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## Glacial and Postglacial Deposits of Northeastern Ohio<sup>1</sup>

JOHN P. SZABO, CHARLES H. CARTER, PIERRE W. BRUNO and EDWARD J. JONES, Department of Geology, University of Akron, Akron, OH 44325

**ABSTRACT.** Recent high levels of Lake Erie have produced severe erosion and mass wasting along the shore. At the same time they have created excellent exposures of glacial and postglacial deposits east of Cleveland, Ohio. Glacial deposits consist of an older "Coastal" till and the Late Wisconsinan Ashtabula Till, whereas postglacial deposits generally are gravels, sands and silts. Lithofacies of the Ashtabula Till exposed at Sims Park in Euclid, Ohio, include sheared, massive diamicts and resedimented diamicts. The lowest sheared massive diamict previously identified as the "Coastal" till possibly represents a lodgement till deposited by Ashtabula ice. Beach deposits at Mentor Headlands resulted from construction of manmade structures. At Camp Isaac Jogues, deltaic sands overlie a sequence of diamicts, which has an unusually high carbonate content when compared to other sections along the shore. The geometry of the overlying sands and the facies sequence strongly suggest a river-dominated deltaic system. Two sand pits in beach ridges (one at the Warren level and the other at the Arkona level) farther inland contain coarse-grained facies that may represent an outwash plain or coastal barrier overlain by dune sand. A log dated at 13.4 ka was found at the Arkona level, 1 km south of the second pit.

OHIO J. SCI. 88 (1): 66-74, 1988

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<sup>1</sup>Manuscript received 15 September 1987 and in revised form 7 December 1987 (#87-38).

## INTRODUCTION

Northeastern Ohio has undergone several glaciations during Late Wisconsinan. The final advance of the Erie Lobe into Ohio deposited the Ashtabula Till (White 1960), the youngest till in Ohio. Mass wasting, caused by high water levels on Lake Erie, has produced nearly continuous bluff exposures of the Ashtabula Till, an older till known as the "Coastal till" (White 1980) that crops out below the Ashtabula Till, and the postglacial sediments exposed in the "beach ridges." The purpose of this field trip is to examine these deposits in order to infer the depositional environments using lithofacies, and to determine the relation of the "coastal till" to the Ashtabula Till.

The geology of the Lake Erie shore has been studied for over 150 years. During the middle part of the 19th century, several general reports on the geology of the field area were published. Charles Whittlesey (1838, 1850, 1869) described the geology of Lake County. Railroad investigators described the Lake Plain surface as drift-covered (Newberry 1857). The first specific geologic reports on both Ashtabula and Lake counties were prepared by Read (1873). Newberry (1874) included data from these counties in the first detailed account of the glacial geology of Ohio. Influenced by earlier workers, Peet (1878) described nearly all the geology of Ashtabula County as drift resulting from ice sheet advances. Glacial striations were noted at Andover, Ohio, by Leverett (1902) in extensive descriptions of moraines in Lake and Ashtabula counties.

Renewed interest in the geology of Lake and Ashtabula counties developed in the second half of this century. Sand and gravel resources have been investigated by Hutton (1940) and Smith (1949). Christopher (1955, 1959) and Gordon (1956) studied shoreline erosion in Lake County. The glacial geology of Ashtabula and Lake counties is shown on the glacial map of Ohio (Goldthwait et al. 1961). Descriptions of the Lake Erie shore are included in shore erosion reports prepared for Lake County (Carter 1976) and Ashtabula County (Carter and Guy 1983). The most recent investigation of glacial geology for Ashtabula County includes a discussion of beach ridges (White and Totten 1979). "Coastal" till exposures are described by White (1980) in the Lake County report. Sand deposits overlying the Ashtabula Till have been studied in Lake County by Jones (1985).

Cuyahoga and Lake counties are in northeastern Ohio. They are bordered on the east by Ashtabula County, on the west by Lorain County, and on the north by Lake Erie (Fig. 1). The field trip area is a strip of land about 8 km wide following the Lake Erie shore from Euclid (Cuyahoga County) to just east of the nuclear power plant at Perry (Lake County). The area is bounded on the north by the wave-eroded bluffs of Lake Erie, and on the south by the morainic complex along the escarpment.

The field trip area is in the Eastern Lake Section of the Central Lowland Province, a 5-8-km-wide belt parallel to the lake shore. It is delineated from the Southern New York Section of the Appalachian Plateaus Province (Allegheny Plateau) by an escarpment, a northeast to southwest trending bedrock belt 2-5 km wide. On this escarpment are three prominent ridges, (Euclid, Painesville and Ashtabula moraines) trending parallel to the escarpment. The Lake Plain is covered by glacial and postglacial deposits of various thicknesses. The north margin of the Lake Plain is a continuous bluff, except where dissected

by stream valleys. The bluff, rising from a few meters to about 20 m above the Lake Erie shore, is subject to severe erosion that leads to the formation of vertical cliffs and irregular steep slopes. The study area is underlain by Devonian shales and siltstones of the Chagrin Formation, which extend northward into the Lake Erie basin.

The stratigraphic relationships of Wisconsinan age tills (Fig. 2) have been investigated in detail (White 1960, 1980, 1982, White et al. 1969, White and Totten 1979). The age of the oldest described till, the Keefus Till, whose lower contact is bedrock at the type section, may be Illinoian or Wisconsinan in age (White and Totten 1979). The Titusville Till which overlies the Keefus Till is exposed in deep cuts in Lake County (White 1980) and on the surface in Ashtabula County, where the thinner younger drift has been eroded at the margin of the Grand River lobe (White and Totten 1979).

The four youngest tills are Woodfordian Substage deposits. The oldest till, the Kent Till (White 1960), which was deposited about 23 ka, is exposed on the surface at the margin of the Grand River lobe as a parallel belt north of the Titusville Till. The Kent Till is discontinuous north of the margin; the younger Lavery Till (Shepps et al. 1959) may lie directly on Titusville Till. The Lavery Till, which was deposited about 16 ka, is present on most of the Lake Escarpment moraines beneath younger tills. Where the thin overlying Hiram Till (White 1960) is missing, the Lavery Till is exposed on the surface. The final advance of the Erie Lobe deposited the youngest till in Ohio, the Ashtabula Till (White 1960). This till forms the surface of the Painesville,

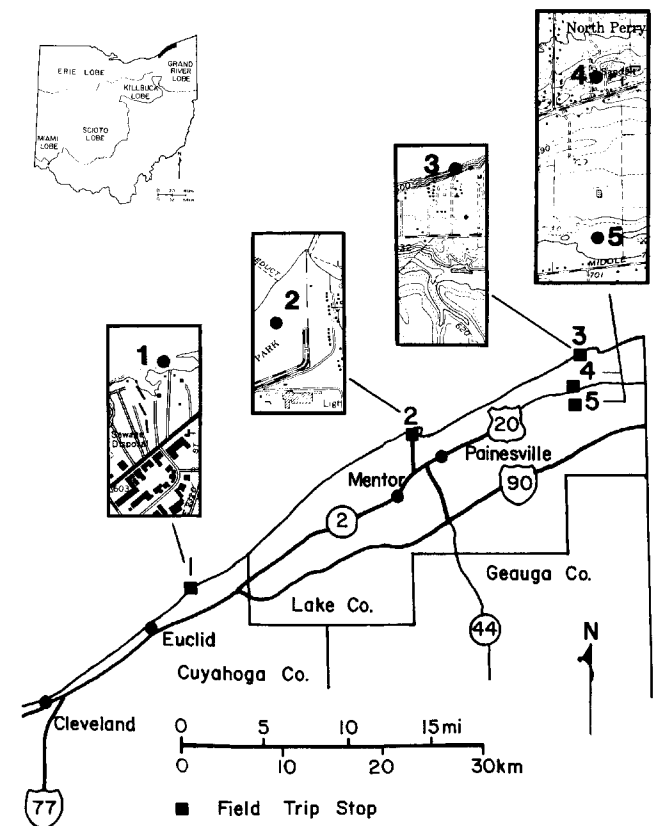


FIGURE 1. Location of field trip area showing stops 1 through 5 in eastern Cuyahoga and Lake counties. Stop 1: Sims Park. Stop 2: Mentor Headlands State Park. Stop 3: Camp Isaac Jogues. Stop 4: Keeney Pit. Stop 5: Osborne Pit.

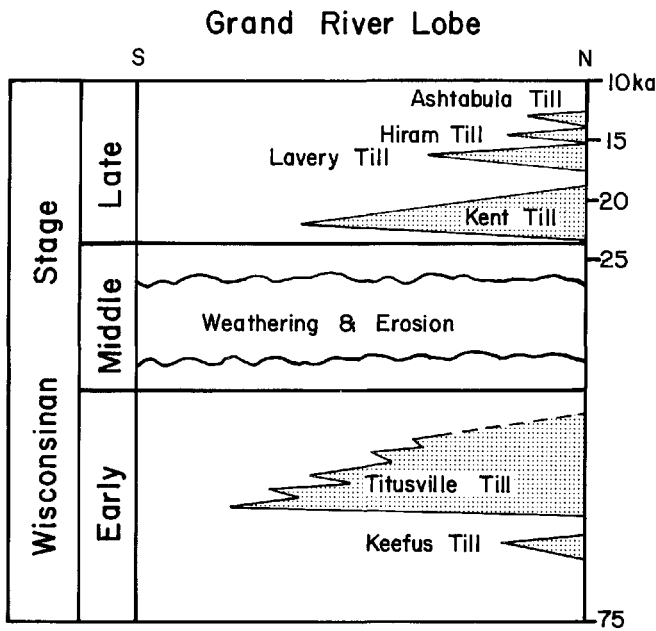


FIGURE 2. Generalized stratigraphic column for Wisconsinan tills of the Grand River Lobe.

Euclid and Ashtabula moraines (White and Totten 1979, White 1980). The Ashtabula Till is thickest near the lake and is covered with sand and silt on the Lake Plain (White 1980). Deposition of the Ashtabula Till occurred when Erie Lobe ice readvanced to the base of the escarpment (White et al. 1969) and southwest to near the present location of Cleveland.

Retreat of the Ashtabula ice from the Lake Erie basin led to the formation of glacial lakes. The highest lake level terraced the Painesville Moraine at an elevation of about 259 m (White and Totten 1979). Subsequent lower levels of the lake affected the Lake Plain by wave action and longshore currents.

**METHODS**

Sections along the south shore of Lake Erie were measured and described using standard methods. Lithofacies were logged according to the procedure of Eyles et al. (1983). Diamicts were sampled at 0.5-1.0-m intervals within uniform lithofacies. Samples also were collected on each side of contacts between different lithofacies. Matrix textures (<2 mm) of samples were determined using settling and pipetting methods (Folk 1974). Carbonate content of the <0.074 mm fractures was determined using a Chittick apparatus (Dreimanis 1962). Quartz-feldspar ratios (Q/F) were calculated from point counts of the fine sand fraction exposed to cathodoluminescence (Ryan and Szabo 1980). Diffraction intensity ratios (DI) of the <2 μ fraction were calculated by dividing the area under the 10 Å illite peak by the area of the 7 Å kaolinite and chlorite peak on x-ray diffractograms (Willman et al. 1966). Composition of the 1-2-mm fraction (herein referred to as coarse sand; Anderson 1957) was determined by point counting with a binocular microscope. Statistical analyses were performed on a microcomputer employing programs of Davis (1986).

**FIELD TRIP ROAD LOG  
STOP DESCRIPTIONS**

This road log consists of three parts. The first part is a generalized description of geology from Akron to Cleveland; the second part consists of a specific road log from Cleveland to North Perry; and the last part is a generalized description from the last stop back to Akron.

As we travel I-77 from Akron to Cleveland, we are moving downsection from the Pennsylvanian Pottsville

sandstones and shales to the Devonian Chagrin Shale. Glacial deposits at Akron consist of Early Wisconsinan kames associated with the Mogadore advance. They have been dissected by Late Wisconsinan outwash channels. Where I-77 crosses Ghent Road and Yellow Creek Valley, the Late Wisconsinan boundary consists of the Summit County morainic complex (White 1982) overlying Mississippian shales and siltstones. Near the Ohio Turnpike (I-80) overpass, I-77 is cut into Hiram, Lavery, and Northampton tills (Szabo and Angle 1983). From the I-80 overpass to Ohio 82, I-77 is constructed on Mississippian shales up to Rockside Rd. where it is cut through Berea Sandstone which overlies red Bedford Shale. At the intersection with I-480, lake deposits overlie Northampton Till (Szabo and Miller 1986) along the Cuyahoga Valley. Across the valley in the east wall are extensive outcrops of Berea Sandstone and Bedford Shale (Pepper et al. 1954). The sewage plant on the right is built partially on a paleo-landslide (Miller 1985).

Distance: km (mi)  
cum. inc.

0.0	(0.0)	0.0	(0.0)	Merge onto I-90, eastbound inner belt freeway.
2.9	(1.8)	2.9	(1.8)	Junction I-90 east/Ohio 2 east/Ohio 2 west. Stay on I-90 east/Ohio 2 east (Dead Man's Curve).
7.2	(4.5)	4.3	(2.7)	Exit for Martin Luther King Blvd., exit right, bear left on ramp, turn left (north).
7.4	(4.6)	0.2	(0.1)	Turn right (east) onto Lake Shore Blvd.
8.8	(5.5)	1.4	(0.9)	Intersection Lake Shore Blvd. with Garfield Lane and Burton Lane. Bear left (east) to stay on Lake Shore Blvd.
12.6	(7.9)	3.8	(2.4)	Intersection Lake Shore Blvd. and Ohio 283. Go straight (east) on Lake Shore Blvd. (Ohio 283).
14.1	(8.8)	1.5	(0.9)	Intersection Lake Shore Blvd. and East 152nd St., turn left, staying on Lake Shore Blvd.
14.4	(9.0)	0.3	(0.2)	Bear right on Lake Shore Blvd.
15.8	(9.9)	1.4	(0.9)	Intersection Lake Shore Blvd. and Nottingham Rd., bear left (east), proceeding on Ohio 283.
21.0	(13.1)	4.2	(3.2)	Intersection of 283 and entrance to Sims Park; turn left (north). There is a church on right, and the drive is just before stoplight (East 232nd St.)
21.3	(13.3)	0.3	(0.2)	Park at Park Office.

**STOP 1. Sims Park**

Sims Park is located in the city of Euclid, east of Cleveland northeast of the Babbitt Road intersection, 1.9 km northwest of I-90 in Cuyahoga County, Ohio (East Cleveland Quadrangle) (Fig. 1).

The outcrop is a lake bluff 160 m northwest of the parking lot and 300 m west of the pier. This outcrop consists of several lithofacies of Ashtabula Till overlying weathered Devonian shale. At the base of the bluff is a hard, dense, gray diamict referred to as the "Coastal till" by White (1980). Does this diamict belong to the lithofacies sequence above it or does it represent a separate glaciation?

Section Description	
Quaternary System	
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Ashtabula Till	
Depth (m)	
0.00 – 0.30	10 YR 4/1, dark gray, friable, leached soil, having crumb structure.
0.30 – 1.63	10 YR 6/1, gray, friable, gritty, clayey, silty, leached till (Dmm). 10 YR 5/8, yellowish brown, mottles. Convoluted lower contact.
1.63 – 2.00	10 YR 4/3, dark brown, blocky, unleached till (Dms). Vertical jointing prominent. 10 YR 5/1, gray, manganese stains present along joints. Weak shale granule and pebble bands. Dolostone cobbles.
2.00 – 4.70	10 YR 4/1, dark gray, blocky, unleached till (Dmm). 10 YR 5/3, brown, mottles concentrated along joints. Gray shale granule and pebble abundances increase downward. Diffuse lower contact.
4.70 – 5.50	5 Y 4/2, olive gray, firm to plastic, slightly platy, silty, unleached till (Dms(r)) containing few pebbles and granules. Silt partings and feather fractures impart weak laminations. 7.5 R 5/6, red, clayey, calcareous, mottles, laminations, and streaks.
5.50 – 6.17	5 Y 4/2, olive gray, firm to plastic, silty, clayey, unleached till (Dms(r)), having 2.5 Y 4/4, olive brown, mottles. Granule and pebble abundances increase downwards. Diffuse lower contact.
6.17 – 6.78	5 Y 4/1, dark gray, firm, slightly plastic to brittle, blocky, massive unleached till.
6.78	Erosional contact on light gray (blue) shale bedrock.

### Field and Laboratory Data

Five lithofacies of Ashtabula Till crop out on the bluff (Fig. 3). The upper lithofacies sequence (about 5.0 m thick) contains a dark gray, blocky, silty, predominantly massive diamict (Dmm) leached to 1.6-m depth, and is capped by 0.3 m of soil (Fig. 3). From 1.6 to 2.0 m depth is a wedge or lens of stratified diamict (Dms). This has a convoluted upper contact and diffuse lower contact, and contains weak bands of shale granules and pebbles. The oxidized color of the stratified diamict (Dms), whose matrix contains more clay and less sand than the massive diamict (Dmm), is dark brown. Vertical joints are most prominent in the stratified diamict (Dms), but are continuous throughout the section. Weathering has proceeded along the joints, staining the fracture surfaces with manganese and iron. Brown mottles occur just above and below the stratified diamict (Dms), and are abundant near fractures.

The unweathered matrix averages 17% sand, 51% silt, and 32% clay. Below the leached zone, the average carbonate content of the <0.074-mm fraction is 3% calcite and 6% dolomite. The mean quartz-feldspar ratio (Q/F) of the fine sand fraction is 2.1; the coarse sand fraction averages 11% carbonate, 29% shale, 49% sandstone, and 8% crystallines, in addition to abundant gypsum crystals around the 4.0-m depth. The mean DI of the <2- $\mu$  fraction is 2.4. Predominant clay minerals are illite, chlorite, and kaolinite. Lepidocrocite is present to about a depth of 1.0 m, and vermiculite was identified in the weathered zone.

Resedimented, stratified diamict (Dms(r)) is about 1.5-m thick (Fig. 3), and is olive gray, blocky, firm to plastic, unleached, and underlies the upper sequence. Silt-partings and feather fractures impart weak laminations. Calcareous, red, clayey diamict forms blebs, streaks, and mottles. The lithofacies has a mean matrix texture of 5% sand, 54% silt, and 41% clay. Average carbonate content of the <0.074-mm fraction is 3% calcite and 6% dolomite. The mean quartz-feldspar ratio of the fine sand fraction is 2.1; the mean DI of the <2- $\mu$  fraction is 2.1. The coarse sand fraction averages 14% carbonate, 30% shale, 31% sandstone, 9% crystallines, and 16% gypsum crystals; major clay minerals are illite, chlorite and kaolinite. The basal contact is diffuse, and red laminae and streaks coalesce to form thin red beds about 12.0 m west of the section. The lower contact of this lithofacies rises up the exposure westward. About 30.0 m west of the section, the massive, sheared diamict (Dmm(s)) is about 2.0 m thicker. A sand lens, underlain by diamict interbedded with an undulatory rubbly layer, is exposed about 1.0 m below the contact at this location.

The lowermost lithofacies (Fig. 3) is a massive sheared diamict (Dmm(s)) 0.6-m thick, having an erosional lower contact on the shale bedrock. The massive diamict is dark gray, blocky, plastic to brittle, and contains feather fractures. Gray shale granules, pebbles, and cobbles are abundant throughout, and also occur concentrated in gravelly, matrix-supported lenses near the lower contact. Orientation of these lenses appears to be north-south. Matrix texture of the lithofacies averages 29% sand, 39% silt, and 32% clay. Mean carbonate averages of the <0.074 mm fraction is 3% calcite and 6% dolomite. The Q/F ratios of the fine sand fraction average 2.1; the DI of the <2- $\mu$  fraction is 1.5. The coarse sand fraction averages 9% carbonate, 45% shale, 38% sandstone, and 7% crystallines. The major clay minerals are illite, chlorite, and kaolinite.

### Discussion

Variations among lithofacies at this outcrop generally are minor. Although textures vary among lithofacies, carbonate contents of the <0.074-mm fraction, Q/Fs, and crystalline contents are nearly equal. There is some variation among percentages of sandstone, shale, and carbonates in the coarse sand fraction. The lowermost lithofacies or "Coastal till" may represent a lodgement till derived from eroded local Devonian shale. The remaining lithofacies are brown in color and may represent the englacial load of the Ashtabula ice. Numerous cobbles and pebbles of Ordovician Grimsby Formation are found in the lithofacies and along the beach. The Grimsby Formation has a higher illite content than the Devonian shale, and may also be responsible for the red color and carbonate content of the Ashtabula Till.

21.6	(13.5)	0.3	(0.2)	Return on Park Rd. to Ohio 283 (Lake Shore Blvd.); turn right (west).
22.2	(13.9)	0.6	(0.4)	Intersection 283/East 222nd St./Babbitt Rd. Turn left and bear left (southeast) onto Babbitt Rd.
24.2	(15.1)	2.0	(1.2)	Intersection Babbitt Rd./I-90/Ohio 2/Lakeland Blvd. Proceed under overpass; turn left (east) onto South Lakeland Blvd. (free-way access road); move to left lane.

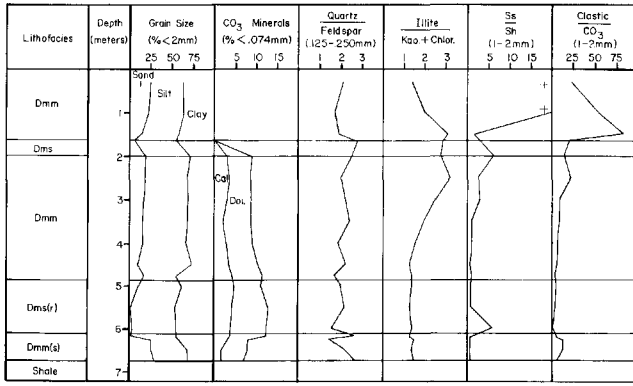


FIGURE 3. Laboratory analyses of lithofacies of the Ashtabula Till at stop 1, Sims Park, eastern Cuyahoga County.

- 24.8 (15.5) 0.6 (0.4) Entrance to I-90/Ohio 2, east; move to left lanes.
- 25.8 (16.1) 1.0 (0.6) Junction I-90 east and Ohio 2 east; move to left lanes and stay on Ohio 2 (east).
- 46.9 (29.3) 21.1 (13.2) Junction Ohio 2 and Ohio 44 north. Exit Ohio 2 to right. Turn left (north) onto Ohio 44.
- 51.0 (31.9) 4.1 (2.6) Intersection of Ohio 44 and Ohio 283 (entrance to Mentor Headlands State Park); stay on Ohio 44 (north) into park; bear right on park road.

**STOP 2. Headlands Beach State Park.**

Headlands Beach is located north-northwest of Painesville at the mouth of the Grand River (Fig. 1).

The buildup of the beach dune complex largely results from man-made harbor structures, whereas the present location of the river mouth is due to bluff erosion. Erosion of the lakeshore led to the interception of a meander bend of the ancestral Grand River that formerly flowed west along the topographic depression now known as Mentor Marsh. The following description of Headlands Beach is from Carter et al. (1981).

Plants found in the dunes include several Atlantic Coastal Plain species (sea rocket, beach pea, seaside spurge, beach grass, and purple sand grass), some unusual northeast Ohio plants (switchgrass, Canada wild rye, wafer ash, and wild bean), and many western plants (winged pigweed, clammy weed, sand dropseed, and four-o'clock). Switchgrass and beach grass are important in dune development, because once established on the upper beach, they "trap" wind-blown sand. Willows, cottonwoods, grape, and poison ivy colonize the established dunes. The Perry Nuclear Power Plant lies about 12 km to the east.

Jetties were constructed at the mouth of the Grand River in 1825. By 1876 the jetties had been extended, so that the west jetty was over 600 m long and the east jetty was 530 m long. In the early 1900s breakwaters were constructed. The west breakwater, which lies normal to and is attached to the shore, has a length of about 1.2 km; the east breakwater, which is parallel to shore, has a length of about 2.1 km. These structures have trapped about 110,000 m<sup>3</sup> per yr of sand from the net west-to-east longshore system (Bajorunas 1961). In doing so, they have had a marked effect on sand transport and deposi-

tion. The orientation of the shoreline west of the structures has changed from nearly east-west in 1825 to northeast-southwest in 1975; the orientation of the shoreline east of the structures has stayed about the same. A comparison of beach widths in 1876 and in 1968 (lake level was about 0.5 m higher in 1876) shows that beach widths have increased for about 1.5 km to the west of the structures and have decreased for at least 6 km to the east of the structures. The change is most marked adjacent to the west jetty-breakwater, where the shoreline has advanced lakeward about 600 m since 1825. A comparison of shore recession rates between 1876-1937 and 1937-1973 shows a decrease in recession rates for about 1.2 km west of the structures (the east breakwater has helped protect this stretch of shore), and then a marked increase (2-4 times the long term (1876-1873) rate along this reach) in the rates for the next 3.2 km to the east. In general, the increased beach width to the west of the structures has led to a decrease in wave energy reaching the shore west of the structures. The decreased beach width to the east of the structures has led to an increase in wave energy reaching the shore east of the structures.

- 53.0 (33.1) 2.0 (1.6) Return to intersection of Ohio 44 and Ohio 283 by Park Rd. Turn left (east) onto 283 (will turn south).
- 54.4 (34.0) 1.4 (0.9) Turn left, staying on Ohio 283.
- 54.6 (34.1) 0.2 (0.1) Turn right; staying on Ohio 283, heading southeast.
- 55.7 (34.8) 1.1 (0.7) Intersection of Ohio 283 and Newell St.; bear left, following Ohio 283 (southeast).
- 56.6 (35.4) 0.9 (0.6) Intersection of Ohio 283/Ohio 535/Skinner Ave. Turn right, staying on 283.
- 57.0 (35.6) 0.4 (0.2) Junction Ohio 283 and Ohio 2. Proceed under overpass; turn left on entrance to Ohio 2 (east).
- 63.4 (39.6) 6.4 (4.0) Ohio 2 merges into U.S. 20. Ohio 2 ends. Proceed east on U.S. 20.
- 67.8 (42.4) 4.4 (2.8) Intersection of U.S. 20 and Middle Ridge Rd.; bear left, staying on 20 (east).
- 72.8 (45.5) 5.0 (3.1) Intersection of U.S. 20 and McMackin Rd.; turn left (north).
- 75.5 (47.2) 2.7 (1.7) Intersection of McMackin Rd. and Chapel Rd.; turn right (east).
- 75.8 (47.4) 0.3 (0.2) Entrance to Camp Isaac Jogues. Turn left (north).
- 76.2 (47.6) 0.4 (0.2) Park in parking lot.

**STOP 3. Camp Isaac Jogues.**

Camp Isaac Jogues (Fig. 1) is located 300 m north of Chapel Road and 600 m west of Haines Road in Madison Township, Lake County, Ohio (Madison Quadrangle).

The lake bluff at this stop contains 9.5 m of glacial deltaic sand (Jones 1985) overlying a 6.5-m thick lithofacies sequence of diamicts. Anomalous carbonate contents make correlation with the Ashtabula Till tenuous. Is the lower sheared diamict part of the overlying diamict sequence?

## Description of Diamict in the Lower Part of the Section

## Quaternary System

## Pleistocene Series

## Wisconsinan Stage

## Woodfordian Substage

## Ashtabula Till?

Depth (m)	Description
0.00	Erosional contact with overlying (9.5 m) sand (Sm, St, Sh).
0.00 - 0.75	10 YR 5/1, gray, silty, friable to plastic, unleached diamict (Dms(c)) interbedded with silt.
0.75 - 2.00	10 YR 5/1, gray, silty, friable to plastic, unleached diamict (Dmm(r)), containing silt partings and sand lenses. Abundant calcareous pebbles.
2.00 - 5.30	10 YR 5/1, gray, platy to prismatic, unleached, silty diamict (Dms(r)), (Dmm(s)) containing abundant sand stringers and 5 R 4/2, weak red, blebs. Wavy and convoluted laminations. Gray shale pebbles decrease abundance downwards. Diffuse lower contact.
5.30 - 6.50	10 YR 4/1, dark gray, stony, silty, clayey, plastic, unleached till (Dmm(s)) containing abundant limestone and shale pebbles. Sand content increases downward; till is very hard to dig.
6.50	Beach.

## Field and Laboratory Data on Diamicts

The diamict has not been leached nor oxidized. The upper 0.8 m (Fig. 4) is gray, silty, friable to plastic, current reworked, stratified diamict (Dms(c)) containing sand lenses. These lenses are not found below 1.0 m in the underlying gray, silty, platy, prismatic, massive diamict (Dmm(r)) containing silt partings. Sand content of the matrix is low and decreases down section. From 2.0 to 3.0 m depth (Fig. 4), abundant sand stringers, in addition to the convoluted silt partings and laminations, are contained in the current reworked, stratified diamict (Dms(r)). Sheared massive diamict (Dmm(s)) below 3.0 to 4.0 m in depth (Fig. 4), contains blebs and smears of weak sediment and overlies 1.3 m of resedimented, stratified diamict (Dms(r)). This diamict has a diffuse lower contact with underlying diamict that is extremely difficult to excavate.

Laboratory analyses show that the matrix averages 8% sand, 61% silt, and 31% clay. Mean carbonate content of the <0.074-mm fraction is 3% calcite and 9% dolomite. The coarse sand lithology averages 18% carbonate, 29% shale, 43% sandstone, and 10% crystallines. The average quartz-feldspar ratio of the fine sand fraction is 2.4; the

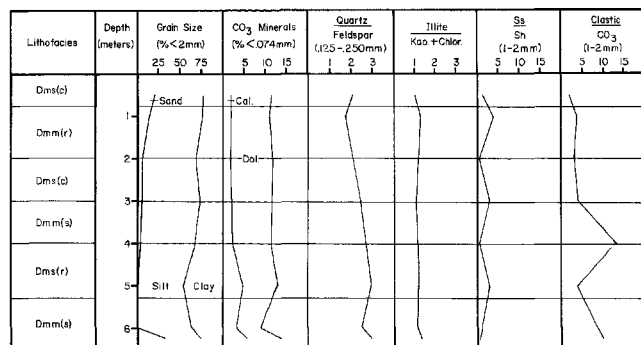


FIGURE 4. Laboratory analyses of lithofacies of the Ashtabula Till at stop 3, Camp Isaac Jogues, eastern Lake County. Section begins at the base of the deltaic sediments (Jones 1985).

mean DI of the clay fraction is 1.2. Illite, chlorite, and kaolinite are the major clay minerals.

Below a depth of 5.3 m is a sheared, massive diamict (Dmm(s)) (Fig. 4). The dark gray diamict is very stony and contains smears of reddish silty clay. Matrix texture is 34% sand, 40% silt, and 26% clay. Quartz-feldspar ratio of the fine sand fraction is 3.0. Carbonate content of the <0.074-mm fraction is 6% calcite and 8% dolomite. The coarse sand lithology contains 9% carbonate, 50% shale, 36% sandstone, and 5% crystallines. The smears of reddish silty clay contain 3% calcite and 6% dolomite; the quartz-feldspar ratio is 2.5. The individual DIs for the matrix and incorporated reddish silty clay are 1.4 and 1.2, respectively. Illite, chlorite, and kaolinite are found in this lithofacies.

## Discussion of Diamicts

The mineralogy of the diamicts of this section is anomalous when compared to other sections along the lakeshore. The carbonate contents of the <0.074-mm fraction and those of the coarse sand fractions are higher than those at other sections. Dolomite percentages are higher than the 6% average for most sections. Quartz-feldspar ratios also are higher in this area. The DIs in these units are most consistent with those of Devonian shales. The carbonate content of the reddish blebs of silty clay is similar to that of the Ashtabula Till along the lake shore.

## Description of Overlying Deltaic Sands

There are four principal facies in this lenticular exposure measured by Jones (1985). They are interbedded sand and clay, rippled and laminated sand, scour-fill sand, and trough cross-bedded sand.

The interbedded sand and clay consist of laterally continuous laminations and very thin beds of thinly laminated clay intercalated with thin beds and lenses of fine, ripple laminated sand. The contacts between the beds are sharp, with the overlying sand commonly eroded into the clay.

The ripple and laminated sand consists of fine- to medium-grained asymmetric ripples interbedded with fine-grained horizontal to subhorizontal laminations. Sparsely distributed flasers occur in the ripple sand that has ripple spacings from 5-10 cm in the fine sand and 10-15 cm in the medium sand. Paleoflows are to the east.

The scour-fill sand consists of medium- to coarse-grained laminated sand that fills solitary troughs. The laminations parallel the bounding surfaces of the scours cut into underlying facies. The scour-fills have a mean thickness of about 15 cm and are laterally continuous for 20-30 m. Paleoflows of these fills are to the north.

The trough cross-bedded sand facies consists of coarse-grained sets, 15-20 cm thick and 1-2 m in length. Paleoflows are to the northwest and northeast.

The vertical sequence (Fig. 5) consists of the basal interbedded sand and clay that overlies the diamict. Above this facies is the rippled and laminated sand facies that is eroded in places by the scour-fill facies. Capping the sequence with an erosional base is the trough cross-bedded facies.

## Discussion of Deltaic Sands

This sequence is characterized by an overall increase in grain size from the base up, as well as by an apparent

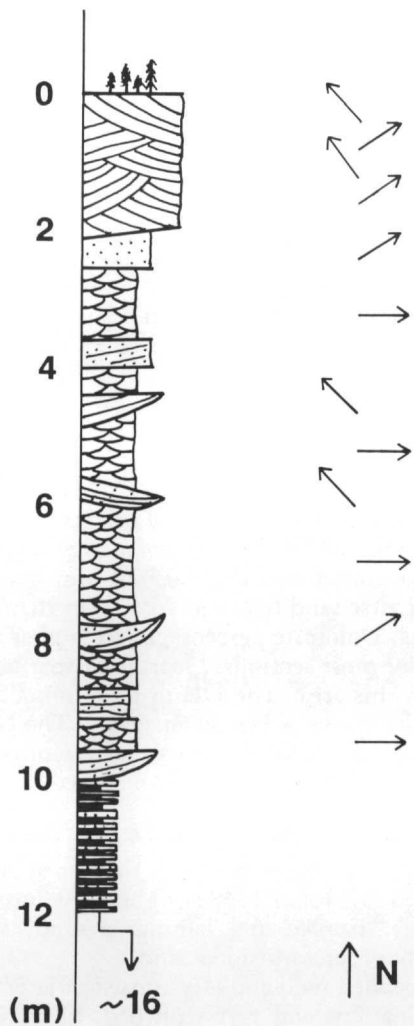


FIGURE 5. Sequence of deposits overlying diamicts at Camp Isaac Jogues, showing facies, upward coarsening, and paleoflow directions.

increase in flow strength from the low flow strength ripples to the moderate strength troughs. The interbedded sand and clay (rhythmites?) indicate tranquil intervals of vertical accretion separated by turbulent intervals of lateral accretion. The scour-fill sands indicate episodic intervals of cut and fill into the interbedded ripple and laminated sand.

This exposure, like several others along the northern Ohio shore, has an erosional, concave-up basal contact and a lenticular shape (Carter 1976, Carter and Guy 1983). Moreover, the extension of this deposit inland with water well records indicates a trough-shaped sand body that trends east-west and whose axis dips to the west (Fig. 6).

The geometry of the deposit and the facies sequence strongly imply a river-dominated deltaic system. The interbedded sand and clay are interpreted as prodelta rhythmites; the rippled and laminated sands are interpreted as delta front current deposits. The trough sets in the upper part of the sequence may represent distributary channel deposits. If this interpretation is correct, cedar wood from the top of the interbedded sand and clay facies was dated by the Illinois Geological Survey, (ISGS 1326 and 1329) at about 13.7 ka, and indicates a marked drop in lake level from the level of Lake Maumee.

76.5	(47.8)	0.3	(0.2)	Return to Chapel Rd. by camp driveway; turn right (west).
76.8	(48.0)	0.3	(0.2)	Intersection of Chapel Rd. and McMackin Rd., turn left (south).
79.5	(49.7)	2.7	(1.7)	Intersection on McMackin Rd. and U.S. 20; turn right (west).
81.4	(50.9)	1.9	(1.2)	Sand pit north of U.S. 20, before intersection of Antioch Rd.; turn right (north).
81.6	(51.0)	0.2	(0.1)	Park.

#### STOP 4. Keeney Pit.

This pit is located in the north side of U.S. 20 about 300 m east of Antioch Road in Perry Township, Lake County, Ohio (Fig. 1; Madison Quadrangle).

A fine sand and an underlying coarse sand and gravel are mined from this pit which lies at the Warren level.

#### Description

There are three principal facies exposed in the pit area. They are laminated sand and granule, tabular cross-bedded sand and granule-pebble, and a trough cross-bedded sand.

The laminated sand and granules consist of gently dipping ( $3-5^\circ$ ) laminations and very thin beds. The laminations dip to the southwest.

The tabular cross-bedded sand and granule-pebble consist of thin to thick beds of tabular to wedge-shaped sets. Contacts are sharp between the sets. Internally, the coarsest sediment is concentrated at the base of the sets although a thin, laminated sand layer commonly makes up the base of the sets. Paleoflows are to the south.

The trough cross-bedded sand consists of fine, well-sorted sand that makes up gently inclined, curved laminations in 5-15 cm thick zones. The laminations commonly thicken downdip and appear to exhibit normal grading in places. Paleoflow measured from one set is to the northeast.

The vertical sequence (Fig. 7) consists of laminated sand and granules capped by tabular cross-bedded sand, and granule-pebble with a sharp, erosional contact. The tabular cross-bedded facies is in turn capped by trough cross-bedded sand with a sharp, curved contact between them.

#### Discussion

There are at least two viable hypotheses for the coarse-grained facies: outwash plain or coastal barrier. The laminated sands may represent deposition from low bar forms in outwash channels, or alternately, from sheetflow during washover and/or in channels cut through coastal barriers. The tabular cross-beds represent deposition from migrating sand waves associated with outwash channels or, alternately, with washover fans associated with coastal barriers. The southerly paleoflows pose a source area problem for the outwash as the glacier is interpreted to have retreated beyond the Erie Basin before these sediments were deposited. The trough cross-bedded sand is interpreted as an eolian deposit, an interpretation consistent with either outwash plain or coastal setting. If related to a coast, a drop in water level would expose sediment to the wind, with subsequent flow contraction and acceleration against the slope to entrain the sand. Flow expansion and deceleration at the slope break would

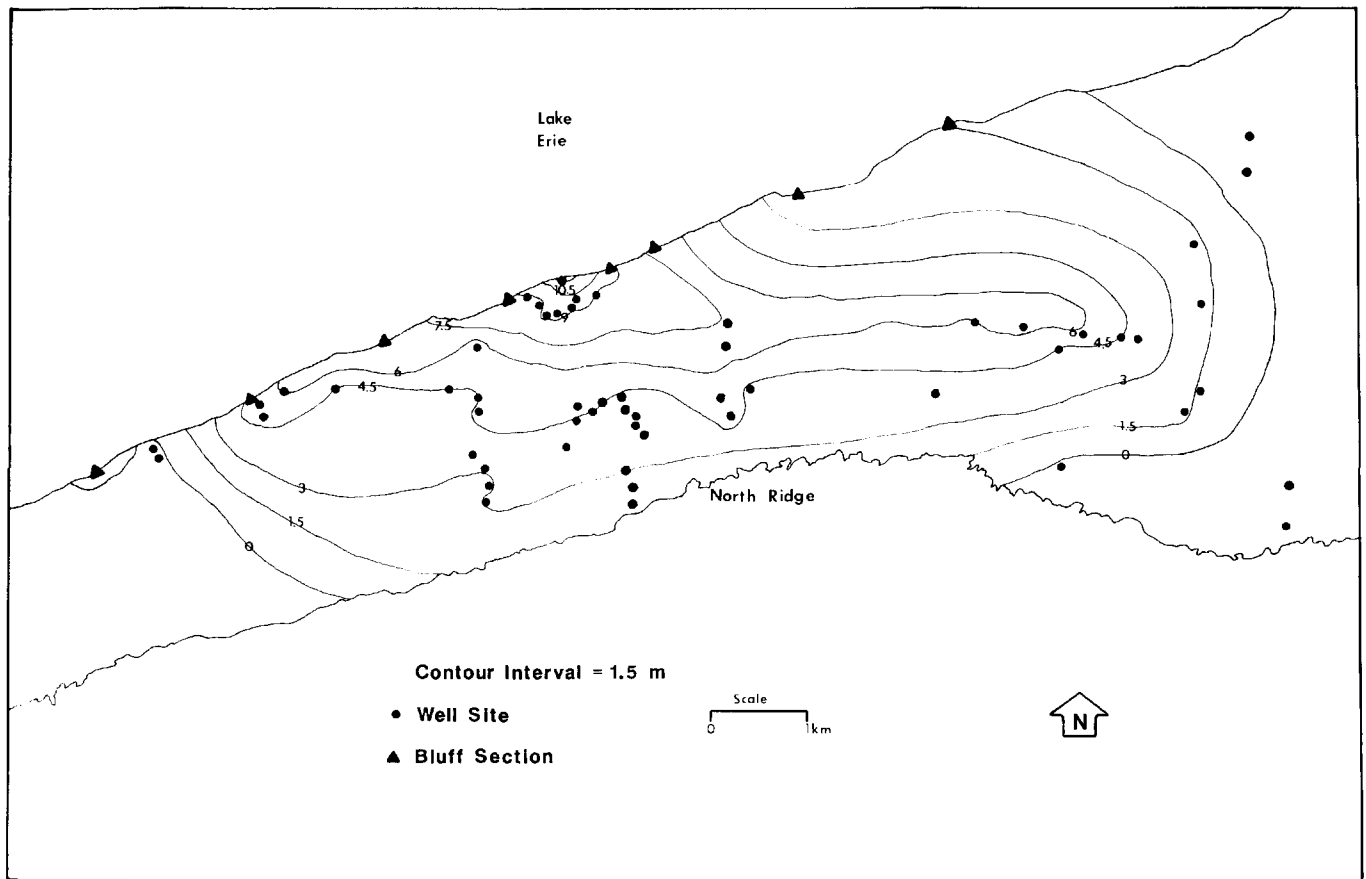


FIGURE 6. Sand isopach of the deposit overlying diamicts exposed at Camp Isaac Jogues (Jones 1985).

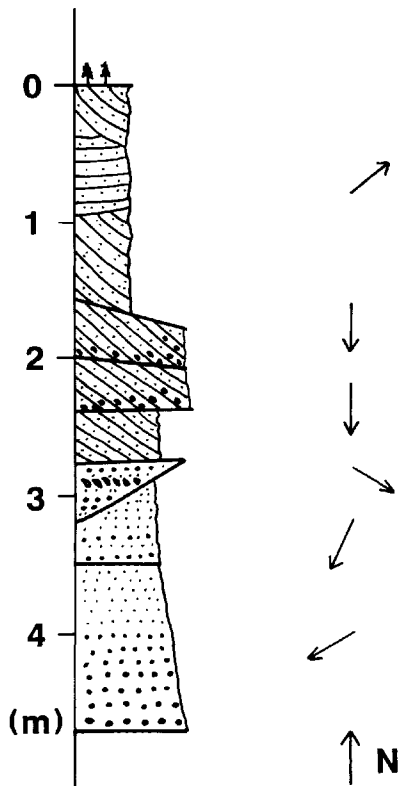


FIGURE 7. Keeney Pit sequence showing facies and paleoflow directions.

then lead to grainfall and subsequent avalanching at the top of the slope.

81.8	(51.1)	0.2	(0.1)	Return to U.S. 20, turn left (east).
82.7	(51.7)	0.9	(0.6)	Intersection of U.S. 20 and Townline Rd.; turn right (south).
83.7	(52.3)	1.0	(0.6)	Intersection of Townline Rd. and Middle Ridge Rd.; turn right (west).
84.6	(52.9)	0.9	(0.6)	Sand pit north of Middle Ridge Rd., turn right (north).

**STOP 5. Osborne Pit.**

This pit is located on the south side of U.S. 20, about 1 km directly south of the Keeney Pit (Stop 4).

A coarse sand and gravel are mined from this pit which lies at the Arkona level.

**Description**

The facies exposed in this pit are similar to those exposed in the Keeney Pit with two exceptions: a 10-cm-thick, pebbly blue-brown clay is exposed at the base of the pit; and the trough cross-bedded sand is missing above the tabular, cross-bedded facies. A 1.5-m-thick zone of laminated sand and granule/pebble overlies the clay. This laminated zone is in turn overlain by a 1.2-m zone of tabular cross-beds made up of sand and gravel clasts. The top of this zone is turbated in places (cryoturbation?). Paleoflows are to the south-southeast in the laminated facies and to the southwest in the cross-bedded facies.



### Discussion

The facies/facies sequences are fairly uniform around the perimeter of this 1.5-km<sup>2</sup> pit. The major difference is in the laminated zone that is replaced by tabular sets in places. In contrast to the Keeney Pit, the sediment is more poorly sorted and more clay-rich with coarse-grained, almost paraconglomerates making up the thick tabular sets in places. This characteristic is indicative of rapid deposition from relatively high strength flows. A question that might be raised is whether or not the Warren and Arkona levels are indeed genetically separate, or have they evolved at about the same time from the same depositional system (i.e., an outwash plain or a coastal barrier)? A log dated by the Illinois Geological Survey (ISG-1480) at about 13.4 ka was found at this level about 1 km to the south of the Osborne Pit.

85.0	(53.1)	0.4	(0.1)	Return to Middle Ridge Rd.; turn right (west).
87.8	(54.9)	2.8	(1.8)	Intersection of Middle Ridge Rd. and U.S. 20; bear left (west) onto 20.
92.0	(57.5)	4.2	(2.6)	Junction U.S. 20 and Ohio 2 west; merge onto Ohio 2.
117.0	(73.1)	25.0	(15.6)	Junction Ohio 2 and I-90; move to left lane. Exit to left onto I-90 east; move to middle lane.

### Road Log Back to Akron

As we follow I-90 west, we are on an upland overlain by Late Wisconsinan tills. We will follow I-271 southward across Cuyahoga County into Summit County. Where I-271 crosses Ohio 14 (Broadway Ave.), Late Wisconsinan kames overlie lacustrine deposits and shales. Many landfills are developed in the impermeable material, and the odor of leachate accompanies a southeast wind. Near the intersection with I-480, I-271 is built on Mississippian shales. High knolls are underlain by Pennsylvanian sandstones. At the intersection of I-271 and Ohio 8, a large buried valley fill consisting of Late Wisconsinan outwash overlain by lacustrine deposits serves as a local aquifer. This will be on our left side (east) as we follow Ohio 8 back to Akron. The valley fill also contains several large kettle lakes that eventually drain into the Cuyahoga River. At the intersection of Ohio 303, the Cuyahoga Valley is 5 km to the right (west). South of this point we cross the Summit County morainic complex. The valley of the Little Cuyahoga River, which is the ancestral valley of the Cuyahoga River, is beneath the Y-bridge just north of downtown Akron.

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