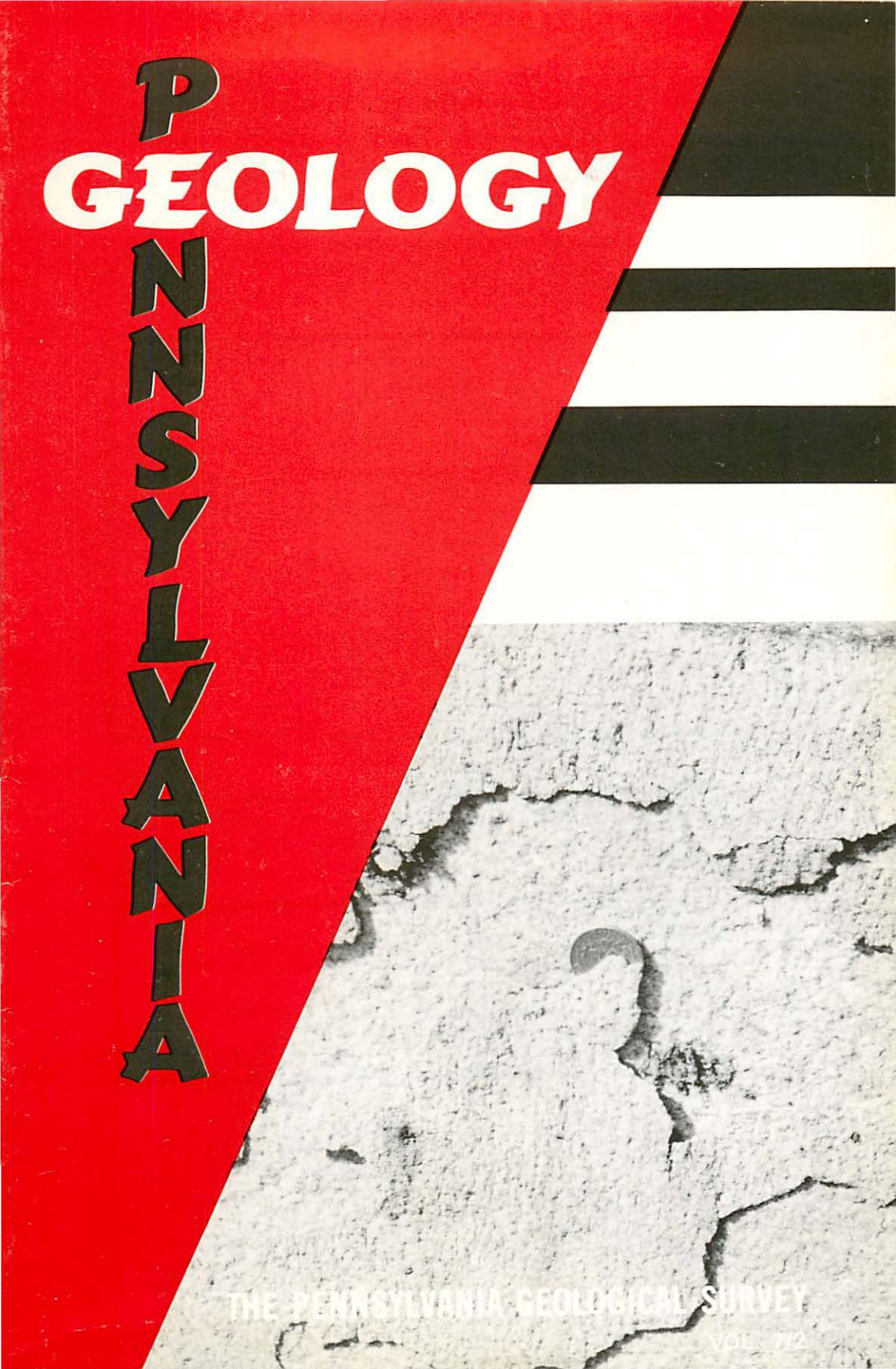
PENNSYLVANIA GEOLOGY



THE PENNSYLVANIA GEOLOGICAL SURVEY
VOL. 22

COMMONWEALTH OF PENNSYLVANIA
Milton J. Shapp, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Maurice K. Goddard, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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Cover Photo: Even rocks decompose! Close-up view of granite foundation stone exposed to Harrisburg elements since 1930. Coin (quarter) in photo gives scale. Photo courtesy of William Bolles.

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APRIL 1976

FROM THE DESK
OF THE
STATE GEOLOGIST...

PENNSYLVANIA'S IRON AGE

Today, Pennsylvania has only two operating metal mines: the Grace Mine (iron ore) at Morgantown and the Friedensville zinc mine near Bethlehem. But it was not always thus. Over the past 200 years, Pennsylvania has had a history of metal mining almost unmatched in numbers and variety. The remains of thousands of such mines are scattered across the Commonwealth and the range of commercially produced ores includes iron, nickel, chrome, manganese, zinc, lead, copper, gold, silver, magnesium, graphite, cobalt, and uranium.

Pennsylvania's iron mines, amongst all the various metal mines, offer the longest history and the greatest number of former operations across the Commonwealth. Our first iron furnace, based on local ore and charcoal, was built in 1716. Best known of former producers was the world famous Cornwall iron mine, Lebanon County, which was in continuous production from 1742 to 1972. The same type of magnetite iron deposit (with sulfides) was mined at Boyertown, Wheatfield, Fritztown, Jones, Fritz Island, and Joanna (all in Berks County); French Creek, Warwick, Knauertown, and Hopewell in Chester County; Dillsburg, Grantham, and Wellsville in York County.

A different type of magnetite ore, concentrated in older, crystalline rocks, was mined in Berks County in the Seisholtzville area, where over 120 mines were developed in nearby Rittenhouse Gap over a stretch of about two miles. This type of magnetite ore was also produced near Vera Cruz, Lehigh County, starting before the Civil War; at this location in 1899 Thomas A. Edison conducted a magnetic survey over the grounds and mapped out an additional 20,000,000 tons of iron ore.

Yet even this is only part of Pennsylvania's great iron mining history. From the difficult terrain of central Pennsylvania's Ridge and Valley Province, scores of mines produced from the sedimentary Clinton hematite formation in Snyder County (Adamsburg, Centerville, Paxtonville, Beavertown), Mifflin County (Yeagertown, Lewistown, McVeytown), Juniata County, Blair County, Huntingdon County (Orbisonia, Mt. Union, Shirleysburg), Union County (Winfield, New Berlin), and Bedford County. This is the same formation which extends southward through the Appalachian Mountains and thickens in Alabama to form the basis for the Birmingham steel industry. In Pennsylvania the limited thickness, low grade, and undesirable impurities eventually brought this mining to an end.

Early in Pennsylvania's iron mining industry a large number of "brown iron ore" deposits were in production, formed in some places in small swamps, and in other places as residual concentrations from weathered limestone bedrock. These were worked in Chester,

(Continued on page 9)

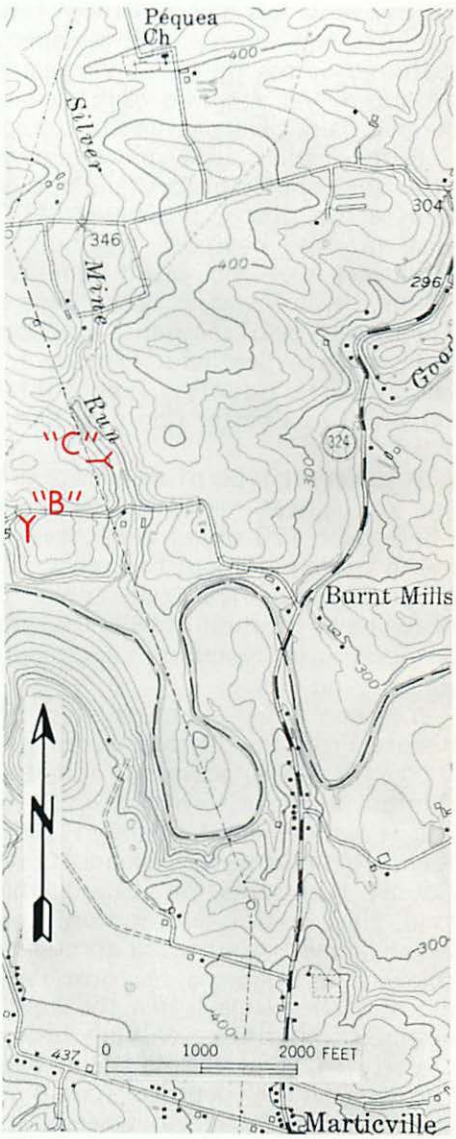
THE HISTORY AND MYSTERY OF THE PEQUEA SILVER MINES

by
Alan R. Geyer

The Pequea Silver Mines, located about five miles south of Lancaster in Lancaster County, were operated off and on for a period of more than 200 years, and perhaps even more than 300 years. Today evidence remains of three mines and a vertical shaft, but no one really knows what workings are actually below the ground there.

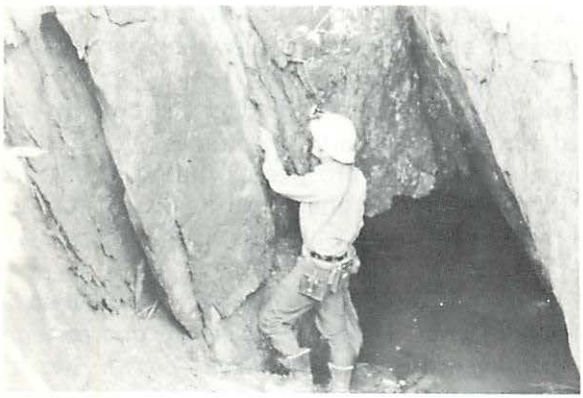
The mines involved extensive tunnels in solid limestone and dolomite developed by miners over these hundreds of years as they followed quartz veins containing the silver-bearing lead ore called argentiferous galena. The ore occurs in small, thin, discontinuous veinlets scattered throughout the enclosing rock. These elusive veinlets may account for the sporadic mining activity and a poorly recorded history.

There is evidence that the Pequea silver mines were worked by the Indians prior to 1643. In a book titled "A Key Into the Languages of America" by Roger Williams in 1643, he states that the Indians developed an art to cast pewter and brass into very neat, artificial pipes. In the late 1920's,



Mr. D. H. Landis, of Lancaster, had some lead pipes in his collection that were taken from the graves of Indians located south of Washington Boro, about eight miles from the mine area. On the thought that these pipes may have been made from lead mined at the Pequea mines, he had one analyzed. It was found that the lead in the Indian pipe contained the equivalent of 250 oz. of silver to the ton, exactly the same amount as one analysis of the argentiferous galena taken from one of the Pequea mines.

Early Colonial records (pre-1709) mention that the Indians of Conestoga were "pressed" into service in the mines. When William Penn heard of this he wrote James Logan and instructed him to verify the presence of a mine and to collect royalties from it for Penn. No records exist to show whether or not Penn received any royalties.



R. C. Smith II at Entrance to Burnt Mills Mine.

The Shawanese Indians came to Lancaster County about 1678 and settled along Pequea Creek near Conestoga. A Mr. D. J. Eckman, about 1927, discovered the site of a large Indian village near Silver Mine Farm. Here, he found evidence of the Shawanese and an earlier Indian culture. Was it the Shawanese Indians that worked the mines during Penn's time? Since the Shawanese came to the Pequea Creek in 1678, what tribe lived here before 1643? Did these earlier Indians discover and work the Pequea mines and if so, when?

There are only tales of the mines being operated periodically from Penn's time to the close of the Eighteenth Century. During the Revolutionary War, it is said the mines supplied lead shot for General Washington's troops but this may be only a tall tale because of the small amount of lead ore available. Many years later, during the Civil War, miners were blasting for a new shaft and accidently discovered an old mine drift with several cross cuts. Within these old workings,

they found several English powder cans and a rod for cleaning the dust out of drill holes. The entrance to these old tunnels was never found; it probably lies below the present water table.

In 1853, the "Journal of Silver and Lead Mining Operations" reported the mines being run with "considerable vigor." At the same time, the editor of the "Lancaster Whig" stated that recent assays by a Dr. Fahnestock (possibly of Lancaster) and by Professor Booth of the U.S. Mint in Philadelphia showed the ore contained "upwards of five hundred dollars ($500) worth of silver to the ton of lead." Mr. Booth states that there was about two tons of ore lying on the ground when he made his geological examination in 1853.

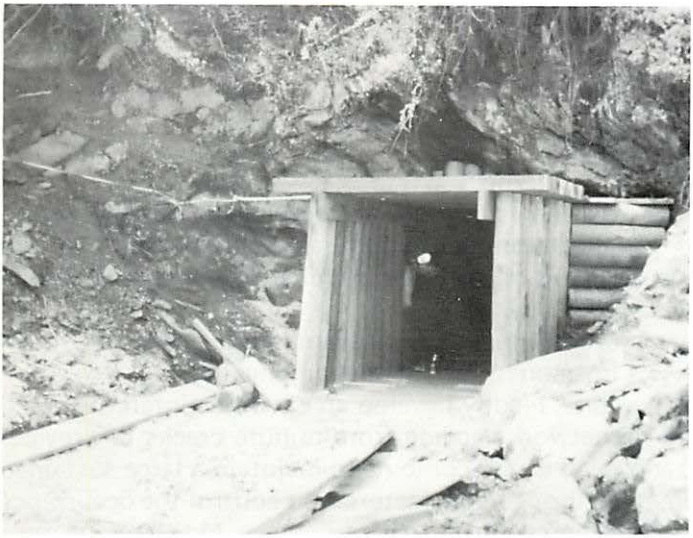
During the early part of the Civil War, mining was carried out by a Captain Joseph Buzzo. Local opinion has it that Captain Buzzo got considerable silver from the operation, but no record of this period has been found. How did a Captain of the Union forces become engaged in mining lead and silver at the Pequea mines when his country was at war? Did the U.S. Government sponsor it?

Sometime during the latter part of the Civil War, a group by the name of Lancaster Lead Company acquired the mines and tried to sell stock to reopen them. A company prospectus (dated 1863) describes much of the mining activity of that period. From this description, it appears that most of the mine workings visible today were completed by 1863.

After the Civil War the mines were inactive until 1874 when a silversmith from Philadelphia, Mr. Harvey Filley, purchased and operated the property. This venture was short-lived but during its one-year life, a mine superintendent, a mineralogist, and many miners were employed.

Geological investigations at the Pequea mines from the 1930's to date have been conducted by the Geology Department and the North Museum at Franklin and Marshall College in Lancaster. Since 1946, the Department's staff and students have studied this area and members of the Pennsylvania Geological Survey staff have periodically examined and sampled the site.

The total production of lead and silver from the Pequea mines is difficult to estimate. No production records exist for either the pre-Colonial or Colonial activities. Two tons of galena-bearing ore (perhaps contianing 5% galena) were mentioned in 1853 and in 1863 the Lancaster Lead Company claimed production of about 10 tons of galena. Estimations based on accessible mine openings and on known other underground workings indicate that 3,500 to 5,000 tons of rock have been mined. Approximately this amount (3,500 to 5,000 tons) has also been quarried at the surface. On the order of 10 tons



Entrance to Mine "C" at Silver Ford along Silver Mine Run.

of galena may have been mined but little of this may have been recovered from the stockpiles and smelted.

Today several mine openings are visible; several additional mine openings are completely slumped or filled; underground workings, drifts and crosscuts are present, no one knows how extensive.

Now a new chapter to this history has been written. The mine property is known as Silver Ford, Inc. and is owned and operated by Mr. James R. Bunting. Mineral collecting, a tour of one of the mines, and the use of all picnic and recreational facilities are available on a fee basis. All arrangements may be made by writing P.O. Box 1137, Lancaster, Pennsylvania 17604.

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ENGINEERING PROBLEMS in areas of limestone springs

by
Samuel I. Root

Boiling Springs, the largest spring in Cumberland County with a median flow of 11,500 gallons per minute ranks 7th in size of springs in the Commonwealth. It is one of the most charming and picturesque areas in the Great Valley.

Most of the major springs in Pennsylvania issue from fissures in carbonate rocks. Limestones, which are among the most solution prone rocks in the state, readily develop an extensive interconnected subsurface drainage network ranging from minute cracks or crevices to wide fissures and caves which combine to maintain a large sustained water yield. Generally, the geologic factors that control the occurrence of a spring are not immediately obvious. They may be due to a particular structure of the rock, variation of rock composition, faulting of the rock, or a combination of these factors.

In the Boiling Springs area those factors that influence the location of the spring are quite evident. The folded Cambrian limestones of the Elbrook Formation at Boiling Springs have been injected by a near-vertical, thin sheet of igneous rock, called a diabase dike. This diabase is virtually impervious to the migration of water and thus acts as a hydrologic barrier. It has an excellent topographic expression forming a narrow ridge—locally termed Stony Ridge—50-100 feet higher than the surrounding limestone terrain. At Boiling Springs the dike splits in two segments, so that the town is located in the interior apex of a "V" formed by the segments (Fig. 1). The general migration of subsurface water in this area is to the north and east from higher elevations on the south. Apparently subsurface waters migrating north becomes progressively confined between the two segments of the impermeable dike until they issue forth from a number of springs at the apex of the two dikes. Immediately northwest of the springs, on the other side of the dike, the bend in the dike also forms a geologic area in which groundwater flow is impeded with a consequent development of solution features.

The presence of a number of springs in limestone rocks in the immediate area is an absolute indication that there are significant fissures and caverns in the area. Therefore, construction in such a region should be preceded by core drilling, or other subsurface investigation, to determine the presence and extent of fissures and caverns in the limestone bedrock.

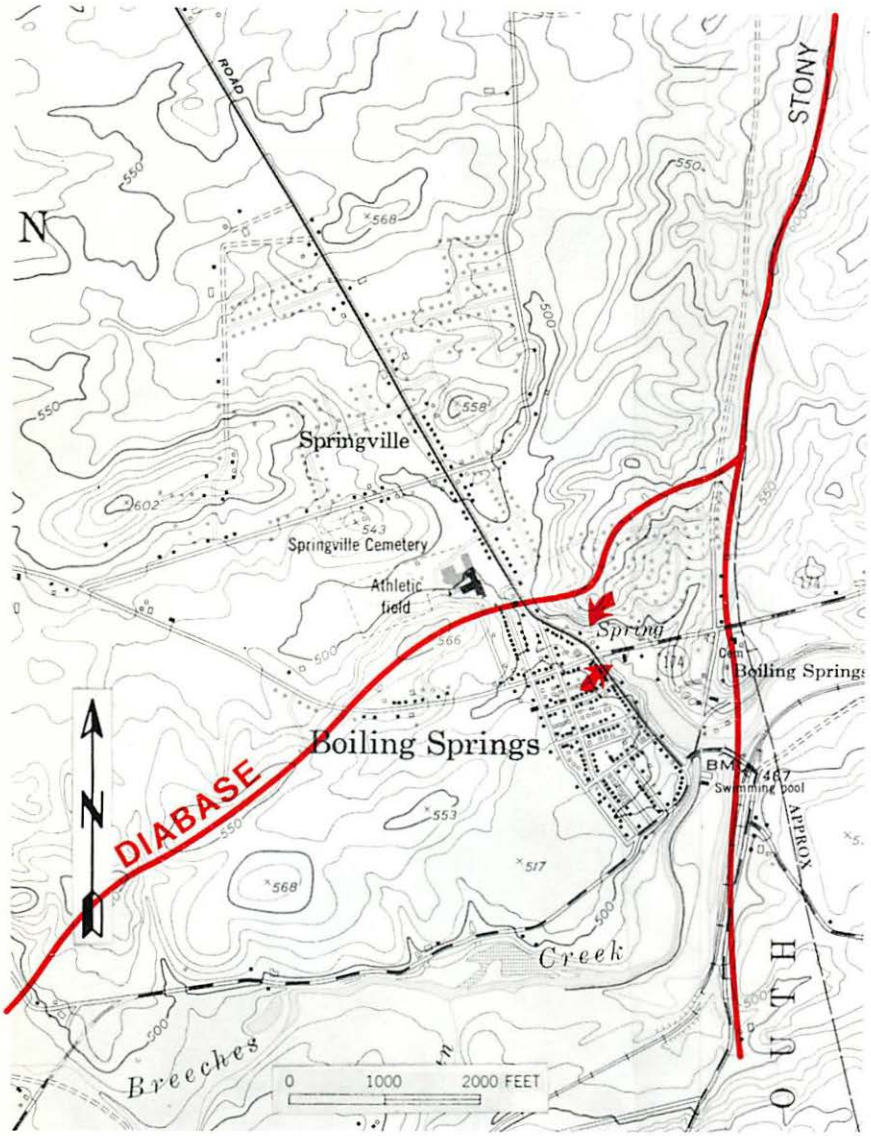


Figure 1.

Recently there have been some construction problems in the Boiling Springs area. A corner section of the new Boiling Springs High School apparently settled into a sinkhole which opened after a series of heavy rains apparently washed out a supportive clay plug (Fig. 2); a more detailed on-site investigation might have prevented such an accident. A number of problems have been encountered dur-

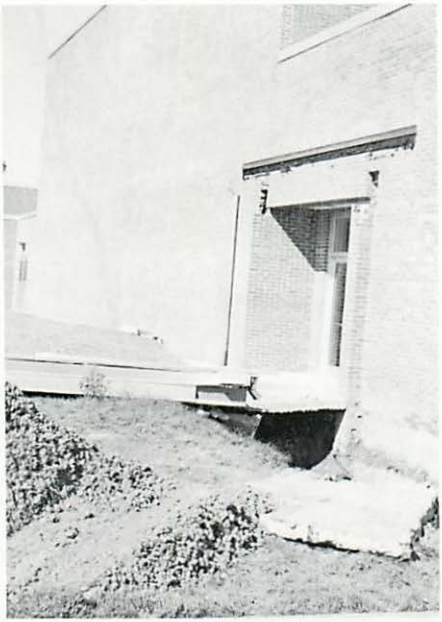


Figure 2. Sinkhole developing beneath entrance to school causing collapse of ground below entrance. (Photo courtesy of J. P. Wilshusen.)

Figure 3. Spring issuing from fissure in rocks, uncovered during excavation of ditch for sewer line.

ing installation of a sewer line. In one instance, excavation of a ditch flushed out a clay plug from a fissure in limestone so that support was withdrawn beneath an old water main which immediately ruptured. In another instance, a ditch excavated between two of the springs exposed a large fissure and intercepted a flow of water to the

springs, so that several thousand gallons of water per minute had to be pumped out (Fig. 3) for an extended period. The fissures are developed parallel to a set of fractures which have been mapped in this area. While the presence of a fissure could best be determined by drilling, their orientation, once encountered, might reasonably be predicted from nearby fracture data.

The Pennsylvania Geological Survey has always cautioned about foundation problems inherent in construction on carbonate bedrock. Springs in a carbonate terrain are an indication of potentially troublesome areas and the ground water conditions should be thoroughly investigated prior to construction in such areas.

there's a long, long trail a winding

We recently received a letter from a Scoutmaster with the following request: "Will you please send my troop the following information: any and all information on the Application Trail in Pennsylvania." We did not have the heart to tell him that the "Application Trail" is one of the most difficult and tortuous trails around. Rather, we took the easier way out and sent him some information on the Appalachian Trail.

FROM THE DESK OF THE STATE GEOLOGIST (Continued from page 1)

Lancaster, York, Centre, and Huntingdon Counties.

Pennsylvania's hundreds of iron mines fed furnaces throughout the Commonwealth and served a vital role in our early economy. Limited reserves and changes in technology and economics gradually brought about the demise of the many small iron mines, but they have left us with a rich heritage, worthy of remembrance in our Bicentennial Year.

Arthur A. Socolow

YORK COUNTY ANNUAL "ROCK SWAP"

The York Rock & Mineral Club Inc. will hold its fourth (4th) Annual "Rock Swap" on Saturday, June 12th and Sunday, June 13th, 1976 at Rohlers Picnic Grounds on Rohlers Church Road. These Picnic grounds are located three (3) miles east of Mt. Royal off Pennsylvania Route 74. Mt. Royal is approximately 2 miles north of Dover, Pennsylvania on Route 74.

For further information, please contact L. Weaver, Public Relations, Grant Road—Box 75, Thomasville, Pa. 17364.

QUIGGLEVILLE GAP PROSPECT–Lycoming County

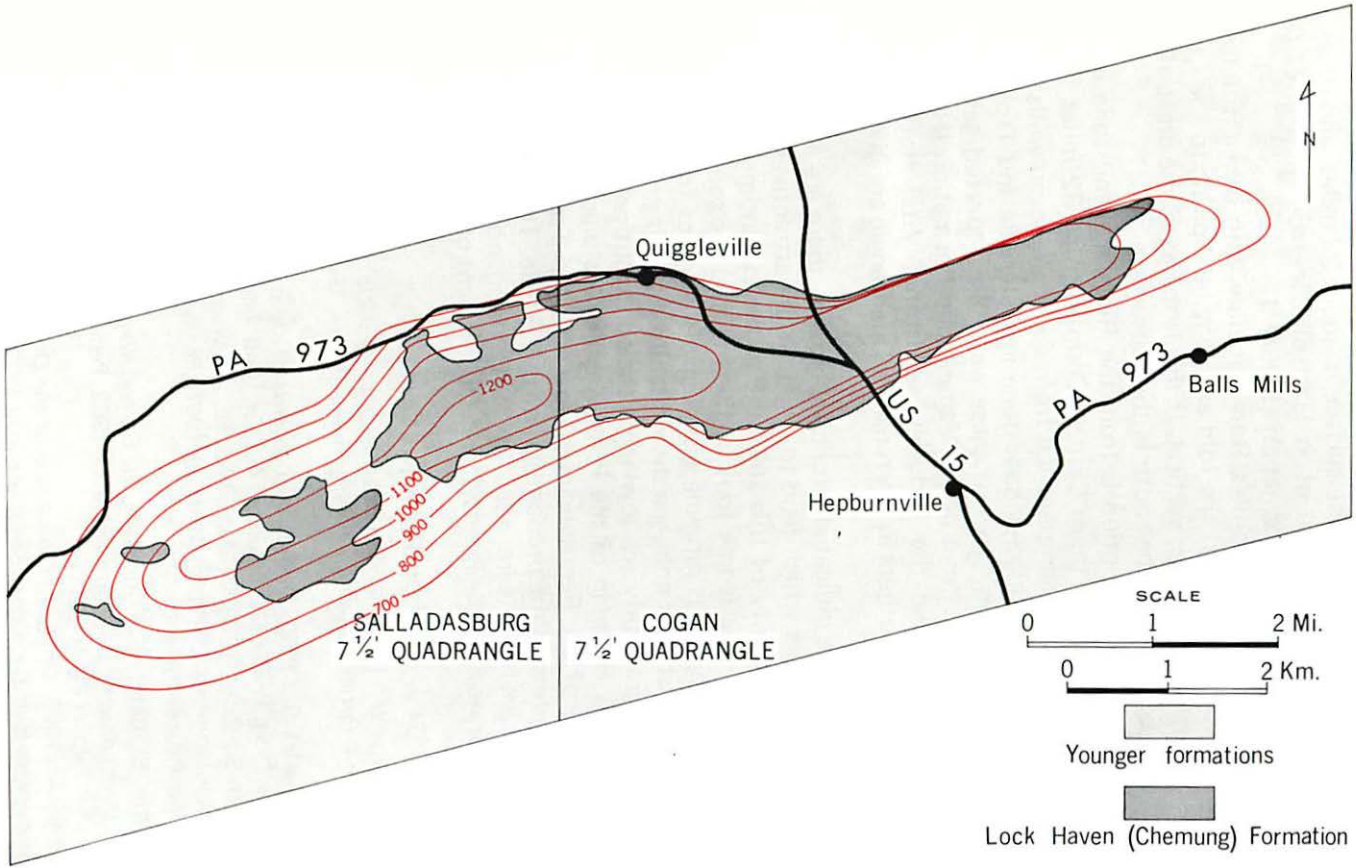
by
Richard B. Wells
Pennsylvania Geological Survey

Recent geologic mapping in central Lycoming County by R. T. Faill and R. B. Wells has outlined an interesting closure on Tomb's Run Anticline. It is the type of structural feature which should be considered for the possibility of containing natural gas. The prospect is located about two miles southwest of Quiggleville in Anthony and Lycoming Townships, on Cogan Station and Salladasburg 7½-minute Quadrangles, Trout Run 15-minute Quadrangle.

The Upper Devonian Lock Haven ("Chemung") Formation is exposed on the crest of the structure, with redbeds of the overlying Catskill Formation present on the flanks. The shallowest formation in which significant porosity and permeability is anticipated is the Lower Devonian Ridgeley (Oriskany) sandstone, which is about 80 feet thick and lies some 7900 feet below the Catskill. In outcrop, the Ridgeley sandstone is white to very light gray, medium and coarse grained, and fossiliferous. It is generally very porous and friable but locally has a calcareous or siliceous cement. The nearest good exposures are in the sand quarries at Lymehurst (one mile east of Williamsport) and Montoursville (three miles east of Williamsport), and along the east side of Pine Creek at Jersey Shore. Analysis of four Ridgeley samples from the Montoursville quarry show an average porosity of 15.6 percent. Sielacher (1968) has described the cementation and diagenesis of the Ridgeley (Oriskany) sandstone.

The formations overlying the Ridgeley Sandstone are predominantly gray shale and siltstone with a few thin limestone units. There are also some very fine grained sandstone beds in the upper 2000 feet of the Lock Haven Formation.

Tomb's Run anticline is the southernmost major fold in the Allegheny Plateau structural province, although it lies about two miles southeast of the Allegheny Plateau front. The fold axis trends about 068° (azimuth) across Salladasburg Quadrangle and about 079° on Cogan Station Quadrangle. It is located about a mile north of the axis of Short Mountain syncline and about three miles south of the axis of Snow Shoe syncline. Tomb's Run anticline has been traced by Colton (1967) from the Swissdale area in Clinton County northeastward into Salladasburg and Cogan Station Quadrangles. Total


N
Quiggleville
PA 973
US 15
PA 973
Balls Mills
Hepburnville
1200
1100
1000
900
800
700
SALLADASBURG
7½' QUADRANGLE
COGAN
7½' QUADRANGLE
SCALE
0 1 2 Mi.
0 1 2 Km.
Younger formations
Lock Haven (Chemung) Formation

length of the structure on the surface is about 23 miles, and present mapping indicates a closure of at least 500 feet on the top of the Lock Haven (Chemung) Formation (Figure 1).

A comparison of the Tomb's Run Anticline with other structures in this region suggests that the fold axis may be dipping to the south at a high angle, rather than vertical. If this is the case, the crest of the fold would be offset to the south in the subsurface.

The nearest gas production is from the Ridgeley sandstone in the Leidy Gas Field in northern Clinton County, some 32 miles to the west. Gas shows have been reported from six of the seven wells which have penetrated the Ridgeley sandstone in Waterville and Trout Run 15-minute Quadrangles. Two of these wells also reported gas shows in the Onondaga limestone or the Mahantango Formation (Hamilton Group), which overlie the Ridgeley sandstone. Vital statistics on these wells, and two others in Warrensville Quadrangle are given below in Table 1.

In addition to the indicated structural closure, there are also several non-geologic factors which tend to augment the attractiveness of this feature. The proximity of this structure to the expanding markets in the Williamsport area (some four or five miles to the south), and the presence of a major gas pipeline less than three miles from the crest of the structure should enhance the drillability of this prospect.

The author gratefully acknowledges the contribution of Rodger T. Faill and Louis Heyman of the Pennsylvania Geological Survey and Richard Howe of the Pennsylvania Department of Transportation to discussions leading to the preparation of this article. The porosity and permeability analyses were done by D. R. Reidenouer of the Soils Testing Laboratory of the Pennsylvania Department of Transportation.

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Table 1. Dry holes drilled in Waterville, Warrensville, and Trout Run Quadrangles. Wells which have penetrated the Ridgeley sandstone in Waterville, Trout Run, and Warrensville Quadrangles.

Well:	Township/ County	Location:	Elevation Total Depth	Comments & Reference
Waterville G-1				
Murphy Oil & Gas #1 Springer	Gallagher, Clinton	7180' N. of 41°15' 3221' W. of 77°25'	1749' 8530	Gas show at 7840' in Mahantango Fm. Fettke, 1956
Waterville G-2				
Manufacturers L. & H. Co. #1 Chatham Water Works	Gallagher, Clinton	3168' N. of 41°15' 5069' W. of 77°25'	1681' 8576'	Gas pockets at 8240', 8357', in Marcellus Fm., and at 8383' in Onondaga limestone. Fettke, 1956
Waterville G-3				
Murphy Oil & Gas #1 Mohawk Rod & Gun Club	Gallagher, Clinton	106' N. of 41°15' 6494' E. of 77°30'	1791' 8576'	No shows reported Fettke, 1956
Waterville C-4				
Felmont Oil Corp. #1 Wm. P. Day	Pine, Lycoming	1750' N. of 41°25' 1500' W. of 77°15'	1799'	Slight gas show in Ridgeley Ss. Lytle and others, 1962
Trout Run A-1				
G. L. Cabot #1 Hughes	Cogan House, Lycoming	6389' N. of 41°25' 10,243' W. of 77°10'	1547' 7579'	Gas shows in Mahantango Fm. and Ridgeley Ss. Fettke, 1956
Trout Run B-2				
G. L. Cabot #1 Codney	Cogan House, Lycoming	9768' N. of 41°25' 2640' E. of 77°10'	1660' 7814'	Gas show 7607-7664' in Ridgeley Fettke, 1956
Trout Run A-3				
Felmont Oil Corp. #1 J. F. Stryker	Cogan House, Lycoming	28,350' S. of 41°30"; 5,400' W. of 77°10'	1555' 7220'	Gas show in Ridgeley Ss; Salt water flow, Ridgeley Ss. Lytle & others, 1963
Warrensville B-1				
Delta Drilling Co. #1 Ambrose Ging	Cascade, Lycoming	4594' N. of 41°25' 7498' E. of 76°25'	1272' 8118'	No shows reported. Fettke, 1956.
Warrensville I-2				
Storey #1 Burkheart	Mill Creek, Lycoming	14,784' N. of 41°15'; 4435' W. of 76°45'	1254' 6854'	No shows reported. Fettke, 1956.

New From the U.S. Geological Survey

USGS Miscellaneous Field Studies Map MF 685-D. *Map of zones where land use can be affected by landsliding, flooding and undermining, Allegheny County, Pa.* by R. P. Briggs and W. R. Kohl. Price: $1.00

This map portrays at a scale of 1:50,000 areas in Allegheny County where 1, 2, 3 or none of the hazards of landsliding, flooding or undermining might occur.

Slope (Clinometric) Maps of Allegheny County.

The USGS has prepared 23 experimental maps by a photomechanican process that shows the land slope in four zones—0–8%, 8–16%, 16–25%, more than 25% slope. These maps are identified by the same name and cover the same area as the standard USGS 7½-minute topographic maps covering Allegheny County. Limited copies of the slope maps are available free from the Pennsylvania Geological Survey, Room 1201, Kossman Building, 100 Forbes Avenue, Pittsburgh, Pa. 15222.

Cumberland County and Delaware County Topographic Map

A new product of the cooperative USGS-Pennsylvania Geological Survey county topographic map program. Scale 1:50,000. Shows contours at 20' intervals, cultural features, forested areas, water and political boundaries. These, plus maps for Union, Sullivan, Forest, Montour and Jefferson counties are available at $2.00 each.

USGS cost publications are available from: Branch of Distribution, U.S. Geological Survey, 1200 S. Eads Street, Arlington, Va. 22202.

First Geologic Map of Pennsylvania Urgently Needed

If anyone knows where the Pennsylvania Geological Survey can obtain a copy or copies of the Geologic Map of Pennsylvania by H. D. Rodgers, 1842, please let us know. We will accept donations with thanks or will purchase copies. We have only one very fragile and worn copy that went through the 1972 flood. We are particularly interested in obtaining this in the original binder, if possible.

MEET THE STAFF...

Alan
R.
Geyer

In every organization there are old-timers. The Pennsylvania Geological Survey is no exception and Alan Geyer is one of them. "Al" joined the Survey during the summer of 1951 as a student assistant and in July of 1953 as a full-time staff geologist. During most of the '50's Al's field work involved the structure and stratigraphy of the carbonate rocks of the Lebanon Valley. Along with others, he was responsible for the discovery of the large Alpine-like overturned folds in the rocks of the valley. This discovery proved to be a vital "tool" in the prospecting and mining of the valuable, high-calcium limestone formation called the Annville Limestone in Eastern Pennsylvania.

In 1957 Al became the Assistant State Geologist and was responsible for those myriad of administrative duties that go along with the running of any office. The Survey was expanding rapidly during this period and in addition to the general administrative duties, purchasing, and service work, this position included the job of being the Survey editor. By 1960, however, a separate Editor's position was created. For a brief moment, from October 1961 through December 1961, Al was Acting State Geologist. Upon Dr. Socolow's appointment as State Geologist, he returned to his old duties as Assistant State Geologist.

From the time of the launching of "Sputnick" in 1957 to the present, Al has been the Survey's representative on many committees involved with the earth sciences in our society. That same year he participated in the Pennsylvania Department of Education's writing committee to create a teachers' guide to earth and space science in

the secondary schools. The very next year he helped write a teachers' guide for the secondary schools on conservation for the Education Department. By this time, Pennsylvania led the nation in introducing the earth sciences to the public school system. At the close of the '50's, the National Science Foundation sponsored a national writing conference, the Duluth Conference, to create a "sourcebook" in geology and the earth sciences for secondary school teachers; Al was invited and spent the latter part of the summer of 1959 writing in Duluth, Minnesota.

With Dr. Socolow as State Geologist, he immediately was sympathetic and encouraged the Survey to become more responsive to the needs and wants of other government agencies and the general public. Thus, the Survey's Educational Series of publications was started. Al co-authored the first booklet in this series and the very popular Bulletin G-33, "Mineral Collecting in Pennsylvania." Al also played a key role in starting the highly popular Survey rock and mineral kits.

By mid-1968 a major emphasis in applied geology was sweeping the field of geology. More attention was being focused on the use of geologic knowledge to solve man's environmental problems and better plan for a quality future. In recognition of this need, the Survey created a new Environmental Geology Division. With Al's broad experience at the Survey and his interest in "applied geology" he was a natural to head up this new division.

With the start of the survey's bi-monthly publication, *Pennsylvania Geology,* Al introduced a semi-regular column in it called the "Earth Science Teachers Corner." More recently he served on the Pennsylvania Department of Education's committee to write a mini-course on the "Environmental Impact of Electrical Power Generation: Nuclear and Fossil" and update and rewrite the Department's teachers' guide to "Earth and Space Science in the Secondary Schools."

Al is a native of Lancaster County, born in Ephrata and grew up in Lancaster. He obtained a B.S. degree in geology from Franklin and Marshall College in 1951 and an M.S. (geology) degree from the University of Michigan. He is a member of several professional societies and in 1973 was presented the Ralph Digman Award by the Eastern Section of the National Association of Geology Teachers (NAGT). This award is given for "outstanding contributions on behalf of laymen-directed geology teaching." Al has authored or co-authored more than 30 published articles and geologic reports and the Survey currently has two more of his reports in press.

Al, his wife Patsy, and their two children, Ray and Beth, reside in Colonial Park, east of Harrisburg. During his off-the-job hours, Al spends his time antiquing, especially for "early" tins.

PENNSYLVANIA GEOLOGICAL SURVEY STAFF

Arthur A. Socolow, *State Geologist*
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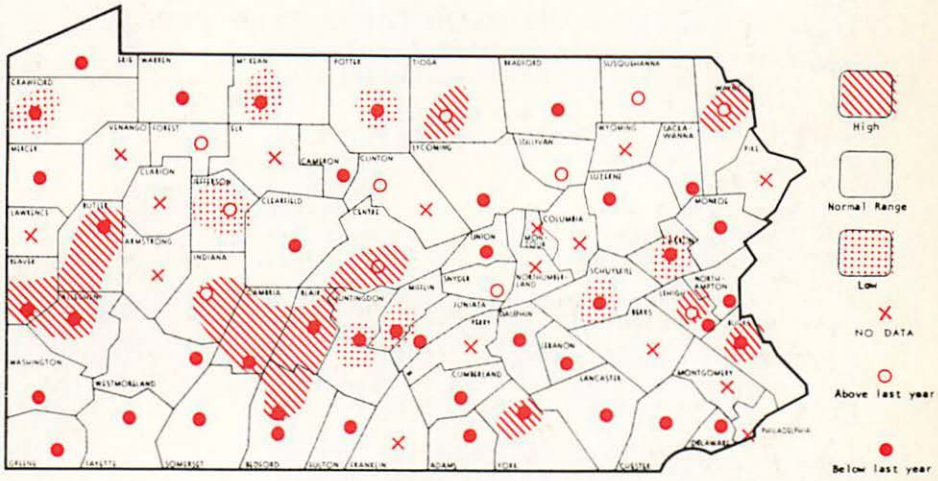
MARCH 1976

GROUND-WATER LEVELS



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