Ohio Geology

A Quarterly Publication of the Division of Geological Survey Summer 1997

REMAPPING OF THE BEDROCK GEOLOGY OF OHIO COMPLETED

by E. Mac Swinford

On June 30, 1997, the Division of Geological Survey reached a major milestone in the 160-year effort to document the geology of Ohio. Staff geologists from the Bedrock Geology Mapping Group and the Environmental and Surficial Geology Mapping Group completed a seven-year program to remap the bedrock geology and the bedrock topography of each of the 788 7.5-minute quadrangles in the state. These geologic maps present fundamental and essential geologic information and will be of tremendous benefit to the scientific community, including geologists, engineers, and environmental specialists; to the mineral industries; and to planners, developers, and a wide range of citizens seeking accurate, up-to-date information on the bedrock geology of the state. The multitude of users of these new maps can now quickly determine the depth to bedrock beneath glacial sediments, the bedrock unit (and thus the type of rock), and the dip (tilt) of the upper surface of the bedrock for any area in the state.

The Division's bedrock-geology reconnaissance-mapping program was initiated by State Geologist Thomas M. Berg in 1990 with the ultimate goal of replacing the 1920-vintage bedrock-geology map of the state—the oldest currently used state bedrock map in the country. This emphasis was a change in focus and methodology from the bedrock-mapping program begun in 1981 by State Geologist Horace R. Collins, which was oriented toward producing detailed county bedrock- and glacial-geology maps from extensive field studies. A decrease in revenues from the severance tax on mineral production in the state and a need to make statewide maps quickly available necessitated the change in focus. The staff of the Bedrock Geology and Environmental and Surficial Geology Groups gained valuable field experience and first-hand familiarity with the state's geology during the county mapping effort and were able to rapidly move into the quadrangle mapping focus of the reconnaissance-mapping initiative.

Portraying the state's geology on maps is not a new idea (see *Ohio Geology*, Spring 1990). Mapping for the purpose of depicting the areal extent of geologic units began in Ohio in 1838 when John Locke's geologic map of Adams County was published in the Second Annual Report of the Geological Survey of Ohio. It was not until 1870 that State Geologist John S. Newberry published the first official geologic map of the state. This small map depicted the general distribution of geologic units in the state based on information gathered by Newberry and other geologists in the interim between the cessation of the first survey in 1838 and the initiation of the second survey in 1869. Extensive field work across the state during the early 1870's by the Survey field corps resulted in the first detailed state geologic map, published at a scale of 1 inch represents 4 miles. This 1879 map published by the Survey under Newberry's direction was the foundation of later geologic maps of Ohio.

Improved versions of the state geologic map were produced by State Geologist Edward Orton in 1888 and by State Geologist John A. Bownocker in 1909. Completion of topographic-map coverage of the state at the 15-minute scale in 1916 allowed Bownocker to compile, for the first time, the distribution of bedrock units in the state on a detailed topographic base, culminating in 1920 with the publication of the currently used bedrock-geology map of Ohio. The 1920 map incorporated original geologic data gathered by several generations of geologists and also reflected many changes in stratigraphic terminology and subdivisions of rock units and systems. It was inevitable that the stratigraphic terminology used on the 1920 Bownocker map has become outdated and that much new geologic data have accumulated in the 77 years since its issuance. Particularly glaring are changes in distribution of rock units beneath deep glacial cover in western Ohio. During Bownocker's time, few wells were available to reveal distributions and contacts of these units.

Bedrock Geology Mapping Group geologists Ernie R. Slucher, Glenn E. Larsen, Douglas L. Shrake, Michael R. Caudill (now at the University of Akron), and supervisor E. Mac Swinford pause while checking stream exposures in Hamilton County. Much of the remapping of the bedrock geology of Ohio was accomplished using existing data in the Survey files; however, the effort required extensive field checking of outcrops in many areas. The vehicle was not part of the Survey fleet. Photo by Bedrock Geology Mapping Group geologist Gregory A. Schumacher.

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Thomas M. Berg, Division Chief and State Geologist

From The State Geologist...

Thomas M. Berg

A LANDMARK ACCOMPLISHMENT FOR THE GEOLOGICAL SURVEY

I like to think that every day at the Ohio Geological Survey advances our understanding of the state's geology, but every so often, we get something done that is really worth crowing about. The lead article for this issue of *Ohio Geology* by Mac Swinford describes the completion of new bedrock mapping for the entire state of Ohio. Having been in charge of a similar project for the State of Pennsylvania, I can sympathize all too well with the blood, sweat, and tears that went into producing the bedrock-geology, bedrock-topography, and structure-contour maps for all 788 quadrangles that cover Ohio. Citizens of Ohio are most fortunate to have the Geological Survey team that produced all of these new geologic maps. A wide variety of people will use the maps, and better land-use, mineral-resource, and ground-water decisions will be made because of their availability.

The Survey staff members who worked on the new bedrock maps of Ohio are listed on page 4 of this issue of *Ohio Geology*. I hold each of them in the highest esteem for this great accomplishment. In particular, I salute Mac Swinford for his enduring patience and endless determination as Supervisor of the Bedrock Geology Mapping Group, and Team Leader for the project. I also applaud the persistence and leadership of Assistant State Geologist Dennis Hull for seeing the project to its completion.

I particularly want to thank my predecessor, State Geologist Buzz Collins, who so ably focused the Ohio Geological Survey on geologic mapping and established the Ohio Geologic Mapping Fund. Without his effectiveness and influence, the Survey's work would have been much more difficult.

The Ohio Department of Transportation provided a large amount of funding for this project, and we believe the maps will significantly assist in maintaining and upgrading the state's transportation infrastructure. I am most grateful to the U.S. Geological Survey for financial support of this project through the COGEOMAP and STATEMAP Programs. In addition, USGS Geologist Chuck Rice did all the geologic mapping for the Ironton 1:100,000 quadrangle. The U.S. Environmental Protection Agency also provided funding for the project; the maps should provide a very sound basis for decisions regarding nonpoint-source pollution in Ohio.

Now that the statewide bedrock-mapping program is completed, the Geological Survey is tackling another major mapping program—the surficial materials of Ohio. The geologists who worked on the bedrock mapping have begun mapping the surficial deposits in the southwestern part of the state. To prepare for this task, they attended the USGS training program called "Surfschool" this past spring. We look forward to another successful statewide mapping enterprise.

New Educational Leaflet on Ohio's glacial geology

The Survey recently released Educational Leaflet No. 7, *The Ice Age in Ohio*, a full-color, 20-panel pamphlet that describes and profusely illustrates the Pleistocene Ice Age in Ohio. This leaflet replaces the 1974 version of EL 7, *Ohio's glaciers*. Both versions were authored by Survey geologist Michael C. Hansen.

The new leaflet features nine color photographs of glacial features, four maps and diagrams, including the new version of the Survey's page-size *Glacial deposits of Ohio* map, and two illustrations depicting Pleistocene life. The text discusses the history of the Ice Age, glacial deposits, drainage changes, life of the Pleistocene, and economic and environmental aspects of Ice Age deposits. Educational Leaflet No. 7 is available from the Survey at no charge.

Canton Symposium

The Ohio Geological Society, in conjunction with the Ohio Oil and Gas Association and the Ohio Geological Survey, is sponsoring the Fifth Annual Technical Symposium on November 12, 1997. The full-day symposium will be held at the Hilton Inn West in Akron. Thirteen presentations on oil- and gas-related geology will be given at the symposium. Preregistration (by November 1) is $55.00: registration at the door is $60.00. The fee includes lunch and a copy of the proceedings volume. Student rates are available. Special room rates are available at the Hilton Inn West (330-867-5000) until October 20, 1997. For further information contact Arie Janssens, P.O. Box 395, Granville, OH 43023. Telephone: 614-587-3876. E-mail: *ariejanssens@compuserve.com*.

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Ohio Department of Natural Resources
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4383 Fountain Square Drive
Columbus, Ohio 43224-1362

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

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

World Wide Web: http://www.dnr.state.oh.us/odnr/geo_survey/

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Editor: Michael C. Hansen
Layout/Design: Lisa Van Doren

Administration/State Geologist
(614)265-6988

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

Bedrock Geology Mapping Group
(614)265-6473

Cartography & Editing Group
(614)265-6593

Coal Geology Group
(614)265-6594

Environmental & Surficial Geology Group
(614)265-6599

Industrial Minerals Group
(614)265-6602

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

Petroleum Geology Group
(614)265-6598

George V. Voinovich, Governor
Donald C. Anderson, Director

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Changing the emphasis of mapping from detailed county mapping to faster reconnaissance mapping on 7.5-minute quadrangles seemed to be the most expedient way to update the state bedrock-geology map. The Division, in cooperation with the U.S. Geological Survey's National Cooperative Geologic Mapping Program (COGEOMAP; later to become STATEMAP), initiated a four-phase program in July 1990 to map the bedrock geology and bedrock topography of the entire state. Mapping was conducted in a reconnaissance fashion on 1:24,000-scale quadrangles (7.5-minute series) using new and existing data, including some additional field work, and a limited number of core holes drilled by the Division. A majority of the data, however, came from existing information in the files of the Division or core samples in the Division's repository. These data include measured stratigraphic sections, drilled core, geophysical logs from oil and gas wells, water-well logs, and data from geologists' field notes. Mapping was done in a reconnaissance mode in order to expediently create a uniform set of maps that would display the Survey's current knowledge of Ohio's bedrock geology.

Three types of maps were produced for most of the 788 7.5-minute topographic quadrangles:

Bedrock geology maps—These maps show the regional distribution of the bedrock at the land surface or immediately beneath unconsolidated sediments.

Bedrock topography maps—These maps depict the configuration and elevation of the bedrock surface as if all unconsolidated sediments had been removed.

Structure-contour maps—These maps, drawn as overlays to the bedrock-geology maps, depict the changes in elevation of the upper surface (contact) of a bedrock unit throughout a map area. There may be up to eight structure-contour maps per quadrangle, each drawn on a different formational contact; most quadrangles have two or three structure maps. Each formation contact displayed on a bedrock-geology map has a corresponding structure-contour map.

The volume of maps produced—about 3,850 individual maps—underscores the magnitude of work required to remap the bedrock geology of the state. The mapping geologists produced 788 open-file 7.5-minute-scale bedrock-geology maps, about 780 open-file 7.5-minute-scale bedrock-topography maps, and about 2,300 open-file 7.5-minute-scale structure-contour maps. All of the open-file quadrangle maps are on scale-stable translucent film (mylar), which allows them to be updated as new information becomes available. In addition, the information for 120 7.5-minute quadrangles in west-central Ohio has been published as four 30 x 60-minute (1:100,000-scale) full-color regional bedrock-geology maps. These four maps are the Piqua, Lima, Bellefontaine, and Marion 30 x 60 minute quadrangles (see index map on p. 7). Additional maps in this series will become available in the future.

The monumental task of compiling this huge number of maps was accomplished by five geologists in the Bedrock Geology Mapping Group and three geologists in the Environmental and Surficial Geology Group. The Cartography and Editing Group created more than 2,000 mylar base maps and hundreds of photoenlargements of existing smaller scale maps.

During the past seven years, the core funding for the mapping effort was provided by the Survey's portion of Ohio's minerals severance tax. These monies also provided matching funds for grants from the U.S. Geological Survey's STATEMAP component of the National Geologic Mapping Act ($494,874), the Ohio Department of Transportation ($500,000), and the U.S. Environmental Protection Agency through the Clean Water Act, Section h ($210,000 to date).

Digitizing of all 788 reconnaissance bedrock-geology maps to construct a new bedrock map of Ohio at a scale of 1:500,000 has begun. Some of the new maps in western Ohio reveal vast differences in the distribution of rock units from those portrayed on the 1920 bedrock map. In the Toledo area, for example, the new maps show an abrupt geologic change created by more than 275 feet of vertical displacement along the north-south-trending Bowling Green Fault. In western Ohio, areas dissected by the preglacial Teays River and its tributaries and now covered with a thick layer of glacial drift were formerly mapped as dolomites of Silurian age but are now known to be underlain by shales and limestones of Ordovician age. Also, the orientation of buried valleys in western Ohio depicts strong northwest-southeast and northeast-southwest alignment, which coincides with deep faulting associated with the East Continent Rift Basin (see *Ohio Geology*, Winter 1996). Compilation of the 7.5-minute quadrangle maps to the 1:500,000 scale will provide a new regional perspective on Ohio's geology.

These new reconnaissance-geology maps provide a framework for future, more detailed mapping and investigations. They can be used for technical purposes such as geologic research, construction engineering, mineral exploration, and environmental protection. The maps are also handy for educational uses such as locating exposures of fossil-bearing formations and as classroom educational tools. Previously, requests for geologic information for a specific location in the state commonly required a long and laborious process of research from a variety of sources. With the new maps such public-service requests for basic geologic information at any site can be quickly accomplished.

Paper copies, produced on a large-format continuous copier, of all of the quadrangle maps from this project are available for purchase from the Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362. Index maps, which show all types of 7.5-minute open-file maps available from the Survey, are provided on pages 4 and 5. Each map is $4.00 plus handling; orders to Ohio addresses must include 5.75 percent sales tax. Credit-card (Visa or MasterCard) orders may be placed by calling 614-265-6576. Please order by quadrangle name and map type as shown on the indexes. The four full-color, 1:100,000-scale bedrock-geology maps are available for $12.00 each, plus handling and sales tax.

The volume of maps produced—about 3,850 individual maps—underscores the magnitude of work required to remap the bedrock geology of the state.

FURTHER READING

Hansen, M. C., 1990, History of the geologic map of Ohio—geology emerging: Ohio Geology, Spring, p. 1-5.

_____ 1996, The geology of Ohio—the Precambrian: Ohio Geology, Winter, p. 1-6.

Coalbed methane—an untapped energy resource in Ohio

Tremendous amounts of methane gas are generated and stored in the coalbeds of eastern Ohio. The presence of this gas has long been recognized owing to explosions and outbursts associated with underground mining. Coal contains micropores, which create a large internal surface area; thus, its gas-storage capacity is as much as 10 times greater than the equivalent rock volume of a conventional gas reservoir. In order for the gas to be released from coal, its partial pressure must be reduced. Pressure is reduced by removing water from the coalbed.

Coalbed methane (CBM) production is increasing at an exponential rate in the United States. In 1985, total annual U.S. coalbed gas production was just 6 billion cubic feet (bcf), primarily from the Black Warrior Basin in Alabama. By 1995, Alabama produced in excess of 112 bcf per year, but the San Juan basin of New Mexico produced nearly 1 bcf *per day* of CBM. With the notable exception of Virginia, which produced 30.4 bcf of CBM in 1995, the Northern Appalachian Basin states have lagged in exploiting this potential resource. It is estimated that the technically recoverable CBM resource in the Northern Appalachian Basin is 11.5 trillion cubic feet (tcf), of which approximately 2 tcf is located in Ohio.

An innovative project demonstrating the potential of coalbed gas in Ohio is currently underway at the Nelms-Cadiz Portal underground-coal-mine complex in Harrison County. Northwest Fuel Development, Inc., in cooperation with Harrison Mining Corp., is using approximately 150 thousand cubic feet per day (mcfd) of coalbed gas from Vent #5 to run several internal combustion engines, which generate 500 kilowatts of electricity for mine use. The flow of gas from Vent #5 is 300 to 500 mcfd and has a 91 percent methane content. Advanced technologies, such as fuel cells and pressure swing adsorption, are being evaluated to utilize the remaining gas.

The Division of Geological Survey considers this development an important case study on using CBM for safety, environmental, and economic benefit to the citizens of Ohio. The Division is creating an alliance with Harrison Mining Corp., Northwest Fuel Development, Inc., the U.S. Department of Energy, and the U.S. Environmental Protection Agency's CBM outreach program to investigate the geologic controls of coalbed gas production at the Nelms mine complex and to assess the overall CBM potential in Ohio. A more complete examination of this untapped energy resource in the state will appear in a future issue of *Ohio Geology*.

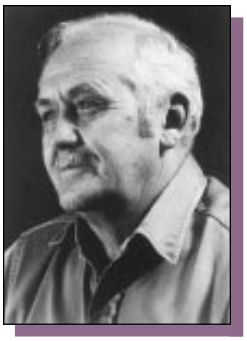
FURTHER READING

Kelafant, J. R., Wicks, D. E., and Kuuskraa, V. A., 1988, A geologic assessment of natural gas from coal seams in the northern Appalachian coal basin: Gas Research Institute Report 88/0039, 84 p.

Lyons, P. C., 1997, Central-northern Appalachian coalbed methane flow grows: Oil and Gas Journal, July 7, 1997, p. 76-79.

—Mark E. Wolfe
Coal Geology Group

Walter R. Lemke, 1906-1997



Walter R. Lemke

Walter R. Lemke, the first captain of the Division's Lake Erie research vessel, the *GS-1*, died on July 17, 1997, at the age of 91. He was captain of this vessel for 23 years, beginning in April 1953 when it was commissioned the *SE-1* for the Division of Shore Erosion. This division became the Lake Erie Section of the Division of Geological Survey in 1961, and Walt continued as boat captain until his retirement in 1976.

Prior to his employment with the state, Walt had many interesting jobs, including farm hand, steel-mill worker, and vineyard worker. He was a commercial fisherman during the heyday of this trade on Lake Erie when blue pike, yellow pike, and burbot were plentiful. He also worked as an oiler-fireman aboard the ferry steamship *Chippewa* from 1925 to 1929 during runs to the islands and Detroit.

One of Walt's more unusual occupations was year-round caretaker of Rattlesnake Island. He served in this capacity for eight years, prior to accepting state employment. Rattlesnake, one of Lake Erie's most picturesque islands, was owned by H. D. Bennett, president of Toledo Scale Company. The 65-acre island, marked by steep shoreline cliffs and in the center of a choice fishing and boating area, was used as an exclusive summer resort. Walt's job as caretaker, assisted by his wife, Ruth, was to keep the grounds in order and to maintain the log guest house, lodge/restaurant, caretaker's house, two runways, a small power house with diesel generators for electric power, and a small yacht basin and its two vessels. Walt supplemented his caretaker's income by selling smoked fish and operating a string of 10 ice-fishing shanties during the popular winter ice-fishing season.

Rattlesnake Island had no telephones. In case of emergency the only way to get assistance was from the daily, but seasonal, passing of commercial fishing vessels or mirror signals to the Ford Tri-Motor airplane which passed overhead daily on its way from Port Clinton to South Bass Island. Fortunately, Walt had few accidents in his years on the notoriously treacherous lake, but one in particular could have been fatal. He was returning alone to Rattlesnake Island from Port Clinton when he lost engine power. Walt dropped anchor, which stopped him about 100 yards off a small yacht basin that would provide protection. After repairing and restarting the engine, he cast off the anchor with a buoy because he could not pull the anchor in alone in the high waves. When nearly in the small harbor, the engine quit again and, now without an anchor, there was nothing that could be done before the boat would be dashed on the rocky coast. Walt jumped overboard, injuring his leg. This injury required Walt to use a cane for the remainder of his life.

Walt Lemke was well known around the Lake Erie area. He had a very friendly nature and always had a cheerful outlook in spite of the many problems he and his wife faced through life. Walt was easy to work with during long voyages in which he and his co-workers were together night and day under cramped and difficult living conditions aboard the *GS-1*. He was proud of the work he had done, especially his work with the Division of

Geological Survey. In his later years he enjoyed listening to baseball games on the radio and kept up with current events.

Walt's retirement from the Division in 1976 was marked by a party on Rattlesnake Island, where he had spent many pleasant years. He greatly enjoyed seeing his many friends in attendance.

Safe voyage, Walt.

—Dale L. Liebenthal
Lake Erie Geology Group

Marion 1:100,000 quad available

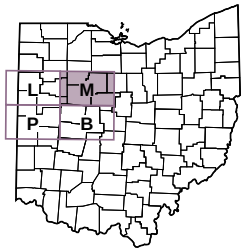
As part of the Division's ongoing program of mapping the bedrock geology of the state, the fourth map in the 1:100,000 (1 inch represents about 1.5 miles) series has been published. This full-color map, *Regional bedrock geology of the Marion, Ohio, 30 x 60 minute quadrangle*, was authored by Survey geologist Douglas L. Shrake. The Marion quadrangle covers all or large portions of Hancock, Hardin, Marion, and Wyandot Counties and smaller portions of Allen, Auglaize, Crawford, Logan, Putnam, Seneca, and Union Counties. The map is the first in the series to be digitally produced.

The distributions of eight bedrock units, ranging in age from Early Silurian to Late Devonian, are depicted in the map area. Each unit is described in detail in regard to lithology, thickness, distribution, relationship to other units, and other characteristics.

The text accompanying the map describes the economic geology, including limestone and dolomite, oil and gas, and ground water; geologic hazards such as earthquakes, karst, and radon; and the physiography and topography of the region. Four accompanying inset maps depict regional structure, local faulting and distribution of oil and gas fields and quarries, bedrock topography, and generalized distribution of glacial deposits. An extensive list of references will enable interested readers to pursue additional detailed information on most topics.

The Marion map, and others in the series, are an important resource for the location, development, and protection of mineral resources; the siting of landfills, schools, hospitals, highways, and other public and private facilities; and for planning and zoning activities.

This publication, known as Map No. 9, is available from the Ohio Department of Natural Resources, Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, for $12.00 plus $3.00 mailing; orders to Ohio addresses must include 5.75 percent tax ($0.69). Credit-card (Visa or MasterCard) orders may be placed by calling 614-265-6576.



*Location of the Marion (**M**) 30 x 60 minute quadrangle and previously published maps in this series: Bellefontaine (**B**), Lima (**L**), and Piqua(**P**).*

Ohio *GeoFacts*

The Survey has published a series of page-size informational sheets on Ohio geology known as *GeoFacts*. Each *GeoFacts* summarizes a particular geologic topic and is accompanied by maps, diagrams, or photographs and a reference list for additional information. *GeoFacts* sheets are compiled by various staff members. It is our intention to eventually produce *GeoFacts* on dozens of Ohio geology topics so that anyone can quickly and easily obtain a succinct summary of nearly any aspect of the geology of the state.

GeoFacts are produced rapidly and reprinted frequently, allowing periodic updating of topical information such as earthquake occurrences and mineral-production information. *GeoFacts* are available at no charge and also can be accessed on the Division's Web site: *http://www.dnr.state.oh.us/odnr/geo_survey/*. *GeoFacts* contain authoritative and timely information but are written in a relatively nontechnical manner. They should be useful to a variety of individuals.

Available *GeoFacts*:

No. 1. Bedrock topography of Ohio
No. 2. Industrial-mineral mine-permitting procedures in Ohio
No. 3. Earthquakes and seismic risk in Ohio
No. 4. Ohio Shale concretions
No. 5. Ohio trilobites
No. 6. *Isotelus*, Ohio's state fossil
No. 7. The Scioto Saline—Ohio's early salt industry
No. 8. Landslides in Ohio
No. 9. Gold in Ohio
No. 10. The Teays River
No. 11. Rocks and minerals mined in Ohio and their uses
No. 12. Mine subsidence
No. 13. The geology of Ohio—the Precambrian
No. 14. History of coal mining in Ohio
No. 15. Coal mining and reclamation
No. 16. Coal and electricity

1996 Report on Ohio mineral industries

The *1996 Report on Ohio mineral industries* features statistics and directories of operators for each mineral commodity produced in Ohio (excluding oil and gas operators) plus an article on rocks and minerals mined in Ohio and their uses.

In 1996, coal was produced by 52 companies at 134 mines in 23 counties. Production totalled 28,323,773 tons (10.9 percent increase from 1995); 16,187,624 tons were produced from 10 underground mines, and 12,136,149 tons were produced at 124 surface mines. This was the second year since 1948 that tonnage from underground production exceeded tonnage from surface production. The total value of coal sold was $727,795,712; average price per ton was $25.43. The five leading counties for 1996 coal production were Belmont, Meigs, Vinton, Monroe, and Morgan. Ohio is the 11th-largest coal-producing state in the nation.[1]

[1]National standings were provided by the U.S. Geological Survey and U.S. Department of Energy, Energy Information Administration.

Wyoming, West Virginia, Kentucky, Pennsylvania, and Texas rank 1st through 5th, respectively. The top five coal-consuming states, in descending order of consumption are Texas, Indiana, Ohio, Pennsylvania, and Illinois.

An estimated 712 new oil and gas wells were drilled in 46 Ohio counties in 1996.[2] The top five counties in the number of new wells drilled in 1996 were Wayne, Stark, Muskingum, Washington, and Coshocton. Ohio ranks 7th nationally in the number of wells drilled. The total reported crude oil production in Ohio in 1996 was 8,305,366 barrels (0.6 percent increase from 1995). The total value of the crude oil produced was $162,403,129; average price per barrel was $19.55. Ohio ranks 19th nationally in the volume of crude oil produced. Natural gas production in Ohio in 1996 was 120,443,871 thousand cubic feet (MCF) (4.7 percent decrease from 1995). The total value of the natural gas produced was $313,631,070; average price per MCF was $2.63. Ohio ranks 17th nationally in the volume of crude oil produced.

Limestone and dolomite were sold or produced by 79 companies at 120 operations in 53 counties in 1996. Sales totalled 69,431,223 tons (2.8 percent increase from 1995). The total value of limestone and dolomite sold was $288,640,762; average price per ton was $4.16. The five leading counties for 1996 limestone and dolomite production were Ottawa, Franklin, Erie, Delaware, and Wyandot. Ohio ranks 2nd nationally in the production of lime; Missouri is 1st, and Kentucky, Alabama, and Pennsylvania are 3rd, 4th, and 5th, respectively. Ohio also ranks 7th in the production of crushed stone, which includes crushed sandstone; Texas, Pennsylvania, Florida, Missouri, Illinois, and Georgia rank 1st through 6th, respectively.

In 1996, sand and gravel were sold or produced by 230 companies at 292 operations in 64 counties plus Lake Erie. Sales totalled 52,092,243 tons (2.9 percent increase from 1995). The total value of sand and gravel sold was $204,846,796; average price per ton was $3.93. The five leading counties for 1996 sand and gravel production were Hamilton, Franklin, Butler, Portage, and Stark. Ohio ranks 4th nationally in the production of construction sand and gravel. California, Texas, and Michigan are 1st, 2nd, and 3rd, respectively, and Arizona ranks 5th. Ohio ranks 8th nationally in the production of industrial sand and gravel. The states leading Ohio in production of industrial sand and gravel, in descending order of production, are Illinois, Michigan, New Jersey, California, Wisconsin, North Carolina, and Texas.

Sandstone and conglomerate were sold or produced by 20 companies at 30 operations in 16 counties in 1996. Sales totalled 1,808,816 tons (1.4 percent increase from 1995). The total value of sandstone and conglomerate sold was $36,268,331; average price per ton was $19.08 for crushed stone and $62.42 for dimension (building) stone. The five leading counties for 1996 sandstone and conglomerate production were Geauga, Perry, Knox, Pike, and Lake. Ohio ranks 18th nationally in the production of dimension stone. Indiana, Georgia, Wisconsin, Massachusetts, and Vermont rank 1st through 5th, respectively.

Clay was sold or produced by 44 companies at 57 operations in 24 counties in 1996. Clay sales (including material for captive use) totalled 1,983,225 tons (22.2 percent increase from 1995). The total value of clay sold was $12,791,571; average price per ton was $6.45. The five leading counties for 1996 clay production were Tuscarawas, Stark, Ottawa, Paulding, and Greene. Ohio ranks 4th nationally in the production of clay and shale. Alabama, Texas, and North Carolina are 1st, 2nd, and 3rd, respectively, and Georgia ranks 5th.

Shale was sold or produced by 25 companies at 35 operations in 20 counties in 1996. Shale sales (including material for captive use) totalled 1,357,276 tons (23.3 percent decrease from 1995). The total value of shale sold was $4,748,461; average price per ton was $3.50. The five leading counties for 1996 shale production were Cuyahoga, Hamilton, Tuscarawas, Marion, and Mahoning.

Salt was produced by 3 companies at 5 operations in 5 counties: two rock salt mines, one each in Cuyahoga and Lake Counties, and three brining operations, one each in Licking, Summit, and Wayne Counties. Salt sales totalled 5,169,757 tons (28.2 percent increase from 1995). The total value of salt sold was $56,928,065; average price per ton was $10.34 for rock salt and $14.70 for salt in brine and evaporated salt. Ohio ranks 3rd nationally in the production of salt. Louisiana and Texas are 1st and 2nd, and New York and Kansas are 4th and 5th, respectively.

Gypsum was produced by 1 company at 1 operation in Ottawa County. Gypsum sales (all material was for captive use) totalled 267,692 tons (7.6 percent increase from 1995). The total value of gypsum sold was $2,543,074; average price per ton was $9.50. Ohio ranks 14th nationally in the production of gypsum. Oklahoma, Iowa, Texas, Nevada, and California rank 1st through 5th, respectively.

Peat production was reported by 4 companies at 4 operations in 3 counties (Champaign, Portage, and Williams). Peat sales (including material for captive use) totalled 7,923 tons (57.3 percent decrease from 1995). The total value of peat sold was $91,440; average price per ton was $11.54. Ohio ranks 12th nationally in the production of peat. Florida, Michigan, Illinois, North Carolina, and Minnesota rank 1st through 5th, respectively.

Copies of the *1996 Report on Ohio mineral industries* are available from the Division of Geological Survey for $7.50 plus $2.00 mailing; orders to Ohio addresses must include 5.75 percent tax ($0.43). Credit-card (Visa or MasterCard) orders may be placed by calling 614-265-6576.

—Sherry L. Weisgarber
Industrial Minerals Group

[2]Information on Ohio was provided by the Ohio Department of Natural Resources, Division of Oil and Gas. National standings were provided by the Independent Petroleum Association.

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Ohio Department of Natural Resources
Division of Geological Survey
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