GEOLOGY PENNSYLVANIA

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 9/3

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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ON THE COVER: Typical Pike County bluestone (flagstone) prospect near Kimble: a small outcrop of planar-stratified sandstone.

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JUNE 1978

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

COMPETITION - FOR WORSE OR BETTER

We have grown up in an era in which we have been taught that competition is desirable, even essential, to sustain our economic way of life and to provide incentives for greater achievements as man (person) strives to outdo man (person).

Around our great Commonwealth, our bountiful nation, and amongst many countries of the world there is a form of competition going on which has tremendous impact on all our lives and particularly on the lives of future generations. It is the competition for the use of land.

Land use competition is fostered by various forces which differ from place to place, and vary in intensity with time. In one area the impetus is created by urban and suburban expansion. In another locale, growing or relocating industry is the active ingredient. Elsewhere it is the recognized need for agricultural acreage, for transportation facilities, for forestry tracts, or for mineral lands. Our environmental awakening has given primary status to the land needs for protecting our watersheds, sustaining wilderness areas and preserving natural and historical wonders.

This competition for land has resulted on many occasions in bitter and acrimonious struggles. Decisions are more often than not based on economic or political leverage. Emotion frequently wins the day, rather than analysis and reason. As many of these land competition conflicts go to court, victory is very likely to go to those who best know, or best can afford, the legal maneuvers.

Bases for decisions have been also determined by what is currently in vogue; in the past dams, highway corridors, levees, shopping centers were favored, often to the detriment of other considerations. Today, there are other favored land uses which receive preferential treatment, which is not necessarily well evaluated. Conversely, there are proposed uses which are categorically in disfavor, according to the temper of the times, regardless of how beneficial the proposed use might be.

We definitely need a sound procedure to deal effectively with the competition for land. It must be a procedure which evaluates all aspects of each problem area, both short range and long range. It must recognize and even quantify where possible, the competing needs and the multiple resources of the land area. It must consider such aspects as uniqueness and irreplaceability, and the needs of the ecosystem, not forgetting the needs of man himself. A system for resolving competition for land will have to develop broad and innovative perspectives, and will have to deal with concepts such as highest order of use, and wherever appropriate, multiple land use.

(Continued on page 11)

Arthur A. Socolow

Bluestone in Pike County, Pennsylvania

by W. D. Sevon

INTRODUCTION In 1886 the Kilgour Blue-Stone Company, Ltd., headquartered at Parkers Glen, Pike County, Pennsylvania (Figure 1), operated 23 bluestone quarries and employed 450 men (Mathews, 1886). The Kilgour stonemills at Parkers Glen operated 24 hours a day sawing, planing and polishing bluestone for all types of building purposes, particularly flagstone. The Kilgour Company was only one of several then active in Pike County.

As the 19th century ended, Portland cement began to replace natural stone as a construction material. A peak of bluestone production in 1912 was followed by rapid decline with only minimal production by 1932 (Stone, 1923; 1932). Now, in 1978, only one man in Pike County quarries bluestone on a part-time basis.

It is not known whether the bluestone industry will revive in Pike County, but an abundance of high-quality rock is available. The purpose of this paper is to discuss the attributes of these rocks and the potential for renewed production.

STRATIGRAPHY Quality bluestone in Pike County occurs in the lower part of the Catskill Formation and is restricted mainly to a unit originally named the Delaware River flags (White, 1882). Some bluestone was quarried from slightly lower and higher stratigraphic positions. Name changes were introduced by Willard and others (1939) and Fletcher and Woodrow (1970), but the interval remains as White defined it: a thick sequence of gray sandstones occurring above the first thin red beds of the Catskill, and below a thick sequence of red beds. White (1882) calculated this unit's thickness at 1430 feet. The stratigraphic terminology used in Figure 1 is that of Fletcher and Woodrow (1970) and Berg (1975).

FIELD OCCURRENCE Pike County bluestone is derived from the lower, planar-stratified part of three similar types of vertical sequence. *Sequence 1* comprises planar-stratified, gray sandstones grading upward into finer-grained, cross-stratified sandstones. The lowest cross-strata are generally very low-angle, tabular cross-strata. Successive sets of cross-strata have higher-angle, tabular or trough

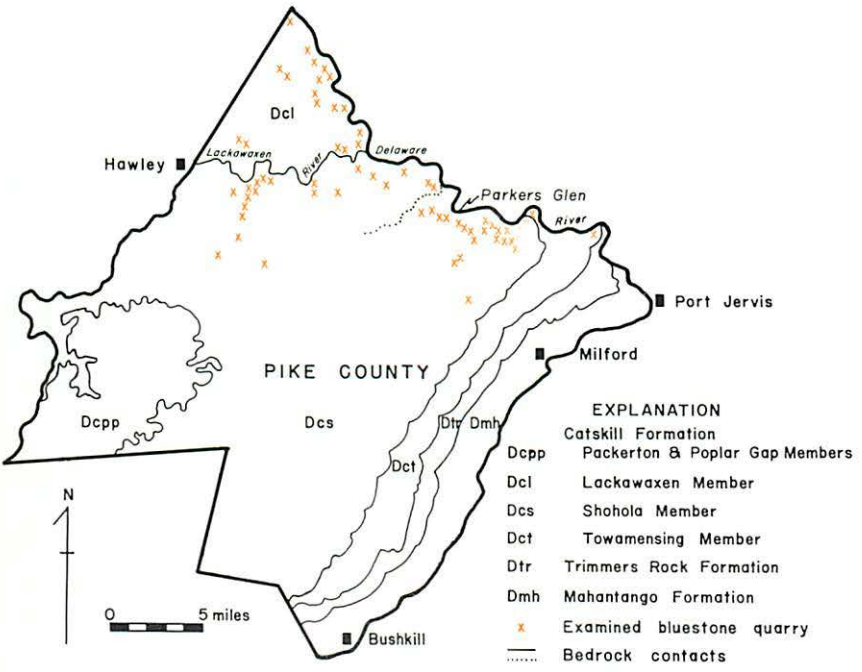

Fig. 1 Geologic map of Pike County, Pennsylvania.

cross-strata and erosional bases. Sandstones above disconformities are often coarser grained than the underlying sandstones. Poorly sorted calcareous breccias containing small dark-gray shale fragments and calcareous nodules, some rounded quartz pebbles and occasional plant fragments occur occasionally at the bases of cross-strata sets. In *Sequence 2,* the planar-stratified, gray sandstones are separated by a pronounced disconformity from overlying coarser grained, trough cross-stratified sandstones (Figure 2). In *Sequence 3,* planar-stratified, gray sandstones grade up into tabular or trough cross-stratified sandstones which in turn grade up into planar-stratified sandstones followed by red siltstones and claystones. *Sequences 1* and *2* occur with about equal frequency; *Sequence 3* is uncommon. The three sequences possess an apparently random vertical stacking.

The planar-stratified sandstones often appear structureless in fresh outcrop, but they possess distinct lamination with spacing of a few millimeters or less and sometimes barely detectable reactivation surfaces. Parting into flaggy pieces one or more centimeters thick occurs along these laminae. Some bedding surfaces display primary current lineation (ties) and parting-step lineation. Many surfaces contain abundant mica flakes and some surfaces show finely broken

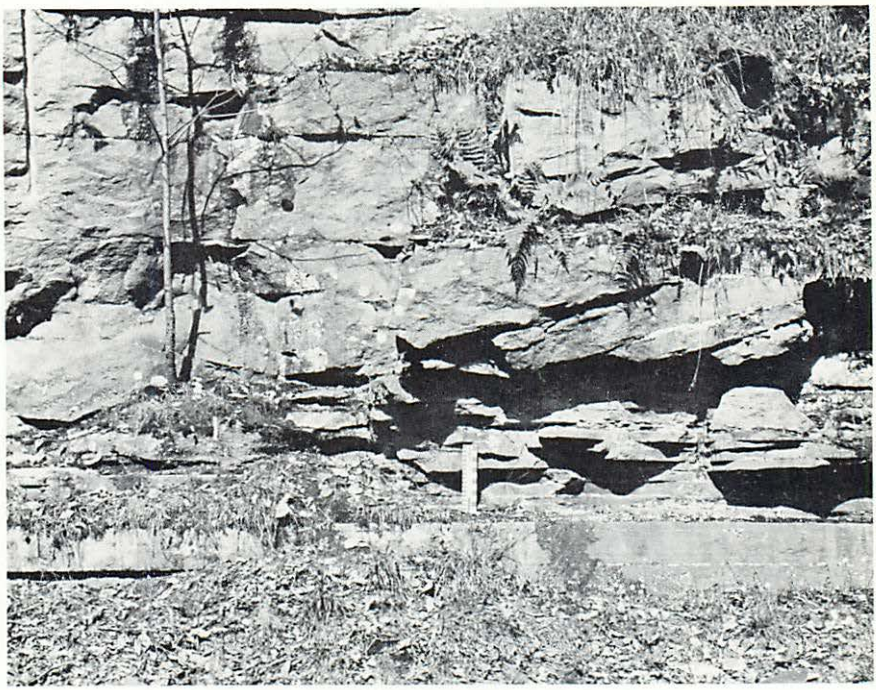

Fig. 2 Typical Sequence 2.

plant fragments. Ripple bedding is noticeably lacking in both the planar- and cross-stratified sandstones. These sequences are frequently less than 10 feet thick, but sometimes are up to 30 feet thick.

Some planar-stratified units appear to be continuous for several hundred feet parallel with the orientation of parting lineation. Continuity normal to parting lineation appears to be less, and the planar-strata are apparently replaced laterally by cross-strata. Cross-stratified sandstones are more abundant, but apparently have more limited lateral continuity than the planar-stratified units.

Pike County bluestone is a well-indurated, fine-grained (average grain size: 0.1 mm), medium-gray sandstone averaging 62 percent framework and 38 percent binder. The average sandstone comprises: 48 percent undulose quartz and 22 percent sericite-chlorite composite matrix; small percentages of silica overgrowth, microcrystalline silica cement, shale clasts, feldspar, coarse micas, chlorite matrix, calcite cement and metamorphic rock fragments; and traces of polycrystalline quartz, limonite cement, chert, stretched metaquartz, heavy minerals (mainly zircon) and siltstone

clasts. Binding is generally very good within individual laminae where silica cement is the main binder and poorer between laminae where sometimes sericite-chlorite matrix is the only binder. Grains are almost always angular and alignment of grain long axes parallel to lamination is common. Lamination is a function of variation in grain size, concentrations of heavy minerals or shale clasts, concentrations of mica, and variations in binding agents. Some chloritization of the clay matrix has occurred in all of the sandstones.

ORIGIN The various features of Pike County bluestone are best explained by deposition in a braided stream system. The planar stratification developed by sand deposition on longitudinal bars under upper flow regime conditions of floods. The thiner planar-stratified units may represent deposition during a single flood, but thicker units with reactivation surfaces between successive planar strata probably resulted from multiple depositional events. Trough cross-stratification is attributable to dune migration and tabular cross-stratification derives from downstream migration of sand waves and transverse bars. Continued aggradation combined with channel shifting and downstream migration of various bedforms resulted in considerable lateral and vertical variation within the bluestone interval. The few red siltstones and claystones were presumably deposited by flood waters in protected areas adjacent to the active braided stream. The input stream derived from an eastern source and entered into Pike County somewhere near Port Jervis, New York (Burtner, 1964).

ECONOMIC GEOLOGY Bluestone is a dense, hard, fine-grained, feldspathic sandstone which splits easily along bedding planes into smooth slabs of various thicknesses. These slabs are used for flagging, tread, veneer, coping, sill, wallstone, slab stock, hearthstones and mantles. The greatest use is for flagging (Mikutowicz and Schenck, 1970a). Although the market is not large, a continuing demand for good quality bluestone still exists, and Pike County formerly produced some of the best.

Commencing a quarry operation in Pike County at this time would be an economic venture of some uncertainty. Consideration should therefore be given to market adequacy, the competitive existence of a bluestone industry in nearby Susquehanna County (Mikutowicz and Schenck, 1970a; Krajewski and Williams, 1971) and some of the potential directions suggested for industry improvement in Susquehanna County (Mikutowicz and Schenck, 1970b).

The location of the bluestone quarries in Pike County (Figure 1) was originally influenced by (1) proximity to transportation facili-

ties along the Delaware and Lackawaxen Rivers and (2) the ease of locating quarryable rock on the outcrop-abundant steep slopes adjacent to these rivers (cover photo). Although sandstone suitable for quarrying exists to the southwest within the same stratigraphic unit, slopes are less steep, outcrops are less abundant and prospecting for suitable bluestone is more difficult.

Many of the 92 inactive quarries examined contain sufficient planar-stratified sandstone for additional quarrying and all of the quarries have large waste piles of rejected rock which has some potential as a source of crushed rock and random-sized flagging (Figure 3). Two problems are apparent in some of the larger quarries. First, because most of the quarries are located on hillsides and the bluestone is mined into the hillside, over-burden thickness increases and becomes a hinderance to profitable operation. Second, as quarrying proceeds into a hillside, the bluestone becomes fresher and can be split only into thicker and thicker pieces. This limits the use diversity and may have been a factor in closing some quarries. Because the ease with which bluestone splits parallel to its laminae is dependent on the degree of adhesion between laminae, the development of planes of splitting ease (rifts) apparently results from decreased adhesion caused by weathering and time-related pressure-

Fig. 3 Bluestone waste pile

release following removal of overburden. As quarrying proceeds and fresher rock is mined, the bluestone apparently splits only along the weakest planes (reeds) which represent significant changes in texture or mineralogy.

Joints, which aid quarrying and also limit stone size, are well developed in Pike County and generally have a spacing of 10 feet or more, although irregularly spaced and oriented joints (cutters) are not uncommon.

Excellent quality bluestone awaits future development in Pike County. Although quarrying bluestone involves much hand operation, new and improved cutting and drilling equipment can greatly assist quarry operation. Almost all of the existing quarries once had road access which could be reestablished with moderate ease. Knowledge of the relationship between parting lineation and continuity of planar-stratification should allow quarry development in the direction of greatest bluestone persistence.

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Field Conference Of Pennsylvania Geologists To Meet In Northeastern Pennsylvania

The 1978 Field Conference of Pennsylvania Geologists will meet in northeastern Pennsylvania to examine Upper Paleozoic rocks bearing uranium minerals. Headquarters for the conference will be in the Hazleton area with one day planned to visit outcrops along the Lehigh Valley and a second day planned to visit outcrops in the Beaver Lake area along the boundary of Lycoming and Sullivan counties. The Pennsylvania Geological Survey, The Pennsylvania State University, and industrial representatives will serve as hosts and guides to the various rock exposures. To receive the final announcement and registration form for the conference, write to the Field Conference of Pennsylvania Geologists, c/o Pennsylvania Geological Survey, P.O. Box 2357, Harrisburg, PA 17120.

The Story Of The Susquehanna River

Dr. Lee E. Boyer, lecturer Emeritus of Mathematics at Harrisburg Area Community College, as a lifetime student of Pennsylvania's natural history, has written a fascinating and informative report entitled, *"On the Susquehanna River: Its Evolution and its Antics"*. Dr. Boyer presents the river as one of those characters you are not likely to forget.

A limited number of copies of the 30 page booklet *"On the Susquehanna River: Its Evolution and its Antics"* are available for $2.00 (to cover publication and mailing) from Dr. Lee E. Boyer, 1508 Pelham Road, Harrisburg, PA 17110.

Nickeloan Pyroaurite Verified From The Cedar Hill Quarry, Lancaster County, Pennsylvania

by Robert B. Finkelman and Patricia A. Estep-Barnes

Davis M. Lapham (1965) suggested that a yellow-green powdery coating on serpentinite surfaces at the Cedar Hill Quarry in Lancaster County, Pennsylvania, might be a nickeliferous magnesium (carbonate?) hydroxide. He noted the similarity between the Cedar Hill mineral and pyroaurite [$Mg_6 Fe_2^{3+}(OH)_{16}CO_3 \cdot 4H_2O$], but, primarily because he observed no positive reaction for carbonate, concluded that the Cedar Hill mineral was an hydroxide, and was related to pyroaurite (Lapham and Geyer, 1972). Lapham (1965; personal communication, 1974) however, acknowledged that the fine-grained, impure nature of this material made identification difficult.

In the present effort to better characterize Lapham's mineral, the following samples were studied: Lapham's type material from the National Museum of Natural History (NMNH 120215); specimens of serpentinite with yellow-green to pistachio-green coatings collected (by RBF) at the Cedar Hill Quarry; samples supplied by

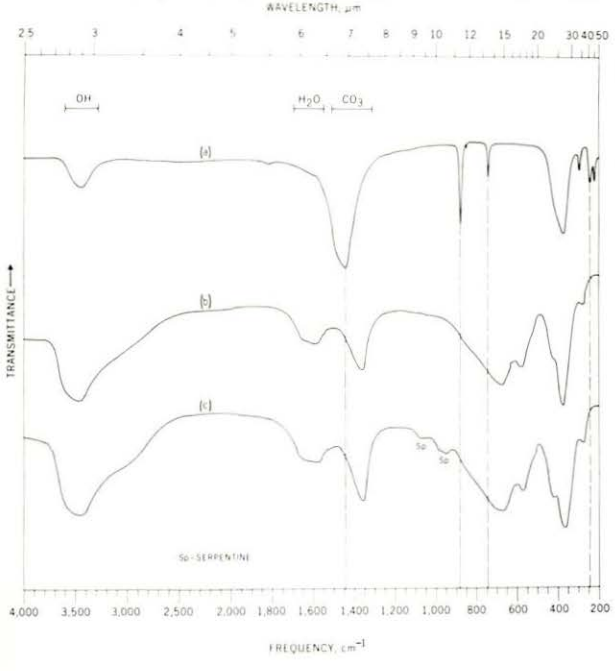

Fig. 1. A scanning electron photomicrograph of the nickeloan pyroaurite crystals from the Cedar Hill quarry.

the Pennsylvania Geological Survey, which may contain the original material studied by Lapham (destruction of the Survey headquarters in Harrisburg by the flood following tropical storm Agnes in 1972 makes verification difficult); a specimen from the quarry loaned by Martin L. Anné of Wrightsville, Pennsylvania, containing white to green, 1 mm diameter, hexagonal crystals (Fig. 1); nickeloan pyroaurite from San Benito County, California, (NMNH 121644) in which Ni^{2+} has replaced some Mg^{2+} in the pyroaurite structure; and pyroaurite from Sterling Hill, New Jersey, (NMNH R16652) and Långban, Sweden (NMNH 10688).

The optical properties and X-ray powder data for all the samples studied were virtually identical to those described by Lapham (1965) for the Cedar Hill mineral. However, microinfrared analysis (Estep and others, 1973) of Lapham's type material (NMNH 120215) gave a spectrum similar to that of pyroaurite (Figure 2). Strong absorption bands characteristic of a hydrated basic carbonate were present which clearly differentiate Lapham's mineral from the admixed simple carbonates such as dolomite and magnesite. Furthermore, the low-frequency absorption band (365 cm^{-1}) was intermediate between the corresponding bands for the Långban pryoaurite (370 cm^{-1}) and the California nickeloan pyroaurite (360 cm^{-1}), suggesting minor variations in cation substitution. This is consistent with the energy dispersive microprobe analysis which indicated a lower nickel content of the Cedar Hill material relative to the California nickeloan pyroaurite. In addition to variable amounts of nickel, all samples contain major magnesium and iron, and several had detectable silicon, probably due to admixed serpentine. As Lapham (1965) suggested, the darker green crystals appear to contain more nickel.

Lapham's conclusion that carbonate was not an essential constituent of the Cedar Hill mineral was based largely on the absence of effervescence in 1.0 normal hydrochloric acid (HCl). Although all of the samples examined in the course of this study dissolved in 1.0 normal HCl, effervescence was not always readily apparent. In concentrated HCl, however, all samples effervesced vigorously.

From the present study it is concluded that the pale green encrustations on serpentinites in the Cedar Hill Quarry are predominantly nickel-bearing pyroaurite, identical in every respect to the nickeloan pyroaurite described by Wilson and others (1976) from Scotland. The nickeliferous magnesium (carbonate?) hydroxide described by Lapham (1965) is, without question, nickeloan pyroaurite.

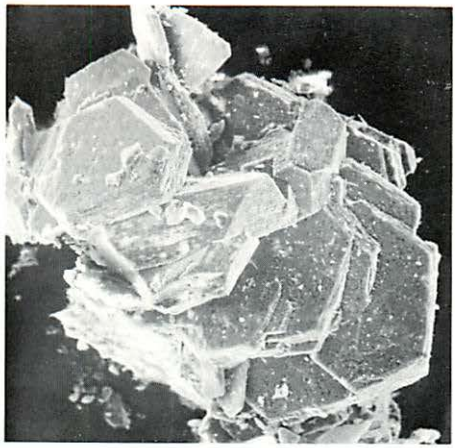

Fig. 2. Infrared spectra of (a) magnesite (San Bernadino Co., California) (b) pyroaurite (Sweden: NMNH 10688) (c) nickeloan pyroaurite (Pennsylvania: NMNH 120215)

Acknowledgments

The advice and encouragement of the late Davis M. Lapham was invaluable in this study.

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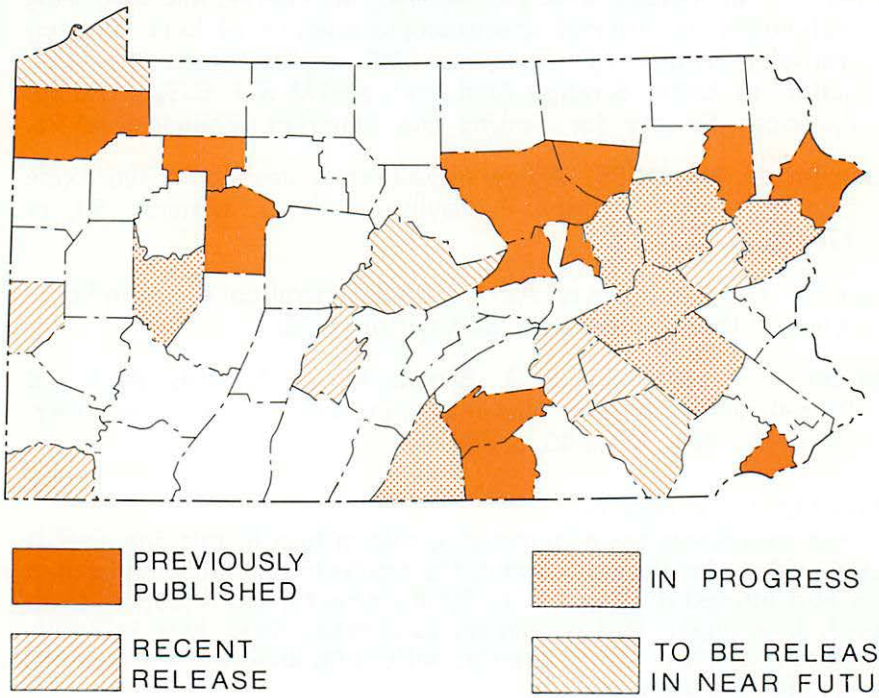
(Continued from page 1)

Past experience has demonstrated that at best in this one area of competition, for the use of land, the results have not always been in the best interest of mankind--or for the physical and biological earth itself. It is urgent that we get on to a better procedure, replacing emotion, leverage, and ignorance, with facts, analysis, and creative, long-range decisions.

U.S. GEOLOGICAL SURVEY ISSUES NEW COUNTY TOPOGRAPHIC MAPS

As a product of the cooperative county mapping program with the Pennsylvania Geological Survey, the U.S. Geological Survey has recently issued new topographic maps of Beaver, Blair, Carbon, Dauphin, Greene, and Lebanon counties. These new maps are at a scale of 1:50,000 (approximately 4000 feet to the inch) and follow the previously issued maps of Adams, Crawford, Cumberland, Delaware, Forest, Jefferson, Lackawanna, Lycoming, Montour, Pike, Sullivan, and Union counties. Soon to be released are maps of Centre, Erie, and Lancaster counties. These maps are multicolored, following the standard colors of topographic maps, with the addition of political boundaries for county, township and boroughs outlined in orange. These county maps are of widespread use to all who are concerned with county and regional planning, engineering, agricultural, and recreational projects. These maps may be obtained for $2.00 each by writing to Distribution Section, U.S. Geological Survey, 1200 S. Eads Street, Arlington, VA 22202.



SURVEY ANNOUNCEMENTS

CHANGE IN FIELD DIVISION LEADERSHIP

Dr. Samuel Root has resigned from the Pennsylvania Geological Survey to take on a position with the Exxon Corporation as a senior exploration geologist, to be based in Rio de Janeiro, Brazil. Sam Root was with the Pennsylvania Survey for 15 years, serving nearly the entire time as Chief of the Geologic Mapping Division. During that period the division achieved an outstanding record of geologic mapping and reports which are widely acclaimed for their professional qualities. Dr. Root himself established a national reputation for his work on Appalachian structural interpretations. The staff of the Pennsylvania Geological Survey extends best wishes to Sam Root.

Succeeding Sam Root as Chief of the Geologic Mapping Division is Thomas Berg. Tom joined the Pennsylvania Geological Survey in 1965 after receiving his B.A. and M.A. degrees in geology from the University of Colorado. He has worked on geologic mapping projects in a variety of geologic settings in Pennsylvania. These have included coal-bearing formations of western Pennsylvania and the Devonian-age formations of northeastern Pennsylvania, along with the glacial deposits of the region. Most recently Tom Berg has headed up the Survey team working on the compilation of a new state geologic map.

We are fortunate to have Tom Berg to take on the duties of Chief of the Geologic Mapping Division. Basic geologic mapping continues to be the foundation upon which all other geologic interpretations and applied aspects are dependent. The Pennsylvania Geological Survey aims to carry on with its assigned task of systematically mapping the geology of Pennsylvania in detail.

PENNSYLVANIA SURVEY'S BEST SELLERS FOR 1977

"Mineral Collecting in Pennsylvania", Pennsylvania Geological Survey Bulletin G-33, was the top seller, with report G-40, "Fossil Collecting in Pennsylvania", a close second. Information on caves was very popular with reports G-67, G-66, and G-65 constituting our third, fourth, and seventh most popular reports. Interest in bituminous coal continues high with our report M-6, Part 1, M-6, Part 2, and M-68 in the top ten sellers. Oil and gas developments

were also of interest with our report PR-189 in fifth place. York County and Fayette County geology and mineral resources were also of interest, as was the general geology report of the Pittsburgh area, our report G-59. The most popular map continues to be Map 1, Geologic Map of Pennsylvania; number two was the map of the coal fields of Pennsylvania, our Map 2. All cost publications issued by the Pennsylvania Geological Survey are sold through the State Book Store, P.O. Box 1365, Harrisburg, PA 17125.

MONROE COUNTY LOCALITY CLOSED TO FOSSIL COLLECTORS

The *Pocono Record* of Stroudsburg recently reported that the "CENTERFIELD CORAL REEF" locality on Pa. Route 191 has been removed from public access by its owners, the Pinebrook Junior College. Large "private property" and "no trespass" signs were painted on the rock face.

This locality is one of the most prolific and famous localities of Devonian corals of many genera and species. Several scientific research articles have been written on the fossils from this locality.

This fossil occurrence was listed as Locality 43 in the book, "Fossil Collecting in Pennsylvania", Bulletin G-40 of the Pennsylvania Geological Survey. Future editions of this booklet will include other localities in Monroe County suitable for fossil collectors, now that the "Centerfield Coral Reef" locality is no longer accessible to interested collectors.

MAPS OF THE DEVONIAN ORGANIC RICH SHALES AND SANDSTONES IN THE SUBSURFACE OF WESTERN PENNSYLVANIA ARE OPEN FILED

The Bureau of Topographic and Geologic Survey, in cooperation with the U. S. Department of Energy (contract EY-76-S-05-5198), is investigating regional geologic and stratigraphic information on the Middle and Upper Devonian clastic rocks in the subsurface of western Pennsylvania. This study is a portion of the resource characterization phase of the Eastern Gas Shale Project with emphasis placed on the stratigraphy and regional geology of the Devonian organic rich black shales. With permission of the D.O.E., we are placing on open file nine stratigraphic cross sections which indicate the major black shale units and sandstones in the Middle and Upper Devonian, as well as a series of three maps at a scale of 1:250,000 which will show: (1) all wells which penetrate the Middle Devonian Onondaga Lime-

stone and indicate which of these have gas shows or gas production from the Devonian black shales; (2) a contoured Drilling Depth Map to the top of the Onondaga Limestone; and (3) a Structure Contour Map on the top of the Onondaga Limestone. In addition, a series of maps at a scale of 1:1,000,000 will show the distribution and thickness of the major black shale units and sandstones defined on the stratigraphic cross sections mentioned previously.

At this time, four of the nine stratigraphic cross sections, the Onondaga Penetration and Devonian shale gas show map at a scale of 1:250,000, and the Drilling Depth Map to the top of the Onondaga Limestone at a scale of 1:250,000, are available. The remaining cross sections and maps will be available when completed.

This material is available for examination at the offices listed below and copies of the maps and cross sections will be made available at the expense of the requestor. Pennsylvania Geological Survey, 1201 Kossman Building, 100 Forbes Avenue, Pittsburgh, PA 15222; Morgantown Energy Research Center, U.S. Department of Energy, Eastern Gas Shale Prcject, P.O. Box 880, Morgantown, W.VA 26505.

Coal-The Burning Question

by Jeanne Sonntag

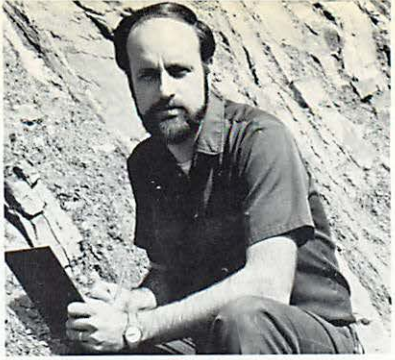
The League of Women Voters of Pennsylvania using a grant made by Pennsylvania Power and Light Company to the League of Women Voters Education Fund has recently published a twenty-page booklet entitled, "Coal—The Burning Question".

The slim publication offers an unbiased and comprehensive citizen's view of the Pennsylvania coal industry. It discusses the impact of such considerations as economics, transportation, research and development, the environment, unions, and health and safety on the coal industry. The booklet also contains tables on methods of removing sulfur from coal, new technologies for coal use and combustion as well as a list of publications for further reading.

The twelve-month study was conducted by thirteen volunteer League members from all parts of the Commonwealth and a small staff based in Harrisburg. The group, called PACT, Pennsylvanians Assess Coal Today, was divided into a western task force to study the bituminous industry and an eastern group to concentrate on anthracite mining. The PACT teams visited universities, coal research facilities, reclamation areas, strip mines and deep mining operations. Extensive interviews were held and contacts made with mine owners and operators, unions, mining engineers, miners, and government representatives.

The free publication may be obtained by writing to League of Women Voters of Pennsylvania, 215 Pine Street, Harrisburg, PA 17101.

Meet The Staff . . .



Thomas M. Berg, Chief
Geologic Mapping Division

Thomas M. Berg joined the Pennsylvania Survey in 1965. Tom has been a member of the Geologic Mapping Division since then, and has completed several Atlas Reports involving detailed geologic mapping in west-central and northeastern Pennsylvania. In addition to his mapping work in the coal-bearing rocks of the western part of the state, Tom participated in the early organization of the Survey's ongoing bituminous coal sampling program. In 1970, he began detailed mapping in Carbon, Monroe, and Pike Counties. This work involved deciphering Middle and Upper Devonian strata, as well as glacial and periglacial deposits.

In 1975, Tom was promoted to the position of senior research geologist, and was assigned the job of coordinating the compilation of a new state geologic map, the fifth such map assembled since 1858. The state map project is now nearing completion.

On April 24, 1978, Tom was appointed to the position of Chief of the Geologic Mapping Division. His responsibilities include planning, supervising, and coordinating basic geologic mapping projects by staff geologists throughout the Commonwealth, as well as steering the activities of the geologists assigned to bituminous coal studies. In addition to his duties as a division chief, Tom continues to oversee the Survey's fossil collection, and answers questions of a paleontological nature.

Tom was born in Vermillion, South Dakota, and obtained his B.A. and M.S. degrees in geology from the University of Colorado in Boulder, Colorado. He spent a large part of his youth in the Washington, D.C. area, and did part of his undergraduate work at Johns Hopkins University in Baltimore. He is a member of the Harrisburg Area Geological Society, the Society of Economic Paleontologists and Mineralogists, and the International Paleontological Association.

Tom, his wife Betty, and their five children reside in Dauphin, Pennsylvania, just north of Harrisburg. He is quite active in his church at Dauphin, where he serves on the executive board and is coordinator of religious education. In addition to his normal family activities, one of Tom's favorite pastimes is a visit to the shore, where he can observe and marvel at the marine invertebrates that live and function in so many similar ways as did the fossils that he finds in Pennsylvania's rocks.

PENNSYLVANIA GEOLOGICAL SURVEY STAFF

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Donald M. Hoskins, *Assistant State Geologist*

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Christine Miles, *Geological Editor*
Virginia Milewski, *Draftsman*
Mary A. Miller, *Stenographer*
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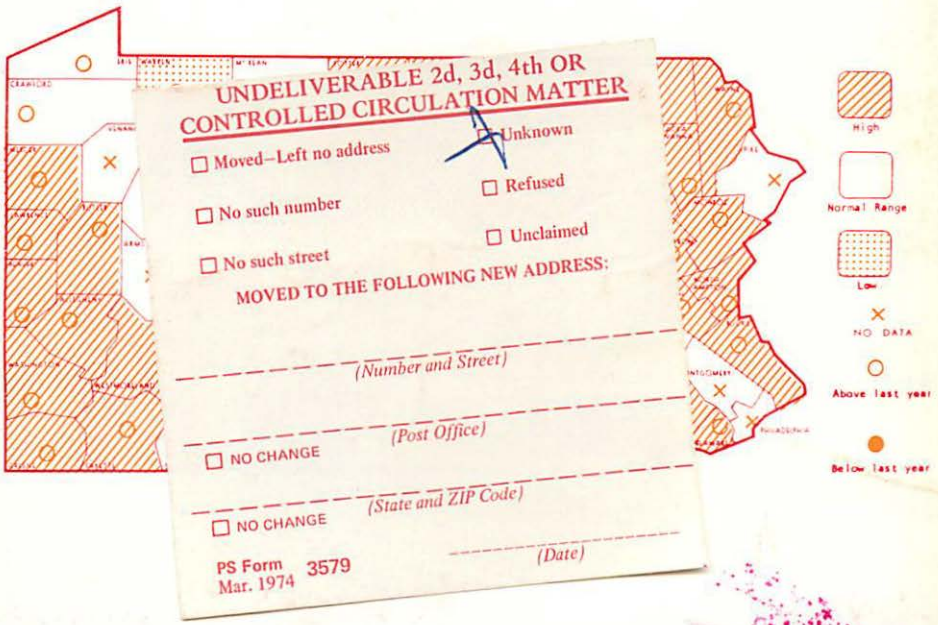
TOPOGRAPHIC DIVISION

In Cooperation with The U.S. Geological Survey

GROUND WATER DIVISION

In Cooperation with The U.S. Geological Survey

GROUND-WATER LEVELS
FOR
MAY 1978



BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
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