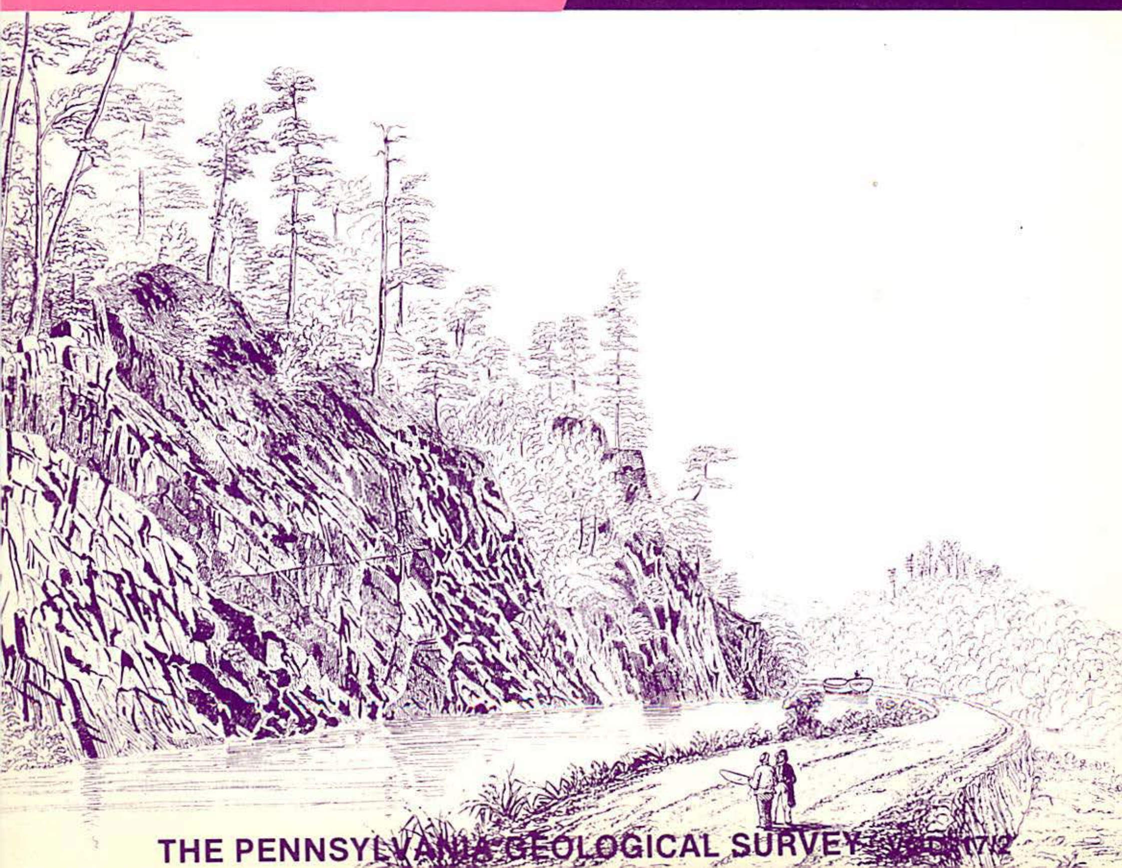
PENNSYLVANIA GEOLOGY

PENNSYLVANIA GEOLOGICAL SURVEY
150TH ANNIVERSARY
1836 - 1986



THE PENNSYLVANIA GEOLOGICAL SURVEY 17/2

COMMONWEALTH OF PENNSYLVANIA
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OFFICE OF RESOURCES MANAGEMENT
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TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

CONTENTS

ON THE COVER: Reproduction of copper plate lithograph of sandstones exposed along the Juniata Canal at Stone Ridge, Huntingdon County, sketched by George Lehman, an artist employed by Henry D. Rogers in the 1840's to illustrate *The Geology of Pennsylvania, a Government Survey,* published in Philadelphia, Pa. in 1858.

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Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

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FROM THE DESK OF THE STATE GEOLOGIST

OUR SURVEY, PAST AND PRESENT

As we proceed through 1986, our sesquicentennial Anniversary, it is appropriate to reflect on the accomplishments and the changes which have taken place in the Pennsylvania Geological Survey over the past 150 years.

It is especially appropriate that we recognize the tremendous geologic achievements of the First and Second Pennsylvania Geological Surveys which spanned the era from 1836 to 1895. Moving about by horse and on foot, and without the benefit of the topographic maps and air photo coverage we take for granted today, the Survey geologists of the last century mapped and reported with skill and detail essentially every sector of the Commonwealth. Under Henry Darwin Rogers and J. Peter Lesley, the geologic staff identified the stratigraphic sequence and complex structural framework which characterizes Pennsylvania's geology. Careful attention was paid as well to recording the economic aspects of geology, the array of mineral resources which by the 1880's were being tapped by hundreds of metallic and non-metallic mines across the state.

The Third Pennsylvania Survey in its brief history between 1899-1919, focused heavily upon the needs of the active mineral industry in the Commonwealth, cooperated in the preparation of quadrangle topographic maps, and also made some additional contributions to the geologic framework of Pennsylvania.

The Pennsylvania Geological Survey today, re-established in 1919 as the Fourth Survey, has moved forward on the foundation provided by our predecessors of the last century. Working in great detail on an area-by-area basis, and with the aid of modern lab techniques, the stratigraphy has been greatly refined and subdivided. Detailed air photos, topographic maps, and re-examination of field data in the light of contemporary structural concepts have enabled our Fourth Survey geologists to redefine the structural framework and genetic history of the multiple deformations of Pennsylvania's rock formations. Sophisticated, modern equipment in the field and lab have enabled our economic geologists to define the nature of our known mineral resources and to locate new resources needed for our ever-consuming mineral industry.

Our Survey continues to function in recognition that the science of geology, like all sciences, is ever-progressing, with increasing ability to serve the needs of Pennsylvania, needs which themselves are ever-changing.

Arthur A. Socolow

A Sesquicentennial Story*

MOUNT ETNA IRON FURNACE PLANTATION, BLAIR COUNTY

by Jon D. Inners
Pennsylvania Geological Survey

In 1836, the inaugural year of the First Pennsylvania Geological Survey, J. F. Frazer conducted a traverse along Yellow Creek, Bedford County, from the Broad Top Coal Basin to the south end of Morrison's Cove. Not only did this investigation establish the bedrock succession of central Pennsylvania (Hoskins, 1986), but it also confirmed the general stratigraphic position of one of the Commonwealth's great historic mineral resources—the "brown hematite" (iron) ores of "Formation No. II" (the Cambro-Ordovician carbonates of modern usage). At the time of Frazer's geologic studies on Yellow Creek, the charcoal iron industry was entering the era of its greatest prosperity. Growing population and a better transportation network led to expanded markets, and the introduction of "hot-blast" technology greatly increased the efficiency of the iron furnaces. Approximately 25 miles north of Yellow Creek, a remarkably complete but unrestored example of one of the many "iron plantations" that flourished in the Morrison's Cove area during the 1830's is preserved at Mount Etna in Canoe Valley (Figure 1).

The Mount Etna ironworks was the first within what is now Blair County. In 1807, John Canan, David Stewart, and William (?)Moore commenced building an iron furnace and forge on land bordering Roaring Run and the Frankstown Branch of the Juniata River in Catharine Township. The furnace (Figure 2) was "blown-in" in 1809 and continued to operate intermittently for the next 68 years, despite frequent changes of ownership. (The furnace and plantation were named for the figurative resemblance of the fire-belching furnace to a volcano, specifically Mount Etna on the Mediterranean island of Sicily). Mount Etna plantation experienced its halcyon days between 1830 and 1865, first under the proprietorship of Henry S. Spang and then of Samuel Isett. Many of the auxiliary structures still standing—including the mansion house, workers' apartments (Figure 3), office-store, and manager's house—were built by Spang in the 1830's and 1840's (Sweetnam and Smith, 1976). In this period at least 130 men were employed as founders, casters, miners, colliers, woodcutters, farmers, blacksmiths, and laborers on the plantation (Blair County Historical Society, 1961). Considering that many of these workers

*Celebrating 150 years of The Pennsylvania Geological Survey—1836 to 1986.

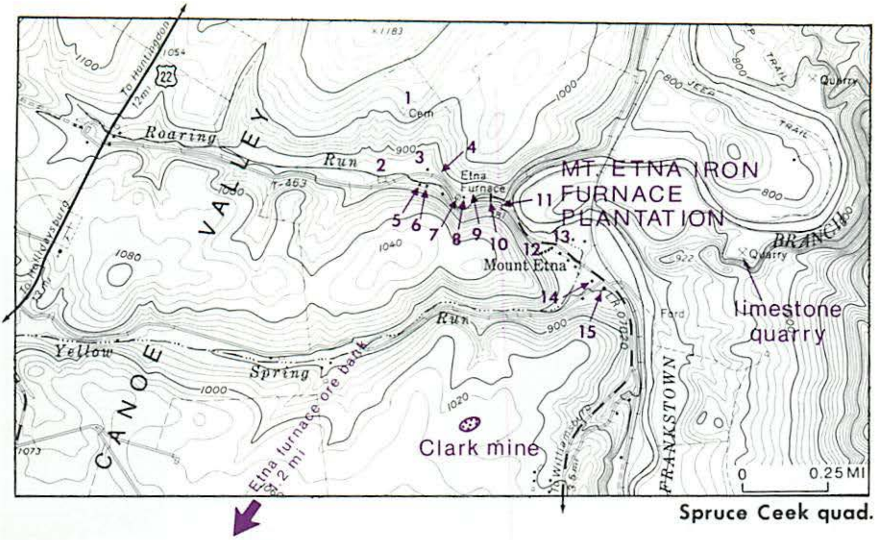

Figure 1. Map of Mount Etna iron furnace plantation, showing location of important buildings, ruins, quarries, ore pits, etc. Key: 1 = childrens' cemetery; 2 = stone barn; 3 = workers' apartments; 4 = blacksmith's shop (ruins); 5 = office-store; 6 = manager's house; 7 = furnace stack; 8 = tender's shack (remodeled); 9 = charcoal house (ruins); 10 = mill dam; 11 = site of grist mill; 12 = site of school; 13 = workers' cabins; 14 = approximate site of forge; 15 = mansion; 16 = church.

had families who lived on the premises, the population of Mount Etna must have been several hundred people. Under Isett, the ironworks apparently prospered during the Civil War, but the enterprise foundered soon afterward. Faced with insurmountable financial difficulties brought on by stiff competition from the rapidly expanding iron and steel industry in Pittsburgh, Isett allowed the furnace to go out of blast in 1877.

The four requisites for the manufacture of iron—iron ore, limestone, fuel, and power—were all in plentiful supply at Mount Etna. Iron ore was obtained from several pits (not all of which are indicated on Figure 1) within three miles of the works. Most of this ore was a mixture of limonite ($FeO{\cdot}OH{\cdot}nH_2O$) and goethite ($FeO{\cdot}OH$) ("brown hematite") that occurred in stalactitic, mammillary, and botryoidal masses in variegated clays weathered from the limestones and dolomites of "Formation No. II." By far the greatest amounts of ore came from "banks" in the Upper Cambrian Gatesburg Formation on the "Barrens" north of Williamsburg. Limestone, needed to flux the impurities in the ore, was secured from a large quarry in the upper part of "Formation No. II" (mainly Middle to Upper Ordovician

Figure 2. Etna furnace stack as it appeared in the spring of 1985. The large work arch, which opened into the casting shed, collapsed in 1975. At the right is the tuyere arch. A high stone wall forms the edge of the charging terrace. Like most remaining structures at Mount Etna, the furnace and terrace walls are constructed of dolomite from the Lower Ordovician Nittany Formation.

Figure 3. Workers' apartments (the "twelve-windowed house" built by Henry S. Spang) and ruins of blacksmith's shop.

carbonates of the Bellefonte, Loysburg, and Hatter Formations) 0.9 mile east of the furnace. The hardwood forests that clothed the hills surrounding the iron works supplied the vast quantities of charcoal fuel necessary to feed the insatiable fires of the blast furnace. Power to run the blast machinery was provided by a large water wheel (Figure 4) situated to take advantage of an abrupt increase in stream gradient (to 200 feet per mile) about 0.25 mile above the mouth of Roaring Run.

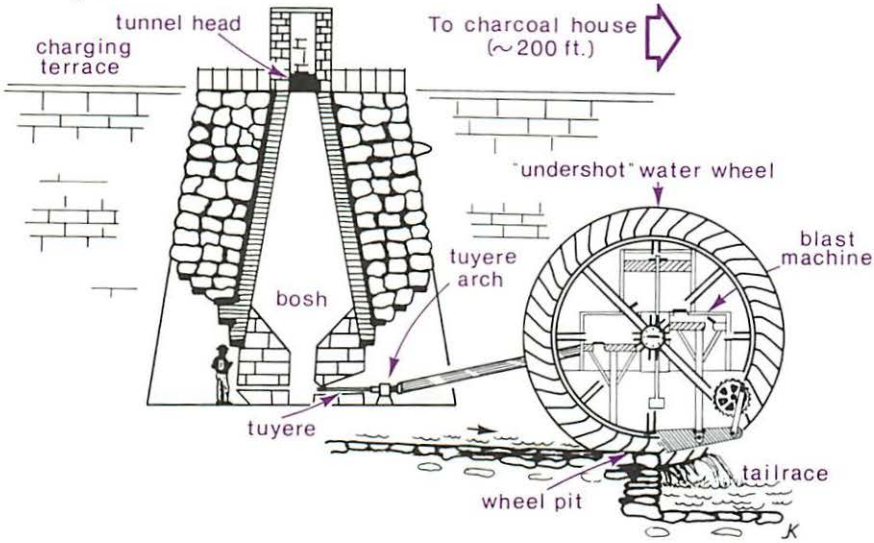

Figure 4. Generalized (and very hypothetical) drawing of Etna furnace as it may have appeared in its early "cold-blast charcoal" period. The furnace was probably converted to "hot-blast" by Spang in the 1840's. Lesley (1859) reported that Etna furnace was 31 feet high and had an 8-foot bosh.

According to Platt (1881), Etna furnace made an excellent cast iron, relatively low in both phosphorus (less than 0.30 percent) and sulfur (less than 0.01 percent). During the decades of its greatest productivity (1830 to 1870), the furnace was capable of producing more than 1000 tons of pig (cast) iron annually (Lesley, 1859). Most of this was used at the forge to manufacture approximately 600 tons of wrought iron in peak years (Blair County Historical Society, 1961).

Mount Etna iron furnace plantation is most easily reached from U.S. Route 22 (see Figure 1). Turn east onto Township Route 463 at the historical marker 1.4 miles southwest of the Blair-Huntingdon County line and proceed 0.9 mile to the first cluster of stone buildings, including the stone barn, workers' apartments, and furnace stack. Approximately 0.3 mile farther east, turn south on L.R. 07020 and continue another 0.2 mile to the second grouping of buildings containing the workers' cabins, mansion, and church. Please bear in mind that all land encompassing the old plantation is *PRIVATE PROPERTY*. Permission to explore the grounds north of Roaring Run can be obtained from the current inhabitants at the "twelve-windowed house." The furnace stack itself is owned by the Blair County Historical Society. Trespassing on the land south of Roaring Run and on the properties near the Juniata River is not permitted.

The author thanks William I. Richardson, Williamsburg R.D. #1, for his invaluable assistance in preparing this article.

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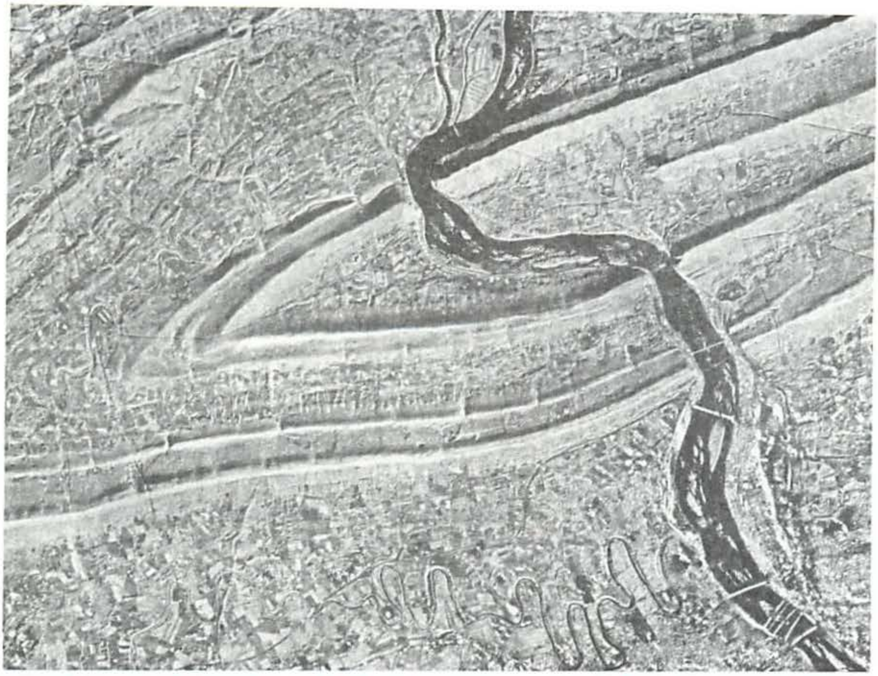
RADAR IMAGE MOSAIC OF CENTRAL PENNSYLVANIA SHOWS FOLDED APPALACHIANS

The folds of the Appalachian Mountains in a portion of central Pennsylvania are vividly depicted in a side-looking airborne radar (SLAR) image mosaic published by the U.S. Geological Survey.

The 1:250,000-scale (one inch represents about four miles) mosaic of the Harrisburg quadrangle is one of several experimental SLAR-image products recently produced as examples of the data acquired under the U.S. Geological Survey's SLAR program. SLAR data of about 527,000 square miles within the counterminous United States and Alaska are now available for purchase.

The mosaic clearly depicts the parallel ridges and valleys characteristic of the extensively folded Appalachian Mountains in Pennsylvania. The Susquehanna River and its many tributaries clearly show up on the SLAR mosaic.



South-central portion of the Harrisburg, PA, Radar Image Map, showing northeast-southwest trending parallel mountains and valleys characteristic of the folded Appalachians in Pennsylvania. The Susquehanna River bisects the image, and is joined on its west bank by the Juniata River near the top of the image. Harrisburg is on the east bank of the river south of the mountains.

The mosaic depicts all of Dauphin, Juniata, Lebanon, Mifflin, Perry and Snyder counties, as well as parts of Adams, Berks, Centre, Clinton, Columbia, Cumberland, Franklin, Fulton, Huntingdon, Lancaster, Luzerne, Montour, Northumberland, Schuylkill, Union and York counties.

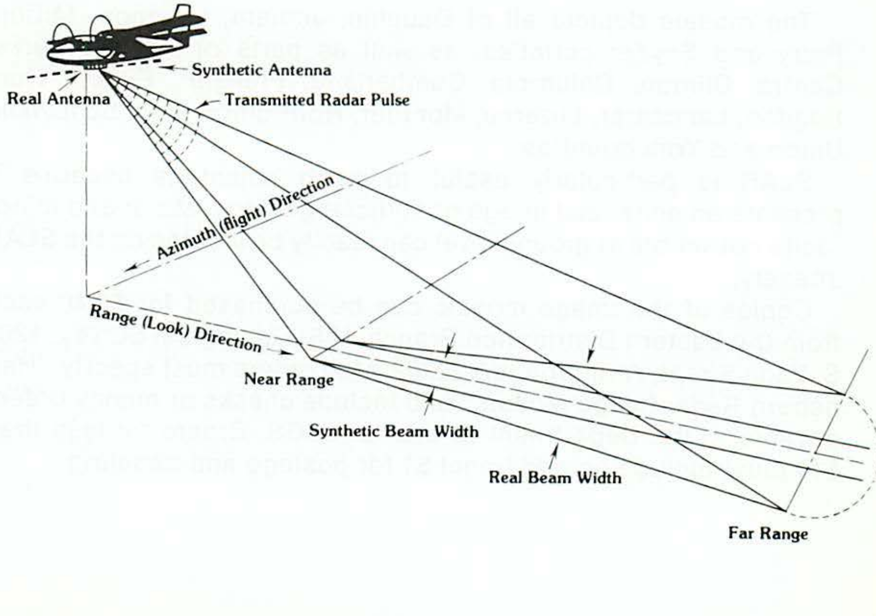
SLAR is particularly useful to earth scientists because it presents an enhanced image of surficial geology. Major and minor faults not visible at ground level can readily be located on the SLAR imagery.

Copies of the image mosaic can be purchased for $2.40 each from the Eastern Distribution Branch, U.S. Geological Survey, 1200 S. Eads Street, Arlington, VA 22202. Mail orders must specify "Harrisburg Radar Image Mosaic" and include checks or money orders payable to the Department of Interior-USGS. Orders for less than $10 must include an additional $1 for postage and handling.

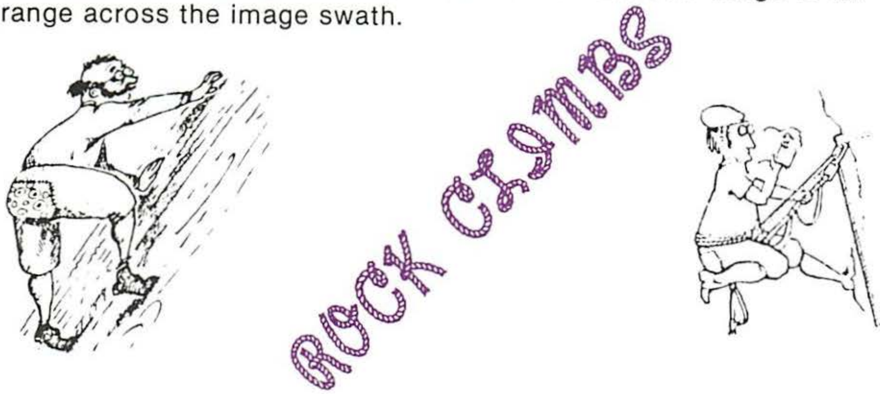
Principles of Slar Imaging

Side-looking Airborne Radar (SLAR) is an image-producing system that derives its name from the fact that the radar beam is transmitted perpendicular to the side of the aircraft acquiring the data. Microwave energy reflected from the terrain is recorded on holographic film, photographic film, or on magnetic tape.

SLAR system geometry defines "azimuth direction" (along-track) as parallel to the flight path, and "range direction" (cross-track) as perpendicular to the flight path. Radar imagery is referred to as near-range (that half of the image swath closest to the flight path) and far-range (that half of the image swath farthest from the flight path). The radar beam is transmitted at a depression angle from the horizontal which becomes shallower from near range to far range across the image swarth. This changing depression angle results in features in the near-range portion of the image having shorter radar shadows than features of equal elevation in the far-range portion. Radar shadows occur where there is no return of microwave energy, for example, where the backslope of a terrain feature is obscured from the radar beam. The Harrisburg radar mosaic was prepared using only the near-range portions of the image swaths where radar shadows are shorter and less terrain detail is obscured. The look direction of a radar image refers to the direction to which the radar beam is transmitted. Both the look direction (or directions) and range of depression angles are chosen to enhance structural detail..



Synthetic-aperture systems improve azimuthal resolution over real-aperture systems by using sophisticated reception and information processing techniques. The special signal processing simulates the reception of a narrow radar beam of uniform width so that azimuthal resolution remains constant from near range to far range across the image swath.



When rock climbers see a rock outcropping they look for routes to take them from the ground to the top. And they are not looking for the easiest route—often the preferred climb is the one with the most difficulty and the most challenge.

"Climb Pennsylvania", edited by Curt Harler, and published by LaSiesta Press of Glendale, California is a guide to the rock climbing areas of the state. The book discusses 38 rock climbing areas in the Commonwealth, as well as several bouldering areas, and offers a list of possible ice climbing sites.

Each climbing area includes a description of the type of climbing available, a brief geological identification, a listing of the more obvious routes and their climbing grade, and specific directions to the climbing area.

The geological information was drawn largely from material in print from the Pennsylvania Geological Survey, which is acknowledged by the editor.

The book is of interest to anyone who is involved in rock climbing, or to anyone who needs to find such exotic rock formations as A Champ's Chimney, Zombie, White Line Fever, or Poison Ivy. It is available at local outdoors shops for $2.50, from the publisher, or for $3.00 including cost of postage and handling, from the Pennsylvania Mountaineering Association, P. O. Box 4490, Harrisburg, Pa. 17111.

Caution is advised that rock climbing is a sport that requires training and experience. This book mentions sources of instruction and guidance in equipment for those interested.

Limestone Production In Pennsylvania's Allegheny Plateau

ALLEGHENY MINERAL CORPORATION

Allegheny Mineral Corporation (AMC), a subsidiary of the Snyder Associated Companies, Inc., of Kittanning, Pennsylvania, operates two limestone-stripping quarries in Butler County and one in Armstrong County. Combined, these three operations mine in excess of 1 million tons of Pennsylvanian-age Vanport Limestone annually. AMC got it's start in the late 1950's as a quality high-calcium (90% $CaCO_3$) limestone producer. In addition to limestone production, other Snyder Associated companies dredge and mine sand and gravel in the Allegheny River drainage (Glacial Sand & Gravel Company) as well as produce fuels such as coal and gas (C. H. Snyder Company).

GEOLOGY AND MINING. AMC's largest and most diversified limestone operation is located about 1 mile NE of Harrisville, in Butler County. This facility was developed in 1958 and produces construction aggregate, agricultural limestone, and coal-mine rock dust, with a cumulative annual production of about 500,000 tons. Here, horizontal layers of Vanport Limestone occur; typically the Vanport is about 15 feet thick and consists of an olive-gray carbonate-mudstone containing occasional calcite "eyes" which may be related to minor marine fossil replacements. Some thin shaly partings, especially near the top of the limestone sequence, can be seen in the production faces. Typical bedding thicknesses range from 1 to 2 feet in most 14- to 16-foot-high faces. O'Neill (1964) reported a chemical analysis of 94.5% $CaCO_3$, 0.5% $MgCO_3$, 3.1% SiO_2, 0.5% $A1_2O_3$, and 0.5% Fe_2O_3 from a washed stockpile sample at this operation.

Bergenback (1964) postulated that the Vanport was deposited in a shallow ($<$40 feet) transgressive marine environment contiguous with, and related to, a deltaic environment of deposition (complete with coal swamps) about 315 million years ago. He also attributed much of the carbonate to a biochemical origin, such as an algal ooze.

Mining limestone within the Appalachian Plateaus Physiographic Province of western Pennsylvania (Figure 1) contrasts significantly with mining limestone in the Valley and Ridge or the Piedmont Physiographic Provinces of central and eastern Pennsylvania. Mining here requires sequential strip-mining cuts about

Figure 1. Partial view of a typical 1400-foot-long stripping cut at AMC's Harrisville operation. Face in the foreground is Vanport Limestone. Fifteen-cubic-yard dragline in the background is casting overburden.

4000 feet long, 100 feet wide (at depth), and about 100 feet deep (to the base of the Vanport). Annual production rates typically require mining 10 to 12 acres per year. (In the Valley and Ridge or Piedmont Physiographic Provinces, obtaining the same production from a 100-foot face would require mining less than 2 acres per year). Nevertheless, AMC's approximately 1500-acre site contains vast reserves.

Topsoil is removed with pans (earthmovers) and stockpiled for later reclamation. Overburden, with thicknesses typically ranging from 80 to 100 feet, is removed year-round with a 15-cubic-yard dragline. And the carbonate producers in central and eastern Pennsylvania think they have overburden problems! Stripping is initiated near the middle of the cut and worked in opposite directions, so that two working faces can be developed and to ease limestone haulage to the plant. Limestone production is generally limited to mid-March through mid-December. An 8- to 10-inch-thick coal (Lower Kittanning) occurs above the Vanport, and is selectively mined and stockpiled with a "Gradall" during winter months. This same machine is used to clean the top surface of the limestone in warmer seasons.

Limestone is transported to the plant by two 50-ton haul trucks and dumped into a 42 inch by 48 inch primary jaw crusher. Oversized material is reduced here with a hydralic ram, and product is con-

Figure 2.Multiple production face at the newly openned Worthington operation. Tracks in the foreground are near the top of the Clarion coal (1). Lowermost face in the pit floor is the Clarion coal (2). Massive light-colored rock in the face on the right is the Vanport Limestone (3). The base of the Lower Kittanning coal marks the top of the cut on the right (4).

veyed to a surge pile. Products, except quarry-run and rip-rap, are further washed and sized in a series of cone crushers, log washers, and screens. Various finished products are stored in bins from which they are transferred by truck to the appropriate stockpile. Year-round production of agricultural limestone and coal-mine rock dust (sprayed on the workings of underground coal mines to reduce combustion) is by a separate milling circuit. Here, two roller mills and an air classification system produce a finely ground product with a minimum of 70% passing through a 200-mesh sieve. These products are available in bulk and in 50-lb. bags.

A similar operation of the company, developed in 1974 and of approximately the same size (about 400,000 tons annually), is located about 1 mile SW of Slippery Rock, Pennsylvania, also in Butler County. The only significant difference between the operations is that no finely ground products are manufactured at Slippery Rock, which is the major rip-rap source for AMC.

About 1 mile west of Worthington, Pennsylvania, in Armstrong County, an additional, smaller operation was developed by AMC in

1985 primarily to supply raw limestone for clinker and mortar production to Armstrong Cement and Supply Corporation in nearby Cabot, Pennsylvania. At this operation, about 150 feet of overburden will be stripped to recover about 15 feet of Vanport Limestone. This additional overburden stripping cost is partial offset by the recovery of the superjacent Middle and Lower Kittanning coals and the subjacent Clarion coal (Figure 2). No plant or crushing facilities have been developed at this site. Keeping all this production in synchronization is a tribute to the skills of the mining and engineering department of AMC.

MARKETING. In general, construction aggregate from these operations is restricted to a 30-mile radius from the plants at Harrisville and Slippery Rock. Agricultural limestone typically has a 30-to 40-mile sales radius from the Harrisville plant, whereas coal-mine rock dust can travel up to a 90-mile radius from here. Rip-rap from the Slippery Rock operation has been sent as far as Erie, Pennsylvania.

We wish to than Mark A. Snyder and Mike Odasso of Allegheny Mineral Corporation for their cooperation in preparing this article.

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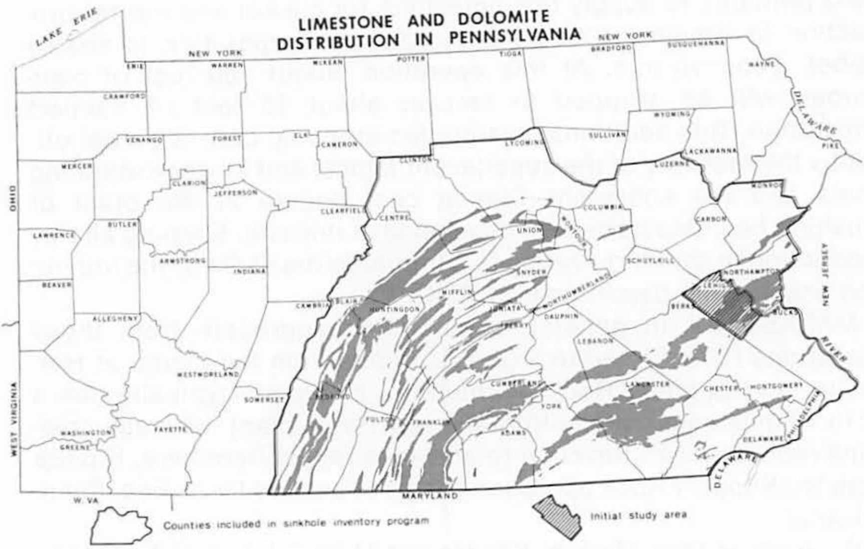
SINKHOLE INVENTORY PROGRAM BEGINS IN PENNSYLVANIA

The Bureau of Topographic and Geologic Survey has recently initiated a project to inventory sinkhole occurrence for those counties in Pennsylvania where limestone or dolomite are at the surface. Lehigh County is the first of 34 limestone-bearing counties which are to be inventoried. Environmental problems associated with sinkhole subsidence in the carbonate rocks of central and southeastern Pennsylvania have dramatized the need for greater understanding and information about weathering processes in carbonate bedrock and how these processes can affect property, business, and the individual.



Sinkhole in Saucon Valley, Lehigh County. Two sinkholes in the background have been filled.

The results of this project will be made available as Open-File Reports consisting of 7.5-minute topographic maps (scale 1:24,000) depicting known sinkhole occurrences, bedrock contacts, and structural data of each county. Along with the location of sinkholes, open-pit and deep mines, caves and other karst-related features will be shown.

Mapped sinkhole locations will be entered into the Survey's computer system by county, township, quadrangle (7.5'), and coordinates (latitude and longitude) for reference, service requests, and continuous up-dating of the database.

The Open-File Reports will be publicly announced and should be of considerable interest to county and municipal planning groups, engineers, state and federal agencies, and residents of the county in planning for construction and land use.

The inventory of Lehigh County will be conducted by staff geologist William E. Kochanov with completion planned for the end of May, 1986.

New Survey Publications

High-Purity Silica Report Identifies Previously Unknown Resources

A new reconnaissance investigation identifying previously unknown high-purity silica resources in Pennsylvania, has been released. This report includes chemical analyses and descriptions of nine Paleozoic formations and six quartz veins from 30 locations in 14 counties of central and eastern Pennsylvania. Percent $A1_2O_3$ and Fe_2O_3 are reported for both ascollected and beneficiated splits. Beneficiation consisted of hot acid baths and magnetic separation. The results for beneficiated samples suggest amounts as low as 60 ppm Al_2O_3 and <15 ppm Fe_2O_3 for quartz veins, and 230 ppm and 40 ppm respectively for some Cambrian-age sediments.

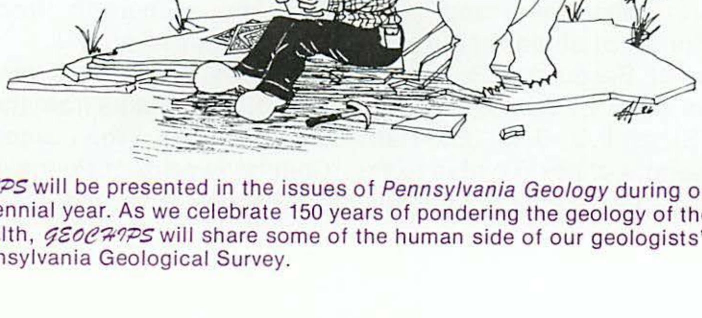
The purity (chemical and mineralogical), thickness, beneficiation potential, and possible uses for each sample are given, as are the resources available. High-tech users of silicon and lasca, in addition to glass, refractories, cement, metallurgical, proppant, and aggregate consumers and producers, should benefit from this description of silica resources in the Commonwealth.

Mineral Resources Report 88, *High-purity Silica Occurrences in Pennsylvania,* by Samuel W. Berkheiser, Jr., is available from the State Book Store, P.O. Box 1365, Harrisburg, PA 17105. When ordering by mail, send a check payable to the "Commonwealth of Pennsylvania" for $7.15 (plus $ 0.43 tax if mailed to a Pennsylvania address).

Geochips

We geologists get to see the balance of Nature almost every day. We're often blessed with examples of the order of things, especially when doing field work off the beaten track.

Some years ago, Bill Sevon, a Geologist in our Mapping Division, recounted an incident which was at the same time humorous, mildy frightening, and indicative of territorial imperative. He was mapping sandstones in Pike County, Pennsylvania. Bill entered an abandoned flagstone quarry on a hot summer afternoon, and began the usual geologist's routine of data gathering and note-taking. While sitting on a slab of flagstone examining his aerial photographs, he noticed something moving at the opposite end of the old quarry. A sizeable bear wandered into his view, apparently oblivious of a geologist's presence. The bear sat down, made himself comfortable, and began to survey the scene, seemingly an equal authority on rocks and the order of things. Not wanting to interfere with the brute's business, Bill made no move, but began to plan a silent, tiptoe exit. As the bear scanned the quarry, he finally recognized the presence of another of Nature's creatures, and froze to judge the seriousness of the situation. After a moment that seemed like an eternity to Bill, the bear apparently decided that this particular quarry was already occupied, and that it would be ill-mannered to interfere with the progress of science. In a fluid and silent motion, he arose on all four paws and tip-toed discretely out of the quarry. With a sign of relief, and grateful for that day's balance of Nature, Bill continued his gathering of data.



GEOCHIPS will be presented in the issues of *Pennsylvania Geology* during our Sesquicentennial year. As we celebrate 150 years of pondering the geology of the Commonwealth, GEOCHIPS will share some of the human side of our geologists' life at the Pennsylvania Geological Survey.

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GROUNDWATER LEVELS
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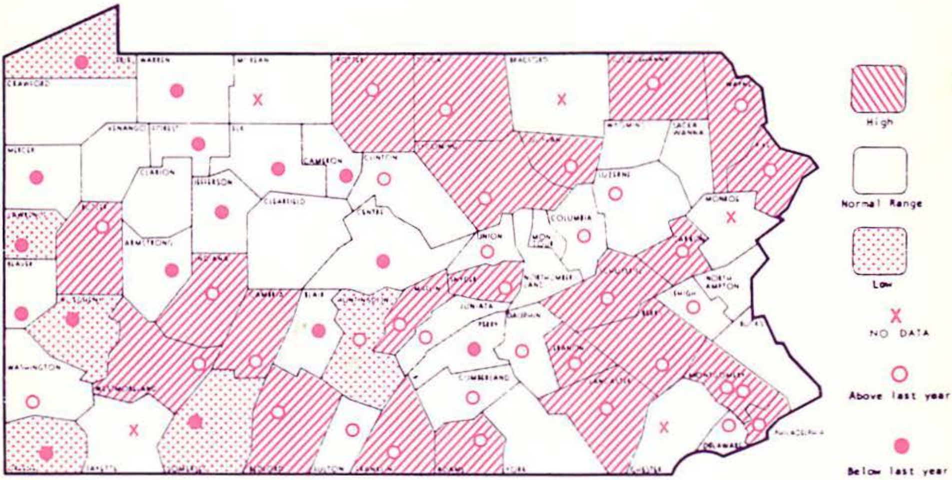

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