Ohio Geology

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AN UNDERGROUND FOREST

by
Robert W. Hook, Austin, Texas
and
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The coal seams in our State vary in thickness from one inch to twelve feet, and as the material composing them has been greatly condensed by pressure, we may infer that they represent beds of peat from one to fifty feet in thickness.

John S. Newberry,
Second State Geologist of Ohio, 1874

Ohio's mineable coal deposits are a record of archaic peat swamps in which now-extinct plants grew and flourished. Fossilized roots commonly are found below coals in underclays (seatearths) that originated as soils some 300 million years ago. Microscopic spores and pollen are extracted from coal for information on the vegetation that lived at the time of peat accumulation. Carbonized leaves, branches, and fruiting structures from coal-bearing deposits provide additional data on the ecologies of ancient floras. Rarely, however, does the fossil record provide a landscape-scale database of more than 500 acres like that discovered recently in an underground mine operated by the Sterling Mining Corporation of Jefferson County, Ohio.

Shortly after the first coal was cut from the Sterling North Mine in 1991, the remains of upright trees were found in the roof above the Mahoning coal (Conemaugh Group, Pennsylvanian). Fossilized as circular coalified rinds up to 4 feet in diameter, the tree stumps proved to be ubiquitous as mining advanced. Although such Carboniferous-age forests have been noted since the early 1800's—the most famous being the Fossil Grove of Victoria Park in Glasgow, Scotland—the Sterling North Mine provided a unique opportunity to study hundreds of trees buried during the final days of a single Carboniferous swamp.

Fossil tree stumps are known to generations of underground coal miners as "kettlebottoms" because of their size and shape and because they present a potentially mortal danger. In most cases, all that remains of the original tree is a thin coaly film that traces the circumference of the outermost bark. The interior of the tree is replaced by mudstone or sandstone, and the contact between the coalified bark and sedimentary infilling is a slickened, almost mirrorlike surface of little structural integrity. Once undercut by mining machinery, the bell-shaped stumps can fall at any time. Alert roof-bolting crews either pry down any loose kettlebottoms or drive steel bolts through the stumps, securing them into overlying strata.

Geologic data show that the Mahoning coal of the Sterling North Mine is part of a larger coal body that originated as a "peat island," an isolated swamp surrounded by lakes and floodplains. At the time of its formation in the Late Carboniferous, the peat deposit occupied a remote area on the deltaic landscape that spread across then-tropical eastern Ohio. Prior to burial, compaction, and coalification, the original peat body may have been up to 50 feet thick. Although the coal now averages only about 4 feet in thickness, its low sulfur and ash content make it one of the state's finest remaining coal reserves. This peat island was first mined in the 1870's, and about 85 percent of its approximately 24-square-mile original area has been exhausted. The Sterling North Mine, when mining ends, will have produced an estimated 3 million tons of high-quality coal for Ohio's industries and power plants.

An in-place lycopsid tree stump, similar to those found underground in the Sterling North Mine, in the Petersburg Mine, a former surface mine in Mahoning County. Stump is about 10 feet tall. Photo by Dave Conrad.

THE NATURE OF THE FOREST

The characteristics of the Sterling stumps indicate that all of them represent lycopsids, a group represented today by the usually inconspicuous clubmosses, quillworts, and spikemosses. During the Carboniferous, the group included a great variety of trees that were the dominant plants of many environments, particularly those in which peat accumulated. Known as "scale trees" because their stems bore a regular pattern of diamond-shaped leaf cushions, lycopsid trees lacked the extensive woody tissues of modern seed plants. They were supported mainly by a thick, water-resistant bark that decayed very slowly. After a tree died, the tough bark remained intact while the spongy interior of the standing trunk rotted, leaving a hollow center. Once the trunk began to

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Thomas M. Berg, Division Chief and State Geologist

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From The State Geologist...

Thomas M. Berg

GEOLOGY AND THE REMARKABLE WORLD OF COMPUTERS

Just about everyone is aware of the enormous and astonishing capabilities of today's computers. At the Ohio Geological Survey, we are moving aggressively ahead in computer mapping, computer management of geologic information, computer processing of maps and publications, and computer communication. Our Bedrock Geology Mapping Group has been using contouring software in the compilation of Ohio's new state geologic map. The individual bedrock-geology quadrangles are being digitized so that they will be available as computer databases. Our Quaternary surficial-materials maps of the state will be digitized shortly. The coastal-erosion maps prepared by our Lake Erie Geology Group are digitized; they were generated using a geographic information system (GIS) in our Sandusky office. The data for our annual *Report on Ohio mineral industries* are compiled in a computer database. Subsurface investigations at the Ohio Survey have used computer technologies for a long time, which is why our geologists working on subsurface geology are part of the Petroleum and Computer Geology Group. The Rose Run investigation, the Gas Atlas project, and the Tertiary Oil Recovery Information System (TORIS) project all relied heavily on advanced computer technology. A series of new oil and gas fields maps for Ohio is being compiled digitally from these data. Our coal investigations in Ohio are being conducted in cooperation with the U.S. Geological Survey and rely entirely on GIS technology.

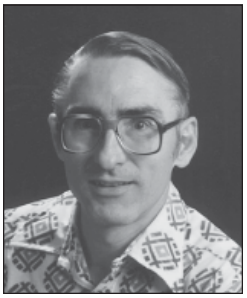
All of our publications are now being prepared using highly sophisticated computers and desk-top publishing technology. Virtually every aspect of the *Ohio Geology* you are reading was prepared with computers, including this article. We are getting ready to print our first full-color geologic map solely using computer technology. The days of traditional scribing of line work and peeling of color masters are behind us.

What amazes me the most right now is electronic communications via computers. All of our staff are now linked with each other, the rest of the Department of Natural Resources, and the rest of the world using electronic mail (e-mail). Our communication efficiency has increased manyfold. I can now communicate with 35 other state geologists by e-mail. Many state geological surveys have home pages (web sites) that are accessible 24 hours a day. A staff team is working on a home page for the Ohio Survey.

When I went through college, the only mathematical device I used was a slide rule. Today's hand-held calculators, lap-top computers, global positioning systems, laser surveying instruments, cellular phones, GIS technology, etc. have radically changed our world and mightily increased our scientific capability. What a remarkable time this is to be a geologist!

Norman Knapp retires

Survey chemist Norman F. Knapp retired on January 31, 1996, after 26 years of service with the Division. A retirement dinner in his honor was held on January 26th.



Norman F. Knapp

Norm is originally from the state of Washington, where he completed a bachelor's degree at Whitworth College in Spokane. He obtained a master's degree in chemistry from New Mexico Highlands University and then came to Ohio in 1964 to begin work on a Ph.D. in chemistry at Ohio University in Athens. Norm joined the Survey as a chemist in the newly organized geochemistry laboratory in 1970 and received his Ph.D. in 1972. He served in this position until 1993, when the Division's geochemistry laboratory was dismantled. Since that time Norm has worked on compiling various reports on previously gathered geochemical data and helped in the Geologic Records Center.

During the more than a quarter of a century that Norm spent at the Survey, he worked on many projects that required analysis of rocks, minerals, and fluids. Included among these projects were extensive analyses of carbonate rocks, coal, and, most recently, brine derived from oil and gas wells. These analyses have resulted in a wealth of geochemical data that have been of vital importance to the characterization of mineral deposits in Ohio. Norm's meticulous attention to detail and proper procedures ensure that these data are of the highest quality and that they will serve as a valuable resource for many years.

Norm will continue to work periodically with Dave Stith on completion of their study of Ohio oilfield brines. Norm also plans to continue work on his family genealogy, to travel with his wife, and perhaps to teach part time.

continued from page 1

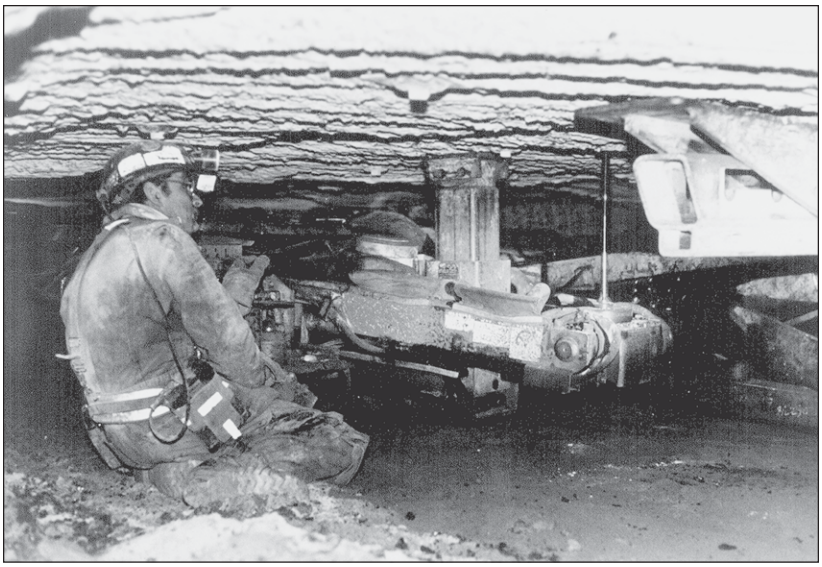
crack, the hollow was filled with mud or sand introduced by sediment-laden waters. In this manner, large numbers of lycopsid trees were fossilized in a wholesale fashion.

To the modern eye, trees of a Carboniferous lycopsid forest would appear quite peculiar. Lycopsid trees grew rapidly as leaf-covered poles that, at first, lacked branched crowns. At a terminal phase, probably after only several years of growth, they developed cone-bearing crowns and released reproductive structures just prior to death. In this economic manner, successive lycopsid stands contributed most of the biomass responsible for many of the Upper Carboniferous coal deposits mined in North America and Europe.

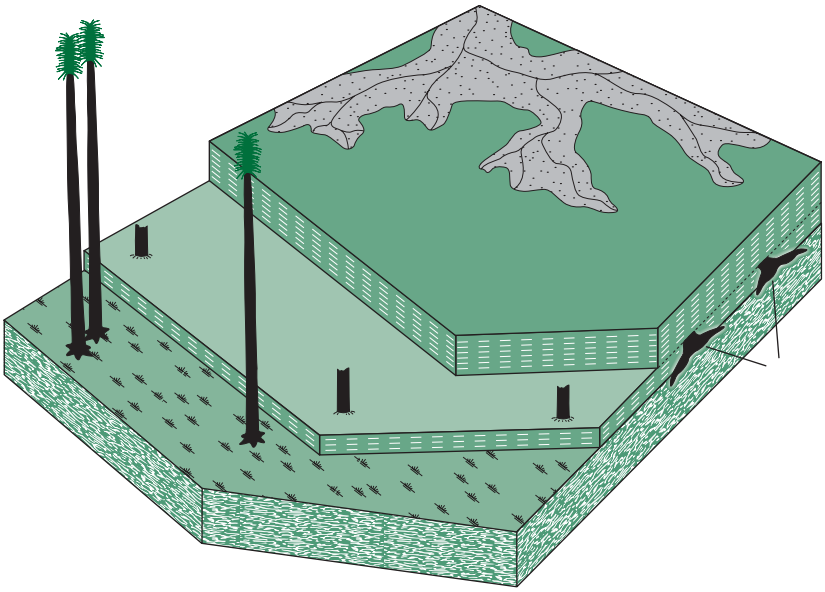
The Sterling forest is detailed in a study completed recently by paleobotanist W. A. DiMichele of the National Museum of Natural History, Smithsonian Institution. With the assistance of mine personnel, DiMichele and his co-workers recorded the distribution and size of more than 800 tree stumps in a series of in-mine transects that covered a distance of approximately 1.6 miles. All stumps appear to represent a single lycopsid genus, either *Lepidophloios* or *Lepidodendron*—certain identification cannot be made because the basal portions of the preserved trunks lack the leaf-attachment details that serve to distinguish genera of lycopsid trees. Such trees could have attained heights on the order of 120 to 150 feet. That only one or a few types of trees would constitute an entire forest is not unexpected because other North American and European coal fields have yielded data to suggest that lycopsid trees existed in low-diversity, if not single-species, stands within lowland environments during the Late Carboniferous. Even today, in swampy, tropical wetlands inhabited by modern seed plants, vast forested areas may be dominated by only one or two tree species.

The Sterling North investigation should help to change the popular perception of Upper Carboniferous coal swamps. As pictured in textbooks and in museum dioramas, such settings are shadowy places in which a great diversity of plants grew together, nearly one on top of another. Even though the tree stumps in the Sterling North Mine appeared to be concentrated in clusters with only an occasional outlier, statistical analysis of the mapping transects indicates a random distribution of trees that are less numerous and less densely spaced than shown in most reconstructions. Far from a dark, heavily shaded forest, the Sterling peat island was relatively open and well lighted because the largest trees were spaced widely and lacked leafy crowns for most of their existence. The presence of only one type of treelike lycopsid in the final days of the Mahoning peat island also underscores the ecologic inaccuracy of most coal-swamp exhibits, which tend to include a great assortment of Carboniferous plants that may have never inhabited a single environment or even co-existed in geologic time.

More than 125 years ago, Newberry elaborated the paleobotanical content of Ohio's coal deposits as "... the tissues of those strange trees that lifted their scaled trunks and waved their feathery foliage over the marshy shores of the Carboniferous continent . . . ." He made his claims without many specimens but with much experience underground. Today, with the co-operation of the coal industry, scientists wearing hard hats, knee pads, and coveralls are able to revisit Newberry's imagery of the past.



A coal miner operates a roof bolter to stabilize the rocks above the Mahoning coal in the Sterling North Mine. Miners secure fossil tree stumps by driving 42-inch resin-coated bolts upward through the stumps and into solid rock. Photo by Timothy R. Miller. From Crowell (1995).



*The Sterling forest records the life and death of a lycopsid-dominated peat swamp. This block diagram indicates the progression from living trees to fossil stumps. In life, the trees were relatively widely spaced and probably grew as simple, polelike trees (**A**). After the trees were inundated, their water-resistant bark remained intact while their spongy interior rotted (**B**). Infilled later by mud and sand, the resulting "kettlebottoms" are ubiquitous in the Sterling Mine (**C**).*

ACKNOWLEDGMENTS

We thank the men of the Sterling North Mine for their assistance underground. W. A. DiMichele (National Museum of Natural History, Smithsonian Institution) allowed us to abstract the findings of his investigation of the Sterling trees.

FURTHER READING

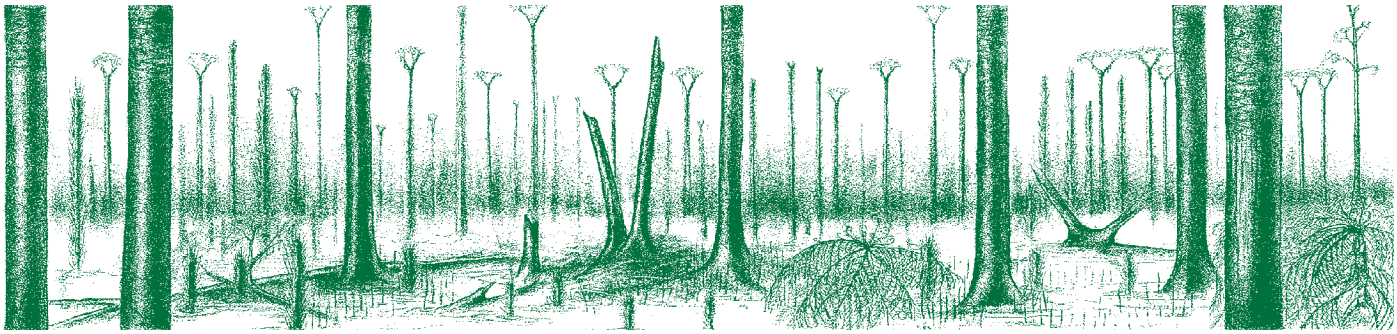
Crowell, D. L., 1995, History of the coal-mining industry in Ohio: Ohio Division of Geological Survey Bulletin 72, 204 p.

DiMichele, W. A., and Hook, R. W., 1992, Paleozoic terrestrial ecosystems, *in* Behrensmeyer, A. K., Damuth, J. D., DiMichele, W. A., Potts, R., Sues, H.-D., and Wing, S. L., eds., Terrestrial ecosystems through time: University of Chicago Press, p. 205-325.

DiMichele, W. A., and Phillips, T. L., 1994, Paleobotanical and paleoecological constraints on models of peat formation in the Late Carboniferous of Euramerica: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 106, p. 39-90.

DiMichele, W. A., Eble, C. F., and Chaney, D. S., in press, A drowned lycopsid forest above the Mahoning coal (Conemaugh Group, Upper Pennsylvanian) in eastern Ohio, USA: International Journal of Coal Geology.

Hansen, M. C., 1990, Coal, how it is found and used: Hillside, New Jersey, Enslow Publishers, 64 p.



Dominated by Lepidophloios *trees, this reconstruction of a Late Carboniferous swamp shows the widely spaced nature of the telephone-pole-like lycopsids found in the Sterling North Mine. Artist: Mary Parrish. From DiMichele and Phillips (1994).*

OHIO ELK

Elk, or wapiti (*Cervus elaphus*), apparently were common animals in Ohio at the time of European settlement in the late 1700's because many pioneer accounts mention their presence. Elk bones are common components of archaeological sites, suggesting that they were an important source of protein for Ohio's prehistoric peoples. These members of the deer family (cervids) inhabit open forests and meadows and reach shoulder heights of 4.5 feet and weights of nearly 1,000 pounds. Elk survived in the state until the time of the First Geological Survey of Ohio, as noted by Jared P. Kirtland in his chapter on the Recent fauna of Ohio in the Second Annual Report (1838). He stated that elk had been killed in Ashtabula County as late as 1837. Their wide distribution at the time of European colonization is attested to by the fact that many Ohio streams, towns, and political subdivisions have the word "elk" as a component of their name.

The fossil record of elk in the state is less copious and has an uncertain chronology. Jane L. Forsyth, in her 1963 Ohio Conservation Bulletin article, "Ice Age census," listed eight occurrences of elk remains, including specimens from Darke, Erie, Logan (three specimens), Pike (two specimens), and Portage Counties. None of these specimens had radiocarbon dates nor were any of them associated with extinct animals such as mastodon. It was therefore uncertain if these fossils were of early postglacial age or if they were only a few hundred or a few thousand years old.

In 1981, a nearly complete elk skeleton was discovered at Cranberry Prairie in Mercer County; this find was described by J. L. Murphy and others in a 1985 Ohio Journal of Science article. This specimen, which had a perforation in the shoulder blade that was interpreted to be a wound from a projectile point, yielded a radiocarbon date of 9,370 years B.P. (before present). This date indicates that elk were in the state soon after the major extinction of large Ice Age animals about 10,000 years ago, but it still does not answer the question as to whether elk were opportunists that exploited the niches vacated by the extinct megafauna or whether they were contemporaries of the mastodons and mammoths.

Mel Lattimer, owner of Lattimer's Peat Moss Farm near West Liberty, Champaign County, holding the skull and antler of the young bull elk. The other antler became detached from the specimen during removal of the specimen from the peat pit but was recovered.

In May 1994, Mel Lattimer, owner of Lattimer's Peat Moss Farm in Champaign County, contacted

the Survey about bones discovered by his son and son-in-law while digging peat from his peat bog near West Liberty. The find included an antler-bearing skull and several long bones and indicated a well-preserved young bull elk. Examination of drying piles of peat taken from the same pit resulted in the recovery of most of the elk skeleton. Mr. Lattimer generously donated the skeleton to the Ohio Historical Society.

The elk skeleton was brought to the surface of a water-filled pit by the bucket of an excavation machine from a depth of about 10 feet. This depth is near the base of the peat deposit, which is underlain by a thin layer of mollusk-bearing marl, which in turn is underlain by a blue clay of undetermined thickness that rests on till. These sediments are all below water level and could only be observed in samples brought to the surface by the excavating machinery. This sedimentary sequence is typical for infilled lakes, which formed in broad depressions left in the till surface during retreat of the ice. Thomas V. Lowell of the University of Cincinnati recently obtained a radiocarbon date of 15,700 years B.P. on a wood sample from a core at the base of the deposit. This date indicates the approximate time of initiation of the lake. Such lakes, most of which are now bogs, are common in this area of Champaign County and neighboring Logan County.

The depth and stratigraphic position of the elk bones suggested that they were several thousand years old, possibly contemporaneous with the major Ice Age extinction about 10,000 years ago. The Ohio Historical Society agreed to provide funding for a radiocarbon date of the bones. An accelerator mass spectrometer date of 9,020±60 B.P. was provided by Thomas Stafford of the Institute of Arctic and Alpine Research at the University of Colorado. This date also does not answer the question of whether elk were contemporaries of the extinct megafauna in Ohio. There are very few radiocarbon-dated elk sites in North America that have yielded specimens older than 10,000 years and only a few sites at which elk bones appear to occur in association with extinct Pleistocene vertebrates. Elk sites of early Holocene age (soon after the extinction event about 10,000 years ago) are very common in the United States. These occurrences suggest that elk may be relatively recent migrants to North America, crossing the Bering Strait from Eurasia and spreading rapidly. Indeed, the European red deer and the American elk or wapiti are now recognized to be the same species.

The Lattimer elk was a young bull, probably between two and three years old, as indicated by its comparatively small size and particularly by its teeth, which show little wear. The last molars in the lower jaws had not completely erupted. The bones are well preserved and it is apparent that the skeleton was in anatomical articulation prior to its disturbance by the excavating equipment. Not only were most of the bones recovered, but several of the vertebrae were still articulated when found in the peat piles.

The cause of death of the young bull is not immediately apparent. It is unlikely that it was killed by native peoples because meat-bearing parts of the animal, such as the upper hind legs, were not removed and the bones show no evidence of butchering—although there is the possibility that the animal may have been mortally wounded but escaped to the pond, where it died. More likely, it became mired in the soft peat or fell through the ice in winter. The details of the elk's death will probably never be known; however, some similar sites do yield their secrets when the bones can be excavated in context with the entombing sediments.

View of water-filled excavation at the Lattimer peat farm. The elk specimen was found at a depth of 10 feet at the lower-right portion of the pit. The former shoreline of this postglacial kettle lake is marked by the low topographic rise in the background.

In August 1995, Richard A. Roberts, president of JP Sand & Gravel Company, contacted the Division of Geological Survey about a skull that was dredged from their sand and gravel pit near Lockbourne in southern Franklin County. The teeth and front portion of the waterworn skull are missing but the basal portions of the antlers are intact, indicating that it was a large male elk. This area of central Ohio contains thick deposits of Wisconsinan outwash, from which the elk was derived. Its stratigraphic occurrence and age are unknown because of the uncertainty of its original position in the 40-foot-deep, water-filled pit. Mr. Roberts also has agreed to donate the specimen to the Ohio Historical Society.

Some of the most interesting elk specimens found in Ohio were discovered in the bottom of Silver Lake (Lake Mac-O-Chee), a natural lake that formed soon after retreat of glacial ice, at Camp Wilson, a YMCA camp in Logan County, near Bellefontaine. Dan Roush, a 15-year-old camper in 1960, recalled that he and several other campers were sitting on the swimming dock and noticed a "stick" projecting from the surface of the lake, which was unusually low because of drought. Investigation of the stick revealed that it was an antler from a large elk. A nearly entire elk skeleton was excavated from the shallow water by the campers. Personnel from the Ohio State Museum were contacted, and a second elk skeleton was located on the opposite side of the lake in a similar shallow-water situation. Both specimens were transferred to the Ohio State Museum and are now housed in the OSU Museum of Biological Diversity.

Robert M. Goslin, an archaeologist with the Ohio Historical Society, published a short note on the elk skeletons from Silver Lake in the July 1961 issue of Ohio Archaeologist. He reported an unusual injury to the first-discovered specimen. While cleaning the specimens, Goslin noticed a large hole in the right scapula (shoulder blade) and a malformed rib that had been split and rehealed by bone over-

Skeletal elements of an elk from Silver Lake, Logan County, found in 1960, and now reposited in the Museum of Biological Diversity, The Ohio State University. Shown are the right lower jaw, right scapula (shoulder blade) with a hole, and two ribs. The upper rib in the photo has abnormal bone growth on the left portion of the shaft. This overgrowth is around three flint chips. This rib, in life, was beneath the hole in the scapula and suggests that this animal recovered from a wound by a flint projectile point. A normal rib is shown for comparison below the damaged rib.

growth. Embedded in the rib were three tiny flint chips. It is apparent that a projectile point had passed through the scapula and into the rib, injuring the animal, but it was an injury from which it recovered.

The Silver Lake elk specimens have never been radiocarbon dated, but it is probable that they are considerably younger than the Lattimer elk, perhaps only a few hundred years old. This age is suggested by their stratigraphic position near the top of the lake sediments, which, according to a 1966 study by J. G. Ogden, III, are about 650 years old at a depth of about 49 inches. In addition, the bones lack the deep, dark-brown patina characteristic of the Lattimer specimen. Although development of such a patina, or lack of one, is not necessarily indicative of age, most specimens of considerable antiquity possess it.

It is probable that many more elk skeletons have been discovered than have been reported in the literature. Undoubtedly, many of these occurrences have been mistakenly assumed to be the recent remains of a deer or domestic animal.

The haunting bugles of these magnificent creatures echoed across the Ohio landscape for nearly 10,000 years. Our only reminder of them is the occasional skeleton that surfaces or the fleeting thought as we speed across a bridge over Elk Creek or Elk Run or some other similarly named geographic feature.

—Michael C. Hansen

FURTHER READING

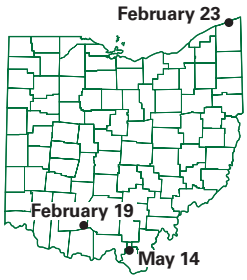
Forsyth, J. L., 1963, Ice Age census: Ohio Conservation Bulletin, v. 27, no. 9, p. 16-19, 31, back cover.

Goslin, R. M., 1961, Projectile point in elk skeleton: Ohio Archaeologist, v. 11, no. 3, p. 85.

Murphy, J. L., Dyer, D. L., and Walker, D. A., 1985, Prehistoric elk remains from Cranberry Prairie, Mercer County, Ohio: Ohio Journal of Science, v. 85, p. 112-115.

Ogden, J. G., III, 1966, Forest history of Ohio. I. Radiocarbon dates and pollen stratigraphy of Silver Lake, Logan County, Ohio: Ohio Journal of Science, v. 66, p. 387-400.

THREE EARTHQUAKES RECORDED IN OHIO DURING 1995



Locations of 1995 earthquakes

Three small earthquakes were recorded in Ohio during 1995. The first one struck at 7:57 a.m. local time on Sunday, February 19, in southeastern Highland County. Ronald Street, seismologist at the University of Kentucky, recorded this event on two of his seismograph stations in northern Kentucky and was able to provide the epicentral location and a magnitude of 3.6. The earthquake also was recorded on the MOMA seismic array (see *Ohio Geology*, Spring 1995).

The U.S. Geological Survey reported Modified Mercalli Intensities of V at Cynthiana in western Pike County, IV at Seaman and III at Winchester in northern Adams County, and III at Mowrystown in southwestern Highland County. Robert G. Van Horn, Deputy Chief of the Ohio Geological Survey, felt the earthquake at his weekend farm in southwestern Ross County, near Bainbridge. Fred N. Bowman, of the same area, also felt the earthquake.

Historically, Highland County and adjacent Pike and Ross Counties have had very low seismic activity—each county had recorded only one event, all of them in the last century. However, in 1994, a 2.5-magnitude event was recorded in western Pike County.

Another earthquake occurred at about 4:32 a.m. local time on Thursday, February 23, in Ashtabula, in northeastern Ohio. According to Ed Somppie, Ashtabula County Emergency Management director, this 2.7-magnitude event woke many residents, as numerous felt reports were received at his office. Many people thought that it was a sonic boom. The lack of seismographs in the area made it difficult for the Division of Geological Survey to confirm that the event was an earthquake and to obtain a magnitude. Seismologists at Lamont-Doherty Earth Observatory of Columbia University in Palisades, New York, analyzed data from seismic stations near Buffalo, New York, and from Ottawa, Canada, and provided a magnitude and general location. Felt reports were confined to the City of Ashtabula, suggesting that this event occurred beneath this community. The seismic stations at Ottawa and Buffalo are at sufficient distance that a precise epicentral location was difficult to determine.

There was some concern that the earthquake may have been related to a Class I injection well in Ashtabula, although the well was shut down in December 1994. Lamont-Doherty seismologists

have suggested that series of small earthquakes—one in 1987, two in 1989, and three in 1992—were triggered by this injection well. The cause of the 1995 earthquake is unknown.

On Sunday, May 14, at 4:21 p.m. local time, Dr. Street recorded a 2.5-magnitude earthquake on his Kentucky network. The epicenter was in northern Lawrence County, in southern Ohio. Although this earthquake was large enough to have been felt in the epicentral area, no felt reports were received from this sparsely populated county. No earthquakes have previously been documented from this area.

The second half of 1995 yielded no documented earthquakes in Ohio, although periodic calls were received by the Survey from citizens indicating that they felt vibrations that they suspected to be earthquakes. None of these events could be confirmed as small earthquakes because, in part, operating seismographs are located at considerable distance from the areas of reports.

—Michael C. Hansen

Wright State University offers Master of Science Teaching in Earth Science degree

The Department of Geological Sciences at Wright State University in Dayton is offering a Master of Science Teaching (Earth Science) degree program for professionals in the earth-science and environmental fields who lead workshops, are involved with partnerships or cooperative efforts with public schools, or who want to enhance their professional experience. This program also is available to teachers who want to add Earth Science to their certification. The program is tailored individually to each student and many courses are offered at times to accommodate busy professionals. No thesis is required. For more information, contact Deborah Cowles, Department of Geological Sciences, Wright State University, Dayton, OH 45435, telephone 513-873-3455.

Coal resources of the Bethesda quadrangle, Belmont County

The Division of Geological Survey has published a pioneering report that used new computer methods to assess the coal resources in the Bethesda 7.5-minute quadrangle in Belmont County. The coal-resource estimates for the quadrangle were calculated by using geographic-information-system software and coal data in the files of the Survey. This methodology allows the data to be used in future regional studies of coal availability and will be applied to other quadrangles by Survey geologists.

The new coal report, Report of Investigations No. 145, *Available coal resources of the Bethesda 7.5-minute quadrangle, Belmont County, Ohio*, was authored by Division geologist Allan G. Axon and is part of a cooperative program with the U.S. Geological Survey to assess the nation's coal resources. This publication contains numerous color maps and graphs and includes tables of coal-resource data. It is available from the Division of Geological Survey for $3.00 plus $2.00 handling and $0.18 tax if mailed to an Ohio address. Credit-card orders may be placed by calling 614-265-6576.

Open-File Report on Richmondian Stage (Ordovician) fossils and rocks of the Cincinnati area

An unpublished manuscript, entitled *The Richmond Group of the Cincinnati Province*, compiled by the late William H. Shideler, has been made available by the Division of Geological Survey as Open-File Report 95-1. Dr. Shideler was a professor of geology at Miami University from 1910 to 1957. He died in 1958.

The information in the manuscript was compiled by Shideler over a period of 17 years; he spent five summers during the 1920's in the employ of the Ohio Geological Survey. For 10 years, Shideler annually visited a series of classic exposures of highly fossiliferous Upper Ordovician rocks in southwestern Ohio and made extensive collections of fossils at these sections. From these data he was able to establish extensive faunal lists for each section and compile range charts for various species.

Shideler's typewritten manuscript was edited by Joe H. Marak, curator of the Carl E. Limper Geology Museum at Miami University. Marak notes that the manuscript is outdated, particularly in regard to the names of many fossil species, but will still be very useful to geologists and fossil collectors.

The 96-page report describes 26 exposures of Richmondian rocks in the Cincinnati area and includes an extensive index. Open-File Report 95-1 is available from the Division of Geological Survey for $3.00 plus $2.00 handling and $0.18 tax if mailed to an Ohio address. Credit-card orders may be placed by calling 614-265-6576.

HANDS-ON EARTH SCIENCE No. 8

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IS IT A ROCK OR A MINERAL?

Kids love rocks and minerals. However, many kids (and adults!) do not know the difference between a rock and a mineral. This activity is designed to train K-5 young scientists to observe and classify while learning how to tell the difference between a rock and a mineral.

What is a mineral? A material must fit the following four general criteria to be called a mineral:

1. Minerals are inorganic, meaning they typically do not form from the remains of plants or animals.

2. Minerals are naturally occurring. True minerals are not manmade.

3. Minerals have the same chemical makeup wherever they are found. For example, the mineral quartz always consists of one part silicon (an element) to two parts oxygen (another element). Some minerals, like gold, copper, and sulfur, are made up of only one element. However, most minerals are combinations of several different elements.

4. Minerals have specific repeating patterns of atoms. This orderly arrangement of atoms forms the mineral's characteristic crystal shape. For example, a crystal of quartz is always hexagonal because of the way the atoms of silicon and oxygen join together. However, if a quartz crystal does not have much room to grow, it may not look hexagonal on the outside, even though the atoms on the inside are arranged in the same orderly pattern.

What is a rock? Minerals are the building blocks of rocks. A rock is made up of one or more minerals. Rocks can be placed in one of three categories depending on how they form:

1. Igneous rocks form from magma (molten rock) either deep within the Earth (for example, granite), or on the Earth's surface when lava cools and hardens (for example, pumice).

2. Sedimentary rocks are layered rocks that form primarily from the accumulation and compaction of sediment which is derived from preexisting rocks by erosion (weathering by water, wind, or ice) (for example, sandstone). Some sedimentary rocks form by precipitation from solution (for example, gypsum).

3. Metamorphic rocks form when preexisting rocks—igneous, sedimentary, or metamorphic—are subjected to extreme temperatures and pressures deep within the Earth. The intense heat and pressure cause the mineral composition and grain size to change. For example, limestones become marbles and shales become slates.

Now that you know the general definitions, how can you tell the difference between rocks and minerals? This is where observation and classification becomes important. Minerals are homogeneous (the same throughout). A mineral will generally have the same appearance both on the interior and exterior of the sample. The properties of color and texture generally do not vary sharply because of this homogeneity. However, color and texture generally do vary sharply in rocks because rocks are made up of a variety of different minerals.

Before having the students classify actual rocks and minerals, have them observe and classify some things they may like better . . . candy. For this exercise you will need to choose bags of the following candies. Make sure you have some candies from both the "rock" list and the "mineral" list. The more variety, the better the exercise. The "rock" list includes: Peanut M & M's™, Nestle's Buncha Crunch™, Butterfinger BB's™, and Hershey Kisses with Almonds™. The "mineral" list includes: Hershey Kisses™, gummy bears, jelly beans, and chocolate or peanut butter chips. (This activity assumes that none of the students is diabetic or allergic to chocolate, peanuts, or almonds.)

After explaining to them the difference between rocks and minerals, distribute to each child a variety of candies making sure each child has some "rocks" and some "minerals." Tell the students that geologists generally break open rocks and minerals to help them identify (or classify) a rock or mineral sample. Therefore, the students should bite open their "rocks" and "minerals" to help them with their classification. Remind them that half of each sample is to be eaten and half is to be saved to observe and classify. They can eat the other half after the exercise is finished.

Have the students keep a record of their observations. Which samples seem to be homogeneous? Which samples are made up of more than one substance or "mineral"? Which samples would they classify as "minerals"? Why? Which samples would they classify as "rocks"? Why?

After they are through classifying the candy, they may want to try classifying real rocks and minerals. You can have them bring in their collections (if they have one) from home, take them outside and let them do some collecting during class time, or give them a homework assignment to collect a variety of rocks and minerals on their own.

When the students bring their collections into class, have them classify (group) the samples as rocks or minerals. Once again, have the students keep a record of their observations. Let them decide on their own criteria for classification. They will probably find it difficult to classify the real thing. It may take a while for them to get the hang of it. However, after they catch on, you may want to suggest that they classify their groups of rocks into subgroups, determining which rocks are the same and which are different. They will probably end up with two subgroups: igneous/metamorphic and sedimentary.

After the classifying is complete, have the students say how they decided which samples were rocks and which were minerals. Then ask how they decided to subdivide their rock group. Remind them that no criterion is dumb, and what appears dumb may even be a better way to classify. You will probably find that they used color, shape, texture, and possibly a few unique criteria! Let them know that the exercise they just completed on observation and classification is what scientists do in real life. Now, they are scientists too!

SOURCES: *Food For Thought: Edible Earth Science*, Betty Crocker, Barbara Reed, and Eddie Shaw, 1992, Idea Factory, Inc. (1-800-331-6204); and *Fairly Simple Exercises in Geology*, John J. and Barbara R. Thomas, 1994, Geology Department, Skidmore College, 100 p.

CORRECTION FOR HANDS-ON EARTH SCIENCE No. 7 IN WINTER 1996 ISSUE OF *OHIO GEOLOGY*: Edward G. Voss of the University of Michigan pointed out that the phrase "times larger than" should read "times as large as" to be mathematically accurate. Our thanks to Dr. Voss for alerting us to this error.

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