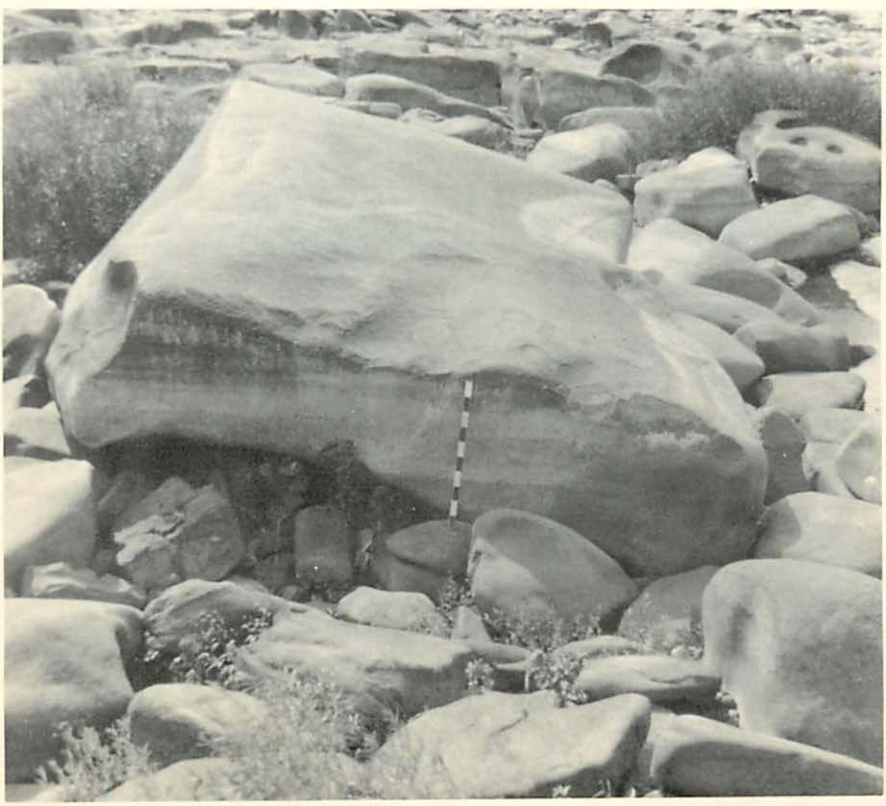
VOL. 24, NO. 2

Pennsylvania GEOLOGY



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ON THE COVER

An accumulation of diabase blocks on the bed of the Susquehanna River at Conewago Falls, northwestern Lancaster County. The blocks were presumably moved by catastrophic flow created by an outburst of glacial Lake Lesley during pre-Illinoian glaciation (see article on page 2). Upstream is to the right. The large block is 30 by 15 by 3 feet; intervals on the scale are 10 cm. Photograph by W. D. Sevon.

PENNSYLVANIA GEOLOGY

PENNSYLVANIA GEOLOGY is published quarterly by the Bureau of Topographic and Geologic Survey, Pennsylvania Department of Environmental Resources, P. O. Box 8453, Harrisburg, PA 17105-8453.
Editors, Christine M. Dodge and Donald M. Hoskins.
Contributed articles are welcome; for further information and guidelines for manuscript preparation, contact D. M. Hoskins at the address listed above.
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VOL. 24, NO. 2 **SUMMER 1993**

STATE GEOLOGIST'S EDITORIAL

The Rocks of Summer

Pennsylvania's summers generally produce a natural cycle of lessened rainfall and lowered streamflow during which rocks, normally obscured by winter's ice and spring's high water, become more apparent along our stream courses. The "ribs" of Pennsylvania, the many rock layers tilted to expose their edges by internal earth stresses over 200 million years ago, begin to appear in south-central and eastern Pennsylvania streams as riffles and rocky impediments to small water craft. Many Susquehanna River canoeists are familiar with scraping their hulls and forced portages over the "rocks of summer." In many reaches of the Susquehanna River, hard, erosion-resistant quartzitic rocks are sufficiently well exposed to allow one to cross the riverbed without becoming significantly wet.

In another area on the Susquehanna, described herein in the article "River on a Rampage," an unusually scenic and photogenic assemblage of rocks becomes accessible for the adventurous hiker during the summer. At Conewago Falls, south of Three Mile Island, diabase, an igneous rock, underlies and impedes the Susquehanna's flow as the normal bed of the river is constricted to 20 percent of its upstream width. The diabase is here pocked by uncounted numbers of large and small potholes. There are also many large blocks containing potholes, some large enough to allow adult persons to crawl from bottom to top. The river-sculpted shapes in the diabase include bowls and tubs in which to sit, as well as wave and ripple-like forms more commonly seen in seashore sand. Here they occur in very hard rock.

The many "rocks of summer" provide more benefits than hindrances. Fishermen use them for better foot access to offshore fishing holes. Visitors to Pennsylvania stream shores appreciate the beauty of their form. Geologists use them to interpret facets of recent and ancient earth history. Whatever is your pleasure or inclination, the "rocks of summer" provide relaxation and enjoyment when Pennsylvania rivers run low and slow.

Donald M. Hoskins

Donald M. Hoskins
State Geologist

RIVER ON A RAMPAGE

by W. D. Sevon
Pennsylvania Geological Survey

Sometimes we can't see the forest because of the trees. Many of us understand that old adage through personal experience. The extraordinary may be so obvious that we overlook it. Such was the case with me and the blocks at Conewago Falls. During many traverses of the falls while studying the geology, I focused narrowly on the prominent potholes and the more subtle ripple forms eroded into the diabase. Then one day I walked the same ground searching only for the best route for a field trip. Suddenly, I noticed the blocks. They are enormous! Blocks of diabase bigger than automobiles litter the surface. And they definitely have been moved. But how? Certainly not during a normal flood of the Susquehanna River. Visions of Washington State's famous channeled scablands jumped to mind. Thus began another adventure in the geology of Pennsylvania.

GEOLOGIC SETTING. A Jurassic-age diabase sill in northwestern Lancaster County, Pennsylvania, just south of Three Mile Island (Figure 1), is made up of a tough, erosionally resistant rock that forms the bed of the Susquehanna River in the area of the low Conewago Falls. The lithologically homogeneous diabase separates into slabs along parting planes that have a low (<10 degrees) north dip and a spacing generally between 2 and 5 feet. These partings parallel the bedding dip of local Triassic-age bedrock. The diabase is broken also by joint planes that are oriented more or less northeast-southwest and northwest-southeast. The joints are variably but widely spaced. The diabase is bounded on top and bottom by hornfels and separates sandstones, siltstones, and shales of the Triassic-age New Oxford Formation (below) and Gettysburg Formation (above). Conewago Falls is a popular fishing area entered through the Falmouth Fish Commission Access. It is known also for potholes and other exotically sculptured forms that have been eroded into the diabase (Sevon, 1989).

For convenience, the falls is divided into three parts: right bank, left bank, and center (Figure 2). Both sides of the river have bank-marginal channels in which the diabase has been eroded several feet below the level of diabase in the near-bank and central areas. Diabase in the near-right-bank and right-bank channel areas is un-

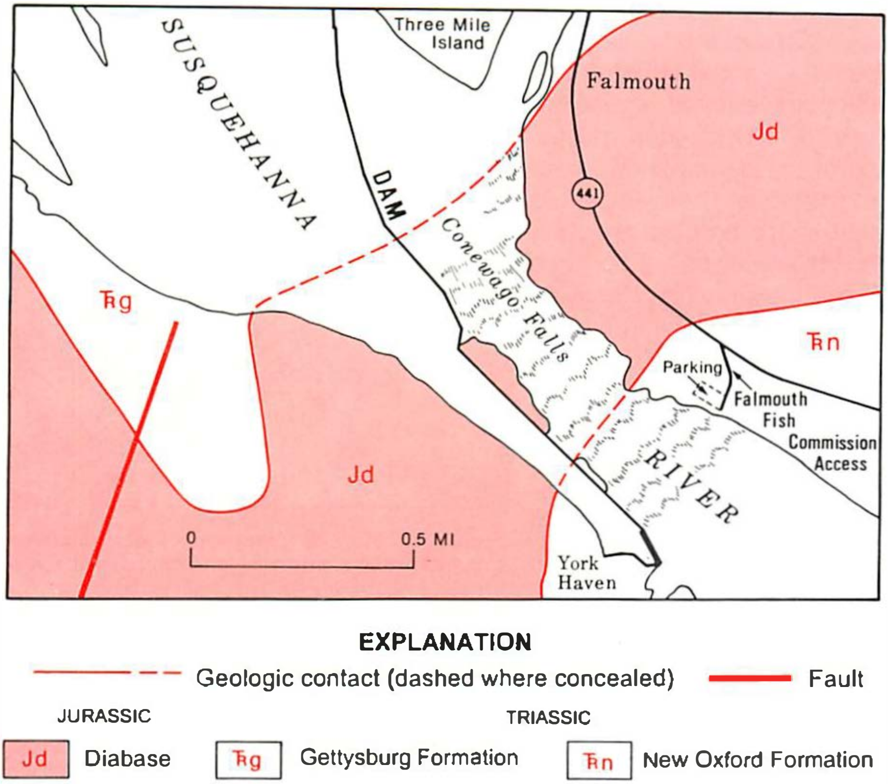

Figure 1. Location and geologic map of the Conewago Falls area.

derwater because of the dam, which funnels water to the York Haven power plant. During very low water stages, the riverbed is exposed in the central area and between the left-bank channel and the left bank itself.

This report concerns only the area between the left-bank channel and the left bank, but transported blocks are also found in the central area, and some blocks in the central area are larger than those on the left bank.

THE BLOCKS. Except for a few large areas that lack anything on the bedrock surface, the in-situ diabase near the left bank is littered with diabase clasts (Figure 3; also see cover) ranging in size from a few inches in diameter to a block that measures 36 by 15 by 5 feet. The mean size of 30 measured blocks is 19 by 11 by 5 feet. Such a block weighs almost 100 tons. The blocks are mainly tabular in shape, and their shape and size are controlled by the parting and joint planes. Thus, the very persistent parting planes keep the small dimension of the blocks generally less than 7 feet, whereas the other dimensions are quite variable.

Many of the blocks have potholes, and it appears that the potholes were eroded before the blocks were moved. All of the blocks show some rounding of their edges so that sharp corners are rare, but there appears to have been no significant erosion of the blocks since they were moved to their present positions. There are many smaller diabase clasts that have diameters of 4 feet or less. These smaller clasts generally appear more rounded than the large blocks, but they have not been studied.

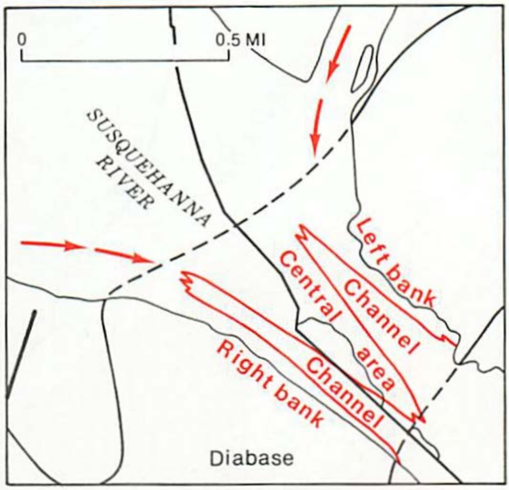

Figure 2. Map of Conewago Falls showing the general location of channels and rock areas.

Figure 3. Several large diabase blocks resting on smaller blocks at Conewago Falls. Upstream is at the back of the photograph. Block sizes are as follows: (1) 23 by 6–16 by 3 feet; (2) 23 by 6 by 3 feet; (3) 13 by 6 by 6 feet.

Because of their tabular shape, most of the larger blocks probably moved by sliding. However, a few blocks are more equant in shape, and some have definitely rolled (Figure 4). Except for a small number of blocks that have moved only a few inches from determinable original positions, the distance of transport of individual blocks is unknown. It is assumed that blocks present on the surface have been transported no farther than the distance between a specific block and the upstream edge of the diabase outcrop and not from a similar diabase sill 5 miles upstream.

TRANSPORT MECHANICS. Fluvial movement of blocks the size of those at Conewago Falls requires the energy imparted by very high discharge. A calculation using an equation from O'Connor (1993)

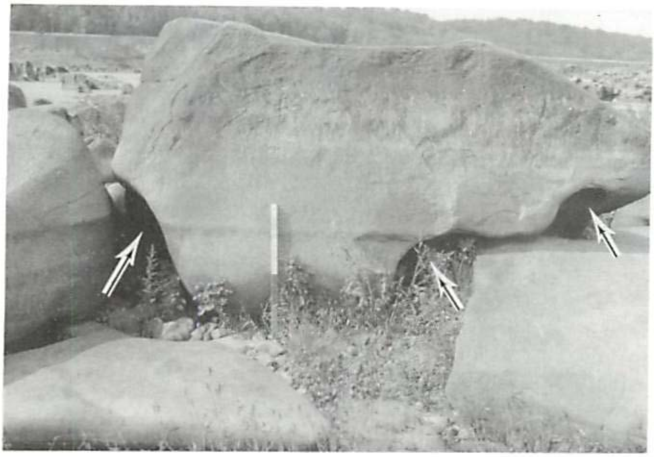

Figure 4. A large (13 by 10 by 6 feet), irregularly shaped block has rolled at least 180 degrees, as indicated by the fact that the potholes (arrows) eroded in it are upside down. Upstream is at the back of the photograph. Intervals on the scale are 50 cm.

yields a required flow velocity of about 32 ft/s (feet per second) to move a block that has an intermediate axis of 11 feet. Some understanding of what this means is gained by considering Susquehanna River flow during tropical storm Agnes in 1972. During that flood, maximum flow velocity at Harrisburg, 13 miles upstream from Conewago Falls, was 8 ft/s. The river at Harrisburg is approximately the same width as it is just north of Conewago Falls. At the falls, the river narrows to about half of its upstream width. This narrowing will cause flow velocity increase in order to accommodate the discharge, but the amount of increase would not be enough to cause movement of the large blocks during a flood equivalent to that of 1972, the flood of record. It appears that a special event is required to produce the extraordinary flow velocities.

OUTBURST HYPOTHESIS. During the Pleistocene, at least one but possibly two glaciers impinged upon Bald Eagle Mountain in the area between Lock Haven and Williamsport. The ice dam formed by this impingement blocked the West Branch Susquehanna River and created glacial Lake Lesley. This lake could have had an area of at least 704 square miles and a volume of 26 cubic miles at its maximum size (Figure 5). The natural lake drain was presumably southwest into the Juniata River drainage at Dix on the Blair-Centre County line.

During deglaciation, ice to the south of Bald Eagle Mountain would have melted gradually, and the ice front would have retreated northward. Eventually, only a narrow ice dam at the east end of Bald Eagle Mountain would have contained Lake Lesley. The pressure of the lake water could have caused catastrophic failure of the ice dam with a resulting outburst of water that might have been over 600 feet deep at the point of outburst. The course for this water would have been down the Susquehanna River.

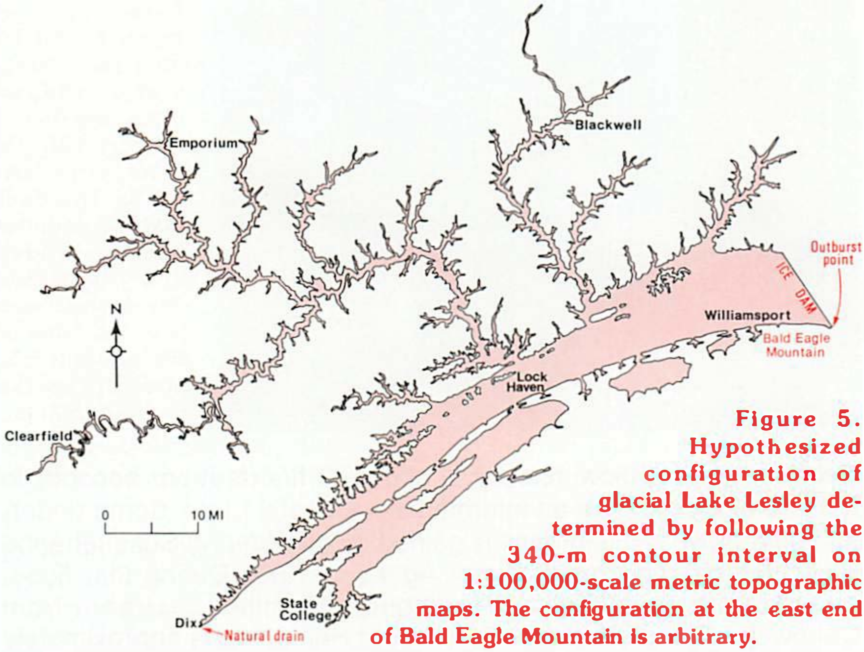

Figure 5. Hypothesized configuration of glacial Lake Lesley determined by following the 340-m contour interval on 1:100,000-scale metric topographic maps. The configuration at the east end of Bald Eagle Mountain is arbitrary.

During its downstream journey, the outburst water would have spread out and decreased in depth and flow velocity in the many wider, low-elevation areas adjacent to the main channel. However, its momentum would have been regained at each constriction, particularly the water gaps in Berry, Peters, Second, and Blue Mountains, as well as Conewago Falls.

At Conewago Falls, where the valley narrows within a few hundred feet to half its upstream width (Figure 1), discharge would have been maximized, and water depth may have exceeded 100 feet. The violence of extreme turbulence would have been concentrated in the two bank-marginal channels, and erosion of diabase would have been severe. Material from these channels presumably rests underwater downstream from the diabase sill. Higher flow velocity, but less turbulence, in the central area would have moved the largest loose blocks but would have done less erosion. All in all, it would have been an extraordinary event.

Similar erosion and transportation of debris would have occurred at the other up-river constrictions. However, the rocks that cause those constrictions are more thinly bedded, have more closely spaced joints, and normally do not produce clasts larger than small boulders. These clasts can be transported by smaller event floodwaters and are thus not recognizable as being related to an extraordinary event. This hypothesized outburst flood could also have contributed significantly to erosion of the schists in Holtwood gorge farther downstream from Conewago Falls (Thompson, 1988).

The ice dam that created Lake Lesley would have existed during one or two pre-Illinoian glaciations. An outburst caused by catastrophic failure of such a dam might have occurred several times if the glacier margin advanced and created a new ice dam following an outburst. Neither of the younger glaciers (Illinoian and late Wisconsinan) moved far enough south into Lycoming County to create a similar ice dam. During these latter glaciations, periglacial activity and deposition of outwash materials would have obscured or destroyed any evidence of earlier catastrophic flooding in most places along the margins of the Susquehanna River. Only at Conewago Falls has the evidence remained undisturbed for hundreds of thousands of years, because no subsequent floods have been large enough to move the blocks.

VISITING CONEWAGO FALLS. If you are interested in evaluating these features for yourself, take a pleasant walk sometime when the water is low. Conewago Falls is approached by walking north along the riverbed from the parking lot of the Falmouth Fish Commission Access just off Pa. Route 441 south of Three Mile Island. The diabase surface of the near left bank is exposed when the river stage is about 4 feet at Harrisburg, and the center area can be reached on foot when the Harrisburg river stage is 3.5 feet or lower. The sill extends from just north of the parking lot to north of the third up-river power line. A trail paralleling the river in the woods on the left bank simplifies returning to the parking lot.

With its potholes, ripple forms, and blocks, Conewago Falls has much to offer as evidence of the erosional activities of the Susquehanna River. The features also demonstrate the relationship between rock characteristics and erosional products. And, who knows, you may see something that others have missed!

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COALBED METHANE: NEW ENERGY FROM AN OLD SCOURGE?

by A. K. Markowski
Pennsylvania Geological Survey

The prospect of extending the lifespan of Pennsylvania's natural gas reserves should pique the interest of energy seekers of today and the future. Coalbed methane, an abundant natural gas in Pennsylvania, and generally considered a scourge to mankind, has been largely overlooked and misunderstood as a resource. It is widely known that methane has caused mine explosions and suffocation accidents throughout the world's coal regions for generations, making it a historical scourge. In addition, coalbed methane is now recognized as one of the world's major greenhouse gases, making it a modern-day scourge as well. Coal is attractive in Pennsylvania as a multiple resource; it is a source of fuel, coke (for steel manufacturing), and a chemical feedstock, as well as being a source and reservoir for methane. The removal and capture of methane prior to coal mining enhances coal resources by reducing accidents and providing an additional fuel supply.

ENVIRONMENTAL CONCERN AS A STIMULUS TO DEVELOPMENT. Methane comprises 18 percent of the world's greenhouse gases and is second only to carbon dioxide in its contribution to global warming (Clark, 1989), yet it has 20 to 30 times the heat-trapping capacity of carbon dioxide (Roane, 1990). As an energy source, coalbed methane rivals conventional natural gas in composition and heating value and lacks nuisance gases such as carbon monoxide, nitrogen oxides, and sulfur compounds. Heating values average 1,000 Btu/ft^3 (British thermal units per cubic foot) (Decker and others, 1986). With the advantage of being an energy source and with the added benefits of removing an ancient and modern scourge from the world environment, coalbed methane should attract the interest of those producing natural gas or seeking future energy resources.

HISTORY. As early as 1802, the English inventor William Murdock disclosed how coal gas (then known as firedamp) could be removed easily and burnt as a light source (Decker and others, 1986). This colorless, odorless, and nonpoisonous gas has been produced in the United States since the early part of the century, and production has occurred from the Pittsburgh seam in the Northern Appalachian coal basin since the 1930's, but generally the gas has been vented to the atmosphere. Multidisciplinary work by the United States Department of Energy in the late 1970's spurred new interest in the direct use of coalbed methane as a natural gas resource.

METHANE GENERATION AND COMPOSITION. Methane is generated in two stages of coalification: (1) the microbial decomposition of plant material (composting), mainly cellulose and lignin; and (2) the coalification of plant material after burial (lithification). In the latter stage, a complex series of chemical reactions is catalyzed by increased temperature and pressure. The primary component of coalbed gas, as determined by gas chromatography, is the simplest and most stable hydrocarbon molecule, methane—thus the name *coalbed methane*. Trace amounts of relatively heavier hydrocarbons such as ethane, propane, butane, pentane, associated isomers, and ethylene and propylene are common (Kim, 1974). Other common components of coalbed gas include oxygen, argon, nitrogen, carbon dioxide, and occasional trace amounts of hydrogen, helium, and carbon monoxide.

RESERVOIR CHARACTERISTICS. A coal seam is both the source and the reservoir rock for coalbed methane. A seam can hold two to three times as much gas as a conventional sandstone reservoir, owing to the large internal surface area of coal, over 1 billion square feet per ton, and the very tight packing of methane molecules (Kuuskraa, 1989). Gas is stored in coal in one of three states: (1) as adsorbed molecules on the micropore (microscopic pore) surfaces, usually retained by hydrostatic pressure; (2) as free gas within the pores and fractures; and (3) as a solute in formation water in the coalbed (Rightmire, 1984).

GAS MOVEMENT. Because methane is adsorbed on the internal surfaces of the coal matrix, it must first be desorbed before the gas can move to the well bore (Figure 1). Release is facilitated when dewatering of the coalbed decreases hydrostatic pressure, allowing the gas to diffuse through the matrix and micropores into small fractures (cleats) and, finally, into larger scale fracture systems. The dominant cleat, or face cleat, is in most cases a continuous, planar, smooth-sided fracture perpendicular to layering. The subordinate cleat, or butt (end) cleat, is a short and discontinuous fracture that terminates against the face cleat at approximately 90 degrees. These are thought to have formed in response to coalification processes and local structural forces (Diamond and others, 1986). Interest in gob gas is also increasing in Pennsylvania. During long-

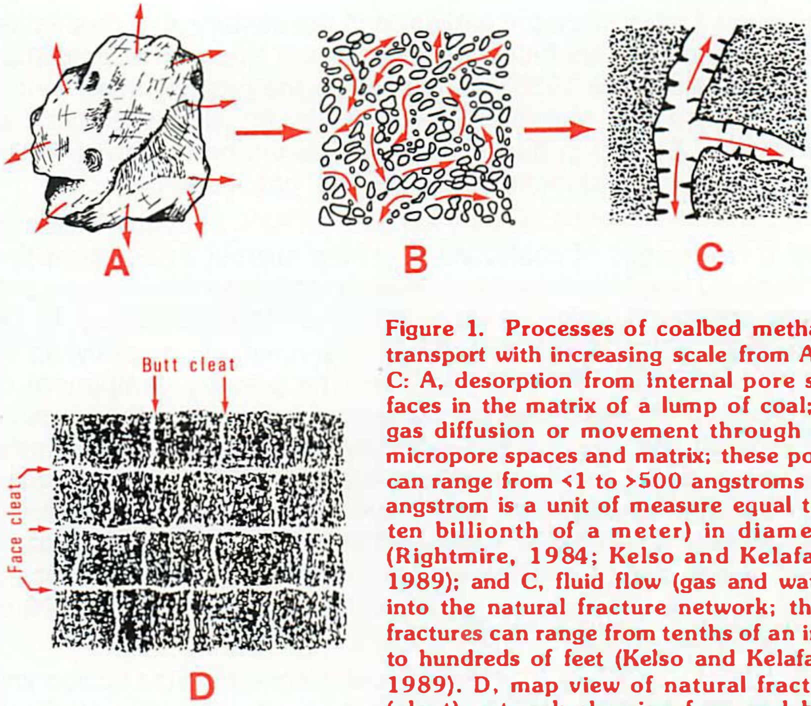

Figure 1. Processes of coalbed methane transport with increasing scale from A to C: A, desorption from internal pore surfaces in the matrix of a lump of coal; B, gas diffusion or movement through the micropore spaces and matrix; these pores can range from <1 to >500 angstroms (an angstrom is a unit of measure equal to 1 ten billionth of a meter) in diameter (Rightmire, 1984; Kelso and Kelafant, 1989); and C, fluid flow (gas and water) into the natural fracture network; these fractures can range from tenths of an inch to hundreds of feet (Kelso and Kelafant, 1989). D, map view of natural fracture (cleat) network showing face and butt cleats (Wicks and Zuber, 1989).

wall mining, the *gob*, or fractured strata above the coalbed, is designed to collapse after the coal has been removed. The gob zone can retain enough gas for capture, and the gas can be used if it is not mixed with ventilation air from the mine.

UTILIZATION. Natural gas from coalbed methane reservoirs can be used in the same ways as natural gas from more conventional reservoirs, including (1) direct flow into natural gas pipelines; (2) use as a boiler fuel in gas turbines to generate electricity at cogeneration plants; (3) use as a chemical feedstock for methanol, ammonia, and other chemicals; and (4) use as a raw material for the production of liquefied natural gas (LNG) and gas products (Kim and Deul, 1986). Another application is *cofiring*, in which natural gas and coal are burned together to utilize coals that are marginally compliant with clean air laws. Levels of sulfur dioxide and nitrogen oxide can be reduced substantially by cofiring up to 20 percent natural gas in a coal-fired boiler (Makansi, 1989). Coalbed methane should perform even better than natural gas in cofiring applications because of its reduced sulfur and nitrogen levels.

In addition, premining degasification of a coal seam and methane capture by vertical boreholes can have a significant positive effect on mining activities. Immediate benefits to the mining community include decreased risk of methane explosions, increased productivity, and reduced costs associated with gassy mines.

RESOURCE ESTIMATES. In 1988, West Virginia, Alabama, Virginia, and Pennsylvania produced more than 35 MMcfgpd (million cubic feet of gas per day) of methane emissions. According to Trevits and others (1991), 294.9 MMcfgpd was vented to the atmosphere from 487 deep coal mines in the United States in 1988. With an estimated 50 percent effective recovery of these emissions, approximately 150,000 homes could be heated per year. The deepest part of the Northern Appalachian coal basin is located in southwestern Pennsylvania and northwestern West Virginia, where the greatest number of coals are found in a vertical section (Kelafant and others, 1988). Exploration costs for the dominantly Pennsylvanian age eastern coals should be relatively low owing to the shallow depth (less than 3,000 feet) and characteristically thin beds (less than 12 feet thick) (Decker and others, 1986). The estimated resource of coalbed methane for southwestern Pennsylvania and northwestern West Virginia is 51 Tcf (trillion cubic feet) of gas in place (Kelafant and others, 1988). This resource could potentially heat 70 million homes for a year, assuming 50 percent effective recovery.

CURRENT RESEARCH AND EXPLORATION. The Pennsylvania Geological Survey has been investigating coalbed methane for about five years. In an initial reconnaissance study of the Main Bituminous field in southwestern Pennsylvania (see back cover), Markowski (in review) concurred with workers on earlier studies that there is a direct correlation between the depth of a coal seam and its gas content. As part of this reconnaissance study, graphs and tables showing depth and thickness versus total gas content, graphs showing time versus cumulative gas content, and statistical studies on emission rates were prepared and are available on open file at the offices of the Pennsylvania Geological Survey.

A more recent regional study of coalbed methane resources in the Northern Appalachian coal basin was supported by the Gas Research Institute (GRI) of Chicago and conducted in association with the West Virginia Geological and Economic Survey (Schwietering and others, 1991). In the study, two stratigraphic units thought to have the greatest coalbed methane potential in southwestern Pennsylvania were identified (Figure 2). Some of the geologic factors cited as affecting coalbed methane production and development include (1) depositional and stratigraphic controls; (2) structural controls, tectonic history, and natural fracture systems; and (3) hydrologic controls.

The most recent work at the Survey involves a second phase of the GRI-funded Pennsylvania-West Virginia study (Oldham and

SYSTEM	SERIES	GROUP OR FORMATION	IMPORTANT COALBEDS
PERMIAN-PENNSYLVANIAN		Dunkard Group (part)	Washington Waynesburg "A" Waynesburg
PENNSYLVANIAN	Upper	Monongahela Group	Uniontown Sewickley Redstone Pittsburgh
PENNSYLVANIAN	Upper	Conemaugh Group	Upper Bakerstown Lower Bakerstown Mahoning
PENNSYLVANIAN	Middle	Allegheny Group	Upper Freeport Lower Freeport Upper Kittanning Middle Kittanning Lower Kittanning Clarion/Brookville
PENNSYLVANIAN	Middle Lower	Pottsville Group	Upper Mercer Lower Mercer Quakertown Sharon
[illegible]	Upper		

Figure 2. General coal stratigraphy and the two stratigraphic intervals (color) having the greatest coalbed methane potential in southwestern Pennsylvania.

others, in review). Major goals of this phase of the project are to map the lesser known stratigraphy of the deeper Allegheny Group coals and associated sandstones, identify coals from regional cross sections, and create coal and sandstone isopleth, isolith, and isopach maps. This information will be used to identify areas of methane potential. Also, ongoing Survey and industry drilling projects provide additional information for the coalbed methane data base.

Exploration and testing by industry are ongoing; however, commercialization of this gas in Pennsylvania has only recently begun with the O'Brien Methane Production Company sale of coalbed methane from Indiana County. Optimism prevails concerning future development. On a national level, coalbed methane is commercially developed in coal seams in the San Juan basin of Colorado and New Mexico and the Black Warrior basin of Alabama. Activity is growing in the Central Appalachian coal basin of Virginia as well.

REGULATORY ISSUES. Legal ownership of coalbed methane is still contested, despite a 1983 court case in which it was concluded that "any gas found within a coalbed must necessarily belong to the owner of the coal!" (Johnson, 1992). Until clear ownership is established, any successful development of coalbed methane will likely depend on agreements among the oil and gas developer, the landowner, and the coal company. Federal legislation proposed to stimulate development includes the concept of forced (involuntary) pooling. Modeled after Virginia's 1990 oil and gas law, forced pooling requires the owners to pool and develop their lands as a unit prior to ownership determination.

CONCLUSION. One of the challenges of current researchers is to learn more about coalbed methane so that we can turn this former waste product that is a mining and environmental hazard into a valuable resource. With this in mind, economic, legal, and environmental factors will ultimately determine the fate of this currently wasted and much maligned, but valuable, resource.

The author thanks Mike Trevits, Gerry Finfinger, and John LaScola from the U.S. Bureau of Mines for supplying mine emissions information used in writing this article.

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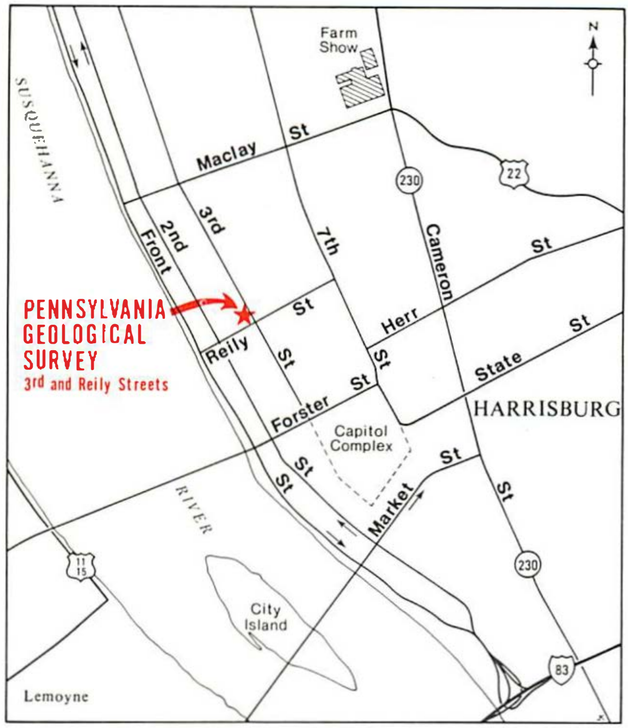
ANNOUNCEMENTS

The Survey Moves to Third and Reily Streets

After nearly two decades of occupancy on the eighth and ninth floors of the Executive House in downtown Harrisburg, the Pennsylvania Geological Survey has moved uptown to facilities in a building at the corner of Third and Reily Streets, about 20 blocks north of its previous location. The building (see photograph) once housed a religious publication and retail business. This former enterprise, now gone for over 20 years, provides the building with its colloquial name: "The Evan(gelical) Press Building." The building provided temporary quarters for the Survey for a few months in 1972 following the destruction of its offices as a result of flooding caused by Hurricane Agnes. It was in this building that the Survey began to rebuild its physical facilities that support public service through geologic mapping and information dissemination.

Evangelical Press Building at the corner of Third and Reily Streets, Harrisburg. The Survey occupies the second floor of the building. The front entrance, shown here, is on Reily Street.

Location of the present Survey quarters in Harrisburg.

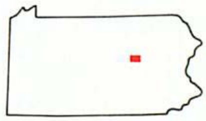


The building has been for many years the location of the central laboratories of the Department of Environmental Resources as well as other Department offices. The Pennsylvania Geological Survey now occupies the entire second floor of the building. Our frequently used library, map collection, and aerial photography files are located near the main entrance and are easily accessible from Reily Street, the entrance seen in the photograph. Visitors are welcome to use the library and its collections and to tour our new offices. Visitors must use the telephone affixed to the building near the main entrance to gain access, because the entire building is protected by a security system that provides safety and quality control for the thousands of environmental samples processed by Department laboratories on the building's first floor and basement.

The Pennsylvania Geological Survey will temporarily occupy these "new" quarters until offices and laboratories are constructed as part of a new Commonwealth building being designed to house several agencies that require laboratories in order to accomplish their missions.

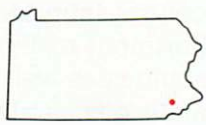
NEW PUBLICATIONS

Geology and Mineral Resources of the Washingtonville and Millville Quadrangles



The Pennsylvania Geological Survey has released **Geology and Mineral Resources of the Washingtonville and Millville Quadrangles, Montour, Columbia, and Northumberland Counties, Pennsylvania.** The report is the newest addition to a series of atlases published by the Survey that cover the geology of the northeastern part of the Appalachian Mountain section of the Ridge and Valley physiographic province. The 51-page text contains discussions of the structural geology, environmental geology, and economic resources of the area. Two full-color plates showing bedrock and surficial geology at 1:24,000 scale accompany the text. Atlas 154cd, by John H. Way of Lock Haven University, is available for $15.85, plus 6 percent state sales tax for Pennsylvania residents, from the State Book Store, 1825 Stanley Drive, Harrisburg, PA 17103–1257. Orders must be prepaid; please make checks payable to *Commonwealth of Pennsylvania*.

Guide to the Geology of Valley Forge National Historical Park



A new, completely revised edition of Park Guide 8, **Valley Forge National Historical Park, Montgomery and Chester Counties,** was recently released by the Pennsylvania Geological Survey as part of the "Trail of Geology" series. The park guide was published in honor of the centennial of the Pennsylvania state park system, which began in 1893 with the opening of Valley Forge State Park (now a federal park). The author, C. Gil Wiswall of West Chester University, describes the rock formations found in the park and explains the geologic history of the area. A centerfold map shows simplified geology and the locations of sites described in the text. The two-color, 13-page booklet is free and may be obtained at the park office or by writing to the Pennsylvania Geological Survey, P. O. Box 8453, Harrisburg, PA 17105–8453.

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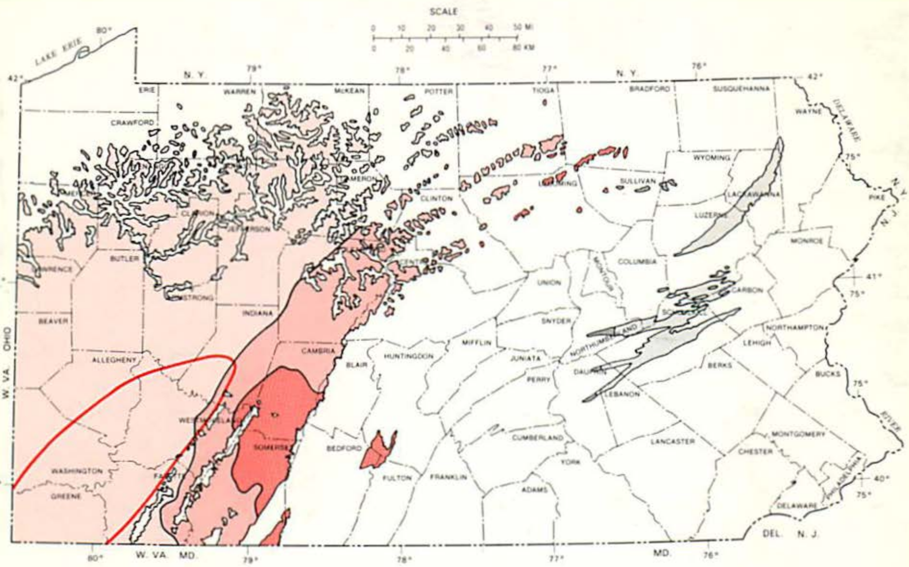
TOPOGRAPHIC MAPPING
GROUNDWATER-RESOURCE MAPPING

DISTRIBUTION OF PENNSYLVANIA COALS

(see article on page 8)



EXPLANATION

BITUMINOUS FIELDS

- High-volatile bituminous coal
- Medium-volatile bituminous coal
- Low-volatile bituminous coal

ANTHRACITE FIELDS

- Anthracite
- Semi-anthracite

Outline of study area for coalbed methane project (see article on page 8)

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