EXHIBIT B-17

Michigan Hydrologic Atlas, Part I (Hydrology for Underground Injection Control in Michigan), Department of Geology, Western Michigan University, Kalamazoo, Michigan, 1981, Pages II-42 through II-68

West Bay Exploration Company (WBEC), Haystead #9 SWD
(Permit #MI-079-2D-0010**)**

Administrative Record
Item # 28

1981

Salina Group

In the Michigan Basin subsurface the Upper Silurian is represented by the Salina and Bass Islands Groups. The Salina Group is a thick sequence of carbonate, anhydrite, salt and shale. A number of these lithologies are restricted to an area roughly equivalent to the combined extent of the basin and shelf facies of the Niagaran Group.

The basal portion of the Salina was designated the "A" member by Landes (1945). The "A" was further subdivided by Evans (1950) into a basal unit he termed the A-1 and an upper unit he named the A-2. Each of these units consists of a lower evaporite unit and upper carbonate. Each of the four "A" elements are extensive enough to warrant formational status, and at least the A-1 Carbonate has been elevated to this rank (Budros, 1974).

Characteristics as an Aquifer. The Salina serves as an aquifer only in its outcrop area in southeastern Michigan and the eastern part of the Northern Peninsula, especially on the St. Ignace Peninsula, where it produces from joints and bedding planes in dolomite.

Characteristics as a Confining Layer. Throughout the central portion of the Michigan Basin where the group contains thick salts and basinward of the reef trend, the unit is essentially an aquiclude.

Characteristics as an Injection Formation. Solution and fracture permeability, variable lithology, and aquifer and hydrocarbon reservoir potential render the Salina Group generally unfavorable as an injection unit. However the Salina is utilized for brine injection in St. Clair County.

Porosity. Porosity associated with joints, brecciation fractures and solution along bedding planes is common in the Northern Peninsula.

Permeability. Highly variable fracture and bedding plane permeability in Northern Peninsula.

Oil and Gas Potential. Near the margins of the evaporite containing Salina, the A-1 and A-2 Carbonates produce hydrocarbons.

A-1 Evaporite

The A-1 Evaporite consists of a basal and upper anhydrite that enclose a thick salt in the basinal area (fig. 2.19, pl. 10). The salt consists mainly of halite (NaCl), but it contains up to 40 feet of sylvite (KCL) in the center of the basin (Matthews, 1970). The unit is anhydrite over most of the Niagaran shelf facies. It is generally not present south of the shelf facies and extends only a short distance onto the bank facies in the northern Lower Peninsula (fig. 2.17 and 2.19). Locally, as long a line from Holland, Michigan southeast to Wayland and beyond, the A-1 salt has been removed by dissolution and the overlying rock has been draped over the abrupt escarpment formed by the salt.

Characteristics as an Aquifer. The A-1 Evaporite is not an aquifer.

Characteristics as a Confining Layer. The anhydrite beds and salt of the A-1 Evaporite are essentially impermeable and are excellent confining layers. Furthermore, they contain only a very small amount of formation water, and fractures in either lithology should "heal" either by flowage or secondary mineral growth.

Characteristics as an Injection Formation. None.

Porosity. Extremely low.

Permeability. Essentially impermeable.

Oil and Gas Potential. The A-1 Salt contains gas over some major structures. Gas was tested from this zone over the Mio anticline in Ogemaw County and over the Kawkawlin anticline in Bay County.

A-1 Carbonate

The A-1 Carbonate overlies that portion of the Michigan Basin underlain by the basin and shelf facies of the Niagaran Group and extends northward some distance onto the northern portion of the bank facies (fig. 2.20). South of the shelf facies in the southern part of the Southern Peninsula, the A-1 Carbonate extends only a short distance onto the bank facies. The carbonates in the A-1 are generally limestone except in areas adjacent to reefal buildups, over the abrupt margin of the A-1 salt in southwestern Michigan, and in local areas along its distal margins.

The A-1 Evaporite is gradational upward into the basal A-1 Carbonate and the A-1 Carbonate is apparently gradational into the overlying A-2 Evaporite. In areas where the A-1 Carbonate is overlain by the A-2 salt and underlain by the A-1 salt, all porosity in it is plugged by salt (halite). The A-1 Carbonate is less than 60' thick in the central part of the Michigan Basin and is more than 150 feet thick where it overlies the carbonate bank facies in the northern Lower Peninsula.

Characteristics as an Aquifer. The A-1 Carbonate is not an aquifer.

Characteristics as a Confining Layer. In areas where the A-1 Carbonate is limestone and salt plugged, it is an excellent confining layer.

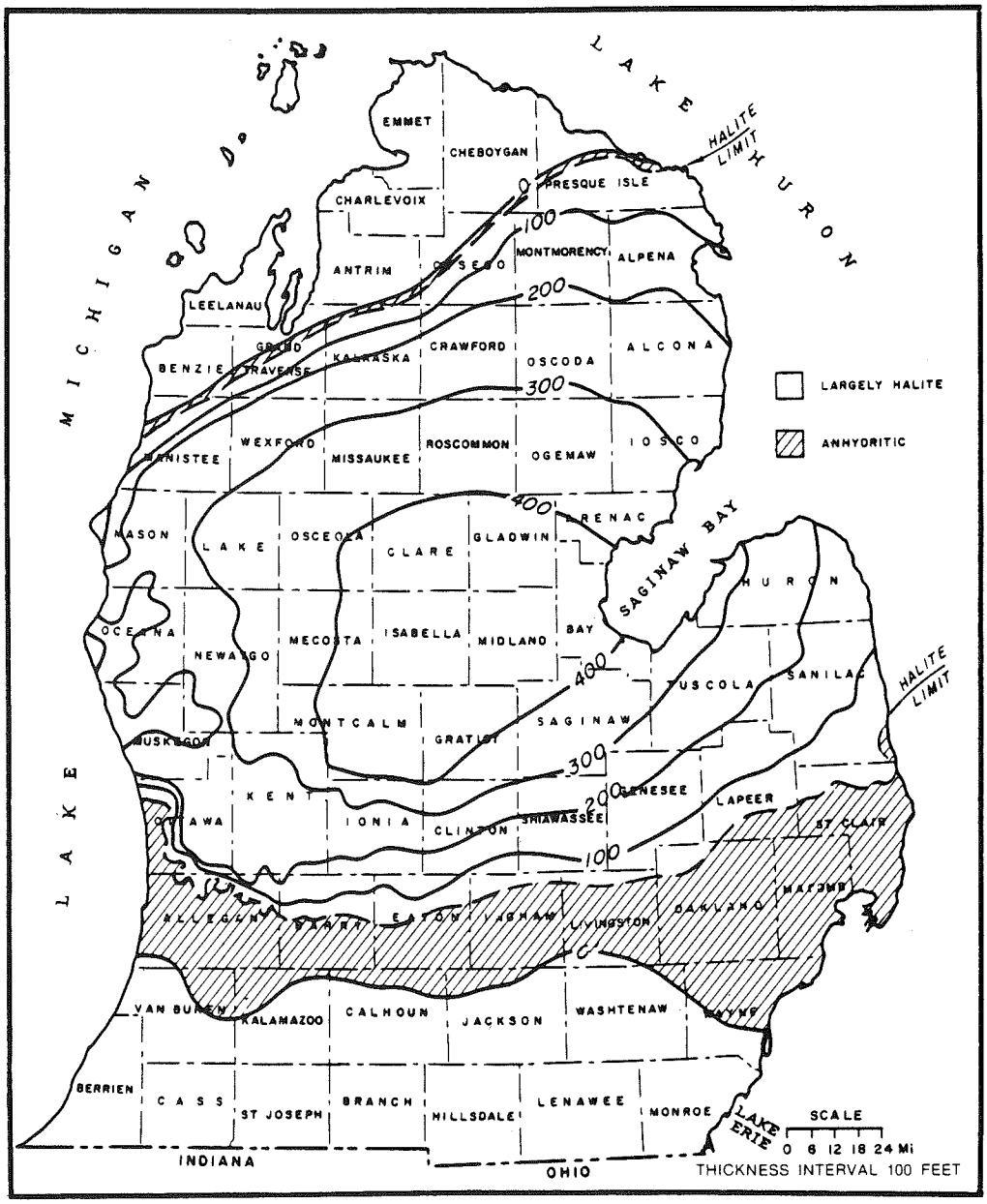

Figure 2.19. Thickness of the A-1 evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

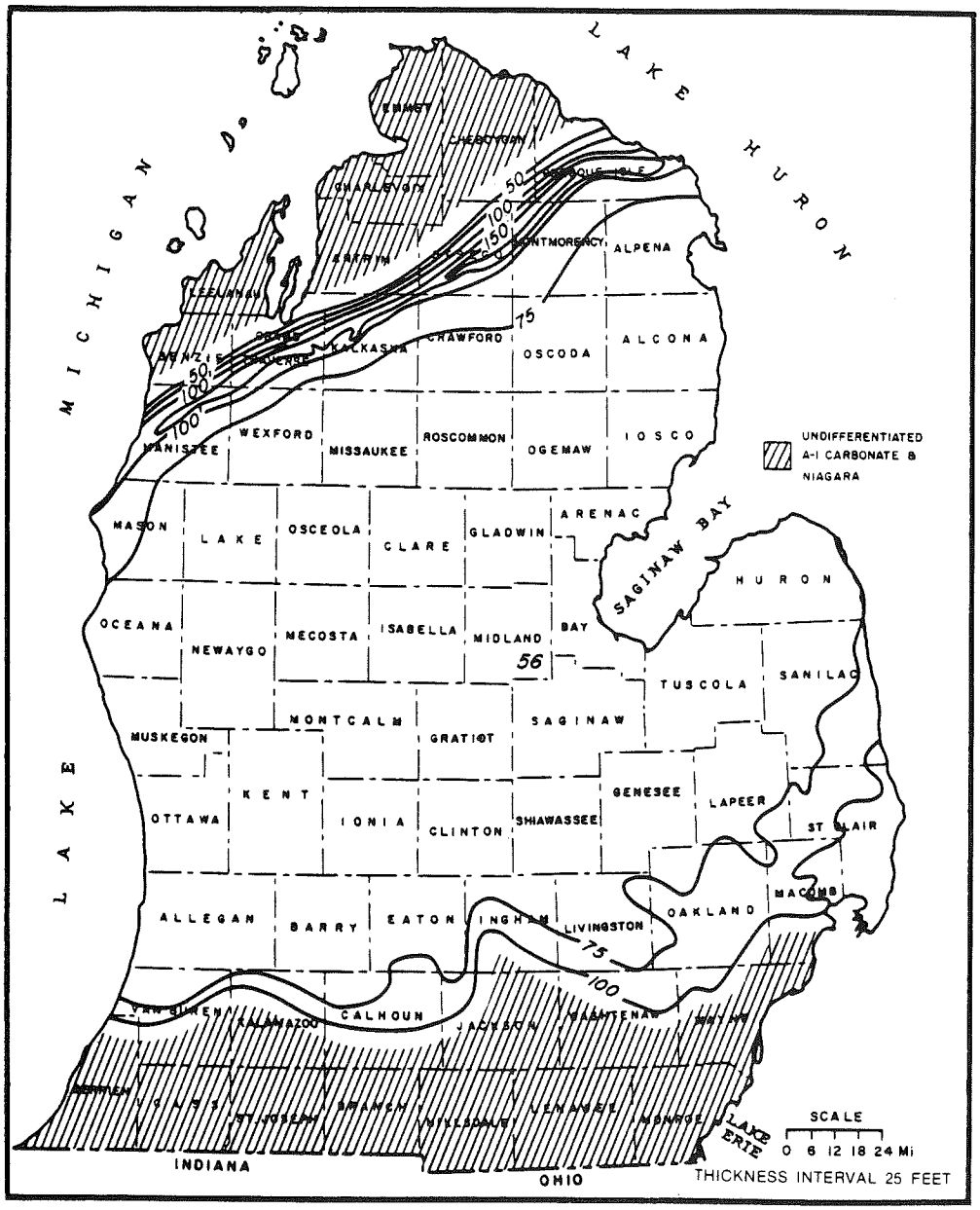

Figure 2.20. Thickness of the A-1 Carbonate. Contour interval is 25 feet. (From Mesolella, 1974.)

Characteristics as an Injection Formation. The A-1 Carbonate will accept fluids only where it is dolomite. In such areas, it is a target for oil and gas exploration, is productive of hydrocarbons, or it is in contact with very permeable reefal dolomites of the Niagaran.

Porosity. In areas where this unit is dolomite, it has low porosity. In areas where it is limestone and salt-plugged, it has extremely low porosity.

Permeability. Dolomites of the A-1 Carbonate are slowly permeable, and salt-plugged limestones are essentially impermeable.

Oil and Gas Potential. The A-1 Carbonate produces hydrocarbons and is an exploration target in those areas where reefs are developed in the Niagara Group.

A-2 Evaporite

The A-2 Evaporite conformably overlies the A-1 Carbonate except over "pinnacle" reefs where it lies directly on the Niagaran (fig. 2.21). It is dominantly halite and ranges from a zero edge at the basin margin to more than 475 feet thick in the central part of the basin (Tremper, 1973). Over the bank reef complex it is a dense anhydrite generally less than 40 feet thick. A-2 salt has been removed by dissolution southwestward of a line that extends from Muskegon southeastward to the Walker Oil Field in Kent County. The A-2 salt, may have been removed in the area just north of the Straits of Mackinac and south to the present salt margin.

Characteristics as an Aquifer. The A-2 Evaporite is not an aquifer.

Characteristics as a Confining Layer. The A-2 Evaporite is an excellent confining layer. It is the seal over the pinnacle reefs that developed in the shelf facies of the Niagaran and has the properites necessary to confine fluids under pressure.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Extremely low.

Permeability. Extremely low.

Oil and Gas Potential. None.

A-2 Carbonate

The A-2 Carbonate is limestone in the central part of the basin and is dolomite over the bank facies and over pinnacle reefs in the southern part of the Lower Peninsula. This unit is more than 150 feet thick in the middle of the basin and thins to less than 50 feet in the northernmost part of the Lower Peninsula (fig. 2.22). It also thins across the southern extension of the bank facies and is difficult to distinguish, or absent, in the area just north of the Michigan-Indiana State line.

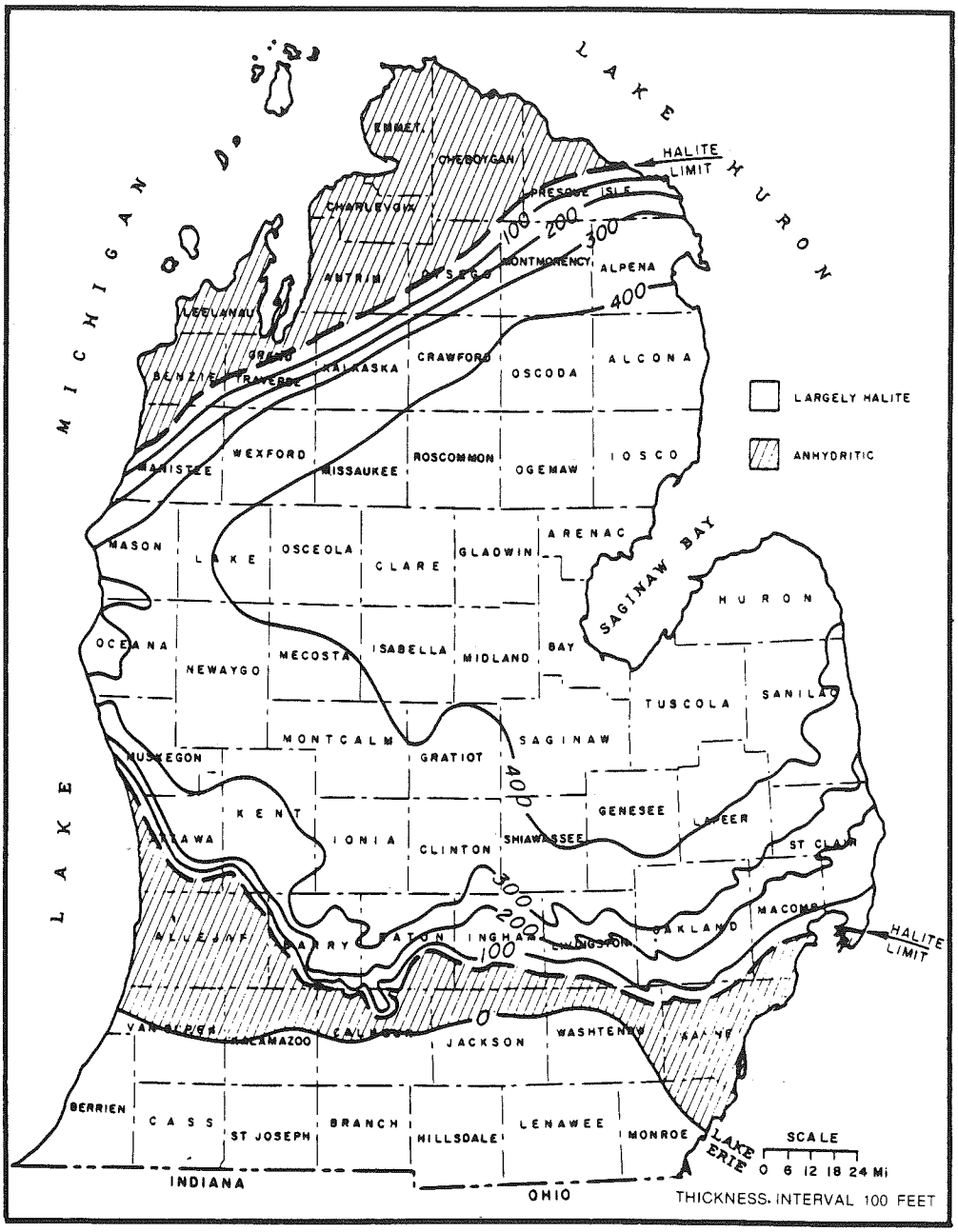

Figure 2.21. Thickness of the A-2 Evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

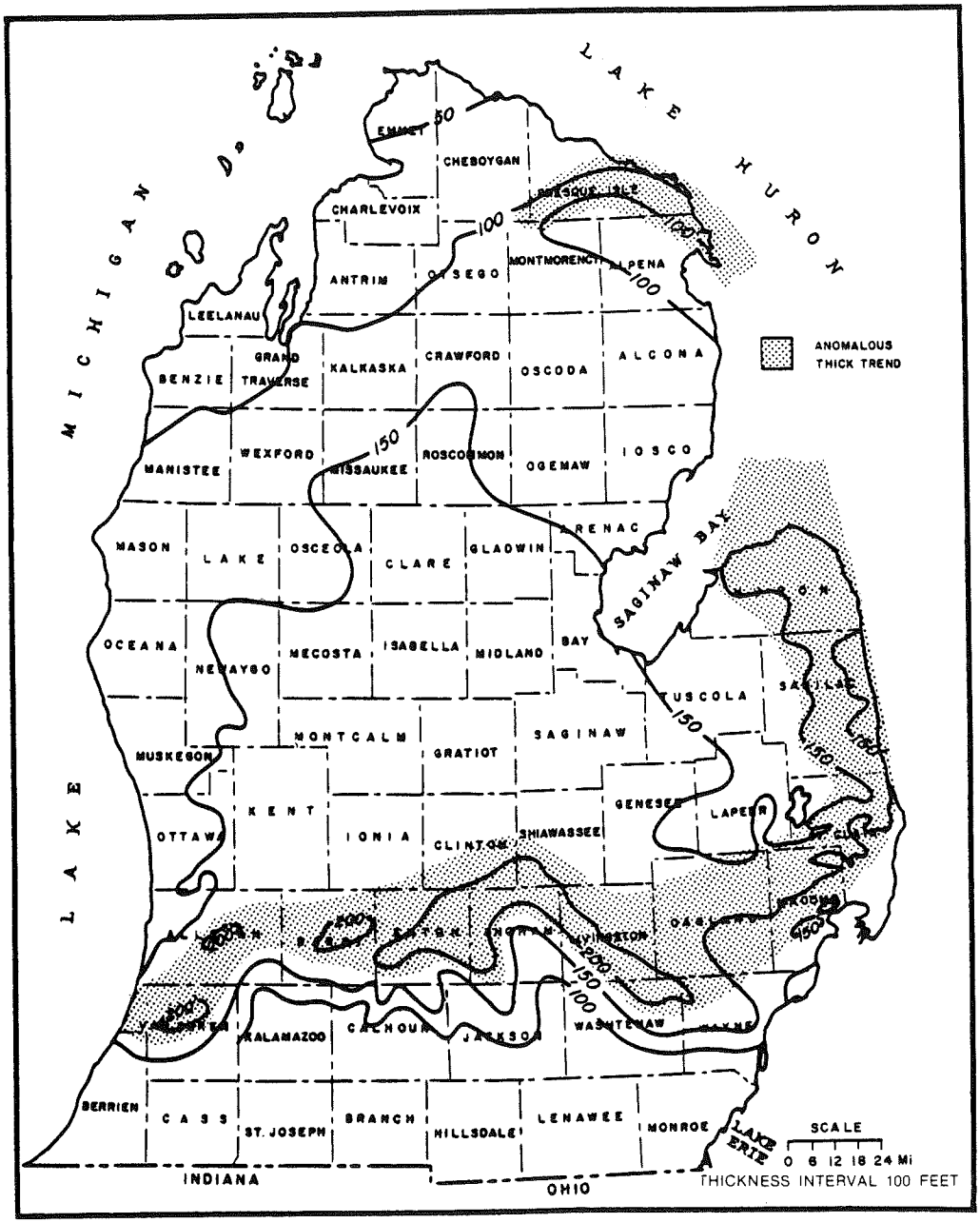

Figure 2.22. Thickness of the A-2 Carbonate. Contour interval is 50 feet. (From Mesolella, 1974.)

Characteristics as an Aquifer. The A-2 Carbonate is not an aquifer. Where the unit is a dolomite, it is slightly porous and slowly permeable, but contains oil and/or gas or brine.

Characteristics as a Confining Layer. In areas where this unit is limestone, all pore space is generally plugged with salt. In such areas it is an excellent aquiclude.

Characteristics as an Injection Formation. In areas where the A-1 Carbonate is dolomite it may serve as an injection formation, but its hydrocarbon potential should first be evaluated. It is currently used as a gas storage reservoir along the A-1 salt edge in southwestern Michigan.

Porosity. Where the A-1 Carbonate is limestone it has very little porosity. In the areas where it is dolomite, it has a porosity of a few percent.

Permeability. The A-2 Carbonate is virtually impermeable in areas where it is a limestone and is salt-plugged. Where it has undergone dolomitization, it is slowly permeable.

Oil and Gas Potential. The A-2 has produced gas in areas where it is dolomite.

B Member

The unit defined as the "B" Member by Landes (1945) includes, in the central part of the basin, up to 450 feet of basal salt and an upper unit comprised of 0 feet to about 80 feet of shale, dolomite and anhydrite (fig. 2.23). The B-salt is thickest in the basin and thins toward the northern carbonate bank where it thickens (Tremper, 1973). North of the thickest portion of the bank facies the unit thins toward the basin margin. On the southern flank of the basin, the B-salt does not extend south of the southern edge of the shelf facies of the Niagaran. The upper part of the B, termed the B-Unit by Ells (1978) thins from a maximum of more than 80 feet in the basin center to a zero edge near the Straits of Mackinac on the north and over the northern part of the bank facies and the southern flank of the basin.

Characteristics as an Aquifer. Neither the B-salt nor the B-Unit is an aquifer.

Characteristics as a Confining Layer. The B-salt and the B-Unit are excellent confining layers. The thick salt section in the central part of the basin would be most effective, but the presence of either salt or anhydrite should indicate that the member is an aquiclude.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Essentially impermeable.

Permeability. Essentially zero.

Oil and Gas Potential. Very little to none.

Figure 2.23. Thickness of the B Evaporite. Contour interval is 100 feet. (From Mesolella, 1974.)

C Shale

The C-Unit is a dolomitic shale with beds of anhydrite and dolomite. It is more than 115 feet thick in the central basin area, thins to 70 feet across the thick portion of the northern bank facies and is more than 100 feet thick near the Straits of Mackinac (fig. 2.24). The unit thins across the southern bank facies, becomes more carbonate rich, and according to Shaver (personal communication, 1980) grades into the Mississenawa Shale in Indiana.

Characteristics as an Aquifer. None.

Characteristics as a Confining Layer. The C-Shale is a plastic shale and should not maintain open fractures at depth. Thus, it is considered to be an excellent confining layer.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Effective porosity is essentially zero. Porosity associated with clay minerals is quite high.

Permeability. Essentially impermeable.

Oil and Gas Potential. None.

D-Unit

The Salina D-Unit is composed of two salt (halite) beds and an intervening argillaceous, anhydritic, fine-grained dolomite. Around the periphery of the basin the D-Unit is thin and consists mainly of shale and anhydrite. It is as much as 60 feet thick in the central basin area but thins to less than 15 at the margins of the basin (Tremper, 1973) (fig. 2.25).

Characteristics as an Aquifer. The D-Unit is not an aquifer.

Characteristics as a Confining Layer. In the basinal areas where the D-Unit salts are present the D-Unit is an aquiclude. Marginal to the area of salt development, the shaly anhydrite should be an aquitard, but would not form as formidable a barrier to the movement of fluids as a thick bed of salt (NaCl).

Characteristics as an Injection Formation. None.

Porosity. Extremely slow.

Permeability. Extremely slow.

Oil and Gas Potential. None.

E-Unit

The Salina E-Unit is a mixture of lithologies. Dominated by shales, it also contains dolomite beds that are locally oolitic and thin beds of anhydrite. It is more than 160 feet thick in the center of the Michigan Basin and thins to less than 90 feet in marginal areas (Tremper, 1973) (fig. 2.26).

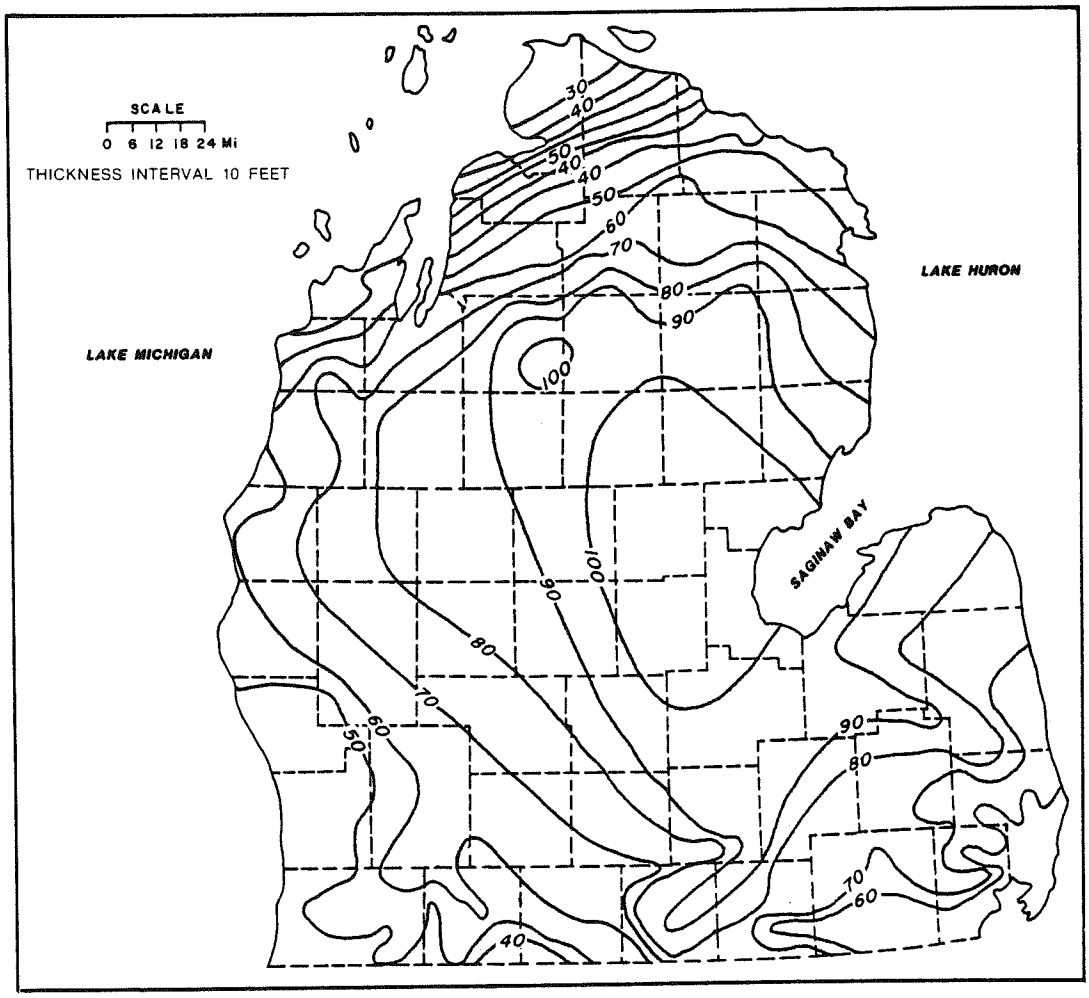

Figure 2.24. Thickness of Salina C Unit. (From Dali, 1975.)

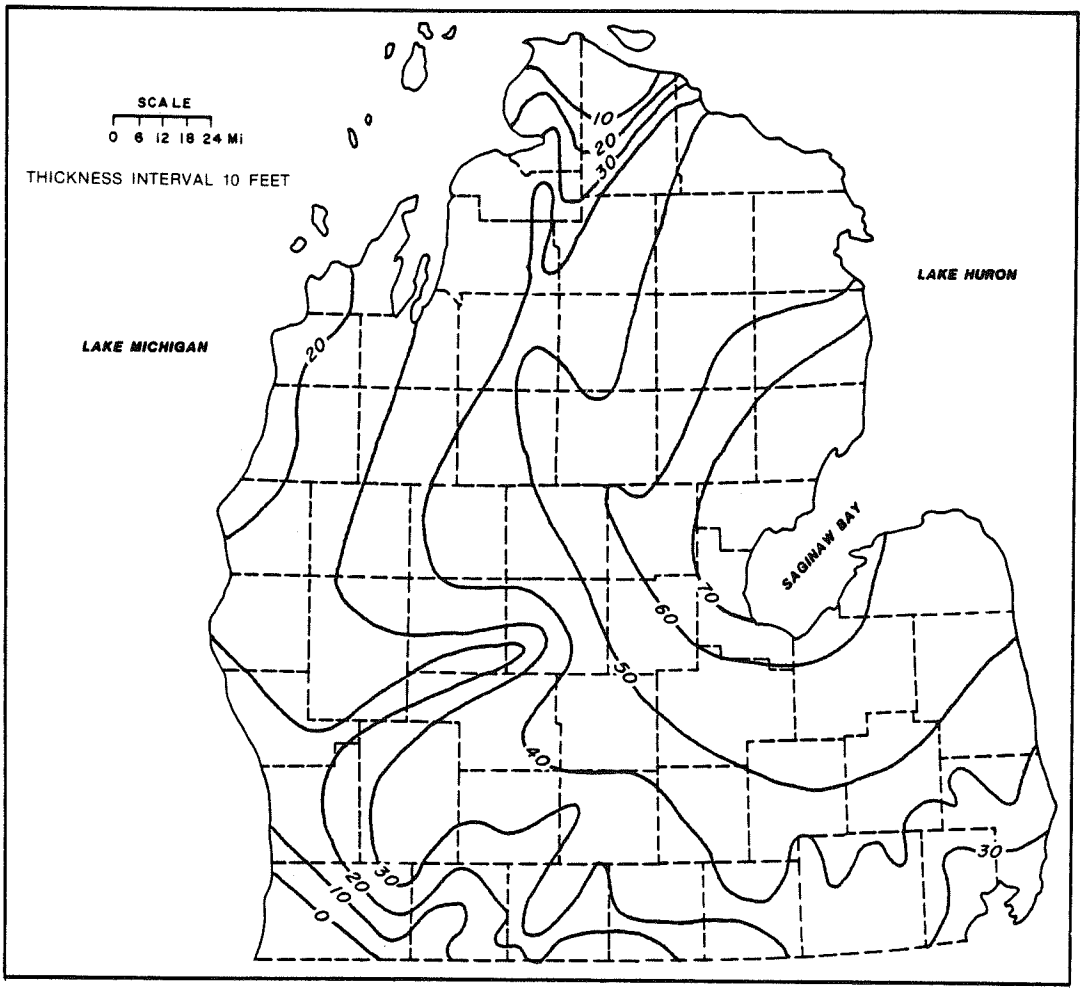

Figure 2.25. Thickness of Salina D Evaporite. (From Dali, 1975.)

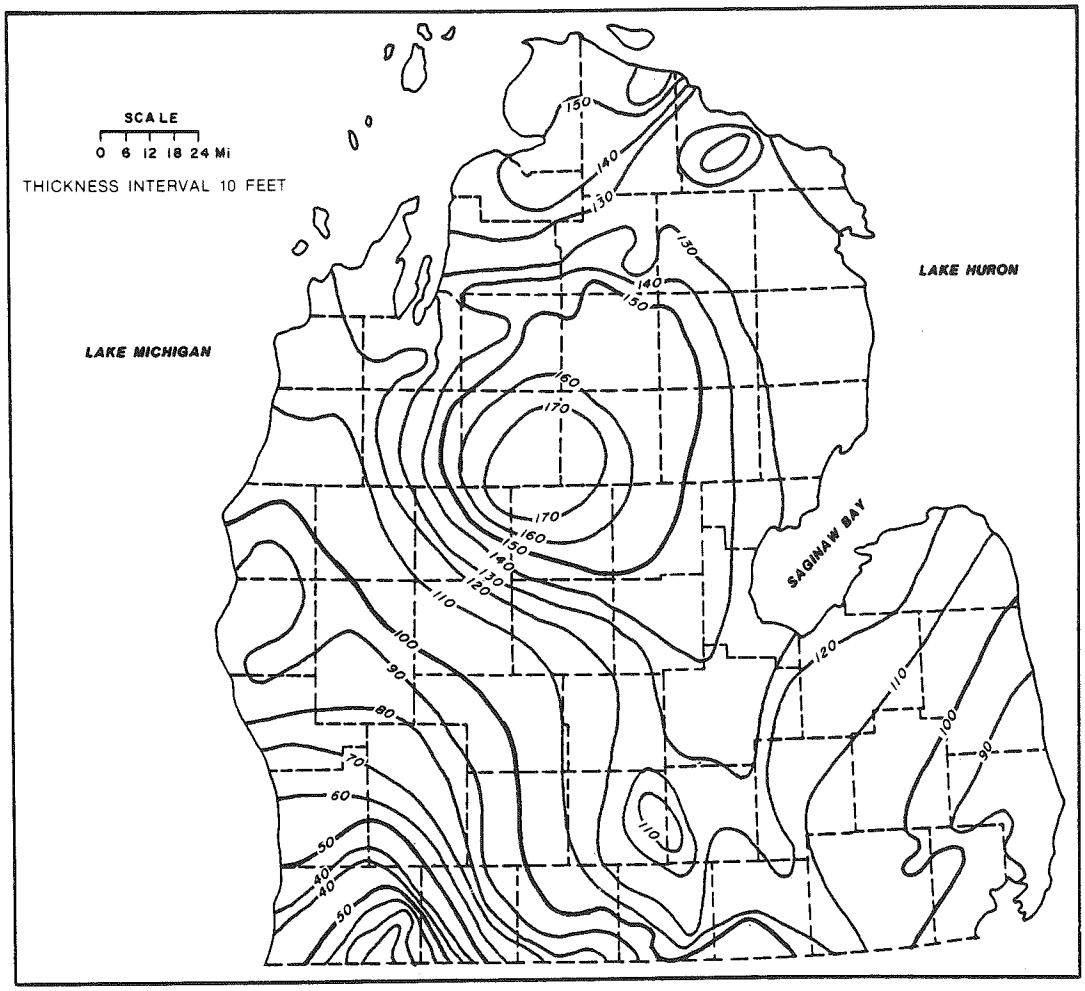

Figure 2.26. Thickness of Salina E Unit. (From Dali, 1975.)

Characteristics as an Aquifer. The E-Unit is not an aquifer.

Characteristics as a Confining Layer. Shales and anhydrite beds in the E-Unit should form a barrier to the migration of fluids. In the central portions of the basin the dolomite beds are most likely salt plugged and also form aquicludes. In areas marginal to salt development, the dolomite beds may permit vertical migration of fluids.

Characteristics as an Injection Formation. Generally unsuitable.

Porosity. Effective porosity of this unit is very low, especially in areas where salt plugging occurs. Marginal to the areas of salt development, the dolomite beds may contain some effective void space. Shales in this unit contain a high ineffective porosity associated with clay minerals.

Permeability. Where salts are developed in the Salina permeability is very low. Marginal to the area of salt development, the dolomite beds are probably permeable.

Oil and Gas Potential. Very low.

F-Unit

The Salina F-Unit comprises a sequence of salt (NaCl) beds with intervening shales and dolomite beds. The top of the unit is generally picked at the top of a buff, fine-grained, anhydritic dolomite. The unit thickens from less than 100 feet on the southwest margin of the basin to over 900 feet at the center of the basin (fig. 2.27). Around the northern margin of the Southern Peninsula the salts are absent and the F-Unit is composed mostly of shale. Southward across the state shale is of diminishing importance in this unit. Shales in the F and G Units probably correlate with the Point aux Chenes Shale in the Salina outcrop belt of the eastern Northern Peninsula.

Characteristics as an Aquifer. The F-Unit is not an aquifer.

Characteristics as a Confining Layer. In the basinal area where salts are present in this unit, and along the northern margin of the Northern Peninsula where the F-Unit is mostly salt, it is an aquiclude. South of the area of salt development the Salina does not contain thick shales and its value as a confining layer is probably minimal.

Characteristics as an Injection Formation. Generally unsuitable.

Porosity. The effective porosity of this unit is very low. Where shales are present, they contain porosity associated with clay minerals.

Permeability. Extremely slow.

Oil and Gas Potential. Extremely low.

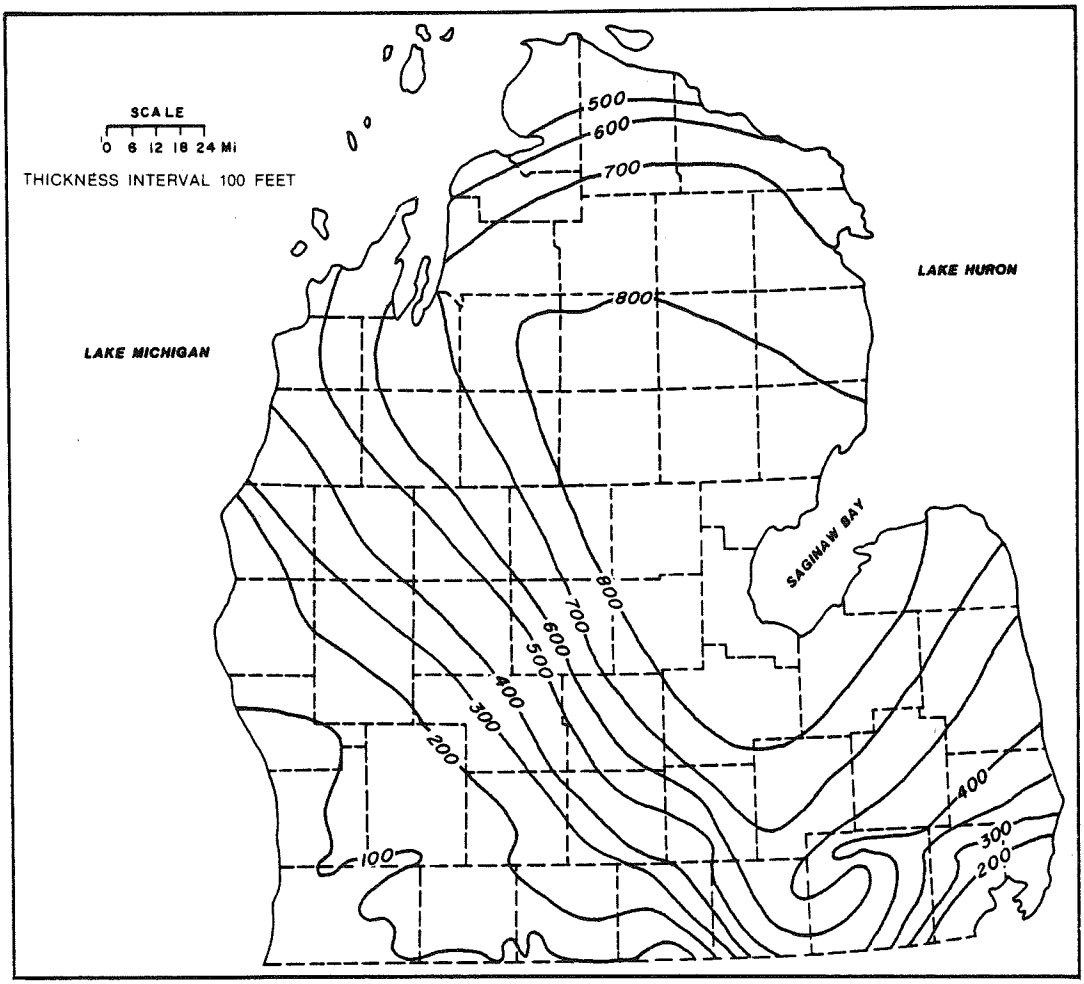

Figure 2.27. Thickness of Salina F Evaporite. (From Dali, 1975.)

G-Unit

The Salina G-Unit is a sequence of dolomitic and anhydritic shales that range in thickness from a zero edge in southern Michigan to more than 100 feet in the northeastern quadrant of the Southern Peninsula (fig. 2.28). This unit is probably correlative with the upper part of the Point aux Chense Shale in the Salina outcrop belt of the eastern Northern Peninsula.

Characteristics as an Aquifer. The G-Unit is not an aquifer.

Characteristics as a Confining Layer. In those portions of the Southern Peninsula where the shales of the G-Unit are more than 40 feet thick it is probably an aquiclude. Marginal to this area (fig. 2.28) its value as a confining layer is probably minimal.

Characterisitcs as an Injection Formation. Generally unsuitable.

Porosity. The effective porosity of the G-Unit is very low.

Permeability. Extremely slow.

Oil and Gas Potential. Extremely low.

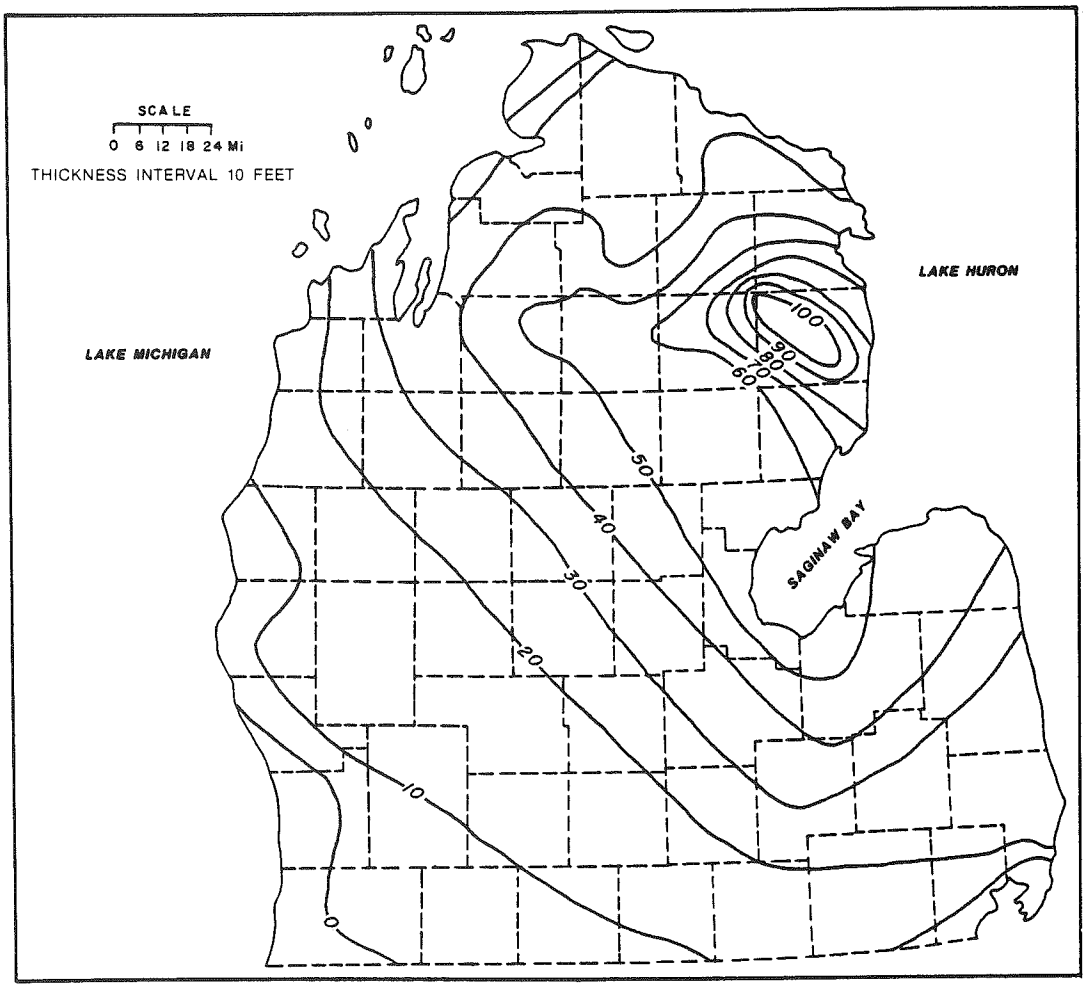

Figure 2.28. Thickness of Salina G Unit. (From Dali, 1975.)

UPPER SILURIAN

The Pointe aux Chenes Shales and the St. Ignace Dolomite comprise the Upper Silurian at outcrop in the eastern Northern Peninsula of Michigan.

Pointe aux Chenes Shale

The Pointe aux Chenes Shale consists of green and red shales, thin beds of dolomite, and small irregular masses and thin seams of gypsum. It is thought to be the equivalent of shales in the F-Unit and G-Units of the subsurface Salina Group. It is likely that it is the lateral equivalent to the shales that exist throughout the column from the B-Unit through the G-Unit.

Characteristics as an Aquifer. The Pointe aux Chenes Shale is not an aquifer.

Characteristics as a Confining Layer. The soft, non-resistant nature of this shale coupled with the presence of gypsum suggests that it is an aquiclude.

Characteristics as an Injection Formation. Unsuitable.

Porosity. Effective porosity is very low. The rock has some porosity associated with clay minerals.

Permeability. Very low.

Oil and Gas Potential. None.

St. Ignace Dolomite

Although placed in the Salina Group by Ehlers and Kessling (1957), the stratigraphic position and lithologic characteristics of this unit clearly suggest that it is the lateral equivalent of the Bass Islands Group. Very likely these rocks are genetically related to rocks of the Salina Group in the same manner that rocks of the Bass Islands Group are related to lithologies in the Salina in more central portions of the Michigan Basin.

The St. Ignace is composed of a evenly bedded dolomite, some of which contains silt-like openings that probably resulted from the solution of anhydrite crystals. Beds of shale ranging from a few inches to a few feet thick are an inconspicuous part of the formation. The upper part of the St. Ignace consists of thick-bedded dolomites that are locally oolitic. Frosted quartz grains are present throughout the formation, but are larger and more abundant near the top.

Characteristics as an Aquifer. Possible source of drinking water on Bois Blanc and Round Islands.

Characteristics as a Confining Layer. Unsuitable.

Porosity. Solution porosity.

Permeability. Solution permeability.

Oil and Gas Potential. None.

Bass Islands Group

At the type sections on the Bass Islands of Western Lake Erie and the outcrop belt in southeastern Michigan, this sequence of dolomites has been subdivided into a number of formations. In the Michigan subsurface it is "lumped" together and referred to as the "Bass Islands". The Bass Islands is a thick sequence of fine-grained dolomites that are characterized by "floating" anhydrite and celestite crystals. In the central portions of Michigan Basin, the Bass Islands contain salt beds, and has been considered an upward continuation of the Salina (Landes, 1945). In the center of the basin, the group exceeds 700 feet in thickness (fig. 2.29).

Characteristics as an Aquifer. Unknown.

Characteristics as a Confining Layer. The Bass Islands should serve as a confining unit throughout much of the Southern Peninsula.

Characteristics as an Injection Formation. Unknown.

Porosity and Permeability. Around the margins of the Michigan Basin the Bass Islands Group has been affected by dissolution and the porosity and permeability greatly increased. Leaching of the relatively soluble anhydrite crystal laths is readily apparent in wells that penetrate these rocks in the northernmost part of the Lower Peninsula. Down dip from this leached zone, dolomites of the Bass Islands are much less soluble and in the area of salt development this unit is only slowly permeable.

DEVONIAN

LOWER DEVONIAN

Garden Island Formation

The Garden Island Formation is known only from isolated patches in the northern part of the Lower Peninsula and at the type section on Garden Island. At the type locality only three feet of dolomitic sandstone, dolomite with frosted sand grains, and hard dolomite with chert nodules is exposed above lake level (Ehler, 1945, p. 73-80).

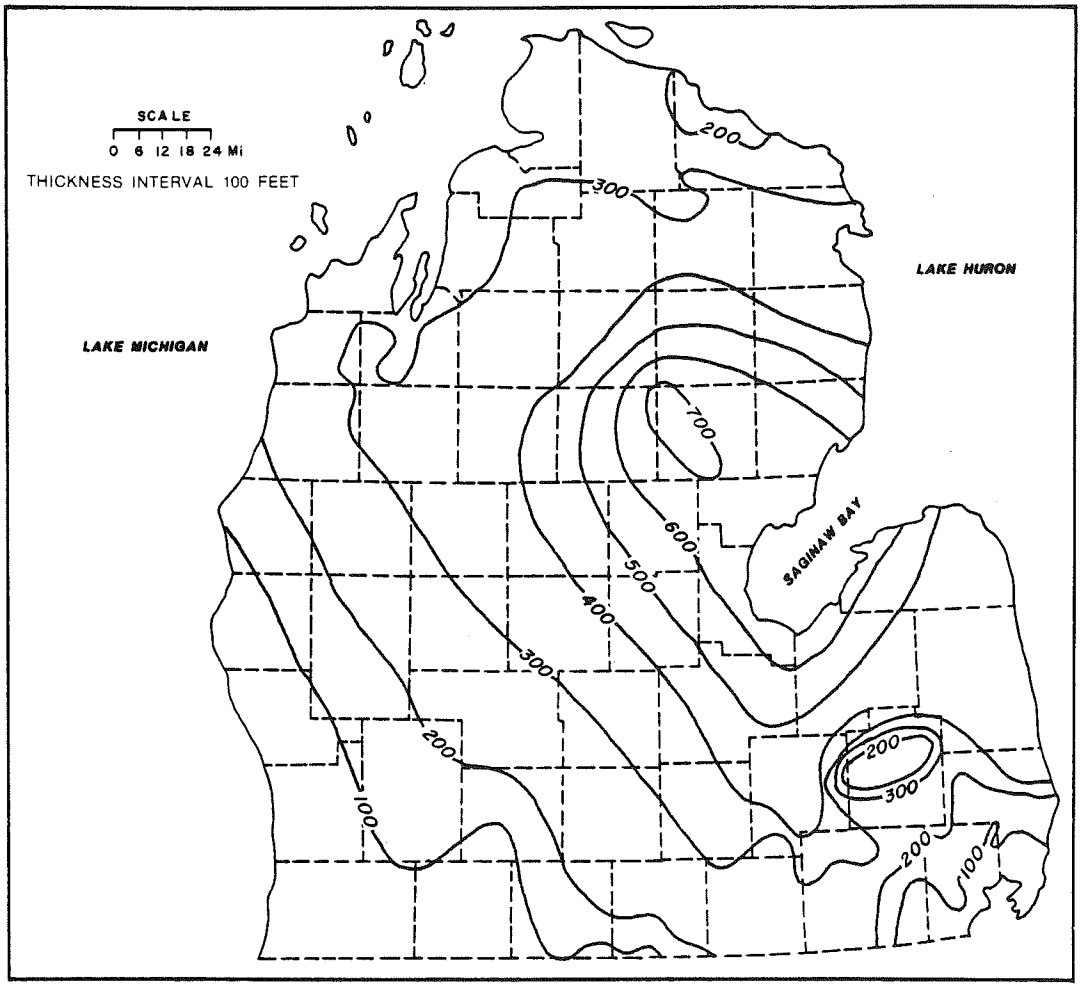

Figure 2.29. Thickness of Bass Islands Group. (After Dali, 1975.)

Characteristics as an Aquifer. Unknown.

Characteristics as a Confining Layer. Unknown. Discontinuous nature of the unit coupled with the presence of sandstone and dolomite do not recommend it as a confining layer.

Characteristics as an Injection Formation. Discontinuous nature of the Garden Island Formation suggests that it would be an inadequate injection formation.

Porosity and Permeability. Unknown.

MIDDLE DEVONIAN

Bois Blanc Formation

From its truncated margin at outcrop in the area of Mackinac Straits the Bois Blanc Formation increases to a maximum thickness of more than 600 feet in Arenac and Gladwin Counties (Cohee, et al., 1951) (fig. 2.30, pls. 5, 6 and 11). The basal 75 feet of the unit is dolomite with interbeds of chert and is overlain by about 200-300 feet of very cherty dolomite and limestone. The upper 75 feet of the unit is fossiliferous limestone.

Characteristics as an Aquifer. The Bois Blanc is not used as an aquifer. In and near the outcrop area it has been leached and could be used as a source of water in the area near the Straits of Mackinac. Proximity of the outcrop area to Lake Michigan and the availability of water in the glacial aquifer have made the use of this aquifer unnecessary to date.

Characteristics as a Confining Layer. Away from the outcrop area the Bois Blanc is very dense and should form a barrier to the movement of fluids. The cherty dolomites are likely to be quite brittle and may have some fracture porosity and permeability. The unit was involved in the subsidence that produced the Mackinac Breccia, and it is very likely highly fractured in the area where this process has occurred (pl. 18).

Characteristics as an Injection Formation. The Bois Blanc Formation is unsuitable for use as an injection formation.

Porosity. Very low.

Permeability. Unknown. Fracture porosity may be present.

Oil and Gas Potential. Low.

Sylvania Sandstone

The Sylvania Sandstone is composed of well-rounded and sorted, fine (0.18 mm) to medium (0.40 mm) grained quartz grains notably free of clay. The sandstone overlies dolomites of the Bass Islands Group with distinct

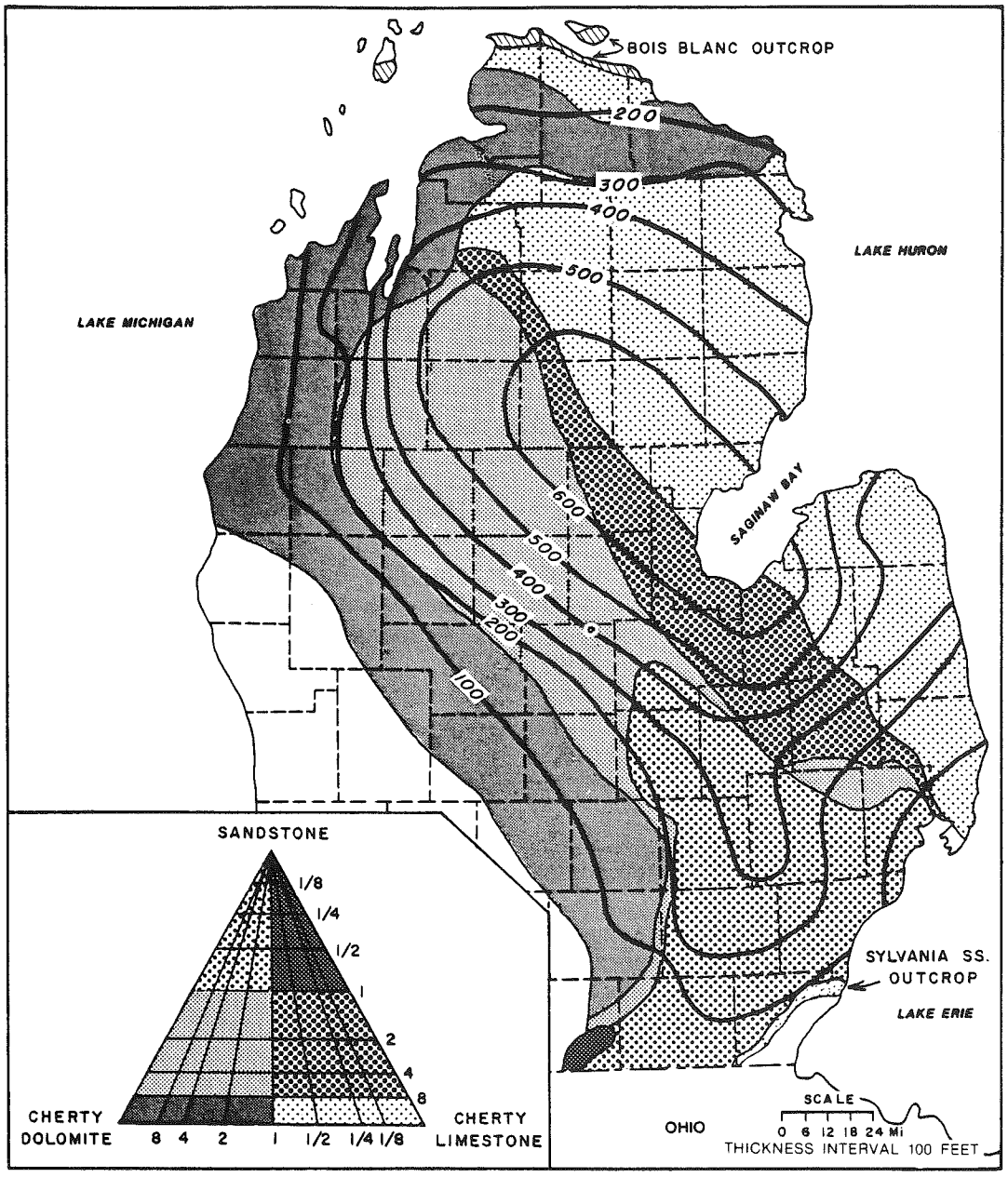

Figure 2.30. Thickness-lithofacies map of Bois Blanc-Sylvania. (From Gardner, 1974.)

disconformity along the northern margin of its development in northern Ohio and southeastern Michigan. To the north where the Bois Blanc Formation is the basal unit of the Middle Devonian, the Sylvania Sandstone interfingers with cherty carbonates. Contact with the overlying Detroit River beds is transitional from sandstone to dolomitic sandstone to sandy dolomite to dolomite. To the northwest in Wexford, Grand Traverse, Missaukee and Kalkaska Counties, the Sylvania contains thick deposits of tripolitic (de-vitrified) chert with amber dolomite rhombohedrons. The Sylvania outcrops in southeastern Michigan and ranges in thickness from a zero edge in southern Michigan to more than 500 feet in the central part of the Michigan Basin (fig. 2.30).

Characteristics as an Aquifer. In and near the outcrop area where it has been flushed the Sylvania Sandstone is a good aquifer, but because it is overlain by glacial lake beds, composed of silt and clay, water in it commonly contains methane and hydrogen sulfide.

Characteristics as a Confining Layer. The Sylvania is far too permeable to be a confining layer.

Characteristics as an Injection Formation. In areas where the Sylvania is overlain by the anhydrite of the Detroit River, it is a potential injection formation and has been used for both chemical and brine disposal. Care should be taken to avoid areas near the outcrop as the overlying carbonate section may have fracture permeability.

Porosity. High effective porosity exists away from the upper transition with the Detroit River and southwest of the area where the Sylvania and Bois Blanc interfinger.

Permeability. Permeability is very high in those portions of the unit that are free of carbonate and chert cement (see above).

Potential for Oil, Gas and Brine Production. No oil or gas fields have been developed in the Sylvania. It is used extensively as a source of brine especially in the vicinity of Midland County.

Amherstburg

The Amherstburg is a dark brown to black, carbonaceous limestone throughout most of the basin, but around the southern and western margins of the Southern Peninsula it has been dolomitized. The informal name "Black Limestone" has been in use for many years as a driller's term. The lithology is very distinctive in the central-basin area, and was used as a marker at which to bottom exploratory tests into the Richfield zone of the Detroit River. The unit is poorly bedded, dense, and ranges in thickness from a zero edge in southwestern Michigan to more than 300 feet in the area of Saginaw Bay (fig. 2.31).

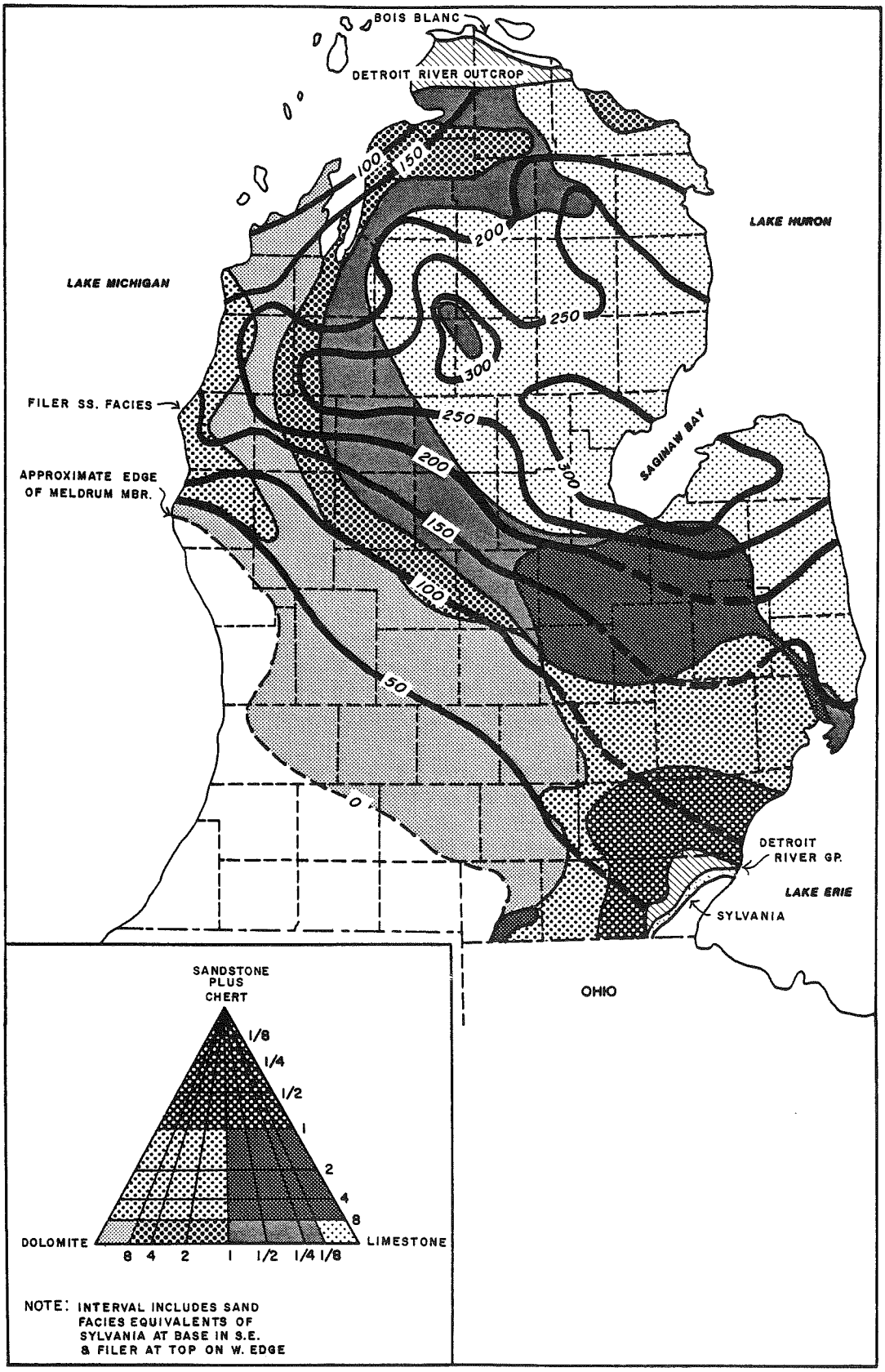

Figure 2.31. Thickness-lithofacies map of Meldrum Member of Amherstburg Formation. (From Gardner, 1974.)

Characteristics as an Aquifer. The Amherstburg is not an aquifer.

Characteristics as a Confining Layer. Except where dolomitized, the Amherstburg is an aquiclude and could be used as a confining layer, in the central portion of the Michigan Basin.

Porosity. The effective porosity of the Amherstburg is low where it is dolomite and very low where it is limestone.

Permeability. The Amherstburg has very low permeability where it is dolomite and is virtually impermeable in those areas where it is a limestone.

Oil and Gas Potential. Very low.

Filer Sandstone Member

The Filer Sandstone is best developed along the western margin of the Southern Peninsula in the area of Manistee. The Filer is a fine to medium grained, quartz sandstone that appears to have been deposited as coastal dunes. Local lenticular sandstone bodies in the central part of the basin appear to be roughly correlative with this unit, and one such unit has been named the Freer Sandstone after a well that penetrated it.

Characteristics as an Aquifer. The Filer Sandstone has excellent aquifer characteristics, but it contains brine.

Characteristics as a Confining Layer. The Filer is far too porous and permeable to be used as a confining layer.

Characteristics as an Injection Formation. The Filer has excellent injection formation characteristics and is used as an injection formation in Michigan.

Porosity. The formation has up to 25 percent effective porosity.

Permeability. Very high.

Oil, Gas and Brine Potential. The Filer has been explored for oil and gas, but to date no sustained production has been developed. The Freer Sandstone had a "one-well" field developed in it. The Filer is a source of brine in the Manistee area.

Detroit River

Although the Bois Blanc Formation, Sylvania Sandstone, Amherstburg (Black Limestone), Lucas and Anderdon Formations have been included in the Detroit River Group, general practice is to call that portion of the column between the Amherstburg (Black Limestone) and the Dundee Limestone the "Detroit River," although it has been named the Lucas Formation. This suite of rocks is quite complex and contains a wide variety of lithologies including sandstone, limestone, dolomite, anhydrite (or gypsum) and halite (figs. to). The Basal unit of the "Detroit River" is the "Richfield zone" or more properly the Richfield Member.

Richfield Zone

The Richfield zone is a sequence of interbedded limestone, dolomite, and anhydrite with minor amounts of sand in the central portion of the basin and a relatively thick sand body, the Filer Sandstone, along the western margin of the Lower Peninsula (fig. 2.32). The limestone beds are dense micrites and contrast with the dolomites which are lighter in color and more permeable. The anhydrite beds have mosaic textures and generally overlie the dolomitized units.

Characteristics as an Aquifer. The Richfield zone is not an aquifer.

Characteristics as a Confining Layer. The anhydrites of the Richfield zone are excellent confining layers. The fact that several of the dolomite zones produce oil attests to the impervious nature of the interbedded anhydrites.

Characteristics as an Injection Formation. The Richfield contains too little permeable rock to be an injection formation.

Porosity. The dolomite zones in the Richfield are slightly porous, but the limestones and anhydrite beds essentially lack porosity.

Permeability. The limestone and anhydrite beds are virtually impermeable. The dolomite units have permeabilities that range from 4.0 to 6.5 milli-darcys.

Oil and Gas Potential. The Richfield has produced oil and gas from several fields in Michigan since the early 1940's.

Massive Anhydrite

The driller's term "Massive Anhydrite" has been traditionally applied to a thick (75-100 feet) anhydrite bed that overlies the Richfield Zone (fig. 2.33). The unit is widespread in the central portions of the basin and thins toward the basin margins. It is best developed in the north-central part of the Southern Peninsula.

Characteristics as an Aquifer. The Massive Anhydrite is not an aquifer.

Characteristics as a Confining Layer. The Massive Anhydrite is essentially impermeable and an excellent confining unit.

Characteristics as an Injection Formation. None.

Porosity. Extremely low.

Permeability. Extremely low to essentially impermeable.

Oil and Gas Potential. None.

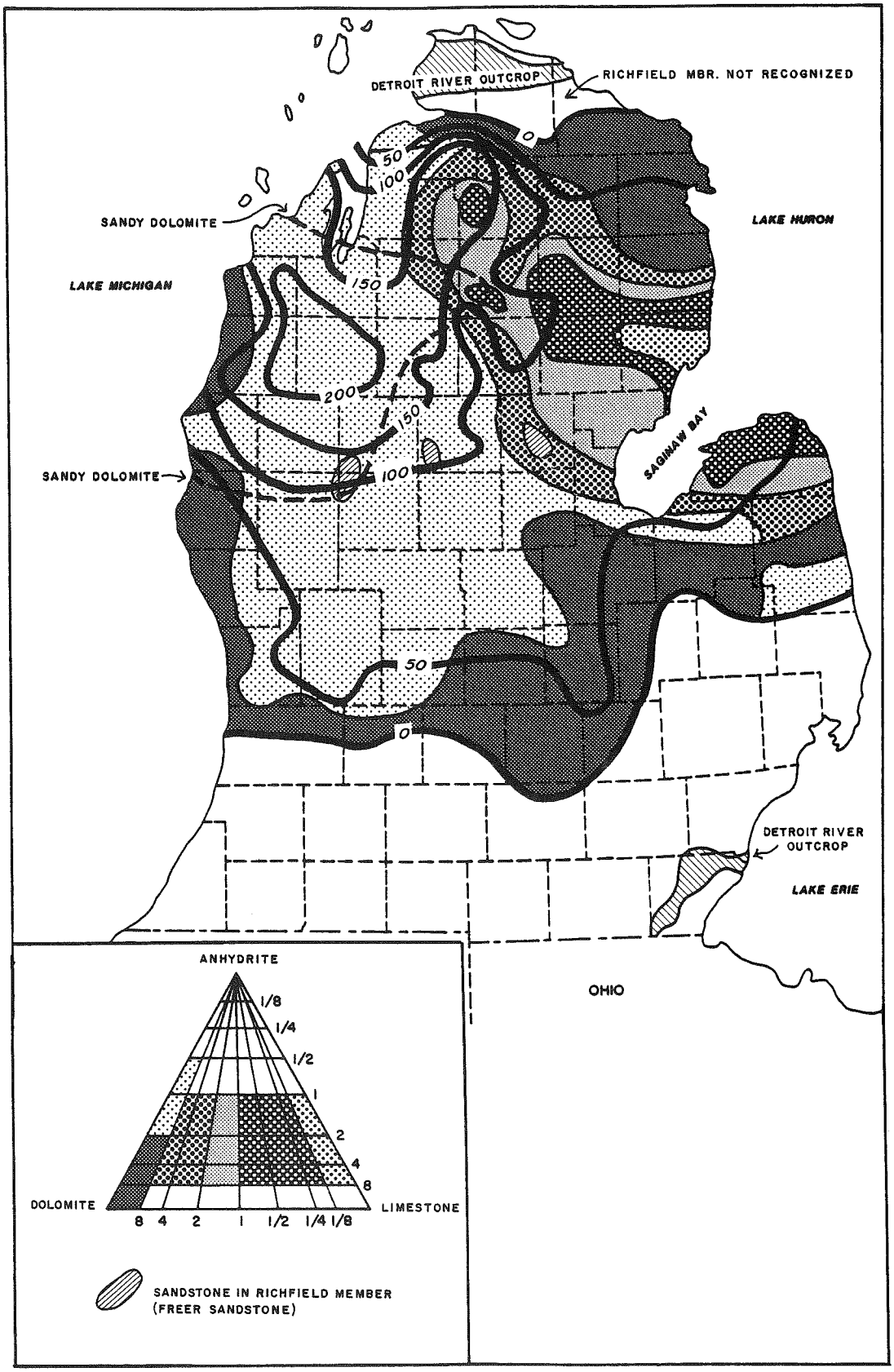

Figure 2.32. Thickness-lithofacies map of Richfield Member of Lucas Formation. (From Gardner, 1974.)