

Ohio Geology Newsletter

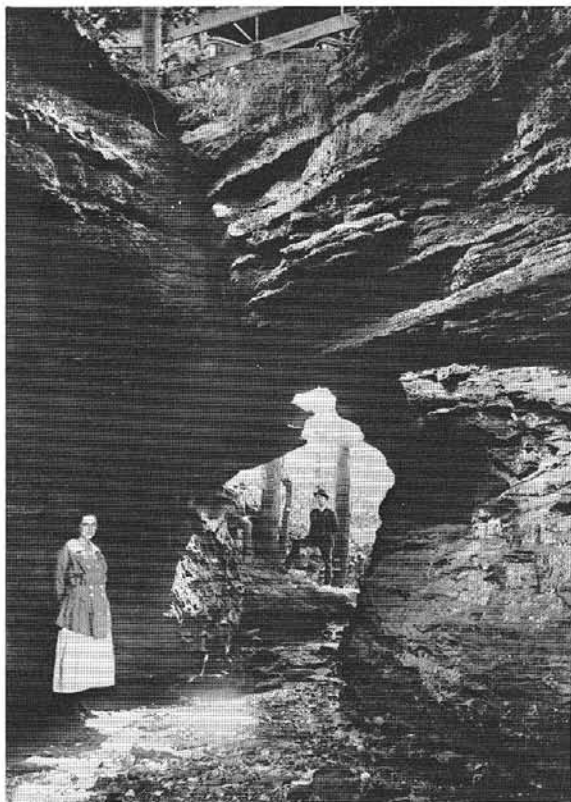
SUMMER 1988

Division of Geological Survey

NATURAL BRIDGES IN OHIO

by Michael C. Hansen

Although in a practical sense they are commonly pathways to nowhere, natural rock bridges and arches are among the most fascinating geological features to the public and stir no small interest among geologists as well. Ohio can't brag of natural bridges that rival in size the famous one in Virginia or those in Utah and Kentucky, but there are more than three dozen in the state that meet the criteria for a natural bridge—a narrow, continuous archway of rock commonly spanning a ravine or valley. Some of the Ohio bridges were popular in the last century as picnic sites and several were touted as a local "claim to fame." In the last few decades, however, most



Natural bridge in the Sharon sandstone, of Pennsylvanian age, beneath Cat's Den Road near South Russell, Geauga County. Photo courtesy of the Ohio Historical Society.



Small natural bridge in sandstone at Raven Rock, Scioto County. From C. S. Van Tassel, 1900, *The book of Ohio*. Photo courtesy of the Ohio Historical Society.

natural bridges in the state have fallen into relative obscurity, and there appears to be a general unawareness, even locally, among most people about the existence of these features. Several bridges have been "rediscovered" recently through perusal of old geologic reports and "photo books" from early in the century, and a few others have been discovered that apparently were never recorded in a formal way. Thus the Ohio total, which was thought to be about a dozen a decade ago, is now more than three times that number.

FORMATION OF NATURAL BRIDGES

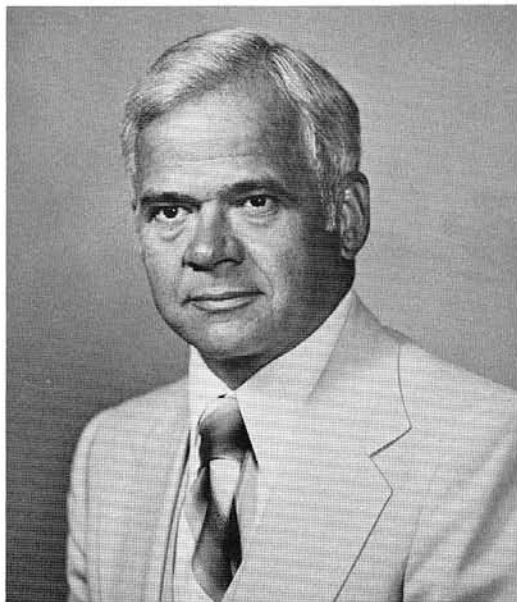
Natural bridges form in a variety of ways. Some are of complex and sometimes debatable origin, but all are the product of erosion and weathering of resistant rocks, such as sandstone or limestone, that possess layers exhibiting differential resistance to these degradatory processes. Commonly, differential cementation of the rock grains causes some layers to be hard and resistant to chemical and mechanical weathering, whereas other, poorly cemented layers are easily weathered and eroded. If the resistant layer is above a softer layer of rock it tends to form a cap that protects the underlying softer layer. However, concentration of moisture at a particular area of softer rock, generally where a vertical joint penetrates, accelerates weathering and erosion in that specific area, thus allowing the softer rock to be eroded and to undercut the resistant capping layer.

Moisture may be in the form of a flowing stream,

continued on page 3

HORACE R. COLLINS—10TH STATE GEOLOGIST

As noted in the spring issue of *Ohio Geology*, Horace R. ("Buzz") Collins retired on April 30, 1988, from the position of Division Chief and State Geologist. In tribute to his distinguished career as a geologist and as Division Chief, the space normally used for the *Chief's Column* is dedicated to his contributions to Ohio.



Horace R. Collins, State Geologist of Ohio, 1968-1988.

Buzz was born in Shawnee, Oklahoma, in the early years of the great Depression. He moved to Barnesville, Ohio, early in his childhood and completed his secondary education there. Buzz then attended Ohio University, where he majored in geology and obtained his Bachelor of Science degree in 1954. After two years' service in the U.S. Army Corps of Engineers, where he attended officer and aviation schools, Buzz continued his geologic training at West Virginia University and received a Master of Science degree.

In August 1959, after completing his graduate work at West Virginia, Buzz joined the staff of the Division of Geological Survey, which at that time was headquartered at Orton Hall on the campus of the Ohio State University. Buzz was brought on as a Conservationist I and was assigned as an assistant to George Denton in the Coal Geology Section. In this capacity, the field description and mapping of coals were his primary responsibility. George Denton resigned in March 1960 and Buzz became supervisor of the Coal Geology Section, in which capacity he served until 1963. In that year the Coal Geology Section was incorporated into a larger section, the Areal Geology Section, and Buzz was appointed as its Head. The Areal Geology Section subsequently evolved into what is now the Regional Geology Section. After three years as Head of the Areal Geology Section, Buzz was promoted to Assistant Chief, a position he held for two years, until 1968, when he was appointed Division Chief and State Geologist, replacing Ralph Bernhagen. Buzz thus became the 10th State Geologist in the 150-year history of the Geological Survey.

At the time Buzz assumed the position of Chief, there were approximately 20 people on the staff and the annual personnel budget was slightly over \$150,000. In the ensuing 20 years the Division staff increased over threefold and the budget increased to almost \$3 million. Along with staff and budget increases, Buzz was able to initiate and complete many major programs and projects through his tenure. The following

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News items, notices of meetings, etc. should be addressed to the attention of the editor. Change of address and new subscriptions should be addressed to the attention of the secretary.

paragraphs highlight some of his more notable accomplishments.

Until the Division's move to its Grandview office in 1962, the Survey had limited capability to conduct chemical analyses of rock, mineral, and fuel resources. In 1971 Buzz was able to acquire the funds needed to hire a chemist and purchase an atomic absorption spectrophotometer (AAS), which was installed in a cramped, makeshift laboratory at the Grandview office. This investment was the beginning of the Division's current Geochemistry Laboratory at Fountain Square (where the Division moved in 1973), which has expanded from the original AAS (which, by the way, is still in service) to an array of modern instrumentation providing the Division the capability of performing a great many types of inorganic chemical analysis.

With environmental and energy crises looming in the 1970's, Buzz engaged the Survey in a program of coal characterization which continues to this day. This program was geared towards development of data on deep, unmined coal resources, especially those having potentially low sulfur content, and on development of a detailed database on the chemical composition and physical properties of Ohio coal. This program has led to the generation of the single, largest database on coal in Ohio.

Several major coal-resource programs were successfully completed during the 1970's. These programs were tremendously expensive, however, as drilling was conducted through contract drilling. In a move to enable continued resource exploration within tight budget constraints, Buzz was able to divert monies accrued through other studies to purchase the Survey's first core-drilling rig, a Mobile B-61 Pacemaker, in 1980. A drilling crew was assembled and drilling began in May 1981. This program proved to be so successful that Buzz directed the purchase of two other drill rigs in 1986—a Longyear Hydro 44 which is capable of core drilling to a depth of almost 6,000 feet, and a CME auger rig which is capable of obtaining continuous, oriented core samples of unconsolidated sediment. In addition to the purchase of these other rigs, the Division's drilling program had gained sufficient appreciation from Ohio mineral industries that one company, the France Stone Company, donated a fourth core-drilling rig to the Survey.

A major milestone in the Division's drilling program was attained in 1985 when the deepest, continuously cored hole in Ohio was drilled in Seneca County. This hole, drilled to a

depth of 2,870 feet, also set a manufacturer's depth record for that model of drill rig. New records are continuing to be established, as the Division's Hydro 44 rig is presently drilling at a depth of 4,200 feet on a hole in Warren County and will be continuing to a depth of perhaps 4,700 feet. This was the last deep hole initiated under Buzz's direction.

One of Buzz's goals was to establish a repository where sample cuttings (rock chips from rotary drilling) and core samples could be stored and retrieved for public use. The beginning of this goal was realized when the Survey acquired a lease on the warehouse at 810 Phillippi Road. Under Buzz's guidance and direction, the 27,500 square feet of space has been evolving into a true sample library. Much work remains to be done, but the groundwork has been established.

Another major piece of equipment acquired through Buzz's efforts is the Leitz Textural Analysis System, which is a microscope connected to a computer which not only controls the microscope but also processes the image. At the time this instrument was purchased, the Division of Geological Survey was one of only several organizations in the United States possessing such a sophisticated imaging system.



Buzz in the field in Tuscarawas County, 1967.

Buzz secured funding for many major studies which not only greatly expanded our knowledge of Ohio geology, but also brought the Division through desperate financial times. Examples of these programs are the Eastern Gas Shales Project funded by the U.S. Department of Energy; the Coal Washability Program funded by the Ohio Air Quality Development Authority; the Shale Gas Project funded by the Gas Research Institute; Deep Coal Studies funded by the former Ohio Department of Energy, the U.S. Department of Health, Education and Welfare, and the National Air Pollution Control Administration. The list could go on, mentioning major programs such as the Abandoned-Underground-Mines Inventory and crucial studies such as the intensive investigations conducted to support Ohio's bid for siting of the Superconducting Super Collider. Perhaps, however, the most important program won and implemented by Buzz is the Statewide County Mapping Program. The goal of this program is to develop maps and reports on the geology and mineral resources of each county in Ohio. The significance and importance of this program cannot be overemphasized; in fact, this is undoubtedly the most important, most intensive, and ambitious program ever initiated during the 150 years of the Survey's history. As most know, Buzz was responsible for the campaigning which led to passage of the enabling legislation in 1981. Buzz, of course, was also key to the effort this year to permanently allocate a portion of the mineral severance taxes to support these mapping activities. The long-term benefits from these accomplishments made by Buzz are incalculable but are sure to be immense.

It is impossible in the limited space of this newsletter to thoroughly review Buzz's accomplishments and contributions. Suffice it to say, then, that Buzz was a scientist, but most of all he was a servant to the people of Ohio, and it is to their well-being through advancements in the understanding of Ohio geology that he unfailingly devoted his career.

—Robert G. Van Horn
Assistant Chief

NATURAL BRIDGES *continued from page 1*

in which case the term "bridge" may be most appropriate, or may be in the form of percolation of surface waters. The term "arch" has been used to refer to a span that has no natural stream flowing beneath it.

Many natural bridges formed in sandstone represent rock-shelter caves in which part of the roof has collapsed, either through breaking away of large blocks of rock or through the slower but just as effective process of grain-by-grain spalling; only a narrow portion of the roof is left intact and forms a bridge. The roof collapse generally takes place in a section that is bounded by joints. It is also probable that water from a surface stream that cascades over the lip of a sandstone cliff is captured upstream in joints and that much flow is within the rock rather than over its surface. Eventually these joints are widened by the flowing water to such a degree that they cut below the uppermost layer of rock and form a natural bridge.

Natural bridges formed in carbonate rocks, such as limestone and dolomite, are also a result of the chemical and mechanical weathering of an underlying, less resistant layer of rock. Commonly, the opening beneath the bridge has been widened by solution weathering from water percolating from the surface along a vertical joint. Many such bridges formed in limestone or dolomite are on narrow ridges. The passage beneath the bridge span is, in effect, a segment of a limestone cavern, formed by solution along a joint, that has been exposed at either end as the ridge of carbonate rock has been narrowed by erosion. Other small bridges or arches are associated with sinkholes. Sea arches, such as Needle's Eye on Gibraltar Island in western Lake Erie, have been created by wave action on limestone cliffs with zones of differential hardness.

Another type of natural bridge is formed when a large, detached block of rock falls or tilts so that it bridges the gap between two other blocks of rock. Although features formed in this way are indeed natural bridges, they are somewhat on the periphery of most strict concepts of natural bridges because they are the result of movement of rocks.

The processes of erosion and weathering are ongoing and continual; natural bridges thus are ephemeral features that represent only one phase in the geomorphic process of landscape development. Eventually, perhaps after only a few hundreds or thousands of years, a span will collapse and leave only a narrow chasm or gap.

Although some reports mention wind as a contributing agent of erosion in the formation of natural bridges in Ohio, it is highly unlikely that wind has played a significant, or even any, role in most natural bridge development. Most bridges in Ohio are in protected valleys where high or continuous winds are rare. Thus, running water, mechanical weathering, chemical solution, and the force of gravity are the primary factors involved in the formation of most natural bridges and many other scenic features in the state.



Approximate locations of natural bridges in Ohio. Numbers correspond to those in the accompanying list.

OHIO NATURAL BRIDGES

County	Name	Size ¹
1 Adams	River Bend Bridge	small
2 Adams	Roadside Arch	small
3 Adams	Scioto Brush Creek Bridge	small
4 Adams	Tiffin Bridge	small
5 Adams	LuPaul Bridge	small
6 Athens	Mineral Rock Bridge	medium
7 Athens	Mustapha Island Bridge	medium
8 Columbiana	Beaver Creek Bridge	small
9 Coshocton	Woodbury Wildlife Area Bridge	small
10 Franklin	Columbus Bridge	small
11 Geauga	Bass Lake Road Bridge	small
12 Geauga	Cat's Den Bridge	medium
13 Highland	Keyhole Bridge (Fort Hill State Memorial)	medium
14 Highland	Baker Fork Bridge (Fort Hill State Memorial)	medium
15 Highland	unnamed (Fort Hill State Memorial)	small
16 Highland	unnamed (Fort Hill State Memorial)	small
17 Highland	unnamed (Fort Hill State Memorial)	small
18 Highland	Miller Nature Sanctuary Bridge	medium
19 Highland	Miller Nature Sanctuary Arch	small
20 Hocking	Conkles Hollow Arch	small
21 Hocking	Rock Bridge	large
22 Hocking	Chapel Ridge Bridge	small
23 Jackson	Lake Katherine Bridge	small
24 Miami	Greenville Falls Bridge	medium
25 Montgomery	David Church Bridge	small
26 Morgan	Lucas Run Bridge	small
27 Ottawa	Needle's Eye Arch	small
28 Pike	Jackson Bridge	medium
29 Pike	Chimney Rocks Arch	small
30 Pike	Lion's Den Bridge	small
31 Portage	Camp Christopher Bridge	small
32 Ross	Trimmer's Bridge	medium
33 Scioto	Raven Rock Bridge	small
34 Scioto	Raven Rock Arch No. 1	small
35 Scioto	Raven Rock Arch No. 2	small
36 Tuscarawas	Devil's Den Bridge	small
37 Washington	Independence (Irish Run) Bridge	large
38 Washington	Ladd Bridge	large
39 Washington	Liberty Bridge	small
40 Washington	Little Bridge	medium

¹Size: small, <25 ft; medium, 25-50 ft; large, > 50 ft.

DISTRIBUTION OF NATURAL BRIDGES IN OHIO

At least 40 natural bridges have been reported in Ohio from various sources, although some may no longer exist and a few reports are unchecked and perhaps dubious. There are undoubtedly other unreported bridges, especially small ones. Most of the bridges in the state are located in southeastern Ohio in sandstone of Mississippian, Pennsylvanian, and Permian ages. Those bridges reported from northeastern Ohio are in rocks of Pennsylvanian age. Thirteen bridges in southwestern Ohio are in carbonate rocks of Silurian age; one bridge in central Ohio is in Devonian limestone; and one bridge in western Ohio (thought to now be destroyed) was in firmly cemented glacial sand and gravel. A small bridge in Spring Grove Cemetery in Cincinnati, pictured as a natural bridge in C. S. Van Tassel's *Book of Ohio*, is not of natural origin according to Survey geologist Scott Brockman, who recently examined the structure. The apparent absence or scarcity of natural bridges in western and northwestern Ohio (except for the Erie islands) is probably due to the lack of relief of the landscape and a consequent paucity of bedrock exposures.

It is probable that all of the large and spectacular natural bridges in the state have been noted on inventories of such features. Small bridges, however, seem to have "fallen through the cracks" simply because most people are unaware that these structures are of any particular interest to anyone. The thrill of discovery can be exciting and leave one with a satisfied feeling of having contributed to the knowledge of the state's geological features. I recall the experience a decade ago of walking up a small valley in Geauga County in order to map outcrops of Sharon sandstone and encountering a delightful little natural bridge, developed in the Sharon,



Lucas Run bridge formed in sandstone, of Pennsylvanian age, in Morgan County. Photo courtesy of the Ohio Historical Society.

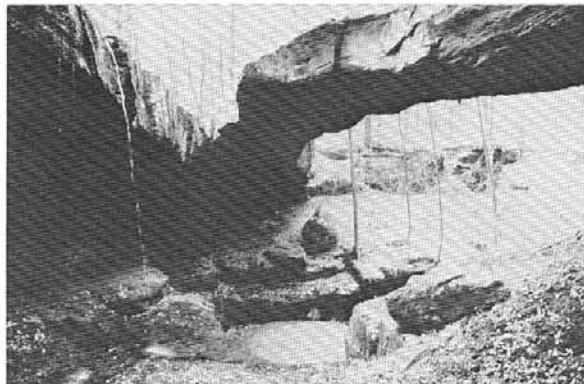
that spanned a valley only a few feet in width. Much to my surprise at the time, this bridge (Bass Lake Road Bridge) had not been previously recorded in the literature. The bridge was known to local residents, but its size was such that it had never been a tourist attraction or even gained any local fame.

A similar "discovery" occurred in 1985 when a color slide was submitted by Sally J. Lewis for the Ohio Geology Slide Contest. The slide did not win an award but it did depict a small, unrecorded natural bridge (LuPaul Bridge) developed in carbonate rocks of Silurian age near Blue Creek in Adams County. Although this is not a spectacular span in terms of size, the record of its existence is important in terms of the inventory of natural features of the state. Those individuals who regularly walk the hills and valleys of the state should keep in mind that many geologic features that they note may not be well known to the scientific community. Such reports are always welcomed by the Survey.

SELECTED OHIO NATURAL BRIDGES

Rock Bridge

The largest and perhaps best known natural bridge in the state is Rock Bridge, near the town of Rockbridge, in Hocking



View of Rock Bridge, in Hocking County, from below and within the rock-shelter cave. The space between the ceiling of the rock-shelter cave, to the left, and the bridge, to the right, is an area where ceiling blocks have collapsed along joint planes. The ceiling and bridge represent a well-cemented, resistant zone in the Black Hand Sandstone, of Mississippian age. Photo by Preston Fettrow.

County. The bridge is developed in the thick Mississippian-age Black Hand Sandstone, which is a resistant, cliff-forming unit in the region. Numerous rock-shelter caves are developed in the area and Rock Bridge was once an undistinguished member of this group. The well-cemented, resistant upper zone of the Black Hand Sandstone forms the roof of these shallow caves, whereas the poorly cemented middle layer of this unit tends to weather much faster, forming a shallow recess.

The distinguishing aspect of the rock-shelter cave at Rock Bridge is the partial collapse of a portion of the roof, which left a narrow section of the roof spanning the valley as a natural bridge. The roof collapse took place along two converging joints which formed the boundaries of the fallen roof block.

The gently arched span is about 100 feet long and stands about 40 feet above the valley floor. The bridge is 20 feet wide at its widest point and narrows to 4½ feet. The thickness of the bridge is about 5 feet.

Rock Bridge has long been known and was a favorite spot for picnicking, especially during the last century, when canal boats plied the nearby Hocking Valley Canal, and later when the Columbus, Hocking Valley, and Toledo Railroad was an active line in the valley. Apparently, the bridge was never a commercial venture and in recent years it has become relatively obscure. Indeed, some residents of the town of Rockbridge, a nearby community that derives its name from the natural feature, have never visited the bridge and are not sure of its precise location. In 1978 the Division of Natural Areas and Preserves of the Ohio Department of Natural Resources acquired the natural bridge and surrounding property as a state nature preserve. The preserve is open year-round from dawn to dusk and is located on the east side of U.S. Route 33 on Good Hope Township Road 503 (Dalton Road).

Ladd Bridge

Another impressive natural bridge, known as Ladd Bridge, is located in Washington County near Frost. The size of this

massive bridge rivals Rock Bridge in Hocking County and it appears to have developed in similar fashion, either by partial collapse of the roof of a rock-shelter cave or by slow widening of the cross joint behind the span. The massive sandstone that forms the bridge is of Pennsylvanian age. The bridge has been poorly known in recent years, but a few decades ago it was a minor tourist attraction, as is attested by a weathered barnside sign along U.S. Route 33 south of Guysville in Athens County inviting travellers to see the natural bridge. Although the bridge is under the private ownership of the Ladd family, it was dedicated in 1984 as the Ladd Bridge Nature Preserve, and can be visited by permit obtained from the Division of Natural Areas and Preserves.

David Church Bridge

Perhaps one of the most unusual bridges in Ohio was located along a small unnamed stream south of Kettering, near Dayton in Montgomery County, and ½ mile south of David Church. This bridge was illustrated by August F. Foerste, Dayton high school teacher and renowned Ohio



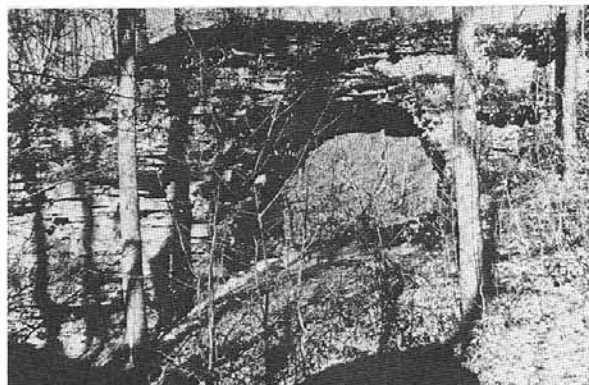
*Natural bridge developed in glacial sand and gravel near David Church, south of Kettering, Montgomery County. This bridge, illustrated by A. F. Foerste in 1915 in his book, *Geology of the vicinity of Dayton*, is now buried beneath fill.*

geologist and paleontologist, in his 1915 book, *Geology of the vicinity of Dayton*. Foerste gave only a brief description and explanation of the origin of the bridge, but his photograph shows a small bridge with an estimated span of 10 feet and a height of 6 feet. What is particularly unusual about this small bridge is that it is constructed of coarse glacial sand and gravel that has been secondarily cemented in layers that are resistant to erosion. Recently, Timothy A. Snyder of the Division of Natural Areas and Preserves visited the site of David Church Bridge and found that the small valley in which it was located had been filled in during development of the area. It is unknown if this bridge still survives buried beneath fill, but certainly such weakly cemented glacial materials would not resist the forces of weathering and gravity for an extended period of time.

Fort Hill bridges

Fort Hill State Memorial, an area encompassing an Indian earthwork in Highland County and administered by the Ohio Historical Society, has five natural bridges or arches developed in carbonate rock of Silurian age. One of these, known as Keyhole Bridge, consists of a narrow, slit-like opening beneath the span. This enlargement is along a readily visible vertical joint. Baker Fork Bridge is the largest of the five in the area and has a relatively symmetrical, arch-shaped passage beneath it. The three additional bridges are small and comparatively unspectacular.

The Fort Hill bridges have not been studied in detail and



Natural bridge, known as Baker Fork Bridge, formed in carbonate rocks of Silurian age at Fort Hill State Memorial, Highland County. This bridge is the largest of five bridges at Fort Hill.

their precise origins are somewhat speculative until such studies are undertaken. However, it is probable that joint-controlled solution weathering of a less resistant lower layer of carbonate rock created the passageway for the bridge. It is possible that the passageways beneath the bridges represent former solution caves that have been exposed at either end by erosion. Fort Hill is open to the public and several of the bridges are readily visible on the hiking trails that traverse the area.

SUMMARY

Of the 40 natural bridges currently identified in the state, 14 are on state-owned or state-administered land. Five of these bridges are at Fort Hill State Memorial. Rock Bridge (Hocking County), Miller Nature Sanctuary Bridge and Arch (Highland County), Lake Katherine Bridge (Jackson County), and Ladd Bridge (Washington County) are state nature preserves. Woodbury Wildlife Area Bridge (Coshocton County), Needles Eye Arch (Lake Erie), and Conkle's Hollow Arch (Hocking County) are on state property. Independence (Irish Run) Natural Bridge (Washington County) is on Wayne National Forest property. The remainder of the bridges are on private property; although many landowners will grant permission to visit the feature, the precise locations are not generally published in order to avoid continual irritation to the landowner. Mustapha Island Bridge, although apparently on private property, is located only a few yards off the pavement on Ohio Route 124 in Athens County just south of the Athens-Washington County line.



Mustapha Island Bridge, along Ohio Route 124, in Athens County. This span is formed in sandstone of Permian age.

The Division of Natural Areas and Preserves of the Ohio Department of Natural Resources maintains a formal list of

natural rock bridges (as well as other natural features in the state) and the Division of Geological Survey maintains an informal record of these features. Information on additional natural bridges in the state would be welcomed by either agency.

ACKNOWLEDGMENTS

Our thanks to Timothy A. Snyder of the Division of Natural Areas and Preserves; James L. Murphy, of the Ohio State University Libraries; and Robert Glotzhober, of the Ohio Historical Society, for assistance with this article.

FURTHER READING

Goodwin, S. W., and Williams, Jan, eds., 1987, *Ohio's natural areas and preserves—a directory*: Ohio Department of Natural Resources, Division of Natural Areas and Preserves, 182 p.
Murphy, J. L., 1975, *Ohio natural rock bridges: The Explorer*, v. 17, no. 4, p. 15-18.

SHERRY W. LOPEZ RECEIVES AWARD

Sherry W. Lopez, geologist and mineral statistician in the Regional Geology Section, received \$100, a gold pin, and a plaque from the State Employee Compensation Board through its Suggestion Award Program. She proposed replacing a leased computer with a purchased stand-alone personal computer. Sherry uses this computer to compile quarterly and annual summaries of mineral production statistics and the annual *Report on Ohio mineral industries*. This replacement of computer systems not only will increase efficiency and accessibility of data, but also will result in an annual savings to the state of about \$6,000.

Sherry is originally from Massillon and came to the Survey in 1984 after receiving bachelor's and master's degrees in geology from Kent State University. She lives in Columbus with her husband, daughter, and son.



Sherry W. Lopez

USGS BOOKLET

The U.S. Geological Survey recently published a 28-page booklet which explains USGS activities and gives an overview of national earth science issues. The booklet, titled *U.S. Geological Survey: earth science in the public service*, is illustrated with color photographs. It is available free of charge from Books and Open-File Reports Section, U.S. Geological Survey, Federal Center, P.O. Box 25425, Denver, Colorado 80225.

COCORP FINDS THICK PROTEROZOIC(?) STRATA UNDER MIDCONTINENT

Editor's Note: The following contribution from the COCORP Research Group, Cornell University, is reprinted from the April 12, 1988, issue of *Eos* (Transactions of the American Geophysical Union) for the benefit of the many readers of *Ohio Geology* who have inquired about the results of the COCORP seismic reflection profile run across Ohio in the fall of 1987 (See *Ohio Geology*, Fall 1987). More detailed results of the Ohio traverse are expected to be released by COCORP in late summer 1988 and will be reported in a future issue of *Ohio Geology*.

Thick, laterally extensive, stratified rocks lie hidden within the Precambrian basement of the central United States. The layers dwarf the overlying Phanerozoic sedimentary section and may exceed in volume the entire Phanerozoic cover of the continental interior.

The extent of the layered rocks became evident last summer as the Consortium for Continental Reflection Profiling (COCORP) completed a major deep seismic-reflection traverse across Ohio, Indiana, Illinois, and part of Missouri. The survey was conducted partly because industrial seismic data and studies by the Illinois State Geological Survey showed basement layering in southern Illinois, partly because earlier COCORP surveys also showed such layering in Oklahoma and Texas, and partly because COCORP's broad program calls for comprehensive exploration of the entire continental basement of the United States.

Although the composition and precise age of the Precambrian rocks are yet to be determined, their seismic reflection character suggests a sedimentary assemblage, at least in part. These layers occur within the Proterozoic Granite-Rhyolite Province, where drilling typically recovers undeformed granite or rhyolite with ages of 1.3 to 1.5 billion years. Such prominent and orderly layering is surprising, given the widespread occurrence of granite rocks. If the layered rocks are indeed igneous, the volume of silicic volcanic material is spectacular. The most likely surface exposure of the Proterozoic rocks is in the St. Francois Mountains, in southeastern Missouri. However, the St. Francois Mountains correspond to an eruptive center and may not be typical of the huge area surveyed.

The most plausible current interpretation is that extensive Proterozoic sedimentary strata, intruded by scattered granites and capped by silicic extrusives, cover this wide area. Alternative hypotheses include a purely igneous origin or extensive intrusion of basaltic sills. Such sills were recently drilled in Proterozoic rocks in Sweden.

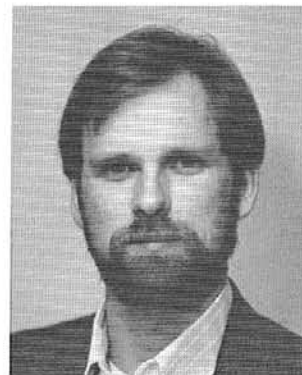
Although this new information is sketchy on a continent-wide scale and is surely an insufficient basis for an economic boom, it may be useful background information for those currently concerned with the possibility of hydrocarbon or mineral occurrence in Proterozoic rocks. Especially intriguing are small-scale features within the layered sequence, such as half-grabens, anticlines, and possibly even amplitude anomalies.

In Ohio, the COCORP survey found dipping layered reflections associated with the Grenville Front, as did scientists of the Great Lakes Multidisciplinary Program on Crystal Evolution (GLIMPCE) in their 1986 Lake Huron survey. COCORP scientists also found another prominent dipping sequence in eastern Ohio that may correspond to a major suture within the Grenville province.

SURVEY STAFF NOTES



Mike Angle



Ernie Slucher

Mike Angle is a glacial geologist in the Regional Geology Section and is originally from Akron. He came to the Survey in 1984 after completing bachelor's and master's degrees in geology at the University of Akron and work on a Ph.D. degree at Miami University. While at Miami, Mike made two trips to Antarctica to study the geochemistry of polar lakes. Mike has mapped the glacial geology of Sandusky County and is currently working in Union County. He particularly enjoys the opportunity for field work with the Survey.

Mike lives near Jersey, in Licking County, with his wife and son and another child is expected soon. He enjoys working on motorcycles and caring for his menagerie of pets.

Ernie Slucher is a geologist in the Regional Geology Section and is currently mapping bedrock in Columbiana County. Ernie is originally from Taylorsville, Kentucky, and came to the Survey in 1984 after working for the Kentucky Geological Survey for four years and a venture into consulting. He holds bachelor's and master's degrees in geology from Eastern Kentucky University. Ernie's specialties include stratigraphy and sedimentology of Pennsylvanian rocks and he enjoys the opportunity to make new discoveries while doing field work.

Ernie lives in Delaware County, near Cheshire, with his wife and two children. His many hobbies include collecting stamps and antiques, fishing, and gardening.

GLACIAL GEOLOGY OF MAHONING COUNTY

The Division of Geological Survey recently published Report of Investigations No. 139, *Glacial geology of Mahoning County, Ohio*, by Stanley M. Totten and George W. White. This publication consists of a 29-page book that describes the glacial deposits of Mahoning County and a full-color glacial geologic map at a scale of 1:62,500. The Mahoning County report is the last in a series of reports on the glacial geology of northeastern Ohio counties authored or coauthored by the late Dr. George W. White (1903-1985), former State Geologist of Ohio (1946-1947) and long-time research associate of the Survey.

The Mahoning County report has sections on physiography and topography, glacial geomorphic features, Pleistocene stratigraphy and history, mineral resources, and geology for planning. Report of Investigations No. 139 is available from the Survey for \$15.44, which includes tax and mailing.

CENTENNIAL FIELD GUIDE

The Geological Society of America, as part of the Decade of North American Geology (DNAG) Project, has published (1987) *Centennial field guide volume 3*, edited by Donald L. Biggs, for the nine-state north-central section of the United States. The 448-page volume concisely portrays 100 field trips throughout this region that were selected to illustrate the diversity of geologic features.

The 11 field trips for Ohio are:

- Kelleys Island: Giant glacial grooves and Devonian shelf carbonates in north-central Ohio*, by R. M. Feldmann and T. W. Bjerstedt
- Garfield Heights: Quaternary stratigraphy of northeastern Ohio*, by B. B. Miller and J. P. Szabo
- The Cuyahoga Valley National Recreation Area, Ohio: Devonian and Carboniferous clastic rocks*, by J. T. Hannibal and R. M. Feldmann
- Wellsville Hill: Exposures in the Pennsylvanian Allegheny and Conemaugh Groups of eastern Ohio*, by R. G. Wiese, Jr.
- Black Hand Gorge State Nature Preserve: Lower Mississippian deltaic deposits in east-central Ohio*, by R. J. Malcuit and K. B. Bork
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- Copperas Mountain: Black shale facies of the Upper Devonian Ohio Shale in south-central Ohio*, by E. H. Carlson

The Serpent Mound disturbance, south-central Ohio, by F. L. Koucky and S. P. Reidel

These sites were selected not only for their geologic significance and diversity, but also for their accessibility. The field trips will be of interest not only to professional geologists, but also to teachers, students, and hobbyists. *Centennial field guide volume 3* is available for \$43.50 from GSA Publication Sales, P.O. Box 9140, Boulder, Colorado 80301 (telephone: 1-800-GSA-1988).

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The *Quarterly mineral sales, January-February-March 1988* table will be printed in the next issue of *Ohio Geology*.

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