Ohio Geology

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THE GEOLOGY OF OHIO—THE ORDOVICIAN

by Michael C. Hansen

To geologists, the Ordovician System of Ohio is probably the most famous of the state's Paleozoic rock systems. The alternating shales and limestones of the upper part of this system crop out in southwestern Ohio in the Cincinnati region and yield an incredible abundance and diversity of well-preserved fossils. Representatives of this fauna reside in museums and private collections throughout the world. Indeed, fossils from Ohio's Ordovician rocks define life of this geologic period, and the rocks of this region, the Cincinnatian Series, serve as the North American Upper Ordovician Standard. Furthermore, in the late 1800's, Ordovician rocks in the subsurface in northwestern Ohio were the source of the first giant oil and gas field in the country.

Compared to other geologic systems, however, the Ordovician is a relative newcomer. Not geologically, of course—it began about 500 million years ago and ended about 440 million years ago—but in terms of being recognized as a separate geologic system. The controversy began in Wales in 1831 when Adam Sedgwick defined a sequence of rocks he called Cambrian and Roderick Murchison studied a younger sequence of rocks he called Silurian. The controversy centered on the fact that Murchison considered Sedgwick's Upper Cambrian rocks to belong to his Lower Silurian sequence. It wasn't until 1879 that another Englishman, Charles Lapworth, settled the problem by placing the controversial beds in a new system, the Ordovician.

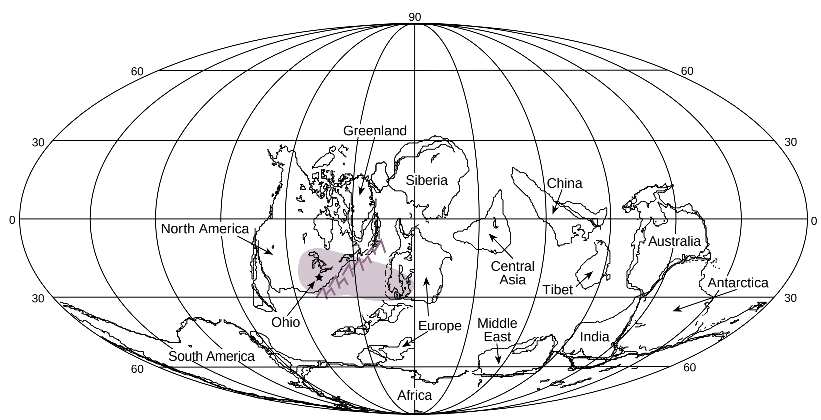
Ohio Geological Survey reports of the last half of the 19th century refer to these rocks in Ohio as the Lower Silurian. Indeed, the U.S. Geological Survey did not accept the Ordovician as a distinct geologic system until 1903, and the term was not used officially in Ohio until 1909 by State Geologist John A. Bownocker on the geologic map of the state.

ORDOVICIAN PALEOGEOGRAPHY, OROGENY, AND VOLCANISM

During the Ordovician, Ohio was in southern tropical latitudes and dominated by warm, shallow seas. The Iapetus, or proto-Atlantic, Ocean, which formed in Late Precambrian and Cambrian time, began to close during the Ordovician. Collision between the North American and European continents during the Middle Ordovician formed a series of island arcs and mountains to the east of Ohio. This event, the Taconic Orogeny, which culminated in the Late Ordovician, is recorded in rocks stretching from Newfoundland to Alabama.

Although Ordovician rocks in Ohio were not directly involved in the collisional event, they record these activities. The widespread Knox unconformity (see *Ohio Geology*, Winter 1997), an episode of emergence and erosion, was formed when the land surface bulged upward (known as a peripheral bulge), accompanying development of a foreland basin to the east at the edge of the orogenic belt. As the Taconic Orogeny reached its zenith in the Late Ordovician, sediments eroded from the rising mountains were carried westward, forming a complex delta system that discharged mud into the shallow seas that covered Ohio and adjacent areas. The development of this delta, the Queenston Delta, is recorded by the many beds of shale in Upper Ordovician rocks exposed in southwestern Ohio.

The island arcs associated with continental collision were the sites of active volcanoes, as documented by the widespread beds of volcanic ash preserved in Ohio's Ordovician rocks (see *Ohio Geology*, Summer/Fall 1991). The ash layers, which to geologists are wonderful time lines because they were deposited instantaneously over a wide geographic area, have been altered to a special type of clay known as a bentonite. There are a number of bentonite beds in Ohio's Ordovician rocks, but two beds in Middle Ordovician rocks, the Deicke bentonite and the Millbrig bentonite, may represent some of the largest explosive volcanic eruptions in the geologic record. These beds have been traced from the Mississippi River eastward across North America and Europe and into Russia. It has been estimated that these eruptions generated about 5,000 times the volume of volcanic ash produced by the eruption of Mt. St. Helens in 1980.



Continental positions in Late Ordovician time. The shaded area depicts the extent of the Millbrig bentonite (altered volcanic ash) at the top of the Black River Group (Middle Ordovician). This bentonite has a volume of about 175 cubic miles and represents the largest known explosive volcanic eruption in Earth's history. The source of the eruption is thought to have been in the southeastern United States along an island arc formed by the closing of the Iapetus Ocean during the Taconic Orogeny. Modified from Coogan (1996) and Potter (1995).

The Cincinnati Arch, a north-south-oriented, positive structural feature in southwestern Ohio and adjacent areas to the south, began to form in the Late Ordovician, perhaps initiated by the Taconic Orogeny. The axis of the arch is east of Cincinnati

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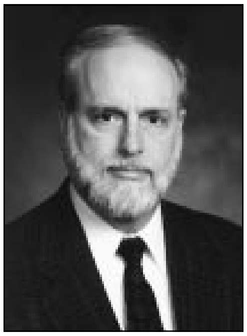

Thomas M. Berg, Division Chief and State Geologist

From The State Geologist...

Thomas M. Berg

A GENTLEMAN AND A SCHOLAR—STATE GEOLOGIST RALPH J. BERNHAGEN

With sorrow in our hearts, we announce the passing of Ralph J. Bernhagen in this issue of *Ohio Geology*. The details of our former State Geologist's career and his outstanding accomplishments are presented in a full article in this issue, but I would like to add my personal reflections in this editorial.

Bernie appeared in my office shortly after my appointment as Chief of the Division of Geological Survey in March of 1989. He offered his full support and friendship as I took on the task of leading the Ohio Survey. My wife, Betty, and I quickly became close friends of Bernie and his wonderful wife, Lillian. As a member of the American Institute of Professional Geologists, Bernie introduced me to members of the Ohio Section—a great way to get to know many in the local geological community. As an Honorary Member of the Association of American State Geologists (AASG), Bernie always joined me at the annual meetings and helped represent the State of Ohio. Of course, Bernie always brought Lillian to those meetings and I brought Betty with me. The spouses usually have their own field trips at AASG meetings, while the state geologists conduct their business sessions. It always brightened our days to have Bernie and Lillian with us at AASG.

Bernie was a soft-spoken and gentle man. He enjoyed a good joke tremendously, and had a wonderful sense of humor. Yet he never found amusement in someone else's misfortune. In the last couple of weeks of his life, Bernie was quite frail and spent some time in a nursing facility. Even in that setting, he could poke fun at himself.

Ralph Bernhagen cared deeply about the welfare of other people, and he wanted geology to serve the public good. He was very well read in geology and in the sciences in general. He was a strong supporter of the Ohio Academy of Science, serving as its President in 1975. Bernie received many honors during his career of public service to the people of Ohio. It was a great privilege for me to present him with the Survey's Mather Medal in 1993. He seemed genuinely humbled by the award, and didn't want people to make a fuss over him.

I was attending the national meeting of the Geological Society of America (GSA) in Salt Lake City when I got word of Bernie's death. (Bernie was a GSA Fellow.) Later that evening, I joined several other state geologists for dinner at a local Salt Lake restaurant. Like most geologists are wont to do, we ordered a round of beers. We toasted Bernie and said, "See you at the next outcrop, friend!" Good work, Bernie. You'll be sorely missed.

Wright State University offers new graduate program

The Wright State University Department of Geological Sciences Master of Science Teaching (Earth Science) program now offers a concentration in environmental science. Students earn this concentration by taking a five-course suite consisting of environmental statistics, environmental chemistry, risk assessment, an environmental sciences seminar, and geologic and environmental applications of geographic information systems within their program of study. This rapidly expanding nonthesis program for formal and informal educators is student centered, standards based, and offers the opportunity to gain valuable educational experience in Earth system science. Many course sections are offered during the evening hours and in concentrated time periods of a week or less during the summer months. Distance-learning opportunities can reduce a student's time on campus. Challenges include solving field-based, hands-on problems in the Appalachian Mountains or at the Jersey shore. Computer skills can be upgraded in the educational technology courses. For more information about the Master of Science Teaching (Earth Science) program at Wright State University, contact Deborah Cowles, Wright State University, Department of Geological Sciences, 260 Brehm Laboratory, Dayton, OH 45435; telephone: 937-775-3455; fax: 937-775-3462; e-mail: *dcowles@desire.wright.edu*.

Hands on Earth Science series available

Readers of *Ohio Geology* are familiar with the *Hands on earth science* feature compiled by Survey geologist and mineral statistician Sherry Weisgarber. The Survey now offers these classroom geology activities as page-size activity sheets. They are of particular value to teachers and students. Additions to this free activity series will be noted periodically in future issues of *Ohio Geology*. *Hands on Earth Science* Series:

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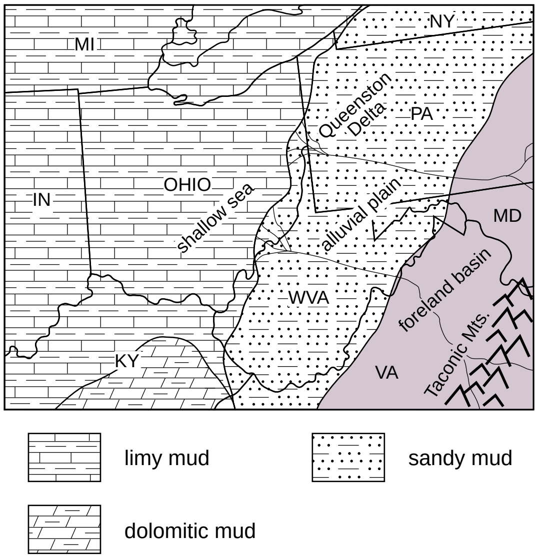


Generalized paleogeography of Ohio and adjacent areas during the Late Ordovician. The Taconic Mountains to the southeast were the source of mud carried far out into the shallow sea that covered Ohio. Modified from Coogan (1996).

and continues northward until it splits into the Findlay Arch to the north and the Kankakee Arch to the west. The broad area formed by the three arches is called the Indiana-Ohio Platform.

The Cincinnati Arch was first discovered by John Locke during his work with the First Geological Survey of Ohio in 1838. It was viewed in a classical interpretation as an anticline, that is, the oldest rocks are exposed along the central axis and progressively younger rocks lie on the flanks. A cursory glance at the geologic map of Ohio implies an anticlinal feature: the oldest rocks exposed in Ohio—Ordovician—crop out along the axis and younger Paleozoic rocks dip eastward into the Appalachian Basin, westward into the Illinois Basin, and northward into the Michigan Basin.

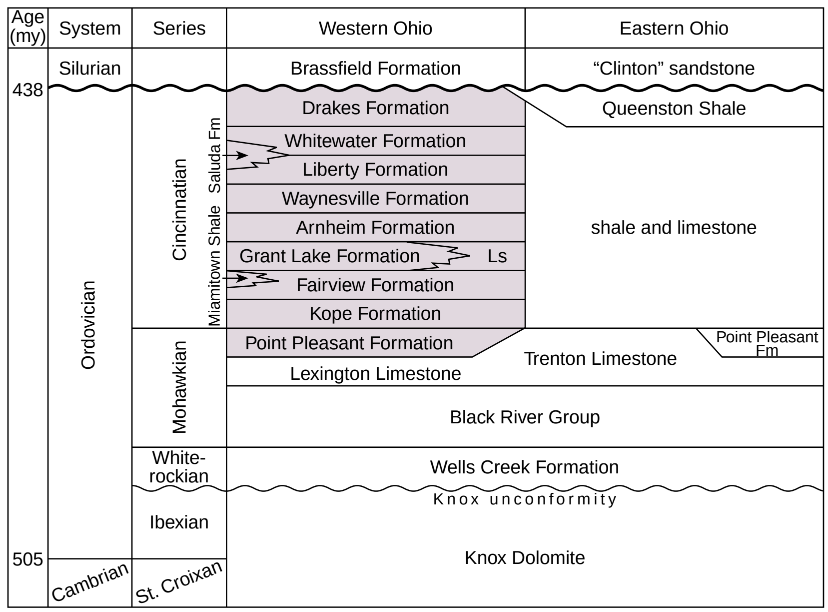
Recent revelations about the geology of the deeply buried Precambrian rocks of the state (see *Ohio Geology*, Winter 1996) indicate that the Cincinnati Arch overlies a sediment-filled rift basin that formed in Late Precambrian time. The area underlain by the rift basin appears to be a comparatively stable crustal block surrounded by subsiding basins. The Cincinnati Arch, therefore, may be viewed not as an anticlinal structure but as a positive feature around which the crust has subsided. This development may have been initiated by the Taconic Orogeny in the Late Ordovician and further accentuated by later Paleozoic orogenic events.

THE ORDOVICIAN SYSTEM IN OHIO

Ordovician rocks crop out in southwestern Ohio and adjacent parts of Indiana and Kentucky along the axis of the Cincinnati Arch. These rocks are well exposed in Hamilton, Clermont, Butler, Warren, and Montgomery Counties; there are lesser areas of exposure or subcrop in Adams, Highland, Clinton, Greene, Clark, Miami, and Preble Counties. Ordovician rocks are particularly well exposed in the southern tier of Ohio counties where the surface is mantled only by thin glacial drift of Illinoian age. Exposed Ordovician rocks belong to the upper third of the system, the Cincinnatian Series, except for some small exposures of the Middle Ordovician Point Pleasant Formation along the Ohio River. However, nearly the entire system is represented in the subsurface of the state to the east and north of the Cincinnati area.

The base of the Ordovician System in Ohio is nowhere exposed in the state and was long interpreted to be at the Knox unconformity, the boundary between the Knox Dolomite and the overlying Wells Creek Formation. The upper part of the Knox Dolomite is now thought to be Early Ordovician in age.

The Ordovician Period is sometimes characterized as the greatest submergence of the North American plate because shallow seas covered such an extensive area, including all of Ohio. The beginning of the Ordovician saw a continuation of shallow-water, tidal-flat environments of the Cambrian portion of the Knox Dolomite. The Knox is sometimes called "The great American tidal flat" because this environment was so extensive.



Stratigraphic column of Ordovician rocks in Ohio. The highlighted units crop out in southwestern Ohio. The remaining units are present in the subsurface of northwestern and eastern Ohio. my = millions of years.

Some time after the erosion that formed the Knox unconformity the seas returned, depositing the Wells Creek Formation, which consists of shale, siltstone, sandstone, and dolomite. This subsurface unit is highly variable in thickness because it was deposited on the topographically irregular surface of the Knox unconformity. The Wells Creek averages about 20 feet in thickness but can be absent on highs on the Knox surface and be up to 60 feet thick in Knox lows. In general, the unit thickens to the east.

Above the Wells Creek is the Black River Group, which in Ohio consists primarily of fine-grained tan or gray limestone. It is about 300 feet thick in northwestern Ohio and thickens eastward to more than 500 feet. The Black River Group is thought to have been deposited in shallow subtidal to supratidal environments.

Overlying the Black River Group is the Trenton Limestone and its equivalent to the south, the Lexington Limestone of Kentucky. This dark-gray to brown fossiliferous limestone includes thin gray to black beds of shale and has abundant zones of secondary dolomitization. The Trenton is not exposed at the surface in Ohio. It ranges from 40 feet thick in west-central Ohio to more than 300 feet thick in northwestern Ohio. It was deposited in platform to open-shelf marine environments that were deeper than those of the Black River Group. This deepening of the sea is interpreted to be the result of increased tectonic activity to the east associated with the Taconic Orogeny. The Trenton Limestone was once the most important economic unit in Ohio for the production of oil and gas.

The Trenton Limestone grades upward and laterally into the Point Pleasant Formation, named for exposures of interbedded gray shales and limestones exposed near the Clermont County town of Point Pleasant. Exposures of the Point Pleasant Formation along the Ohio River have been quarried for many years and it was long known as the "River Quarry Beds." The Point Pleasant Formation marks the end of Middle Ordovician time.

Upper Ordovician rocks form the Cincinnatian Series, named for the magnificent exposures in the Cincinnati area (and adjacent parts of Kentucky and Indiana). They consist of about 750 feet of interbedded limestones and shales that at first glance appear lithologically monotonous and repetitive. However, these rocks are full of exquisitely preserved fossils that have been the focus of attention of a diverse group of collectors, ranging from curious children to professional paleontologists, for more than a century and a half. Indeed, an uncommon number of these curious children from the Cincinnati area became professional geologists and paleontologists, many of national and international prominence. Literally hundreds of technical papers and reports on Cincinnatian rocks and fossils have been published through the years, and these rocks serve as the official reference section for Upper Ordovician rocks in North America.

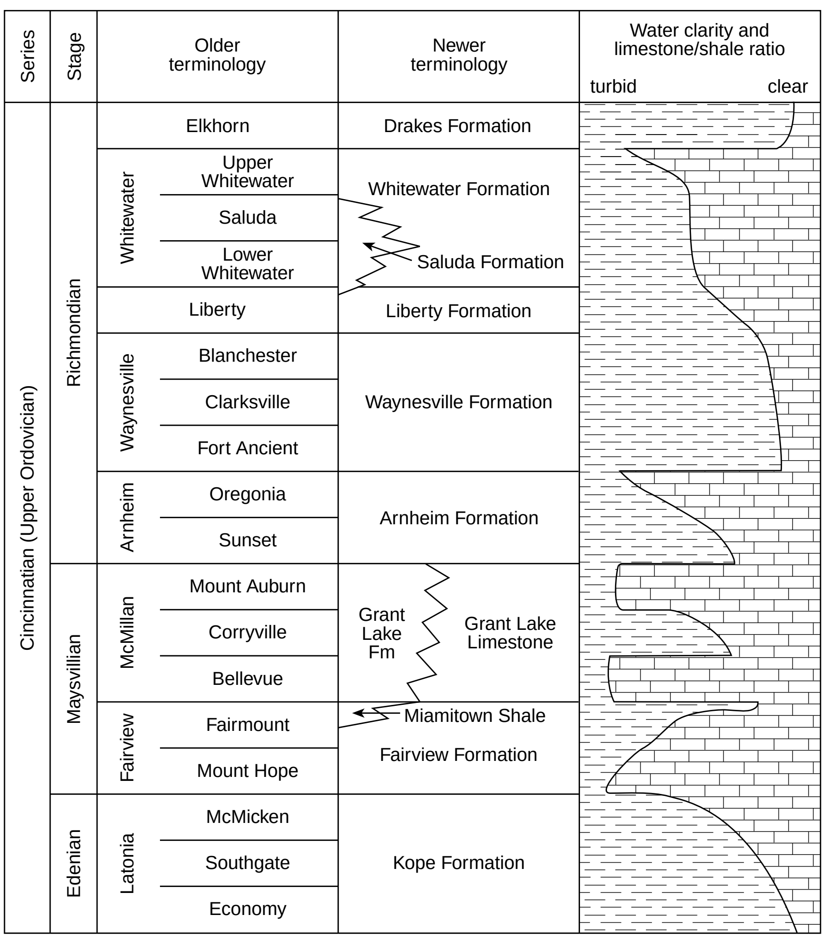
The interbedded limestones and shales of the Cincinnatian Series have been subdivided into a number of formations and members using a variety of schemes. Older classifications used a combination of lithology (rock type) and biostratigraphy (fossil distribution) to subdivide the Cincinnatian. Modern classifications use lithology, bedding type (such as wavy or planar), and percentage ratios of shale and limestone as a basis of subdivision of units. Some of the older unit names have been redefined to adhere to modern classifications, and new names have been introduced for some formations. The result is a large number of unit names, which can be confusing, especially when consulting both vintage and modern literature.

Overall, the Cincinnatian rocks represent a transgressive sequence in which most shale-dominated units reflect deposition in deeper, quieter waters and the limestone-dominated units represent deposition in clearer, shallower waters. Many of the thin beds of limestone show evidence, such as graded bedding, of having been deposited during storm events and are called "tempestites."

Cincinnatian rocks can be divided classically into three vertically repetitive facies or intergrading suites of rocks: offshore, transitional, and shoreface. Offshore facies formed in deeper (perhaps 150 feet or more), open-marine waters in which the sea bottom was below the fair-weather wave base. The offshore facies is dominated by shale and generally has well-preserved fossils that have not been broken and abraded by wave action. The Kope Formation, Waynesville Formation, and Miamitown Shale were deposited in this offshore environment. The lower part of the Kope Formation is dominated by dark, graptolite-bearing shales (informally called "Utica" shale) that were deposited in deeper water in the Sebree Trough, an elongate basin that extended from western Kentucky into northwestern Ohio.

The transitional facies is represented by units that have nearly equal percentages of limestone and shale. These rocks were deposited in shallower (less than 50 feet) waters, but the sea bottom was still below the fair-weather wave base. The Fairview Formation; portions of the Grant Lake Formation, the Grant Lake Limestone, and the Arnheim Formation; and the Liberty Formation were deposited in this environment.

The shoreface zone has the highest percentage of limestone beds, which are composed of broken and worn fossils, and represents deposition in a shallow, high-energy environment where waves and currents extensively reworked and winnowed bottom sediments. Portions of the Grant Lake Formation, the Grant Lake Limestone, and the Arnheim Formation and the Whitewater Formation were deposited in this environment. The Saluda and Drakes Formations represent deposition in a tidal-flat environment, the ultimate in shallowing marine conditions.



Stratigraphic terminology and comparative limestone/shale ratio of Cincinnatian (Upper Ordovician) rocks in southwestern Ohio. Older terminology, which was determined on both lithology and fossil distribution, has now been replaced by lithologic terms. However, older terminology is commonly encountered in the literature. Units dominated by shale are interpreted to have been deposited in deeper, more turbid waters, whereas units dominated by limestone are interpreted to have been deposited in comparatively shallower and clearer waters.

ORDOVICIAN LIFE

The marine invertebrate life that appeared in abundance in the Cambrian Period (see *Ohio Geology*, Winter 1997) continued into the Ordovician, and many groups diversified into numerous species. Testimony to the abundance and success of marine invertebrates during the Ordovician is the diversity and abundance of fossils preserved in the rocks of southwestern Ohio. It has been suggested that if all of the fossils could be removed from the Ordovician rocks of the Cincinnati area, Cincinnati would be below sea level. Anyone who has examined these rocks in the field immediately notes that, volumetrically, many beds are tightly packed with fossils.

Perhaps the most common fossil remains are those of bryozoans, colonial animals that lived in branching, treelike colonies or flattened, encrusting masses on shells of other invertebrates. In some areas bryozoans litter the outcrop. Brachiopods are no less spectacularly abundant than bryozoans and are a favorite of the beginning collector. They range in size from tiny species to the walnut-sized *Platystrophia ponderosa*.

The most desirable fossils from Cincinnatian rocks seem to be trilobites. The remains of these arthropods are found in considerable abundance in some beds. The most common Cincinnatian trilobite, *Flexicalymene*, is best known from the Corryville Member of the Grant Lake Formation and from the middle part of the Waynesville Formation. Much less common are well-preserved specimens of *Isotelus*, Ohio's official State Fossil. This trilobite may have reached lengths of nearly 2 feet.

Advanced fossil collectors seek the rare and exquisitely preserved echinoderm fossils found in the Cincinnatian. Perhaps the most recognizable echinoderm fossils are starfish, which look very similar to those found in modern oceans. Crinoids, edrioasteroids, carpoids, cystoids, cyclocystoids, and machaeridians are other echinoderms found in Cincinnatian rocks.

These rocks produce spectacular fossils of many other kinds of organisms, including mollusks (cephalopods, gastropods, and pelecypods), corals, graptolites, and many other macroscopic and microscopic remains. Also included in this list are trace fossils such as tracks, trails, burrows, and feeding traces impressed into the soft bottom muds in the teeming Late Ordovician sea. Many fossils occur only in certain beds or zones, and the serious fossil collector soon learns where to seek specific fossils among the thousands of outcrops in the tri-state area that centers on Cincinnati.

Perplexingly, Cincinnatian rocks have yet to yield remains of fishes. These vertebrates are well known from rocks of similar age in other areas, primarily in the form of small bony plates. These fishes were jawless and are referred to as agnathans (without jaws). They lived by ingesting bottom sediments and digesting organic matter. Most Ordovician occurrences of agnathans appear to be in nearshore marine environments. Perhaps the sediments represented by Upper Ordovician rocks in Ohio were deposited too far offshore or in unsuitable environments for these fishes.

ECONOMIC AND ENVIRONMENTAL GEOLOGY

Currently, Ordovician rocks of Ohio are not of great economic importance in comparison to rocks of other geologic systems exposed in the state. In the last century, some of the Upper Ordovician limestones in southwestern Ohio were quarried for building stone and other uses. Limestone of the Point Pleasant Formation was quarried at several locations, including Cincinnati and Point Pleasant, where it is exposed along the Ohio River. This unit was known to the quarrymen as the "River Quarry Beds."

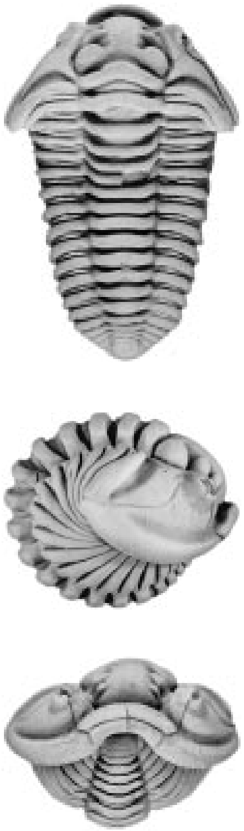
Limestone beds in the Fairview Formation were quarried from exposures on hilltops in Cincinnati. Such a readily available source of limestone in the Cincinnati area would seem to be an ideal situation.

Exposure of the Fairview Formation capped by the Grant Lake Formation, "near Bellevue Incline," a street-car incline along Clifton Avenue in Cincinnati. The Fairview Formation was the source of local building stone in the Cincinnati area and was referred to as the "Hill Quarry Beds." Note the alternating, repetitive, thin beds of limestone and shale. Photo by R. S. Bassler, circa *1915. From Fenneman (1916).*

However, the fossils that pack these limestone beds, making the area so paleontologically famous, spoil the stone for building purposes. The surface of the stone weathers unevenly because of the fossils and is difficult to carve for the same reason. Also, very few of the beds are more than a foot or two thick and have interbedded shale units that must be removed and discarded. Too much waste material, therefore, must be removed and handled to make the Cincinnati limestones economically competitive.

Although very little oil or gas is currently produced from Ordovician rocks in Ohio, the Trenton Limestone was once the most important oil-bearing unit in the United States and was the first giant oil field to be discovered in North America. Commercial quantities of oil and gas were first discovered in northwestern Ohio in 1884. Frenzied drilling soon began in a 185-mile-long area stretching from Toledo to Indianapolis that became known as the Lima-Indiana Oil and Gas Trend. At least 60 individual fields were named within this trend.

Records from this era are poor, but it is estimated that at least 100,000 wells were drilled in the trend, 76,000 of them in Ohio. By 1910 the trend had been depleted, but at least 500 million barrels of oil and 1 trillion cubic feet of gas had been produced during its life. From 1895 until 1903 Ohio was the nation's leading producer of oil. The fascinating story of Trenton drilling and production was faithfully recorded by third State Geologist Edward Orton, who published detailed accounts in Survey publications, particularly Volume 6 in 1888. More recently, Survey geologist Lawrence H. Wickstrom



Flexicalymene meeki

and former Survey geologists John D. Gray and Ronald D. Stieglitz published a historical summary of Trenton drilling and a modern interpretation of the geology of this oil and gas field in Survey Report of Investigations No. 143.

Environmentally, few would suspect that the Cincinnati area has the highest per capita cost from landslide damage of any city in the United States, according to a 1980 U.S. Geological Survey study. Most of these landslides occur in colluvium (slope accumulations of fragmental, weathered rock) formed over outcrops of the Kope Formation, a 220-foot-thick, shale-rich unit at the base of the Upper Ordovician Cincinnatian Series. Rotational slumps and earthflows occur in the Kope when it becomes wet. The shale slakes and hydrostatic pressure builds up, causing failure along the contact between the colluvium and unweathered bedrock. Most of these slope failures occur on shaded, north-facing slopes, which tend to have excess moisture.

The Miamitown Shale also is prone to landslide problems. However, the Miamitown is much less of a problem in the Cincinnati area because of its limited distribution and because it is a comparatively thin unit, only reaching about 20 feet in thickness.

Although Ohio's Ordovician rocks may not be the most important in the state economically, they form scenic vistas that are enjoyed by all and yield such wonderful fossil remains that only those individuals devoid of curiosity about the natural world would not be impressed. To geologists, these rocks have long been, and will continue to be, a source of inspiration and fascination.

ACKNOWLEDGMENTS

I thank Gregory A. Schumacher and E. Mac Swinford for their assistance with this article.

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Coal thickness and overburden maps available for selected 7.5-minute quadrangles in eastern Ohio

Coal thickness and overburden maps are a product of the cooperative Ohio Division of Geological Survey and U.S. Geological Survey Coal Availability program. The computer-generated, two-color map of each coal bed includes point data on coal thickness, coal isopach contours, coal outcrop lines, and 20:1 overburden-to-coal-thickness lines. The maps are at a scale of 1:24,000 (1 inch equals 2,000 feet) and show the quadrangle outline so they can be overlain on the 7.5-minute topographic maps. Please order maps by quadrangle name and coal seam. Each map is $4.00 plus tax and shipping. Send orders to the Ohio Division of Geological Survey, 4383 Fountain Square Dr., Columbus, OH 43224-1362. Credit-card (Visa/MasterCard) orders can be placed by calling 614-265-6576. Maps are available for the following quadrangles and coal seams:

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- Washington (No. 12)

East Palestine quadrangle:
- Clarion (No. 4A)
- Lower Kittanning (No. 5)
- Middle Kittanning (No. 6)
- Lower Freeport (No. 6A)
- Upper Freeport (No. 7)
- Mahoning

Jewett quadrangle:
- Lower Kittanning (No. 5)
- Middle Kittanning (No. 6)
- Lower Freeport (No. 6A)
- Upper Freeport (No. 7)
- Harlem
- Pittsburgh (No. 8)
- Redstone-Pomeroy (No. 8A)
- Meigs Creek (No. 9)

Lower Salem quadrangle:
- Pittsburgh (No. 8)
- Meigs Creek (No. 9)
- Uniontown (No. 10)
- Washington (No. 12)

Randle quadrangle:
- Brookville (No. 4)
- Bedford
- Lower Kittanning (No. 5)
- Middle Kittanning (No. 6)

Strasburg quadrangle:
- Middle Mercer
- Upper Mercer (No. 3A)
- Tionesta (No. 3B)
- Brookville (No. 4)
- Lower Kittanning (No. 5)
- Strasburg (No. 5A)
- Middle Kittanning (No. 6)

Zaleski quadrangle:
- Quakertown (No. 2)
- Lower Mercer (No. 3)
- Brookville (No. 4)
- Winters
- Clarion (No. 4A)
- Lower Kittanning (No. 5)
- Middle Kittanning (No. 6)

Zanesville East quadrangle:
- Lower Kittanning (No. 5)
- Middle Kittanning (No. 6
- Upper Freeport (No. 7)

—Mark Wolfe

Ralph J. Bernhagen, 1910-1997

Ralph J. Bernhagen, 1957

With regret, we report the death of former State Geologist Ralph J. Bernhagen on October 19, 1997, at the age of 87. He was the ninth individual to hold the position of State Geologist of Ohio, serving from 1957 to 1968. However, he served the citizens of Ohio both before and after his tenure as State Geologist, accumulating a total of 47 years of state service.

Ralph, known as "Bernie" to his many friends and colleagues, was born in Toledo on August 2, 1910, and attended Toledo public schools. He attended Michigan State University in 1929 and 1930, the University of Toledo in 1930, and then transferred to The Ohio State University, receiving a B.A. degree in geology in 1937 and an M.A. degree in geology in 1939. He was a Bownocker Scholar at OSU, an award named for the fifth State Geologist of Ohio. From 1939 through 1941 he worked as a paleontologist for the Shell Oil Company and as an engineering geologist in Houston, Texas.

In 1941, Bernie returned to Ohio to serve as a geologist for the Ohio Water Supply Board, thus beginning a career in state service that would continue until his retirement from the Ohio Department of Natural Resources in 1988. His work with the Water Supply Board sparked a continuing interest in water resources. From 1945 until 1952, he served as chief geologist for the Ohio Water Resources Board and became assistant chief of the Division of Water upon creation of the Ohio Department of Natural Resources in 1949.

In 1952, State Geologist John Melvin asked Bernie to become assistant state geologist for the Division of Geological Survey. Bernie became State Geologist and Division Chief when Melvin left state service in 1957. At that time the Division was quartered in Orton Hall, the home of the Department of Geology, on The Ohio State University campus. Bernie enjoyed this close relationship with both students and faculty, many of whom worked part time for the Survey, but in the early 1960's an event in Ohio geology occurred that would sever this close, long-standing physical tie. At this time, oil and gas were discovered in Morrow County, setting off a boom that created an overwhelming demand for oil and gas information and drilling permits. The Survey's already cramped quarters in Orton Hall were inadequate to meet this demand, and Bernie reluctantly moved the Division of Geological Survey to new quarters in the Columbus suburb of Grandview Heights in 1963.

At about this same time, in 1961, the Division of Geological Survey assumed the responsibilities of the former Division of Shore Erosion, headquartered in Sandusky. This division became the Lake Erie Section of the Survey. The Survey inherited the employees and equipment of the Division of Shore Erosion, including the 48-foot research vessel, the *SE-1*. It was rechristened the *GS-1* and still serves as a vital part of the Division's Lake Erie program.

A major achievement by Bernie during his tenure as State Geologist was the completion of topographic mapping of Ohio at the 1:24,000 scale. State Geologist Melvin had vigorously campaigned to have Ohio remapped at this detailed scale, but it was not until 1957, soon after Bernie had assumed the position of State Geologist, that the Ohio General Assembly appropriated matching funds to initiate the remapping of Ohio. Within six years, at a cost of $6.5 million, all 788 7.5-minute topographic quadrangles had been prepared for the state. Ohio was the first state to have complete coverage at this scale.

During Bernie's service as State Geologist, the Division published 13 Bulletins, including county reports on Athens, Fairfield, Knox, Morgan, and Stark Counties; 35 Reports of Investigations; and 13 Information Circulars. This productivity was accomplished with a full-time staff of only about 20 people.

In 1968, Bernie left the Division of Geological Survey to become the head of the Water Planning Section in the Ohio Department of Natural Resources. In 1972 he became coordinator of the Lake Erie Harbors Program for ODNR, finally retiring from the Department in 1988.

Throughout his long career, Ralph Bernhagen was a supporter and active member of many professional organizations. He was a founding member of the Ohio Geological Society, created during the Morrow County oil boom of the 1960's, and a founding member of the Ohio Section of the American Institute of Professional Geologists. Perhaps his longest and fondest association was with the Ohio Academy of Science, an organization he joined in 1944, becoming a fellow, Vice President of the Geology Section in 1950, and Academy President in 1975. He attended the Academy's Annual Meeting faithfully until the end and was long-time supporter and judge in the State Science Day for Junior Academy members.

Ralph J. Bernhagen received many honors during his long and productive life, including the Orton Award in 1975 from the Department of Geological Sciences of The Ohio State University, Outstanding Conservationist Award from the League of Ohio Sportsmen in 1982, honorary membership in the Association of American State Geologists in 1990, and the Mather Medal of the Division of Geological Survey in 1993. These awards only punctuate an illustrious career that brought many benefits to Ohio's citizens and many contributions to his professional colleagues and to the science of geology that he loved so much. All of us who knew him will miss his periodic visits to the Survey offices, and the Geology Section at the Ohio Academy of Science Annual Meeting will have an empty chair that will never again be filled.

Bernie is survived by his wife Lillian, daughters Janet and Penny, and brother Howard.

Survey staff changes

Janet H. Kramer is the Survey's new Fiscal Officer, replacing Jim Miller, who left to pursue personal business interests. Janet transferred to the Survey from the ODNR Division of Recycling and Litter Prevention. Joseph G. Wells has been hired as the Survey's Database Manager. Joe has a degree in GIS from West Virginia University. Prior to joining the Survey he was employed by the city of Mesa, Arizona, developing their city planning GIS.

HANDS-ON EARTH SCIENCE

by Joseph T. Hannibal
The Cleveland Museum of Natural History

PLAYING ROBINSON'S WALL GAME

There is probably a stone wall somewhere near you. The wall may be a fence or a foundation or other part of a building. Such stone walls can be fascinating geologically, especially when they are constructed of more than one kind of stone. For students at any level, they make excellent places for hands-on discovery.

Stone fences generally are made with local bedrock or, in glaciated areas, with local glacial erratics. In the case of buildings, many older structures are made of local stone; more recent buildings may be made of more exotic stones imported to the area for a particular project. In some cases, stone may have even been reused from other projects.

Eric Robinson, a geologist in London, England, has promoted the study of stone walls and other structures in Great Britain, devising exercises for those who might want to examine stone in cities and cemeteries. The techniques outlined here are adapted from Robinson's exercises ("Wall Games") first designed for cathedral precincts (including Gloucester, Ely, and Winchester) in Great Britain.

My favorite local stone wall for such projects is part of an old foundation in Cleveland, Ohio. This wall is now on the campus of Urban Community School. Two cornerstones can be found on the wall. They mark the dates of churches that once stood on the site, providing information on the time spans when this foundation—and its predecessor—were erected.

Several types of sandstone are used for this wall. Each of these stone types differs in color, weathering characteristics, and provenance. The main stone used is a gray to beige sandstone that has medium-sized grains. Red, yellow, and purple sandstones also are used. The gray to beige sandstone is the famous Berea Sandstone, long quarried in northern Ohio. The red stone appears to be the Jacobsville Sandstone, shipped to Ohio from the Upper Peninsula of Michigan. The other stone types are more difficult to place.

Students can study such a wall by carefully sketching it, then noting color, grain size, sedimentary structures, weathering characteristics, etc. Alternatively, and to move the project along at a quicker pace, the instructor can provide a sketch of part of the wall, thus giving students more time for analysis. Eric Robinson has found, however, that too much detail is not good; a simple skeleton sketch, like that shown here (but larger in scale and covering a smaller area) is best. It should depict the outline of each block in the area of interest, enough so that the student may orient himself or herself. The easiest way to make such a sketch is to photograph the wall and trace the outlines of the stone blocks onto a sheet of tracing paper. The drawing can then be enlarged using a photocopier.

Younger students will enjoy coloring the blocks according to stone type using crayons; older students can use colored pencils or just pencil shading. Once the rocks are colored in, a key should be devised and notes on grain size and weathering can be jotted down on the diagram or in a notebook. Follow-up discussions in the field or the classroom can include simple comparisons of weathering characteristics or more advanced comparisons of grain size and composition among the stones. More good ideas on this topic can be found in the sources listed below. Additional information on stone used for Ohio structures can be found in publications of the Ohio Division of Geological Survey.

FURTHER READING

Robinson, Eric, no date, The Gloucester Wall Game: London, Geologists' Association, 11 p.

Robinson, Eric, 1996, A version of "The wall game" in Battersea Park, *in* Bennett, M. R., and others, eds., Geology on your doorstep: the role of urban geology in Earth heritage conservation: Bath, The Geological Society Publishing House, p. 163-170.

Acknowledgments: Thanks are due to Michael Sandy, and, especially, Eric Robinson, for references and other information.

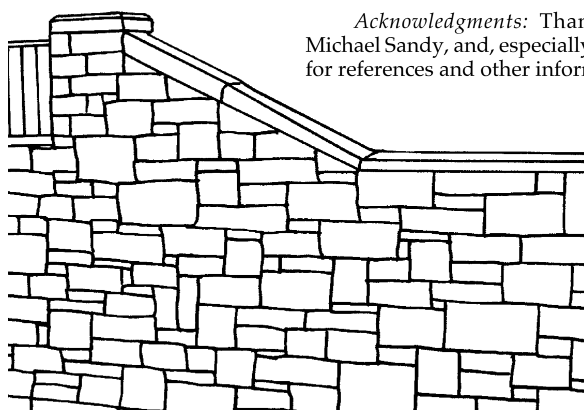

Photo of stone wall at Urban Community School in Cleveland, and a sketch of the wall.

Ohio Geology

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