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Ohio Geology

a quarterly publication of the Division of Geological Survey

MINERALS OF OHIO—THE BOOK

by Michael C. Hansen

The Survey has reached a milestone of sorts with the recent publication of Bulletin 69, *Minerals of Ohio,* authored by Kent State University Associate Professor Dr. Ernest H. Carlson. This long-awaited, well-illustrated, comprehensive volume fills a significant void in Ohio's geologic literature. Numerous mineral collectors from Ohio and other states now have available a concise, well-organized, and authoritative compilation of information on Ohio minerals and their occurrence. Previous publications on minerals in Ohio have been widely scattered and generally inaccessible to most individuals. We anticipate that *Minerals of Ohio* will, like its companion volume, *Ohio fossils,* become an immediate classic and serve both this and future generations of those fascinated by unique products of geologic processes.

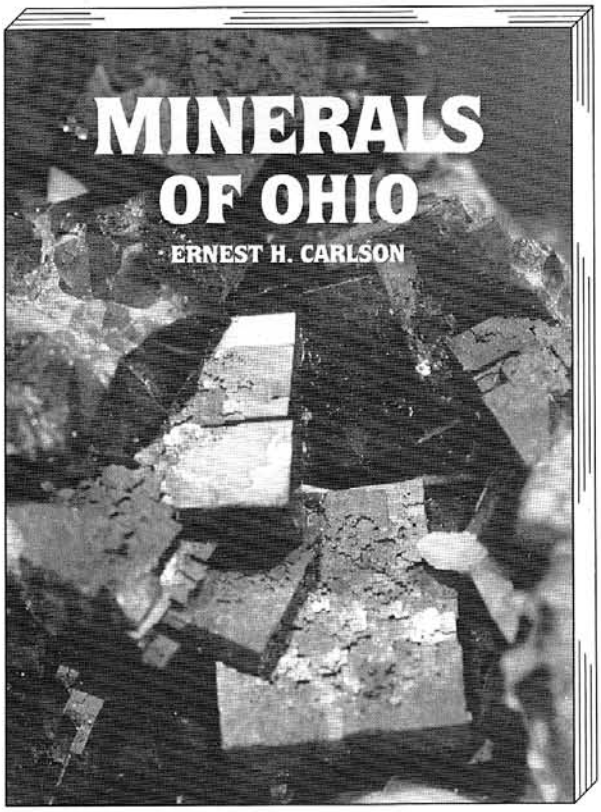
Mineral collecting has perhaps always been a human activity. Ancient peoples as well as modern humans have pursued, possessed, and coveted native elements such as gold and silver and natural crystals such as diamond, emerald, ruby, and sapphire, among others. Indeed, conflict and intrigue have commonly been associated with obsessive desires to possess rare metals and gemstones. Although these minerals have long served as decorative items indicative of wealth, other minerals have been sought throughout history for their practical value for manufacturing tools and weapons or to use in conjunction with other minerals or substances to produce various products. Flint, Ohio's official gemstone, was sought by American Indians not for its gem value but as a raw material from which tools and weapons could be fashioned.

In the modern world, the desire to obtain and possess mineral specimens has expanded far beyond the gem category. To many people, few objects are more captivating than an exquisite cluster of crystals of a mineral such as calcite, fluorite, or quartz. The location, collection, and exhibition of mineral specimens has become a business to some and an engrossing hobby to many. The popularity of rock shops and rock and mineral clubs is testimony to the popularity of mineral specimens.

The following brief summary of minerals and mineral collecting in Ohio represents information taken primarily from Dr. Carlson's new book and is presented in order to provide those unfamiliar with this subject an appreciation of the "gems" that await them within its pages.

Ohio is not commonly thought of as a state that has abundant and spectacular mineral specimens that are highly desired by collectors. However, at least 42 kinds of minerals have been recorded from Ohio, and celestite and calcite crystals from the northwestern part of the state are known worldwide. Mineral specimens can be found in many areas of Ohio—78 of Ohio's 88 counties have recorded the occurrence of one or more kinds of mineral specimens from at least 430 localities: Adams County in southern Ohio has recorded 16 varieties and Wood County in northwestern Ohio is known to possess at least 15 varieties.

A mineral, by definition, is a naturally occurring, homogeneous, inorganic substance that generally has a definite chemical composition and specific physical properties. In most cases the term "mineral" is restricted to a crystal or aggregate of crystals. Minerals are the building blocks of rocks; that is, rocks are composed



Cubic iridescent fluorite crystals from Seneca County. The large fluorite crystal is ¾ inch across. This photo is featured in full color on the cover of Minerals of Ohio.

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ODNR
OHIO DEPARTMENT OF NATURAL RESOURCES

George V. Voinovich, Governor • Frances S. Buchholzer, Director

FROM THE STATE GEOLOGIST . . . by Thomas M. Berg

ENVIRONMENTAL EDUCATION AND THE EARTH SCIENCES

Director Frances S. Buchholzer recently established the Environmental Education Task Force in the Ohio Department of Natural Resources. The task force is chaired by Sally Prouty, Deputy Director for Resource Management in ODNR. The establishment of this working group reflects Director Buchholzer's strong commitment to educating Ohioans about our environment and raising public awareness of the importance of our natural resource heritage. Michael C. Hansen and Suzan E. Jervey of the Geological Survey have been assigned to the task force.

Our Division is glad to be a part of the Department's environmental education effort, and we feel that we have a lot to offer because of our long record of involvement in earth-science education activities. The Geological Survey has provided a wide variety of educational materials for many years, including page-size maps of geological features, leaflets on diverse aspects of Ohio geology, and our widely acclaimed quarterly publication, *Ohio Geology*. We provide rock and mineral sets for classroom use, and loan copies of a film, titled "The Search," which dramatizes the history and duties of the Survey. Our geologists frequently give presentations for grade school and high school classes, lead field trips for scout troops, and give talks to civic groups. One of the most important educational presentations that the Division of Geological Survey makes is the annual Ohio's Mineral Industries Teachers Workshop, which is organized by Sherry W. Lopez of the Mineral Resources and Geochemistry Section. The week-long workshop is arranged in cooperation with the University of Akron and carries 2 college credits. This intensive training session for earth science teachers combines classroom and field experience to help them convey the great importance of mineral industries to their students.

Geological organizations in the United States such as the American Geological Institute, the National Association of Geology Teachers, the National Earth Science Teachers Association, the American Association of Petroleum Geologists, the Geological Society of America, the Association of Engineering Geologists, the Association of American State Geologists, the U.S. Geological Survey, and many others recognize the critical need for earth science education and for greatly heightened public awareness of geological issues today. On the average, most Americans are very poorly informed about the importance of the geosciences in their everyday life. Citizens voting on weighty issues such as location of landfills, water supplies, mineral resources, and fossil fuels generally have little or no understanding of geological processes or the three-dimensional geologic framework beneath their feet.

The Ohio Division of Geological Survey will continue to participate in earth-science educational programs and will integrate those programs with the Department of Natural Resources' environmental education initiatives. We welcome Director Buchholzer's and Deputy Director Prouty's enthusiasm and look forward to participating in this important program.

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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.

NEW QUADRANGLE MAPS AVAILABLE

As reported in the Winter 1991 issue of *Ohio Geology*, the Survey has available on open file quadrangle-scale (1:24,000) maps resulting from the statewide mapping program now underway. Maps for the two quadrangles listed below have been completed. Blueline copies of these maps are $5.48 per map, which includes tax and mailing. Add $1.00 per order for mailing in a tube. Please order by quadrangle name and map title. An index to topographic quadrangle maps in Ohio is available at no charge from the Survey. PLEASE NOTE: There is no bedrock-topography map for the Salineville quadrangle; the listing in the winter issue of *Ohio Geology* was in error.

Maysville East (Ohio portion only) *(Brown and Adams Counties)* bedrock geology, bedrock topography, structure contours on top of Kope-Fairview Formations, structure contours on top of Bellevue Member of Grant Lake Limestone and Grant Lake Limestone undivided, structure contours on top of Arnheim-Waynesville Formations undivided and Drakes Formation.

Minerva (N portion only) *(Carroll, Columbiana, and Stark Counties)* bedrock geology, bedrock topography, structure contours on base of No. 6 (Middle Kittanning) coal bed, structure contours on base of No. 6A (Lower Freeport) coal bed, structure contours on top of No. 7 (Upper Freeport) coal bed or inferred contact of Allegheny-Conemaugh Groups.

SURVEY RECEIVES COGEOMAP AWARD

The U.S. Geological Survey has awarded the Division of Geological Survey a $90,000 grant for 1991 as part of the national COGEOMAP program. These monies will be used in the Division's statewide bedrock geologic mapping program. In 1990 the Division received a $50,000 grant from the COGEOMAP program.

In addition, the USGS will provide up to $10,000 in geological services to support the Division's efforts to produce a new state bedrock map. Such services include radiometric and paleontologic dating of rocks and other determinations or analyses that are beyond the Division's capabilities. The Ohio Geological Survey is most grateful for the continued cooperation and support of the U.S. Geological Survey.

ORDERING MINERALS OF OHIO

Ohio Division of Geological Survey Bulletin 69, *Minerals of Ohio,* by Ernest H. Carlson, is a 155-page soft-cover book that includes a catalog of mineral localities by county, 32 maps and drawings, 32 photographs, 11 tables (including a key to Ohio mineral species), plus four plates of color photographs of mineral specimens. The cover features a full-color photograph of iridescent fluorite. *Minerals of Ohio* is available for $8.00 plus $0.46 sales tax for over-the-counter sales. Mail orders to Ohio addresses must include $1.75 mailing and $0.46 tax ($10.21 total). Out-of-state orders do not need to include the tax. *Minerals of Ohio* can be ordered from: Division of Geological Survey, Ohio Department of Natural Resources, 4383 Fountain Square Drive, Columbus, OH 43224-1362. Telephone: 614-265-6605.

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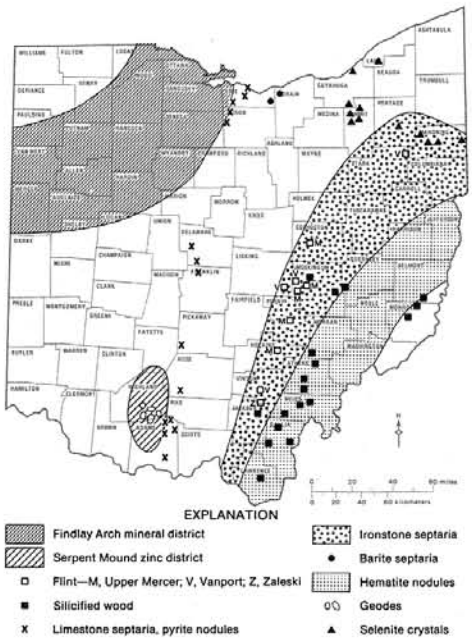
of aggregates of one or more minerals. Rocks are large bodies of mineral matter. Geologists commonly refer to deposits of rocks of economic significance as industrial minerals; however, the term "mineral" in this context is not meant to refer to specific crystals or small aggregates of crystals.

Native Ohio minerals either formed in place in sediments soon after their deposition, were deposited by mineral-bearing ground waters in cavities, vugs, or other openings in consolidated rock, were deposited by hydrothermal solutions in cavities or fractures, or were deposited as precipitates from evaporating seawater.

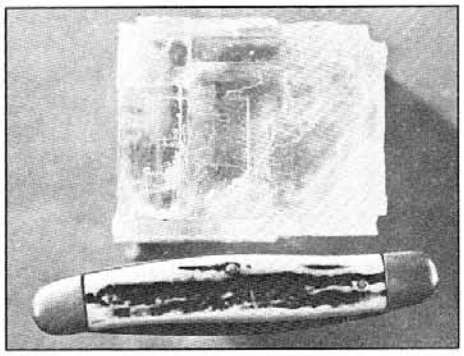
Additional minerals found in the state were transported from sometimes distant sources. Gold, diamonds, and a host of other minerals were brought here by glaciers of the Pleistocene Ice Age. Meteorites, which obviously came from a very distant source, also are included as mineral specimens known from Ohio.



Minerals districts and the generalized locations of selected mineral types in Ohio (from Carlson, 1991).

Ohio has three mineral districts, although mineral occurrences are certainly not limited to the confines of a particular district. Perhaps the most notable area is known as the Findlay Arch mineral district, which stretches in a northeast-southwest-trending belt across northwestern Ohio. Host rocks for mineralization are mostly limestones and dolomites of Silurian and Devonian age. Common minerals include calcite, celestite, fluorite, galena, and sphalerite. Most of these minerals occur in spaces such as vugs, cavities, or enlarged fractures that postdate the deposition and lithification of the rock.

More than 100 localities in this region have produced specimens, some of which are spectacular and are known to mineral collectors and mineralogists worldwide. Of particular significance are large, well-formed crystals of calcite and celestite.



Cubic halite crystal from Cuyahoga County. Knife is 3½ inches long (from Carlson, 1991).

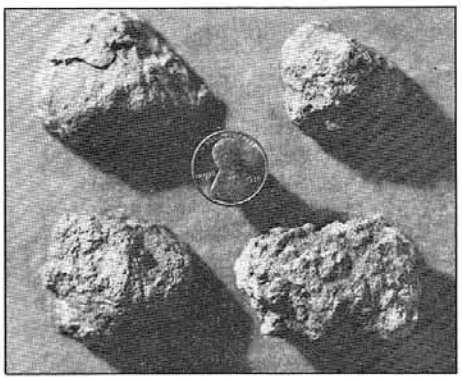
This glaciated region of Ohio has very little relief, and exposures of bedrock are confined primarily to quarries. Unfortunately for collectors, most of these quarries are no longer open to collecting because of safety and legal restrictions.

Interestingly, the mineralization in the Findlay Arch district is similar to what is commonly called Mississippi Valley-type mineralization, in reference to the lead/zinc-producing areas of Missouri and adjacent areas in the Mississippi Valley. Although there has been some exploration for ore bodies in northwestern Ohio, none of economic significance have been found as yet.

Scalenohedral calcite crystals on dolomite matrix from Wood County. Specimen is 3 inches across (from Carlson, 1991).

The Serpent Mound zinc district in southern Ohio is centered on the Serpent Mound cryptoexplosion structure—a circular area of deformed rocks that has a diameter of about 5 miles. Vein and vug fillings of zinc minerals such as sphalerite, smithsonite, hydrozincite, and hemimorphite are found in association with this unusual structure, the origin of which is still debated. Some researchers have regarded the Serpent Mound structure as an astrobleme, that is, an impact area from a meteorite or other extraterrestrial mass. More recent ideas suggest that the structure was formed by an explosion of gas or fluid derived from deep in the Earth's crust. It has also been proposed that the Serpent Mound structure might represent the intrusion of a kimberlite pipe (see *Ohio Geology,* Winter 1985). Limited outcrops and deep surface weathering are detriments to mineral collecting in the area. Interestingly, this area is the only place in Ohio where geodes are relatively common, although most of them are not nearly as spectacular as those found in Indiana and other neighboring areas.

Lastly, rocks of Pennsylvanian age in southeastern Ohio provide a variety of minerals including flint, petrified wood, septarian concretions, and hematite nodules. These rocks lie in mostly unglaciated terrain, which in some areas has considerable topographic relief. Consequently, exposures of bedrock are abundant. Additionally, extensive strip mining of coal in the region has created numerous exposures of fresh bedrock.



Hematite nodules from Noble County. Coin indicates scale (from Carlson, 1991).

This brief summary touches only a few of the high points of *Minerals of Ohio.* The book represents the culmination of more than a decade of effort by Dr. Carlson to bring together all of the previously published information on Ohio minerals and the results of his extensive research and field investigations throughout the state. This monumental work will fascinate the novice mineral collector, providing basic step-by-step information, and will be of great value to the advanced collector, professional geologist, and mineral explorationist as well. The Division of Geological Survey is pleased to offer this volume to the citizens of Ohio.

1990 OHIO OIL AND GAS DEVELOPMENTS

by Michael P. McCormac
ODNR, Division of Oil & Gas

1990 ACTIVITY

Overall permitting activity for oil and gas wells continued to decline as Ohio's oil and gas industry entered the 1990's. The Division of Oil & Gas issued 3,420 permits in 1990, a decline of 9 percent from 1989. This total includes permits issued to drill new wells, revised locations, and permits to convert, deepen, plug back, plug and abandon, reissue, and reopen. As in 1989, December was the most active permitting month in 1990 and February the slowest. The Division issued 1,699 permits to drill for oil and gas in 1990, a 9.1 percent decline from 1989. These permits included 1,492 new permits and 207 reissue permits.

The Division estimates that 1,306 oil and gas wells were actually drilled during 1990, the same number drilled in 1989. However, the 1990 new-well count is the lowest since 1975 when 1,220 wells were drilled. Wells were drilled in 40 of Ohio's 88 counties, three fewer than 1989. Although the majority of Ohio wells were drilled by rotary tools (1,028), cable tool rigs drilled 115 wells (10 percent) and operated in 21 counties. The average depth per well drilled by cable tool was 2,585 feet; rotary-drilled wells averaged 4,550 feet.

New wells drilled for oil and gas in Ohio in 1990, by county.

Ohio oil and gas owners/operators submitted 1,143 well completion reports to the Division, representing 87.5 percent of the wells drilled in 1990. These reports showed that 976 wells were productive and 167 were dry holes, an 85.4 percent completion rate. Average well depth increased to 4,352 feet, an increase of 237 feet per well from 1989. Total depth of the deepest well drilled, in Columbiana County, was 8,345 feet. Thirty-two additional reports were received for other types of drilling operations.

Approximately 10 percent (112) of all wells completed were classified as exploratory wells. Thirty-one were completed and 81 were dry holes, representing a 27.7 percent success rate. The Lower Ordovician Rose Run and Cambrian Trempealeau accounted for 80 percent of all exploratory drilling. Of the exploratory wells drilled to these zones, 77 percent (70) were categorized as deeper pool wildcats or wildcats.

1990 DRILLING OPERATIONS BY TYPE OF WELL

Type of hole	*Drilled*	*Converted*	*Total footage*
Productive wells	976	0	4,131,366
Dry holes	167		843,248
Reopened wells	5		0
Lost holes	17		26,557
Gas storage wells	0	11	0
Conventional brine-injection wells	1	6	760
Enhanced-recovery wells	3	8	2,250
Solution-mining wells	6	0	16,557
TOTAL	1,175	25	5,020,738

COMPLETION ZONES

Completion zones ranged from the Pennsylvanian Cow Run sandstone to the Precambrian basement rock. Washington County had the most diverse drilling activity. Wells were drilled in this county to five different geologic zones ranging from the Pennsylvanian Cow Run sandstone to the Ordovician Black River limestone.

Seventy-four new wells were dry in their permitted formation but were plugged back to produce from a shallower zone. Sixty wells were plugged back from the Rose Run sandstone to the "Clinton" sandstone. Six existing wells were plugged back to shallower producing zones, and five existing wells were drilled to a deeper producing formation.

"Clinton" sandstone

The Silurian "Clinton" sandstone continued to be the most actively drilled zone since 1965. Sixty-eight percent (779) of the total wells were completed in this zone. This is the lowest number of "Clinton" wells drilled since 1966. "Clinton" sandstone wells had a 98.7 percent completion rate and averaged 4,476 feet in depth, an increase of 123 feet per well from 1989. "Clinton" wells were drilled in 31 counties. The top five counties for "Clinton" drilling were Stark (74), Washington (70), Mahoning (62), Trumbull (59), and Ashtabula (46).

Rose Run sandstone

Drilling to the Ordovician Rose Run sandstone exceeded the 100-well mark for the first time with 123 wells. Rose Run drilling began a gradual increase in 1980. Although 73 percent of Ohio's estimated 660 Rose Run wells were drilled during the past decade, the dramatic upturn in activity began in 1987; 378 Rose Run wells have been drilled since 1987.

In 1990, Rose Run wells were drilled in 14 counties by 39 operators. Holmes County led the Rose Run activity with 38 wells, followed by Coshocton (35) and Ashtabula (11) Counties. The continued increase in Rose Run activity can be attributed partly to lowered risk presented by "Clinton" sandstone plug-back potential. Since 1987, 81 percent of Rose Run dry holes have been plugged back to produce from the "Clinton" sandstone.

Trempealeau dolomite

Eighty-seven wells were drilled to the Cambrian Trempealeau dolomite in 1990, the most active year since 1967, when 132 wells were drilled. Morrow County has historically been the most active county for Trempealeau drilling, and 1990 was no exception. Although drilling in this zone occurred in 10 other counties, more than half (48) of the Trempealeau wells were drilled in Morrow County. Forty percent of all Trempealeau wells were completed as productive.

Devonian shale

Drilling interest in the Devonian Ohio Shale tapered off in 1990; only 84 wells were drilled, compared to 135 in 1989. Although Monroe County led Devonian shale drilling with 43 wells, this number represents a decrease of 63 wells from 1989. Devonian shale drilling spread west into Noble County, where 34 wells were drilled, a 22-well increase from 1989. All Devonian shale wells were reported as productive and 69 percent were dual-completed in the Berea Sandstone.

Berea Sandstone

The Mississippian Berea Sandstone ranked fifth among producing formations; 44 wells were drilled in 15 counties. Morgan County had the most Berea wells (7). The Berea Sandstone was a co-producing formation in 58 wells completed in the Devonian shale.

TEN MOST ACTIVE COUNTIES

Stark County led the 1990 top-10 list with 91 new wells drilled. Only twice since 1961 has the first-ranked county had fewer than 100 wells drilled (in 1988 Trumbull County had 91 wells).

Seven of the 10 most active counties for drilling are located in northeastern Ohio (see table below). Washington County remained active, and moved into second place with 86 new wells. Holmes and Coshocton Counties ranked third and fourth, respec-

tively; the Rose Run sandstone was the primary target zone.

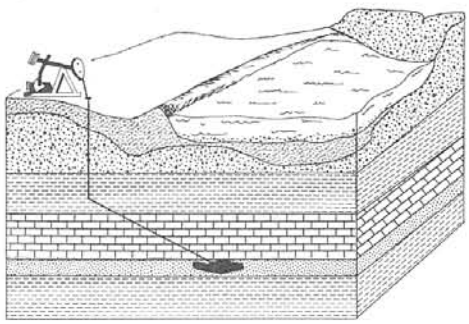
Eight of 10 counties retained top-10 status from 1989; Medina and Summit Counties dropped from the 1990 list. Ashtabula and Noble Counties regained top-10 status after being absent since 1986 and 1976, respectively.

TEN MOST ACTIVE COUNTIES IN 1990

1990 Rank	County	1989 Rank	Wells drilled	Permits issued	Footage drilled
1	Stark	3	91	129	414,139
2	Washington	6	86	104	411,628
3	Holmes	10	77	88	348,498
4	Coshocton	7	76	88	365,533
5	Mahoning	2	71	69	334,583
6	Noble	13	68	85	220,051
7	Wayne	4	65	80	210,351
8	Ashtabula	16	62	109	262,503
9	Trumbull	5	61	60	285,217
10	Monroe	1	55	70	107,397

DIRECTIONAL DRILLING

Requests for directional-drilling permits have increased in the last two years. A directionally drilled well is generally drilled vertically to a predetermined depth, then deviated at an angle designed to encounter the producing formation. Before 1989, the Division issued fewer than three directional-drilling permits per year; issuance increased to six in 1989 and 14 in 1990. All of these permits targeted the "Clinton" sandstone, and all but two were issued in northeast Ohio. In 1990, eight directional-drilling permits were issued to drill under Berlin Reservoir, which was leased by the U.S. Bureau of Land Management. The proposed total depth for these wells was approximately 5,300 feet.



Diagrammatic sketch of a directionally drilled well.

Directional drilling can access areas where vertical drilling cannot be used. Operators have obtained these permits to drill acreage covered by water, to comply with safety and zoning specifications, to avoid sensitive surface conditions (such as a wetland area), and to recover reserves that could not be produced due to collapsed production casing. In one of the more interesting requests, the surface acreage was in a cemetery where not enough space was available to set up a drilling rig.

The target zone, the point where the borehole enters the producing formation in a directionally drilled well, must meet the state spacing requirements. The surface-entry hole must meet all safety requirements. After the well is drilled, the operator must submit a copy of the borehole deviation survey and a revised surveyor's plat showing the actual point of entry into the producing formation.

The Division issued two permits for horizontal drilling in 1990. Horizontal drilling maximizes the length of the pay zone behind production casing.

PRODUCTION

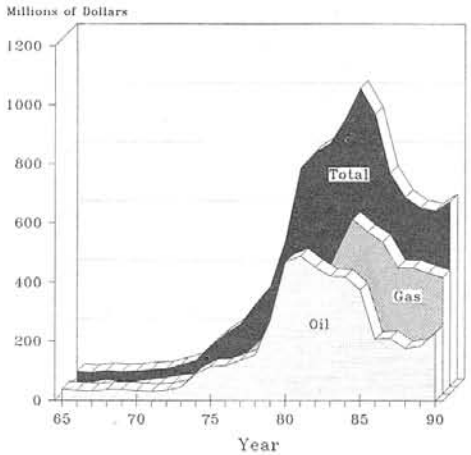
Ohio's total reported crude oil production was 10,008,263 barrels. Although this figure is the lowest production volume recorded since 1976, it is only a 2 percent decrease from 1989. A significant milestone was reached as cumulative oil production exceeded the billion-barrel mark. Through 1990, Ohio wells have produced 1,001,530,384 barrels.

In 1990, Ohio wells produced 154,618,630 MCF of natural gas, a decrease of 3 percent from 1989. Gas production figures include an estimated 1,515,869 MCF of natural gas used on the lease. Through 1990, Ohio wells have cumulatively produced 6,399,529,937 MCF of natural gas.

MARKET VALUE

The market value of Ohio crude oil increased 25 percent in 1990 to $231,240,162. Although oil production declined 2 percent from 1989, higher oil prices raised Ohio's crude-oil dollar value by $46,327,651. The average price per barrel in 1990 was $23.10, a 28 percent increase from the 1989 average price of $18.10 per barrel.

Ohio natural gas production was valued at $393,043,833, a decrease of 4 percent from 1989. The average price per MCF was $2.54 in 1990, one cent less than in 1989.



Dollar value of oil and gas produced in Ohio, 1965-1990

Ohio's combined oil and gas market value increased by 5 percent in 1990; this increase was the first following five consecutive years of decline since 1984. The total dollar value was $624,283,995, the highest market value recorded in three years.

SUMMARY

Oil-and-gas-well permitting and drilling activity for 1990 looked much like that of 1989. Not even the Middle East crisis and sudden jump in oil prices could stimulate new well drilling. Existing well owners may have realized greater profits in 1990 as the average price per barrel increased by $5.00. For the fourth consecutive year, gas prices remained stable.

Trends in Ohio well drilling indicate that the "Clinton" sandstone is the producers' mainstay; this formation accounted for 68 percent of the wells drilled in 1990. The Rose Run sandstone, an increasingly attractive prospect, exceeded the 100-well mark for the first time. In 1990, 31 more wells were drilled to the Rose Run than in 1989. The Trempealeau dolomite made an interesting comeback; renewed exploration made 1990 the most active year for this formation in 23 years.

Northeast Ohio is the active area for new-well drilling in the state. Not only did this area have seven of 1990's top-10 counties for drilling, it also had most of the directional-drilling activity, which has steadily increased over the past several years.

Overall, Ohio now has 64,695 active wells and 3,323 well owners. In 1990, these wells produced over 10 million barrels of oil and nearly 155 million MCF of natural gas. The market value of Ohio's oil and gas production exceeded $600 million.

COMPUTERIZATION AT THE OHIO GEOLOGICAL SURVEY

As with most businesses, schools, and government offices, computers are steadily taking a more prominent role in the operations of the Division of Geological Survey. About five years ago the Division took delivery of its first personal computer; today the Survey owns 13 personal computers, a minicomputer, two dual-screen workstations, and a single-screen workstation along with various peripheral devices and software.

Although this quick growth in computer acquisitions may seem impressive, the Survey's job of computerization has just begun. We still have a long way to go in the procurement of hardware and software—13 PC's are not adequate for a staff of 48. But the real task before the Survey is getting all our information into computer databases and designing our applications around their use.

Section 1505.01 (E) of the Ohio Revised Code states that the Division of Geological Survey "Shall make, store, and have available for distribution maps, diagrams, profiles, and geological sections portraying the geological characteristics and topography of the State...." These records presently include more than 250,000 oil and gas well records, more than 60,000 suites of geophysical logs, approximately 17,000 measured stratigraphic sections, more than 2,000 core records, more than 1,000 measured sections in glacial deposits, more than 2,100 laboratory analyses, thousands of geochemical analyses, and thousands of maps. Each year thousands of new records and maps are added to the files. As the volume of geological information has grown, so has the demand and need for such information. Much of the private sector and most state and federal agencies which utilize the Division's information are using and producing information in digital form. Therefore, in order for the Division to respond to information requests with the expected promptness and in the preferred form, computerization of our databases is essential.

The Survey is only one of many state organizations which are in the process of office automation. However, our files are the primary source of information for the mineral and fossil-fuel industries, which represent in excess of $2 billion per year to the economy of Ohio. In addition, the information in our files and publications forms the basis upon which many environmental issues, such as hazardous and municipal landfill siting, industrial waste-disposal-well siting, and land use/land-development decisions, are decided. To better serve these interests and the general public, our information must be computerized in the near future. The Ohio Geological Survey is already behind many other states and private industry in this task.

One of the main tasks of the Division of Geological Survey is to produce technical publications on the state's geology. Within the last decade, technology has advanced rapidly in the field of electronic publishing. Use of this new technology will increase the efficiency and speed for producing these publications. This technology has additional time-savings advantages by allowing fast and easy updates and changes to the publication material, thus reducing the cost for editing and publishing updates. As part of the Division's computerization effort it will be beneficial to produce our text and maps in digital form.

Potential jobs and the proper utilization of Ohio's mineral resources are threatened when the Survey cannot respond to requests for technical information. The health and safety of Ohio's citizens are at risk when the Division cannot compile and provide comprehensive technical information to regulatory agencies, land-use planners, citizens, and geotechnical consultants in a timely fashion. In addition, effective review of proposed landfill sites and other major construction projects is dependent on rapid compilation, manipulation, and evaluation of the pertinent records on file within the Division. Because of the rapidly increasing volume of records and the skyrocketing need for geological information, the Division will soon find itself in a position where it cannot easily respond to requests nor physically manage or maintain accurate records economically or efficiently. The computerization of our geologic records, combined with the use of a Geographic Information System, will greatly assist the Survey in maintaining its effectiveness.

PAST AND PRESENT COMPUTERIZATION EFFORTS

The Division's first computers were purchased in late 1985 for use by the Subsurface Stratigraphy and Petroleum Geology Section on a project sponsored by the Gas Research Institute (GRI). This project required the Survey to produce computer databases for information pertaining to all the Devonian-shale producing wells in a five-county area of southeastern Ohio. This information then was used to produce a series of maps and cross sections illustrating the structural and stratigraphic controls on Devonian-shale oil and gas production. To complete this project the Survey purchased three personal computers and a dual-screen workstation with associated peripherals and software. The GRI-sponsored project was completed in late 1988.

Survey geologist/ Computer Coordinator Larry Wickstrom using dual-screen Intergraph workstation.

Also during this time the Survey was able to purchase a PC for use by our Mineral Statistician, one for use by our geologists working on the Superconducting Super Collider siting, and another for use by our staff working with the Ohio Environmental Protection Agency and U.S. Environmental Protection Agency on deep hazardous-waste injection wells.

In late 1988 and early 1989, Survey personnel began to plot an overall course towards computerizing many of our records and automating processes. For the 1990-91 biennium the Division of Geological Survey requested a budget item slightly in excess of $1,000,000 to begin the immense task of computerizing our records and processes. The proposed budget included funds for equipment acquisition as well as a staff for coordination and data input. The Legislature was able to appropriate $570,800 for computerization in the 1990-91 biennial budget. This funding was approved for the acquisition of equipment and services but did not allow for additional staff to be hired at that time.

The special appropriation was used to purchase a VAX/Intergraph minicomputer, two graphics workstations, networking hardware and software, database management software, printers, input terminals, and additional PC's. In essence, the core of a data-processing and automated-mapping system was acquired. The Division took delivery of most of these items by April 1990. Since delivery of these items, we have been steadily training staff and developing our database and mapping applications.

Necessary statewide budget cuts in 1990 and early in 1991 resulted in a $167,000 reduction in funds available for computerization. The biggest effect on the program was that temporary help could not be hired to perform data input as planned.

The first major database to be developed under this funding is the oil-and-gas-well information system, which will eventually contain in excess of 200,000 records. The Survey has been working with personnel from the ODNR, Division of Oil and Gas and Office of Systems Development to design and implement this database. By combining the Survey's database with the Division of Oil and Gas' system we will eliminate duplication of effort between divisions and reduce costs. All future oil-and-gas-well records will be brought into the system from the Division of Oil and Gas. The Division of Geological Survey will be responsible for entering all the previously permitted and drilled wells (approximately 170,000) into the system. The Survey plans to implement the oil-and-gas-well database on a county-by-county basis. As each county is completed its database will be made available to the public. The computerized form of these data will enable users to search and manipulate it in ways and at speeds which were never before possible.

Because we are designing an overall computer environment and integrated set of databases for the entire Survey, we want to show the full utility of this approach as soon as possible. As a demonstration, we chose an area of the state with as much geological variety as possible. Stark County is uniquely situated to illustrate many facets of Ohio's geology and has been selected as the starting point for our databases. Foremost among its

many attributes is that this county contains both glaciated and unglaciated areas and has abundant coal, petroleum, and nonfuel mineral resources. Once we have completed the oil and gas database for this county we will add other counties in order of drilling intensity and industry interest.

Much of the information the Division produces and has available is in the form of maps, charts, and geophysical logs, all of which are graphical displays. Therefore, as the Division computerizes its records we will be digitizing selected existing graphical displays as well as producing new ones with the assistance of the computer. During the current biennium we have used some funds for a consultant to assist us in setting up digitizing procedures so that more than 100 sets of geophysical logs can be entered into the system.

A listing of the digital geophysical logs is now available and we will soon announce pricing and procedure for purchasing these files. These logs represent over 100 of the deepest wells ever drilled in the state and will constitute the backbone of a digital correlation system for Ohio's geology. Our geologists are currently constructing a cross-section network which will criss-cross the entire state and extend into all the surrounding states and Ontario. This project should add much to our understanding of regional stratigraphy.

The Rose Run sandstone and other porous Cambrian strata have recently become one of the hottest petroleum exploration plays in the eastern U.S. In response to this interest, the Division is using the new computer system to construct a database of all wells which reach the Rose Run sandstone in the productive trend. From this database we have constructed a series of computer-drafted maps showing wells reaching the Knox unconformity and deeper. These maps, which will be periodically updated, are now available as part of the Division's new Digital Chart and Map Series. (See accompanying article on "New publication series.")

The Division of Geological Survey is committed to producing a new statewide geologic map within the next four years. The Division's computer system is an integral part of this large undertaking. Our geologists are entering their observations into a database which can be manipulated and used to produce structure and thickness contour maps. Using these maps and bedrock-topography maps we will then digitize the outcrop patterns into the system. All of the files from the different mapping areas will then be combined in the system to produce 1:100,000-scale and ultimately 1:250,000- and 1:500,000-scale maps of the entire state.

The Division of Geological Survey continues to pursue outside sources of funding. These grants and contracts allow us to perform additional investigations which would not be possible with limited state funds. Within the last two years the Survey has secured in excess of $600,000 in contracts from outside sources. These projects include U.S. Department of Energy contracts to study the Rose Run sandstone reservoirs in Ohio and to assess coal reserves, and U.S. Geological Survey grants for bedrock mapping, coal availability, and the National Coal Resources Data System. In addition to these federal sources of funds, the Survey is working in cooperation with the Indiana and Kentucky Geological Surveys (Cincinnati Arch Consortium) to characterize Precambrian basins of southwestern Ohio; this project is funded in part by several petroleum companies. All of these projects depend heavily on the Division's computer resources for completion. Although each of these grants pays for its respective amount of computer usage, we cannot depend upon outside funds for our computer acquisitions and development. On the contrary, in many instances the fact that we have the computer capabilities helps secure the funding. Therefore, continued development of our data processing and computer-assisted mapping are essential to our continued success in obtaining outside support of geologic investigations.

THE FUTURE

The Division of Geological Survey began an aggressive program of computerization with funding received in the 1990-91 biennial budget. Although that funding has gone far to provide the Survey with much-needed equipment and programming, it has not provided for any additional personnel or for all of the equipment necessary for full-scale computerization. Under better budget conditions, the Division plans to create a Computer Geology Section, which will both support the other sections of the Survey and accomplish its own specialized programs and goals.

Once large portions of data are in digital form we expect to design programming which will allow the public to have interactive access to the system from terminals in our offices as well as remote systems via telecommunications. The Survey will also be working closely with the other divisions and offices in the Department of Natural Resources and other State agencies to use our data in a Geographic Information System (GIS). GIS technology holds much promise for expanding the use of our data by ourselves and many others because geologic information forms the foundation on which so many other decision-making processes are based.

Although computerization is costly, the long-term benefits will save our taxpayers hundreds of thousands of dollars. If the Ohio Geological Survey is to be an effective and useful agency in our computer-based information society of the future, we must aggressively continue the process. The Geological Survey recognizes this need and plans to succeed.

— Lawrence H. Wickstrom
Subsurface Stratigraphy and
Petroleum Geology Section

NEW PUBLICATIONS SERIES

To accommodate the output from the Survey's new computer information and mapping system and to allow quick availability of this type of product, the Survey has developed a new series of publications called the Digital Chart and Map Series (DCMS).

This new series enables the Survey to sell direct computer products such as maps, cross sections, digital databases, printouts, digital geophysical logs, etc. Because these publications are a direct output from the computer, they can be quickly updated and edited as necessary without costly redrafting and reprinting. Many new products of this type are now under consideration and development.

The following publications in this series are available:

DCMS-1 Map of southeastern Ohio showing wells reaching Knox unconformity and deeper. Scale 1:250,000.

DCMS-2 Map of northeastern Ohio showing wells reaching Knox unconformity and deeper. Scale 1:250,000.

DCMS-3 Map showing wells reaching Knox unconformity and deeper in Coshocton and portions of Holmes and Tuscarawas Counties, Ohio. Scale 1:62,500.

DCMS-4 Core location map for Ohio (formerly Open-File Map 273). Shows cores on repository at the Survey. Scale 1:500,000.

DCMS-5 Borehole geophysical-log stratigraphic cross section showing Cambrian and lower Ordovician strata from Greenup County, Kentucky, to Crawford County, Pennsylvania. Vertical scale 1 inch = 125 feet.

DCMS-6 Borehole geophysical-log stratigraphic cross section showing Cambrian and lower Ordovician strata from Morrow County, Ohio, to Wood County, West Virginia. Vertical scale 1 inch = 125 feet.

Blueline copies of these publications are available for $10.00 each plus $0.58 tax over-the-counter in the Subsurface Stratigraphy and Petroleum Geology Section of the Survey; add $2.25 handling for mail orders (add $1.00 per order for mailing in a tube). Custom color plots are available on request; call 614-265-6598 for pricing.

EDITOR'S NOTE: A DECADE OF *OHIO GEOLOGY*

This issue marks the completion of a decade of *Ohio Geology*. My greatest apprehension when we launched this publication in 1981 was that we would quickly exhaust the list of interesting topics on the geology of Ohio. It is perhaps more of a tribute to the wonderful diversity of the geology of Ohio, rather than to our creativity, that we have been able to fill 40 issues of *Ohio Geology* with articles on many aspects of the state's geology. And, frankly, there is much yet to write.

The responses by our readers have been gratifying through the years. Many readers seem to simply enjoy learning about different aspects of the geology of Ohio and the current activities of the Survey. We have also learned that many teachers, ranging from middle school to college, use *Ohio Geology* as an educational tool in the classroom.

Production of *Ohio Geology* is a team effort. From the beginning, Jean Lesher has done the typesetting, Phil Celnar and his Technical Publications staff have done the layout, design, halftones, and illustrations, Donna Schrappe has maintained the mailing list and mailed out each issue, and Merrianne Hackathorn has provided her editorial and proofreading skills to the text and illustrations. Editorial opinions and insights have been provided by two State Geologists, Horace R. Collins and Thomas M. Berg. Sherry W. Lopez has regularly provided mineral statistics, and a number of other staff members have contributed articles from time to time.

As we enter the second decade of *Ohio Geology* we look forward to producing articles on many different aspects of the state's geology. We welcome your suggestions and opinions.

QUARTERLY MINERAL SALES, OCTOBER—NOVEMBER—DECEMBER 1990

compiled by Sherry W. Lopez

Commodity	Tonnage sold this quarter[1]	Number of mines reporting sales[1]	Value of tonnage sold[1] (dollars)
Coal	8,272,315	159	$249,327,350
Limestone/dolomite[2]	12,263,654	101[3]	44,790,231
Sand and gravel[2]	10,837,494	208[3]	36,984,292
Salt	989,610	5[4]	14,002,142
Sandstone/conglomerate[2]	377,303	19[3]	6,352,117
Clay[2]	425,945	25[3]	1,793,091
Shale[2]	374,713	19[3]	914,266
Gypsum[2]	46,587	1	442,577
Peat	7,867	2[3]	59,366

[1]These figures are preliminary and subject to change.
[2]*Tonnage sold* and *Value of tonnage sold* include material used for captive purposes. *Number of mines reporting sales* includes mines producing material for captive use only.
[3]Includes some mines which are producing multiple commodities.
[4]Includes solution mining.

1990 OHIO MINERAL SALES[1]

compiled by Sherry W. Lopez

Commodity	Tonnage sold in 1990[2]	Number of mines reporting sales[2]	Value of tonnage sold[2] (dollars)	Percent change of tonnage sold from 1989[2]
Coal	32,294,715	214	$967,737,119	+1.81
Limestone/dolomite[3]	46,160,490	109[4]	165,529,710	-3.22
Sand and gravel[3]	41,538,256	255[4]	139,906,063	+1.26
Salt	4,138,417	5[5]	50,440,319	-3.26
Sandstone/conglomerate[3]	1,633,328	23[4]	22,051,738	-8.98
Clay[3]	1,250,425	29[4]	4,012,861	-17.10
Shale[3]	1,250,343	23[4]	2,115,256	-34.96
Gypsum[3]	204,539	1	1,943,121	-13.71
Peat	45,697	4[4]	271,738	+33.20

[1]The sums of previously reported quarterly totals may not necessarily equal the annual totals reported here owing to the receipt of additional information or corrections to previously reported figures.
[2]These figures are preliminary and subject to change.
[3]*Tonnage sold* and *Value of tonnage sold* include material used for captive purposes. *Number of mines reporting sales* includes mines producing material for captive use only.
[4]Includes some mines which are producing multiple commodities.
[5]Includes solution mining.

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DIVISION OF GEOLOGICAL SURVEY

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