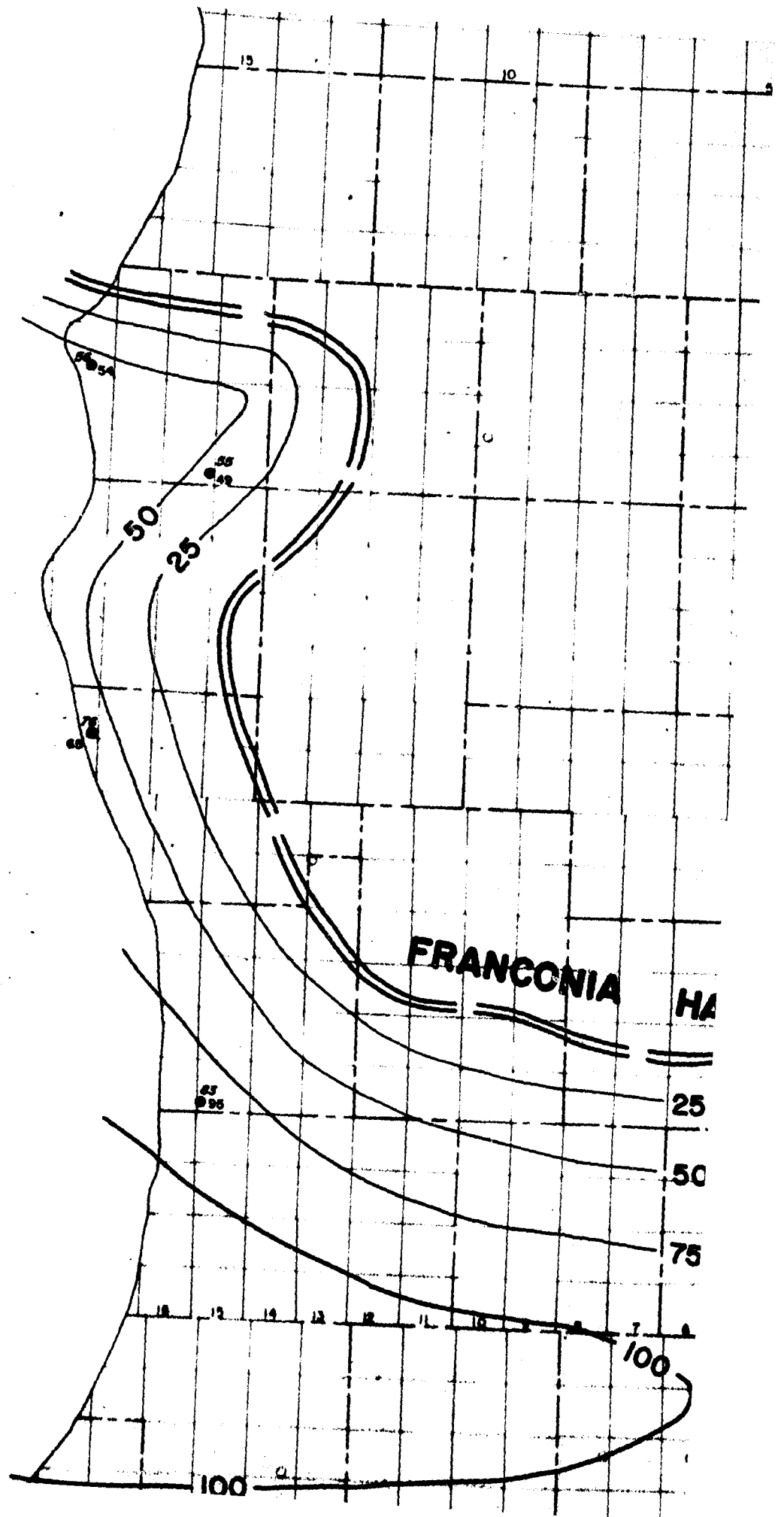
**CANADA**

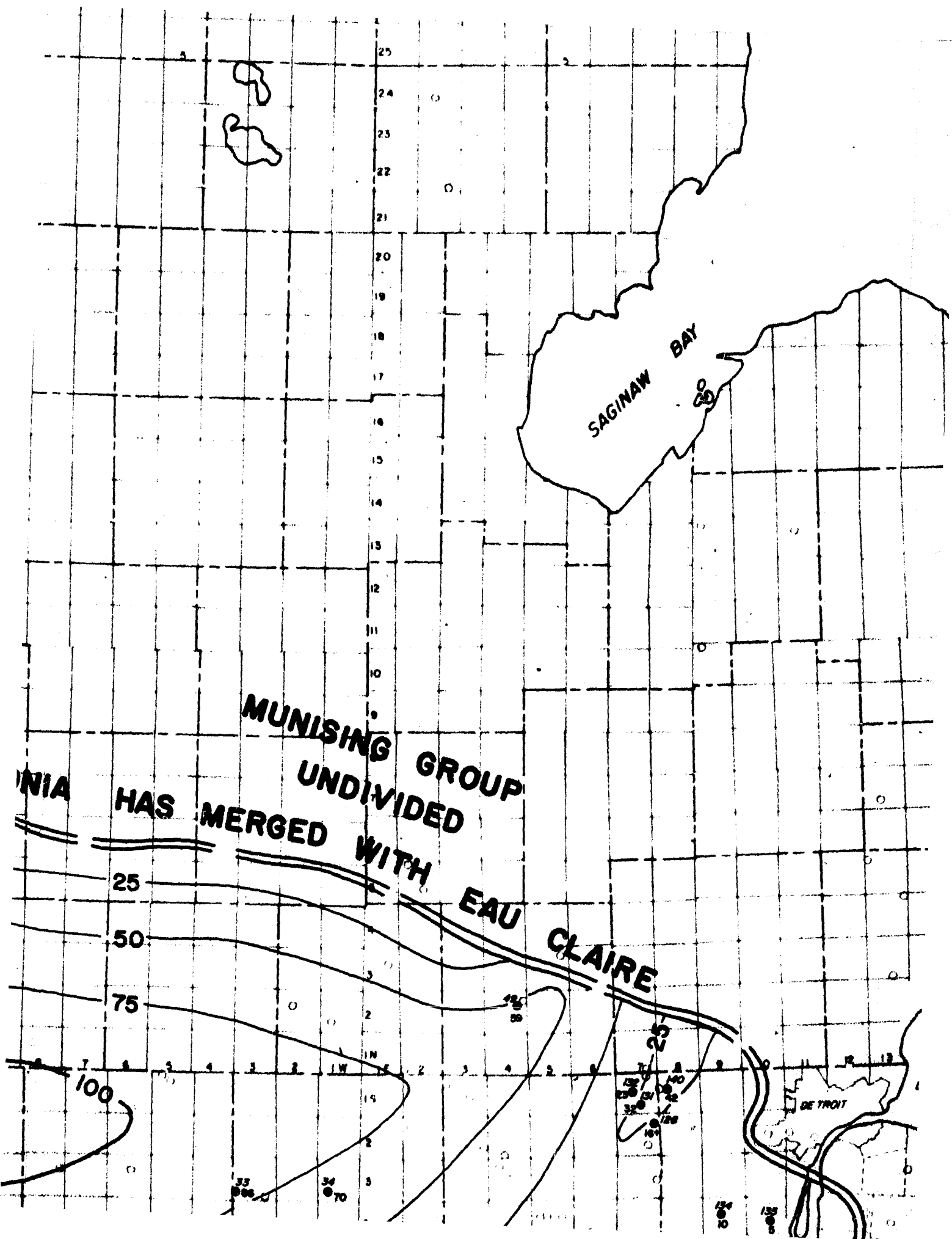


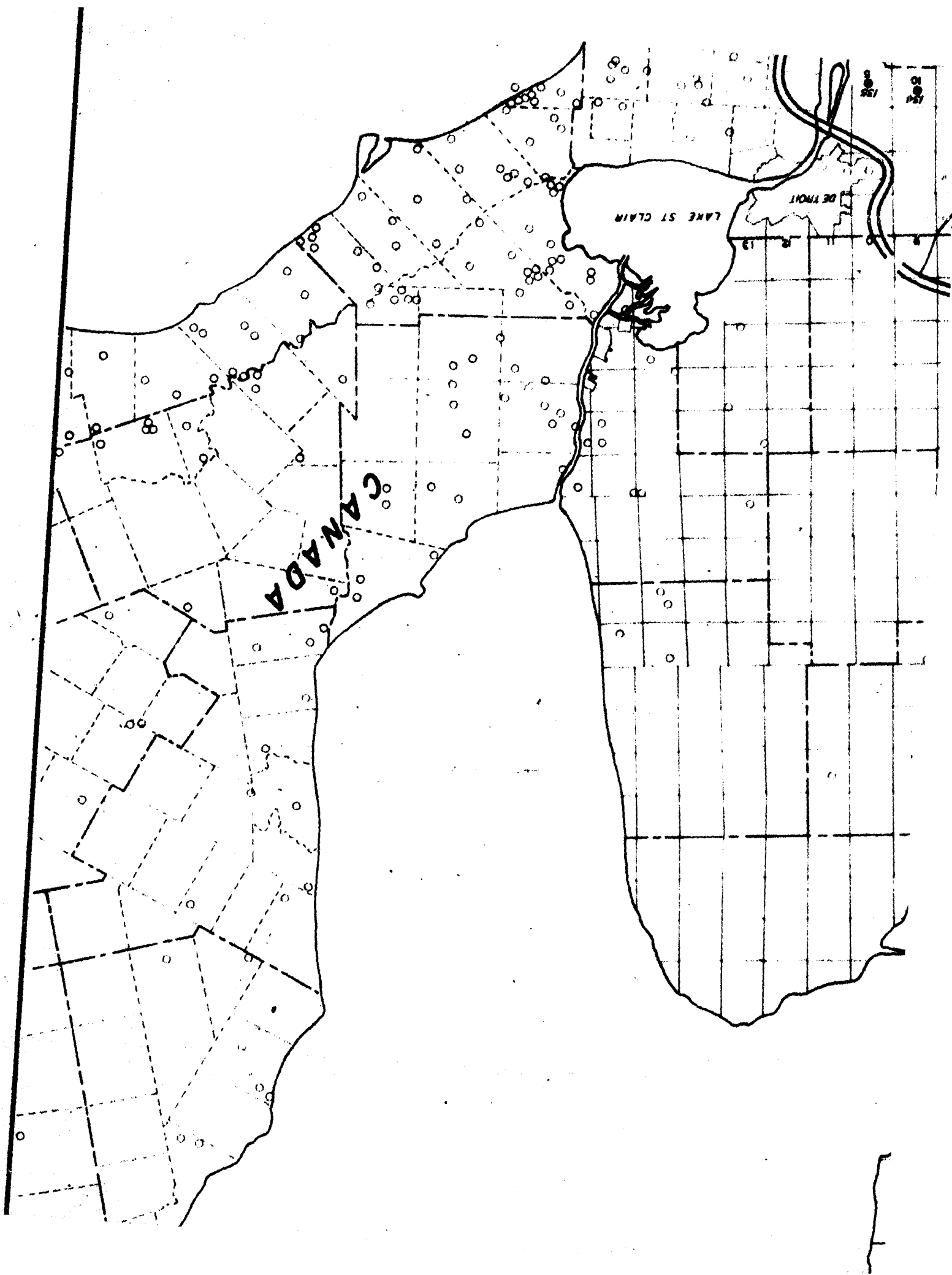
**LAKE HURON**



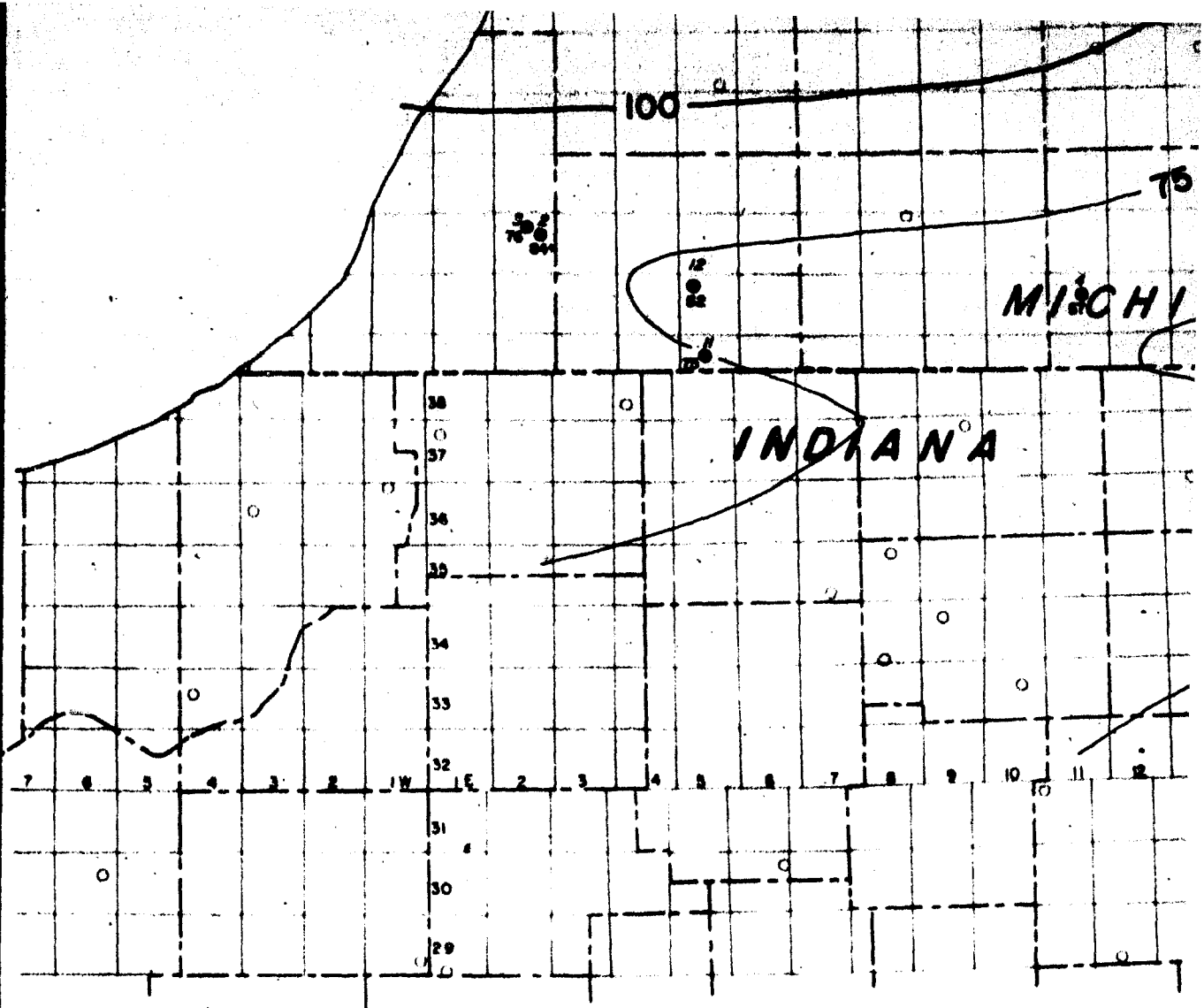
LAKE MICHIGAN



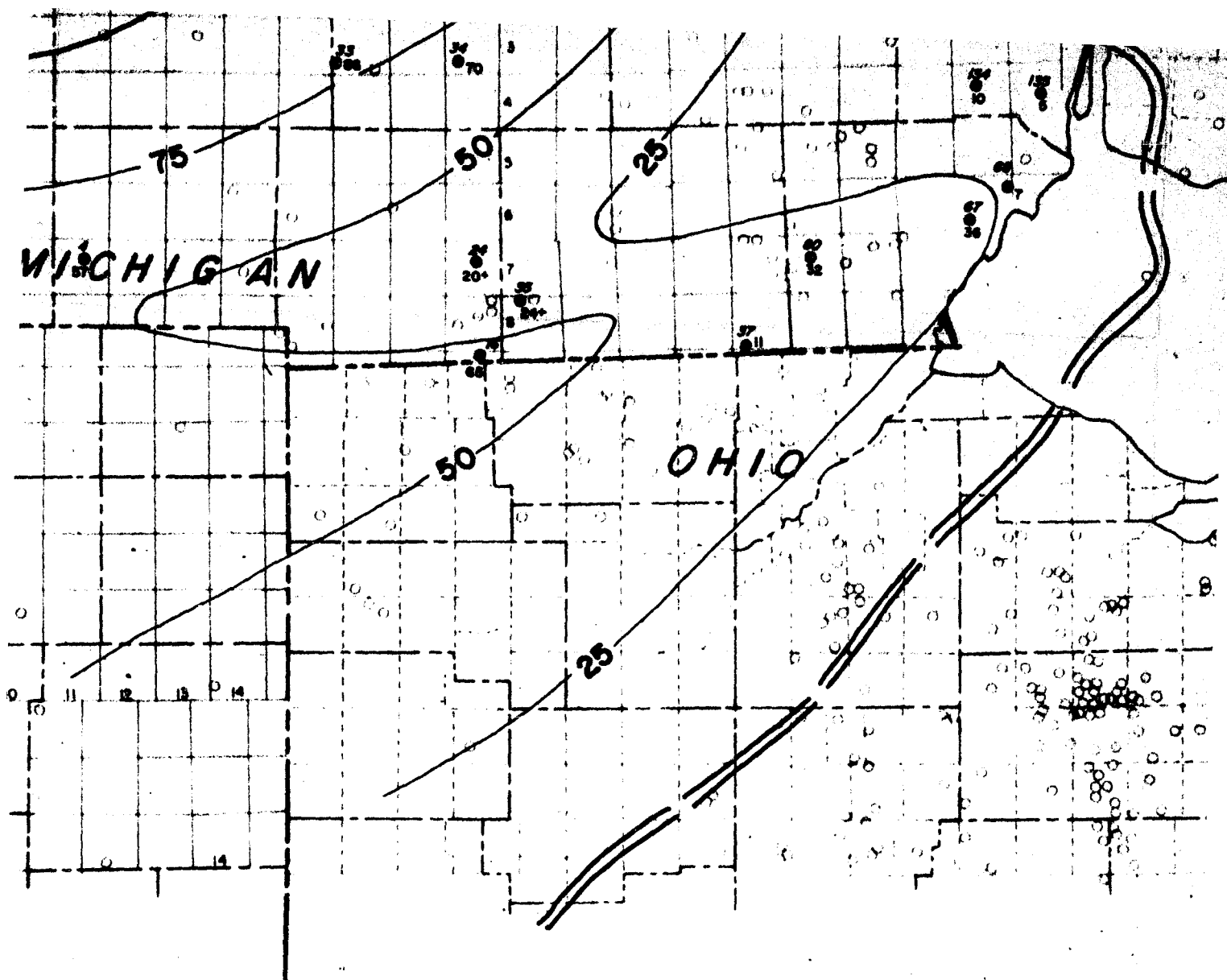






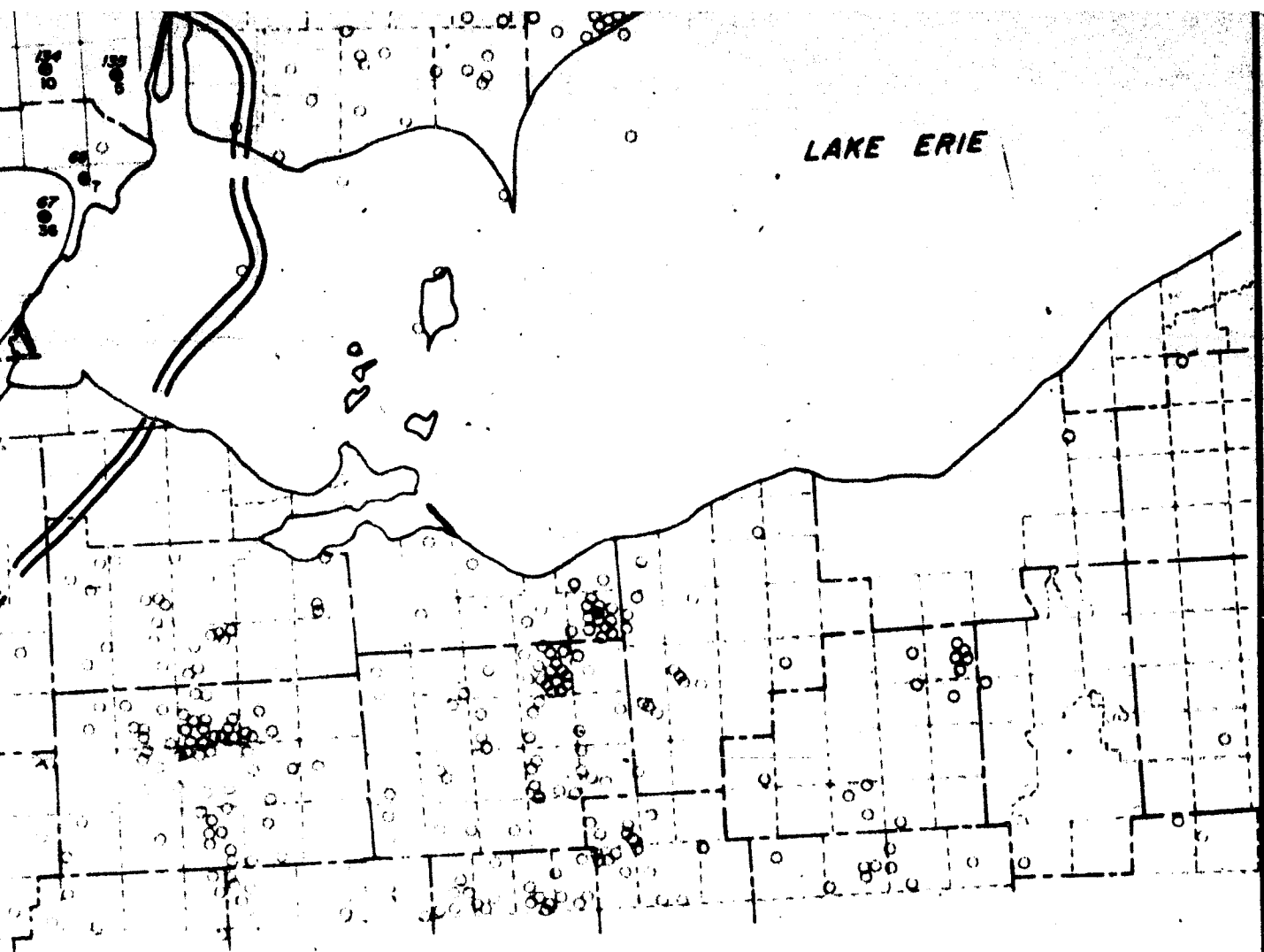


PAUL A CATACOSINOS  
1972



**PLATE 6**

**ISOPACH MAP OF THE  
FRANCONIA FORMATION**



### SOURCES OF DATA

CANADA.....Sanford and Quillian (1959)

UPPER  
PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

OHIO.....J.H. Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
Emrich (1966)

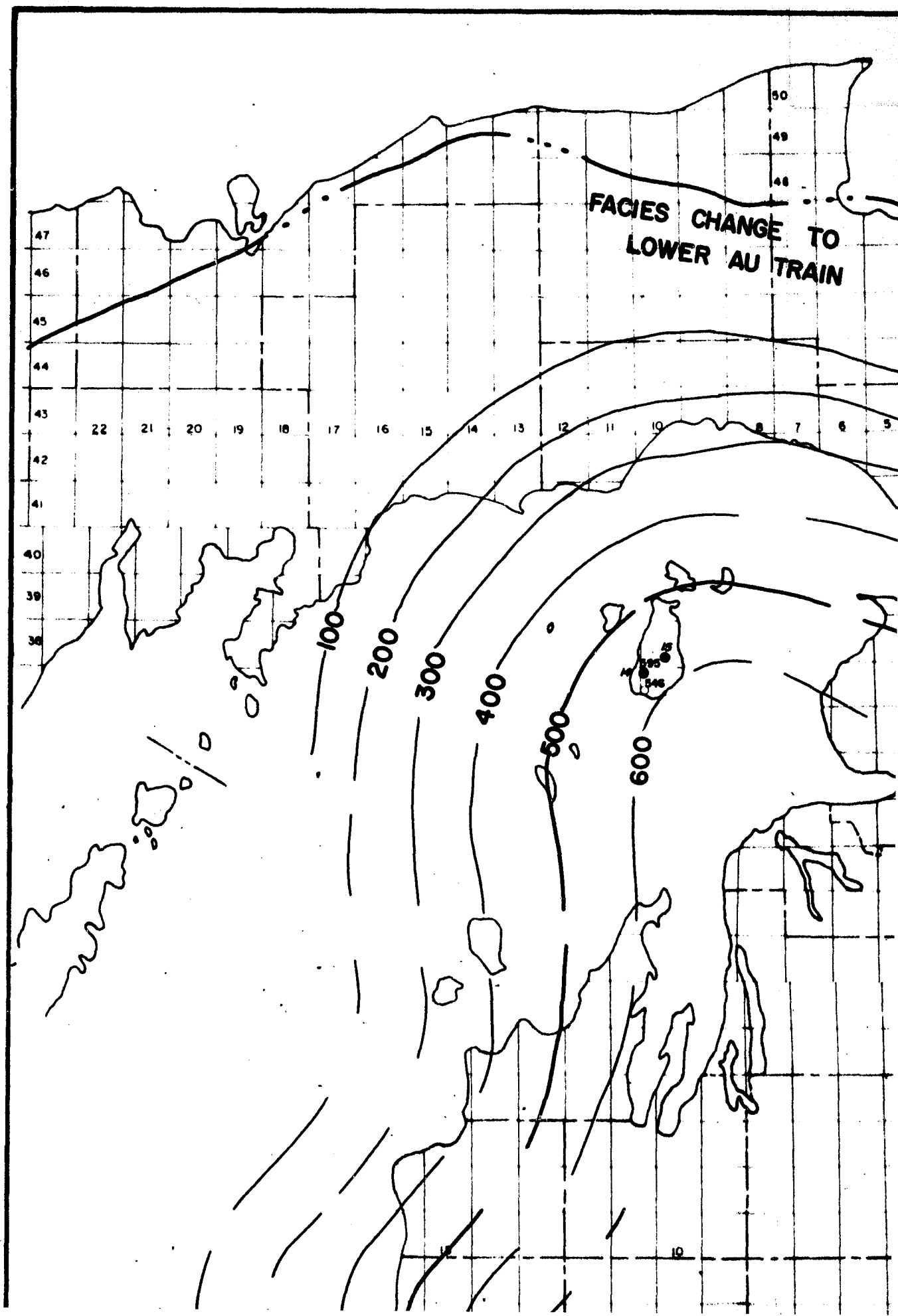
### Edge of Galesville Sandstone

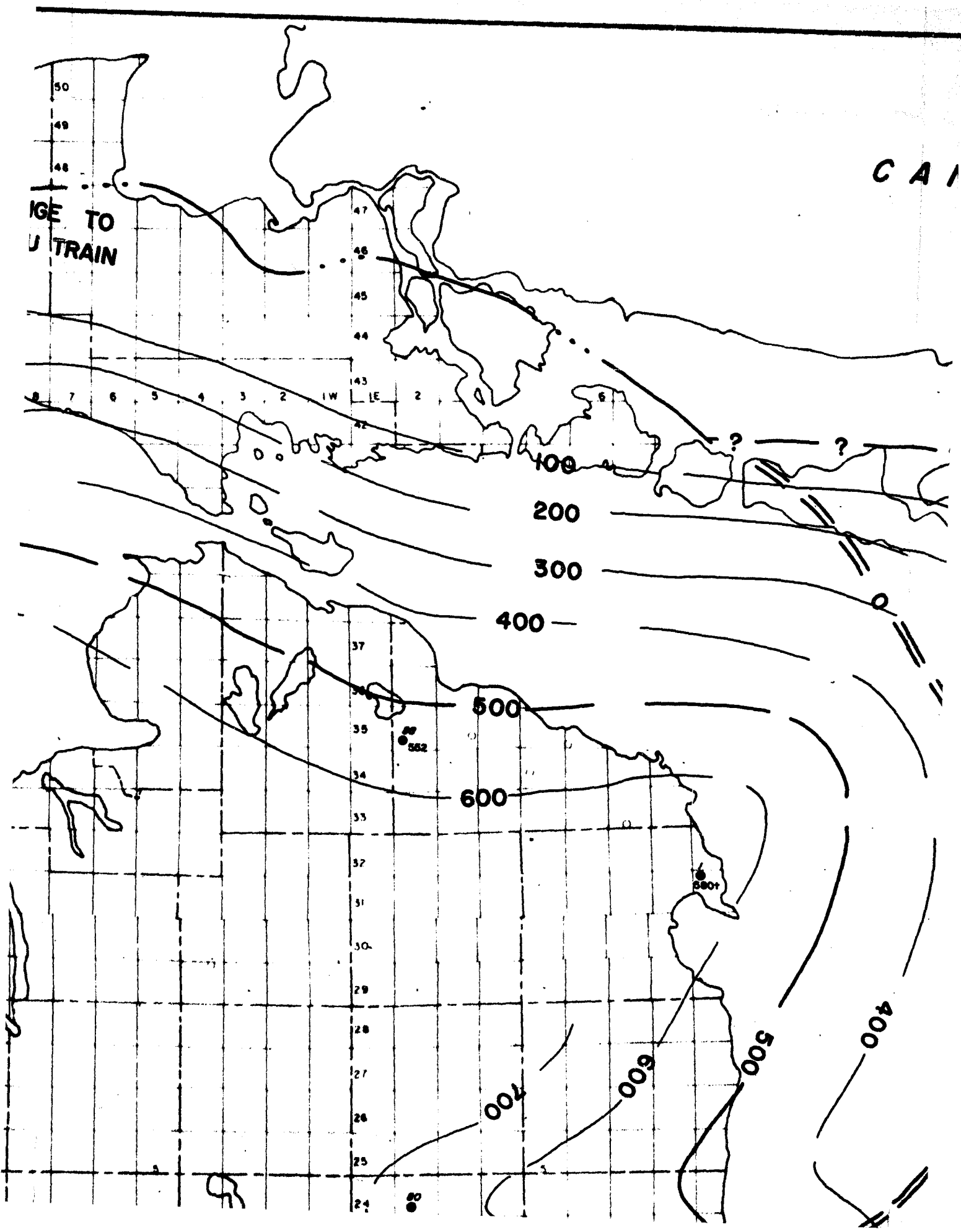


WELL DATA POINT  
CONTOUR INTERVAL = 25 FEET

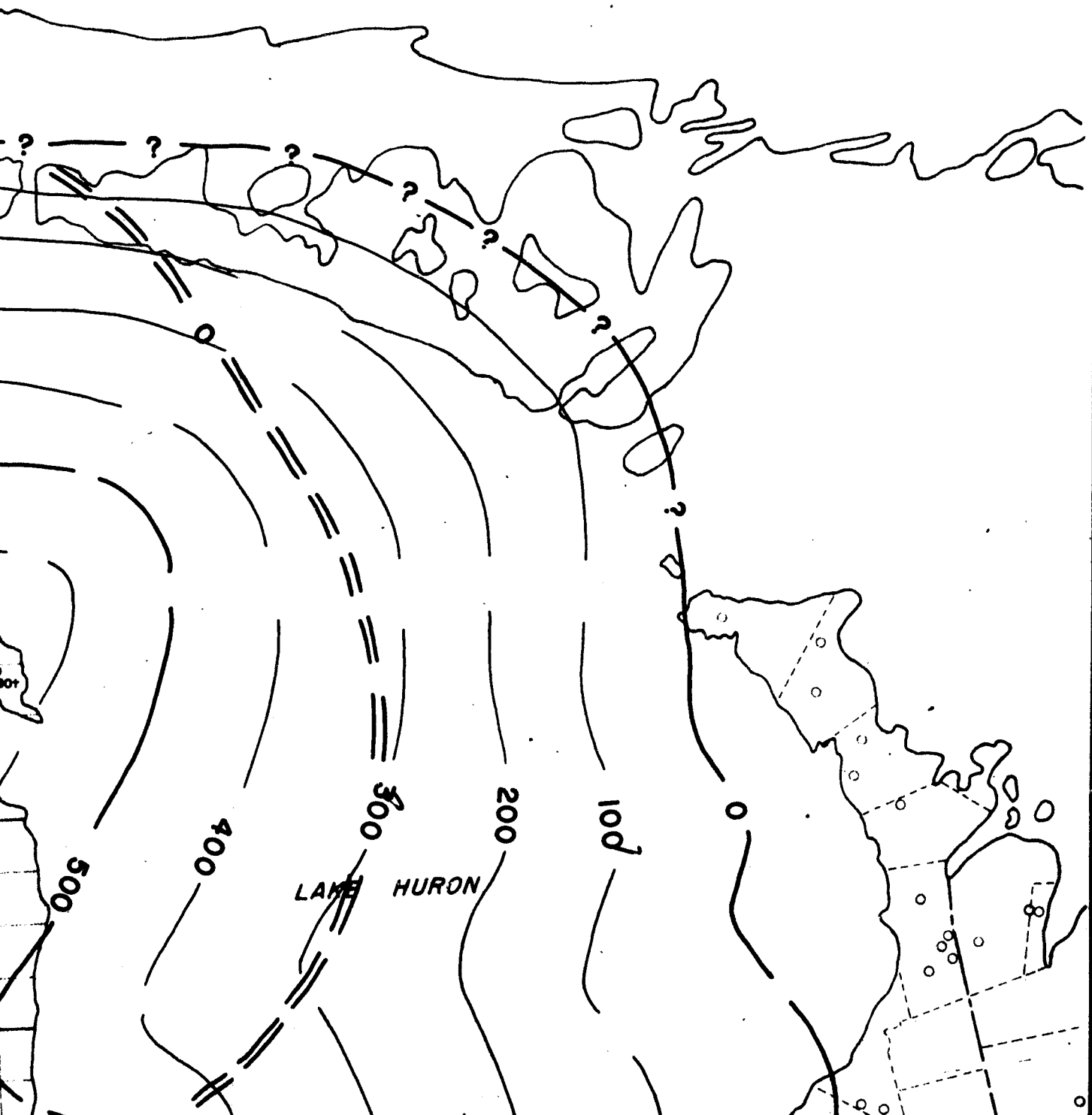
Scale 1:1,000,000

10 0 10 20 miles

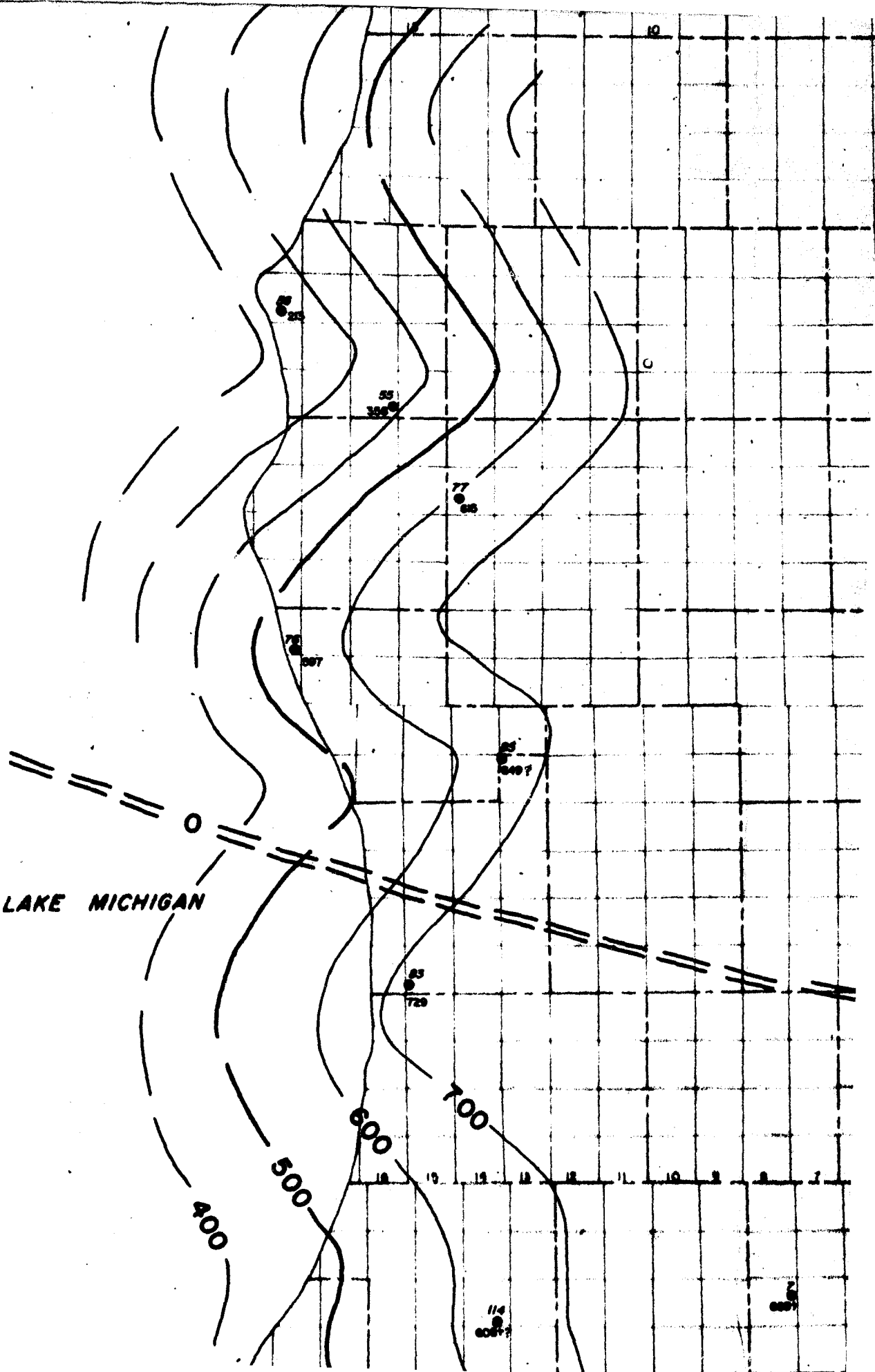


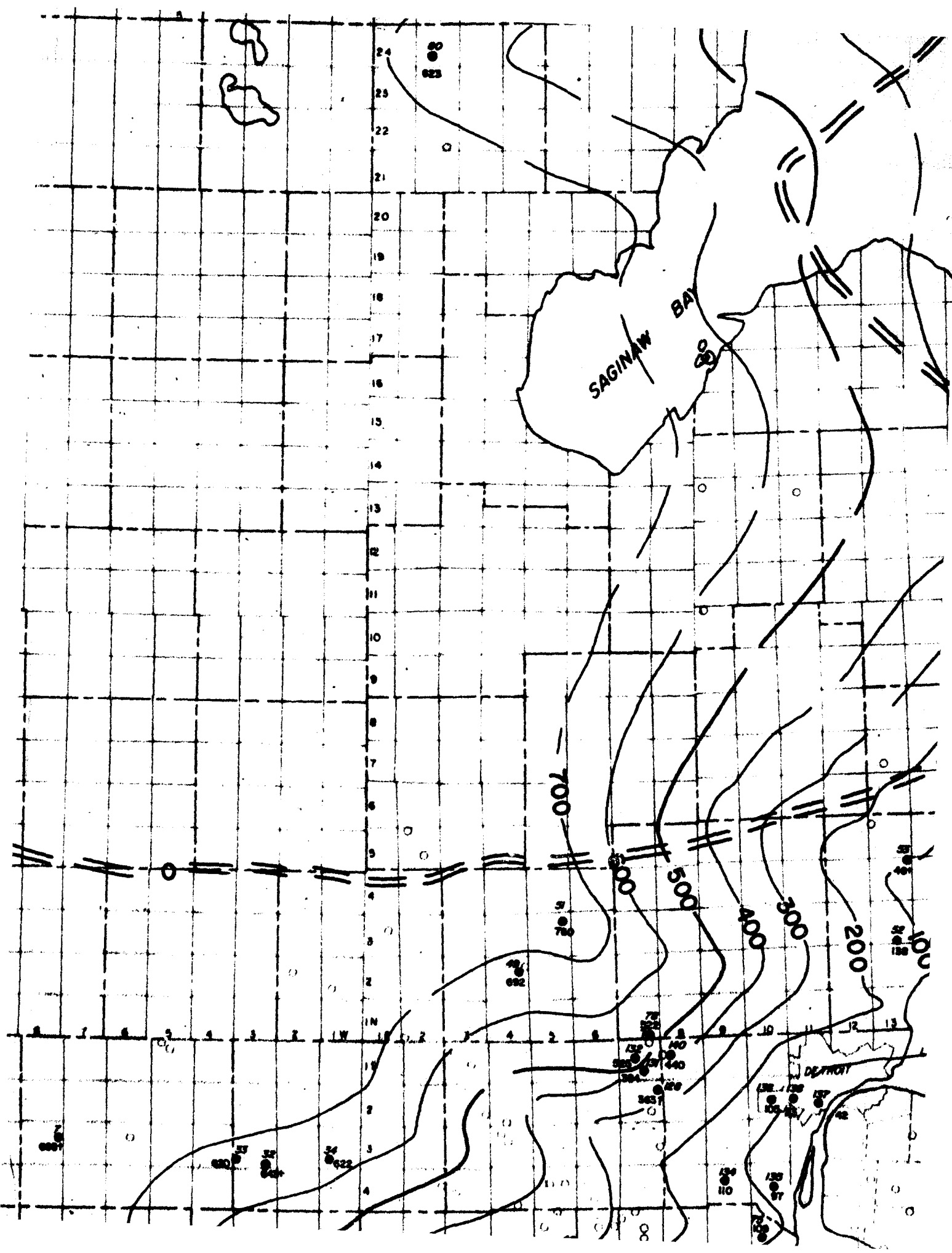


CANADA

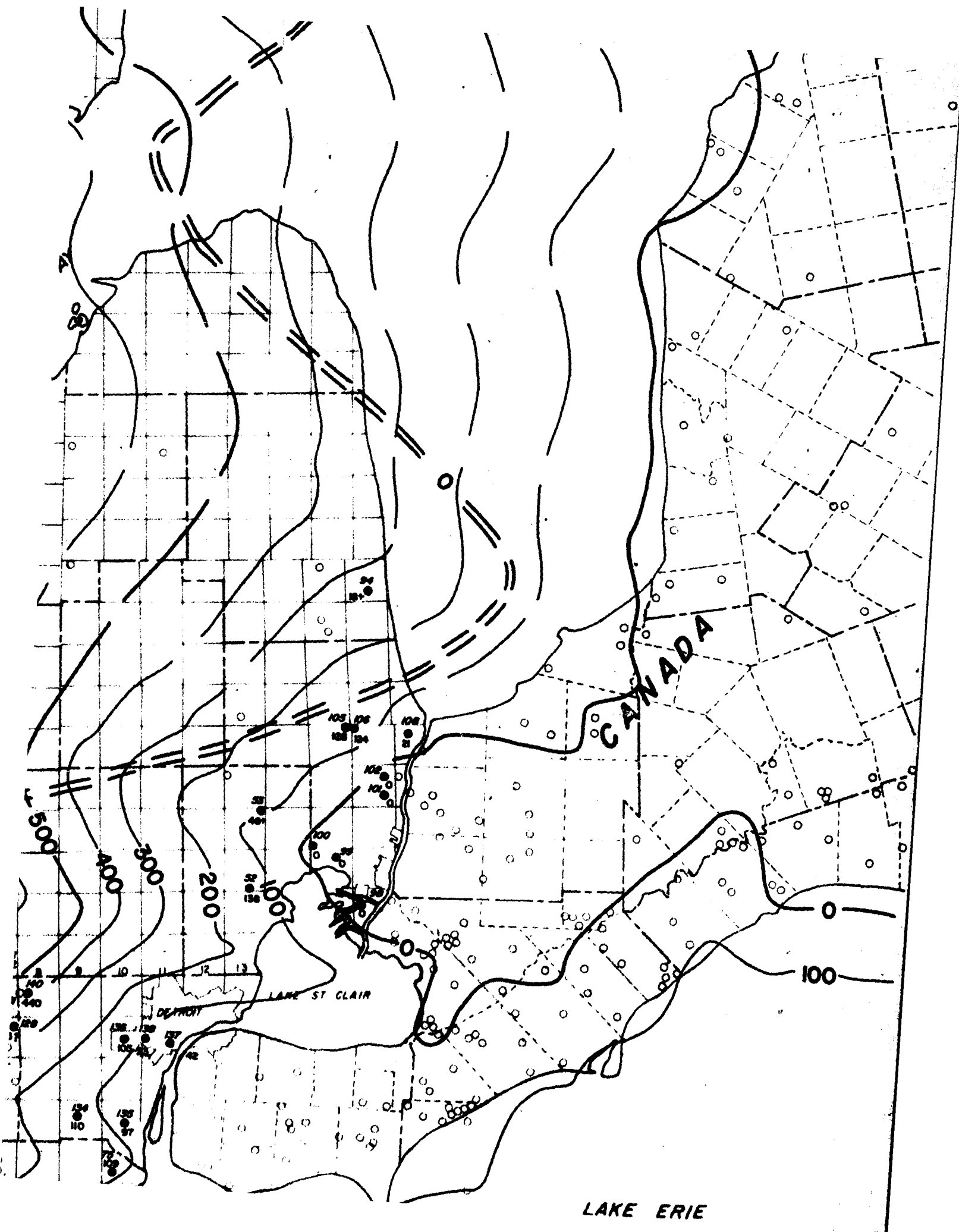


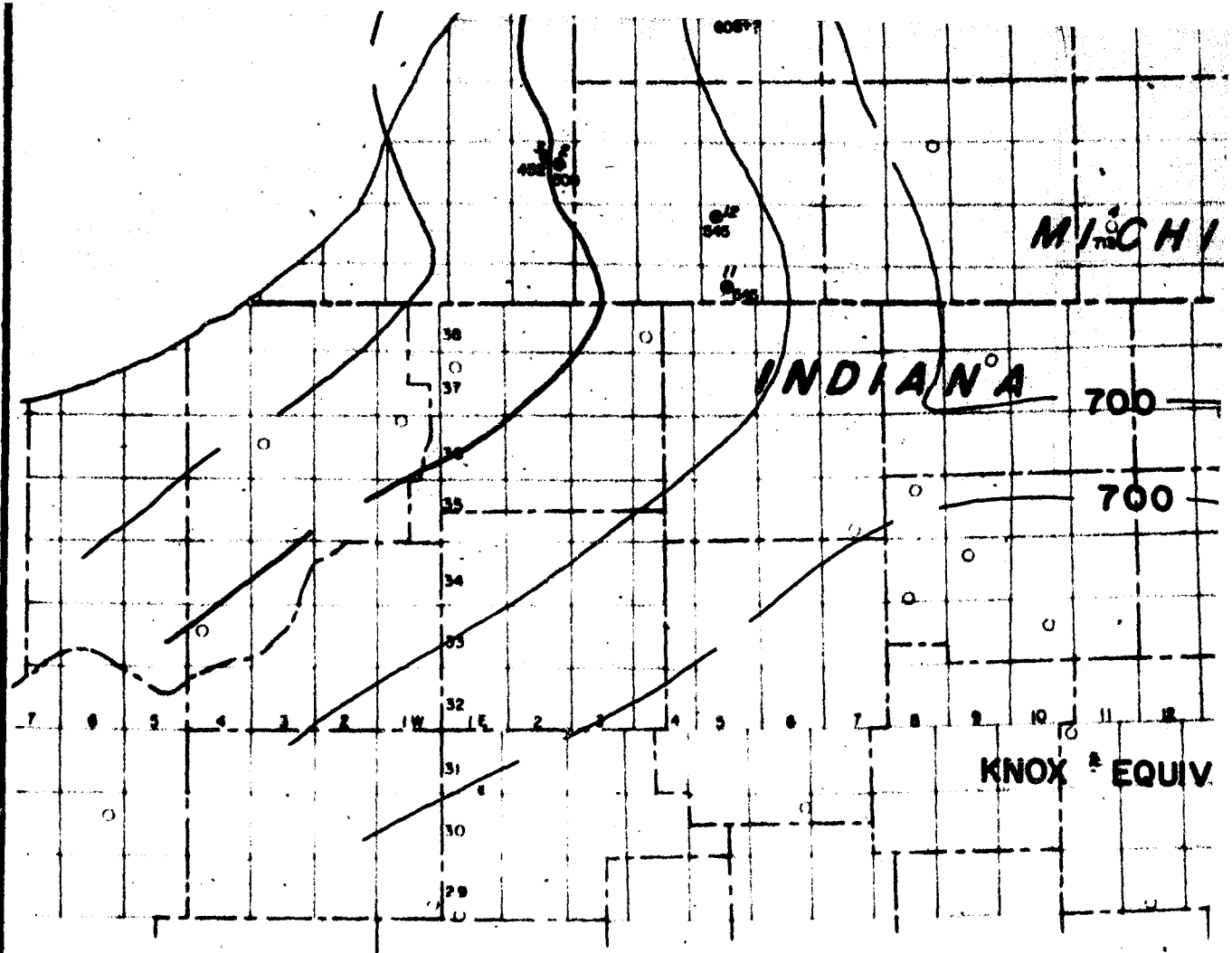
LAKE MICHIGAN











PAUL A CATACOSINOS  
1972

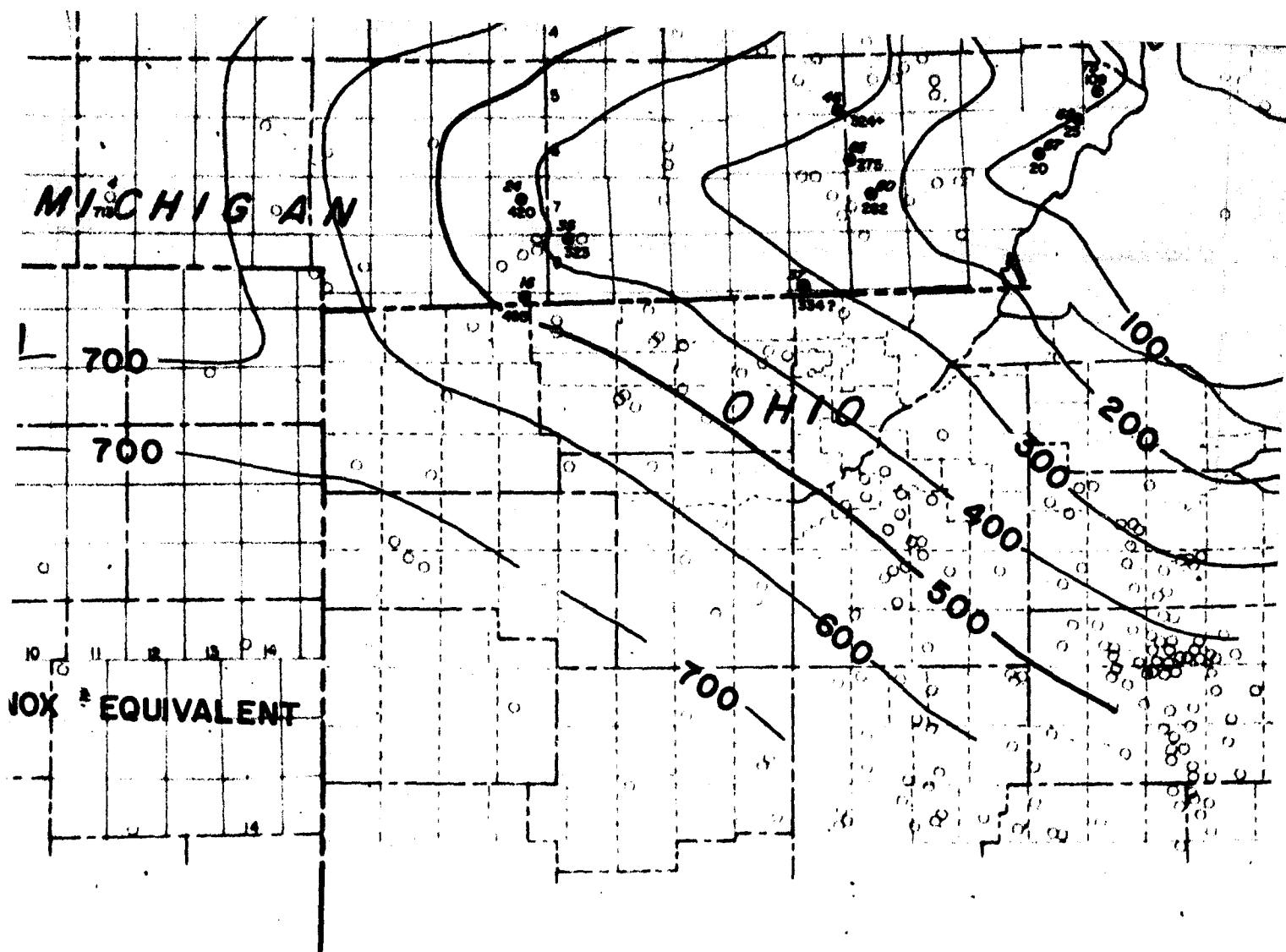
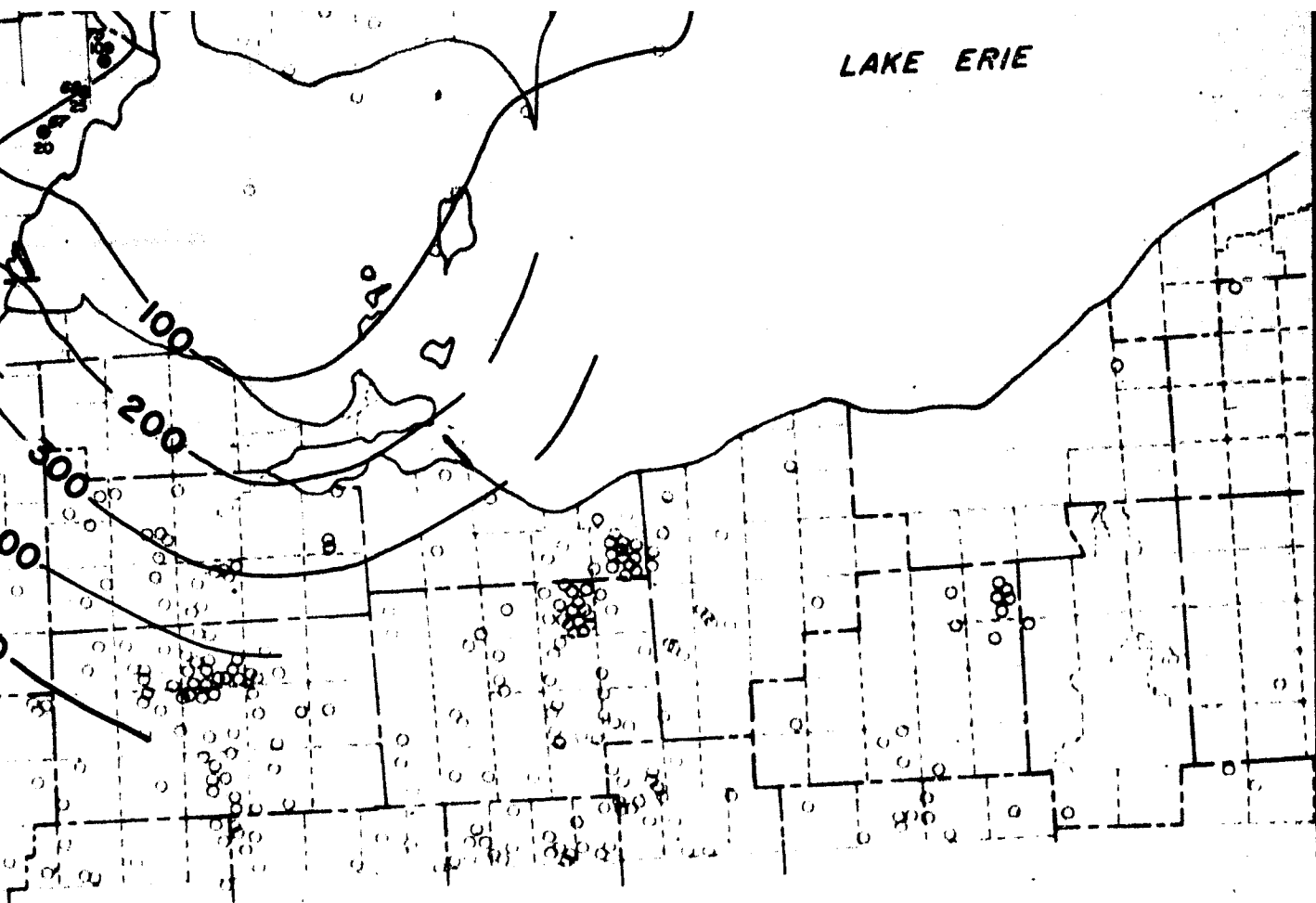


PLATE 7

ISOPACH MAP OF THE  
ST. LAWRENCE FORMATION



### SOURCES OF DATA

CANADA.....Sanford and Quillion (1959)

UPPER  
PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

OHIO.....J.H. Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
Emrich (1966)

**Edge of Jordan Sandstone**



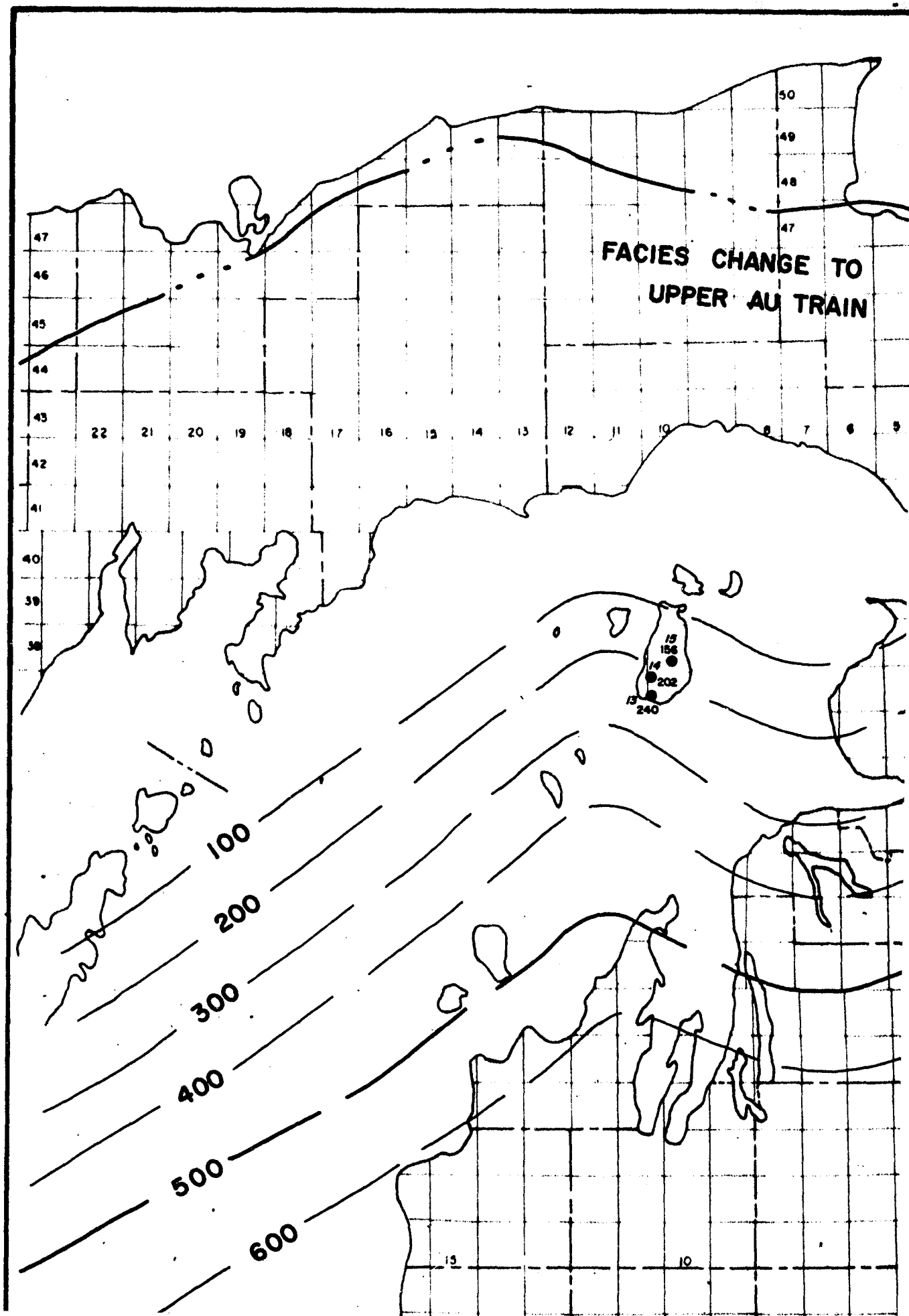
**Eroded Edge of Au Train Formation**



80  
206 WELL DATA POINT  
CONTOUR INTERVAL = 100 FEET

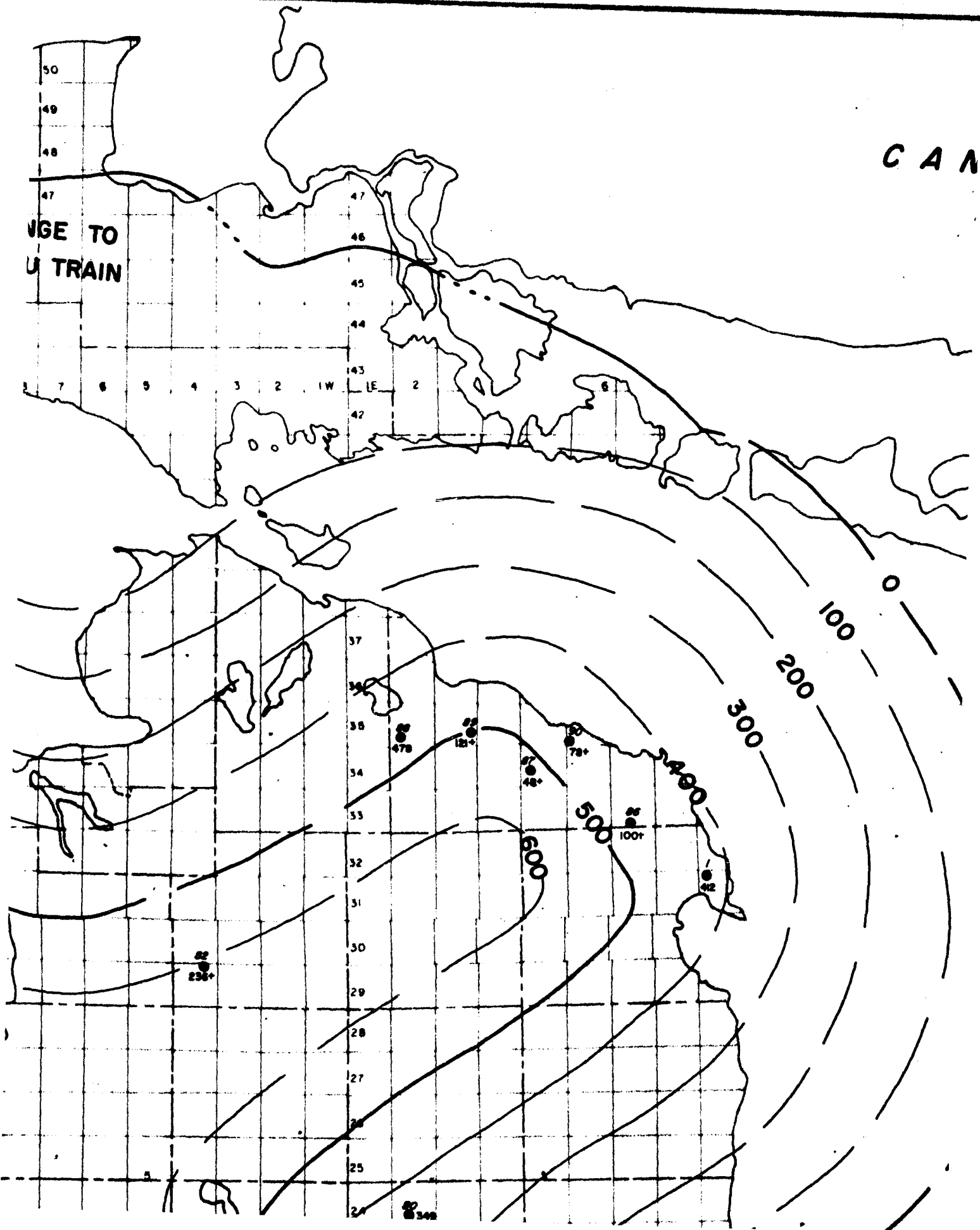
Scale 1:1,000,000



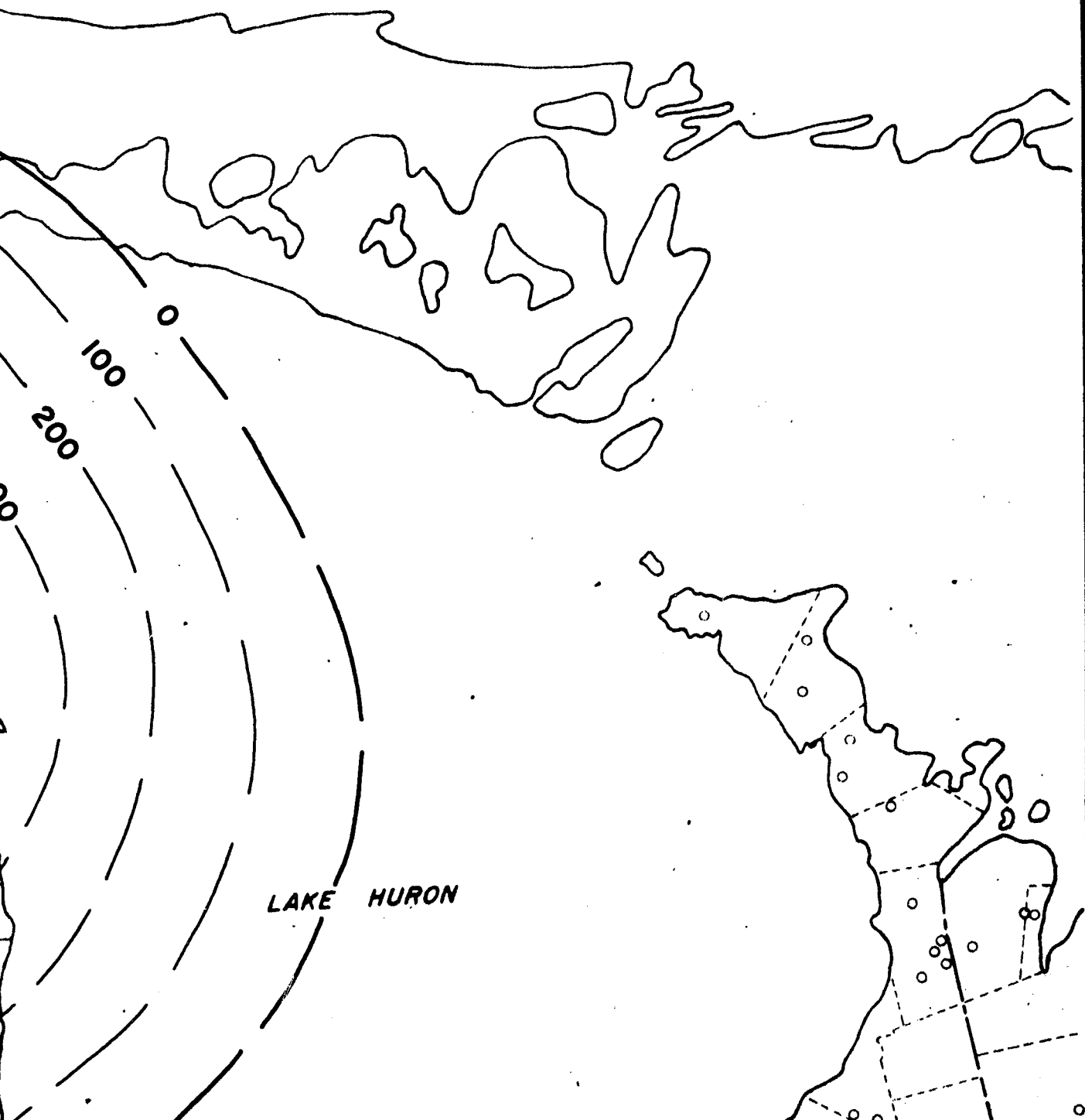


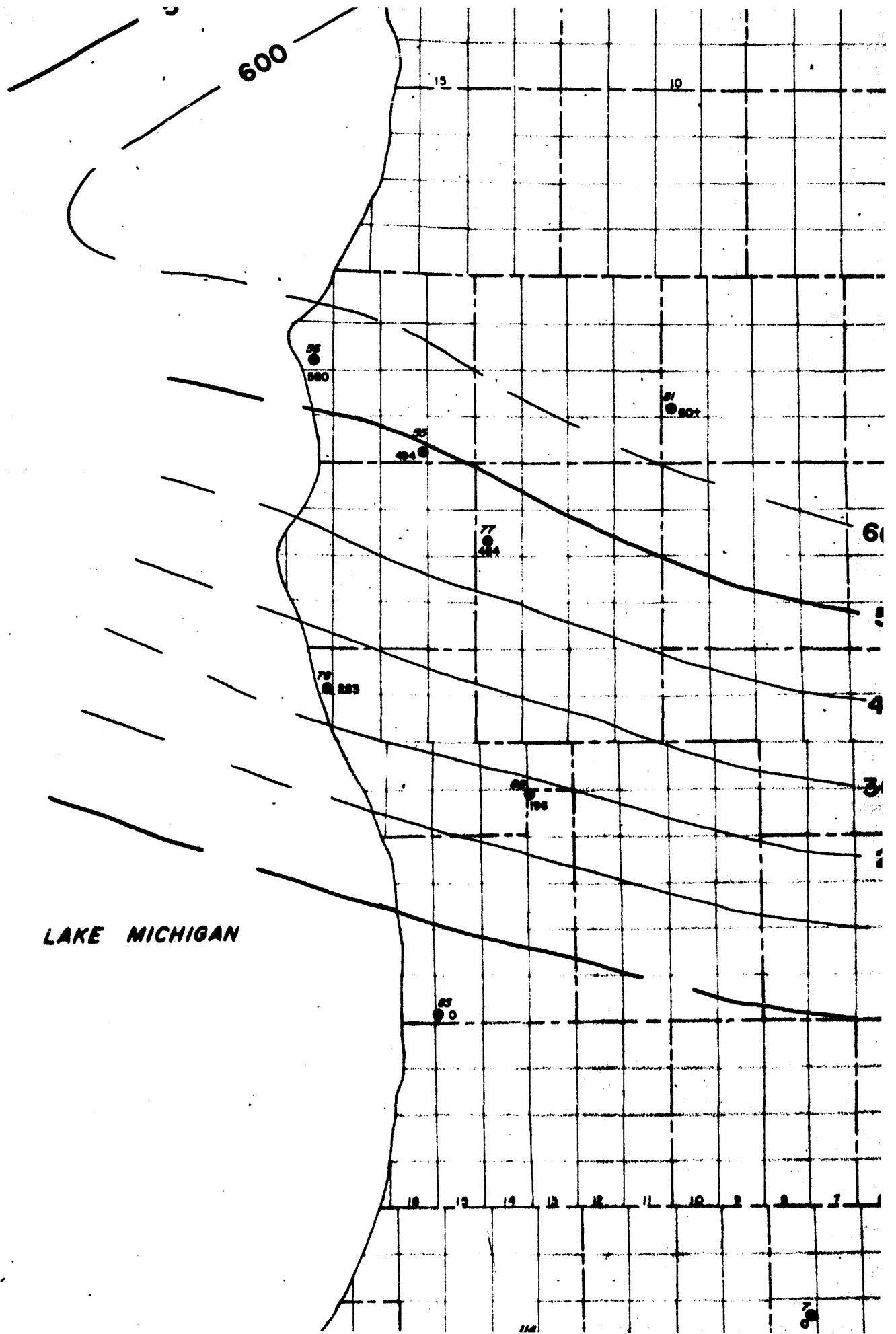
C A N

UGE TO  
U TRAIN

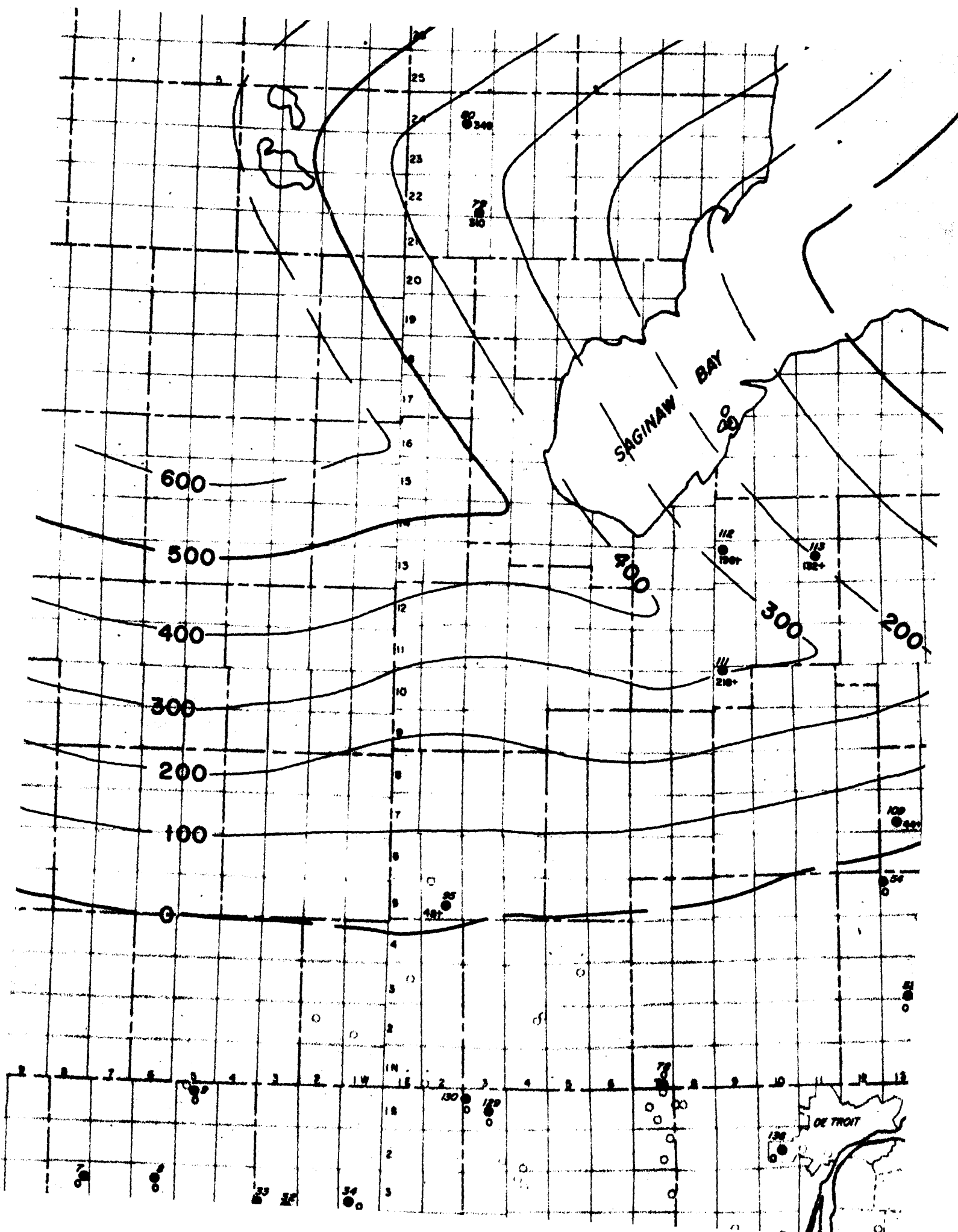


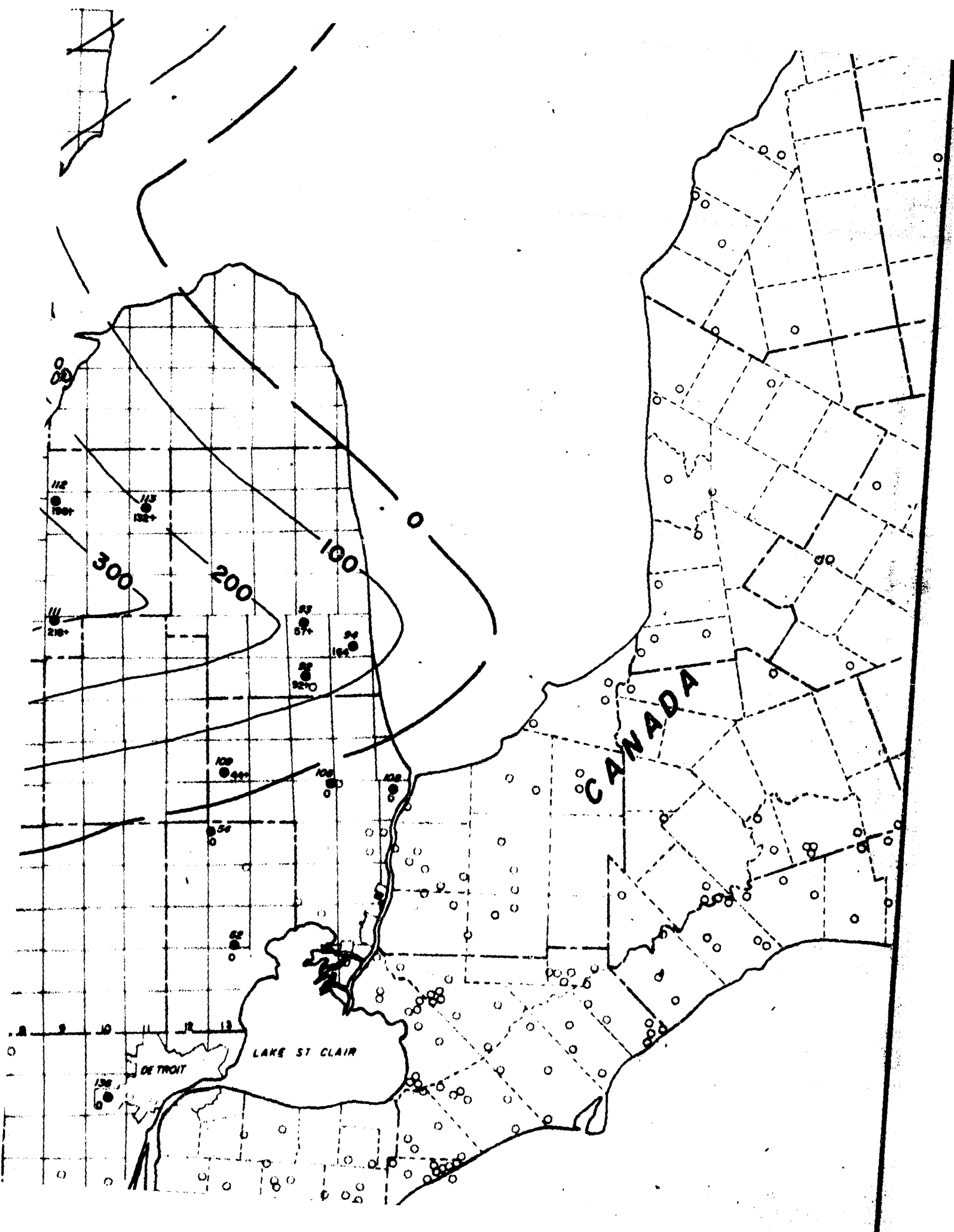
CANADA

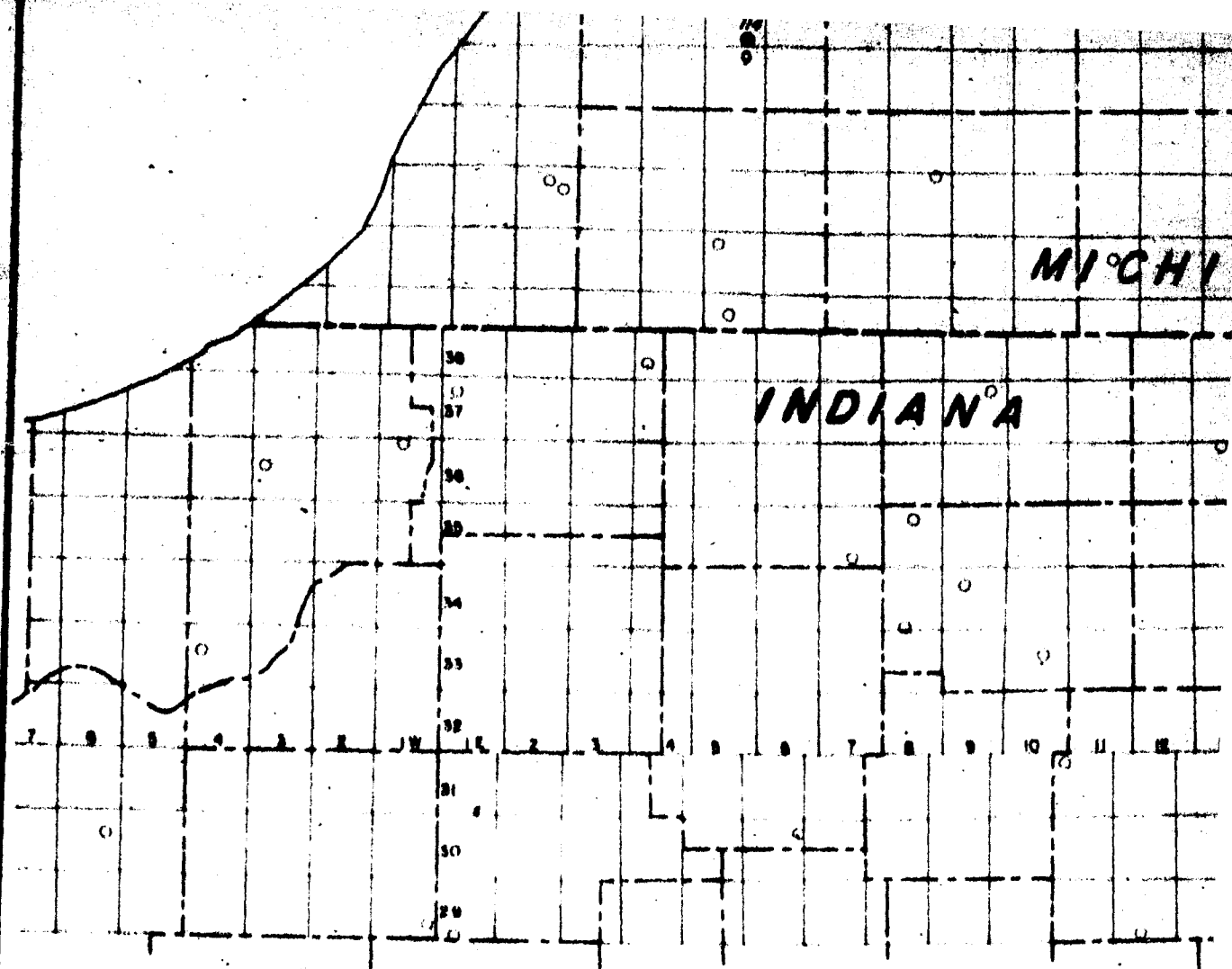




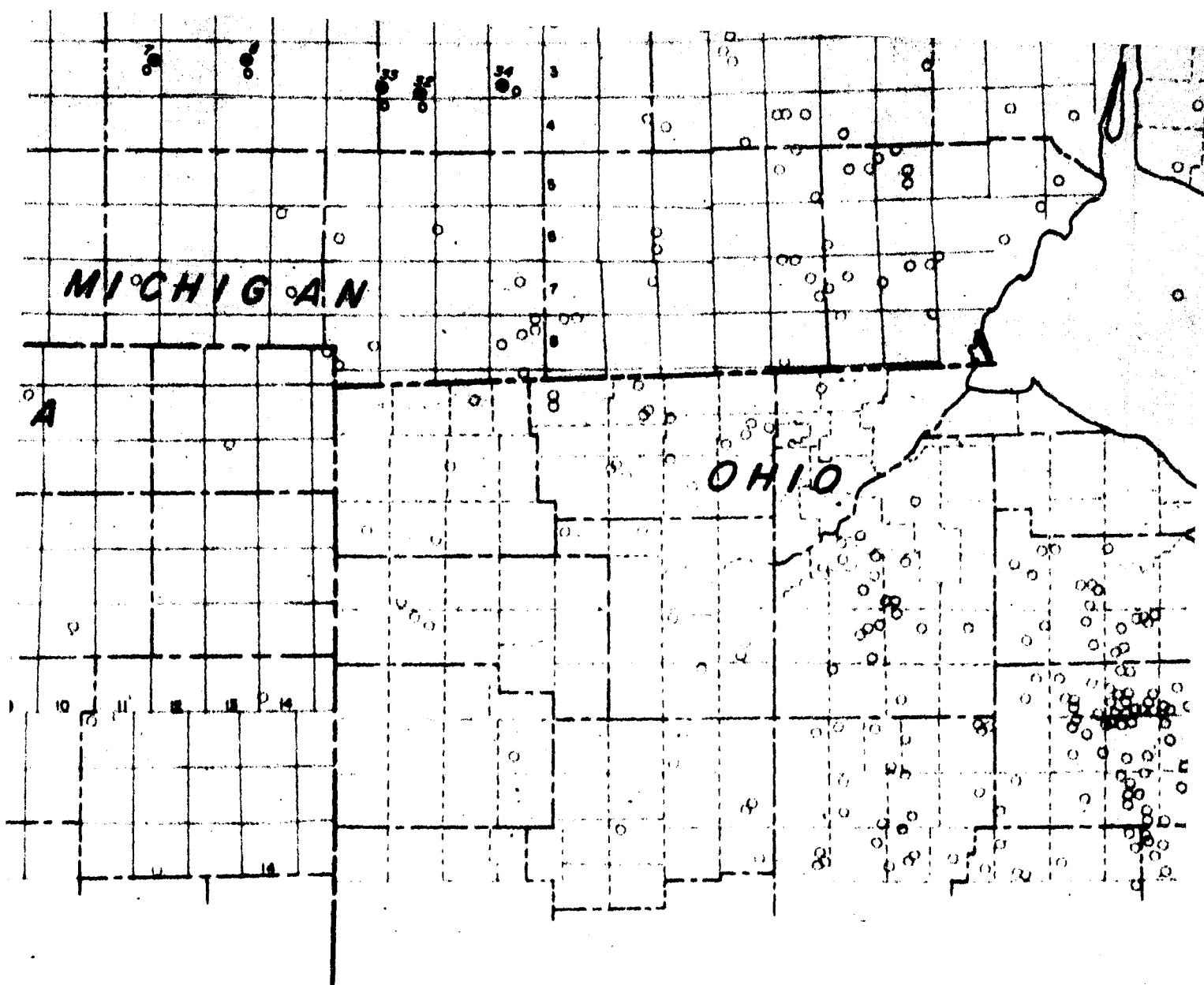






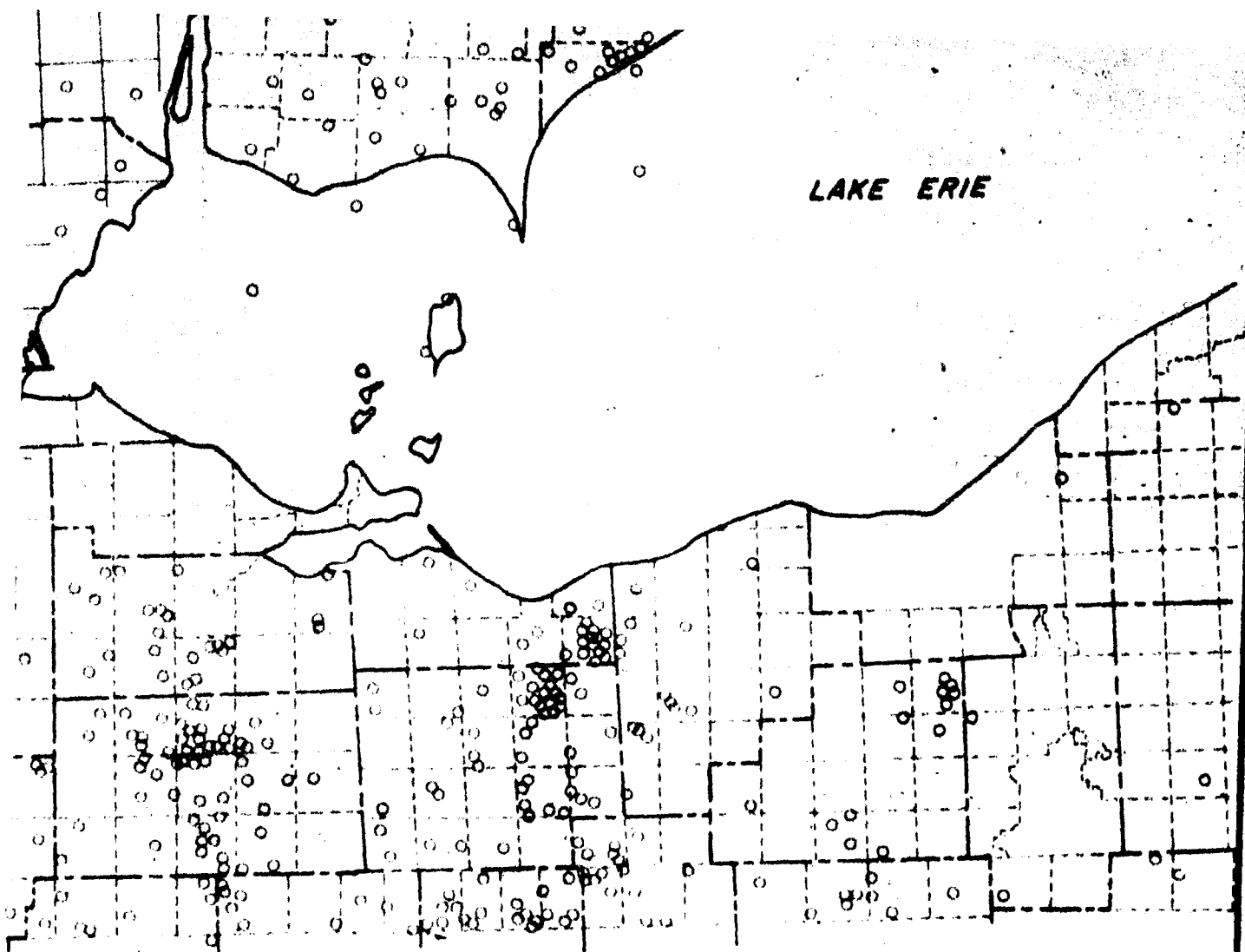


PAUL A CATACOSINOS  
1972



**PLATE 8**

**ISOPACH MAP OF THE  
JORDAN SANDSTONE**



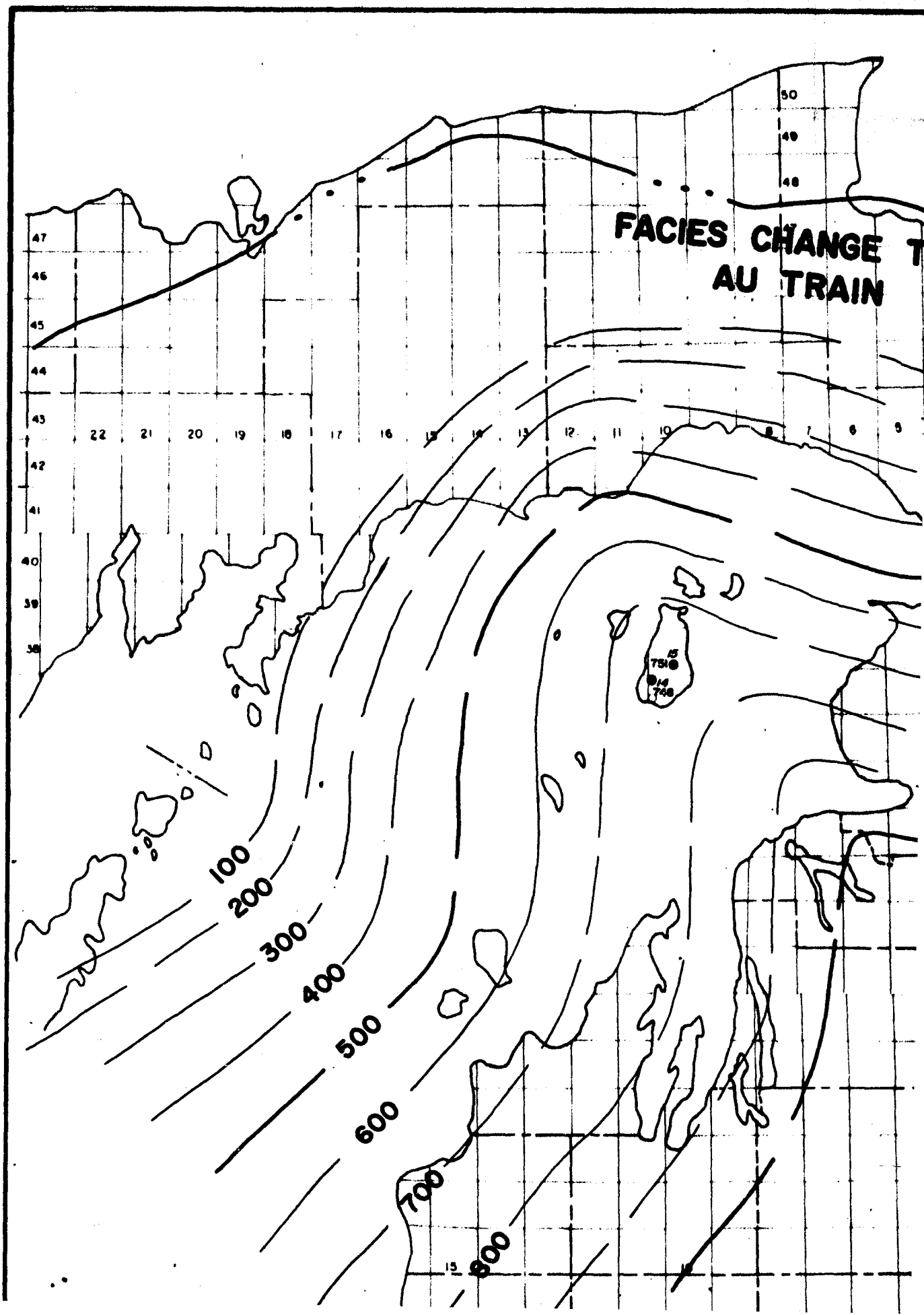
### SOURCES OF DATA

- CANADA.....Sanford and Quillian (1959)
- UPPER  
PENINSULA .....Hamblin (1958)
- INDIANA.....Gutstadt (1958)  
Dawson (1960)
- OHIO.....J.H. Fisher (Unpublished)
- ILLINOIS.....Buschbach (1964)  
Emrich (1966)

**Eroded Edge of Au Train Formation**

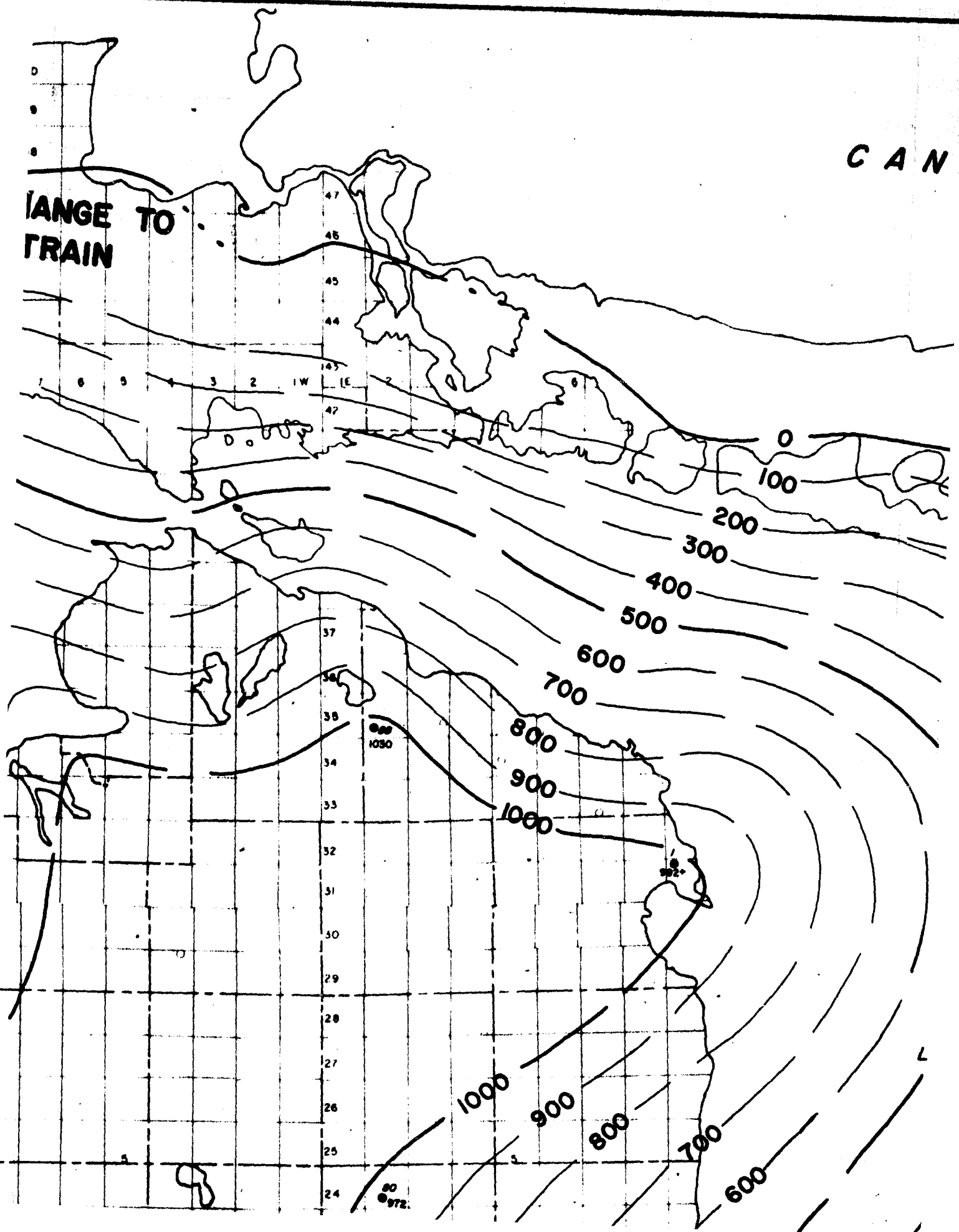
80  
206 WELL DATA POINT  
CONTOUR INTERVAL = 100 FEET  
Scale 1:1,000,000

10 0 10 20 miles

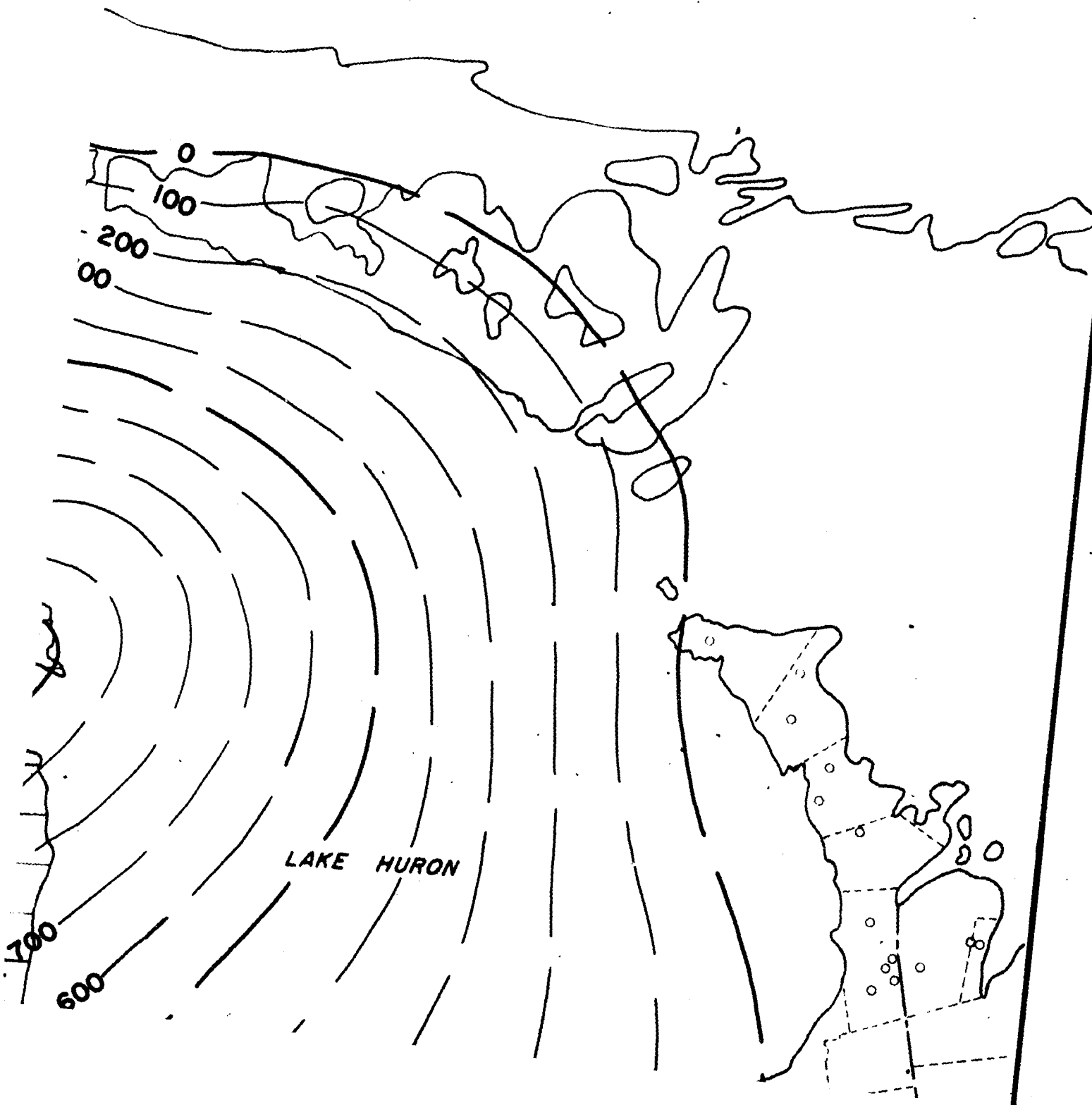


CAN

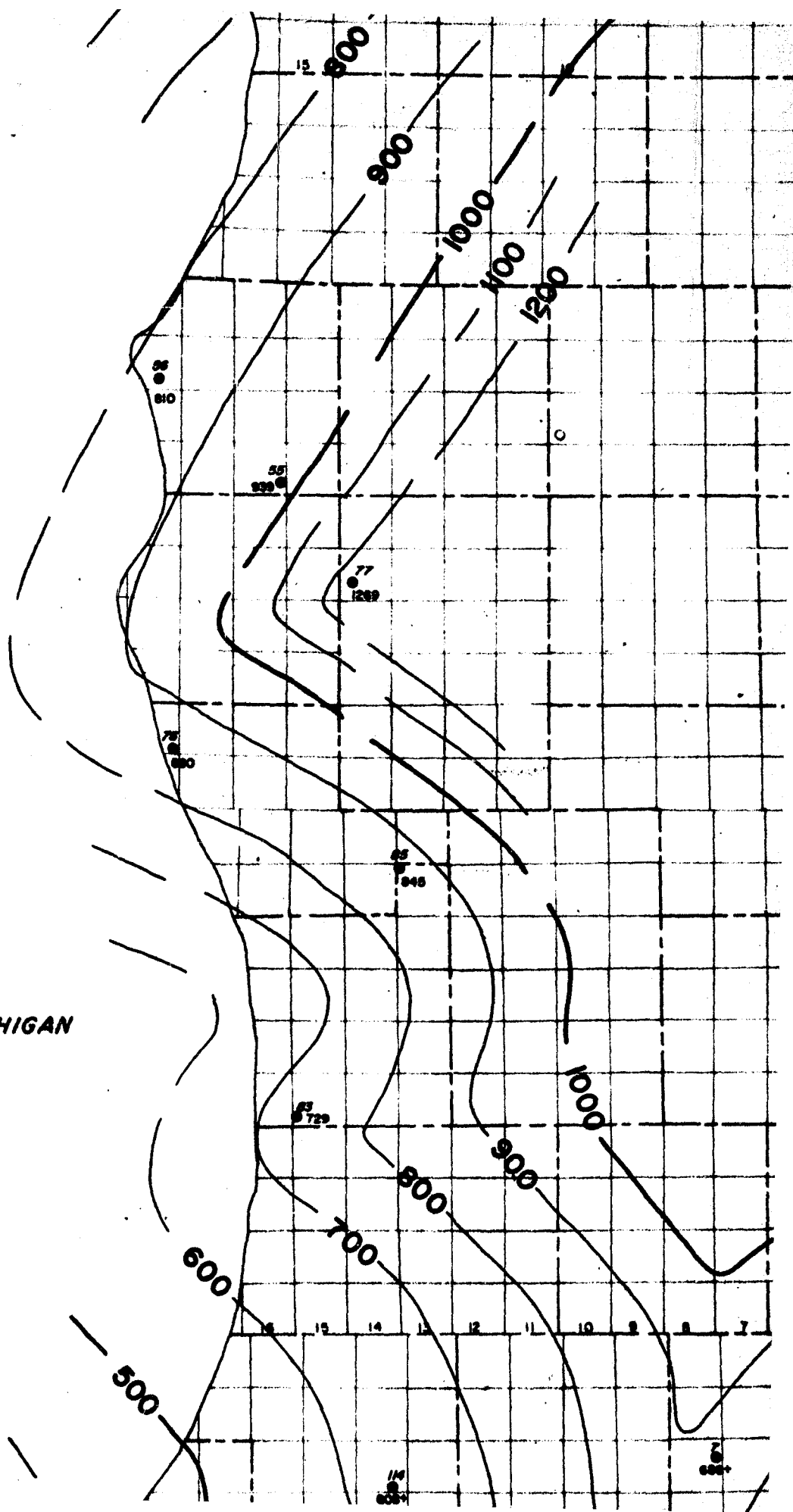
CHANGE TO  
TRAIN

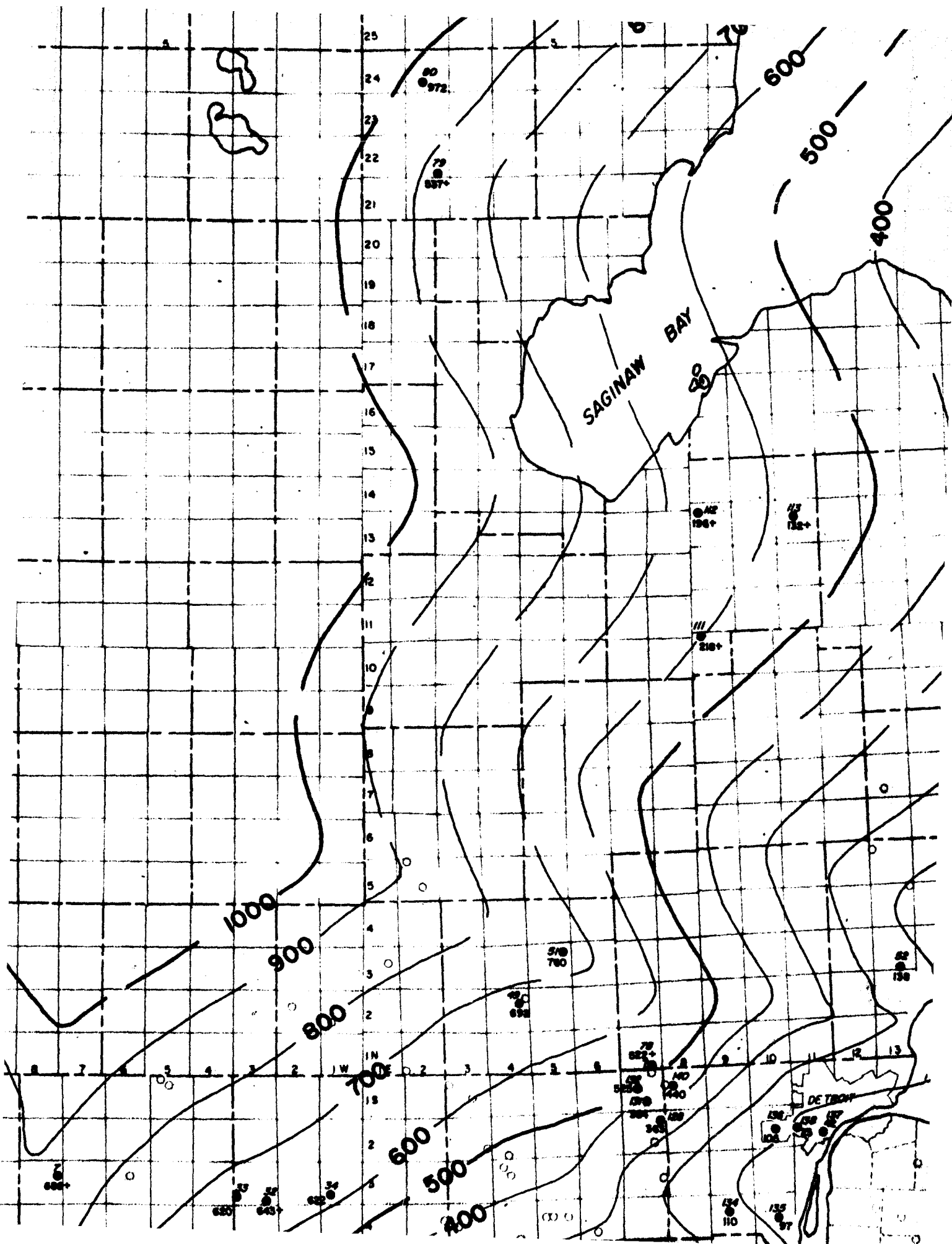


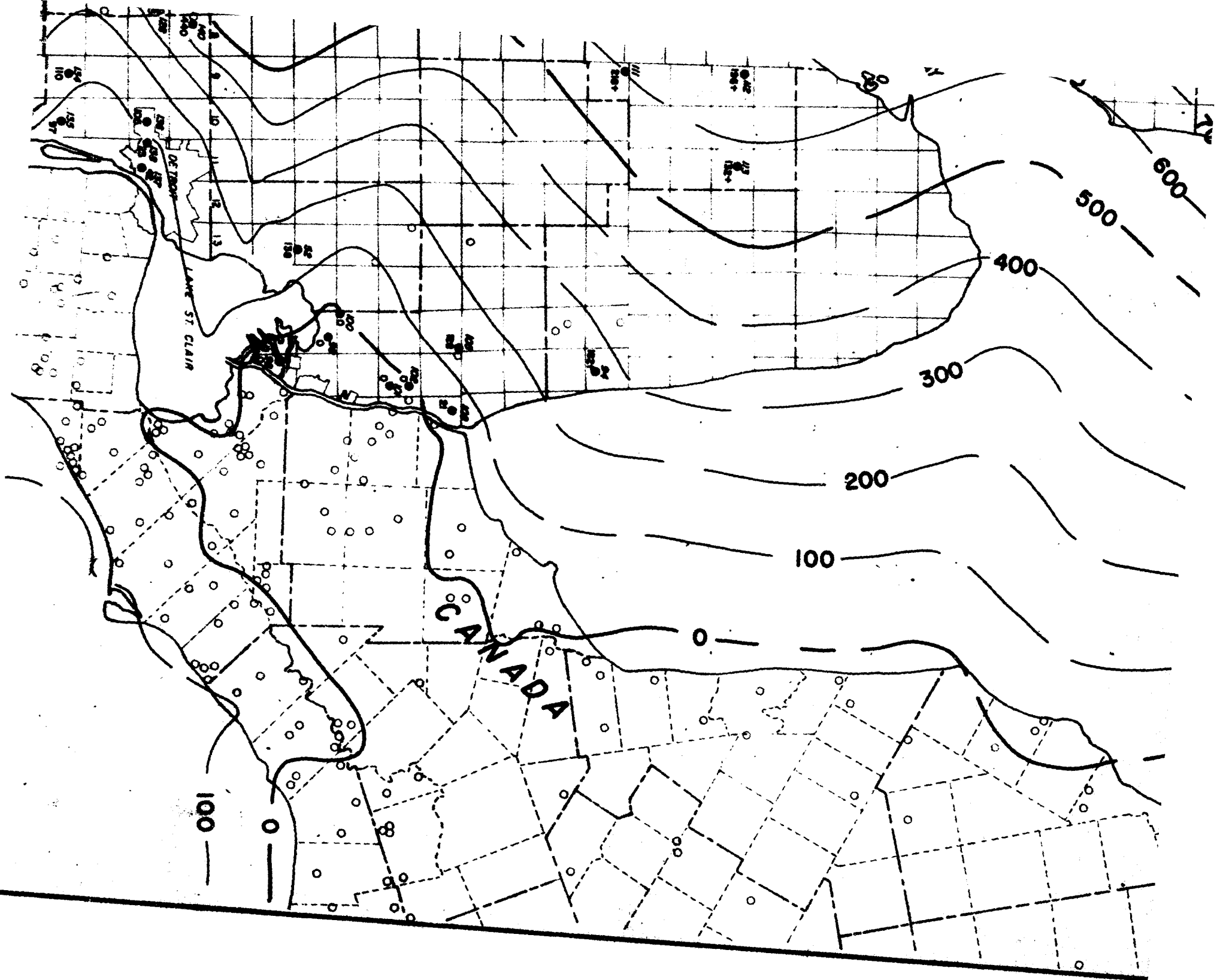
CANADA

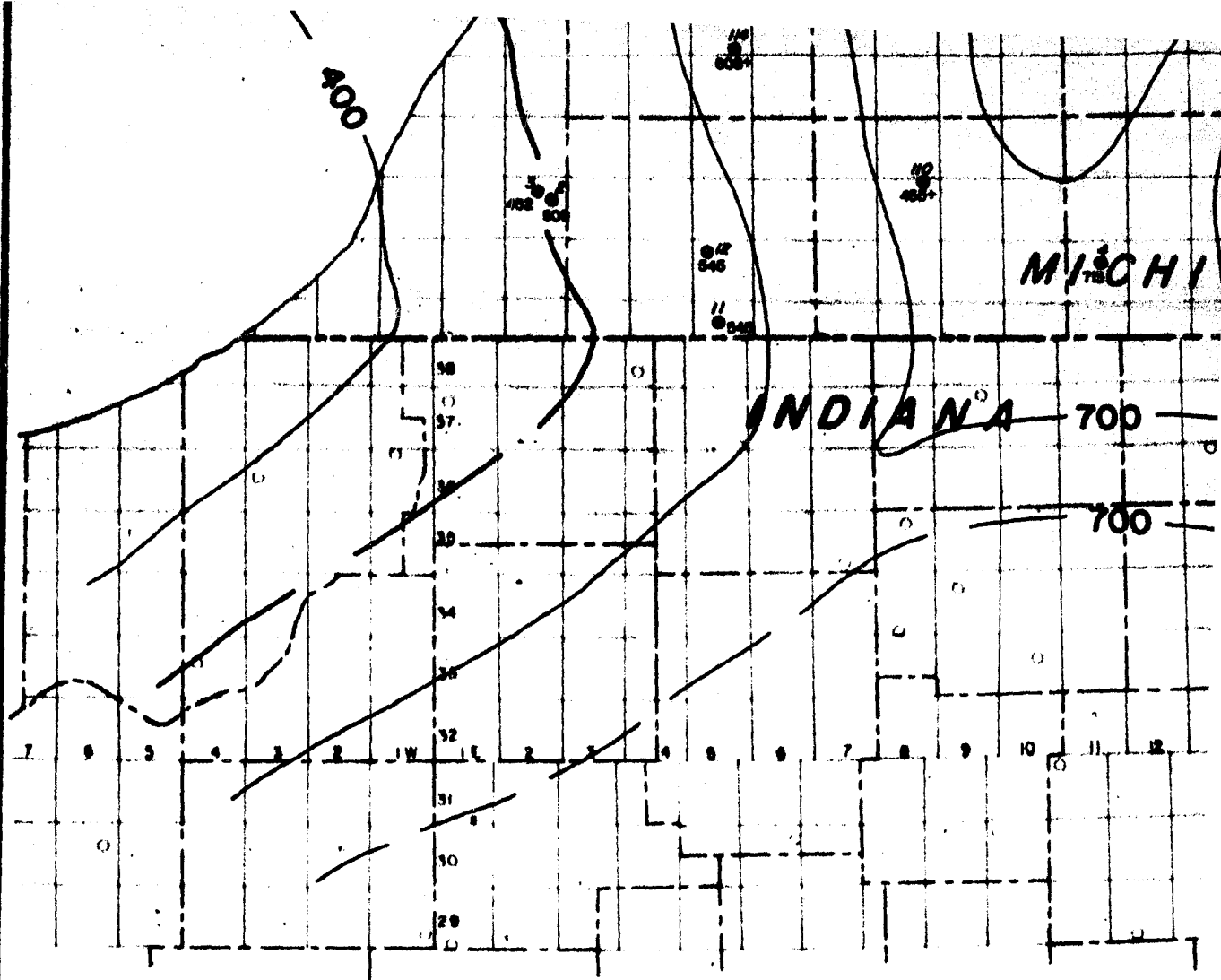






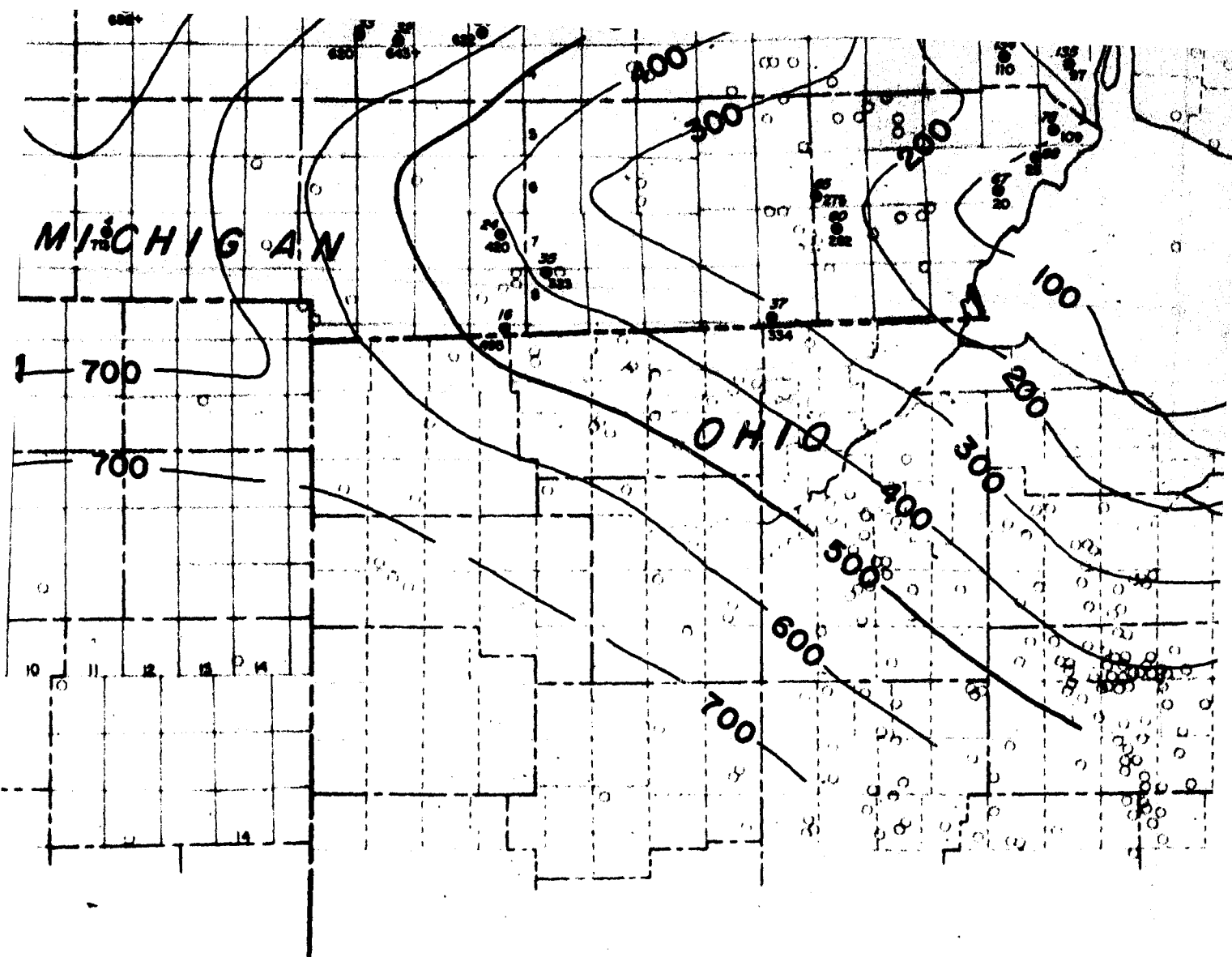






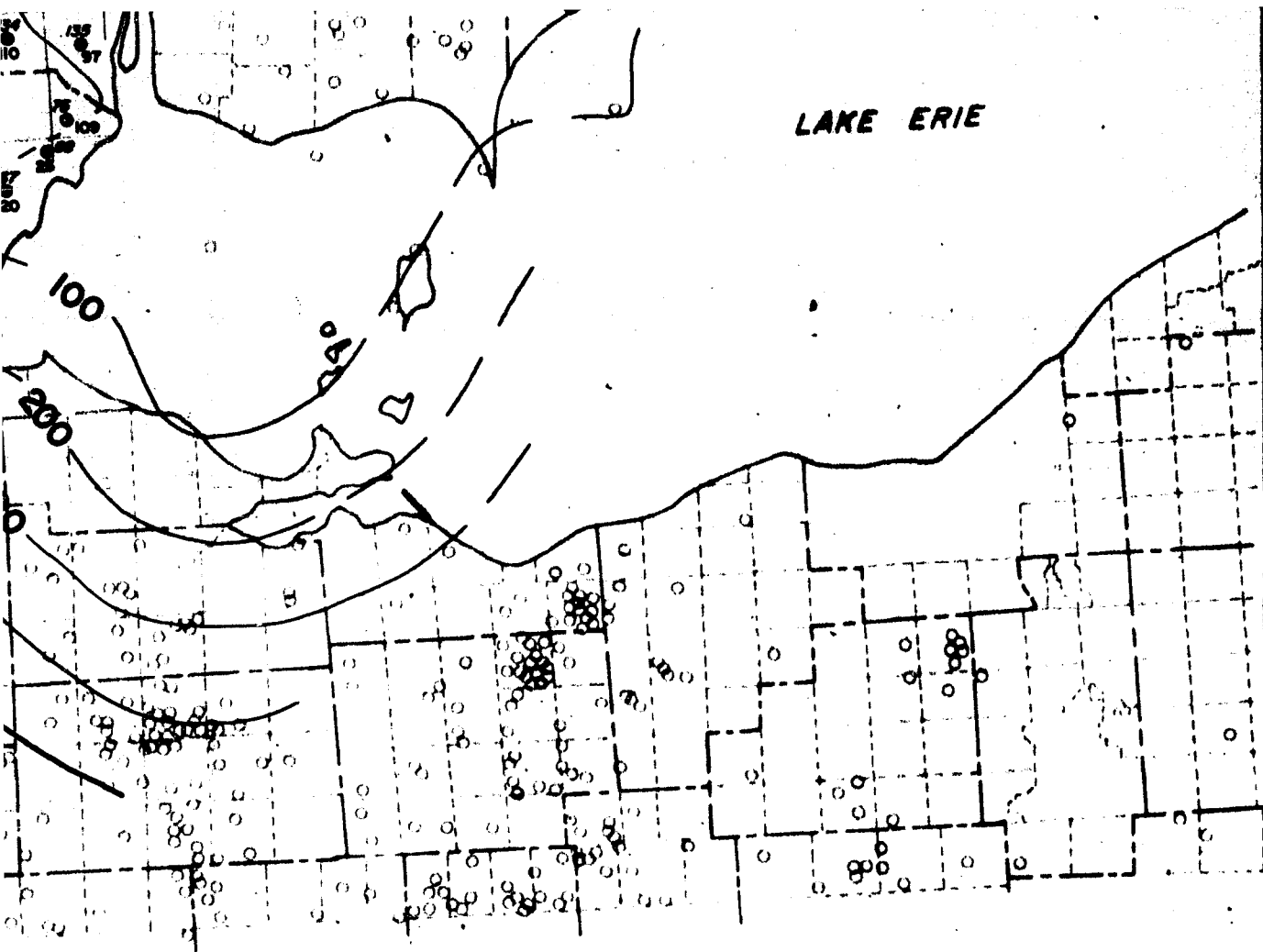
PAUL A CATACOSINOS  
1972

A



**PLATE 9**

**ISOPACH MAP OF THE  
COMBINED JORDAN, "LODI,"  
AND ST. LAWRENCE FORMATIONS**



### SOURCES OF DATA

CANADA.....Sanford and Quillian (1959)

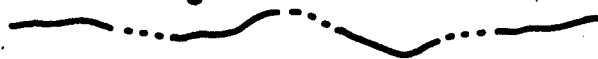
UPPER  
PENINSULA .....Hamblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

OHIO.....J.H. Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
Emrich (1966)

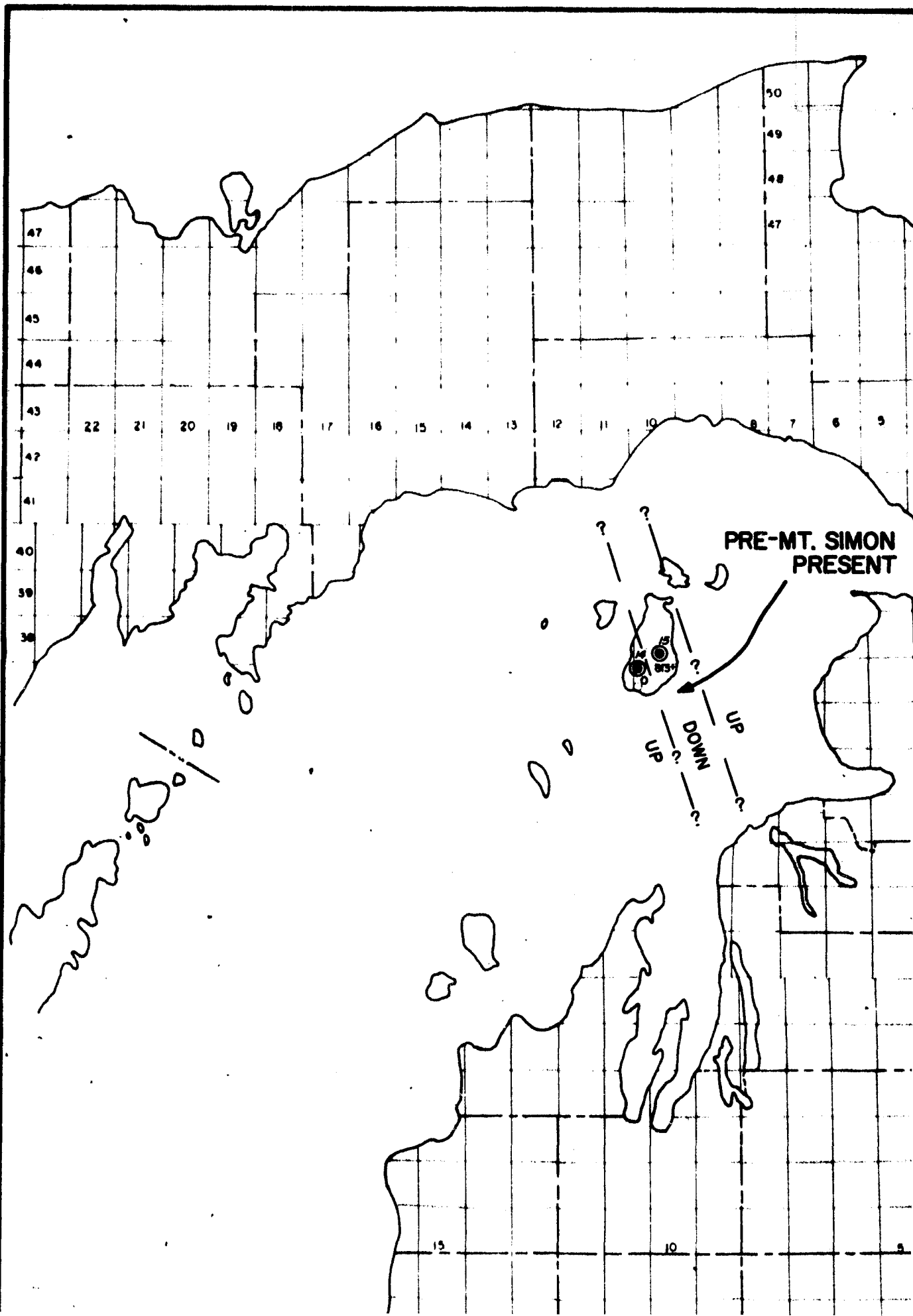
**Eroded Edge of Au Train Formation**

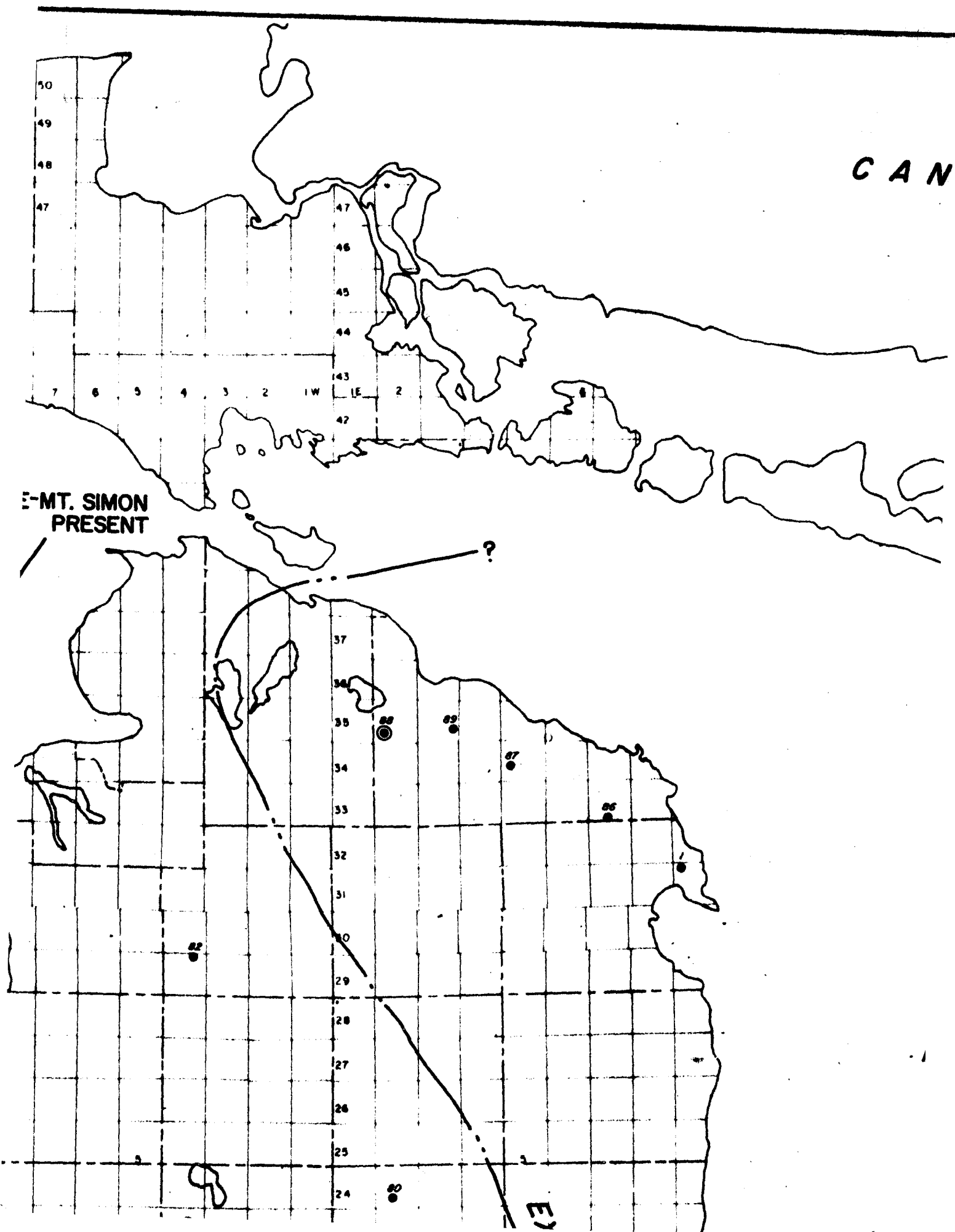


30  
206 WELL DATA POINT  
CONTOUR INTERVAL = 100 FEET

Scale 1:1,000,000

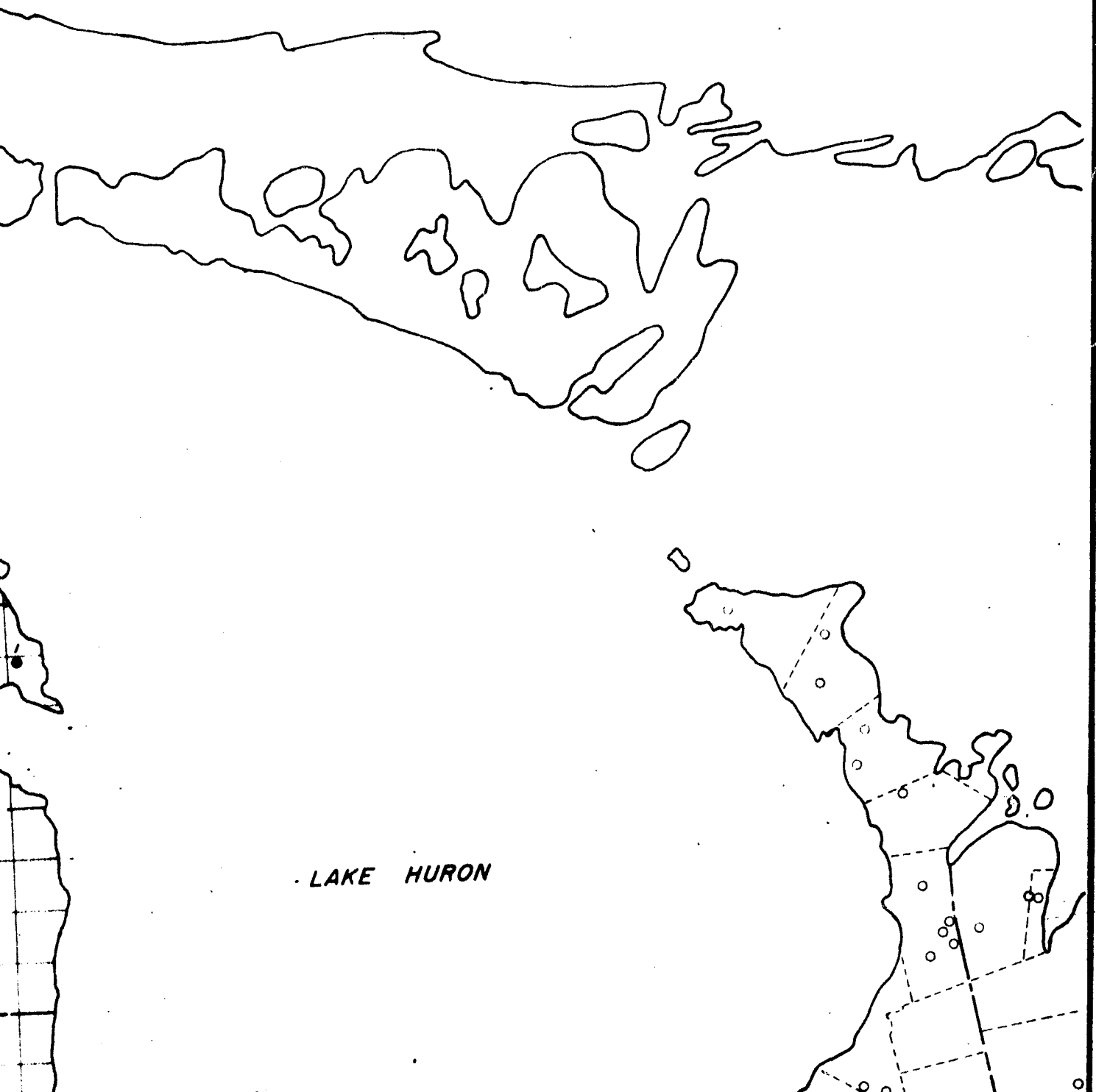
10 0 10 20 miles



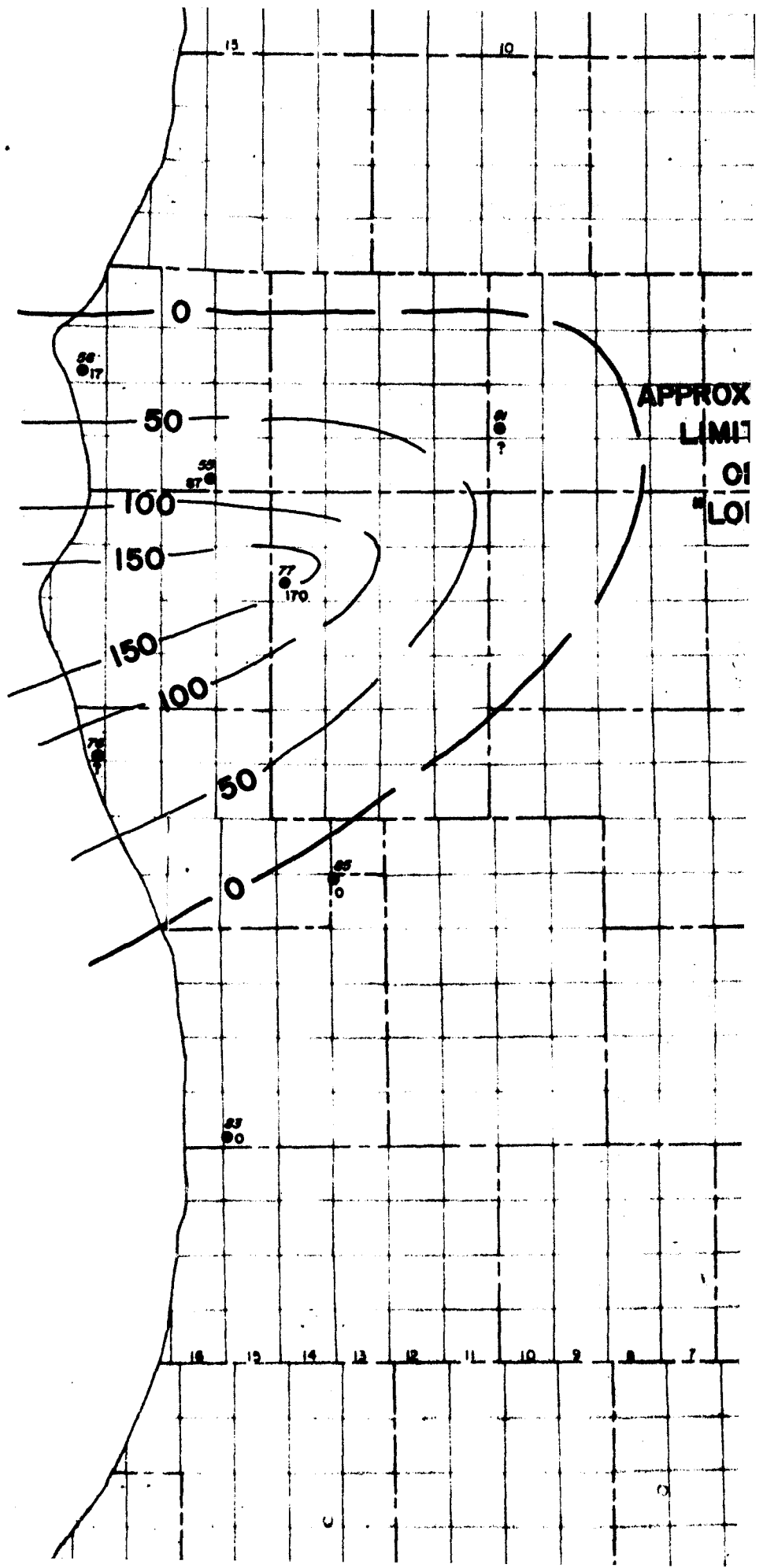




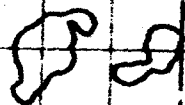
CANADA



LAKE MICHIGAN



APPROXIMATE  
LIMITS  
OF  
"LODI"

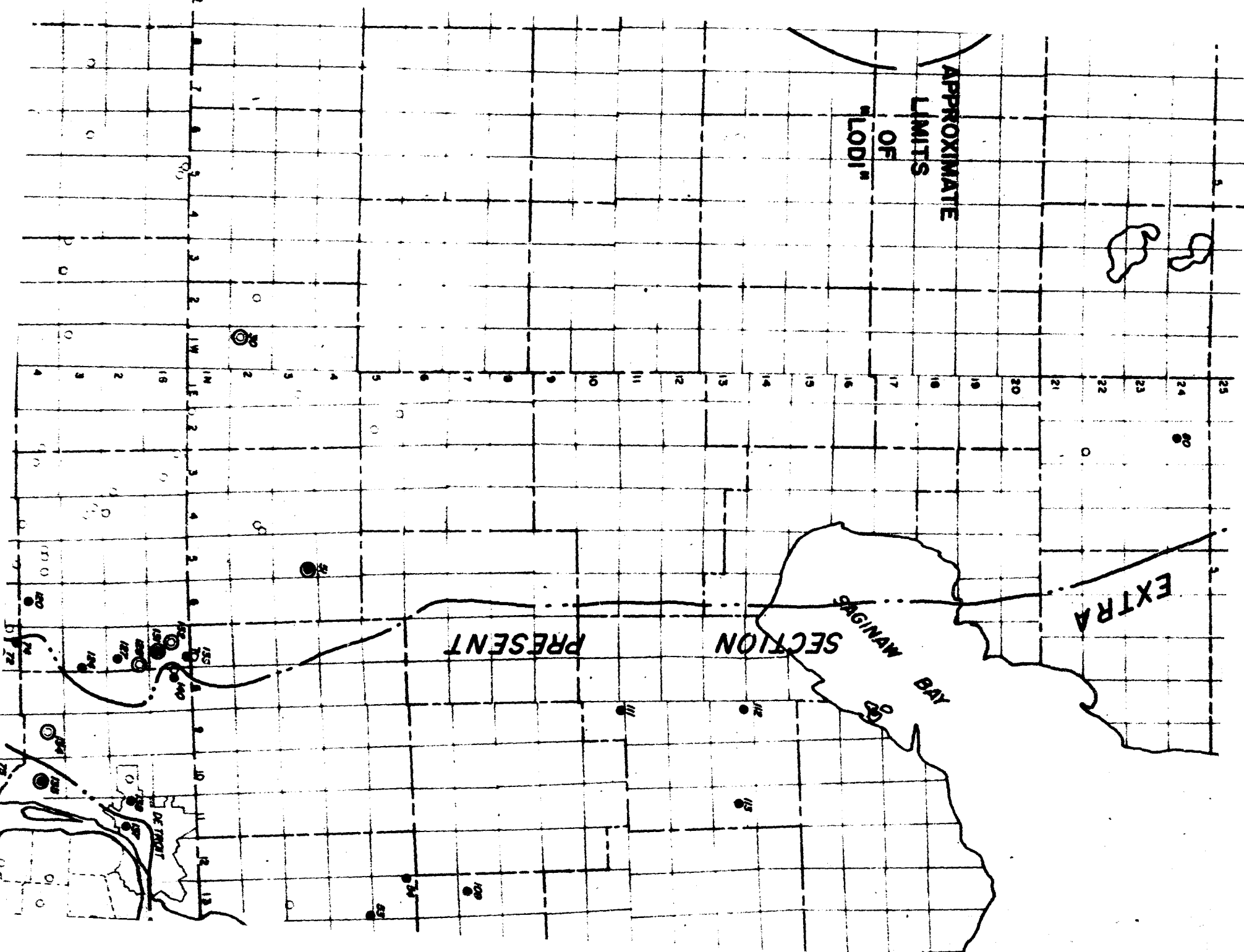


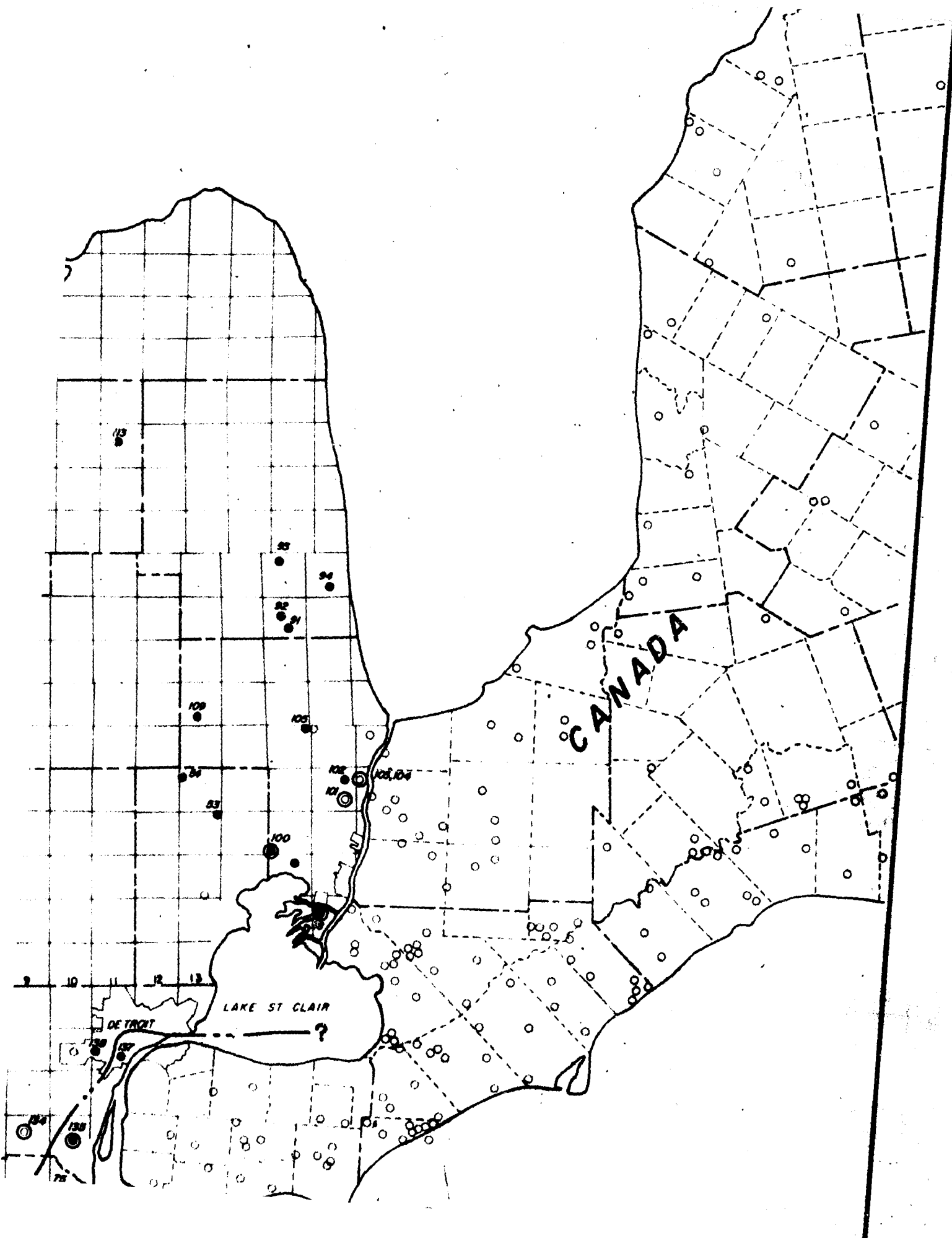
EXTRA

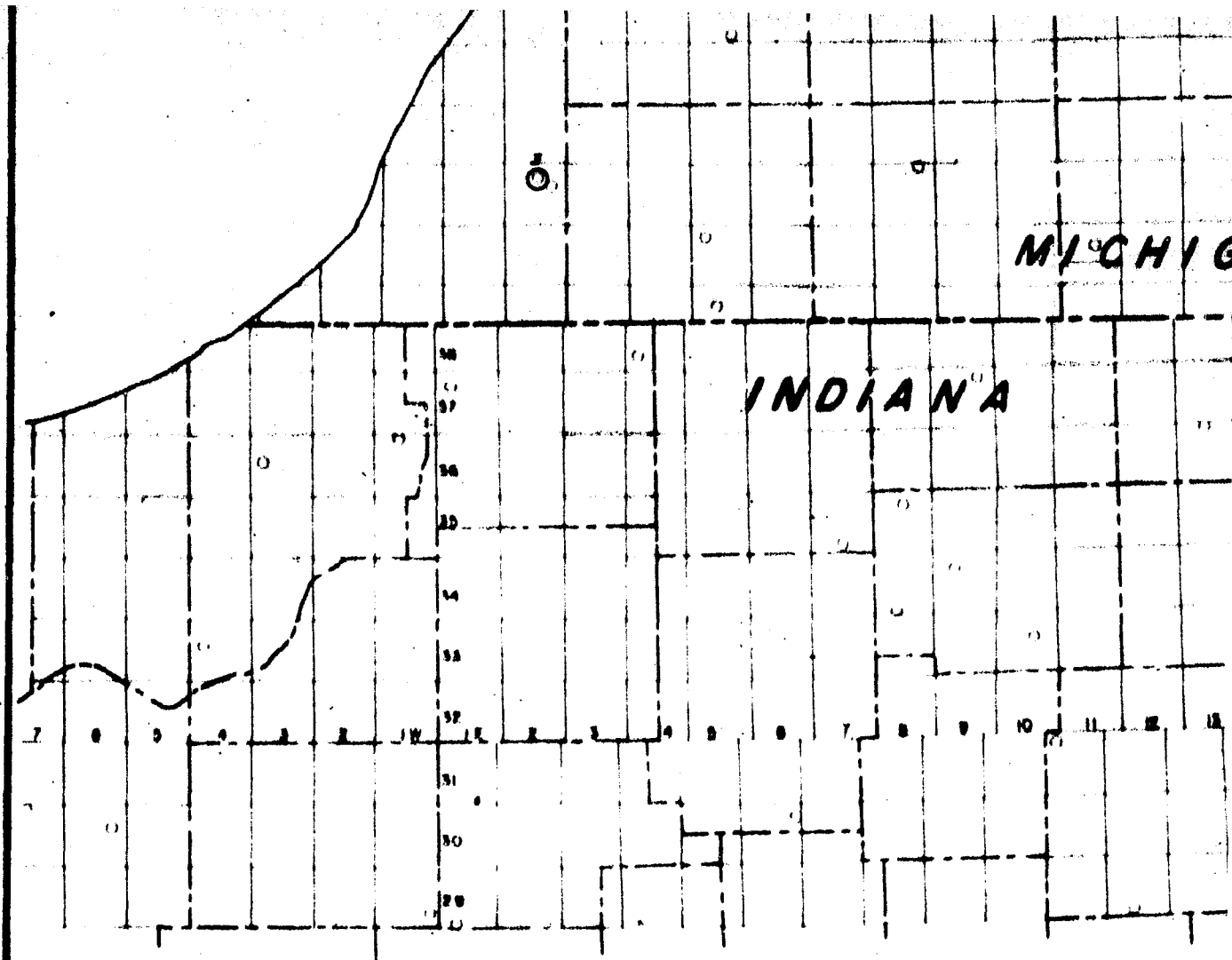
SECTION

SAGINAW BAY

PRESENT







PAUL A CATACOSINOS  
1972

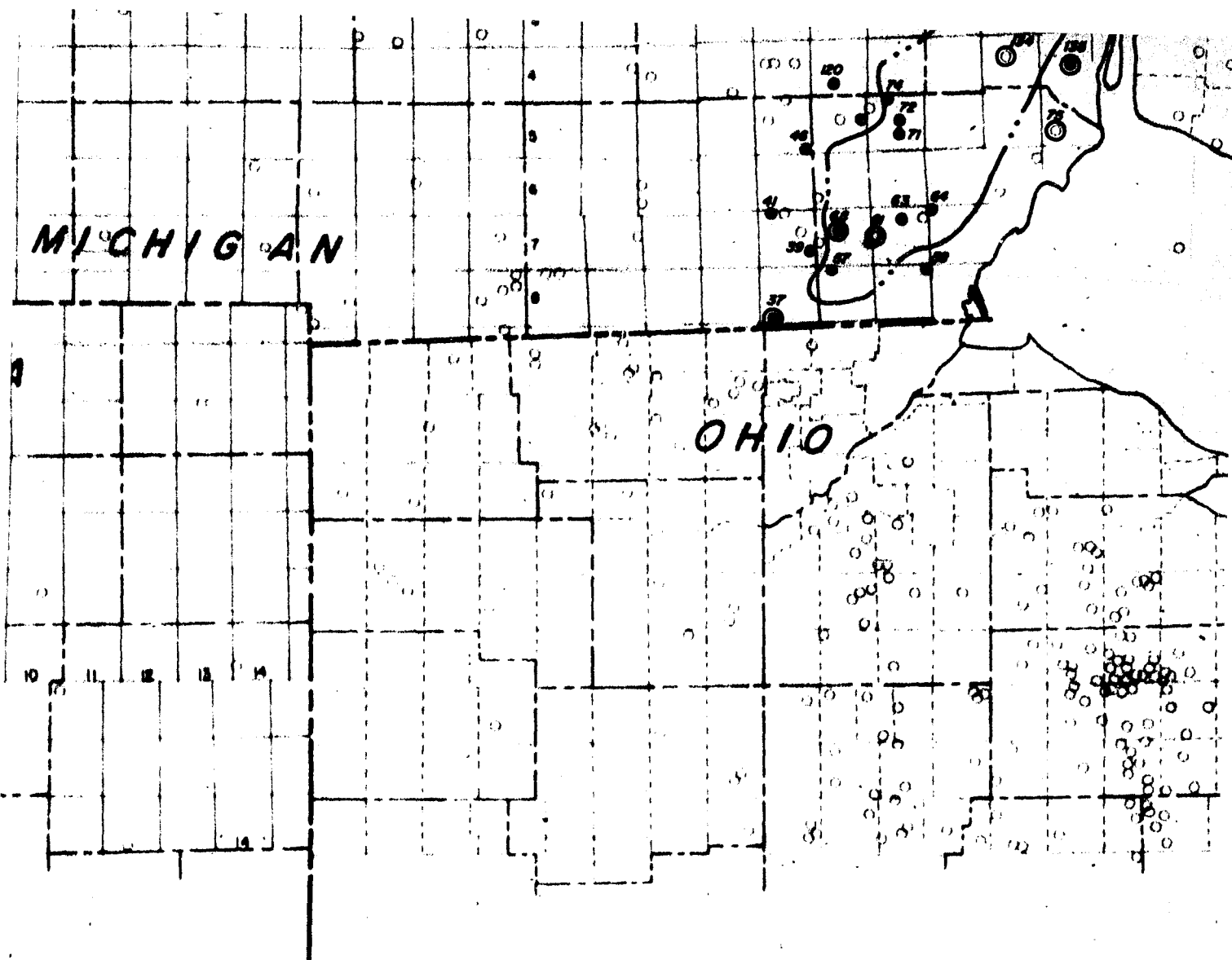
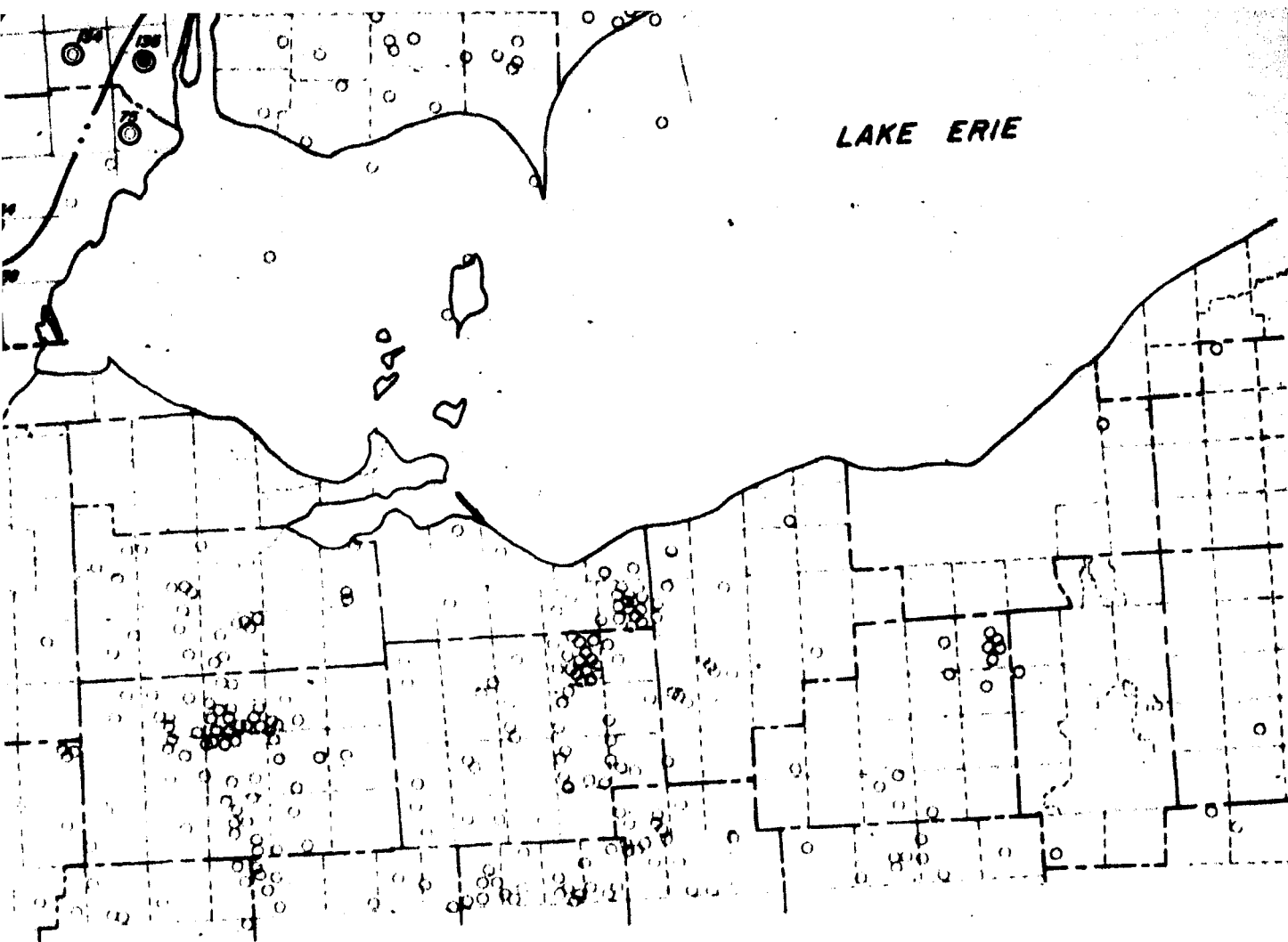


PLATE 10

DISTRIBUTION OF THE EXTRA SECTION  
AT BASE OF BLACK RIVER FORMATION,  
PRE-MT. SIMON FORMATION, ISOPACH  
MAP OF THE "LODI" FORMATION,  
AND LOCATION OF PRECAMBRIAN  
TESTS IN THE LOWER PENINSULA



### SOURCES OF DATA

CANADA.....Sanford and Quillian (1959)

UPPER  
PENINSULA .....Homblin (1958)

INDIANA.....Gutstadt (1958)  
Dawson (1960)

OHIO.....J.H. Fisher (Unpublished)

ILLINOIS.....Buschbach (1964)  
Emrich (1966)

? Inferred Fault ?

Edge of Extra Section

© Precambrian Well

20  
206 WELL DATA POINT  
CONTOUR INTERVAL = 50 FEET

Scale 1:1,000,000

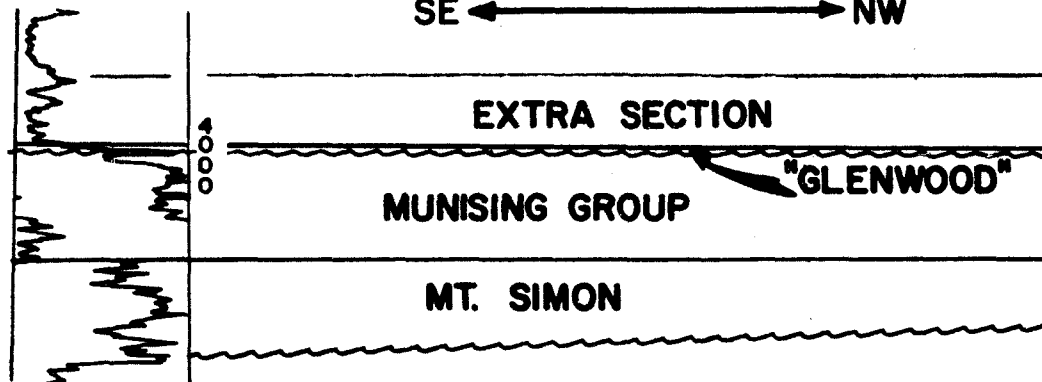


ON  
N,  
H

98  
ST CLAIR CO.  
BERNHARDT-PUZZUOLI #1  
Sec 17-T2N-R16E (Proj)  
25780 ELEV 581 DF

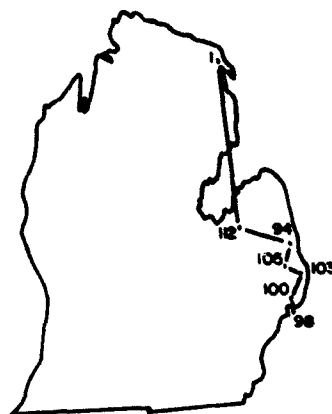
SE ← 11 MILES → NW

BC



TD 4186

PRECAI





100  
ST CLAIR CO.  
CON PWR-BD #1  
Sec 31-T4N-R15E  
BD 139 ELEV 616 KB

103  
ST CLAIR CO.  
CON PWR-1  
Sec 7-T5N-R  
BD 152 ELEV 6

16 MILES  
SW ← → NE

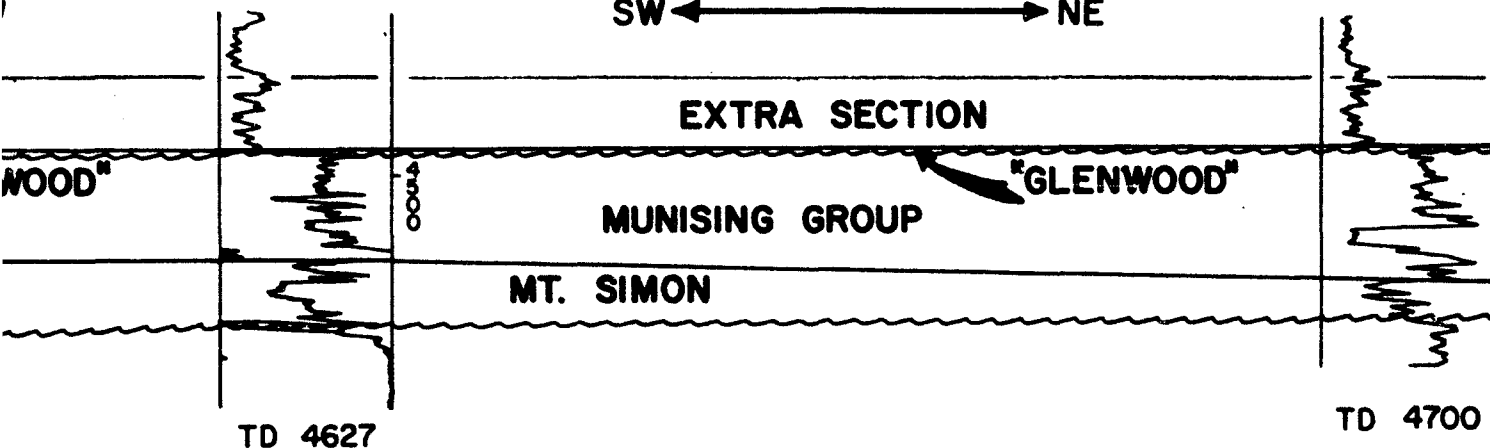


PLATE II

CROSS-SECTION

NORTH - SOUTH

EAST SIDE

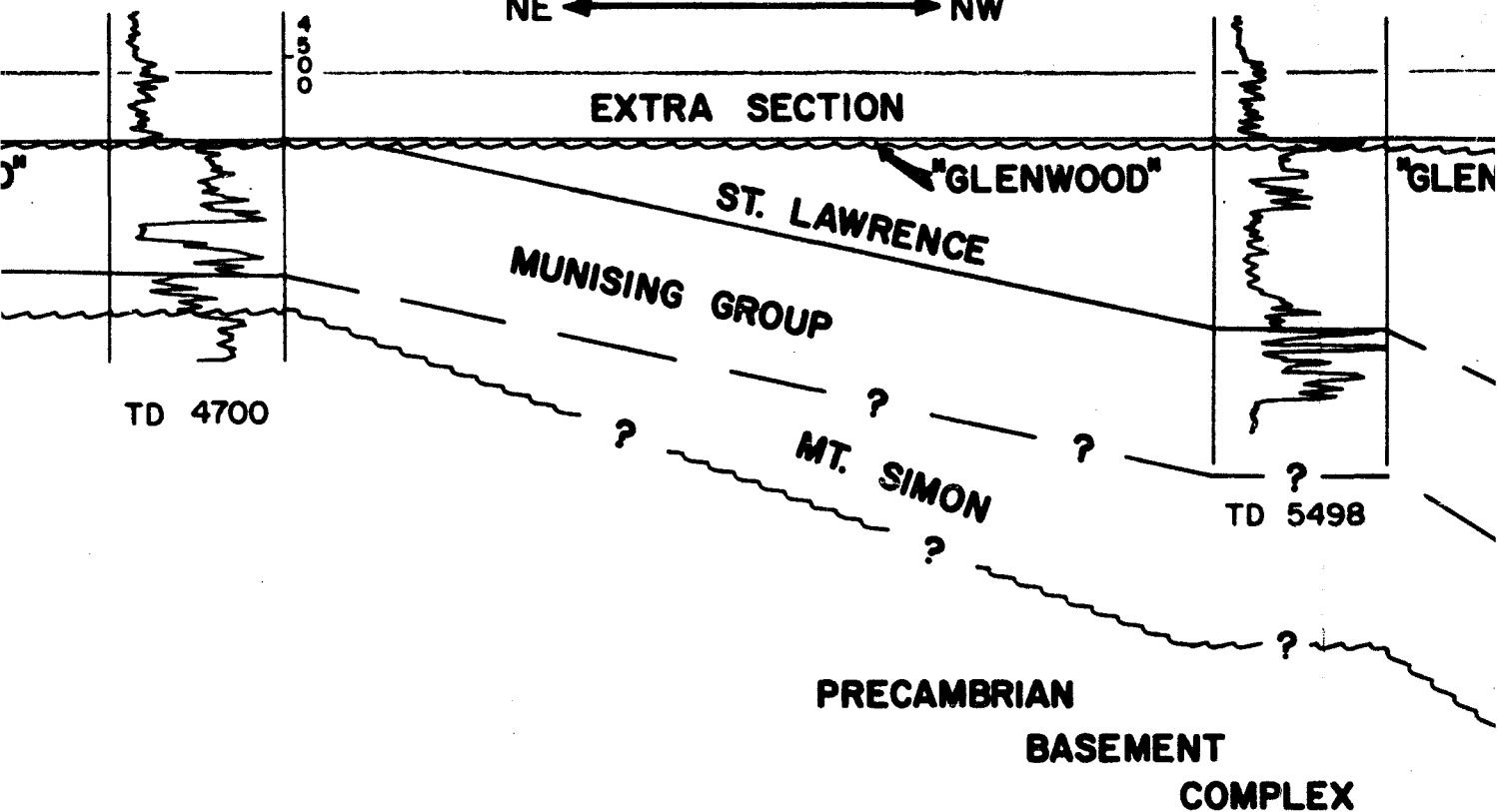
103

ST CLAIR CO.  
CON PWR-BD #2-7  
Sec 7-T5N-R17E  
BD 152 ELEV 632 KB

105

ST CLAIR CO.  
NADCO-CONRAD #  
Sec 1-T6N-R15E  
26086 ELEV 709 R

NE ← 10 MILES → NW

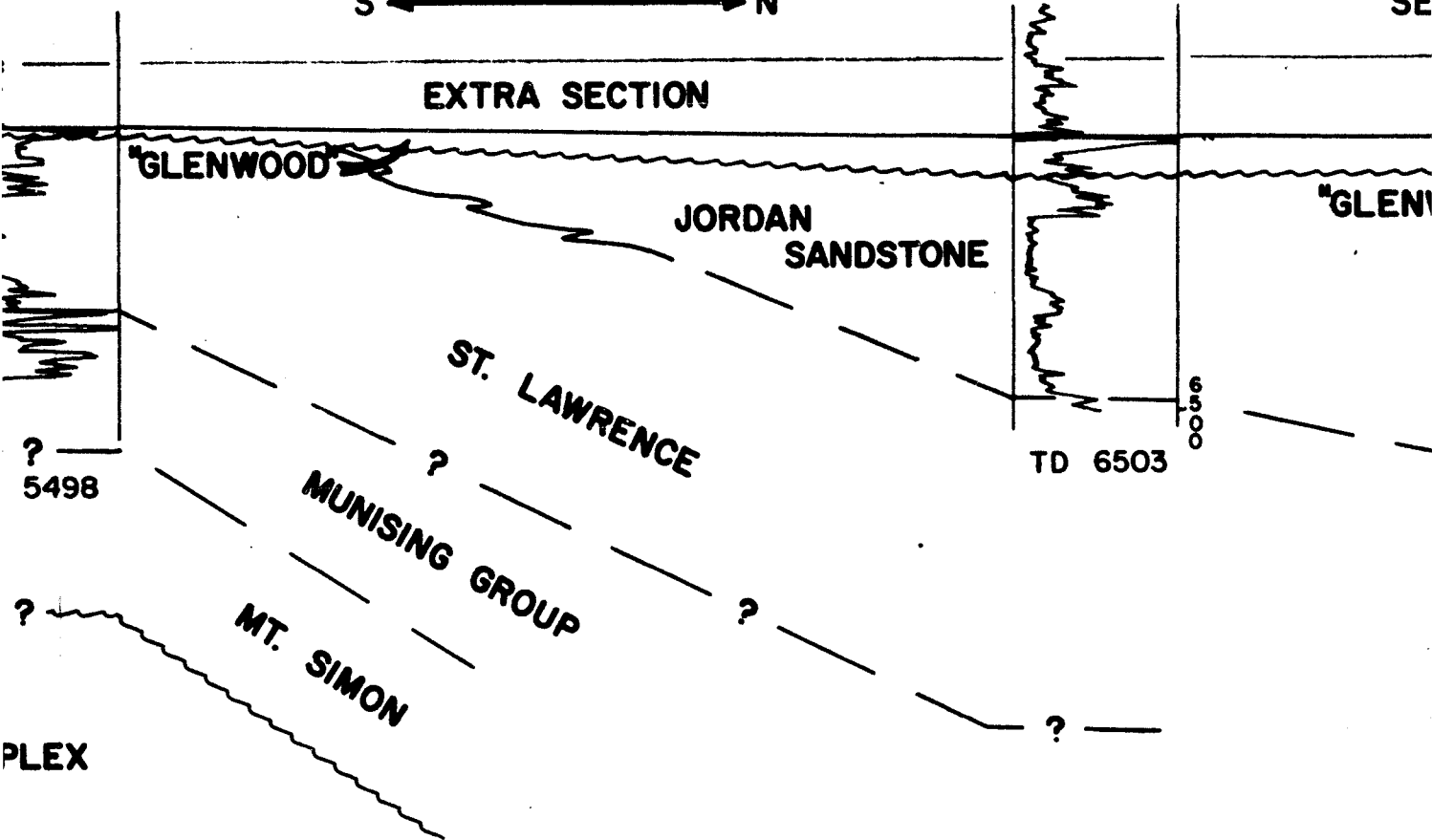


105  
CLAIR CO.  
D-CONRAD #1  
T6N-R15E  
ELEV 709 RB

94  
SANILAC CO.  
PHILLIPS-LONG #1  
Sec 27-T10N-R16E  
2444 ELEV 770 KB

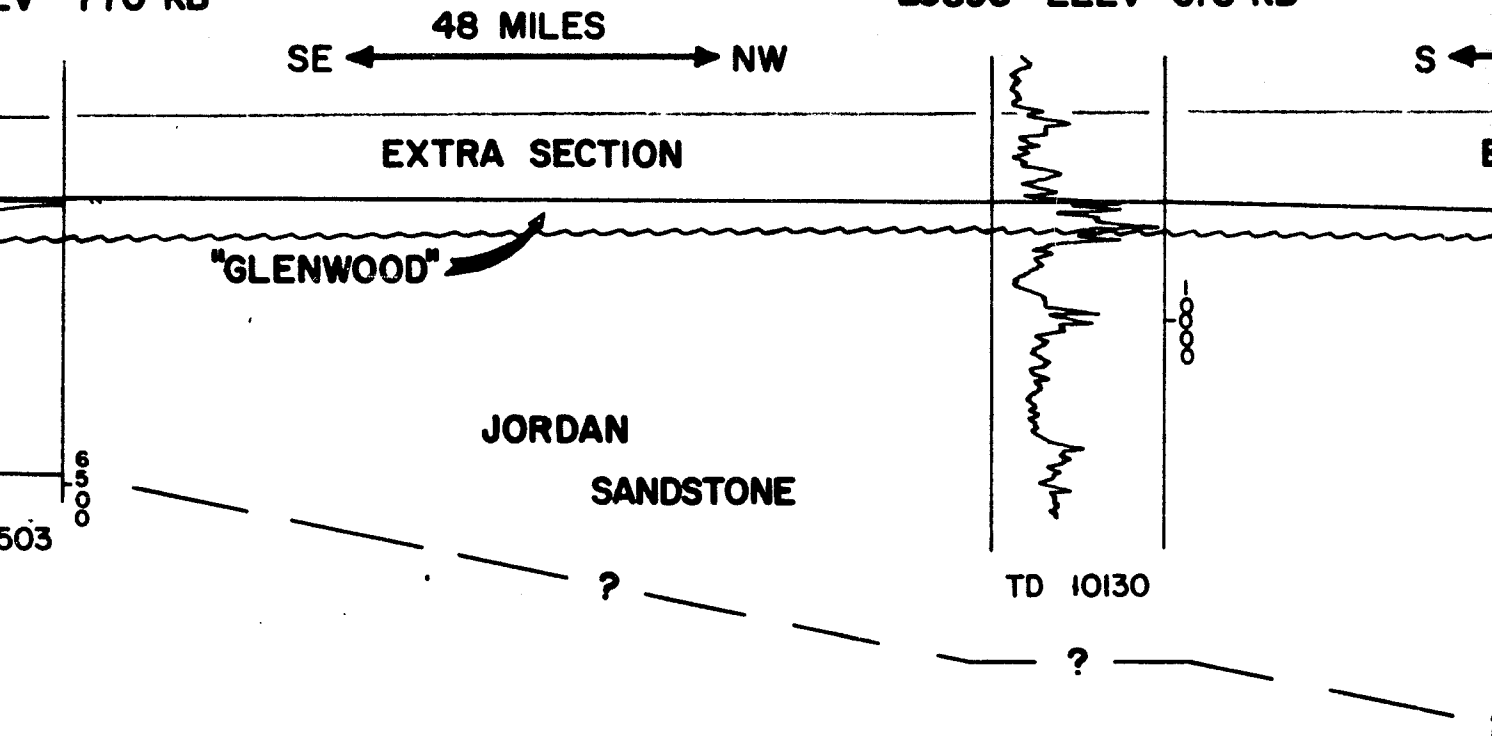
S ← 20 MILES → N

SE



4  
AC CO.  
-LONG #1  
ON-R16E  
EV 770 KB

112  
TUSCOLA CO.  
SIMPSON-SATTELBERG #1  
Sec 8-T13N-R9E  
23890 ELEV 678 KB



CO.  
LBERG #1  
-R 9E  
678 KB

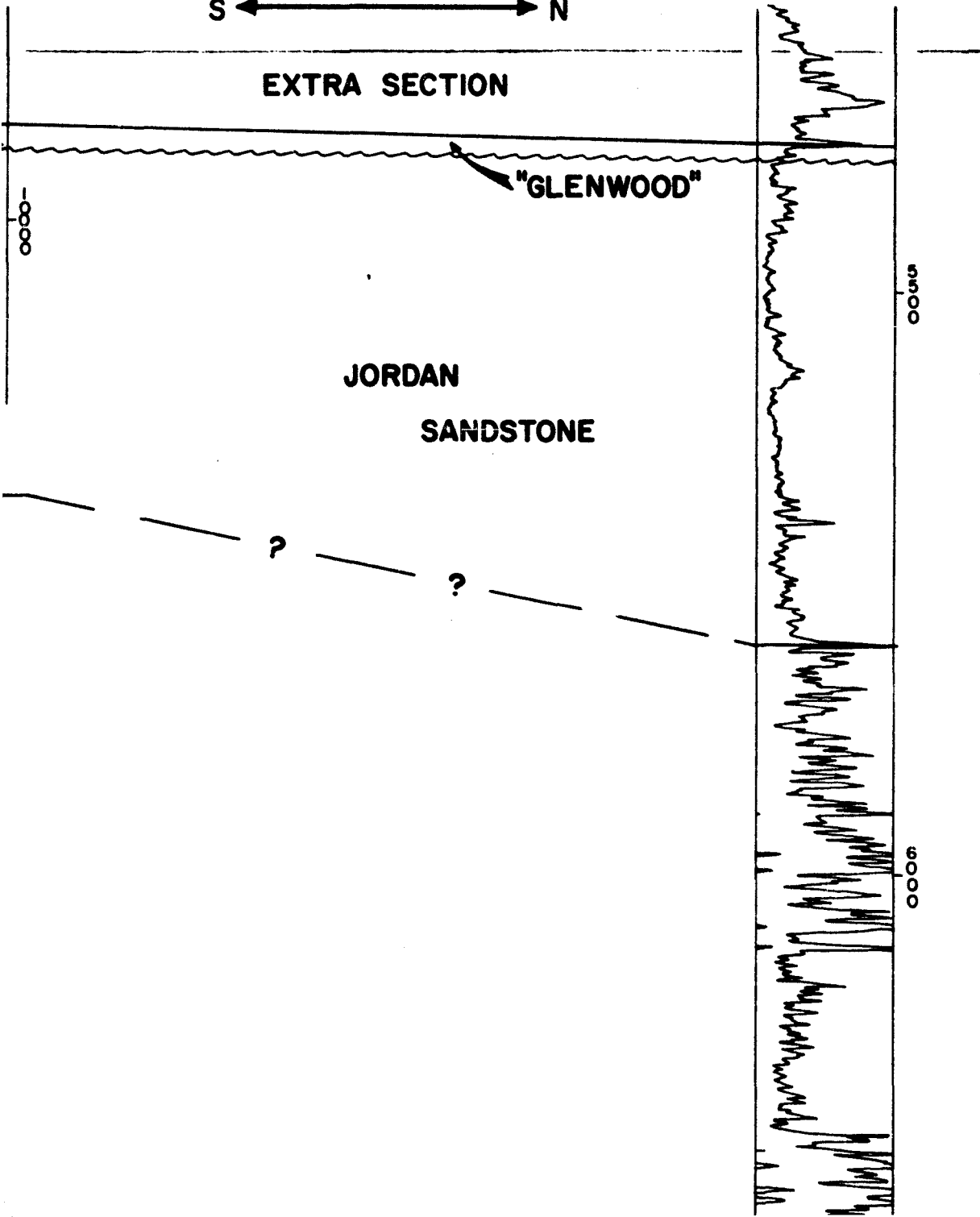
1  
ALPENA COUNTY  
PANHANDLE - FORD #1-5  
Sec 5-T 31N-R 9E  
25690 ELEV 684 GR

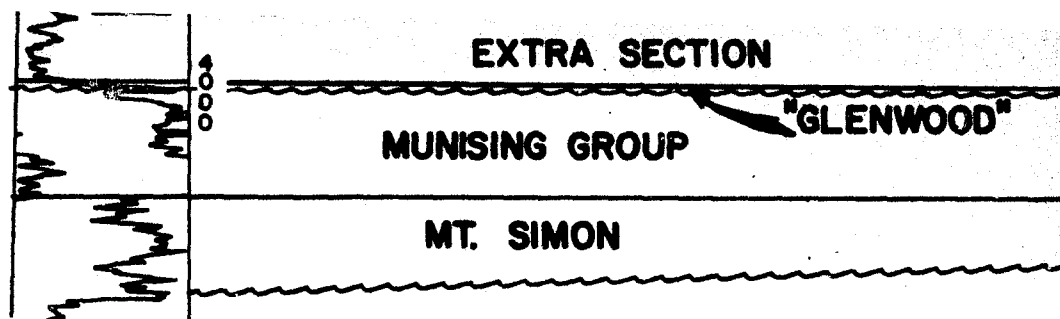
108 MILES  
S ← → N

EXTRA SECTION

"GLENWOOD"

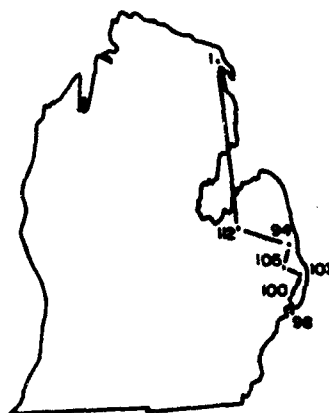
JORDAN  
SANDSTONE





TD 4186

PRECAM



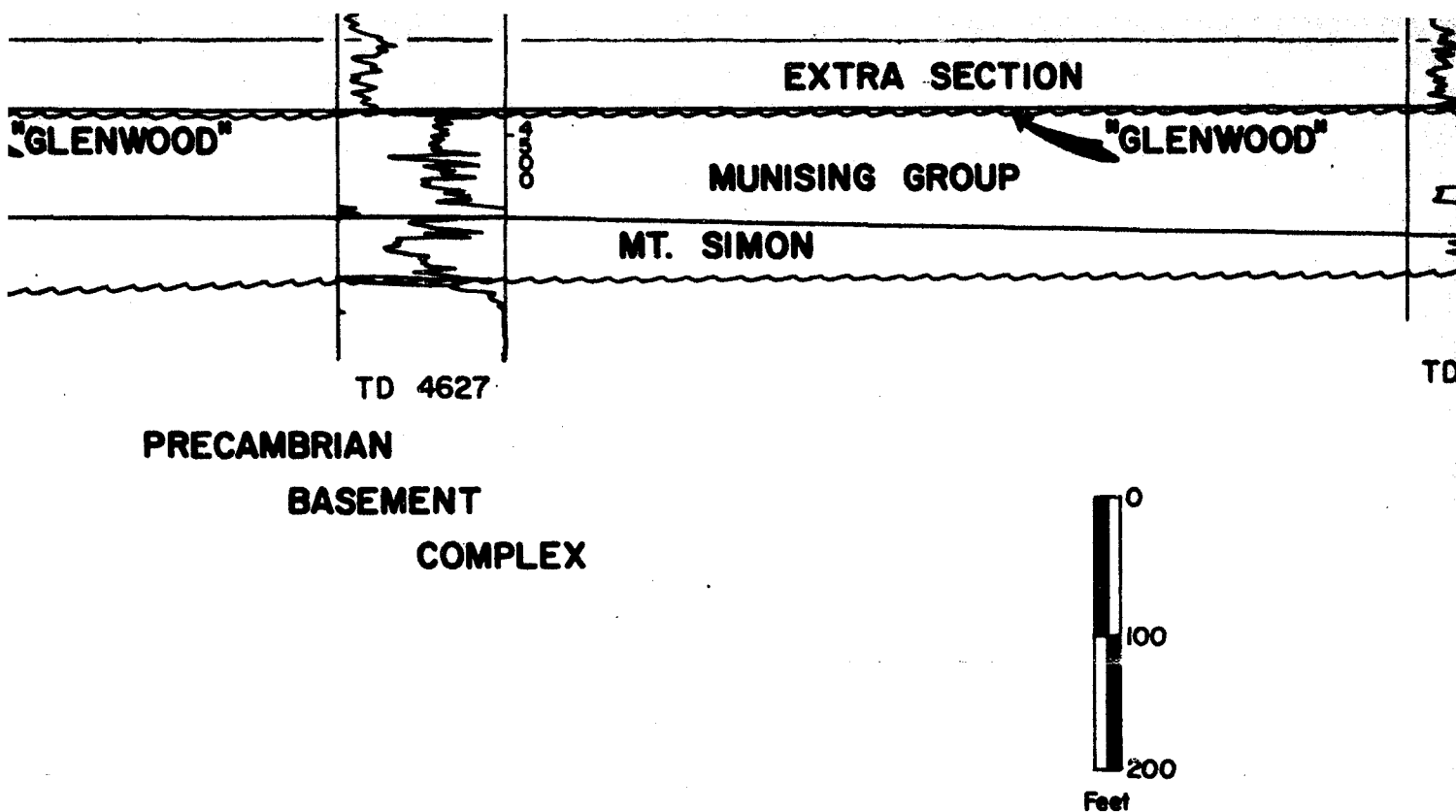


PLATE II

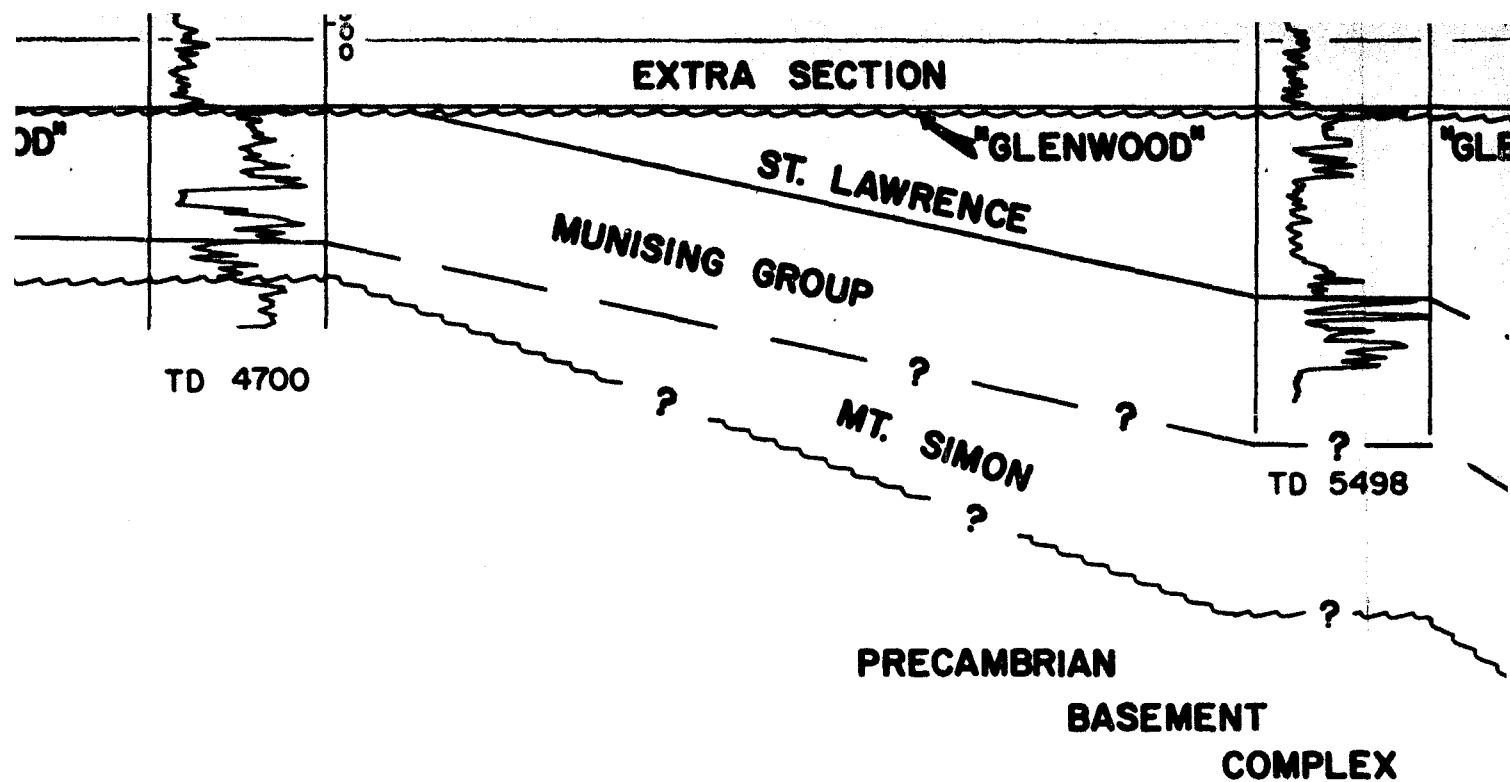
## CROSS-SECTION

NORTH - SOUTH

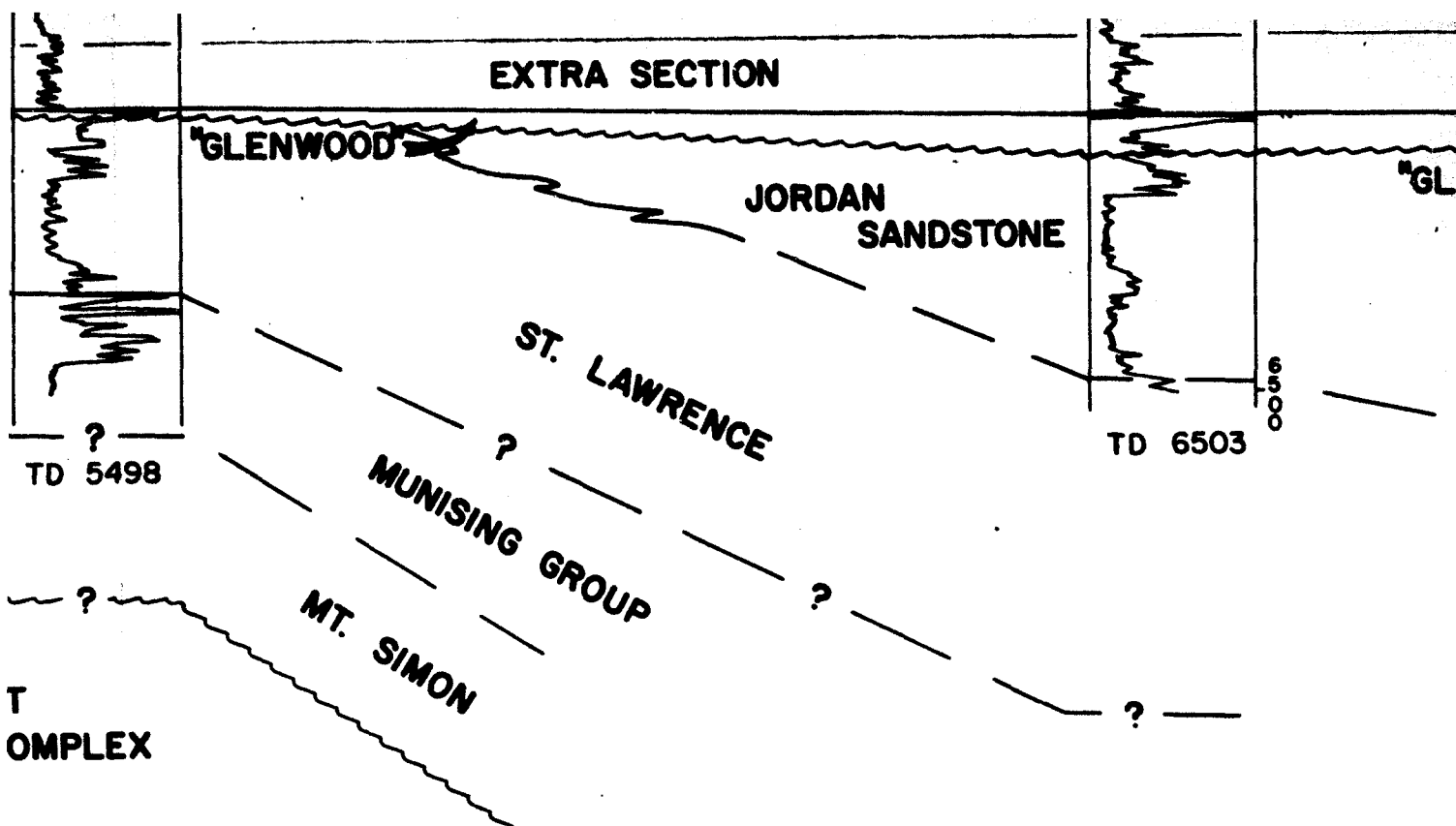
EAST SIDE

PAUL A. CATACOSINOS

1972







EXTRA SECTION

EXT

"GLENWOOD"

JORDAN

SANDSTONE

TD 10130

?

?

?

EXTRA SECTION

"GLENWOOD"

JORDAN  
SANDSTONE

ST.  
LAWRENCE

TD 6380

0055

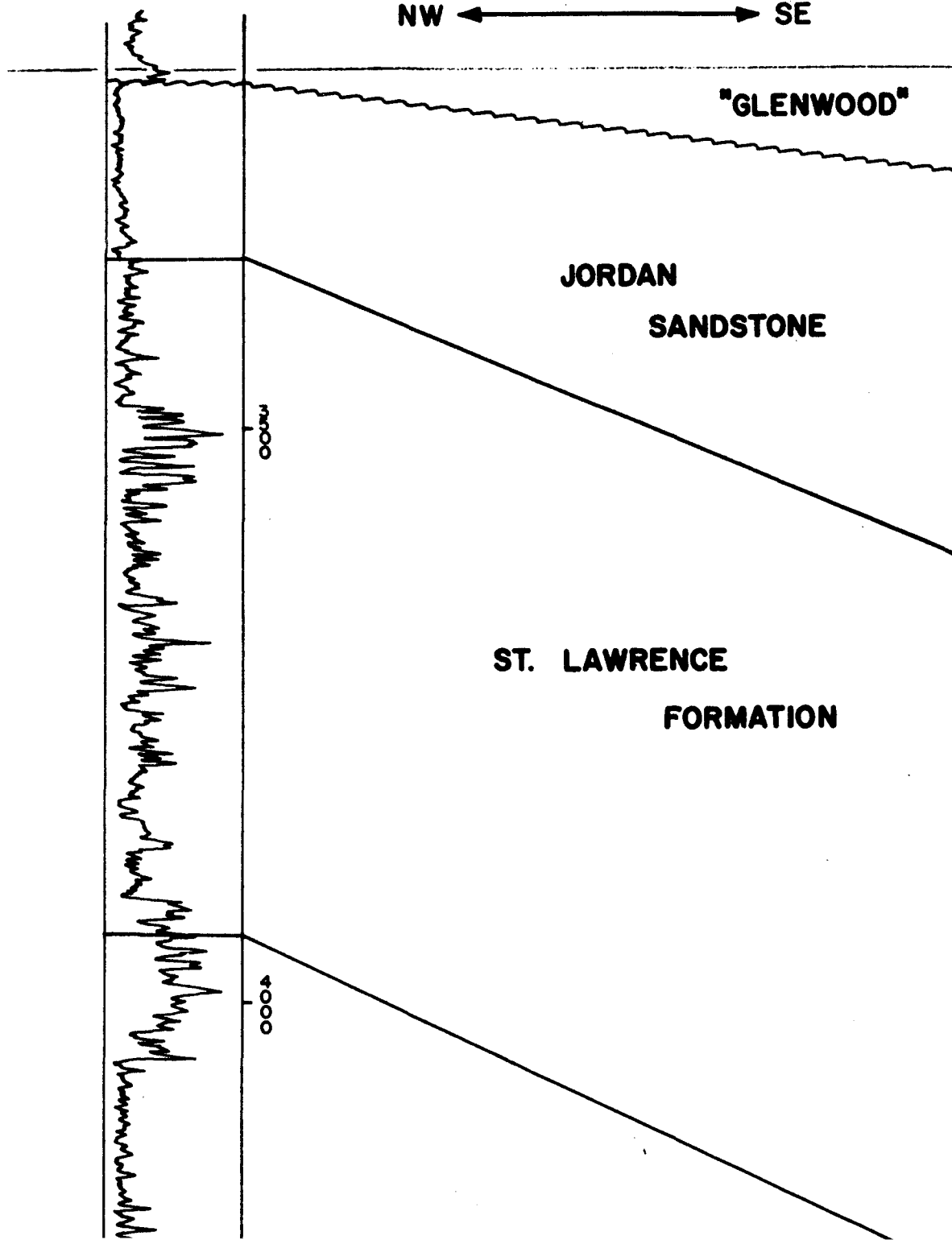
0056

15  
CHARLEVOIX COUNTY  
MC CLURE BEAVER ISLAND #1  
Sec 27-T38N-R10W  
#23435 ELEV 680 KB

BRAZO  
Sec  
#2501

99 MILES

NW ← → SE



80  
OGEMAW CO  
BRAZOS-STATE FOSTER #1  
Sec 28-T24N-R2E  
#25099 ELEV 1477 KB

88  
PRESQUE ISLE  
PAN AM-DRA  
Sec 29-T35N-  
#27199 ELEV 1

66 MILES

S ← → N

WOOD"

"GLENWOOD"

EXTRA  
SECTION

JORDAN  
SANDSTONE

ST. LAWRENCE  
FORMATION

88  
ESQUE ISLE CO  
N AM-DRASEY #1  
c 29-T35N-R2E  
99 ELEV 808 KB

1  
ALPENA COUNTY  
PANHANDLE - FORD #1-5  
Sec 5-T31N-R9E  
#25690 ELEV 684 GR

46 MILES

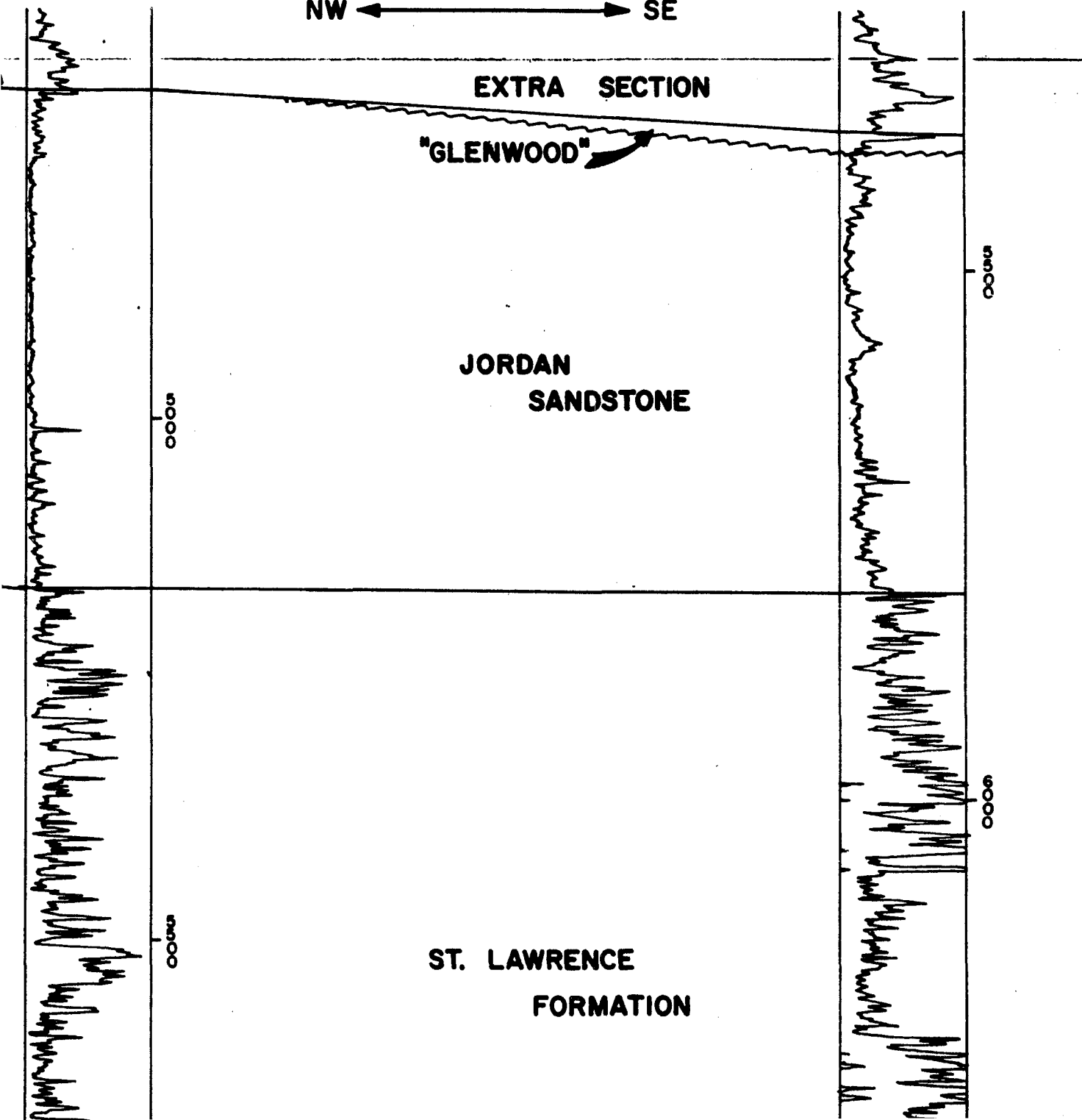
NW ← → SE

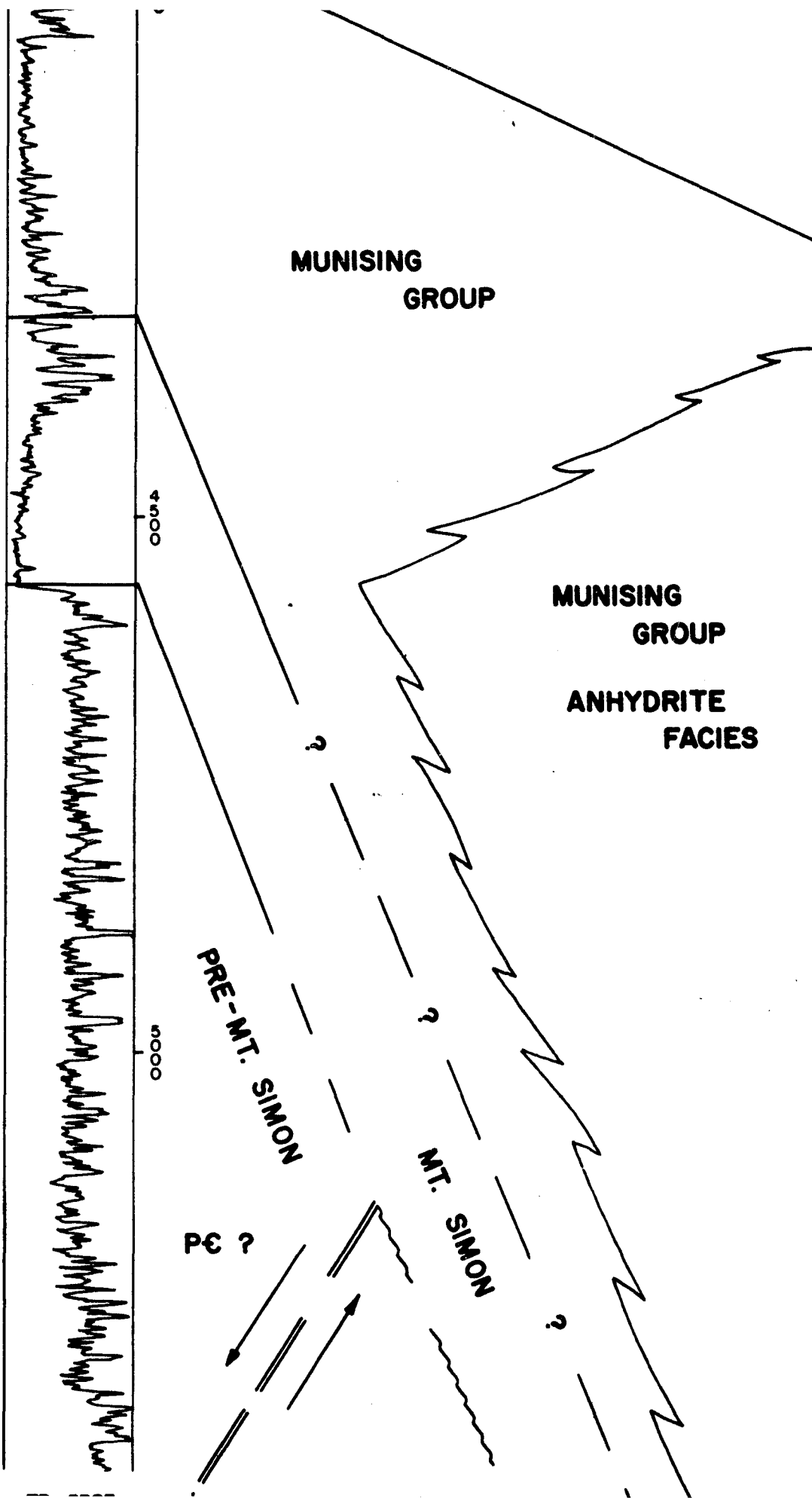
EXTRA SECTION

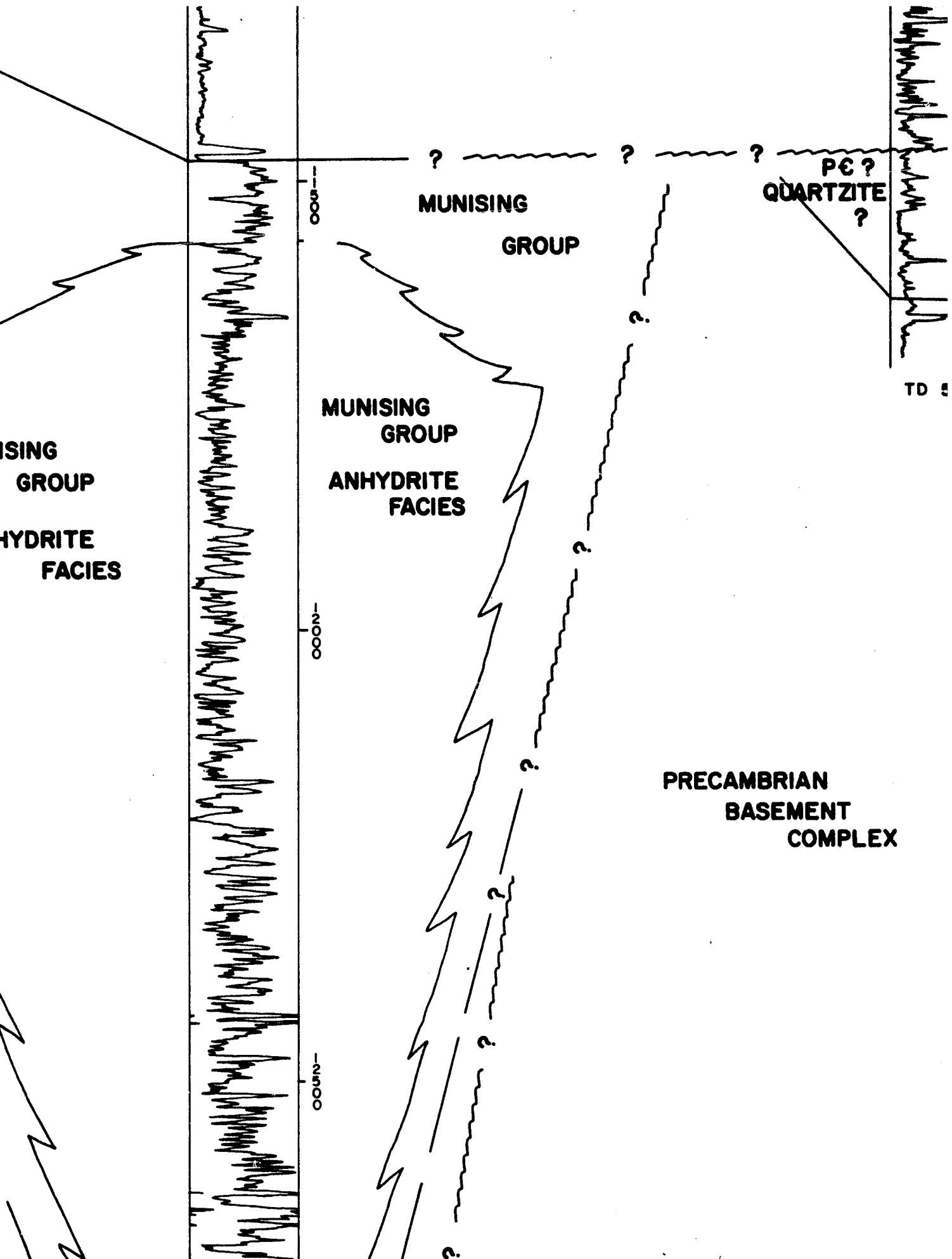
"GLENWOOD"

JORDAN  
SANDSTONE

ST. LAWRENCE  
FORMATION

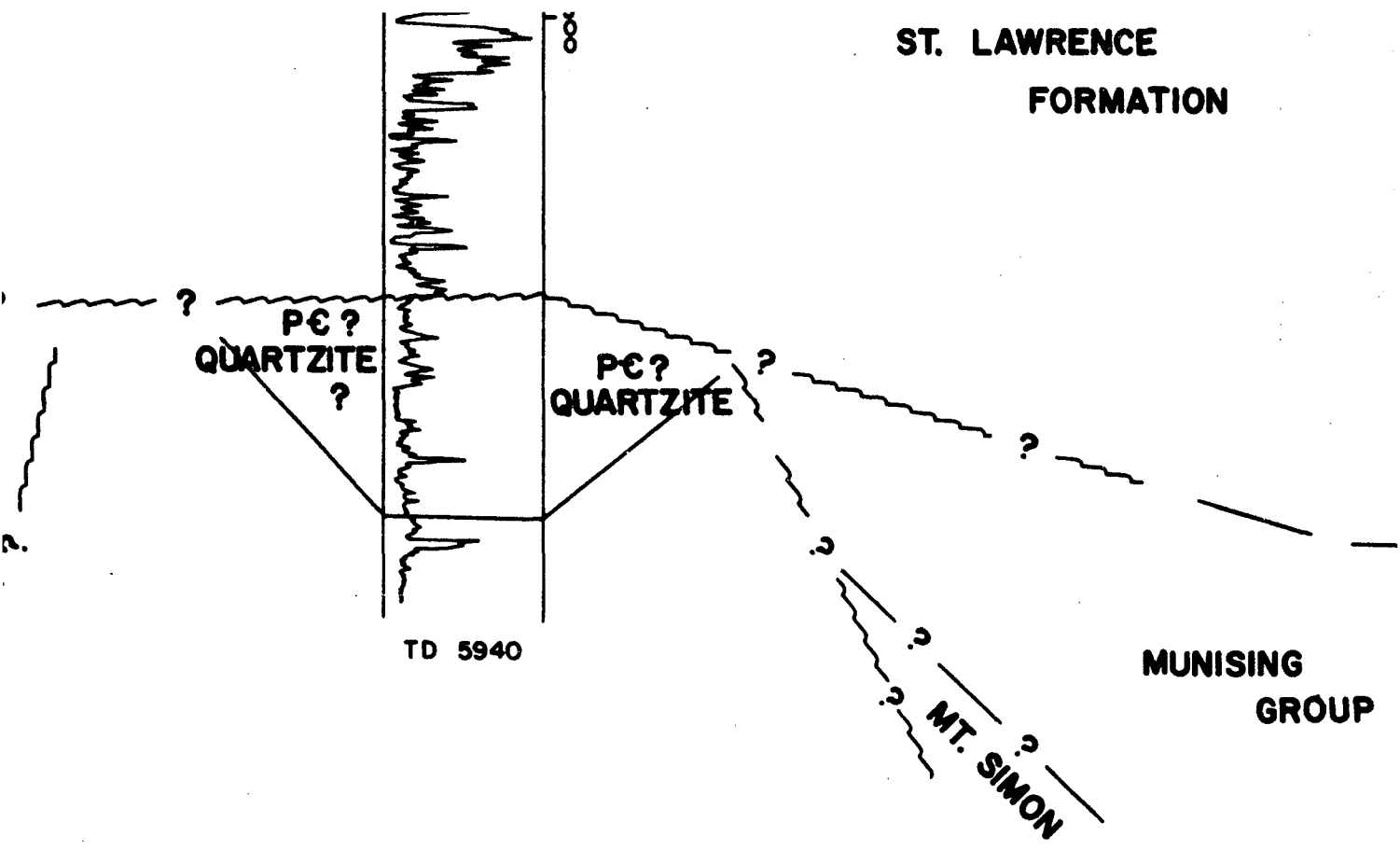




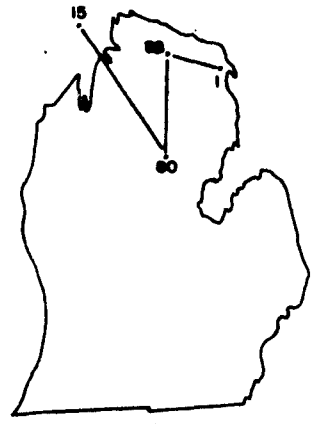


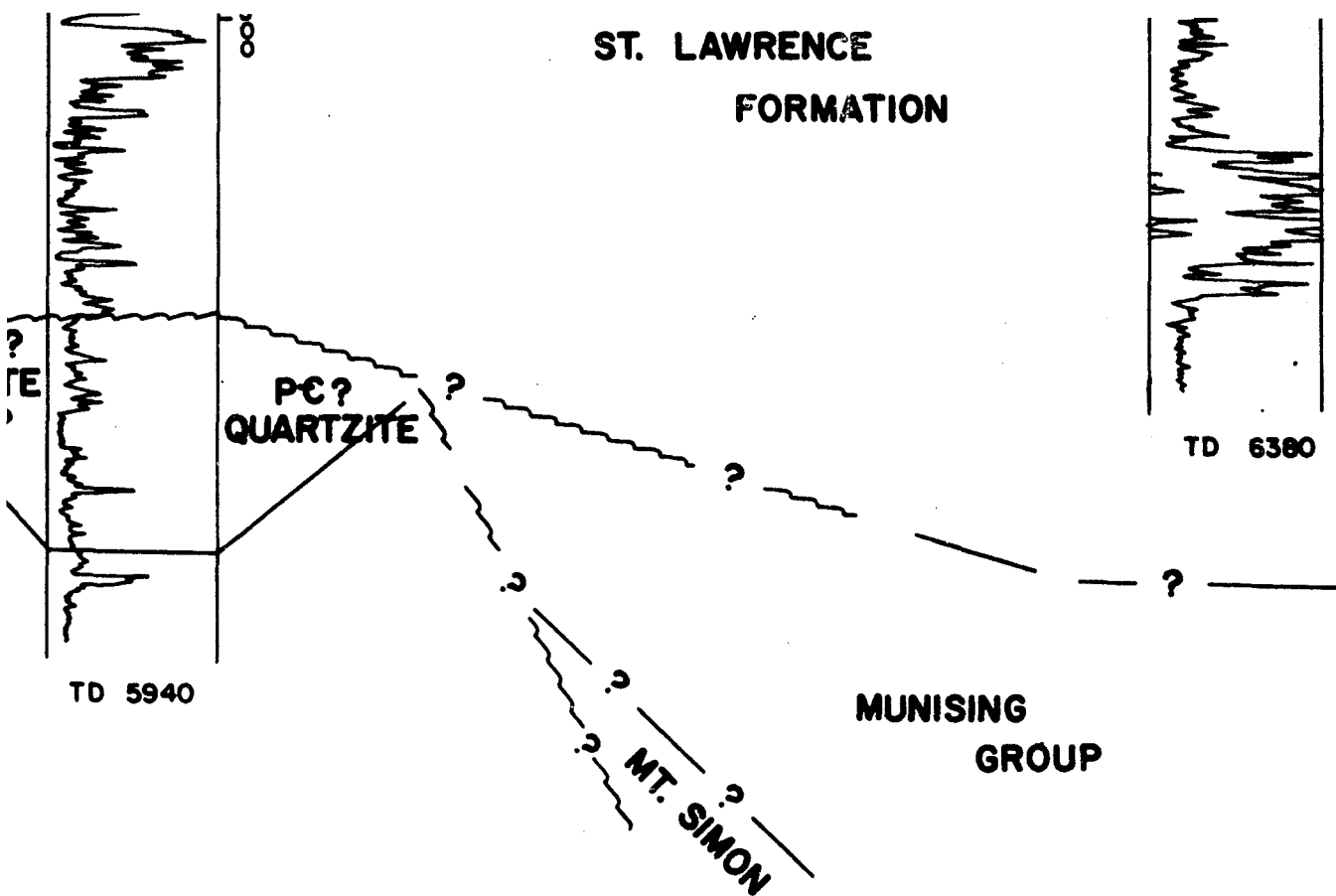


**ST. LAWRENCE  
FORMATION**

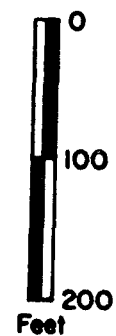
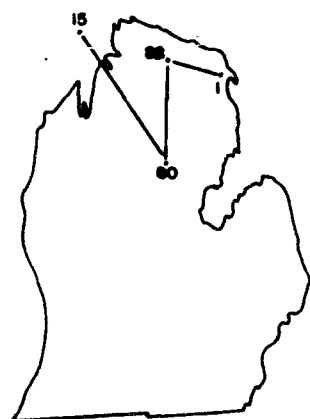


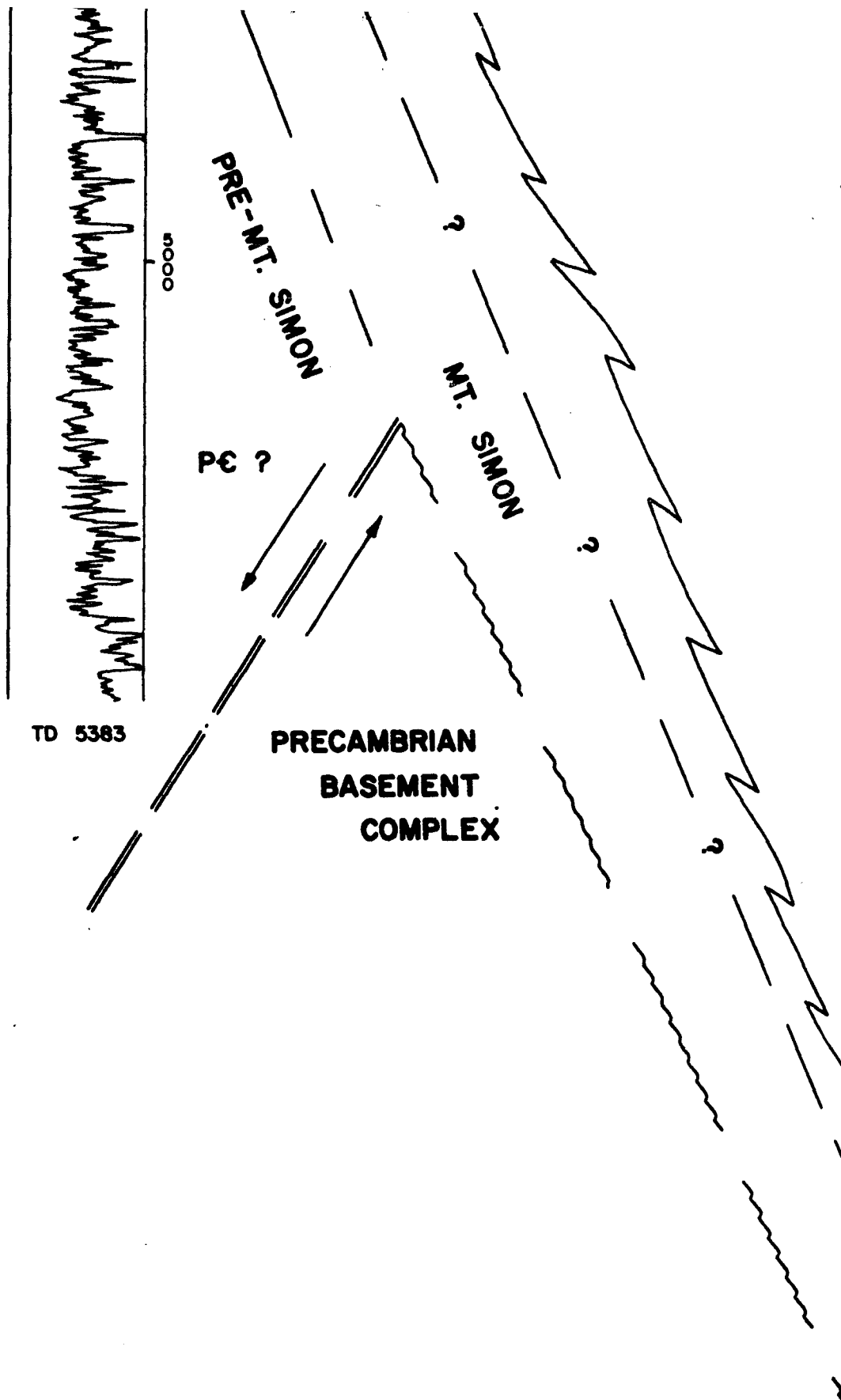
**PRECAMBRIAN  
BASEMENT  
COMPLEX**



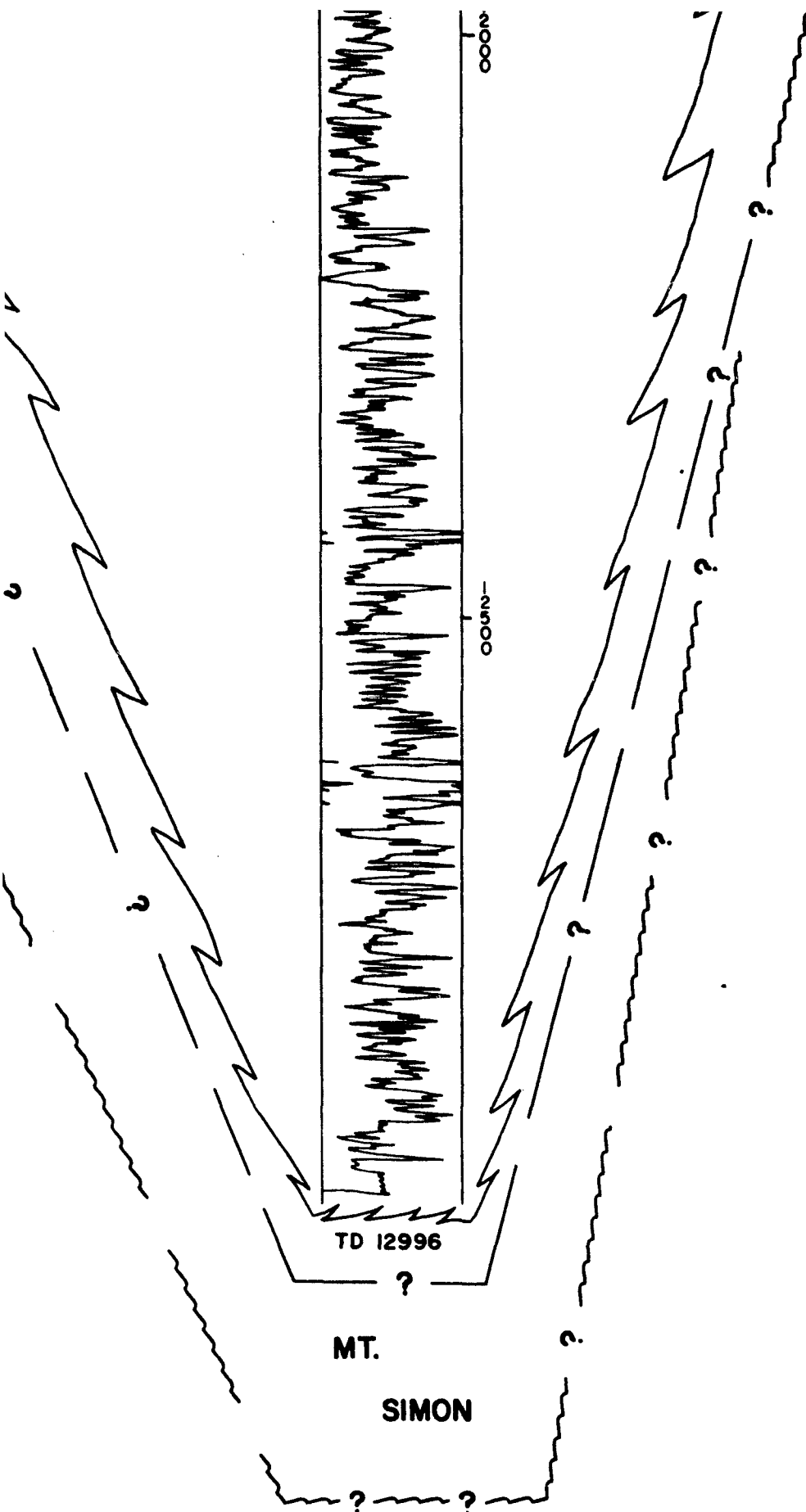


EX





**PRECAMBRIAN  
BASEMENT  
COMPLEX**



V  
NT  
MPLEX

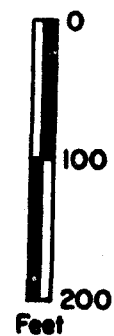
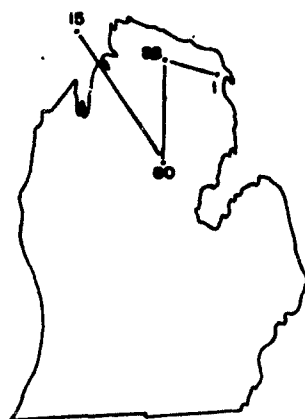


PLATE 12

**CROSS-SECTION  
NORTHWEST - NORTHEAST  
NORTHERN MICHIGAN**

**PAUL A. CATACOSINOS  
1972**

56

MASON CO.

DOW, BRAZOS-TAGGART #1

Sec 27-T19N-R18W

#17789 ELEV 647 RB

BRAZ

S

#2

117 MILES

WSW

ESE

"GLENWOOD"

JORDAN  
SANDSTONE

"LODI"

ST. LAWRENCE FORMATION

FRANCONIA FM.

GALESVILLE

EAU CLAIRE  
FM

80

OGEMAW CO.

BRAZOS-STATE FOSTER #1

Sec 28-T24N-R2E

#25099 ELEV 1477 KB

15

CHARLEVOIX CO.

MC CLURE-BEAVER ISLAND

Sec 27-T38N-R1E

#23435 ELEV 680

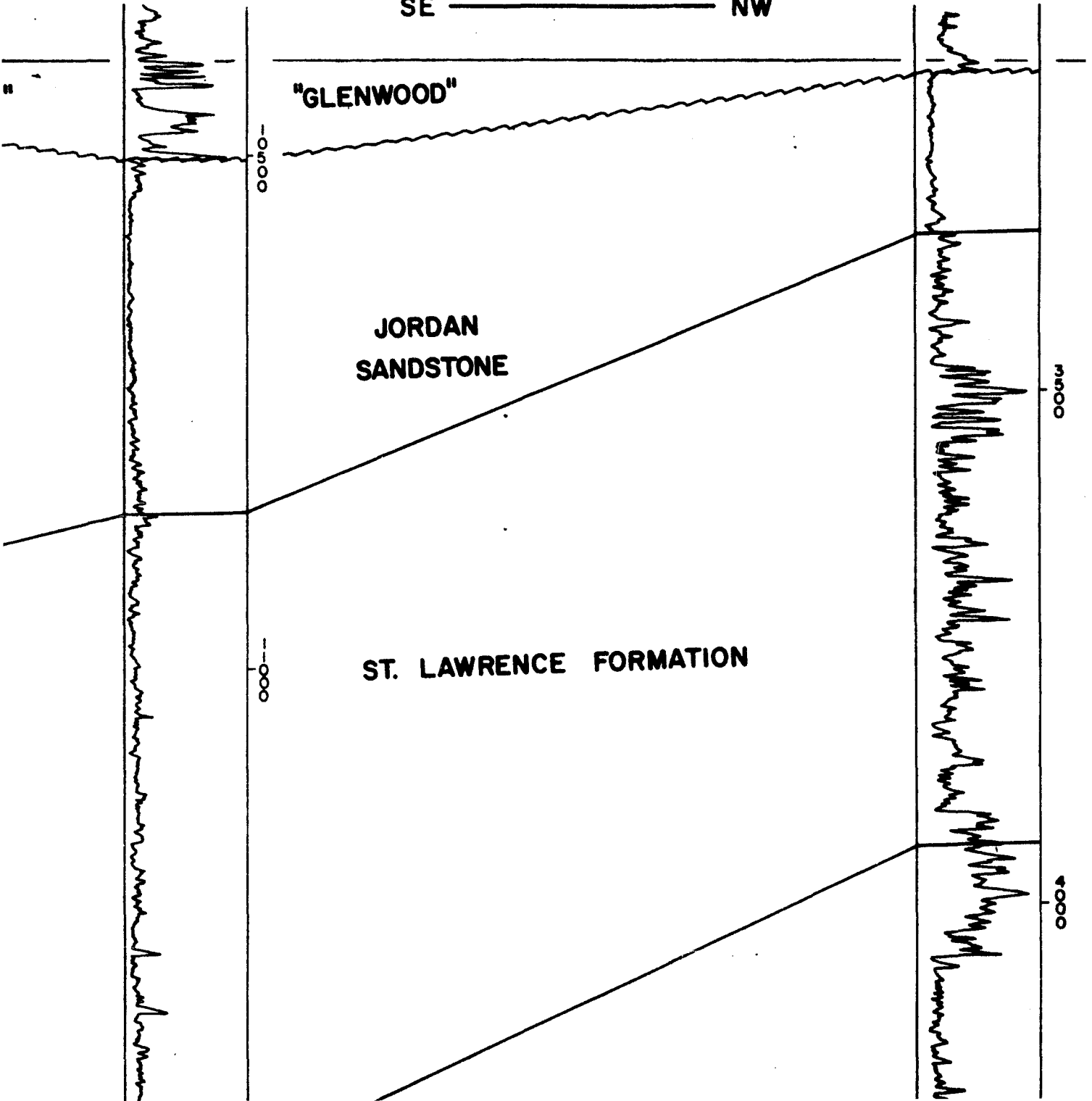
99 MILES

SE NW

"GLENWOOD"

JORDAN  
SANDSTONE

ST. LAWRENCE FORMATION



15

CHARLEVOIX CO.

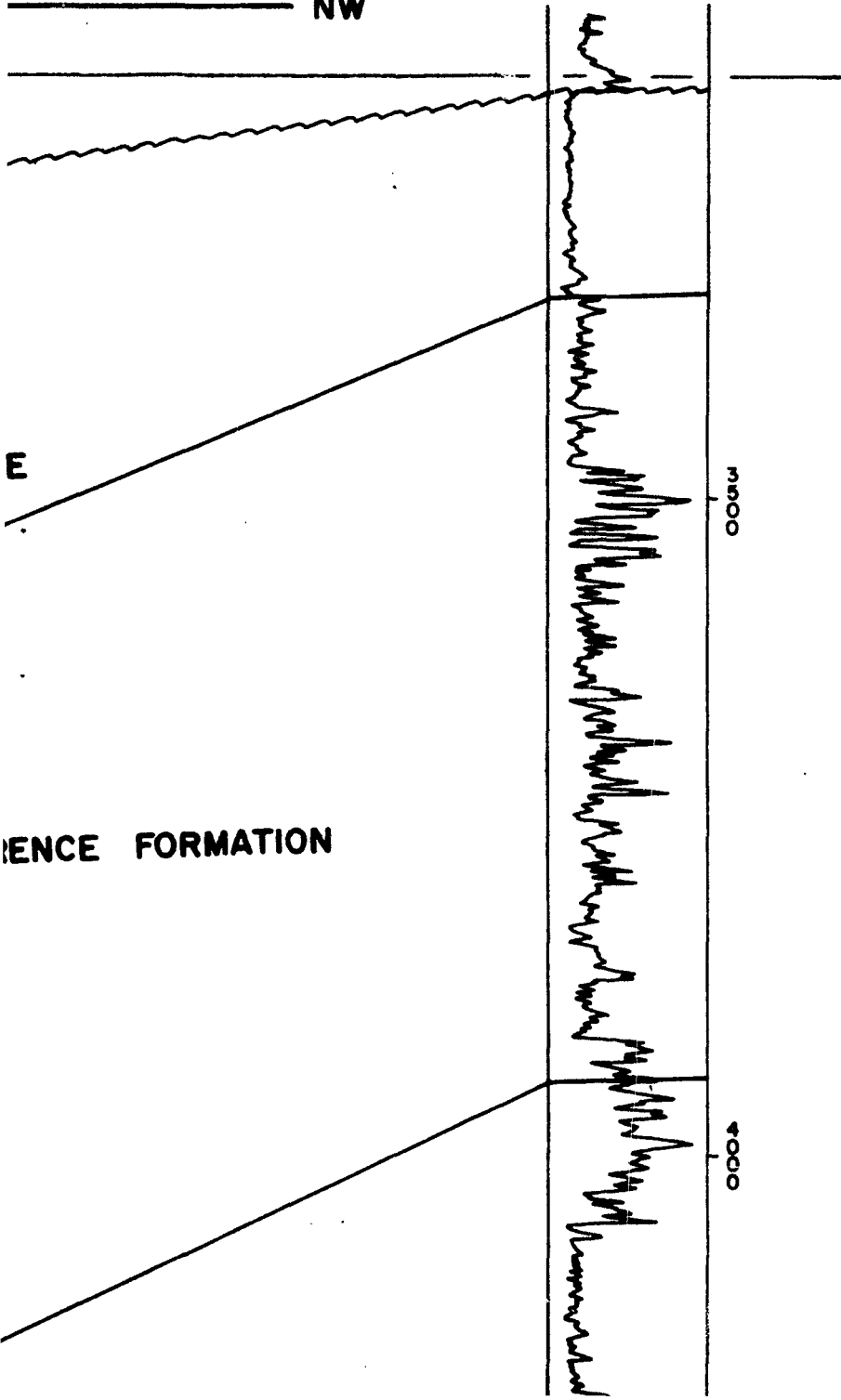
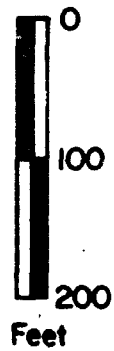
MC CLURE-BEAVER ISLAND #1

Sec 27-T38N-R10W

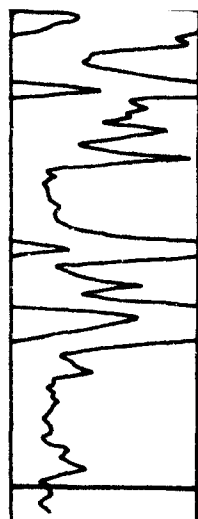
#23435 ELEV 680KB

99 MILES

NW







TD 6617

EAU CLAIRE  
FM.

MUNISING GROUP

ANHYDRITE FACIES  
MUNISING GROUP

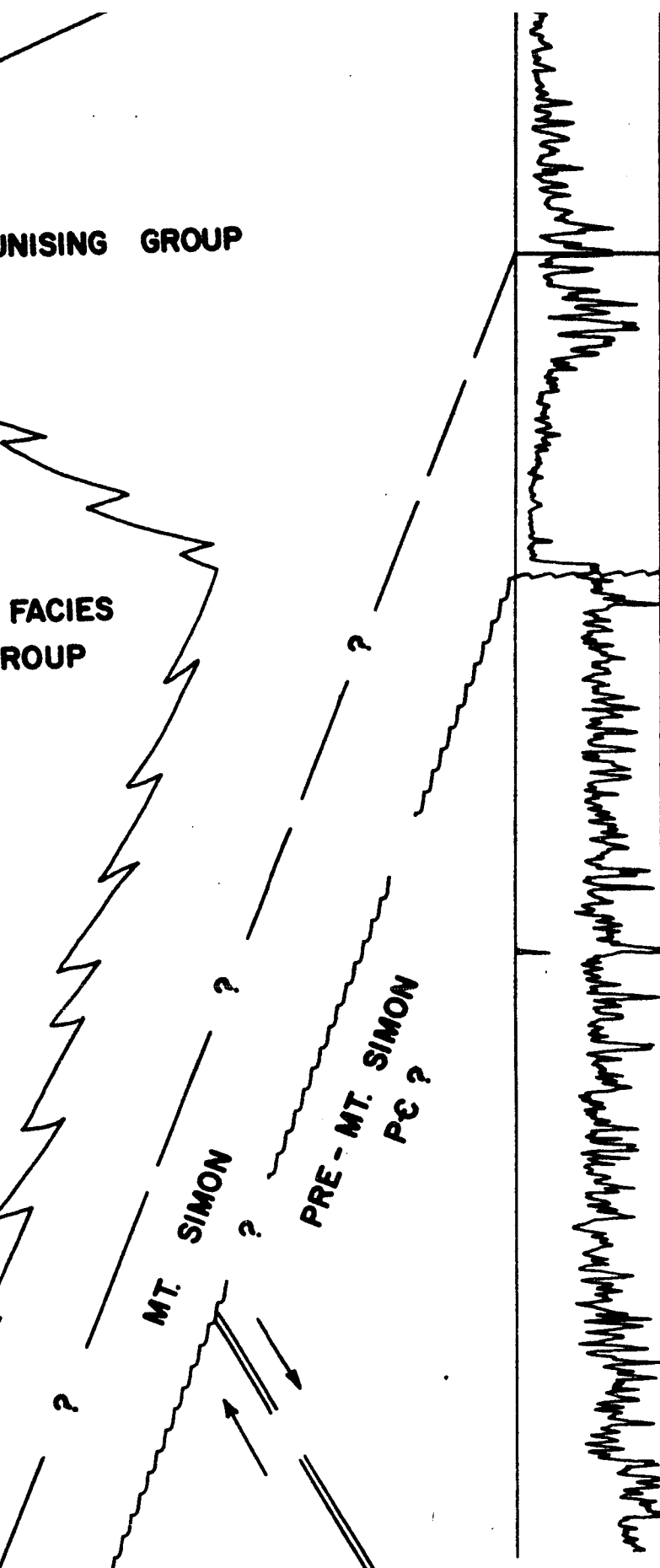
MT. SIMON  
SANDSTONE

PRECAMBRIAN  
BASEMENT  
COMPLEX



UNISING GROUP

FACIES  
ROUP

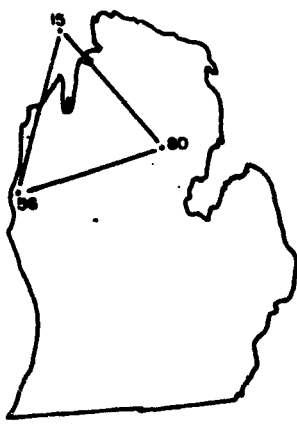


TD 5383

**PRECAMBRIAN  
BASEMENT  
COMPLEX**

**ANDSTONE**

**SIMON**



?

?

?

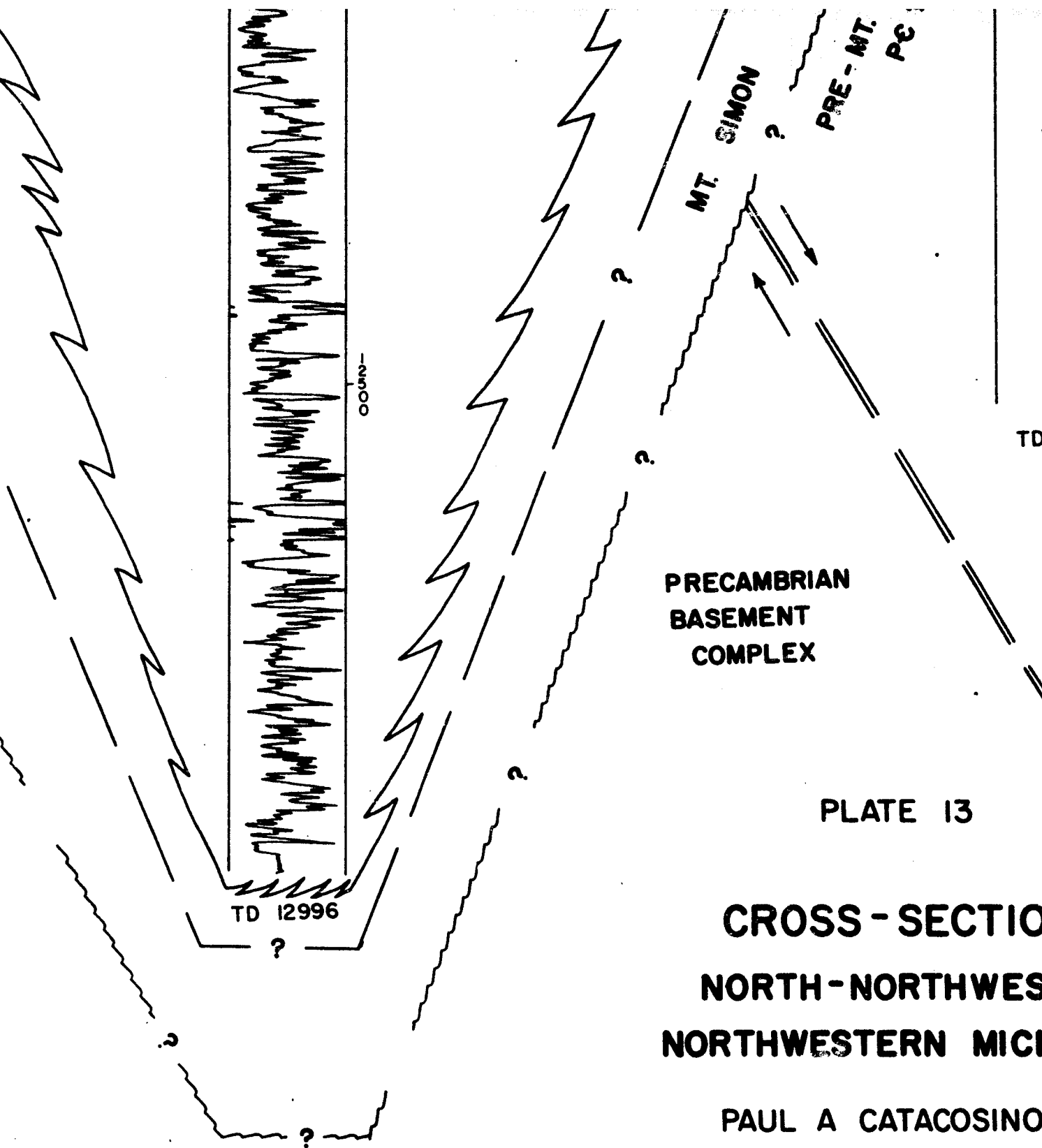


PLATE 13

**CROSS-SECTION  
NORTH-NORTHWEST  
NORTHWESTERN MICHIGAN**

**PAUL A CATACOSINO  
1972**

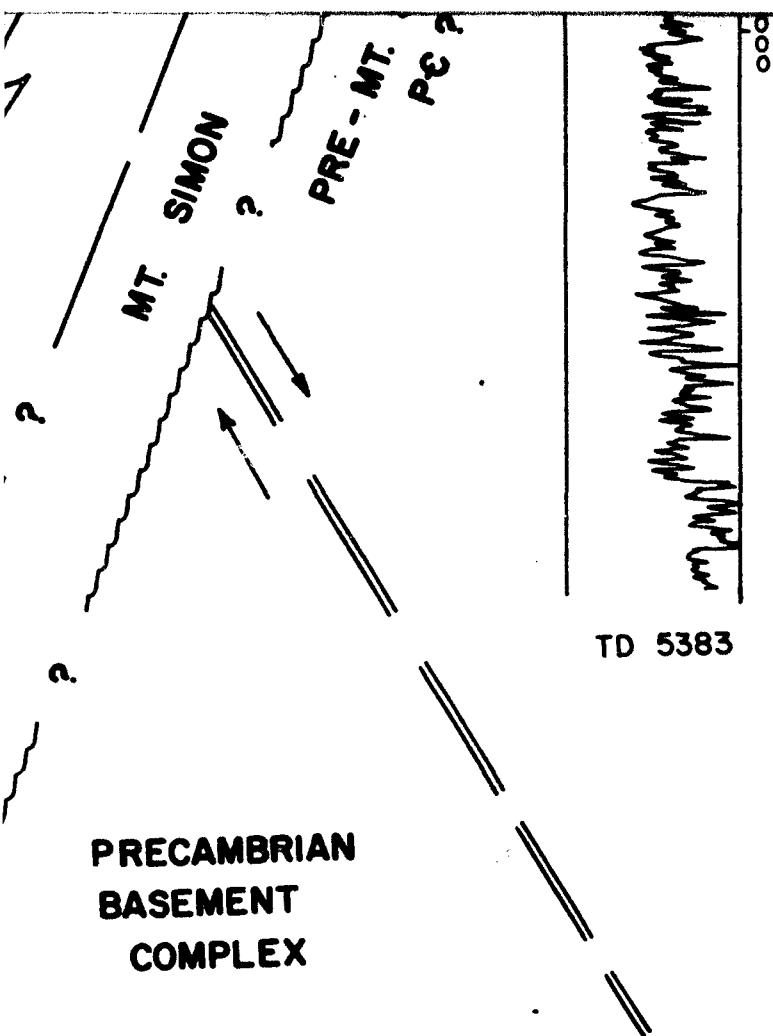


PLATE 13

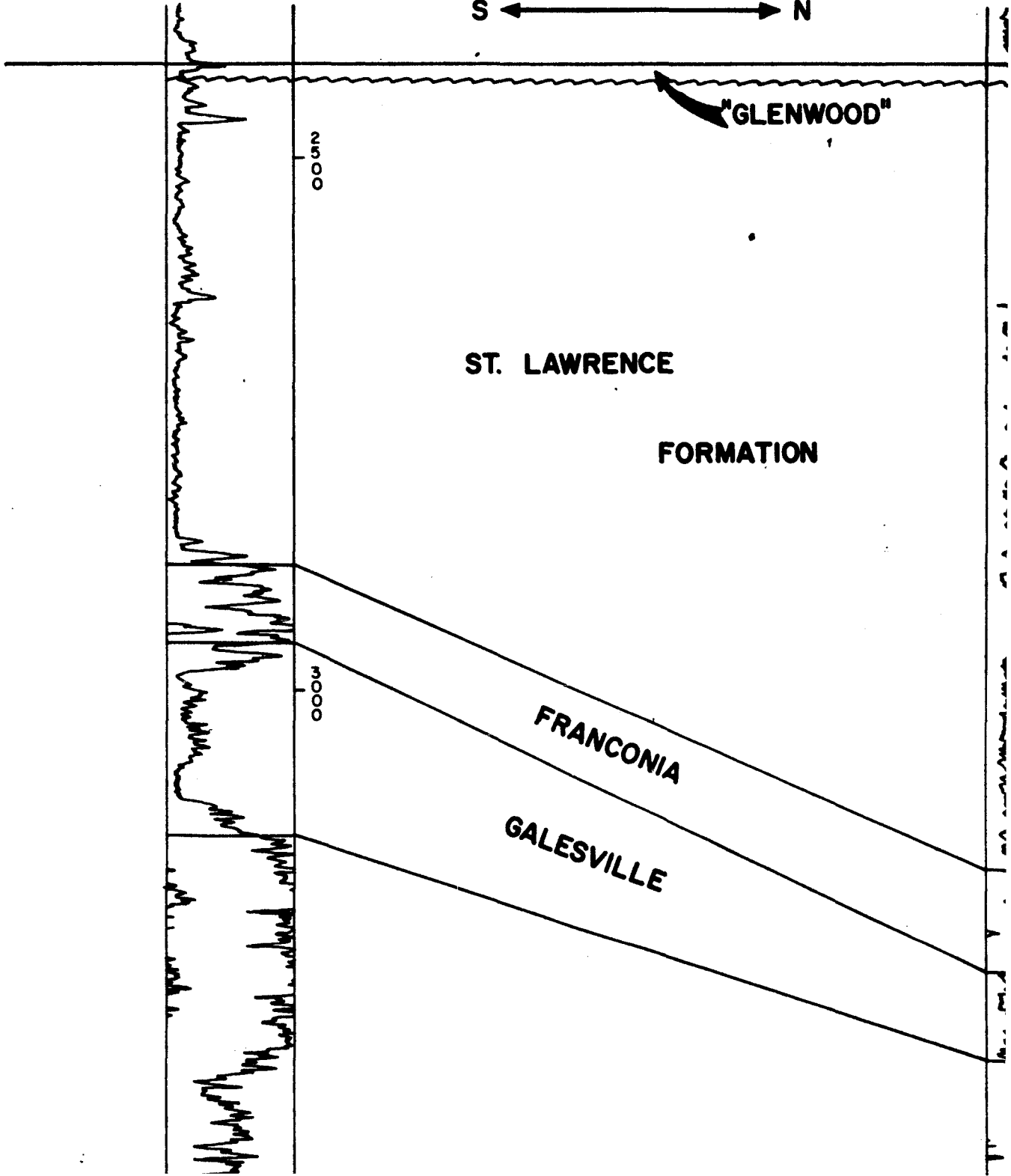
**CROSS-SECTION  
NORTH-NORTHWEST  
NORTHWESTERN MICHIGAN**

**PAUL A CATACOSINOS  
1972**

3  
BERRIEN CO.  
SECURITY-THALMANN #1  
Sec 10-T6S-R17W  
# 26112 ELEV 804 KB

01  
HOLLAND  
Sec 3  
Disposal

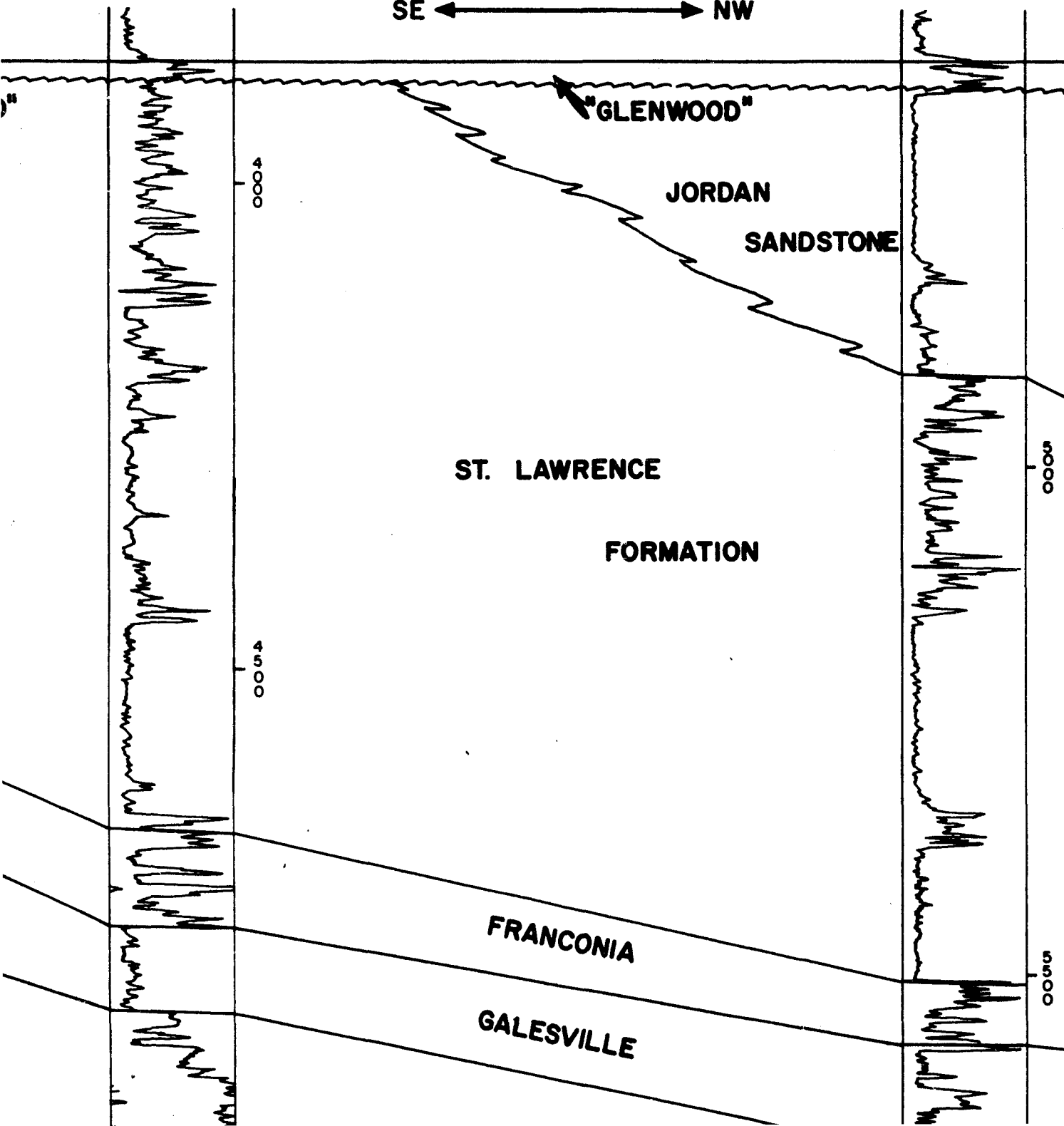
S ← 57 MILES → N



83  
OTTOWA CO.  
HOLLAND-SUCO WELL #1  
Sec 30-T5N-R15W  
Disposal ELEV 623 RB

76  
MUSKEGON CO  
DUPONT #1  
Sec 36-T12N-R11  
Disposal ELEV 654

SE ← 46 MILES → NW





76

MUSKEGON CO.

DUPONT #1

Sec 36-T12N-R18W

sposal ELEV 656 KB

55

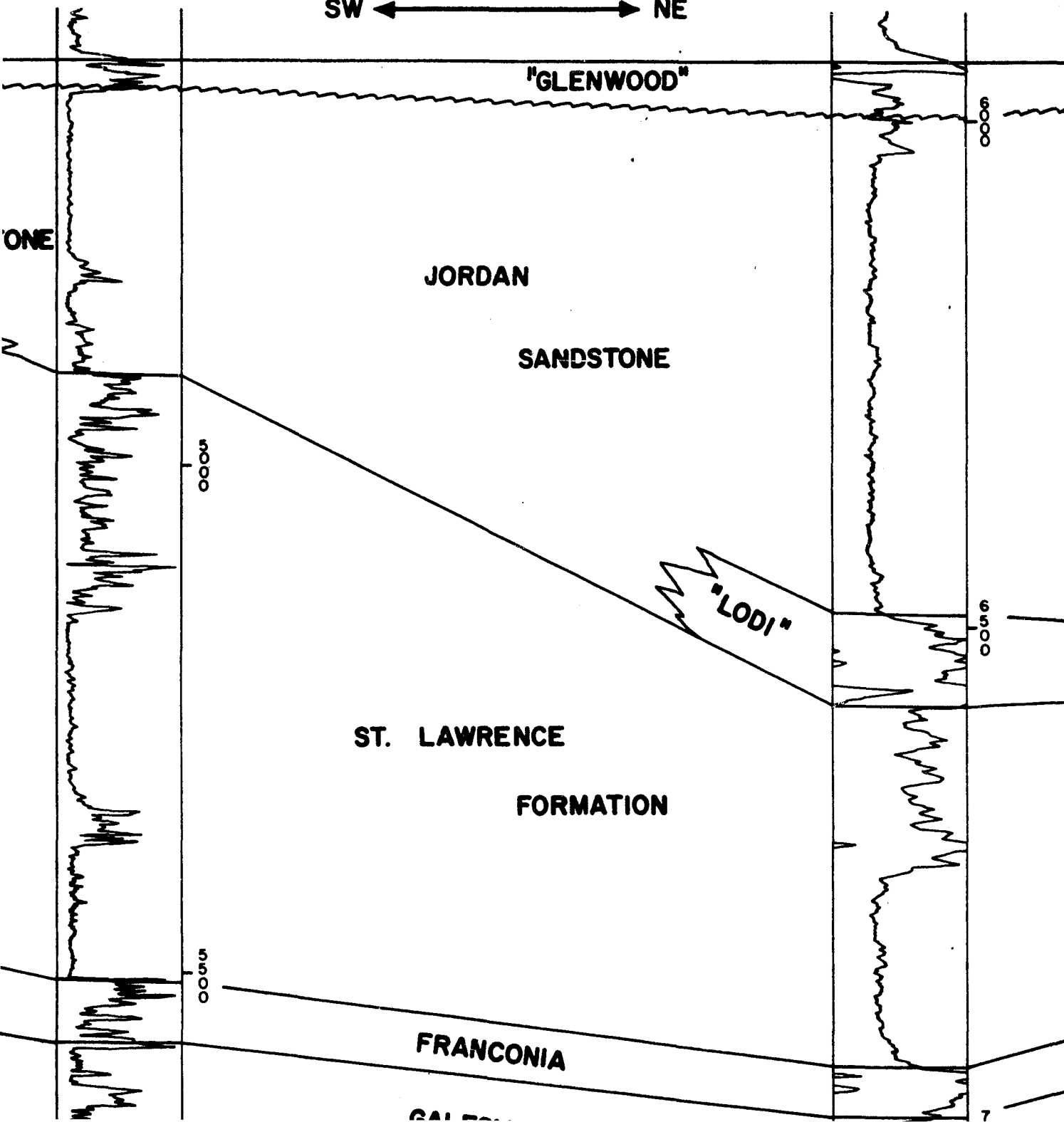
MASON CO.

SUPERIOR-SIPPY #17

Sec 25-T17N-R16W

#18905 ELEV 726 KB

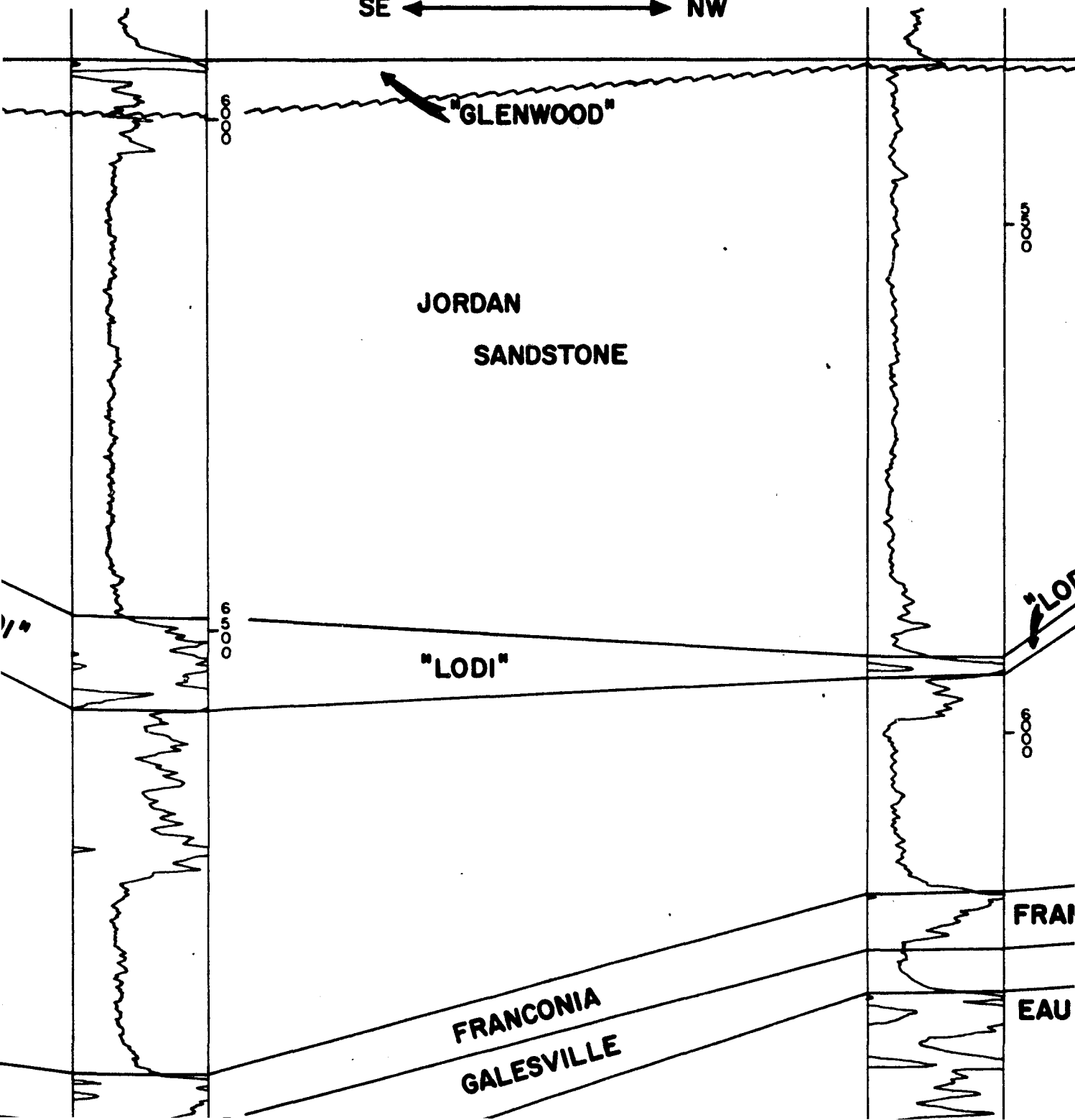
SW ← 33 MILES → NE



55  
MASON CO.  
SUPERIOR-SIPPY #17  
Sec 25-T17N-R16W  
18905 ELEV 726 KB

56  
MASON CO.  
DOW, BRAZOS-TAGGART  
Sec 27-T19N-R18W  
#17789 ELEV 647 I

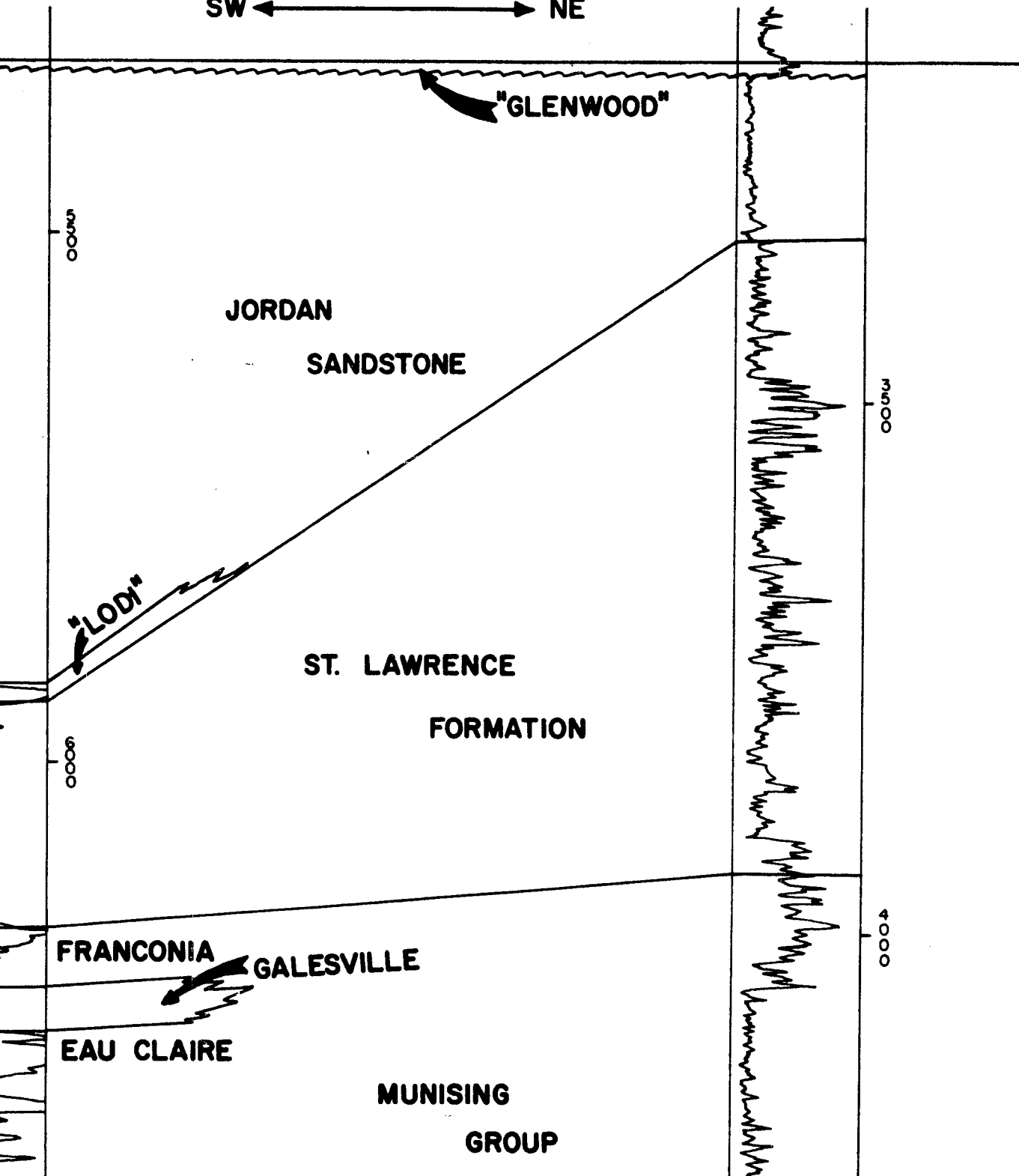
SE ← 18 MILES → NW

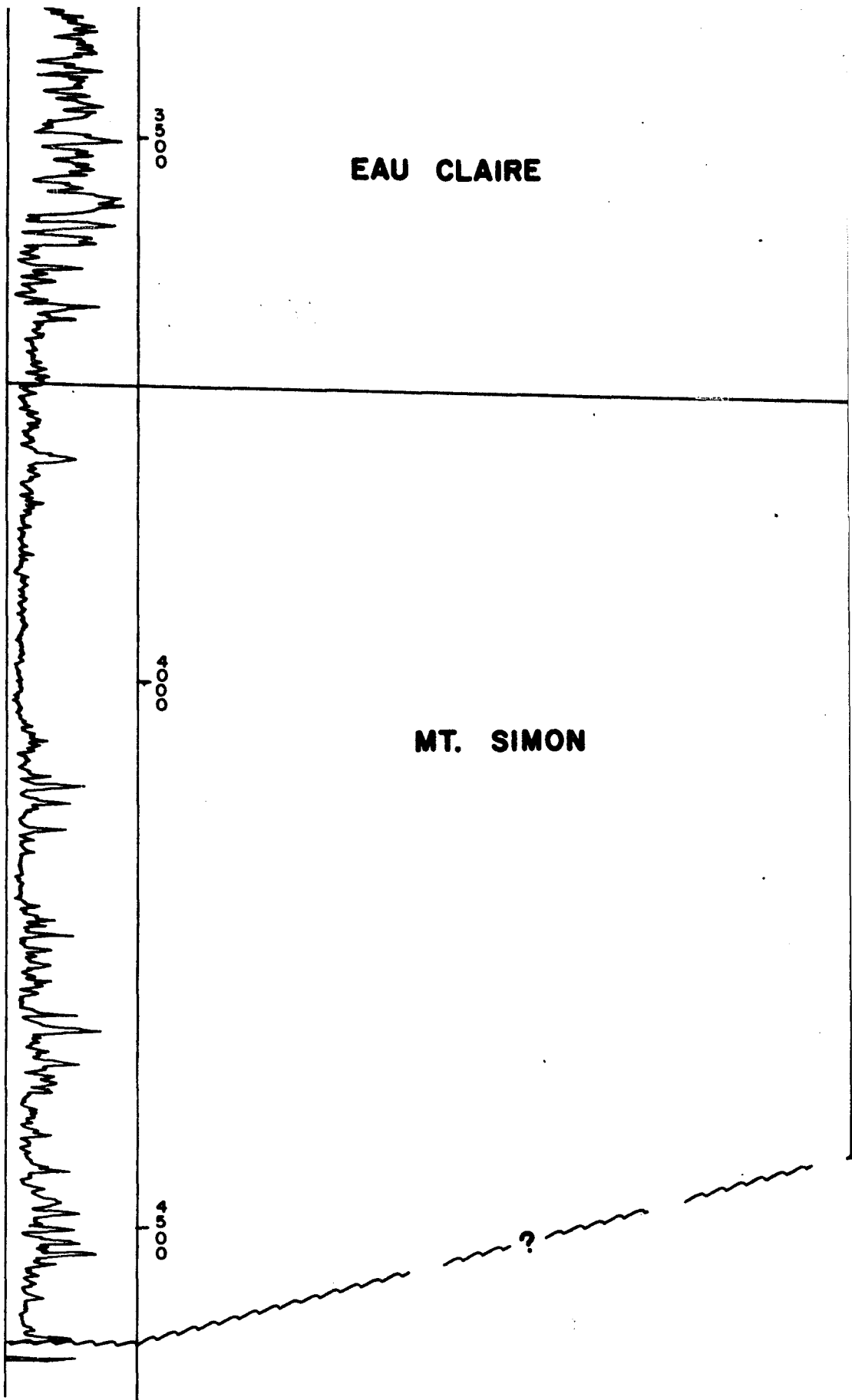


S  
I CO.  
TAGGART #1  
19N-R18W  
Elev 647 RB

15  
CHARLEVOIX CO.  
MC CLURE-BEAVER ISLAND #1  
Sec 27-T38N-R10W  
#23435 Elev 680 KB

SW ← 123 MILES → NE





EAU CLAIRE

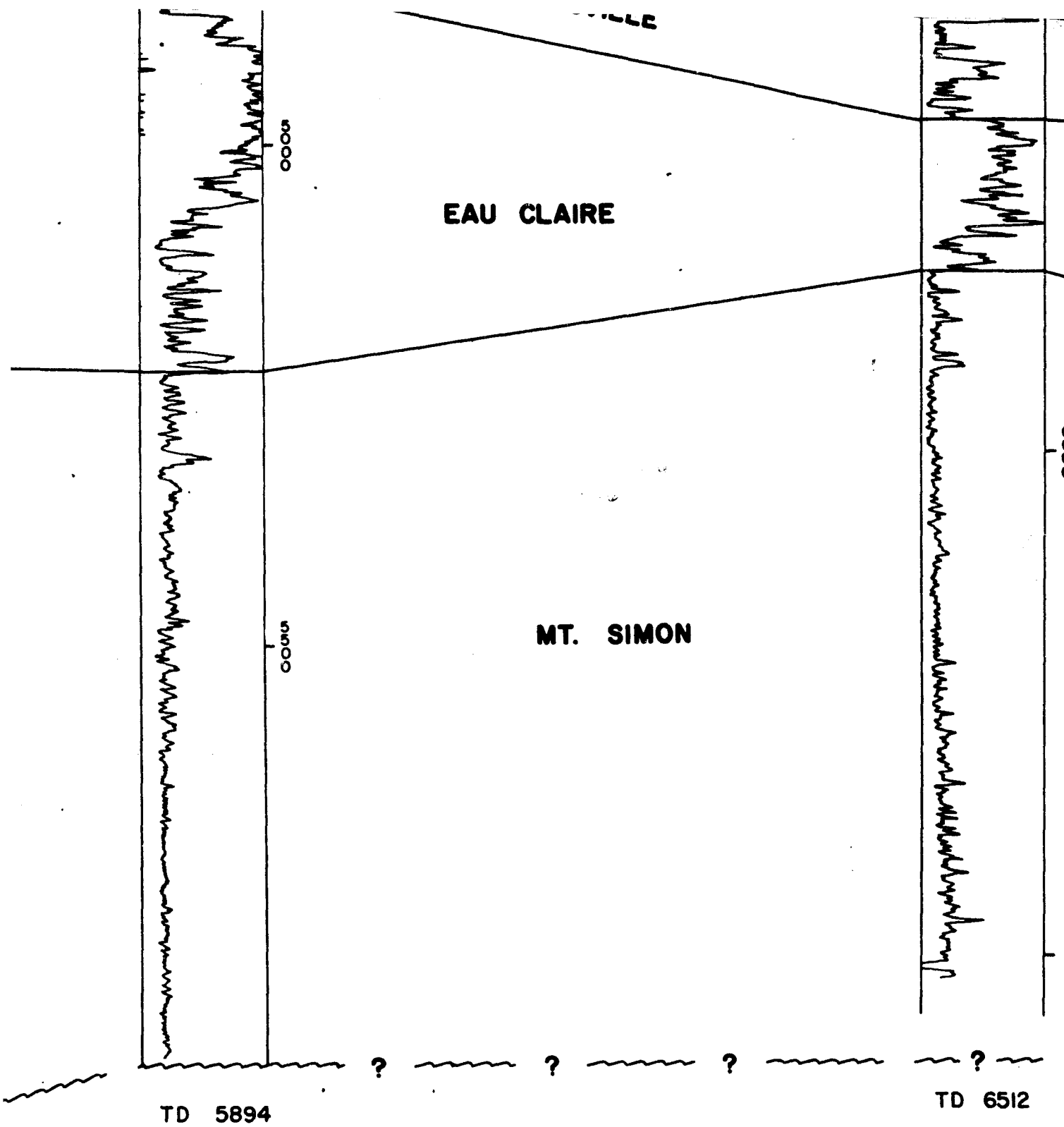
MT. SIMON

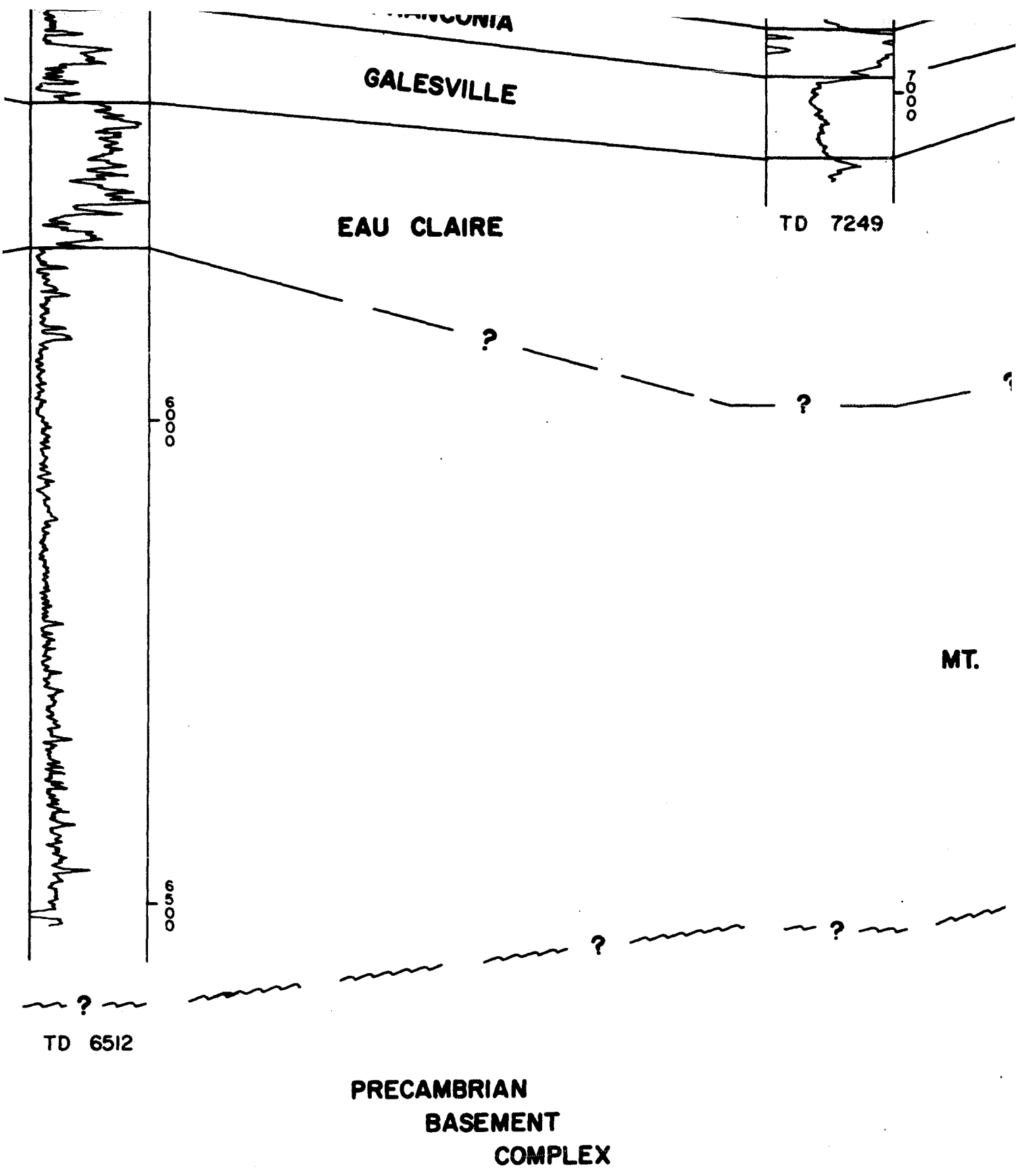
0000

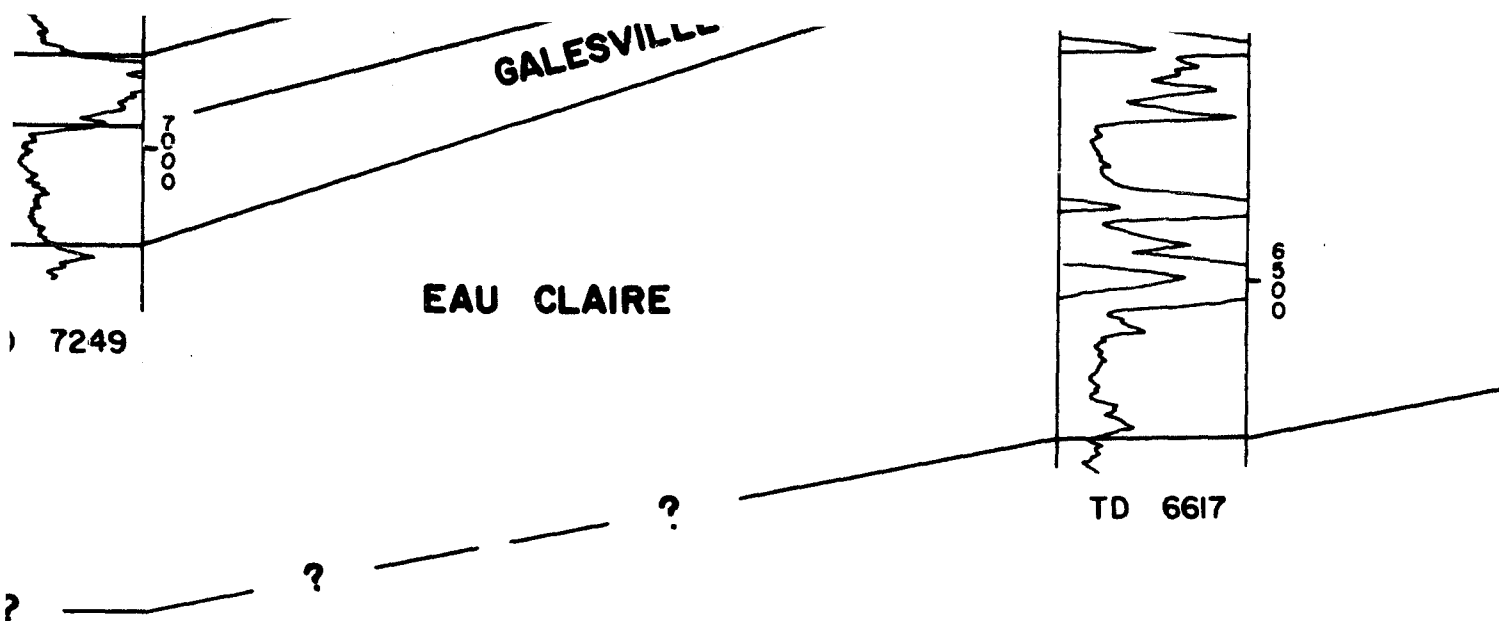
0004

0004

?







MT. SIMON

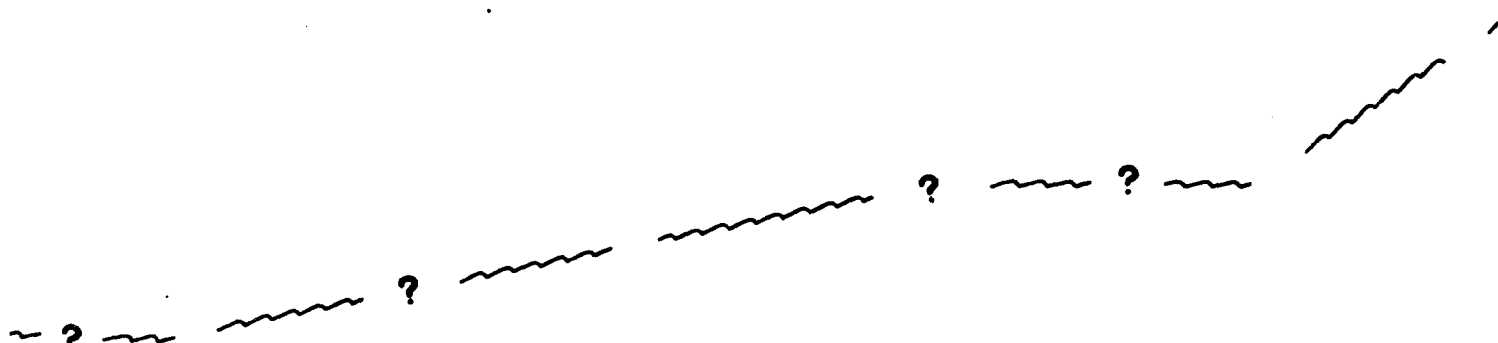
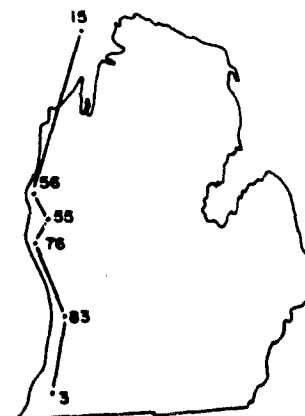


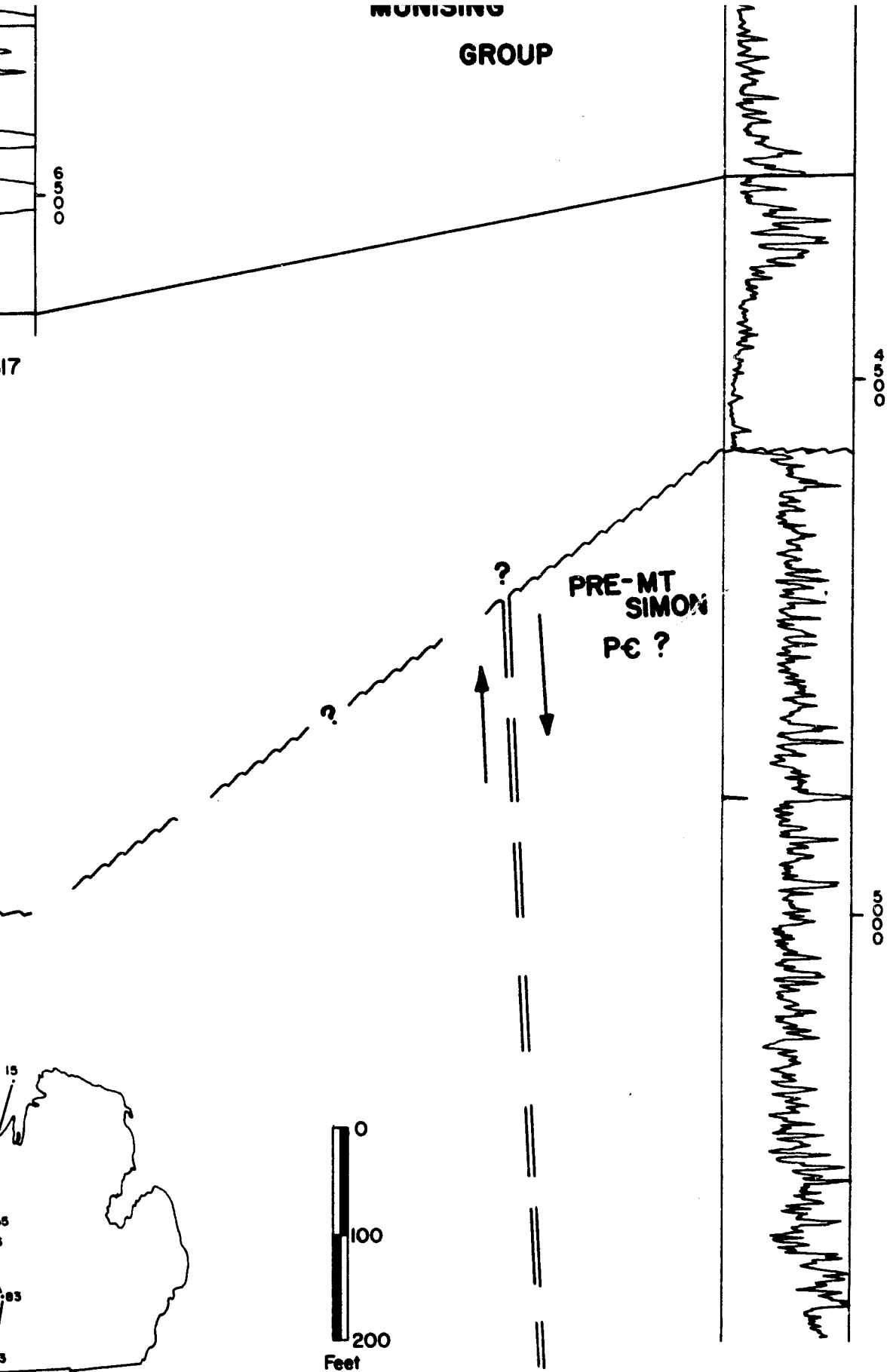
PLATE 14

**CROSS-SECTION  
NORTH-SOUTH  
WEST SIDE**

PAUL A. CATACOSINOS  
1972



# **MONTISINO GROUP**



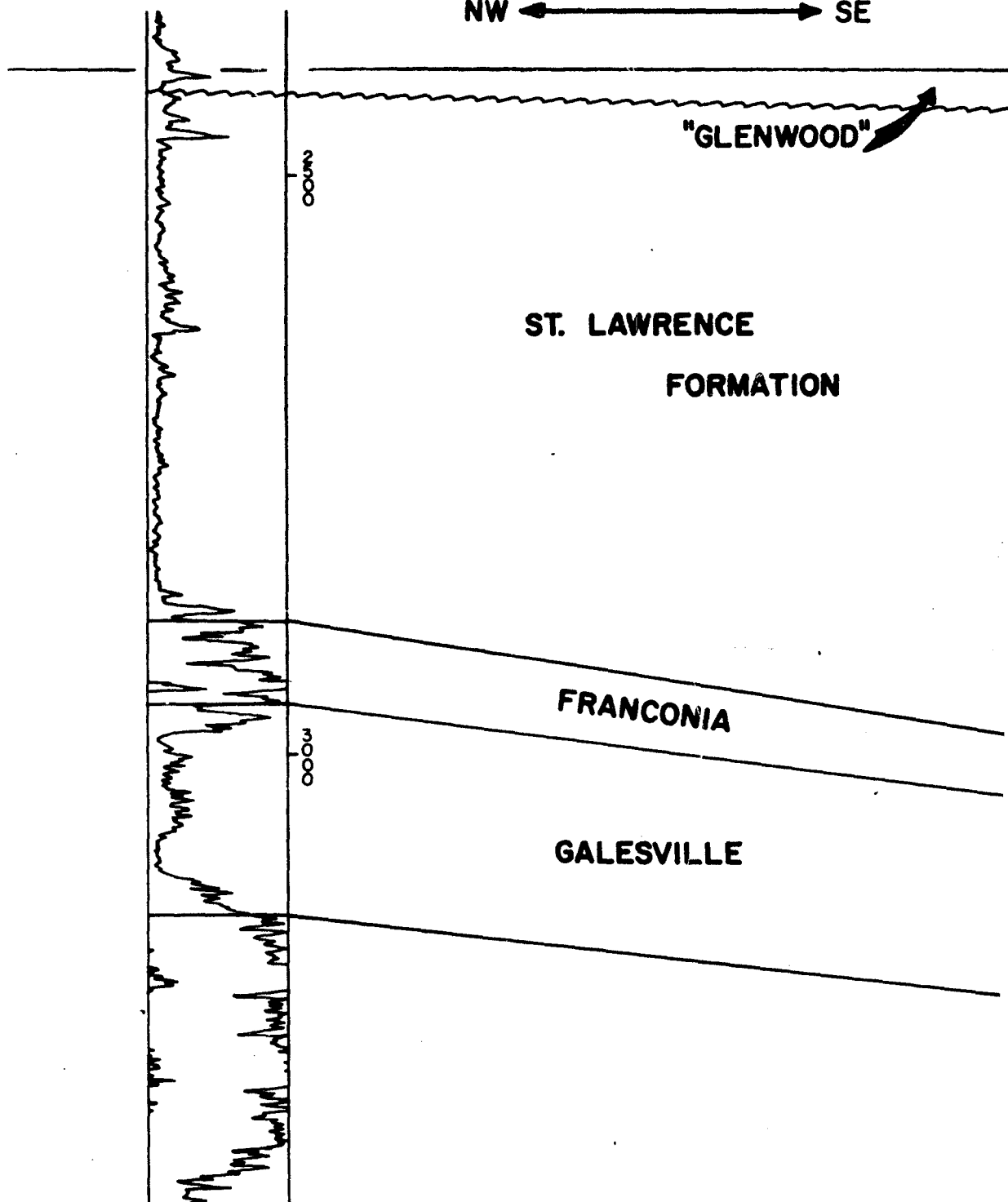
TD 5383



3  
BERRIEN CO  
SECURITY-THALMANN #1  
Sec 10-T6S-R17W  
#26112 ELEV 804 KB

#23

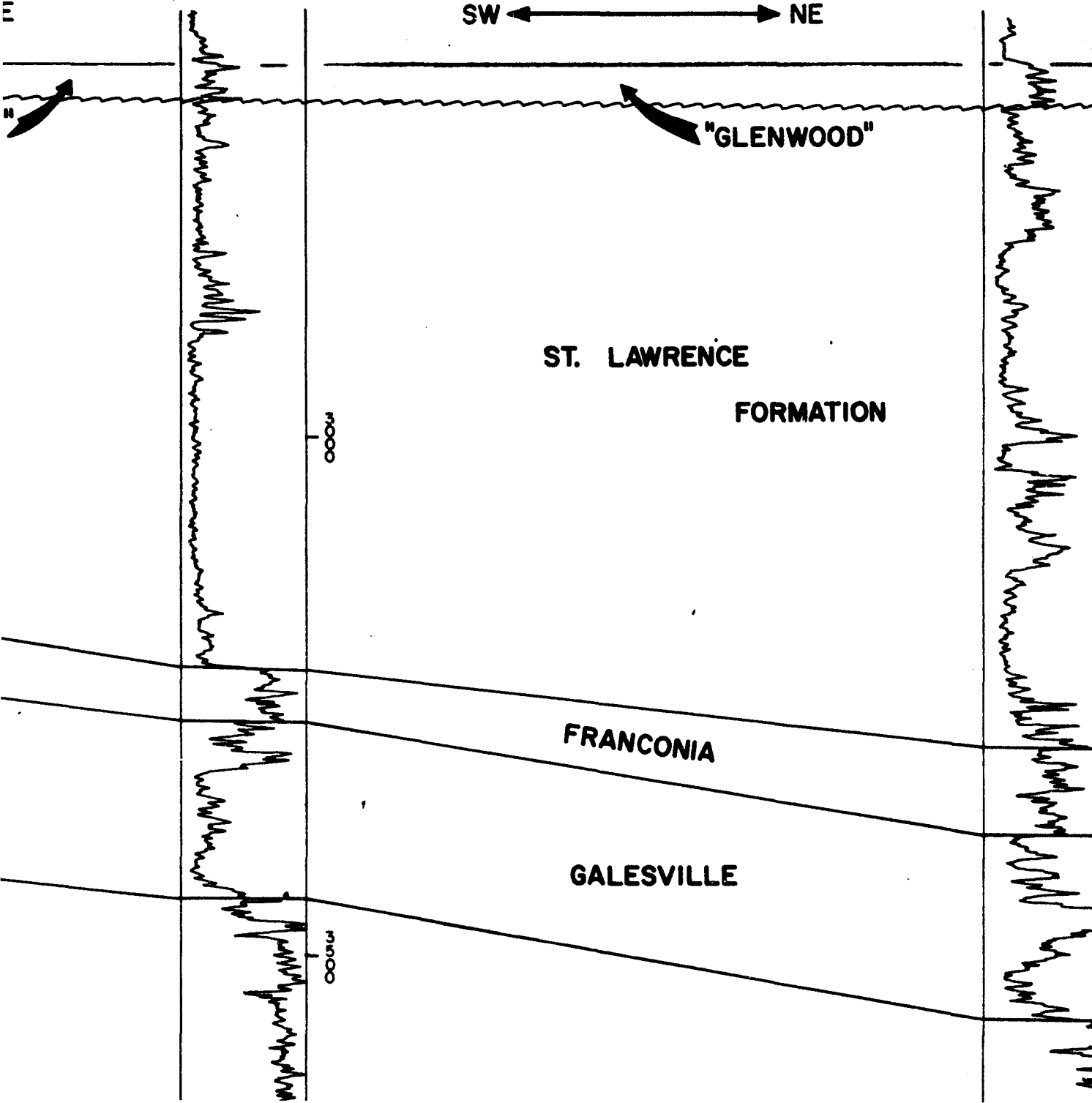
NW ← 17 MILES → SE



12  
CASS CO  
PERRY-WOODEN #1  
Sec 8-T7S-R14W  
#23289 ELEV 865 KB

33  
JACKSON  
NANCO-SMIT  
Sec 30-T3S  
#27137 ELEV

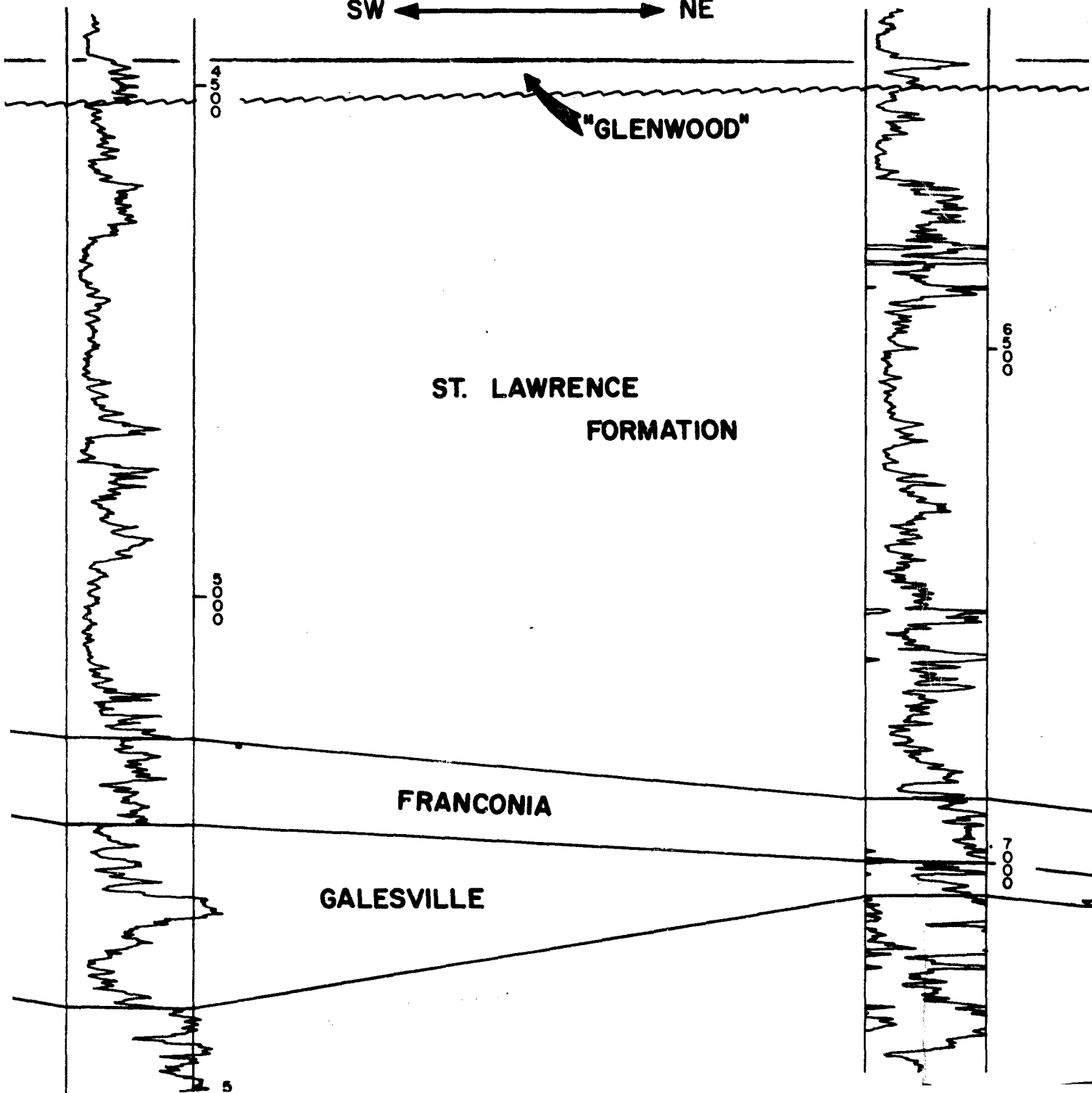
SW ← 68 MILES → NE



33  
JACKSON CO  
NANCO-SMITH #2  
Sec 30-T3S-R3W  
#27137 ELEV 1018 KB

49  
LIVINGSTON CO  
BRAZOS-KIZER #1  
Sec 14-T2N-R4E  
#25868 ELEV 938 KB

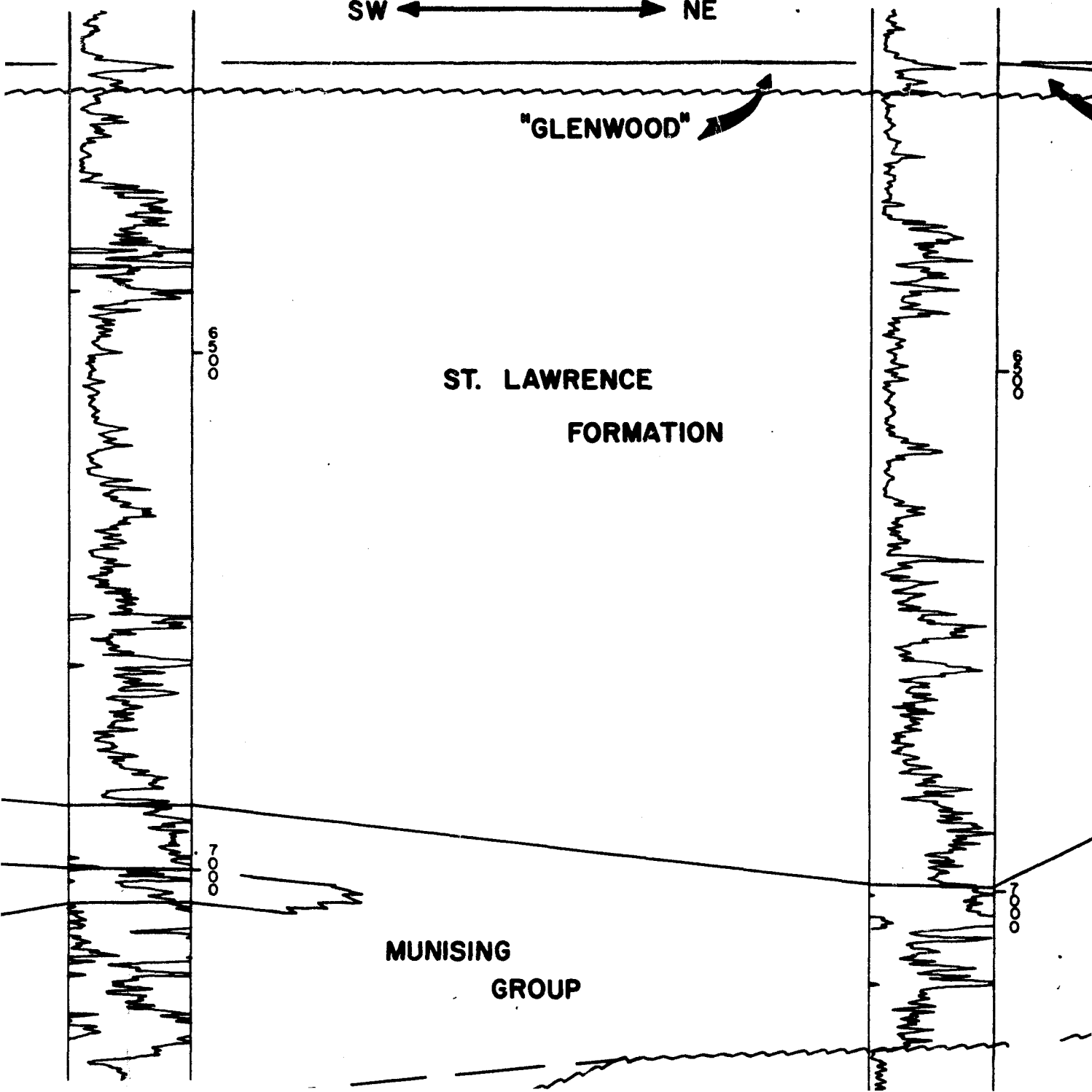
SW ← 48 MILES → NE



49  
LIVINGSTON CO  
BRAZOS-KIZER #1  
Sec 14-T2N-R4E  
25868 ELEV 938 KB

51  
LIVINGSTON CO  
MOBIL-MESSMORE #1  
Sec 11-T3N-R5E  
#27986 ELEV 980 KB

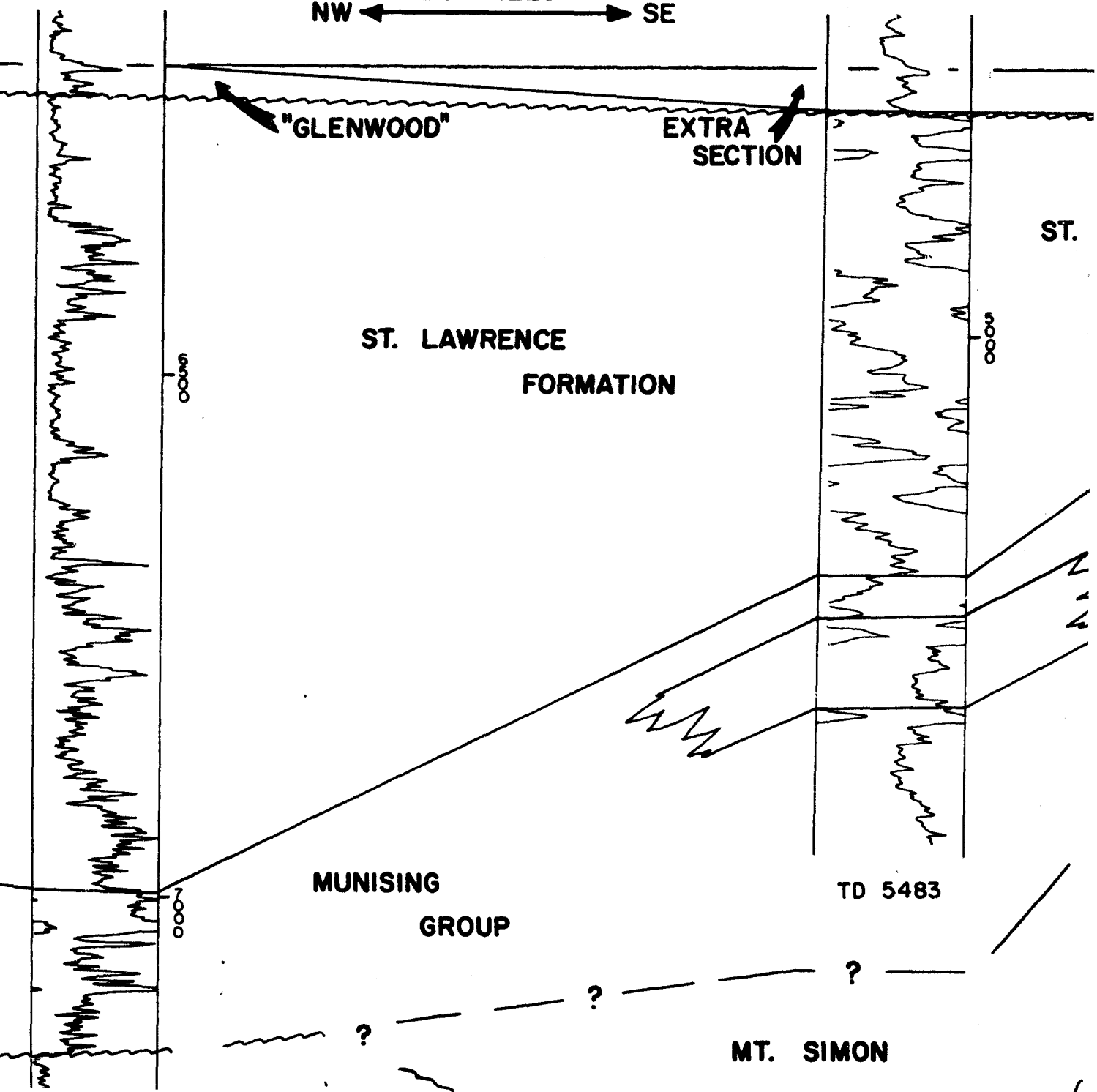
SW ← 2 MILES → NE



51  
LIVINGSTON CO  
OBIL-MESSMORE #1  
Sec 11-T3N-R5E  
986 ELEV 980 KB

140  
WAYNE CO  
CON PWR-DEHOCO #3  
Sec 17-T1S-R8E  
#19496 ELEV 900 RB

NW ← 24 MILES → SE



CO #3  
BE  
00 RB

98  
ST CLAIR CO  
BERNHARDT-PUZZUOLI #1  
Sec 17-T2N-R16E (Proj)  
#25780 ELEV 581 DF

SW ← 50 MILES → NE

EXTRA SECTION

"GLENWOOD"

ST. LAWRENCE  
FORMATION

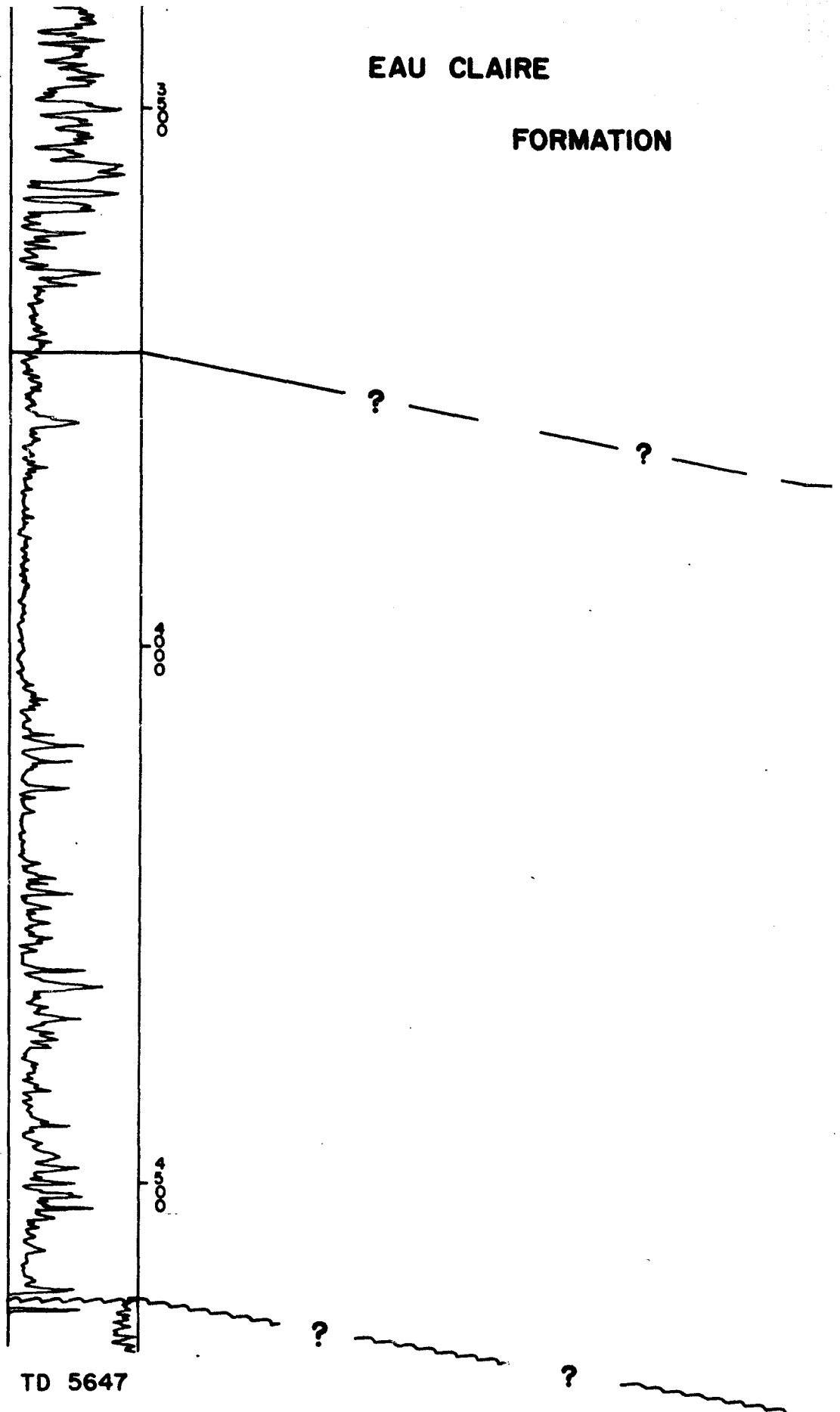
MUNISING  
GROUP

TD 4186



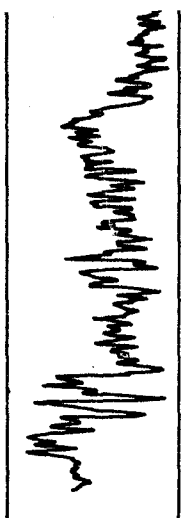
EAU CLAIRE

FORMATION



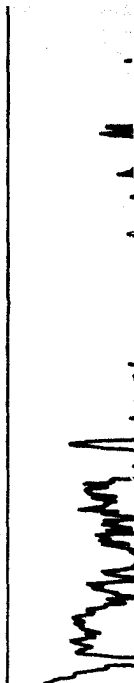
TD 5647

IN

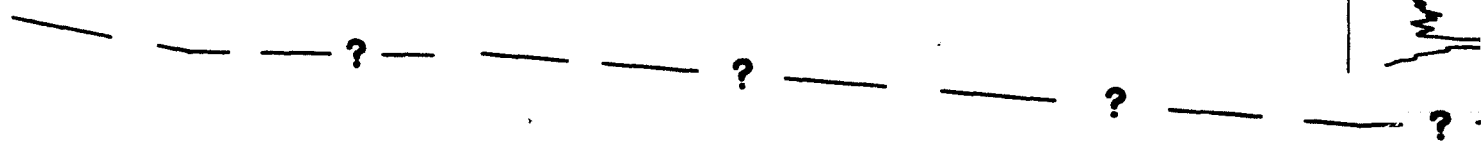


TD 3950

**EAU CLAIRE  
FORMATION**

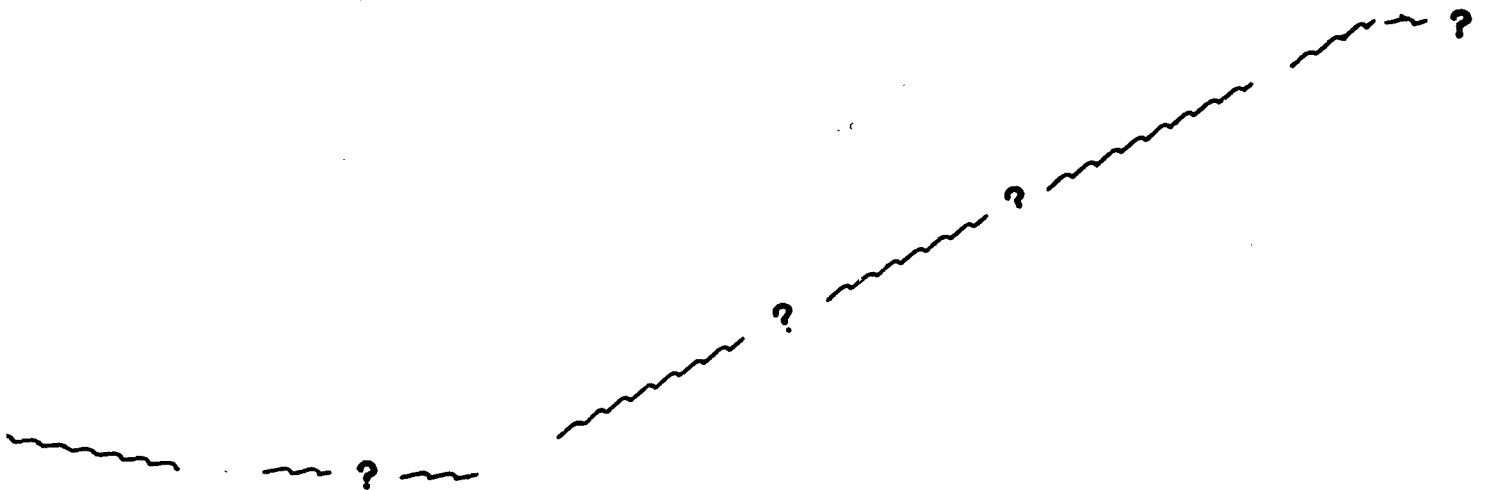


TD 593



**MT. SIMON**

**SANDSTONE**

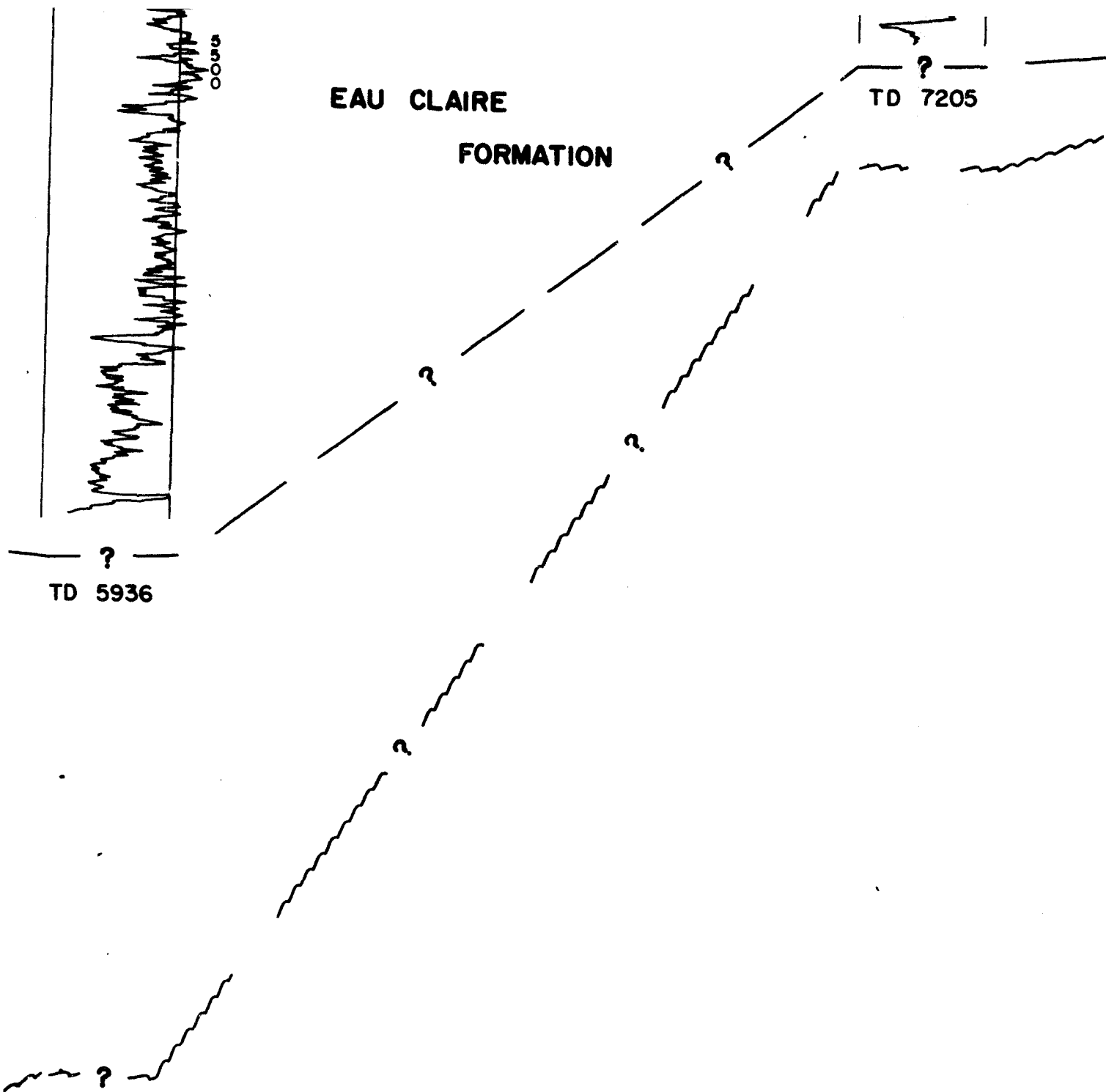


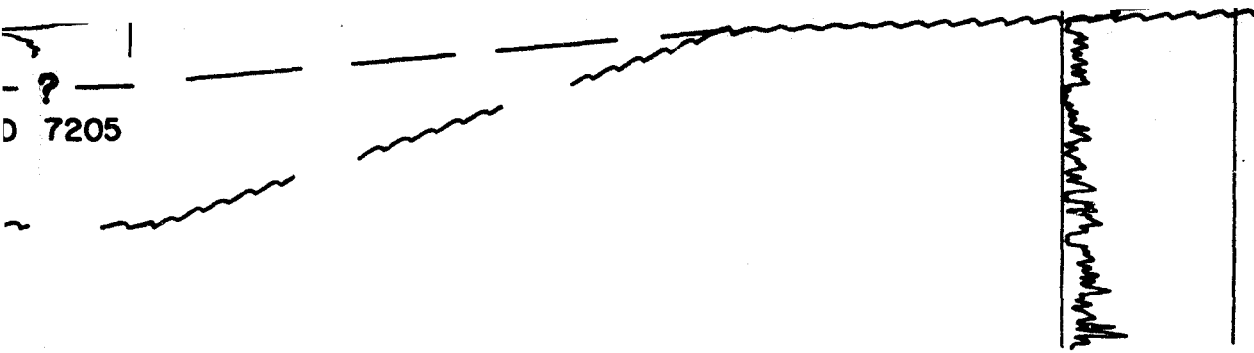


EAU CLAIRE  
FORMATION

TD 7205

TD 5936





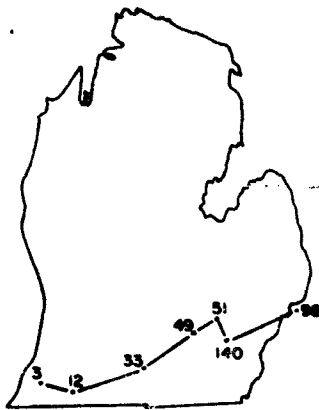
D 7205

TD 7589

**PRECAMBRIAN  
BASEMENT  
COMPLEX**



**MT. SIMON**



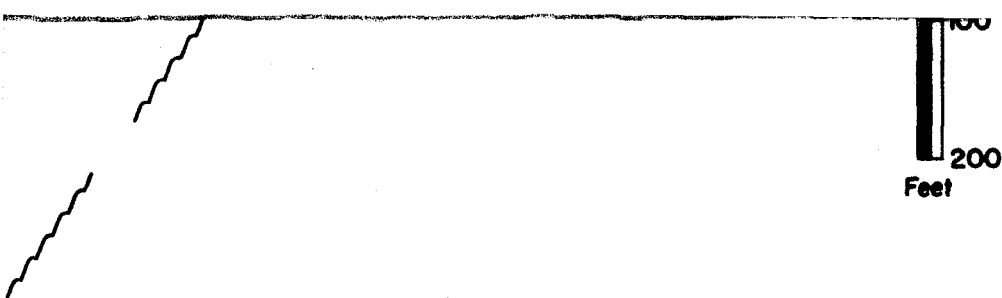
**PLATI**

**CROSS-1**

**EAST -  
SOUTH**

**PAUL A. CAT**

**197**



100  
200  
Feet

PLATE 15

# **CROSS-SECTION**

**EAST - WEST**

**SOUTH SIDE**

PAUL A. CATACOSINOS

1972