PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY

VOL. ~~3/5~~ 5/2

COMMONWEALTH OF PENNSYLVANIA
Milton J. Shapp, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Maurice K. Goddard, Secretary

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Flagstone quarry in Lackawanna County. Photo courtesy of R. E. Laudenslager.

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

APRIL 1974

FROM THE DESK OF THE STATE GEOLOGIST . . .

WOULD YOU RATHER OWN A DIAMOND MINE OR A GRAVEL PIT?

Shortly after our wedding, my wife confessed that she married me because she figured that I might find her a diamond mine. I pointed out that she would be better off if I found a gravel pit! The simple fact is that while the U. S. has no commerical production of diamonds, the value of sand and gravel mined last year was $1.2 billion. The message here is that real value is not necessarily connected with glamour materials. In recent months our attention has been focused on prices and shortages of mineral fuels, and while there is also a growing concern over our increasing dependence on foreign sources of metallic minerals, there still is a surprising lack of awareness of the tremendous role which our non-metallic, industrial minerals serve in our economy.

Last year, while the total value of all metallic minerals produced in the U. S. (including gold, siver, copper, lead, zinc, manganese, etc.) totaled $3.5 billion, the combined value of all the non-metallic categories alone (stone, cement, sand and gravel) had a $4.2 billion production value, thus exceeding all metallic mineral production.

The importance of non-metallic mineral resources can further be demonstrated by per capita use data. In 1973 for every man, woman and child in the U. S. there was used 9,000 pounds of sand and gravel, 8,500 pounds of stone, 800 pounds of cement, 600 pounds of clays, 450 pounds of salt, 1200 pounds of other non-metals; this made a total of 20,550 pounds per capita of all non-metallic as compared with 1340 pounds of metals per person.

In Pennsylvania last year nearly 40 percent of the Commonwealth's $1.3 billion total mineral production value consisted of non-metallic industrial minerals: cement, stone, lime, sand and gravel, and clay.

These non-metallic minerals are called industrial minerals for the very reason that they are critical raw materials necessary to maintain our industrial capability and responsible for employment of great numbers of people. Non-metallics also provide the raw materials from which we construct our homes, offices, factories, roads, bridges, railroads, and airports.

With their great dollar value and importance to our society, we are fortunate that Pennsylvania and the U.S. have great reserves of the industrial minerals. We must, however, assure their future availability by carefully mapping their distribution, planning for their accessibility, and establishing mining procedures compatible with being good neighbors to our citizens and our environment.

Arthur A. Socolow

GROUND-WATER CONDITIONS CAUSED BY TROPICAL STORM AGNES

Ground Water — that usually invisible but important source of water, became a visable and unwanted water body in many places after the passing of tropical storm Agnes. Many homes, remotely situated from the surface flooding along streams and rivers, suddenly had indoor swimming pools in their basements as the ground-water table rose to record heights. Wells overflowed the surface, surface depressions became ground water lakes, and basement walls collapsed and floors heaved from the record high ground-water levels.

Ground water in the Susquehanna River Basin occurs in fractured-rock aquifers and in the unconsolidated glacial drift and alluvial aquifers. Unconsolidated aquifers are limited to that area in the northern part of the basin

Figure 1. Map of Susquehanna River Basin showing location of observation wells and well number assigned by the U. S. Geological Survey.

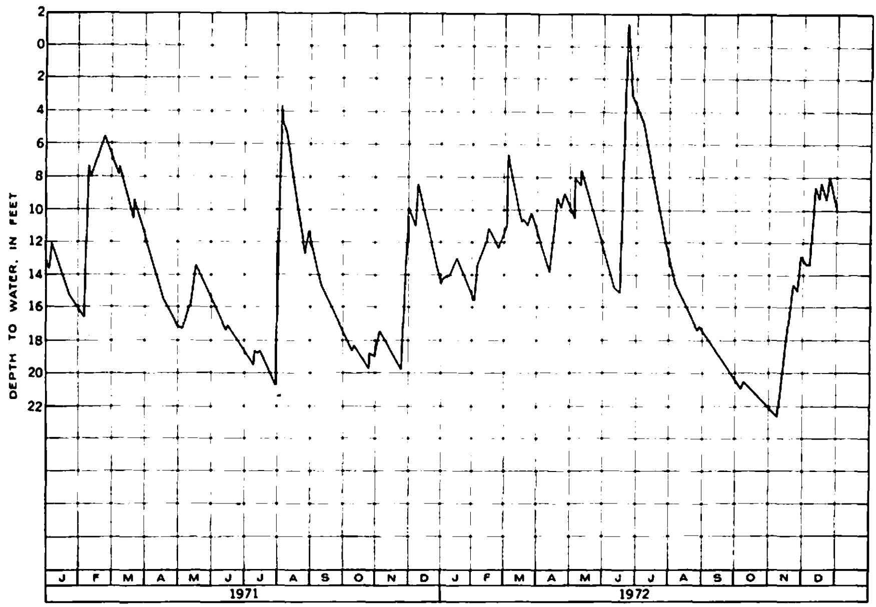


Figure 2. Water level hydrograph from well Cu-200, during 1971-72.

that was once covered by glaciers and to the alluvium along major stream valleys. Because of its occurrence along streams, the unconsolidated aquifer has a shallow water table and its level and fluctuation is affected by the stream stage. Whenever the stream channel is full the water table rises in response to the recharge from the stream, as well as to rainfall on the land surface. Consequently, those developed areas along flood plains are highly subject to ground-water flooding, even if they are not flooded overland.

Fractured rock aquifers are made up of a network of openings formed by intersecting fractures, solution cavities, and separations between rock layers. Most of the water-bearing openings are in the weathered zone and in the immediately underlying fractured rock. Normally the water table lies within the lower part of the weathered zone, or locally in the upper part of the fractured zone. The permeable soils permit much of the precipitation to infiltrate to the water table. The rocks have comparatively low transmissivity and their drainable void space decreases rapidly with depth. Therefore, under intense precipitation, such as occurred with tropical storm Agnes, water percolates to the water table faster than it is transmitted to points of discharge. Thus, the void spaces in the rocks are filled and the ground-water levels rise rapidly.

Hydrographs from U. S. Geological Survey observation wells, located throughout the basin, were analyzed to determine ground-water response

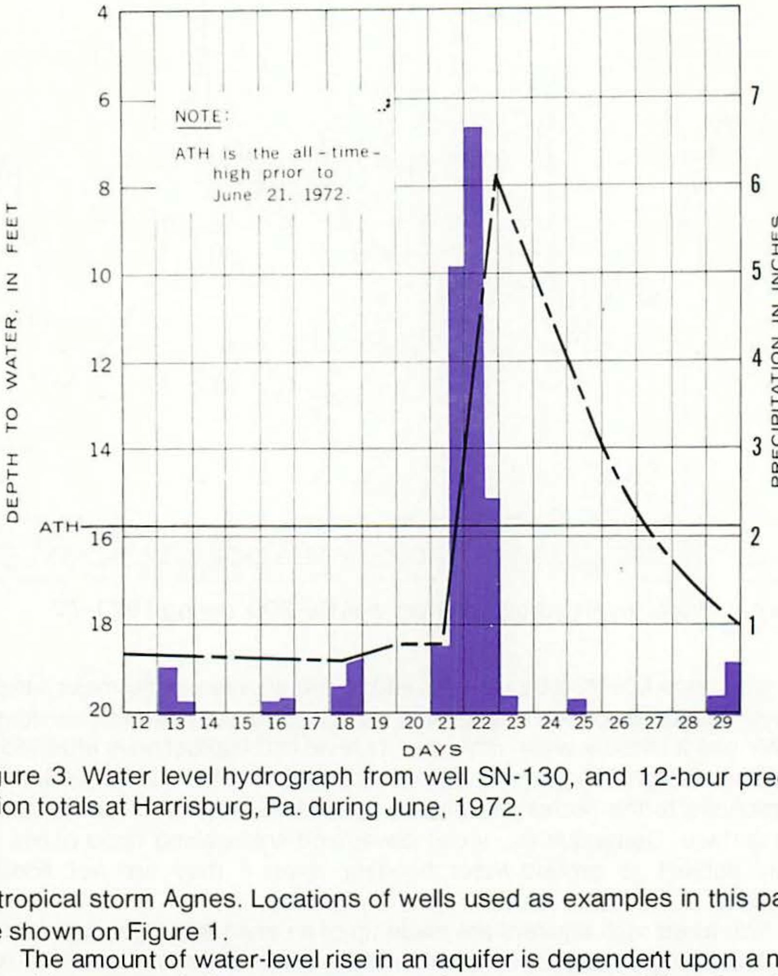


Figure 3. Water level hydrograph from well SN-130, and 12-hour precipitation totals at Harrisburg, Pa. during June, 1972.

to tropical storm Agnes. Locations of wells used as examples in this paper are shown on Figure 1.

The amount of water-level rise in an aquifer is dependent upon a number of factors, including: the amount and intensity of rainfall, soil and soil moisture conditions, and topographic setting. The amount and intensity of rainfall associated with the tropical storm was sufficient to create all-time-high water levels in most of the observation wells in the basin. The water levels in most of the wells were normal for June prior to the storm; however, soil moisture conditions were near saturation because the response to rainfall was immediate.

Had the pre-storm water level been below normal, the extent of ground-water flooding would have been reduced. For example, the record from a well in Cumberland county (Fig. 2) shows a rise in water level at the end of July, 1971 to be of the same magnitude as that recorded for the "Agnes" storm. However, the antecedent water level conditions were such for the July, 1971 storm that the peak was 5 feet lower than that which occurred during the "Agnes" storm.

Topography greatly influences water-level fluctuations. Most of the basin has high topographic relief and is underlain by sandstone, siltstone, and shale. Water-level fluctuations in wells tapping these aquifers range from a few feet to a hundred feet, depending upon topography. Wells drilled on hillsides and hilltops fluctuate to a greater degree and have greater depth to water than those drilled in valleys. The following four hydrographs were selected to illustrate the effect of Agnes on water levels in each topographic setting. All the hydrographs were obtained from wells drilled in shale.

The hydrograph for a hilltop well, located in Snyder County (Fig. 3) shows about 12 inches of rainfall resulted in an 11-foot rise to a peak of 7.7 feet below land surface, which exceeded the previous all-time-high by 8.1 feet.

The hydrograph for a hillside well, in Bedford County, (Fig. 4) shows 5.7 inches of rainfall resulted in a 10-foot rise to a peak about 3-feet below land surface, which exceeded the previous all-time-high by 1.7 feet.

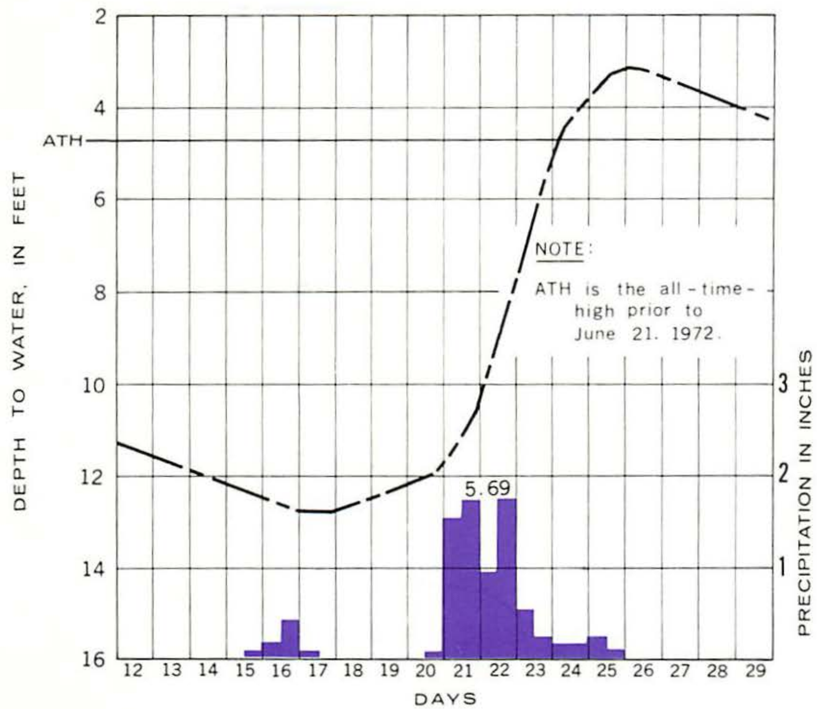


Figure 4. Water level hydrograph from well BD-150 and 12-hour precipitation totals at Everett, Pa. during June, 1972.

All water-levels in wells located in valleys rose to or above land surface. The water level in a well located near the headwaters of Little Loyalsock Creek in Sullivan County (Fig. 5) responded to 7.7 inches of rainfall by rising 20-feet to a peak about 6-feet below land surface. This water level exceeded the previous all-time-high by 11.5 feet.

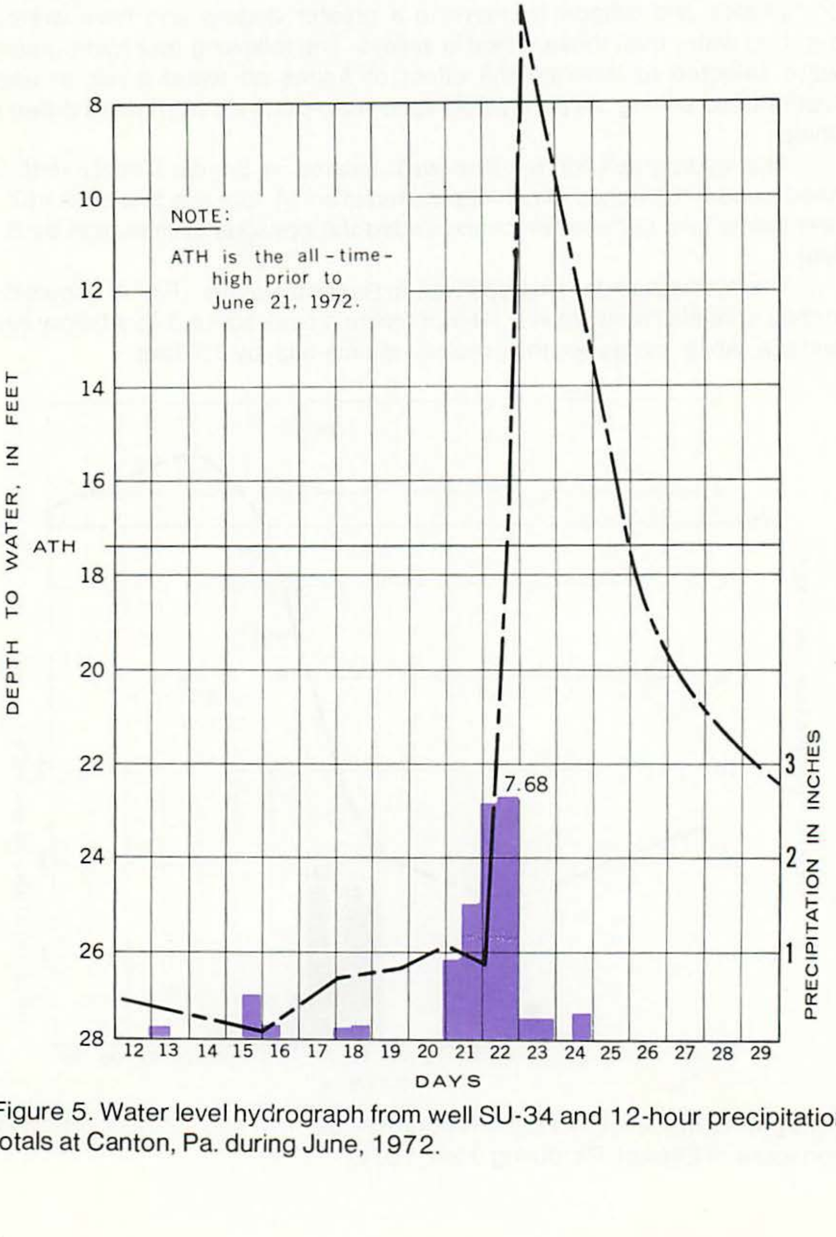


Figure 5. Water level hydrograph from well SU-34 and 12-hour precipitation totals at Canton, Pa. during June, 1972.

Figure 6. Water level hydrograph from well BR-92 and 12-hour precipitation totals at Towanda, Pa. during June, 1972.

A well located near the Susquehanna River, in Bradford County (Fig. 6) shows 7.2 inches of rainfall caused the water level to rise 10.3 feet to a peak about 2-feet above the land surface, which exceeded the previous all-time-high by 4.2 feet. Post "Agnes" record for this well was lost, because the recording device was a victim of the flood.

Although the occurrence of limestone in the basin is relatively minor, its weathering characteristics provided the fertile valleys and spring fed streams along which large population centers have developed. Chemical weathering of carbonate rocks by ground and surface water created a land surface that has low topographic relief, poor surface drainage, and numerous depressions. In many areas the water table fluctuates near the land surface (Fig. 2). As the result of "Agnes" the water table rose to above land surface in many areas, flooding many basements and forming lakes. Some lakes remained for several weeks after "Agnes" departed.

The hydrograph for the well located in the Wyoming Valley, Luzerne County (Fig. 7) shows the effect the high river level had on the ground-water level behind the river levee. The well is located 1000 feet behind the levee north of Forty Fort. Only 3.8 inches of rainfall was recorded at the Wilkes-

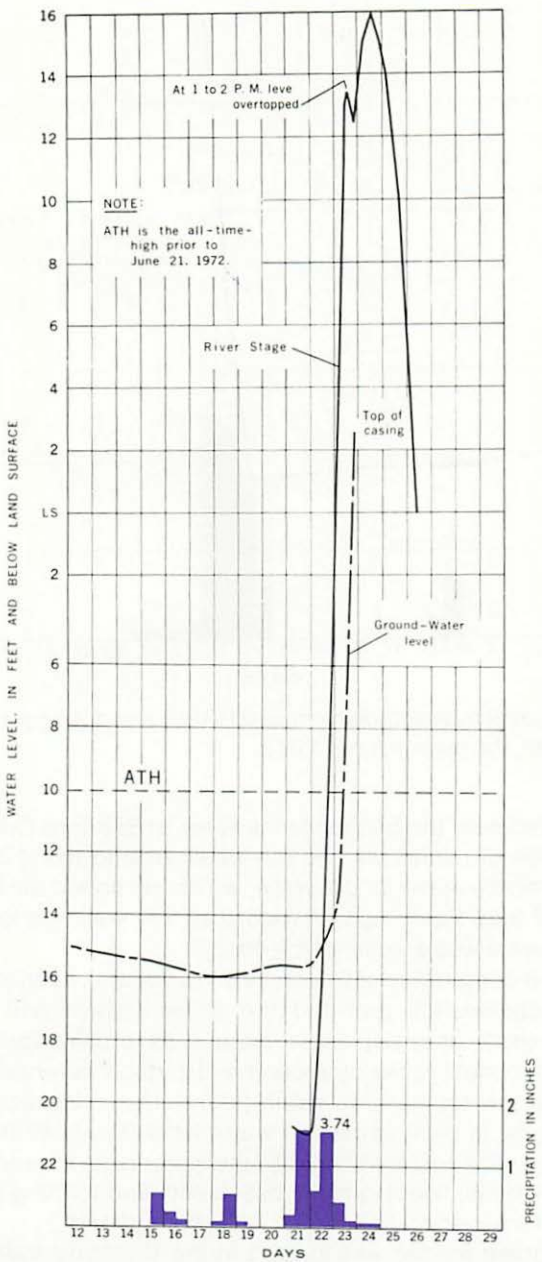


Figure 7. Water level hydrograph from well LU-309, Susquehanna River Stage and 12-hour precipitation totals at Wilkes-Barre-Scranton Airport for period June 12-26, 1972.

Barre-Scranton airport; however, the water level in the well rose to above land surface (Fig. 7). This was the combined result of the local precipitation and the recharge to the aquifer from the high river stage. The post "Agnes" record was lost under 7 feet of flood water; however, the water-level recorder was in operation long enough to show the ground water had risen above land surface prior to the failure of the levee at Forty Fort.

Had the levee not been overtopped and had it contained the river, much of the low-lying area behind the levee would have been flooded by ground water. The aquifer throughout much of the flood plain is a very coarse grained glacial outwash deposit, capable of transmitting water to wells at a rate of 2000 gpm. The area behind the dike could, using the present altitude of the levee system, receive over 60,000 gallons per minute of water from the river when the stage is near the top of the levee. Because of the high transmissivity of the near surface materials "sand boils" would have been common and possibly a threat to the stability of the levee.

Underground coal-mine pools in the Wyoming Valley attained record high levels also. Natural and man-made openings into the mines were spouting water. These overflows did not create a hazard, but the high mine pools did. Basements and back yards dropped into the mines in some 28 locations. At one location a 40-foot tree dropped out of sight. These so called "*potholes*" developed in areas where underground mining left little support for the unconsolidated gllacial drift overburden. The more serious potholing into mine voids occurred in the Parsons area, east of Wilkes-Barre. During the storm six potholes developed over the sub-surface contact of the coal beds and the glacial drift. The potholing was probably the combined result of saturation of the glacial drift by precipitation and increased hydraulic head imposed from below through rock fractures and mine openings by rapidly rising mine pool. The possibility of future potholing is being reduced by filling of mine voids through joint State and Federal efforts.

Ground water continued to plague some unfortunate home owners after the flooding was over. Heavy duty pumping equipment rushed into service, quickly emptied many of the basements only to remove the equalizing pressure within the basement against the ground water outside, which caused basement floors to blow up or walls to cave in. Basements were not damaged where the water was permitted to drain away, or was pumped out after ground-water levels returned to below basement elevations.

In comparison to the destruction by overland flooding, ground-water flooding destruction is relatively unseen. However, it is by no means minor. As a result of Agnes, the geologic and topographic settings subject to ground-water flooding were recognized and can be delineated. Future building codes and zoning of these areas should be accomplished.

J. R. Hollowell
Susquehanna River Basin Commission

1973 - A GOOD YEAR FOR THE MINERAL INDUSTRY OF PENNSYLVANIA

The value of mineral production in Pennsylvania in 1973 was $1.3 billion, 7.1 percent more than recorded for 1972, according to the U. S. Bureau of Mines. Mineral fuels accounted for 65 percent of the State's dollar value with nonmetals making up 32.4 percent and metals accounting for the remaining 2.6 percent. After coal, the most valuable minerals produced were cement, crushed stone, lime, sand and gravel, natural gas and petroleum.

Each of the non-metallic mineral commodities registered an increase in production over the previous year. With the closing of the iron mine at Cornwall in 1973, the iron mine at Morgantown and the zinc mine at Friedensville are the only two active metal mines in Pennsylvania.

The table below shows the production and value by mineral commodities for Pennsylvania in 1973:

1973 production in Pennsylvania
(As prepared by U.S. Bureau of Mines)

		1973 Quantity	1973 Value (thousands)
Cement:			
Portland	thousand short tons	8,640	$177,000
Masonry	do	490	14,700
Clays	do	2,950	18,902
Coal: Anthracite	do	6,500	79,950
Bituminous	do	75,020	731,450
Copper: (recoverable content of ores, etc.)	short tons	1,395	1,660
Gem stones		NA	9
Lime	thousand short tons	2,260	40,155
Natural gas	million cubic feet	71,445	25,363
Peat	thousand short tons	27	416
Petroleum (crude)	thousand 42-gallon barrels	3,803	20,118
Sand and gravel	thousand short tons	18,943	37,507
Stone	do	72,755	139,168
Zinc (recoverable content of ores, etc.)	short tons	18,590	7,458
Value of items that cannot be disclosed:			
Iron ore, scrap mica, tripoli, and natural gas liquids		XX	25,149
Total		XX	1,319,005

PENNSYLVANIAN PALEOBOTANY OF THE BERNICE BASIN, SULLIVAN, WYOMING, AND LUZERNE COUNTIES, PENNA.

Examination of four hundred and thirty-nine (439) plant fossil specimens collected from the Bernice Coal Basin and surrounding areas of Sullivan, Wyoming, and Luzerne Counties, has resulted in the identification of approximately twenty-eight (28) genera and approximately eighty-nine (89) species. The location of the collecting sites are shown superimposed on the State Geologic Map (Gray and others, 1960) in Figure 1. Summary lists of the more important fossil plants are given in Table 1.

Comparison of the biostratigraphic suite represented by these plant forms to the floral zonation for Upper Paleozoic rocks of the central Applachians (Reed and Mamay, 1964) gives a good overall correlation with zones 7, 8, 9, and 10. In particular, however, the most diagnostic forms of zones 7, 9, and 10 are not found, and only *Neuropteris tenuifolia*, the

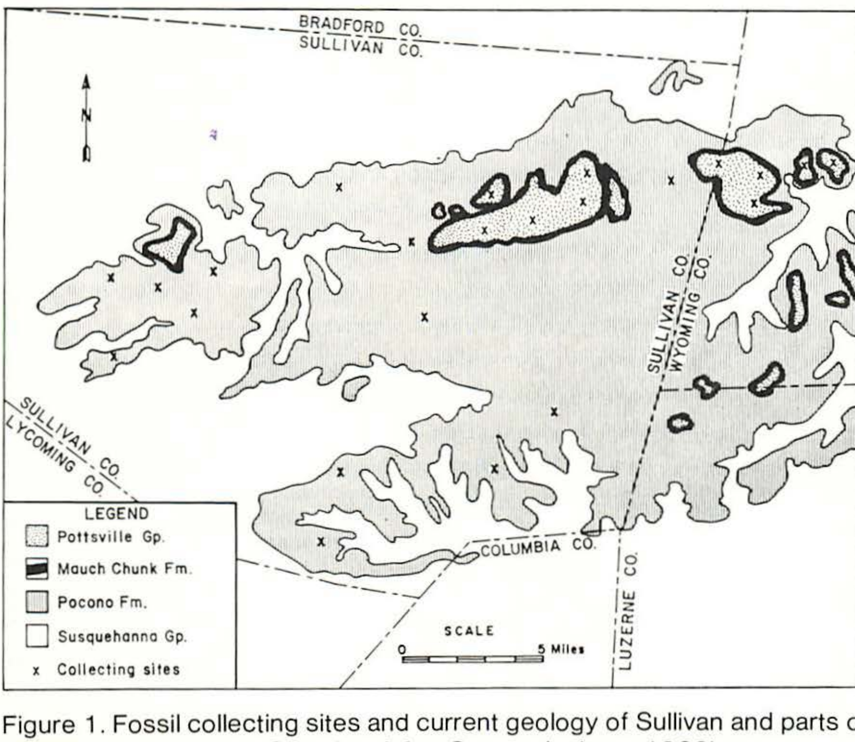


Figure 1. Fossil collecting sites and current geology of Sullivan and parts of Luzerne and Wyoming Counties. (after Gray and others, 1960)

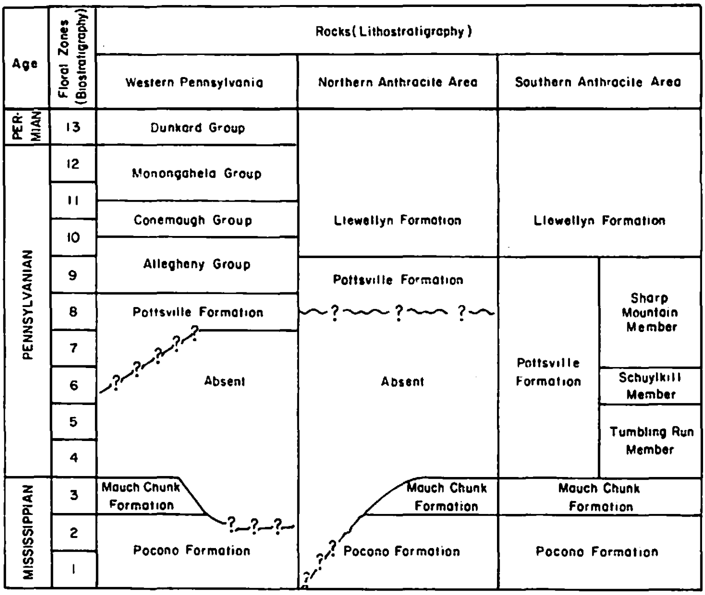


Figure 2. Presumed chronostratigraphic biostratigraphic and lithostratigraphic relationships of the Upper Paleozoic of Pennsylvania.

Table I. Genera and species of fossil plants collected in northeast Sullivan County.
The number in parentheses are the occurrences.

Alethopteris sp.	(8)	*Neuropteris capitata*	(2)
grandifolia	(7)	*gigantea*	(12)
serlii	(4)	*flexuosa*	(2)
Annularia ramosa	(2)	*ovata*	(14)
stelata	(5)	*ravineruis*	(16)
Astrophyllites sp.	(5)	*tenuifolia*	(21)
equeseformis	(3)	*schuechzeri*	(25)
minutus	(4)	*Pecopteris sp.*	(6)
Calamites sp.	(17)	*dentata*	(5)
ramosus	(11)	*miltoni*	(27)
suckowii	(28)	*Sigillaria sp.*	(9)
Calamocladus	(8)	*brardii*	(2)
Calamostachys ramosus	(7)	*Sphenophyllum furcatum*	(3)
Lepidodendron sp.	(20)	*emarginatum*	(2)
dichotomum	(5)	*Sphenopteris sp.*	(11)
obovatum	(3)	*mixta*	(5)
vestitum	(7)	*spinosa*	(9)
Lepidodendron "leaves"	(11)	*Trigonocarpum*	(5)
Lepidostrobus	(9)	*olivaeforma*	(1)
obovatum	(6)	*Trigonocarpus*	(21)
Mariopteris	(16)	*Trigonocarpus seeds*	(14)
nervosa	(3)	*Triphyllopteris spp.*	(3)
Megalopteris spp.	(1)	*Ulodendron*	(15)
		Total	388

diagnostic form of zone 8, is present. Most of the zone 7, 9, and 10 forms encountered are long-ranging types which also occur in zone 8. It appears, thus, that the fossil suite of this area is assignable most specifically to floral zone 8.

Customarily, floral zone 8 is considered to be Middle Pennsylvanian age and to be characteristic of the upper part of the Pottsville Group. The presumed chronostratigraphic, biostratigraphic, and lithostratigraphic relationships are summarized in Figure 2.

As shown on the State Geologic Map (Gray and others, 1960), the coal-bearing rocks of the Bernice Basin itself appear to be correctly identified as Pottsville Group (see Figure 1). However, outside the immediate Bernice Coal Basin, in areas currently shown as entirely Pocono Formation, many ridge tops are capped by rocks containing this same upper Pottsville flora. It appears, then, that extensive additional areas around the Bernice Basin should be shown as underlain by the Pottsville Group.

Deborah Birx

References:

Gray, C. and others (1960) *Geologic Map of Pennsylvania*, Pa. Geol. Survey, 4th series, map no. 1.

Reed, C. B. and Mamay, S. H. (1964) *Upper Paleozoic Floral Zones and Floral Provinces of the United States*, U. S. Geol. Survey, Prof. Pap. 454K.

ABOUT THE AUTHOR

Miss Birx is a 1973 graduate of Carlisle High School and is presently attending Houghton College. She was 1973 girls' grand champion in the Capital Area Science and Engineering Fair and took third place in the Earth and Space Science division at 1973 International Science and Engineering Fair at San Diego, California. She was also awarded an honorable mention from the American Association of Petroleum Geologists and first place awards from the U. S. Army and U. S. Navy. Needless to say, Miss Birx has been pursuing studies in this area for several years.

SURVEY ANNOUNCEMENTS

PHILIPSBURG QUADRANGLE REPORT ISSUED

The Pennsylvania Geological Survey has published *The Geology and Mineral Resources of the Philipsburg Quadrangle*, by Gary Glass. This comprehensive, 241-page report complete with full-color maps and plates, describes the nature and occurrences of the surface and subsurface rock units of a 56-square-mile area of western Centre County and eastern Clearfield County.

The locations, quality and quantity of coal and other mineral resources in the area are stressed. Six major coal seams occur in the area although two seams of minor importance, coupled with splits of the major seams and locally important rider coals, swell this number to fifteen. Coal is the most important resource at this time, with unmined reserves totaling a minimum of 122 million short tons in seams over 28 inches thick. Clay, shale, building stone, and limestone are other mineral resources of the area. A glossary is included to assist nontechnical readers.

This report should be of particular use to mineral industries, planners, highway and construction engineers, conservationists, and students of geology and natural history of Pennsylvania. The report provides the geologic information prerequisite to landuse planning and mineral resource development.

Bulletin A95a, "Geology and Mineral Resources of the Philipsburg Quadrangle" is available from the Pennsylvania Bureau of Publications, P. O. Box 1365, Harrisburg, Pennsylvania, 17125 for $10.10 plus State tax for Pennsylvania residents.

LEHIGH COUNTY WATER REPORT PUBLISHED

One of the most comprehensive water resources reports ever issued for any county has been released by the Pennsylvania Geological Survey as Bulletin W 31, "Water Resources of Lehigh County, Pennsylvania." The study was co-sponsored by the Pennsylvania Geological Survey, U. S. Geological Survey, and the Lehigh County Soil and Water Conservation District. This 263-page report, complete with full-colored maps and illustrations, was co-authored by Charles Wood, Herbert Flippo, Jr., Joseph Lescinsky, and James Barker of the U. S. Geological Survey.

The report presents the quantity and quality of Lehigh County surface and subsurface waters, the relationships between streamflow and groundwater, and watertable maps of the area underlain by carbonate rocks. Data on past and present water use is included, along with future projections.

This report will be valuable to planners and persons interested in land and water management. It will also aid industries, consulting engineers and geologists, and officials of local governments who are seeking new supplies of water or trying to find suitable sites for disposal of liquid and solid wastes. Sportsmen and conservationists will better understand how man's use has affected and will affect streamflow. Persons planning to drill wells for individual homes and businesses can use this report to estimate the probability of obtaining an adequate supply.

Bulletin W 32, *Water Resources of Lehigh County,* is available from the Pennsylvania Bureau of Publications, P.O. Box 1365, Harrisburg, Pennsylvania, 17125, for $9.15, plus State tax for Pennsylvania residents.

MORE SURPLUS TOPOGRAPHIC MAPS

After we announced a list of surplus topographic maps in the October, 1973, issue of this bulletin, we were quickly "cleaned out" by requests from near and far. Now again, as a result of our ongoing revision program, we have a stock of surplus 71/2-minute topographic quadrangle maps for over 400 different Pennsylvania quadrangles. We are again offering these at no charge, singly or in small quantities, to all interested parties. The list of quad names is too long to enumerate. It will be best if you simply indicate how many different quadrangles (and the number of copies of each) you desire from either northeast, southeast, north-central, south-central, northwest, or southwest Pennsylvania. We shall then try to send quad maps from the region indicated.

GEOLOGICAL SURVEY BEST SELLERS

For the past several years the Pennsylvania Geological Survey has been keeping records of the sale of our publications. For four of the past five years Bulletin G33, "Mineral Collecting in Pennsylvania," has been #1 on the best seller list and Bulletin G40, Fossil Collecting is #2.

Map #1, the Geologic Map of Pennsylvania, has been the best seller of our map series for as long as we have kept records. The top ten list for 1973 includes the three Environmental Geology Reports issued to date (EG 1, 2, 3), the guides to the Geology of the Philadelphia and Pittsburgh areas (G 41, 59), Coal Reserves of Pennsylvania (IC 72), Oil and Gas Developments in 1971 (PR 184). Tied for 10th were the Bibliography to 1969 (G 61) and the Petroleum Industry and the future petroleum province in Pennsylvania (M 65).

SURVEY LIBRARY NEEDS

The Pennsylvania Geological Survey Library has need for the following items to help with its post-flood library rebuilding program. If anyone has any of these publications please contact State Geologist Arthur A. Socolow.

American Journal of Science: 1960, 1961, 1970, 1971
Clay Minerals: 1959 through 1964
Coal Age: 1971
Economic Geology: 1960, 1962, 1963
Geotimes: vol. 8 #4 part 2 December 1963
vol. 8 #5 part 1 January 1964
vol. 17 #12 December 1972
Journal of Geology: 1904 through 1914, 1969, 1970, 1971
Micropaleontology: 1969 through 1971
Transactions AIME: 1969 through 1973
Transactions AGU: 1969 through 1971

U.S.G.S. Prof. Papers:	54	486 A	560 A
	189 C, H	502 B	563 A, B
	191	530	750
	254 F, C	541	
	402 C, D	549 A	
U.S.G.S. Bulletins:	89	954 A	
	127	995 I	
	301	1085 B	
	846 A		

STUDENT INTERN AT THE SURVEY

Joe Fox, a senior Earth and Space Science major at West Chester State College, joined the Survey staff in late January and will be with us for sixteen weeks. He is one of many Pennsylvania State College students participating in the Intern Program sponsored by the Department of Education.

Originally from Philadelphia, Joe is now a resident of Glenolden. He will finish his studies at West Chester this December and hopes to do graduate work in the field of geology education. Joe has participated in student government at West Chester and has served on various committees formulating academic policy during his junior year.

In addition to learning the basic operations and functions of the Survey, Joe will be engaged in several short-term research projects. These include an inventory of the ground water resources of the Upper Susquehanna River Basin as part of the State Water Plan, analysis of glacial sands and gravels in Pike and Monroe Counties, and organization and identification of specimens in our paleontological collection.

PENNSYLVANIA GEOLOGICAL SURVEY STAFF

Arthur A. Socolow, *State Geologist*
Donald M. Hoskins, *Assistant State Geologist*

TECHNICAL SERVICES

Shirley J. Barner, *Stenographer*
Sandra Blust, *Librarian*
Joanne Bowman, *Typist*
John G. Kuchinski, *Draftsman*
Christine Miles, *Asst. Geological Editor*
Virginia Milewski, *Draftsman*
Mary A. Miller, *Stenographer*
Marjorie Steel, *Stenographer*
Albert Van Olden, *Draftsman*
John P. Wilshusen, *Geological Editor*

ENVIRONMENTAL GEOLOGY DIVISION

Alan R. Geyer, *Division Chief*

Jesse Craft, *Geologist* (Pittsburgh Office)
Eugene H. Hess, *Geologist*
Evan T. Shuster, *Geologist*
Donna M. Snyder, *Stenographer*
Grace Tyson, *Clerk*

GEOLOGIC MAPPING DIVISION

Samuel I. Root, *Division Chief*

Thomas M. Berg, *Geologist*
William E. Edmunds, *Geologist*
Rodger T. Faill, *Geologist*
Albert D. Glover, *Geologist*
Jon D. Inners, *Geologist*
David B. MacLachlan, *Geologist*
Phyllis Ritter, *Typist*
William D. Sevon, *Geologist*
Mark A. Sholes, *Geologist*
Viktoras W. Skema, *Geologist*
John H. Way, Jr., *Geologist*
Richard B. Wells, *Geologist*

MINERAL RESOURCES DIVISION

Davis M. Lapham, *Division Chief*

John H. Barnes, *Geologist*
John C. Benson, *Typist*
Leslie T. Chubb, *Laboratory Technician*
Bernard J. O'Neill, *Geologist*
Robert C. Smith, *Geologist*

OIL AND GAS DIVISION

(Pittsburgh State Office Bldg.)

William S. Lytle, *Division Chief*

Lajos Balogh, *Draftsman*
Robert Fenton, *Laboratory Technician*
Lillian Heeren, *Draftsman*
Louis Heyman, *Geologist*
Cheryl Cozart, *Stenographer*
Elizabeth A. Eberst, *Typist*
Walter R. Wagner, *Geologist*

TOPOGRAPHIC DIVISION

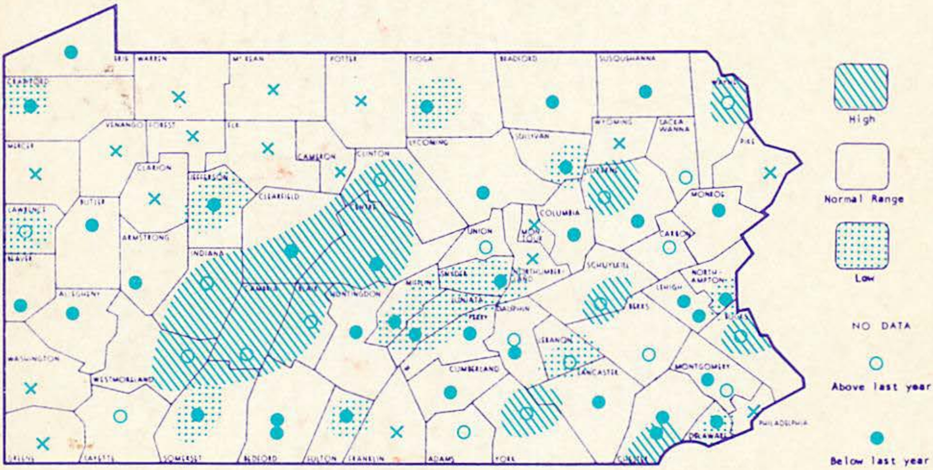
In Cooperation with The U.S. Geological Survey

GROUND WATER DIVISION

In Cooperation with The U.S. Geological Survey

MARCH 1974

GROUND-WATER LEVELS



BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
DEPT. OF ENVIRONMENTAL RESOURCES
HARRISBURG, PA. 17120

BULK RATE
U. S. Postage
PAID
Harrisburg, Pa.
Permit No. 1

CORRECT ADDRESS REQUESTED

DR HOWARD A MEYERHOFF
3625 S FLORENCE PLACE
TULSA OKLA 74015