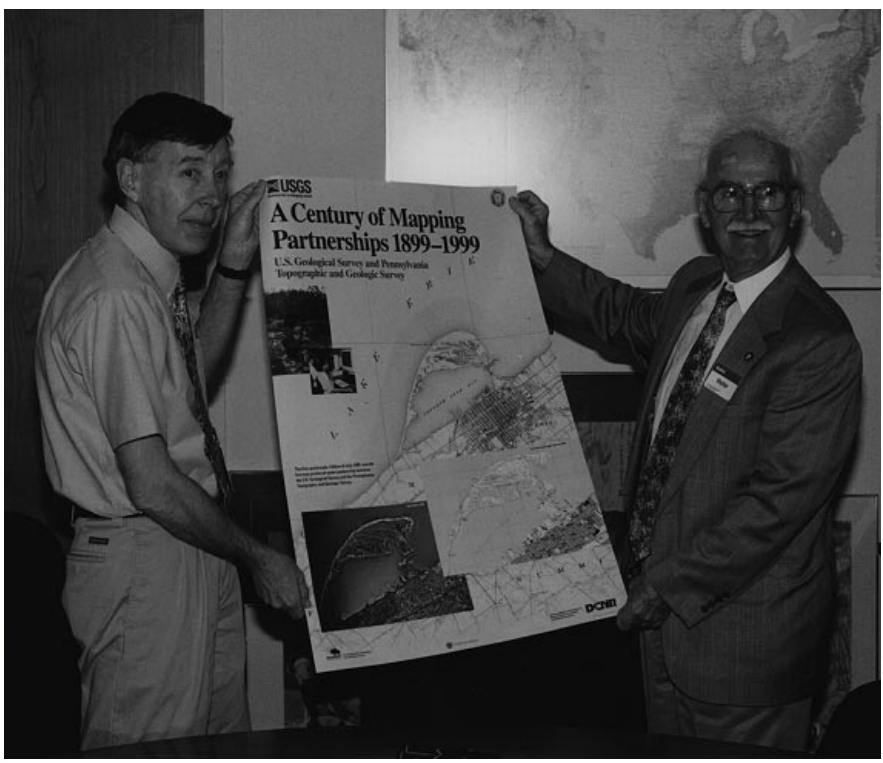
VOL. 30, NO. 1/2

Pennsylvania GEOLOGY



COMMONWEALTH OF PENNSYLVANIA
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John C. Oliver, Secretary

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ON THE COVER

State Geologist and Director of the Pennsylvania Bureau of Topographic and Geologic Survey Donald M. Hoskins (right) and Director of the U.S. Geological Survey Charles G. Groat (left) hold a copy of a poster commemorating 100 years of cooperation during a special ceremony in Reston, Va. (see article on page 1). Photograph by C. H. Dodge.

PENNSYLVANIA GEOLOGY

PENNSYLVANIA GEOLOGY is published quarterly by the Bureau of Topographic and Geologic Survey, Pennsylvania Department of Conservation and Natural Resources, P. O. Box 8453, Harrisburg, PA 17105–8453.
Editors: Anne B. Lutz, Christine E. Miles, and Donald M. Hoskins.
Contributed articles are welcome. Guidelines for manuscript preparation may be obtained through the Internet at URL <www.dcnr.state.pa.us/topogeo/mag-ins.htm> or by contacting the editors at the address listed above.

VOL. 30, NO. 1/2 **SPRING/SUMMER 1999**

A Century of Cooperation

In cooperation with the National Mapping Division of the U.S. Geological Survey, the Bureau of Topographic and Geologic Survey has issued a full-color poster entitled *A Century of Mapping Partnerships 1899–1999.* The poster is intended to acknowledge and celebrate the century-long cooperation between Pennsylvania and the United States in mapping and publishing topographic and geologic maps of the Commonwealth. The partnership began in 1899 with an act signed by Governor William Stone.

The Erie quadrangle edition of 1900 was the first topographic map of Pennsylvania printed under the state/federal partnership. The poster features the Erie 15-minute quadrangle, which prominently displays Presque Isle as it appeared in 1899. Presque Isle is the site of one of Pennsylvania's most popular state parks, and it is the location of geological features and rare plants unseen elsewhere in the Commonwealth. The poster also features as insets a 1987 color-infrared aerial photograph of Presque Isle and a portion of the most recent (1996) topographic quadrangle map. The map and insets show the progressive changes in Presque Isle that have occurred over a century as current-driven movement of lake sand continually modified the spit. Smaller insets on the poster show original field processes for topographic mapping and modern digital processes for map compilation.

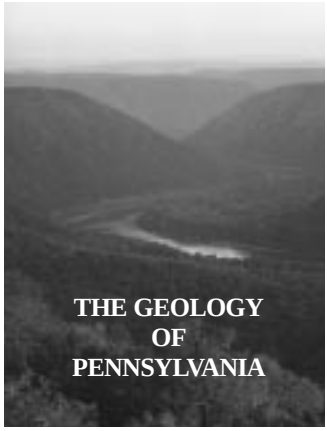
Since the partnership began, complete topographic-map coverage of Pennsylvania at several different scales has been achieved. Familiar to long-time users of topographic maps is the original 15-minute ("inch to a mile") series of individual quadrangle maps. Extensively used until the 1950's, this series is no longer produced and has been supplanted by the modern 7.5-minute series of quadrangle maps. The partnership continues to this day, resulting in revision and replacement of individual quadrangle maps and the production of derivative digital data that support many geographic information systems (GIS) applications.

Copies of the poster are available at no charge from the Bureau by writing to us at the address given on the back cover or by calling 717–787–2169.

Donald M. Hoskins
State Geologist

Special Publication 1

The Geology of Pennsylvania



The Bureau of Topographic and Geologic Survey is pleased to announce the release of **Special Publication 1, The Geology of Pennsylvania,** copublished by the Survey and the Pittsburgh Geological Society.

The 888-page two-color book is divided into 10 parts (Introduction, Stratigraphy and Sedimentary Tectonics, Structural Geology and Tectonics, Regional Geophysics, Physiography, Geologic History, Mineral Resources, Water Resources, Environmental and Engineering Applications, and The Geologic Tourist), which cover all major aspects of the state's geology. Within the 10 parts are 57 chapters, authored by 90 individuals from academia, government, and industry. The book contains more than 800 illustrations, an extensive bibliography, a detailed index, and a 16-page section printed in full color.

The publication is the product of a partnership between the Pittsburgh Geological Society and the Pennsylvania Geological Survey. The Society, through a special committee, planned and organized the chapters, selected authors, and raised almost half of the money needed for printing. Reginald P. Briggs, of Geomega, Inc., was head of the committee and managing editor of the project. The editor of the volume is Charles H. Shultz, a professor at Slippery Rock University. Society members were also authors and/or reviewers of several chapters in the book.

The Bureau of Topographic and Geologic Survey made significant contributions to the publication. Fourteen Bureau staff members were authors or coauthors of 19 of the chapters, and most staff geologists were also involved in the technical review of the manuscript. Production of the book from manuscript stage through printing, including technical editing of text and illustrations, typesetting and layout, drafting of camera-ready, color-separated artwork, preparation of page

proofs for review by authors, and liaison with the state contract printer, was done by staff in the Geologic and Geographic Information Services Division of the Bureau. The Pennsylvania Department of Conservation and Natural Resources paid the portion of the printing costs not covered by the Society.

The Geology of Pennsylvania thus is not only the result of a successful partnership, but it is also an extraordinary group accomplishment by many dedicated authors, reviewers, and other contributors from academia, industry, and government.

Special Publication 1 is available from the State Book Store, 1825 Stanley Drive, Harrisburg, PA 17103–1257, telephone 717–787–5109. Books may be purchased **over the counter for $20.00 plus $1.20 state sales tax** or **by mail for $24.00 plus $1.44 state sales tax** if sent to a Pennsylvania address. All orders must be prepaid; please make checks payable to *Commonwealth of Pennsylvania.* An order form is available on the Bureau's web site at www.dcnr. state.pa.us/topogeo/SP1/PaGeo.htm.

In a ceremony held at the state capitol on August 9 to announce the release of *The Geology of Pennsylvania*, Reginald P. Briggs, Managing Editor (center) presented a copy of the book to John C. Oliver, Secretary of the Department of Conservation and Natural Resources (left). Also present were Mike Keeliher, President of the Pittsburgh Geological Society (left center), Donald M. Hoskins, Director of the Bureau of Topographic and Geologic Survey (right center), and Charles H. Shultz, Editor (right). Photograph by Helen L. Delano.

IRON IN VENANGO COUNTY: Oil's Older Sibling

by John A. Harper
Bureau of Topographic and Geologic Survey

When one thinks of nineteenth century industry in Venango County, the first thing that comes to mind is oil. Pennsylvania Grade crude oil is what made the county, and adjacent areas of northwestern Pennsylvania, famous. But long before Colonel Drake set foot in the Oil Creek valley, Venango County had a very different mineral-resource industry—iron manufacturing!

ANDREW CARNEGIE'S PREDECESSORS. Early nineteenth century ironmaking was a very different business than it is today. There were no enormous industrial parks having blast furnaces, Bessemer converters, electric hearths, forges, rolling mills, coke ovens, or mountains of ore, limestone, and coal; other on-site facilities were also absent. Iron manufacturing in the early 1800's was a relatively simple affair; a small stone furnace for smelting ores (Figure 1) was built where the most important resources could be found in sufficient quantity to assure many years of production. These resources included the following: (1) iron ore, generally of low quality, but usable; (2) limestone beds that could be quarried for flux; (3) wood for charcoal[1]; and (4) running water to generate the power needed to keep the blast machine operating. The old iron furnaces of western Pennsylvania commonly were situated along a small- or moderate-sized stream having a steady flow of water. One exception, Stapley Furnace in Richland Township (Figure 2, number 20), sat on elevated ground and used a steam engine to power the blast machine.

Early iron manufacturers operated their furnaces only six to nine months each year. The remaining time was spent cutting lumber for charcoal and making repairs to the furnace and equipment. They made iron by dumping alternating charges of ore, limestone, and charcoal or coke into the *bosh* through the *tunnel head* at the top of the furnace (Figure 1). The blast machine, a waterwheel-powered bellows or air pump, forced air into the furnace through a *tuyere*, a

[1]Wood was used exclusively until about 1836, after which some ironmasters began using coke made from bituminous coal (Swank, 1878).

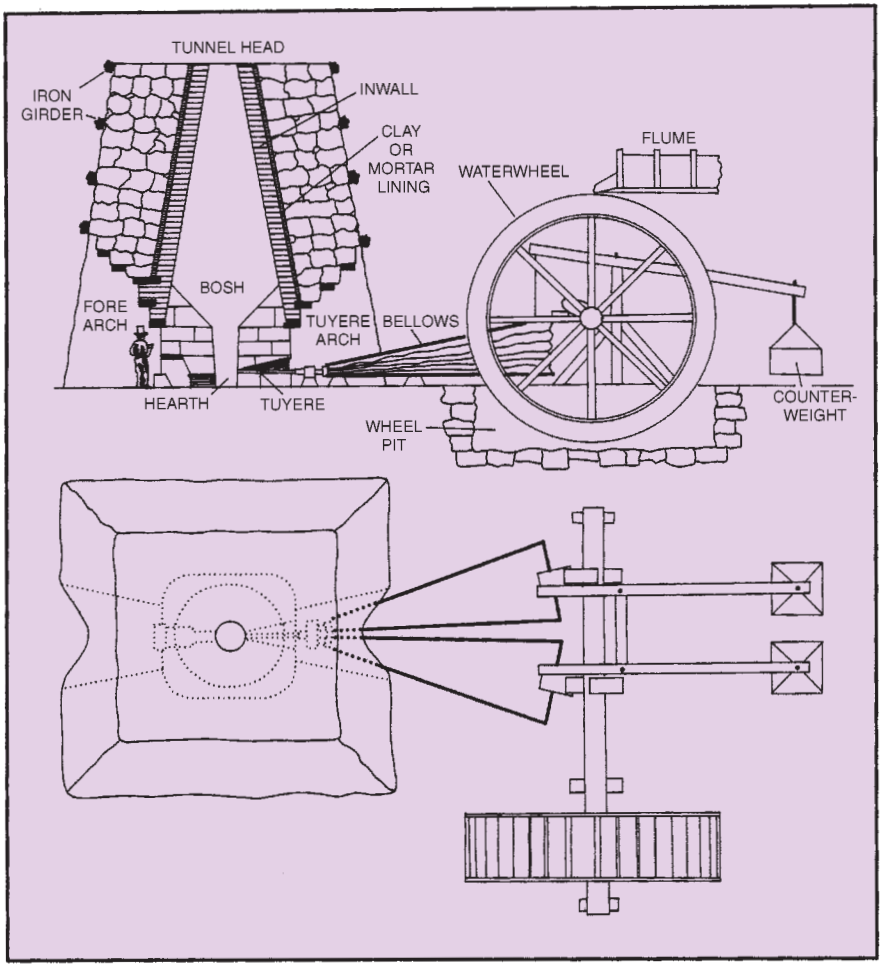


Figure 1. Generalized plan of an early American iron furnace (modified from Bining, 1938, p. 78). Early furnaces were equipped with bellows to provide the blast. In the 1800's, however, iron manufacturers developed a different kind of blast machine consisting of pistons and cylinders (see Inners, 1986, for an illustration). The latter machines probably were used with Venango County's 25 furnaces (see Figure 2).

small opening leading to the hearth. There, the air blasted into the bosh, raising the temperature high enough to smelt the iron. At the front of the furnace was a casting shed where the ironmaster drew off the *slag*, a scum of cinders, for discarding, and the iron ran into sand molds to become pig-iron ingots. These ingots were later forged into nails, wagon wheels, horseshoes, and a variety of other useful

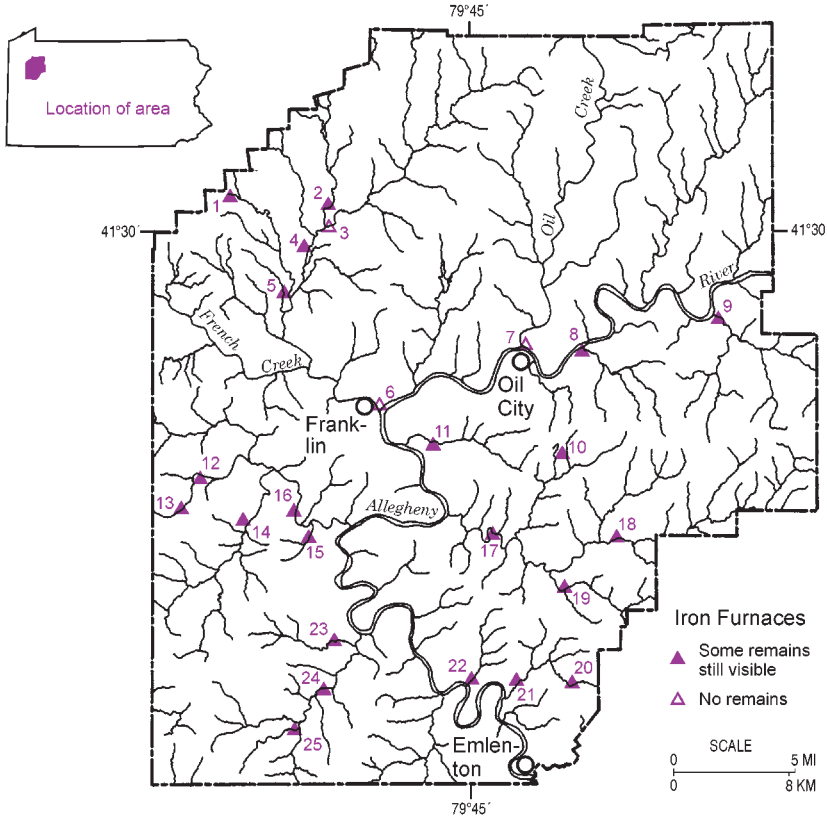


Figure 2. Streams and generalized locations of early iron furnaces in Venango County. Numbers refer to the list in Table 1.

Table 1. *Names of Iron Furnaces Shown in Figure 2*

(Compiled from Anonymous, 1988, and Lesley, 1859)

Map no.	Furnace name	Map no.	Furnace name	Map no.	Furnace name	Map no.	Furnace name
1	Liberty	8	Horse Creek	15	Victory	22	Rockland
2	Union	9	President	16	Sandy	23	Bullion
3	Kroemer	10	Halls Run[1]	17	Slab	24	Anderson
4	Texas	11	Van Buren	18	Jackson	25	Jane
5	Valley	12	Reno	19	Webster		
6	McCalmont	13	Raymilton	20	Stapley		
7	Oil Creek	14	Castle Rock	21	Porterfield		

[1]Listed in Cranberry Township assessments in 1840, but apparently never put into operation (Anonymous, 1988).

domestic products. Two tons of local ore, 1 or 2 tons of charcoal or coke, and a few shovelfuls of limestone would produce about 1 ton of pig iron (Anonymous, 1988). When you consider that the Venango County furnaces produced between 150 and 800 tons of iron per year, you can readily imagine the kind of pick-and-shovel labor that went into the mining and lumbering to keep them stocked.

TO BE ORE NOT TO BE . . . ORE! The principal ore used in western Pennsylvania furnaces was *siderite*, or iron carbonate ($FeCO_3$). Siderite occurs in association with numerous Pennsylvanian-age limestone and shale beds in western Pennsylvania (Figure 3), from the shales below the Waynesburg coal of the Upper Pennsylvanian Dunkard Group in Greene County to those occurring within the Sharon sandstone of the Pottsville Formation in northwestern Pennsylvania. The primary siderite bed throughout western Pennsylvania is the "Buhrstone ore," a layer associated with the Vanport Limestone Member of the Allegheny Formation. This layer, which is about 40 percent iron in composition, averages 1 foot in thickness in the Butler-Clarion-Venango County area, but thicknesses of between 2 and 6 feet have been noted. Many of the iron furnaces found in the southern part of Venango County used Vanport ore, for example, Rockland Furnace on Shull Run in Rockland Township (Figure 2, number 22; Figure 4). Many of the furnaces in the northern part of the county relied on ores from the Pottsville Formation. For example, Liberty Furnace, situated on a small, unnamed tributary of Beatty Run in Jackson Township (Figure 2, number 1), used a 2-foot-thick layer of Sharon ore found in the vicinity of the furnace (White, 1881). It also used locally mined Sharon coal for coke and Upper Meadville limestone (Cuyahoga Group) for flux (Figure 3).

Another common type of ore utilized in some of the Venango County furnaces, for example, Van Buren Furnace in Cranberry Township (Figure 2, number 11), was *bog iron ore*. This is an impure ore formed in wetlands by precipitation from iron-bearing water and through oxidation by algae or bacteria. Bog-ore deposits typically are restricted in area, so furnaces that used them also had to use another supply of ore or they quickly went out of business.

AND THE REST IS HISTORY. The first furnaces built and operated in Venango County were erected in 1824. John Anderson, who had experience in the iron industry in Juniata County, built the Anderson Furnace on Big Scrubgrass Creek near present-day Kennerdell in the southern part of the county (Figure 2, number 24). He also built Oil Creek Furnace (Figure 2, number 7), which was situated at the

mouth of Oil Creek on land bought from Chief Cornplanter, the head of the Seneca Indian Nation. By 1858, Venango County had 25 iron furnaces (Swank, 1878). By that time, however, most of the furnaces had been abandoned for a variety of reasons, any one of which could have single-handedly subverted the industry. These included exhaustion of the source for charcoal by overlumbering; depletion of relatively higher quality iron ore; increased costs of mining ores and hauling raw materials; increased tariffs (always a business killer); and increased competition from large manufacturing towns, such as Pittsburgh and Sharon, brought on by the more profitable use of coal for coke and higher quality iron ores shipped in from the Lake Superior region.

Venango County had a rich trade in iron manufacturing while it lasted. Many of the wealthier people in the region invested in the industry and got back a tidy dividend for their investment. Iron provided a considerable amount of money to the local economy during times when few other industries could. In a sense, iron manufacturing helped the county residents weather the economic problems of the early to middle 1800's until oil became the primary industry.

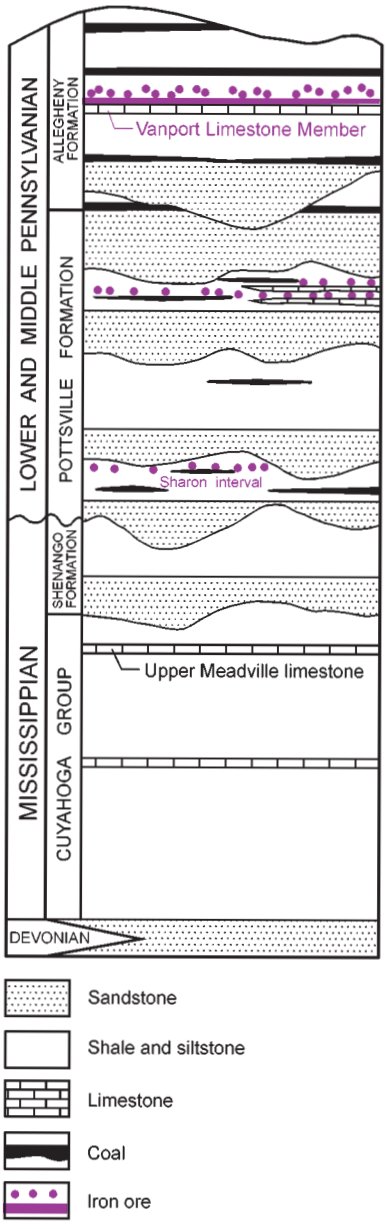


Figure 3. Generalized stratigraphic column for Venango County. Iron ores are most common in the Allegheny and Pottsville Formations, but other formations had potentially economic quantities that might have been used in the county.

Figure 4. Remains of Rockland Furnace along Shull Run in the southern part of Rockland Township, Venango County. In addition to the stack, the millrace and wheel pit also are well preserved.

GONE, BUT NOT FORGOTTEN. Today, iron manufacturing in Venango County is just a memory. Fortunately, we still have the picturesque remains of many of the old furnaces (such as that shown in Figure 4) to help us remember. The geological tourist who is interested in viewing the remnants of the furnaces is encouraged to obtain a copy of *Exploring Venango County* (Anonymous, 1988), which provides directions to each site. Some of the furnaces are in out-of-the-way places, and long, arduous hikes in the woods and creek beds are required in order to find the remains. But then, when it comes to geological tourism, exploring is half the fun!

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An Earthquake in York County, Pennsylvania

by Charles K. Scharnberger
Millersville University
Jeri L. Jones
York County Department of Parks and Recreation
William Kreiger
York College of Pennsylvania

THE EARTHQUAKE. A small but interesting earthquake occurred near Dillsburg in York County, Pa., in the early morning hours of June 16, 1997. The earthquake, having an estimated magnitude of 2.4, was recorded at Millersville University and at the Delaware Geological Survey in Newark, Del. The local time was 1:43 a.m. EDT. At least one aftershock was felt at 10:04 p.m. on the same day and was recorded by Dickinson College in Carlisle, Pa. Its magnitude was estimated to be 1.6. Millersville University did not record the aftershock because its drum recorder was off line for approximately 2 minutes at that time in order for the paper to be changed (a good example of Murphy's Law).

Some residents who live near the estimated epicenter of the main shock reported feeling possible small earthquakes around 9:45 p.m. on the previous evening, June 15, and about 3:22 a.m. on June 16. A few residents claimed to have felt mild shocks over a period of months preceding June 16. A report of an additional aftershock came on August 3 from a person living near the inferred epicenter of the main shock.

The authors conducted an intensity survey through approximately 60 personal interviews with residents, supplemented by 16 returned survey questionnaires that were published in the *Dillsburg Banner* newspaper. Through these interviews and questionnaires, an isoseismal map was constructed using the Modified Mercalli scale of earthquake intensities (Figure 1). Our best estimate of the location of the epicenter is the center of the intensity IV zone, that is, 4 km (2.5 mi) southeast of Dillsburg, at latitude 40.445°N, longitude 77.003°W.

An immediate speculation about the cause of the earthquake was that it was caused by collapse of one of about 25 abandoned iron (magnetite) mines in the area. After completion of the isoseismal map

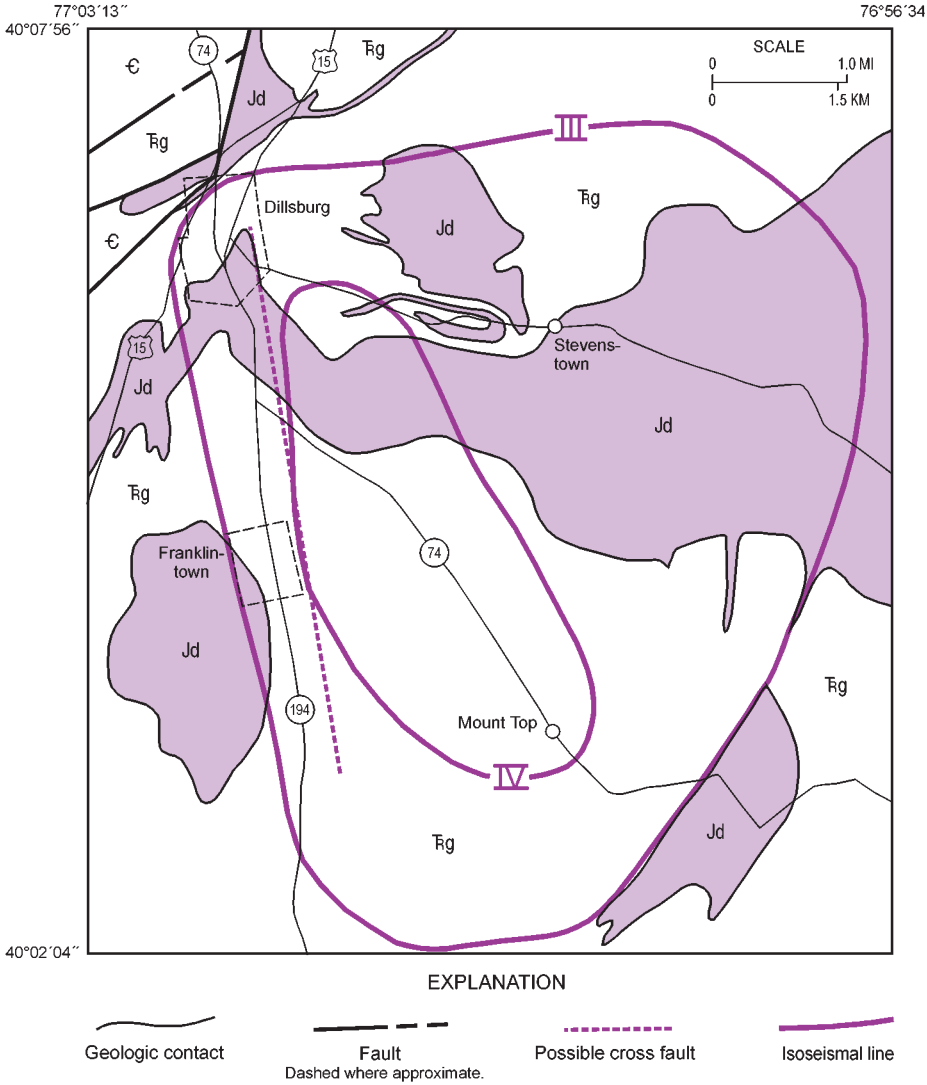

Figure 1. Isoseismal map showing a possible cross fault. The fault trace is inferred; the isoseismal lines are Modified Mercalli intensities. €, Cambrian rocks; Trg, Triassic Gettysburg Formation; Jd, Lower Jurassic (?) diabase intrusions.

and examination of the location of the mines, however, the authors concluded that the epicenter was located approximately 3 km (1.9 mi) from the mines to the north, near Dillsburg, and the same distance from those to the south, near Wellsville, and that no mines were known to exist in the immediate area of the epicenter (Jones, 1996).

IS THERE A FAULT? Although this earthquake was very small, it has several points of interest. First, this event confirms previous observations that seismicity in southeastern Pennsylvania is associated with the margins of the Newark and Gettysburg basins (Scharnberger, 1993). This is the first well-documented earthquake in that portion of the Gettysburg basin west of the Susquehanna River. It is unusual, however, in that the epicenter appears to lie within, rather than just outside, the basin.

The asymmetry of the intensity III zone suggests enhancement of intensity on diabase bedrock. On the other hand, none of the people interviewed who live on diabase just west of Franklintown felt any of the shocks. The 10:04 p.m. aftershock was felt on the diabase uplands only to the east of the inferred epicenter. The intensity III zone may be even more compressed on the west side than shown since so few persons in Franklintown felt any of the events. The elongation of the maximum intensity zone, and the existence of higher intensities east of the inferred epicenter compared to the west, suggest movement on a roughly north-striking cross fault associated with the Triassic border fault along the northwest margin of the Gettysburg basin, where the east side is the relatively upthrown hanging wall of a reverse fault. This interpretation is consistent with the results of investigations of previous earthquakes in Lancaster and Berks Counties, and with what is known of the regional stress field (Armbruster and Seeber, 1987; Seeber and others, in press).

During field work conducted in July and August 1997 by one of the authors (JLJ) in the area of the shocks, evidence of a fault paralleling the intensity III zone was found. Stose and Jonas (1939) mapped the area as being underlain by the Gettysburg Formation and associated diabase sheets. In a new excavation for a housing development at the south end of Dillsburg, hornfels showing pronounced slickensides was found. Another exposure of slickensides in the Gettysburg sandstone was located to the south-southeast in a stream cut. These two exposures, a new interpretation of the mapped contact between the Gettysburg Formation and the diabase in the Dillsburg area, interpretation of the aeromagnetic map of the area, and the pronounced linearity of a stream channel, combine to imply the existence of a fault striking approximately N10°W (Figure 1). Several other cross faults near the Triassic border have been mapped previously (Wood, 1980).

CONCLUSION. This small earthquake near Dillsburg serves as a reminder of the relatively mild, yet persistent, seismicity associated with the Mesozoic rift basin of southeastern Pennsylvania. In fact, this event was followed 5 months later by a magnitude 3.0 earth-

quake south of the basin in Lancaster County on November 13, 1997. Whether a seriously damaging earthquake, one having a magnitude as high as 6.0 or so, could occur in this region remains a matter of conjecture, but certainly it is not out of the question. In fact, during the past 400 years, approximately 90 earthquakes of magnitude 6.0 or greater have occurred in regions of stable continental crust, two thirds of them associated with crust that has been tectonically extended during Phanerozoic time (Johnston and others, 1994).

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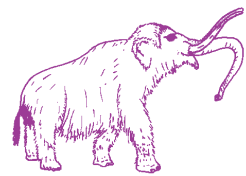
NEW RELEASES

New Educational Series Booklets Published

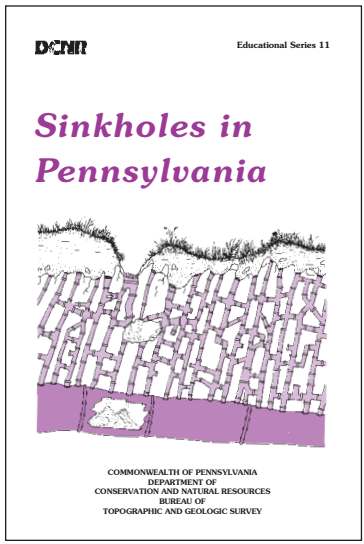


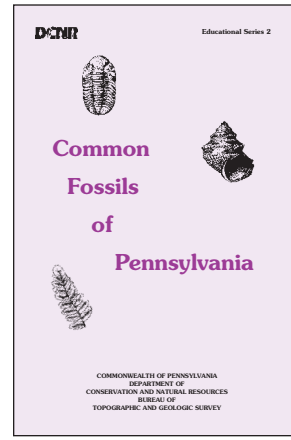
The Bureau of Topographic and Geologic Survey has published **Educational Series 11, Sinkholes in Pennsylvania,** by staff geologist William E. Kochanov. This well-illustrated booklet, which is written in nontechnical language for students and the general public, contains information on how sinkholes form, how

to recognize a sinkhole-related land subsidence problem, and what safety precautions should be taken. It also includes a general discussion on the repairing and prevention of sinkholes.

The Bureau has also published revised editions of two popular Educational Series booklets that were out of print. They are **Educational Series 2, Common Fossils of Pennsylvania,** and **Educational Series 6, Pennsylvania and the Ice Age.**

Common Fossils of Pennsylvania, written by Bureau Director Donald M. Hoskins, has been redesigned so that the illustrations of fossils are now alongside the text where the fossils are described. The booklet also includes explanations of what fossils are, some of their uses, and the basics of classification of plants and animals.





A description of what life was like in Pennsylvania during the Ice Age is one of several new topics included in an extensively revised edition of **Pennsylvania and the Ice Age,** by Bureau staff geologists W. D. Sevon and Gary M. Fleeger. The booklet has many new illustrations as well, including a full-color centerfold map showing glacial deposits in Pennsylvania. In addition, the booklet includes new information on periglacial features and relative temperatures during the glacial intervals, and a section on the importance of glaciation to Pennsylvania.

Copies of Educational Series 2, 6, and 11 are free upon request and may be obtained by contacting the Pennsylvania Geological Survey at P. O. Box 8453, Harrisburg, PA 17105–8453, telephone 717–787–2169. The booklets may also be viewed on the Bureau's web site at www.dcnr.state.pa.us/topogeo/.

Oil and Gas Well Location Maps Now Available on CD–ROM

The Bureau of Topographic and Geologic Survey has released improved oil and gas well location maps on CD–ROM.

The new maps, which are now created and maintained digitally, contain the same oil and gas well location information as the older, hand-drafted maps—well symbols and identification numbers positioned on a U.S. Geological Survey (USGS) topographic map background. However, the digital maps are also interactive. The user can retrieve and view essential data-base features by clicking on any well.

Because they are created as digital files, these maps can be generated quickly and updated in minutes as new data are obtained.

The new maps are digital-raster-image, full-color topographic maps having black well-location symbols and identification numbers, and they are designed for use with Arc/Info and ArcView software. The maps and associated data may also be viewed using ArcExplorer, a free software package that can be downloaded from www.esri.com/software/arcexplorer/index.html. A complete explanation of well symbols is included with the maps.

The user can print these maps if he or she has a printer large enough to print full-sized topographic maps.

The first counties to have full digital base-map coverage (see back cover) are Indiana (24 maps), Centre (12 maps), Clinton (20 maps), Fayette (25 maps), Allegheny (23 maps), Westmoreland (33 maps), and Lycoming (14 maps). Also complete are 55 maps in 20 counties in the Eastern Overthrust Region. Armstrong, Clearfield, and Erie Counties are presently being prepared.

Through a newly developed public/private partnership, CD–ROM's for the completed maps indicated above can be purchased from WhiteStar Corporation, 333 West Hampden Avenue, Suite 604, Englewood, CO 80110–2330, telephone 1–800–736–MAPS, fax 303–781–5275.

For those who do not have access to the digital software and hardware, paper copies can be purchased from Mathias Reprographics, Inc., 950 Penn Avenue, Pittsburgh, PA 15222, telephone 412–281–1800. The paper copies have wells printed as dark symbols on a subdued, gray topographic background.

Printed copies of the maps are also available for viewing at the Bureau's Pittsburgh office at 500 Waterfront Drive. For additional information, contact the Pittsburgh office at 412–442–4235 (fax 412–442–4298).

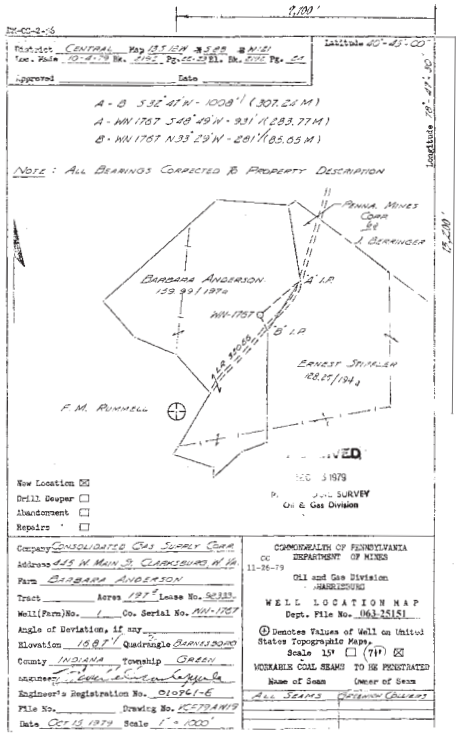
New Digital Oil and Gas Information Service (PA*IRIS)

The Pennsylvania Internet Record Imaging System (PA*IRIS) is the newest digital oil and gas information service of the Bureau of Topographic and Geologic Survey. Location plats, well completion reports, and plugging certificates for all wells in the Bureau's files (approximately 142,000 at the end of September 1999) have been scanned. The images are available for viewing, downloading, and printing in the Bureau's Pittsburgh and Harrisburg offices during normal work hours. New plats, records, and plugging certificates are being added to the system on a daily basis.

PA*IRIS is a public/private partnership in which approximately 30 oil and gas companies have invested. For their investment, each company will receive complete access to all the scanned records via the Internet, allowing them to access the images from their home offices.

PA*IRIS uses Hyland Software's OnBase™ database software for managing the records. This product allows records to be quickly retrieved based on very limited details. In addition, there is full search capability on a number of important fields as well as on the permit number.

For more information about this service, contact Cheryl Cozart, Bureau of Topographic and Geologic Survey, 400 Waterfront Drive, Pittsburgh, PA 15222–4745, telephone 412–442–4234.



Example of a location plat record (detailed well location constructed by a registered surveyor) that is available as a scanned image.

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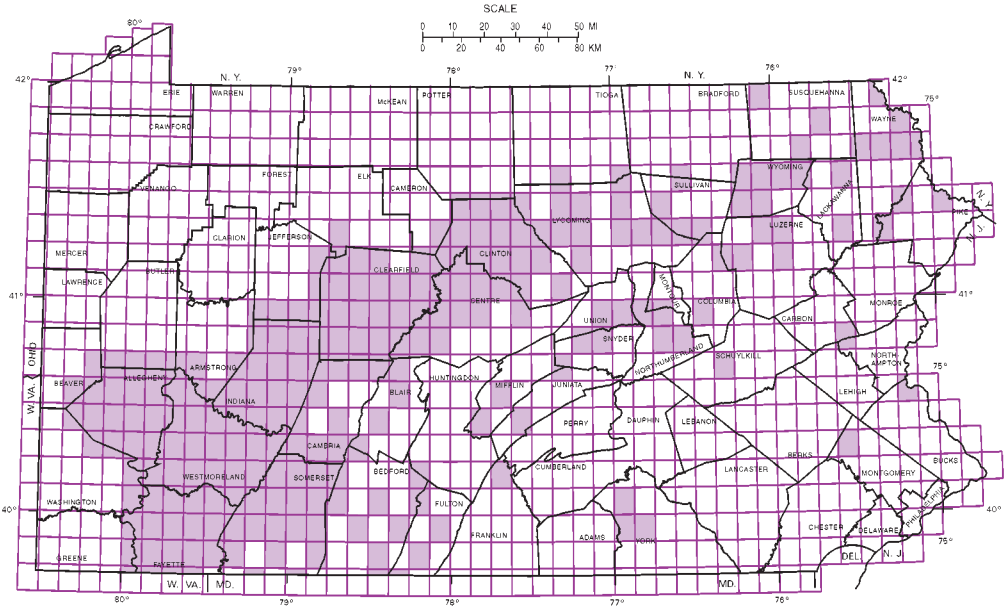
(See article on page 15)



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