

Ohio Geology Newsletter

Division of Geological Survey

OHIO'S MINERAL INDUSTRIES

Ohio's mineral industries are big business and, more importantly, they are an integral part of the state's economic well-being. Estimates of the value of raw mineral commodities produced each year in Ohio approach a total of nearly one and a half billion dollars, of which about two-thirds is attributable to fuels—coal, petroleum, and natural gas.

Impressive as these figures are, they do not, however, reflect the importance of these raw materials in the economy of the state. Many thousands of jobs and billions of dollars of construction and manufacturing are directly dependent upon the raw materials and products produced by Ohio's mineral industries. The total number of people employed in the extraction of Ohio's mineral resources is over 28,000 individuals.

This brief summary of Ohio's mineral industries provides background information to those who may not be familiar with this aspect of Ohio geology. In future issues of the newsletter we will feature more detailed articles on individual industries.



Bricks manufactured from the Bedford Shale (Mississippian) at the Galena Brick Company, Delaware County.

Clay and Shale

Development of Ohio's clay and shale resources began with the arrival of the first permanent European settlers in the late 1700's; among their ranks were individuals experienced in brick making. Pottery making began in Cincinnati in 1799, and by the 1840's the pottery and fire-brick industries began to exploit the thick Pennsylvanian underclays in northeastern Ohio, particularly in the East Liverpool area. The sewer-pipe industry, in which Ohio is a leader, originated in the state in 1851. Soon after, in the late 1800's, Ohio clays and shales were adapted to a variety of products, including fire-proofing materials, vitrified brick, and eventually electrical conduits and electrical porcelain.

Clays and shales used in the ceramic industry in Ohio are derived from Pleistocene glacial clays, principally in northwestern Ohio, from shales of Devonian and Mississippian age in central and northeastern Ohio, and from Pennsylvanian clays and shales in eastern Ohio.

Ohio has traditionally held a leading position in both the quantity and value of clay products. In 1979 the state ranked third in production of clay and shale with 3,374,000 short tons valued at \$13,495,000 being produced by 40 companies in 34 counties.



Division of Geological Survey geologists sampling the Middle Kittanning (No. 6) coal. Boich Mining Co., Muskingum County.

Coal

Coal is Ohio's most valuable mineral resource and forms the foundation upon which many of the state's industries have been built. The general abundance of coal in the eastern portion of the state has led to Ohio's present position as the largest coal-consuming state in the nation. Most of the coal (both domestic and imported) consumed in Ohio is utilized in the generation of electric power; 98 percent of the electricity produced in Ohio is from coal.

The commercial production of coal in Ohio dates back at least to 1800 and probably before that date in a small way. Lewis Evans' 1755 map of the middle British colonies in America indicated the presence of coal in the vicinities of Stark-Tuscarawas Counties and Athens County. The production of coal in Ohio began an upward climb about 1870 and reached a peak during World War I. The general abundance and low cost of petroleum and natural gas and the Great Depression led to a sharp decline in Ohio coal production during the 1930's. During the 1950's and 1960's, production climbed and reached an all-time high of 55,136,699 tons in 1970. Several factors, principally the establishment of clean-air standards that mitigated against burning Ohio's high-sulfur coal, have caused a decline in production from the 1970

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Ohio Department of Natural Resources

James A. Rhodes, Governor • Robert W. Teater, Director • Horace R. Collins, Chief

Chief's corner by Horace R. Collins

This newsletter, the first of a quarterly series, is being introduced as a means of increasing communication between the Division of Geological Survey and the users of the services of the Division. There has been a phenomenal growth in the number of requests for geological information in the past several years, and it has become evident that there is need for more awareness concerning the information available through the Geological Survey. This forum also will provide information on current projects and activities of the Survey as well as news items from other sources concerning the geology of Ohio.

For most of the Geological Survey's history the principal users of geologic data have been the mineral industries, and information provided by the Survey has played a significant role in the development of mineral resources. These industries are still major users of our services; however, in recent times there has been a tremendous service growth in nonindustry areas. Geological information is now used by legislators and by governmental and quasi-governmental agencies in making legislative, regulatory, or policy decisions. Similarly, teachers are making increased use of information on Ohio geology in their classrooms. Land owners, both city and rural, are requesting information on subjects ranging from earthquakes to mineral resources. Environmental and public awareness organizations are making extensive use of mineral resource and geological hazards information. Attorneys, engineers, architects, scouting groups, rock and mineral collectors, fossil collectors, even law enforcement agencies, are but a few of the people assisted by the Geological Survey.

This diversity in the types of organizations and individuals served underscores what geologists have been telling each other and the public-at-large for many years—that geology has a vital contribution to make to the well-being of society. Although individuals may differ on development, regulatory, or land-use policies relating to geology and mineral resources, an intelligent decision is much easier to reach if it is based on objective geologic information. Developing such information and making it available to all segments of society is the statutory role of the Division of Geological Survey. Through this newsletter we hope to be better able to meet our responsibility. We hope in the months ahead you will find this newsletter useful and we invite your comments and suggestions on how to better serve you.

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high. In 1979 production was 43,527,651 tons. Figures for 1980 and 1981 promise to be even lower.

Coal is produced in Ohio from Pennsylvanian and to a very minor extent from Permian rocks in the eastern and southeastern portions of the state. Although 60 individual coal beds have been identified in Ohio, significant economic production has come from only 14 of these. The Pittsburgh (No. 8), Middle Kittanning (No. 6), and Meigs Creek (No. 9) coals are the leading productive seams in Ohio, accounting for slightly over 65 percent of the total in 1978.

The majority of Ohio coal mines are surface (strip)

OHIO GEOLOGY

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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.

mines; indeed only 31 of the 471 coal operations in Ohio in 1978 were underground, although they produced 28 percent of the coal. Of Ohio's 26 coal-producing counties, Belmont, Harrison, Muskingum, and Jefferson Counties are the leaders, accounting for 54 percent of the total production.

Gypsum

Gypsum is a soft light-colored evaporite mineral composed of hydrous calcium sulfate. When heated gypsum loses its water content (a process known as calcining), and then can be used as a molding compound when water is added. Plaster of Paris is a good example. Calcined gypsum is used extensively to make plaster wallboard and in various industrial processes. Uncalcined gypsum is used in large quantities to control the hardening rate of concrete.

Gypsum in economic quantities crops out in Ohio only along the Lake Erie shore in Erie and Ottawa Counties near Sandusky Bay. These deposits, of Late Silurian age, were first discovered in 1821 and were exploited soon after. Ohio produces comparatively small quantities of gypsum but produces 14 percent of the nation's output. Gypsum currently is mined only on the Marblehead peninsula in Ottawa County.

Limestone and Dolomite

Ohio is the leading lime-producing state in the nation, a position it has held for many years. Limestone and dolomite are present in many areas of the state but are most extensively quarried from rocks of Silurian and Devonian age in western Ohio. Small quantities of limestone also are produced from Mississippian and Pennsylvanian rocks in east-central and eastern Ohio. Fifty-three Ohio counties produced a total of over 50 million tons of limestone in 1978. Eight counties, Sandusky, Erie, Ottawa, Wyandot, Lucas, Mahoning, Seneca, and Paulding, accounted for 53 percent of the total production.

The earliest production of limestone in Ohio is unknown, but certainly the earliest pioneers utilized outcropping limestone for foundations and chimneys. Ohio limestones now have a wide variety of applications, including concrete aggregate, crushed stone for road metal, as a fluxstone, in cement manufacture, and as agricultural lime. Reserves of limestone and dolomite are large in Ohio, although high-purity limestone is always an object of further exploration.

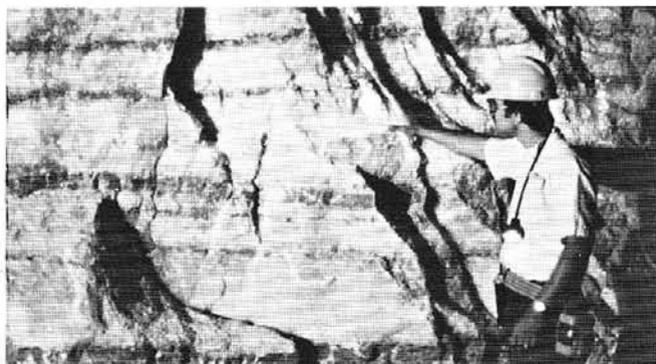
Oil and Gas

The oil and gas industry developed in Ohio soon after Colonel Drake's famous well was drilled in 1859 at Titusville, Pennsylvania, although oil was discovered in Ohio in 1814 in Noble County in a well drilled for brine. In the mid-1880's the discovery of the Findlay field in northwestern Ohio (in the Trenton Limestone of Ordovician age) catapulted Ohio into a leading role in hydrocarbon production. Since the discovery of major fields in Texas and Oklahoma, Ohio has not occupied a leading position in oil and gas production.

Energy demands and more favorable economic climate have spurred recent drilling in Ohio. Figures for 1979* indicate that 3,532 drilling operations were active, a new modern record. Preliminary figures in 1980 suggest an even greater number of wells will be drilled.

Oil and gas have been produced from nearly all geologic systems in Ohio, although each system has not necessarily produced oil and gas throughout wide areas of the state. In 1979, 77.8 percent of the wells drilled in Ohio were to the "Clinton" sandstone of Silurian age, and 96.5 percent of those were productive; 14.8 percent of Ohio wells were drilled to the Berea Sandstone of Mississippian age, and 95.1 percent of those were productive.

*Statistics supplied by T. A. DeBrosse, ODNR, Division of Oil and Gas.



Exposure of salt in the International Salt Company mine at Cleveland.

Salt

The earliest extraction of salt in Ohio is unknown, but the various Indian cultures that inhabited the state extracted salt from natural brines at several salt licks. The most important early salt lick in the state was the Scioto Saline in Jackson County. One of the first acts of the Ohio Legislature when Ohio gained statehood in 1803 was to place the Scioto Saline under state control.

It was soon discovered that natural brines occurred at depth, and drilling operations were begun in 1809 in Gallia County, where brine was obtained at a depth of 100 feet. Brine operations became numerous in the eastern half of the state and by 1850 natural brines were being obtained at a depth of 1,000 feet at Pomeroy, Meigs County.

In 1889 rock salt was discovered near Cleveland, and artificial brines were soon produced in quantity. It was not until 1957, however, that the first of Ohio's two mines in the salt was begun. These two mines, the International Salt Company mine at Whiskey Island, Cleveland, Cuyahoga County, and the Morton Salt Company mine at Fairport Harbor, Lake County, use room-and-pillar methods to extract rock salt at a depth of approximately 2,000 feet beneath Lake Erie.

Rock salt (the mineral halite) in Ohio is of Late Silurian age and occurs in the subsurface of the eastern third of the state. In addition to the two shaft mines in Cuyahoga and Lake Counties, there are four brining operations active in the state, one each in Licking and Wayne Counties and two in Summit County.

Since the opening of the mines in northern Ohio, the state has held a leading national position in both the quantity and value of salt. In 1979 the state ranked fourth in quantity (4,135,000 tons) and third in value (\$79,598,000). Ohio's salt reserves are large; the Division of Geological Survey estimates that at present rates of consumption the state could supply the entire nation for 32,000 years.

Salt from the two northern Ohio mines is used principally in snow and ice control, whereas most salt produced by brining operations is used in the chemical and food-processing industries.

Sand and Gravel

A populous and industrialized state such as Ohio is fortunate in having large and widespread reserves of sand and gravel because these commodities are an integral part of the construction industry. They are used extensively for road-paving materials and as a principal constituent of concrete. The low per-unit cost of these commodities is influenced favorably in Ohio by the widespread occurrence; transportation costs are kept at a minimum.

Sand and gravel deposits in Ohio are a result of the glaciers of the Pleistocene Ice Age, which covered nearly three-fourths of the state. Sand and gravel—rock fragments scooped up by the ice in its southward advance across Canada and the northern United States—were deposited by meltwater flowing across or within the ice (kames and eskers) or by meltwater flowing away from the ice in large glacial streams (outwash). Because of these circumstances of deposition, sand and gravel deposits are found not only throughout the glaciated portion of the state but also along major streams, such as the Hocking, Scioto, and Ohio Rivers, that drained meltwater. Sand and gravel deposits also are found as beach deposits along former shorelines of Lake Erie and are extracted by dredging in some areas of the lake bottom.

The sand and gravel industry in Ohio was rather small until the beginning of this century, when the building industries began to consume large quantities of this commodity. In 1979 Ohio ranked fifth in the nation in quantity (45,944,000 tons) and fourth in value (\$121,148,000) of sand and gravel.



Quarry in the Berea Sandstone at South Amherst, Lorain County.

Sandstone

Ohio has long held a leading position in the production of sandstone, although this commodity has suffered serious

competition from increased use of concrete, brick, and artificial stone. The earliest production of sandstone in Ohio was as a building stone and as a source of grindstones.

Sandstone is produced in 18 counties in Ohio, all in the eastern half of the state. These sandstones are either Mississippian or Pennsylvanian in age and are either crushed or produced as dimension stone. Crushed sandstone is used as foundry sand, as glass sand, as a refractory, as aggregate, for polishing and grinding, as engine, fire, or furnace sand, and as riprap. Dimension stone is used as curbing, grindstones, flagging, and in rough construction and architectural uses.

In 1978 Ohio sandstone production was 2,051,859 tons—1,955,591 tons of crushed sandstone and 92,268 tons of dimension sandstone. Total value was \$14,856,132.

The Future

Ohio's mineral industries have not been without problems in the past and will not be without problems in the future. As a whole, perhaps the greatest assets of the state's mineral industries are relatively large reserves, in most cases, and proximity to market areas. This latter asset has become increasingly important in recent years as gasoline costs have skyrocketed and transportation costs have increased accordingly.

Aside from the general economic climate, Ohio's mineral industries face competition from substitutes for particular commodities and increased costs owing to sometimes complex safety and environmental regulations. Small operations in particular have had difficulty in dealing with this latter problem.

Another problem that has seriously affected many mineral producers in recent years is the competition for space. The rapid expansion of many metropolitan areas into former rural areas has effectively removed many prime mineral deposits from consideration as sources of a particular mineral commodity. This problem has been particularly acute in the sand and gravel industry, where finite deposits of this commodity represent prime development land for homes and offices. Because sand and gravel are low priced per unit, distance of transportation is a significant factor in the economic competitiveness and availability of these commodities. Construction on or close to major deposits of sand and gravel is therefore a potentially poor zoning practice.

The future of Ohio's mineral industries is of course difficult if not impossible to predict. Many factors, including the general economic climate of the country, are significant to the general health of Ohio's mineral industries; however, at least some of the factors in the long-term future success of these industries are dependent upon a populace that can make intelligent, informed decisions and mineral producers who are energetic and flexible in their approaches to new conditions and situations.

"THE SEARCH" AVAILABLE

The award-winning film, "The Search: the Geological Survey of Ohio," produced in 1976 by ODN's Broadcast and Film Section, is available for loan to groups. The 28-minute film traces the beginnings of the Survey in 1837 through the Newberry and Orton Surveys to the modern organization. "The Search" emphasizes the development of the state's mineral industries and the geological history of Ohio.

Requests for loan of the "The Search" should be directed to: Film Library, Ohio Department of Natural Resources, Fountain Square, Columbus, Ohio 43224.

JULY EARTHQUAKE CREATES CONSIDERABLE INTEREST

The earthquake that shook Ohio and all or portions of 13 other states and southern Canada on July 27, 1980, initiated numerous media and citizen inquiries concerning this particular earthquake and the general seismicity of Ohio. Many residents of Ohio were amazed to learn that the state had ever experienced any previous earthquakes and were startled to find out that more than 100 earthquakes have been reported from the state since 1776. The personal involvement in this event by such a large segment of the state's population effectively brought considerable attention to the geological sciences in Ohio. Division personnel answered numerous telephone inquiries and participated in a number of television, radio, and newspaper interviews. The response to a news release announcing the availability of the Survey leaflet *Earthquakes in Ohio* was overwhelming. Copies of this leaflet, EL 9, may be obtained free of charge from the Survey.

Preliminary information placed the epicenter of the earthquake near Sharpsburg, Bath County, Kentucky (38.19N, 83.94W), at a focal depth of 13 km. Origin time was 18:52:21 UTC (2:52 PM Eastern Daylight Time), and Richter magnitude was 5.1.

The earthquake was monitored in Ohio by the Seismological Observatory at John Carroll University in Cleveland and by the University of Michigan seismic network in western Ohio. The seismograph at Bowling Green State University in Bowling Green was turned off because of local blasting, and the Xavier University station near Cincinnati has been down for some time.

Soon after the earthquake, teams from the U.S. Geological Survey and several universities reached the epicenter area to monitor aftershock activity and to make damage assessments. At least 30 aftershocks were recorded; one on July 31 at 0:9:27 had a magnitude of 2.5.

Questionnaires were mailed to postmasters by the U.S. Geological Survey National Earthquake Information Center in Denver, Colorado, and the University of Michigan sent questionnaires to numerous newspapers to be printed, clipped out by subscribers, and returned. Isoseismal maps will be prepared from these data but are not available at this time.

Assessments of damages from the July 27 event are as yet incomplete, but from media reports and cursory sampling of Ohio communities along the Ohio River it appears that damage to property ranged from minor to moderate. Maysville, Kentucky, located about 30 miles northeast of the epicenter, was particularly hard hit. Media reports issued a week after the tremor indicated damages of more than \$1 million in Maysville; 59 homes and 27 businesses sustained major damage and 210 homes and 10 businesses sustained minor damage. Few property owners carried earthquake insurance. The Ohio communities of Manchester, Aberdeen, Ripley, and West Union reported various degrees of damage. In Aberdeen several chimneys were knocked down and merchandise was toppled from store shelves. Manchester reported an undetermined number of chimneys down, one of which fell on a car (see photo). The community of West Union reported cracks in the block and concrete of the municipal building, constructed in 1974, and in Ripley the chimney was toppled on the John P. Parker house, listed on the National Register of Historic Places. Residents in Manchester and Ripley reported a roaring sound, like a strong wind, just before experiencing the vibrations from the earthquake. Media reports also indicate that Cincinnati experienced some damage, including a cornice that fell from

the city hall building and crushed the steps beneath it. It is of interest to note that most cases of damage to chimneys and other masonry structures were confined to older buildings in which deterioration of the mortar had taken place.



Chimneys and car at a residence in Manchester, Adams County, damaged during the July 27, 1980, earthquake. Photo courtesy of Bill Woolard, Manchester Signal.

Dr. Frederick J. Mauk of the University of Michigan Seismological Observatory reported that a focal mechanism for the July 27 earthquake indicates a thrust fault, with a large strike-slip component, striking 42° NE with a dip of 50° E. Movement was right lateral. This location and orientation places the fault in the vicinity of the Lexington fault zone, although the earthquake has not been identified with any fault mapped on the surface in this area. Mauk also noted that much of the energy released by the quake was focused northward; this northward focus accounts for the widespread alarm over most of Ohio. Further observations by Dr. Mauk suggest that many of the damaged buildings were located on alluvial terraces along the Ohio River. Maximum intensities from this earthquake were probably in the high VI to low VII range on the Modified Mercalli Scale.

The earthquake of July 27, 1980, is not without precedence in northern Kentucky, although it is the first sizeable event to be precisely located and from which a considerable amount of data has been derived. Very imprecisely located earthquakes were recorded from northern Kentucky in 1779 and in either 1791 or 1792. In 1828 four shocks, one on March 9 and three on March 10, were reported from the Maysville, Kentucky, area. These events were estimated to be in the IV-V range of intensity on the Modified Mercalli Scale. On February 20, 1869, an intensity IV shock was felt at Lexington, Kentucky, and on May 28, 1933, an intensity IV event was experienced at Maysville, Kentucky. Two earthquakes have been reported just north of the Ohio River. On January 23, 1877, an intensity III shock was reported in Adams County, Ohio, and on July 23, 1957, an intensity III event was reported from Ripley, Brown County, Ohio.

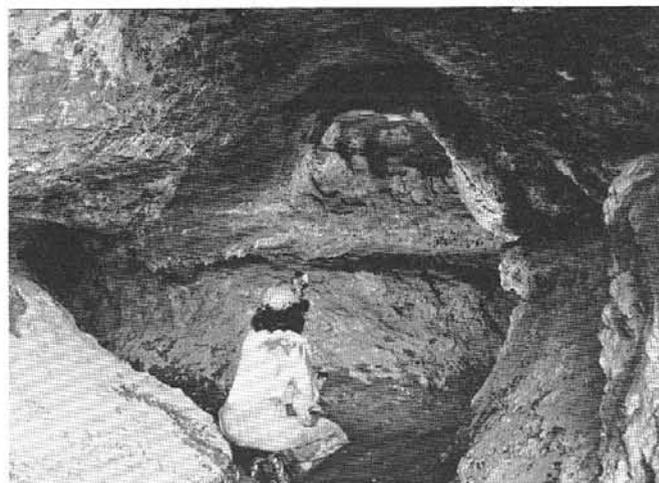
SMALL EARTHQUAKE IN WESTERN LAKE ERIE

A small earthquake with a Richter magnitude of 2.5 (University of Michigan) or 3.0 (National Earthquake Information Center) shook residents of eastern Michigan, southern Ontario, and northwestern Ohio on the morning of August 20, 1980. The epicenter was in the Canadian waters of western Lake Erie at 41.9° N, 82.9° W, approximately on the axis of the Findlay arch. Origin time (UTC) was 09:34:53.4 (5:34 AM Eastern Daylight Time). No damages were reported.

INVENTORY OF OHIO CAVES BEGUN

This past summer Dr. Horton Hobbs III of Wittenberg University began an inventory of caves in the western part of Ohio. Dr. Hobbs, with the assistance of students, is attempting to locate, map, and characterize each cave in regard to its fauna and geological features.

The cave study is under the sponsorship of the Division of Geological Survey and the Division of Natural Areas and Preserves and will probably take at least three field seasons to complete phase I, an inventory of limestone caverns in the western and central portions of the state. Phase II of the project, an inventory of rock-shelter caves in the sandstone bedrock of eastern Ohio, will be undertaken at a later date. Forty caves were mapped this past field season, including several that had not been reported previously in the literature. New state and county records were obtained for several elements of the cave faunas and a new species of pseudo-scorpion was recorded.



Cedar Fork Cave, Adams County, Ohio. Photo by Horton Hobbs.

Dr. Hobbs' interest in and dedication to this project are both refreshing and welcome. Although Ohio has neither large numbers of caverns nor, apparently, caves of large size, there has never been a complete inventory of these features. The only existing study of Ohio caves is that of Dr. George White published in 1926 in the Ohio Journal of Science. The Ohio Cave Survey, organized and publicized by Phillip Smith in the early 1950's under the sponsorship of the Division of Geological Survey, was abruptly terminated upon the departure of Smith from the state. Unfortunately, the Survey obtained very little information from Smith in regard to location and extent of Ohio caves. A more complete knowledge of Ohio caves is desirable in regard to assessment of the geological features of the state and to enable Survey

staff to better respond to the many citizen requests regarding caves in Ohio.

Dr. Hobbs welcomes any information about the location or history of Ohio caves. He may be contacted at the Department of Biology, Wittenberg University, Springfield, Ohio 45501, telephone 513-327-7029.

SURVEY STAFF NOTES



Richard M. DeLong

James A. Brown

Richard M. DeLong is well known among Ohio geologists and mineral producers for his many authoritative publications on coal and regional geology of the Pennsylvanian System in Ohio. Dick obtained a B.S. degree from Ohio Wesleyan University and an M.S. degree in geology from Ohio State University in 1951. After army service in World War II and a brief sojourn in the petroleum business, Dick came to the Survey in 1954, a tenure which makes him the senior member of the Survey staff. Dick is active in the Ohio National Guard, is married, has one child, and one grandchild.

James A. Brown is a skilled cartographer whose expertise has been essential in the production of numerous detailed geologic maps published by the Survey. Jim came to the Survey in 1965 with previous experience as a draftsman and since then has become a key member of the cartographic staff. Jim lives in Delaware County with his wife and three children and is noted for his landscape paintings, particularly of barns.

CHEMICAL ANALYSES OF OHIO COALS

The ongoing program to chemically characterize Ohio coals is nearing completion. This cooperative program between the Division of Geological Survey, the U.S. Geological Survey, and the U.S. Bureau of Mines has resulted in analyses of over 500 channel samples representing mineable coal seams from most of the eastern and southern portions of the state. Only a few sites in northeastern Ohio remain to be sampled. Results of the first 150 analyses were compiled in 1978 in Information Circular 47, *Analyses of Ohio coals*, by Division geologists George Botoman and David A. Stith. Copies of this report are available from the Survey for \$3.44 (including tax and mailing).

George Botoman has been responsible for collecting the samples, which are then sent to the U.S. Bureau of Mines for standard proximate-ultimate analysis and to the U.S. Geological Survey for chemical (trace element) analysis. These data add greatly to the knowledge of the character of Ohio coals.

UNIVERSITY OF ILLINOIS HONORS GEORGE WHITE

In ceremonies held November 19, 1979, Dr. George W. White, Emeritus Professor of Geology at the University of Illinois and former State Geologist of Ohio (1946-47), was honored for his many years of enthusiastic acquisition of rare and important books for the University of Illinois collection. A bronze plaque dedicating the geology library to Dr. White was placed on the building which houses one of the outstanding geologic libraries in the country.

Dr. White has maintained an active association with the Division of Geological Survey through his continued glacial mapping program in northeastern Ohio.

SHARON COAL STUDY IN PROGRESS

A study of the Sharon (No. 1) coal seam in the area of Jackson County in southern Ohio is being conducted by Clark L. Scheerens of the Division of Geological Survey. The Sharon coal is of particular interest at present because of its relatively low (1 percent or less) average sulfur content. The study will provide information on the areal extent and quantity of original resources and estimated remaining reserves of the Jackson Field area. Data have been derived from existing file information and maps and recent field investigations.

SURVEY UNDERTAKES COAL WASHABILITY STUDY

The Division of Geological Survey recently was awarded a \$211,000 grant from the Ohio Air Quality Development Authority to investigate the properties of Ohio coals in regard to their suitability for decreasing sulfur content through coal-washing techniques. This 2-year study will develop information on total sulfur, pyritic sulfur, ash, moisture, volatile matter, BTU, float-sink separation characteristics, and petrography of Ohio coals. At least 200 samples, each weighing approximately 200 pounds, will be collected from several coal seams in eastern and southern Ohio.

The objectives of this project are to more adequately characterize Ohio steam coals both chemically and petrographically and to develop a rapid and efficient means of petrographically determining the washability characteristics of individual coals. Such techniques and data have considerable potential value in regard to gasification and liquefaction of Ohio coals and will be of particular value to operators of small coal operations.

Geochemical testing will be carried out in the Survey's geochemistry laboratory under the direction of David A. Stith. Petrographic studies will be conducted by Richard W. Carlton using a Leitz Orthoplan-Pol/MPV 2 microscope photometer in conjunction with a Leitz T.A.S. automatic-image-analysis system.

REGIONAL GEOLOGY SECTION REORGANIZES

The recent move of the Division of Oil and Gas to Building A in the Department of Natural Resources complex at Fountain Square made available additional office space on the second floor of Building B. This new space has made it possible to consolidate most of the staff and records of the Regional Geology Section of the Survey. Stratigraphic and core records, open-file geologic and coal maps, abandoned-mine maps, aerial photographs, and other records are now available in one location for both public and staff convenience.

SERPENT MOUND CRYPTOEXPLOSION STRUCTURE DECLARED NATIONAL NATURAL LANDMARK

The Serpent Mound cryptoexplosion structure, located in southern Ohio on the eastern edge of the Cincinnati arch at the junction of Adams, Pike, and Highland Counties, was recently declared a National Natural Landmark. It was cited as one of the finest examples of these enigmatic cryptoexplosion structures, which are scattered across the central United States.

The Serpent Mound structure is a highly disturbed, circular feature with a diameter of about 5 miles. It consists of an uplifted central area of radiating anticlines cut by high-angle faults, a depressed outer ring of synclines cut by high-angle faults, and a ringlike intermediate area of folded and faulted beds that has suffered the least amount of vertical displacement.

The cryptoexplosion structure takes its name from the Adena effigy mound on its west flank; however, contrary to the idea advanced in a recent publication, Adena Indians could not have been inspired to build their elaborate mound after witnessing "a star falling to earth." The cryptoexplosion structure was formed before the next to the last glaciation (Illinoian)—well before Adenas or any other Indian culture traversed the area!

The disturbed strata of the Serpent Mound structure were first noted by Dr. John Locke, perhaps one of the keenest observers of the geological corps of the first Geological Survey of Ohio. Locke noted (Ohio Geological Survey, Second Annual Report, 1838, p. 266)

... it became evident that a region of no small extent had sunk down several hundred feet, producing faults, dislocations and upturnings of the layers of the rocks.

Locke further stated (p. 267)

As the top of the slate [Ohio Shale] is found here more than 300 feet lower than in the strata in situ in the surrounding knobs, and as these strata are broken and upturned, 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."

Walter Bucher of the University of Cincinnati was the first to study the Serpent Mound structure in detail and in 1933 advanced the idea that it had a cryptovolcanic origin because of its resemblance to the Steinheim cryptovolcanic structure in Germany. The term "cryptoexplosion" was offered somewhat later, as was the proposal that the structure is an astrobleme (meteorite impact structure). Because of the lack of confirmed occurrences of the high-temperature silicate coesite and because of other factors, the astrobleme theory has lost favor with most geologists.

Stephen P. Reidel remapped the structure in 1975 and concluded that a series of gas explosions along a pre-existing zone of weakness was responsible for creation of the Serpent Mound structure. Reidel's color map (scale 1:12,000) with a brief explanatory text is available as Ohio Geological Survey Report of Investigations 95 from the Division of Geological Survey. Cost is \$3.44 (including tax and mailing).

MINERAL RESOURCES ADVISORY COUNCIL ESTABLISHED

Ohio Department of Natural Resources Director Robert W. Teater has announced the appointment of an eight-member advisory council on the state's mineral resources. The principal purpose of this group is to provide input to the

Historical vignettes



Many of the small coal mines in the early days of the coal industry in Ohio employed any available power source. Dog teams such as the one pictured here were used to haul coal out of low-ceilinged drift mines. This mine was in the Middle Kittanning (No. 6) coal near Zanesville, Muskingum County. (Photo by Wilber Stout, circa 1916.)

Survey on the geologic needs of Ohio's mineral industries and the identification of priority programs in the area of geology and mineral resources.

The council is composed of Phil Bowman, Vice President, Waterloo Coal Company, Oak Hill; William Hole, Jr., President, American Aggregates Corporation, Columbus; Edward Lorenz, Vice President, Stone Creek Brick Company, Stone Creek; Clair Martig, President, France Stone Company, Toledo; William U. Milliken, Vice President, Bowerston Shale Company, Bowerston; Robert Patton, Chairman of the Board, Davon, Inc., Columbus; Berman Shafer, oil and gas producer, Wooster; William Spiker, Vice President for Administration, R & F Coal Company, Cadiz.

STAFF CHANGES

COMINGS

- Rodney D. Fritz, Laboratory technician, Geochemistry Section.
- Richard C. Guimond, Environmental technician, Geochemistry Section.
- Evelyn M. Jennings, Laboratory technician, Geochemistry Section.
- Douglas E. Keen, Cartographer, Technical Publications Section.
- Allan T. Luczyk, Environmental technician, Subsurface Geology Section.
- Karen J. Van Buskirk, Publication specialist, Technical Publications Section.

AND GOINGS

- John C. Hadley, Geology technician, Subsurface Geology Section, to Well inspector, Division of Oil and Gas, Columbus.
- F. Mitchell Honeycutt, Geologist and Acting Section Head, Subsurface Geology Section, to Atlantic Richfield Company, Tulsa.
- Richard H. Kingsbury, Jr., Geologist, Subsurface Geology Section, to Texaco, Inc., Tulsa.
- Frank L. Majchszak, Section Head, Subsurface Geology Section, to oil and gas consulting, Columbus.
- Jerry M. Parks, Geology technician, Subsurface Geology Section.
- Victor J. Saylor, Cartographer, Technical Publications Section, to Mitchell Energy and Development Corp.

GLACIAL MAP OF OHIO NOW AVAILABLE

The glacial map of Ohio, U.S. Geological Survey Map I-316, scale 1:500,000, has been reprinted by the USGS and is now available from either the USGS or the Division of Geological Survey. This map has been out of print for two years and, judging from the number of inquiries we have had, its availability will be welcomed. Cost is \$2.00 (including tax and mailing).

BIBLIOGRAPHY OF OHIO GEOLOGY ISSUED

In late 1979 the Division issued a comprehensive bibliographic compilation of Ohio geology, *Bibliography of Ohio geology, 1755-1974*. This 249-page work, compiled by geologist Pauline Smyth, cites over 5,000 reports pertaining to the geology of Ohio. The bibliography, Information Circular 48, may be ordered from the Survey for \$7.17 (including tax and mailing).

Since the retirement of Pauline Smyth in 1977, after 26 years of valued service to the Survey, the task of compiling the bibliography has been taken over by the Division editor, Merrienne Hackathorn. The next supplement to the bibliography will cover the years 1975-1980 and probably will be issued in 1981. Merrienne has requested that researchers in Ohio geology please add the Survey to their reprint list for all papers that pertain to the geology of the state. This practice not only insures that the papers are included and properly indexed in the *Bibliography of Ohio geology*, but also is a

welcome addition to the Survey reprint file, which has been added to somewhat sporadically in recent years. Copies of these on Ohio geology would be welcomed also. Please address reprints to Merrienne Hackathorn in care of the Division of Geological Survey.

SURVEY HISTORY REPRINTED

The Division of Geological Survey recently reprinted the paper "A brief history of the Ohio Geological Survey," by Michael C. Hansen and Horace R. Collins. This paper traces the development of the Survey beginning in 1837 and was reprinted from the Ohio Journal of Science (1979, v. 79, no. 1, p. 3-14). Single copies are available free of charge from the Survey.

EDUCATIONAL MATERIALS

The 1980 revision of the educational materials listing, *Publications of interest to teachers, students, and hobbyists*, is now available from the Division of Geological Survey. There is no charge for this list, which describes technical and nontechnical Survey publications of interest to junior and senior high school teachers, earth science students, and hobbyists. Included are publications on fossils, rocks and minerals, general geology, geography, and scenic features; guidebooks; and various maps.

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Address Correction Requested