Ohio Geology
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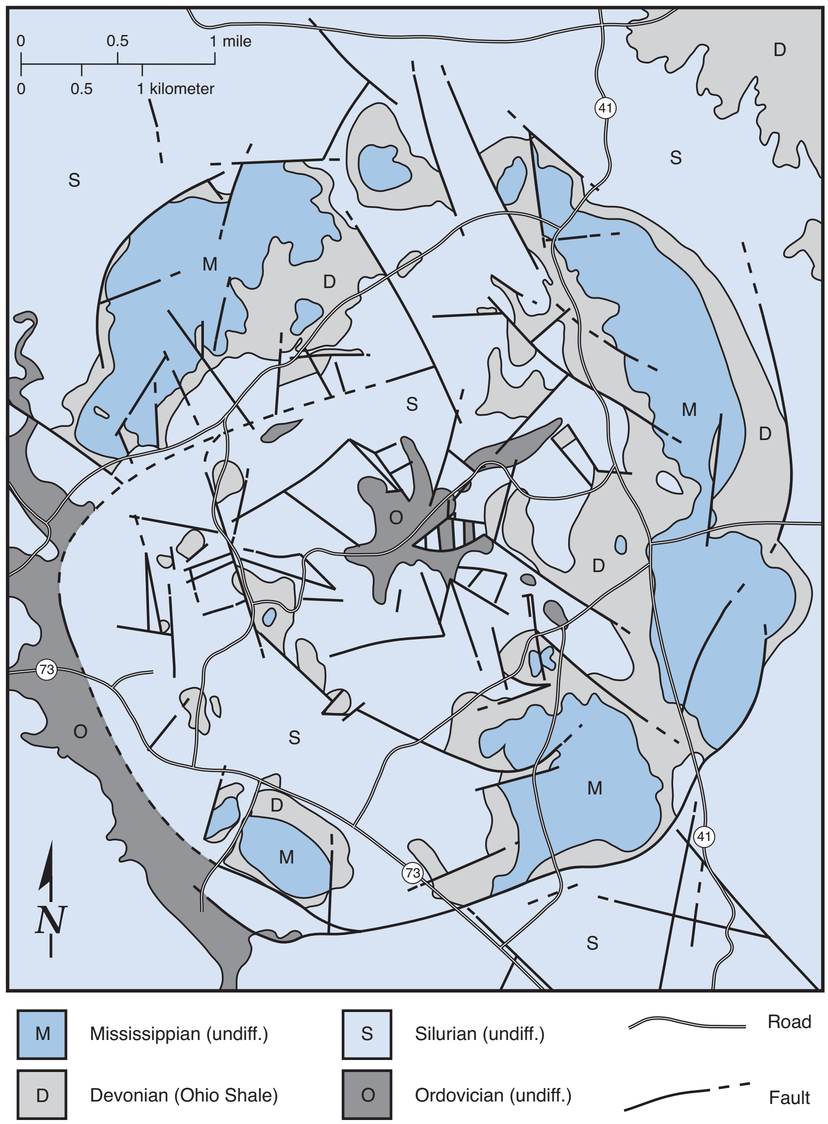
RETURN TO SUNKEN MOUNTAIN: THE SERPENT MOUND CRYPTOEXPLOSION STRUCTURE

by Michael C. Hansen

The geologic record is punctuated by evidence of cataclysmic events of such proportions that they must have wreaked havoc upon regions or, some speculate, perhaps the entire planet. Such an event, of regional scale, is recorded in the rocks in northern Adams County, Ohio. A circular area of more than 12 square miles suffered utter chaos, wrought at an uncertain time by a force that remains speculative. This event had sufficient energy to disturb more than 7 cubic miles of rock and uplift the central portion of the circular feature at least 1,000 feet above its normal position. Some think it was caused by a small asteroid, weighing about 2 billion tons, that hurtled through the atmosphere at 15 miles per second; others think it was caused by a massive eruption of explosive gases associated with molten rock from the Earth's mantle. An area 4 miles in diameter filled with intensely disturbed and dislocated rocks, known as the Serpent Mound cryptoexplosion structure, is testimony to this long-ago event.

Geologists are certain that this disturbance occurred between Early Mississippian time, about 345 million years ago, and deposition of sediments by the Illinoian glacier about 125 thousand years ago, but there is considerable uncertainty as to when in this immense span of time Ohio experienced its perhaps worst catastrophe. Did the massive explosion strike in a shallow sea that covered the state periodically until about 295 million years ago and send massive waves crashing into shorelines hundreds of miles away? Or did it occur on a land area during the time of the dinosaurs, flattening vegetation, and reptiles, for tens of miles in every direction as the shock wave and ensuing dust cloud radiated outward from ground zero?

Perhaps coincidentally, perhaps purposefully some suggest, the most spectacular American Indian effigy mound in the United States, Serpent Mound, lies on the western flank of the cryptoexplosion structure. The mound is in the form of an uncoiling serpent, 1,348 feet long, that appears to be swallowing an egg. Archaeologists have long thought that the mound was constructed by the Adena culture between 800 B.C. and 100 A.D. Ohio Historical Society archaeologist Dr. Bradley T. Lepper indicates that recent calibrated radiocarbon dates from the effigy mound are about 1070 A.D., suggesting that the mound was constructed by the Fort Ancient culture. Lepper points out that the brightest and most spectacular recorded display of Halley's comet was in 1066 A.D. and suggests that the serpent effigy mound may have been inspired by this event as the Fort Ancient Indians interpreted the comet and its long tail as a celestial serpent.



Greatly generalized geologic map of the Serpent Mound cryptoexplosion structure (modified from Reidel, Koucky, and Stryker, 1982).

The first geologist to observe the geologic structure was the remarkable Dr. John Locke (see *Ohio Geology*, Winter 1984), during his foray in the southwestern part of the state for the First Geological Survey of Ohio. In his report on the geology of southwestern Ohio for the 1838 Second Annual Report of the Geological Survey of Ohio, Locke

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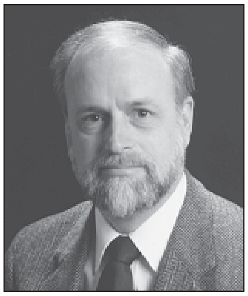

Thomas M. Berg, Division Chief and State Geologist

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From The State Geologist...

Thomas M. Berg

TOUCHING THE EDGE OF THE UNIVERSE

Recently I had an interesting discussion with an astronomer about funding of scientific endeavors in the United States. The discussion was prompted by my viewing some of the television coverage of the repairs to the Hubble space telescope satellite by American astronauts. Knowing that the repair work cost millions upon millions of our tax dollars, I asked the astronomer how we could afford these efforts in space when so much geoscientific work remains to be done at home on Planet Earth. His opinion was that, quite simply, decision-makers find it easier, more appealing, and more defensible to allocate funds for projects that will enable humanity to "touch the edge of the universe." I really don't know if the astronomer is right, but I do know that in today's world economic situation, it is becoming more and more difficult to finance the scientific work that needs to be conducted by the state geological surveys and the U.S. Geological Survey.

The work that the geological surveys urgently need to conduct does not often have the pizzazz of "touching the edge of the universe." The work that needs to be done provides critically important information for locating and properly zoning mineral resources such as sand and gravel or limestone needed for construction. Research that is required provides information on the location, quantity, and quality of our domestic energy resources—coal, oil, and natural gas. Investigations that are necessary provide the information that permits identification of new ground-water resources and safe waste-disposal sites. Other geological work that needs to be done provides information for assessing geological hazards such as earthquakes, landslides, sinkholes, and indoor radon. Although this kind of practical research does not have the stirring appeal of space exploration, it is clearly unavoidable if we wish to live safe, productive lives within an acceptable standard of living.

At the Ohio Geological Survey, we occasionally have the opportunity and the desire to explore scientifically unusual and exciting geological phenomena such as the newly discovered East Continent Rift complex in western Ohio. For some time, we have wanted to drill through the Serpent Mound cryptoexplosion structure in southern Ohio, the subject of this issue's lead article by Dr. Michael C. Hansen. But even investigating these unusual phenomena has some practical value. The rift and the cryptoexplosion structure may bear strategic minerals or precious metals of considerable value. The investigation of the East Continent Rift was supported by private industry. The Serpent Mound Working Group is seeking private funding to drill the cryptoexplosion structure. Paragon Geophysical, Inc. has already donated seismic-stratigraphic services and John Carroll Minerals, Inc. has donated core samples from the structure. These are examples of quality partnerships that our Governor advocates, and that will advance geologic research in unusual areas.

Our citizens need to know that their state geological survey is committed to quality service and prioritizes its greatest efforts toward developing information needed to make daily, practical decisions. Our main focus is not something akin to "touching the edge of the universe," but is more akin to "providing accurate geology for wise land-use and planning decisions." Don't get me wrong. I am enthralled by the accomplishments of our national space program, and I look forward to seeing clearer views of distant galaxies. I just think we need to balance our scientific investments so that the immediate, practical needs of our citizens have the highest priority.

Ohio Geology—a new look

We hope that it is obvious to readers of *Ohio Geology* that this issue has a significantly different appearance from the design we have used since 1981. In a large way, this redesign is possible because of our acquisition of a Macintosh desktop publishing system. However, most of the credit goes to Survey cartographer and principal Macintosh operator Lisa Van Doren, who redesigned *Ohio Geology* in consultation with Ed Kuehnle, Merrianne Hackathorn, and Mike Hansen. We would appreciate your comments.

With this redesign, we introduce a new column by Survey geologist and mineral statistician Sherry Weisgarber that features hands-on experiments and projects that will be a value to students, teachers, and perhaps parents who must help their child with a science project (usually the evening before it is due). Sherry welcomes your comments and suggestions about projects that can be shared with other readers.

We have also made a concerted effort to update and correct the *Ohio Geology* mailing list. Please check the mailing label and notify us if there are any errors in your name or address, or if you are getting duplicate copies. Please also notify us when you move, so that you will continue to receive each issue. Of course, we welcome new readers. So, sign up a friend or colleague. Additions and address changes should be sent to the attention of Sherry Weisgarber, Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362.

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observed (p. 266-267) that in northern Adams County ". . . it became evident that a region of no small extent had sunk down several hundred feet, producing faults, dislocations and upturning of the layers of the rocks . . . . On travelling from Locust Grove to Sinking Spring, I found that a tract large enough for a township, reaching within a mile of Sinking Spring and extending several miles up Straight creek, was in the same manner dislocated and sunken about four hundred feet . . . ." Locke stated ". . . it is evident that this mountain at some remote period of time, has sunk down from its original place, and I ventured to call it the *'Sunken Mountain.'*"

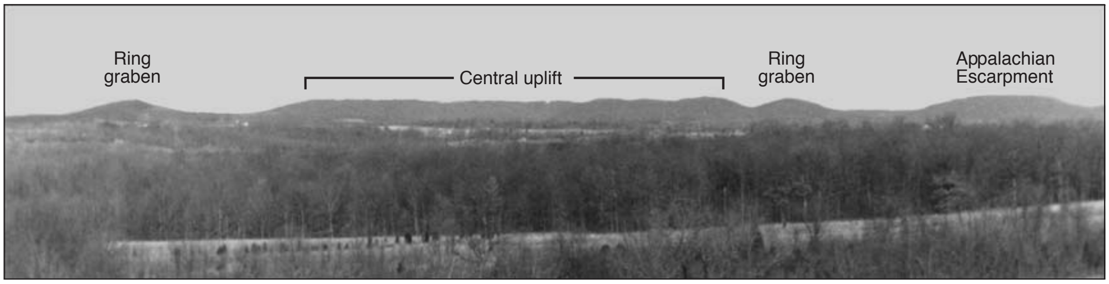
Surprisingly, the Serpent Mound cryptoexplosion structure received almost no additional attention from geologists in the 19th century. Edward Orton, in his report on the geology of Highland County for the 1871 Report of Progress of the Geological Survey in 1870, mentioned (p. 289) Locke's observations in neighboring Adams County and added that "Waverly sandstone, slates, the various limestones of the county, are involved in inextricable confusion." Orton commented (p. 53) on the structure in the 1890 First Annual Report of the Geological Survey of Ohio (Third Organization), indicating that "In the northeast corner of Adams county and in adjacent territory, there are a number of square miles throughout which the strata are really dislocated."

It was not until about 1919 that the Serpent Mound cryptoexplosion structure received its first serious investigation, which resulted from a curious circumstance. Professor Walter H. Bucher remarked to the students in a geology class he was teaching at the University of Cincinnati that the rocks in Ohio were nearly flat lying, and never upturned. The story continues, as told by Dr. Bucher's son and related by Dr. Frank L. Koucky of the College of Wooster, that a student in the class had the audacity to tell Professor Bucher that his statement was incorrect, because the rocks on his family farm in Adams County were not flat lying, but standing on end. The student's persistent challenge led Bucher to visit the farm and embark on a lifelong study of the Serpent Mound structure and similar features throughout the world. Bucher was apparently unaware of the observations of Dr. Locke many years earlier and, instead of using Locke's appellation of "Sunken Mountain," used the name of the serpent-shaped effigy mound for the geologic structure.

Bucher mapped the geology of the Serpent Mound structure in 1920 and reported the first details of the feature. He quickly arrived at a theory of origin of the disturbance, interpreting it to have been formed by a deep-seated intrusion of molten rock that generated gases that escaped to the surface with a violent force sufficient to disrupt a considerable volume of rock. Bucher referred to it as "cryptovolcanic" and compared it to the Steinheim basin in Germany. In 1933 Bucher published a detailed paper (in German) on the Serpent Mound structure and in 1936 published a summary of Serpent Mound and several similar structures that he had studied and mapped.

GEOLOGY OF THE SERPENT MOUND STRUCTURE

Investigations of the Serpent Mound structure have included gravity and magnetic surveys, geochemical and mineralogical analyses, and a complete remapping of the feature. The most significant work has been that of Stephen P. Reidel, who remapped the structure for a master's thesis at the University of Cincinnati. His map was published by the Division of Geological Survey in 1975 as Report of Investigations No. 95[1]. Later papers by Reidel and Frank L. Koucky have added considerable detail to our knowledge of the Serpent Mound structure.



View of the Serpent Mound cryptoexplosion structure from Ohio Route 770, southwest of the feature. The central uplift and outer ring grabens are clearly expressed as topographic highs owing to their erosional resistance. Photo by Stephen P. Reidel.

The Serpent Mound cryptoexplosion structure can be divided into three zones—central uplift, transition zone, and ring graben—which are defined by rock units and their relative stratigraphic positions, and by structural characteristics. Such zones are typical of cryptoexplosion structures.

Central uplift

The center of the structure is known as the central uplift and occupies about 9 percent of the total surface area of the feature. This area consists of Ordovician and Silurian rocks that have been uplifted at least 1,000 feet above their normal stratigraphic position. These rocks have been faulted and folded into seven radiating anticlines, some of which are overturned. The anticlines are separated by downdropped grabens which exhibit the most intense deformation in the structure in the form of vertical to overturned beds and shock features known as shatter cones. The central uplift forms a topographic high.

Shatter cones developed in Ordovician limestone from the central uplift of the Serpent Mound structure. Photo courtesy of Stephen P. Reidel.

Transition zone

The transition zone surrounds the central uplift and represents a transitional area between the radial structures of the central uplift and the concentric structures of the outer ring grabens. The rocks in this zone are mostly Silurian carbonates at or near their normal stratigraphic positions. About 19.5 percent of the surface area of the structure is occupied by this zone, which is topographically low relative to the other two zones.

Ring graben

The perimeter of the cryptoexplosion struc-

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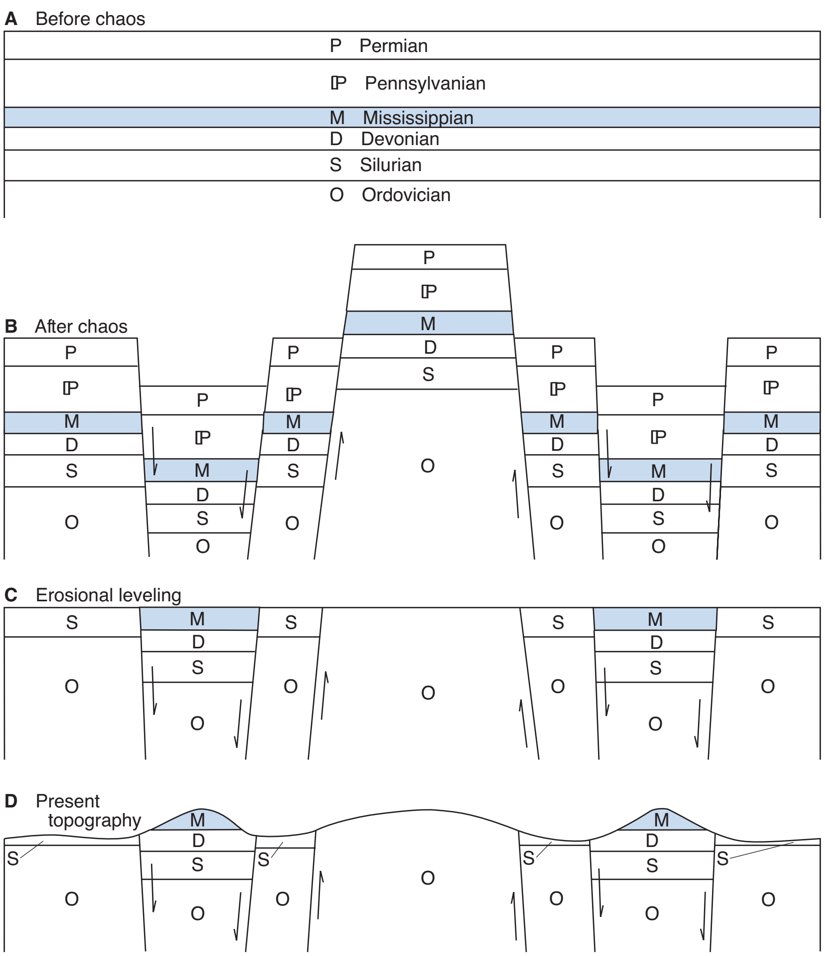
[1]Division of Geological Survey Report of Investigations 95, *Bedrock geology of the Serpent Mound cryptoexplosion structure, Adams, Highland, and Pike Counties, Ohio,* authored by Stephen P. Reidel and published in 1975, has been out of print for several years. The Survey is planning to reprint this map with a revised text. Its availability will be announced in a future issue of *Ohio Geology*.

ture is sharply defined by nearly continuous, concentric faults. The rocks of the ring-graben zone are mostly of Devonian and Mississippian age and are structurally lower than the rocks of the other two zones or surrounding undisturbed rocks. About 71 percent of the area of the structure is occupied by the ring-graben zone, which is topographically higher than the transition zone.

The topographic expression of the Serpent Mound structure clearly defines the configuration of the feature and delineates the major structural zones. It appears that this expression is a function of the structural arrangement of the rocks in each zone and the resistance of these rocks to erosion.

The accompanying diagram illustrates the structural and topographic development of the disturbance. There is no direct evidence that Pennsylvanian and Permian rocks covered the area, but it is



Diagrammatic erosional development of the Serpent Mound structure. It is probable that rocks of Pennsylvanian age, and possibly rocks of Permian age, once covered northern Adams County and were involved in the disturbance. If they were present, all evidence of them has been removed by erosion during a length of time thought to approximate 200 million years. Rocks younger than Silurian have been eroded from the undisturbed borders of the structure. Devonian and Mississippian rocks present in the outer ring graben have been preserved because they were downdropped during the disturbance. These rocks currently form a topographic high because of erosional resistance. The oldest rocks exposed in the disturbance are of Ordovician age and are exposed in the central uplift.

reasonable to assume their presence. The disturbing force, whether from above or below, elevated the central uplift and depressed the outer ring graben. Erosion during the Mesozoic and Tertiary removed perhaps as much as 1,000 feet of rock. Continued erosion has exposed the resistant Mississippian and Devonian rocks that were preserved in the downdropped ring grabens. The outer ring grabens now define the outer margin of the structure as wooded hills. The transition area, composed of carbonate rocks of Silurian age, is topographically low. The central uplift, composed of Ordovician shales and limestones, stands as a topographically high area. These zones are clearly visible from either ground or low-angle aerial perspectives.

Mineralization

The zinc sulfide mineral sphalerite locally cements fault breccia and fills fractures, primarily in Silurian carbonate rocks within the structure. Reidel indicates that most of the sphalerite is crushed and ground into fine particles, which suggests that additional movement occurred along the faults after the sphalerite had been deposited. A second episode of sphalerite mineralization was not brecciated, indicating that no additional movement of the faults occurred after it was deposited. Dr. Ernest H. Carlson, in his 1991 Survey bulletin, *Minerals of Ohio*, describes the mineralization of the Serpent Mound structure and provides localities where minerals can be collected.

Age

It is difficult to assign an exact age to the Serpent Mound structure because of the absence of igneous rocks for radiometric dating. The timing of the event can be determined to be later than Early Mississippian, because rocks of this age were involved in the disturbance, and earlier than the Illinoian glaciation (125,000 years ago), because these sediments are undisturbed in the northern part of the structure. Provocative information on a possible age for the structure was collected for a senior thesis by Jonathan D. Istok, under the direction of Professor Hallan C. Noltimier, at The Ohio State University in 1978. Istok studied the paleomagnetism of zinc minerals in Silurian rocks in the structure and discovered that they recorded a Late Triassic pole position. This observation may indicate the approximate age of formation of the structure or perhaps a later phase of hydrothermal mineralization. If an endogenic origin of the structure is accepted, a Late Triassic date of formation coincides with extensional tectonics associated with opening of the Atlantic Ocean.

CRYPTOEXPLOSION STRUCTURES

The Serpent Mound cryptoexplosion structure is not unique and is one of many similar features scattered throughout the Midwest. Well-known ones include Kentland in Indiana; Jeptha Knob, Versailles, and Middlesboro in Kentucky; Calvin 28 in Michigan; Wells Creek and Flynn Creek in Tennessee; Glasford and Des Plaines in Illinois; and Crooked Creek and Decaturville in Missouri.

These structures are generally circular in plan and have dimensions of several miles. All exhibit greatly disturbed rocks within the structure and are surrounded by nearly horizontal sedimentary rocks. Many of these structures exhibit an intensely disturbed central uplift where rocks may be a few hundred to a few thousand feet above their normal stratigraphic positions. A number of these structures, but not all, coincide with fault zones along the 38th parallel or along structural zones perpendicular to the faults.

NEW INFORMATION

Previous studies of the Serpent Mound structure have been primarily restricted to data gathered from surface studies. Many researchers think that the ultimate evaluation of the structure will require detailed data from the deep subsurface through direct or indirect information-gathering techniques.

Gravity and magnetic surveys of the structure, techniques that produce images of certain characteristics of the rocks deep beneath the surface, have given some data on subsurface features. These studies indicate the presence of positive anomalies, suggestive of deep igneous intrusions. Recently, two data sets have become publicly available and have added greatly to our knowledge of the Serpent Mound cryptoexplosion structure.

In 1991, at the urging of oil and gas consultant Dr. Arie Janssens (former Head of the Survey's Subsurface Geology Section), the Survey convened an informal committee of individuals, known as the Serpent Mound Working Group, interested in the Serpent Mound structure. The group concluded that a core which would reach basement rocks at a depth of several thousand feet would be required to determine the origin of the structure. Additionally, it was concluded that a seismic line across the structure would yield invaluable data on the configuration of the structure at depth and would provide insight on siting of a core hole.

Seismic data

Perry Dean of Paragon Geophysical, Inc., Mount Gilead, Ohio, generously agreed to donate his services to run a seismic line across the structure. The nearly 3-mile-long line used 228 shot points and obtained data to a depth of 2.0 seconds. The raw geophysical information was processed by Lauren Geophysical, Inc., Denver, Colorado.

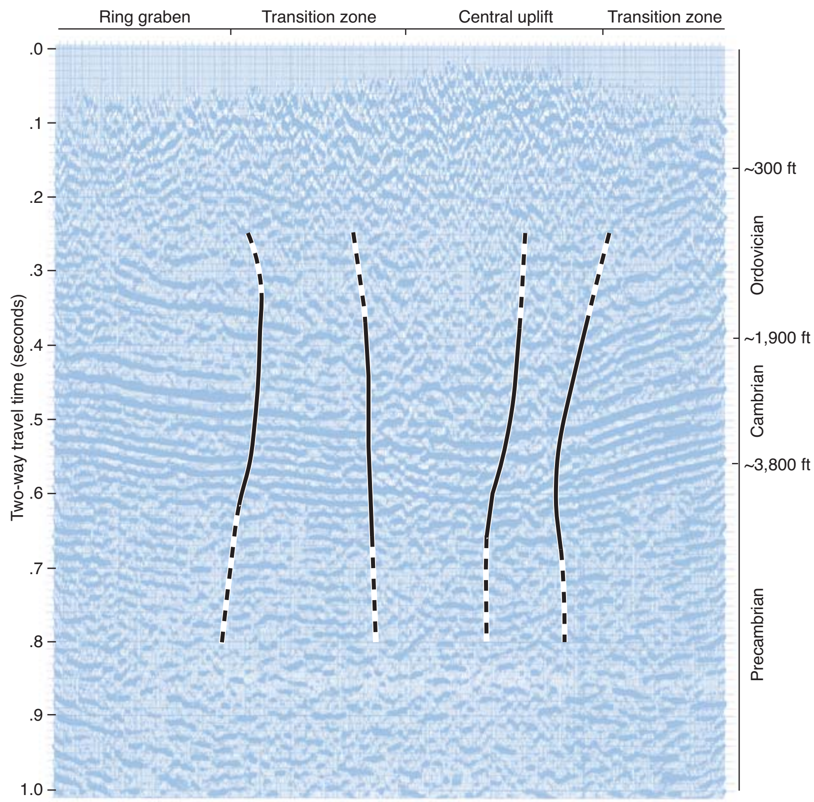
The resulting seismic cross section of the structure indicates a bowl-shaped area of disturbance that extends through the entire thickness of Paleozoic sedimentary rocks into Precambrian basement rocks. Survey geologist Mark T. Baranoski has correlated various reflectors in Cambrian and Lower Ordovician rocks on the seismic line with geologic units known from oil and gas wells in the region. Prominent faults interpreted by Baranoski appear to correlate with the general demarcations of the central uplift, transition zone, and ring grabens, as mapped on the surface. Dr. Doyle Watts of the University of Glasgow, Glasgow, Scotland, is currently attempting to improve resolution of the seismic output by using advanced computer techniques. This research, combined with the geology known from the area, may improve the interpretations of faulting in the structure and identification of the prominent reflectors.

A second seismic line, run in 1989 by Columbia Natural Resources, Inc., Charleston, West Virginia, was made available to the Working Group by CNR Vice President of Exploration, Richard Beardsley. This north-south line traverses the ring graben on the eastern edge of the structure. Faulting seen on this line indicates displacements through the entire Paleozoic sedimentary section and into Precambrian basement rocks.

Core drilling

The Survey's core-drilling rigs were considered to drill a continuous core within the structure, but it was decided that these relatively small rigs had insufficient capacity to drill through the highly fractured and faulted rocks in the cryptoexplosion structure. The Working Group decided that to successfully drill a core, an industry rig would be needed. Unfortunately, the modest funding available was not sufficient to engage an industry rig for this task.

In anticipation of possible drilling, a ground-based magnetic profile was run across the central uplift of the structure by Ohio State University graduate students John Memmi and John Weaver. The profile was made in order to identify potential structures that would direct drilling to specific targets. This preliminary magnetic profile suggests the presence of an anomaly that may represent an ultramafic intrusion in basement rocks.



Compressed and migrated seismic section across the Serpent Mound cryptoexplosion structure. The section begins in the southwestern portion of the structure, crosses the outer ring graben, and proceeds northeast across the central uplift and into the transition zone. The boundary between crystalline basement rocks and Cambrian sedimentary rocks is at a depth of about 3,800 feet and defined by prominent reflectors, which are faulted. Seismic line courtesy of Perry Dean, Paragon Geophysical, Inc. Processing courtesy of Lauren Geophysical, Inc. Interpretation by Mark Baranoski, Division of Geological Survey. Faults dashed where inferred.

It was known that John Carroll Minerals, Inc., New York City, drilled two small-diameter cores in the central uplift area of the structure in the early 1970's. Mr. John Carroll graciously consented to donate the cores to the Survey. Although these cores have not yet been studied in detail by Survey geologists, a cursory examination of the deeper core (OGS 3274) by Survey geologist E. Mac Swinford suggests that it reached into the Knox Dolomite at a depth of 2,957 feet. Shatter cones are evident at various intervals, including near the bottom of the core. The cores, now at the Survey's core repository in Columbus, have been reboxed but have not been logged. It is the intention of the Survey to make the cores available to qualified researchers for study.

ORIGINS

It is natural for us to seek the causes of unusual or catastrophic events. Consequently, studies of the Serpent Mound cryptoexplosion structure have always had the ultimate goal of determining the mechanism that created this chaos, although the lure of economic concentrations of sulfide minerals or hydrocarbons is part of the equation.

Imperfect data commonly lead to debate and sometimes very different conclusions. The Serpent Mound structure is no exception. The two principal ideas ventured to explain the structure employ an exogenic source such as a meteoroid or asteroid, or an endogenic origin by explosive eruption of gases derived from a deep magmatic source in basement rocks—sort of a "dry" volcanism. Each theory has its appeal, evidence, and strong supporters.

Perhaps fortunately for civilization, we have never witnessed the formation of a cryptoexplosion structure. Most such features are poorly exposed and have undergone significant erosion since they formed, thus making interpretation even more difficult. Furthermore, few cryptoexplosion structures have received intensive study, which would include surface mapping, geophysical and geochemical investigations, and multiple deep core holes.

The general morphology of complex cryptoexplosion structures—a circular disturbance with an uplifted central portion and a depressed outer portion—is typical of impact craters from meteoroids and of craters caused by subsurface explosions. Walter Bucher proposed that the Serpent Mound structure and other such disturbances he studied were caused by an igneous intrusion. He referred to them as cryptovolcanic in origin. Later, when the idea of meteoroid impact became popular, the less specific term of cryptoexplosion was applied to these features. This term includes structures of either endogenic or exogenic origin.

"The lack of knowledge or complete understanding of a process does not discredit it but merely reminds us of our own lack of omniscience. Discarding a hypothesis should ultimately result from its inability to fit the data, not from our inability fully to comprehend the processes involved."

Reidel, Koucky, and Stryker

Reidel, Koucky, and Stryker, in a 1982 American Journal of Science article, pointed out several lines of evidence that appear to conflict with an impact origin of the Serpent Mound structure. These include:

1. Many midwestern cryptoexplosion structures are aligned along a major fracture zone known as the 38th parallel lineament or, as in the case of the Serpent Mound structure, along basement structural features that are perpendicular to this lineament. Some geologists argue that it is improbable that random meteorite impacts would coincide with basement structural features.
2. At least two episodes of deformation are reported to be present at Serpent Mound, which is incompatible with an impact hypothesis.
3. Shock metamorphic features such as shatter cones, touted by some researchers to be incontrovertible evidence of impact, can be created by other mechanisms.
4. The high-pressure silicate mineral coesite, thought to be formed only by hypervelocity impact, has not been confirmed to be present at Serpent Mound.

To these points must be added the fact that impact craters, on Earth or other planetary bodies, seem to exhibit a ratio of the diameter of the crater compared to the diameter of the central uplift that is close to 0.22. An average of measurements of the Serpent Mound structure gives a ratio of 5.0, suggesting some other mechanism may be responsible for creating this disturbance.

The Paragon Geophysical seismic line suggests deformation well into basement rocks, a mile or more beneath the surface. Would an impacting body of the size necessary to produce a 4-mile-diameter crater create fracturing and displacement to this depth?

The impact hypothesis is appealing for a number of reasons, including the fact that we are familiar with nearly pristine impact craters that can easily be observed on the moon. Surely, bodies similar to those that created lunar craters have struck the surface of the Earth many times during our history. Indeed, it is very likely that some, if not many, of the circular features scattered across the continents are astroblemes created by impacting bodies from the solar system. It is enticing to accept this origin for all such features, including the Serpent Mound structure, but some geologists remain skeptics.

Endogenic processes that could have created the Serpent Mound structure and similar ones have not been observed in historic times and are not easily explained by known geologic processes. Some geologists suggest mantle-derived, gas-rich ultrabasic magmas may be intruded along vertical fractures and expand with explosive force when they approach the reduced-pressure environment near the surface. Could this molten rock have been an ultrabasic known as kimberlite, perhaps diamond-bearing, that shot upward from the mantle?

Another idea, suggested by retired USGS geologist Rudolph Kopf, is that a slurry of rock fragments and water trapped along fault planes may be compressed to such an extent during movement of the fault that the material is forced into fractures with explosive results. The depth of the Serpent Mound structure as seen on the seismic line would seem to be a problem with this mechanism.

Reidel, Koucky, and Stryker suggest "The lack of knowledge or complete understanding of a process does not discredit it but merely reminds us of our own lack of omniscience. Discarding a hypothesis should ultimately result from its inability to fit the data, not from our inability fully to comprehend the processes involved."

The mystery, and debate, on the Serpent Mound structure continues. It is unlikely that a single bit of new evidence will solve the enigma of whether a chunk from the asteroid belt blasted a hole in southern Ohio or whether a molten plume of magma shot upward from its 30-mile-deep lair to accomplish the same task. As with many geological problems, solutions emerge with intensive investigations and, perhaps more importantly, imagination.

ACKNOWLEDGMENTS

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Geology symposium to be featured at Ohio Academy of Science Annual Meeting in Toledo

The Annual Meeting of the Ohio Academy of Science will be held in the Toledo area at The Medical College of Ohio on April 22-24, 1994. At least 20 oral presentations and posters will be presented in the geology session. Of special interest to geologists will be a symposium on Friday, April 22, titled "Joints in fine-grained materials and contaminant remediation strategies in the Ohio Lake Plain and beyond." Symposium speakers will address the causes and consequences of jointing in lacustrine and glacial materials, case histories of rapid migration of contaminants, and old and new remediation techniques. The speakers include representatives from academia, the geotechnical community, and governmental agencies, including the Ohio Environmental Protection Agency, the Division of State Fire Marshal, and the Division of Geological Survey.

The Annual Meeting will feature geology field trips on Sunday, April 24. One trip will visit the Essroc Quarry in the Silica shale of Middle Devonian age. There will be an opportunity to collect the world-famous fossils from this unit. The second trip will be to the Sun Oil refinery in Toledo. Contact Dr. Mark Camp at the University of Toledo (419-537-2398) for more information on field trips. For information on the Annual Meeting, contact the Ohio Academy of Science (614-488-2228). For information on the geology program and symposium, contact Scott Brockman at the Survey (614-265-7054).

Building stones of Columbus

The Survey has published a field guide to the stones used in buildings in downtown Columbus. The guide, prepared for a field trip in conjunction with the 1992 annual meeting of the Geological Society of America in Cincinnati, is designed to be a walking tour of some of the prominent buildings in Columbus. The publication, known as Guidebook No. 6, *Guide to the building stones of downtown Columbus: a walking tour*, was compiled by Ruth W. Melvin of Delaware and Garry D. McKenzie, Associate Professor of Geological Sciences at The Ohio State University.

The 33-page guide features 19 buildings in downtown Columbus, including the Ohio State House and Senate Building, the Ohio Theatre, Columbus City Hall, LeVeque Tower, One Nationwide Plaza, Broad Street United Methodist Church, and American Electric Power Building. Stops beyond the downtown area include Orton Hall, home of the Department of Geological Sciences on The Ohio State University campus, and the Division of Geological Survey's Earth Day monument at Fountain Square in north Columbus.

The explanation for each building featured on the tour includes information on the history, construction, and building stones used in the structure. More than 30 different types of stone are featured, including both native Ohio stones and those from other states and Europe. Photographs are included along with maps illustrating the locations of the buildings and the sources for the stones. The text is written in a nontechnical manner and geological terms are defined in a glossary. Tables accompanying the report include a summary of the uses, sources, and ages of major types of building stones in the featured buildings.

Guidebook No. 6 is the third in a series of guidebooks to the building stones of Ohio cities. Previously published guidebooks are Guidebook No. 5, *Guide to the building stones of downtown Cleveland: a walking tour*, and Guidebook No. 7, *Guide to the building stones of downtown Cincinnati: a walking tour*. These guidebooks are available from the Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362 for $3.50 each. Please include $0.21 tax per guidebook for orders shipped to Ohio addresses and $2.00 mailing charge. Telephone credit-card orders can be placed by calling 614-265-6576.

Photomicrographs of pre-Phanerozoic rocks available

The cooperative study of the East Continent Rift Basin by the Ohio, Indiana, and Kentucky geological surveys (Cincinnati Arch Consortium) produced a large number of color photomicrographs of rocks from the rift zone. The cost of publishing the entire suite of color plates was prohibitive, but the Division of Geological Survey has produced a color xerographic copy of the plates for office use by interested researchers. This report, entitled Open-File Report 93-1, *Atlas of photomicrographs of pre-Phanerozoic rocks, including a regional interpretation of the basement geology in the tri-state area,* includes 85 color plates and a brief text written by Nicholas Rast, Charlotte Allen, and Peter T. Goodman. David C. Harris compiled the report. Open-File Report 93-1 may be examined in the Survey offices from 8:00 a.m. to 4:30 p.m., Monday through Friday.

Guidebook to glacial geology in southwestern Ohio and southeastern Indiana

The Survey has published Guidebook No. 10, *The Sangamonian-Wisconsinan transition in southwestern Ohio and southeastern Indiana,* as part of the series of field-trip guides prepared for the 1992 annual meeting of the Geological Society of America in Cincinnati. The 38-page guidebook was authored by Robert D. Hall, Indiana University-Purdue University at Indianapolis, with contributions by six other experts, including Survey geologist Scott Brockman.

The guidebook features six stops at localities that have long been known as standard Pleistocene sections. The description for each stop includes a detailed discussion of the stratigraphy and a location map. Guidebook No. 10 is available from the Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362 for $3.00 plus $2.00 mailing and $0.18 sales tax if mailed to an Ohio address. Telephone credit-card orders can be placed by calling 614-265-6576.

HANDS-ON EARTH SCIENCE No. 1

By Sherry Weisgarber
(614)265-6588

CRYSTAL GARDEN

This often used project provides wonder and excitement as the crystals grow.

Materials:

- 6-7 barbecue charcoals or stones (1 to 2 inches across)
- shallow bowl (aluminum pie pan works fine)
- 4-6 tablespoons table salt
- 4-6 tablespoons liquid laundry bluing (see NOTE below)
- 4-6 tablespoons water
- 1 tablespoon ammonia (be careful using ammonia around children)
- food coloring

Collect several small pieces of limestone, brick, coal, or barbecue charcoal. You may want to try a bowl of each to determine which material grows the best crystals. Place the charcoal or stones clustered together in the bowl. Mix all of the ingredients together, except the food coloring, in the order listed using the same amount of salt, bluing, and water for each batch made. Pour the mixture very slowly over the stones with a spoon. The mixture may not be dissolved depending on the number of tablespoons of ingredients used. You may want to make different batches using different amounts of ingredients to see which works best. Drop food coloring over the coated stones. Using different colors produces a variegated crystal garden. Crystals should begin to form in about 20 minutes and continue growing for a day or two. Adding any excess mixture to the bottom of the bowl over the next few days may keep the garden growing longer. This creation will crumble very easily, so don't move it around too much.

NOTE: Laundry bluing comes in a small blue bottle and generally can be found in the laundry section of a grocery store next to the starch and bleach products.

SOURCE: *Kids create!*, Laurie Carlson; and Nevada Mining Association, Lois K. Ports.

1994 Teachers Workshop

The 1994 Ohio's Mineral Industries Teachers Workshop will be conducted June 27-July 1. The workshop, held in conjunction with Akron University, carries 2 semester hours of credit. The workshop familiarizes participants with the geology of Ohio, the importance of Ohio's fuel and nonfuel mineral industries, and how environmental protection can be compatible with mining. For more information contact Sherry Weisgarber, ODNR, Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362 (telephone: 614-265-6588), or Dr. Roger Bain, Department of Geology, Akron University, Akron, OH 44325-4101 (telephone: 216-972-7659).

Correction

The price of the *Out of the Rock* video noted in the Fall 1993 issue of *Ohio Geology* has been increased to $10.00. This increase is a result of increased production costs of the distributor, the SME Foundation for Public Information and Education.

Midwest Friends Of The Pleistocene Meeting

The 39th annual Midwest Friends of the Pleistocene meeting will be held May 13-15, 1994, at Miami University. The field trip will be in southwestern Ohio and southeastern Indiana. The topic of the meeting is glacial cycles and will focus on cyclicity of wind, water, and ice deposits left by multiple glacial advances. A banquet is scheduled at the Cincinnati Museum of Natural History and will include the internationally acclaimed walk-through glacial exhibit. Cost of the meeting and field trip is $90. For more information, contact Tom Lowell at the University of Cincinnati (513-556-4165) or Scott Brockman at the Survey (614-265-7054).

Ohio Geology

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OHIO DEPARTMENT OF NATURAL RESOURCES DIVISION OF GEOLOGICAL SURVEY

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