

P GEOLOGY

N N S Y L V A N I A

THE PENNSYLVANIA GEOLOGICAL SURVEY

VOL. 2/3

COMMONWEALTH OF PENNSYLVANIA

Milton J. Shapp, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES

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TOPOGRAPHIC AND GEOLOGICAL SURVEY

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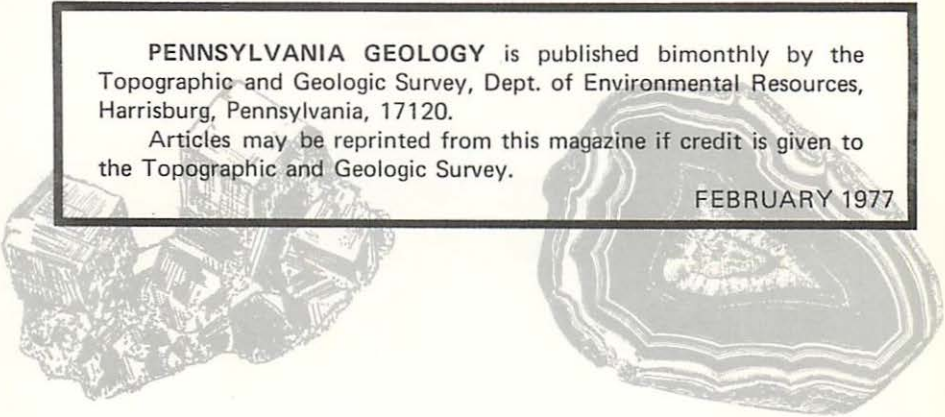
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ON THE COVER: The striking feature of Split Rock lends its name to the nearby Village of Split Rock in Carbon County. Formed by weathering and erosion along two parallel joints which cut the quartz-sandstone Duncannon member of the Catskill Formation, this natural gap is about 25 feet high and 6 feet wide. Photo courtesy of William Bolles.

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FEBRUARY 1977



FROM THE DESK
OF THE
STATE GEOLOGIST . . .



THE MANY FACES OF GEOLOGY

It is fascinating to this writer to find how diverse is the impression amongst various individuals, including geologists, as to what the subject of geology is all about. I do not refer to those who simply have a preference or specialization in one aspect of the science, but rather to those who do not have an awareness of the many ramifications of geology and the variety of ways the subject relates to the lives of man: A review of the contents of this issue of our journal reveals some of the diversity of geologic applications.

The structural geology article on page 2 integrates observed Appalachian Mountain features with practical engineering design procedures imposed by the geologic conditions. On pages 6, 14, and 15 the reader is introduced to Pennsylvania's role as a major source of the energy resources coal, oil, and gas, along with the geologic procedures utilized in locating and defining the distribution of those vital resources. The role of geology in land use planning is demonstrated by the environmental geology reports and maps announced on pages 14, 15, and 16. The recreational aspects of geologic features are presented on pages 7, 9, and 15. The role of geology in helping to safeguard mining techniques is shown by the article on page 12. And on page 8, we find a description of how contemporary geologic theories are being integrated into our educational systems.

The office of the State Geological Survey is a focal point of every geological activity and event imaginable — and some that are unimaginable! They include basic scientific investigations, applied programs of critical mineral and water resources development, long-range land use planning guidelines, the crises of geologic hazards (such as landslides and sinkholes), as well as involvement in recreational planning (as mineral collecting and trail designs).

We hope that through the medium of this periodic journal, we are helping to make our readers somewhat more aware of the many and diverse ways in which geology relates to their daily lives.

Arthur G. Socolow

Structure and Engineering Geology at the Rockville Cut

by S. I. Root and J. P. Wilshusen

During construction of the River Relief Route north of Harrisburg a large excavation was made through Devonian Montebello quartzitic sandstones near the Rockville railroad bridge crossing of the Susquehanna River. This cut is interesting because of geologic structure visible on the face and the engineering geology of the rocks.

Several thrust faults inclined at low angles to the earth surface, offset dramatically contrasting light gray, dark gray, and dark brownish-red beds of sandstone that stand vertically (Figure 1). Offsets on the faults range from several feet (Figure 1) to less than one inch (Figure 2). However, fault geometry and mechanics are similar in both the largest and smallest faults. Faulting of this type was described in 1943 by E. Cloos and C. H. Broedel in a paper entitled "Reverse Faulting North of Harrisburg, Pennsylvania" which appeared in The Bulletin of the Geological Society of America. According to the authors, these faults occurred after the strata had been folded from their original horizontal position to their present vertical position. The stress that caused faulting was essentially directed horizontally and movement direction, as shown by fault striae or grooving, was perpendicular to the trend of the mountains. Net effect of faulting has been to produce a series of "wedges" that extend the rocks in a vertical sense and diminish the width across the rock layers (Figure 3). Total vertical thickening and lateral shortening may aggregate to several hundred feet in an area of several miles.

This faulting was the last effect of the large scale deformation that formed the Appalachian Mountains. Some 240 million years are estimated to have elapsed since the earth's crust in eastern North America was deformed into these scenic mountains.

The geologic features exposed in the new cut are not only of interest in what they illustrate about the manner of deformation during which the Appalachian Mountains were developed; they are of equal interest for their effect upon construction and development of the roadcut. The cut is large, 218 feet deep and 272 feet along the slope from top to bottom. The angle of slope is $\frac{3}{4}$ horizontal to 1

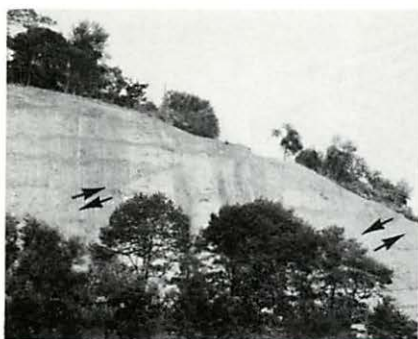


Fig. 1. View of road cut in Montebello sandstones showing thrust faults, with displacement of several feet, offsetting vertical strata. Direction of fault movement shown by arrows. Horizontal dark lines with no offset are blasting "lifts".

vertical which is 53 degrees measured from the horizontal. This angle was designed to be approximately parallel to a prominent fracture direction in the rock, thereby providing a more stable cut.



Fig. 2. Thrust faulting producing "wedges". Displacement of lower fault is about $3/4$ inch (note coin for scale just below fault), displacement on upper fault is about $1/8$ inch. Direction of fault movement shown by arrows.

Careful blasting technique is required to plane off the end of a mountain leaving a relatively smooth surface in rock units of varying hardness. The drilling and blasting method followed is called pre-splitting, i.e., a single crack is split along and parallel to the cut face by blasting, with the line fired a fraction of a second before the entire rock body to be removed is broken. The work is done in "lifts" of 20 to 30 feet from the top of the cut down (Figure 4). On this cut holes are drilled along the proposed face at a 53 degree angle, parallel to principal fractures, and spaced 30 inches apart.

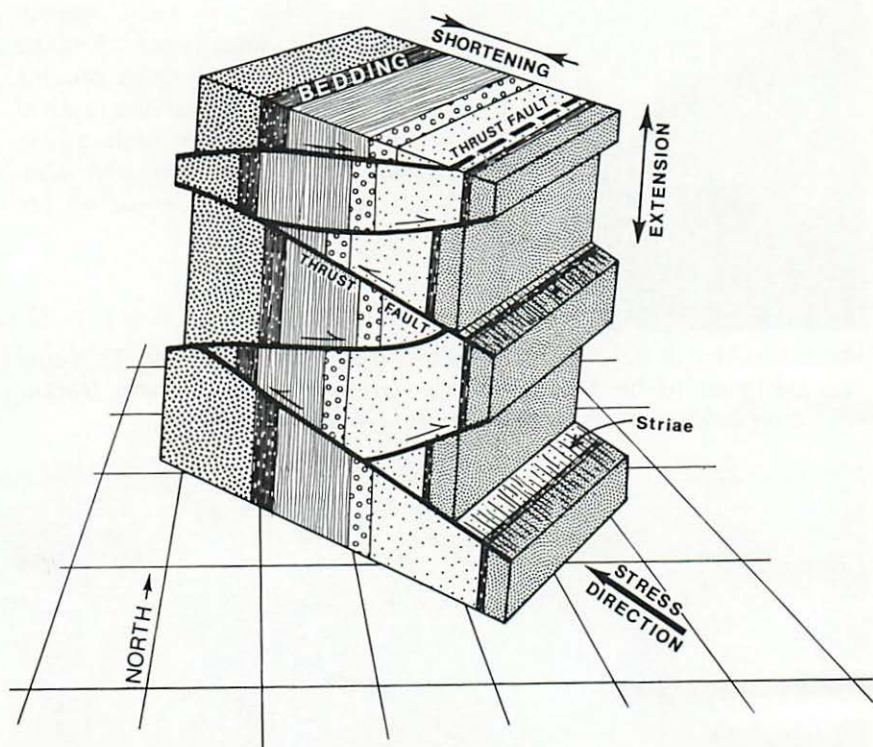


Fig. 3. Development of faulted "wedges" which extend strata vertically and shorten strata horizontally. Arrows show direction of fault movement. Modified from Cloos and Broedel (1943).

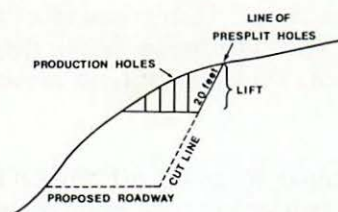


Fig. 4. Cross section sketch of a drilled lift for a road cut.

Next, vertical holes are drilled in the mass to be broken and removed. All the holes are loaded with explosive and as the shot is fired the explosive in the presplit line goes off first with the mass of rock against it; then, the rock to be removed is shattered. The millisecond delay allows the rock to split from hole to hole along the face, leaving a smooth surface.

Work on this cut was started in December 1975. Under the direction of District 8-0 of the Pennsylvania Department of Transportation, the Central Pennsylvania Quarrying and Stripping Company will excavate approximately 325,000 cubic yards of rock. The time of completion of the cut according to Joseph Schuech, Soils Engineer, will depend upon scheduling of other parts of the River Relief Route construction. The new highway is intended to be open to traffic by December 1, 1978.

During the course of excavation some unusual geologic features have been exposed. Spherical concretions of uncertain origin have been found in the hard Devonian sandstone which makes up most of the ridge. The concretions range in size from that of a cannon ball to several feet in diameter and are dense and heavy. Concretions are common sedimentary features developed during, or just after, deposition of the sediment which forms the sandstone. Sometimes the introduction of foreign matter into an accumulating sediment will cause a segregation of some of the constituents of the sediment. Concretions can form, therefore, in chemical response to an equilibrium disturbance. In other cases it appears, that there is a segregation of some of the minor mineral constituents of the sediment after



Fig. 5. Crumbly, unconsolidated sand bed between hard, indurated sandstone units. Note 3 inch Brunton compass on the right for scale.

deposition. However, analyses of concretions do not always give conclusive evidence of the origin of these secondary structures.

Another unusual geologic feature seen on the cut face are zones of crumbly sand in the midst of hard, well-indurated sandstone beds. (Figure 5) These softer zones form bed-parallel fissures recessed a few feet into the cut face and unconsolidated sand is frequently present. Apparently they are due to a general surficial leaching of beds rich in calcareous fossil shells. It is anticipated that these zones will not cause maintenance problems.

Several pronounced springs can be observed issuing from the new cut. These appear to be following along some of the more pronounced fracture zones, as well as the open zones where there has been leaching and removal of the crumbly sandstone.

Pennsylvania's Oil and Developments

A comprehensive summary of Pennsylvania's increased oil and gas activities is presented in the Bureau of Topographic and Geologic Survey's Progress Report 189, Oil and Gas Developments in Pennsylvania in 1975, by W. S. Lytle, R. G. Piotrowski, and Louis Heyman. Detailed data on drilling, discoveries, and production for the year is given in this annual report on a county-by-county basis. It is noteworthy that drilling for oil increased 3% and gas well drilling increased 36% over the prior year 1974. The most active gas well drilling was in Indiana County, while Warren, Venango, and McKean Counties saw the most active oil drilling. 1399 new wells were drilled in Pennsylvania during the year; of the 112 exploratory wells, 51% were successful; of the 1287 new development (field extension) wells 99% were successful. This is an excellent record of success. Total Pennsylvania oil production for 1975 was 3,199,000 barrels; gas production was 84,772 million cubic feet. All who are interested in Pennsylvania's oil and gas industry and the Commonwealth's ability to contribute to its oil and gas needs will find a wealth of information in this new report.

Progress Report 189 is available for \$1.30 (plus tax for Pa. residents) from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125.

EAST visits WEST

Mr. Sudip Kumar Bose, a geologist with the Directorate of Geology and Mining, Uttar Pradesh, India, received some in-service training experience with the Pennsylvania Geological Survey during July 1976. Mr. Bose, who is the recipient of a United Nations Fellowship, is visiting selected geological organizations in various parts of the United States to become acquainted with the methods and techniques being used in the exploration, evaluation and development of industrial or non-metallic minerals. While in Pennsylvania, his attention was directed especially to field work on geological projects concerning limestones, clays, and shales.



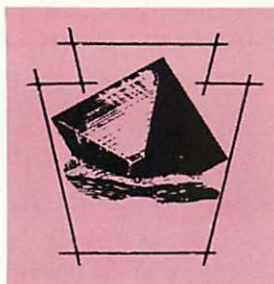
The training program in industrial minerals for Mr. Bose is a combination of academic and in-service training experience. Mr. Bose spent January through June taking selected courses at the School of Earth Sciences, Stanford University. The remaining portion of his program is being arranged through the Office of International Geology of the U. S. Geological Survey, and includes training with Federal and State agencies, and private industries. Upon completion of his training, Mr. Bose will return to his duties as a geolo-

gist with the Directorate of Geology and Mining, Uttar Pradesh, India. We hope that his Pennsylvania experience will help in the industrial development of India.

york mineral and gem show

The York Rock and Mineral Club will hold its Eighth Annual Mineral and Gem Show on Saturday, April 2 and Sunday, April 3, 1977 at the Manchester Township Fire Co. No. 1, in the Manchester Township Building, Emigsville, Pa. The firehouse is located in Emigsville, Pa. on Route 181, going north from York, Pennsylvania.

Show hours are Saturday, April 2, 10:00 a.m. to 9:00 p.m. and Sunday, April 3, 10:00 a.m. to 6:00 p.m.



EARTH SCIENCE TEACHERS' CORNER

plate tectonics in the classroom

In August the first planning conference of the National Association of Geology Teachers Education Project on Crustal Evolution was held at the University of Oklahoma which is the host institution for the project. The project will produce, as supplements to existing earth science curricula in grades 8 thru 12, a number of 1 to 3-day classroom instructional units. These will be based on current scientific research into the composition, history, and processes of the earth's crust and the applications of this knowledge to man's activities.

The intense oceanographic investigations during the past decade of the geological and geophysical properties of the ocean floors, and related studies on the continents, have led to a "revolution" in thought about the development of the earth and the formation of the most fundamental aspects of its framework. Thus, there exists today a "breaking story" in the earth sciences which is considered to rank in importance with such scientific advances as the development of the Darwinian Theory of Evolution, and the Bohr Atomic Model. A part of the rationale for this curriculum project is that teachers and students have a unique opportunity to share in the present unfolding of what is considered to be one of the most important interpretations of modern civilization about the nature of this planet, and its structure and development. The new crustal evolution concepts have touched off a period of accelerated activity that is rapidly expanding our knowledge of the origin of mountain ranges, thermal resources, earthquakes, volcanoes, zoogeographic distribution of plants and animals and metalliferous deposits. This is leading to increased ability to predict the location of potential mineral and energy resources, and the sites of future earthquakes, and has many other applications of importance to man's future. It is hoped that this project will be able to demonstrate a model for shortening the time lag for translation of ongoing research into useful classroom materials.

Development of instructional units will be carried on at centers located throughout the country, by teams consisting of college-based science educators, junior high school teachers, and active researchers.

A trip along Pennsylvania's Interstate 81, the Penn-Can Highway, can be turned into a geological field trip through use of a just-published booklet produced in cooperation by the Pennsylvania Geological Survey (Department of Environmental Resources) and the Bureau of Curriculum Services (Department of Education). The 35-page booklet, titled *Interstate 81 - Geologic Guide*, points out such problems encountered in building the road, outstanding geologic and scenic panoramas and numerous other points of interest along the route. A continuing map runs through the booklet to help pinpoint the items discussed.

A copy is available free of charge from Mr. William H. Bolles, Bureau of Curriculum Services, Department of Education, Harrisburg, Pennsylvania 17125.

Survey Draftsman Receives Award



Governor Shapp recently awarded Mr. Jack Kuchinski, Cartographic Draftsman of the Pennsylvania Geological Survey staff, a citation and a U. S. Savings Bond for a cost-saving procedure that Mr.

Kuchinski had developed. Mr. Kuchinski's money-saving technique involved the use of scribing tools to etch words, letters, and numbers directly onto mylar sheets being used to prepare detailed geologic maps. This eliminated several costly and time-consuming steps in the drafting and printing processes. Accompanying Mr. Kuchinski at the presentation was his supervisor, Christine E. Miles, Geologic Editor of the Bureau of Topographic and Geologic Survey.

Two Geologists Join Survey Staff

We are pleased to announce that Larry E. Taylor has joined the staff of the Pennsylvania Geological Survey at the Survey's Harrisburg office, and Stephen A. Krajewski at our Pittsburgh office.

Larry Taylor will work with the Environmental Geology Division and will primarily be responsible for projects in the area of ground water. Larry received his Bachelor of Science Degree in geology from the University of Toledo, Ohio in 1971 and his Master of Science Degree in geology from the same university in 1974. After graduation, he joined the staff of Moody and Associates, Inc., a groundwater consulting and well drilling firm located in Meadville, Pennsylvania. Larry had various assignments with Moody, ranging from participation in regional groundwater pollution to water supply development projects. He is a member of the Technical Division of the National Water Well Association and is interested in all aspects of groundwater resource utilization and management.

Steve Krajewski is assigned to the Oil and Gas Geology Division. His primary responsibility is to work on the Eastern Shale Gas Project being conducted in cooperation with the U. S. Energy Research and Development Administration. Steve received his B.Sc. degree in geography in 1968, his M.Sc. in geology in 1971, and he anticipates receiving his D.Ed. in earth science in June 1977, all degrees from the Pennsylvania State University. His geologic work experience includes geochemical field prospecting for platinum and nickel in the Stillwater Complex, Montana for Johns-Manville Corp.; paleo-environmental reconstruction in the Upper Devonian of Northeastern Pennsylvania for the mining of flagstones; conducting coal reserve exploration programs in West Virginia, Virginia and southwestern Pennsylvania for Jones and Laughlin Steel Corp.; sedimentologic analysis of Late Pleistocene barrier island sands in the Eastern Shore area of Virginia. In addition, he has taught geology, geography and oceanography at Washington and Jefferson College in Washington, Pennsylvania.

Prominent Limestone in Mifflin County

This photograph shows a rock promintory at the edge of the Juniata River near the Borough of Newton Hamilton. There are numerous similar exposures of this size in Pennsylvania but this one is unusual because it is made of limestone, a rock type that generally underlies valleys and does not often form prominent ridges.

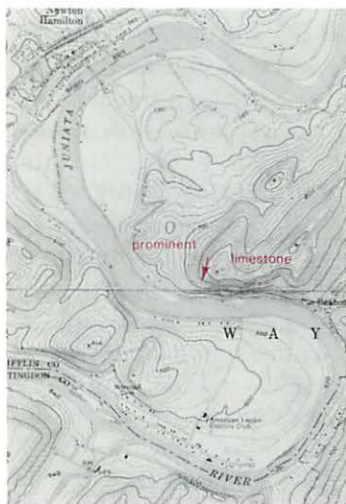
Limestone is composed mostly of calcite, a mineral which is readily soluble in acid. As the rainwater falls through the air, it picks up small amounts of carbon dioxide which combines to form weak carbonic acid. As the water percolates through the soil the acidity increases with the addition of organic acids. It is most common, therefore, in humid climates to see limestone weather faster than surrounding rock types resulting in the formation of valleys.

The anomolous exposure in the photograph is the result of structural forces which have deformed the rock and bent it into a large, tight fold. The result of that geologic deformation was to increase fracturing in the rocks on either side of the limestone causing them to weather away faster and leaving a limestone "wall" behind.



Keyser Limestone along the Juniata River near Newton Hamilton.

Photo by:
Peter Wilshusen, February 1976.



Ancient River a Possible Hazard to Coal Mining

by Mark Sholes

Modern rivers deposit sand, silt, and clay in characteristic patterns. The lithified equivalents of modern river (or fluvial) deposits can be recognized in ancient rocks. Ancient rivers locally cut deep channels, (in the same manner as modern rivers) which filled with sand and which are important today in western Pennsylvania because they cut down to or through mineable coal deposits. Where a sandstone cuts down through a coal, it may be necessary to drive a heading through the sandstone to mine the coal on the other side of the channel. In addition, certain areas associated with channels provide particularly weak mine roofs and present a serious hazard to underground mining (Kent, 1974). It is therefore important to locate ancient river deposits where they are associated with mineable coal deposits.

An ancient river deposit must have some distinctive characteristics in order to be recognized because not all sandstones in coal-bearing strata formed as fluvial channels. Sand may have been deposited as a beach, a barrier bar, a delta front bar or in tidal channels. The sand bodies produced in these different depositional environments have different shapes, geographic distributions and effects on mining operations in the vicinity of the sandstone body. Distinctive characteristics of fluvial-channel-fill sandstone bodies in western Pennsylvania are:

1. The lower boundary is erosional, a basal conglomerate is generally present, and other conglomerates are locally scattered through the sand body.
2. Grain size of the sediment decreases upward from the base.
3. Plant fragments are locally abundant in the sandstone and marine fossils are absent.
4. The general shape of the sandstone body is elongate in map-view and lens-shaped across the width in cross section.

In the Philipsburg-Houtzdale area of Centre and Clearfield counties there is an excellent example of an ancient river deposit which has a major affect on the local coal and its recovery. Glass (1971) traced the Kittanning sandstone across the Philipsburg 7½' quadrangle by noting where the Clarion coal has been eroded away and replaced by the Kittanning sandstone, the areas where the sandstone is directly on the coal, and the westward and eastward

increasing thickness of shale which overlies the Clarion coal where the sandstone rises off the coal (Fig. 1). Recent work in the southern half of the Houtzdale 15' quadrangle using drill hole core descriptions allows the extension of this channel through southern Houtzdale and a more accurate determination of the three-dimensional shape of the sand body than was possible by Glass (Fig. 1). In addition to the sand-filled main channel, a variety of other sediments associated with the channel were deposited. These include levee deposits, overbank mud and locally peat. The Kittanning sandstone is representative of a medium-sized channel-fill deposit in western Pennsylvania. The effect of the sandstone on coal mining, however, depends not so much on the size of the sandstone as its relationship to the coal.

References

- Glass, G. B., (1971), Channel sandstones in coal: Pennsylvania Geology, vol. 2, no. 5, p. 4-6.
 Kent, B. H., (1974), Geologic causes and possible preventions of roof fall in room-and-pillar coal mines. Bur. Topo. and Geol. Survey, I. C. 75, 17 p.

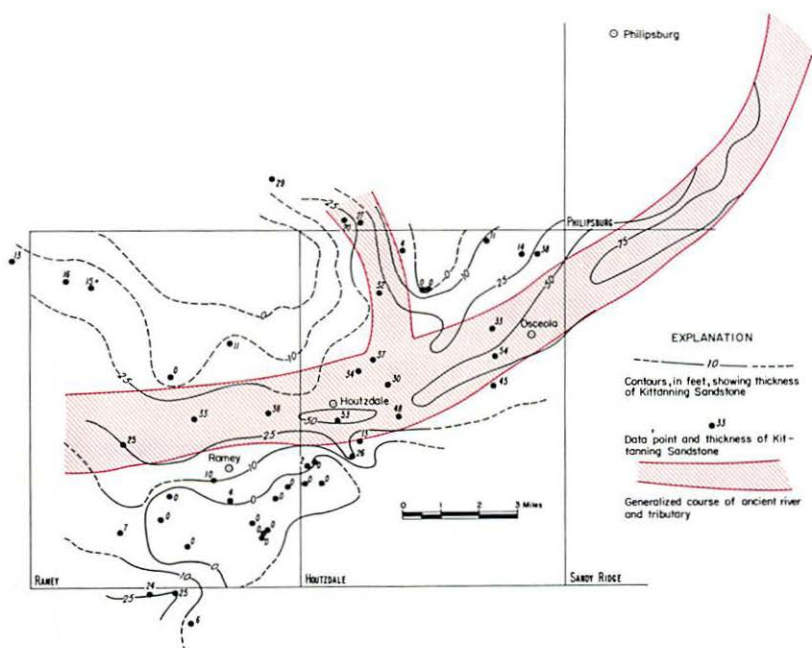


Fig. 1. Thickness of the Kittanning Sandstone in the Philipsburg — Ramey area.

SURVEY ANNOUNCEMENTS

GREATER HARRISBURG AREA ENVIRONMENTAL ATLAS

One of the most complete compilations of geologic and environmental data ever offered for an entire metropolitan area has been published by the Bureau of Topographic and Geologic Survey as *Environmental Geology of the Greater Harrisburg Metropolitan Area*. Authored by former Staff Geologist William G. McGlade and Alan R. Geyer, the report presents by maps and text all of the detailed physical elements essential to effective engineering and transportation design, as well as agricultural and recreational development.

Covering an area of 16 by 20 miles, from Mechanicsburg to Hershey, the Harrisburg Area environmental atlas includes seven large, full-colored maps, each presenting data on a critical environmental factor: (1) layered relief map, (2) slope map, (3) drainage and flood-prone area map, (4) soil associations map, (5) geology and mineral resources map, (6) groundwater availability map, and (7) engineering geology map. All planning or zoning efforts, all transportation designers, and every community, commercial, or private entity involved with any type of construction of land use activity would greatly benefit by utilizing the information offered by these maps and their accompanying texts. By offering the citizens of the Greater Harrisburg Area information on physical conditions, natural resources, and natural hazards, they should be able to make decisions which will effect greater economy, greater safety, and wiser land use.

Environmental Geology Report #4, *Environmental Geology of the Greater Harrisburg Area*, is available for \$17.65 (plus tax for Pa. residents) from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125.

OIL AND GAS RELATIONSHIP TO LOCAL STRUCTURES

The relationship of oil and gas fields to local and regional geologic structures is presented in the Bureau of Topographic and Geologic Survey's Information Circular 80, *Greater Pittsburgh Region Revised Surface Structure and Its Relation to Oil and Gas Fields*, by the late Walter R. Wagner and by William S. Lytle. This illustrated, 20-page report is available for \$0.80 (plus tax for Pa. residents) from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125.

WILLIAMSPORT AREA GEOLOGIC MAPS AND REPORTS ON OPEN FILE

The Pennsylvania Geological Survey is placing on open file the recently completed geologic maps and accompanying reports of four 7½-minute quadrangles between Williamsport and Jersey Shore in Lycoming County. The quadrangles are Linden, Williamsport, Salladasburg, and Cogan Station. The maps show both the bedrock geology and the distribution of the surficial deposits throughout the area. The reports, which are being readied for printing, describe each of the geologic units, discuss the various types of geologic structures, provide evaluations of the environmental and engineering properties of each of the geologic units, and describe the significant economic deposits and occurrences within the area. These reports, authored by staff geologists Rodger T. Faill, Richard B. Wells, and William D. Sevon, may be examined at the Harrisburg offices of the Pennsylvania Geological Survey, Room 914, Executive House, 101 S. Second Street, Harrisburg, Pennsylvania 17101.

MAP TO AID PROPER COAL DEVELOPMENT

The depths to one of the major coal deposits underlying Allegheny, Westmoreland, Beaver, Butler, and Armstrong Counties are given in detail on the Bureau of Topographic and Geologic Survey's new Map #49, **Greater Pittsburgh Region Thickness of Rocks Over the Freeport Coal**. Knowing the thickness of the rocks overlying this coal formation is important (1) in planning the future mining techniques for this valuable coal deposit, as well as (2) in planning and designing appropriate surface development in the areas where the coal will be (or already has been) mined beneath the surface. This map will serve as an important aid to all who are concerned with both energy resource development as well as effective land use conservation.

Map #49 is available for \$2.10 (plus tax for Pa. residents, from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125).

CAVES OF PENNSYLVANIA

In keeping with its long tradition of providing up-to-date maps and reports on Pennsylvania's caves, the Bureau of Topographic and Geologic Survey has issued two new publications on the subject.

General Geology Report 67, **Caves of Western Pennsylvania** provided details of 79 caves in the 12 counties of Allegheny, Armstrong, Butler, Clarion, Fayette, Indiana, Jefferson, Lawrence, Mercer,

Somerset, Venango, and Westmoreland. There are 45 figures and plates to supplement the 97 pages of text material which were compiled by members of the Mid-Appalachian Region of the National Speleological Society and edited by Dr. William B. White of the Pennsylvania State University.

Caves of Western Pennsylvania is available for \$3.00 (plus 6% tax for Pennsylvania residents) from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125.

Geology and Biology of Pennsylvania Caves is the title of the Bureau of Topographic and Geologic Survey's newly issued General Geology Report 66. Edited by Dr. William B. White of the Pennsylvania State University, this 103-page report has three parts: The part on The Geology of Caves is by Professor White; the part on The Cave Fauna of Pennsylvania is by Professor John Holsinger of Old Dominion University; the part on Appalachian Bone Caves is by Dr. John E. Guilday of the Carnegie Museum.

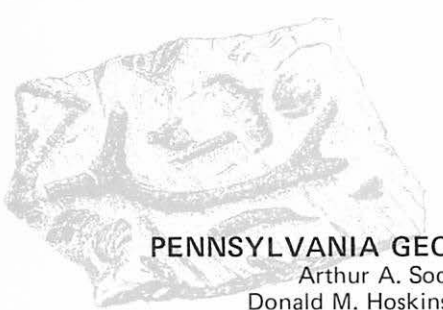
Bulletin G 66 provides the reader with a comprehensive understanding of the origin of Pennsylvania's caves, their forms and features, and their animal populations or past and present. **Geology and Biology of Pennsylvania Caves** is available for \$2.00 (plus 6% tax for Pa. residents) from the State Book Store, P. O. Box 1365, Harrisburg, Pa. 17125.

Jefferson County Topo Map to Pinpoint Local Sites

Modifying the Jefferson County topographic map cooperatively issued by the Pennsylvania and U. S. Geological Surveys, the Jefferson County Planning Commission has prepared a new map with a detailed grid overprint that can be used by police, fire and local officials as well as the public to accurately locate problem sites and other points of local concern.

These new county maps are intended to provide an accurate topographic map at reasonable scale for use by local citizens and officials. We are pleased to see that the county is making this unexpected use of these maps. Copies of the modified Jefferson County topographic maps may be obtained at \$2.00 each from the Jefferson County Planning Commission, 82 Barnett Street, Brookville, Pennsylvania, 15825.





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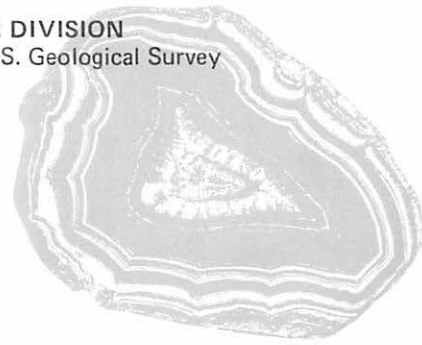
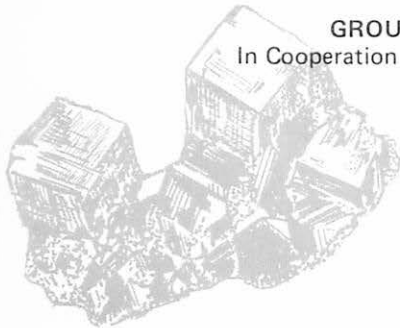
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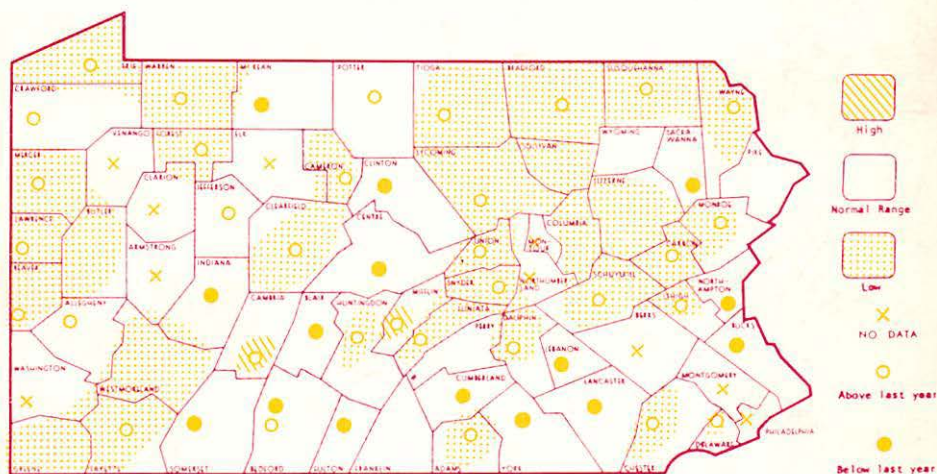
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