Ohio Geology

A Quarterly Publication of the Division of Geological Survey Summer 1994

THE MARTINS CREEK MASTODON: A TALE OF MAN AND BEAST

by Michael C. Hansen

The discovery of a mastodon (*Mammut americanum*) bone or tooth, or even a partial skeleton, generally ignites public interest for a short time, but to scientists who study such things, mastodons are fairly common fossils. Indeed, remains representing perhaps 200 individual mastodons have been found just in Ohio (see *Ohio Geology*, Winter 1990, Winter 1992). But new insights and new techniques have added another dimension to our interpretation of the life habits of mastodons and their predators and the environment in which they lived. Each new mastodon site, therefore, has the potential to add to our knowledge of a very different but geologically recent environment that prevailed in Ohio at the end of the Pleistocene Ice Age.

A case in point is a mastodon skeleton excavated during the summer of 1993 by Dr. Nigel Brush, curator of the Killbuck Valley Museum (Holmes County) and lecturer in environmental studies at the University of Akron and in anthropology at Kent State University. He and his students rediscovered a mastodon in Holmes County, northwest of Berlin, in the bed of an early postglacial lake along Martins Creek. Interestingly, the mastodon site is only about 2 miles west of the site of the discovery (in 1890) of the Holmes County ground sloth (*Megalonyx jeffersoni*) that has long been displayed at Orton Geological Museum at The Ohio State University.

The Martins Creek mastodon was first discovered in 1928 during the digging of a drainage ditch. The nature of the obstruction to digging was apparently not immediately recognized, as it was thought that tree roots or stumps were causing the problem. Dr. Brush speculates that the roots may have been the tusks of the mastodon. Dynamite was employed as an all-purpose stump remover, obliterating the obstructions.

A decade later, J. J. Miller, the father of the current landowner, was digging another drainage ditch in the same area and discovered a femur and eight teeth. The skull of the mastodon may have been destroyed at this time by the trenching machine. Dr. Karl Ver Steeg, then professor of geology at the College of Wooster, examined the specimen and wrote a short article about it in the journal Science. The remainder of the bones were badly decomposed and not removed. In the interest of future science, leaving the bones in the ground was probably a good thing.

During the course of the careful excavation of the remaining portions of the skeleton by Dr. Brush and his students, several medium-size flint flakes were found in proximity to the mastodon bones. Deer bones also were found in the general vicinity, along with bones of beaver, muskrat, and shrew. Finding pieces of worked flint in association with extinct Ice Age animals is cause for excitement for both geologists and archaeologists because it may be additional evidence that Paleo-Indians were not only in the area during the last phases of the Pleistocene Ice Age, but also that they hunted mastodons. Such a fact should not be surprising, but direct evidence of association of Paleo-Indians with extinct Pleistocene animals has been elusive in eastern North America.

Close-up of some of the mastodon bones and the flint flake (MM) that tested positive for elephant antiserum. Dr. Nigel Brush points to this small flake with a trowel.

The close spatial association of worked flint and mastodon bones suggests, but does not necessarily prove, that the two items are contemporaneous and that the flint represents flakes used to butcher the mastodon. The skeleton, which is about 30 percent complete, was very close to the surface (at a depth of about 20 inches), and Dr. Brush was concerned that some of the flint had been worked downward into an older layer by plowing, rodent burrowing, or some other mechanism. The shape of the flint flakes did not shed any light on the problem because these nondescript pieces of flint are not unique to any particular culture.

This puzzle may have remained unsolved were it not for a technique known as immunological analysis. Dr. Brush submitted five flint flakes from the site to Dr. Margaret Newman at the University of Calgary, Alberta, Canada, for testing. This technique is capable of detecting extremely small amounts of blood residue on an object such as a flint artifact. One of the flint flakes tested positive for

continued on page 3

Thomas M. Berg, Division Chief and State Geologist

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From The State Geologist...

Thomas M. Berg

ON THE SELLING OF THE GEOLOGICAL SCIENCES

For the remainder of this decade and into the next century, geologists will be forced to "market" their science as never before. Geologists in the private consulting community are already accustomed to marketing their services for site-specific investigations. In the academic and government arenas, however, the pressure to "sell" geological investigations will continue to grow.

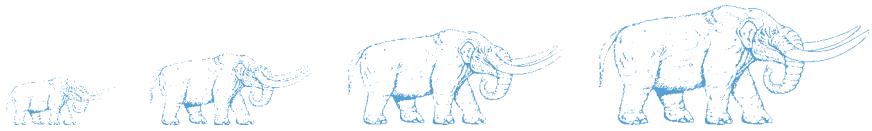
Legislators and government policy-makers are overwhelmed by a tremendous number of requests for public funds to deal with issues that require immediate action such as health care, defense, and a deteriorating transportation infrastructure. Geological surveys provide the sound scientific basis for many critical and urgent government-decision issues such as nonpoint-source pollution, coastal erosion, diminishing fossil-fuel resources, indoor radon, zoning limits on mining and drilling, and failing aquifers. Yet the sound geoscience is taken for granted or instinctively consigned to the private sector. What is not understood is that much statewide and regional geologic mapping or geologic framework investigations simply have not yet been done to today's standards. No private geological consulting firm could afford to compile up-to-date geologic maps or subsurface databases for the entire state, constantly update the maps and databases as new information is obtained, use the maps and databases to judge the accuracy and validity of site-specific work done by other private consultants, *and at the same time agree to make no profit*.

Geological surveys will not be supported unless legislators and policy-makers understand the long-term benefits of what the surveys do. In a similar way, state-supported university geology departments may not be completely sustained without demonstrating how the basic research they conduct and the instruction they provide relate to the long-term welfare of the taxpayers. And in that regard, there should be a close partnership between state surveys and the academic geoscience communities in each state so that the basic geologic research conducted in the universities can be carried to everyday users through the applied investigations of the state geological survey.

At this time in our history, when we speak of information "superhighways," instantaneous news from around the planet, development of high-speed geographic information systems, fiber-optic surgery, etc., there is, in my mind, a greatly heightened sense of urgency to provide a reliable and accurate base of geologic information for our law-makers and decision-makers. Geologists need to be able to market their science so that there is no doubt about its necessity and no doubt about its applied value.

For example, the derivative products coming from basic geologic mapping need to be emphasized. Maps showing aquifer potential and pollution potential need to be emphasized. Maps showing suitability of land areas for waste disposal need to be emphasized. Maps showing areas of valuable sand and gravel resources need to be emphasized. Maps showing areas of potential landsliding need to be emphasized. Although we geologists know that the derivative products cannot be compiled without accurate geologic mapping, we must "sell" the derivative products. The users, our taxpayers, need to see results they can understand. More often than not, they do not want to know the intricacies and complexities of the geology of an area or a particular formation. They want answers. They want to know, "Can I build here?" "Can I drill for water there?" "Can I safely dispose of waste here?"

A final word to our geology majors in college: If you want to be successful in the world of geology today, plan on developing your marketing skills. Plan on learning how to justify your practice of this science by showing immediate and clearly practical results. Learn how to write and speak well. Plan on testifying at public hearings and before legislative committees in language the general public can understand. Be prepared to give fast, succinct answers about geological issues. Be prepared to sell the geological sciences.



continued from page 1

deer antiserum, but a second specimen tested positive for elephant antiserum. There can be little doubt that this flint flake was used to butcher the mastodon.

Additional investigations of the site and its materials are ongoing. Samples have been submitted for radiocarbon dating, pollen is being analyzed, and mastodon authority Dr. Daniel Fisher of the University of Michigan will examine the badly weathered bones for cut marks from flint tools used to slice flesh from the bone.

So, although each mastodon find may yield little new anatomical information, there is still a wealth of potential new discoveries from the surrounding sediments, associated human artifacts, butcher or scavenger marks on the bones, and the configuration of the bones within the sediments. Decades from now new techniques, and new ideas, may make our current investigations seem primitive, but, judging from the fairly regular discovery of mastodon remains in Ohio for more than a century and a half, there should be adequate numbers of specimens still in the ground for yet unborn or yet untrained scientists to make new discoveries.

View of a portion of the mastodon skeleton. Mastodon bones are noted by single letters. The letters "MM" identify a flint flake that tested positive for elephant antiserum. The letters "BB" identify a flint flake that tested positive for deer antiserum. The mastodon bones rest on top of a layer of light-colored marl, which is overlain by dark-colored peat and muck. Note the shallow depth of burial of the bones; oxidation has resulted in very poor preservation of them.

The bones of the Martins Creek mastodon are on display at the Killbuck Valley Museum in Killbuck, Holmes County. Museum hours are 1 p.m. to 5 p.m., Friday, Saturday, and Sunday. We thank Dr. Nigel Brush for his assistance with this article.

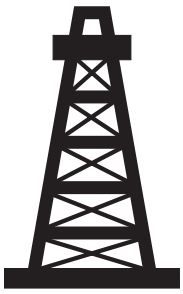
Morrow County oil boom anthology

The Ohio Geological Society has published the long-awaited volume on the 1960's oil boom in Morrow County. It has been worth the wait. This 452-page softbound volume is a treasure chest of valuable data, historical information, and often-amusing anecdotes, much of it written by the players in this oil-field saga.

William E. Shafer, who as a young geologist and geophysicist participated in the Morrow County boom, has gathered numerous contributions on the technical aspects of the oil field, historical narratives, and summaries of people's experiences during this frenzied time. The volume contains nine original historical papers, five reprinted historical papers, nine original technical papers, and 15 reprinted technical papers. The volume includes 50 historic black-and-white photographs.

Morrow County was not an area of historical oil and gas production, but, in December 1959, farmer and former Texas oilman Noel J. Monk drilled a well on his farm that produced 95 barrels of oil and 265,000 cubic feet of gas per day. However, it was not until 1961, when United Producing Co. drilled the Orrie Myers No. 1 well in Canaan Township, that the boom began. When word spread that this well had a capability of producing more than 2,000 barrels of oil a day, Morrow County became the focus of nationwide attention. Soon, large rotary drilling rigs, then uncommon in Ohio, moved into the area from Oklahoma, Texas, and other states. Oil and gas laws were lax in Ohio at the beginning of the Morrow County boom and there were hardly any restrictions on drilling. Shafer summarizes the sight:

> Town-lot drilling, outlawed in the 1920's and 1930's in the progressive states west of Ohio, was again in vogue. Promoter, operator and landowner were having a go at town-lot "privilege," "tooth and nail." Leasing and drilling took off right where the Ordovician, Trenton Boom of 1885 had ended. If the landowner blinked at the kitchen negotiating table, the well operator would move the garage to get the big rig into a back yard that was the size of a postage stamp. Rigs set up on the town traffic triangle, fair grounds, school grounds, narrow town lots, rail right-of-way and other unusual places. Rigs blossomed seemingly at every road intersection, out in the wood lot and all along U.S. Route 42 between Cardington and Mt. Gilead. It wasn't unusual to count 15 and more drill masts at one time within one view, with puffs of diesel coming off of the power plant when they came off-bottom tripping-out. In the evening time, the count was even better because the string of lights on the mast could be seen for some distance, even off in the back wood lots and in the swampy places. When did that rig move in there? Rigs spilled out into Delaware County along U.S. 23 adjacent to Mom Wilson's pork sausage and ham farm store and then south to the north end of Delaware City.



Shafer further chronicles the spectacle:

> At night, 1963 through 1965 with the wells flaring great amounts of gas, the gross sky view over Mt. Gilead and Cardington was aglow with a deep, opaque, orange-red color, like the sun setting in a summer storm. The evening dew or winter snow reflected red-orange off of the ground and low clouds. The glow could be seen for some miles before actually entering the area and that pungent aroma of bubbling crude. The big orange glow in the sky seemed to pulsate like something alive, trying to get

Aerial view of town-lot drilling along U.S. Route 42, looking northeast from Cardington, Morrow County. March 1964.

out. Discounting a superstitious explanation, this witness finally concluded, that the apparent pulsations were caused by surface breezes in the area. It was "a hell of a show," or a show of hell depending on which side of the gate you stood during those years.

At the peak of the boom at least 150 rigs were actively drilling to depths of about 3,500 feet in an attempt to reach oil-bearing erosional remnants of the Ordovician-age Copper Ridge dolomite (known to drillers as the Trempealeau). By early 1964, production reached 35,000 barrels of oil per day (at $2.90 per barrel). More than 28 million barrels of oil were produced between 1961 and 1967, and more than 40 million barrels of oil have been produced from this field to date.

The Morrow County report, known as "The Anthology," can be ordered from the Ohio Geological Society, P.O. Box 14322, Columbus, OH 43214 for $55.00 for OGS members and $65.00 for nonmembers. Please make checks payable to The Treasurer, OGS/Anthology. Each copy of the first press run of 1,000 copies is numbered.

Mather Medal awarded to Stanley E. Norris

Stanley E. Norris, a geologist retired from the U.S. Geological Survey, Water Resources Division in Columbus, was awarded the Mather Medal of the Ohio Geological Survey in ceremonies on May 19, 1994. This award recognizes significant, lifelong contributions to the knowledge of the geology of Ohio and is named after William W. Mather, Ohio's first State Geologist (1837-1838). The medal was presented at a special dinner by Division Chief and State Geologist Thomas M. Berg before more than 60 of Stan's friends, family members, and associates.

State Geologist Thomas M. Berg (right) presenting the Mather Medal to Stanley E. Norris.

The Mather Medalist is selected by the Mather Medal Committee of the Survey from nominations submitted by Survey staff. The 1994 Mather Medal Committee included chairwoman Sherry Weisgarber, Don Guy, Glenn Larsen, Ron Riley, and Garry Yates. Previous Mather Medalists are Myron T. Sturgeon (1987), Richard P. Goldthwait (1989), George W. White (1989, posthumously awarded), Jane L. Forsyth (1990), Wayne D. Martin (1991), Ralph J. Bernhagen (1992), and Richard M. DeLong (1992).

Mr. Norris was awarded the Mather Medal for his contributions to the geology of Ohio during a 36-year career with the USGS as a hydrogeologist and a postretirement career as a consulting hydrogeologist. Stan has an enviable breadth of knowledge, and his writings span Ohio's geologic column. Stan considers himself more a persistent researcher than a scholar; most people consider him modest.

Stan's geologic career began not long after he graduated from The Ohio State University in 1939. He worked for the predecessor of the Ohio Department of Natural Resources, the Ohio Division of Conservation, consulting on dam foundations. Stan became acquainted with Wilber Stout, the well-known state geologist, who hired him to work on Bulletin 44, *Water in Ohio*, one of the Survey's most popular publications ever.

After service in World War II, Stan learned, through a series of connections that led from Ralph Bernhagen (1992 Mather Medalist), who was chief geologist on the Water Supply Board, and Chief Engineer C. V. Youngquist, that the USGS was looking for geologists. For 36 years Stan worked for the USGS in Columbus, retiring in 1981. Since retirement, Stan has been a consulting geologist, most recently with Metcalf and Eddy.

Much of Stan's work, especially with the USGS, has affected the Ohio citizenry and enlightened our knowledge of Ohio geology. Through the years, he has worked and shared publications with Richard P. Goldthwait, George W. White, Andrew M. Spieker, William P. Cross, Cecil Spicer, Richard E. Fidler, Gregory Mayer, Herbert B. Eagon, and many others. He has written extensively on ground-water conditions across the state, including the communities of Piketon, Lancaster, Springfield, Dayton, Ashland, Piqua, Circleville, and Marion, and regionally in west-central, southeastern, and northeastern Ohio.

Stan has dealt with the range of Ohio's geologic materials: outwash, alluvium, till, lacustrine sediments, carbonate and clastic bedrock, and salt. He has had a particular fascination with bedrock topography, culminating with the delineation of the deeply buried preglacial Teays Valley in west-central Ohio.

Stan has had a tendency to be ahead of his time. In April 1994, Stan chaired a session of a geology symposium of the Ohio Academy of Science that was the best attended geologic event in the 103-year history of the Academy. The symposium was on a

hot new topic, touching the lives and livelihood of many people, namely, the leaking fractures in till and other glacial deposits that affect landfills, buried tanks, etc. Thirty-five years earlier Stan penned some of the initial ideas on the subject in at least two papers. The Division of Geological Survey is indeed honored to have such a forward-looking geologist as a Mather Medalist.

—C. Scott Brockman

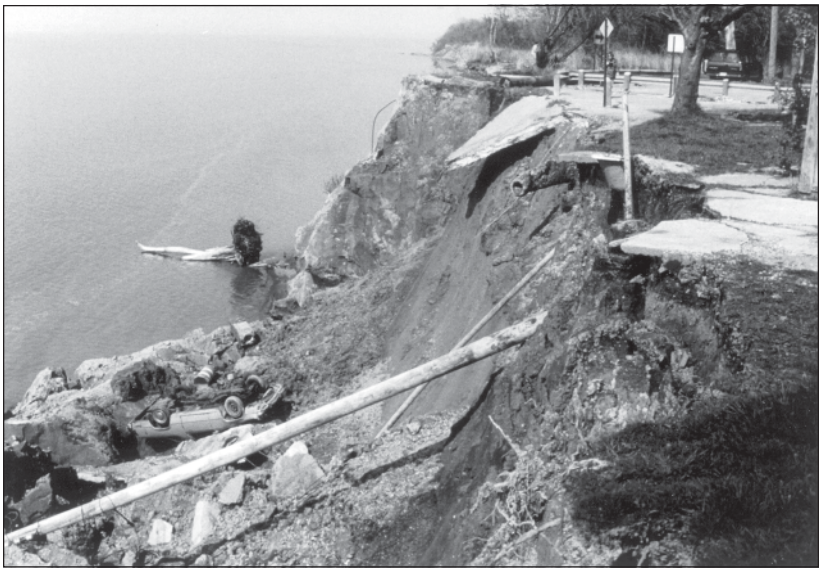
LAKE ERIE BLUFF COLLAPSE

Early in the morning of May 4, 1994, what remained of Ronald and Charles Henson's lakefront yard succumbed to the forces of gravity and plunged into Lake Erie, leaving their home teetering on the edge of the bluff and ensuring that it be condemned as unfit for habitation. On the basis of historical data, erosion was not unexpected in this portion of Painesville Township, Lake County, but a rotational slump of this magnitude is unusual. Lake Erie's storm waves have been gnawing at this bluff for many years, eating into scenic lakefront property at an alarming rate. Indeed, a Cleveland Plain Dealer story indicated that the Hensons had purchased the home two years ago for $2,000, fully aware that their stay would be a short one.

Aerial photographs taken in 1954 and 1993 show that this particular stretch of lakeshore has receded more than 400 feet in less than 40 years, taking with it a number of homes and a portion of former Ohio Route 535. The bluff collapse on May 4th is just another example of the erosion processes that continually eat away at the lake bluffs.

This portion of the Lake Erie shore is characterized by 55-foot-high bluffs composed of till deposited by glaciers of the Pleistocene Ice Age. The till is overlain by laminated clay and sand deposited when lakes preceding Lake Erie were at higher levels than today. These unprotected bluffs of unconsolidated sediment are particularly vulnerable to Lake Erie's storm waves. Wave erosion along the base of the bluff steepens the bluff profile, inducing mass wasting higher in the bluff.

The Painesville Township bluff collapse on May 4th is technically known as a rotational slump, a type of downslope movement in which a large block rotates backward along a curved slip plane. This slump block was about 100 feet long, 10 to 25 feet wide, and 20 to 45 feet thick, according to Scudder Mackey and Don Guy of the Survey's Lake Erie Geology Group. Coincidentally, these geologists were in the area adjusting digital monitoring equipment on the morning of the slide and were able to make first-hand observations of the event. They noted that the slump broke into large blocks 10 to 20 feet across. When Mackey and Guy returned to the site approximately one month later, they noted that more than half of the slump block had been removed by wave action.

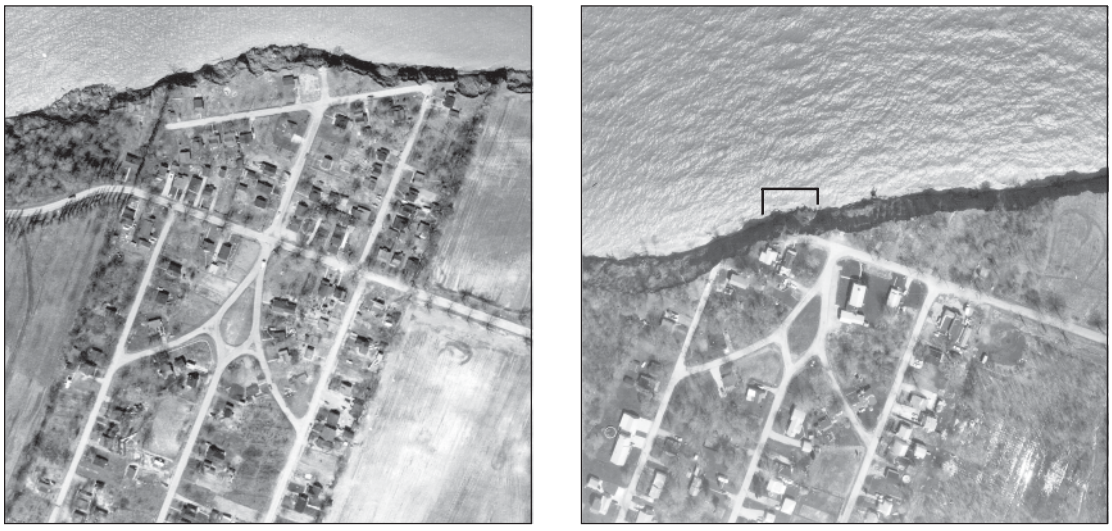


Bluff collapse on May 4, 1994, in Painesville Township, Lake County. The automobile that tumbled over the bluff was an abandoned vehicle parked near the bluff edge.

About 75 percent of Ohio's 262-mile-long Lake Erie shore is classified as easily erodible. Erosion by waves and mass wasting imposes considerable financial burdens on lakefront communities. A study conducted by Lake County authorities found that losses due to shore erosion along the 30-mile shore of the county were as much as $9,000,000 in 1985 alone. Extrapolating to the remainder of the lakeshore, losses in 1985 may have exeeded $100,000,000.

In 1991, the Division began a five-year cooperative project with the U.S. Geological Survey's Coastal Geology Center in order to better understand the problem of coastal erosion. The Ohio program is examining the dynamics of erosion along the Lake Erie shore.

—Michael C. Hansen



Comparative aerial photographs (scale: 1 inch represents 400 feet) of the Lake Erie shoreline taken in 1954 and 1993 in Painesville Township, Lake County, Ohio. Note that the shoreline has receded about 400 feet during this time and many homes present in 1954 have disappeared. The area of the May 4, 1994, bluff collapse is indicated.

ASSOCIATION OF AMERICAN STATE GEOLOGISTS ANNUAL MEETING HELD IN OHIO

The Division of Geological Survey hosted the 86th annual meeting of the Association of American State Geologists (AASG) on June 4-8 at Maumee Bay State Park in Lucas County. More than 140 people representing state geological surveys in 40 states and a number of federal agencies attended the meeting.

Field trips to Kelleys Island to see the world-famous glacial grooves (see *Ohio Geology*, Spring 1988) and to view coastal erosion, salt mining, and bedrock and glacial geology in northern Ohio were popular activities.

This is the first time in 67 years that AASG has met in Ohio. The comments received by participating Survey staff indicated that the attendees considered their trip to Ohio to be most pleasant and very productive. Much of the credit for organizing the meeting goes to David A. Stith, Head of the Mineral Resources and Geochemistry Group. Numerous other staff members and spouses assisted with various aspects of the meeting.

State geologists examine exposures of the Columbus Limestone at the historic Marblehead Lighthouse on Lake Erie.

State geologists and federal guests were greeted by State Senator Betty Montgomery, who emphasized the importance of government partnerships, especially in issues of coastal erosion and geologic mapping. Ohio Department of Natural Resources Deputy Director Wayne Warren welcomed the meeting participants with words of praise for the Ohio Division of Geological Survey and the efforts of other state surveys working together on regional investigations.

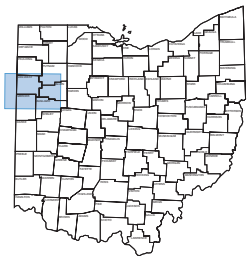
Recently appointed U.S. Geological Survey director and Ohio native Dr. Gordon P. Eaton was a featured speaker at the meeting. He reported on the state of the USGS and summarized his views of future directions of the national survey.

The AASG meeting was made possible, in part, by the generous support of a number of sponsoring organizations and companies including BankOne, Bowerston Shale Co., Central Silica Co., Clinton Gas Systems, Inc., Cravat Coal Co., France Stone Co., Hilltop Basic Resources, Inc., Indiana Mineral Aggregates Association, Inc., Kellstone, Inc., Morton Salt Division of Morton International, Inc., National Lime & Stone Co., Ohio Aggregates Association, Ohio Mining and Reclamation Association, Ohio Oil and Gas Association, Oxford Oil Co., Seaway Sand & Stone, Inc., and Stoneco, Inc.

A variety of topics were discussed at the business sessions, including coastal erosion, digital geologic mapping, earth science education, national energy policy, environmental geology, geologic hazards (including central U.S. earthquakes), and registration of geologists. The topic that received the greatest time and discussion was the National Geologic Mapping Program and the role of the state geological surveys in that program.

Dr. Robert L. Bates, Emeritus Professor of Geological Sciences at The Ohio State University, gave a lively and entertaining presentation of geologic poems, titled "The Earth in Verse," at the annual banquet. (The death of Dr. Bates two weeks after the AASG meeting is reported elsewhere in this issue.)

Bedrock geology of the Lima quadrangle available



Location of the Lima 30 x 60 minute quadrangle

The Division of Geological Survey has published the second map in a series of full-color bedrock geology maps covering the state at a scale of 1:100,000 (1 inch represents about 1.5 miles). This map, titled *Regional bedrock geology of the Ohio portion of the Lima, Ohio-Indiana 30 x 60 minute quadrangle*, was authored by Survey geologist Glenn E. Larsen.

The map covers Van Wert County, large portions of Allen, Auglaize, Mercer, and Putnam Counties, and a small portion of Paulding County. Six bedrock units, of Ordovician and Silurian age, are depicted on the map. The oldest surface rocks, of Ordovician age, are present in the southern portion of the map area in the valley of the preglacial Teays River. This river was destroyed by an early glaciation and its valley is now filled with up to 400 feet of sediment.

An extensive text on the Lima map sheet describes the stratigraphy and economic geology of the area. A columnar section, a cross section, and a list of references are included. This map, and others in the series, will be an important resource for the location, development, and protection of mineral resources; the siting of landfills, schools, hospitals, highways, and other public and private facilities; and for planning and zoning activities.

This publication, known as Map No. 7, is available from the Ohio Department of Natural Resources, Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, for $12.00 plus $0.69 tax and $3.00 mailing ($15.69 total). Credit-card phone orders can be placed by calling 614-265-6576.

ROBERT L. BATES, 1912-1994

We are saddened to report the death of Dr. Robert L. Bates, Emeritus Professor of Geology in the Department of Geological Sciences, The Ohio State University. Dr. Bates died on June 21, 1994, a week after suffering a heart attack at his home. Just two weeks earlier he was the featured banquet speaker at the annual meeting of the Association of American of State Geologists (see accompanying article). Dr. Bates is survived by his wife, Marion, and a son and daughter. A memorial service in his honor was held on July 1 at the Park of Roses in Columbus.

Bob Bates was well known nationally in the geological community for his long-running (22 years) column in Geotimes, called "The Geologic Column," which focused on his passion for preserving the integrity the English language. Bob chronicled the sometimes humorous mangling of the language by scientists in technical reports. His focus, of course, was to point out how such use interferes with effective communication of ideas. His book *Pandora's bauxite* was a collection of what may be termed the best of Bob Bates.

Dr. Bates also was known for his interest in industrial minerals and he was a leader in this field. He authored a widely used textbook, *Geology of the industrial rocks and minerals*, published in 1960 by Harper & Brothers, and coauthored, with P. W. Harben, a 1990 textbook, *Industrial minerals: geology and world deposits*. He published several smaller volumes on industrial minerals and their uses that were oriented toward a general audience. In 1965, Bob organized the First Midwest Forum on Geology of Industrial Minerals, which consisted of a symposium on the geology of industrial limestone and dolomite. Thirteen papers, which were published in the Ohio Journal of Science in 1966, were given at the meeting, held at The Ohio State University. This forum has continued on an annual basis since the initial meeting organized by Bob Bates. He is affectionately known as the "father" of the forum and was the only person to have attended all 30 meetings, a fact for which he was honored at the 1994 meeting in Halifax, Nova Scotia.

Bob's most widely used book is the American Geological Institute's *Glossary of geology*, which he edited with Julia A. Jackson. It is probable that every geologist has consulted this work upon occasion or, for some of us, almost on a daily basis.

Bob's work in Ohio was mostly focused on industrial minerals, and he wrote several papers on this topic. He authored Division of Geological Survey Educational Leaflet No. 4, *Focus on oil*, in 1954. The *1993 Report on Ohio mineral industries* is dedicated to Dr. Bates.

Robert L. Bates was born in Brookings, South Dakota, where his father taught English at South Dakota State College. He spent part of his youth, from ages 5 to 15, in Vermont and then moved to New Jersey. He received an A.B. degree in geology from Cornell University in 1934 and M.S. (1936) and Ph.D. (1938) degrees in geology from the University of Iowa. Bob worked briefly in the oil industry, then, in 1941, became a geologist with the New Mexico Bureau of Mines and Mineral Resources. He served in this position until 1945, when he became chief of the oil and gas division of that state geological survey. In 1947, Bob began teaching at Rutgers University.

Bob Bates came to The Ohio State University in 1951 as an assistant professor and taught petroleum geology and the geology of industrial rocks and minerals at this institution until his retirement in 1977, when he became professor emeritus. Retirement did not seem to slow Bob, as he wrote many papers and textbooks during this time and gave numerous lectures, many of them both humorous and insightful. Bob was much in demand as an after-dinner speaker at numerous professional functions. Much of his free time was spent as a volunteer gardener at the Columbus Park of Roses. Indeed, Bob had worked at the park on the day of his fatal heart attack.

Dr. Bates was very active in education and editing. He served as president of the National Association of Geology Teachers (1967-1968), president of the Ohio Section of the American Institute of Professional Geologists (AIPG) (1975), and president of the Association of Earth Science Editors (1982). He served as editor of the Journal of Geological Education and AIPG's The Professional Geologist.

The geological community has lost one of its leaders and an articulate and witty spokesperson. We are fortunate that Bob Bates left us with a written legacy of his thoughts and observations, which will be enjoyed for generation to come.

Robert L. Bates

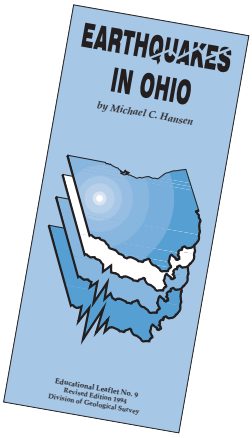
New earthquake brochure available

The Division of Geological Survey has published a revised and expanded version of Educational Leaflet No. 9, *Earthquakes in Ohio*, which was first issued in 1975. The new leaflet is completely rewritten and includes new diagrams and maps, which reflect the tremendous knowledge about earthquakes and the geology of the Precambrian basement rocks that has accumulated in the last two decades.

In addition to an epicenter map that shows the location, date, and intensity for felt earthquakes in Ohio, the leaflet also contains a map of basement geologic structures in the state. This map has been adapted from the Division's Digital Chart and Map Series map DCMS-7. Also included is a map that depicts the potential Modified Mercalli intensities that would be generated from an 8.0-magnitude earthquake centered at New Madrid, Missouri; a map that depicts seismic risk based on historic earthquake activity; and a probabilistic map of horizontal acceleration.

The leaflet discusses the nature and causes of earthquakes, earthquake waves, measurement of earthquakes, and the geology of basement rocks and faulting in Ohio. Also presented are a synopsis of historic earthquake activity in the state and an annotated list of significant historic Ohio earthquakes. An additional section discusses seismic risk and seismic hazard in the state.

Single copies of Educational Leaflet No. 9, which was authored by Michael C. Hansen, can be obtained at no charge from the Division of Geological Survey. Please contact the Survey (614-265-6576) for information regarding orders of more than 10 copies of the leaflet.



1993 REPORT ON OHIO MINERAL INDUSTRIES

The *1993 Report on Ohio mineral industries*, which will be available by September, features statistics and directories of operators for each mineral commodity produced in Ohio (excluding oil and gas), plus an article on the importance of geologic mapping.

In 1993, coal was produced by 81 companies at 192 mines in 21 counties. Production totalled 27,585,575 tons (0.6 percent decrease from 1992); 17,113,249 tons were produced at 183 surface mines, and 10,472,326 tons were produced from 9 underground mines. The total value of the coal sold was $759,668,811. Total average price per ton was $27.44. The five leading counties for 1993 coal production were Belmont, Vinton, Meigs, Harrison, and Tuscarawas. Ohio is the 12th-largest coal-producing state in the nation.[1] Wyoming, Kentucky, West Virginia, Pennsylvania, and Texas rank first through fifth, respectively.

Limestone and dolomite were sold or produced by 78 companies at 121 operations in 48 counties in 1993. Sales totalled 60,705,114 tons (+14.2 percent from 1992). The total value of the limestone and dolomite sold was $242,836,089; average price per ton was $4.00. The five leading counties for 1993 limestone and dolomite production were Erie, Wyandot, Franklin, Sandusky, and Ottawa. Ohio ranks first nationally in the production of lime, followed by Alabama, Pennsylvania, Kentucky, and Texas. Ohio also ranks seventh in the production of crushed stone, which includes crushed sandstone; Texas, Illinois, Pennsylvania, Florida, and Kentucky rank first through fifth, respectively.

In 1993, sand and gravel were sold or produced by 253 companies at 329 operations in 66 counties plus Lake Erie. Sales totalled 47,769,475 tons (+6.8 percent from 1992). The total value of the sand and gravel sold was $173,626,143; average price per ton was $3.63. The five leading counties for 1993 sand and gravel production were Hamilton, Franklin, Butler, Portage, and Stark. Ohio ranks second nationally in the production of construction sand and gravel. California is first, and Michigan, Texas, and Washington rank third through fifth, respectively.

Sandstone and conglomerate were sold or produced by 23 companies at 33 operations in 19 counties in 1993. Sales totalled 1,933,259 tons (+4.2 percent from 1992). The total value of the sandstone and conglomerate sold was $34,057,410; average price per ton was $17.62. The five leading counties for 1993 sandstone and conglomerate production were Geauga, Perry, Knox, Ross, and Lake. Ohio ranks seventh nationally in the production of dimension (building) stone. Indiana, Georgia, Vermont, and Texas rank first through fourth, respectively. However, Ohio ranks first nationally in the production of sandstone dimension stone.

Clay was sold or produced by 44 companies at 55 operations in 30 counties in 1993. Clay sales (including material for captive use) totalled 1,711,083 tons (-31.8 percent from 1992). The total value of the clay sold was $6,797,062; average price per ton was $3.97. The five leading counties for 1993 clay production were Stark, Tuscarawas, Paulding, Montgomery, and Butler. Ohio ranks fifth nationally in the production of clay and shale; Georgia, California, Wyoming, and Alabama rank first through fourth, respectively.

Shale was sold or produced by 25 companies at 37 operations in 21 counties in 1993. Shale sales (including material for captive use) totalled 1,301,416 tons (-37.4 percent from 1992). The total value of the shale sold was $3,878,089; average price per ton was $2.98. The five leading counties for 1993 shale production were Tuscarawas, Cuyahoga, Marion, Mahoning, and Stark.

Salt was produced by 3 companies at 5 operations in 5 counties: two rock salt mines, one each in Cuyahoga and Lake Counties, and three brining operations, one each in Licking, Summit, and Wayne Counties. Salt sales totalled 3,562,352 tons (+21.5 percent from 1992). The total value of the salt sold was $48,066,967; average price per ton was $13.49. Ohio ranks fourth nationally in the production of salt; Louisiana, Texas, and New York rank first through third, respectively, and Kansas ranks fifth.

Gypsum was produced by 1 company at 1 operation in Ottawa County. Gypsum sales (all material was for captive use) totalled 233,172 tons (+13.7 percent from 1992). The total value of the gypsum sold was $2,215,135; average price per ton was $9.50. Ohio ranks 16th nationally in the production of gypsum. Oklahoma, Iowa, Texas, Michigan, and Nevada rank first through fifth, respectively.

Peat production was report by 4 companies at 4 operations in 3 counties (Champaign, Portage, and Williams). Peat sales (including material for captive use) totalled 17,833 tons (+2.0 percent from 1992). The total value of the peat sold was $173,390; average price per ton was $9.72. Ohio ranks 13th nationally in the production of peat. Florida, Michigan, Wisconsin, Minnesota, and Illinois rank first through fifth, respectively.

Copies of the *1993 Report on Ohio mineral industries* can be obtained from the Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, for $7.50 plus $0.43 sales tax and $2.00 handling ($9.93 total). Credit-card phone orders can be placed by calling 614-265-6576.

—Sherry L. Weisgarber

[1]National standings were provided by the U.S. Bureau of Mines and U.S. Department of Energy, Energy Information Administration.

Ohio Geology

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OHIO DEPARTMENT OF NATURAL RESOURCES DIVISION OF GEOLOGICAL SURVEY

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