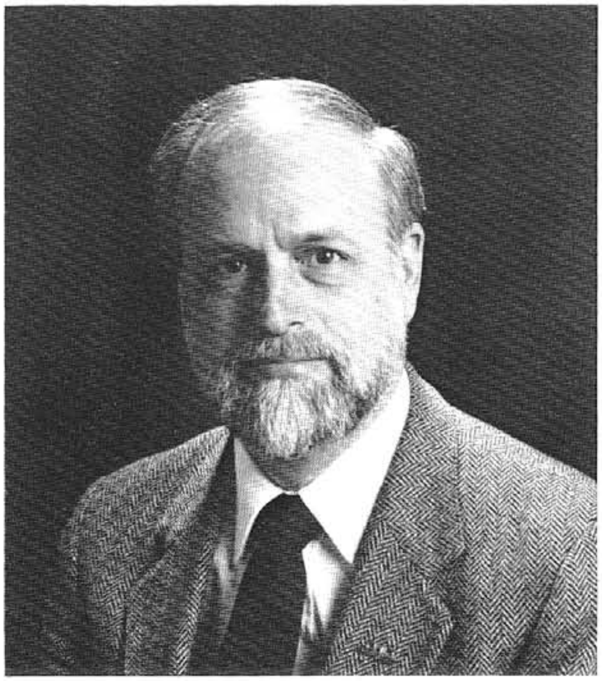
SPRING 1989

Ohio Geology Newsletter

Division of Geological Survey

THOMAS M. BERG, OHIO'S NEW STATE GEOLOGIST



Thomas M. Berg, 11th State Geologist of Ohio

Thomas M. Berg was appointed to the position of State Geologist and Chief of the Division of Geological Survey by Ohio Department of Natural Resources Director Joseph J. Sommer. The appointment became effective on March 13, 1989. Berg, the 11th State Geologist of Ohio since 1837, replaces Horace R. Collins, who retired on April 30, 1988.

Tom Berg comes to the Ohio Geological Survey with a diverse background and extensive experience in geology and administration acquired during nearly 25 years of service with the Pennsylvania Geological Survey. He served as Chief of the Geologic Mapping Division and as Associate State Geologist with that organization. Tom has authored or coauthored more than 40 geologic papers, reports, and maps on a variety of topics. Among these many contributions is the *Geologic map of Pennsylvania,* a project on which he served as chief compiler.

Tom was born in Vermillion, South Dakota, where his father was a law professor at the University of South Dakota. After World War II, Tom and his family moved to Boulder, Colorado, where his father taught law at the University of Colorado. In 1952, the Berg family moved to the Washington, D.C., area when Tom's father accepted a position as Administrative Assistant to Senator Wayne L. Morse of Oregon.

Upon graduation from high school, Tom enrolled at Johns Hopkins University in Baltimore, Maryland, and, after two years, transferred to the University of Colorado in 1960. Tom received a bachelor of arts degree in geology from the University of Colorado in 1962 and a master of science degree in geology in 1967. His master's thesis was titled *Pennsylvanian biohermal limestones of Marble Mountain, south-central Colorado.* While at the University of Colorado, Tom received two scholarship awards and an award from the Rocky Mountain Association of Geologists as outstanding graduate student.

Tom joined the Pennsylvania Geological Survey in 1965 and began mapping bedrock geology in the bituminous coal fields of western Pennsylvania. During the next 10 years, Tom did extensive mapping of both bedrock and surficial geology in the Valley and Ridge Province and the Pocono Plateau of Pennsylvania.

In 1975, Tom was appointed Senior Research Geologist and began work as the principal compiler of the *Geologic map of Pennsylvania.* He supervised other geologists in this work and was responsible for compiling the north-central region and several other areas of Pennsylvania. The new state map was published in 1980.

Tom was appointed to the position of Chief of the Geologic Mapping Division, the largest division in the Pennsylvania Geological Survey, in 1978. In this capacity he supervised field mapping projects and the Coal Section of the Survey.

In 1987, Tom was appointed Associate State Geologist of Pennsylvania while continuing as Chief of the Geologic Mapping Division. In this new capacity, he took on many additional policy-making and administrative duties.

Tom and his wife, Betty, have five grown children, four sons and one daughter, and one grandchild. Betty is in clinical nursing education and will be seeking employment in this field in Columbus as well as continuing her work towards a master's degree. Their children are pursuing careers or studies in architecture, computers, journalism, and photography. The sons reside in Pennsylvania and their daughter lives in Cincinnati.

Tom's hobbies include camping, hiking, and sailing. Much of his free time is spent serving as a Permanent Deacon in the Catholic Church.

Stratigraphy, sedimentology, and geologic mapping are three areas of geology in which Tom takes great interest and enjoyment. He is also interested in trace fossils and the history of geology. Tom's interest in history is an outgrowth of his fascination with origins—including the science of geology and his own family ancestry. His pursuit of genealogy has led him to Ohio roots in Hillsboro (Highland County), where his great-great-great grandfather settled on a farm in the 1830's.

Tom's plans for the Survey are based on his perception

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ODNR
OHIO DEPARTMENT OF NATURAL RESOURCES

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

OHIO GEOLOGY

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SO WHAT?

The first signals of spring and the annual renewal of Nature were visible as I drove into Ohio in March to begin my new career with the Ohio Geological Survey. The trees of the eastern Ohio hill country were just beginning to show a reddish tinge that accompanies the formation of buds, and I wondered if there was a message there for a geologist to share with fellow citizens. I think there is a powerful message for all of us to remember: *Nature does renew itself. But the processes of renewal of mineral resources are so slow, that humanity must always think of them as essentially nonrenewable.* As stewards of Earth, we humans must remember that every pound of coal, every quart of oil, every bag of sand, every shaker of salt—once taken from the earth—can never be replaced during our lifetimes by the slow processes of formation. Yes, most of us have heard about plate tectonics and how the continents move about the planet, forming mountain ranges, volcanoes, great rift valleys, and inland seas. These processes account for the rocks and minerals that we use on a daily basis, but millions upon millions of years pass during their formation. Geologists are so used to thinking in terms of millions and billions of years that they rarely talk to fellow citizens about geologic time and geologic processes. Just as it is important for people to know about biological processes like the budding of trees which help sustain life, it is important for people to understand geological processes and the abundance and limitations of rock and mineral resources.

State geological surveys are uniquely equipped to provide citizens with a full understanding of geological processes and geological resources that affect their daily lives. At the Ohio Division of Geological Survey, one of our most important methods of depicting geological processes and resources is through maps. We make maps showing the distribution of bedrock formations and surficial deposits. We make maps showing the location of coal seams and coal mines. We make maps showing how the bedrock is folded, faulted, and fractured—especially in the deep subsurface. We make maps showing where all the oil and gas wells are in Ohio. We make maps showing how the rock units change their character from one place to another. We make maps showing where landslides have occurred, and where they may occur again. We make maps of the present-day and historical Lake Erie shorelines and predict erosion-hazard areas. We make maps showing the thickness of glacial deposits. Our maps are very important in the exploration for ground water, an increasingly critical resource. We show the location of aggregate resources. We show the location of silica and clay resources. The list goes on and on. Today we are on the threshold of new technologies using computers to make maps and perform map operations which used to take months and years to do by hand.

In order to make maps that will serve Ohioans and help them locate and manage their nonrenewable mineral resources, our staff needs to build the geological "framework" for the state. Just as a physician needs to develop a detailed medical history and complete many diagnostic tests before surgery or other medical treatment can be carried out, so too the geologist needs to develop a detailed geologic history and carry out many sophisticated tests before a geologic map can be prepared.

Our friends in the media often play devil's advocate for taxpayers, to find out if their tax dollars are being well-spent. And I congratulate them for doing that. Citizens need to know if their taxes are being used for legitimate purposes. However, it is often difficult for a geologist to respond to the tough question: *"Yeah, so what?"* The geologist who had poured out hours, days, weeks, and months building the geologic framework and carefully drawing the formations on the geologic map sometimes feels disconcerted when asked: "What good is all this for the average citizen?" *That is why geologists today must become very good at communicating the worth of their research and mapping, and explaining the importance of their work for today's citizens and citizens many generations into the future.* It is as simple as this: Without the work produced by the state geological surveys, and by the U.S. Geological Survey, future generations will not know where to find the mineral resources, the water, and the fuels they need to exist. They will not know how to properly plan their use of the land. Some people have suggested that private industry could take over many of these research and mapping tasks. But no private organization could profitably undertake the broad scope of geological research conducted by a state geological survey. Sure, many site-specific investigations are carried out by private consulting firms; indeed, that is their function. But what private firm would release its hard-earned information at no charge to the public? What profit-making organization would conduct the research for a statewide geologic map to be published and released only for the cost of printing? Tax-supported geological surveys benefit *all* citizens, not just a privileged few who can afford to pay for them. In fact, this concept was the major justification for reactivating the Second Geological Survey of Ohio in 1869. Privatization of state geological survey operations would never work because only a few citizens would benefit. State geological surveys are increasingly called upon to protect the public interest by providing unbiased information and judgment regarding geological work being done for the public by private industry. Is a proposed landfill safely located? Is a toxic-waste facility going to affect a municipal water supply? Is a planned wellfield for a new suburban development going to dry up an important wetland and unique habitat? All geological surveys and their partner agencies in state government are beset by enormously growing demands to pass judgment on such critically important environmental and engineering questions. These questions are being answered, but generally few citizens know how much the geological survey served their needs.

The problem is that state geological surveys don't have a large, vocal constituency. Critical social problems having immediate human-survival implications have advocates who speak out loudly and clearly. Governments commit tax dollars for the most immediately critical needs. The geological needs of future generations are longer ranging and simply do not rank as high when budgets are set.

In one corner of my office stands an Ohio Geological Survey flag bearing the inscription: "Geology serves Ohio." I want our readers to know that I am a lifelong public servant—and I enjoy it. I get a thrill out of making my science serve the people. What is even more thrilling for me has been to discover that my staff in Columbus and in our Lake Erie Office in Sandusky share that mindset and personal conviction. Despite serious budgetary constraints, the Division of Geological Survey in the Ohio Department of Natural Resources is committed to serving all Ohioans today and for many years into the future. I challenge all Ohioans to become fully aware of their geological environment and the commonly fragile nature of their nonrenewable mineral resources. We are committed to helping our citizens understand the importance of geology and to answering the question: *"So what?"*

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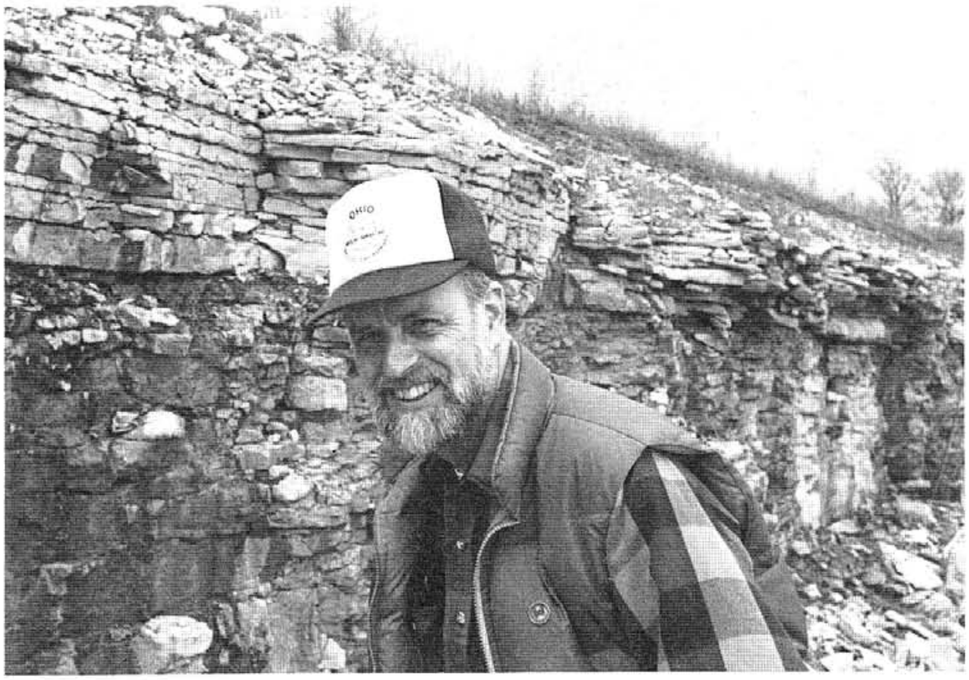


Tom Berg pursues his keen interest in field geology at an outcrop of Brassfield Limestone in a Warren County quarry.

that geology is an exciting and important discipline. He is firmly committed to increasing public awareness of the importance of geology and geologists in the formulation of public policy on mineral resources and environmental issues. He also wants the Survey to serve the public in the best and most efficient manner possible.

Some of his goals (which are expanded upon in the accompanying editorial column, *From the State Geologist . . .*,) include close relationships with mineral industries, state and federal agencies, and universities. Computerization of Survey records, rapid publication of Survey reports, and, in the near future, a new bedrock geology map of Ohio are also among his goals. Tom is also committed to increasing the Survey's budget through alternative funding sources.

Tom Berg brings experience and enthusiasm to the Division of Geological Survey, and he assumes leadership of an organization with a long and rich tradition of service to the citizens of Ohio. The fiscal, organizational, and scientific challenges ahead are formidable, perhaps, but Tom welcomes them.

—Michael C. Hansen

LANDBAN PROGRAM

The Division of Geological Survey has received funding from the Ohio Environmental Protection Agency to review the geology at Class I injection-well sites in Ohio. This program, known as LANDBAN, is mandated by the U.S. Environmental Protection Agency in order to regulate the disposal of nonradioactive hazardous wastes in deep injection wells. Survey geologist Lawrence H. Wickstrom is administering the program for the Survey. Under contract to the Survey, Dr. E. Scott Bair of the Department of Geology and Mineralogy at The Ohio State University is reviewing the hydrologic computer models of the injection-well sites.

There are currently 15 permitted Class I injection wells in Ohio operating at seven separate locations. Thirteen of these wells are injecting wastes that are considered hazardous under the new USEPA regulations. Industrial and hazardous wastes disposed of through deep-well injection in Ohio are by-products of chemical and fertilizer production and metal alloying. An overview of the geology and operation of Class I injection-well sites in Ohio will be presented in a future issue of *Ohio Geology*.

—Lawrence H. Wickstrom
Subsurface Geology Section

CAESAR CREEK FOSSIL GUIDE AVAILABLE

Division of Geological Survey Open-File Report 87-1, *Guide to the fossils and geology of Caesar Creek State Park*, by Survey geologist Douglas L. Shrake, has been revised and reprinted. This 20-page book describes the Ordovician rocks and common fossils found in the Caesar Creek State Park area of Warren County. Particular emphasis is given to the rocks and fossils found along the emergency spillway at Caesar Creek dam. Open-File Report 87-1 is available from the Division of Geological Survey for $2.86, which includes tax and mailing.

COAL-BED ANALYSES: ASH AND SULFUR

Since 1975 the Division of Geological Survey has published or republished nearly all of its coal chemical analyses. Four Survey Information Circulars (IC 47, IC 50, IC 52, IC 55) collectively contain 1,619 analyses of coal, the earliest dating back to 1906. Over 1,000 of these analyses can be considered representative of the whole-bed or production bench. The remainder are analyses of upper or lower benches or cores which do not penetrate the entire thickness of the coal. Analyses of 88 additional samples can be found in Open-File Report 82-2. In this report, 10 are benched or oxidized samples and 78 are representative of the whole bed.

This article points out the need for more coal chemical data, especially ash and sulfur forms, for Ohio's most productive coal beds and presents possible uses for these data once they have been obtained.

ASH AND SULFUR AVERAGES AND PYRITIC/ORGANIC SULFUR RATIOS

Table 1 shows a breakdown of the number of analyses of ash, total sulfur,

TABLE 1.—NUMBER OF ASH AND SULFUR-FORM ANALYSES FOR THE MOST PRODUCTIVE COAL BEDS IN OHIO

Seams, in order of decreasing production (1986)	Number of ash analyses	Number of total sulfur analyses	Number of pyritic sulfur analyses	Number of organic sulfur analyses
Pittsburgh (No. 8)	148	147	72	71
Middle Kittanning (No. 6)	262	262	168	146
Meigs Creek (No. 9)	84	84	29	29
Clarion (No. 4A)	70	70	50	38
Lower Kittanning (No. 5)	166	166	134	111
Lower Freeport (No. 6A)	56	56	50	47
Waynesburg (No. 11)	34	34	22	19
Brookville (No. 4)	39	39	31	29
Upper Freeport (No. 7)	115	115	59	54
Redstone (No. 8A)	28	28	20	20
Washington (No. 12)	5	5	4	3
Harlem	6	6	5	5
Sharon (No. 1)	11	7	6	6
TOTAL	1,024	1,019	650	578

pyritic sulfur, and organic sulfur for the top 13 producing beds (based on 1986 production) in Ohio. There are significantly more ash and total sulfur analyses than pyritic and organic sulfur analyses for many of the beds because (1) the tendency prior to the early 1970's was to analyze only for total sulfur, and (2) the organic sulfur value is obtained by subtracting the pyritic and sulfate sulfur from the total sulfur. It is also apparent from table 1 that the Survey has very few ash and sulfur analyses on individual coal beds. For example the Survey only has 147 representative coal-bed sulfur determinations on the Pittsburgh (No. 8) coal. In comparison, the Illinois State Geological Survey has 1,294 analyses on the Herrin coal, the most productive bed in Illinois. Many more chemical analyses of the Pittsburgh coal probably exist, but they are scattered throughout the files of many private companies and labs and are in most cases not available to the public. Other analyses exist in files and publications of federal agencies such as the U.S. Geological Survey, the U.S. Bureau of Mines, and the Pittsburgh Energy Technology Center.

Table 2 lists the averages for ash and total, pyritic, and organic sulfur for the 13 most productive beds (based on 1986 production) in Ohio. Two other values are shown in this table, the pyritic/organic sulfur ratio and the estimated recoverable reserves. The reserve figures are rough updates of the values published in 1960 in Survey Bulletin 58. Presently, much of the pyritic sulfur in Ohio coal can be removed using modern washing techniques. Organic sulfur is much more difficult to eliminate and cannot as yet be economically removed with precombustion sulfur-removal techniques. Therefore, the pyritic/organic sulfur ratio is important to the coal producer. High ratios for a specific coal suggest that physical washing methods will be successful in removing a high percentage of the

TABLE 2.—SULFUR AND ASH DATA FOR THE MOST PRODUCTIVE COAL BEDS IN OHIO

Number of samples used to determine the averages are shown in table 1

Seams, in order of decreasing production (1986)	Average percent				Pyritic/organic sulfur ratio	Estimated recoverable reserves (tons)
	Total sulfur	Pyritic sulfur	Organic sulfur	Ash		
Pittsburgh (No. 8)	10.58	4.24	2.56	1.67	1.53	1.9 billion
Middle Kittanning (No. 6)	9.12	3.48	2.07	1.47	1.41	3.5 billion
Meigs Creek (No. 9)	13.04	4.00	1.69	1.85	0.91	1.1 billion
Clarion (No. 4A)	12.89	4.19	2.41	1.59	1.52	0.5 billion
Lower Kittanning (No. 5)	11.19	4.50	3.16	1.44	2.19	1.4 billion
Lower Freeport (No. 6A)	11.82	3.72	2.51	1.19	2.41	1.0 billion
Waynesburg (No. 11)	17.31	2.93	1.64	1.12[1]	1.46	0.02 billion
Brookville (No. 4)	12.60	3.15	1.87	1.35	1.39	0.2 billion
Upper Freeport (No. 7)	11.01	3.11	2.21	0.91	2.43	4.0 billion
Redstone (No. 8A)	12.34	3.52	2.44	1.15	2.12	0.3 billion
Washington (No. 12)	28.30[1]	2.41[1]	1.42[1]	0.82[1]	1.73	0.3 billion
Harlem	8.72[1]	0.97[1]	0.50[1]	0.49[1]	1.02	0.02 billion
Sharon (No. 1)	10.01[1]	0.84[1]	0.50[1]	0.38[1]	1.32	0.03 billion

[1]Averages based on fewer than 20 samples.

total sulfur content of that coal. With the development of advanced physical coal cleaning (APCC) technologies, knowledge of this ratio will be even more helpful to the coal industry. From table 2 it is apparent that the Upper and Lower Freeport coals have large reserves remaining and also should be good candidates for APCC processes because of their high pyritic/organic sulfur ratio and low organic sulfur content. On the other hand, the Meigs Creek coal, which has large reserves, does not appear to be a good candidate for physical cleaning because so much of its sulfur is in the organic form.

OHIO'S HIGH-SULFUR COALS

Unfortunately, very few of Ohio's coals can meet the New Source Performance Standards for SO_2 emission, issued by the U.S. Environmental Protection Agency in 1979, even if all the pyritic sulfur is removed from the coal before combustion. For example, a large electric utility plant built in Ohio after September 1978 and burning Upper Freeport (No. 7) coal with 3.11 percent total sulfur, 2.21 percent pyritic sulfur, and an average Btu content of 13,000 Btu/lb would liberate approximately 4.78 lbs of SO_2 per million Btu. By law, for this particular coal, 87 percent of the SO_2 must be removed from the raw coal so that a ceiling limit of 0.60 lb of SO_2 per million Btu can be reached. If all the pyritic sulfur were removed prior to combustion in this example, the SO_2 production would be 1.38 lbs of SO_2 per million Btu, more than twice the amount allowed by law. On average, the remaining 12 seams in table 2 would produce even more SO_2 after removal of pyrite. Within the next five years these restrictions may become even more severe; hence the necessity for eliminating the organic sulfur as well as the pyritic sulfur from Ohio's coal becomes obvious. Although removal of pyritic sulfur is only a partial solution to Ohio's SO_2 problem, it is currently easier and less expensive to remove pyritic sulfur with precombustion techniques than it is to remove organic sulfur. Thus, coal beds with high pyritic/organic sulfur ratios, under ideal conditions, should be more desirable for physical cleaning than those with low ratios. Additionally, samples with the lowest organic sulfur content will be valuable because smaller amounts of sulfur will have to be removed by nonphysical methods such as chemical cleaning, fluidized-bed combustion, or postcombustion processes.

One of the Survey goals in the next several years is to convince private companies and labs to contribute their coal chemical data to the Division's database. Data from federal agencies, where appropriate, also will be entered into the database. The Survey has received a USGS grant to computerize its coal information files and add to the Survey's coal-related database (see article elsewhere in this issue).

Much of the coal-quality data in the Survey files is clustered in specific areas of the state. Of the 72 pyritic sulfur analyses for the Pittsburgh (No. 8) coal, 25 are from Belmont County. In order to make valid maps and interpretations of the data, point-source information on a coal must be as evenly distributed as possible over the entire area of the coal bed. The computer analysis technique called kriging can be used to delineate areas where more data are needed; such analysis eliminates the possibility of weighting clustered points too heavily and most importantly can be used to construct statistically rigorous computer contour maps showing trends in sulfur and ash values. This method could also be used to predict coal thicknesses, ash fusion temperatures, and other physical or chemical point-source data.

—Richard W. Carlton
Regional Geology Section

THE VALUE OF MONEY

What weighs 200 pounds, looks like green spaghetti, and gives new meaning to the phrase "Money is like muck, not good except it be spread" (Francis Bacon, from *Of Seditions*)? The answer to this riddle is a lost-circulation material or plugging agent composed of approximately 93,600 shredded dollar bills.

This riddle is one result of a 5,380-foot core hole drilled into Precambrian sedimentary rocks near Lytle, Warren County, Ohio, by the Division of Geological Survey. This hole (DGS 2627), only the second continuously cored hole drilled into the Precambrian in Ohio, is a success of extraordinary note. Two familiar sayings with respect to money—"It takes money to make money" and "That's money down the drain"—both describe the completion of DGS 2627. It took money, lots of money—approximately 200 pounds of shredded money—pumped literally down the hole as an unconventional drilling-fluid additive to successfully complete this core hole.

The need for a plugging agent in this core hole began at a depth of 1,804 feet when the return water circulation of the hole was lost owing to the high vugular porosity and numerous open fractures in the Knox Dolomite (Cambrian-Ordovician). The degree of lost circulation increased over the next 40 feet of drilling to the point where the drilling fluid was lost entirely to the dolomitic formation whenever the drill rig's water-pumping station was shut off and the drill-rod connection was broken. This situation necessitated that the inner core barrel (sample tube) be mechanically lowered and seated into the outer core barrel rather than allowed to free fall through the normally fluid-filled drill rods, thus adding significantly to the turnaround time between core runs.

At this point several unsuccessful attempts were made to restore circulation using a combination of bentonite clay, liquid and granular polymers (compounds used to increase drilling-fluid viscosity), and mica flakes (a common plugging agent) in varying concentrations. Other standard plugging agents of varying particle size and type such as shredded cellophane, organic fibers, and wood chips were not tried because of certain restrictions, such as the small annular space (the space between the outside of the drill pipe and the rock) in a 3-inch-diameter core hole and the small size of the rig's water-pumping station. Experience has shown us that we may have to use less than the recommended specified concentration of common plugging agents in our drilling fluid to avoid plugging up either the water pump or the annular space of the core hole; as a result, the drilling fluid is of ineffective plugging consistency. Cement is another type of lost-circulation material which may successfully seal off fluid-robbing vugs, cavities, and open fractures. However, cement, which is used generally in severe cases of lost circulation, was not employed due to the expense of materials, labor, and the amount of down time involved.

The only method to regain circulation, if it is not restored through the use of plugging agents, is to set casing through the lost-circulation zone. However, this idea was dismissed because the Survey lacks enough 3½-inch-diameter surface casing to reach a depth of 1,840 feet. Also, geophysical logs from nearby oil and gas wells (the closest is 2 miles away) indicated numerous zones of high porosity over an additional 860 feet of the Knox Dolomite; each of these high-porosity zones would have the potential to cause loss of circulation and would need to be cased off. Casing off the entire high-porosity interval could be accomplished by setting 3-inch-diameter drill rods as an intermediate casing string and completing the hole with smaller diameter drill rods. Each successive lost-circulation zone encountered in the Knox would be sealed off by advancing the intermediate casing string. This is an effective, yet potentially very time consuming, multi-step process. Therefore, the Survey elected to drill "blind" (that is, pump enough drilling fluid to cool the bit and lift the cuttings into the zone of loss) through the Knox Dolomite and then set the 3-inch drill rods as an intermediate casing string in a single-step process to complete the hole to the Precambrian.

After drilling blind another 190 feet into the Knox, the complete loss of drilling fluid to the formation and, to a lesser degree, the accumulation of cuttings in the hole caused two surface-set diamond core bits to be destroyed while drilling the interval between 2,020 and 2,030 feet. Apparently the formation porosity was such that all or nearly all the drilling fluid was escaping to the formation, leaving an insufficient amount of fluid to flush and cool the face of the diamond core bit. Circulation had to be restored if core drilling was to continue.

With few options remaining, consideration returned to the utility of a lost-circulation material, in particular an unconventional drilling-fluid additive, such as shredded money. The idea of using shredded money as a plugging agent is not original with the Survey, but it is not a common or well-known practice. The Survey learned of the practice in a seminar on drilling-fluid technology sponsored several years ago by Wright State University.

Shredded money, courtesy of the Federal Reserve Bank, Cincinnati Branch Office.

Survey driller Mike Mitchell tamps in shredded money to be used as a lost-circulation material. The shredded money is placed into drill pipe by driller's helper Mark Clary.

In order to experiment with the method, the Survey received permission from the Board of Governors of the Federal Reserve Bank to obtain approximately 200 pounds of shredded paper currency—money that is routinely destroyed by the federal government when the currency is considered to be excessively worn, damaged, defaced, or otherwise unfit for circulation. The money consisted of approximately 93,600 dollar bills of various denominations shredded lengthwise (468 bills weigh approximately 1 pound) and appeared much like green spaghetti. Because of their high linen content, dollar bills do not readily degrade in water and remain sufficiently intact to plug the voids in a formation without plugging the annular space in a core hole. To overcome the limitation of pumping such material through a relatively small pump, the shredded money was "loaded" directly into the drill pipe by loosely inserting numerous handfuls with a 4-foot dowel rod, a method similar to muzzle loading a musket. To facilitate the movement of the shredded money down the drill pipe and of the money and cuttings up the annular space of the core hole, 1-2 gallons of liquid polymer were poured into the drill pipe immediately preceding the loading of the shredded money. This load of shredded money and liquid polymer was then pumped down the drill pipe and into the annular space of the hole and the voids of the formation while the drill pipe was rotated slowly. This procedure was repeated several times until the void spaces within the bedrock were plugged and circulation was restored. At this point, core drilling was resumed. Periodically more shredded money and polymer were pumped into the core hole to maintain circulation as successive lost-circulation zones were encountered. When the base of the Knox Dolomite was reached, the intermediate casing string of 3-inch drill rods was set, thereby sealing off the hole and the problematic Knox Dolomite at a depth of 2,700 feet.

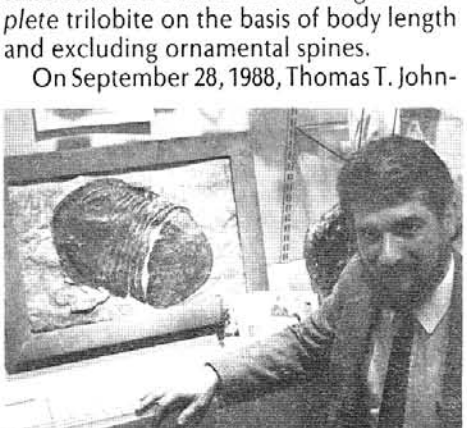
The use of shredded money as a lost-circulation material insured the successful completion of the core hole 1,980 feet beyond its original target depth of 3,400 feet (the depth at which Precambrian crystalline rock was expected to be encountered). However, instead of drilling into Precambrian metamorphic or igneous rocks, the Survey cored 1,910 feet into an unexpected lithic sandstone. This newly discovered, massive sandstone formation, pre-Mount Simon (Cambrian) in age, is associated with an apparent rift system in the Precambrian basement rocks of western Ohio. An 8-mile-long seismic line running east-west through the drill site suggests that this sandstone body may be approximately 3,500 feet in thickness. Core drilling reached TD (total depth) at 5,380 feet, 100 feet beyond the mile mark. More than 1,900 feet of this impressive addition to Ohio's stratigraphy has been cored. A more comprehensive treatment of the importance to Ohio geology of this core hole will be reported in a future issue of *Ohio Geology.*

—Douglas L. Crowell
Regional Geology Section

LARGE *ISOTELUS* FOUND

Until recently, the Huffman Dam (near Dayton) specimen of Ohio's official state fossil, *Isotelus*, was considered to be the largest complete trilobite ever found. This specimen, which resides in the National Museum of Natural History at the Smithsonian Institution in Washington, D.C., is 14.5 inches long (see *Ohio Geology*, Summer 1985). Larger trilobites did exist, most notably *Terataspis* from the Devonian of North America and *Uralichas* from the Ordovician of Portugal. Each of these trilobites is estimated to have reached about 28 inches in length, including a lengthy posterior spine. However, it is unclear whether either of these trilobites is known from complete specimens or if their measurements are estimates based solely on partial specimens. So, for the purpose of bragging rights (with qualifications, of course), *Isotelus* could be considered the largest *complete* trilobite on the basis of body length and excluding ornamental spines.

On September 28, 1988, Thomas T. Johnson of Morrow, Ohio, discovered a 16-inch-long specimen of *Isotelus* in Ordovician rocks temporarily exposed at a construction site in Montgomery County. Johnson's specimen is larger than the Huffman Dam specimen and almost holds the unofficial record for the "world's largest complete trilobite."



Thomas T. Johnson exhibiting 16-inch Isotelus *specimen from Montgomery County at "What on Earth" in Columbus.*

The record is held, apparently, by a 16.9-inch specimen of *Isotelus* from Upper Ordovician rocks exposed along the shore of Hudson Bay near Churchill, Manitoba. This specimen, illustrated in 1988 in the journal Palaeogeography, Palaeoclimatology, Palaeoecology (v. 65, p. 93-114), resides in the National Type Fossil Collection at the Geological Survey of Canada in Ottawa. Although this specimen beats Johnson's specimen by a nose (technically, a glabella), it is not nearly as well preserved because of exposure to the elements along the Hudson Bay shore.

Johnson, who is a professional trilobite collector, suspects that even larger specimens of *Isotelus* lie buried in Ordovician rocks of Ohio. Isolated pieces of exoskeleton of *Isotelus* suggest that specimens as large as 20 inches in length may one day be discovered.

Trilobite collectors such as Johnson and Dan Cooper of Fairfield, Ohio, look for large *Isotelus* specimens by excavating in fresh shale. The exoskeletons of large individuals of this trilobite are so thin and fragile that exposure to air and moisture destroys the specimen almost immediately. This fragility explains why large *Isotelus* specimens are not commonly discovered lying on the surface of an outcrop.

Johnson has been conducting a "dig" for *Isotelus* specimens at Caesar Creek State Park, in Warren County, on property maintained by the U.S. Army Corps of Engineers. All specimens recovered by Johnson are being incorporated into the collections of the Smithsonian Institution. Survey geologists Gregory A. Schumacher and Douglas L. Shrake have been conducting a study of the mode of deposition of the trilobites and other fossil remains found at the Caesar Creek site.

Dan Cooper owns several acres of land in Highland County at which he carries out periodic excavations for *Isotelus* and other fossils in the Ordovician Arnheim Formation. Cooper has found complete *Isotelus* specimens up to 10 inches in length at this site.

Through the diligent efforts of dedicated collectors such as Johnson and Cooper, Ohio may one day recapture the honor of being the source for the "world's largest complete trilobite." After all, it is our state fossil.

—Michael C. Hansen

SURVEY AWARDED COAL GRANT

The Division of Geological Survey recently received $15,000 from the U.S. Geological Survey (USGS) to enter stratigraphic data for 170 cores and 500 stratigraphic sections into the USGS National Coal Resources Data System (NCRDS). Most of the grant money will be used to purchase a computer system capable of storing and manipulating a large coal database and of producing sophisticated maps and cross sections from coal-related data. Ultimately, the Survey intends to computerize information on over 10,000 measured stratigraphic sections and approximately 2,500 cores from coal-bearing areas of the state. Many chemical analyses of Ohio coals already in the NCRDS database will be readily accessible with the new computer equipment. All of the Survey's 1,619 coal analyses and any new analyses will be entered into the computer databases.

The coal-bed crop line for the Lower Kittanning (No. 5) coal in Mahoning County will be digitized as part of this project. This preliminary study will familiarize Survey personnel with the digitizing equipment and techniques. Long-range plans include digitizing of all the major coal-bed crop lines in Ohio. From these digitized crop lines and other computerized information, coal reserves, distribution of sulfur forms, ash distribution, and many other types of maps can be drawn. This program will be a significant contribution of Ohio coal data to the national program and will increase the capabilities of the Survey to provide coal data, cross sections, and maps to industry and the public.

RICHARD P. GOLDTHWAIT RECEIVES MATHER MEDAL

Richard P. Goldthwait, right, receives the Mather Medal from Michael C. Hansen of the Division of Geological Survey.

The Mather Medal of the Division of Geological Survey was awarded to Dr. Richard P. Goldthwait, Emeritus Professor of Geology and Mineralogy at The Ohio State University, on April 13, 1989, at a dinner held in his honor at the Faculty Club at Ohio State. The ceremonies were in conjunction with the Bownocker Lectures sponsored by the Department of Geology and Mineralogy.

The Mather Medal recognizes significant, lifelong contributions to the geology of Ohio and is named after William Williams Mather, Ohio's first State Geologist (1837-1838) (see *Ohio Geology*, Winter 1987). The first Mather Medal was awarded in 1987 to Dr. Myron T. Sturgeon. Goldthwait is the second recipient of the medal.

The Mather Medalist is selected by the Mather Medal Committee of the Survey from nominations submitted by Survey staff. The 1989 Mather Medal Committee is composed of C. Scott Brockman, Philip J. Celnar, Merrianne Hackathorn, Michael C. Hansen, and Lawrence H. Wickstrom.

Dr. Goldthwait received the Mather Medal for his outstanding work on the Pleistocene geology of Ohio. The medal was presented by Michael C. Hansen, chairman of the Mather Medal Committee.

Richard P. Goldthwait was born in New Hampshire, where his father was a professor of geology at Dartmouth College. He received a bachelor's degree from Dartmouth in 1933 and master's (1937) and Ph.D. (1939) degrees from Harvard University. He taught geology at Brown University (1939-1943) and served with the U.S. Army Air Force (1943-1946). From 1944 to 1946 Dr. Goldthwait was stationed at Wright Field in Dayton.

In 1946, the late George W. White, another noted glacial geologist and former State Geologist of Ohio (1946-1947), recruited Dick Goldthwait for the Ohio State faculty, where he remained until his retirement in 1977. Soon after his arrival at Ohio State, Dick began his long career of investigating the glacial geology of Ohio.

In 1947, Dr. Goldthwait began work on the glacial deposits in Ohio for the Division of Water. He spent the summers of 1950-1955 in the field for the Division of Geological Survey. In 1950, he published the first of more than 30 papers on the Pleistocene geology of Ohio. Throughout his tenure at Ohio State, Dr. Goldthwait had numerous students who did theses or dissertations on Ohio glacial geology.

Perhaps the most significant of Dr. Goldthwait's Ohio publications was the *Glacial map of Ohio*, published in 1961 by the U.S. Geological Survey, and coauthored by George W. White and Jane L. Forsyth.

Dick Goldthwait was among the first to use carbon-14 dating to help decipher the complex glacial stratigraphy in Ohio. Much of the present knowledge of glacial geology in western Ohio is through the efforts of Dick Goldthwait and his students.

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SURVEY STAFF NOTES

Mark T. Baranoski

Ronald A. Riley

Mark Baranoski is a geologist in the Subsurface Geology Section and has been working on the Survey's Gas Research Institute-sponsored project on Devonian shales in southern Ohio. Mark is originally from Toledo and received bachelor's and master's degrees in geology from the University of Toledo. He spent three years with Gulf Oil in Casper, Wyoming, and one year in consulting in the Michigan Basin before coming to the Survey in 1985.

Mark's particular interest is structural geology and the mapping and interpretation of joint patterns. He enjoys using computers to carry out such investigations.

Mark and his wife live in Columbus and enjoy travel. Mark's hobbies include restoration of old houses and cars.

Ron Riley is a geologist in the Subsurface Geology Section, a position he has held since 1985. Ron is originally from West Carrollton (Montgomery County) and holds a bachelor's degree in geology from Miami University and a master's degree in geology from Bowling Green State University. He worked for five years in petroleum exploration with Texaco in Tulsa, Oklahoma, and Denver, Colorado, prior to joining the Survey staff.

Most of Ron's efforts at the Survey have been with the Gas Research Institute-sponsored study of Devonian shales in southern Ohio. He enjoys working with a variety of people at the Survey and the challenges of petroleum geology.

Ron is a Columbus resident. His hobbies include fishing, snow skiing, tennis, and volleyball.

SURVEY STAFF CHANGES

COMINGS

- Thomas M. Berg, Division Chief and State Geologist.
- Barbara M. Cain, Administrative Secretary.

GOINGS

- Allan T. Luczyk, Environmental Technician, Subsurface Geology Section, to Division of Oil and Gas.

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Dr. Goldthwait's 1959 presidential address to the Ohio Academy of Science, *Scenes in Ohio during the last ice age*, was published in the Ohio Journal of Science (v. 59, p. 193-216) and is a fascinating, detailed, highly readable account of the Wisconsinan glaciation in Ohio.

Dr. Goldthwait's studies of the glacial grooves on Kelleys Island were initiated after a section was exposed by the Ohio Historical Society in 1972 (see *Ohio Geology*, Spring 1988). He explained the probable origin of these complex and intricate features by suggesting that they were carved by erratics frozen in the base of the glacier.

The Mather Medal honors Dr. Goldthwait for his significant work in Ohio, but he has gained international fame for his studies of glaciers throughout the world, including both polar areas. Dr. Goldthwait was the founder and first director of the Institute of Polar Studies (now Byrd Polar Institute) and has received such honors as the Antarctica Medal, Outstanding Quaternary Scientist, and the first Distinguished Career Award from the Geological Society of America. He also had an Antarctic mountain and the library of the Byrd Polar Institute named after him.

Dr. Goldthwait's long and productive career has greatly benefited the citizens of Ohio. The results of his field studies have influenced the exploration and development of ground water and sand and gravel deposits and are a basis for land-use planning. Richard P. Goldthwait's contributions to Ohio geology have been immense. The Division of Geological Survey is honored to recognize his achievements by presentation of the Mather Medal.

—Michael C. Hansen

QUARTERLY MINERAL SALES, OCTOBER—NOVEMBER—DECEMBER 1988

compiled by Sherry W. Lopez

Commodity	Tonnage sold this quarter[1]	Number of mines reporting sales[1]	Value of tonnage sold[1] (dollars)
Coal	8,881,332	187	244,762,313
Limestone/dolomite[2]	11,788,415	98[3]	42,151,755
Sand and gravel[2]	10,898,739	203[3]	33,909,364
Salt	1,111,912	4[4]	14,107,346
Sandstone/conglomerate[2]	383,118	24[3]	6,424,190
Clay[2]	423,681	27[3]	991,126
Shale[2]	495,617	21[3]	491,631
Gypsum[2]	61,331	1	420,117
Peat	9,067	1	41,960

[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.

1988 OHIO MINERAL SALES[1]

compiled by Sherry W. Lopez

Commodity	Tonnage sold in 1988[2]	Number of mines reporting sales[2]	Value of tonnage sold[2] (dollars)	Percent change of tonnage sold from 1987[2]
Coal	31,957,414	215	979,071,998	-4.1
Limestone/dolomite[3]	43,719,012	108[4]	158,290,910	-3.0
Sand and gravel[3]	42,046,097	245[4]	134,466,907	+6.0
Salt	3,680,236	5[5]	39,214,399	+9.5
Sandstone/conglomerate[3]	1,716,646	28[4]	29,646,186	-9.1
Clay[3]	1,869,471	34[4]	3,695,626	+35.9
Shale[3]	2,300,483	26[4]	2,923,952	+15.1
Gypsum[3]	239,828	1	1,573,208	-6.4
Peat	24,577	4	115,719	-29.0

[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.

EDITOR'S NOTE

Readers of *Ohio Geology* may have noted some changes in the newsletter beginning with the Winter 1989 issue. We have gone to an 8½- by 11-inch page size and a three-column format for interior pages. With this issue, we've added a bit of color. We think that these changes improve the readability of the newsletter, and they allow us greater flexibility with illustrations. Comments on *Ohio Geology* are always welcome.

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