U. S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

2ND ANNUAL

LAKE ERIE COASTAL EROSION STUDY WORKSHOP

February 2-4, 1994

USGS Center for Coastal Geology

St. Petersburg, FL

Edited by

David W. Folger

Open File Report 94-200

This report is preliminary and has not been reviewed for conformity with U. S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

April 1994

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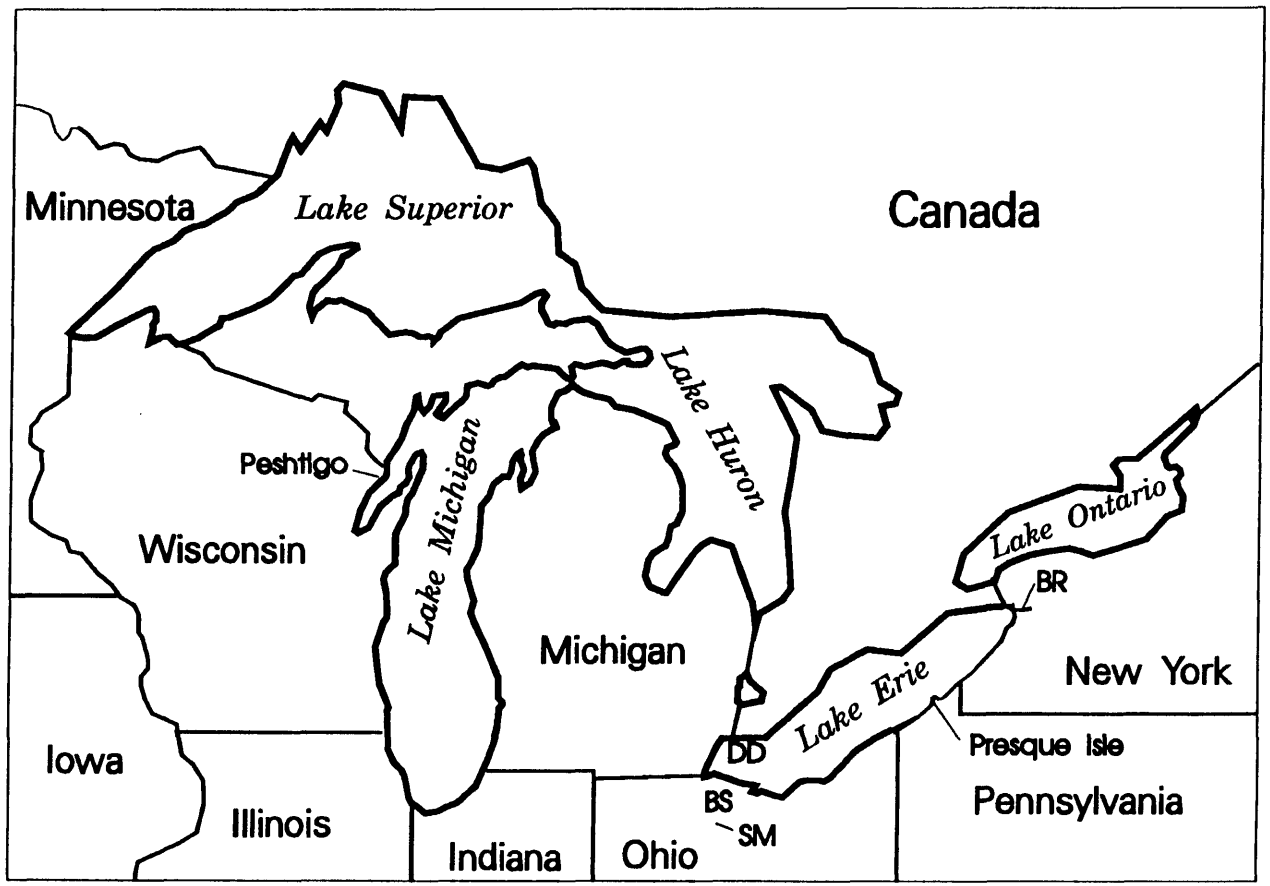
FIGURES

APPENDIX



BS - Black Swamp; SM - Springville Marsh; DD - Detroit Delta; BR - Buffalo River

Fig. 1a

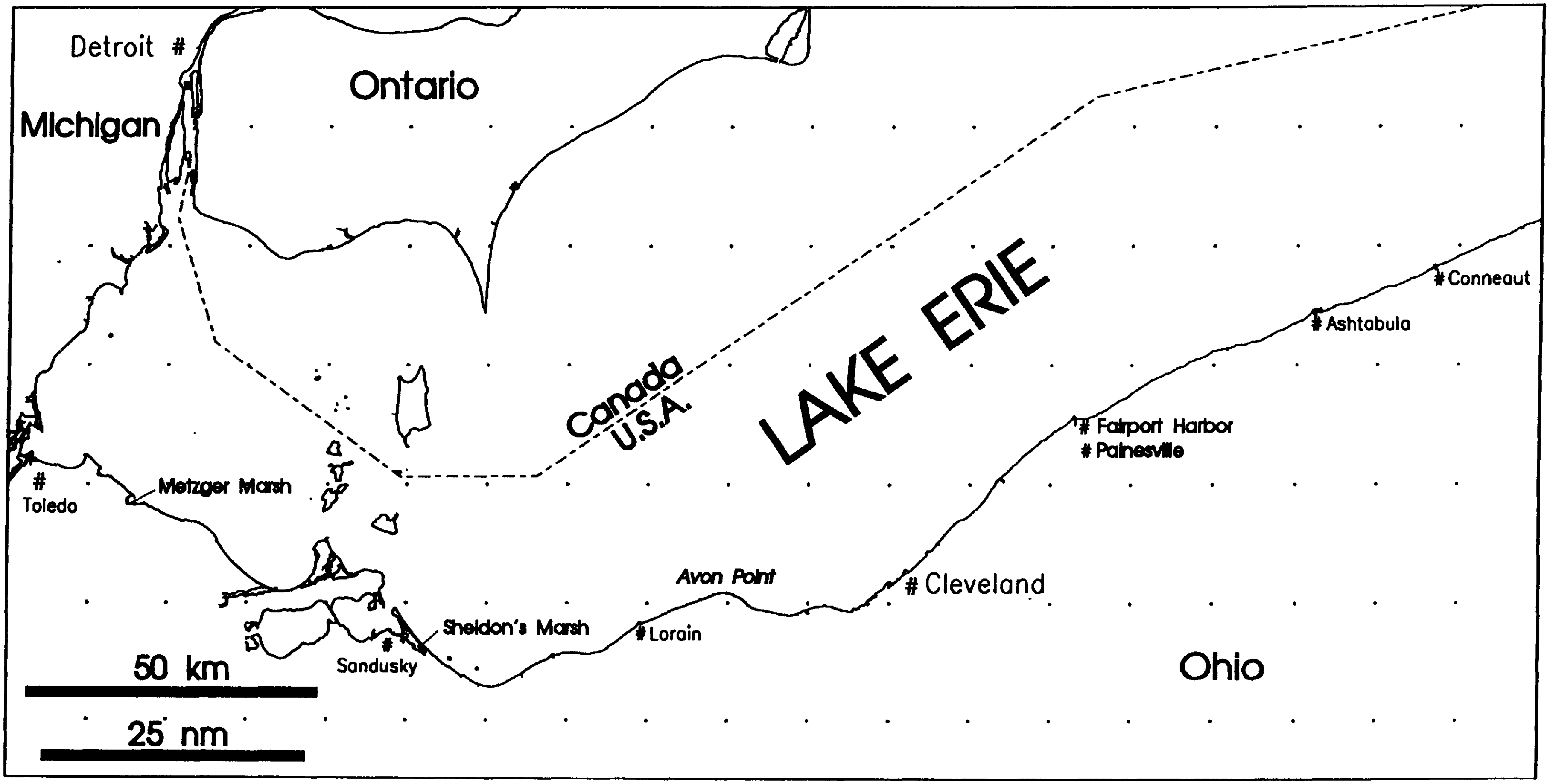

Detroit #
Michigan
Ontario
Toledo
Metzger Marsh
Canada
U.S.A.
LAKE ERIE
Sheldon's Marsh
Sandusky
Lorain
Avon Point
Cleveland
Fairport Harbor
Painesville
Ashtabula
Conneaut
Ohio
50 km
25 nm

Fig. 1b

INTRODUCTION

The Lake Erie Coastal Erosion Study, a cooperative between the Ohio Geological Survey and the U.S. Geological Survey, was initiated in FY 1991 to document the rates of retreat along the Ohio shoreline, map the nearshore geology, and assess some of the processes responsible for the retreat.

Participants have included Scudder Mackey, Donald Guy, Jonathan Fuller, and Richard Pavey of the Ohio Geological Survey and John Haines, Robert Oldale, Peter Barnes, Byron Stone, Ronald Circe, and Gerald Shideler of the USGS. In October of 1993 Steven Colman, David Folger, and David Foster of USGS joined the team.

Field work for the study is about 50% complete. The majority of the remaining work will be carried out in the summer of 1994.

Evaluation and compilation of data already acquired will be completed during 1994-95. This work includes: 1) Quantity and fate of sediments in the coastal ice along the Ohio Lake Erie coast, 1993 and 1994 (Barnes, McCormick, & Guy); 2) The distribution of surficial sediments in Lake Erie's western basin (Circe and Fuller); 3) Surficial bottom sediment distribution between Sandusky and Conneaut, Ohio (Foster); 4) Offshore geology of the Ohio part of Lake Erie interpeted from high-resolution seismic reflection profiles (Fuller and others); 5) Video monitoring of a bluffed coast, Ohio (Haines, Holman, & Townsley); 6) Comparison of long- and short-term recession rates along Ohio's central basin shore of Lake

Erie (Mackey and Guy); 7) Geologic framework and restoration of an eroded Lake Erie coastal marsh-Metzger Marsh, Ohio (Mackey and Guy); 8) Till lithostratigraphy, bluff morphology, and erosion rates in the Lake Erie coastal zone of Ohio (Pavey, Stone, and Prosser); 9) Mapping and CD-ROM shore course (Polloni); 10) Potential for wetland expansion in the Lake Erie basin following lacustrine regressions (Robbins); 11) Bedrock surface topography and Quaternary stratigraphy in the western Lake Erie coastal zone, Northwestern Ohio and southeastern Michigan (Stone & Shideler); 12) Geologic studies of coastal wetlands processes (Williams).

The format for presentation and publication of the final collection of papers will be determined at the February, 1995 Workshop in St. Petersburg.

AGENDA

2nd ANNUAL WORKSHOP

LAKE ERIE COASTAL EROSION STUDY

USGS CENTER FOR COASTAL GEOLOGY

St. Petersburg, FL

February 2-4, 1994

Purpose: To review and integrate all aspects of the study

WEDNESDAY

February 2, 1994

Introductory Comments

0830	Status of USGS coastal studies	Abby Sallenger
0845	Agenda for the workshop	Dave Folger

Review of Work Accomplished

GEOLOGIC FRAMEWORK

0900	Introduction	John Haines & Scudder Mackey
0930	Seismic Data Analysis	Jonathan Fuller & Robert Oldale
1000	Coffee Break	
1015	Sidescan Sonar Analysis	Ronald Circe & David Foster
1045	Nearshore Mapping	Byron Stone & Jerry Shideler
1115	Discussion	
1200	Lunch	
1300	Nearshore land geology	Byron Stone & Richard Pavey

PROCESSES

1330	Introduction	John Haines
1400	Rates and processes of bluff retreat	Scudder Mackey & Donald Guy
1430	Discussion	
1500	Coffee	
1515	Video monitoring of shoreline and ice features	John Haines
1545	Coastal ice regime and its impact on coastal erosion	Peter Barnes
1615	Lake Erie sediment budget	Scudder Mackey
1645	Discussion	
1715	Adjourn	

THURSDAY

February 3, 1994

LACUSTRINE STRATIGRAPHY

0830	A prospectus	Steven Colman

COASTAL WETLANDS RESEARCH PROGRAM

0900	Introduction	Jeffress Williams
0915	Metzger Marsh	Scudder Mackey
0945	Lower lake levels and transgressing wetlands	Eleanora Robbins
1015	Coffee	
1030	Discussion	
1200	Lunch	

SUMMARY

1300	Summary of work completed	Scudder Mackey & John Haines
1330	Objectives for 1994-95	John Haines & Scudder Mackey
1400	Schedule for completion of study elements	David Folger
1430	Plan for integration and publication of papers	David Folger
1500	Coffee	
1515	Discussion	
1700	Adjourn	

FRIDAY

February 4, 1994

MAPPING & CD ROM SHORT COURSE
(Optional)

0830-1200

C. Polloni

ABSTRACTS

QUANTITY AND FATE OF SEDIMENTS IN THE COASTAL ICE ALONG THE OHIO LAKE ERIE COAST, 1993 AND 1994

Peter Barnes[1], Michael McCormick[1], and Donald Guy, Jr.[2]
[1]U.S. Geological Survey, Menlo Park, CA 94025; [2]Lake Erie Geology Group, Ohio Division of Geological Survey,
1634 Sycamore Line, Sandusky, Ohio 44870-4132

In February, 1993, the midwinter Lake Erie coastal ice complex was composed of the shoreface ice foot and a single ice ridge about one meter in height. Offshore ice extended to the horizon and typically consisted of large ice plates or sheets of ice 1-15 cm thick formed during calm conditions and smaller quantities of wave-formed brash and pancake ice. Ice samples from 11 locations along with daily photographs at 5 sites indicate that each meter of coastal ice out to 200 m carried an average sediment load of 45.6 kg. About two thirds of the sediment load (30 kg/m of coast) occurs in the grounded icefoot and one third (16 kg/m of coast) occurs in the floating offshore ice. Daily photographs show that most of the grounded ice gradually melted in place, while the advected ice melts offshore leading to a loss of sediment from the littoral zone.

A 1977 study of Lake Erie coastal erosion found an average loss of 4800 kg/m/yr of sand and gravel. Ice rafting in 1993 was less than 1% of that value. Photographic monitoring indicates that initial breakup started at the end of March, 1993, and ice was absent from the coast by April 16. Ice-generated beach relief of 10-20 cm was

smoothed by waves within a day of ice disappearance. These observations suggest that the winter ice canopy was only a minor factor affecting Lake Erie coastal erosion during the winter of 1993.

Preliminary observations for the winter of 1994 suggest a much more vigorous ice interaction with the coast. Beach freezing and anchor-ice formation were first observed on December 22, 1993, and a larger, sediment-laden, coastal ice complex had developed by the end of the month, more than a month earlier than in 1993. Storms with southerly winds, and lingering heat in the lake, resulted in destruction, reworking, and partial removal of coastal ice several times since it first formed in December, 1993. Anchor ice containing sediment was observed at the 8 sites studied in detail. Ice will continue to be active in incorporating and removing sediment from the coast until wave action is eliminated by the formation of a stable offshore ice sheet. We expect the potential influence of ice on coastal erosion to be significantly higher in 1994.

THE DISTRIBUTION OF SURFICIAL SEDIMENTS IN LAKE ERIE'S WESTERN BASIN

Circe, R. C.[1] and Fuller, J.A.[2]

[1]U.S. Geological Survey, Reston, VA 22092
[2]Lake Erie Geology Group
Ohio Division of Geological Survey
1634 Sycamore Line, Sandusky, Ohio 44870-4132

Data, collected along 324 km of trackline with a 100 kHz sidescan-sonar system, were analyzed to characterize the surficial sediment distribution of Ohio's portion of the Western Basin of Lake Erie. Results were combined with a bottom sediment map previously compiled from sample data by the Ohio Geological Survey. These two data sets show that mud is the most widespread surficial sediment with smaller areas of sand, muddy-sand, and gravel in shallower waters of the basin. Bedrock, primarily limestone, crops out only rarely in the open basin.

The basin bottom, which is generally less than 10 m deep, is shallower than wave base during major storms and is also widely scarred by what are believed to be ice scour marks. The shallowness of the basin and these scour marks imply that bottom sediment is frequently resuspended. However, the relative roles of ice scour and wave activity in the resuspension and dispersion of sediment have yet to be assessed.

PRELIMINARY MAPPING OF LAKE ERIE BOTTOM SEDIMENTS BETWEEN SANDUSKY AND CONNEAUT, OHIO BASED ON SIDESCAN SONAR IMAGERY

David S. Foster, U.S. Geological Survey, Woods Hole, MA 02543

Based on 1300 line-km of 100 kHz sidescan sonar data collected in Lake Erie by the U.S. Geological Survey and Ohio Geologic Survey, I have begun to map the distribution of bottom sediment based on acoustic backscatter of sidescan sonar records and existing bottom sample data.

Deposits of recent lacustrine fine sand and mud result in low acoustic backscatter and relatively featureless sidescan records. Most of the offshore area of Lake Erie consists of these deposits. Deviations from the low backscatter in lacustrine deposits occur only where linear features that are several hundred meters long and tens of meters wide cross the sidescan records. These features are most distinct and common in water <20m deep. They are similar to those mapped in the western basin of Lake Erie, and may be caused by ice scouring of the lake bed (R. Circe, personal communication). Areas with subcircular rings of high backscatter occur within charted dumping areas. They are similar to those we have observed in Lake Michigan, and attribute to dredge spoil.

Areas of high acoustic backscatter consist of shale, glacial till, or coarse lag deposits derived from the till. Bedding and fractures in the shale give a distinct pattern on the sidescan sonar records. The shale bottom is coincident with a rough lake-floor reflection and the merging of lake-floor and bedrock reflections on 3.5 kHz and boomer seismic profiles. Glacial till or coarse lag deposits on the till cause high acoustic backscatter on the sidescan records but are relatively featureless compared to shale areas. In some areas, lag deposits of coarse sand and gravel form sediment waves (~1 m in wavelength) resulting in ripple patterns on the sidescan records.

Shale crops out close to shore as far offshore as the 10-m isobath east of Cleveland to Conneaut. Shale also crops out at Avon Point west of Cleveland. A large area from Cleveland to Fairpoint Harbor, lakeward to the 20-m isobath, is characterized by high backscatter with patchy areas of low backscatter. I interpret this area of the lake floor to be composed of glacial till and coarse lag deposits over till with a patchy distribution of fine-grained lacustrine deposits.

Mapping the distribution of bedrock, till, and lacustrine deposits in the nearshore provides an important framework for coastal erosion and sediment transport studies. Except for a series of shore-parallel lines close to shore in the eastern part of the study area, not enough data are available to map the nearshore sediment distribution in detail. Additional shore-parallel lines, and shorter shore perpendicular lines are needed. Bottom sampling and video are also needed as ground truth for the interpretation of the sidescan sonar data. Sidescan sonar mosaics, generally 5-10 km^2, should be run close to shore where significant erosion problems or problems related to sediment transport occur. This type of work will require more precise navigation (differential GPS) than has previously been used in the Lake Erie surveys.

OFFSHORE GEOLOGY OF THE OHIO PART OF LAKE ERIE INTERPRETED FROM HIGH-RESOLUTION SEISMIC-REFLECTION PROFILES

Fuller, J.A.[1], Oldale, R.N.[2], Circe, R.C.[3]
Liebenthal, D.L.[1], Parolski, K.E.[2], Nichols, D.R.[2], Cross, V.A.[2]

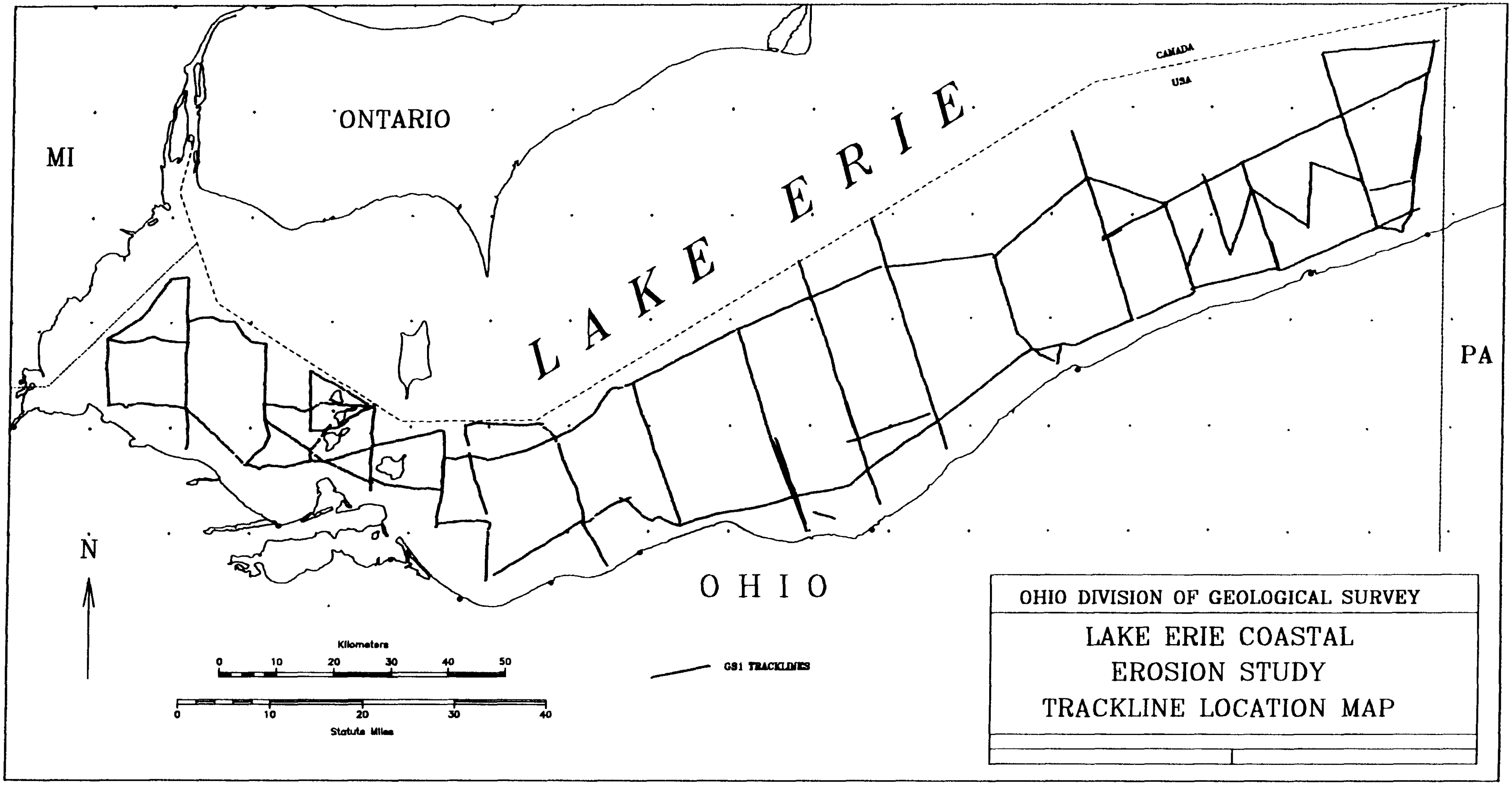
[1]Lake Erie Geology Group,Ohio Division of Geological Survey,1634 Sycamore Line, Sandusky, Ohio 44870-4132; [2]U.S. Geological Survey, Woods Hole, MA 02543; [3]U.S. Geological Survey, Reston, VA 22092

High-resolution seismic-reflection (pinger and boomer) records representing approximately 1300 km of trackline (fig. 1) were interpreted to map the acoustic boundaries inferred to represent the contacts between postglacial lacustrine deposits and glacial deposits, and between the glacial deposits and bedrock. All interpretations were verified wherever possible by comparison with existing cores, borings, or jetted holes. Within 3 kilometers of shore most of the seismic records show both glacial and postglacial deposits pinching out against the rising bedrock surface. Offshore of most major rivers, the glacial deposits and/or bedrock surface appear to have been eroded; presumably this erosion represents preglacial drainage ways and/or down-cutting which took place during lower lake level stands. Lakeward from the shore, the bedrock surface and overlying sediments dip independently toward the centers of the western and central basins.

The shale bedrock surface of the deeper central basin has a relatively smooth surface; in contrast the carbonate bedrock, seen primarily in the western basin, shows as much as 20 m of local relief.

The glacial deposits have, in places, strong internal reflectors which may represent multiple tills. These internal reflectors are most common in areas of thicker glacial deposits of the central basin between Cleveland and Ashtabula. The records also reveal a possible extension of the late Wisconsinan Lake Border Moraine extending at least part way across the lake near Cleveland. The glaciolacustrine deposits are the uppermost Wisconsinan sediments in most places and are represented by both multiple reflectors and acoustically transparent sections on the seismic records.

The last glacier left the Lake Erie basin by way of the Niagara escarpment about 12,600 years before present. The removal of the ice dam and the fact that the eastern basin was an isostatically depressed area resulted in an extreme low stand of the lake. The postglacial lacustrine deposits began to accumulate in the restricted lake area during this low water phase and are associated with a transgression as lake level rose due to isostatic rebound. These postglacial lacustrine deposits are relatively thin throughout most of the study area when compared to the glacial deposits but are thickest in the central part of the basins where sedimentation has been nearly continuous since the melt-back of the glacial ice.



MI
ONTARIO
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Kilometers
0 10 20 30 40 50
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Statute Miles
GS1 TRACKLINES
OHIO DIVISION OF GEOLOGICAL SURVEY
LAKE ERIE COASTAL
EROSION STUDY
TRACKLINE LOCATION MAP

VIDEO MONITORING OF THE SHORELINE NEAR PAINESVILLE, OHIO

Haines, J. W.[1], Holman, R. A.[2], and Townsley, W.[1]

[1] U.S. Geological Survey, 660 4th St. S., St. Petersburg, FL 33701;
[2] College of Oceanography, Oregon State University, Corvallis, OR 97331

Video monitoring of nearshore processes has proved to be a reliable and inexpensive method of acquiring long time series of spatially extensive data. As part of the U.S. Geological Survey and Ohio Geological Survey cooperative we have begun efforts to monitor shoreline position, beach width, and development of the nearshore ice complex along a section of Ohio coast with a high bluff.

Imagery is acquired by a remote field station, digitized on-site, and transferred across commercial phone lines to an archiving site managed by USGS in St. Petersburg. Data acquisition is fully programmable, allowing a variety of sampling schemes including collection of instantaneous (snapshot) and time-lapse imagery.

Analysis of the imagery to date has included the development of algorithms to identify visible features such as the shoreline, bluff toe, and ice edge. Automated detection of these features will support the production of data sets tracking the evolution of the bluff and ice complex. We will demonstrate that algorithms can be written which reliably identify a variety of features. We will also investigate the critical transformation from image coordinates to the desired ground coordinate system.

The utility of this type of data may be greatly enhanced by combining it with other data types, including ground surveys and measurements of sediment transport. We will open a discussion on the future directions of this effort in the context of the Lake Erie study, taking into consideration the potential utility of the data to all interested researchers.

COMPARISON OF LONG- AND SHORT-TERM RECESSION RATES ALONG OHIO'S CENTRAL BASIN SHORE OF LAKE ERIE

Scudder D. Mackey and Donald E. Guy, Jr.

Lake Erie Geology Group, Ohio Division of Geological Survey,
1634 Sycamore Line, Sandusky, Ohio 44870-4132

Recession rates were determined for 213 km of the Lake Erie shore between Conneaut and Sandusky, Ohio (figure 1). Along this stretch, the shore rises 3 to 20 m above lake level and is composed primarily of till or glaciolacustrine silt and clay. Exceptions are the shale-bluffed shore along the central part of the study area and a sand spit in the westernmost part.

Recession rates were determined by comparing the position of bluff lines shown on 1:10,000-scale U.S. Lake Survey charts (circa 1876) and more recent 1:12,000- to1:4800-scale aerial photographs (1930's to 1990). Bluff-line positions from these charts and photographs were transferred to 1:2400-scale enlargements of aerial photographs taken in 1990 using a map-o-graph. Positions of the transferred lines were then digitized along approximately 7000 shore-normal transects spaced 30 m apart (Mackey and Guy, in prep).

Preliminary analysis of rates for two periods 1876/77 to 1973 and 1973 to 1990 reveals several patterns in the data. First, short-term rates are typically higher and show a greater range in values than long-term rates (table 1, figures 2 to 6). Short-term rates range from 0-17.2 m/yr, whereas long-term rates range only from 0-3.8 m/yr (table 1). The higher rates between 1973 and 1990 probably reflect increased erosion during record-high lake levels of 1973 and 1985-1986. Second, the data show a relationship between shore lithology and rates, as might be expected (figure 2). Where the shore is composed of cohesive particulate material, rates are higher and have a greater range of values (figures 3 and 4) than where the shore is composed of shale (figure 5) or where shale crops out in shallow water in the nearshore zone (figure 6). Along the sand spit, rates were either less than 0.3 m/yr or as high at 3.66 m/yr (figure 2). Low rates occurred along the protected stable part of the spit, and high rates occurred along an unprotected unstable part of the spit.

References:

Carter, C.H., Benson, D.J., and Guy, D.E., Jr., 1980, Shore protection structures: effects on recession rates and beaches from the 1870's to the 1970's along the Ohio shore of Lake Erie: Environmental Geology, v. 3, p. 353-362.

Mackey, S.D., and Guy, D.E., Jr., 1994, A different approach to mapping coastal recession -- combining the old with the new: Geological Society of America, North Central Meeting, Kalamazoo, MI.

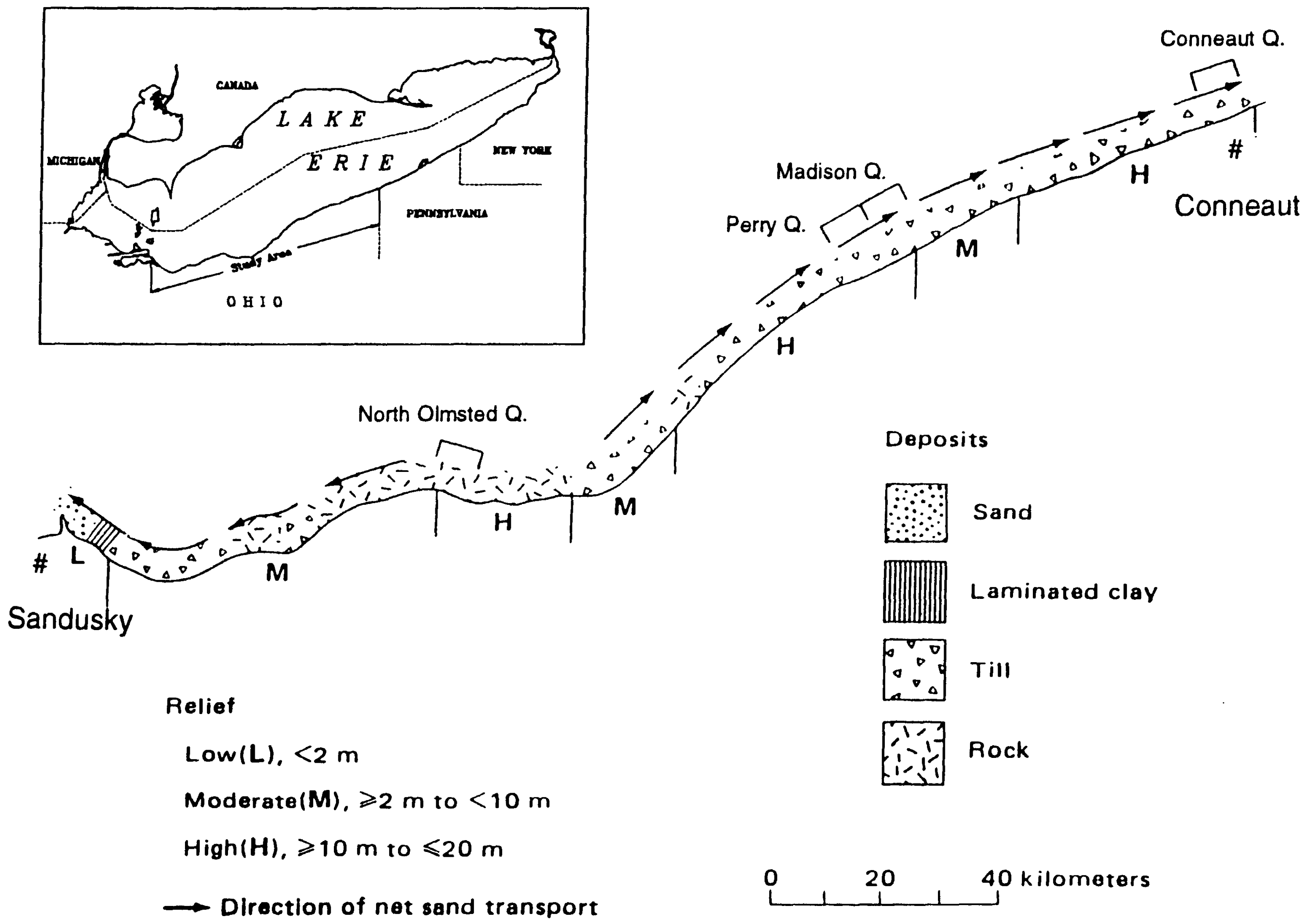


FIGURE 1.- Geologic materials, relief, and direction of net sand transport for the Ohio shore of Lake Erie between Conneaut and Sandusky (from Carter, Guy and Fuller, 1981). Brackets show location of quadrangle maps used in figures 3 to 6.

TABLE 1. RECESSION RATE STATISTICS FOR THE OHIO SHORE OF LAKE ERIE FROM CONNEAUT TO SANDUSKY.

	Ashtabula County	Lake County	Cuyahoga County	Lorain County	Erie County
Number of transects	1443	1619	1567	1139	1171
Long-term distance, m					
Maximum	121.62	230.12	136.86	106.38	190.50
Minimum	0.00	0.00	0.00	0.00	0.00
Mean	24.68	48.85	18.48	24.18	31.38
Long-term rate, m/yr					
Maximum	1.26	2.37	1.41	1.09	3.84
Minimum	0.00	0.00	0.00	0.00	0.00
Mean	0.25	0.50	0.19	0.25	0.46
Short-term distance, m					
Maximum	53.04	63.40	40.84	39.01	291.69
Minimum	0.00	0.00	0.00	0.00	0.00
Mean	10.23	10.74	2.33	3.69	18.64
Short-term rate, m/yr					
Maximum	2.90	3.73	2.39	2.30	17.17
Minimum	0.00	0.00	0.00	0.00	0.00
Mean	0.60	0.63	0.14	0.22	1.09
Bluff height, m					
Maximum	20.42	19.51	24.38	15.24	10.06
Minimum	1.83	1.52	1.52	0.91	0.61
Mean	14.33	10.76	12.33	6.39	4.61

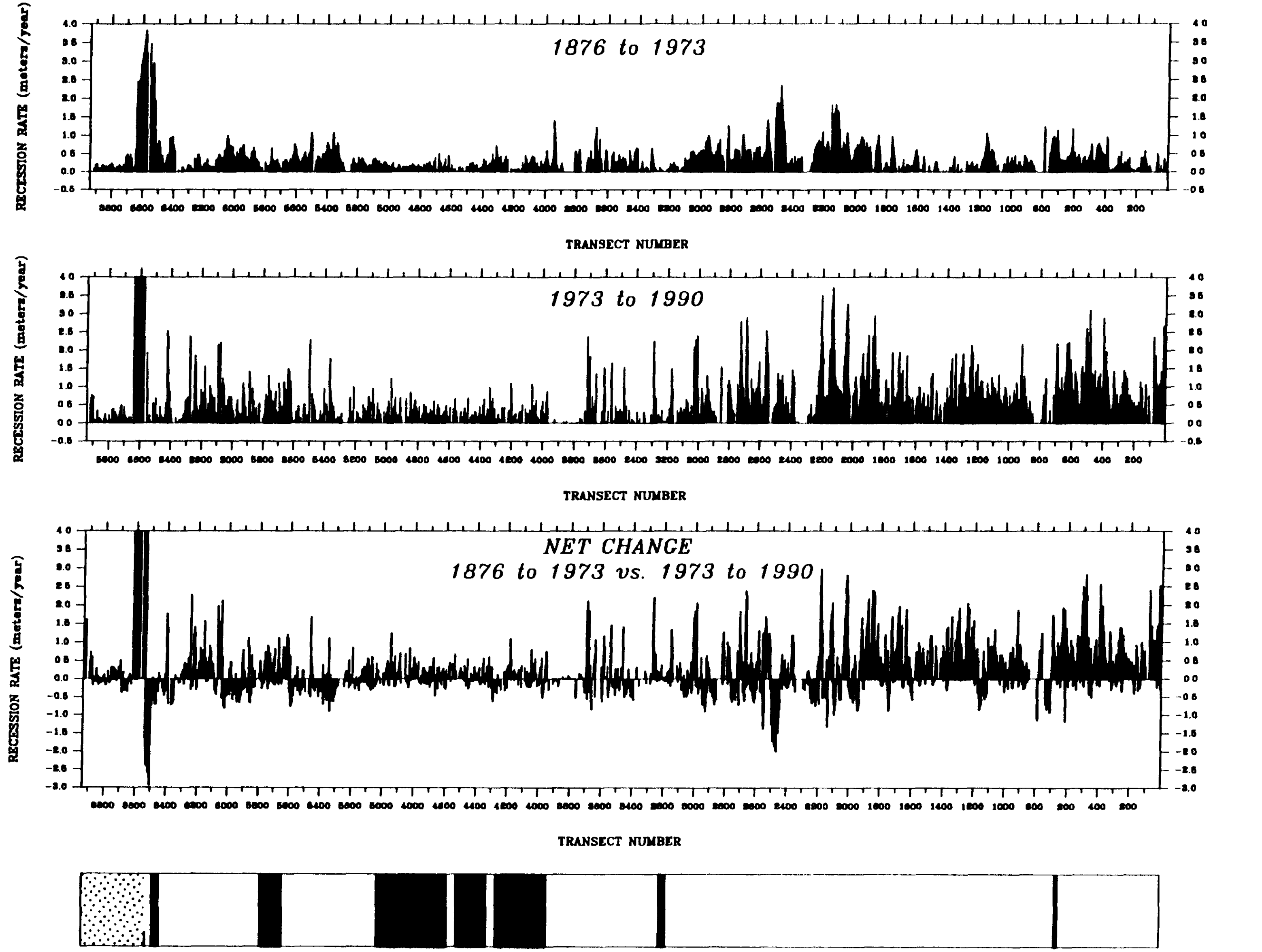


FIGURE 2.- Recession rates and geologic materials along the Ohio shore of Lake Erie from Conneaut to Sandusky. Geologic materials for the lower part of the bluff (the wave erosion zone) are shown in the lower bar with till in white, shale in black, and sand in a stippled pattern.

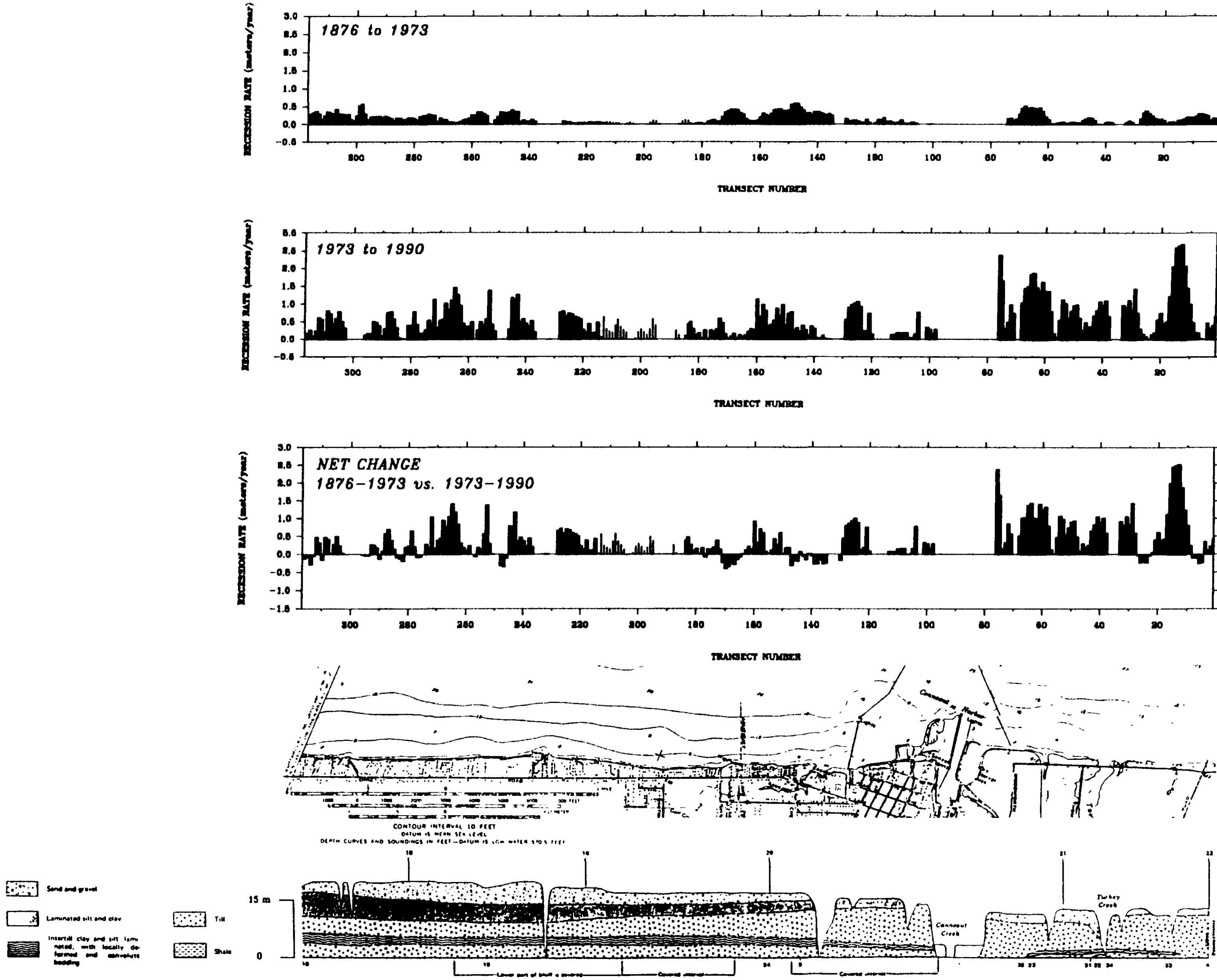


FIGURE 3.- Recession rates, relief, and geologic materials on the Conneaut Quadrangle.

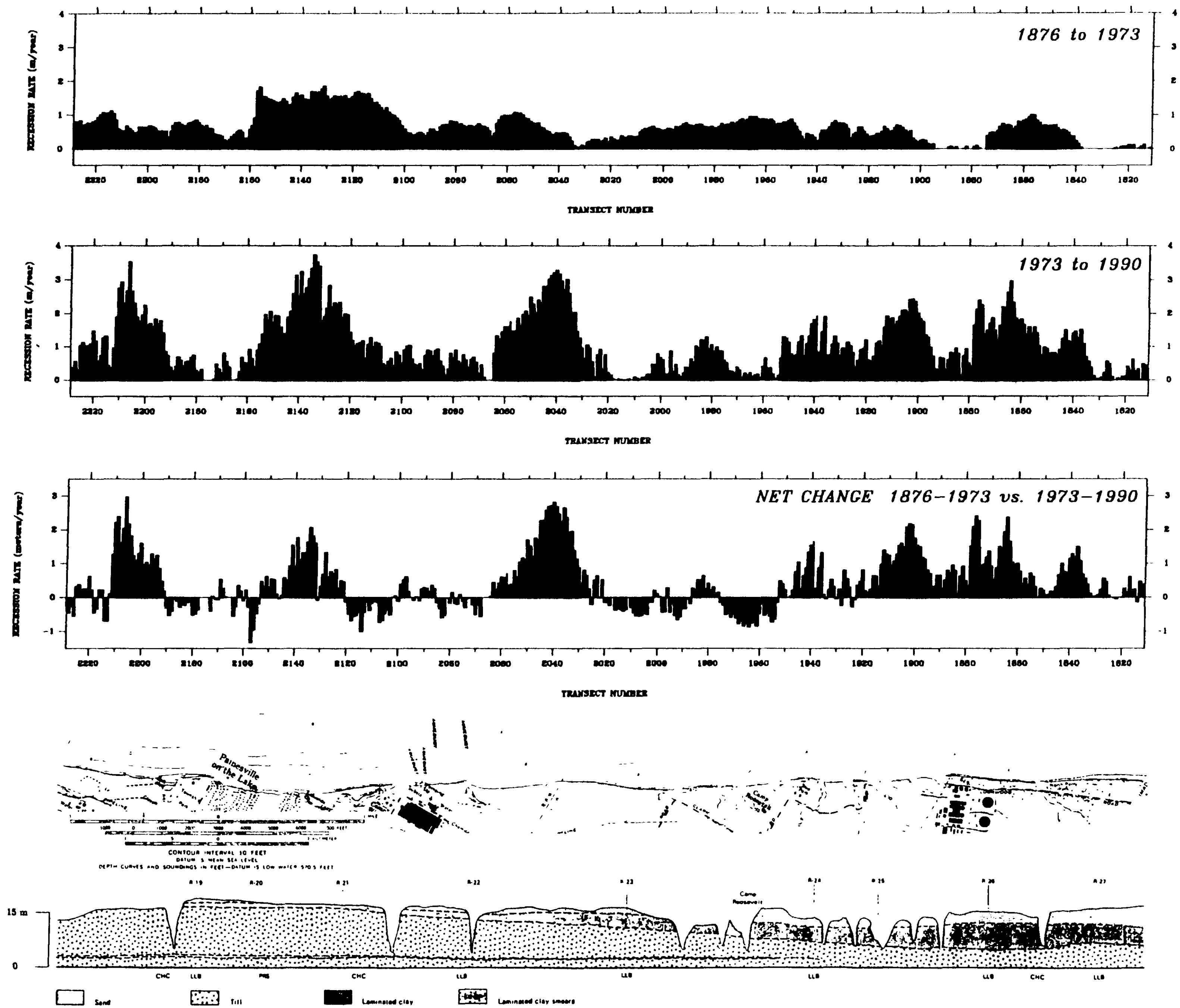


FIGURE 4.- Recession rates, relief, and geologic materials on the Perry Quandrangle.

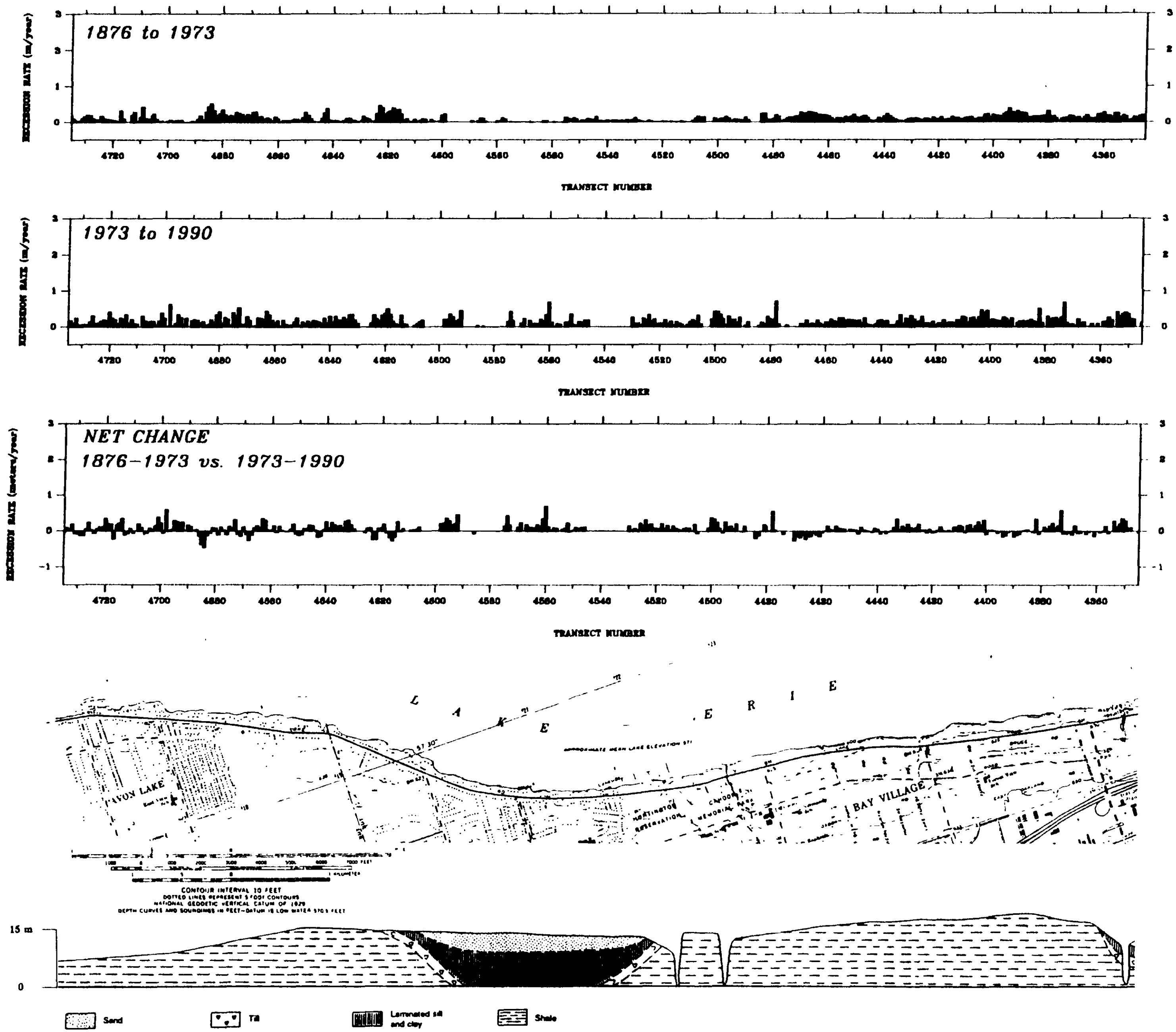


FIGURE 5.- Recession rates, relief, and geologic materials on the North Olmsted Quadrangle.

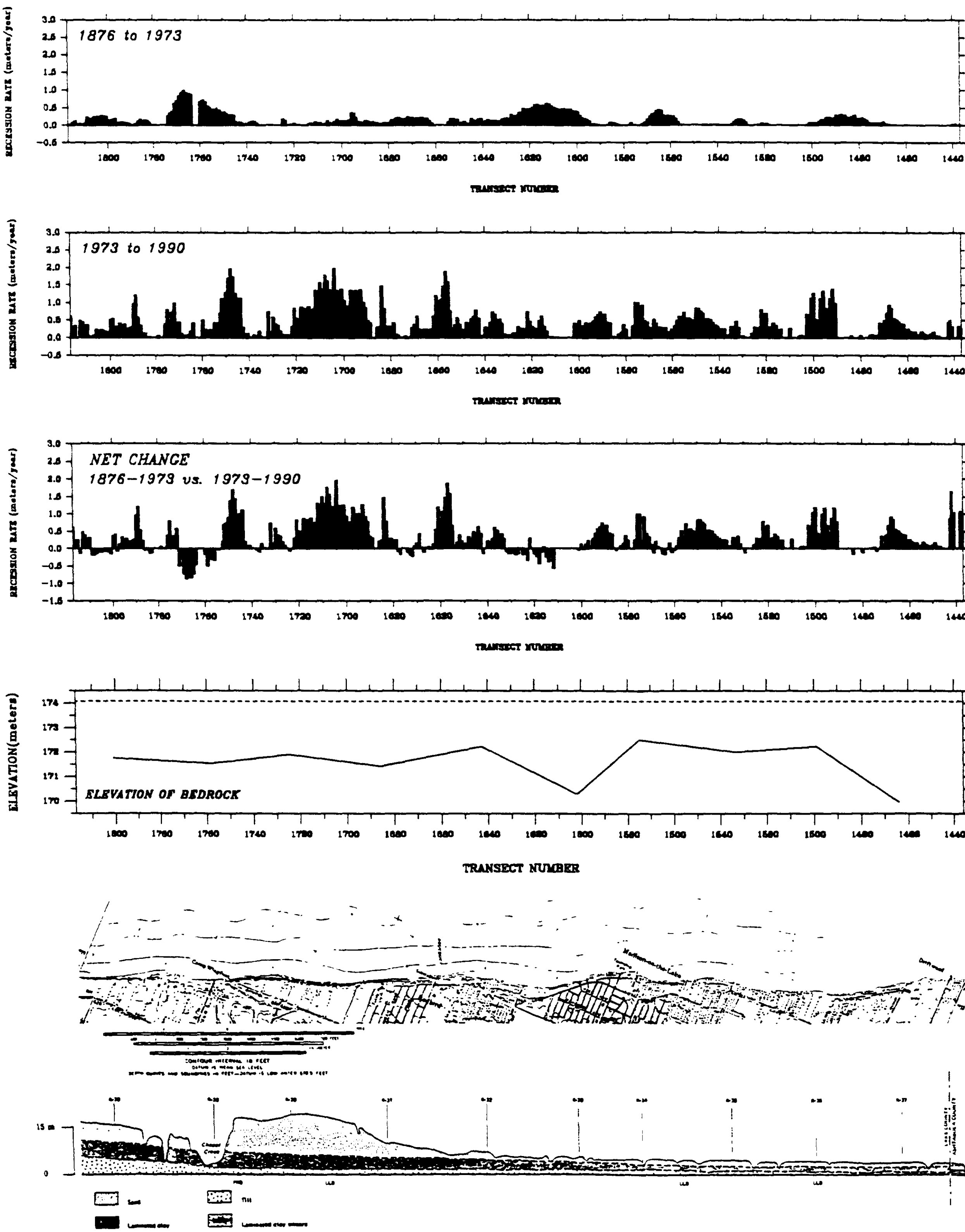


FIGURE 6.- Recession rates, relief, and geologic materials on the Madison Quadrangle. Elevation of bedrock (referenced to IGLD, 1985) is measured 150 meters offshore. Long-term mean lake level is approximately 174.07 m (IGLD, 1985).

GEOLOGIC FRAMEWORK AND RESTORATION OF AN ERODED LAKE ERIE COASTAL MARSH - METZGER MARSH, OHIO

Mackey, Scudder D. and Guy, Donald E., Jr.

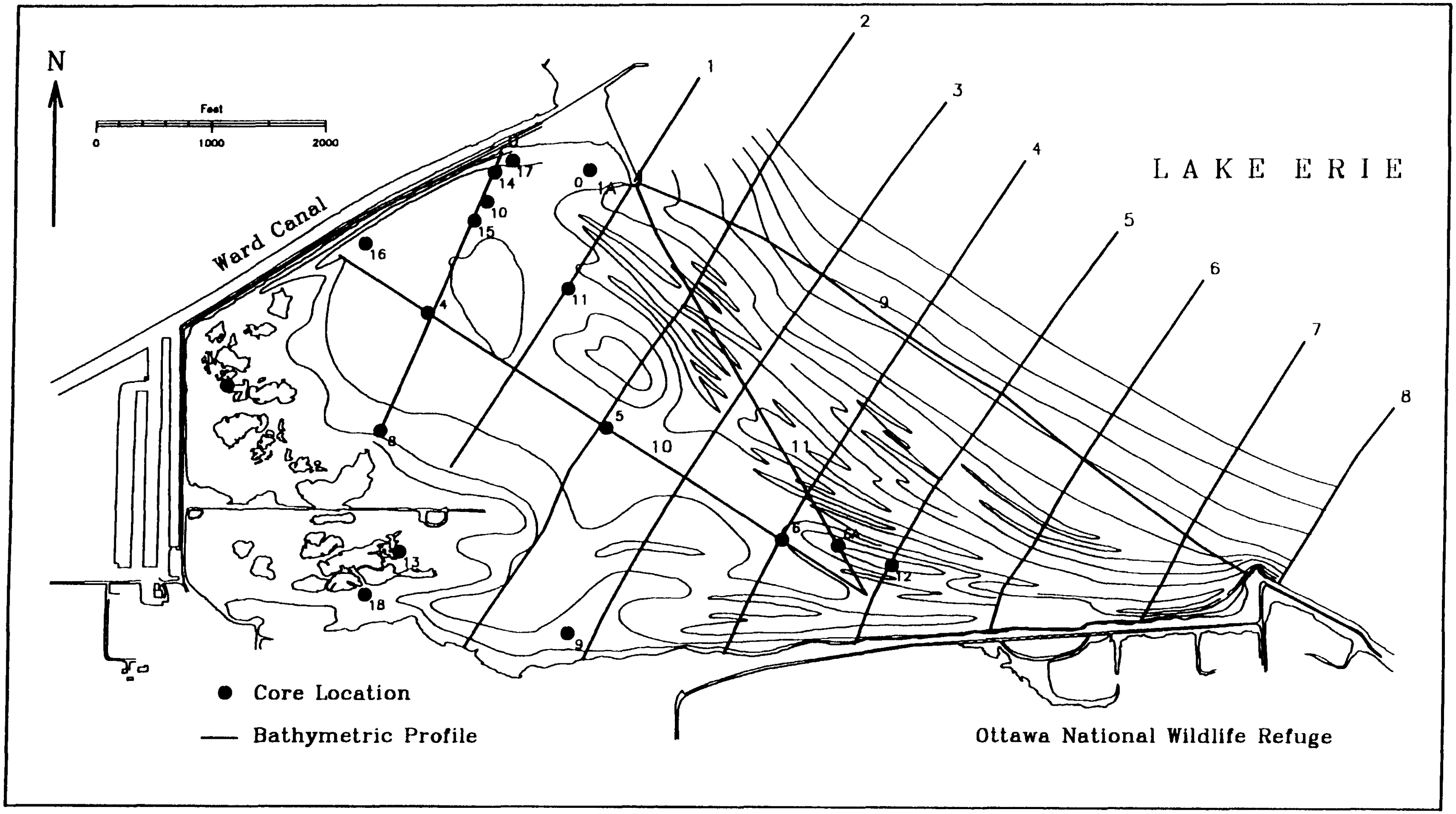
Lake Erie Geology Group,Ohio Division of Geological Survey,
1634 Sycamore Line, Sandusky, Ohio 44870-4132

Metzger Marsh is located on the south shore of the western basin of Lake Erie in Lucas County, Ohio. Metzger Marsh is a remnant of the Great Black Swamp that formed during a gradual rise in lake level which inundated the glacial lake plain in northwest Ohio (ca. 4000 years BP). During high water periods in the early 1950's, the low relief barrier beach/dike protecting Metzger Marsh was breached and subsequently eroded. As the barrier eroded, marsh deposits of fibrous peat, organic material, and sediments were exposed to direct wave attack and rapidly removed creating a shallow 275 hectare (680 acre) embayment. We have documented recession rates and loss of more than 111 hectares (275 acres) of coastal marsh using aerial photography from 1940 through 1990. Recession rates exceeded 3 meters/year for the period 1950 through 1973. A recent survey and coring program by the Ohio Geological Survey in cooperation with the U.S. Geological Survey and Western Michigan University reveals a complex system of sand shoals and bars in the eastern portion of the embayment and organic-rich silts and clays overlying fibrous peat deposits in the western portion of the embayment. These deposits rest on a surface that dips gently to the north and east and overlie a cohesive substrate of lacustrine clay and glacial till. Additional detailed surface-sediment sampling is

planned for spring, 1994.

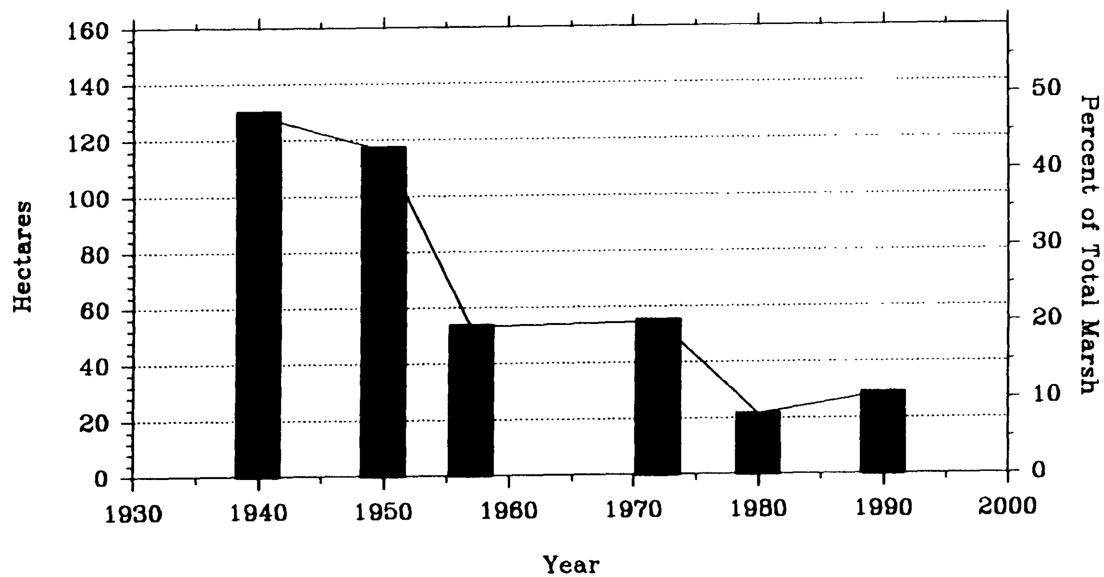
Preliminary substrate data and a detailed bathymetric map produced from this survey have had a major impact on the Metzger Marsh Restoration Project proposed by the Ohio Division of Wildlife, U.S. Fish and Wildlife Service, and Ducks Unlimited. The initial project design called for a solid dike to be constructed across the mouth of the embayment so that water levels within the marsh could be regulated by the installation of two large pumps. A cross-pool dike separating State and Federal lands was also part of the initial design concept. Given the importance of coastal marshes to fisheries and nutrient exchange with the lake, changes were made in the design to include an "open concept" 20 hectare (50 acres) experimental pool at the eastern edge of marsh. However, after examination of the geological and bathymetric information provided by our survey, the 20 hectare experimental pool and cross-pool dike were eliminated, and the location of water/fish access openings and pump sites were adjusted in response to sediment substrate distribution and bathymetry within the marsh. More than 165,000 cubic meters of sand may be impounded behind the structure when built. Provision may be made to divert a significant portion of this important sand resource back into the littoral system. The results of this study demonstrate the pressing need for accurate geologic information before initiating complex coastal/wetlands projects.

METZGER MARSH, OHIO



METZGER MARSH, OHIO

Loss of Emergent Wetland



TILL LITHOSTRATIGRAPHY, BLUFF MORPHOLOGY, AND EROSION RATES IN THE LAKE ERIE COASTAL ZONE OF OHIO

Pavey, R. R.[1], Stone, B. D.[2], and Prosser, C.[2]

[1]Ohio Division of Geological Survey, 4383 Fountain Square Dr., Columbus, OH 43224; [2]U.S. Geological Survey, 928 National Center, Reston, Va. 22092

The distribution and lithogenesis of three late Wisconsinan tills control a large portion of the disparate bluff morphologies, erosional processes, and relatively high erosion rates along the Ohio shore of Lake Erie. This region is replete with stratigraphic nomenclature; however, only the three field-mappable till units recognized in this study are described here, in descending stratigraphic order.

Along the eastern lake shore, the silty Ashtabula Till underlies a high (10-20 m of relief), nearly vertical escarpment. This till directly overlies Devonian shale which crops out just below water level along most of this part of the shore. The Ashtabula Till includes a basal, compact, calcareous till with 25-35% matrix sand, and a dominantly illite/kaolinite clay mineral suite. The till is commonly homogeneous, displays a subhorizontal fissility marked locally by silt lamina, and has a preferred SW to WSW till-stone fabric (s1 values >0.65). It has moderate to high dry strength, and contains local lenses of compacted to sheared, laminated clay to fine sand. This basal unit is inferred to be a lodgement facies. The overlying compact, locally-stratified facies of the Ashtabula Till characteristically contains elongate lenses of microlaminated to thin-bedded clay to fine sand and some gravel. Fabrics show little preferred orientation (s1 values <0.55). This unit is inferred to be a basal meltout facies. The total thickness of both facies commonly exceeds 15m at the shore, but thins southward to zero within 16.4 km (10 mi) or less. The thickness of the Ashtabula Till at the coast may be related to a recessional subaqueous ice-margin, ice grounding-line deposition, or thrust-stacking of sediment-laden ice near the margin. A prominent vertical joint system controls the predominant failure modes of rotational slump and blockfall in the Ashtabula Till bluffs. Erosional recession of these bluffs has exceeded 2 m/yr during periods of high lake levels.

Most of the low (<10 m relief) bluffs along the central Ohio and island shores contain a compact, calcareous, clayey till. This till is correlative to the Hayesville Till (and may include the Hiram Till) of northeastern Ohio and "clayey till" of northwestern Ohio. It is most often homogeneous, has a matrix of 8-20% sand and 33-50% clay, has subhorizontal fissility, and has moderate to high dry strength. Most of the till unit is <5 m thick, and is inferred to be mostly a basal lodgement facies. It commonly overlies a lower till and/or exposed Devonian shale or carbonates. The lower till, correlative to the Millbrook (?) Till of northeastern Ohio and the "hardpan till" of northwestern Ohio, is coarser (25-35% sand, 20-35% clay), extremely compact, and has high dry strength. This till shows little to no evidence of subaerial weathering and is interpreted by us as Late Wisconsinan, but may be as old as Illinoian. The low bluffs underlain by these tills erode during periods of high-water at rates of <1 to 3 m/yr, mostly developed in composite multitill or till/bedrock bluffs, where erosion processes are dependent on the elevation of contrasting materials.

The clayey till is exposed in many of the very low bluffs of the western shore. In this region, the clayey till contains a clay mineral suite dominated by illite, which is weathered to illite/smectite in the upper part, and has lesser amounts of kaolinite, vermiculite, quartz, calcite, and dolomite. The till commonly is beneath a thin surface deposit of mineralogically similar glaciolacustrine silt/clay; some bluffs expose only this less-compact material. The clay till locally crops out in shallow offshore erosional platforms.

Mapping and CD-ROM Short Course

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The Office of Energy and Marine Geology (OEMG) is archiving data on CD-ROM for publication and distribution (Polloni and Ambroziak, 1993). This short course reviews the methods and tools used to assemble, format, and combine data for transfer to CD-ROM and includes a summary of collection, quality, and formatting standards used for the process.

Making a CD-ROM for publication is primarily an organizational task: a job of creating realistic budgets and schedules. In this process three factors determine the scope of the project: (1) the design specifications, (2) the time allotted, and (3) the resources allocated (Strauss, 1993). These factors will influence the quality of the CD-ROM more than the type of data that is being archived.

Our objectives are to deliver economical tools to researchers, collaborators, and the public, providing them easy access to USGS information, and desktop mapping and data-retrieval capabilities. Some examples of products already produced or in production are: the CD-ROM Atlas of the Deepwater Parts of the U.S Exclusive Economic Zone in the Atlantic Ocean, the Gulf of Mexico, and the Eastern Caribbean Sea (Twichell and Polloni, 1993); the Southern Lake Michigan Coastal Erosion Study CD-ROM, (Polloni et al, 1993);

and a Regional Great Lakes CD-ROM, demonstrated as a sampler CD-R (cd-rom recordable one-off).

The data integration tools and concepts allow us to organize data into "neat piles" as a preliminary step to building a USGS Knowledge Bank of the Marine Realms. One part of this effort is a Geologic Information Visualization (GIV) package developed by Russ Ambroziak of the USGS. A course of instruction for using the GIV package, which represents an expanded version of a mapping course given at the 1993 Geological Society of America National meeting in Boston, (Ambroziak and others, 1993, Woodwell and Ambroziak, 1993) is offered at Mary Washington College . For information on the current status of GIV software contact Christine Cook (ccook@oemg.er.usgs.gov) at the USGS National Center in Reston. The GIV software is available by anonymous ftp at oemg.er.usgs.gov in directory pub/GIV. Check the readme file for the latest information on updates.

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POTENTIAL FOR WETLAND EXPANSION IN THE LAKE ERIE BASIN FOLLOWING LACUSTRINE REGRESSIONS

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Current wetlands research in the Lake Erie basin is being focused on several major topics. 1) How do wetland plants take advantage of newly exposed lake bottom? 2) What factors control deposition of peat in such wetlands? 3) What events in Lake Erie's history would have enhanced wetland expansion and growth? 4) Where are the most likely places to prospect for former wetlands and their associated peat deposits under Lake Erie? 5) How can geophysical techniques be used to locate former wetlands or peat under the lake?

When lake levels fall, newly exposed land may be vegetated rapidly by wetland plants. One strategy involves laying down of vast seed beds; these may get buried by rising water, but when former wetlands are reexposed by falling water levels, new wetland plants germinate almost instantaneously. This phenomenon was first noted in Peshtigo Harbor (Green Bay, Lake Michigan) where monospecific communities of soft rushes bloom on mudflats exposed during drought years. Cores have revealed that this cycle has been repeated many times. Having more than one reproductive strategy, such as dispersal by seeds or by vegetative means, gives herbaceous plants, such as water lilies and cattails, selective advantage when new land becomes exposed.

Having wind-dispersed seeds helped cottonwoods become established within a year of land exposure at Presque Isle, Pennsylvania. Elms, ash, and maples having winged seeds become established within similar time frames. Trees having relatively heavy seeds, such as hickory, oaks, and conifers undoubtedly require longer periods of time to establish their presence in forested wetlands.

Peat accumulation in boreal and temperate wetlands is enhanced by interactions between hydrologic, phytological, chemical, and sedimentological processes. Constant water levels or slowly rising water levels are conducive to peat accumulation. In wetlands, such as the remnant Black Swamp in Ohio, where water levels rise and fall annually, little or no peat has accumulated. Peat accumulation can also be enhanced by the plants themselves. A wetland that is dominated by vegetation that can grow on peat, such as the calciphilic sedge and rush community at Springville Marsh, Ohio, or herbaceous vegetation that provides little nutrition and therefore is not grazed, or woody vegetation that does not rot easily, such as cedar, has the best chance to accumulate as peat. Chemical factors are also important. Mildly acid and circumneutral pH values have been shown to enhance preservation. Sediment input enhances the growth of some wetland plants and discourages the growth of others. Peat accumulates in the places isolated from sediment sources.

The geologic history of Lake Erie and its precursor lake phases is complex. Within the past 14,000 years, as many as 15 highstands have transgressed across the Lake Erie basin. The early Lake Erie phase began when the Buffalo River outlet was established around 12,600 B.P.; water levels fell as much as 40 m lower than present and the western basin was exposed. Rising water levels slowed around 9,000 B.P. when the lake stood about 10 m lower than present, and around 5,000 B.P. when it stood about 5 m lower. Water flow through the Detroit River was reestablished around 3,000 B.P., flooded the western basin, and deposited a delta. Since then, the lake has been rising slowly to its present level, aided by differential isostatic rebound.

Knowledge of these past events can help us focus on specific areas to prospect for buried peat deposits. Lowstands would have exposed new lake-margin areas on which fringing wetlands may have flourished in a semi-concentric zonation. C-14 dates on peat, muck, and tree remains, in cores and grab samples, show that herbaceous and forested wetlands communities were growing within the western basin from 12,600 to 2,500 BP. The slow but inexorable transgression of Lake Erie into its western basin would have drowned these communities and shifted wetland habitat to increasingly higher ground. Lake transgression, channelization, and delta contruction that followed establishment of the Detroit River may have eroded or buried existing peat deposits. The area offshore from Sheldon's Marsh in Ohio has had a long history of wetland growth. C-14 dates on peat, from offshore cores and from peat balls that are tossed onto its beach by storms, show that the original wetland extended a significant distance offshore 5,000 years ago. Historical and sedimentological evidence has documented that the present day barrier beach/spit that now protects the modern wetland was once farther offshore and has subsequently prograded across the peat deposit with rising Lake Erie waters. Growth of such wetlands along the southwestern shore of Lake Erie may be aided, in part, by differential isostatic rebound.

Seismic and side-scan sonar methods have potential for documenting wetland growth in areas that are presently underwater. Sequence stratigraphy has been used to delineate coal deposits associated with disconformities, and has focused on peat that accumulated during marine lowstands and highstands elsewhere. Similarly, seismic reflection profiles of Lake Erie may help delineate a disconformity which should be present at the eastern edge of the western basin, where rising lake levels transgressed over the extensive wetland complex growing in the basin. Another disconformity should be present at the northwestern edge of the western basin, where the Detroit River delta prograded over the same wetland complex.

Wetlands are dynamic systems typically studied on seasonal or annual time frames; they may or may not deposit peat. This research expands the Lake Erie wetlands model into offshore areas that may have peat accumulations. The information may be used to help reconstruct former climate changes, to identify potential future sources of energy, to learn about the nature of plant and animal biodiversity before anthropogenic activity changed the natural communities, and to provide information about natural rates, scales, and time spans of the shoreline protection and the sediment trapping functions in pristine wetlands.

BEDROCK SURFACE TOPOGRAPHY AND PRELIMINARY QUATERNARY STRATIGRAPHY IN THE WESTERN LAKE ERIE COASTAL ZONE, NORTHWESTERN OHIO AND SOUTHEASTERN MICHIGAN

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In contrast to other Lake Erie coastal sectors and the Erie islands, where shoreline bedrock outcrops tend to slow coastal erosion, bedrock does not crop out along the low shoreline of the western Erie basin west of Port Clinton. Analysis of 120 km (75 statute mi) of new high-resolution seismic reflection profiles and onland well records in the southwestern coastal zone shows that the bedrock surface is highly dissected. These subsurface data confirm that multiple glaciations have removed virtually all pre- and interglacial surficial materials and have modified extensively the preglacial fluvial/weathered-rock landscape. A regional map of the bedrock-surface topography shows differential erosion of bedrock units with differing erosional resistance. Consequently, bedrock topography greatly affected glacial flow directions and erosion. Areas of deep glacial scour coincide with shale and dolostone subcrop belts in which strike direction was subparallel to glacial flow directions during early and late phases of glaciation. Locally, deep scouring also occurred over zones of fractured bedrock. In southeastern Michigan, the trends of large east-draining valleys, widened and deepened by glacial erosion, are preserved on the north side of the area of the Erie ice lobe. To the south in areas of axial flow of the Erie lobe and prolonged southerly ice flow during glacial maxima, traces of preglacial valleys have been more severely modified by glacial erosion. The Erie islands, with >10 m of local bedrock-surface relief, are regionally unique erosional outliers of resistant dolostone, carved by diverging directions of glacial flow.

Striations in the region record three such diverging ice-flow and erosional directions of the last ice sheet. In one quarry exposure, the position and cross-cutting erosional relationships of the three striation sets indicate their relative ages. The oldest set trends SSW, followed by a SW set, and a youngest W-trending set. The SSW-trending set is overlain directly by a compact, silty clay till containing abundant Canadian-shield crystalline gravel clasts, including scattered small boulders. The till and the striations are inferred to date from the initial Late Wisconsinan ice advance into the region. The younger striation sets are preserved at higher altitudes on the bedrock surface and are overlain by the clayey, shale-rich till of the recessional Erie lobe.

Onshore, compact glaciolacustrine silty clay overlies the clayey till. The clay deposit thickens from a feather-edge contact over till to several meters in coastal areas. The clay deposit is a massive mud commonly less than 2 m thick that fills broad troughs between areas of till at the surface. Offshore, seismic profiles reveal stratification in the clay deposit. The onshore surface distribution and locally preserved gravel-lag deposits on the till surface indicate that wave-erosion reworked the till surface and filled the intervening areas with locally derived mud during Late Pleistocene shoreline migration across the region. This erosional levelling process probably continues in shallow offshore areas of the present lake where seismic profiles depict infilling by modern mud of low areas between bedrock/till highs. An auger test hole in the beach west of the mouth of Turtle Creek penetrated 5 m of organic mud deposited as valley fill during the late Holocene transgression of Lake Erie.

GEOLOGIC STUDIES OF COASTAL WETLANDS PROCESSES

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Wetlands in general and coastal wetlands in particular are ecosystems of national and even global importance. By their dynamic nature, they support some of the greatest biodiversity and are among the most productive ecosystems on earth. Wetlands sustain nearly all commercial and recreational fisheries, providing critical habitats for fish and shellfish during some stage in their life cycles. In the United States alone, this a $13 billion-per-year industry.

Of the wetlands that existed at the time Europeans settled the United States, approximately one-half have been lost through natural processes, man's activities, or a complex combination of both, and the losses are continuing at alarming rates. Improving our scientific understanding of the geologic processes driving the origin and evolution of wetlands as well as the geologic framework within which the processes operate is important for making land management decisions, mitigating wetland losses, restoring wetlands previously destroyed, and conserving wetlands which still remain.

To address the need for baseline geologic information and improved scientific understading, the U.S. Geological Survey (USGS) has undertaken studies of coastal wetlands in three regions:

The **Florida Wetlands Study** was initiated in 1991 as a five-year project to determine the causes of the decline of wetlands in the Big Bend area of northwest Florida. These wetlands are exposed directly to the Gulf, which makes them susceptible to storm damage and salt water intrusion. In addition, the Floridan Aquifer, the major source of drinking water in central Florida, may supply freshwater to the coast to support brackish water vegetation. Field activities conducted in coperation with the University of South Florida and the Florida Geological Survey have included sediment sampling, subbottom profiling, and deployment of instruments to measure the flux of water and sediments and the impact of waves and storm-surge flooding on the wetlands.

The **Great Lakes Wetlands Study** was started in 1991 and is a multiyear effort focused on delineating and mapping wetlands environments and on gaining an improved understanding of the physical processes affecting the wetlands. The Great Lakes are products of Pleistocene glaciation, and the wetlands surrounding the Lakes, the products of post glaciation processes. In addition to being subject to cyclic changes in water level, storm surges, and erosion, and human activities, they are also affected by crustal rebound. As the land rises, wetlands and beach ridges in northerm regions are becoming emergent, while wetlands in the southern regions are being flooded. A map of past and current wetlands around Lake Erie has been completed. Detailed mapping and coring of wetlands around Lake Michigan (Manistique, Sleeping Bear Dunes, Indiana Dunes) is in progress. Similar studies of Lakes Superior (White Fish Point, Apostle Islands National Lakeshore) and Erie are underway. These studies are joint efforts with the National Biological Survey, the National Park Service, Ohio State University, and the Indiana Geological Survey.

The **Louisiana Wetlands Loss Study** began in 1989 as a joint effort with the U.S. Fish and Wildlife Service (now the National Biological Survey), the U.S. Army Corps of Engineers, and Lousiana State University. The study encompasses a 300-kilometer-wide stretch of delta plain wetlands, extending from the Atchfalaya Delta, west of the Mississippi River, to the Chandeleur Islands, east of the Mississippi River. The primary focus has been on two representative wetland basins - the sediment-starved Terrebonne with badly deteriorated wetlands and the sediment-rich Atchafalaya with an emergent and recently vegetated delta and healthy wetlands - in order to compare and contrast the natural and human-influenced processes affecting delta plain wetlands in general.

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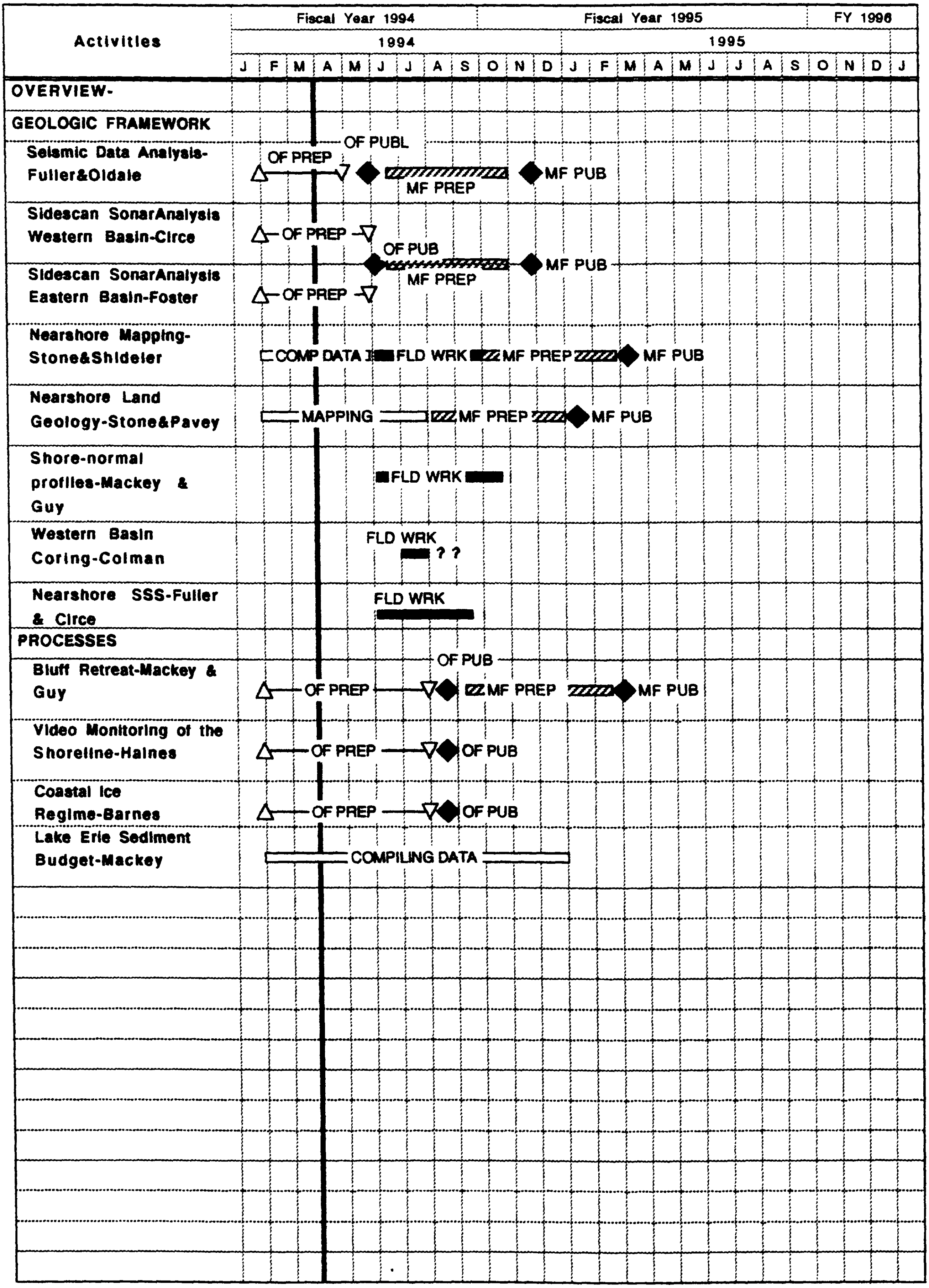
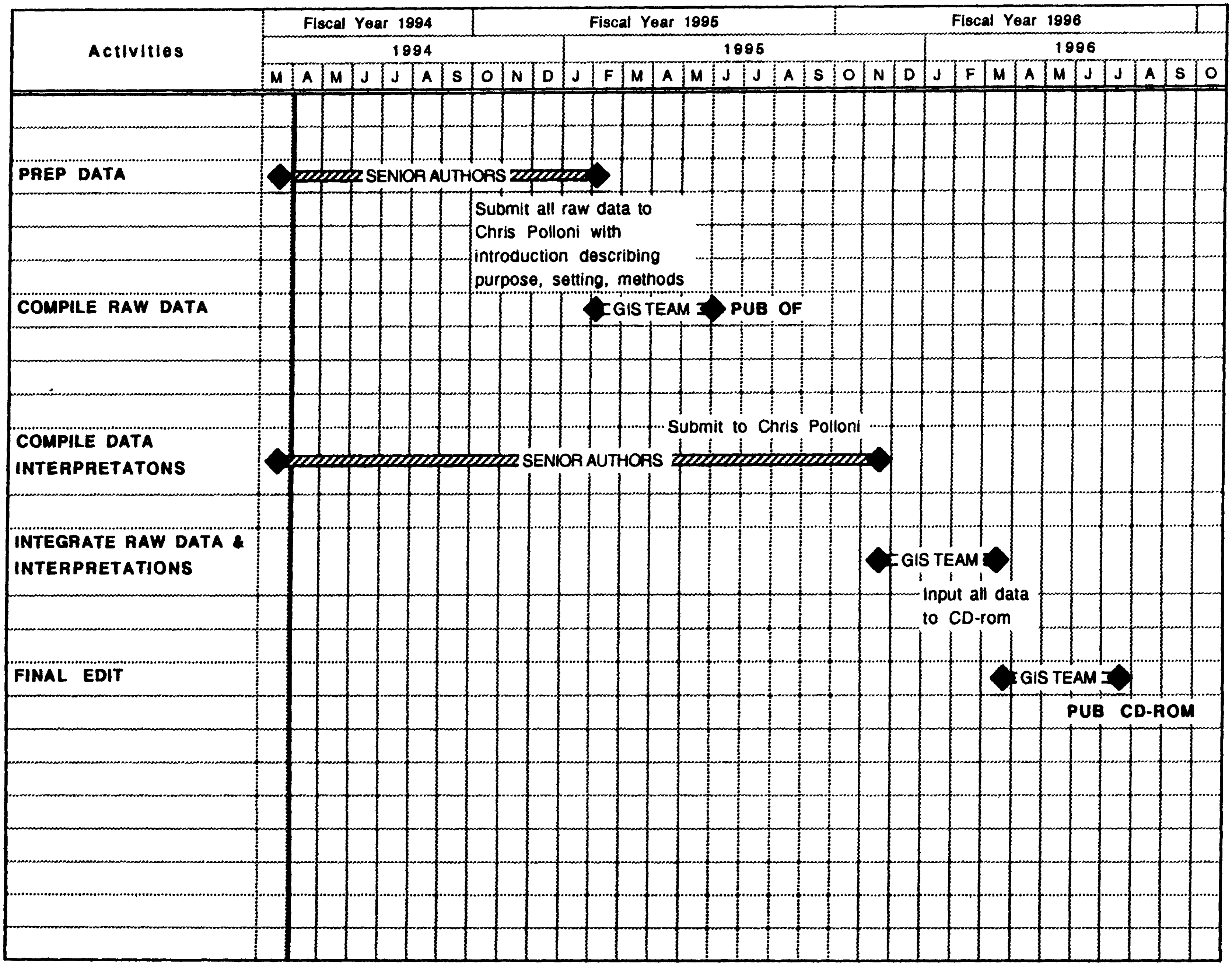
APPENDIX A

LAKE ERIE SCHEDULE



APPENDIX B

LAKE ERIE CD ROM PREP SCHEDULE



APPENDIX C

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