PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 11/3

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: A portion of Baers Rocks along the Appalachian Trail on the crest of Blue Mountain, at the border between Schuylkill and Lehigh Counties. These rocks are the broken, upturned edge of the 1600-foot thick Silurian (440 million years old) Shawangunk Formation, here a cross-bedded conglomeratic quartzite. These massive joint blocks illustrate characteristic rock weathering on ridge crests, providing a source for down-slope accumulations of boulders. Photo by J. P. Wilshusen.

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FROM THE DESK OF THE STATE GEOLOGIST . . .

ACHIEVEMENTS YES, APOLOGIES NO

There are some who have been saying in recent years that the United States, with approximately 6% of the world's population, has no right to be consuming some 30% of the world's annual production of mineral resources. Such remarks have been particularly stimulated by the unsettled world energy situation.

I, for one, am not yet ready to apologize for the extent of our consumption. To begin with, the early settlers of our nation had no forehand knowledge that this was a continent blessed with an abundance of mineral resources, including coal, oil, and natural gas. We owe no apologies for our early pioneers who had the initiative to move westward and who braved unbelievable hardships as they settled in the wilderness. Nor do we owe apologies for the prospectors and miners who endured and conquered physical dangers and economic risks to locate and develop our mineral deposits, and are still doing so today at greater and greater costs as the easily discovered mineral resources are long gone.

And we should not be apologetic for the initiatives of industry and labor whose combined efforts created our industrial society and standard of living which is the envy of both developed and undeveloped nations of the world—even as our industrial society is the very basis for our massive mineral resource consumption.

America's technological and scientific genius which has created the marvels of transportation, communication, housing, disease controls, and scientific agricultural should also not be asked to apologize for their achievements, even as they too have added to our consumption of resources.

The challenge to our society is not simply to consume less out of some sense of guilt. We should rather eliminate wasteful procedures so that our known mineral resources will go farther, and improve our technology to find deeply hidden resources and to utilize low grade resources.

The underdeveloped nations have every right to aspire to greater use of mineral resources, greater industries, and high standards of living. But the challenge to those nations is to take the initiative to find and develop the resources in their own back yard. Our national achievements or our levels of consumption are not the cause of their underdevelopment and underconsumption.

While some countries have been blessed with a greater abundance of mineral raw materials than others, and some nations have moved far along to depleting their rich, easily discovered mineral deposits, the fact is that the world is not really running out of mineral raw materials. There remain in the earth's crust both deeply hidden, highgrade deposits, as well as known low-grade deposits of vast dimensions waiting to be "harvested" by improved technology. These challenges are compounded by political barriers which so often prevent freedom of movement of mineral resources between have and havenot nations.

Yes, our country is a major consumer. Yes we have challenges to face in order to sustain our standards of consumption. Those challenges call for achievements, not apologies.

Arthur A. Socolow

FRACTURE TRACES AND WATER WELLS, A REVIEW

Larry E. Taylor, Hydrogeologist

This is a brief history of the studies which have led to the present use of aerial photographs and remote sensing imagery to identify fracture traces and lineaments which are then utilized in an attempt to locate high yield water wells. Some of the following information is from an unpublished report by Snyder (1975) that gives a good review of modern works pertaining to fracture traces and ground water. It is noteworthy that research and discussion on fractures and linear features have been cited in the literature since the 1800's.

Hobbs (1904, 1911) has been generally credited with the introduction of modern techniques of study of natural linear features. He was preceded by over a century of less rigorous investigations that are discussed by Hodgson (1974). Rich (1928) was apparently the first to report about the observation of linear features from the air. He recognized linear vegetational, tonal, and topographic alignments while flying over the limestone areas of Oklahoma. He suggested the use of aerial photographs to further study these linear features which he related to bedrock jointing. Little work was done using Rich's idea until the major oil companies became interested in the use of fracture trace studies for their exploration programs in the early 1950's (Keim, 1962, p. 2).

In 1955, Lattman and Olive presented a brief note showing that the rate of dip of limestones in the semi-arid Stockton Plateau of Trans-Pecos region of Texas could be established from mapping joint sets on aerial photographs. Blanchet and Molland (1957), in separate papers, used aerial photographs to map linear features in western Canada. They both introduced theories as to the mechanisms causing fracture traces and lineaments. In 1958, Lattman published a paper presenting techniques for mapping fracture traces and lineaments and introducing his nomenclature for linear features.

None of these studies made any mention of the use of fracture traces and lineaments to locate water wells. The first published attempt to correlate high yield wells with fracture traces was described by Meisler (1963). This study found no significant relationships between the specific capacity of water wells and their location with respect to fracture traces (Meisler, 1963, p. 33).

Before continuing, it should be mentioned that use of linear valleys, depressions, and other natural alignments for well location is not new. A few drillers, "water witches," and geologists have been aware of topographic influence on the degree of bedrock fracturing and, thus, well yields for many years. Unfortunately, very little information about this has been published, although there are a few instances. A paper by Graeff (1953) deals with the use of trough like linear depressions to locate water wells. This report is in some respects more credible than some of the recent literature because the depressions were correlated to prominant joint trends in Graeff's study area. This use of natural linear depressions relied on subtle changes in topography rather than aerial photographs to locate water well drilling sites. Some modern authors contend that this is still the best method to locate wells (Nutter, 1973, p. 26).

Lattman and Parizek (1964) attempted to demonstrate the utility of fracture traces for the location of high yield wells in the Nittany Valley. Their investigation had two basic deficiencies: 1) There was an insufficient number of wells intentionally located on and off fracture traces; 2) Little attempt was made to separate the influence of fracture traces from other hydrogeologic variables that affect well yields.

Siddique and Parizek (1971) published a paper intended to "satisfy skeptics" (p. 1296) as to the utility of fracture traces for high yield well locations. Statistical analyses were used to attempt to isolate the different hydrogeologic factors influencing well yields and thereby show that the most important factor in a given geologic setting was location with respect to fracture traces. A basic problem with this study is that many of these hydrogeologic factors are not easily separated which results in the authors having to make certain assumptions that are not acceptable to all investigators.

A considerable amount of literature pertaining to fracture trace location of water wells has been published in the 1964-1979 period. None can be said to fully demonstrate the utility of the method because they have not addressed themselves to the inherent theoretical problems that exist with the method. Some of these problems are as follows: 1) variation in joint density with lithology and bedding thickness, 2) paucity of vertical fractures in some geologic settings, 3) refraction of inclined joints at lithologic contacts and the refraction of vertical joints at inclined lithologic contacts, 4) signifigraphs, and 5) statistical advantage of the fracture trace method as opposed to a strict topographic method.

In summary, the identification of fracture traces on the ground and on air photos has a long history. In some geological settings, the location of such fracture traces has been an apparent aid in chosing sites for high yield water wells. In other geological settings, however, well data indicate that the use of fracture traces has not been particularly helpful for picking favorable water well sites.

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DISTINGUISHED EDUCATION AWARD TO STATE GEOLOGIST

In recognition of services rendered to geologic education, Dr. Arthur A. Socolow, Director of the Bureau of Topographic and Geologic Survey, has been selected by the National Association of Geology Teachers as the 1980 recipient of the Ralph Digman Award. Named after an outstanding educator and founder of the Association of Geology Teachers, the award is bestowed annually upon an individual who has made outstanding contributions to geologic education while not directly serving as a teacher.

In granting the award to Dr. Socolow, the Association of Geology Teachers cited his many years of personal attention and services to students and teachers of all grade levels, as well as his leadership in developing and providing educational geology materials at the Bureau of Topographic and Geologic Survey. Under Dr. Socolow's guidance, the State Geologic Survey has prepared a nationally acclaimed series of nine geology booklets on subjects of widespread interest, a set of geologic resource maps of Pennsylvania, a series of geologic guides to Pennsylvania's State Parks, and a variety of rock and mineral specimens to help stimulate the beginning geologist. Since these educational materials were initiated under Dr. Socolow's direction in 1962, over 2 million students, teachers, and general public have utilized these elementary geologic aides.

In accepting the award at the Annual Meeting of the National Association of Geology Teachers' Eastern Section, held at New Kensington on May 3rd, Dr. Socolow noted that such services for students and the public enable them to better understand and appreciate the complexities and importance of the geology which they encounter in their daily lives. Dr. Socolow stated, "The educational geologic services and materials which we provide constitute a proper balance to the highly scientific geology reports which are prepared by our outstanding staff of geologists. I am pleased that this broad program of activities by the Pennsylvania Geologic Survey thus covers the needs and interests of our entire citizenry."

Decoding A Fossil Trail

Wayne F. Downey, Jr., Geologist
R. E. Wright Associates

One of the more puzzling paleontological problems of central Pennsylvania is the classification and origin of the index fossil *Arthrophycus alleghaniensis* commonly found along bedding planes in the Tuscarora sandstone of lower Silurian age. The Tuscarora trends northeast-southwest and underlies many of the Appalachian mountains from southeastern New York to Maryland. (Figure 1).

Near Mt. Union (Figure 2) *Arthrophycus* occurs as bundled cylindrical fillings of tunnels on the lower bedding surface and contact of the Tuscarora quartzite. (Figure 3A). The quarry at Mt. Union exposes 58 feet of Tuscarora overlying olive-green, silty, fissile shales.

The sandstone is well sorted, fine (.2 mm) to medium (.5 mm) grained and silica cemented. It contains minimal argillaceous material and in most areas only traces of iron in the form of localized ferrous stains with minor hematite and siderite granules.

The Tuscarora is clean, containing less than 3% clays, and silt with low trace element content. The sand grains fall between .4 and .6 roundness parameters. The Tuscarora has probably been reworked, representing a second or third stage sandstone derived from earlier quartzites.

The Tuscarora (Schwartz, 1934) contains a shallow marine fauna and is represented by a few fragments of eurypterids, a few brachiopods and a very prominent fossil burrow, *Arthrophycus*. (Figure 3). Since some samples exhibit hard-bodied marine fossils, a shore environment is suggested as a possible site of deposition.

The curving stems of *Arthrophycus* are simple or usually terminate in bunches, which gradually curve upward in section. The surface of the raised cylinders frequently show regularly spaced transverse ridges. These ridges are curved smoothly and extend the total circumference of the cylinders. (Figure 5). The branches are found along bedding planes in disarray, with no apparent pattern. Branches bisect and crosscut other branches indiscriminately. (Figure 6). Vertical orientation is minimal, implying the branches are the casts of restricted shallow feeding burrows made by perhaps a marine annelid (worm) which churned the beach sand 400 million years ago. (Figure 3B).

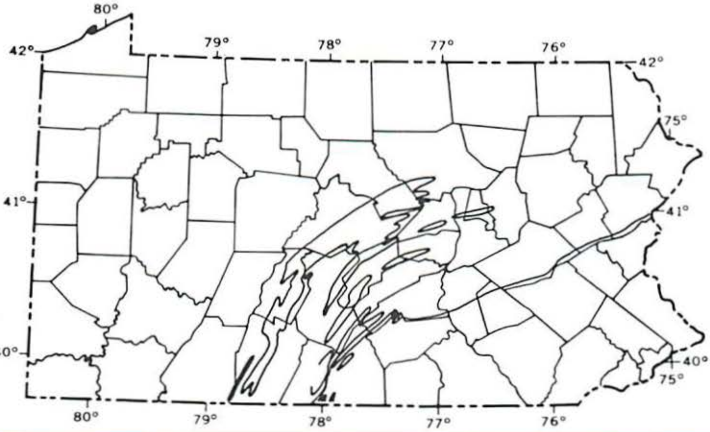

Figure 1. Areas of Pennsylvania where the Tuscarora sandstones occur.

The "annelid" most likely formed membranous tubes utilizing an organic gelatinous substance secreted through its cuticula. The binder allowed the preservation of the fossil burrows seen today. (Figure 4).

Figure 2. Topographic map of Mt. Union area where *Arthrophycus* occurs near top of Jacks Mountain in an abandoned quarry.

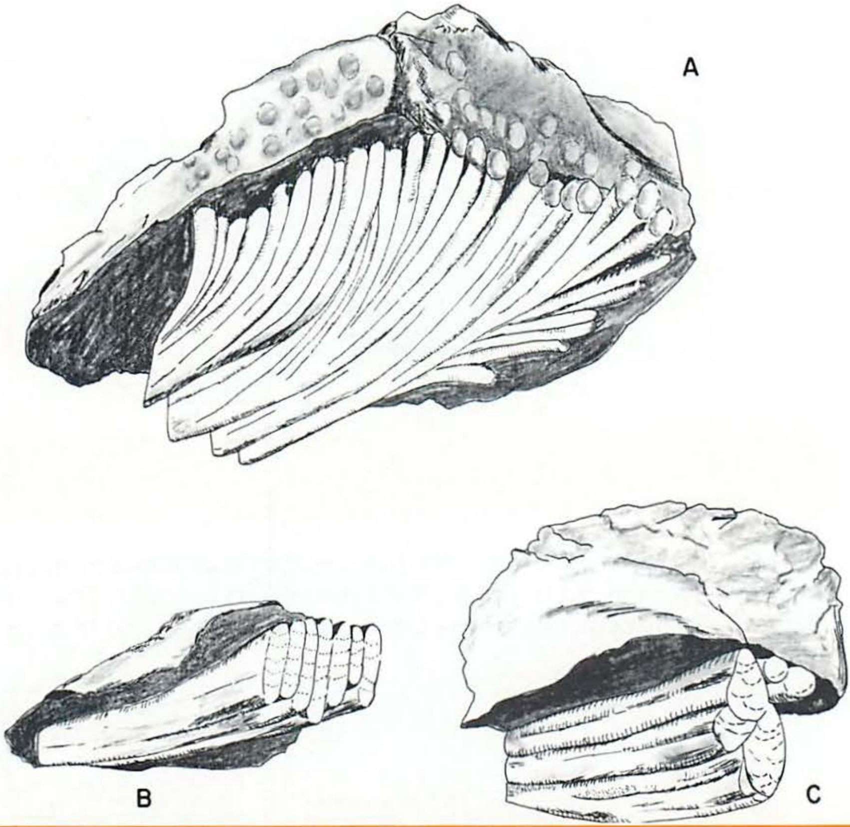

Figure 3. Schematic depictions of *Arthrophycus* detail illustrating common mode of termination and banding.

Upon examination of thin sections of *Arthrophycus* tubes, it becomes evident that the creature responsible for them was a deposit-feeder, that is, it would burrow and feed on sand containing organic detritus supplied by organisms which died in the shallow littorial zone of a Silurian sea. The sand was "eaten," ingested, and passed through the digestive tract where nutrients were extracted. Finally, the biochemically bleached sand grains were expelled from the posterior of the worm through a large intestine where they backfilled the feeding tube. The excretion consisted primarily of ammonia, urea, and nitrogenous compounds. These are easily dissolved and are absent from the fossil record, but excess iron, not used in manufacturing of hemoglobin, could have been excreted through the skin periodically in high concentrations and collected as a pronounced

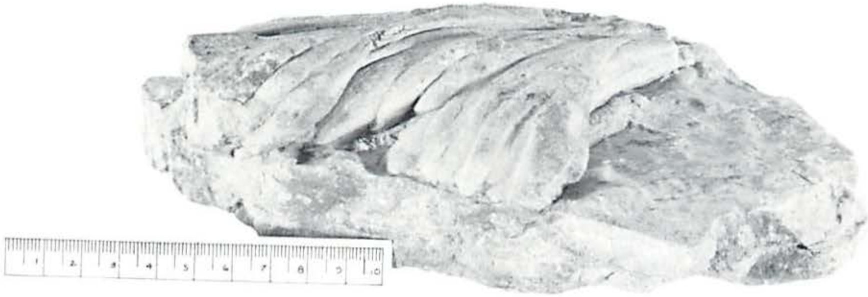

Figure 4. *Arthrophycus*. From near Mount Union, Huntingdon Co., Pa. W.P.M.M. Sample #T33. Photo courtesy of William Penn Memorial Museum.

iron stain on the peripheral edges of the burrows. (Figure 3A). "This mechanism may be aided by sulfur contained in the organic binder, preferentially reacting with additional iron in surrounding sediment precipitating hematite and various iron sulfides." (Roger D. K. Thomas - personal communication).

Figure 5. *Arthrophycus*. From east slope of Loop Mountain, Frankstown Twp., Blair Co., Pa. W.P.M.M. No. T6. Shows branching terminations and "ribbed" structure.

Figure 6. *Arthrophycus*. Locality unknown, from W.P.M.M. collection, Sample No. T8. Illustrates common intersecting branching burrows.

Most living deposit feeders feed in mud substrates or in rich organic oozes. These are unusually unsegmented; however, *Arthrophycus* was a sand feeder, and had very prominent segments. It apparently could subsist on minimal organic material, and adapted prominent segments for rapid locomotion through loose sediment. This is accomplished by rapid contraction of the longitudinal muscles on both sides of a segment with a concomitant expansion of another segment producing rhythmic, paristaltic waves of constriction. The last few posterior segments expand against the inside walls of the tube causing frictional resistance and imprinting characteristic ridges observed in fossils today. (Figure 3C).

A more difficult structure to explain is the dichotomous branching terminations that are commonly exhibited by *Arthrophycus* burrows. Asexual reproduction may explain the off-shoots. Regeneration of a complete individual from artifically separated segments is possible through spontaneous fragmentation of the body. Heads could possibly have been produced on almost any segment, following simple fragmentation. The currently existing family, Nephtyidea, a marine annelid, is characterized by numerous segments, rather wide girth (up to 7 mm or 8 mm) and lengths to 60 cm or more. Within the Nephtyidea family subspecies *Agaophamus circinata*, this type of reproduction is relatively common today. It has been calculated that a single individual could give rise to 15,000 others within a two month period. This proliferation would result from approximately 25 separate individuals being produced in a single day by one parent. (Pratt 1935).

A possible explanation for *Arthrophycus* is here suggested. Forming in one tube each *Anthrophycus* offspring selected a different direction to eat its way to the sediment surface. The young annelids surely must have had a voracious appetite and needed substantially more nutrients to grow than the sand provided. Upon reaching the surface, they probably sought out simple seaweed-type plants to parasitically remove juices from them. Whereupon growth would have been rapid, the adolescent annelids would burrow back into the substrate to lead more sedentary lives. There are a number of species living today in the intertidal zone within beach depositional environments which follow a very similar pattern of life. This explains both the sudden junctures of *Arthrophycus* burrows and also the high angle surface trajectories the burrows show soon after disjunction.

No fossil example exists of the actual animal organism which produced the burrow *Arthrophycus*, so most of the theory as to its appearance and classification is purely speculation.

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Mineral Collector's Field Guide, The Northeast, by Bill Shelton and Bud Webster. Published by Mineralogy, P.O. Box 504, Wallingford, Ct. 06492. $8.50.

This book attempts to provide information on what the authors consider to be some of the premier collecting localities in northeastern United States and southeastern Canada. The work is not intended to be a complete listing of collecting localities but rather a guide to the geologically interesting and/or specimen-rich localities and gives more details than could be included in a more general guide. Of the 50 localities described two are in Pennsylvania. One is the Faylor Middlecreek Quarry in Winfield, PA and the second is the Meckley Quarry in Herdon, PA.

LANDSLIDES IN BEAVER COUNTY, PA.

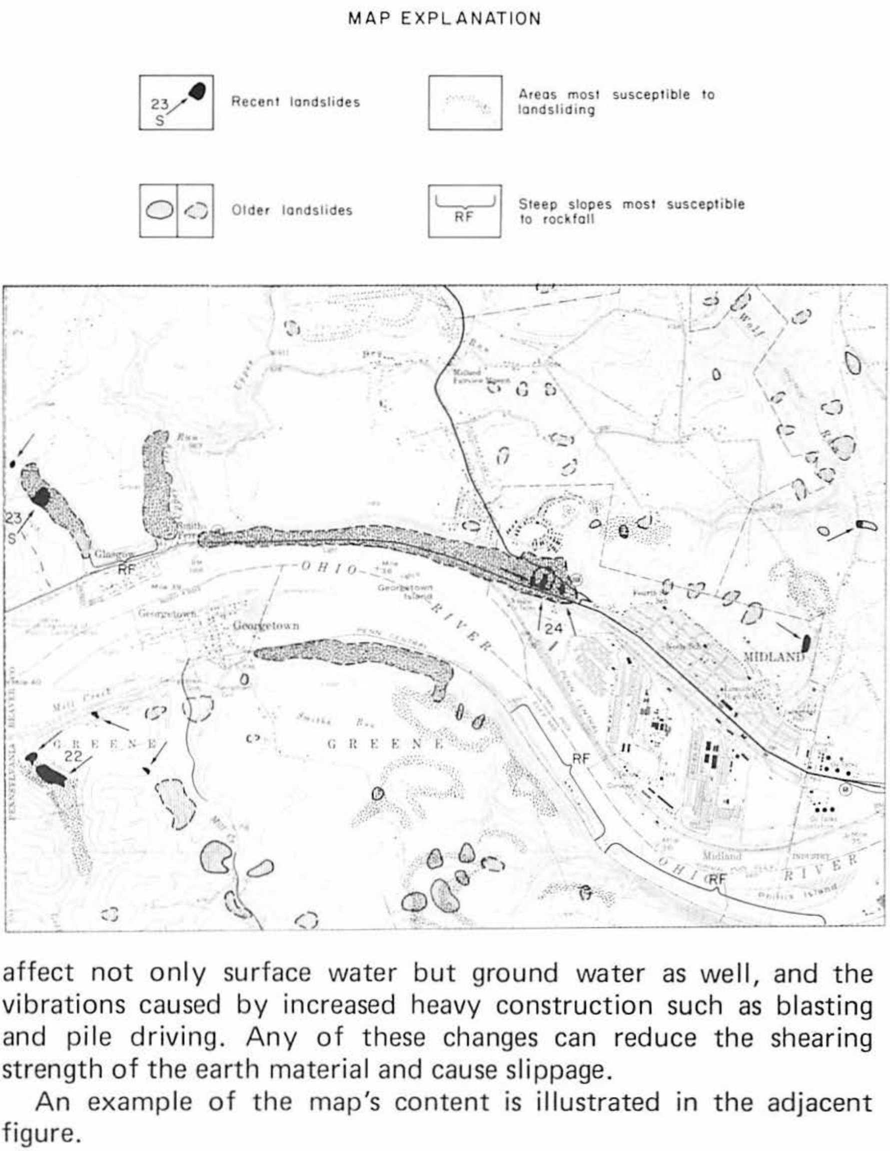
A new map showing over 3,000 landslides and areas most susceptible to future landsliding in Beaver County, Pa., has been published by the U.S. Geological Survey, Department of the Interior.

The map covers a 440-square-mile area in the western part of the state, about 15 miles northwest of Pittsburgh and is part of a series of 1:50,000-scale (1 inch represents about 1.25 miles) county maps that identify areas with potential slope stability problems that could be significant to regional development in the Greater Pittsburgh region.

Using shading and symbols, the map identifies more than 250 recent landslides and about 3,000 older landslides. Also shown are selected examples of ground slumping, areas most susceptible to landsliding, and steep slopes susceptible to rockfall. More than 90 percent of the recent landslides are small, generally less than 100 feet (30 meters) in width or length.

Although a few recent slides have been triggered by natural causes, such as unusually high amounts of rainfall, most have been man-generated and occur near roads and construction sites.

Many of the slides are triggered by manmade modifications of sensitive slopes. These activities include excavating at the base of a slope so that the slope becomes oversteepened, overloading a slope with fill and causing instability, altering drainage conditions that



affect not only surface water but ground water as well, and the vibrations caused by increased heavy construction such as blasting and pile driving. Any of these changes can reduce the shearing strength of the earth material and cause slippage.

An example of the map's content is illustrated in the adjacent figure.

Copies of the map, titled, "Map Showing Landslides and Areas Most Susceptible to Sliding in Beaver County, Pa.," and released as Miscellaneous Investigations Series Map I-1160, can be purchased for $1.25 each from the Branch of Distribution USGS, 1200 South Eads St., Arlington, Va. 22202. Purchases must include check or money order payable to the U.S. Geological Survey.

PREVENTING WATER WELL EXPLOSIONS IN GAS AREAS

Water well installations in homes or buildings located in oil and gas producing areas of Pennsylvania should be vented to prevent the possible accumulation of explosive mixtures of natural gas within the building. This recommendation is being made by State Geologist Arthur A. Socolow of the Department of Environmental Resources with the hope that personal injury and property damage may be avoided in the future by making the public aware of the problem. Over the years a number of damaging explosions have occurred which have been attributed to such natural gas accumulations.

In the oil and gas fields of western and northern Pennsylvania the natural gas frequently occurs at shallow depths and has the ability in certain situations to move upward through cracks and pore spaces in the rocks until the gas reaches the water table.

Water wells provide a favorable channel along which the gas may rise into the basement of the overlying building.

Venting a water well installation basically involves a pipe which leads from the well head to a location outside the building. Such well vents for new or existing wells may be installed by competent water well drillers or pump installers.

To help interested persons to understand where Pennsylvania's oil and gas producing regions are located, DER's Bureau of Topographic and Geologic Survey has prepared a page sized map showing the oil and gas field areas of the Commonwealth. This map is available from the Survey at no charge by writing to P.O. Box 2357, Harrisburg, Pa. 17120.

TO REPAIR A SINKHOLE

In February 1979, sinkholes opened under Bullfrog Valley Road in Derry Township not far from the Hershey Convention Center. It took almost a year to conduct a foundation investigation, design the remedial procedures and repair the roadway before it could be opened to traffic again in January 1980. That is a short time when one considers the amount of construction that had to be designed and executed.

The area of sinkhole collapse was bridged by a reinforced concrete span supported by caissons 41 feet long, drainage control structures were installed, subgrade replaced and the roadway repaved. The accompanying sequence of photographs shows collapse, repair and present condition.

COLLAPSE

REPAIR

PRESENT

Photos by W. Bolles

FAMOUS PENNSYLVANIA MINES FEATURED IN STATE MUSEUM EXHIBIT

Famous Mineral Localities Exhibit, a colorful display relating to the ore deposits at Cornwall, Lebanon County, and the French Creek Mines, St. Peters, Chester County, is being shown at the William Penn Memorial Museum, Third and North Sts., Harrisburg.

The subject treats the mineral origins, and presents a brief historical sketch of the world-famous iron deposits at the two Pennsylvania sites. In addition, many fine specimens collected at both localities are displayed with photographs and other artwork. Cornwall Furnace, near Lebanon, is maintained as an historic site by the Pennsylvania Historical and Museum Commission (PHMC).

The exhibit, organized by Donald Hoff, curator of earth sciences at the State Museum, continues through Sunday, Aug. 3.

The Cornwall deposits were an important source of iron ore from colonial times. Mining began at Cornwall in 1742 when ironmaster Peter Grubb completed construction of the original Cornwall Furnace. This furnace was remodeled in 1857. More than 100-million tons of Cornwall commercial ores were mined before the mines were finally exhausted in 1973. Copper, silver, gold, cobalt, and sulfur, in addition to iron, were obtained from the ores during the 20th century.

The French Creek Mines deposit supplied a moderate amount of iron ore beginning in 1846, with final depletion of ore in 1928. This locality was probably most important as a source of excellent mineral specimens which are now in the collections of many museums throughout the world. Most of the French Creek Mines specimens displayed in this exhibit are from the John Frankenfield Collection which was purchased by the Pennsylvania Historical and Museum Commission in 1973.

The Central Pennsylvania Rock and Mineral Club, Inc. will hold its Fifteenth Annual Gem, Mineral & Jewelry Show in the Tile Room of the Zembo Temple, 2801 N. Third Street, Harrisburg, on Saturday, September 6, 10 AM to 9 PM, and on Sunday, September 7, 10 AM to 5 PM.

There will be mineral, gem lapidary, fossil, and carving exhibits; demonstrations by club members; and dealers who will display minerals, fossils, gemstones, and jewelry.

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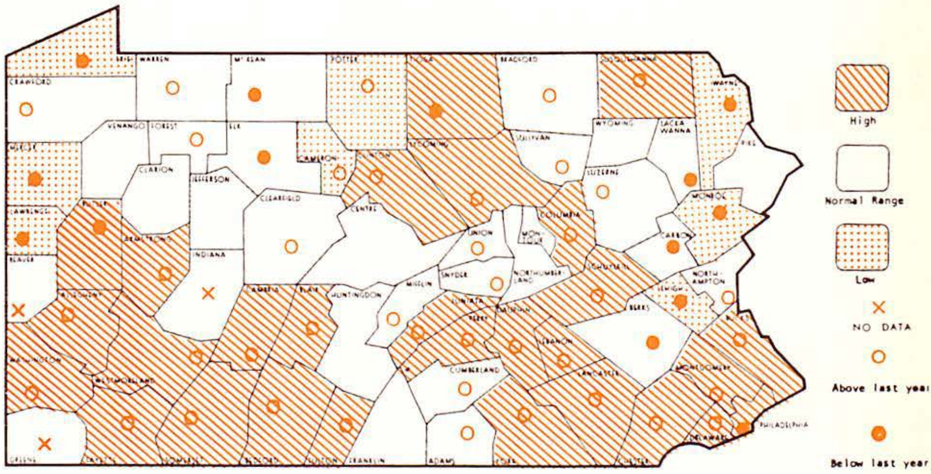
GROUND-WATER LEVELS

FOR

MAY 1980



Bureau of Topographic and Geologic Survey
Dept. of Environmental Resources
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Harrisburg, Pa. 17120

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