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THE GLACIAL HISTORY OF EARLY LAKE SAGINAW

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THE GLACIAL HISTORY OF EARLY LAKE SAGINAW

By

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ABSTRACT

THE GLACIAL HISTORY OF EARLY LAKE SAGINAW

By

Marsha Jane Ward

Through the utilization of soil management units and topographic analysis the history of Lake Saginaw was related to the glacial features of the Maple Rapids region of Central Michigan. By mapping soil management units, such glacial features as moraines and lakes can be related to the dominant soil profile texture.

During Late Wisconsin glaciation, repeated oscillations of the Saginaw ice lobe led to the development of a series of ice marginal lakes in the Saginaw Basin. The earliest of these was Early Lake Saginaw (735 ft. elevation) which developed following the formation of the Owosso moraine. The Imlay River Channel received drainage from Lake Saginaw via the Lewis and Duplain Spillways. With the retreat of the ice front northward, various levels of Lake Saginaw developed, with the lake often becoming merged with surrounding lakes in the basin.

ACKNOWLEDGMENTS

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INTRODUCTION

The research problem of this thesis focuses on the development and history of glacial Lake Saginaw which occurred in south central Michigan approximately 12,500 years before the present (Farrand, 1977). Critical reading of reports and reviews concerning the glacial lake stages in the Saginaw Basin during the late Wisconsinian (Leverett and Taylor, 1915; Leverett, 1939; Bretz, 1951, 1953, 1966; Hough, 1958, 1966; Eschman and Farrand, 1970) reveals a major difference of opinion with regard to the history of Lake Saginaw. In particular, Leverett and Taylor (1915, p. 358) contend that "The earliest beginnings of Lake Saginaw were just after the building of the Flint moraine." They also state (p. 323) that, during the later stages of Lake Maumee, Lake Saginaw "received the drainage of the Imlay outlet river."

Bretz (1951, p. 255), on the other hand, proposes that "Early Lake Saginaw ... was dammed by the Owosso Moraine." He also states (p. 252) that the "Imlay River never entered Lake Saginaw." To support this conclusion Bretz refers to the existence of a "valley train" (p. 253) which supposedly represents a Lake Saginaw spillway leading directly into the Imlay Channel.

The objectives of this study are: (1) to determine whether early Lake Saginaw formed after the development of the Flint or the Owosso moraine; and (2) to determine how both the Imlay River channel and the valley train fit into the history of Lake Saginaw during its various stages of development.

DEGLACIATION HISTORY

According to Leverett and Taylor (1915) there are in the southern peninsula of Michigan four systems of recessional moraines marking the progressive retreat of the Saginaw ice lobe (Figure 1). They are: (1) the Kalamazoo, (2) the Charlotte, (3) the Lake Border, and (4) the Port Huron. In addition, they state that each system is composed of several individual recessional moraine members, with some members being more easily distinguishable than others. Crosscutting these moraines from east to west is the Glacial Grand Valley. According to Leverett and Taylor (1915) during the retreat of the Saginaw lobe, this valley served as a major drainage-way for meltwater produced from the retreating ice front. The valley also periodically acted as a drainage outlet for several large ice marginal lakes which formed within the Saginaw basin.

THE KALAMAZOO MORAINIC SYSTEM

Martin's map (1955) of the surfacial geology of Michigan suggests that the Kalamazoo morainic system (Figure 1)

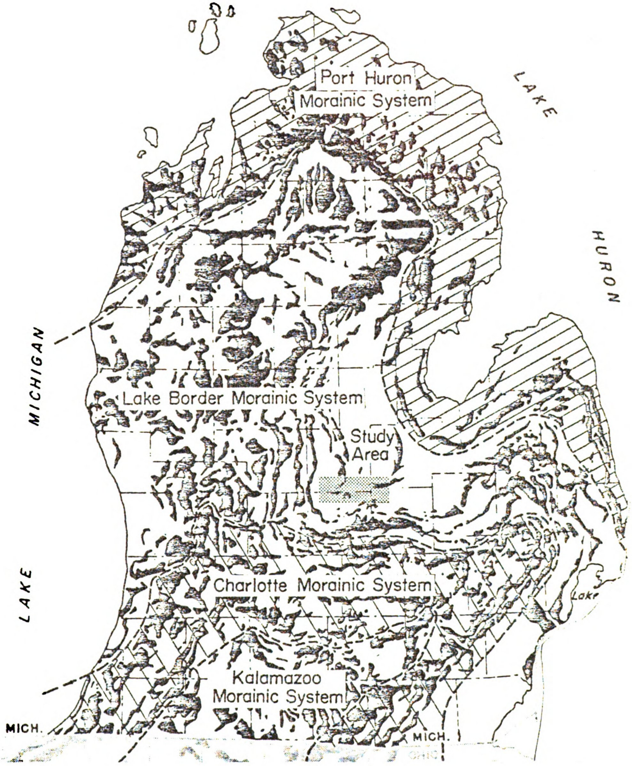

Figure 1. The area of central Michigan in study and the four morainic systems.

associated with the retreat of the Saginaw lobe is correlative with the Kalamazoo morainic system of the Lake Michigan lobe. In addition, the map suggests that the Kalamazoo system is also correlative with the Mississinawa morainic system of the Huron-Erie lobe which developed 14,800 years ago (Farrand, 1977). According to Leverett and Taylor (1915), the outer or southernmost boundary of the Kalamazoo system is defined by a large outwash apron along much of its courses; whereas, the inner members of the system die out east of the Grand River. The most conspicuous outwash plains in Michigan are those of the Kalamazoo morainic system. They are extensive in the reentrant angles between both the Saginaw and Lake Michigan lobes and the Saginaw and Huron-Erie lobes. The entire morainal belt passes through parts of Barry, Jackson, Calhoun and Washtenaw counties.

Martin's map also shows that several chains of eskers appear between the Kalamazoo and the Charlotte morainic systems. Two such esker chains are the Rives and Walton. According to Leverett and Taylor (1915), the Rives esker chain can be subdivided into 3 sections lying end to end. The Walton chain of eskers shows more clearly the consecutive northward construction of the esker as the ice lobe receded.

THE CHARLOTTE MORAINIC SYSTEM

Leverett and Taylor (1915) suggest that the Charlotte morainic system (Figure 1) is correlative to the west with the Valparaiso morainic system of the Lake Michigan lobe.

The outer boundary of this moraine is generally vague since the till forming the moraine rises gradually over a wide area. The ridges forming the morainal crests usually occur within a single belt four to eight miles wide and pass through parts of Eaton, Kent, Allegan, Barry, Ingham and Livingston counties. Small eskers associated with the Charlotte moraine are very common, with the more conspicuous eskers being the Charlotte, the Mason, the Williamston-Dansville, an the Oak Grove-Howell-Chilson system.

THE LAKE BORDER MORAINIC SYSTEM

The Lake Border morainic system (Figure 1) formed following the retreat of the Saginaw lobe from the Charlotte morainic system. These moraines are crowded together in the reentrant angles between the Saginaw and Lake Michigan lobes to the west and between the Saginaw and Huron-Erie lobes to the east. However, along the frontal edge of the Saginaw lobe the moraines are more widely spaced and are also much more prevalent south of the Glacial Grand Valley than to the north of the valley. The height of the moraines is about 20 feet above the surrounding till plains (Leverett and Taylor, 1915). Eskers are also associated with this system and include the Mason esker, Thread River esker, and various other smaller eskers.

The Lake Border morainic system delineating the western edge of the Saginaw lobe is strongly developed and extends to the northeast as far as the bend of the Au Sable River in

Alcona County. The moraines of the system are each four to eight miles in width and encompass parts of Oscoda, Ogemaw, Roscommon, Gladwin, Clinton and Clare counties. Near the northern part of the West Branch channel the moraines of the Lake Border system appear to converge and form a single massive deposit of irregular shape. Farther south, however, the moraines appear as separate individual ridges with roughly parallel courses.

The Lake Border system depicting the eastern and southern edge of the Saginaw lobe lies between the Glacial Grand River channel and the western boundary of Lapeer County. The distribution of the moraines forming the system in this area is evidently dependent upon the local bedrock topography. It appears that, as the ice advanced out of the deeper Huron Basin to the northeast, it conformed itself to a wide shallow basin (Saginaw) already present. The symmetrical front of the ice is clearly revealed by the configuration of the Lake Border system with each moraine in the system tending to form an almost perfect arc.

Within the Lake Border system there are thirteen individual moraines (Leverett and Taylor, 1915). Starting with the oldest which dates approximately 13,800 years B.P. (Farrand and Eschman, 1974), they are: (1) the Lansing, (2) the Grand Ledge, (3) the Ionia, (4) the Portland, (5) the Lyons, (6) the Fowler, (7) the St. Johns, (8) the Flint, (9) the Owosso, (10) the Henderson, (11) the West Haven,

(12) the Chesaning, and (13) a moraine north of Chesaning. The last four of these moraines are water lain and are generally fainter than the rest.

Each of the thirteen moraines which make up the Lake Border morainic system will be described individually. This will be done as the limit of the edge of the ice front can be defined by tracing the existence of the moraines. Thus the fluctuations of the ice lobe as it retreated northeastward will become evident.

Lansing Moraine

The oldest moraine of the Lake Border system is the Lansing moraine. North of the Glacial Grand River Channel the Lansing moraine is divided into three moraines which diverge toward the south. Where it crosses the Grand River it is one and a half miles wide but farther southward it becomes extremely narrow and sharply defined. At Lansing, the moraine is cut by the Grand River and Sycamore Creek. Eastward as far as Okemos the broken and irregular form of the moraine is still distinguishable; but, beyond that the exact position of the moraine is uncertain.

Grand Ledge Moraine

The Grand Ledge moraine on the other hand, is extremely narrow throughout its length, and barely more than a quarter of a mile wide where it crosses the Grand River. From the Grand River it trends generally south and then south-eastward until reaching the city of Grand Ledge; whereupon it trends directly towards the east. It can then be traced just north of Lansing and then northeast to Pine Lake (Lake Lansing).

Ionia Moraine

The Ionia moraine passes north-south through the city of Ionia and then parallels the Grand Ledge moraine to Lansing. Near Ionia, it is about two miles wide and rises 20-25 feet above the surrounding till plain. From Ionia to Bath, however, it is more slender and only about two miles wide. North of the Grand River the moraine becomes broken and irregular.

Portland Moraine

The Portland moraine follows the north bank of the Grand River and crosses the Grand River channel about two miles west of the city of Muir. At this point it is about a mile wide. It then curves gradually toward the east, and passes seven miles north of Lansing. According to Leverett and Taylor (1915, p. 240), it then trends east-northeast to "the southwest corner of Genesee County where it appears to override the Ionia moraine."

Lyons Moraine

The Lyons moraine crosses the Glacial Grand River channel about a mile northeast of Muir. It then trends east toward Laingsburg and then southeast toward the western boundary of Shiawassee County. Here it appears to override the Portland moraine. Scattered remnants of this moraine can be traced eastward into Lapeer County.

Fowler Moraine

The Fowler moraine crosses the Glacial Grand River channel about twelve miles northeast of Ionia and passes just south of the city of Fowler. East of Fowler it passes through the center of Shiawassee and Genesee Counties. This moraine tends to be very narrow but remains well-defined and is easily distinguishable from the surrounding till plain.

St. Johns Moraine

The St. Johns moraine is not easily distinguishable north of the Grand River channel. However, near the city of St. Johns it forms a narrow sharp ridge rising 30-40 feet above the surrounding till plain (Leverett and Taylor, 1915, p. 241). Northeast of St. Johns, the moraine is recognizable only by a few scattered knolls above the till plain. By following the trend of the knolls, the moraine appears to cross the Glacial Grand River channel about 2-3 miles west of Maple Rapids. East of St. Johns the moraine is well developed and passes almost due east through Shiawassee County and just south of Flint.

Flint Moraine

East of Perrinton the Flint moraine extends southward and then curves south-eastward at a point just east of Maple

Rapids. From Maple Rapids to Duplain the moraine trends eastward and is represented by scattered knolls. However, east of Duplain it becomes much more definable and extends southeast toward Duffield and follows a northeasterly trend toward Flint.

Owosso Moraine

The Owosso moraine also extends southward from Perrinton and upon crossing the Glacial Grand River channel it swings eastward past the city of Elsie and continues toward the Essex-Greenbush Township line of Clinton County. Between the Glacial Grand River Channel and Elsie the moraine is represented by scattered knolls. East of Elsie and north of the cities of Owosso and Corunna the moraine can be traced as a continuous ridge.

Henderson Moraine

The Henderson moraine (Leverett and Taylor, 1915, p. 243) is not easily definable near the head of the Glacial Grand River and is separated from the Owosso moraine by a broad lake plain. A distinct divide, however, does exist between the Maple River and a branch of the Bad River about 1-1/2 miles northeast of Bannister and about 17 miles east of Maple Rapids (Leverett and Taylor, 1915). West of this divide the lake plain is bouldery but also reveals a few distinct morainal knolls. It appears the Henderson moraine extends from about one mile south of Chapin southeast to about one mile south of Henderson. It can then be traced northeast to Flushing. However, due to its faintness, the moraine cannot be traced east of the Flint River.

West Haven Moraine

A mile north of Chapin there is a second bouldery belt surrounded by lake bottom materials. This belt has been called the West Haven moraine (Leverett and Taylor, 1915, p. 244). Often it is hard to distinguish this moraine because of its subdued water-lain character.

Chesaning Moraine

The Chesaning moraine (Leverett and Taylor, 1915, p. 244) is also marked by a bouldery belt overlying lake plain materials extending south and west of Layton's Corners. It extends to the Shiawassee River south of Chesaning and on its surface according to Leverett and Taylor (1915, p. 244) appears a surf wasted zone of Arkona beaches. The wave action appears to have winnowed out much of the fines in the moraine but some knolls are still clearly discernable. It appears to have formed in relatively shallow water.

Moraine North of Chesaning

Leverett and Taylor (1915, p. 244) also make reference to a poorly developed "moraine north of Chesaning." This moraine is surrounded by lake plains and it forms a faint boulderly tract two miles northwest of Chesaning and appears by its altitude and general relationship to the surrounding area to be a discernable moraine from its predecessor the Chesaning moraine and the later Port Huron morainic system.

THE PORT HURON MORAINIC SYSTEM

The Port Huron morainic system (Figure 1) is composed of the Port Huron, Bay City, and Tawas moraines. The Port Huron moraine is very well-developed and thus appears as a distinct ridge developed on the lake plain. The other two moraines, however, are much fainter.

Port Huron Moraine

This moraine is easily distinguishable and can be traced continuously across the Great Lakes region. In fact, it can also be traced eastward across Ontario and as far as New York (Leverett and Taylor, 1915, p. 293). The Port Huron moraine marks a pronounced ice advance around 13,300 ± 400 years B.P. (Farrand and others, 1969) and played a prominent role in the lake history of the Huron-Erie basin. In general the morainal relief is generally 50-60 ft. (Leverett and Taylor, 1915, p. 215). It appears to have been water-lain in parts due to the subdued relief in some areas. A distinct division between the land and water-laid portions, which define the limit of the lake water, however, is not possible as it is obscured by sand from the bordering sandy plains. The till plains associated with this moraine are generally widespread and are characterized by a swell and sag topography. Also, outwash from the predecessor of the Au Sable River often obscures the till plain and the Arkona beaches.

Bay City Moraine

The Bay City moraine extends 10-12 miles north of the Port Huron moraine. It forms a faint morainic belt and presumably was deposited in deep water. The general relief of this moraine is low, usually under 10 feet (Leverett and Taylor, 1915, p. 301).

Tawas Moraine

The Tawas moraine extends south of the Au Sable River to Alabaster and into Arenac county. It, too, was water-lain and tends to be fragmentary with a general relief of 15-20 ft. (Leverett and Taylor, 1915, p. 301).

SUMMARY OF DEGLACIATION HISTORY

From the formation of the Lansing moraine to the time of the Tawas moraine the ice lobe in the Saginaw basin retreated northwestward. The path of retreat is evident from the concentric arcs the moraines form (Figure 1). Slight readvances led to the development of several of the moraines such as the Owosso moraine.

THE GLACIAL GRAND VALLEY

Leverett and Taylor (1915) state that the Glacial Grand River was formed entirely by drainage of lake waters in the Saginaw basin over an "ill-defined depression in the surface of the till." On the other hand, according to Bretz (1953), the origin of the Glacial Grand River includes three episodes: (1) the erosion of a premorainal Pleistocene channel, (2) meltwater discharge and channel erosion during the development of recessional moraines, and (3) deepening of the channel during discharge from succeeding lake stages in the Saginaw basin.

As evidence for his premorainal channel Bretz (1953, p. 365), cites "two of the largest depressions attributable to a premoraine Grand River valley lie on either side of the Fowler moraine, Stoney Creek occupying the western depression, Hayworth Creek the eastern one." Bretz supports his second episode using the gradients of the north and south flowing tributary valley trains as they meet the Glacial Grand. The gradients of these valley trains are steeper than those of the Glacial Grand due to the fact that these streams ceased to carry meltwater as the ice retreated from the corresponding moraine and because the influx of material was greater than the streams could handle. The third episode, marked by the deepening of the Glacial Grand, is the result of glacial lake discharge down the Glacial Grand following the retreat of the ice from the Fowler moraine. According to Bretz (1953), this deepening is evidenced by "the increase in flow due to the ponded Glacial Lake Saginaw and Glacial Lake Maumee's shift from the Wabash spillway to the Glacial Grand."

LATER LAKE STAGES

The retreat of the ice front from the Port Huron moraine about 12,500 years B.P. (Farrand and Eschman, 1974), resulted in the unification of Lake Whittlesey (738 ft.) and Lake Saginaw (lowest Arkona, 695 ft.) to form Lake Warren.

A major difference of opinion exists concerning the lake stages which followed the development of the Port Huron moraine. This difference of opinion is summarized in Table 1 and centers on the temporal relationship of Lake Wayne and Lake Warren. Leverett and Taylor (1915) state Lake Wayne is associated with the retreat of the Port Huron ice and represents an unimportant lower lake stage. They support this by the fact that the Lake Wayne beach "shows clear evidence of submergence and modification, and the (later) Warren beach does not..." (Leverett and Taylor, 1915, p. 386). They also state the Grand River outlet was abandoned during the Lake Wayne stage and tend to lean toward the possibility of an eastern outlet. Hough (1966) is also unsure as to the outlet of Lake Wayne but feels this point is of little importance. He assumes "the Wayne, as a minor low-water event, will fit comfortably between the middle and late Warren"

Table 1. Lake History in the Saginaw Basin.

Glacial Event	Authors*	Lake Huron Basin	Grand River Valley
Port Huron (12,500 yrs B.P.)[1]	B	late Arkona stage	discharge
	H	late Arkona Stage	discharge
	L&T	Wayne; 660 feet	abandoned
Bay City	H	early Warren stage middle Warren stage	discharge
Tawas	H	Wayne stage, minor	discharge
	H	late Warren stage	discharge
	H	retreat of late Port Huron ice in Ontario basin opens outlet to Mohawk River	dry
	H	Grassmere stage; 640 ft	dry
	H	Lundy stage; 620 ft	dry
	H	early Algonquin stage; 605 ft	dry
	H	retreat of ice opens straits; Algonquin joins Toleston at same level; discharge through Port Huron outlet continues	dry
	H	further retreat of ice opens Kirkfield outlet	
Two Creeks Interval (11,850 yrs B.P.)[2]	B	Wayne stage, part of extensive lowering; discharge to Mohawk River	dry
	H	Kirkfield stage; 560 ft	
	B	advance of Valders ice across Ontario basin closes eastern outlet	
	H	advance of Valders ice closes Kirkfield outlet	

*B = Bretz (1951, 1966), H = Hough (1958, 1966), L&T = Leverett and Taylor (1915).

(1) Farrand et al., 1969.

(2) Farrand and Eschman, 1974.

(Hough, 1966, p. 67). Bretz, on the other hand, states Lake Wayne is a major event representing a time of extensive lowering. He dates Lake Wayne in the Two Creeks interval (11,850 B.P.) (Broecker and Farrand, 1963) which represents a later time from that presented by Leverett and Taylor (1915) and Hough (1966). He also suggests that there was an outlet for Lake Wayne to the east into the present Mohawk River.

Lakes Grassmere, Lundy and early Algonquin of post-Port Huron time also present problems of interpretation. In particular, the direction and point of discharge for each lake has not been determined as there is no supporting field evidence. Hough (1966) has suggested that Lowest Warren, Grassmere and Lundy are pre-Valders. Hough (1963) believes the three lakes drained into the Michigan basin via a channel where the present day Mackinaw straits are since their altitudes of 640 ft. (Grassmere), 620 ft. (Lundy) and 605 ft. (early Algonquin) coincide with the altitudes of the stages in the Michigan basin; the Glenwood at 640 ft., the Calumet at 620 ft., and the Toleston at 605 ft. There exists, however, no field evidence for this channel since it was undoubtedly obliterated by later advance of the Valders ice. If the lakes did drain via the straits, the ice to the east, which impounded Lowest Warren, Grassmere and Lundy, would have to be Port Huron ice. This is further suggested by palyntological studies of Terasmae (1959) and archaeological evidence of Mason (1960). These studies suggest that Lowest Warren, Grassmere, and Lundy were impounded by an ice dam of the waning Port Huron ice. Leverett and Taylor (1915), on the other hand, state that Grassmere and Lundy discharged to the east, however, they fail to present supporting evidence for this idea.

The Grassmere beach (640 ft. elevation) and the Lundy beach (620 ft. elevation) record brief static periods during the lowering of the waters in the Huron and Erie basins (Hough, 1958). Since there is no Algonquin level beach in the Erie basin it can be assumed that this lake was short-lived and drained eastward when ice retreated from the Ontario basin. This would help to explain the coinciding altitudes (605 ft.) of the Chicago and St. Clair River outlets.

The Valders glacial substage was the next advance which filled the Superior basin. The ice apparently blocked part of the Trent Valley dischargeway which had drained the Ontario basin and forced the water in the Huron basin to rise and discharge southward to the Erie basin, and down the Grand River Valley to the Michigan basin and Des Plaines River. Hough (1963) suggests that the final grading of the Glacial Grand River Valley was accomplished as the Valders substage melted away. As the Valders ice front retreated waters in the Michigan basin drained northeast into the Huron basin and then the Ontario basin down the Trent Valley outlet. Further retreat of the ice opened up even lower outlets to the east and led to the development of the following lakes: Wyebridge, Penetang, Cedar Point and Payette, Sheguiandak, and Kirah. The exact outlets for these lakes are unknown but by Payette time the discharge seemed to pass through a channel at Fossmill, Ontario (Hough, 1963). The lowest of the post-Valders, post-Algonquin Lakes was the Stanley stage in the Huron basin. The presence of this lake was inferred by Stanley (1936, 1937) from a shallow-water sandy and shelly layer within the deep-water clays of Lake Huron.

Eustatic uplift of the land then became dominant in the lakes' history. As the level rose Lake Huron began discharging southward through the St. Clair River. As the North Bay outlet ceased to function, all the discharge from the three upper Great Lakes flowed southward. With the down-cutting of the St. Clair outlet, the lake surfaces of Huron and Michigan reached their present altitude of 580 ft. above sea level.

GLACIAL LAKE SAGINAW

Glacial Lake Saginaw occurred about 13,800 years ago (Farrand, 1977), and was the first of the lake series to leave a positive record in the Saginaw basin. The greatest areal extent of Lake Saginaw is shown in Figure 2, and includes large portions of Clinton, Gratiot, and Shiawasee counties.

PREVIOUS INVESTIGATIONS

As mentioned earlier a major difference of opinion concerning the history of Lake Saginaw exists between Leverett and Taylor (1915) and Bretz (1951, 1953). Specifically, they disagree on the time of the initial formation of Lake Saginaw as related to the Flint and Owosso moraines. They further disagree on how the Imlay channel fits into the history of Lake Saginaw as well as the outlet channels in use during the various stages of the lake.

LEVERETT AND TAYLOR

According to Leverett and Taylor (1915, p. 358) the first possibility for standing water in the Saginaw basin occurred with the retreat of the Saginaw lobe from the Flint

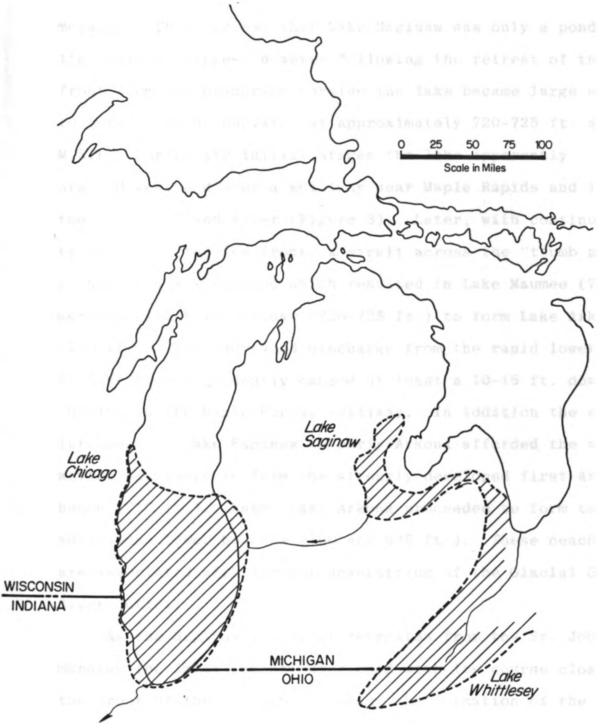

Figure 2. The areal extent of Lake Saginaw.

moraine. They suggest that Lake Saginaw was only a pond in its earliest stages, however following the retreat of the ice front from the Henderson moraine the lake became large enough to form a beach (Duplain) at approximately 720-725 ft. above M.S.L. During its initial stages the lake apparently drained westward over a spillway near Maple Rapids and into the Glacial Grand River (Figure 3). Later, with continued recession of the ice front, a strait across the "thumb area" of Michigan was exposed which resulted in Lake Maumee (780 ft.) merging with Lake Saginaw (720-725 ft.) to form Lake Arkona (710 ft.). The increased discharge from the rapid lowering of Lake Maumee evidently caused at least a 10-15 ft. downcutting in the Maple Rapids spillway. In addition the enlargement of Lake Saginaw to early Arkona afforded the wave action necessary to form the strongly developed first Arkona beach (710 ft.). Later Lake Arkona proceeded to form two additional lower beaches (700 and 695 ft.). These beaches are associated with further downcutting of the Glacial Grand River outlet.

As the Saginaw ice front retreated from the St. Johns moraine the Imlay Channel developed with its course close to the front of the ice lobe. During the formation of the Flint moraine the channel carried meltwater discharge and possibly water from Lake Maumee. The portion of the Imlay Channel east of Owosso was not in use continuously and therefore not as well developed as the western portion of the

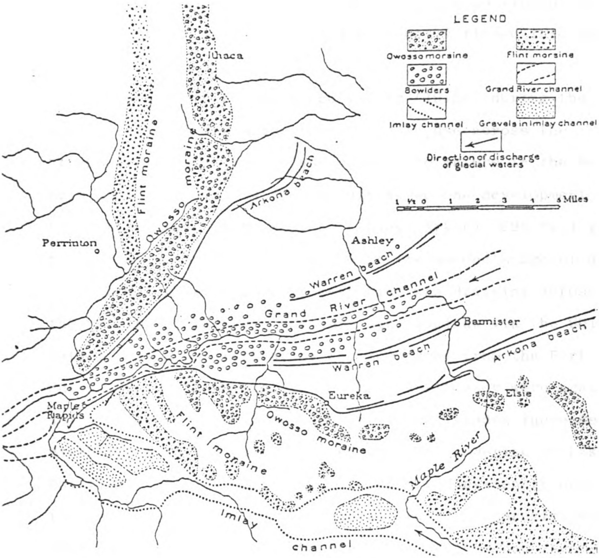

Figure 3. Leverett and Taylor (1915) - Interpretation of the Glacial Features of the Maple Rapids Area of Michigan.

channel, around Maple Rapids. The abandonment of the eastern portion took place as the path of discharge continued northward from Flint to Flushing and eventually flowed into Lake Saginaw.

According to Leverett and Taylor (1915), during the advance of Port Huron ice the strait in use across the "thumb area" was blocked, and caused the waters in the Huron-Erie basin to raise 44 feet resulting in the development of Lake Whittlesey. Lake Saginaw (lowest Arkona, 695 ft.) was then again a separate entity and in its second stage of development. Lake Whittlesey meanwhile was draining across the "thumb" of Michigan and into Lake Saginaw via the Ubly outlet. With the retreat of the ice front from the Port Huron moraine, Lake Saginaw and Lake Whittlesey were again joined to form Lake Wayne (660 ft.). The sudden increase of discharge down the Glacial Grand with the lowering of Lake Whittlesey to the Arkona 695 ft. level had evidently downcut the spillway leading to the Glacial Grand by approximately 35 feet. Later, much of the area Lake Saginaw had encompassed "was to become incorporated" into the later lakes such as Lake Warren and Lake Lundy in the Erie basin (Leverett and Taylor, 1915, p. 359).

BRETZ

Bretz (1951, 1953) generally agrees with the history of Lake Saginaw as presented by Leverett and Taylor. However, he suggests that an early stage of ponded water was marked by ice front retreat from the Fowler moraine. The height of the Fowler moraine was such that it could act as a dam for waters ponding between the moraine and ice edge. He also suggests that a later lake related to this could have also developed following the retreat of the ice front from the Flint moraine. However, evidence for this, such as beaches, is lacking and may have been obliterated by the later readvance of the ice front to build the Owosso moraine. The existence and extent of both of these water bodies would have been dependent upon how low the breaks or sags were in the Flint and Fowler moraines. Bretz also suggests that upon retreat from the Owosso moraine a second Lake Saginaw (735 ft.) was established, which drained across the Owosso moraine and into the Glacial Grand River.

The main emphasis of Bretz (1951) concerns the development of the Owosso valley train, which is associated with the Imlay channel, and can be traced from Owosso to Maple Rapids (Figure 4). According to Bretz (1951) the Imlay river flowed through Hayworth channel when ice associated with the Owosso moraine covered much of the lowland just west of the city of Duplain. The Owosso valley train apparently developed when water flowing in the Imlay channel was unable to carry all the detritus discharging from the ice edge. Later, as the ice front withdrew from the Owosso moraine the Imlay River became underloaded which resulted in the dissection of the valley train. Consequently, today

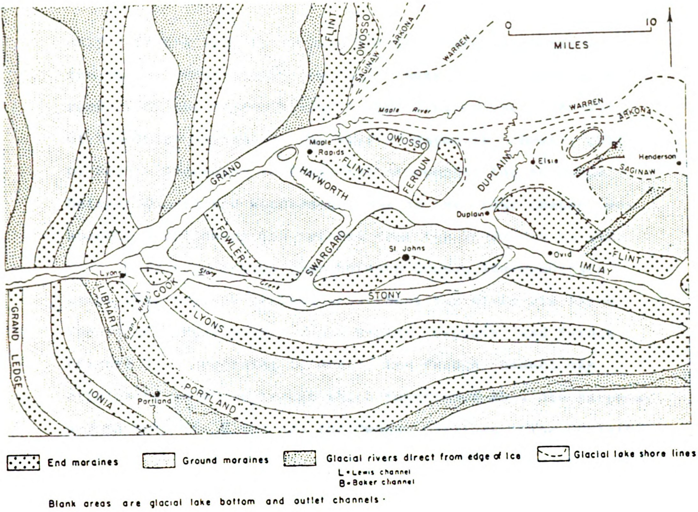

Figure 4. Bretz (1951) - Interpretation of the Glacial Features of the Maple Rapids Area of Michigan.

only terraces and flat-topped knolls remain as remnants of the valley train within the Imlay channel. A conspicuous remnant of the Owosso Valley train "lies on the south side of the Imlay channel at the head of Hayworth" (Bretz, 1951, p. 253). According to Bretz the dissection had to occur between Owosso and Henderson times as the Imlay channel was abandoned following ice retreat from the Henderson moraine.

Bretz also states that between Owosso and Henderson times Lake Saginaw drained into the Imlay River via three functioning spillways: Maple Rapids, Duplain, and Ferdun (Figure 4). According to Bretz, the Ferdun channel was originally an esker trough which functioned as a dischargeway across both the Flint and the Owosso moraines. The Duplain spillway leading into the Imlay, and the Maple Rapids spillway leading into the Glacial Grand, were both contemporaries of the Ferdun spillway. Later during the dissection of the Owosso valley train the Glacial Grand Valley was deepened and led to a competition between the three functioning spillways. Even as the ice retreated from the West Haven moraine, the three spillways were apparently still functioning simultaneously. Only upon the retreat of ice front from the Chesaning moraine did the Maple Rapids spillway downcut sufficiently so that the two other spillways became abandoned. According to Bretz (1951) it was during this deepening of the outlet that Lake Arkona fell to its intermediate level (710 ft.).

DISCUSSION

The extent and position of the earliest Lake Saginaw shorelines are of particular interest since Leverett and Taylor (1915) and Bretz (1951, 1953) differ on their opinions concerning the time of the lake's formation. Leverett and Taylor, for example, cite that the initial beginnings of Lake Saginaw occurred as the ice front retreated from the Flint moraine and that the Duplain beach, which they claim to be the first beach associated with Lake Saginaw, developed only after the ice front had retreated from the Henderson moraine. Leverett and Taylor (1915, p. 358) define the Duplain beach as "a very faint fragmentary shoreline--in places a faint cliff, but more commonly a narrow low ridge of gravel--[that] lies 10-15 feet above the much stronger Arkona ridges and 720-725 feet above sea level." In Figure 3 these beaches can be traced northwestward from Duplain and lie predominantly at an elevation of 725 feet. Leverett and Taylor also suggest that the lake did "little toward straightening its shore" (Leverett and Taylor, 1915, p. 358). This is evidenced by the irregularity of the shoreline northwest of the city of Duplain where the beach tends to change its course from a northeast-southwest trend to more east-west trend.

Bretz (1951, p. 255), on the other hand suggests that "early Lake Saginaw, the first of the lake series in the Saginaw basin to leave positive records, was dammed by the

Owosso moraine." He believes that the Lake Saginaw beaches are evident at 735+ feet and occur on the back side of the Owosso moraine particularly in the area just northwest of Duplain (Figure 4) where the Owosso moraine had "piled upon the back of the Flint moraine" (Bretz, 1951, p. 245).

PRESENT INVESTIGATION

METHODOLOGY

The approach taken in this investigation is based on the premise that through a detailed study of the present soils within Clinton, Gratiot, and Shiawassee counties, the glacial events in the Maple Rapids area would become more apparent and more easily interpreted. In this type of analysis, pertinent soils maps are assembled to denote the dominant soils present in the counties involved. The soils are then catalogued with respect to their parent material through their association with known deposits of glacial gravels, sands, till, or lake clays. The next step involves making a detailed glacial geologic map of the area relative to the distribution of soil types. The glacial map is then analyzed to determine the deglaciation history of the area.

The Use of Soils Maps

Soils developed in glaciated areas are closely related to the surficial geology and are the product of the following factors: parent material, topography (drainage and slope), organisms, time, and climate (Foth and Turk, 1952).

In this study, it is assumed that parent material and topography are the major factors affecting soil development through the moisture relations and the rate of soil removal by erosion. Geologically the parent material and topography are the most pertinent factors. In this study the basis is the relationship of the soils with both factors.

Soil maps of the tri-county area around Maple Rapids were obtained through reports and manuscripts published by the United States Department of Agriculture, Soil Conservation Service (Pregitzer, 1978; Threlkeld and Feenstra, 1974; Feenstra, 1976). The various soil types described in these publications were mapped as discreet units utilizing both naturally exposed soil profiles and bucket augering to a depth of about five feet. Samples of the soils were generally taken every 8-10 acres and were recorded onto an aerial photographic base. The soil mapping units listed in the soil surveys define the predominant soil series and are subdivided on the basis of slope. A soil series normally has similar properties such as mineralogy, texture, or grain size composition (Pregitzer, 1978).

The major advantage in the use of soil maps is the greater number of samples taken to generate the maps. Sampling of every 8-10 acres is concentrated enough to generate an accurate map of the soils. The concentrated sampling can often also be a disadvantage as it creates too much detail. A very small area of a specific soil type will often appear anomalously within an area dominated by another soil type. The shallow sampling of about five feet is also a disadvantage if the soil profile is very deep.

The soil series listed on the aerial photographic base were assembled into soil management groups (see Table 2).

> "The soil management group (SMG) concept combines soil series with similar dominant profile texture and natural drainage conditions. These groups are designated systematically with numbers and letters....
>
> Mineral soils are given a number based on the dominant profile texture as follows: 0 - fine clay, more than 60% clay; 1 - clay, 40 to 60% clay; 1.5 - clay loam and silty clay loam; 2.5 - loam and silt loam; 3 - sandy loam; 4 - loamy sand; and 5 - sand....
>
> Soils developed from uniform parent materials are represented by one number (...Table [3]). Soils developed from two storied parent materials or with contrasting textures in their profiles are represented by fractions (Table [4]). The numerator represents the texture of the upper story and the denominator the lower story. For example, [3/5] represents soils with 50 cm to 1 m of sandy loam over sand .
>
> Soils which are very gravelly or stony throughout their profile are indicated by a capital 'G'. Alluvial or lowland soils having stratified materials and subject to flooding are preceded by a capital 'L'.
>
> Organic soils are indicated by a capital 'M' for muck or peat....
>
> Lower case letters are used to indicate natural drainage conditions: a - well and moderately well drained; b - somewhat poorly drained (formerly called imperfectly drained); and c - poorly and very poorly drained.... The letters follow the numbers or capital letters of the dominant profile texture in the soil management group symbol" (Mokma and Robertson, 1976).

Finally, an association is made between dominant soil management groups and underlying glacial material from Leverett and Taylor's (1915) morphologic map. An example

TABLE 2. COMPARISON OF SOIL SERIES, MANAGEMENT GROUP AND GLACIAL GEOMORPHIC FEATURES

Soil Series and Slope	Dominant Profile Textures From Soil Management Group	Glacial Geomorphic Features
Lenawee - 0-2% slope	1.5 Clay loam and Silty clay loam	Lake plains
Sims - 0-2% slope		
Capac - 0-4% slope	2.5 Loam and silt loam	Moraines Till plains
Capac-Marlette - 1-6% slope		
Marlette - 2-5% slope		
Parkhill - 0-2% slope		
Fox - 2-6% slope	3/5 Sandy loam over sand	Outwash plains (sand and gravel) Glacial drainageway
Matherton - 0-3% slope		
Sebawa - 0-2% slope		

COMPARISON OF SOIL SERIES (continued)

Soil Series and Slope	Dominant Profile Textures From Soil Management Group	Glacial Geomorphic Features
Boyer - 0-6% slope	4 Loamy sand	Outwash plains (sand and gravel) Beaches Glacial drainageway
Wasepi - 0-3% slope		
Gilford - nearly level		
Spinks - 0-6% slope		
Thetford - 0-3% slope		
Oshtemo - 0-3% slope		
Oakville - 0-6% slope	5 Sand	Outwash or beaches
Granby - 0-2% slope		
Gravel pits	G Gravel	Outwash (sand and gravel)
Sloan - nearly level	L-2 Alluvial-loamy	Flood Plain (alluvial deposits)
Adrian Edwards Houghton Palms } nearly level	M Muck	Glacial channelways and Depressions

Table 3. Interrelationships of soil management groups for soils developed from <u>uniform parent material</u> (Mokma and Robertson, 1976).

Dominant profile texture	Symbols
Fine clay, over 60% clay	0
Clay, 40-60% clay	1
Clay loam and silty clay loam	1.5
Loam and silt loam	2.5
Sandy loam	3
Loamy sand	4
Sand	5
Gravelly or stony loamy sand to loam	G
Bedrock, less than 50 cm	R
Alluvial or lowland soils	L
loamy	L-2
sandy	L-4

Table 4. Interrelationships of soil management groups for mineral soils with <u>contrasting parent materials</u> (Mokma and Robertson, 1976).

Dominant profile texture	Symbols
Sandy loam, 36-100 cm, over clay	3/1
Sandy loam, 50-100 cm, over loam to clay loam	3/2
Sandy loam, 50-100 cm, over gravelly sand	3/5
Loamy sand, 36-100 cm, over clay	4/1
Sand to loamy sand, 50-100 cm, over loam to clay loam	4/2
Sand to loamy sand, 1.0-1.5 m, over loam to clay	5/2

of an association would be the Capac soil series with moraines and till plains.

Morphologic Maps

Leverett and Taylor's (1915) map on file with the Michigan Department of Natural Resources was used as the morphologic map for the interpretations of the soil-glacial material association. For example, the crests of the moraines were defined on the basis of isolated broad topographic highs which follow a general northwest-southeast trend. The gently undulating area between morainal crests was differentiated as till plain. Generally, beach ridges appeared as isolated long and narrow topographic highs following a general north-east-southwest trend.

Drainage channels in the area were defined by broad, flat areas with organic soils or marshy conditions. Two types generally form: (1) Those which followed the ice edge and which are intermorainal in character, and (2) those which trend in a north-south direction and crosscut the moraines.

Valley train outwash deposits appear as isolated terraces within present day stream valleys and along the banks of the major meltwater channels. In some cases sand bars occur within the channels.

Lake plains generally appear as large flat areas and often are associated with beach ridges.

Field Check of the Study Area

The field check of soil profile textures with glacial deposits also substantiated the soil-morphologic associations listed in Table 2. For example, sand and gravel deposits were identified in several gravel pit operations in the Imlay channel area. One pit, in Section 36 of Greenbush Township, shows stratified coarse sands and gravels about 35 feet thick. Another gravel pit in Section 27 of Essex Township, Clinton County, was also checked. Here the coarse sand and gravel deposits are about 10 feet thick and overlie cross bedded sands. In each case the sandy loam over sand soils developed in these areas suggested the occurrence of thick deposits of sand and gravel. Beach sands were verified to be associated with loamy sand textures (Boyer soil series) in Sections 4, 5, 8, and 9 of Greenbush Township. The beach is distinguished by a ridge and the presence of pine trees. The lake plains north of beaches in Greenbush Township are associated with clay loam and silty clay loam profile textures such as Lenawee and Sims.

RESULTS

Figure 5 shows a glacial geologic map of the Maple Rapids area generated entirely from the association of soils and glacial deposits listed in Table 2. It is evident from the map that many of the glacial morphologic features recognized by Leverett and Taylor and Bretz are also distinguishable on the basis of soils alone. In addition, the map shows several features not recognized by the previous investigations.

The Owosso and Flint Moraines

In Figure 5 both the Flint and Owosso moraines are defined by the presence of a loam and silt loam soil unit associated with till. The loam and silt loam developed on the moraines show a wide variation in the percentages of clay, silt, and sand and reflect the heterogeneous nature of the drift forming the moraines.

From the soils it is evident that the surface morphology of the moraines is also very variable and consists of surface slopes of 6% or greater. The Flint moraine, for example, is characterized by isolated topographic highs with elevations ranging from 750 to 765 feet above sea level. The Owosso moraine, however, is slightly lower than the Flint and is characterized by isolated highs at 745 to 750 feet above sea level.

The Flint moraine shown in Figure 5 extends from just east of Perrinton and curves south-eastward towards Ovid. The crest of the moraine appears to be continuous up to the Essex-Greenbush Township line through Sections 3, 10, 14, and 15 of Essex Township of Clinton County. However, eastward from this point, the moraine consists of only scattered knolls and ridges. It can be traced east of Duplain almost to the Clinton-Shiawassee County line through Sections 26, 27, 33, and 36 of Duplain Township in Clinton County.

The Owosso moraine on the other hand trends just east and north of the Flint moraine and extends from just east of Perrinton southward to the Glacial Grand River Channel. Upon crossing the Glacial Grand River Channel the moraine swings eastward and passes through the town of Eureka. The crest of the moraine is continuous through Essex Township, up to about the Essex-Greenbush Township line. However, eastward from this point, the moraine is defined only by scattered knolls. East of Duplain, the moraine is again more evident particularly in Sections 25, 26, and 27 of Duplain Township.

The Imlay Channel

The Imlay channel in Figure 5 extends from Maple Rapids to Imlay City, Michigan and shows remnants of an eroded valley train. The outwash comprising the valley train forms a loamy sand soil unit which is characterized by large percentages of sand and very little silt and clay. The surface of the outwash is generally flat with minor gentle slopes and, in the Imlay channel, lies approximately 735 feet above sea level. The gradient of the outwash surface is approximately 25 feet/mile and slopes toward the west. Near the head of the Glacial Grand River Channel, the surface of the valley train lies at an elevation of 720 to 725 feet above sea level.

As suggested by Bretz (1951) the valley train deposits in the Imlay channel were undoubtedly formed when streams draining the ice became overloaded with sediment and developed into braided streams. During the development of the Valley train the ice front was at the Owosso moraine. The valley train can be traced through Owosso and Middlebury Townships of Shiawassee County and Ovid, Duplain, Greenbush, and Essex Townships of Clinton County. Conspicuous "islands" of outwash also appear in Sections 35 and 36 in Greenbush Township, Clinton County and in Section 10 of Ovid Township, Clinton County. These islands of outwash lie at an elevation of 735 feet above sea level and represent the only surviving remnants of the valley train in the area around Duplain that were not eroded away by later meltwater drainage.

Some of the spillways or channelways such as the Baker and Lewis in Figure 5 which grade into the Imlay channel appear to be floored with deposits of muck and sandy loam. The muck is generally recent and consists of organic matter in an advanced state of decomposition. It is a result of grasses and sedges accumulating within low spots and depressions in the channelways. Morphologically, the channelways are defined by broad, relatively flat valleys with steep banks. The banks usually consist of loamy sand and generally are best defined near the channel mouths. For example, the Baker channel can be traced on the basis of soil textures southwestward through Sections 18 and 19 of Rush Township and Sections 13, 21, and 27 of Fairfield Township of Shiawassee County. Likewise, the Lewis channel can be traced southwestward through Sections 12 and 14 of Middlebury Township and Sections 5 and 6 of Owosso Township in Shiawassee County. Both the Lewis and Baker channels are similar in that they contain organic soils. Likewise, the Ferdun channel, further to the west, can be traced on the basis of soil textures southward through Sections 17, 18 and 19 of Greenbush Township, Clinton County.

Beaches

The beaches shown in Figure 5 are defined by loamy sand or a sand textured soil. These soils generally show a high percentage of sand reflecting the removal of the fine clay material by wave action. Morphologically, the beaches are defined by long narrow ridges which lie at specific elevations. The beach just east of Duplain in Sections 34 and 28 of Duplain Township lies predominantly at an elevation of 725 feet above sea level, but it varies as much as 5 to 10 feet above and below the 725 foot elevation. The same beach is also evident in Sections 22 and 23 of Duplain Township and in Section 8 of Greenbush Township, Clinton County.

A second beach at 705 to 715 feet above sea level also appears in Sections 8, 9 and 10 of Duplain Township. This trend possibly extends further toward the northeast into Shiawassee County, but it is not easily discernable in this area.

Lake Plains

Lake plains in Figure 5 are evident by large expanses of continuous clay loam and silty clay loam soil textures. More than 50 percentage of clay sized particles is an indication of past standing water. Morphologically, the lake plains appear as flat, featureless areas. Most of the lake plains occur in Clinton and Gratiot Counties. In Duplain and Greenbush Townships, Clinton and County the lake plains are associated with the beach deposits. However, in Dallas and Bengal Townships of Clinton County, the lake beds are present but in direct association with beaches.

SIGNIFICANCE OF RESULTS

Mapping the glacial geology on the basis of soils provides a means of defining the deglaciation history of the Maple Rapids area. The deposits and morphologic features which provide the most valuable information in regard to the deglaciation history are the Flint and Owosso moraines, the valley trains associated with the Imlay channel and the beaches which record the major lake stages in the Saginaw basin.

The Flint and Owosso Moraines

The Flint and Owosso moraines have been previously mapped by Leverett and Taylor (Figure 3) and by Bretz (Figure 4). Although the precise boundaries of the moraines vary between authors they tend to be in general agreement.

For example, both Leverett and Taylor and Bretz show the Flint moraine extending southward from a point just east of the city of Perrinton and then curving south-eastward upon reaching the Glacial Grand River channel. The map derived from the present study (Figure 5) tend to confirm this trend. However according to Leverett and Taylor (1915, p. 243), only the Flint morainal system (Figure 3) is present east of Duplain. Bretz (1951, p. 245), on the other hand, cites that in this area both the Flint and Owosso moraines are present with the Owosso moraine "piling on the back of the Flint moraine" (Figure 4). The results of the present study (Figure 5) appear to confirm the presence of both morainal systems east of Duplain. The northern most morainal crest would represent the Owosso moraine while the southern most crest would represent the Flint moraine. Leverett and Taylor (1915) define the moraines south of the Glacial Grand (Figure 3) as being part of the Flint and Owosso systems. However, from the Glacial Grand River eastward to Elsie, they define (1915, p. 242) the Owosso moraine as consisting of only "scattered knolls". Bretz (1951), on the other hand, shows the Owosso moraine in this area to be relatively continuous although in places dissected by the Ferdun and Duplain channelways (Figure 4). East of Duplain Bretz also shows the Owosso moraine paralleling the sinuous course of the Flint moraine with the two being separated by an imperfectly developed marginal stream. The present study (Figure 5) shows that both the Owosso and Flint moraines do indeed extend eastward from the Glacial Grand River channel to Duplain and that both are relatively well developed.

The Owosso Valley Train

According to Bretz (1951) the Owosso valley train can be traced from the town of Owosso all the way to Maple Rapids. Bretz (1953, p. 377) defines the valley train as a gravel deposit usually about "30 feet thick" and represented by the "720 to 725 foot terraces of the Hayworth flat". He points out that a conspicuous remnant of the Owosso valley train covers "about two square miles, lies on the south side of the Imlay channel at the head of the Hayworth and the junction of Duplain and Maple-Imlay" (Bretz 1951, p. 253), and that another remnant forms "a mid-channel hill about a mile long, separating Maple and Little Maple rivers where both are using the Imlay channel west of Ovid" (Bretz, 1951, p. 253). In the present study (Figure 5) both of the Owosso valley train remnants cited by Bretz are very evident. The "triangular area, about two square miles" is located predominately in Section 36 to Greenbush Township (Clinton County) and extends up into parts of the surrounding sections. Another mid-channel remnant is also distinguishable west of Ovid in Section 10 at an elevation of 735 feet.

Beaches

Leverett and Taylor (1915) and Bretz (1951, 1953) define differently the beaches recording the major lake stages of Lake Saginaw. Leverett and Taylor (1915, p. 358) for example, define the Duplain beach, the first beach of Lake Saginaw, as "a very faint fragmentary shoreline--[which] lies 10 to 15 feet above the much stronger Arkona ridges and 720 to 725 feet above sea level." Bretz (1951, p. 255), on the other hand, defines the early Lake Saginaw beaches as lying "735+ feet A. T.". The present study (Figure 5) confirms the existence of a beach at an elevation of 725 feet above sea level. This beach can be traced northwestward from the city of Duplain.

In northern Greenbush Township in Clinton County the beach laps directly onto the Owosso moraine and is not in direct association with the Flint moraine. The beaches lying 705 to 715 feet above sea level in Figure 5 are Lake Arkona beach ridges and define lower stages of Lake Saginaw.

Lake Bottom Deposits

Neither Leverett and Taylor (1915, Figure 3) nor Bretz (1951, Figure 4) defined lake bottom deposits directly, but inferred their extent by association with well defined beaches. The present study (Figure 5), however, shows the actual extent of lake bottom deposits and their relationship to the beaches. It is evident from Figure 5 that in Dallas and Bengal Township of Clinton County, there appears to be no direct association between beaches and lake deposits.

On the proximal side of the Fowler moraine in Figure 5, just north of Fowler, are some discontinuous deposits of lake clays. These deposits represent one of the earliest proglacial lakes in the Saginaw basin. Initially, these relatively small lakes probably drained to the south, possibly into the Stoney channel. However, upon retreat of the Saginaw ice lobe toward the northeast, a lower outlet was exposed thus allowing the lakes to drain northward.

Channels

The Imlay channel shown in Figure 5 probably first formed as the ice along the ice of the front was against the Flint Moraine or just north of it. It is evident from the remnants of the Owosso Valley train within the channel that most of the drainage was from east to west and confined to the Imlay channel. However, as the ice front retreated farther past the Flint moraine the drainage appears to have shifted towards the north side of the Flint moraine via the Ferdun channel. Later, as the Owosso moraine formed by a readvance of the ice front drainage was again confined to the south side of the Flint moraine. Several channels were cut into the moraine as the result of meltwater draining from the ice into the Imlay channel.

The Development of Glacial Lake Saginaw

On the proximal side of the Fowler moraine, just north of Fowler, are discontinuous deposits of lake clays. This ponding of water represents the earliest proglacial lake in the Saginaw basin. Initially, the lake probably drained to the south, possibly into the Stoney channel. However, upon further retreat of the ice lobe towards the northeast a lower outlet appears to have been exposed, allowing the lake to drain northward. As the ice front retreated further past the Flint moraine another pond (or a series of ponds) was formed. This relatively small lake (early Lake Saginaw) apparently was not capable of producing beaches. The Owosso moraine was formed by a readvance of the ice lobe leading to the obliteration of the small lake (early Lake Saginaw).

It is evident from Figure 5 that following the development of the Owosso moraine Lake Saginaw was large enough to form a major beach at 725 feet. The northeast-southwest trend of the beach is evident east of Duplain and west of Eureka at the head of the Ferdun channel. In the latter area there is a jog in the beach as it laps onto the Owosso moraine, thus definitely dating it post-Owosso. The beaches define the extent of the lake from northwestern Greenbush Township eastward to the city of Duplain. The southern boundary of the lake is marked by the Owosso moraine which follows the Imlay Channel while northward the boundaries of the lake extend out of the study area. The water which initiated the formation of Lake Saginaw was derived from the waning Saginaw ice lobe. During its initial stages the lake drained into the Imlay Channel via the Ferdun and Duplain spillways and continued to flow westward to join the Glacial Grand River at Maple Rapids.

As the ice continued to retreat northward Lake Saginaw eventually merged with Lake Maumee to form early Lake Arkona (second Lake Saginaw). Early Lake Arkona is defined by beaches at 705 to 715 feet. These beaches can be seen in Figure 5 extending east-west from Eureka to Elsie. The drainage for Lake Arkona was also down the Glacial Grand River via the Maple Rapids Spillway.

SUMMARY AND CONCLUSIONS

The history of Lake Saginaw was related to the glacial features through the utilization of soil management units and topographic analysis. Soil maps were initially generated which related the parent material of the soil to the dominant soil profile texture. This relationship was established by a comparison with known deposits of glacial gravels, sands, till, or lake clays. A topographic analysis of the area followed with Leverett and Taylor's (1915) morphologic map used as a reference. The soils map and the morphologic map were then combined to form a synergistic overlay.

The following conclusions of the history of early Lake Saginaw can be drawn from the synergistic overlay:

(1) Early Lake Saginaw, large enough to be defined by beaches, was developed following the formation of the Owosso moraine. The lake drained into the Imlay channel via the Ferdun and Duplain spillways.

(2) The Imlay channel came into existence following the retreat from the St. Johns moraine and flowed westward toward the Glacial Grand River until post-Henderson times. The channel carried the discharge waters of Lake Saginaw westward where it joined the Glacial Grand River at Maple Rapids.

(3) The Owosso valley train was deposited as the ice stood at the Owosso moraine and was then dissected during post-Henderson times. The Lewis and Duplain channels provided part of the detritus for its existence.

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GLACIAL GEOMORPHIC FEATURES GENERATED FROM DOMINATE SOIL TEXTURE AND TOPOGRAPHY

by

Marsha J. Ward

Sept. 1978

N

Scale: 1/62500

1 1/2 0 1 2 3 4 Miles

Contour interval 5 feet   Datum: mean sea level

LEGEND

Color Code	Dominant Soil Texture	Glacial Geomorphic Features
	clayloam and silty clayloam	lake plain
	loam and siltloam	till and moraines
	loamy sand and sand	beaches
	loamy sand and sand	outwash
	loamy - alluvial	modern alluvial
	muck	glacial channelway