

Ohio Geology Newsletter

Division of Geological Survey

THE HISTORY OF LAKE ERIE

by Michael C. Hansen

Lake Erie, the great body of fresh water forming Ohio's north coast, is the fourth largest of the five Great Lakes; nevertheless, Lake Erie should not be considered an also ran, as it is the twelfth largest freshwater lake in the world. Lake Erie provides a nearly unlimited water supply to communities along its shore, is an unmatched recreational and sport-fishing mecca, and provides significant quantities of sand and gravel for construction.

Lake Erie is also a dynamic body of water noted for the ferocity of its storm waves and the havoc they wreak along the lakeshore. Waves, currents, shore erosion, and flooding are all problems that must be dealt with in coastal areas.

The common perception may be that Lake Erie is a timeless entity, formed in the distant past and as ancient as any visible rock or landscape, and a feature that will remain essentially unchanged for eternity. Geologists, however, view Lake Erie in its present form as a very recent feature—less than 4,000 years old—that is destined for a relatively short life, geologically speaking. Indeed, the known history of the lake and its predecessors has taken place in the last 14,000 years; most of this time is within what geologists term the Recent.



Modern Great Lakes system. Drainage of all five lakes is into the St. Lawrence River.

The history of Lake Erie within this brief span of geological time is remarkably complex, involving numerous lake-level stages that were at elevations different than the modern lake—some stages may have been as much as 230 feet higher. These higher lake stages have had a profound influence on the landscape, agriculture, transportation, and economy of northern Ohio, especially northwestern Ohio.

Fertile clays deposited on the lake bottom during

high-water stages and the wetland areas that remained when lake levels dropped form one of the richest agricultural regions of the state. The beaches which formed along the shorelines of these higher lake stages are preserved as ridges elevated above the nearly flat former lake beds. These beach ridges, at a characteristic elevation for each lake stage, not only outline the configuration and extent of each stage, but also provided dry passage through swampy terrain. Indian and pioneer trails faithfully followed the beach ridges in many areas of northern Ohio; later, highways followed the ridge trails.

SETTING THE STAGE FOR A GREAT LAKE

Lake Erie owes its fundamental existence to the presence of a basin or lowland that originated long before the Pleistocene Ice Age began about 2 million years ago. This lowland was the valley of an east-flowing river, known as the Eriean River, that some geologists speculate was the downstream portion of the preglacial Teays River (see *Ohio Geology*, Fall 1987).

The first of the major glacial advances obliterated this drainage system and deepened and enlarged the basin. Succeeding glaciations further deepened and enlarged it. Lake Erie, the southernmost of the Great Lakes, is also the shallowest because the ice was relatively thin (therefore lacking significant erosive power) when it reached so far south.

The Lake Erie basin is underlain by Silurian and Devonian carbonates (limestone and dolomite) on the west and by Devonian shales on the east. The carbonate rocks are generally more resistant to erosion than are the shales; therefore, the western basin is comparatively shallow, averaging less than 25 feet in depth. Glacial ice was able to scoop out to a greater extent the less resistant shales underlying the central and eastern basins. The deepest point in Lake Erie is 210 feet in the eastern basin.

The detailed history of the Lake Erie basin can be surmised only from the time of retreat of the last Pleistocene glacier, the Wisconsinan, about 14,000 years ago. It is probable that the basin was occupied by lakes as each of the three earlier ice sheets retreated, but geologists can only speculate on these events because the evidence was destroyed by succeeding glaciers.

THE LAKE STAGES

The initial phases of lake formation in the Erie basin began as soon as the ice had retreated north of the drainage divide and exposed a lowland in which water could accumulate. The complex series of lakes that

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FROM THE STATE GEOLOGIST . . . by Thomas M. Berg

BETWEEN THE WATER AND THE LAND— A REMARKABLE BOUNDARY

For as long as I can remember, I have always had a great attraction for the sea-shore. Perhaps it is the freedom, the fun in the surf and sun, the excitement of the boardwalk, the escape from classroom or office. I think there may be a deeper attraction—something that has to do with unfathomed and uncharted instincts within us humans. Perhaps the attraction has to do with the instinct that makes us want to reach out to the farthest planets or the smallest subatomic particles. I have experienced great exhilaration watching and listening to an angry sea raging in the black of night. I have experienced similar exhilaration atop a 14,000-foot mountain peak with nothing but crystal-blue sky above. These are the "boundary zones" of the human environment, those places where we cannot easily go beyond.

Whether the reasons are pure aesthetics, or instincts to confront the unknown, or simply delight and enjoyment, *coastal areas are extremely valuable to all people.* Here in Ohio, we have a varied coast along Lake Erie that provides citizens with a treasure of geological, biological, and recreational resources. To be good stewards of our environment, we must participate in careful planning that assures balanced utilization and preservation of these resources. In order to carry out the needed planning, we need to develop a thorough and accurate understanding of the inter-related, dynamic processes that affect Lake Erie and its ever-changing shoreline. Water levels, winds, wave activity, ice conditions, rainfall, storm events, and the works of humanity all contribute to a constantly changing system of erosion, transport, and deposition that must be investigated on an ongoing basis. Accurate mapping of the beaches, bars, spits, river mouths, wetlands, and bluffs—and the changes in these features over time, is needed for accurate evaluation and prediction of the future impacts of human activities.

On December 13, 1988, in the City of Cleveland, Governor Celeste signed legislation which established a coastal management program for Ohio's Lake Erie shoreline. Known as Senate Bill 70, the legislation designates the Ohio Department of Natural Resources as the lead agency for developing and implementing the coastal management plan. Part of Senate Bill 70 limits construction and other human activity within the Lake Erie "erosion hazard

area." Our Lake Erie Section in Sandusky is responsible for determining shore recession rates and mapping this erosion hazard area.

The Ohio Geological Survey also has the responsibility of assessing and mapping the mineral resources on and beneath the bed of Lake Erie. This responsibility goes back several decades and is one of the principal reasons for maintaining a well-equipped research vessel to carry out the investigations needed to assess and map the lake's resources. The only mineral resources presently removed from the Ohio bed of Lake Erie are sand and gravel dredged for fine and coarse aggregate. The presently permitted dredging areas need to be expanded, and new areas need to be identified for continued successful development of this important mineral resource. These tasks can be done only when the Ohio Survey has made a thorough investigation of the bed of Lake Erie. In order to efficiently accomplish such research, costly new equipment (including side-scan sonar and a subbottom profiler) needs to be obtained.

It is becoming increasingly clear that the Ohio Geological Survey needs to expand its capability to serve the citizens who live in or visit the coastal area. The Survey also needs to augment and strengthen its capacity to characterize the entire bed of Lake Erie to the international border. Our Lake Erie Section in Sandusky (whose duties are described elsewhere in this issue) has limited human and economic resources. As a result of the coastal management legislation, the section did receive some additional funding for the 1990-91 biennium, but a much greater investment will be needed to adequately address the pressing needs of Lake Erie and the coast. For example, side-scan sonar and a subbottom profiler for our research vessel would cost a minimum of \$80,000 alone.

To accomplish the research and investigations that need to be carried out at Lake Erie, we are actively seeking to establish new cooperative relationships with the federal government and with academia. During the first week of August, for example, the Survey, Kent State University, the University of Connecticut, and the National Oceanic and Atmospheric Administration cooperated by deploying a

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News items, notices of meetings, etc. should be addressed to the attention of the editor. Change of address and new subscriptions should be addressed to the attention of the secretary.

remotely operated vehicle with a video camera on several transects of the bottom of Lake Erie. The accompanying article in this issue of *Ohio Geology* by Timothy Wilson and Lori Lesney (Kent State University) describes this research initiative in more detail. On August 25, Bob Van Horn, Rick Pavey, and I (Ohio Geological Survey) met with Gary Hill, Abby Sallenger, and Jeff Williams (U.S. Geological Survey) at the Office of Energy and Marine Geology of the USGS to discuss directions of the National Coastal Geology Program. Abby and Jeff have kindly contributed an article for this issue of *Ohio Geology* to explain the national program. We expect that there will be strong opportunities for Ohio to participate in the national program during the next several years, and we will be working hard to gain the support that will make our state a national leader in the Great Lakes program.

I am very proud of the dedication, talent, training, and experience that we have in our Lake Erie Section. Rick Pavey (Acting Head), Nate Fuller and Don Guy (Geologists), Dale Liebenenthal (Research Vessel Captain and Operations Officer), and Mary Lou McGurk (Secretary) give outstanding service to our citizens who use the lake and coast. Quite frankly, however, our small staff in Sandusky is stretched to the limit—and beyond. If you derive any benefit from Lake Erie and its "remarkable boundary" with the land, let your voice be heard. The Ohio Geological Survey is anxious to participate in the careful management of the lake and the coast, but we need the economic and human resources to do the best possible job for Ohioans.

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occupied this expanding basin, apparently in rapid succession during a few thousand years, owe their existence to several factors. These factors include the configuration of the glacial ice to the north and the ice dams it created, low spots that filled with water until drainage divides were breached to form drainage outlets, and depression of the land surface by the weight of the glacial ice and the subsequent slow rise (rebound) after the ice retreated.

Lake Maumee

The earliest lake to form in the Erie basin, about 14,000 years ago, has been named Lake Maumee and is divided into three substages. The initial stage, known as Highest Maumee or Maumee I, formed beaches at an elevation of about 800 feet above sea level. As the Maumee waters rose, they eventually found an outlet through a low point in the Fort Wayne Moraine in Indiana and made their way along the Wabash River to the Mississippi drainage.

As the ice receded northward, Lake Maumee expanded its surface area, but the lake level dropped to an elevation of 760 feet when a new and lower drainage outlet was exposed. This outlet was in central Michigan and allowed the waters of this lake stage, known as Lowest Maumee or Maumee II, to be discharged through the Grand River to Lake Michigan and then to the Mississippi River.

The ice soon readvanced, closing part of the Grand River drainage outlet and raising the lake level to about 780 feet. This phase of Lake Maumee, known as Middle Maumee or Maumee III, was too low to discharge through the Fort Wayne outlet, but found an intermediate outlet in Michigan known as the Imlay channel. This westward-flowing drainageway eventually connected with the Grand River. There is some evidence that Lakes Maumee II and III may be reversed in sequence.

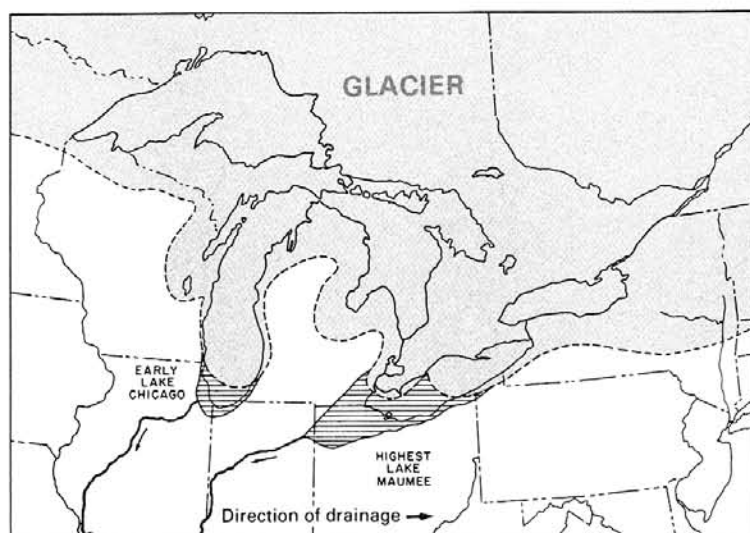
Lake Arkona

Continued northward retreat of the ice and downcutting of the westward-flowing outlet through the Grand River in Michigan lowered the water level to the Lake Arkona stages at successive elevations of 710, 700, and 695 feet. Recent evidence suggests that the lowering of lake level may have been influenced by changes in climate and precipitation. Each Arkona stage is marked by indistinct beaches which are poorly developed, presumably because lake level was constantly being lowered and because of erosion by the later, higher Lake Whittlesey. The lowest stage of Lake Arkona has been dated by the radiocarbon method at about 13,600 years ago.

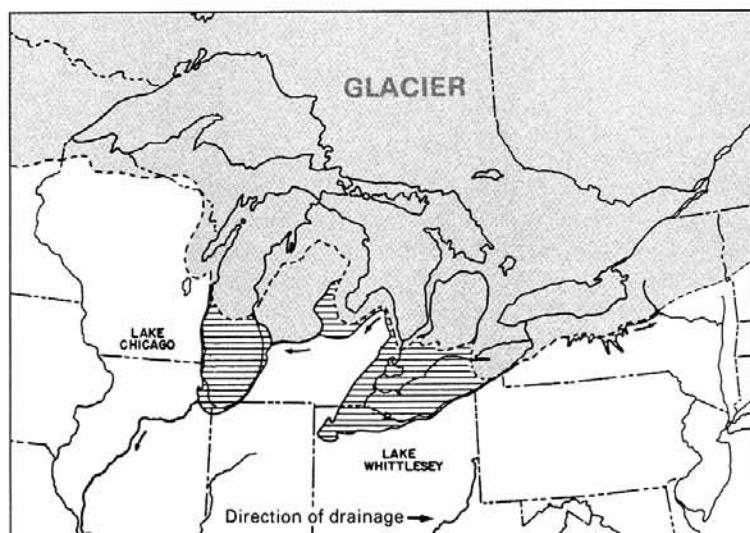
There is evidence that an additional low-water stage, known as Lake Ypsilanti, may have existed in the Erie basin for a brief period prior to about 13,000 years ago and the establishment of the next major lake stage, Lake Whittlesey.

Lake Whittlesey

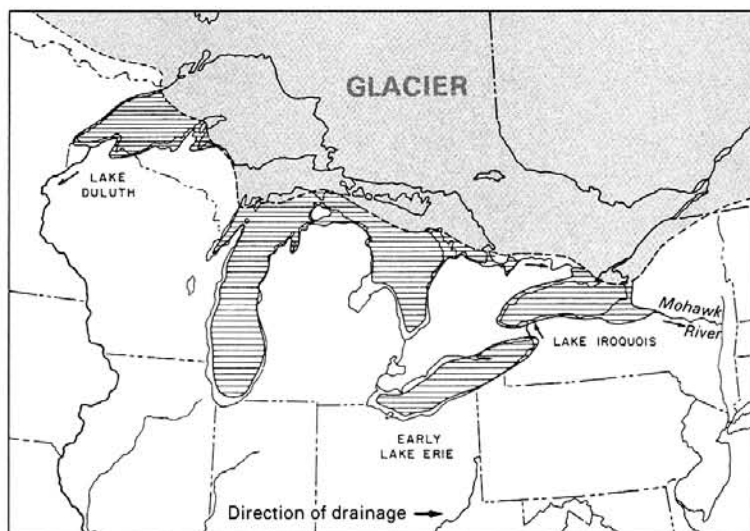
A major pulsation of the Wisconsin glacier known as the Port Huron readvance closed part of the Grand River drainage outlet and raised lake level to an elevation of about 738 feet about 13,000 years ago. The new lake stage was named Lake Whittlesey in honor of Charles Whittlesey, a geologist and topographer with the first Geological Survey of Ohio in 1837-1838. The outlet for Lake Whittlesey was a westward-flowing channel, known as the Uby channel, that connected with the Grand River in central Michigan.



Highest Lake Maumee (Maumee I) stage in the Erie basin. Drainage was westward across Indiana into the Wabash River system. Modified from Hough (1958).



Lake Whittlesey stage in the Erie basin. Drainage was westward across central Michigan. Modified from Hough (1958).



Early Lake Erie stage, when lake level was lower than modern Lake Erie. Drainage was eastward into Lake Iroquois (a predecessor of Lake Ontario) and then into the Mohawk River in New York. Modified from Hough (1958).

The beach ridges that mark the former shoreline of Lake Whittlesey are some of the most prominent and well-preserved in Ohio. They are particularly well-developed in northeastern Ohio because, according to Dr. Jane L. Forsyth in Division of Geological Survey Information Circular No. 25, *Beach ridges of northern Ohio*, the fetch of the prevailing westerly winds was greater and larger beaches were produced.

Lake Whittlesey came to an end when the glacier made a significant retreat. Lake level dropped dramatically, even below that of modern Lake Erie. It has been postulated that Lake Whittlesey was finally emptied through a drainage outlet (St. David Gorge) in the Niagara Gorge area. This outlet was, at the end of Lake Whittlesey time, much lower than today because it was still greatly depressed from the weight of recently retreated glacial ice.

Lakes Warren and Wayne

A readvance of the ice raised lake level to about 685 feet. This new lake, known as Highest Lake Warren (Warren I), was later lowered to about 670 feet (Lowest Lake Warren or Warren III). Weakly developed and discontinuous beach ridges at an elevation of about 675 feet define an intermediate Warren (Middle or II) lake level. Some investigators have surmised that a lake at an elevation of 660 feet immediately preceded Lowest Lake Warren. This lake, called Lake Wayne, is thought to have drained eastward through the Mohawk River valley in New York. Radiocarbon dates suggest that Lake Warren and Lake Wayne existed between about 13,000 and 12,000 years ago.

Lake Lundy

After many pulsations through a relatively brief period of time, perhaps only 2,000 years or so, the Wisconsin glacier made its final retreat and Lake Erie came closer to its final configuration. The last stage of the predecessor lakes in the Erie basin is known as Lake Lundy. This lake is thought to have had its drainage outlet through the Mohawk River valley in New York, but a western outlet in Michigan may have been used. Wherever the outlet may have been, it was evidently being continuously lowered by erosion, as beaches representing possibly three substages of Lake Lundy have been recognized. These substages, which have been given separate names, and their elevations are: Lake Grassmere (640 feet), Lake Dana (590 feet), and Lake Elkton (620 feet).

There is some doubt that this sequence is correct. Modern studies of the weakly developed and discontinuous beach ridges

of these substages suggest that they are actually offshore bars or wind-blown sand. Lake Dana is now thought to be a restricted lake in New York and not a basinwide feature.

Modern Lake Erie

After final retreat of the ice, the land surface began to rise or rebound as it was released from the great weight of the glacier, but the rebound was relatively slow. When the drainage outlet through the Niagara Gorge was finally free of glacial ice it was about 150 feet lower than it is today.

The implications of the opening of the Niagara outlet are dramatic. Water level in the Erie basin would have been lowered by about 150 feet; this lowering may have occurred suddenly when the ice-dammed waters finally broke through the confining edge of the glacier, creating a flood that quickly drained the Erie basin.

The Erie basin is so shallow that the 150-foot drop in water level would have completely drained the western basin and left water only in the deeper eastern basin and perhaps a small lake confined by a moraine in the central basin. It is likely that the Niagara Gorge and several other gorges in the area were cut by these cascading floodwaters.

The moderately slow rise of the land in the area of the Niagara outlet created a consequent rise in the water level in the Erie basin. By about 3,500 to 4,000 years ago lake level was perhaps only about 30 feet below that of the modern lake. A rapid 10- to 20-foot rise in lake level occurred about 2,600 years ago when the upper Great Lakes again began to drain through the Erie basin. Following this rapid rise there has been a continued slow rise of the water level that has brought Lake Erie to its current mean level of 572 feet above sea level.

DECIPHERING LAKE HISTORY

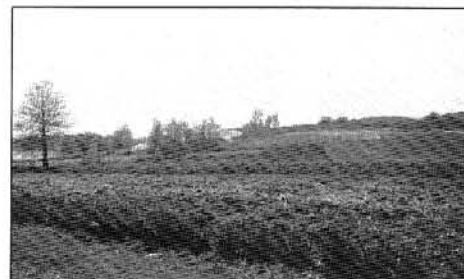
The sandy beach deposits rising above the nearly flat lake plains, especially in the region called the Black Swamp, in northwestern Ohio, captured the attention of Indians, European explorers, and settlers because the ridges provided dry passage through the swamps formed on the former lake beds. The Indian trails along the beach ridges were succeeded by primitive roads and later by paved highways such as U.S. Route 30 west of Delphos and U.S. Route 20 west of Norwalk and east of Cleveland.

Whether or not these early travellers deduced that the sandy avenues were evidence of higher levels of lake waters is not recorded. However, it was not long after the settlement of Ohio that scientists and



Lake Maumee beach ridge, near the intersection of Ohio Route 12 and Ohio Route 69 (now Ohio Route 235), Hancock County. Photo by Jane L. Forsyth, 1958.

naturalists began to speculate on the origin of these unusual ridges. One of the earliest observers was Charles Whittlesey. In the Second Annual Report (1838) of the first Ohio Survey, Whittlesey (p. 55) called these features "Lake Ridges" and observed that Lake Erie must have once stood more than a hundred feet higher than its present elevation. The reason for such a higher lake level perplexed Whittlesey, as he could not account for a natural barrier that would have impounded the waters. The theory of glaciation was just being introduced by Louis Agassiz in Europe at this time and it would be some years before the theory was widely noted, and accepted, in the United States.



Lake Whittlesey beach ridge and dunes, near Berlinville, Erie County. Photo by Jane L. Forsyth, 1958.

The famous British geologist, Sir Charles Lyell, known as the father of geology, visited Cleveland in 1842 and observed the beach ridges under the guidance of Jared P. Kirtland, naturalist for the first Geological Survey of Ohio. Lyell recorded his observations in his book *Travels in North America, 1841-1842*. He noted that the ridges resembled ancient beaches parallel to the shore of Lake Erie. Lyell speculated that the ridges may have been formed beneath the water or formed as beaches along the shoreline.

It wasn't until the latter half of the 19th century, after the acceptance of the idea that vast continental ice sheets had once covered the north-central United States, that a mechanism was available to raise

and lower lake levels by the alternate blocking and freeing of drainage outlets. Charles Whittlesey, John S. Newberry (second State Geologist of Ohio), and Edward W. Claypole, among others, attacked the complex problem of the rise and fall of Lake Erie and its predecessors.

The most comprehensive and definitive works on Lake Erie history were Frank Leverett's U.S. Geological Survey monographs *Glacial formations of the Ohio and Erie basins* (1902) and *Pleistocene of Indiana and Michigan and the history of the Great Lakes* (1915), the latter coauthored with Frank B. Taylor. In the 1915 volume, Taylor wrote the section on Great Lakes history. Both monographs included detailed maps of beach ridges and the former extent of individual lake stages.

Between 1909 and 1916, Frank Carney, professor of geology at Denison University, published extensively on the distribution and extent of beach ridges in northern Ohio. Much of this work was sponsored by the Ohio Geological Survey. Although the Survey never published Carney's detailed maps and report, they survive in the Survey files. Jane L. Forsyth published a generalized version of Carney's maps in her 1959 Survey publication on beach ridges.

Detailed study of beach ridges and lake history continues to the present. The development of radiocarbon dating in the 1950's added a new dimension to the investigation of lake history because lake stages could now be placed in an absolute as well as a relative sequence.

The most comprehensive modern general work on Great Lakes history is the 1958 book by Jack L. Hough, *Geology of the Great Lakes*. A technical volume, *Quaternary evolution of the Great Lakes*, was published in 1985 by the Geological Association of Canada.

BEACH RIDGES— FUNDAMENTAL EVIDENCE

Beach ridges were recognized at an early date by the first geologists to traverse the region, but it took several decades of detailed field work before the beaches representing various stages of Lake Erie, and the other Great Lakes, could be mapped and correlated. Although other geologic evidence has been of great importance in deciphering lake history, the beach ridges have been the primary evidence of lake stages.

A complicating factor in deciphering various lake stages, particularly in the northern Great Lakes, has been a phenomenon known as glacial rebound. When the beaches were being formed along the

shorelines of various lake stages, the land surface was still greatly depressed from the tremendous weight of the recently departed glacier. As the land has slowly risen during the last 14,000 years, the beaches, which formed at equal elevation for each lake stage, have risen at unequal rates dependent upon the local degree of rebound. Consequently, a beach formed during a particular lake stage may be considerably higher in elevation to the east and north in comparison to the same beach to the west and south.

Near the turn of the century, the famous U.S. Geological Survey geologist G. K. Gilbert, who began his career with the Second Geological Survey of Ohio in the 1870's, developed a method for interpreting the degree and extent of glacial, or isostatic, rebound. This concept allowed geologists to begin meaningful mapping and correlation of beach ridges. The glacial ice was not of sufficient thickness in northern Ohio to cause extensive downwarping of the crust, so most beach ridges in Ohio do not exhibit significant deformation.

Although it is unlikely that the history

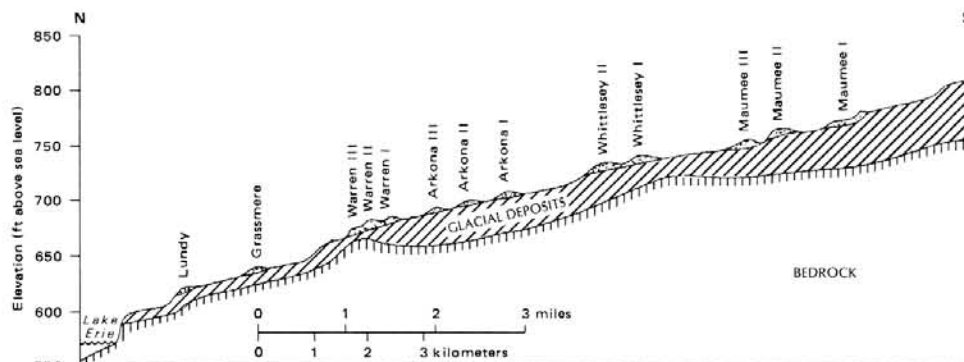
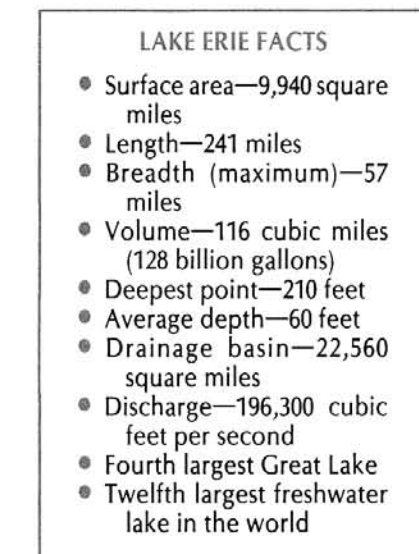
of Lake Erie and the other Great Lakes will undergo major revision, modern studies are continually fitting together more pieces of the complex puzzle. Additional detailed mapping of beach ridges and their associated deposits, such as that being carried out by Survey geologists in the statewide county geologic mapping program, may add significant new insights into the early history of Ohio's Great Lake.

THE FUTURE OF LAKE ERIE

The brief history of Lake Erie presented here illustrates the ephemeral nature of such a body of water. Although the lake will not experience the major changes in lake level it did during the latter part of the Pleistocene Epoch, it is likely that Niagara Falls will eventually migrate upstream to the point where Lake Erie waters enter the Niagara River. At such time Lake Erie will be lowered dramatically and most of the basin will be occupied by a river flowing into Lake Ontario.

Perhaps the more immediate dangers to the demise of Lake Erie are through the process of premature eutrophication—that is, the rapid aging and filling in of the lake from algal growth and increased sediment influx—and contamination with toxic materials. The crystal-clear waters of Lake Erie described by pioneers will never return. The fertile lands of northwestern Ohio, which were lake bottom during preceding lake stages, were opened to agriculture in the late 1800's when the great Black Swamp was drained. Although such fertile lands have been of immense benefit to Ohio, the draining and plowing of the land removed a natural filtration system that prevented sediment from entering streams draining into the lake. Sediments can now freely enter the lake along with fertilizers and pesticides utilized in agriculture.

There are, of course, no easy answers to



Composite cross section of beach ridges showing their elevations and relative positions in Lorain and Cuyahoga Counties. Modified from Totten (1982).

such problems. As many people are beginning to realize, and what has long been evident to professionals in natural resources, there are no free lunches in the ecosystem.

ACKNOWLEDGMENTS

We thank Dr. Jane L. Forsyth of Bowling Green State University and C. Scott Brockman, Donald E. Guy, Jr., Jonathan A. Fuller, and Richard R. Pavey of the Survey staff for their assistance with this article.

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COASTAL GEOLOGY PROGRAM OF THE U.S. GEOLOGICAL SURVEY

The coastlines and wetlands of the United States are experiencing extreme erosion and land loss. Coastal areas are becoming dumping grounds for pollutants, and the concentration of these pollutants is a rapidly growing concern. Additionally, as the U.S. population becomes more concentrated along our coasts, the need for new and replacement cultural and engineering structures and beach nourishment to mitigate erosion is placing large demands on sand and gravel resources. In order to address problems related to erosion and pollution and to assess coastal mineral resources, the U.S. Geological Survey is developing a broad-based Coastal Geology Program consisting of three parts:

- 1) *Coastal erosion*—The overall objective is to better determine the physical processes causing erosion. By better understanding processes, we will be able to improve our ability to predict future erosion. With improved prediction, the appropriate state and federal agencies will be able to properly establish construction setbacks along an eroding shoreline and can better assess the utility of man's attempt to mitigate erosion.
- 2) *Coastal pollution*—The objective is to document and improve our understanding of the processes causing the accumulation of fine sediments and pollutants in coastal waters. Silt- and clay-size sediments have chemically active surfaces which can absorb a wide variety of pollutants. Consequently, processes which control the transport and deposition of fine-grained sediments play a major role in the transport and fate of pollutants. The research will lead to

improved predictions of the location and concentrations of toxic pollutants and the impact of man's activities on the coastal waters.

- 3) *Coastal resources*—The objective is to better understand the processes concentrating hard mineral resources and thus be able to predict locations of economically valuable deposits. Nearshore regions of the U.S. continental shelves offer high potential for certain hard mineral resources. The minerals of greatest value—gold, platinum, and titanium—occur in placer sand and gravel deposits that are the result of the dynamic processes along the coast.

At present, most of the research in the Coastal Geology Program is focused on coastal erosion and wetland processes. Four major studies will be underway in fiscal year 1990.

- "Louisiana barrier island erosion study" in cooperation with the Louisiana Geological Survey
- "Louisiana wetland loss study" in cooperation with the U.S. Fish and Wildlife Service
- "Southern Lake Michigan coastal erosion study" in cooperation with the Illinois State Geological Survey and the Indiana Geological Survey
- "Alabama/Mississippi coastal erosion and pollution study" in cooperation with the Alabama Geological Survey and the Mississippi Bureau of Geology

The USGS, in coordination with the National Oceanic and Atmospheric Administration, will develop a plan of study involving topographic, bathymetric, and geologic mapping relevant to coastal erosion throughout all five Great Lakes. The

plan will be completed during FY 1990.

The present studies are scattered geographically and are focused on specific regional problems. In recognition of these characteristics of the existing program and in awareness of the emerging coastal problems throughout the country, Congress has directed the USGS to develop a plan of study of national scope. During FY 1990, the USGS will work with coastal and Great Lakes states, other federal agencies, and the academic community to develop an appropriate National Coastal Geology Program that reflects regional, topical, and national research needs and that adequately utilizes expertise within the academic community, state agencies such as the Ohio Geological Survey, and federal research laboratories.

—Asbury H. Sallenger, Coordinator
and
S. Jeffress Williams, Associate Coordinator
Coastal Geology Program
U.S. Geological Survey

NATIONAL COAST WEEKS

This issue of *Ohio Geology* focuses on Lake Erie and the Ohio portion of its shoreline—the state's north coast. Our effort is part of the Fall 1989 celebration of National Coast Weeks, an event sponsored by the Coastal States Organization. National Coast Weeks is intended to draw attention to the importance and value of coastal areas, both marine and freshwater.

The Ohio Department of Natural Resources held several events as part of this celebration at various sites along the Lake Erie shore. Among these events were driving tours along the shoreline with stops to examine various coastal processes. These tours were conducted by Donald E. Guy, Jr. and Jonathan A. Fuller of the Survey's Lake Erie Section. One tour began in Cleveland and ended at Headlands Beach State Park in Lake County. The other tour began at Marblehead Lighthouse in Ottawa County and ended in Lorain County.

NEW PUBLICATIONS LIST

The Survey recently issued a new publications list which supersedes all previous lists. The new catalog, titled *List of in-print publications and open-file materials*, contains only those publications currently available from the Survey. Please note that the prices of many publications have changed in the new list. Copies of the new publications list are available at no charge from the Division of Geological Survey, Fountain Square, Building B, Columbus, OH 43224.

LAKE ERIE SECTION

The Lake Erie Section of the Survey began in 1949 as the Lake Erie Geological Research Group within the Division of Beach Erosion (renamed the Division of Shore Erosion in 1950) and in 1961 became a part of the Survey. The principal responsibilities of the Lake Erie Section are the analysis and prediction of erosion rates along the Ohio shore of Lake Erie and mapping of the distribution and characteristics of bottom sediments in the lake.



The Survey's 48-foot research vessel, the GS-1.

The Survey maintains an office in Sandusky from which Lake Erie studies are performed. Central to the completion of these studies is the Survey's 48-foot research vessel, the GS-1. This steel-hulled boat was built in 1953 and underwent a major overhaul in 1986. The GS-1 is used principally for bottom-sediment studies, seismic reflection profiling, water-current studies, and as a base for studies of shore erosion. LORAN-C and radar are used for navigation and precise positioning of the vessel during data-gathering activities.

A principal function of the Lake Erie Section has been to evaluate the significant problem of erosion of the Ohio shore of the lake. Valuable lakefront property is annually consumed by waves along many sections of the shore, a circumstance of great concern to lakeshore residents and local government officials. In a series of county shore-erosion studies, researchers in the Lake Erie Section have characterized the susceptibility of the shore materials to erosion and, through analysis of older maps and air photos, attempted to predict future recession.

Another principal focus of the Lake Erie Section is characterization of the subbottom sediment in the lake. Data are gathered by a specially designed vibratory coring device operated from the GS-1. Such information may enable the Survey to locate new deposits of sand and provide important data on the geologic history of Lake Erie.

Instrumental to the understanding of the dynamic interactions along the lake-shore is detailed knowledge of wave activity and sand transport. Such knowledge can be used to design more efficient shore-

protection structures and to develop beach-nourishment projects for preserving or rebuilding the Lake Erie beaches.

Through the years, the Lake Erie Section has made significant progress towards a better understanding and characterization of the Lake Erie shoreline. However, a number of important projects remain to be completed, particularly a coring project in the central basin of the lake and wave and sand-transport studies.

SEABED DRIFTERS

As part of a study to track sediment movement in Lake Erie in order to restore and nourish beaches, personnel from the Lake Erie Section of the Survey released 25 seabed drifters from the Survey research vessel, the GS-1, on September 18, 1989. The drifters were released about 2,000 feet offshore from the Cedar Point spit in Erie County. This site was used in 1987 for disposal of sandy sediment dredged from the federally maintained navigation channel at Sandusky. Additional drifters were released in mid-October, and more will be released next spring.

The drifters provide information on sediment movement in the vicinity of the disposal site. Data derived from the study will be used to adjust disposal areas at existing sites and to locate new sites for disposal of sandy sediment dredged from Sandusky and other harbors.

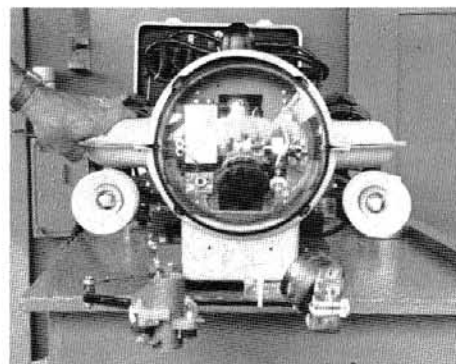
Each drifter is a red, 7.5-inch-diameter plastic disk attached to a 20.5-inch-long plastic stem. A 14-gram weight attached to the stem prevents the drifter from rising in the water column during storms. Also attached to the plastic stem is a card asking the finder for information as to when and where the drifter was found.

REMOTE UNDERWATER ROBOT VISITS LAKE ERIE

The Survey's research vessel, the GS-1, was used in August for an unusual task—it served as the support platform for an underwater Remotely Operated Vehicle (ROV) to study Lake Erie. The project demonstrated the usefulness of ROV technology for a team of visiting scientists interested in studying Lake Erie's geology, geochemistry, biology, and fisheries. The scientists took turns using the ROV to conduct a series of underwater scientific experiments across the lake bed. The eight-day cruise started in the western basin near the Niagara reef, west of the Bass Islands; underwater traverses continued at the Lorain-Vermilion sand-dredging and confined-disposal sites, the Cleveland spoil-disposal site, and the deep area in

the eastern basin off Erie, Pennsylvania.

The project is part of the Great Lakes of the World Program sponsored by the National Oceanic and Atmospheric Administration. The science team was headed by Dr. Timothy Wilson of Kent State University and included Jonathan Fuller and Richard Pavey of the Division of Geological Survey; Roger Knight of the Ohio Division of Wildlife; Kevin Breen, Donna Myers, and Gregory Koltun of the U.S. Geological Survey Water Resources Division office in Columbus; Dr. Peter McCall and Dr. Gerald Matisoff of Case Western Reserve University; Dr. Donald Hall of Michigan State University; and Dr. Douglas Lee of the University of Connecticut.



Head-on view of Remotely Operated Vehicle (ROV).

The 3-foot-long ROV was tethered to the GS-1 during operation and had a video camera for viewing and taping the lake bottom. The ROV was "flown" through the water by David Lavalvo of Oceanics Research Corp., who used joy sticks and an onboard video monitor much like a video game. The ROV's mechanical claw held a variety of sediment-sampling devices and a pump system for collecting water samples from the bottom. Other devices, such as plankton nets, were mounted on the ROV for biological studies. In essence, the ROV placed the scientists' eyes and hands on the lake floor to make accurate measurements, to videotape bottom conditions, and to collect samples not readily available using traditional methods.

Ohio Geological Survey personnel used the ROV to begin evaluating the potential for expanding the Lorain-Vermilion sand-dredging area. Wildlife personnel evaluated fish-spawning areas in the lake. While researchers are currently evaluating the data collected from this year's cruise and reviewing the many hours of videotape collected, plans are already underway to bring the ROV back to Lake Erie next summer.

—Timothy Wilson and Lori Lesney
Department of Geology
Kent State University

I-77 ROAD GUIDE

The Survey recently issued Educational Leaflet No. 15, *Guide to the geology along Interstate 77 between Marietta and Cleveland*. This full-color leaflet was authored by Survey geologist and *Ohio Geology* editor Michael C. Hansen.

The road guide describes Devonian through Permian rocks, glacial deposits, mineral industries, and environmental geology along the 165-mile Ohio portion of Interstate 77. Twelve areas along the high-

way are featured in the text with descriptions of the geologic feature and its origin. Each highlighted feature is located by number on strip maps of bedrock and glacial geology. The leaflet also contains a summary of the geologic history of the area, supplemented by paleogeographic maps and a north-south cross section.

Educational Leaflet No. 15 is another in a series of guides to the geology along Ohio's major transportation routes. Others in the

series are Educational Leaflet No. 11, *Guide to the geology along U.S. Route 23 between Columbus and Portsmouth*; Educational Leaflet No. 13, *Guide to the geology along Interstate 75 between Toledo and Cincinnati*; and Educational Leaflet No. 14, *Guide to the geology along Interstate 70 between the Ohio-Indiana boundary and Columbus*. Single copies of these leaflets are available free of charge from the Division of Geological Survey, Fountain Square, Building B, Columbus, OH 43224.

QUARTERLY MINERAL SALES, JANUARY—FEBRUARY—MARCH 1989

compiled by Sherry W. Lopez

Commodity	Tonnage sold this quarter ¹	Number of mines reporting sales ¹	Value of tonnage sold ¹ (dollars)
Coal	8,468,413	182	249,909,998
Limestone/dolomite ²	6,951,539	102 ³	26,251,820
Sand and gravel ²	4,895,428	190 ³	15,134,420
Salt	1,104,741	5 ⁴	15,098,605
Sandstone/conglomerate ²	379,432	23 ³	4,654,880
Clay ²	230,999	22 ³	540,259
Shale ²	361,697	14 ³	428,046
Gypsum ²	59,445	1	564,728
Peat	8,301	1	36,259

¹These figures are preliminary and subject to change.

²Tonnage sold and Value of tonnage sold include material used for captive purposes. Number of mines reporting sales includes mines producing material for captive use only.

³Includes some mines which are producing multiple commodities.

⁴Includes solution mining.

QUARTERLY MINERAL SALES, APRIL—MAY—JUNE 1989

compiled by Sherry W. Lopez

Commodity	Tonnage sold this quarter ¹	Number of mines reporting sales ¹	Value of tonnage sold ¹ (dollars)
Coal	6,927,617	174	229,356,445
Limestone/dolomite ²	9,295,458	88 ³	33,366,606
Sand and gravel ²	10,313,402	200 ³	33,730,452
Salt	862,562	5 ⁴	7,149,574
Sandstone/conglomerate ²	428,065	21 ³	6,211,903
Clay ²	367,613	24 ³	970,430
Shale ²	448,110	16 ³	489,503
Gypsum ²	57,602	1	547,219
Peat	7,100	1	32,272

1990 ODNR CALENDAR

The 1990 Ohio Department of Natural Resources calendar is now available. This year's 13-month calendar features color photographs of Ohio birds. Each month features a different bird, field notes on that particular species, and a list of ODNR events. Also provided, on separate pages at the end of the calendar, are location maps and lists of state forests, nature preserves, parks, public boating areas, and public hunting and fishing areas. Each list includes the location of the area, available facilities, activities, and other pertinent information.

The 1990 ODNR calendar is available for \$3.92, which includes tax and mailing, from Publications Center, Ohio Department of Natural Resources, Fountain Square, Building B, Columbus, OH 43224.

Ohio Department of Natural Resources
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