Ohio Geology

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THE GEOLOGY OF OHIO—THE MISSISSIPPIAN

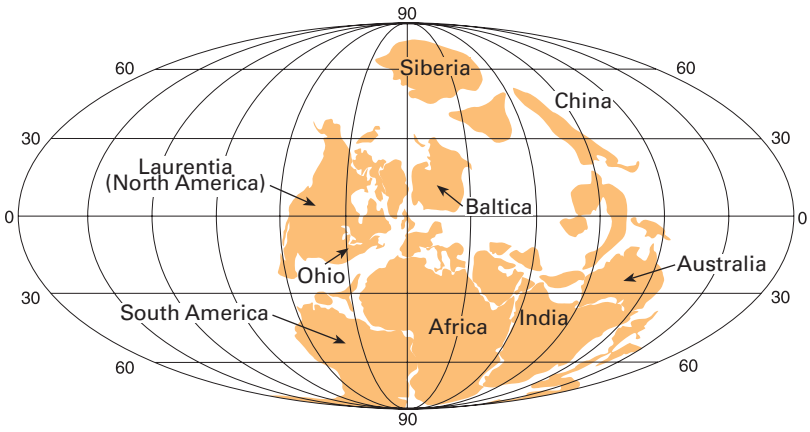
by Michael C. Hansen

A cursory glance at Mississippian-age rocks in Ohio suggests a monotonous sequence of poorly fossiliferous shales and sandstones. But these rocks have been and continue to be of economic importance to the state. They also form some of Ohio's most spectacular geological scenery, including cliffs, gorges, waterfalls, natural bridges, and rock-shelter caves. Mississippian rocks record a quiescent phase in Late Paleozoic continental collision and mountain building during most of the period, but provide a signal of the great revolution that occurred at the end of the Paleozoic Era: the rise of the Appalachian Mountains. During the Mississippian Period, which began about 360 million years ago and ended about 325 million years ago, Ohio was in equatorial latitudes and had a warm, tropical climate. Although the preserved fossil record of the Mississippian in Ohio is relatively poor, life flourished in the seas and, more importantly, gained a strong foothold on the land.

As geologists began to study the sequence of Paleozoic rocks in Europe, especially in Great Britain, they recognized a coal-bearing sequence of rocks that was underlain by a generally barren sequence. These rocks were collectively grouped into the Carboniferous System. Eventually, the Carboniferous was divided into the Lower and Upper Carboniferous. This terminology was followed in the United States until 1891, when the U.S. Geological Survey assigned the lower sequence to the Mississippian Series, named for exposures in the Mississippi River valley, and the upper sequence to the Pennsylvanian Series, named for exposures in Pennsylvania. In 1906, it was proposed to raise these series to systemic rank, a practice that has been followed in the United States since then. In Europe, and indeed in most of the rest of the world, Lower Carboniferous and Upper Carboniferous are the generally accepted terms.

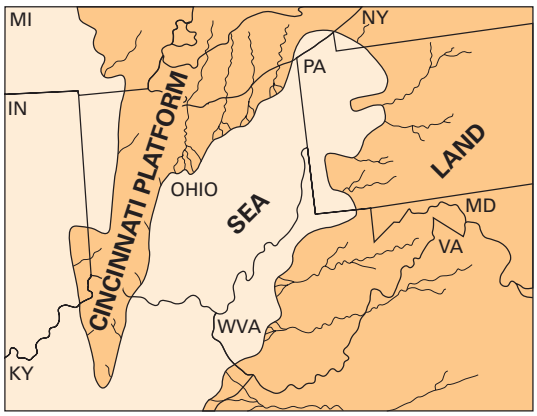
MISSISSIPPIAN ROCKS IN OHIO

Rocks of Mississippian age in Ohio crop out in a 30- to 50-mile-wide belt through the center of the state from the Ohio River in Scioto County northward almost to Lake Erie and then eastward in a narrower belt to the Pennsylvania line, paralleling the Lake Erie shore. These rocks were deposited on the western edge of the Appalachian Basin. The outcrop area covers more than 8,500 square miles, or about 20 percent of the state. Mississippian rocks also are present in the northwestern corner of the state, primarily in Williams and Fulton Counties; however, they are deeply buried beneath thick glacial sediments and are not exposed at the surface. These rocks were deposited in the Michigan Basin, on the west side of the Findlay Arch.



Continental configuration during Mississippian time. Modified from W. S. McKerrow and C. R. Scotese, 1990, Revised World maps and introduction, in *Palaeozoic Palaeogeography and Biogeography, Geological Society Memoir 12, fig. 17.*

Traditionally, the boundary between the Devonian and the Mississippian Systems has been drawn at the contact between the Ohio Shale and the overlying Bedford Shale. This contact is sharp and marked by a significant change in lithologies, from the dark, carbonaceous Ohio Shale to the light-gray Bedford Shale. It was noted by early geologists that this sharp lithologic change marked the disappearance of the large arthrodire fishes so characteristic of the Late Devonian seas in which the Ohio Shale was deposited. More recently, some geologists have suggested that the boundary



Generalized paleogeographic map of Ohio and surrounding areas during Early Mississippian time. Streams flowing into the Ohio sea from the north and east carried mud and fine-grained sand. The Cincinnati Arch formed a low platform that was probably periodically emergent as sea level fluctuated.

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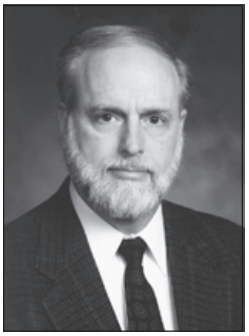

Thomas M. Berg, Division Chief and State Geologist

From The State Geologist...

Thomas M. Berg

STATE GEOLOGISTS HONOR CONGRESSMAN REGULA OF OHIO

Several years ago, the Association of American State Geologists (AASG) established the Pick and Gavel Award to recognize individuals who have made significant contributions to advancing or facilitating the role of geoscience in the public-policy arena. On March 20, 2001, at an AASG banquet in Washington, D.C., I had the distinct honor to be able to present the Pick and Gavel Award to Representative Ralph Regula of Ohio's 16th Congressional District. AASG honored Representative Regula with the award because of his continuing promotion of good geoscience and geologic mapping in the United States. The 2001 Pick and Gavel Award was a beautiful, 11-inch-high specimen of black siliceous limestone from Nevada covered with white barite crystals and drusy quartz. At the base of the specimen, the Pick and Gavel Award displays a geologist's pick (representing the profession of geology), a gavel (representing the deliberative process of government), and the Nation's Capitol (where the two come together in formulating national public policy). The following is my citation for Congressman Regula:

Congressman Ralph Regula

Citation for the 2001 Pick and Gavel Award of the Association of American State Geologists to the Honorable Ralph Regula, Member of Congress, for his enduring support of good geoscience and geologic mapping

It gives me great pleasure to present the citation for Congressman Regula of Ohio. Mr. Regula is well known for his strong and enduring support of good geoscience carried out by the U.S. Geological Survey and the state geological surveys. He is enthusiastic about maps of all kinds, and has been a wholehearted supporter of the National Cooperative Geologic Mapping Program. Only last year, while visiting the USGS at Reston, he was shown some maps of his farm near Navarre in northeastern Ohio, and he surprised the geologists by pointing out coal mines and glacial deposits. It is a tremendous benefit for Americans to have members of Congress who understand geology and the enormous value of geologic maps for the assessment and management of our natural resources.

Congressman Regula began his career as a schoolteacher and principal with Stark County schools in Ohio, and he later served on the Ohio Board of Education. He obtained his Bachelor of Arts degree from Mount Union College, and obtained a law degree from the William McKinley School of Law. He spent two years on active duty with the U.S. Navy during World War II. After serving in the Ohio House and Senate, Mr. Regula was elected to the U.S. House of Representatives in 1972 where he is now serving his fifteenth term. Honorary doctoral degrees have been awarded to him by The University of Akron, Mount Union College, Ashland University, and Malone College. He and his wife, Mary, maintain the farm near Navarre, and his three children and two grandchildren live nearby.

He served as Chairman of the House Appropriations Subcommittee on Interior and Related Agencies for six years. In that role, Congressman Regula became very familiar with the role and the goals and objectives of the national and state geological surveys. The subcommittee plays an important role in protecting natural resources, public lands, and cultural resources, and in promoting development of energy resources. Mr. Regula understands the many-faceted responsibilities of the USGS in today's world, and he is aware of the close interaction of the USGS with the state surveys and the Association of American State Geologists. He has supported funding of the National Cooperative Geologic Mapping Program. He was strongly supportive of Ohio's Lake Erie Coastal Erosion Program—a USGS-Ohio Survey partnership—assuring that funding was appropriated to carry out the research and coastal-erosion-area mapping. He has always encouraged such partnerships and is an enthusiastic advocate of the Central Great Lakes Geologic Mapping Coalition.

Congressman Regula was instrumental in starting funding for OhioView, a consortium of Ohio universities working together to obtain satellite imagery for earth-science research. OhioView has become an important cog in the Gateway to Earth Project wherein data of the USGS will be made more readily accessible to the general public. Through Mr. Regula's efforts last year, the USGS received the largest budget in its history, and the National Cooperative Geologic Mapping Program received a major increase. I am sure that the Association of American State Geologists will do everything it can to build on that legacy.

Ladies and gentlemen, it is with enormous pride and enthusiasm that I present Congressman Ralph Regula of Ohio, a distinguished educator, legislator, and public servant who has provided enduring support of good geoscience and geologic mapping in the United States, and is now a Year 2001 AASG Pick and Gavel Awardee!

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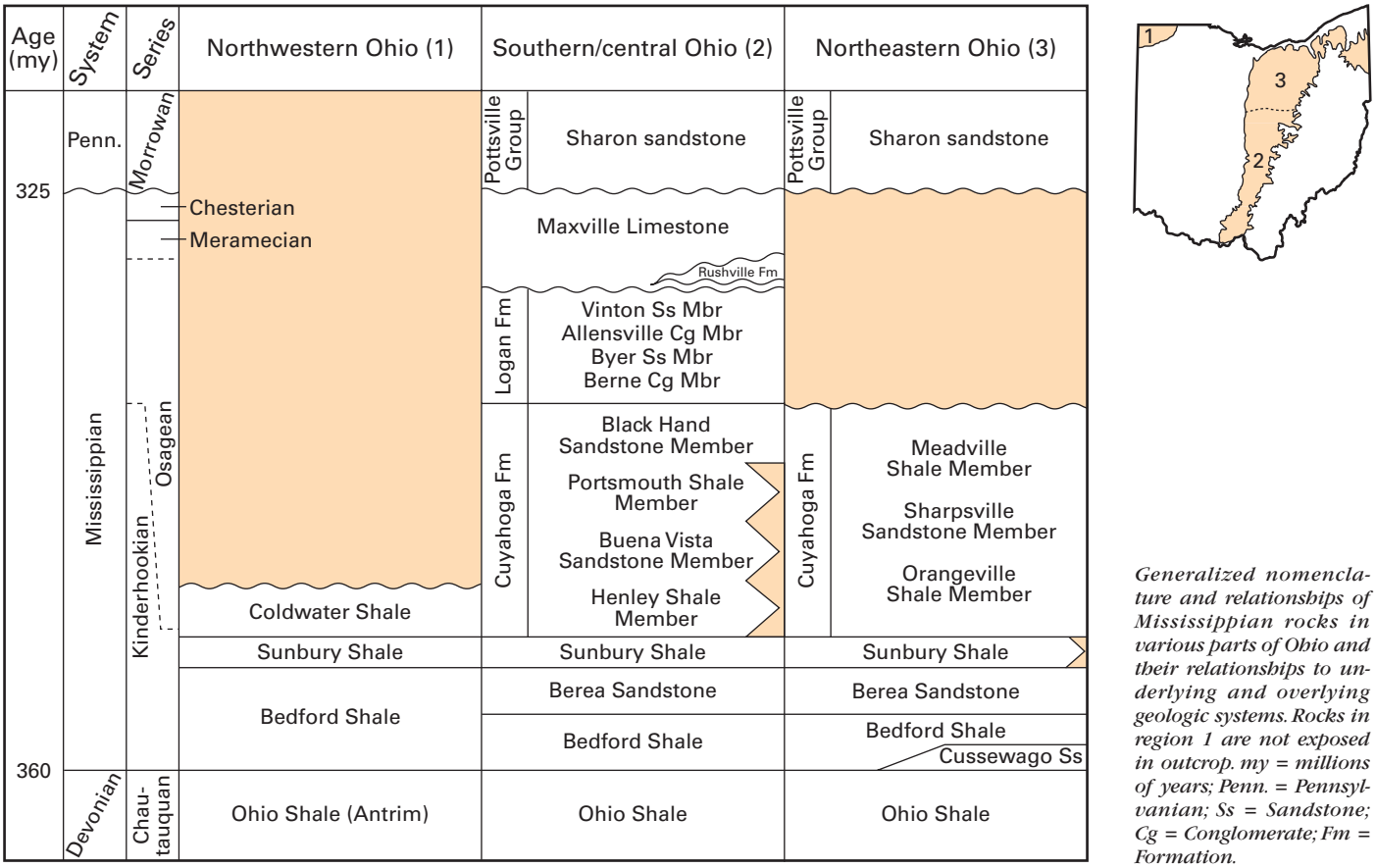
between the two systems is much higher and should be drawn at the top of the Berea Sandstone. The uncertainty of this boundary is primarily a result of restricted fossil remains in both the Ohio Shale and the Bedford Shale and contrasting depositional environments. The Ohio Shale was deposited offshore in comparatively deep, stagnant marine waters that harbored fishes and other swimming/floating creatures in the oxygenated upper portion. The Bedford, which represents deposition in a shallower, oxygenated, but muddy sea, is generally poorly fossiliferous but has a well-developed bottom-dwelling invertebrate fauna in the basal portion. One possibility is that the Bedford-Berea sequence is Late Devonian in the Ohio portion of the depositional basin and Early Mississippian to the east. The Division of Geological Survey has more recently considered the Bedford Shale to be Devonian-Mississippian in age, which alludes to the equivocal nature of the evidence.

Mississippian rocks reflect a sharp change in depositional environments in Ohio as the Devonian-age Acadian highlands and the Catskill and Pocono deltas to the east were eroded during a long, relaxational phase of Late Paleozoic continental collision. Streams carried these sediments into the Ohio basin, creating muddy to sandy seas in which up to 1,000 feet of strata were deposited. The shales and sandstones that dominate Mississippian rocks were clearly recognized as being a major change from underlying rocks by geologists of the First Geological Survey of Ohio in 1837-38. Charles Briggs named this group of rocks, beginning at the base of the Bedford Shale and ranging to the base of the Sharon sandstone of Pennsylvanian age, the Waverly Sandstone Series.

The current classification of the Mississippian System in Ohio was developed, with some later additions, in the late 1800's and early 1900's by geologists working for the Ohio Geological Survey. It is a complex system dominated by shale and fine-grained sandstone and includes many transitional lithologies or facies. The lack of abundant fossils for correlation and zonation has made subdivision and classification difficult and challenging.

The Bedford Shale was named for the town of Bedford, in Cuyahoga County, and consists of about 95 feet of gray, sandy shale that is reddish in the middle part in central and southern Ohio. East of Cleveland to the Pennsylvania line, the Bedford includes lenses of sandstone (called the Euclid bluestone) that have been quarried locally for flagstone. The Bedford is generally unfossiliferous except for the lower few feet of the unit. Along the Ohio-Pennsylvania border in northeastern Ohio, the Cussewago Sandstone underlies the Bedford Shale. This greenish-yellow, poorly cemented sandstone is about 30 feet thick and has been traced into Ohio from northwestern Pennsylvania.

The Berea Sandstone has its type area at the town of Berea, in Cuyahoga County, where it was quarried at an early date for grindstones. The Berea is a fine, angular-grained sandstone throughout most of its outcrop area but becomes a gray siltstone in southern Ohio. In northern Ohio, near South Amherst in Lorain County, it reaches a



Generalized nomenclature and relationships of Mississippian rocks in various parts of Ohio and their relationships to underlying and overlying geologic systems. Rocks in region 1 are not exposed in outcrop. my = millions of years; Penn. = Pennsylvanian; Ss = Sandstone; Cg = Conglomerate; Fm = Formation.

thickness of 235 feet in channel-like features. This area has been the site of important quarries since the mid-1800's. The Berea is almost totally devoid of fossils but is noted for sedimentary features such as ripple marks, load casts, and flow rolls. Recent investigations by the Division of Geological Survey in northwestern Ohio suggest that the Berea is not present in this area.

The Sunbury Shale, named for outcrops near the village of Sunbury, in Delaware County, is a dark, fissile, organic shale very similar to the Devonian-age Ohio Shale. It averages about 20 feet in thickness and is widespread from southern Ohio northward, but pinches out toward the Pennsylvania state line in northeastern Ohio. The Sunbury Shale suggests return of a quiet, deeper, stagnant sea over Ohio for a brief period. The Sunbury is sparsely fossiliferous, containing rare fossils of swimming and floating organisms.

The Cuyahoga Formation was named for exposures along the Cuyahoga River in northeastern Ohio and consists of shale, sandstone, and conglomerate. The Cuyahoga is a complex package of rocks that have many separate facies and poorly known age relationships. The formation reaches a maximum thickness of 625 feet in the Hocking Valley region of south-central Ohio. In northern Ohio, the Cuyahoga is dominated by shale, some of which is locally fossiliferous, and has been divided, in ascending order, into the Orangeville, Sharpsville, and Meadville Members. Sandstone is more prevalent in the Cuyahoga Formation in central and southern Ohio. The Black Hand Sandstone Member reaches 200 feet in thickness in outcrops in the Hocking Valley region. The Buena Vista Sandstone Member is prevalent in southern Ohio, where it has been quarried for many years. The Coldwater Shale, in part an equivalent of the Cuyahoga Formation, is present in northwestern Ohio and reaches a thickness of about 130 feet.

The Logan Formation, named for the town of Logan, in Hocking County, is dominated by fine-grained sandstone and sandy shale and is developed in southern and central Ohio. The formation is absent in northern Ohio, where it was removed by erosion during the Late Mississippian and Early Pennsylvanian. It is generally poorly fossiliferous, but has yielded marine fossils locally.

The Rushville Formation is composed primarly of shale, but has a foot-thick limestone near its base. It is known only from one outcrop near the town of Rushville, in Fairfield County. This unit would seem to be insignificant; however, study of conodonts (microscopic, phosphatic fossils) reveals that it represents the only depositional record in Ohio during the latest Early Mississippian time, thus demonstrating that there were intervals of nondeposition and/or erosion.

The Maxville Limestone was named for the community of Maxville, in Perry County. The Maxville is discontinuous in its outcrop distribution as well as in the subsurface and is present only in southern and east-central Ohio. The unit averages about 50 feet thick on the outcrop, but reaches a thickness of nearly 200 feet in the subsurface. It rests disconformably on the underlying Logan Formation. Study of conodonts indicates that the Maxville Limestone consists of beds that span both middle and late Mississippian time. The unit is generally poorly fossiliferous and was deposited in discontinuous "pods," which were then significantly dissected by early Pennsylvanian streams. The disconformities within the Maxville and evidence that some beds were deposited in very shallow, perhaps tidal-flat environments suggest that it records a developing structural "forebulge," which signaled the beginning of continental collision to the east and the development of the Appalachian Mountains. The Maxville has been quarried for a number of years.

SCENIC GEOLOGY

Perhaps no other geologic system in the state can rival the Mississippian for spectacular scenic features. Thick beds of sandstone, particularly the Black Hand Sandstone Member of the Cuyahoga Formation and the Berea Sandstone, are nearly pure quartz and well cemented—therefore making them resistant to erosion. Because of this resistance, these units form steep cliffs that line gorges in some parts of the outcrop belt.

The Black Hand Sandstone Member is the best-known unit for providing scenic gorges, waterfalls, and rock-shelter caves. Most Ohioans have visited, or at least heard about, the spectacular features formed in the Black Hand in Hocking Hills State Park in Hocking County. The separate park areas—Ash Cave, Cedar Falls, Conkle's Hollow, Old Man's Cave, and Rock House—owe their existence to the nearly 200-foot thickness of the Black Hand in this area and to the fact that it is differentially cemented. The middle part of the unit is less resistant to erosion than the top and bottom layers and therefore weathers more quickly, forming deep amphitheaterlike recesses known as rock-shelter caves, such as Old Man's Cave. The resistant upper part of the Black Hand forms the rims of the deep gorges, over which waterfalls plunge. At

Upper Falls at Old Man's Cave, Hocking Hills State Park, Hocking County. This waterfall is developed in the upper resistant layer of the Black Hand Sandstone Member of the Cuyahoga Formation. Photo by Robert Wheaton.

Old Man's Cave, the upper part of the Black Hand forms Upper Falls and the lower part of the unit forms Lower Falls.

There are many nonpublic areas within the Hocking Hills region where the Black Hand Member forms features similar to those in the park areas. Northward, into Fairfield and Licking Counties, the Black Hand provides many scenic areas, including Black Hand Gorge on the Licking River east of Newark and Rising Park in Lancaster. It was from the Black Hand Gorge that the unit received its name. Early pioneer settlers in Ohio described a large image of a human hand, inscribed with soot or charcoal, on the sandstone wall of the gorge. Legend was that this petroglyph was placed there by American Indians as a marker to the well-known flint beds of Flint Ridge, a few miles south of the gorge. The hand was accidentally blasted away during the building of the Ohio and Erie Canal in the early 1800's.

The Mohican area of Richland County represents the northernmost outcrop area of thick Black Hand Sandstone Member. Although rock-shelter caves are not as well developed as in the Hocking Hills, there are still many breathtaking waterfalls and cliffs in this region. Mohican State Park is the best area for viewing these features.

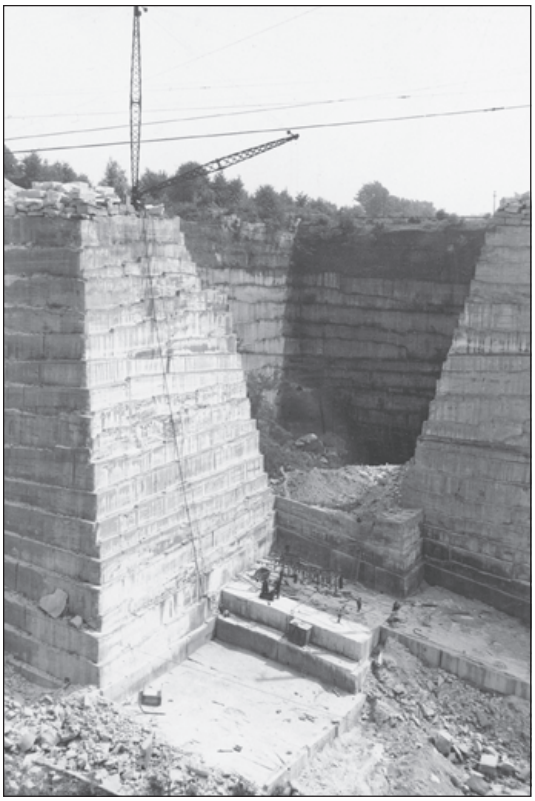
The Berea Sandstone, particularly where it is thick in northern Ohio, forms many cliffs, gorges, and waterfalls. Areas such as Tinkers Creek Gorge and Stebbins Gulch, among many others, have scenic exposures of Berea Sandstone.

ECONOMIC GEOLOGY

The shales and sandstones of the Mississippian System in Ohio have been of significant economic importance to the state almost from the beginning of settlement. Early pioneers noted that the Berea Sandstone in the vicinity of its type area was well suited for use as grindstones, which were previously imported at considerable expense from Nova Scotia. By 1832, John Baldwin of Berea had established a commercial operation for production of grindstones. This industry soon became important for Ohio, and many small grindstone quarries were opened in the Berea Sandstone. The fine, uniform, angular quartz grains made this stone well suited to this purpose.

By 1855, quarries were opened in the Berea near South Amherst in Lorain County, where this unit reaches more than 200 feet in thickness. These large quarries soon became an important source of building stone throughout the eastern half of North America. Many public and private buildings in cities from Chicago to Toronto to Boston were constructed of Berea Sandstone from the South Amherst quarries. Here the stone was uniform and could easily be sawed and shaped into both structural and decorative stone. Eventually, most of the quarries were acquired by the Cleveland Quarries Company. Their No. 6 quarry is reported to be the largest sandstone quarry in the world.

The Berea Sandstone was quarried at numerous operations along the outcrop area, from just south of Lake Erie to the Ohio River. Grindstones,



Buckeye quarry of the Cleveland Quarries Company at South Amherst, Lorain County. The Berea Sandstone is more than 200 feet thick at this location. Photo taken in 1952 by Charles H. Bowen.

curbing for roads, foundation stone for buildings and bridges, and decorative architectural stone were just some of the uses of this durable and versatile rock. Not only are there still many prominent buildings built of Berea still in existence, but many older homes in numerous communities have foundations of Berea Sandstone. Some communities still have sidewalks constructed of slabs of Berea that have withstood the ravages of the elements and the footsteps of many generations.

The rise to prominence of portland cement and the wide use of concrete for construction soon after the beginning of the 20th century signaled the decline of the use of the Berea and many other sandstones in the building industry. Only two Berea quarries in Ohio reported production in 1999.

A number of other, geographically restricted sandstones of Mississippian age have been quarried in the state. Particularly important have been the Buena Vista and the Black Hand Members of the Cuyahoga Formation. The Buena Vista looks superficially very similar to the Berea, but it is younger than the Berea. The Buena Vista is restricted to an area from Scioto County to Pike County in southern Ohio. This unit was quarried near Buena Vista as early as 1814 and soon became popular with architects and builders in Cincinnati, who could obtain it easily by shipping on the Ohio River. A prominent bed, about 3 to 4 feet thick, became known as the City Ledge because of its extensive use in Cincinnati buildings. In 1905, the Waller Bros. Stone Company began operations

near McDermott in Scioto County and is still active today quarrying the Buena Vista for dimension stone and other products.

The Black Hand Sandstone Member, which is perhaps better known for the scenic vistas and erosional features created by its prominent cliffs, was once actively quarried from Licking County southward to Hocking County. Although the Black Hand was used in the construction of some buildings, it was used primarily for canal locks and railroad bridges and as a glass sand because of its purity. Currently, there is only one active quarry in the Black Hand, in Knox County, where the unit is crushed into sand for glass and a variety of industrial and construction uses.

The Bedford Shale was used as a source of clay for production of brick, tile, and other ceramic products in central and northern Ohio. Competition from concrete and plastics eventually led to the demise of these operations in the last few decades. Two quarries reported production of the Bedford Shale in 1999.

Oil and gas also have been important commodities obtained from Mississippian rocks. The Berea Sandstone first yielded natural gas from wells drilled at East Liverpool, in Columbiana County, in 1859 or 1860. Berea hydrocarbon fields have been developed in eastern Ohio. The Black Hand Sandstone Member, or "Big Injun" as it is known to drillers, has produced natural gas, particularly in southern Ohio. In 1999, 28 wells were completed in Mississippian rocks in the state.

MISSISSIPPIAN LIFE

The traditional dioramas or scenes of life during the Mississippian Period commonly depict vast stands of stalked crinoids waving in the currents of warm, clear, tropical seas. These typical crinoids are surrounded by a variety of brachiopods, mollusks, and other benthic creatures on the limy sea floor. Such recreations are accurate for areas west of Ohio during this period. Indeed, the Mississippian limestones of the midcontinental United States are literal hashes of crinoid columnals and shell fragments of other creatures. Some of the finest examples of articulated crinoid remains have come from these rocks.

In Ohio, however, the mud and sand that were carried into the sea across the state created turbid waters that were unfavorable for extensive development of bottom-dwelling animals. Many Mississippian units in Ohio seem to be nearly devoid of fossils. There are exceptions to this general observation, as some units at some localities yield an abundant and diverse assemblage. However, preservation is commonly poor because shell material has been replaced by iron minerals such as limonite or goethite, or the fossil consists of a cast of the original animal. Particularly common in some units are trace fossils—tracks, trails, and burrows of marine worms that lived within the muddy sediments.

The Bedford Shale can be very fossiliferous in the basal few feet of the unit, just above its contact with the underlying Ohio Shale. In fact, one argument for the Mississippian age of the Bedford Shale and the overlying Berea Sandstone is the presence of a coiled nautiloid cephalopod, *Wocklumeria,* at the base of the Bedford. This cephalopod defines the top of the Devonian System in Europe. The Berea Sandstone is almost totally devoid of fossils except for a few specimens of a bony fish, *Gonatodus brainerdi,* found in the last century in quarries at Chagrin Falls. The Sunbury Shale is poorly fossiliferous but is noted for remains of a shark, *Stethacanthus,* and phosphatic brachiopods such as *Lingula* and *Orbiculoidea.*

The Cuyahoga Formation is, in general, poorly fossiliferous with a few notable exceptions. There are layers within the Orangeville Shale Member and the Sharpsville Sandstone Member, especially in northeastern Ohio, that are very fossiliferous. In southern Ohio, the Portsmouth Shale Member yielded an abundant and diverse fauna from a locality know as the Sciotoville Bar; this ledge along the Ohio River was submerged in 1920 when the river was dammed. These fossils were described by Case Western Reserve University geologist Jesse E. Hyde in Ohio Geological Survey Bulletin 51, published in 1953. The uppermost unit in the Cuyahoga in northern Ohio, the Meadville Shale Member, is very fossiliferous, especially in the vicinity of Lodi, in Medina County. More than 125 species have been reported from the Meadville.

The Logan Formation is poorly fossiliferous throughout its outcrop area in southern and central Ohio, but some localities yield a variety of brachiopods. The uppermost Mississippian unit, the Maxville Limestone, is unlike the highly fossiliferous limestones of the Midcontinent in that it yields few fossils. It is probable that much of the Maxville was deposited in restricted, shallow, hypersaline, tidal-flat conditions in which few animals could flourish. There are some beds, especially in the upper part of the unit, that are very fossiliferous. A thin shale bed in Perry County yielded fossil clams, *Aviculopecten winchelli,* that preserve the original color patterns on the shell.

No terrestrial vertebrates have been found in Mississippian rocks in Ohio, but nearby at Greer, West Virginia, an important assemblage of Late Mississippian amphibians was discovered in the late 1960's. This occurrence provides an enticing view of the conquering of the land that would take place in the succeeding Pennsylvanian Period, a saga that is well represented by fossils from Ohio.

Mississippian rocks continue to yield economic returns to the state and were of great importance to industrial development and prosperity during the 1800's. The scenic respites provided by the cliffs and waterfalls developed on Mississippian rocks will continue to be treasures to Ohioans.

ACKNOWLEDGMENTS

We thank Survey geologist Ernie R. Slucher for his comments on this article.

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Dick Carlton retires

Survey geologist Dr. Richard W. Carlton retired on March 31, 2001, after more than 30 years of service with the Division. Dick is originally from Longview, Washington. He completed a B.S. degree in geology at Washington State University in Pullman and obtained his M.S. and Ph.D. degrees in geology from Oregon State University in Corvallis. Dick came to the Survey as a research geologist in November 1970 and received his Ph.D. degree in 1972.

Dick devoted a large portion of his career to work on several energy-related federal and state cooperative programs. During the late 1970's, Dick was one of several researchers from a multistate area working on the U.S. Department of Energy Eastern Gas Shales Project. He characterized the mineralogy of Ohio's Devonian black shales in an effort to quantify and enhance recovery of natural gas from the Devonian shales of the Appalachian area. In the early 1980's, Dick was one of the principal investigators in a coal-washability research project for the Ohio Air Quality Development Authority. His work on pyrite size distribution in coal marked the beginning of his extensive interest in sulfur-removal prediction techniques. Since 1989, Dick has been the lead worker in the development of a computerized database on Ohio coals for the National Coal Resources Data System (NCRDS) of the U.S. Geological Survey. During the past 12 years, Dick and his many interns have computerized data for more than 25,000 coal-point locations. In the midst of this effort, Dick performed a modern assessment of Ohio's coal resources and reserves for the U.S. Department of Energy, Energy Information Administration and provided technical support to the U.S. Geological Survey for its National Coal Assessment Program regarding point locations and elevations for the Pittsburgh, Upper Freeport, Middle Kittanning, and Lower Kittanning coals.

Perhaps Dick's greatest interest, and passion, was petrographic and mineralogic analysis. His analyses have included clays for their well-plugging ability, "Clinton" sandstone for its oil- and gas-producing potential, and most recently, quartz grains for their solution to the mystery of the origin of the Serpent Mound disturbance.

Dick will be missed professionally and personally at the Survey. Survey staff, geologic consultants, the mining community, and the U.S. Geological Survey have called upon his expertise frequently. As a result of his dedication, Ohio Department of Natural Resources Director Joseph Sommer presented Dick with the Professional Recognition Award in October 1990.

A recent first-time grandfather, Dick plans to garden, play golf and tennis, and travel with his wife, Patty, and his father. He has his sights set on a trip to Alaska, a float trip down the Colorado River through the Grand Canyon, and a trip to China.

—Douglas L Crowell

Richard W. Carlton

Scudder Mackey resigns

Dr. Scudder D. Mackey, supervisor of the Survey's Lake Erie Geology Group in Sandusky, Ohio, since 1992, resigned his position effective February 21, 2001. He has accepted a position with the Great Lakes Protection Fund in Evanston, Illinois. During his nine years with the Survey, Scudder oversaw a number of major projects, including a five-year cooperative study of the Ohio shore of Lake Erie with the U.S. Geological Survey and a six-year effort to designate Lake Erie coastal erosion areas for the Ohio Coastal Management Program.

Scudder and his staff used geology and geologic principles to develop innovative solutions to environmental problems. He advocated creation of a riparian wetland on the floor of the drained Ivex Reservoir on the Chagrin River, using his expertise with fluvial processes to guide design of the wetland to minimize erosion of the exposed sediments. In October 1995, the City of Chagrin Falls presented Scudder with a proclamation in recognition of his contributions to the project.

Scudder helped design and supported placing a fish gate in the dike at Metzger Marsh, so that fish and other aquatic species can access the wetland during their life cycle. The gate also allows water levels in the wetland to fluctuate in phase with Lake Erie, thereby mimicking the natural fluctuations that occurred in all Lake Erie coastal wetlands prior to their diking.

Scudder D. Mackey

Scudder also oversaw mapping of geologic substrates in the nearshore areas of Lake Erie and along tributaries to Lake Erie; these data will be used for habitat studies and habitat restoration projects. One of Scudder's greatest contributions to coastal geology may have been promoting cooperative lakewide research by state and federal agencies.

In recognition of Scudder's exceptional service to the State of Ohio, the Ohio Senate formally commended him in March 2001. The commendation, signed by Senator Richard H. Finan, President of the Ohio Senate, and Senator Jeffrey J. Armbruster, recognized Scudder for . . . *unwavering dedication to performing your duties and fulfilling your responsibilities with the utmost efficiency and competence. Always sincere and energetic in your approach to your work, you have given freely of your time and abilities far beyond what was required or expected and have displayed a genuine commitment to achieving your goals in a skillful and professional manner.*

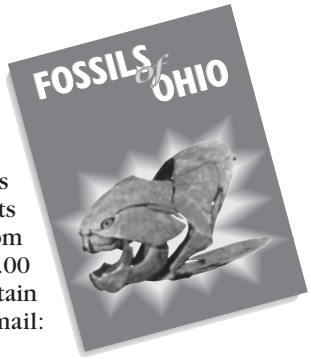
Scudder had a great rapport with the media and with the public. His enthusiasm and knowledge of the lake and lake processes will be missed.

Mapping Groups reorganized

On March 1, 2001, Division Chief Thomas M. Berg announced an organizational change within the Division. The Bedrock Geology Mapping Group and the Environmental & Surficial Geology Mapping Group have been combined into a single unit called the Geologic Mapping Group. Mac Swinford is the group supervisor, handling administrative duties for the group, including performance evaluations in line with the new Ohio Performance Review System. Rick Pavey is the administrative assistant for the group. He will continue to guide surficial-materials mapping in Ohio and serve as the principal liaison to the Central Great Lakes Geologic Mapping Coalition.

The principal thrust of the Geologic Mapping Group for the foreseeable future will be mapping the surficial materials in Ohio in three dimensions. This is an enormous challenge, but much needed by Ohio's citizens, particularly as they look to more carefully manage the state's ground-water resources.

Fossils of Ohio wins award



Division of Geological Survey Bulletin 70, *Fossils of Ohio*, has received the Outstanding Publication Award for the year 2000 from the Association of Earth Science Editors (AESE). In an announcement about the award, AESE praised the book for "its beautiful drawings, fine photographs, and excellent indexes. The introductory matter was helpful to a lay audience and should invite the reader in to the more technical sections."

The AESE Outstanding Publication Award recognizes an earth-science publication—book, map, journal, or other individual publication, including those produced electronically—for the quality of its editing, design, illustration, writing, production cost-per-copy, and overall effectiveness in achieving its publication goal. The Division of Geological Survey is very pleased and honored to receive this award from AESE. *Fossils of Ohio* continues to be the Division's top-selling publication and is still a bargain at $20.00 (plus handling and Ohio sales tax). To order a copy, contact the Geologic Records Center, 4383 Fountain Square Drive, Columbus, OH 43224-1362, telephone: 614-265-6576, fax: 614-447-1918, e-mail: geo.survey@dnr.state.oh.us. Visa and MasterCard are accepted.

Ohio Geology

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