

Harrisburg
Area
Geological
Society



**SOUTH MOUNTAIN
FIELD TRIP GUIDE**

April 24, 1982

GEOLOGY IN THE SOUTH MOUNTAIN AREA

PENNSYLVANIA

FIELD EXCURSION GUIDE

Editor: Noel Potter, Jr., Dickinson College

Contributors:

Albert E. Becher, U.S. Geological Survey
Samuel W. Berkheiser, Jr., Pennsylvania Geological Survey
Henry W. A. Hanson, Dickinson College
F. James Knight, Gannett Fleming Corddry & Carpenter
William D. Sevon, Pennsylvania Geological Survey
J. Peter Wilshusen, Pennsylvania Geological Survey

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Copies may be obtained from:
Harrisburg Area Geological Society
c/o Pennsylvania Geological Survey
P. O. Box 2357
Harrisburg PA 17120

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PREFACE

In the Fall of 1981 the officers of the Harrisburg Area Geological Society decided that it would be useful for their members to run a one-day Spring field excursion to an area near Harrisburg. They believed that the HAGS membership should have the opportunity to visit and discuss good exposures from among the wonderfully diverse geology that we have in our back yards. A secondary purpose for the proposed trip was to prepare a guide to good exposures in the area that might be of use to local schools for educational purposes.

J. Ronald Mowery and I were asked to prepare a list of exposures in the Harrisburg area and suggest how visits to some of these might be organized for appropriate day-long excursions. Our list was sufficiently long to prepare several different excursions. The officers chose to confine the trip to a relatively small area with a diversity of geology that would appeal to the broad range of interests of its membership. This year it was decided to examine a variety of exposures and problems in the vicinity of South Mountain.

The contributors to this guidebook have been helpful and cooperative during its preparation, and I acknowledge their help with pleasure. I have particularly appreciated the editorial and logistic assistance of Bill Sevon and the encouragement of HAGS President Jane Eggleston.

Noel Potter, Jr.
Dickinson College
April, 1982

The cover drawing is by Nancy Jarvis, Dickinson College.

INTRODUCTION

The purpose of this trip is to examine several aspects of the geology on and near South Mountain. The trip route is shown in Figure 1.

South Mountain is the northern extension of the Blue Ridge into southern Pennsylvania. It is at the core of an anticlinorium composed of rocks that range in age from Precambrian through Ordovician (Fig. 1). The Precambrian rocks are the Catoclin volcanics, which are altered rhyolite and basalt. These are overlain by the Lower Cambrian(?) Chilhowee Group of clastic rocks that make up the resistant core of South Mountain. The Cumberland Valley, which lies to the north of South Mountain, is underlain by a thick sequence of Cambro-Ordovician carbonate rocks. Some of these carbonates also occur locally in the valley of Mountain Creek to the south of the crest of South Mountain. The stratigraphy and structure of South Mountain are discussed in Root (1970).

The South Mountain anticlinorium is complex in detail, but overall it is an asymmetrical fold with a near-vertical to overturned northwest limb and a gentler right-side-up limb on the southeast. Cleavage that is developed approximately parallel to the axial plane of the fold and dips southeast. Fold axes plunge gently northeast. Root (1970) concludes that only one period of deformation, the Alleghanian in the Late Paleozoic, is evident in South Mountain. The southeast and east sides of the South Mountain fold are truncated by the Triassic basin just southeast of the trip area.

Our knowledge of the late Mesozoic and Cenozoic history of the South Mountain area is in many ways less satisfactory than that of the Paleozoic for which we have a sedimentary record in the mountain and to the north in the Appalachian Valley and Ridge Province. Thick aprons of colluvium and alluvium composed of quartzite rubble mantle the north flank of South Mountain and extend out over the carbonate rocks in the Cumberland Valley. Although some of this rubble continues to be deposited today, the age of the oldest of these deposits is quite speculative. Some of the quartzite rubble may be as old as Late Cretaceous (Pierce, 1965; Tschudy, 1965).

AN OVERVIEW OF THE TRIP

The problems to be examined at the stops on this excursion are diverse. At Boiling Springs (Stop 1) we shall discuss the complex hydrogeology of the north flank of South Mountain and the adjacent carbonate rocks. Between Boiling Springs and Mount Holly Springs we shall stop briefly to discuss the nature of the quartzite rubble aprons on the north flank of South Mountain.

GREAT VALLEY AND SOUTH MOUNTAIN

CUMBERLAND VALLEY SEQUENCE

- | |
|-----|
| Csg |
|-----|

SHADYGROVE FORMATION
 Pure, light-colored limestone, stromatolitic in part; abundant pinkish limestone and cream-colored chert.
- | |
|----|
| Cz |
|----|

ZULLINGER FORMATION
 Interbanded and interlaminated limestone and dolomite, thin- to thick-bedded; stromatolitic limestone; several thin, local quartz sandstone beds.
- | |
|----|
| Ce |
|----|

ELBROOK FORMATION
 Light-colored calcareous shale and silty limestone at top; medium-gray limestone and dolomite in middle; pure, dark limestone at base.
- | |
|-----|
| Cwb |
|-----|

WAYNESBORO FORMATION
 Interbedded red to purple shale and sandstone and some beds of dolomite and impure limestone.
- | |
|----|
| Cl |
|----|

TOMSTOWN FORMATION
 Massive dolomite containing thin shaly interbeds.
- | |
|----|
| Ca |
|----|

ANTIETAM FORMATION
 Gray, buff-weathering quartzite.
- | | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----|----|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <table style="display: inline-table; vertical-align: middle; border-collapse: collapse;"> <tr> <td style="border: 1px solid black; width: 15px; height: 10px; text-align: center; font-size: 8px;">Chm</td> <td style="padding: 0 5px;">▶</td> <td style="font-size: 10px;">Ch</td> </tr> </table> | Chm | ▶ | Ch | HARPERS FORMATION (Ch)
Dark-greenish-gray phyllite and schist containing thin quartzite layers; includes Montalto Member (Chm)—gray quartzite. |
| Chm | ▶ | Ch | | |
- | |
|-----|
| Cwl |
|-----|

WEVERTON AND LOUDOUN FORMATIONS, UNDIVIDED
 In descending order: Weverton—gray to purplish-gray quartzite and quartzose conglomerate containing rounded pebbles. Loudoun—sericitic slate and purplish-gray, crumbly, poorly sorted, arkosic sandstone and conglomerate.

- ★ 6 Field trip stop
- ➔ Field trip route

Base map and explanation from: Berg, T. M. and others, 1980, Geologic map of Pennsylvania: PA Geological Survey, 4th ser., Map 1.

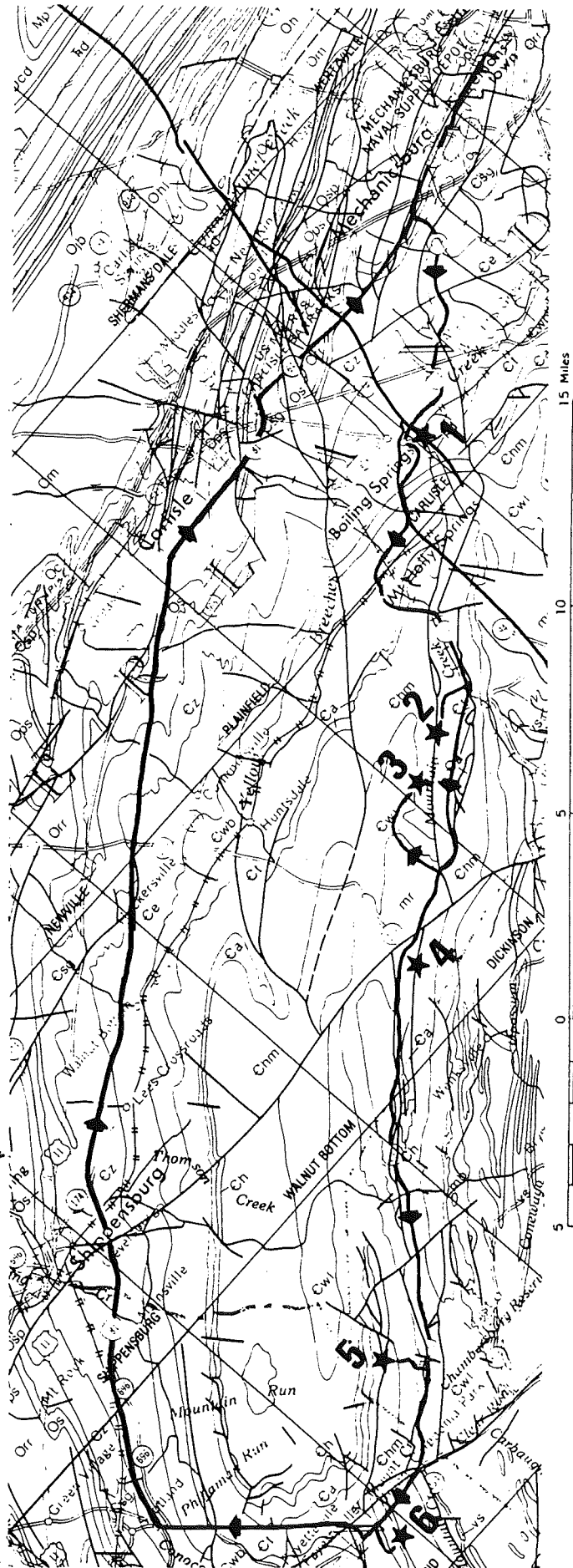


Figure 1

At the Hempt Brothers Clay and Aggregate Pit at Toland (Stop 2), we shall discuss the origin of thick clay deposits that have developed adjacent to the mountain on carbonate rocks and the structure of these and adjacent rocks. In addition, we can see a small sample of the occurrence of the residual iron deposits that have been prominent in the history of mining at Pine Grove Furnace and elsewhere along the flanks of South Mountain.

At Hammond's Rocks on the crest of South Mountain (Stop 3) we shall discuss the depositional environment of the conglomeratic facies of the Weverton formation and examine the prominent cleavage developed in these rocks.

Pine Grove Furnace (Stop 4) was mined for iron ore from the late 18th century until about 1900, and we shall outline that history at our lunch stop.

The new Chambersburg Reservoir (Stop 5) east of Caledonia will give us an opportunity to discuss some aspects of the problems of engineering geology on the clastic rocks of South Mountain.

Finally, at the Mt. Cydonia Sand Co. Pit (Stop 6) near Fayetteville we shall discuss the depositional environment of another of the Cambrian units, the Antietam quartzite.

MAPS PERTINENT TO THE TRIP

For those who take the trip independently, the following list of maps may be useful. The U.S. Geological Survey 7½' topographic quadrangles that cover the trip route, in order of use, are: Lemoyne, Mechanicsburg, Carlisle, Mount Holly Springs, Dickinson, Arendtsville, Caledonia Park, Scotland, Shippensburg, Walnut Bottom, and Plainfield.

There are several geologic maps that cover the trip route in varying amounts of detail. The Geologic Map of Pennsylvania (Berg and others, 1980) gives a useful view of the region adjacent to South Mountain. The Cumberland Valley (but not South Mountain) geology is covered by the 1:50,000 geologic map in Becher and Root (1981). Geologic maps at a scale of 1:24,000 that cover portions of the trip route are: Harrisburg West (Root, 1977); Carlisle and Mechanicsburg (Root, 1978); Mount Holly Springs (Freedman, 1967); and portions of the Caledonia Park, Scotland and Arendtsville Quadrangles (Fauth, 1968).

ROAD LOG

The trip begins at the Windsor Park Shopping Plaza on the east edge of the Borough of Mechanicsburg on the south side of Simpson Ferry Road.

From here to Boiling Springs the trip route traverses Cambro-Ordovician carbonate rocks that are folded with axial surfaces that dip southeast, and cut by several southeast-dipping thrust faults. A short distance east of Windsor Park on the north side of Simpson Ferry Road are several tank farms used for fuel storage. In February, 1969 gasoline was found in the carbonate rocks just north of these tanks. By March, 1974, a total of 219,000 gallons had been recovered (Becher and Root, 1981; Rhindress, 1971).

- 0.0 EXIT from Windsor Park Shopping Plaza and TURN LEFT on Simpson Ferry Road. CONTINUE west through Borough of Mechanicsburg. Simpson Ferry Road becomes West Simpson Street in the center of Mechanicsburg.
2.4
- 2.4 STOP sign. TURN LEFT on Trindle Road, PA Route 641.
1.2
- 3.6 Cross over Pennsylvania Turnpike.
0.5
- 4.1 TURN LEFT on PA Route 174, heading south.
0.9
- 5.0 Note South Mountain on left in distance.
0.5
- 5.5 Churchtown. CROSS Appalachian Trail.
0.6
- 6.1 STOP sign. CROSS PA Route 74 and CONTINUE straight ahead.
1.4
- 7.5 Allenberry on left.
0.8
- 8.3 Boiling Springs Lake on left. TURN RIGHT into Boiling Springs Tavern parking lot and park.

STOP 1. HYDROGEOLOGY AND THE SOURCE OF BOILING SPRINGS, CUMBERLAND COUNTY, PENNSYLVANIA. Albert E. Becher, U.S. Geological Survey.

Boiling Springs is one of the three largest springs in the Cumberland Valley and ranks as the seventh largest in the state. Average daily discharge is about 16.5 million gallons based on six instantaneous measurements made between 1944 and 1971 by the U.S. Geological Survey (Flippo, 1974). The water is used solely for recreational purposes in Boiling Springs Lake and the world-renowned trout fishing waters of Yellow Breeches Creek. Until recently, the sequence of carbonate rock formations that floor the southern part of the Cumberland Valley was considered to be the source of water for the springs.

Flow from Boiling Springs is through openings in strongly folded limestone of the Elbrook Formation about 1 or 2 miles

north of South Mountain (SM) (Figure 2). The Elbrook Formation is composed of interbedded calcareous shale, argillaceous limestone, and medium-bedded to massive limestone. Rocks typical of the formation are well-exposed north of Boiling Springs Tavern. A diabase dike of Triassic age extends across the valley from the north and just north of Boiling Springs, splits into two branches that enclose the spring area. To the south, on the flank of SM, alluvial, colluvial, terrace and residual deposits overlie the carbonate rocks to depths up to several hundred feet. Deposits are thickest near the contact between quartzites of SM and the overlying carbonate rocks.

There are two major areas of ground-water discharge from Boiling Springs; one in the walled basin north of the tavern; the other near the southwestern shore in the northwest corner of the lake (Fig. 2). In both areas the discharges can be seen as boils that rise several inches above the water surface. Head differences between water in the openings and in the basin may be several tens of feet. The water level in the basin is 10 to 15 feet above Yellow Breeches Creek.

Characteristics of the spring discharge openings can be seen best in the basin (Fig. 3). Here two intersecting linear zones of discharge that parallel local joint directions are visible. Additional flows may be present under the north wall.

Three alternative sources of water were considered for Boiling Springs. The magnitude and degree of fluctuation of the flow, water quality and seasonal variability, and geologic factors, however, support only SM as the source. Many stream channels on the flank of SM lose water to the colluvium and some often are dry before reaching Yellow Breeches Creek. It is probable that precipitation and runoff from SM infiltrates the colluvium and moves downward through permeable zones into solutionally-enlarged openings in the carbonate bedrock, then under Yellow Breeches Creek and finally discharges, under pressure, through openings at the narrow end of the funnel created by the branching diabase dike.

A drainage area of more than 20 mi² is needed to collect the amount of water discharged by Boiling Springs based on the average basin-wide ground-water discharge of 0.81 million gallons per day per square mile. From the ground-water divide, separating drainage to Conodoguinet and Yellow Breeches Creeks, south to the springs, the drainage area is only about 3 mi². Ample drainage area exists only on the flank of SM.

Temperature of the spring water issuing from the boils in the basin fluctuates only 0.2°C annually (Fig. 4) and lags air temperature changes by 4 to 6 months. The temperature of other perennial springs that obtain water from shallow local sources fluctuates with the seasons and by as much as 5°C. The specific conductance (electrical measure of dissolved ionic species) of water from Boiling Springs is about half that of ground water in nearby wells but is like water from wells in carbonate rock on the flank of SM. Wells on SM are completed as open casings

Base map from U. S. Geological Survey Carlisle and Mechanicsburg 7 1/4-minute quadrangles.

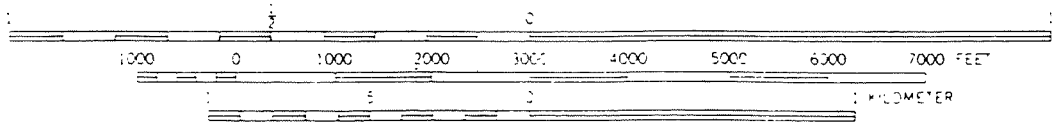
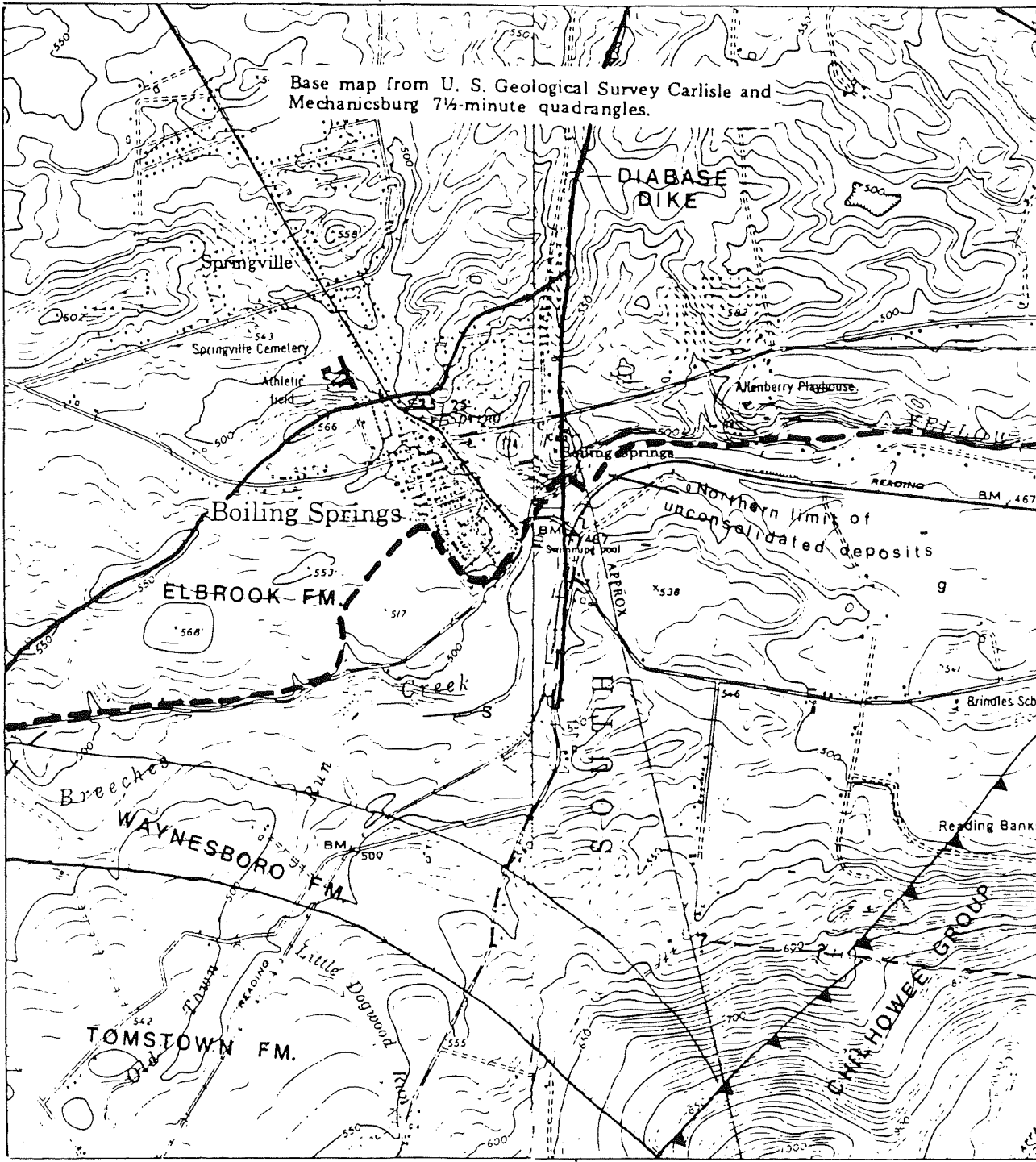


Figure 2. Map of the Boiling Springs area.

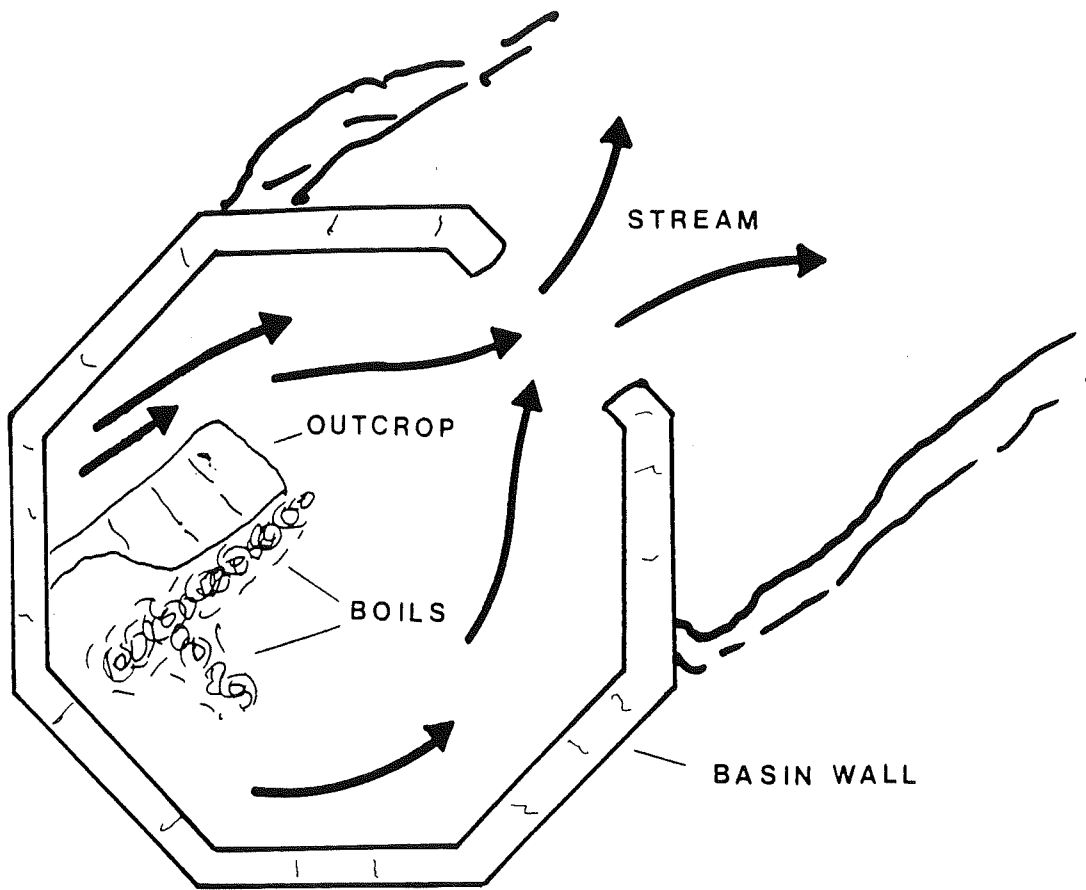


Figure 3. Diagram of walled spring basin behind Boiling Springs Tavern.

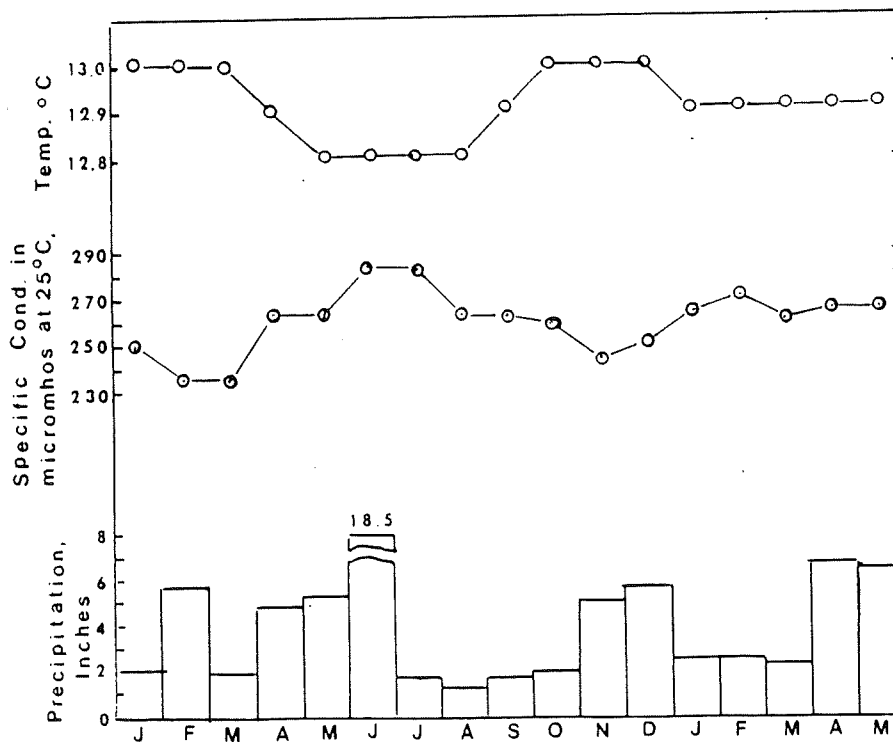


Figure 4. Monthly temperature, and specific conductance of water from Boiling Springs and precipitation at Carlisle.

that penetrate only a few feet into bedrock below the consolidated overburden. The lag in spring water temperature suggests a longer residence time; the slight fluctuation suggests deep, well-mixed water; but the lower specific conductance means lesser contact with carbonate rock. A SM source fits these interpretations.

Spring and well data suggest that the movement of water under Yellow Breeches Creek occurs along the entire flank of SM. Much of this water is then discharged into the Yellow Breeches but some moves under the apparent ground-water divide into the Conodoguinet Creek drainage basin (Becher and Root, 1981).

- (8.3) EXIT parking lot and TURN RIGHT, then immediately TURN LEFT on Front Street along the lake shore.
0.1
- 8.4 STOP sign. CONTINUE straight ahead.
0.2
- 8.6 TURN RIGHT on Race Street. The mill on left across bridge was built in 1784.
0.3
- 8.9 TURN HALF LEFT onto Walnut Street toward Mount Holly Springs.
1.2
- 10.1 CROSS Yellow Breeches Creek. Ridge straight ahead is underlain by the western branch of the diabase dike described at Boiling Springs.
0.5
- 10.6 CROSS Petersburg Road.
0.1
- 10.7 CROSS diabase dike.
0.5
- 11.2 PPG Industries Float Glass Plant on left. Plate glass is made here by extruding molten glass out over a bed of molten tin on which the glass cools and hardens, then continues the length of the plant from east to west. When in full operation, two ribbons of glass are formed and cut continuously during 24-hour operation. The plant is roughly 1/2 mile long.
0.3
- 11.5 TURN RIGHT onto Pumphouse Road and follow road to South Middleton Township Water Authority tower and pumphouse. STAY IN BUS.

The fields beside the entrance road are mantled with cobbles of quartzite rubble that is typical of the debris aprons that extend 1-2 mi northward from the base of South Mountain across the carbonate rocks. Some of these rubble deposits are fan-shaped, with their apices at the mouths of stream valleys that drain off South Mountain. Several shallow closed depressions (dolines) that can be seen adjacent to the entrance road are typical of the karst topography that is common on the quartzite rubble.

Depth to bedrock at the wellsite is slightly over 100 ft. Within a few months of the time the well was drilled, a sinkhole

20 ft in diameter and 20 ft deep formed about 100 yards SE of the wellsite. The sink is now filled in. Exploratory drilling prior to construction of the PPG plant showed average depths to bedrock of 75-100 ft, and in one hole, bedrock was not reached at a depth of 230 ft. Quartzite colluvium and alluvium overlies thick residuum derived from weathering of the underlying carbonates. The coarse quartzite rubble protects fine clay-rich residuum beneath it from subaerial erosion (Hack, 1960). Pierce (1965) has described a site at the northwest base of South Mountain at Pond Bank, southeast of Chambersburg, where he infers that a Late Cretaceous (Tschudy, 1965) lignite deposit rests on more than 170 ft of residuum. He uses the insoluble residue content of the underlying rocks (about 10%) to infer that in the process of accumulation, the residuum has been lowered more than 1400 ft. This is considerably greater than the present height of South Mountain above the valley floor.

The numerous karst depressions on the quartzite rubble attest to the long-continued solution of the underlying carbonates. Many of the shallow dolines, including those here adjacent to the road, hold ponded water for days or weeks after large storms such as the Agnes storm in June, 1972.

- TURN AROUND at pumphouse and RETURN to paved highway.
0.4
- 11.9 TURN RIGHT on highway toward Mount Holly Springs.
0.3
- 12.2 CROSS Zion Road. CONTINUE straight ahead. Disturbed area on right just past Zion Road were pits from which Hempt Brothers removed sand and gravel from alluvial deposits of quartzite from Mountain Creek and Yellow Breeches Creek.
0.9
- 13.1 CROSS Mountain Creek.
0.2
- 13.3 STOP sign. TURN LEFT on PA Route 34 and proceed through village of Mount Holly Springs. Mt. Holly Gap straight ahead is where Mountain Creek cuts through South Mountain.
0.4
- 13.7 Village center.
0.3
- 14.0 Enter Mt. Holly Gap. Cambrian Antietam Quartzite occurs on both sides of the gap as near-vertical beds on the north limb of Mt. Holly anticline (Freedman, 1967). Freedman reports (p. 61) on a 419-ft bore hole on the property of the Schweitzer Division, Kimberly-Clark Paper Co. here. The logger's terminology makes it difficult to interpret the sequence in the well, but it seems clear that several thick clay layers were penetrated to depths of at least 235 ft, and that weathering has occurred to the depth of the bottom of the hole. Water was about 3 ft deep over this stretch of highway from flooding of Mountain Creek during Tropical Storm Agnes in June, 1972.
0.1
- 14.1 Deer Lodge on right.

- 0.2
14.3 CROSS Mountain Creek.
0.2
14.5 CROSS railroad tracks.
0.2
14.7 BEAR RIGHT on PA Route 34. Eaton-Dikeman paper plant on right. This plant and the Schweitzer plant near Mount Holly both were early users of local clays derived from residuum weathered from the Tomstown formation.
1.3
16.0 Roadside rest on left.
0.5
16.5 TURN RIGHT at sign for Hempt Bros. Sand and Gravel, Toland Plant. Follow entrance road up hill to weigh station. If coming here on an independent trip, stop and obtain permission to enter pit.

STOP 2. HEMPT BROTHERS CLAY PIT AT TOLAND. Samuel W. Berkheiser, Jr., Pennsylvania Geological Survey; Noel Potter, Jr., Dickinson College; and William D. Sevon, Pennsylvania Geological Survey.

Introduction

The now-active Hempt Brothers aggregate operation at the former Philadelphia Clay Company pits near the village of Toland on the southeast flank of Mount Holly, Dickinson Township, Cumberland County (40°04'28"N, 77°13'03"W) has had a long and checkered mining history (Fig. 5). Iron ore was actively mined in the mid-1880's from two separate operations believed to be located on the property. Both underground and strip mines for "bombshell" ore exposed varicolored clays which were sporadically exploited until the 1970's. Today the waste dumps are being reworked for fine and coarse aggregate material.

Geologic Setting

The abandoned clay pits are associated with a major fault contact zone between the Lower Cambrian clastics (Harpers Formation-Antietam Quartzite) and the Lower Cambrian carbonates (Tomstown dolomite). This fault is believed to be steeply dipping with relative upward movement on the northwest side (clastics) (Freedman, 1967).

Economic Geology

Iron Ore--d'Invilliers noted in the fall of 1886 that hundreds of small ore bank pits were opened by farmers between Scotland and Harrisburg. Only a few of these pits were of considerable size and had encountered good ore. Most pits he noted were long-abandoned. These limonite ores apparently averaged about 40% iron and contained objectionable amounts of phosphorous and silica (d'Invilliers, 1886). Smith (1978) reports that iron ore deposits in this area become progressively richer in manganese toward the southwest. In the clay pit

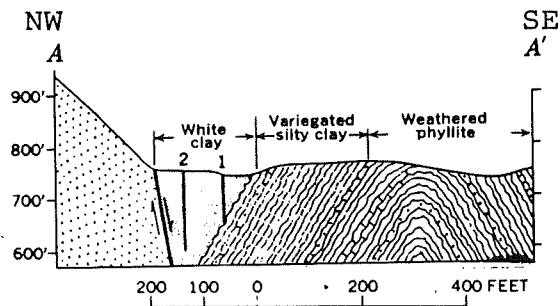
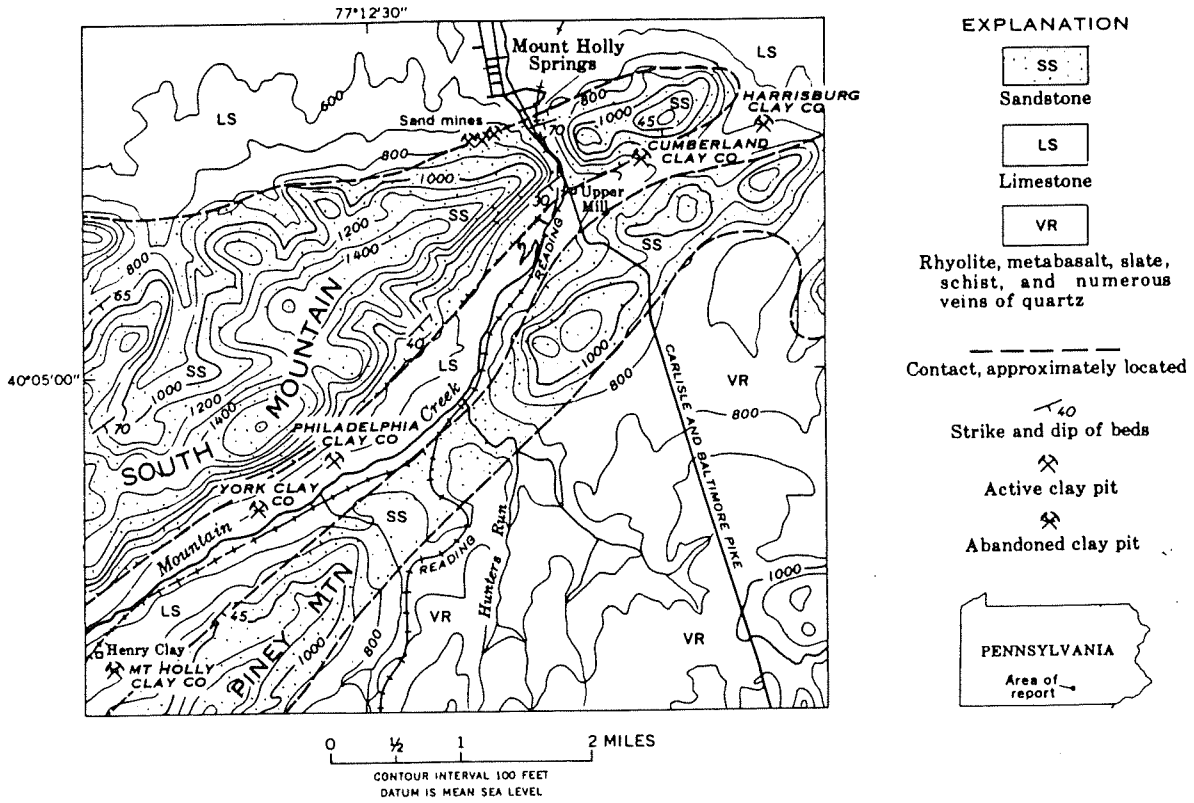


Figure 5. Generalized geologic map of the Philadelphia Clay Co. area and interpretive cross-section perpendicular to structure. From Stose, 1907 and Hosterman, 1969.

at Toland the "limonite" contains 0.9% Mn, whereas the Laurel No. 1 bank to the southwest yielded 11.6% Mn (Smith, 1974). The occurrence of manganese oxide nodules in the clay is not uncommon. It is estimated that about 700,000 tons of manganese ore (calculated as KMn_2O_7 - 56% Mn per unit mineral) and 1,800,000 tons of iron ore (calculated as Fe_2O_3 - 70% Fe per unit mineral) exist near White Rocks, southeast of Boiling Springs on the north flank of South Mountain in a similar geologic setting (Foose, 1945).

White Clay--Clay mining has been sporadically active since about 1880 until recently, but little production data is available. White clay from the Philadelphia Clay Co. pit was used in the past for paper filler and coatings, and for light-colored brick. More recently it was used as a whitener in Portland cement. The Toland pits in the mid-1960's produced about 40,000 tons of raw clay per year for use in hydraulic white cement manufactured in West York. The clays were mined by underground methods in earlier days, but later were mined from the open pit.

The white clay deposit at Toland is lens-shaped (about 1600 ft by 200 ft) with no known vertical extent at depth. The fault contact on the northern boundary is distinct, whereas the southern boundary is gradational and characterized by change to varicolored silty clay (Hosterman, 1968; 1969). Chemically the white clay averages about 71% SiO_2 , 19% Al_2O_3 , and 0.4% Fe_2O_3 by weight (Hosterman, 1969). Texturally the white clay is composed of 70% clay, 24% silt, and 6% sand. There is a 9:1 ratio of kaolinite to illite in the clay fraction (Hosterman, 1969). Analysis of the clay dumps (waste clay) are interpreted to suggest that the colored clay has a potential for decorative brick, tile, and low duty refractories (O'Neill and others, 1965).

Aggregate--The only mining presently associated with the Toland pits is the reworking of the clay waste dumps to extract quartzite for an aggregate source. There is no bedrock mining at present. The aggregate is a PenDOT approved Type A, Fine Aggregate and Type C, Coarse Aggregate. The failure of this material to meet Type A, Coarse Aggregate specifications can be attributed to the friable nature and brittleness of the quartzite. Leaching and weathering of this colluvium has made passing the abrasion test difficult.

As one can observe from the ratio of clay to quartzite in the waste dumps, demand for this type of aggregate source is great enough to overcome the economics of material handling, washing, and crushing. Experimental mining of colluvium and weathered bedrock on Mt. Holly have also met with similar test results.

Origin of the White Clay

The origin of the clay is still a matter of some debate.

Perhaps multiple working hypotheses shall continue to predominate until further research clarifies the origin of these deposits. Hosterman (1968; 1969) identified alunite and an increase of Al_2O_3 with depth from auger holes in these pits. He infers that this supports formation by hydrothermal alteration along the fault zone. If this were the case, the limonite may represent the gossan from a series of hydrothermal sulfide deposits (Smith, 1978).

Stose (1907) proposed that the origin of the deposits was from weathering. Surface observations suggest the clay is a residuum formed by the weathering of argillaceous rock in the Tomstown formation. Supergene enrichment (leaching) has formed countless other similar iron, alumina, and clay deposits. Mineralogical and chemical observations at Toland are equivocal.

Slump Development

A large portion of the mountainside above the deepest part of the pit has slumped into the pit, presumably as a result of removal of material at the base of the slope. Numerous slump scarps, some of which have displacements of 10-15 ft, extend nearly to the crest of South Mountain above the pit. Analysis of tree rings in tilted trees on some of the highest scarps indicates that some movement had occurred as early as the 1930's.

Some questions to consider as you examine the pit:

1. Does the nature of the clay occurrence support the origin by hydrothermal alteration?
2. Why are some areas of shale less altered to clay than others?
3. How difficult is it to differentiate colluvium from spoil in some of the exposures?
4. Is there evidence for additional structural deformation of the shale near the fault?
5. To what extent can one distinguish between folds developed tectonically during the Alleghanian and folds developed more recently as a result of slumping off of South Mountain or subsurface weathering of the Tomstown formation?
6. Note the presence of reddish-brown iron-rich bands in the variegated clay and nodules of "iron ore" on the pit floor and speculate on their origin.
7. The sides of the pit are being modified rapidly by running water and mass movement. You may wish to compare some of the miniature landforms with larger ones you have seen elsewhere.
8. Speculate on the potential for future movement of the large slump on the north side of the pit.

RETURN to PA Route 34.

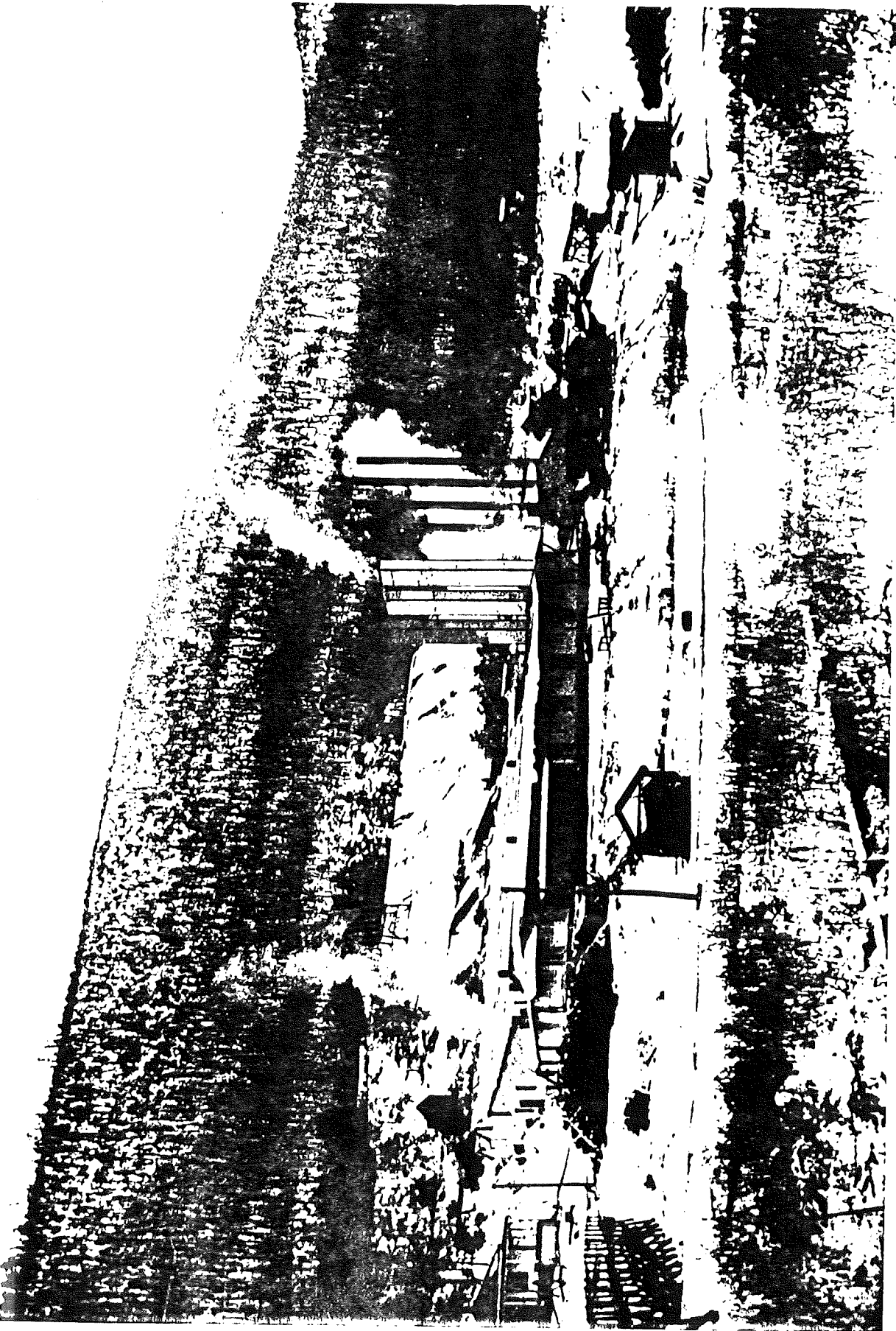


Figure 6. The Philadelphia Clay Company in about 1880, apparently near Toland. South Mountain in the background. Most workings were apparently underground at that time. Note denuded vegetation on mountain, presumably from charcoal making industry. Photograph courtesy of the Cumberland County Historical Society.

- (16.5) TURN RIGHT on PA Route 34.
0.2
- 16.7 TURN RIGHT at Tagg Run Campground sign.
0.4
- 17.1 CROSS railroad tracks.
0.3
- 17.4 STOP sign. TURN RIGHT toward Pine Grove Furnace.
0.4
- 17.8 Old entrance to Philadelphia Clay Co. (now Hempt) pit on right. Village of Toland. The buildings on the right are part of the former Philadelphia Clay Co. "company town" housing development for employees. It was near here that the company's beneficiating plant (Fig. 6) stood. Note large arcuate escarpments at head of slump above clay pit.
0.9
- 18.7 Mountain Creek Campground on right.
1.8
- 20.5 Enter Michaux State Forest.
0.6
- 21.1 The bicycle-hiking trail that crosses the road diagonally here is built on the old bed of the railroad that formerly was used to carry materials to and from the mines at Pine Grove Furnace.
0.3
- 21.4 CROSS Mountain Creek. Laurel Lake dam on left was built in the late 1800's.
0.2
- 21.6 MAKE SHARP RIGHT TURN onto Cold Spring Road. PROCEED to the top of South Mountain.
0.9
- 22.5 Pavement gives way to gravel. Road ahead is rough, but passable by car, except when snow-covered.
1.3
- 23.8 Crest of South Mountain. TURN RIGHT on Ridge Road.
0.9
- 24.7 Turnout on right. PARK HERE and walk to exposures to south.

STOP 3. HAMMOND'S ROCKS. Henry W. A. Hanson, Dickinson College.

Introduction

Hammond's Rocks is one of a number of natural exposures of the Lower Cambrian(?) Weverton Quartzite along the crest of South Mountain. This outcrop differs from others of the Weverton nearby in its large size, bold topographic expression, and coarseness of the sediment. Exposure of conglomeratic Weverton is not particularly unusual, but most of the natural exposures are sandy rather than conglomeratic.

The Weverton Quartzite was named by Keith (1893) at exposures along the Potomac River in Maryland. The thickness of the unit is probably 1200-1400 ft (Fauth, 1968). No fossils have been found in the Weverton, but Early Cambrian fossils have been reported from overlying quartzites (Fauth, 1968). The unit is therefore generally assumed to be Early Cambrian.

According to John Fauth (personal communication, 1982), who has mapped the Weverton in Maryland and Pennsylvania, there are substantial changes in the lithology along the strike of the unit that probably reflect a variety of depositional environments. Fauth (1968), working in the Caledonia area west of Hammond's Rocks, describes, but does not include on his map, four "lithologic intervals" in the Weverton. The basal member is phyllitic graywacke and quartzose graywacke. The lower middle interval is phyllitic quartzose graywacke. The upper middle interval is a graywacke conglomerate, and the upper interval is protoquartzite and quartzite with thin interbeds of quartz pebble conglomerate. He notes that the two middle intervals are not well-exposed. Freedman (1967), who mapped the Mount Holly Springs Quadrangle, including Hammond's Rocks, recognized and mapped two members of the Weverton: a lower conglomeratic member and an upper fine-grained member.

Any geologist who visits Hammond's Rocks has the opportunity to consider three challenges:

- 1) Interpret the depositional paleoenvironment of the rocks.
- 2) Gain instant fame by finding some fossils.
- 3) Interpret the structure of the exposure.

On a clear day, from the top of the rocks, one can get a magnificent view that extends from the southeastern Piedmont to the Folded Appalachians.

The sketch map of Hammond's Rocks (Fig. 7) shows several points of interest at the site. The selected points show sedimentary and structural relationships with a clarity that is unusual at the site. Look around at other parts of the exposure to see whether you can figure out the stratigraphic and structural relationships.

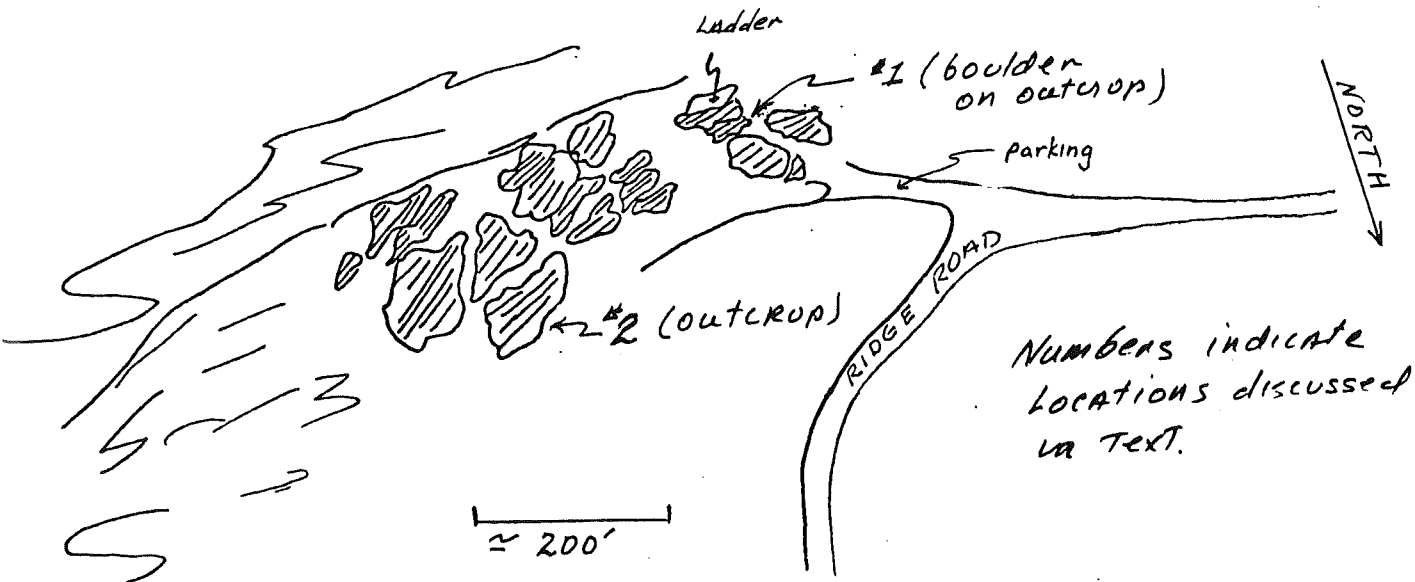


Figure 7. Hammond's Rocks. Sketch map.

Location 1.

The boulder at Location 1 on the sketch map (Fig. 7) and illustrated in the sketch below (Fig. 8) shows several well-defined beds. The upper bed, about 1.5 m of conglomeratic sandstone, is clearly cross-bedded. The maximum angle between the cross-beds and underlying beds is about 40° , which is greater than the angle of repose (35°) for moderately angular material with a 1 cm diameter. This suggests thickening of the beds during deformation, perhaps by shear across the cross-beds which steepened their angle to the underlying beds. Cleavage is at an angle of about 75° to the lower bed, a pebbly sandstone, but is refracted in the upper bed, where it is parallel to the cross-beds. The lower bed also shows cross-bedding on a smaller scale, with a different (opposite?) direction of transport. Scour marks within this lower bed suggest that the boulder is "right side up." What kind of bed forms do these cross-beds represent? Some possibilities seem to be dunes, sand waves, or point bars.

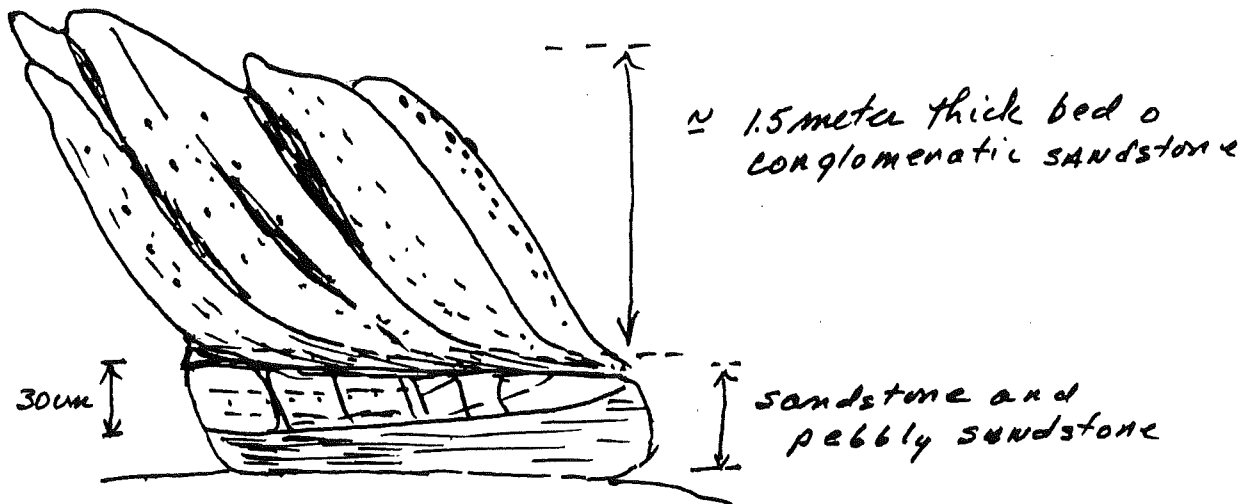


Figure 8. Boulder at Location 1. For location see Fig. 7.

Location 2.

The long outcrop, shown in Fig. 9, is best viewed from the northwest. The long face of the outcrop shows a prominent channel in the upper midsection of the exposure. The channel floor is scoured in conglomerate and the fill is cross-bedded sandstone. A prominent quartz pebble that protrudes into the channel is 12 cm by 5 cm.

The critical shear velocity required to move such a pebble in traction can be estimated from Shield's diagram (Blatt, et. al., 1980, p. 101) and is on the order of 20 cm/sec. That velocity would put into suspension quartz grains with a diameter up to 2 mm. Shear velocity, making some assumptions as to the nature

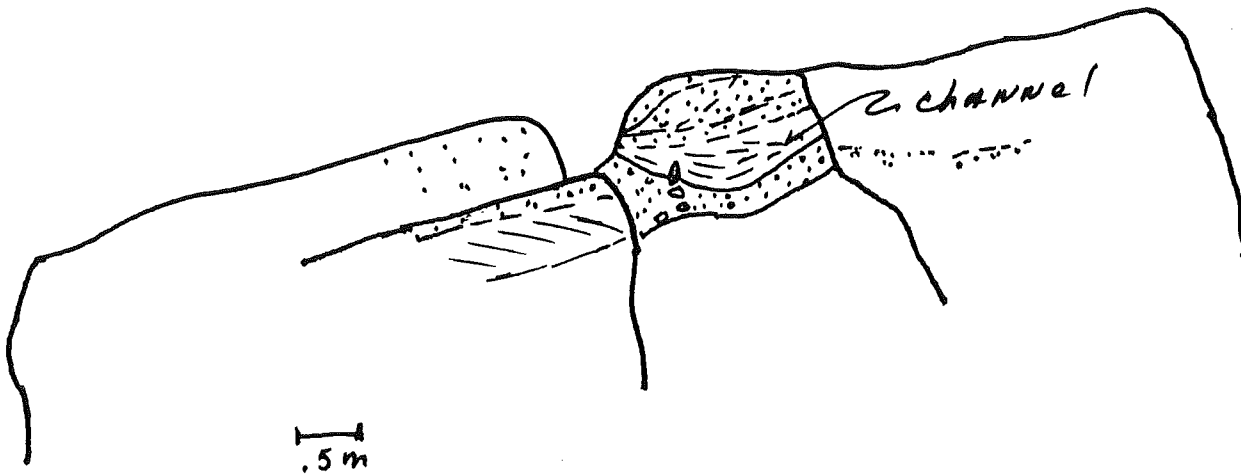


Figure 9. Outcrop at Location 2 viewed from the northwest.
For location, see Fig. 7.

of the flow, is equal to the \sqrt{GDS} , where G = acceleration due to gravity, D = depth, and S = slope. The slope of a stream (or tide) flowing over its own sediment, on a plane, is not far from 0.001. Therefore such a shear velocity would be expected in a channel with a slope of 0.001 if the depth were about 4 m. Alternatively, one can assume a depth of 1 m and use Hjølstrom's diagram (Blatt, et. al., 1980, p. 105) to estimate velocity. In that case, a velocity of approximately 5 m/sec would be required to remove the material, and that is an unusually high velocity.

The channel that the cobble protrudes into has an apparent depth of less than one-half m, suggesting that the channel is either a scour mark in deep water, or that much of the channel was removed by subsequent erosion.

This exposure is also interesting from a structural point of view. The southwest end of the long outcrop displays the core of an anticline with a sandy bed in the core, overlain by a conglomeratic bed. Pebbles are oriented with their long axes parallel to the axial plane cleavage, presumably as a result of rotation or stretching during deformation. The lower part of the conglomerate, at the crest of the fold, is cut by numerous quartz veins. The fold axis has a bearing and plunge of N60°E, 15°NE. Cleavage is oriented N60°E, 85°SE. The axis of an adjacent small syncline (on the northwest side of the small anticline?) appears at the northeast end of the exposure.

Paleoenvironmental Speculation

There is both direct and indirect evidence of a somewhat localized paleotransport system, such as a river or tidal channel, at the location of Hammond's Rocks:

- 1) There is a local concentration of coarse material, exposed in bold relief.

- 2) There are channel structures, or at least scour structures preserved.
- 3) Cross-bed sets more than 1 m thick demonstrate the movement of large bed forms.
- 4) At times the channel(s) probably were on the order of 4 m deep.

The lack of terrestrial vegetation in Early Cambrian time makes it difficult to suggest that there is a strong similarity with modern environments. However, depths of 4 m are typical of rivers flowing over their own sediment and of the tidal channels between modern Atlantic barrier islands. Graf (1971, p. 118) considers the ideal, stable cross-section of channels in granular material. According to his model, in an example (p. 112), a stream with a depth of 3.7 m and a slope of 0.001 in granular material with an angle of repose of 37° would have a cross-sectional area of 36 m² and a discharge of 935 m³/sec (about 32,000 cfs). A model, such as this one by Graf, should be taken with great caution when considering ancient sediment transport systems. But it is helpful to know that these sediments may have been deposited by a system that carried, at least at times, a volume of water comparable to the average discharge on the Susquehanna River.

- (24.7) RETURN back west along Ridge Road.
0.9
- 25.6 TURN LEFT, returning downhill along Cold Spring Road toward Laurel Lake.
2.2
- 27.8 TURN RIGHT toward Pine Grove Furnace.
0.1
- 27.9 Laurel Lake on left.
1.7
- 29.6 Fuller Lake Recreation Area entrance on left.
0.2
- 29.8 Junction with PA Route 233. CONTINUE straight ahead. The white house on the left is the Pine Grove Furnace State Park Headquarters. Inside one can obtain a map of the park, and there are some natural history exhibits and old photographs illustrating the history of mining in the park.
0.1
- 29.9 TURN LEFT down hill at sign that points to "Trailer/Tenting Area." Just past the store on the right is the old ironmaster's mansion. KEEP LEFT again opposite the mansion.
0.1
- 30.0 TURN LEFT again, and PARK in parking area on left near remains of old furnace.

STOP 4. PINE GROVE FURNACE. J. Peter Wilshusen, Pennsylvania Geological Survey.

Pine Grove was an active iron mining area and furnace from 1773 to 1893 and was one of many iron ore deposits mined in

Pennsylvania. This mining and iron industry had a notable effect upon the developing economy of Pennsylvania and contributed materially to the Revolutionary and Civil Wars.

Ore was extracted from open pits and shallow underground workings and smelted in a furnace using charcoal and limestone flux. This iron was shipped by wagon, and later by railroad, to forges and foundaries where it was further processed and cast for cannon shot, stoves, pipe, tools, and wrought iron articles. Mountain ore yielded iron that was satisfactory for casting in foundaries, but this ore was not sufficiently malleable for forging until it was processed with higher quality "valley" ore. Valley ore, different from that at Pine Grove and other mountain sources, occurs in contact metamorphic deposits related to the intrusions of igneous dikes and sills in limestone.

History of the charcoal iron industry is well-documented in the hiker's Guide to the Appalachian Trail from the Susquehanna River to the Shenandoah National Park (Potomac Appalachian Trail Club, 1970). A narrative history of Pine Grove Furnace, including what life was like at the mines, is given in Flower (1975). The geology and origin of the ore bodies, however, was not studied until the mines had been in operation for many years. There had always been enough ore, and not until it became scarce did people wonder about its occurrence and genesis. General descriptions of ore banks and tables of chemical analyses were published in 1846 in reports of the First Geological Survey of Pennsylvania. In 1886, Second Geological Survey reports gave detailed descriptions of the shape, size, and attitude of ore deposits, but as exemplified by the following quotation from the Survey's Annual Report of 1886, it was already too late:

"For, inasmuch as this opening has practically been abandoned for the time being, many of the working faces and old shafts were filled in and it was with difficulty that several of them were located at all." (d'Invilliers, 1886)

During most of the history of mining, potential ore reserves were not considered. The ore was apparently plentiful, as was limestone flux and wood. A blue haze of smoke covered the hills from hundreds of hearths making charcoal. Timber was cut and burned day and night. Approximately 24 cords of wood were required to produce the charcoal to smelt enough ore to yield one ton of pig iron.

Deposits of iron ore throughout South Mountain are near the contact between the Tomstown dolomite and either the Antietam Formation or the Montalto Member of the Harpers Formation, and are often associated with faulting. The most notable occurrences in this area are below White Rocks south-east of Boiling Springs, at Mount Holly Springs, at Pine Grove, at Big Pond, and at Quarry Gap. Pine Grove is the best-preserved, not only of these ore occurrences, but also

of the remains of the furnace, the mansion house, and other buildings as well. Remnants of the ore occur in the 90-ft deep quarry, part of which is now Fuller Lake (Fig. 10), as well as south of the lake and across a small ridge where other quarry excavations are visible.

These iron deposits result initially from leaching of phyllite of the Harpers and Antietam Formations by the downward movement of slightly acid water and subsequent precipitation and supergene enrichment from solution in slightly sandy beds of the Tomstown dolomite as the acidity of the solution changed in the presence of carbonate bedrock (Hosterman, 1968; 1969). Iron mineralization, often associated with manganese oxides, comes primarily from widely disseminated magnetite and lesser amounts of illite in the phyllitic bedrock. Fault zones and developing solution openings in the dolomite provided sites of deposition for the iron ore. This slow chemical process was active over a long period of time as the dolomite weathered to its present position.

This iron industry, which had been so prominent in southeastern Pennsylvania, came to a close before the start of the 20th century. This happened because extensive hematite deposits in the Lake Superior region were developed, and the Bessemer process, invented in 1855, came to the United States to give the world its first low-priced steel. In addition, the supply of wood used for making charcoal was all but gone, and as a final blow, the deep pit at Pine Grove was flooded.

During a walk around the Park, starting from the old furnace, you might visit the following:

1. Examine the furnace, and consider the former extensive buildings now gone (Fig. 11).
2. Walk back northwest from the furnace to see the ironmaster's mansion, now restored on its exterior.
3. Walk east along the bicycle-hiking trail that follows the old railroad bed a short distance to Fuller Lake, the site of one of the old ore pits (Fig. 10). Adjacent to the pit are several mounds that are former dumps.
4. Walk a short distance up onto the hill south of Fuller Lake to visit a small quarry in which an exposure of the elusive Tomstown dolomite can be found.
5. Walk back northeast to the Park Headquarters building and look at the natural history and historic exhibits there.

RETURN TO Ironmaster's Mansion.

- 0.1
- 30.1 TURN LEFT in front of mansion.
- 0.2
- 30.3 STOP sign. TURN LEFT on PA Route 233 toward Caledonia.
- 3.5



Figure 10. The iron ore pit at Pine Grove Furnace in about 1875. The pit is now Fuller Lake. Photo courtesy of the Cumberland County Historical Society.

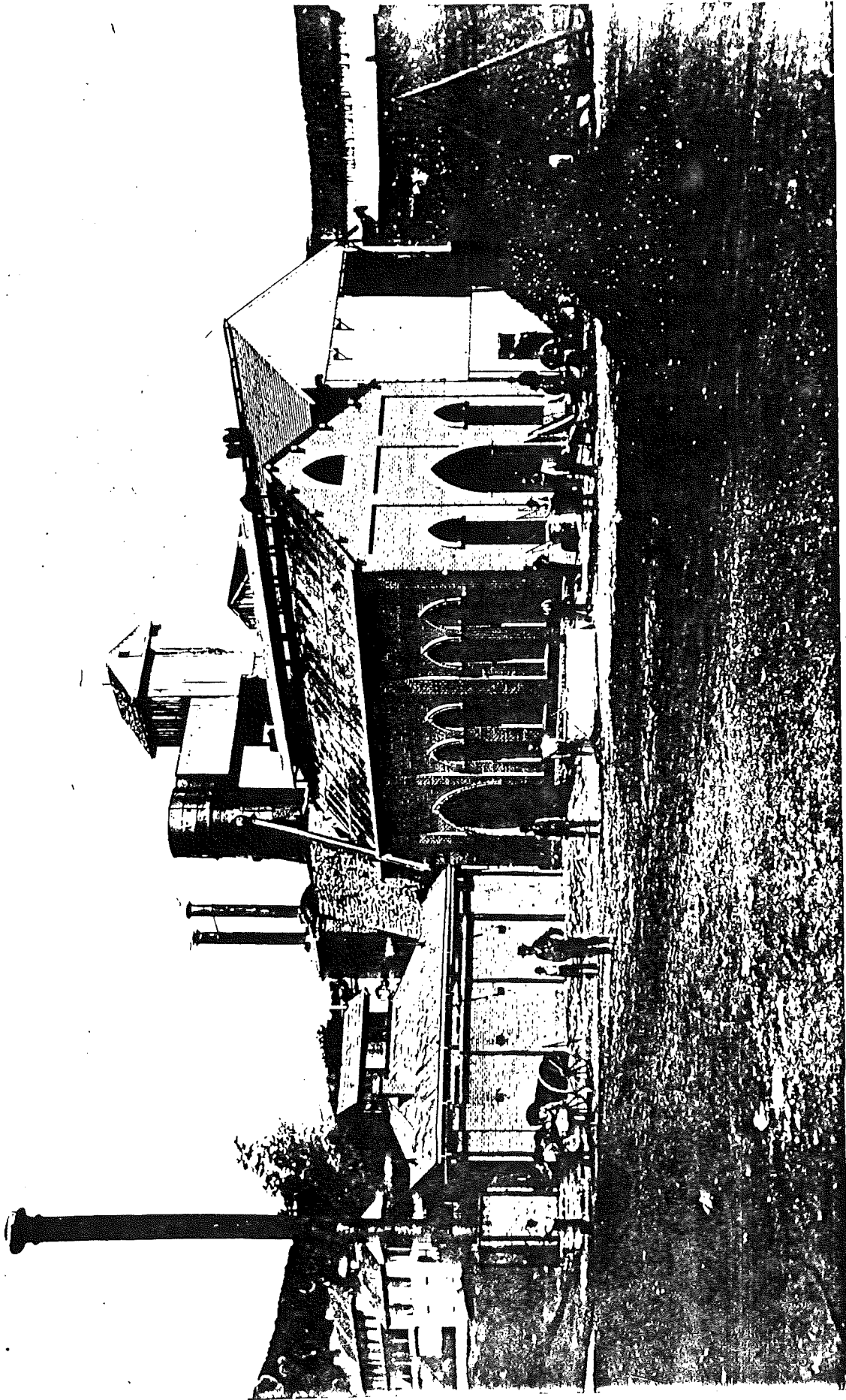


Figure 11. Pine Grove Furnace in 1875. The stone furnace, which still stands today, is enclosed by the buildings. The ironmaster's mansion is at the left. Photo courtesy of the Cumberland County Historical Society.

- 33.8 Adams County line.
4.8
- 38.6 Leaving Michaux State Forest.
0.9
- 39.5 Return to Michaux State Forest.
1.2
- 40.7 Old Chambersburg Reservoir on left.
0.4
- 41.1 TURN RIGHT on gravel road, proceed up hill to new Chambersburg Reservoir, approximately 1.5 miles to dam.

STOP 5. LONG PINE RUN DAM. F. James Knight, Gannett Fleming Corddry and Carpenter.

Owner.....The Municipal Authority of the
Borough of Chambersburg, Pennsylvania
 Constructed.....1969-70
 Cost.....\$3,300,000
 Type of Structure.....Earthfill
 Height.....115 feet
 Length.....1,070 feet
 Volume of Embankment.....660,000 cubic yards
 Capacity.....1,759,700,000 gallons
 Reservoir Area.....150 acres
 Purpose.....Municipal Water Supply
 Designer.....Gannett Fleming Corddry and Carpenter, Inc.
 Contractor.....Green Construction Company

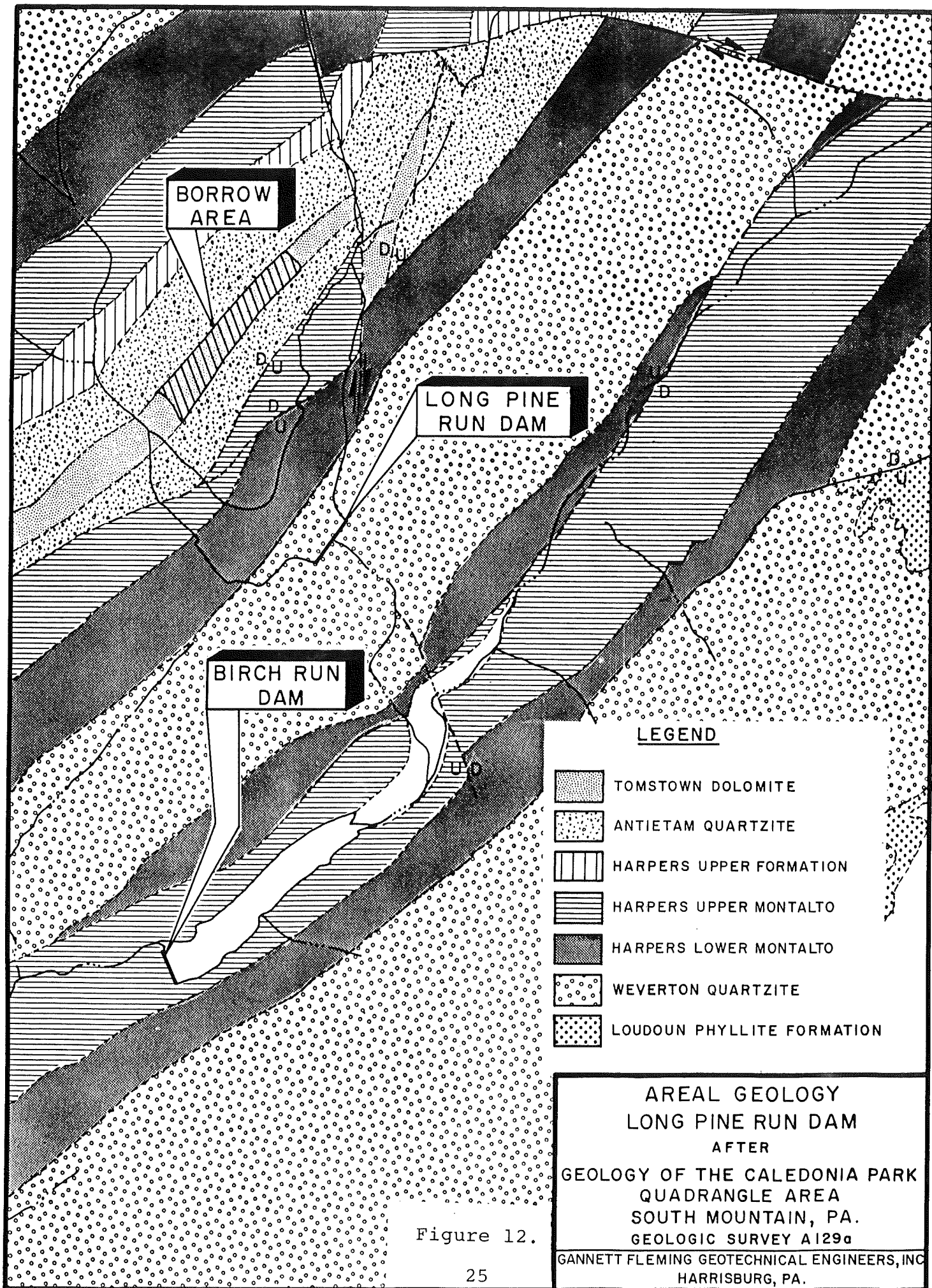
Background

By the mid-1960's the water supply of the Borough was approaching the safe yield of the old reservoir, located on Birch Run near Route 233. Water quality problems, materializing in the preceding years, also reached the point where additional treatment was required. As part of an overall expansion and upgrading of the water supply system, a new treatment plant was constructed near Route 30 east of Fayetteville on Conococheague Creek, and the Long Pine Run Dam was constructed on a major tributary to Birch Run, which is in turn a tributary to Conococheague Creek.

Water is stored in the Long Pine Run Dam Reservoir until needed and is then released to the stream. After passing through the Birch Run Reservoir, it is picked up at an intake on Conococheague Creek near the plant, treated and piped to the Borough.

Geologic Setting

The dam is located in a steep-sided valley where Long Pine Run cuts across a high ridge of relatively resistant Weverton Formation (Fig. 12). The Weverton is a gray-green quartzitic sandstone at this location. The strike is N30°E (roughly parallel to the dam's axis) and the dip is about 40°SE (downstream). While faults have been mapped at loca-










BORROW
AREA

LONG PINE
RUN DAM

BIRCH RUN
DAM

LEGEND

-  TOMSTOWN DOLOMITE
-  ANTIETAM QUARTZITE
-  HARPERS UPPER FORMATION
-  HARPERS UPPER MONTALTO
-  HARPERS LOWER MONTALTO
-  WEVERTON QUARTZITE
-  LOUDOUN PHYLLITE FORMATION

AREAL GEOLOGY
LONG PINE RUN DAM
AFTER
GEOLOGY OF THE CALEDONIA PARK
QUADRANGLE AREA
SOUTH MOUNTAIN, PA.
GEOLOGIC SURVEY A129a
GANNETT FLEMING GEOTECHNICAL ENGINEERS, INC
HARRISBURG, PA.

Figure 12.

tions both north and south of the damsite, and their projected extensions would pass through the dam foundation, no displacement was observed in the rocks exposed during construction.

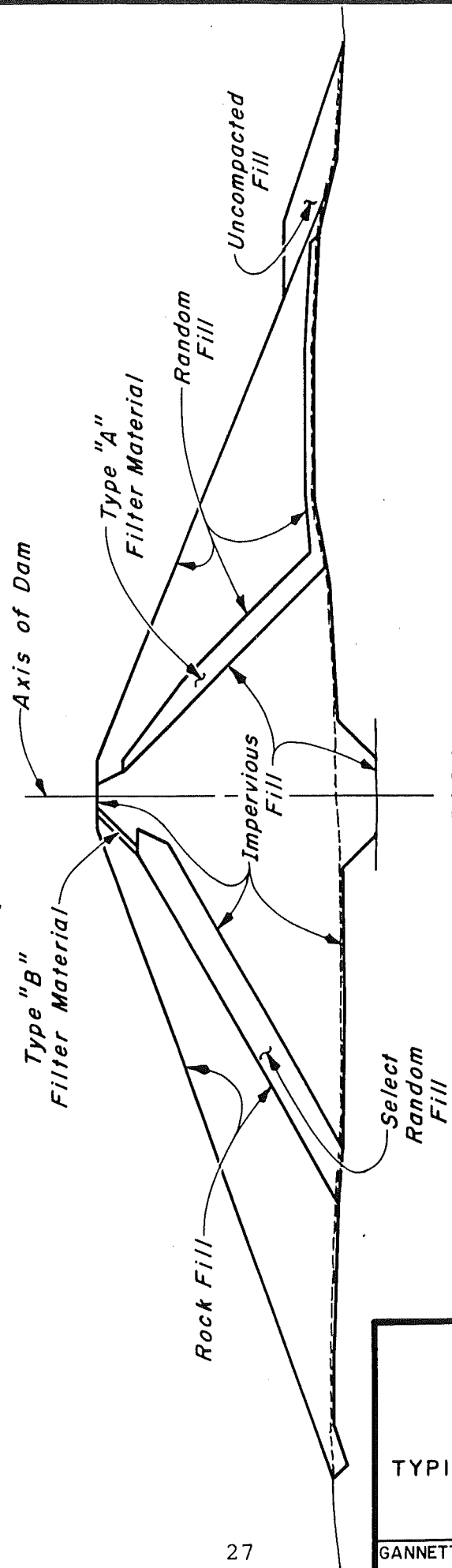
Geotechnical Problems

While the site was well suited to construction from a topographic sense, it did present some special problems in constructing the dam. Because the Weverton is a competent unit, it has been extensively fractured by tectonic activity. When the rock surface was exposed in a cutoff trench excavation along the centerline of the embankment, a blocky irregular surface was exposed which had numerous open cracks up to about 3 inches in width. While the irregular surface provided a good rock to fill interface, closing the numerous fractures was a significant problem. The removal of loose rock was only practical for a few feet. The irregular, interlocked nature of the remaining foundation would have required extensive blasting for continued removal. In addition, numerous overhanging surfaces were found which could not remain. A positive slope is necessary to ensure that placed fill remains in contact with the foundation after consolidation and loading. A grouting program had been anticipated and was included in the design, but the excavation of a uniform notch in which to place a "grout cap" was virtually impossible in the foundation which was exposed.

Several design changes were made to accommodate these conditions. It was decided that loose rock would be removed to the practical limit of vigorous, normal equipment, and hand methods. The remaining surface was cleaned by hand, air, and water. Overhanging areas were removed by trimming where possible and the remainder were corrected by placing extensive "dental" concrete. Concrete fill was also placed in numerous angular depressions and in all fractures which were large enough. Pipes were placed in every possible crack and a program of low-pressure preliminary grouting was completed to close as many openings as possible. The "grout cap" was eliminated as being impractical. A triple grout curtain, by stage grouting methods, was then carried out with careful attention to final results.

After grouting was completed, the embankment was constructed in the usual manner (Fig. 13). Only one known leak has been detected after several years of operation. When the reservoir is full, a clear flow of a few gallons per minute develops near the lower end of the spillway. Water is believed to be leaking through an unclosed fracture in the area between the dam and the spillway. The leak has been clear and unchanging throughout its history and it is not believed to be causing damage to the embankment or its foundation. No effort has been made to correct this minor leak.

Finding adequate impervious fill, in an area where most



TYPICAL
EMBANKMENT SECTION

Figure 13.
LONG PINE RUN DAM
SCHEMATIC
TYPICAL EMBANKMENT SECTION

formations do not weather to a deep fine-grained soil, was a problem. The only material identified as being suitable without excessive haul distance was along the Tomstown Dolomite outcrop north of the dam. A borrow area was developed between the two branches of Long Pine Run. Sufficient fill material was taken from this location and after construction, the area was regraded and planted with trees. Rockfill and random fill materials were obtained from the spillway excavation. Filter materials were imported from offsite commercial sources.

RETURN to PA Route 233.

- (41.1) TURN RIGHT on PA Route 233 toward Caledonia.
0.4
- 41.5 Caledonia State Park entrance on right.
0.3
- 41.8 Franklin County line.
0.6
- 42.4 Caledonia State Park entrance on right. An iron furnace was built here in 1837 and supported a small community. It was later purchased by Thaddeus Stevens, and was destroyed by Confederate troops in 1863. The State has owned the Park since 1902 (Shirk, 1980).
0.1
- 42.5 TURN RIGHT on US Route 30 toward Chambersburg.
0.1
- 42.6 Thaddeus Stevens blacksmith shop on right.
1.9
- 44.5 TURN LEFT onto Stump Road at red and white sign for Mt. Cydonia Sand.
0.5
- 45.0 TURN RIGHT on Mt. Cydonia Road.
0.3
- 45.3 Pavement ends, Mt. Cydonia Quarry office and plant on left. CONTINUE straight ahead on dirt road. If coming here on an independent trip, stop and obtain permission at office.
0.3
- 45.6 TURN LEFT on Kettle Spring Road.
0.2
- 45.8 Where dirt road cuts off to left toward quarry, stop and PARK.

STOP 6. MOUNT CYDONIA SAND COMPANY PIT. J. Peter Wilshusen and William D. Sevon, Pennsylvania Geological Survey.

The purpose of this stop is to examine the Antietam Quartzite and some of the features which occur within the unit, in particular some spectacular megaripples and the trace fossil Skolithus linearis. Both occur in the quarry to your left as you stopped to park. In addition, good exposures of colluvium occur in the pit to the right as you parked and show the type of surficial material which covers the slopes of South Mountain in many places.

The following statement about the megaripple occurrence is modified from an article which originally appeared in Pennsylvania Geology (February, 1981, v. 12/1, p. 2-8). After

examining the rocks, reflect upon the following questions:

1) Does the proposed origin of the megaripples seem reasonable? What alternative origin might be suggested?

2) What information about the source area can be derived from these rocks?

GIANT RIPPLES AT MOUNT CYDONIA

by J. P. Wilshusen and W. D. Sevon

A magnificent exposure of huge, ancient sand megaripples (Fig. 14) is presently exposed in an active quarry of the Mount Cydonia Sand Company near Fayetteville in southeastern Franklin County, Pennsylvania. These megaripples occur near the middle of the Early Cambrian Antietam Quartzite which is exposed along the north side of South Mountain (Fig. 15).

The Antietam Quartzite at Mount Cydonia is a clean, coarse-grained, quartzose sandstone. The sand grains comprise almost entirely subangular to well-rounded quartz, accompanied by rare grains of chert. Quartz overgrowth on the grains are common and these, as well as intergranular quartz, serve as the binder for the rock. The formation has two lithologic subdivisions: a lower resistant, bluish to pink quartzite which varies from structureless, to planar bedded, to thin beds with small-scale, multi-directional cross-bedding and an upper white to pinkish sandstone containing abundant Skolithos tubes (fossil animal burrows). The prominent megarippled surface (Fig. 14) is the approximate boundary between the two rock varieties. The Antietam is about 800 feet thick in the quarry and varies regionally from 700 to 900 feet thick (Stose, 1932).

The Antietam Quartzite was folded during the post-Ordovician period mountain building which formed the South Mountain anticlinorium and gave the present 70° northwest dip to the megarippled beds. This deformation also imparted to the Antietam a spaced cleavage which dips perpendicular to the bedding and strikes approximately parallel to bedding.

The trace fossil Skolithos linearis occurs in profusion in the upper part of the Antietam and superb examples can be seen in unquarried rock faces and in numerous quarried blocks. In weathered rock Skolithos linearis appears as a remarkably straight, sand-filled tube which has a circular cross section. These tubes are prominent on weathered surfaces because of differential weathering of the apparently less well-cemented tube. Skolithos is not readily discernable in fresh rock. These tubes are thought to have been formed by a worm that lived in the tube and may have fed at or near the sediment-water interface. Skolithos linearis is found almost exclusively in sandstones and is one of a suite of trace fossils interpreted to be associated with dominantly high energy

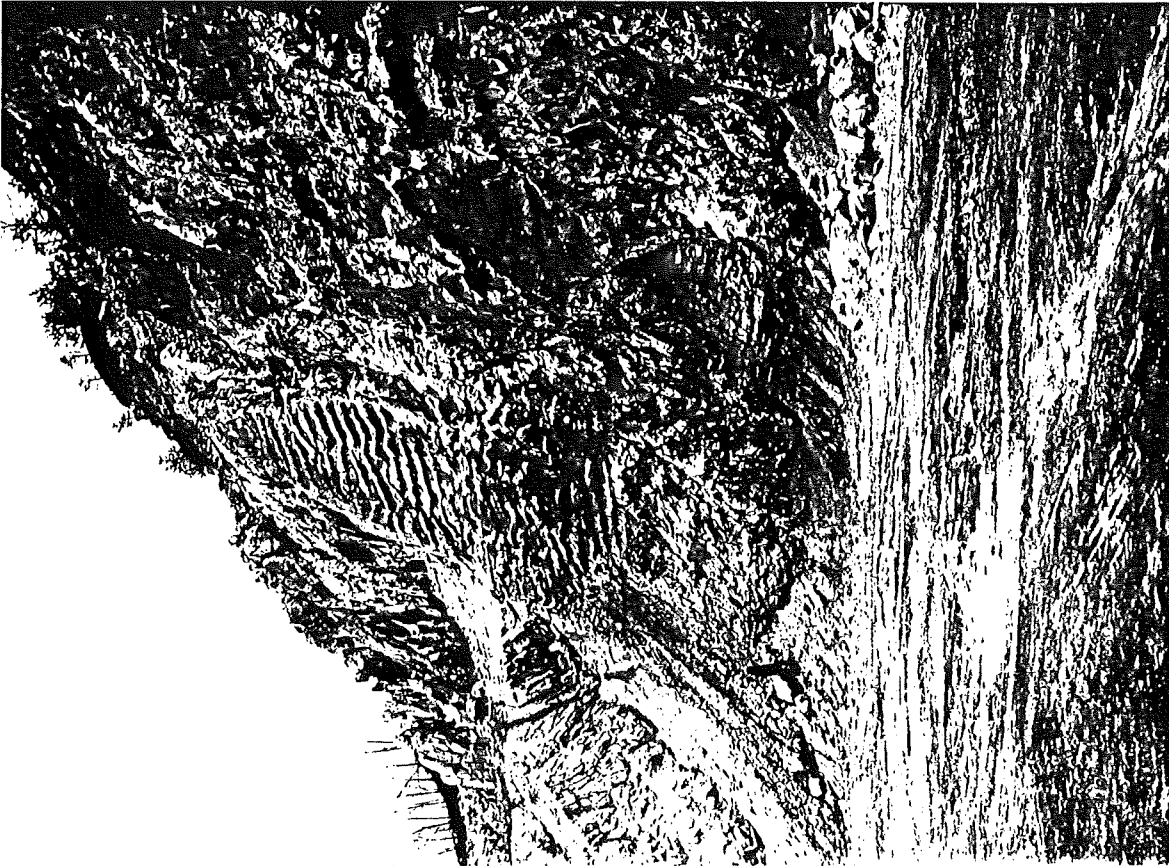


Figure 14. Corrugated surface of megaripples in Lower Cambrian Antietam Quartzite.

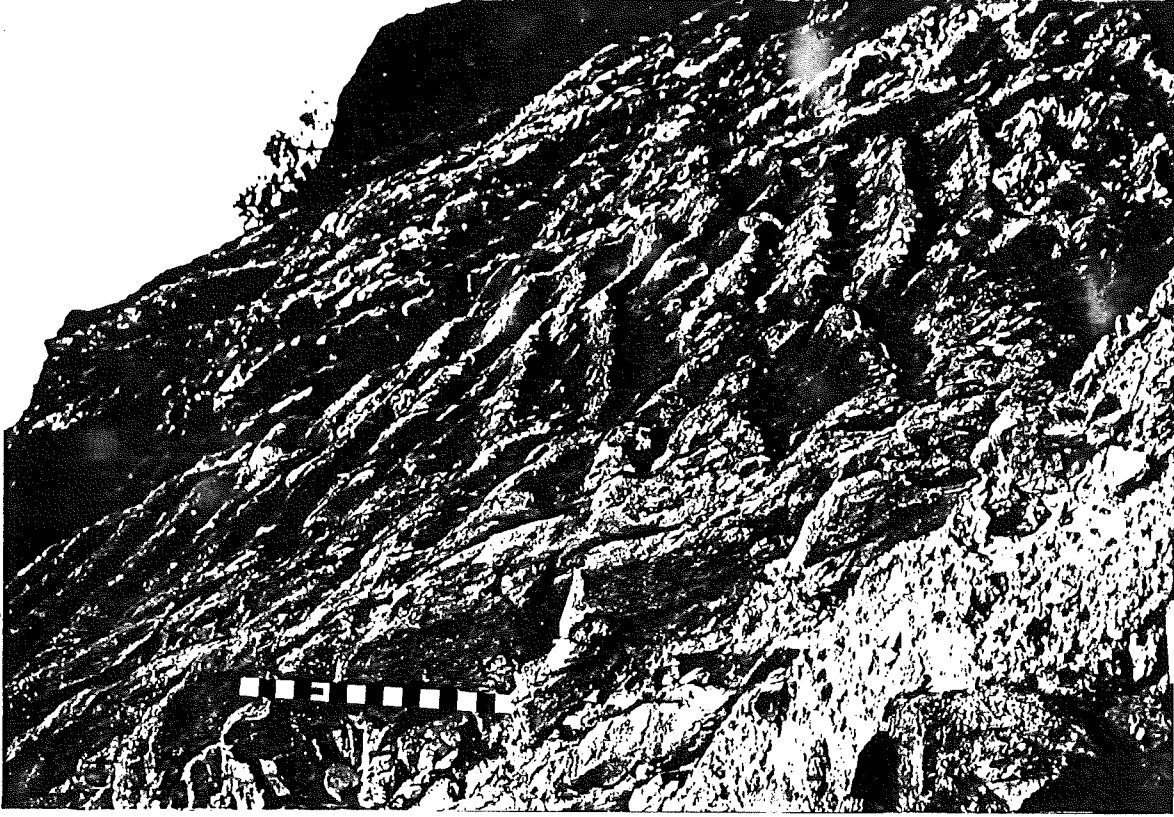
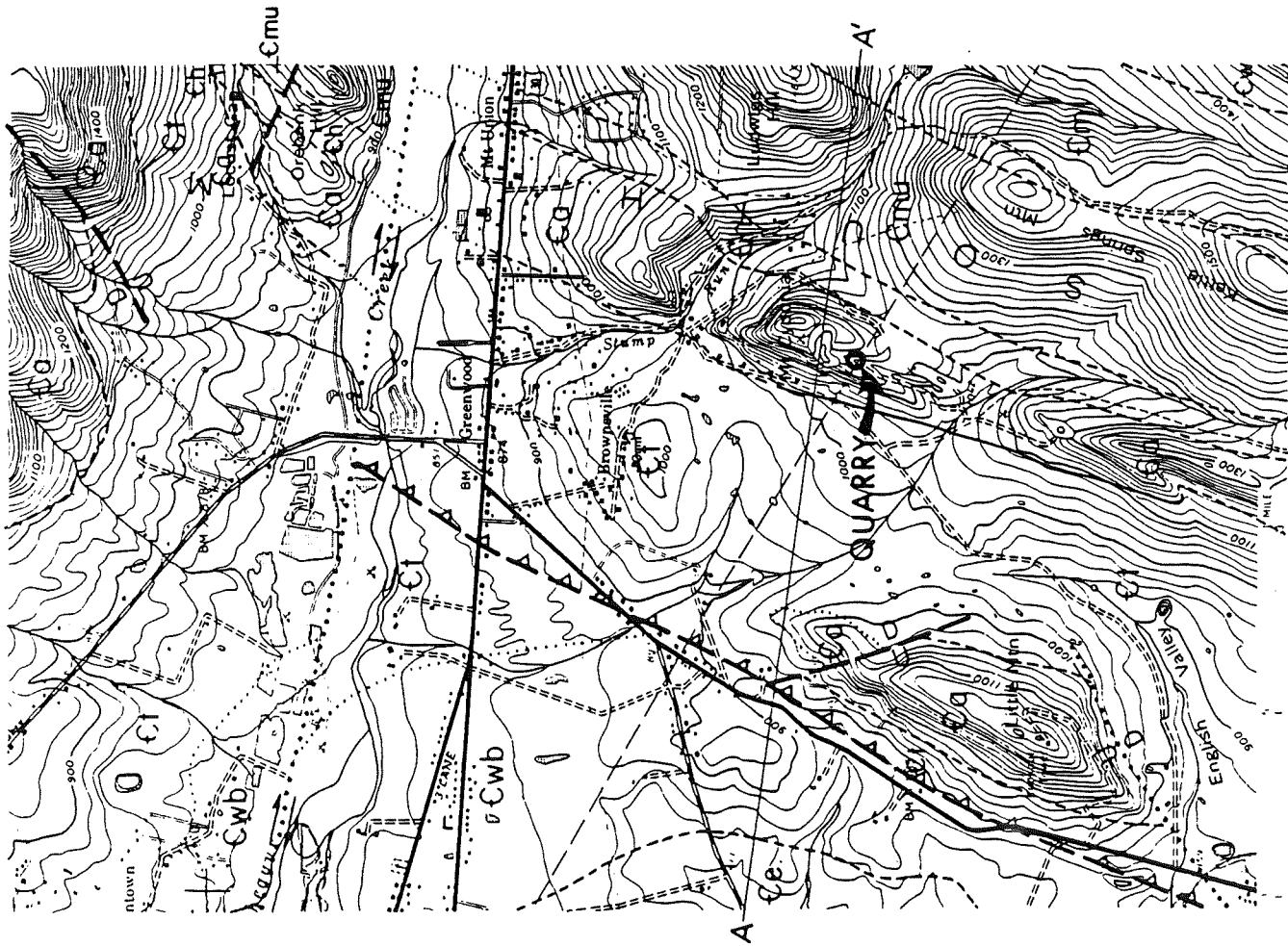


Figure 16. Asymmetrical megaripples in Antietam Quartzite. Scale interval: 10 cm.



From Fauth, 1968

LEGEND

Ce

ELBROOK FORMATION

Gray limestone and calcareous sandstone with finely laminated, shaly limestone in lower half.

Cwb

WAYNESBORO FORMATION

Bluish limestone and dolomite with interbedded sandstone and shale.

Ci

TOMSTOWN FORMATION

Gray dolomite with interbeds of white limestone.

Ca

ANTIETAM QUARTZITE

White to gray, medium- to coarse-grained sandstone and quartzite.

Ch, Emu, Cml

HARPERS FORMATION

Greenish-gray graywacke, Harpers Formation (Ch), light-gray sandstone and quartzite, Upper Montalto Member (Emu), gray, thin-bedded sandstone and quartzite, Lower Montalto Member, (Cml).

Cw

WEVERTON FORMATION

Interbedded sandstone and graywacke with conglomerate and phyllite intervals.

SYMBOLS

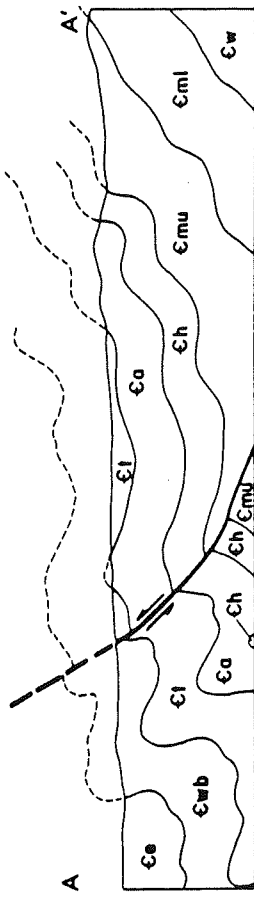


Thrust fault



Line of cross section

CROSS SECTION



Scale: Same as map
No vertical exaggeration

From Fauth, 1968

Figure 15. Geologic map and cross section.

shallow marine depositional environments such as offshore bars and beaches and, to a lesser degree, deeper offshore sediments (Banks, 1970). Its presence, as well as rare marine fossils reported from other localities (Fauth, 1968), establishes a marine origin for the Antietam Quartzite.

The megaripples which occur below the zone of Skolithos tubes have amplitudes of 5 to 10 inches and wave lengths of 18 to 30 inches (Fig. 16). The megaripples are asymmetrical in cross section and have unidirectional foreset laminae which dipped northwest prior to folding. Individual megaripples are laterally persistent and vary from linear to slightly sinuous. The crests of the megaripples are rounded. Other beds near the megaripple horizon have rippled surfaces, but the ripples are smaller in scale. These ripples also have northwest dipping foreset laminae.

Megaripples are formed in sand under water by any of three mechanisms: (1) by unidirectional flow of water, such as in a stream, (2) by oscillatory motion of waves in shallow waters of oceans or lakes, and (3) by combination of (1) and (2), such as in a tidal channel. A wave-generated origin in which oscillatory flow is stronger in one direction, generally landward, than the other seems probable for the Mount Cydonia megaripples. Such an interpretation seems particularly reasonable because the megaripples occur between the lower part of the Antietam, which has sedimentary structures probably formed in ancient offshore environments below non-storm wave base, and the upper part, which certainly represents ancient near-shore deposition. Thus the megaripples represent wave-generated ripples formed during shallowing of water during deposition of Antietam sands.

Whether or not these megaripples formed along the real coast of the continent in Early Cambrian times or along barrier islands fronting the continent (Kauffman and Frey, 1979) is not known. However, acceptance of a wave-generated origin for the megaripples and a landward dip for their foreset layers supports the concept that the source area for the Antietam Quartzite lay to the northwest and that the development of the southeastern source area which dominated most of Paleozoic deposition in Pennsylvania occurred after deposition of the Antietam Quartzite.

RETURN along road used for entrance.

0.2

46.0 TURN RIGHT.

0.3

46.3 Office and plant on right.

0.4

46.7 TURN LEFT on Stump Road.

0.5

47.2 STOP sign. TURN LEFT on US Route 30.

0.2

47.4 TURN RIGHT on PA Route 997 toward Scotland.

0.3

47.7 CROSS Conococheague Creek. The gravel operation on the

left is also operated by Mount Cydonia Sand Co. Alluvium from Conococheague Creek is screened and washed here. Pierce (1966) has noted that the Conococheague Creek now carries roundstones of Catoctin volcanics, but that older "roundstone diamictons" that occur adjacent to and above the present floodplain of Conococheague Creek do not contain Catoctin volcanics. He infers that the Catoctin volcanics were deposited in the older roundstone diamictons, but have since been destroyed by weathering.

- 0.9
- 48.6 Orchard on left. For the next couple of miles, the route is over colluvial and alluvial quartzite from South Mountain. Numerous shallow karst depressions in the surficial deposits can be seen on both sides of the road. Depths to bedrock in several wells near here are 150-200 ft.
- 3.8
- 52.4 Chambersburg Mall on left. The steep cut bank at the southeast end of the parking lot contains rounded cobbles of quartzite up to 3 inches in diameter.
- 0.2
- 52.6 TURN RIGHT on Interstate 81 North. I-81 from here to near Carlisle traverses Middle and Upper Cambrian carbonates of the Elbrook, Zullinger, and Shadygrove Formations. The route from the Cumberland County line near Shippensburg to Mechanicsburg can be followed on the geologic map in Becher and Root (1981).
- 4.1
- 56.7 Fayette Street, Exit 9.
- 2.2
- 58.9 Colluvium from South Mountain can be seen in the barnyard on the right.
- 2.2
- 61.1 King Street, PA Route 174, Exit 10.
- 4.4
- 65.5 Large depression on left was excavated when I-81 was constructed. The depression is surrounded by colluvium and/or alluvium from South Mountain.
- 4.1
- 69.6 Newville Exit, PA Route 233, Exit 11.
- 0.5
- 70.1 Rest Area on right.
- 6.7
- 76.8 Plainfield, Exit 12.
- 0.4
- 77.2 On right, spectacular pinnacle weathering in Ordovician Rockdale Run Formation was exposed when soil was stripped during construction of I-81.
- 1.2
- 78.4 College Street, Exit 13.
- 1.1
- 79.5 Hanover Street-Mount Holly Pike, Exit 14.
- 1.4
- 80.9 TURN OFF at York Street, Exit 15. (Note: There is no northbound exit at Trindle Road from I-81.)
- 0.2

- 81.1 STOP sign. TURN LEFT on PA Route 74.
0.1
- 81.2 TURN RIGHT on Fairfield Street.
0.4
- 81.6 TURN RIGHT on PA Route 641 (Trindle Road) and FOLLOW
to Mechanicsburg.
3.0
- 84.6 Tree-covered Ironstone Ridge is underlain by a Triassic
diabase dike. Where the dike is exposed on the Pennsyl-
vania Turnpike about a mile to the north of here, it is
near-vertical and about 50 ft wide.
2.2
- 86.8 Village of Locust Point.
1.2
- 88.0 CROSS over Pennsylvania Turnpike.
1.2
- 89.2 TURN RIGHT on West Simpson Street and FOLLOW through
Mechanicsburg.
2.4
- 91.6 TURN RIGHT into Windsor Park Shopping Plaza. END OF TRIP.

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