SPRING 1988

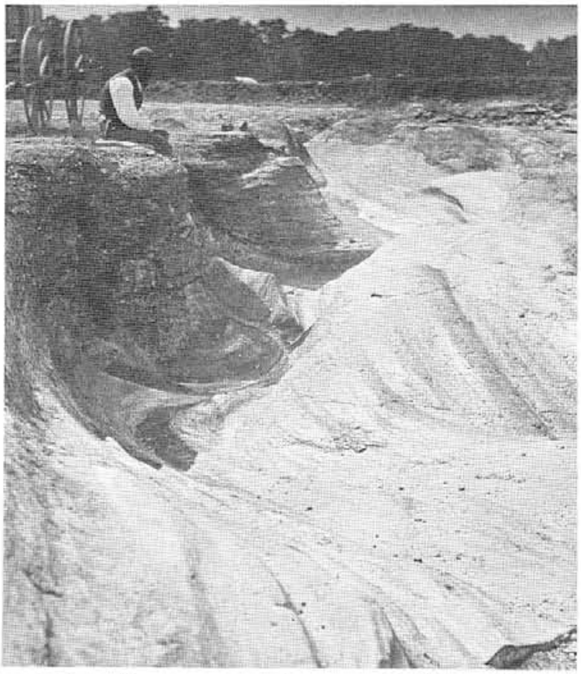
Ohio Geology Newsletter

Division of Geological Survey

GLACIAL GROOVES: "ROCK-SCORINGS OF THE GREAT ICE INVASIONS": REVISITED

by Michael C. Hansen

Glacially formed grooves, striations, and gouges and planed and polished rock surfaces are common features in Ohio and are particularly well developed on the limestone and dolomite bedrock in the western and central portions of the state. The glacial grooves on Kelleys Island, in western Lake Erie, are among the most spectacular and well-known glacial grooves in the world and have been an attraction to both geologists and tourists for more than a century. The origin of such grooves is still a topic of debate and speculation among geologists, and these and other grooves and striations in Ohio were among some of the most formidable evidence cited in the nineteenth century for the former presence of continental glaciers in the northern United States.



Portion of a megagroove known as the "Great Groove" (now destroyed) that was in the Old North Quarry and parallel to the megagroove now displayed in the state park on Kelleys Island. Note the sinuosity of the groove channel. Photo by A. C. Platt, circa 1872-1873, courtesy of the Ohio Historical Society.

Glacially planed and striated surfaces on limestone bedrock attracted the attention of early geologists and particularly geologists of the First Geological Survey of Ohio. W. W. Mather, Ohio's first State Geologist, authored a section titled "Geological Queries" in the First Annual Report of the Survey in 1838. This section, directed to landowners in the state, presented a long list of questions that were to be used as a guide in geological observations of features on an individual's property. Among Mather's inquiries were: "Where ledges of rock have been recently uncovered by excavation, are the surfaces smooth?" and "Do any of the surfaces show grooves and scratches, as if hard masses had been dragged over them?"

The short duration of the First Geological Survey precluded Mather publishing or commenting on citizens' responses to these queries. However, one of Mather's assistant geologists, Dr. John Locke, addressed the questions admirably in the Second Annual Report of the Survey, published late in 1838.

"Diluvial grooves" in Mr. Light's quarry, north of Dayton, as illustrated by John Locke in the 1838 Second Annual Report of the First Geological Survey of Ohio.

continued on next page

ODNR
OHIO DEPARTMENT OF NATURAL RESOURCES

Richard F. Celeste, Governor • Joseph J. Sommer, Director

Chief's corner by Horace R. Collins

The Division of Geological Survey is again offering its Ohio Mineral Industry Workshop for junior and senior high school science teachers this year, in June (see announcement elsewhere in this issue for details). This workshop, designed especially for science teachers, received extremely high marks from last year's participants. This year's participants will hear from industry, regulatory, academic, and Survey experts on the geology and mineral resources of Ohio, with special emphasis on the role of minerals in modern society.

The program offers an excellent opportunity for teachers to gain first-hand knowledge of minerals and their significance, obtain valuable source materials, and become acquainted with some of the "key players" in the Ohio geology and mineral resource scene.

Attendees will participate in both a two-day and a one-day field trip to gain hands-on experience with active mines, a coal-cleaning plant, a brick plant, a silica plant, an oil and gas well, waste-disposal facilities, prehistoric quarries, and innovative reclamation projects. An additional two days of lectures will supplement the program and provide source materials for teaching units. Participants may also receive two hours of graduate credit through the University of Akron.

Last year's attendees were unanimous in their praise for the quality of the workshop and its usefulness to them as teachers. We hope this year's workshop will be equally well attended and received. In addition to the Department of Natural Resources and the University of Akron Center for Environmental Studies, the Ohio Mineral Industry Workshop is supported by the Ohio Aggregates Association, the Ohio Oil and Gas Association, the Ohio Mining and Reclamation Association, and the Ohio Coal and Energy Association.

MINERAL INDUSTRY WORKSHOP

A workshop designed to familiarize educators with the geology and economic mineral resources of Ohio will be held June 27-July 1, 1988, at ODNR headquarters in Columbus. The Mineral Industry Workshop is sponsored by the Survey and the University of Akron. For additional information, contact Dr. Jim Jackson, University of Akron, Oak Hill Center, 4570 Akron-Peninsula Road, Peninsula, Ohio 44264 (Telephone: 216-657-2815). Deadline for registration is June 1, 1988.

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Locke gave a detailed description, illustrated by an engraved plate, of the striations and planed surface of limestone (Silurian in age) in "Mr. Light's quarry," 7 miles north of Dayton. Locke was particularly impressed with the smooth surface of the limestone, which was "completely ground down to the plane as perfectly as it could have been done by a stone cutter, by rubbing one slab on another, with sand between them," and by the "diluvial grooves" (Locke's quotation marks) that marred the smooth surface.

OHIO GEOLOGY

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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.

Louis Agassiz's glacial theory, proposed in Europe in 1837 but not widely published until 1846, may not have been known to Locke or others of the First Geological Survey of Ohio, but certainly Locke may have been close to proposing a similar mechanism for the origin of planar surfaces and grooves on Ohio's bedrock. The following statements by Locke in his discussion of Light's quarry suggest that he was certainly considering ice as the mechanism, although there is no direct hint that he perceived the ice to have been part of an extensive continental glaciation.

> In many places, in addition to the planishing, grooves and scratches in straight and parallel lines, evidently formed by the progress of some heavy mass, propelled by a regular and uniform motion, are distinctly visible.
>
> The grooves appear as if they had been formed by icebergs floating over the terrace, which is the highest in the neighborhood, and dragging gravel and boulders frozen into its lower surface, over the plane of the stone. The rectilinear course of these grooves corresponds with the motions of an immense body, the momentum of which does not allow it to change its course upon slight resistances.

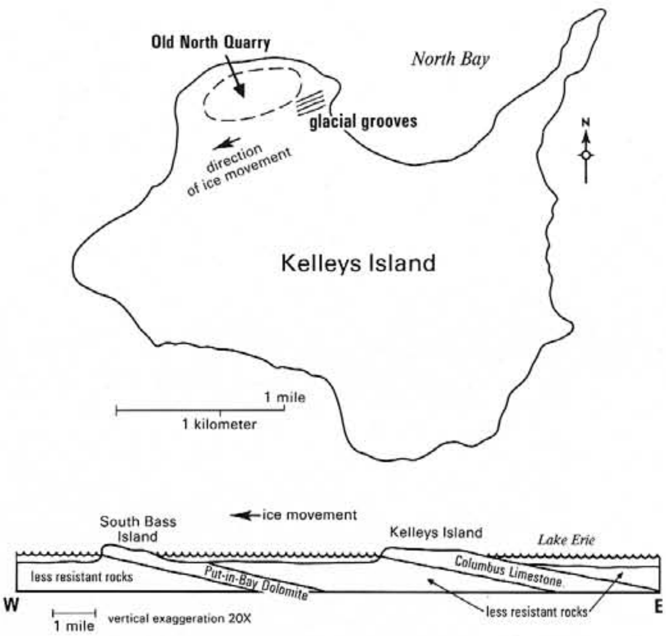
American geologists were slow to embrace Agassiz's theory of glaciation, but Ohio, and Ohio geologists, soon became a focal point for exposition of the idea. Samuel St. John, professor of geology at Western Reserve College (then at Hudson, Ohio) and mentor of Ohio's second State Geologist, John Strong Newberry, was apparently the first American convert, in 1851, to the glacial theory. Charles Whittlesey, an assistant to Mather on the First Geological Survey, earned the reputation as the first glacial geologist in North America through a number of publications on the topic. Newberry, Whittlesey's rival for the position of State Geologist of Ohio in 1869, succeeded Whittlesey as the leading student of glacial geology in America.

Among the early debates (which continued into the 1890's) among geologists on glaciation in the United States was the erosive power of ice. Both Newberry and Whittlesey expounded, and apparently developed independently, the idea that glacial ice had sufficient erosive power to form planed and grooved bedrock surfaces and even to excavate basins such as those occupied by the Great Lakes.

Serving as fuel for these debates were numerous papers describing glacial grooves and striations. The pinnacle of these contributions was T. C. Chamberlin's 1888 U.S. Geological Survey Annual Report, ostentatiously titled "The rock-scorings of the great ice invasions." In more than 100 pages, Chamberlin, a leading glacial geologist, examined the erosive power of ice, the distribution of glacially induced grooves and striations in North America, the various categories of such phenomena, and possible modes of origin of these features. The evidence from Ohio figured prominently in this treatise, with 19 of the 50 illustrations being from the state—five were of grooves on the surface of the Berea Sandstone at Amherst and 14 were of the famous grooves at Kelleys Island.

KELLEYS ISLAND GLACIAL GROOVES

Undoubtedly, the most famous, most visited, and most photographed glacial grooves, by both geologists and the general public, are the ones on Kelleys Island in western Lake Erie. This 4.5-square-mile island, the second largest in Lake Erie (Canadian-owned Pelee is larger), is composed almost entirely of Columbus Limestone (Middle Devonian) with a thin veneer of till.



Map of Kelleys Island showing locations of glacial grooves and direction of ice movement. The cross section of western Lake Erie (modified from Carman, J. E., 1946, Ohio Journal of Science, v. 46, no. 5, p. 282) illustrates how the resistant Columbus Limestone and Put-in-Bay Dolomite form Kelleys Island and South Bass Island, respectively. Ice movement was from east to west, up dip, and formed a gently sloping eastern shoreline and steep, cliff-dominated western shoreline on these islands.

Much of the island, particularly on the north and east sides, exhibits evidence of grooves, striations, and glacially planed surfaces. Such features are reported to have attracted the attention of European visitors to the island very early in the nineteenth century. Apparently, the first published notice of the remarkable grooves on the island was by Charles Olmstead of Connecticut in 1833, a year that also marks the acquisition of the island by Irad and Datus Kelley and the beginning of limestone quarrying in the area.

The spectacular grooves on the island, particularly those exposed by quarrying operations on a limestone ridge on the north side of the island, became the focus of attention in the 1870's and 1880's for a number of prominent geologists, including Whittlesey, Newberry, Chamberlin, and G. K. Gilbert. By the late 1800's the glacial theory was universally accepted in North America; grooves such as those on Kelleys Island played no small part as evidence of this glaciation. The grooves now served as a testimonial to the erosive forces of continental glaciers. In 1888, the same year that Chamberlin's monograph was published, the Kelleys Island grooves received national attention when they were the focus of a field trip in conjunction with the annual meeting of the American Association for the Advancement of Science in Cleveland.

Although glacial grooves have been found at numerous locations on Kelleys Island, the most spectacular ones were on a northeast-southwest-oriented ridge on the north side of the island. This ridge forms the highest part of the island and was the site of initial quarrying operations, beginning in 1833. This area is now known as the Old North Quarry.

Glacial grooves were discovered soon after limestone quarrying began and, as noted above, they attracted wide attention. The grooves uncovered during removal of overlying till prior to quarrying, particularly during the 1870's, are reported to have been the largest and most spectacular on the island. These grooves included one deep groove, known as the "Great Groove," parallel to the existing groove at the state park. Unfortunately, the Great Groove and others were destroyed by quarrying activities.

Although we are today horrified by the fact that such unique and spectacular grooves were quarried and sold as bulk limestone, in all fairness we must keep in mind the fact that the nineteenth century was not a time in our history in which conservation and preservation of natural features were high priorities of society.

Partially exposed megagroove on the shore of North Bay, Kelleys Island. It is thought that this portion of a groove, now destroyed, was continuous with the megagroove on display in the state park. Photo by A. C. Platt, circa 1872-1873, courtesy of the Ohio Historical Society.

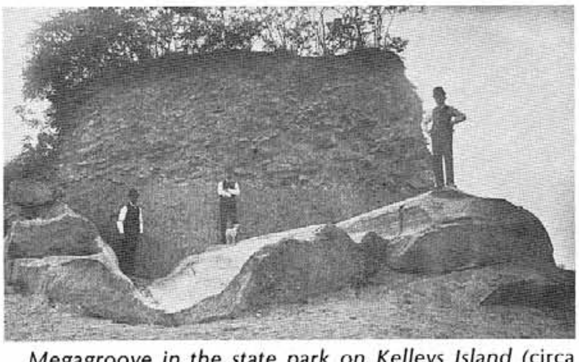
Despite this attitude, the spectacular grooves did elicit some pangs of preservationism in the quarrymen. Newberry, writing in Volume 1, Part 1 (1874), of the Second Geological Survey of Ohio, indicated that J. W. Dunn, foreman of the G. W. Calkins and Company quarry, had the grooves photographed so that some record of them would be available after they had been quarried away. That this was not a casually done exercise is evidenced by the photographs, which show the spectacular grooves cleaned of thick, hard till and other overburden.

This nineteenth-century photographic record of the grooves, although by no means an adequate substitute for preservation of the original grooves, does provide documentation of them. There are, apparently, a large number of such photographs, probably taken by a variety of photographers. The most famous photographs were taken by A. C. Platt of Sandusky, Ohio. Chamberlin, in his 1888 monograph on grooves and striations, utilized engravings of some of Platt's photographs. Apparently, Platt produced some quantity of these photos as stereoscopic pairs designed for parlor-room stereoscopes popular in the era. The Kelleys Island photos were under the series title, "The Isles of Lake Erie."

None of the Platt photographs of the glacial grooves are dated; however, one of them shows the steamer *B. F. Ferris* at the dock in North Bay on Kelleys Island. According to Charles E. Frohman's book, *Put-in-Bay* (1971, The Ohio Historical Society), the *B. F. Ferris* plied the waters of western Lake Erie from 1872 through 1882. It is probable that the Platt photos were the ones referred to by Newberry (1874) that were taken in the G. W. Calkins Quarry. This information suggests that the Platt photos of the grooves were taken in 1872 or 1873.

EXCAVATION OF THE MODERN GROOVES

In 1932, with cessation of limestone quarrying on the north side of Kelleys Island, the Kelleys Island Lime and Transport Company and the Cleveland Museum of Natural History donated land, totalling 7 acres, to the State of Ohio that included a 35-foot-long section of glacial grooves. These grooves became a State Memorial under the jurisdiction of the Ohio Historical Society, and the adjacent lands eventually became a state park under the jurisdiction of the Ohio Department of Natural Resources.



Megagroove in the state park on Kelleys Island (circa 1891) before it was completely exposed by the Ohio Historical Society in the early 1970's. Overburden visible in the background consists of clay-rich till at the base and overlying limestone blocks that represent fill from old quarry operations. Photo courtesy of the Ohio Historical Society.

This small but interesting set of glacial grooves served as a popular tourist attraction for the next three decades. In 1971, the Ohio Historical Society began, under the direction of Carl Albrecht and Reed Masse, a project to remove overburden above the apparent continuation of the grooves into the hillside. Using a backhoe, geology students from Ohio State University, and various laborers to excavate and clean the grooves, the Ohio Historical Society unveiled a sight which exceeded all expectations. A 34-foot-wide, 15-foot-deep channel was exposed for nearly 400 feet. Early photographs and records indicate that this set of grooves formerly extended about 150 feet west (into the Old North Quarry) and about 300 feet east to the shore of North Bay.

The exposed channel, or megagroove, revealed intricate fluting, deep undercuts, and a highly polished surface on the Columbus Limestone and rivaled the grooves quarried away during the last century. This magnificent exposure, owned by the Ohio Historical Society and since 1981 under the management of the Division of Parks and Recreation of the Ohio Department of Natural Resources, now serves as a marvel for both the general public and the many geologists who visit the site annually.

ORIGIN OF THE KELLEYS ISLAND GROOVES

To most of the public, perhaps, the explanation that the grooves were "carved by the glaciers of the Ice Age" is sufficient to satisfy their curiosity. But to most geologists, beginning with those who first studied the grooves in the last century, such an explanation is hardly sufficient to explain how glacial ice managed to form such intricate, convoluted features and why such features appear to be concentrated in some places and absent in others, even though the bedrock is similar.

There seems to be little disagreement that shallow scratches or striations on bedrock surfaces were cut by pebbles embedded in the ice; however, the deep, sinuous, commonly undercut grooves such as those on Kelleys Island have sparked imagination and speculation. G. K. Gilbert, the famous U.S. Geological Survey geologist, provided, during his early years of training with the Ohio Geological Survey, an observation that may explain the localized nature of deep grooves. Gilbert (1873, Ohio Geological Survey, Volume 1, Part 1) observed "The tendency . . . of glacial ice to prolong a resisting knob into a ridge and [to prolong] a cavity into a groove, seems to afford a better explanation of the long, smooth, even furrows so frequently seen, than the theory that they have been engraved or plowed by large bowlders." Gilbert thus attributed such grooves to preexisting topographic features.

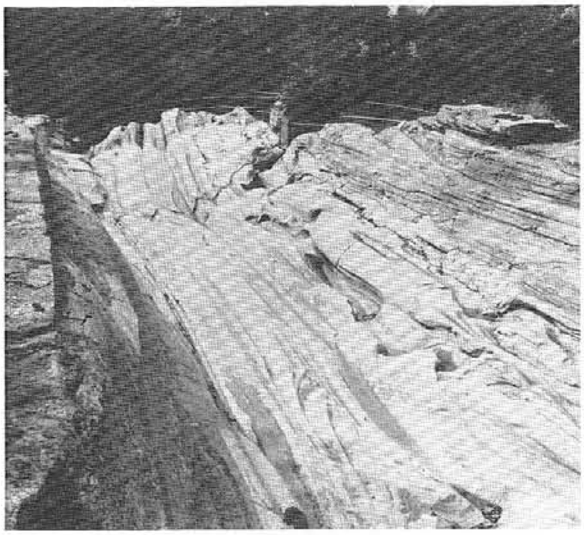
Excavation of glacial grooves on Kelleys Island by the Ohio Historical Society, June 1973. Workers are removing till which filled the grooves. Ice movement was from left to right. Photo courtesy of the Ohio Historical Society.

Although Charles Whittlesey accepted the theory that small grooves and striations were cut by pebbles and boulders in the base of the ice, in 1879 he suggested a different origin for the deep, sinuous grooves on Kelleys Island. Rather than being subglacial features, Whittlesey imagined such unusual grooves to have been cut at the margin of the glacier by running water flowing, at considerable pressure, from beneath the ice and being highly charged with sand and gravel.

Similar debates and speculations have emerged from time to time since the days of Gilbert and Whittlesey, but it was not until the 1971 excavation by the Ohio Historical Society that a unique opportunity arose to reconsider the origin of the Kelleys Island grooves. Dr. Richard P. Goldthwait of Ohio State University and several of his students were closely involved with the excavation process and were able to examine the fresh, unweathered surface of the limestone and examine the fill material in the grooves.

Their studies concluded that the large channellike megagrooves on Kelleys Island represent small, preexisting stream channels into which fast-moving glacial ice, near the pressure-melting point, was funneled. Angular rock debris in the base of the ice served as cutting tools to scour out the intricate second- and third-order grooves within a megagroove. Much of the limestone surface of the grooves exhibited a high polish (which disappeared through weathering within one season) that probably was formed by clay till in the base of the glacier acting as a polishing agent.

Goldthwait suggested that the principal carving of the Kelleys Island grooves took place between 25,000 and 15,500 years ago—the time of late Wisconsinan glaciation in Ohio—because of the fresh, unweathered till that filled the grooves. He also suggested that the principal cutting may have taken place beneath thick ice (perhaps a mile thick) at or near maximum glaciation. As the ice traveled southward from Canada it was deflected westward by the Erie basin (grooves on the Erie islands have orientations just a little south of west), where it further deepened the basin and was squeezed upward over higher areas such as the Erie islands.



Glacial grooves as they are now visible on Kelleys Island.

Goldthwait's conclusions may provide an important clue as to why large, deep glacial grooves such as those on Kelleys Island are apparently not found throughout the glaciated limestone terrain of western and central Ohio, even though the bedrock is similar in many of these areas. Although glacially planed and polished surfaces bearing shallow scratches and striations are common, large, deep grooves seem to be lacking except on the Erie islands and in areas within a few miles of the lakeshore.

The apparent dearth of large grooves in other areas may be a reflection of the rapid thinning of the ice sheet south of the Erie basin. Such thin ice may have lacked the necessary dynamics at its base to form such deep and spectacular grooves. Even some of the earliest known and best studied evidence of glaciation in Ohio still holds its mysteries.

FURTHER READING

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NEW BOOK ON LAKE ERIE SHORELINE PROBLEMS

Duke University Press, in conjunction with the National Audubon Society, has published another fine book in their *Living with the shore* series—this one concentrates on Lake Erie and will be of particular interest to Ohioans. The senior author of this volume, Dr. Charles H. Carter, is well qualified for this task, having served for 10 years as Head of the Lake Erie Section of the Division of Geological Survey. Dr. Carter is now an associate professor of geology at the University of Akron, where he specializes in research on coastal processes. Additional authors of the volume are William J. Neal, William Haras, and Orrin H. Pilkey, Jr.

This very readable 224-page book, written at a technical level that is intelligible to those with a minimal technical background, gives an excellent summary of Lake Erie history, coastal dynamics, and the influence of man on the shoreline. An extensive section, titled "Selecting a site on the Lake Erie shore," is devoted to practical criteria for choosing a building site. The entire shoreline is divided into sections and each section is accompanied by a discussion, photos, and a map that gives the type of shoreline material and divides the shoreline into hazard zones of low to high risk.

This book discusses government programs that deal with the Lake Erie shoreline in the U.S. and Canada and has an extremely useful list of federal, provincial, and state agencies involved in coastal development. A bibliography provides the reader with an overview of important literature.

Living with the Lake Erie shore is available from Duke University Press, 6697 College Station, Durham, NC 27708 for $12.95 (paper) or $35.00 (cloth). Please add $1.95 for the first copy and 60¢ for each additional copy to cover postage and handling.

SURVEY STAFF CHANGES

GOINGS

Jack A. Leow, Geologist, Regional Geology Section, to Division of Water, Ohio Department of Natural Resources.

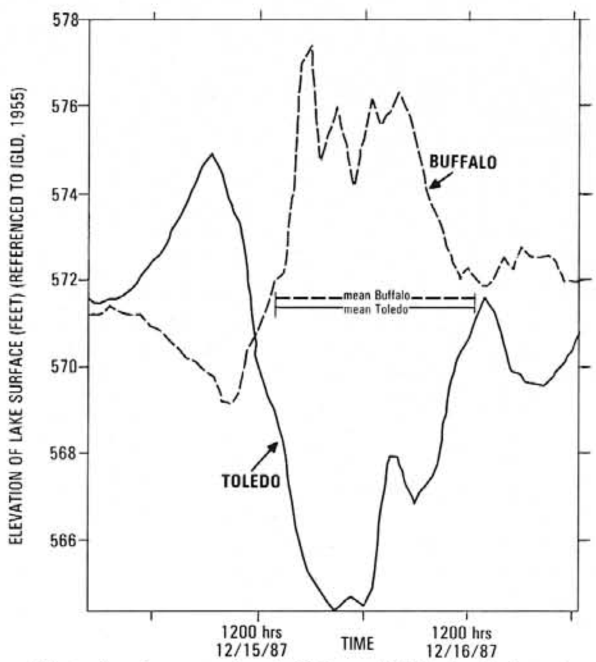
Katherine M. Peterson, Geologist, Regional Geology Section, to Division of Water, Ohio Department of Natural Resources.

STORM-INDUCED WATER-LEVEL CHANGES IN LAKE ERIE

Storm surges, or wind tides, are the result of wind blowing across the surface of a lake. The wind not only builds waves, but also pushes surface water in the direction that the wind is blowing. The result of this pushing is a tilted water surface with a lower elevation at the upwind end of the lake and a correspondingly higher elevation at the downwind end. Following a storm, the tilted water surface attempts to return to a state of equilibrium and in the process "sloshes" back and forth several times—such sloshing events are known as seiches.

Lake Erie storm surges/wind tides are most severe when the wind blows from the southwest or northeast, along the major axis of the lake. In addition to wind direction, the amount of time (duration), the distance over open water (fetch), and the speed of the wind affect the magnitude and position of the tilted water surface. A 1975 study by the National Oceanic and Atmospheric Administration (NOAA) examined storm frequencies from 1940 to 1972 and calculated that a setdown (depression of the water surface) at Toledo of 4.5 to 5.0 feet occurs about once each year and a setdown of 7 feet or greater has a recurrence interval of 16.5 years.

The storm of December 15 and 16, 1987, illustrates the effect of storm surges on Lake Erie. This event started with a northeast wind that tilted the water surface; setup (raising of the water surface) at Toledo, at the western end of the lake, was about 3.6 feet above the mean lake level and setdown at Buffalo, at the eastern end of the lake, was about 2.5 feet below the mean. Near noon on December 16th the wind shifted rapidly from northeast to south and then to southwest and was accompanied by an increase in speed.



Water-level curves for Buffalo and Toledo during the storm of December 15-16, 1987.

Following the shift in wind direction, the lake water, which had been moving to the southwest, began to move in the opposite direction. The lake level at Toledo then dropped to 7 feet below the mean, resulting in a total drop of lake level of 10.6 feet from the morning setup. This change occurred in only 14 hours. The National Weather Service had broadcast a flood warning to communities in the western basin on the morning of December 16th, but by that evening lake levels had dropped so dramatically that the flood warning was replaced by a notice to the shipping industry that water levels would be below critical levels in the channels of the western basin.

At Buffalo the water level rose 5.8 feet above the mean after the wind shift to the southwest. This 8.3-foot rise from the morning setdown of 2.5 feet below the mean occurred in 9 hours. Adding the 8.3-foot change at Buffalo to the 10.6-foot change at Toledo ranks this event as having one of the greatest changes in water levels recorded within a 24-hour period on Lake Erie.

The length of time that the lake was held in a tilted state is a measure of duration of a storm. During the December 1987 storm the water level at Toledo remained at least 2 feet below the mean for more than 20 hours, while at Buffalo the water level remained at least 2 feet above the mean for more than 16 hours.

Comparison of the December 1987 storm with past storms with southwest-blowing winds suggests that the reasons the December 1987 event stands out are the magnitudes and rates of rise (Buffalo) and fall (Toledo) of the lake level rather than the absolute levels achieved. The relative levels for this storm are large because the magnitudes of the changes were accentuated by the early storm setup at Toledo and setdown at Buffalo. Water-level records show that a storm on December 2, 1985, was more intense, but water levels in the western basin did not reach the minimums of the 1987 event. A storm on April 6, 1979, created the greatest recorded elevation difference between Toledo and Buffalo (16.7 feet) but lacked the duration of the 1985 and 1987 storms. Events such as these occur periodically on Lake Erie and serve to demonstrate the dynamic nature of this body of water.

—Jonathan A. Fuller
Lake Erie Section

FURTHER READING

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Pore, N. A., Perrotti, H. P., and Richardson, W. S., 1975, Climatology of Lake Erie storm surges at Buffalo and Toledo: NOAA Technical Memorandum NWS TDL-54, 28 p.

Richardson, W. S., 1979, A frequent visitor to Lake Erie (storm surges): Mariners Weather Log, v. 23, no. 6, p. 375-378.

RESEARCH IN OHIO GEOLOGY, 1986-1987

Every two years the Division of Geological Survey canvasses academic, government, and other researchers in order to compile a list of current research projects dealing with the geology of Ohio. Anyone who has initiated, completed, or published research on Ohio geology in 1986 or 1987 is asked to provide the title, author(s), and projected completion date/publication citation for each project. We are particularly interested in thesis and dissertation projects. Reporting forms can be obtained from Merrianne Hackathorn at the Survey (telephone 614-265-6590). The nominal deadline for submission of forms was March 31, but late forms will be accepted. Each researcher submitting a form receives a free copy of the compilation. Please note this request is for current or recent research on Ohio geology only.

NEW MAGNETIC ANOMALY MAPS

The U.S. Geological Survey recently released an additional set of maps, on a single sheet, in its geophysical map series for Ohio. This publication, Map GP-967, *Filtered magnetic anomaly maps of Ohio,* by T. G. Hildenbrand, was prepared in cooperation with the Ohio Division of Geological Survey, and gives Ohio perhaps the most comprehensive, publicly available suite of geophysical maps of any state. Other maps in this series include GP-961, *Residual total magnetic intensity map of Ohio,* GP-962, *Complete Bouguer gravity anomaly map of Ohio,* and GP-963, *Gravity anomaly maps of Ohio.*

The latest, and final, map in this series, GP-967, consists of five separate maps at a scale of 1:1,000,000. Three of these maps are computer-generated color maps in which magnetic intensity is indicated by a color gradient. Each of the three maps presents the same magnetic data set modified by various filtering techniques to enhance certain aspects of the magnetic anomalies in order to provide information for interpretation of specific features.

Of the three color maps, the *Residual total magnetic field reduced to the north magnetic pole* map shifts the anomalies so that they are centered above the source of the anomaly. The *First-vertical derivative of the magnetic field* map enhances the resolution of small, local anomalies. The *Magnitude of the horizontal gradient of the pseudo-gravity field* map delineates structural boundaries and contacts between various rock types.

The other two maps in the series are shaded (black-and-white) magnetic relief maps and resemble aerial photographs of surface topography; however, the hills and valleys are actually areas of high or low magnetic intensity in basement rocks. One map has an artificial illumination angle from the northwest, whereas the other map is illuminated from the northeast. These shaded-relief maps tend to enhance lineaments perpendicular to the direction of illumination and to enhance local anomalies while suppressing regional magnetic gradients.

This map, GP-967, along with the other magnetic and gravity maps in the series, provides a remarkable insight into the complexity of the crystalline basement rocks beneath Ohio. This information, coupled with the COCORP profile (see *Ohio Geology,* Fall 1987) across the state, may open a new era in the interpretation of many aspects of the geology of Ohio and, conceivably, could inaugurate exploration for hydrocarbons and mineral commodities in areas that have previously received little consideration in this regard. GP-967 is available from the Division of Geological Survey for $3.28, which includes tax and mailing.

SURFICIAL MATERIALS OF PORTAGE COUNTY

The Division of Geological Survey recently issued Report of Investigations No. 138, *Surficial materials of Portage County, Ohio,* authored by Dennis N. Hull. This 1:62,500-scale map, on a single sheet and accompanied by explanatory text, depicts the distribution of various sediments that characterize the upper 25 feet of the land surface of Portage County.

Most of these sediments were deposited by or in association with Wisconsinan glacial ice. Fourteen separate categories of surficial materials are depicted on the map. RI 138 is available from the Division of Geological Survey for $6.00, which includes tax and mailing.

SURVEY STAFF NOTES

Ron Rea

Scott Brockman

Ron Rea is a geologist in the Regional Geology Section and coordinator of Upper Paleozoic mapping for the Survey's statewide county geologic mapping program. Ron came to the Survey in 1984 after completing a bachelor's degree in geology at Morehead State University, a master's degree in geology at Eastern Kentucky University, and service as a high school science teacher and a geologist for a major oil company. He is currently mapping the bedrock geology in Mahoning County and enjoys the mixture of field and office work required by this assignment.

Ron enjoys hunting and fishing as hobbies and holds a second-degree black belt in judo. He is orginally from Ross County but now lives with his wife and son in Delaware County.

Scott Brockman is a geologist in the Regional Geology Section and is currently mapping the glacial geology of Hamilton County as part of the Survey's statewide county geologic mapping program. Scott began his work with the Survey in 1984 after receiving bachelor's and master's degrees in geology and a master's degree in education from the University of Cincinnati. He also taught high school earth science and chemistry in his hometown of Cincinnati. Engineering geology is a particular research interest of Scott's.

Scott pursues hobbies of woodworking and hiking. He lives in Delaware County with his wife and two children.

MONTGOMERY COUNTY SAND AND GRAVEL REPORT

The Division of Geological Survey recently published Report of Investigations No. 135, *Sand and gravel resources of Montgomery County, Ohio,* authored by Richard A. Struble. This map, at a scale of 1:62,500, depicts the distribution of sand and gravel deposits in the county by mode of origin (outwash, kame/esker) and resource category (measured, indicated, inferred). In addition, the report contains explanatory text, strip logs of water wells and measured sections, and tables listing resource tonnages by township, pebble counts, and sieve analyses.

Montgomery County, with a 5.7-billion-ton resource, contains significant deposits of sand and gravel in a highly populated area. This report will be of particular interest to those involved in exploration for deposits of sand and gravel and to local planning agencies. Report of Investigations No. 135 is available from the Survey for $11.78, which includes tax and mailing.

1987 OHIO MINERAL SALES[1]

compiled by Sherry W. Lopez

Commodity	Tonnage sold in 1987[2]	Number of mines reporting sales[2]	Value of tonnage sold[2] (dollars)	Percent change of tonnage sold from 1986[2]
Coal	32,991,217	219	1,020,008,401	-5.5
Limestone/dolomite[3]	42,509,006	100[4]	159,122,431	+4.5
Sand and gravel[3]	37,917,522	200[4]	126,296,562	+11.7
Salt	3,360,613	5[5]	32,002,012	-13.5
Sandstone/conglomerate[3]	1,888,899	27[4]	25,480,159	+10.0
Clay[3]	1,376,016	30[4]	5,726,136	+26.6
Shale[3]	1,999,384	23[4]	2,077,417	+52.0
Gypsum[3]	256,307	1	2,434,918	+19.8
Peat	19,056	3	162,904	+10.9

[1]The sums of previously reported quarterly totals may not necessarily equal the annual totals reported here owing to the receipt of additional information or corrections to previously reported figures.
[2]These figures are preliminary and subject to change.
[3]*Tonnage 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.
[4]Includes some mines which are producing multiple commodities.
[5]Includes solution mining.

QUARTERLY MINERAL SALES, OCTOBER—NOVEMBER—DECEMBER 1987

compiled by Sherry W. Lopez

Commodity	Tonnage sold this quarter[1]	Number of mines reporting sales[1]	Value of tonnage sold[1] (dollars)
Coal	8,588,337	210	259,432,175
Limestone/dolomite[2]	11,617,019	98[3]	42,398,776
Sand and gravel[2]	9,893,548	200[3]	33,448,074
Salt	1,110,854	5[4]	10,659,067
Sandstone/conglomerate[2]	448,566	17[3]	5,983,886
Clay[2]	458,764	26[3]	1,338,852
Shale[2]	454,439	23[3]	417,001
Gypsum[2]	59,449	1	564,766
Peat	5,961	2	29,168

[1]These figures are preliminary and subject to change.
[2]*Tonnage 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.
[3]Includes some mines which are producing multiple commodities.
[4]Includes solution mining.

CHIEF RETIRES

Horace R. ("Buzz") Collins, Chief of the Division of Geological Survey and State Geologist, recently announced his retirement effective April 29, 1988. He has been with the Division for 30 years, 20 of which were in the capacity of Chief. The next issue of *Ohio Geology* will feature a tribute to his long and productive career with the Division.

Dennis N. Hull, Head of the Regional Geology Section, will serve as acting Chief until a permanent replacement is selected. Applications for the position of State Geologist and Division Chief are solicited from qualified individuals.

Ohio Department of Natural Resources
Division of Geological Survey
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Columbus, Ohio 43224

OHIO DEPARTMENT OF NATURAL RESOURCES DIVISION OF GEOLOGICAL SURVEY

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