Ohio Geology

A Biannual Publication of the Ohio Department of Natural Resources, Division of Geological Survey 2005, No. 1

THE LARGEST KNOWN FOSSIL BRYOZOAN REASSEMBLED FROM NEAR CINCINNATI

By Roger J. Cuffey, Pennsylvania State University, and Ronny L. Fine, Dayton, Ohio

Our discovery of the largest known fossil bryozoan colony probably won't attract the attention of the *Guinness Book of World Records*, but it is certainly the talk of rock and mineral shows. This huge bryozoan was recently reassembled by Ron Fine from preserved fragments collected near Cincinnati, and identified as *Heterotrypa frondosa* by Roger Cuffey from thin sections made from its branches. The maximum dimension of the colony is at least 26 inches; most fossil bryozoan "bushes" grew to no more than 6 inches, although a very few have been reported as up to about 12 inches. Additional photos of this large specimen and associated bryozoans can be seen on the Dry Dredgers Website (http://www.drydredgers.org/ronsbryos2.htm), and the larger ones are being donated to the Cincinnati Museum Center (Cincinnati Museum of Natural History) where citizens and scientists interested in ancient Ohio-area sea life will have an opportunity to view them.

Overall view of the three largest Heterotrypa frondosa *bryozoans reassembled by Ron Fine, laid out as they were found very close together in the outcrop (total volume occupied 30 inches maximum linear dimension). Note the lettuce-like "leaves" or fronds, low-slung growth out across the ancient sea bottom, and erect fronds growing upward above the first-formed portions. The largest (26 inches maximum dimension) is left into center-front (the center-foreground is a piece broken off from this specimen); the next-to-largest (21 inches maximum dimension) is right-rear; the third-largest (13 inches maximum dimension) is center-rear.*

The greater Cincinnati region of southwestern Ohio and adjacent north-central Kentucky and southeastern Indiana is world famous as one of the richest fossil-bearing areas in North America. Strata there of Late Ordovician age, roughly 450 million years old, yield numerous marine invertebrate fossils, which can be found easily by the public, schoolchildren, and scientists alike. Richard Davis' *Cincinnati Fossils* is an excellent illustrated guide to recognizing and identifying the most common fossil species from the Cincinnati region.

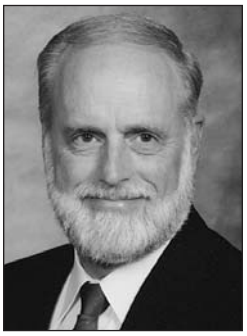
Bryozoans are among the most common and noticeable Cincinnati fossils, and are characterized by small twig-like or thin cylindrical fragments whose surfaces are covered with minute pin-prick-like holes. These fossils are the broken remnants of small animal colonies that resemble miniature corals. The tiny holes are the openings into extremely thin tubes in which lived tiny flower-like polyp animals. These polyps, technically termed zooids, and their enclosing tubes (zooecia), have a more complex anatomy than corals, and hence they are classified as a separate phylum—the Bryozoa. For more details, please see the recent article on "Bryozoans" (Cuffey and Utgaard, 1999) in the *Encyclopedia of Paleontology*, written so as to be understandable by students and interested collectors, as well as by specialists.

Bryozoans are of limited size, partly due to their genetic and metabolic heritage, and partly due to the fact that their soft tissues do not contain symbiotic unicellular algae (zooxanthellae). Algae boost the skeleton-secreting powers of corals and giant clams which contain them, so that their colonies and shells attain much larger size than most other fossilized invertebrates.

Most Cincinnati bryozoans occur as scattered fragments of originally larger, low, bush-like or thicket-like colonies. These fragments are usually so widely separated from one another due to post-mortem washing around on the ancient sea floor, or break-up when weathering out of the outcrop, that reconstructing the original colonies' exact shape and size is very difficult. That challenge has been approached mostly through statistical analysis of branch measurements; results suggest that ancient bryozoan colonies generally attained a mature size on the order of approximately 4 inches high by 6 inches across.

In sharp contrast to the foregoing, occasional bryozoan specimens are collected in which the fragments can be physically reassembled. Careful uncovering of the fossils, examination of where the fragments lie in relation to one another, removal, cleaning, fitting pieces together, and gluing them into their original three-dimensional positions can all be involved. Apparently, specimens permitting such reassembly were fossilized under unusual conditions of quiet water or rapid burial, so that

continued on page 3



Thomas M. Berg, Division Chief and State Geologist

From The State Geologist...

Thomas M. Berg

THE OHIO DIVISION OF GEOLOGICAL SURVEY MOVES

The saying "change is good" is a debatable statement. However, not changing with the times sets a course for certain misfortune. The central office of the Division of Geological Survey has just completed a big change by moving from Building B to the first and second floors of Building C at ODNR's Fountain Square complex on the north side of Columbus. The move is just one phase of a long-term program to renovate buildings in the ODNR complex. We are still located at Fountain Square just one building over from our previous home. Our new address is 2045 Morse Road, Building C-1, Columbus, OH 43229-6693. The survey's main telephone number, fax number, staff telephone numbers, and web and e-mail addresses remain unchanged.

This move represents the fourth major move of the survey's central office since 1900. Prior to 1900, the survey operated from the homes and offices of the State Geologist and of the geologists hired to conduct geological investigations. In 1900, the Survey became a formal, permanent organization of state government when it moved into The Ohio State University's Orton Hall under the direction of then State Geologist Edward Orton, Jr. This relationship with The Ohio State University, Department of Geological Sciences, continued until 1962 when the flood of new records resulting from the Morrow County oil boom swamped the available storage space. At that time, then State Geologist Ralph Bernhagen moved the division into leased office space in Grandview, a few miles west of the OSU campus, where it remained for 11 years. In May of 1973, the survey, then under the direction of State Geologist Horace R. Collins, moved into Building B of the ODNR office complex at Fountain Square.

In the most recent move from Building B to Building C, the survey's floor space was reduced by 30% and necessitated the removal and storage of some less frequently used records to the Horace Collins Laboratory at Alum Creek State Park. Public access to these records is still encouraged and, with proper notice, our staff will gladly retrieve these records for inspection.

The division's staff who handle administration, cartography, geologic records, and petroleum and coal geology are located on the first floor of Building C. The geologic mapping staff, mine-subsidence project personnel, and the survey's conference room occupy part of the second floor, which is shared with the Division of Parks and Recreation, the Reclamation Commission/Oil and Gas Commission, and the Division of Real Estate and Land Management. The Geologic Records Center is now conveniently located next to the lobby of Building C along with attractive display cases containing fossils and minerals. Please come visit us in our new location and make note of our new address.

RECENT OHIO EARTHQUAKES

The Ohio Seismic Network recorded six earthquakes in 2003, ranging in magnitude from 1.5 to 3.5 (mbLg). All of these events were in northeastern Ohio and three of them were felt. Two earthquakes were in, or offshore from, Lake County, and four were in, or offshore from, Ashtabula County.

The first Ohio earthquake of 2003 was on January 18 at 6:08 p.m. Eastern Standard Time, about 1.5 miles east-southeast of Geneva, Ashtabula County. This instrumentally detected event had a magnitude of 1.5, which is generally well below the threshold at which people can feel seismic vibrations.

A 2.4-magnitude earthquake occurred on February 10 beneath Lake Erie, about two miles offshore from Kingsville-on-the-Lake, northeast of Ashtabula. A 2.4-magnitude earthquake occurred in this general vicinity in 1995. Only one person reported feeling the February 10 event, which is not surprising considering the magnitude and the fact that it occurred at 12:34 a.m. Eastern Standard Time. Both earthquakes appear to be related to an ongoing sequence of seismic events that began in the Ashtabula area in 1987 presumably as a result of fluids being injected into deep, subsurface formations via a now-abandoned, deep, Class I injection well (see *Ohio Geology*, 2001, No. 3).

continued on page 4

Ohio Geology

A biannual publication of the

Ohio Department of Natural Resources
Division of Geological Survey
2045 Morse Road, Bldg. C-1
Columbus, Ohio 43229-6693

614-265-6576
614-447-1918 (FAX)

E-mail: geo.survey@dnr.state.oh.us

World Wide Web:
http://www.ohiodnr.com/geosurvey/

Ohio Geology is a free publication. To become a subscriber please contact the Division of Geological Survey at the above address, phone numbers, or e-mail.

Compilers: Mac Swinford and Greg Schumacher
Layout/Design: Lisa Van Doren

Administration/State Geologist
614-265-6988

Geologic Records Center
614-265-6576 or 614-265-6585

Cartography & Editing Group
614-265-6593

Geologic Mapping Group
614-265-6473

Coal & Industrial Minerals Group
614-265-6473

Lake Erie Geology Group
419-626-4296
419-626-8767 (FAX)

Petroleum Geology Group
614-265-6598

Bob Taft, Governor
Sam Speck, Director

An Equal Opportunity Employer - M/F/H

continued from page 1

there was no opportunity for fragments to wash around and scatter widely. Several such bryozoans have recently been found just south of Cincinnati, and reassembled with great care and patience.

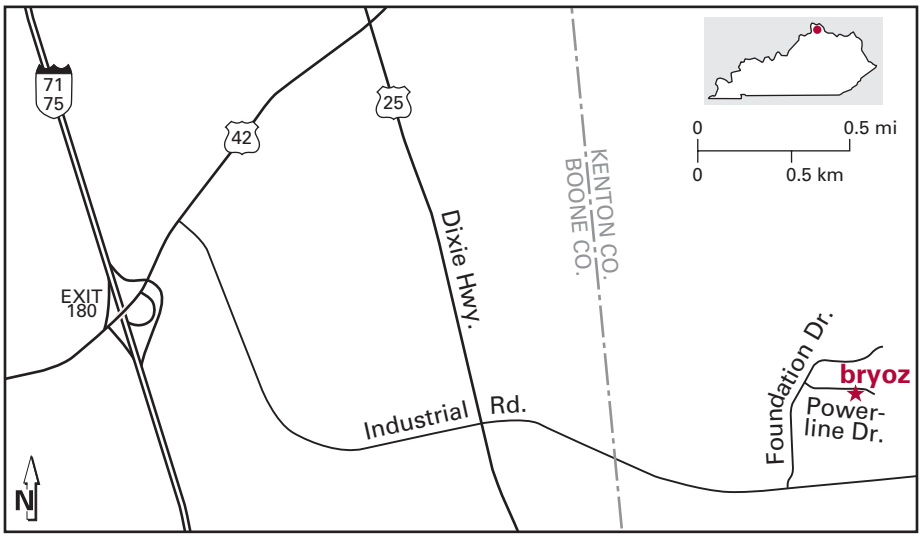
These reassembled specimens reveal not only their exact shapes, but also their unusually large sizes, ranking them among the largest fossil bryozoans ever uncovered.

Documenting these unique specimens is important for their "record size;" such large extremes may suggest something about the potential growth metabolism for the phylum or type of animal which they represent.

These unusually large bryozoans were collected in 2001 from a low roadcut or bank along Powerline Drive, in the suburb of Florence, Kentucky, about 9 miles southwest from downtown Cincinnati. The road bank, since removed during further roadway construction, exposed thinly interbedded limestones and shales of the Upper Ordovician Corryville Formation, high in the middle third of the Cincinnatian Series. These rocks were deposited in a warm shallow sea, as detailed in the introduction to Ohio Division of Geological Survey Guidebook 13 (Cuffey, 1998).

The accompanying photograph (p. 1) documents the overall appearance of these unusually large bryozoans as reassembled. Their branches flared out into leaf-like fronds as they grew lengthwise and bifurcated (split into two parts). Many fronds grew just above the ancient sea floor, with barely enough space above the bottom for the polyps to get their microscopic planktonic food from the surrounding water. Other fronds, particularly above the first-formed, older parts of the colony, grew more vertically, upward into the water above the sea bottom.

The three reassembled bryozoans lay very close together in the outcrop, as exhibited at the 2002 Gem, Mineral, Fossil, and Jewelry Show of Greater Cincinnati; the combined total space occupied measured 30 x 21 x 7 inches (77 x 53 x 18 cm). The reassembled bryozoans were also measured individually. The largest was 26 x 14 x 6 inches (66 x 35 x 15 cm). The next largest was 21 x 13 x 7 inches, and best shows how intricately interwoven the fronds and branches can be in these big bryozoans. Maximum dimension of the third largest was 13 inches. Although possibly surprising to some readers, exact maximum sizes are seldom recorded in the technical literature, so that further investigation of museum collections and field photographs should be undertaken to see if there might be any larger specimens somewhere else. These three reassembled bryozoans were not themselves physically connected; however, they were preserved lying very close together. This suggests two possible interpretations of their growth history. Perhaps, the individual separate bryozoans had originally been one larger colony which broke apart due to environmental stresses during life or after burial. Some pieces may have continued to grow long afterwards, as is sometimes seen among bryozoans and corals living today. Alternatively, each separate bryozoan frond may have grown up from its own founding larva, all of which happened to settle close together on the sea bottom, and the colonies almost grew together and intertwined as they matured.



Location of reassembled unusually large bryozoans within the suburb of Florence, Kentucky.

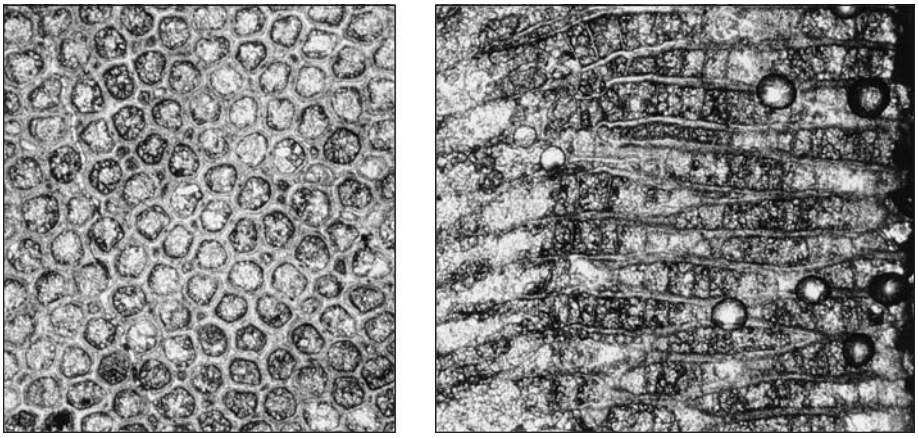
Cincinnati bryozoan fossils must be identified by making very thin slices (thin sections) through them and examining those microscopically. We prepared each reassembled bryozoan in this fashion, and found that all belong to the same extinct species, namely *Heterotrypa frondosa*, originally described by the French paleontologist d'Orbigny in 1850.

Those thin sections (photos, p. 4) are dominated by the tubes (zooecia) which housed the tiny polyps in life. The tubes are long, thin, bundled tightly side-by-side, and filled with internal partitions. The tubes appear polygonal when cut in cross-section (technically a tangential section) and linear when cut length-wise (a longitudinal section). In the former, the microscopically laminated structure within each tube's surrounding walls also can be seen. There are neither large swellings at each angle or bend in those walls (such swellings would be cuts across the bases of surface spines known as acanthorods), nor much smaller tubes (mesopores) between the normal-sized zooecial tubes. In the longitudinal section, the zooecial tube walls are noticeably thicker immediately underneath the branch's exterior surface, and the tubes are crossed by straight, solid partitions (diaphragms).

Interestingly, some colonies of *Heterotrypa frondosa* previously studied also tended toward large size as noted by Waugh and Erickson's (2002) recent paper. Apparently, this species' genetic makeup must have allowed for size increase beyond that of other Ordovician bryozoan species.

Rare, unusually large, hard-skeletoned, bryozoan colonies have been reported from fossil deposits or modern environments around the world. Some may possibly be almost as large as the Ordovician *Heterotrypa frondosa* documented herein, but all are noticeably beyond the usual size for their phylum. Comparisons can be made with Cuffey's (1988) description of Silurian *Monotrypa benjamini*, Mezentseva's (2000) of Devonian *Heterotrypa enormis*, Kloc's (1983, personal communication) of Devonian *Leptotrypella asterica*, Hakansson and Madsen's (1991) of Permian *Tabulipora* sp., Wood and co-workers' (1996) of Permian fenestrates, Cuffey and Fonda's (1976) of modern *Schizoporella errata*, Bradstock and Gordon's (1983)

of living *Celleporaria agglutinans*, and Hageman and colleagues' (2003) of Cenozoic-Recent *Celleporaria gambierensis*. Within the phylum Bryozoa, only present-day fresh-water gelatinous phylactolaemates (*Pectinatella magnifica*) occasionally grow somewhat larger, over 2 feet in maximum dimension according to Hyman's (1959) invertebrates book. This species sometimes comes to public attention as the mysterious, large, jelly-like masses in lakes, cattle ponds, and golf-course water-traps, a far cry from the ancient Ordovician sea floors inhabited by their distant relatives like *Heterotrypa frondosa*.



(Left) Tangential section of largest Heterotrypa frondosa*, showing zooecial tubes cut in cross-section, with laminated tube walls, lack of spine-like acanthorods, and absence of tiny mesopore tubes. (Right) Longitudinal section of same bryozoan, showing zooecial tubes cut lengthwise, with diaphragm cross-partitions and thickened tube walls immediately below the branch's surface (to the right). Height of area shown by each thin section photograph is 2.2 mm.*

REFERENCES CITED AND FURTHER READING CONCERNING REASSEMBLED BRYOZOANS

Brown, G.D., and Daly, E.J., 1985, Trepostome Bryozoa from the Dillsboro Formation (Cincinnatian Series) of southeastern Indiana: Indiana Geological Survey Special Report 33, p. 1-95.

Cuffey, R.J., 1998, An introduction to the type-Cincinnatian: Ohio Division of Geological Survey Guidebook 13, p. 2-9.

Cuffey, R.J., and Cheetham, A.H., 1982, Reconstruction of bryozoan colonies from measurements of branch fragments [abs.]: Geological Society of America Abstracts with Programs, v. 14, p. 13.

Cuffey, R.J., and Utgaard, J.E., 1999, Bryozoans, *in* R. Singer ed., Encyclopedia of Paleontology, Fitzroy Dearborn, v. 1, p. 204-216.

Davis, R.A., ed., 1992, Cincinnati fossils, rev. ed.: Cincinnati Museum of Natural History, 61 p.

Singh, R.J., 1979, Trepostomatous bryozoan fauna from the Bellevue Limestone, Upper Ordovician, in the tri-state area of Ohio, Indiana, and Kentucky: Bulletins of American Paleontology, v. 76, no. 307, p. 157-288.

Waugh, D.A., and Erickson, J.M., 2002, Functional morphology of the anastomosing frondose growth form reported in *Heterotrypa frondosa* (d'Orbigny)(Bryozoa: Trepostomata) from the Cincinnatian (Late Ordovician) of Ohio: Bryozoan Studies 2001 (P.N. Wyse Jackson, C.J. Buttler, and M.E. Spencer Jones, eds.; Balkema/Swets & Zeitlinger), p. 331-338.

REFERENCES CITED ON OTHER UNUSUALLY LARGE BRYOZOANS

Bradstock, M., and Gordon, D.P., 1983, Coral-like bryozoan growths in Tasman Bay, and their protection to conserve commercial fish stocks: New Zealand Journal of Marine & Freshwater Research, v. 17, p. 159-163.

Cuffey, R.J., 1988, Lock Haven coral-bryozoan reef, Middle Silurian, Pennsylvania, *in* Geldsetzer, H.H.J., James, N.P., and Tebbutt, G.E. eds., Reefs, Canada and adjacent areas: Canadian Society of Petroleum Geologists Memoir 13, p. 285-287.

Cuffey, R.J., and Fonda, S.S., 1976, "Giant" *Schizoporella*—Sedimentologically important cheilostome bryozoans in Pleistocene and Recent carbonate environments of Bermuda, the Bahamas, and Florida [abs.]: Geological Society of America Abstracts with Programs, v. 8, p. 474-475.

Hageman, S.J., Lukasik, J., McGowran, B., and Bone, Y., 2003, Paleoenvironmental significance of *Celleporaria* (Bryozoa) from modern and Tertiary cool-water carbonates of southern Australia: Palaios, v. 18, p. 510-517.

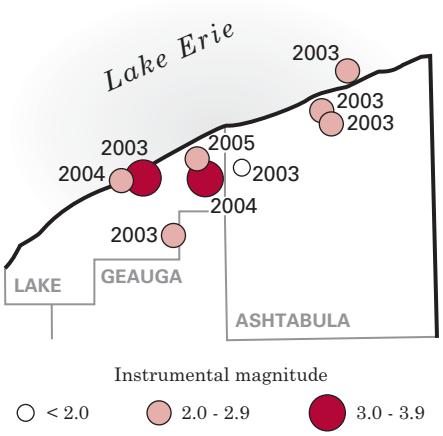
Hakansson, E., and Madsen, L., 1991, Symbiosis—A plausible explanation of gigantism in Permian trepostome bryozoans: Bulletin de la Société des Sciences Naturelles de l'Ouest de la France, Mémoire HS 1, p. 151-159.

Hyman, L.H., 1959, The invertebrates: smaller coelomate groups (vol. 5): McGraw-Hill, 783 p.

Mezentseva, O.P., 2000, Variability of the trepostome bryozoan *Heterotrypa enormis* Astrova in abnormal conditions: Nature and Economics of Kuzbass (Novokuznetsk Government Pedagogical Institute), v. 8, p. 46-61.

Wood, R., Dickson, J.A.D., and Kirkland, B.L., 1996, New observations on the ecology of the Permian Capitan Reef, Texas and New Mexico: Palaeontology, v. 39, p. 733-762.

EARTHQUAKES *continued from page 2*



Earthquakes in Ohio from 2003 to February 2005. Mercer County earthquake not shown (see table).

On May 2, a 2.0-magnitude earthquake was detected instrumentally in Leroy Township, Lake County, near the Lake-Geauga County boundary. No felt reports were received for this event, which was close to the lower threshold of felt earthquakes. This earthquake occurred in the general vicinity of the Akron Magnetic Lineament, a northeast-trending seismogenic zone along which the 5.0-magnitude LeRoy (Chardon) earthquake occurred in 1986.

The largest Ohio earthquake in 2003 was a 3.5-magnitude event on June 30, beneath Lake Erie, offshore from Painesville, Lake County. This event was widely felt along the lakeshore from East Cleveland to Erie, Pennsylvania and generated considerable media attention. The U.S. Geological Survey's Community Internet Intensity Maps Website recorded 86 felt reports for this earthquake. One media report indicated more than 300 phone calls to the Lake County sheriff's office. The instrumental epicenter of this event is similar to that of small earthquakes in 1983, 1988, and two in 1992.

A 2.5-magnitude earthquake occurred on July 16 at 8:44 p.m. Eastern Daylight Time on the southeast side of Ashtabula and was felt by numerous people in this area. The U.S. Geological Survey Community Internet Intensity Maps Website received 45 felt reports for this event. The instrumental epicenter was in the vicinity of the epicenter of

Technical data for recent Ohio earthquakes.

DATE	ORIGIN TIME	LAT	LON	MAG	DEPTH	COUNTY	MMI/FELT AREA
				2003			
JAN 18	23:08:44.94	41.76	80.96	1.5	5 F	ASHT	NF
FEB 10	05:34:43.07	41.95	80.72	2.4	2.5 F	ASHT	F
MAY 2	15:59:07.00	41.67	81.11	2.0	5 F	LAKE	NF
JUN 30	19:21:17.20	41.80	81.20	3.4	4.6 C	LAKE	IV/0.53
JUL 17	00:44:10.80	41.86	80.76	2.5	2.5 F	ASHT	III/0.3
JUL 22	15:54:01.24	41.87	80.77	2.1	2.5 F	ASHT	NF
				2004			
JAN 30	12:10:04.14	40.67	84.62	2.5	5 F	MERC	III
MAR 14	05:05:10.28	41.77	81.24	2.4	5 F	LAKE	III
JUN 30	04:00:14.58	41.78	81.07	3.3	5 F	LAKE	IV
				2005			
FEB 1	13:01:13.30	41.80	81.10	2.3	5 F	LAKE	III

Dates and times are Universal Coordinated Time (UTC). Latitude is west; longitude is north. Magnitudes are mbLg. Hypocentral depths are fixed (F) or calculated (C). MMI represents Modified Mercalli Intensities; Felt Areas are in 1,000 square kilometers. NF indicates that no felt reports were received; F indicates that the event was felt but no MMI was assigned.

the January 25, 2001 4.5-magnitude mainshock that damaged more than 50 homes and businesses. At the request of the Ohio Seismic Network, Dr. John Armbruster of Lamont-Doherty Earth Observatory at Columbia University deployed five portable seismographs in the epicentral area on July 21 as part of an ongoing study by these two institutions of the Ashtabula induced-earthquake sequence (see *Ohio Geology*, 2001, No. 3). The Ashtabula County Emergency Management Agency downloaded data on a weekly basis from these portable instruments. The portable seismographs were deployed until September 21. The Ohio Seismic Network and the portable instruments recorded a 2.1-magnitude earthquake on July 22 at 11:54 a.m. (Eastern Daylight Time) near the epicenter of the July 16th event. No felt reports were received for this earthquake.

Seismicity quieted a bit during 2004 with only three felt earthquakes recorded. The first occurred on January 30 near Rockford, Mercer County. This 2.5-magnitude earthquake was the first since 1994 in the western Ohio, or Anna, seismic zone, which has traditionally been Ohio's most active area, with more than 40 felt earthquakes. The Rockford earthquake startled many residents.

On March 14, a 2.4-magnitude earthquake was felt just after midnight from Mentor to Painesville and most strongly felt at Grand River and Fairport Harbor. The epicenter was calculated to be beneath Lake Erie just offshore from Painesville-on-the-Lake. Many residents were frightened by the loud boom and sharp jolt of the earthquake.

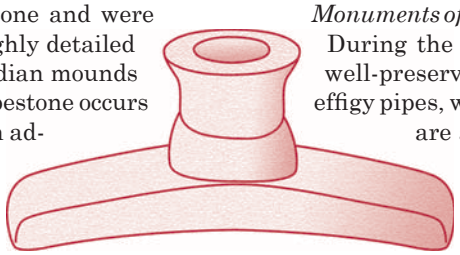
On June 30 a 3.3-magnitude earthquake shook the Painesville, Madison, and Perry areas of Lake County. This event, which was widely reported to local authorities, was located close to the epicenter of the 3.5-magnitude earthquake that occurred on June 30 of the previous year.

A small earthquake (2.3 magnitude) occurred between North Perry and North Madison in eastern Lake County on February 1, 2005 and frightened several residents of these communities. Several small earthquakes have occurred in this general area in recent years.

—Michael C. Hansen
Coordinator, Ohio Seismic Network

THE GEOLOGY OF OHIO PIPESTONE

Pipestone usually refers to a pink, or mottled pink-and-white, argillaceous rock that was used by early American Indians to make smoking pipes. Catlinite, a pink to red clay from southwestern Minnesota, is the rock that most people associate with pipestone. Pennsylvanian-age flint clays in eastern Ohio, however, also are sources of pipestone and were used by ancient craftsmen to carve the highly detailed platform and effigy pipes discovered in Indian mounds of southern Ohio. Unlike catlinite, Ohio pipestone occurs in various shades of gray, tan, and green in addition to pink. One of the most important discoveries of prehistoric clay effigy pipes in the United States was made at Tremper Mound near Portsmouth.



Depiction of a platform pipe.

Tremper Mound is located 5 miles north of Portsmouth on a terrace overlooking the Scioto River. (Note: Tremper Mound is located on private property.) The archeological significance of the site was first recognized in the 1840's when Charles Whittlesey surveyed the area and published a map with description in the classic text *Ancient Monuments of the Mississippi Valley,* by Squire and Davis. During the 1915 excavation of Tremper Mound, 145 well-preserved pipes, including 60 remarkable animal-effigy pipes, were discovered. The Tremper Mound pipes are astonishing in their variety and exquisite in their detail. More than 20 types of birds and mammals are represented, including mountain lions, wolves, and parakeets that no longer live in Ohio. A collection of Tremper Mound pipes is on display at

the Ohio Historical Society Center in Columbus.

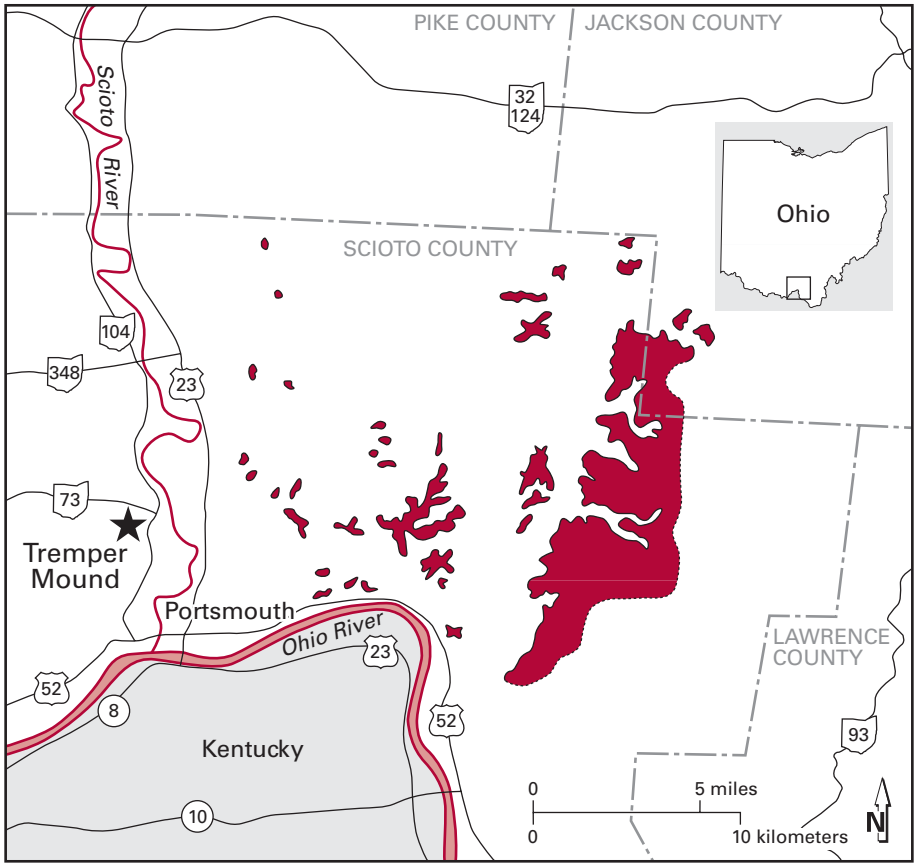
Most of the pipes recovered from Tremper Mound were made from the locally mined, Pennsylvanian-age Sciotoville clay, and are believed to have been carved with flint knives by people of the Hopewell Culture (100 BC to 500 AD). High-quality flint for carving knives and other tools was readily available from Licking and Muskingum Counties (Flint Ridge), and from Coshocton, Perry, and Vinton Counties.

Ohio pipestone is a type of clay known as flint clay or semi-flint clay and is characterized by being a hard, dense substance that breaks with a conchoidal fracture and that rarely exhibits bedding planes. A flint clay weathers into sharp, angular pieces that are non-plastic. A semi-flint clay weathers into irregular masses and develops limited plasticity. Flint clay and semi-flint clay in Ohio are predominantly kaolinite (hydrous aluminum silicate). Color normally varies from tan to dark gray with occasional green tints. A pink to red variety, often called pink-eye, develops when iron oxide (Fe_2O_3) ranges from 2 to 15 percent of the clay. Semi-flint clay in shades of tan or gray was used most often by the American Indians in Ohio because of its accessibility and ease of carving.

Flint clays in Ohio are found in association with early Pennsylvanian-age, Pottsville- and Allegheny-Group marine and brackish-water sedimentary rocks and coals. Flint clay and semi-flint clay in the overlying Conemaugh Group are rare, and nearly absent in the late Pennsylvanian-age, Monongahela Group. Ohio flint clay is thought to have formed from ancient soils (paleosols). Soil leaching, as well as plant and microbial activity, resulted in partial removal of silica, aluminum, iron, or potassium and probably accounts for the different varieties of clay found within a single horizon or between horizons. Other chemical changes and compaction of the paleosols would eventually change the clay component of these ancient soils into flint clay—a rock composed of well-ordered, interlocking crystals of the mineral kaolinite.

The most extensively developed flint clay and semi-flint clay in Ohio is the Sciotoville clay of the lower Pottsville Group in Scioto and Jackson Counties. Average clay thickness is 4 feet, but the deposits are laterally discontinuous and can vary from a few inches thick to more than 14 feet thick. The pink-eye variety occurs as small lenses in eastern Scioto County. The Sciotoville clay, along with other Mississippian-age and Pennsylvanian-age clays and shales, was used extensively from the 1860's until the 1970's in the Portsmouth area to manufacture ceramic products such as fire bricks, paving bricks, and face brick.

The Scioto and the Ohio Rivers were natural transportation corridors used by the American Indians to transport and trade finished Ohio pipes for copper, obsidian, and mica from other parts of North America. Artifacts made from Ohio flint and pipestone found in the eastern U.S. are evidence of the considerable influence of Ohio's natural resources (flint, pipestone, navigable rivers) on the development of early American Indian cultures.



Location of surface exposures of Sciotoville clay in Scioto and Jackson Counties, Ohio and location of the Tremper Mound. Modified from Stout (1916).

ACKNOWLEDGMENTS

I would like to thank Mike Hansen, former editor of *Ohio Geology*, for providing much of the background information for this article. I also greatly appreciate the insightful comments provided by Martha Otto, Curator of Archaeology at the Ohio Historical Society. Lastly, I am grateful to the citizens of Ohio for continually asking geologically related questions that need to be answered.

SUGGESTED READING

Holzapfel, Elaine, 1995, Ohio Pipestone: Ohio Archaeologist, v.45, no.3, p. 4-6.

Keller, W. D., 1981, The sedimentology of flint clay: Journal of Sedimentary Petrology, v. 51, no. 1, p. 233-244.

Otto, M. P., 1984, Masterworks in pipestone: treasure from Tremper Mound: Timeline, v.1, no.1, p.18-33.

Squire, E. G. and Davis, E. H., 1848, Ancient monuments of the Mississippi Valley: comprising the results of extensive original surveys and explorations: Washington, Smithsonian Institution, 304 p.

Stout, Wilber, 1916, Geology of southern Ohio: Ohio Division of Geological Survey Bulletin 20, 723 p.

Stout, Wilber, Stull, R. T., McCaughey, W. J., and Demorest, D. J., 1923, Coal formation clays of Ohio: Ohio Division of Geological Survey Bulletin 26, 588 p.

—Mark E. Wolfe

Richard M. DeLong, 1923-2004

It is with regret that we note the passing of Richard Marion DeLong on November 4, 2004 at his residence in Columbus. Dick retired from the Division of Geological Survey in 1988 after 34 years of continuous service.

Dick was born in Marion County, Ohio and served in the South Pacific during World War II. After leaving military service, he attended Ohio Wesleyan University in Delaware and obtained a bachelor's degree in geology in 1950. He pursued a master's degree in geology at The Ohio State University where he mapped Mississippian and Pennsylvanian rocks in Jackson County. After graduating in 1951, Dick went to work for the Carter Oil Company and sat on wells in Wyoming and Illinois.

In 1954, Dick returned to Ohio and began his long career with the survey. His first assignments were mapping bedrock geology and coal resources in eastern Ohio, an area of research that would be his primary focus for the remainder of his career at the survey. Dick published 11 Reports of Investigations and coauthored two major bulletins—*Geology of Stark County* (with George W. White) and *Coal Resources of Ohio* (with Russell A. Brant). Dick also produced an unpublished report on the geology of Harrison County.

Dick used his mapping skills to prepare two popular educational publications—the geologic maps of the Hocking Hills and Flint Ridge areas, published in 1967 and 1972, respectively. Over the course of his career, Dick mapped the geology of more than 1,500 square miles of Ohio, measured hundreds of stratigraphic sections, and contributed greatly to the survey's substantial geologic database.

Perhaps Dick's greatest contribution to the citizens of Ohio may be the 189 maps of the Abandoned-Underground-Mine Map Series, which he completed late in his career with the assistance of survey geologist Doug Crowell. These maps depict the location and extent of thousands of abandoned-underground mines in eastern Ohio and are one of the most popular map series offered by the survey.

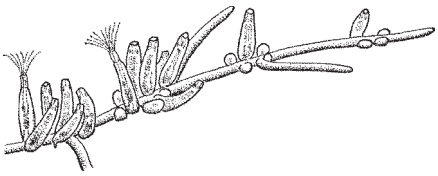
The career of Richard M. DeLong was characterized by hard work and dedication to understanding the geology of Ohio, particularly the complex, Pennsylvanian-age strata in the eastern portion of the state. All who had the privilege of working with and knowing Dick will remember and admire his great sense of humor, his love of Scottish Country dancing, his devotion to family, and his legacy of maps and data that will live on. Dick DeLong is survived by his wife, Juanita, his daughter Sandra DeLong-Wynkoop, and his grandson and former survey intern Richard Judson Wynkoop.

Richard M. DeLong

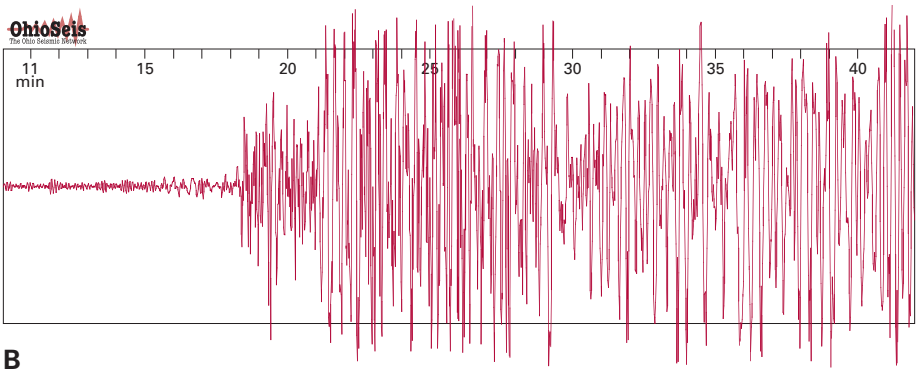
Portions of this article were modified from the Spring 1993 issue of *Ohio Geology*.

TEST YOUR KNOWLEDGE

Test your knowledge is an interactive feature that challenges readers to identify some aspect of Ohio's geology. Below are two images to identify.



A



B

Answers are given below. Complete answers and additional information will be provided in the next issue of *Ohio Geology*.

Test your knowledge answers: A, Artist's depiction of a living bryozoan colony; B, Seismograph of northern Sumatra earthquake that caused the massive tsunamis of December 26, 2004, recorded in Delaware County.

Test your knowledge answers for *Ohio Geology* 2004, No. 2

To refresh your memory of the photographs in the last issue, see our web site <http://www.ohiodnr.com/geosurvey/oh_geol/04_No_2/tyk.htm>.

A *John Hunt Morgan.* The longest cavalry raid of the Civil War was led by Confederate General John Morgan. The raid began at McMinnville, Tennessee on July 2, 1863 and ended near the eastern Ohio village of West Point on July 26th. On July 13, Morgan's Raiders rode into the western Ohio town of Harrison and brought the Civil War to Ohio for 13 harrowing days. John Morgan was born in Huntsville, Alabama on June 1, 1825, and later moved to Lexington, Kentucky. At age19, he enlisted in the U.S. Army and during the Mexican-American War his regiment fought and defeated Santa Anna in the Battle of Buena Vista. After the war, Morgan returned to Lexington, married Rebecca Bruce, opened a highly successful business, served on Lexington City Council, and joined the Kentucky Rifles as a Captain. With the outbreak of the Civil War, he left Lexington with the Kentucky Rifles to join the Confederate Army mobilizing in Tennessee. Prior to the longest raid, he served with distinction at the Battle of Shiloh, led many raids attacking the supply lines of the Federal Army of the Cumberland, married his second wife, Martha Ready, and rose to the rank of general. After his capture near West Point, Ohio on July 26, 1863, he was imprisoned at the Ohio Penitentiary from which he would later escape and return to service in the Confederate Army. He was killed in action at Greeneville, Tennessee on September 4, 1864.

B *Allegheny Escarpment.* The Allegheny Escarpment of southern Ohio is an irregular line of steep-sided, flat-topped hills that abruptly rise 300 to 400 feet above the rolling terrain of the Outer Bluegrass and Till Plains physiographic regions. The escarpment is the western boundary of the Allegheny Plateau, a very rugged region characterized by narrow, steep, sided valleys separated by high, narrow ridges rising between 400 to 800 feet above the valley bottoms. The Allegheny Escarpment is best developed in Adams, Highland, Pike and Ross Counties of southern Ohio. To the north, the escarpment was affected by glaciation, making it a less distinctive topographic feature.

Did you know . . . ?

Did you know . . . that much of the road salt spread on Ohio's roadways is mined almost one-half mile below Lake Erie from underground mines that extend nearly 2 miles offshore from the cities of Cleveland and Fairport Harbor? In 2003, two mines operated by Cargill Incorporated and Morton International's Morton Salt Division produced over 3 million tons of rock salt valued at nearly 65 million dollars from the Silurian Salina Formation. Ohio's rock salt is used primarily for ice control on roadways, but is also used as a water-softening agent, an additive to animal feed, and for cattle salt blocks. (Sources: Tomastik, 2001, Ohio Division of Geological Survey *2001 Report on Ohio Mineral Industries* and Wolfe, 2004, Ohio Division of Geological Survey *2003 Report on Ohio Mineral Industries*)

Ohio Geology

Ohio Department of Natural Resources
Division of Geological Survey
2045 Morse Road, Bldg. C-1
Columbus, Ohio 43229-6693

PRSRT STD
U.S. Postage
PAID
Columbus, OH
Permit No. 5767

recycled paper

DIVISION OF GEOLOGICAL SURVEY
OHIO DEPARTMENT OF NATURAL RESOURCES