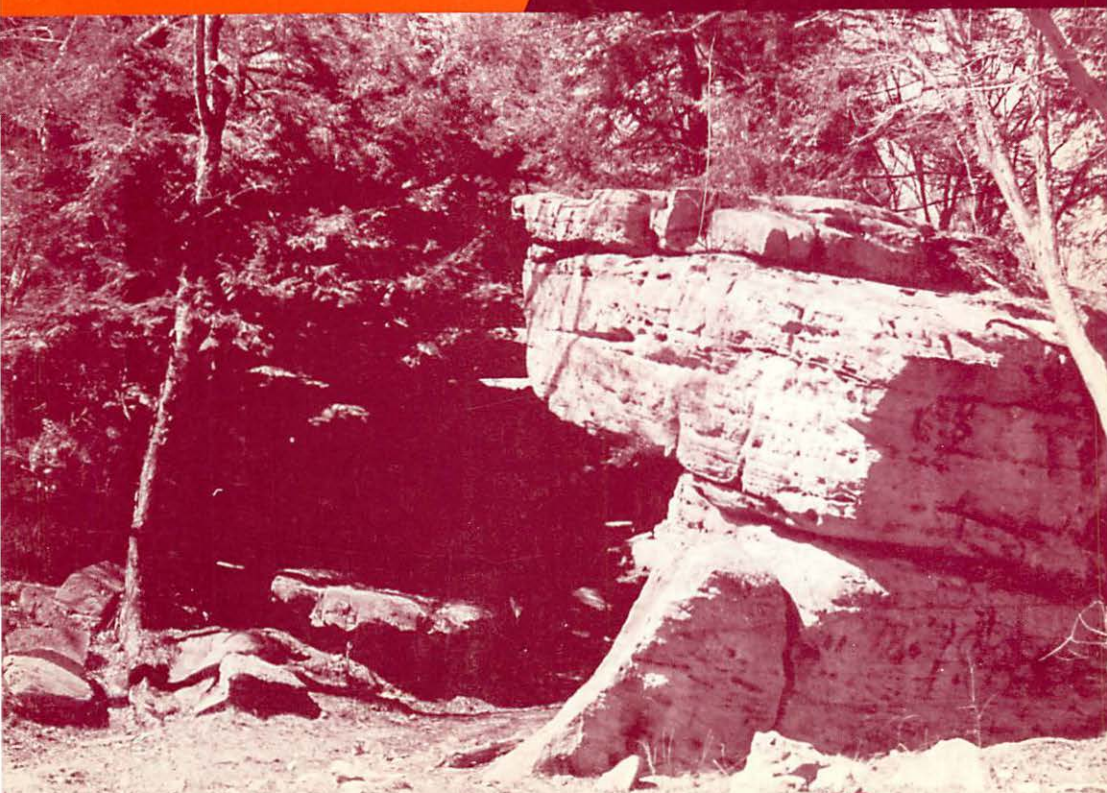


# **G E O L O G Y**

# **PENNSYLVANIA**



THE PENNSYLVANIA GEOLOGICAL SURVEY

**COMMONWEALTH OF PENNSYLVANIA**

Richard L. Thornburgh, Governor

**DEPARTMENT OF ENVIRONMENTAL RESOURCES**

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**OFFICE OF RESOURCES MANAGEMENT**

Patrick J. Solano, Deputy Secretary

**TOPOGRAPHIC AND GEOLOGICAL SURVEY**

Arthur A. Socolow, State Geologist

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**ON THE COVER:** Bilger Rocks, on Pike Township Route 203, 4 miles northwest of Curwensville, Clearfield County. Huge blocks of cross-bedded Homewood Sandstone, bounded by joint separations form a "rock city."

**PENNSYLVANIA GEOLOGY** is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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**February 1983**



FROM THE DESK  
OF THE  
STATE GEOLOGIST . . .



GEOLOGIC SERVICES CONTINUE THROUGH GOOD TIMES OR BAD

The minerals industry, as the basic source of raw materials for our nation's industrial sector, is one of the major victims in times of a depressed economy. Thus it is that Pennsylvania's production of industrial and construction minerals has sagged in the past year, as has exploration for new reserves of those minerals.

Yet we at the state's Geological Survey find that the number of incoming requests for geologic services and information remains high, even increasing in certain subject areas. Questions from individuals, municipalities, and industry concerning groundwater and water well locations have increased, probably a result of recent drought episodes and the recognition that water management is a growing necessity in eastern United States.

Our geologic services to the recreational community show up in the calls which come to us concerning mineral and fossil collecting sites, scenic geologic trails and outstanding geologic features, accessible caves, and availability of our topographic maps for hunting, fishing, and camping activities.

The public has begun to recognize our role and assistance in matters of geologic hazards, such as sink hole problems in eastern Pennsylvania, landslides in western Pennsylvania, bluff failures (Lake Erie), mine subsidence, flood-prone areas, and even earthquake potential. Our geologic data and knowledge of the processes involved serve not only to implement corrective actions after the fact, but also help to initiate preventive measures in hazard-prone areas.

As more and more communities and individuals recognize the need for both cleaning up existing sites as well as operating new waste disposal sites, we find increasing questions coming to us concerning the identification of favorable and unfavorable geologic conditions affecting such sites, involving both solid wastes and liquid wastes.

Construction activities, although considerably reduced, still result in geologic service needs relating to foundation conditions under bridges and dams, availability of appropriate nearby building stone and construction aggregates, and location of least difficult (and least costly) geologic routes for new pipelines, transmission lines, phone lines, and roadways.

Even as the activity of the coal and metals exploration industry has decreased somewhat, conversely exploration and development of Pennsylvania's natural gas and oil has markedly increased, resulting in a wide range of requests for geologic information and services, from regional geologic maps and cross sections, to discussions of site specific data and well samples on file here for all to utilize.

The Pennsylvania Geological Survey is pleased to be carrying out its mandate to serve the geologic needs of the public and extends a standing invitation to one and all to utilize our geologic data and expertise. We welcome phone calls to the main office in Harrisburg (717) 787-2169 or our branch office in Pittsburgh (412) 565-5030, and we invite inquiries by mail or personal visit to these offices at 914 Executive House, 101 S. Second Street, Harrisburg, PA 17101 or 1201 Kossman Bldg., 100 Forbes Avenue, Pittsburgh, PA 15222.

*Arthur G. Socolow*

# CHARACTERISTICS OF PENNSYLVANIA'S ROCK FORMATIONS

A new Pennsylvania Geological Survey publication which describes the practical, engineering and construction characteristics of bedrock formations in the state, has recently been published and released. This is a completely revised second edition, especially prepared to accompany the revised 1980 State Geologic Map. The book contains 300 pages of information useful to anyone dealing

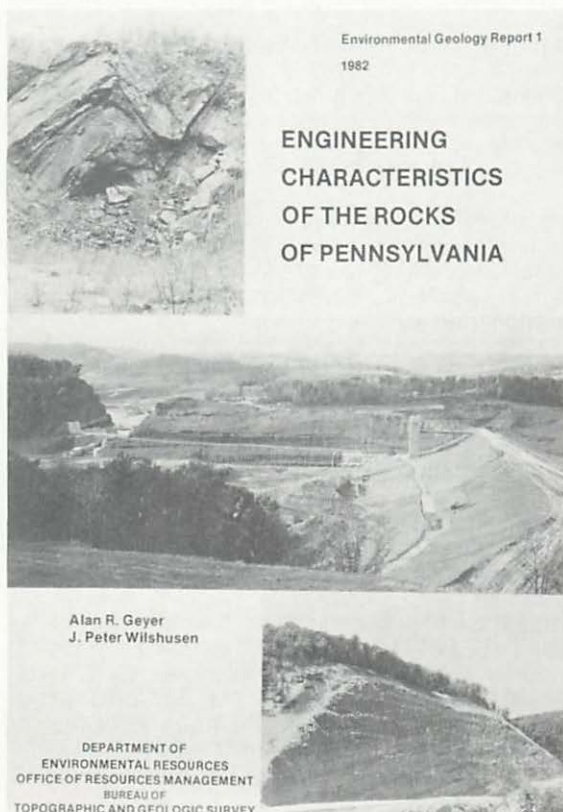


Photo of the cover of Environmental Geology Report 1



with one or more of the 210 geologic rock units in Pennsylvania as shown on the state geologic map.

With introductory material describing major engineering characteristics of the rocks of Pennsylvania, each geologic unit (a group, formation or member) is enumerated, outlining the lithology, bedding, fracturing, and weathering characteristics, topographic expression, drainage conditions, porosity and permeability, ground-water potential, ease of excavation, cut-slope stability, foundation stability and availability as potential construction material. Laboratory Rock Test Data on representative samples is provided where available for some formations. Photographs accompany the descriptions of most rock units to provide visual impressions of the rock units listed.

*Engineering Characteristics of the Rocks of Pennsylvania*, Environmental Geology Report 1, Second Edition, Revised, 1982, by Alan R. Geyer and J. Peter Wilshusen is available from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The mail order price is \$3.90 (plus 6% sales tax for Pennsylvania residents). Check made payable to the Commonwealth of Pennsylvania must accompany the order.

## Bless our students

From a transplanted Pennsylvanian, Professor Don Groff at Western Connecticut State College, come these "gems":

"The theory of evolution was greatly objected to because it made men think."

"Charles Darwin was a naturalist who wrote the Organ of the Spices."

"The Earth makes a resolution every twenty-four hours."

"The moon is a planet just like the Earth, only deader."

### CORRECTION

The price listed for Map 1, "Geologic Map of Pennsylvania" in the December, 1982 issue of Pennsylvania Geology is incorrect. The correct price is \$11.50 plus 6% sales tax for Pa. residents.

# BARITE IN THE DEVONIAN MARCELLUS FORMATION, MONTOUR COUNTY

by John H. Way and Robert C. Smith  
Pennsylvania Geological Survey

Barite nodules and trace sphalerite have recently been discovered within a Devonian marine sequence of limy black shales in the north-central portion of the Valley and Ridge province in Montour County. The 16+ ft. thick series of interbedded, dark, fissile mudstones and massive limestones occurs in the Marcellus Formation in the Washingtonville 7½' quadrangle. This interval is thought to be equivalent to the Purcell limestone, an informal member of the Marcellus, reported in the subsurface of central and southwestern Pennsylvania (Cate, 1963, p. 232). This occurrence was identified during aerial mapping for the forthcoming Pennsylvania Geological Survey Atlas report A154cd involving the Washingtonville and Millville quadrangles.

The mineralized exposure (41°04'44"N/76°40'22"W), on the property of the P. E. Wemple family, is located just northwest of Pennsylvania Power and Light Company's Montour Steam Electric Station in Derry Township, approximately 2 mi. north of Washingtonville and 9 mi. north-northwest of Danville. At this locality, three distinct limestone beds form resistant ledges within the stream-cut, northwestern bank of Chillisquaque Creek and across the creek bed itself.

## Mineralogy

Several varieties of nodules, ranging from 1.5 to 8 in. in diameter, weather out of the fissile mudstone and accumulate on the bank and in the creek bed. Although the composition of the different varieties of nodules tends to overlap, four types were recognized: (1) barite rich: very dense, dark gray to black nodules (Figure 1) composed of concentric layers of radiating barite, along with varying amounts of pyrite; also some disseminated, yellowish-gray sphalerite and trace chalcopyrite can be observed; primarily from the middle portion of the zone; (2) pyrite rich: usually smaller, often



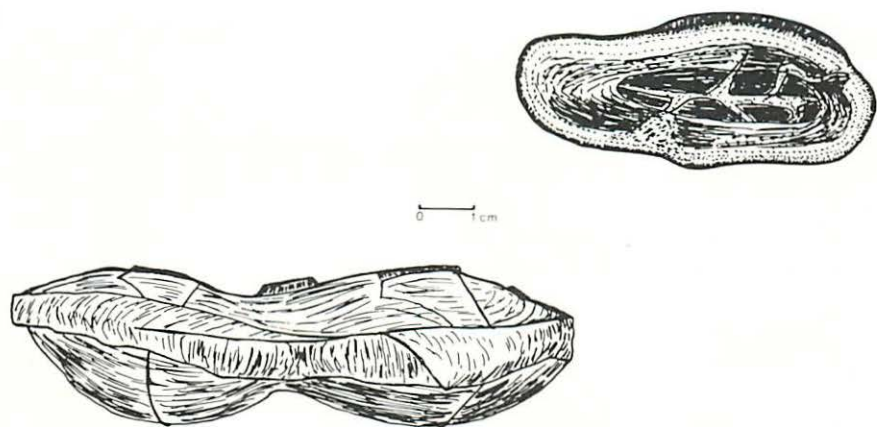


Figure 1. Sketch of complete and broken barite-rich nodules from the Washingtonville barite locality, Montour County. The fractures in the core of the nodule are usually filled with coarse, crystalline, clear barite in contrast to the darker, fine-grained barite matrix. Pyrite forms distinct bands toward the outer rim of the nodules as well as being disseminated throughout the barite matrix.

highly weathered, and most common in the upper and lower zones; (3) slightly mineralized: large, very tough nodules, having a small amount of barite and/or sphalerite in thin fracture fillings, usually with the sulfides toward the outer rims; concentrated in a zone below the lowest limestone; (4) unmineralized: very tough nodules composed primarily of very fine grained calcite and quartz, a small amount of pyrite, and possibly muscovite and chamosite, occurring throughout the mineralized interval. Figure 2 is a columnar section of this interval. Barite-rich nodules are concentrated between the lowest and middle major limestones and the large nodules containing sphalerite in fracture fillings occur below the lowest major limestone.

Three true channel samples I, II, III, (Figure 2) were cut through this section and results of the analyses are summarized in Table 1. Based on X-ray diffraction scans, the bulk rock consists of major amounts of quartz and calcite, minor muscovite and feldspar such as albite, and trace barite, pyrite, and a chlorite such as chamosite. Comparison with similar mineral mixtures containing known amounts of barite suggests that sample I contains about 1.5% barite, II contains about 0.6% barite, and III contains less than or equal to 0.2% barite.

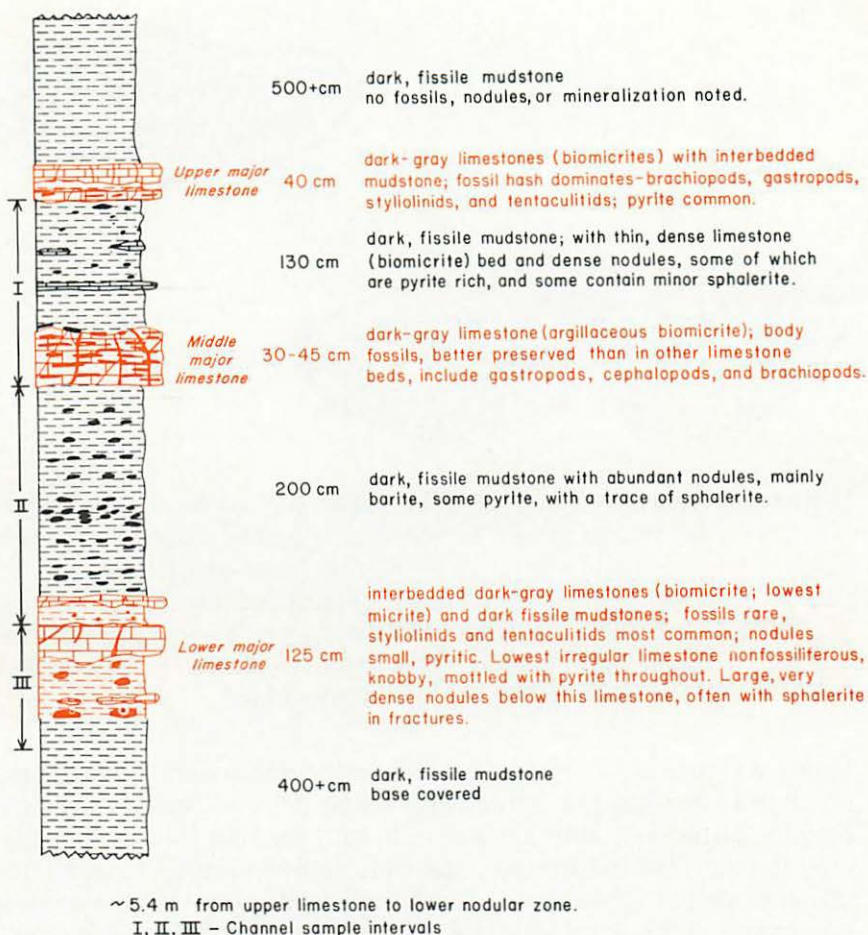


Figure 2. Stratigraphy of the Washingtonville barite locality.

X-ray fluorescence scans verify that barium is strongly enriched in the relative amounts indicated above, and that zinc and copper are slightly enriched relative to most black shales. These scans and commercial, semiquantitative emission spectrophotographic analyses suggest that other elements such as silver, arsenic, molybdenum, lead, and vanadium, that are enriched in other black shale units, are not anomalous at this locality.

The verification of barite from the stratigraphically lower Tioga Ash Bed in Perry and Northumberland counties suggests that volcanically derived barium may have been introduced into a restricted



marine environment such as is represented at this locality. Paleontologic evidence and the absence of other heavy metals, however, tends to rule out a deep, euxinic (oxygen-depleted) environment.

### Stratigraphy

Although the dark, fissile mudstones within this interval appear similar to exposures in the typical Marcellus Formation observed in nearby outcrops and adjacent quadrangles, the limestones are unique and have not been reported from adjacent quadrangles. Calcareous (siderite?) concretions and very fine grained limestone nodules had been reported as occurring within the Marcellus Formation, but barite and sphalerite have not.

The limestones in this interval vary in appearance and composition from very dense biomicrites to more argillaceous biomicrites. The fossils, which for the most part are fragmentary, are dominated by styliolinids and tentaculitids, ostracodes, brachiopods, trilobites, and gastropods. This fauna is similar to that reported by Rickard (1952) from the Cherry Valley limestone, a member of the

Table 1. Semiquantitative estimates of the percent barite and the mineralogy of continuous channel samples through the mineralized zone from top to bottom.

Sample	Thickness & Lithology	% Barite <sup>1</sup>	Minerals		
			Major	Minor	Trace
I	1.25 m dark mudstone 0.5 m dark limestone	1.5	calcite, quartz	feldspar (such as albite), dolomite	muscovite (such as 1 M and 2 M.), barite, pyrite (?), chlorite (such as chamosite)
II	1.85 m dark mudstone	0.6	quartz, calcite	muscovite (such as 1 M and 2 M.), feldspar (such as albite), chlorite (such as chamosite)	barite, pyrite (?)
III	0.5 m dark mudstone 0.4 m dark limestone	0.2?	quartz, calcite	muscovite (such as 1 M and 2 M.), feldspar (such as albite)	barite (?)

(1) % Barite represents an estimate by X-ray powder diffraction which compares the 3.10 Å barite spacing with known mixtures of pure minerals; relative amounts partially verified by X-ray fluorescence and semiquantitative emission spectrography.

Marcellus Formation in eastern New York state. A fragment from a large cephalopod, *Agoniatites vanuxemi* var. *nodiferus* (Hall), estimated to have been at least 26 cm (10 in) in diameter, was collected from a float block, presumably from the middle major limestone. *A. vanuxemi* is reportedly confined to a thin interval occurring below the base of the Cherry Valley limestone at its type section, and to a thin limestone within the Cherry Valley further to the southeast (Rickard, 1952, Fig. 2). While the lithologic descriptions of the Cherry Valley limestones themselves do not appear to be similar to the limestones here, the presence of pyrite nodules found abundantly in the lower layers of this unit (Rickard, 1952, p. 512), the presence of similar fauna including *A. vanuxemi*, and the position stratigraphically within the Marcellus Formation would suggest some basis for the correlation of this interval with the Cherry Valley.

In the subsurface of southwestern Pennsylvania, the Marcellus Formation grades from calcareous shales in the west to dark, silty or carbonaceous shales containing thin limestone units in the basal portions in the east (Cate, 1963, p. 232). These basal limestones were seen to have utility as subsurface markers and Cate (1963, p. 232) informally named a particular unit in the A. Morris No. 1 well, drilled in the Purcell gas field in Bedford County, the Purcell limestone.

The Purcell occurs as concretionary to lenticular limestone beds and is generally sparsely fossiliferous. Dennison, Hoskins, Hasson, and de Witt have reported this unit from Marcellus exposures throughout the central Appalachians and it is thought to be a good time marker because of its regular stratigraphic position about the Tioga Ash Bed, a thin zone comprising several layers of tuff and tuffaceous shales representing an extensive volcanic ash deposit. Based on subsurface work in Pennsylvania and New York both Cate and Dennison have suggested that the Purcell limestone in Pennsylvania is equivalent to the Cherry Valley limestone in New York (Dennison and others, 1972, p. 56).

If, in fact, the Purcell and Cherry Valley limestones are correlatable, it is suggested here that the barite-rich limestone sequence near Washingtonville is equivalent to this interval. These beds may also correlate with the Selinsgrove upper limestone (White, 1883, p. 79) at Selinsgrove Junction, Northumberland County, and limestones noted by Faill and others (1978, p. 9) west of Sunbury and near Shadle, Snyder County.

Barite nodules as well as barite and sulfide mineralization within nodules have been noted in several other localities within the Wash-



ingtonville quadrangle, adjacent quadrangles, and at a similar stratigraphic horizon in other portions of the folded belt. W. de Witt, Jr. has collected barite nodules from Bedford County and noted sphalerite in barite nodules from the Lock Haven area (personal comm. 10/82). Distinctive "golf balls with a radiating interior structure" have been reported by Dennison and others (1972, p. 56) from this horizon, suggesting the possibility that this mineralization may persist into Maryland, West Virginia, and Virginia as well.

Based on knowledge of other nodular barite occurrences in the Marcellus, the presence of base-metal sulfides at this locality, and our verification of barite in the Tioga Ash Bed, the Devonian marine section appears to be an attractive exploration target for bedded-barite deposits.\* Anomalous barium contents of stream sediments from this portion of the 1° x 2° Williamsport quadrangle (Cook, 1981), suggest that the Washingtonville 7½' quadrangle would be a good place to start.

\* D. A. Brobst, economic geologist formerly with the U.S.G.S., pointed out that in Nevada such nodular barite is peripheral to the more massively bedded barite, and, in places, is peripheral to massive sulfide ore deposits such as at Rammelsberg and Meggen in West Germany (1980, oral communication to A. V. Heyl, U.S.G.S.).

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## SURVEY ANNOUNCEMENTS

### COAL RESOURCE REPORT FOR NORTHEASTERN GREENE COUNTY

A new report, *"The Economic Geology of the Upper Freeport Coal in Northeastern Greene County, Pennsylvania"* has been published by the Bureau of Topographic and Geologic Survey, Department of Environmental Resources.

The report, written by staff geologist Viktoras W. Skema and former staff geologists Mark A. Sholes and William E. Edmunds, provides information concerning the important characteristics of the Upper Freeport coal and its distribution in the Waynesburg and Mather area of Greene County. In addition to giving a detailed description of the coal, the publication attempts to reconstruct the setting in which the coal was deposited, so that patterns of its distribution and internal characteristics can be better understood. With this approach, a more accurate prediction can be made of the coal's nature and location in adjacent unexplored areas.

The 51 page publication contains 21 figures and a table of coal resource estimates. Included among the figures are: (1) stratigraphic cross sections showing the position of the Upper Freeport coal in relationship to key beds in the overlying Glenshaw Formation; (2) detailed cross sections of the coal with non-coal partings and character of the immediate roof rock indicated; (3) various maps showing thickness, distribution, and ash and sulfur content of the coal; (4) maps showing composition, thickness and distribution of rock units both above and below the coal; and (5) maps interpreting environments of deposition during and after development of the coal-forming peat.

The publication is designated as Mineral Resource Report 76 and may be obtained from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, PA 17125. The mail order price is \$3.00 (plus 6% sales tax for Pennsylvania residents). Check payable to Commonwealth of Pennsylvania must accompany order.

### NEW REPORT HIGHLIGHTS INCREASED OIL AND GAS ACTIVITY

Oil production in Pennsylvania rose 27 percent in 1981 over the prior year and gas production rose 26 percent according to figures released in the Pennsylvania Geological Survey's new report *"Oil*



*and Gas Developments in Pennsylvania in 1981.*" Oil production for the year totalled 3,729,214 barrels, and equally important, Pennsylvania oil reserves increased to 50,946,000 barrels. At prices ranging from \$38.00 to \$35.00 per barrel, Pennsylvania's oil production had a crude oil value of well over \$100 million.

Gas production in the state in 1981 amounted to 97.4 billion cubic feet and the gas reserves increased 7 percent to 2316 billion cubic feet. While the price paid for the gas varied widely, the total value of the gas produced during the year was on the order of \$200 million.

The total number of oil and gas wells drilled in Pennsylvania in 1981 was 3,554, a 76 percent increase over the prior year. The most active oil well drilling was in Warren, Venango, and McKean Counties, while the most active gas well drilling was in Indiana, Crawford, Erie, Jefferson, and Clearfield Counties.

Details of these and all other oil and gas development and exploration activity are presented in the Pennsylvania Geological Survey's Progress Report 195, "Oil and Gas Developments in Pennsylvania in 1981." This 116 page report complete with tables and maps, was compiled by staff petroleum geologist Dr. John A. Harper. The report may be ordered by mail from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125. The mail order price is \$2.50 (plus 6% sales tax for Pennsylvania residents). Check payable to the Commonwealth of Pennsylvania should accompany the order.

## **BLOOMSBURG-MIFFLINVILLE GEOLOGIC ATLAS**

A detailed atlas on the geology and mineral resources of the Bloomsburg and Mifflinville quadrangles and northwest corner of the Catawissa quadrangle, Columbia County, has been issued by the Pennsylvania Geological Survey. Authored by staff geologist Dr. Jon D. Inners, the report consists of a well-illustrated 152-page text accompanied by a full-color bedrock geologic map (with four cross-sections) and a full-color surficial material map. Special attention is devoted to the economically-important sand and gravel resources in the Susquehanna River and Fishing Creek valleys, as well as the influence of geology on problems of cut-slope stability, excavation difficulty, foundation stability, and flooding. The text includes detailed discussions of the stratigraphy, structural geology, environmental and engineering geology, and mineral resources of the area.

The Bloomsburg-Mifflinville area lies within a glaciated portion of the Valley and Ridge topographic province. Bedrock units range from the Middle Silurian Rose Hill Formation to the Upper Mississippian Mauch Chunk Formation. Important geologic structures in-

clude the Berwick anticlinorium, Lackawanna synclinorium, and Light Street thrust fault. The surficial units include Illinoian and Wisconsinan glacial and glaciofluvial deposits, windblown silt (Nescopeck Loess), and various types of colluvium and alluvium. Late Wisconsinan glacial-border deposits occur in the northeast corner of the Mifflinville quadrangle.

Anyone dealing with geologic, hydrologic, foundation engineering, and land-use problems in central Columbia County or nearby areas will find this report of considerable interest and benefit.

Atlas 164cd, *"Geology and Mineral Resources of the Bloomsburg and Mifflinville quadrangles and part of the Catawissa Quadrangle, Columbia County, Pennsylvania,"* is available by mail from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125, at a cost of \$17.40 (add 6% sales tax if mailed to a Pennsylvania address). Check made payable to the Commonwealth of Pennsylvania must accompany order.

## **Estimates of Undiscovered Oil and Gas in the United States**

A new USGS publication has been released, entitled "Estimates of Undiscovered Recoverable Conventional Resources of Oil and Gas in the United States."

Authored by G. L. Dolton and others, the latest USGS estimates of United States Conventional Oil and Gas Resources are presented for the Nation as a whole, and for 137 provinces, 15 regions, onshore areas, offshore areas, continental shelf, continental slope, Alaska, and the lower 48 states. Methodology for resource appraisal is outlined; comparison with other recent estimates is included.

For the Nation as a whole, the undiscovered recoverable conventional oil resources are estimated to range from 64.3 to 105.1 billion barrels with a mean estimate of 82.6 billion barrels; gas resources are estimated to range from 474.6 to 739.3 trillion feet with a mean estimate of 593.8 trillion feet.

Reserve figures for Pennsylvania are included in the Appalachian Region statistics. For the Appalachian Region the undiscovered recoverable conventional oil resources are estimated to range from 0.1 to 1.5 billion barrels with a mean estimate of 0.6 billion barrels. Gas resources are estimated to range from 6.4 to 45.8 trillion feet with a mean estimate of 20.1 trillion feet.

USGS Circular 860 is free and available from: Eastern Distribution Branch, U.S. Geological Survey, 604 South Pickett Street, Alexandria, Virginia 22304.



# SILICA AS PURE AS THE DRIVEN SNOW? NOT YET, BUT WE'RE GETTING CLOSER!

by R. C. Smith II, and  
S. W. Berkheiser, Jr.  
Pennsylvania Geologic Survey

A composite sample of about 50 ft of Tuscarora Formation sandstone from Tuscarora Mountain, Franklin County, was found to contain only 0.06%  $\text{Fe}_2\text{O}_3$  and 0.30%  $\text{Al}_2\text{O}_3$ . A favorable low dip, negligible overburden, and good roads suggest that the area warrants investigation by the silica industry in central Pennsylvania. Acid beneficiation reduced the  $\text{Al}_2\text{O}_3$  to 0.06%.

The sampled site (latitude 39°57'02"N and longitude 77°56'13"W) is a natural outcrop located at an elevation of about 2,400 ft on the east-facing slope of the portion of Tuscarora Mountain known as Big Mountain. The outcrop is about 150 ft east of a former fire tower and overlooks Path Valley. The outcrop is in Buchanan State Forest, 3.0 mi northwest of Fort Loudon, Metal Township, Franklin County. It is easily reached from the east or west by U.S. Route 30, turning north on Aughwick Road, and northeast on an excellent gravel road along the crest of Tuscarora Mountain.

As mapped by Pierce (1966), the outcrop is just above the base of the Lower Silurian Tuscarora Formation in an area where bedding dips gently to the west (Fig. 1). Bedding at the slightly slumped outcrop trends about N35°E, 15°NW. Neither tectonic breccia nor slickensides, potential traps for iron mineralization, were observed.

Pierce (1966) estimates that the Tuscarora Formation in this area is 520 to 600 ft thick. The sampled interval represents the basal, horizontally laminated lithofacies of the Tuscarora Formation (Cotter, 1982). General characteristics of this lithofacies in Pennsylvania include: light gray to white, fine to medium-grained sandstone units up to 90 ft thick; lack of lithic clasts or shaly interbeds; exceedingly pure sandstone containing only traces of chert and heavy minerals; and no *Arthropycus*, *Skolithos* and *Monocraterion* are commonly present. Cotter further interprets this sequence to represent a moderate-to high-energy beach depositional environ-



FIGURE 1.

Basal portion of Tuscarora Formation outcrop on Tuscarora Mountain looking south. Note conspicuous horizontal laminations and low dip.

ment, and suggests the supermature nature of this unit can be attributed to the abrasion of quartz grains against each other in a beach environment.

The typical bed at the sample site is 4 inches to 3 ft thick. Most of the sampled interval is composed of 0.5-to 1-mm size quartz grains, the majority of which appear to be rounded, milky or frosted quartz. Traces of monazite (?), limonite (yellow staining), anatase (?), and tourmaline (?) appear to be present. Silica cementation generally causes the rock to break through individual grains. Minor white "clay-mica" can be observed in the matrix of some of the rare, coarser grained beds. These beds are characteristically more friable, presumably due to less silica cement. A finer grained (0.25 mm) vitreous quartzite also occurs locally. These beds appear to be very pure and attain individual thicknesses of about 3 ft.

The lower limit of sampling is at a conspicuous increase in hematitic and limonitic staining. Presumably, Cotter's (1982) basal pink transitional lithofacies, or the underlying brownish-red Juniata Formation, is not far below. The base of the sampled interval is near the lower limit of exposed outcrop. The upper limit of sampling is similarly defined as the first significant occurrence of hematitic and limonitic staining. About 17 ft of unsampled iron-stained sandstone is exposed in the upper part of the outcrop.

Unlike some Tuscarora outcrops in central Pennsylvania, the exposure lacks *Arthropycus* and *Skolithos*, suggesting a deposi-



tional environment low in organics and clay. Hematitic blebs were also absent in the sampled interval, and evidence of shale clasts is rare. Because of the apparent intense weathering (discussed below), one cannot rule out the possibility that thin interbeds of shale have been removed by erosion and weathering.

A composite sample of 44 chips, obtained at approximately 15-inch intervals from the exposed beds, was analyzed for  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$ . These results, together with corresponding data for a beneficiated sample, are tabulated below. Beneficiation consisted of leaching in two hot baths, one of 50% HCl and the other of 50%  $\text{H}_2\text{SO}_4$ , each at 80°C for 6 hours, followed by a single pass through a Frantz Isodynamic Magnetic Separator with front slope of 15°, side slope of 1°, and 1.5 A current.

	% $\text{Al}_2\text{O}_3$	% $\text{Fe}_2\text{O}_3$
Sampled interval, as collected	0.30	0.06
Sampled interval, beneficiated	0.06	0.06

Recognizing the strikingly low iron content, the nature of that limited iron content is worthy of note. Many individual beds within a natural outcrop are concentrically zoned with what appears to be organic and iron(?) staining (Fig. 2). From the outside in, a typical block exhibits the following zones:

- A. An outer highly leached rind or pure white quartz sand about 4 mm thick.
- B. A few centimeter thick intermediate zone with a sharp outer limit and a gradational inner limit and with dark brown staining (organics and iron(?)) or individual sand grains.
- C. A core of nearly pure quartz assumed to be unweathered.



FIGURE 2. Example of color zonation thought to be related to weathering and concentration of organics and iron (?) by capillary action of rainwater.



It is postulated that the intermediate zone of organic and iron(?) enrichment is a result of weakly acidic precipitation carrying traces of dissolved organics and iron(?) from the outer layers of sandstone into the dryer interiors via capillary attraction. It is further postulated that as the rock eroded, this zone migrated inward from the new erosional surface and became more concentrated.

Interpretations of preliminary observations suggest that the sampled material could be a source for acid refractories and specialized use of high-purity silica where angular fragments of crushed aggregate are not detrimental. This occurrence appears to be of much higher quality than those heretofore reported. Previously published chemical analyses from Tuscarora outcrops and quarries in Huntingdon, Blair, Bedford, and Fulton Counties are relatively uniform with about 1% each of  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  (Moore and Taylor, 1924); the previous best analyses had about 0.75% each of  $\text{Al}_2\text{O}_3$  and  $\text{Fe}_2\text{O}_3$  as compared to the 0.30%  $\text{Al}_2\text{O}_3$  and 0.06%  $\text{Fe}_2\text{O}_3$  at this Franklin County locality.

A reconnaissance study of other silica occurrences by S. W. Berkeheiser, Jr. is nearing completion and will be announced in *Pennsylvania Geology* later this year. Several of the occurrences show promise of yielding mineable configurations of even purer silica. Approximately 35 samples selected from sedimentary formations and vein occurrences ranging in age from Precambrian to Pennsylvanian are being analyzed. Magnetic and acid beneficiation test results will also be reported.

## REFERENCES

- Cotter, E. (1982) *Tuscarora Formation of Pennsylvania*; Society of Economic Paleontologists and Mineralogists, Eastern Section, Guidebook, p. 15-17.  
Moore, E. S. and Taylor, T. G. (1924), *The silica refractories of Pennsylvania*; Pa. Geol. Survey, 4th ser., Mineral Resource Report 3, p. 28-32.  
Pierce, K. L. (1966), *Bedrock and surficial geology of the McConnellsburg quadrangle, Pennsylvania*; Pa. Geol. Survey, 4th ser., Atlas 109a, p. 28-27 and Plates 1 and 2.

## *And then — Letters from Our Constituents . . . . .*

Dear Sir:

Sometimes it is difficult for us to write down exact direction and location, because, there is more than one way to be located from north.



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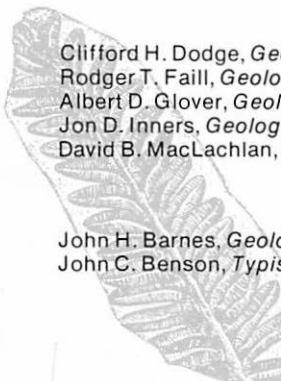
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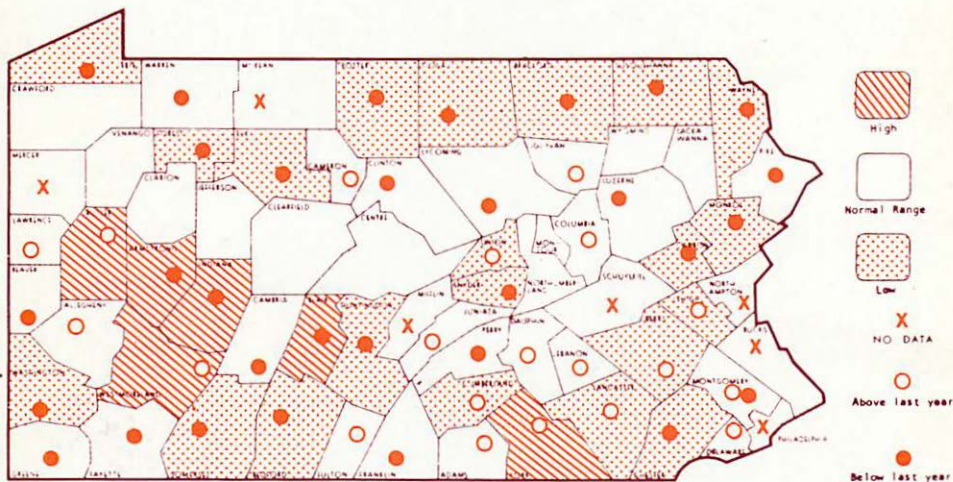
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# GROUND WATER LEVELS

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