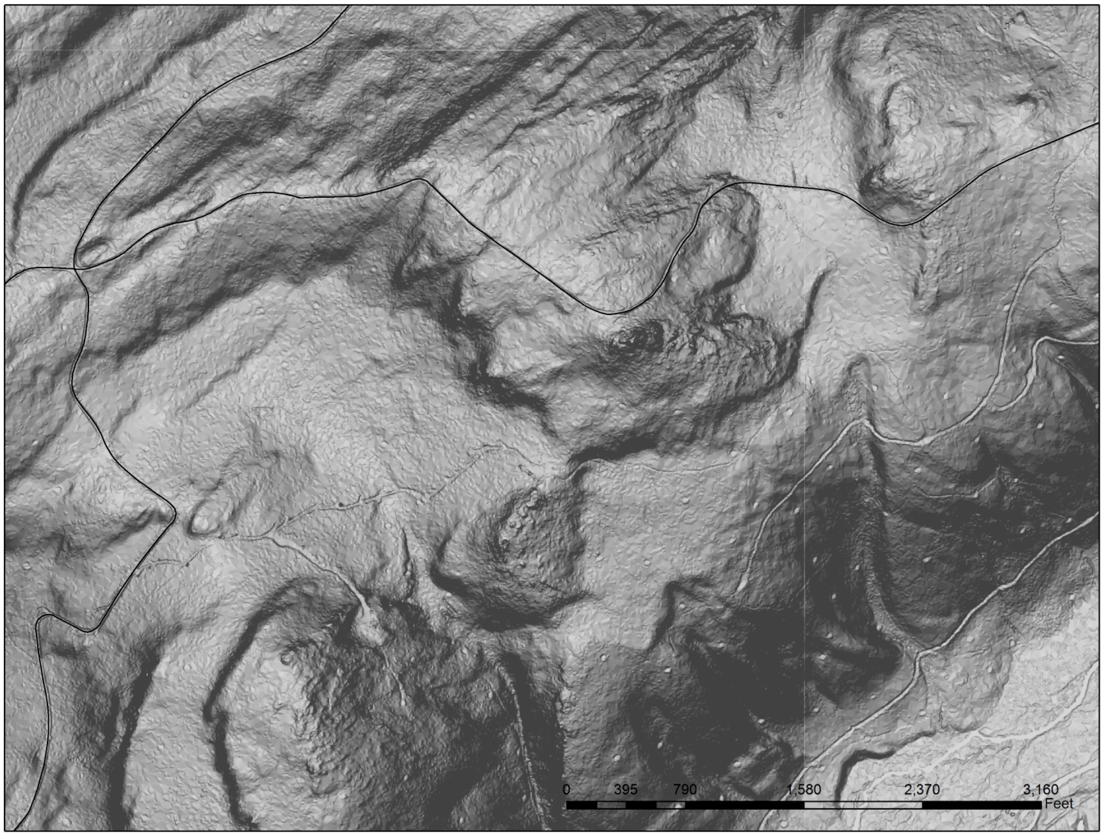
Harrisburg Area Geological Society
20th Field Trip

Geology and Geomorphology of the South Mountain Area, Cumberland and Franklin Counties, Pennsylvania



May 14, 2011

Guidebooks for HAGS Field Trips

1st Annual Field Trip- Geology in the South Mountain area, Pennsylvania, Noel Potter, Jr., editor, April 24, 1982, Reprinted 1992. 37 p. $5.00 plus $2.00 S&H.
2nd Annual Field Trip- Geology along the Susquehanna River, south-central Pennsylvania, J. Ronald Mowery, editor, April 16, 1983, 55 p. $5.00 plus $2.00 S8H.
3rd Annual Field Trip- Stratigraphy, structural style, and economic geology of the York-Hanover Valley, G. Robert Ganis and David Hopkins, April 28,1984, 51 p. $5.00 plus $2.00 S&H.
4th Annual Field Trip- Pennsylvania's polygenetic landscape, William D. Sevon, April 27, 1985, Reprinted 1992, 55 p. $5.00 plus $2.00 S&H.
5th Annual Field Trip- Selected geology of Dauphin and Northumberland Counties, Pennsylvania, by W. D. Sevon, W. E. Edmunds, G. R. Ganis, and J. P. Wilshusen, May 17, 1986, 22 p. $5.00 plus $2.00 S&H.
6th Annual Field Trip- Lower Jurassic diabase and the Battle of Gettysburg, D. T. Hoff, J. R. Mowery, and G. R. Ganis, April 25, 1987,17 p. plus appendices. $5.00 plus $2.00 S&H.
7th Annual Field Trip- The geology of the Lower Susquehanna River area, a new look at some old answers, Glenn H. Thompson, Jr., editor, May 7,1988, 56 p. $5.00 plus $2.00 S&H.
8th Annual Field Trip- Karst development and environmental geology in the carbonate rocks of the Lehigh and Lebanon Valleys, William E. Kochanov, April 29, 1989, 33 p. $5.00 plus $2.00 S&H.
In cooperation with the 20th annual Binghamton Geomorphology Symposium at Dickinson College- The rivers and valleys of Pennsylvania, then and now, by William D. Sevon, October 20, 1989, 59 p. $5.00 plus $2.00 S&H.
10th Annual Field Trip- The Ridge and Valley Physiographic Province and the East Broad Top Railroad, William D. Sevon, June 1, 1991, 24 p. $5.00 plus $2.00 S&H.
11th Annual Field Trip- Paleozoic geology of the Paw Paw-Hancock area of Maryland and West Virginia, Marcus M. Key and Noel Potter, Jr., May 9,1992, 25 p. $5.00 plus $2.00 S&H.
12th Annual Field Trip- South Mountain and the Triassic in Adams County, Pennsylvania, Raymond Britcher, editor, May 22, 1993, 41 p. $5.00 plus $2.00 S&H.
13th Annual Field Trip- Geology of the Lebanon Valley and western end of the Reading Prong, Charles Scharnberger, editor, April 23. 1994, 68 p. $7.00 plus $2.00 S&H.
15th Annual Field Trip- Pseudo-Morainic Topography of the Allentown Area of Eastern Pennsylvania, Duane D. Braun and William E. Kochanov, May 4, 1996, 28 p. $7.00 plus $2.00 S&H.
16th Annual Field Trip- Notes on the Hamburg Klippe: biostratigraphy, ash layers, olistostromes, and "exotics," G. Robert Ganis, April 26, 1997, 52 p. $15.00 plus $2.00 S&H
17th Annual Field Trip- Geomorphology in the Northern Cumberland Valley, PA, including the Carlisle Deluge of 1779, Noel Potter, Jr., Donald Hartman, and Helen Delano, April 18, 1998, 49 p, $7.00 plus $2.00 S&H.
18th Annual Field Trip- The Cove Syncline by canoe, William M. Roman and Michael A. Knight, May 15, 1999, 16 p. plus maps, Out of Print
19th Annual Field Trip- Geology of the Kishacoquillas Valley and vicinity, Mifflin County, Pennsylvania, Michael A. Knight and William M. Roman, May 20, 2000, 18 p. plus maps and sections, $7.00 plus $2.00 S&H.
No formal guidebooks were prepared for the 9th (1990) and 14th (1995) Field Trips. The 2001 trip was a repeat of the 2000 trip.

Available from:
Harrisburg Area Geological Society, Joan Anderson, Treasurer, PA Dept of Military and Veteran Affairs, Bureau of Environmental Management, Environmental Compliance Division, Bldg. 0-11, Ft. Indiantown Gap, Annville, PA 17003 (717) 861-9414
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Harrisburg Area Geological Society
20th Field Trip

Geology and Geomorphology of the South Mountain Area, Cumberland and Franklin Counties, Pennsylvania

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May 14, 2011

Cover Image: LiDAR Shaded Slope Map of Hammond's Rock area. See Figure 26.

INTRODUCTION

HAGS has a long tradition of running field trips for its members and friends. The guidebooks listed on the back of the cover are a testament to our lively interest in our local geology. We should also not forget the wonderful trips that Don Hoff organized in the late 1980's to raft the Grand Canyon, explore Iceland, and see some of geology's roots in England and Wales. One of us (Noel) organized the first HAGS trip 29 years ago in 1982. The trip examined the geology of South Mountain, and indeed two of our stops on this trip, Hammond's Rocks and Pine Grove Furnace were visited on the 1982 trip. Why go back? We have learned new things since then, and hope to share the results of new technologies (particularly LiDAR) and discoveries with you.

HAGS almost died a few years ago. But fortunately new people, led by Jennifer Kehler, joined by Joan Anderson, Rose-Anna Behr, and a cast of supporters have brought the organization back to substantial attendance at meetings, lively discussion, and the field trips that we enjoy. An attendance of 50+ people for this trip is one more testament to the resurrection of HAGS. We are pleased that some members of the Baltimore-Harrisburg-Washington Chapter of the Association of Engineering Geologists will join us. We appreciate the help of Jennifer, Joan, and Rose-Anna in managing most of the logistics for our trip. Join us in thanking those who brought HAGS back to life.

We also thank Valley Quarries, particularly Randy VanScyoc and Fuzz Gehrett for permission to enter the Mainsville pit and courtesies at the pit regarding its history and operation.

We hope you enjoy the trip.

Noel Potter and Bill Sevon

Copies of this guidebook are available from:

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SOUTH MOUNTAIN OVERVIEW

If you drive along I-81 between Carlisle and the PA-MD state line, you get a lovely view to the southeast of South Mountain . From that distance it seems to be an elongate, wooded mountain with little of distinction to mark its existence. Nothing could be further from the truth. South Mountain (SM) is a geological and topographic complex. The geology of SM is shown in Figure 1.

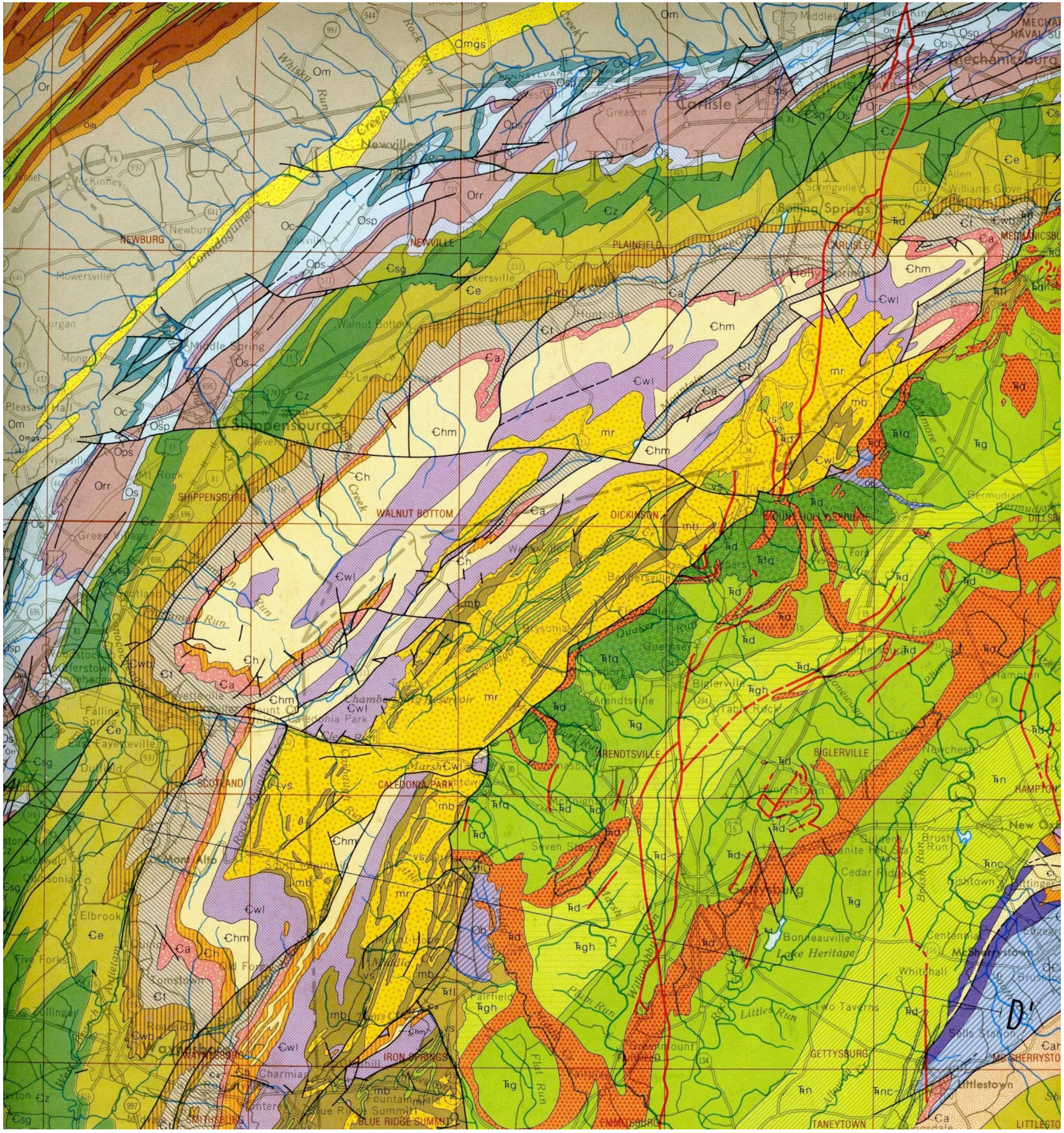


Figure 1. Geologic map of South Mountain (from Berg and others, 1980). Units are: Ce – Elbrook Fm., Cwb – Waynesboro Fm., Ct – Tomstown Fm., Ca – Antietam Fm., Ch – Harpers Fm., Chm – Harpers Fm., Montalto Mbr., Cwl – Weverton and Loudon Fms., mr – metarhyolite, vs – greenstone schist, mb –metabasalt, miscellaneous Triassic units including basalt, fanglomerate, and sedimentary formations.

SM is an anticlinorium that is short and broad and represents the southeasternmost subdivision of the Ridge and Valley Province (Faill, 1998, p. 148). Long considered to be the northern end of the Blue Ridge of Virginia and Maryland, this concept was discounted by MacLachlan (1991) and Faill (1998). This overview will look briefly at the general geology and topography of the mountain and will focus on the west side and crest of the mountain and deal minimally with the east side.

To the west of SM is the Great Valley Section, also known as the Cumberland Valley. This broad valley is underlain by numerous Cambro-Ordovician limestone and dolomite units. The structure is complex, the rock hardness variable, and the resulting erosional topography is varied with lowlands, low ridges, and drainage variations. Immediately adjacent to SM is an apron of colluvium that will be discussed later (Stop 6). The first rock unit forming SM is the Antietam quartzite. This resistant rock forms a steeply dipping, nearly vertical in most places, narrow ridge along the whole west side of SM. The quartzite is quarried at several locations, one of which is viewable at mileage 15.5 and another is viewed at its entrance at mileage 50.1. Excellent exposures of the Antietam occur at mileage 18.3. The ridge is cut by 19 streams between Mountain Creek at Mount Holly Springs and Conococheague Creek at Fayetteville. Stop 5 is a view stop to give some idea of what the mountain slope and the stream-cut notches look like from a moderate distance.

Each of these creeks drains a small basin that is underlain by Harpers Fm., phylite and schist with abundant quartz, and the Montalto Mbr., quartzite. Forming the upper part of SM is the Weverton Fm., quartzite and quartz conglomerate, and Loudoun Fm., phyllite interbedded with sandstone. These units will be seen at Stop 3, Hammond's Rocks. Hammond's Rocks is one of several tors produced by periglacial erosion during the Pleistocene. Some metarhyolite also occurs. The crest of SM gives way to slopes on the east side that are developed mainly on metarhyolite all the way east to the rocks of the Early Mesozoic Birdsboro basin (Faill, 2003). Axes of several anticlines trend with the length of SM, but are not very clear in Figure 1.

The east and west slopes of the main SM mass are littered with boulders and blocks of bedrock. These are well displayed on the routes traveled to get to and from Hammond's Rocks, mileages 25.4-30.9, and also mileages 33.4-35.7 when SM is again crossed. Occasionally an outcrop occurs on the slopes.

Topographically SM comprises basically NW and SE slopes and a variable upland. Near Scotland in southeastern Franklin County, carbonate outer reaches of SM occur at elevations around 700 ft. Almost due east is SM's highest point, 2,100 ft, just northeast of Methodist Hill. Slope elevations are quite variable and are controlled by the mountain's upland elevations that are generally less than 2,000 feet and the erosional resistance of the bedrock. Much of the upland is rounded but a large elongated area called Big Flat Ridge forms the crest of the mountain for about 5 miles (Fig. 2). This upland is noticeably flat when being crossed on Ridge Road and has elevations generally between 1,900 and 2,000 feet. This flat, and other smaller ones on SM, are thought to be the result of extensive cryoplanation, landscape flattening, caused by periglaciation during the Pleistocene (Clark, 1991, 84-90). For excellent overviews of

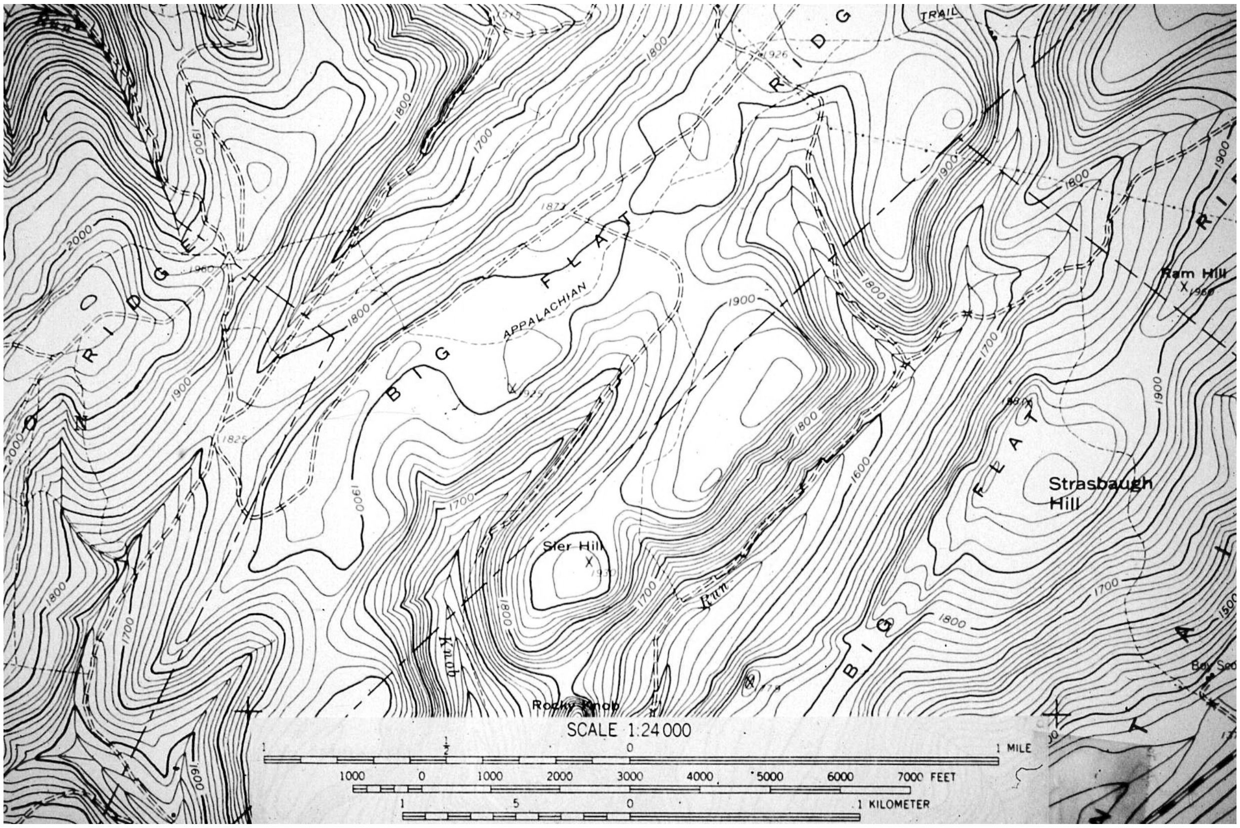


Figure 2. Small topographic area on the crest of South Mountain showing part of Big Flat Ridge and some of the local topographic variations.

the topography, study the 1:50,000 scale topographic maps of Adams, Cumberland, and Franklin Counties.

Figure 1 shows that SM is crossed by two large faults. The northern fault seems to have little effect on the topography. The southern fault caused greater offset of geologic units and apparently has been an area of considerable erosion. Conococheague Creek follows this fault to the easternmost head of the creek.

As stated earlier, the western margin of SM has an apron of colluvium. This apron is composed of material derived from erosion of both the Antietam and the older rocks that occur in the 19 drainage basins. The complexity of this fan is discussed at Stop 6. Of considerable importance is Stop 1B, Kings Gap Pond. This site is developed within the colluvial apron and is a vernal pond from which cored material was dated. Other such sites exist, but, except for Crider's Pond (Watts, 1979), they have not been cored or dated. The numerous undrained depressions on the surface of the colluvium reflect the development of karst topography on the underlying carbonate rocks. Such depressions are seen between milages 39.2 and 50.

SM is covered largely by Michaux State Forest and much of the access to the upland areas is provided by well-maintained state forest roads. Long range views of adjacent low areas such as the Cumberland Valley are not abundant because of the extensive forest that obscures views even in the winter when leaves are gone. The best view to the west is at the Kings Gap Environmental Education Center reached by continuing up the mountain on the road at mileage 10.4.

Two sites on the trip are only marginally a part of the mountain per se. Stop 2 is at a legacy sediment site south of Mount Holly Springs. Legacy sediments are sediments that accumulated behind long-gone mill dams (Walter and Merritts, 2008). Reconnaissance work in the SM margins indicates that Stop 2 is probably only one of several such sites near SM. Stop 4 is Pine Grove Furnace where locally derived iron ore was processed. In addition, we hope to show the value of LIDAR for examination of topographic features that are not clear on regular aerial photographs, such as at Stop 1A.

We hope you enjoy this trip, learn a lot, and will perhaps be inspired to do some research in the area.

ABOUT THE LIDAR IMAGES IN THIS GUIDEBOOK

LiDAR (Light Detection and Ranging) is becoming popular for depicting topographic surfaces in great detail. A laser beam scans surfaces and the time of return pulses is recorded. Through computer processing, a detailed image of the surface can be presented or manipulated in 3D.

Airborne LiDAR is obtained from a plane by an instrument that scans a swath of ground, measuring the time delay of reflected pulses. Location is obtained from GPS and inertial measurements in the plane. In forested terrain, especially if flown in the spring when leaves are off, some pulses make it through branches to the ground and return. Multiple pulses from objects at different heights can be distinguished. The returns can be processed to use only those pulses that go the greatest distance to produce a “bare earth” digital elevation model (DEM), the stuff of geomorphologists’ dreams!

We are fortunate that Pennsylvania is one of the few states with LiDAR and various derived products, including DEM’s for the entire state. The data is available to all users through PAMAP. Vertical accuracy of PAMAP LiDAR data is 18.5 cm (7 inches) in open areas and 37 cm (14 inches) in tree cover. PAMAP DEM's are gridded with a 3.2 foot (1 m) pixel size. Also available are files of 2 foot contours—much better than the old standard USGS topographic maps.

PAMAP orthophotos and LiDAR data are freely available to all through the Pennsylvania Spatial Data Access site (www.pasda.psu.edu). Files can be downloaded for use in GIS software. Numerous software products can produce images or perform analysis using LiDAR data. LiDAR derived images in this guidebook are Shaded Slope Maps—where each pixel's value reflects steepness of slope, and the darker the color the steeper the slope.

Another useful visualization tool for LiDAR is a hillshade image, where calculated brightness represents effects of a false sun angle in the modeled landscape. A statewide hillshade image can be viewed from a link at www.pamap.dcnr.state.pa.us Higher resolution hillshades, or ones with other sun angles can be made with GIS software from the LiDAR DEM files.

Terrestrial LiDAR is obtained on the ground by tripod- or vehicle-mounted instruments, often of buildings, engineering works (e.g., bridges, road cuts, etc), or even large outcrops.

HAGS FIELD TRIP ROAD LOG AND STOP DESCRIPTIONS

Mileage	
0.0	Leave parking lot of Kaufman Hall, Dickinson College, NE corner of Cherry and W Louther Streets, Carlisle, PA. Turn LEFT onto Cherry St. Immediate STOP at Stop sign for W. Louther St. Go STRAIGHT AHEAD.
0.1	Traffic light. TURN RIGHT onto W. High St.
0.3	TURN LEFT onto Mooreland Ave.
0.5	Stop sign. Go STRAIGHT AHEAD crossing W. South St.
1.2	Traffic light. Turn RIGHT onto Walnut Bottom Rd. Follow this road under I-81 and through several traffic lights.
3.1	Traffic light at PA 465. Go STRAIGHT AHEAD.
4.4	Cross Burnt House Rd. Go STRAIGHT AHEAD.
5.9	Note lovely karst topography on the LEFT.
7.2	TURN LEFT at junction of PA 174 E onto Montsera Rd. DO NOT do an extreme left onto PA 174.
7.7	BEAR LEFT at road fork. Coming ahead is a good view of South Mountain.
8.2	BEAR RIGHT on Montsera Rd.
8.3	Cross railroad tracks.
8.4	Cross Yellow Breeches Creek.
8.6	Stop sign. TURN RIGHT onto Pine Rd. followed by an immediate LEFT onto road to Kings Gap Environmental Education Center (Figs. 3 and 4). On both sides of the road there are abundant sandstone cobbles derived from South Mountain. These overlie Cambrian Tomstown dolomite at depth.
9.1	Entrance to Kings Gap Pond on left. Go STRAIGHT AHEAD.
10.4	At curve to left, go STRAIGHT AHEAD to Pond Area.
10.5	**STOP 1A. Pond Area.** PARK in parking area. Here are last rest rooms before lunch.

From the parking area we will examine 2 small features on the enlarged LiDAR image, which is near the greatest extent of good resolution (Fig. 5). First we will walk W along a short trail that encircles the first feature labeled "Lobe" W of the parking lot. Note that the lobe is tongue-shaped and has a steep front about 5 m high. You can also walk back along the entrance road over a second lobe and along a trail beneath its steep front. A third lobe marked on Figure 5) SW of the parking lot is larger with a front about 10 m high. In addition, a prominent N-S trending steep front ~10-15 m high is uphill E of the parking area.

These features are lobes and a sheet that consist of bouldery colluvial rubble that has moved down hill some time in the past. There is no evidence that they are moving now. Similar features occur in abundance on South Mountain. We shall see more.

We interpret these features as solifluction or gelifluction sheets and lobes as periglacial features that formed during the Late Wisconsinan, 18,000-12,000 yr ago when glaciers were approximately 100 km north of here. We will present evidence of a cold periglacial climate here at Stop 1B. Stay tuned. For the moment, note how rather small and subtle features can be seen on the LiDAR images that cannot be seen through the forest on standard aerial

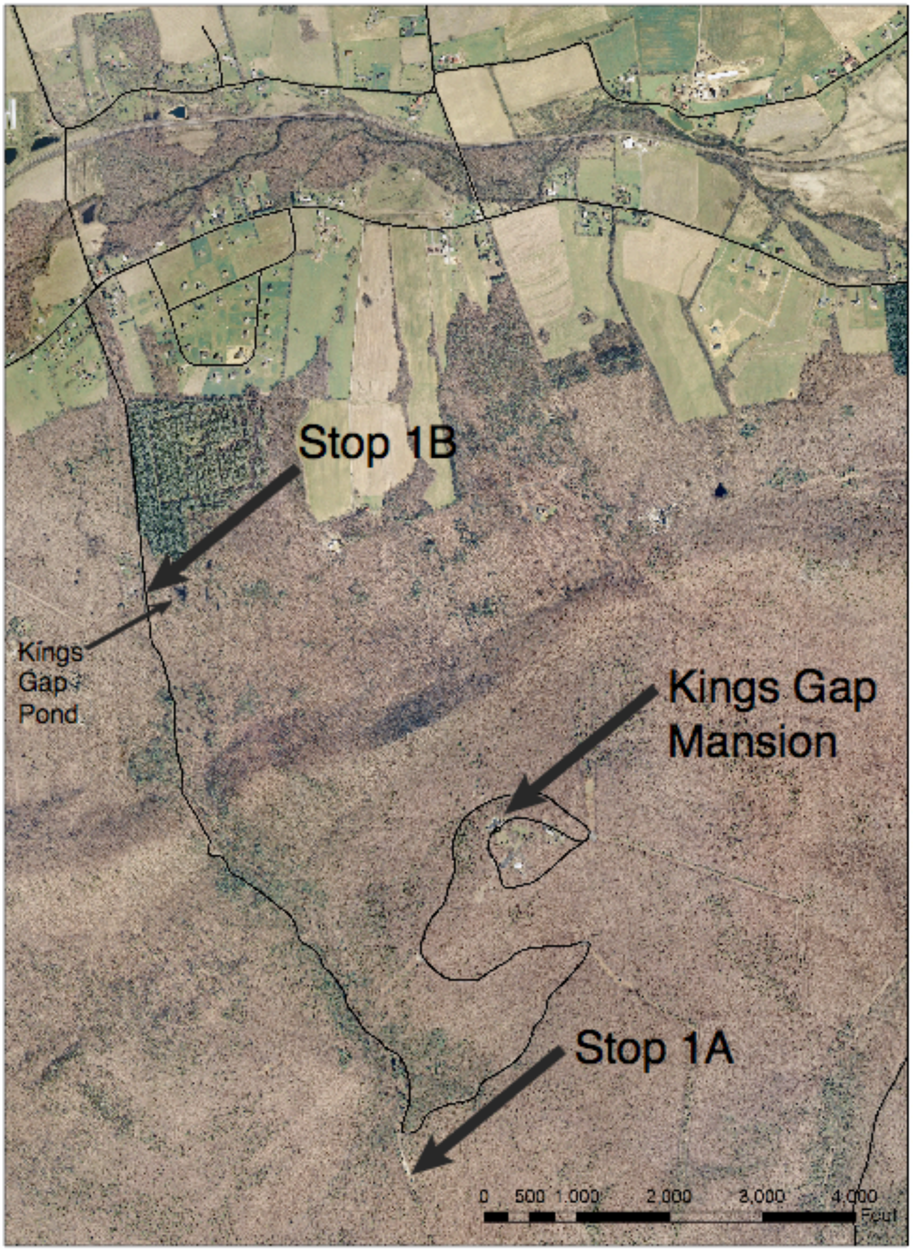


Figure 3. Orthophoto from PAMAP showing locations of Stops 1A and 1B in Kings Gap State Park. Compare to Fig. 4.

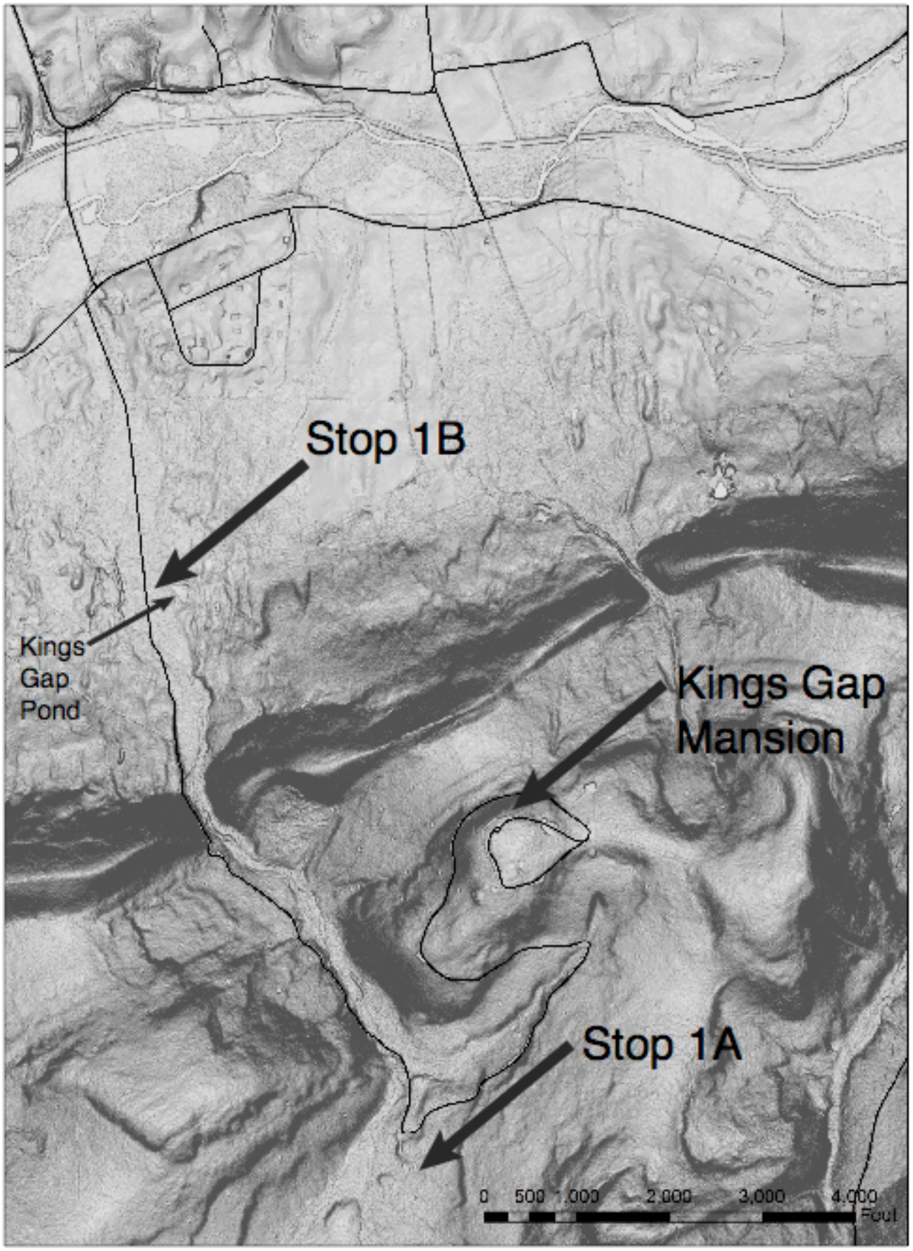


Figure 4. LiDAR Shaded Slope Map from PAMAP showing locations of Stops 1A and 1B in Kings Gap State Park. Compare to Fig. 3.

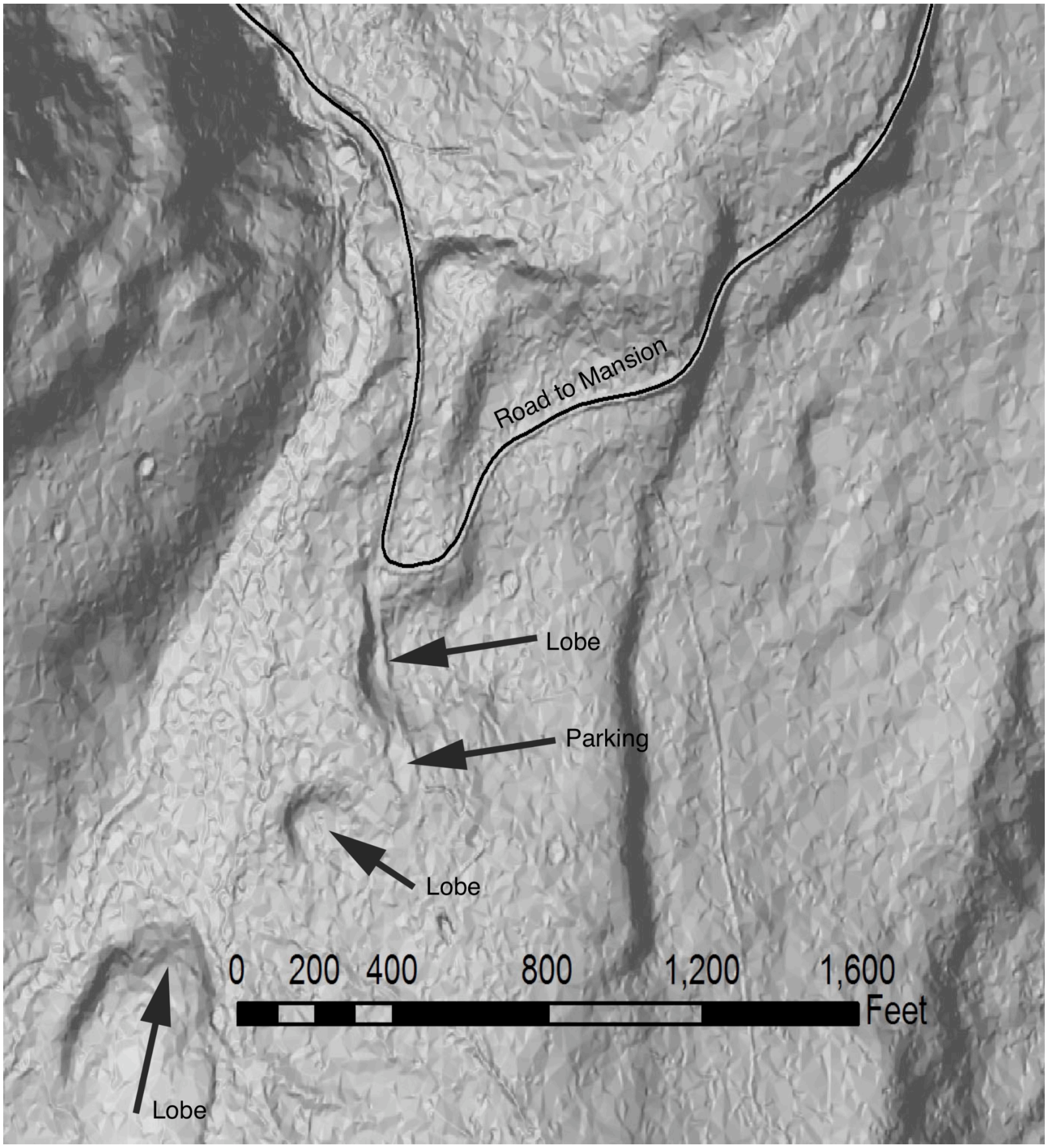


Figure 5. LiDAR Shaded Slope Map of Stop 1A area.

photographs, and that might even be otherwise missed by walking through the woods.

LEAVE parking area and RETURN the same route going downhill.
10.6 Stop sign. STRAIGHT AHEAD. Note colluvial debris along the road.
11.3 Antietam quartzite outcrop on LEFT.
11.7 Small bridge. Now out on the colluvial flat. Note boulders.
11.9 **STOP 1B. Kings Gap Pond.** Park on RIGHT side of road.

Access to the pond (Fig. 6) is a short walk along a dirt service road with a "No Parking" sign on a wooden post in the middle of it a short distance from the paved road. This is opposite a driveway to 2 houses, one with a wooden rail fence. For parking it is best to go on up the road a short distance, turn around and park on the E side of the road facing N. To get to pond, walk up service road about 150 m past the first spur off to the right. At the second spur to the right, turn S at right angles to the road you've been walking on and follow an indistinct path up over a gentle rise to the pond.

Figure 6. Kings Gap Pond (1/2008) looking SE at moderate mid-winter height. In a very wet Spring the pond overflows an outlet behind the photographer. In a dry Summer, the pond is reduced to a muddy puddle occupying the space well beyond the logs in water.

There are three parts to our story here: 1) Kings Gap Pond and what it tells us about past climate, 2) lobate features just to the S & E of KGP, and 3) karst topography from the lobate feature northward.

<u>1) Kings Gap Pond</u> (KGP, Fig. 6 and 7) is a karst depression, a doline, formed by solution of the Lower Cambrian Tomstown dolomite deep beneath the colluvium of quartzite debris washed from South Mountain. Depth to bedrock here is a bit over 100 feet, based on nearby water well information. KGP is a vernal pond; that is, its level fluctuates significantly with the seasons. In late fall and winter it fills so that it is a meter or more deep, most years reaching maximum depth in Spring. During the summer water levels go down due to drainage and evaporation, and in some years KGP becomes a small mudhole near the NE corner of the pond

in Fig. 6. KGP is one of hundreds of similar vernal ponds on the NW flank of South Mountain, mostly formed as karst depressions in the colluvium/alluvium at the base of the mountain. The ponds are important habitat for several species of salamanders and frogs, which go to the ponds to breed (Wingert, 2001).

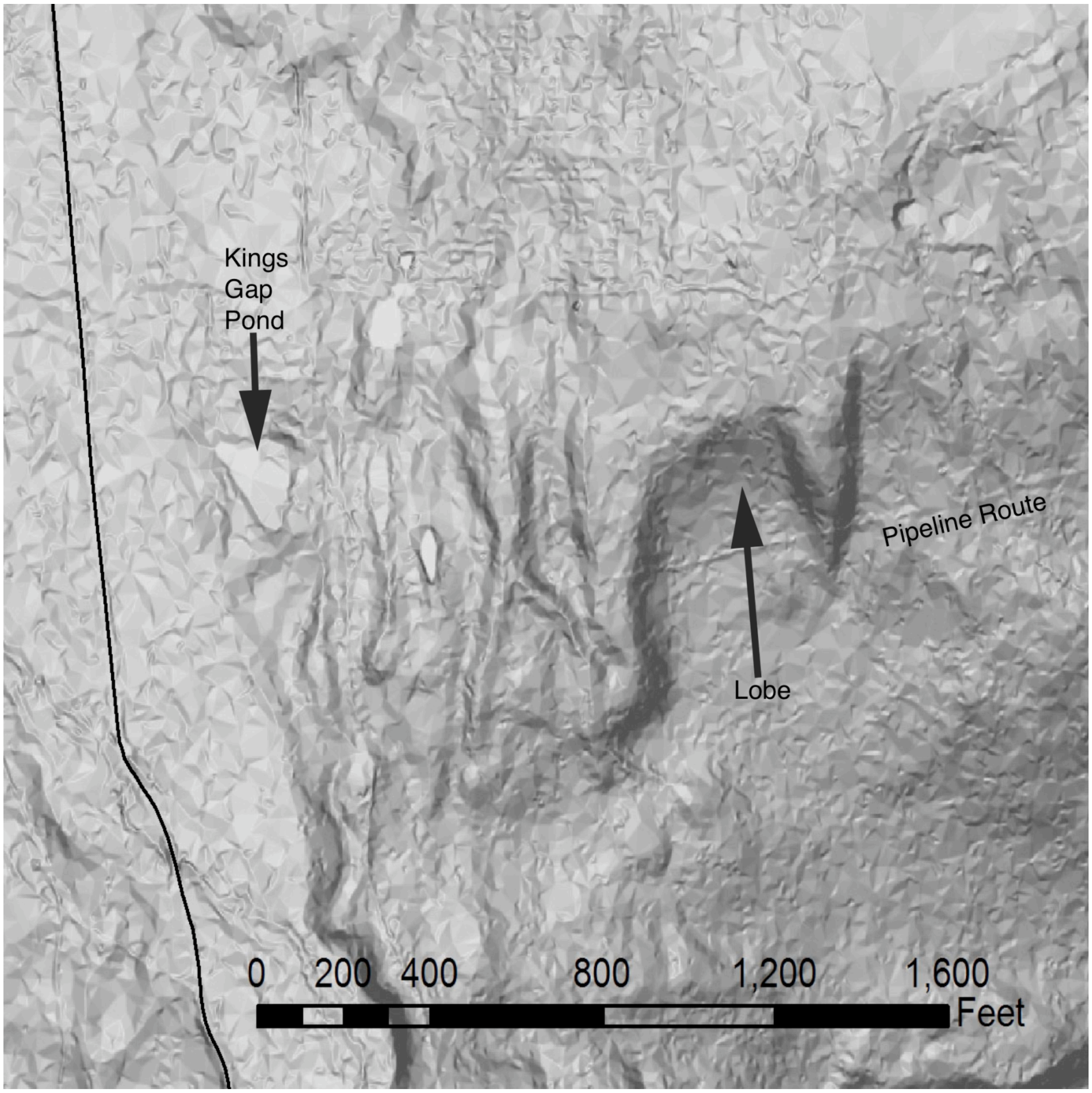


Figure 7. LiDAR Shaded Slope Map of Stop 1B area.

One of these vernal ponds, Crider's Pond, about 20 km SW of here and SW of Shippensburg, was cored in the 1970's, and Watts (1979) published pollen and plant macrofossil diagrams from it. The core there had a basal date of about 14,000 years BP, and the dominant vegetation then was spruce, followed by pine, then hardwoods to the present.

In January, 2001 Noel Potter, Bill Sevon, Helen Delano, and a cast of helpers cored KGP and obtained just short of 5 m of core (Delano and Potter, 2001; Delano, et al., 2002). We obtained a basal date on the core of 16,080 years BP and a date about half-way up of 14,450 years BP (Fig. 8). The sediment was alternating layers of silty clay and sand, with sand less abundant in the top meter. Norton Miller, of the New York Biological Survey, studied the plant macrofossils from the KGP core and in that core the dominant vegetation from the base to a bit above the 14,450 year date was tundra vegetation, with the key indicator *Dryas arctifolia*, a classic and distinctive tundra plant, along with dwarf willow also common on tundra. The tundra zone is followed by a spruce zone, then pine, then hardwoods to the present. Think of the vegetation one would traverse traveling from northern Hudson's Bay to our hardwood

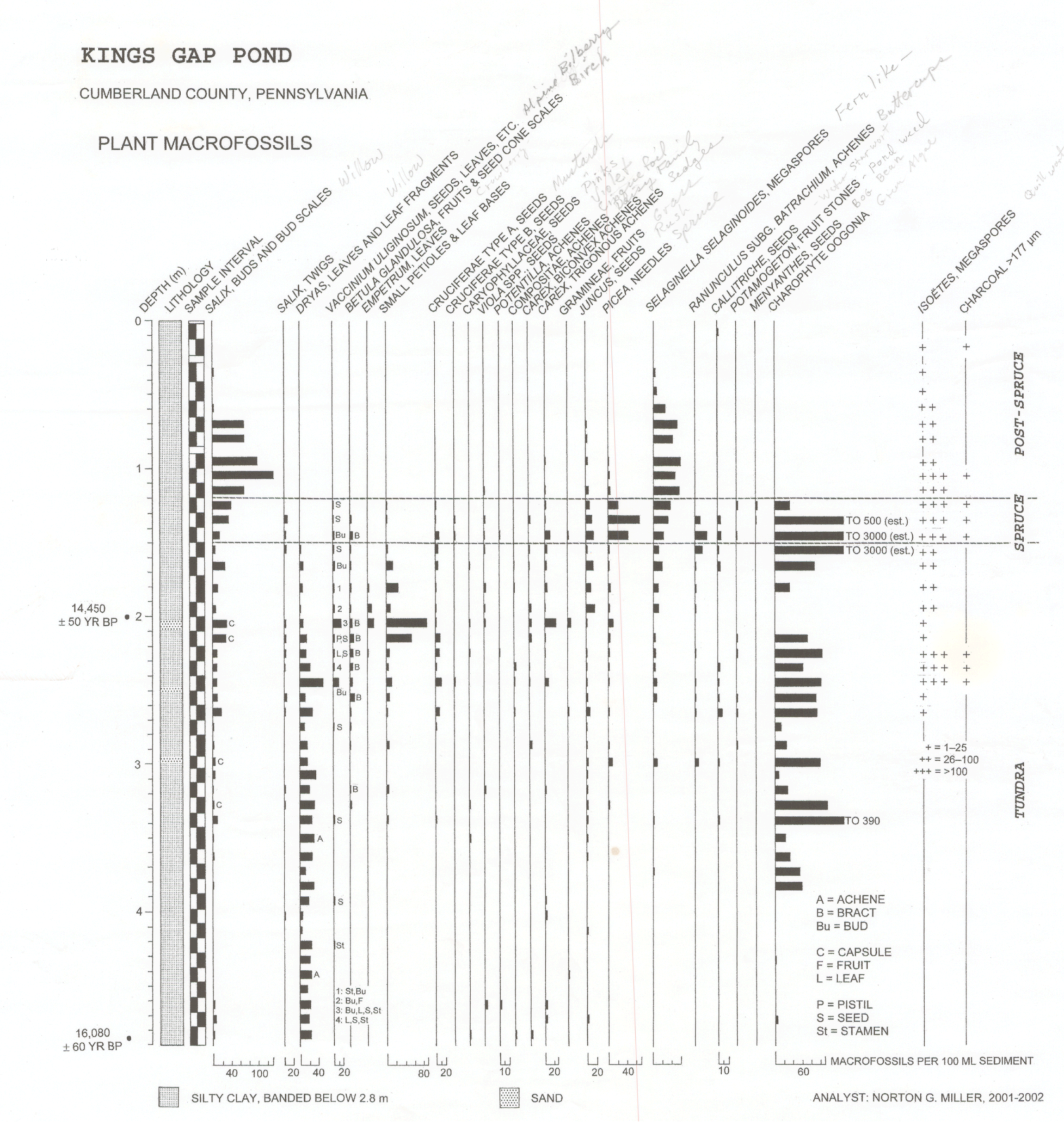


Figure 8. Norton Miller's Plant Macrofossil Diagram for Kings Gap Pond. Note two C-14 dates along left side, and plant zones along right side.

forests here. As one moves south to warmer climates one would leave the tundra to spruce forests, to pine forests, to mixed pine and hardwood such as one would find in the Adirondacks and northern New England, to the hardwoods we have in Pennsylvania. These vegetation changes are a measure of climate change since the Late Wisconsinan.

It is interesting to note that the lower half of the core represents only about 2,000 years, whereas the upper half covers roughly 14,000 years. This probably means that the whole Holocene is represented by less than the top meter of sediment. The significance of the tundra vegetation during the Late Glacial at this site at the base of South Mountain, means that locally the top of South Mountain was also tundra. This strengthens the case that bedrock knobs like Hammond's Rocks (Stop 4, this trip) are tors.

2) Lobate Features S and E of KGP. A prominent lobe and steep front occurs about 800 ft E of KGP (Figs. 4 and 7). The steep front is about 10 m high, and to the S of this front topography is subdued compared to N of it (Fig. 7). The material in the lobe is bouldery colluvium with abundant clasts of sandstone derived from steep slopes on the near-vertical Antietam sandstone just to the south.

As with the lobes we saw at Stop 1A, we interpret these lobes as solifluction or gelifluction lobes that moved northward from South Mountain periglacial conditions during the Late Wisconsinan. These features are not active in our present climate. The lobes are almost perfect replicas of periglacial gelifluction lobes and sheets, ubiquitous in arctic and alpine regions today. Figures 9 through 11 (Washburn, 1947) show analogous features on Victoria Island in the Canadian Arctic. Introductions to similar features can be found in Benedict (1976), Matsuoka (2001), and French (2007, especially Chapter 9). These features generally move a few centimeters a year.

Solifluction vs. Gelifluction? Solifluction, " the slow viscous flow of waterlogged soil and other unsorted and saturated surficial material" (Neuendorf, et al., 2005) is the more generic term that may or may not have frozen ground beneath. Gelifluction occurs over frozen ground. The frozen ground may be deep annual frost or permanently frozen ground (permafrost). Clearly frozen ground is highly conducive to downslope movement of overlying soil, for the thawed active layer in summer remains saturated because downward movement of water is impeded.

Thus we ask—was there permafrost here on and near South Mountain? Clark (1991) and Ciolkosz, et al. (1986) catalog an abundance of periglacial features on South Mountain, including sorted stone stripes, small block fields, and tors, but none of these requires permafrost—merely cold periglacial conditions. Tundra vegetation from the KGP core could have existed on permafrost, but can also exist where there is only deep annual frost. The higher sedimentation rate in KGP during the Late Wisconsinan is not surprising given the cold conditions and surface thaw inferred from the lobes just to the south. Gelifluction can occur in deep annual frost. The best indicator of permafrost is ice-wedge casts, for the ground must be

Figure 9. Gelifluction sheets and lobes on Victoria Island, Canadian Arctic. Horizontal lines are raised beaches. (From Washburn, 1947)

Figure 10. Gelifluction sheets and lobes on Victoria Island, Canadian Arctic. (From Washburn, 1947)

Figure 11. Bouldery front of a gelifluction lobe on Victoria Island, Canadian Arctic. Person for scale. (From Washburn, 1947)

permanently frozen for ice-wedges to develop. Ice-wedge casts have been described from the Pine Barrens of southern New Jersey and in the northern Delmarva Peninsula (French, et al., 2003; French, 2007), and a map by French (2007, Fig. 11-13) showing reconstruction of the maximum extent of Late Pleistocene periglacial conditions in the USA south of maximum glaciation limits shows the southern limit of "continuous and discontinuous permafrost" crossing the northern part of Chesapeake Bay into Virginia and West Virginia. We can not say from local evidence that there was permafrost on and near South Mountain, but the evidence from adjacent areas says it likely was here.

3) Karst from the lobate features northward—North of the lobate features, including KGP and the area we traversed to get to the lobe, topography is much more hummocky (Figs. 4 and 7), typical of karst. This topography persists, with abundant sandstone clasts at the surface, all the way north to the floodplain of Yellow Breeches Creek near Pine Road. We infer that this surface is much older than the lobes because it is modified by karst, and it is clear that at least in the case of KGP, the bottom has not sunk significantly in the last 16 k years. Are these older colluvial deposits also of periglacial origin, but much older? We will re-visit this question at Stop 6, where we will see a deep pit into the colluvial material.

LEAVE Stop 1B and CONTINUE STRAIGHT AHEAD.

12.4 Stop sign. TURN RIGHT onto Pine Rd. Ahead on the right are good views of South Mountain. The surface between the steep mountain front and Pine Rd. is underlain by colluvium.

14.9 Cold Spring Rd. on the right. Continue STRAIGHT AHEAD.

15.5 Large pit on the side of South Mountain to the right is Pennsy Supply quarry where Antietam quartzite is being mined.
16.2 TURN RIGHT onto Mountain View Rd.
16.3 Cross railroad tracks. Good view of quarry pit on right. Crossing a surface of colluvium on top of karst topography.
16.6 TURN LEFT onto unnamed road.
17.5 Enter Borough of Mt. Holly Springs.
18.0 Traffic light. TURN RIGHT onto PA 34, Baltimore Ave.
18.1 Holly Inn on the left. On August 7, 1892 C. D. Walcott, staying with family here, visited outcrops just to the south and found fragments of *Olenellus* trilobites in what is now called the Antietam sandstone. Prior to this these sandstones were believed to be of Medina age, equivalent to the Silurian Tuscarora sandstone in Blue Mountain on the opposite side of the Cumberland Valley. The fossils proved these rocks in South Mountain to be of Early Cambrian age (Yochelson, 1991).
18.3 Excellent outcrops of Antietam quartzite on right at north edge of parking lot and across the creek on the left.
18.4 Cross Mountain Creek.
18.9 TURN RIGHT following PA 34. PA 94 goes straight ahead.
19.1 **STOP 2 at end of guard rail. Eaton-Dikeman Legacy Sediment Site (Fig. 12).**

At the end of the guide rail and before the first house on the right there is room to park only one or two vehicles. Disembark quickly from the bus, go around the guide rail and go back north a short distance to a place where you can cross a shallow channel.

Following is reprinted with minor changes from: Potter, N., Jr., Merritts, D. J., Walter, R. C., Rahnis, M. R., and Jenschke, M., 2008, Legacy sediments at Mount Holly Gap Marsh, Pennsylvania: Field Conference of Pennsylvania Geologists, Guide for Pre-Conference Field Trip, September 25, 2008, 14 p.

The discovery that tens of thousands of 17th to 19th century milldams for water-powered mills in the eastern U.S. trapped fine sediments, called legacy sediments, 1-5 meters thick, burying extensive vegetated wetlands that existed before European settlement is documented in Walter and Merritts (2008, and references therein). The presence of these legacy sediments and what they buried has implications, among others, for: 1) pre-Colonial settlement, vegetation and stream conditions, 2) erosion rates upstream from where dams existed, 3) modern-day sediment yield where dams are now breached, 4) the continued removal of dams where they still exist, 5) our geomorphic view of meandering streams, and 6) stream restoration in these settings.

Our visit to Mount Holly Gap Marsh is intended to show you many of the distinct characteristics of milldam legacy sediments and to discuss some of the implications listed above. We are on Mountain Creek, which originates south and west of us in a valley on soluble Cambrian Tomstown dolomite, flows through resistant Cambrian sandstones of the Chilhowee group in Mount Holly Gap, and thence northward into the Great Valley on soluble Cambrian carbonates to join Yellow Breeches Creek and flow eastward to the Susquehanna River and

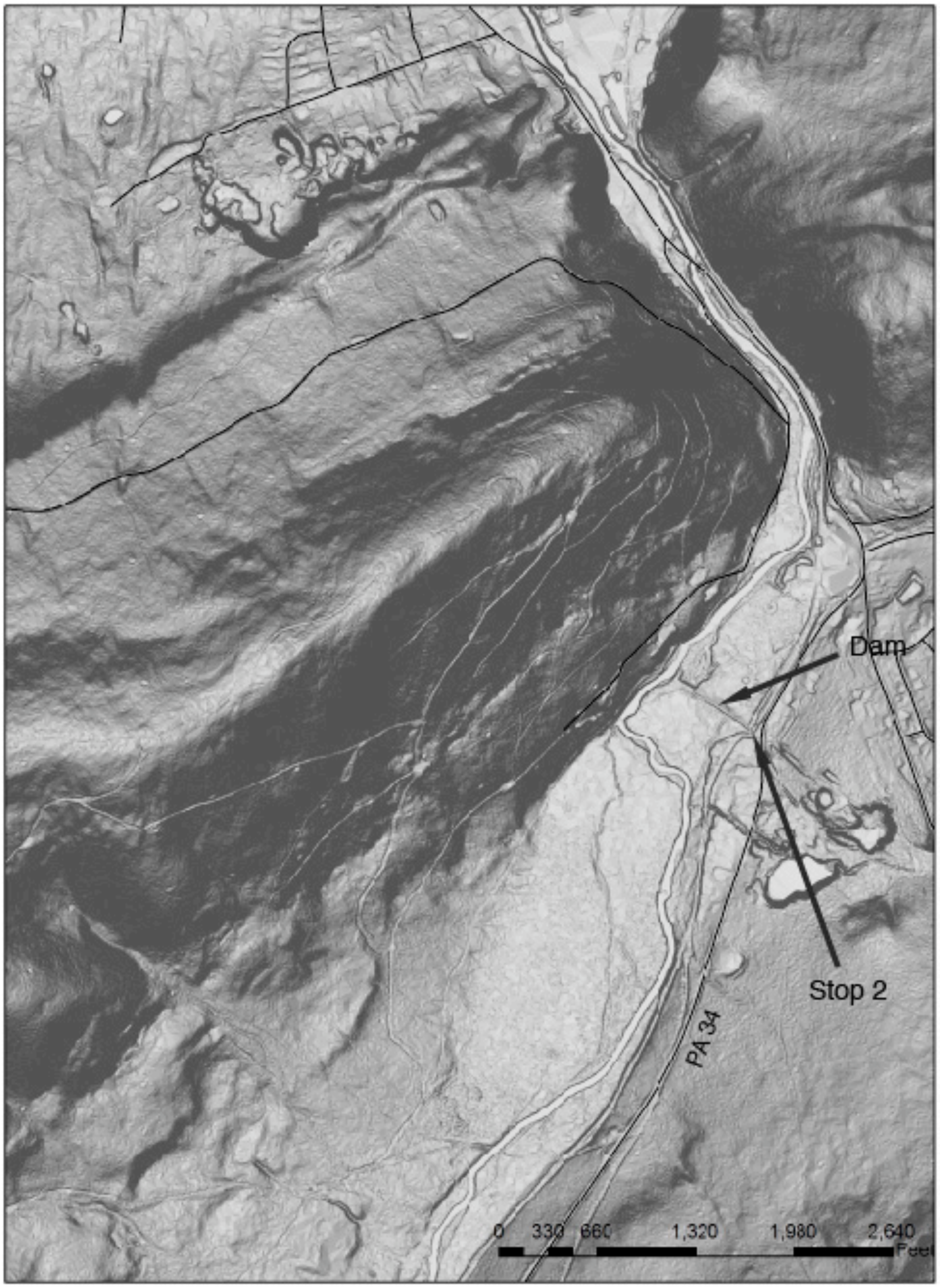


Figure 12. LiDAR Shaded Slope Map of Stop 2 area.

south to Chesapeake Bay. With the exception of a few modest residential plots, the watershed upstream is forested.

The west side of the valley here is part of the Mount Holly Marsh Preserve, owned by Cumberland County and managed by the Nature Conservancy office in Harrisburg. The preserve was set aside in part to protect two endangered species, the glade spurge and the bog turtle. Part of the property we will visit , on the west side of the valley is owned by the Ahlstorm Corporation, a specialty paper manufacturing firm with a number of plants in the world and based in Helsinki, Finland. Their plant at the junction of PA 34 and 94 near where we will begin our walking tour makes filter papers for both industrial and scientific uses. Their plant is a descendant of a succession of paper manufacturing operations that date back at least to the 1850's. We enter the Ahlstrom property with their kind permission.

A succession of dams built on Mountain Creek at Mount Holly Gap beginning in the 1850's (Fig. 12) trapped sediment until the millpond was nearly full and the dam was removed in 1985. Since that time Mountain Creek has carved a channel through the legacy sediments that are as much as 2.5 m thick and cover approximately 25 acres of the former pond. An organic layer, including tree stumps, is exposed beneath the legacy sediments at approximately present water level. The sediments are actively being eroded during flood events and in winter by formation of needle ice.

Aerial photographs dating back to 1938 and in later years show the millpond filling. A thick file, held by the PA Department of Environmental Protection (PA DEP), Bureau of Dam Safety, preserves records and photographs from at least 1915 when a dam breach occurred (Fig. 13) to the removal of the dam in 1985. Several inspection reports are among these documents. At least 5 breaches of the dam are recorded.

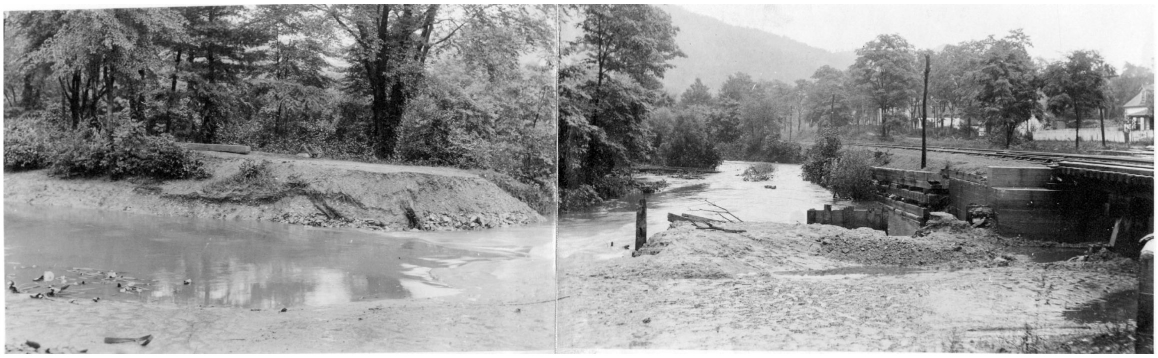


Figure 13. Dam breach in 1915 at the Mount Holly legacy site. View looks north. The railroad and present-day PA 34 on the right still exist. PA DEP photo.

By the early 1900's there was a nice lake behind the dam, and there was some landscaping, boats and a boathouse. By the 1980's the pond was nearly full of sediment (Fig. 14).

Figure 14. Mount Holly legacy site pond in 1982. Photo looks south from near west end of dam. Vegetated area to the left of the water is all legacy sediment. PA DEP photo.

In 1985 the west end of the dam was breached and removed. A succession of DEP photos is most informative of what happened to Mountain Creek (Figs. 15 through 19).

Figure 15. The channel just upstream from the dam on 3/27/1985 shortly after removal of the dam. View is from approximately same position as Fig. 14. PA DEP photo.

Figure 16. Same channel on 6/18/1985. PA DEP Photo.

Figure 17. By February, 1986 the channel looked like this. PA DEP Photo.

Figure 18. By 6/26/1987 rip-rap had apparently been added to the west side of the channel. PA DEP Photo.

Figure 19. On 5/7/2007 the channel near the same location looked like this. The entire section on the left above river level is legacy sediment deposited in the former pond. R. Walter and D. Merritts Photo.

Our Walking Trip. For locations referred to below, see Figure 20.

STOP A. The channel here was the old millrace from the pond behind the dam. The rusty gates for the millrace are still here.

Walk a short distance south along the RR track and stop just before you reach a bridge over the millrace channel. Figure 13, taken in 1915 looking north, shows a breach of the dam near here. The RR bridge is in the photo. Just north of the bridge, turn right (west) and follow the crest of the former earthen dam westward.

STOP B. As you proceed west along the dam, note the large flat area to your left (south). This is the location of the former mill pond and is underlain by >2 m of legacy sediments. To your right (north) are some buildings. It is near these that the predecessor of Ahlstorm Corporation drilled wells to obtain ground water in anticipation that they would stop using surface water from the pond. Continue west across old dam to Mountain Creek.

The geology of Mount Holly Gap is shown in Fig. 21 (map) and 22 (interpretive cross-section). The geology on the map is from Freedman (1967), showing Cambrian Montalto quartzite underlying the S flank of the mountain, and the valley of Mountain Creek underlain by younger Cambrian Tomstown dolomite. The interpretive cross-section based on the geology in the wells drilled in 1983 shows a fault dipping SE between the quartzite and the dolomite. This is not a sedimentary contact because the Tomstown should overlie the Antietam quartzite (younger than Montalto). The fault must be a normal fault. This is unusual for an Alleghanian structure. Ordinarily one would expect SE-dipping reverse faults in this setting. Note that beneath the former pond is thick clay residuum from weathering of the Tomstown dolomite.

STOP C. Here we overlook Mountain Creek where the dam was removed and the pond was drained in 1985. Across the creek beyond the former dam in the side of the hill is a small quarry where resistant Cambrian quartzite of the Mont Alto member of the Harpers formation was obtained to build the dam. Look upstream, compare Figures 5 to 10, and consider the changes that have occurred since the dam was removed. While the dam was here, base level was raised and fine-grained legacy sediment was deposited in the slack water of the pond. With removal of the dam, the stream began to cut downward, removing fine-grained legacy sediment to re-establish its pre-dam equilibrium profile. Note that the bed material is coarse, up to 10-20 cm in diameter. Now the stream is carving laterally into the legacy sediment on the outside of bends.

Follow the edge of the bank, on top of the legacy sediments, south to D on Figure 20.

STOP D. Here we are on top of legacy sediments about 2.5 m thick (Fig. 23). By moving north or south, you can look down on the layered legacy sediments, and those so inclined can

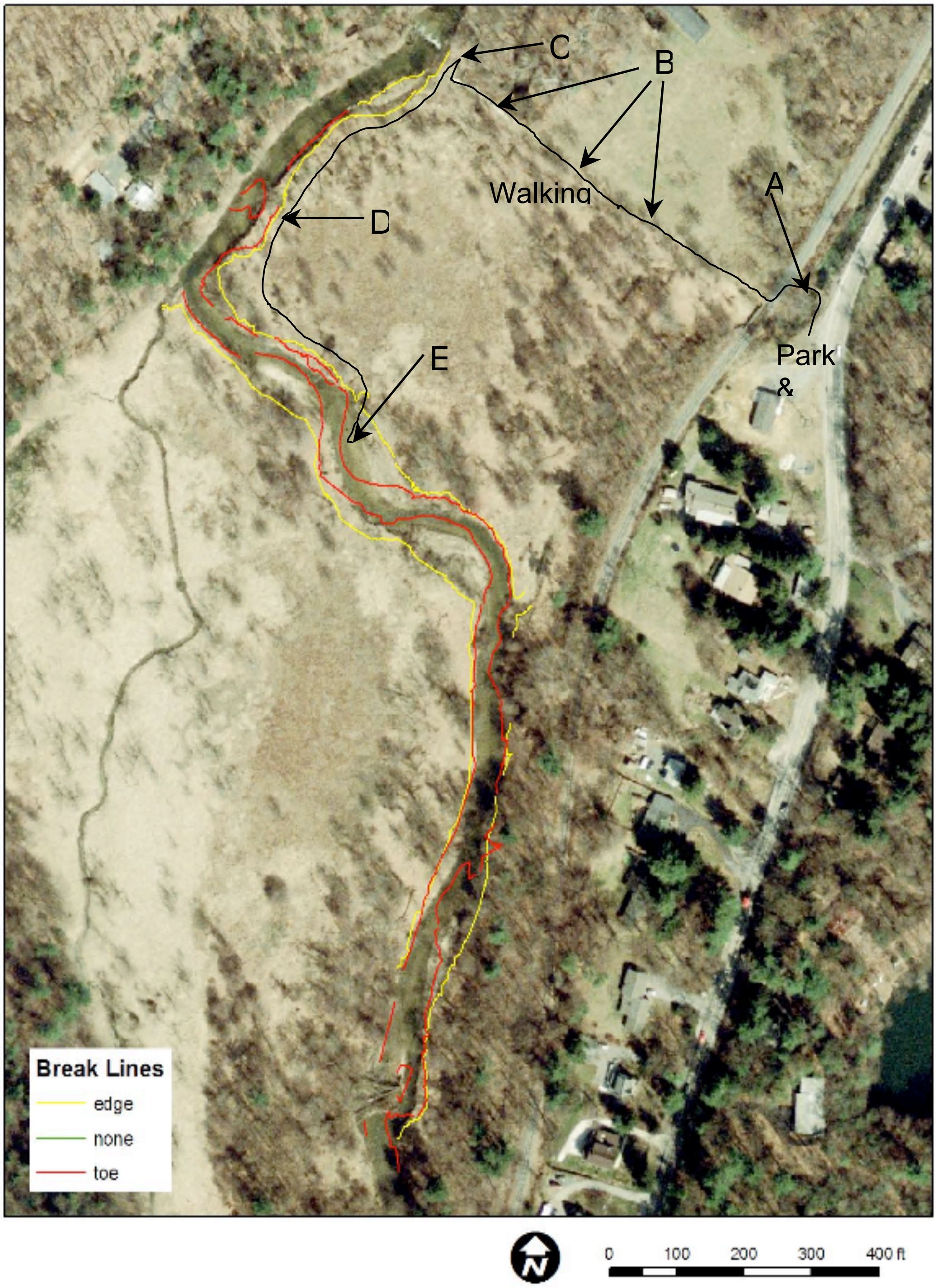
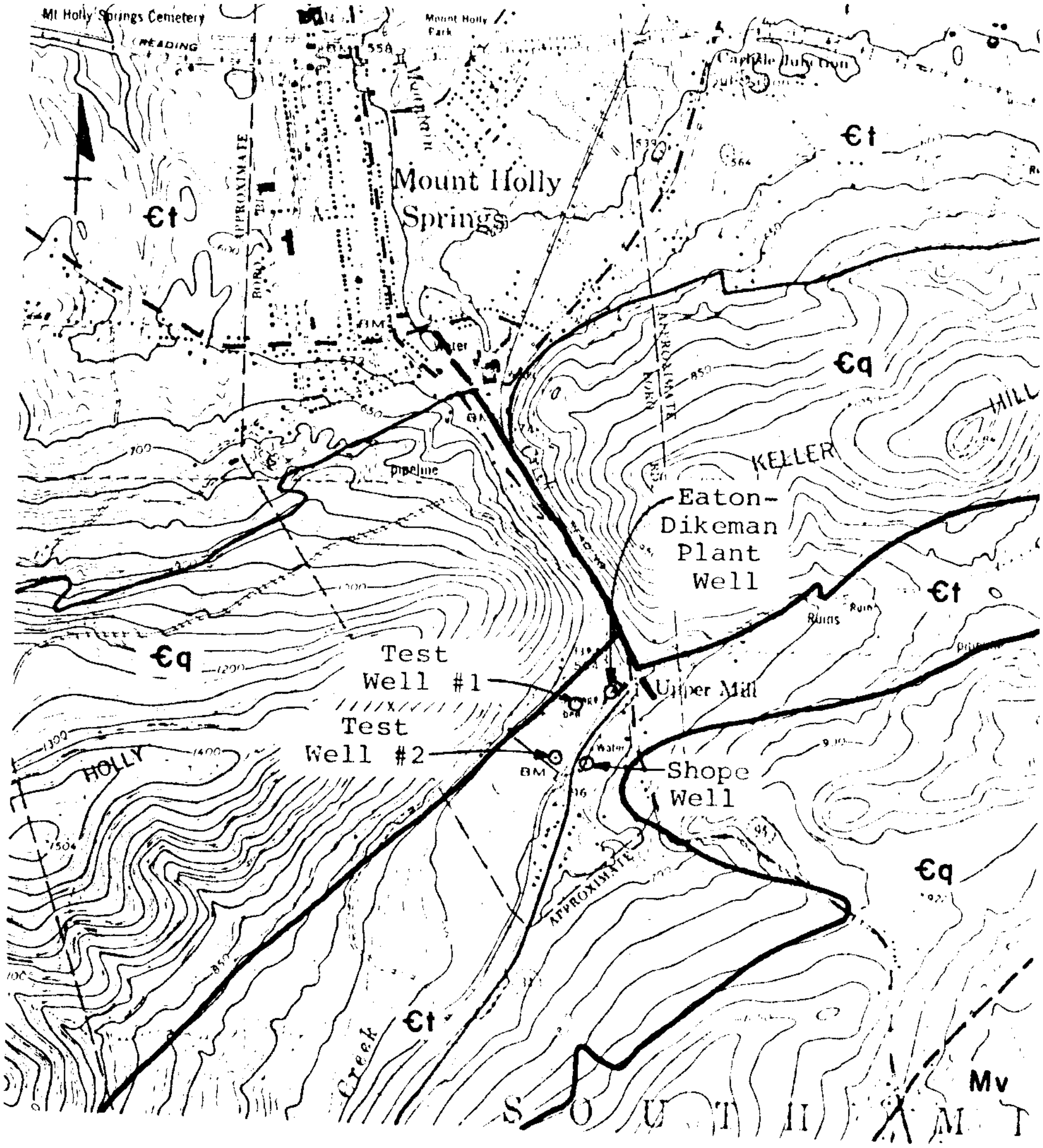


Figure 20. 2003 PAMAP Aerial Photograph of Mount Holly legacy site with trip walking route and lettered stops indicated. Break lines surveyed using GPS by Michael Rahnis on 8/15/08 show changes in channel edges since 2003. Highway along right edge of photo is PA Route 34, just S of its intersection with PA 94.

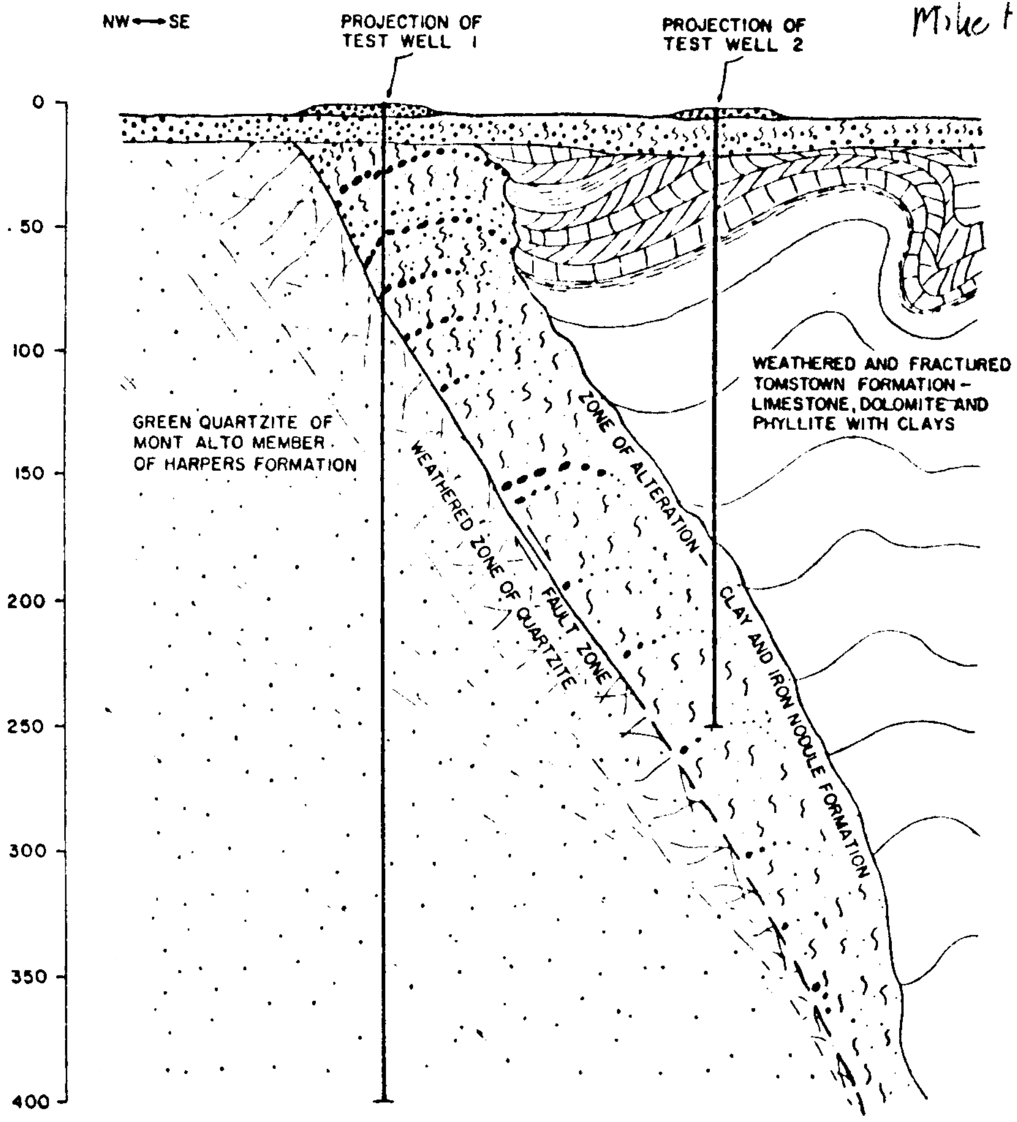


1" = 2000' Contour Interval = 10'

Figure 1: Location map of Eaton-Dikeman paper plant and environs

Ꞓt - Tomstown Dolomite	━━ - Fault
Ꞓq - Quartzite	── - Geologic contact
Mv - Metavolcanic rock	

Figure 21. Geologic map of Mount Holly Gap (presumably from Freedman, 1967) showing locations of wells drilled in 1983 by R. E. Wright and Associates. Dam is just SW of Test Well #2, the producing well. See Fig. 49-2 for interpretive cross-section.



Mike t

Horizontal Scale: 1 inch is approximately 160 feet
2½x vertical exaggeration

Figure 2 : Generalized geologic cross-section across Eaton-Dikeman property

r.e. wright associates, inc.

Figure 22. Interpretive cross-section from wells near Eaton-Dikeman Pond. Locations of wells are on Fig. 21.

scramble down at one or two places to sample them. The sediments are alternating layers of coarse sand and silty clay or clayey silt, deposited layer upon layer in the former pond. The sandy layers contain fragments of vesicular slag, presumably from the old iron works at Pine Grove Furnace State Park about 7 miles upstream from here. Charcoal is also abundant in the legacy sediments, presumably from the thriving charcoal industry associated with the iron works that denuded South Mountain of substantial trees by the time the furnace shut down just before 1900.

Figure 23. The bank below STOP D on 2/3/08. Note fractures in cohesive sediment, and accumulation of silty "crumbs" on bank from just above water to about half way up.

In January, 2008 Jeff Hartranft and Scott Cox of PA DEP surveyed a profile here.. The ends of the profile are monumented with steel rebars embedded in small concrete columns. We drove 3 meter-long rebars horizontally into the cut bank below where we stand, and measured the length left protruding from the bank to determine bank erosion. Potter has episodically re-measured the rebars, though floods in Spring, 2011 caused several 4-foot rebars to fall out. The profile was resurveyed in April, 2011, and in 3+ years the top of the cut bank has retreated 4.8 feet.

In winter, needle ice forms in the silty sediments (this is just the right grain size for good needle ice to form) and pushes "crumbs" of silty material away from the near-vertical surface. The "crumbs" accumulate on small benches in the layered sediments (Fig. 23). Fractures also form in the cohesive sediment (Fig. 23). In late winter and early spring when most floods occur, the "crumbs" and some lumps of silty clay are removed. Sandy layers are removed more easily, and sometimes "benches" of silty clay are left behind with fallen lumps of silty clay on top of them. From D, proceed south, then east along the top of the legacy sediments to E on Fig. 20.

Figure 24. The cut bank at STOP D with Mountain Creek flooding on 3/5/08. Legacy sediments underlie all the flat surface beyond the cut bank.

STOP E. We are on a river bar on the north side of Mountain Creek where it travels east to west. A second profile, established in January, 2008 goes across the river here, and there are 3 rebars in the cut bank on the far side of the creek (Fig. 25). From January, 2008 to April, 2011, 3+ years of erosion had removed 8.3 feet at the top of the cut bank in sandy sediment, and left a "bench" of cohesive silty clay beneath. A flood in mid-April nearly reached the top of the legacy sediments here.

The river bar here is a good place to examine bed load in the present stream. The entire bar was under water during major floods. Clasts in the bar are up to 10 cm across compared to the sand and finer material in the legacy sediments. Clasts of all of the bedrock lithologies upstream are represented in addition to pieces of slag, presumably from Pine Grove Furnace.

The coarse material in the bar is derived from pre-legacy sediment exposed in the bottom of the channel.

Merritts, et al. (2011) discuss in detail the base level controls on Anthropocene streams with historic mill dams, including the one here.

When finished here, retrace the path you have taken back to rejoin the bus.

Figure 25. Legacy sediments at profile at STOP E. Rebars are beneath small orange flag. Photo 3/7/08 shortly after flood of 3/5.

When leaving CONTINUE STRAIGHT AHEAD on PA 34.

20.6	Road on right goes into Hempt Bros. Toland Plant, where they quarry Antietam quartzite for sand and aggregate.
20.8	BEAR RIGHT onto Green Mtn. Rd.
21.4	Stop sign. CONTINUE STRAIGHT AHEAD on Pine Grove Rd.
21.8	Village of Toland. This is the remnant of the "company town" for a large clay mining operation in clay residuum over Tomstown dolomite at the base of South Mountain behind the town.
25.0	Sign on left Enter Pine Grove Furnace State Park. CONTINUE STRAIGHT AHEAD.
25.3	Laurel Lake dam on left.
25.4	SHARP RIGHT TURN onto Cold Spring Rd.
26.3	Pavement ends. CONTINUE AHEAD on gravel road. Note boulders and blocks on slope.

27.6 TURN RIGHT onto Ridge Rd.

28.3 **STOP 3. Hammond's Rocks.**

Hammond's Rocks (HR) is a prominent knob of sandstone and conglomerate that protrudes above bouldery surfaces that gently slope away from it (Fig. 26). HR has been interpreted by Clark (1991) as a tor, a prominent erosional remnant that sticks up above an otherwise gently-sloping surface that is inferred to have formed in a periglacial climate during the colder part of the Pleistocene. Other similar knobs occur to the south and north of HR (Fig. 26). A modern tor in Alaska is shown in Figure 33. We know that during the late Wisconsinan, from at least 16,000 to 14,000 yr BP, there was tundra here (see Stop 1B—Kings Gap Pond).

HR (most detailed description is in Potter, et al., 1991) is composed of the Weverton formation, which is mostly sandstone, but part of the rocks here are conglomeratic. Typically pebbles are 2-5 cm long, but at least one is 12 cm long. The Weverton is the next to bottom formation of the Lower Cambrian Chilhowee group clastic rocks (which overlies the bottom-most Loudon formation, which in turn overlies Precambrian metavolcanics) (see Key, 1991). Source for the Weverton formation was from the West on the North American craton, as determined by Whitaker (1955), in contrast to younger Paleozoic clastic rocks north of the Cumberland Valley whose sources were from the East (Fig. 27). In many places in the outcrop cleavage, which dips SE, is more prominent than bedding, so one has to be careful to find compositional differences, usually pebbly layers, to make sure one is seeing bedding. Bedding is near vertical to slightly overturned in most of the outcrop (Fig. 28, Net A), but in a few places beds dip gently East, forming a girdle that shows a fold hinge that gently plunges ~N70°E. Cleavage consistently dips ~60°SE (Fig. 28, Net B). A plot of bedding/cleavage intersections (Fig. 28, Net C) shows that they trend ~N70°E, 10°NE.

Pebbles in conglomerate are flattened so that their shortest axes are nearly perpendicular to cleavage (Fig. 29). Long axes of these flattened pebbles form a diffuse girdle with the same orientation as cleavage (Fig. 28, Net D), showing that though the short axes of pebbles are nearly perpendicular to cleavage, long axes lie in any direction near parallel to cleavage. Surfaces on the pebbles that are parallel to cleavage often have very fine striae on them. These striae are always parallel to tectonic a, the direction of tectonic transport, and perpendicular to bedding-cleavage intersections, despite random orientation of long axes of pebbles in or near the plane of cleavage (Fig. 30). A hand lens and a strong flashlight (or mirror using the sun) to give low oblique illumination are best for seeing the striae. It is inferred that shear parallel to cleavage removed the "tops and bottoms" of the pebbles by pressure solution.

A map and series of cross-sections of HR are reproduced as Figs. 31 and 32. The map of HR (Fig. 31) has a number of stations labeled with Roman numerals. A series of cross sections (Fig. 32) along lines labeled with Arabic numbers are also reproduced here. Highlights from the map are:

I) a prominent channel with lag gravel in it. This is one of the few places where beds are horizontal in the outcrops here. It is an interesting place to ask where one would go to find a similar environment of deposition today (Coastal Plain?). Remember that there was no land vegetation in the Cambrian.

II) good cross beds at the E end of the outcrop.
III) a good view of pebbles flattened in cleavage.

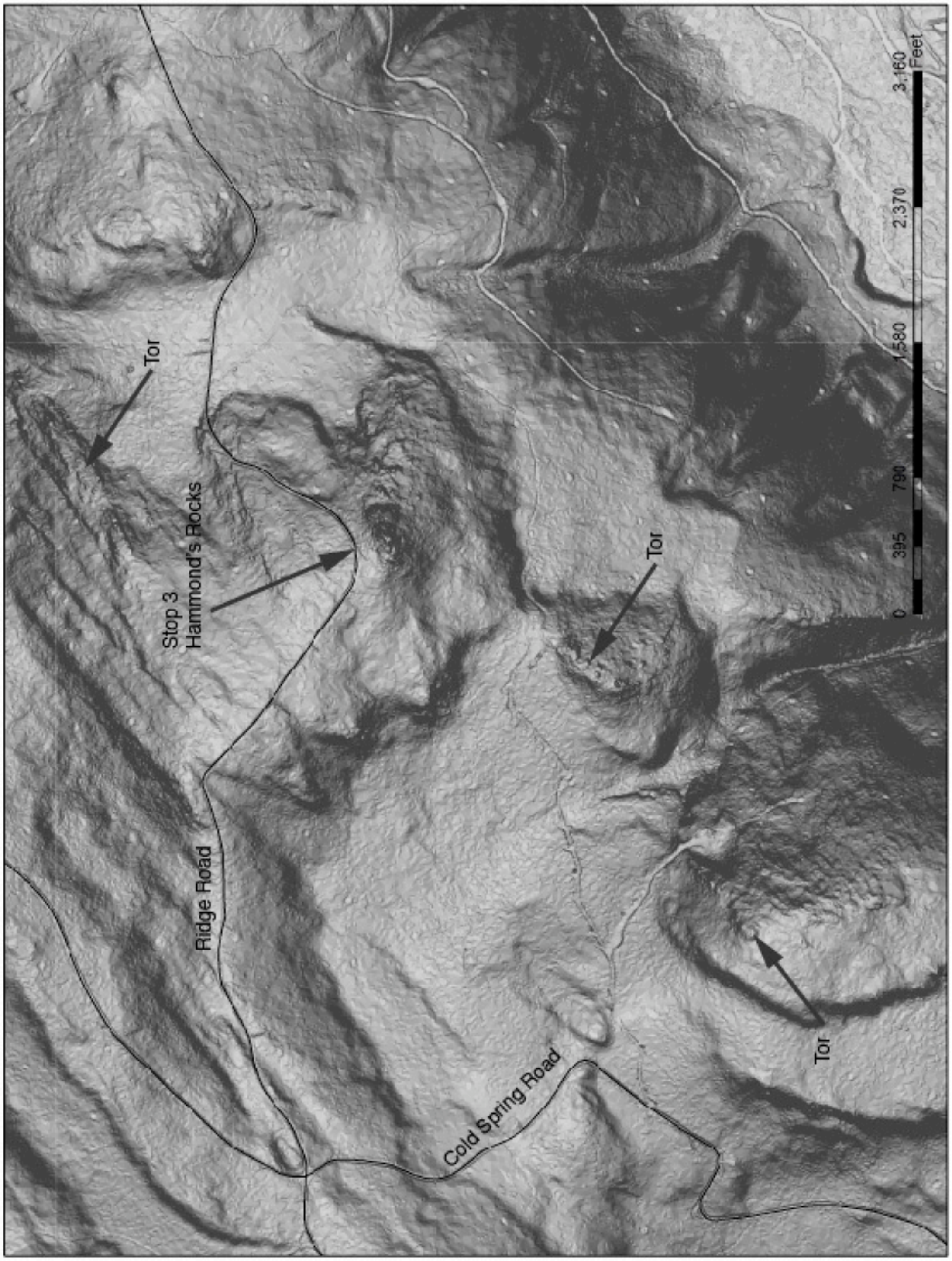


Figure 26. Stop 3. LiDAR Shaded Slope Map of Hammond's Rock area. North is toward the left.

IV) If you crawl under the large (several m long and high) block here, you can find three irregularly spaced quartz veins in the block above and the rock below to see that the large block has moved about 1 m downslope. Note on cross-sections several large blocks with cleavage dipping the wrong way (N rather than SE).

We collected 350+ pebbles that had weathered out of HR and measured their 3 axes and plotted their axial ratios on Flinn diagrams (Potter, et al., 1991, Fig. 64). By far, more were oblate spheroids (hamburgers) rather than prolate (hot dogs).

We attempted to determine paleocurrent direction using cross-beds here, but in nearly all cases when we measured inferred topset and foreset beds and plotted them on a stereonet, the angle between the two was much greater than the angle of repose for sand—presumably the angle between the two has been changed during deformation.

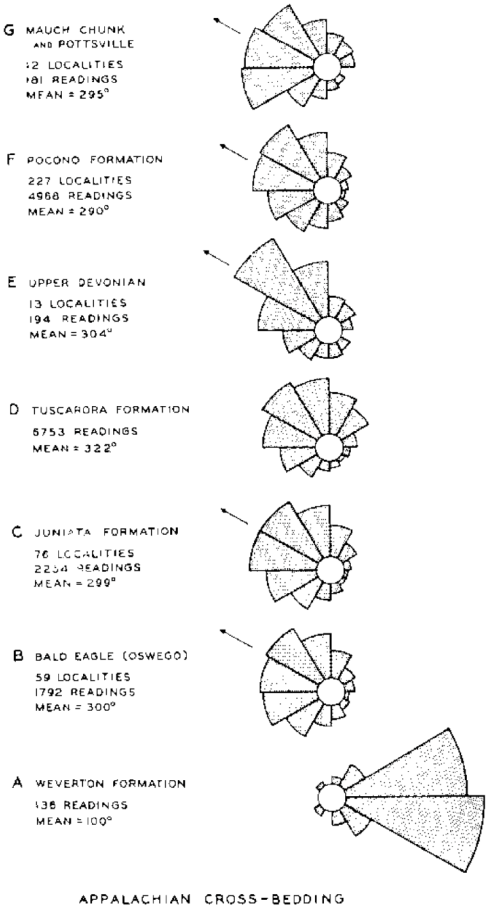


FIG. 12. Cross-bedding azimuthal distributions in central Appalachian area. A, Weverton (Cambrian) (after Whitaker, 1955); B, Bald Eagle and C, Juniata (Ordovician) (after Yeakel, 1959); D, Tuscarora (Silurian) (after Yeakel, 1959); E, Catskill (Devonian), F, Pocono and G, Mauch Chunk (Mississippian) (after Pelletier, 1958).

Figure 27. Paleocurrent directions showing how Cambrian Weverton formation is derived from West, whereas later Paleozoic sediments are derived from East. (From Pettijohn, 1962).

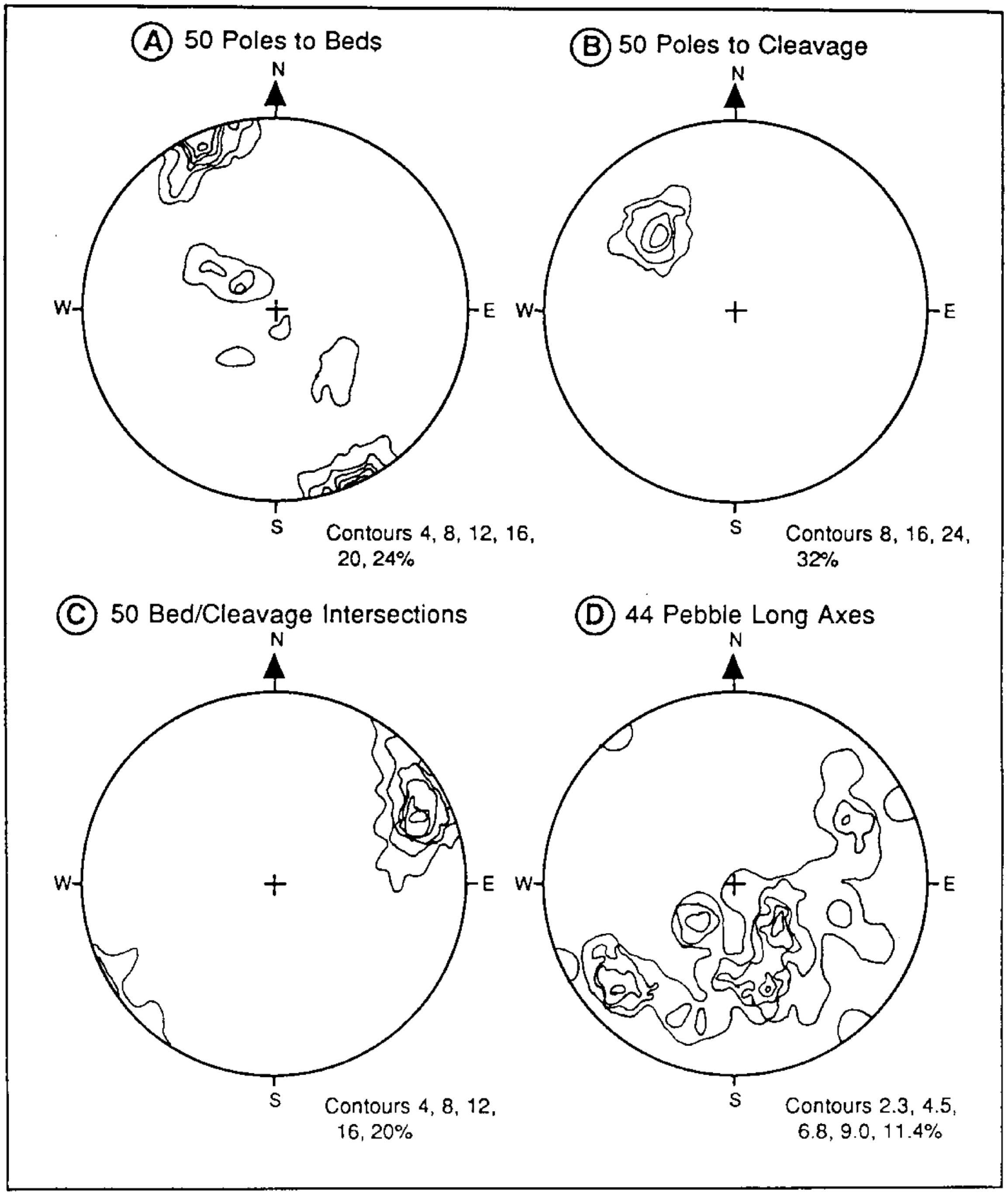


Figure 60. Equal-area nets showing orientation of (A) bedding, (B) cleavage, (C) bedding/cleavage intersections, and (D) pebble long axes at Hammond's Rocks.

Figure 28. From Potter, et al., 1991, STOP 8.

Figure 29. Pebbles flattened in the plane of cleavage, which dips downward to the right (SE). View is looking NE. Divisions on scale are in decimeters.

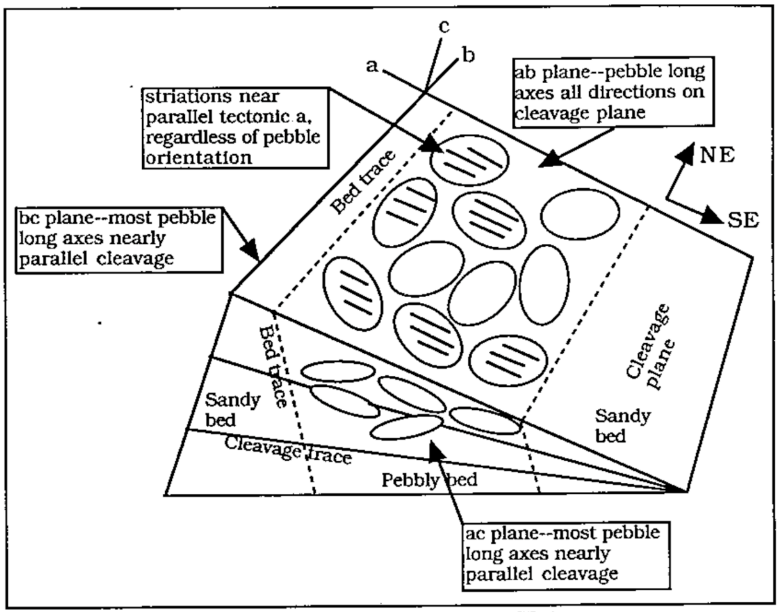


Figure 30. Relation of flattened pebbles and striations to bedding and cleavage at Hammond's Rocks and the Chinese Wall. (Diagram from Potter, et al., 1995)

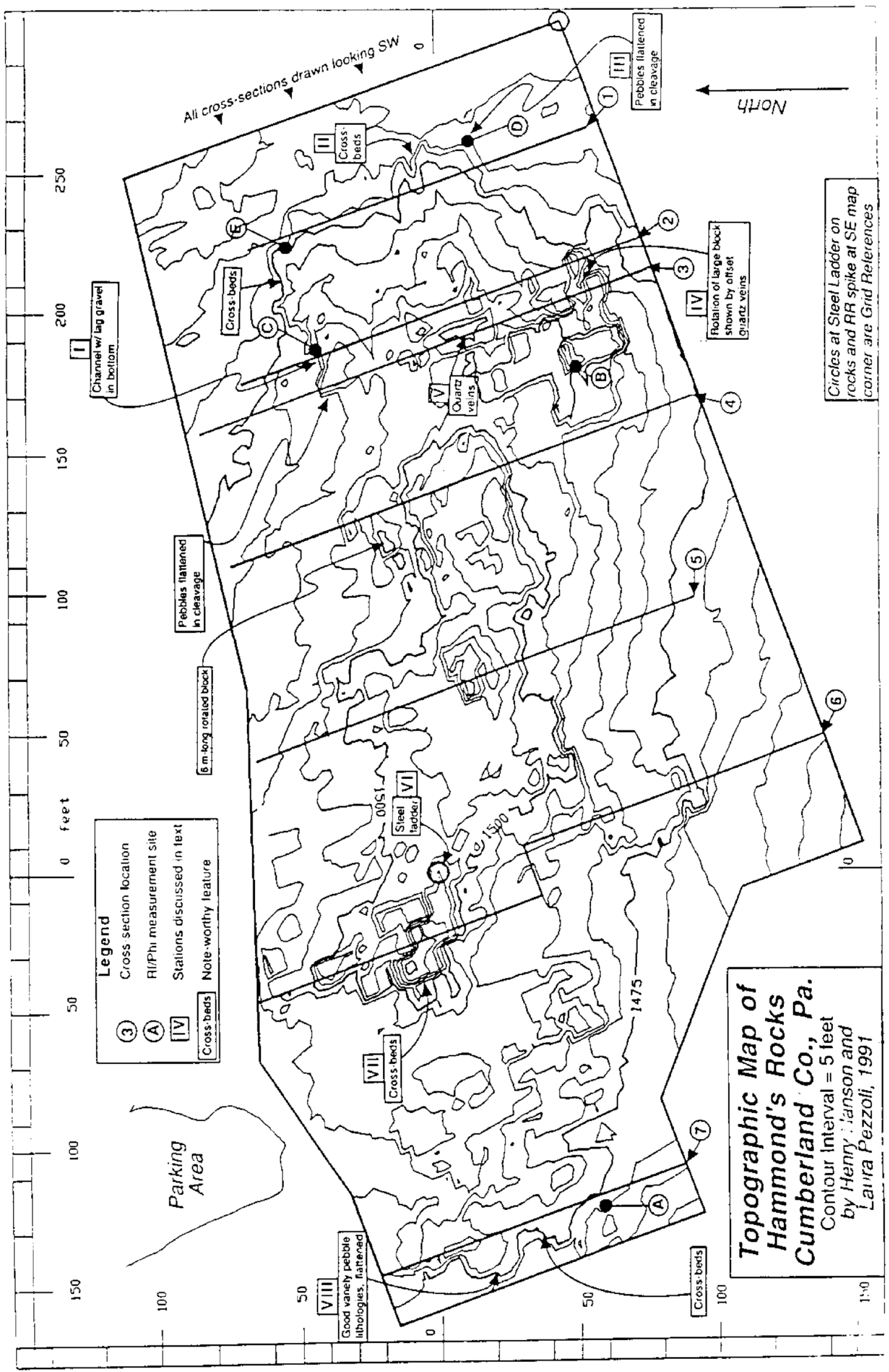


Figure 58. Topographic map of Hammond's Rocks showing locations of features discussed in text.

Figure 31. From Potter, et al., 1991, STOP 8.

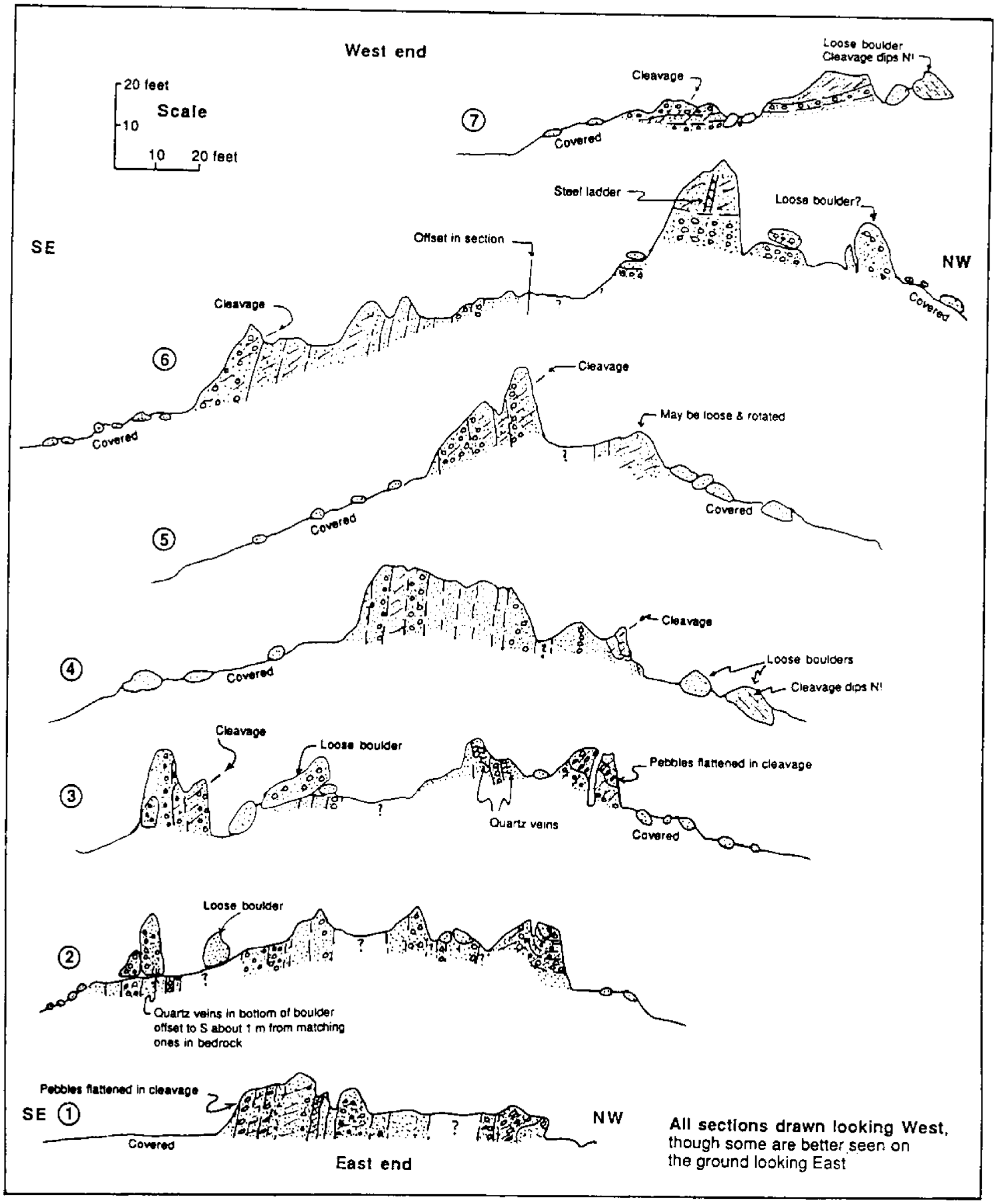


Figure 59. Cross sections of Hammond's Rocks. All sections are drawn looking WEST for ease of comparison, despite the fact that some are better seen at the outcrop looking in the opposite direction. Locations of sections are shown on Figure 58.

Figure 32. From Potter, et al., 1991, STOP 8.

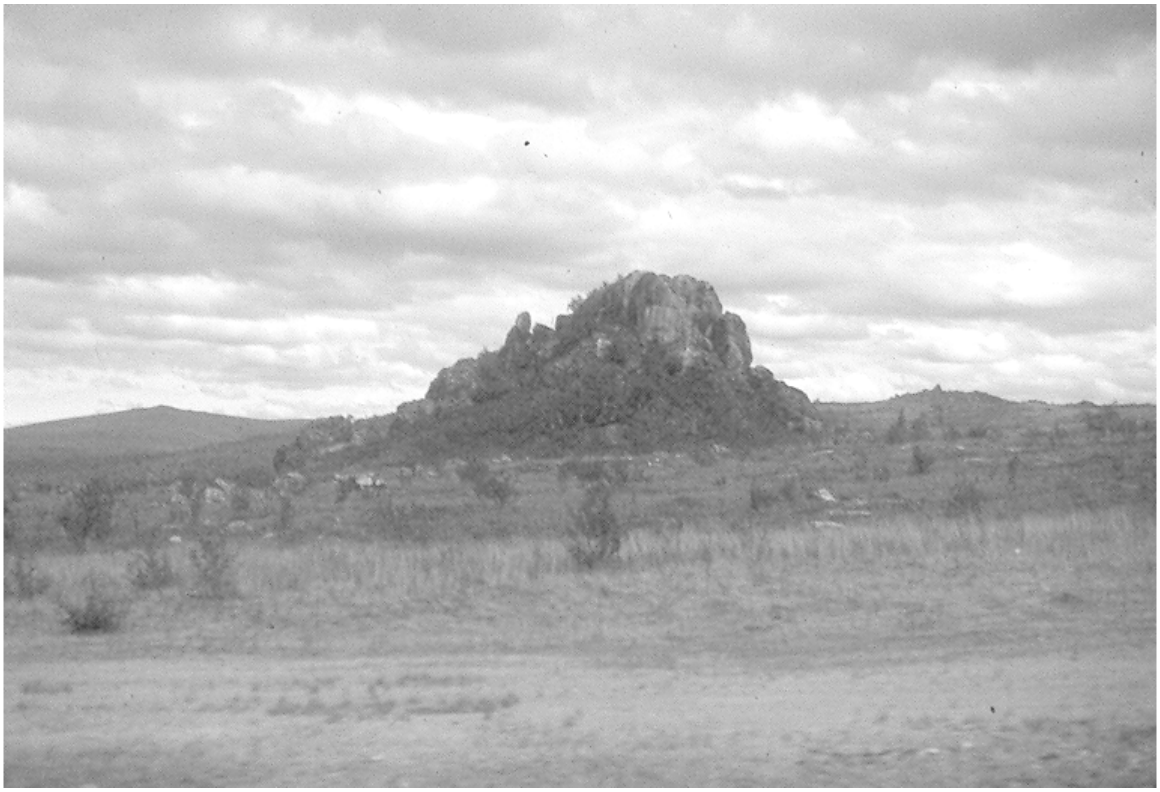


Figure 33. A modern tor in Alaska. Note gently sloping surface covered with boulders at base of bedrock knob.

TURN AROUND and return the way came.
29.0 Cross Cold Spring Rd. Continue on Ridge Rd.
30.9 TURN LEFT onto PA 233 (paved road).
32.8 Stop sign. TURN RIGHT following PA 233.
32.9 TURN LEFT onto Bendersville Rd.
33.0 STAY LEFT on Bendersville Rd. Take an immediate LEFT into Furnace Stack Day Use Area.
33.1 **STOP 4.** Park in parking area. **Pine Grove Furnace State Park.** Lunch in pavilion.

Pine Grove Furnace (PGF) State Park (Fig. 34) preserves some remnants of early iron making in the South Mountain area. Of particular interest may be the restored furnace stack (Fig. 35) just SW of the park office and visitor center, the former Ironmaster's Mansion (Fig. 36) now restored and managed by the Central Pennsylvania Conservancy, and Fuller Lake, which occupies the former ore pit (Fig. 37). There is abundant parking at these localities.

Pine Grove Furnace (PGF) is the result of the presence of all the resources needed for iron making near one another here. These resources are iron ore, albeit low grade,

Figure 34. Stop 4. LiDAR Shade Slope Map of Pine Grove Furnace area. North is toward the left. White dots near Pole Steeple and elsewhere are the platforms where charcoal was made.

carbonate rock for flux, metarhyolite for ganister to line the stack, sand for making molds, and abundant trees in the adjacent forest for charcoal making to heat the furnace. See Figure 34 for the sources of each of these. Iron making occurred from colonial times to the 1890's, when the whole operation ceased as high grade iron ore was discovered in the Precambrian of Michigan, Wisconsin, and Minnesota. In its heyday, PGF was a thriving community (Fig. 38).

PGF and the valley of Mountain Creek SW of PGF are underlain by the Cambrian Tomstown dolomite, the first carbonate unit above the Cambrian Chilhowee Group. Precambrian metarhyolite is faulted against the Tomstown just to the N of PGF. The iron ore here was lumps and nodules of limonite and related iron oxides, which occur within the clay residuum formed from chemical weathering of the Tomstown.

The iron ore was mined from a large pit (Fig. 37) where Fuller Lake is today. Tomstown was quarried from just S of the furnace stack. Charcoal was made by cutting trees on South Mountain, stacking the wood, covering it with soil, and letting the mass smolder for a week or so. By the late 1800's, South Mountain was nearly denuded of trees to make the charcoal. The iron making process and features that can be seen today are described in Way, (1986, 1991) and Wilshusen (1982, 1983).

There is a USGS Stream Gage on Mountain Creek at the bridge just S of the Ironmaster's Mansion. Real-time stage and discharge, plus historic data is available. USGS Stream Gage URL: http://waterdata.usgs.gov/nwis/uv?01571184 Flooding on Mountain Creek every few years is severe enough to break the small berm between Mountain Creek and the bathing beach at Fuller Lake. The swimming site is so popular that it is usually repaired within a month or so. The USGS also has a ground water observation well near PGF just N of the mansion, which is in metarhyolite. Real-time stage plus historic data is available. USGS Ground Water Observation Well URL: http://groundwaterwatch.usgs.gov/CRNSites.asp?S=400209077183301

Figure 35. The restored stack at Pine Grove Furnace today. Compare Fig. 38, taken in 1875 when the iron works was in operation.

Figure 36. The Ironmaster's Mansion at Pine Grove Furnace has been restored and is now operated by the Central Pennsylvania Conservancy.

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

Figure 37. The iron ore pit at Pine Grove Furnace in about 1875. The pit is now Fuller Lake. Photo courtesy of Cumberland County Historical Society.

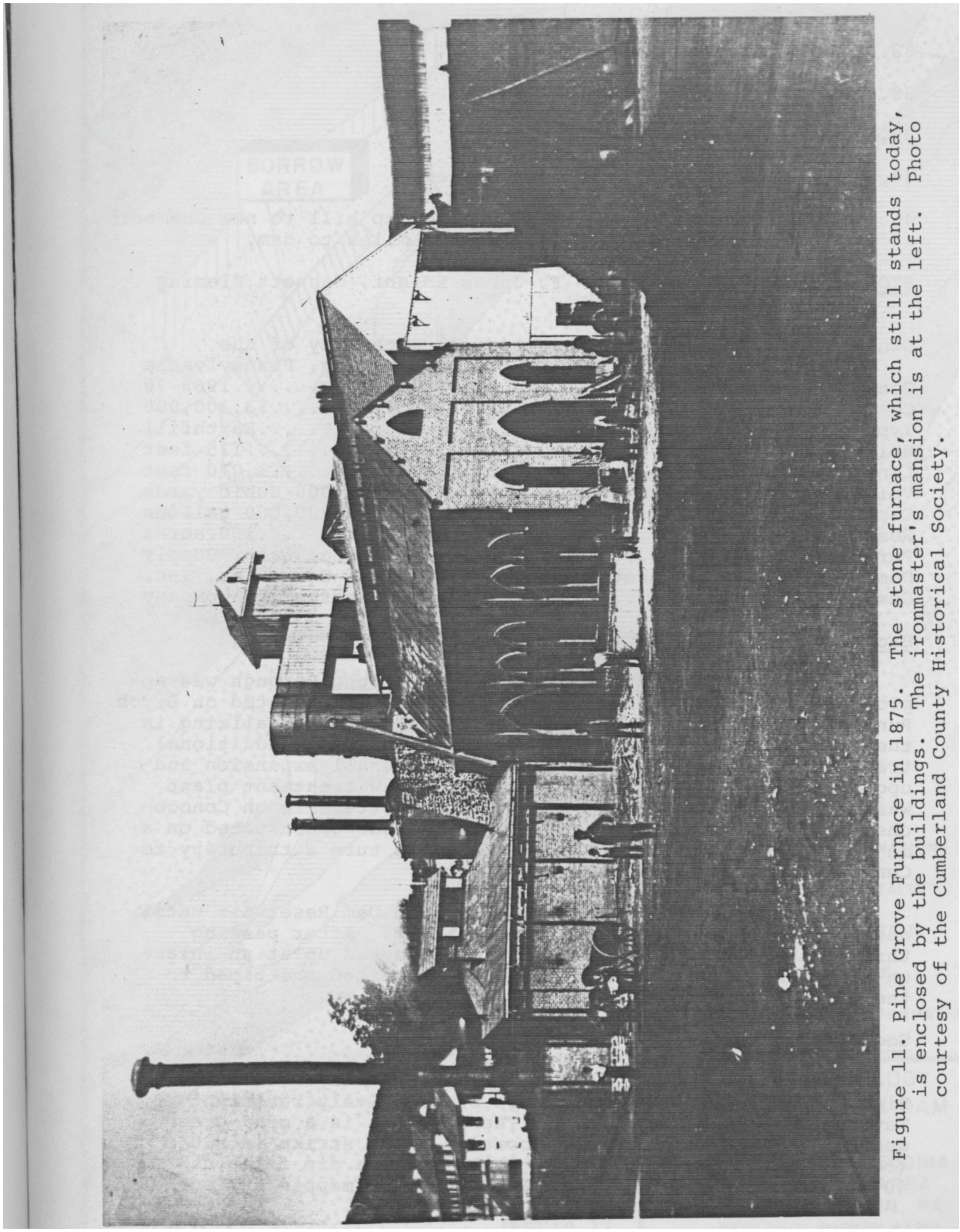


Figure 11. Pine Grove Furnace in 1875. The stone furnace, which still stands today, is enclosed by the buildings. The ironmaster's mansion is at the left. Photo courtesy of the Cumberland County Historical Society.

Figure 38. Pine Grove Furnace in 1875. The stone furnace furnace stack, which still stands today, is in center behind first building. Ironmaster's Mansion is in distance at far left. Photo courtesy of Cumberland County Historical Society.

TURN AROUND and RETURN WAY CAME.
33.2 Stop Sign. TURN RIGHT. Iron Masters Mansion straight ahead.
33.3 Stop sign. TURN RIGHT onto PA 233.
33.4 TURN LEFT following PA 233.
35.3 Cross Ridge Rd. CONTINUE ahead on PA 233 across the crest of South Mountain.
37.5 HALF RIGHT off PA 233 onto unnamed road that is Point Drive.
37.7 Stop sign. CONTINUE STRAIGHT ahead on Point Drive. Note karst depressions on left. Travelling down a colluvial fan surface.
38.6 Stop sign. TURN RIGHT onto Pine Rd. Make immediate LEFT onto Lebo Rd. Note the PA Fish Commission Huntsdale Hatchery complex on both sides.
38.7 Cross Yellow Breeches Creek. Note sign collection ahead on right.
38.9 TURN LEFT onto Church Rd.
39.0 Road curves right. CONTINUE STRAIGHT AHEAD to church parking lot.
STOP 5. Park in church parking lot. **View Stop** (Fig. 39).

We stop here to get an overview of the topography at the northern base of South Mountain. This is one of the best places to view fan surfaces at the northern base of the mountain. Most of fan surface is underlain by the Cambrian Tomstown dolomite, which is dissolved by acid rain runoff from silicate rocks on South Mountain. Fans are composed of coarse gravel alluvium and colluvium washed from the Antietam quartzite, Harpers phyllite, and Montalto quartzite in South Mountain and extending as far north as Yellow Breeches Creek. Apices of fans are at the mouths of streams that drain South Mountain. Beneath the gravels in the fans is thick clay residuum from weathering of the Tomstown. The fan surfaces are dotted with karst depressions where residuum and gravel has dropped into cavities in the carbonates beneath. The fact that the fan surfaces are modified by karst suggests that they are quite old.

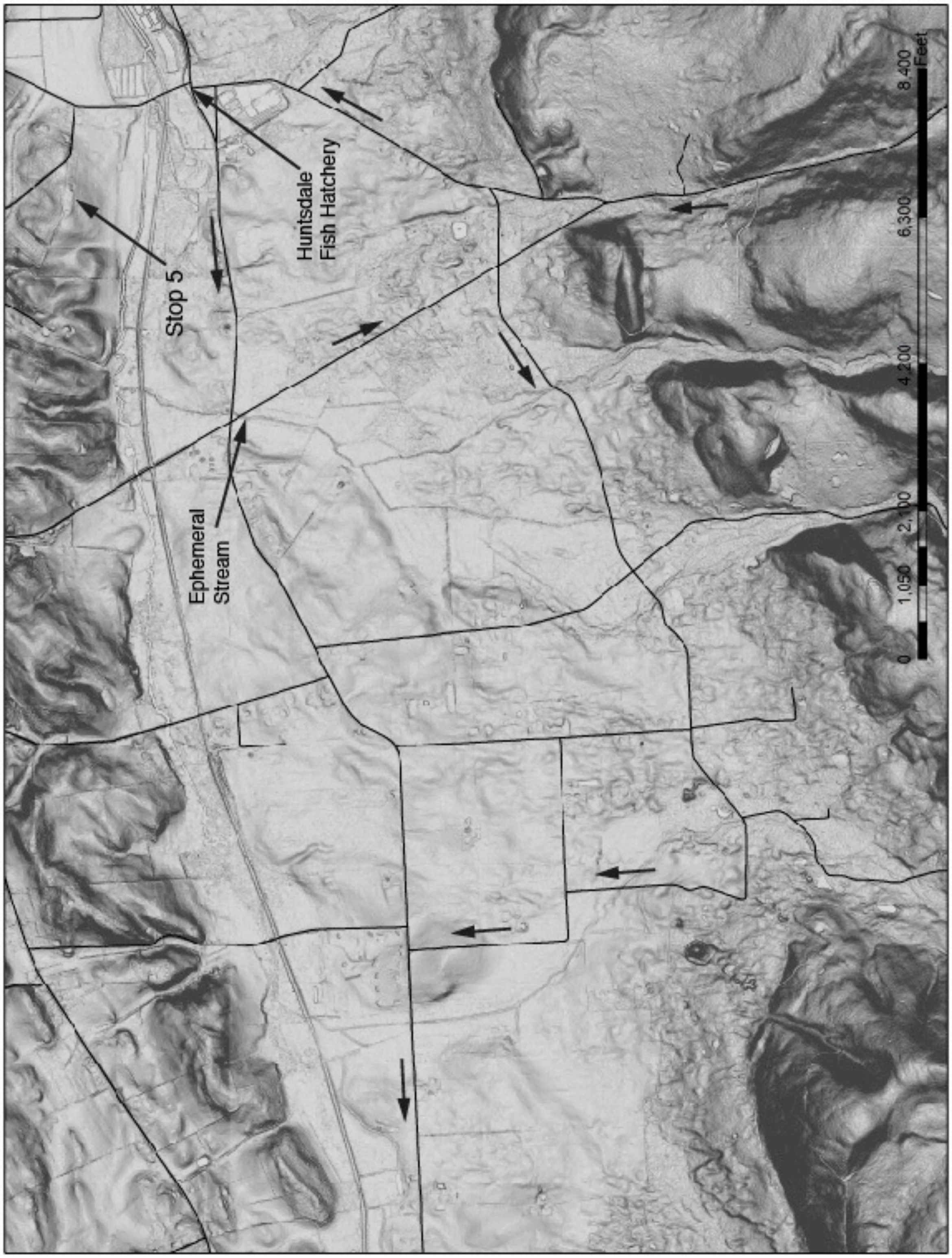


Figure 39. Stop 5. Overview N of Huntsdale. North is toward the left.

Leave parking lot and return the way came.

39.2 Stop sign. CONTINUE STRAIGHT AHEAD on Church Rd.

39.4 Stop sign. TURN RIGHT onto Lebo Rd.

39.7 Stop sign. TURN RIGHT onto Pine Rd.

Karst with water on right.

40.6 Stop sign. TURN LEFT onto PA 233, and immediately cross small stream. Figure 40 is an aerial view of the area near this road junction. Note the numerous ponds in karst depressions.

Figure 40. Junction of PA 233 (trends toward upper right and South Mountain) and Pine Road in mid-March 2011. Note karst depressions full of water. Stream referred to in Figs. 41 through 44 crosses just S of intersection.

Figures 41 through 44 show this stream in Springtime and Autumn. In Springtime the stream has substantial discharge, whereas in Autumn it is dry. Water that runs from South Mountain infiltrates near the base of the mountain. In Spring there is sufficient water to feed surface runoff, but by late Summer what little water flows off the mountain all infiltrates so that there is insufficient discharge to feed the surface stream.

Figure 41. Ephemeral stream at PA 233 and Pine Road W of Huntsdale, looking upstream during minor flood on May 12, 2008.

Figure 42. Ephemeral stream at PA 233 and Pine Road W of Huntsdale, looking upstream during dry period on September 19, 2008.

Figure 43. Ephemeral stream at PA 233 and Pine Road W of Huntsdale, looking downstream during minor flood on May 12, 2008.

Figure 44. Ephemeral stream at PA 233 and Pine Road W of Huntsdale, looking downstream during dry period on September 19, 2008.

41.3 TURN RIGHT onto South Side Drive.
41.9 Several karst depressions on right.
43.0 Water filled karst on right.
45.2 TURN RIGHT following paved road. Karst depressions on right covered with colluvium (Fig. 45).

Figure 45. Karst depression after several inches of rain in March, 2011 at Mile 45.2.

43.6 Stop sign. TURN LEFT onto Seavers Rd.
43.8 TURN RIGHT. Colluvial stones in field on left.
44.2 Stop sign. TURN LEFT.
46.2 TURN LEFT onto Mt. View Rd. Other road goes right though railroad overpass. Karst ahead.
47.1 View of South Mountain. Cobbles on hill after road makes a sharp right. Figure 46 shows the view here looking toward South Mountain in the distance. Note that the hill we are on is littered with cobbles of quartzite from South Mountain. How did these cobbles cross the large low area between us and the mountain? The only solution (pun intended) seems to be that sometime in the past the cobbles travelled from the mountain across a surface sloping north, and that subsequently the area between us and the mountain has been lowered by solution of the carbonates beneath. Estimates of the rate of lowering of carbonates in the area by solution is on the order of 10 meters/million years. How old might the surfaces with cobbles on them be?

Figure 46. View toward South Mountain at Mile 47.1 . Note sandstone cobbles on slope in foreground, and large low area between these and source on South Mountain. How did these cobbles cross the depression to get to the hill we are on?

47.3	Water filled karst and cobbles in field on right.
47.4	Cross road. CONTINUE STRAIGHT AHEAD.
48.0	Stop sign. TURN LEFT onto Furnace Hollow Rd.
48.3	Karst with water on right.
49.2	STRAIGHT AHEAD onto gravel road. Paved road goes right.
49.4	TURN RIGHT at road fork.
49.9	TURN LEFT onto Sand Bank Rd.
50.1	Mt. Cydonia Sand Plant III. Quarrying Antietam quartzite.
50.7	Stop sign. TURN LEFT onto Strohm Rd. Gravel in road cut across road.
50.9	TURN LEFT onto Walnutdale Rd.
52.1	Karst areas on right. Figure 47 is an aerial view of Walnutdale Road near here. Note numerous karst depressions filled with water.

Figure 47. Aerial view of Walnutdale Road at Mile 52.1 in mid-March, 2011 after heavy rain. Note numerous karst depressions full of water.

53.0 Pond on right in karst depression.
53.1 Stop sign. STRAIGHT AHEAD onto Cleversburg Rd.
53.2 BEAR LEFT following main road in Cleversburg.
53.3 BEAR RIGHT following main road in Cleversburg.
54.0 Stop sign. BEAR LEFT across Baltimore Rd. CONTINUE AHEAD on McCulloch Rd.
54.5 Cobbles on hill on right. View of South Mountain on left.
56.3 Stop sign in Mainsville. TURN LEFT onto Lindsay Lot Rd.
57.1 TURN RIGHT to Valley Quarries Inc. Mainsville Site #2. Take an immediate left.
57.6 Quarry gate. **STOP 6. MAINSVILLE QUARRY, EXTRACTION OF COLLUVIUM.**

The western margin of South Mountain (SM) has an apron of colluvium that extends several miles from the base of the mountain to near Yellow Breeches Creek in the northeast and I-81 farther south. The apron is much more narrow south of Conococheague Creek (Fig. 48).

The colluvial apron is variable in thickness and thins away from SM. Figure 49 presents an isopach map of the thickness of the colluvial apron. There are areas within the isopach map that are probably moderately inaccurate because of the lack of data. The apron has not been surveyed by any geophysical or other sub-surface method. Little, if any, more recent data is available because of the lack of development and drilling on the apron. However, the map presents a good picture of the thickness of the apron and the variations within same. The apron of sediment has been there for some time because karst solution of the underlying

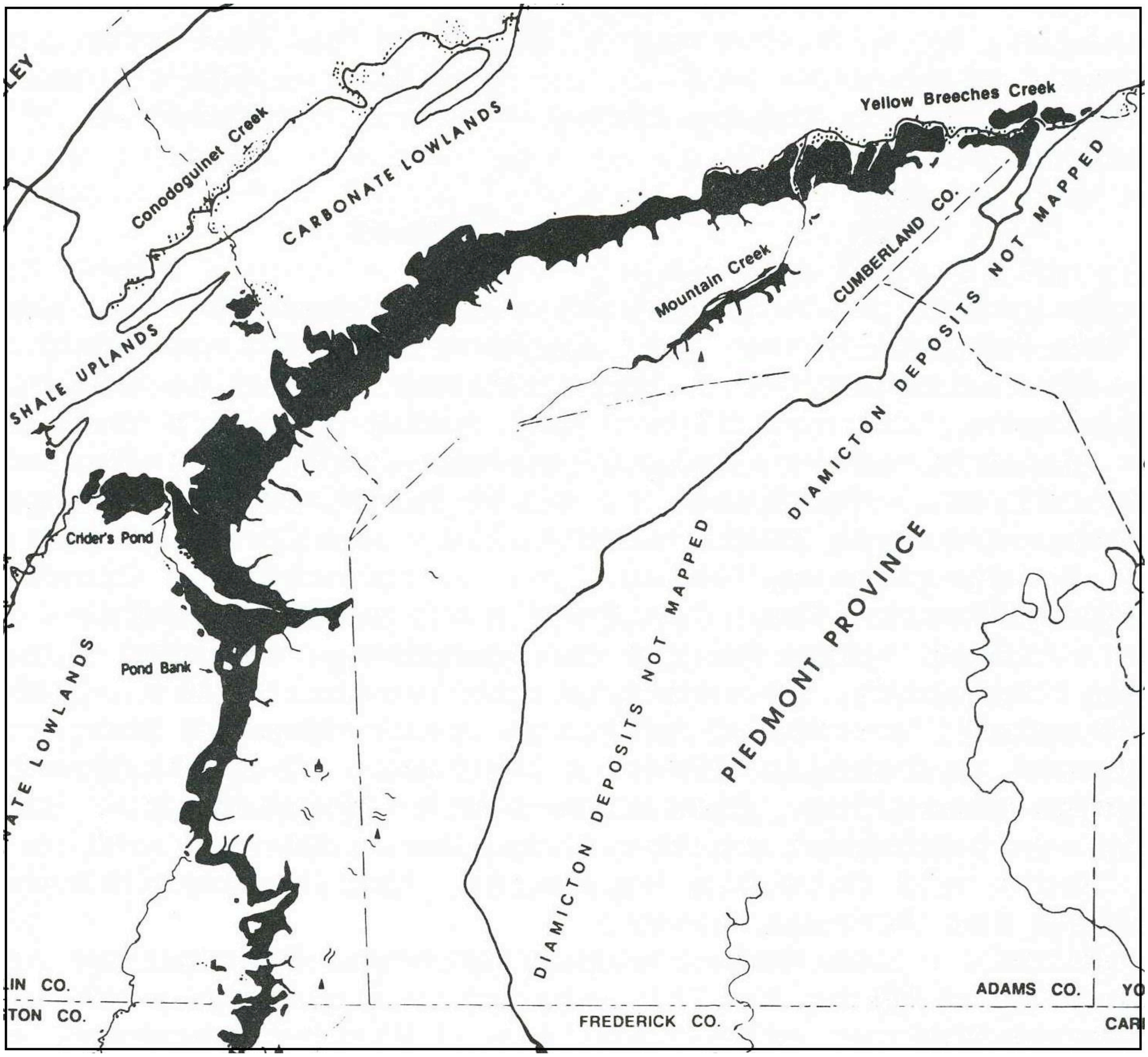


Figure 48. Black area shows distribution of colluvial apron along the west side of South Mountain (from Clark, 1991, Figure 12, p. 61). Lettering for the word PIEDMONT represents approximately 5 miles length on the map.

carbonates have created depressions on the colluvial surface as noted along route mileages 39.2-50.

The quarry at Mainsville (Fig. 50) (note that permission from Valley Quarries is required to visit this locale) is the best place to see the colluvial material that comprises the apron. The quarry has exposed the material to considerable depth and exposures are generally excellent. The colluvial material is composed of clay, silt, sand, pebbles, cobbles, and occasional small

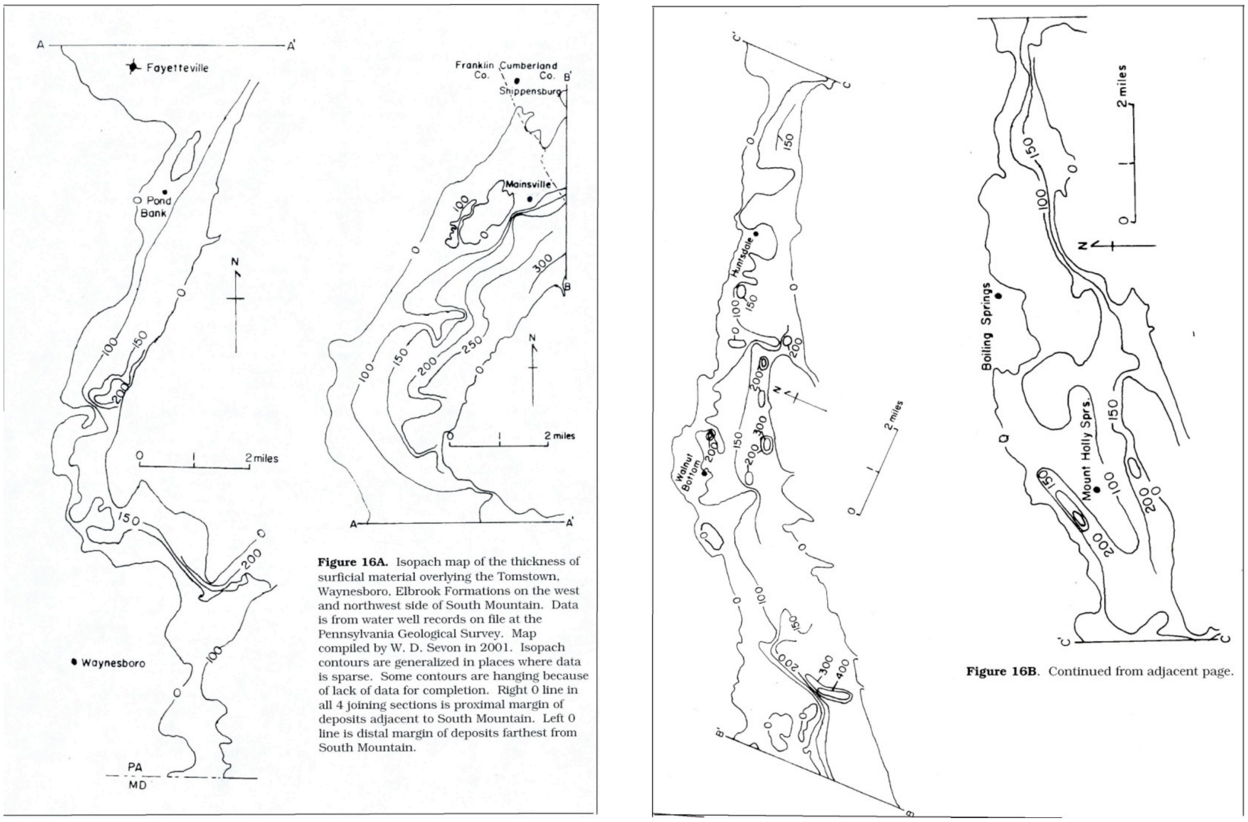


Figure 16A. Isopach map of the thickness of surficial material overlying the Tomstown, Waynesboro, Elbrook Formations on the west and northwest side of South Mountain. Data is from water well records on file at the Pennsylvania Geological Survey. Map compiled by W. D. Sevon in 2001. Isopach contours are generalized in places where data is sparse. Some contours are hanging because of lack of data for completion. Right 0 line in all 4 joining sections is proximal margin of deposits adjacent to South Mountain. Left 0 line is distal margin of deposits farthest from South Mountain.

Figure 16B. Continued from adjacent page.

Figure 49. Isopach map of the thickness of surficial material overlying the Tomstown, Waynesboro, Elbrook Formations on the west and northwest side of South Mountain. Data is from water well records on file at the Pennsylvania Geological Survey. Map compiled by W. D. Sevon in 2001. Isopach contours are generalized in places where data is sparse. Some contours are hanging because of lack of data for completion. Right 0 line in all 4 joining sections is proximal margin of deposits adjacent to South Mountain. Left 0 line is distal margin of deposits farthest from South Mountain. Map is from Sevon, 2001, p. 24-25. The accuracy of the isopach information has probably changed little since 2001 because of the lack of new well information.

Figure 50. The Mainsville Pit in April, 2011. Trackhoe for scale at far left end in bottom.

boulders (Fig. 52). At the entrance to the quarry are a number of 0.5-1 m diameter boulders, presumaly of Weverton or Montalto, that travelled from their source to this area. How? Periglacial transport is the most probable answer. Much of the exposed granular rock is so weathered that cobbles and small boulders disintegrate readily with only minor force required. In some places the colluvium is totally unsorted (Fig. 52), and can be called a diamicton, in some places it shows vague stratification (Fig. 53), and in other places excellent stratification and separation of sediment sizes (Fig. 54). No pattern of stratification variation has been detected. In addition to the clast dominated colluvium that makes up the bulk of the material at Mainsville, there are large deposits of iron-coated quartz sand. Such a deposit near the top of the quarry is mined for sale as baseball-diamond sand. An apparently similar sand filling a 100' diameter plug is not saleable, apparently because the iron content is less. The sharp margin of this sand plug is shown in Figure 55 as it appeared when the plug was first exposed in the early 1990's. Note the abrupt change from colluvium (right) to sand (left). The contact margin had clay slickensides that indicated that the sand plug had moved downward. Presumably, the sand was filling a circular karst hole of some origin.

The well-stratified parts of the colluvium (Fig. 56) are not abundant, at least during the times that Noel and I have examined the quarry. Thus, it appears that the bulk of the material was transported and deposited as an unsorted, unconsolidated mass of debris. This strongly suggests that the material was brought in by debris flows. Occasionally, the local stream emanating from the gap in the Antietam quartzite would transport and deposit specific sediment material and create the stratified units. The streams flowing through the 19 gaps in the Antietam ridge between Mountain Creek at Mount Holly Springs and Fayetteville have created an overall pattern of coalescing alluvial fans.

The big question created by this apron of colluvium is how long has this process been going on. Back in 1991 there was a clastic dike that had well preserved soils at its top (Sevon, 1991, p. 180-184). The uppermost soil was modern. Beneath that soil was a paleosol of undetermined age. The soil coloration suggested that it was of pre-Wisconsin age. It may have been Illinoian or pre-Illinoian in age, but no positive determination was possible. Because the soil was near the uppermost surface of the deposit, that soil development probably occurred subsequent to the end of the alluvial fan deposition and possibly during downcutting that created the present incised stream channels. Add to that a few other facts.

It is possible to find many places where colluvium on the apron is well removed from the SM margin and occurs at higher levels than the landscape between it and SM. Such a situation occurs about 2000 feet NW of Mainsville quarry where another smaller quarry occurs (Fig. 51). The surface of the colluvial apron contains abundant depressions caused by karst subsidence beneath the surface. The overall terrain of the colluvial apron is irregular rather than smooth and gently west-sloping as would occur for a normal colluvial apron developed above non-carbonate rocks. Based on all these factors, we must assume that the underlying carbonate rocks have been leached and have developed an irregular karst topography beneath

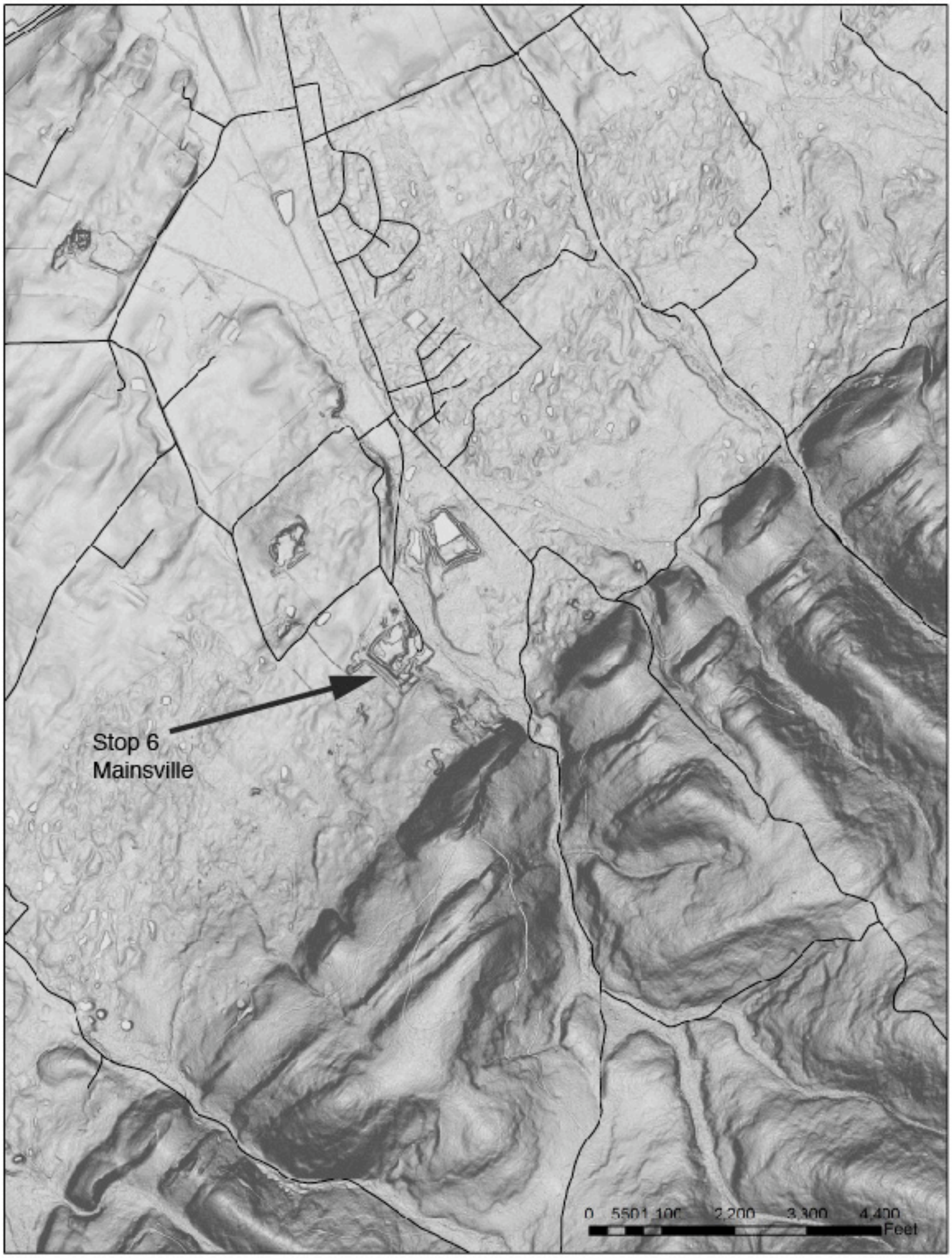


Figure 51. LiDAR Shaded Slope Map of Stop 6, Mainsville and the South Mountain Area.

the colluvium. This is not unanticipated considering the overall permeability of the colluvium, the rapid weathering rate of the carbonate rock, and the potential length of time involved. The problem remains, how long has the process been progressing.

We do not know what the colluvial materials are at the bottom of the apron. However, we can guess that they are similar to those we see. Our previous assumption was that most of the material came from the small drainage basins east of the Antietam ridge. If, as I now suspect, this process has been going on for a lot longer than formerly thought, then it is possible that much of the lowermost material was derived from erosion of the Antietam itself as that rock was removed to expose the Harpers and Montalto along the whole mountain crest. An idea worth speculating upon.

An additional aspect is the influence of periglacial gelufluction on the deposited material. As we have tried to show on this trip through attention to LIDAR imagery, SM has an abundance of gelufluction lobes, particularly near the mountain front (Fig. 51). We understand that when quarrying was initiated herein the NE corner near the entrance it was started in such a lobe. LIDAR imagery shows that lobes do occur in the vicinity. We have not detected, probably because of lack of careful investigation, any irregularities in the exposed sediments that would indicate periglacial activity. Such evidence may exist in as yet unexamined or unreacheable quarry sites. Braun (1989) estimates that Pleistocene periglacial erosion rates were an order of magnitude greater than present day fluvial erosion rates. Jacobson, et al. (1989) conclude that "the events that have been the most effective in sculpting the Appalachian landscape are largely the result of events associated with what appears to have been a very different geomorphic climate in the Pleistocene." Most of the landscape we see on South Mountain is a remnant of the cold phases of the Pleistocene.

We hope that you enjoy this stop and that it opens your mind to the concept that not everything is always clear despite the availability of exposure. The answers are not always clear.

Figure 52. Colluvial diamicton.

Figure 53. Vaguely stratified diamicton. Scale divided into 10 cm intervals.

Figure 54. Stratified colluvium. Scale divided into 10 cm units.

Figure 55. Contact of sand plug (left) and colluvium (right). Scale divided into 10 cm intervals. Note slickensided clay at contact.

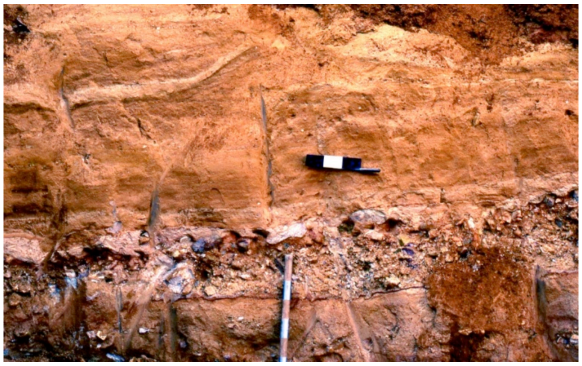


Figure 56. Stratified colluvium with very contrasting grain sizes. Both scales divided into 10 cm intervals

TURN AROUND and return to Mainsville the way came.
58.2 TURN LEFT onto Lindsay Lot Rd.
58.9 House on left constructed of cobbles, the local building stone.
59.0 Stop sign. TURN RIGHT onto Mainsville Rd.
59.6 Cross road at Cumberland-Franklin counties line. CONTINUE STRAIGHT AHEAD.
61.3 Stop sign. STRAIGHT AHEAD onto Cleversburg Rd.
61.9 TURN LEFT onto Neil Rd.
62.9 Railroad underpass then stop sign. CONTINUE STRAIGHT AHEAD across Airport Rd.
63.7 Stop sign. BEAR LEFT and STRAIGHT ACROSS to I81 entrance ramp. Colluvium in this area.
79.8 EXIT 45 to College Street.
80.0 Traffic light. TURN LEFT onto Walnut Bottom Rd.
80.1 Traffic light. CONTINUE STRAIGHT AHEAD.
80.2 Traffic light. TURN LEFT onto Belvedere Street.
80.6 Stop sign. CONTINUE STRAIGHT AHEAD.
80.9 Stop sign. CONTINUE STRAIGHT AHEAD:
81.1 Stop sign. TURN RIGHT onto W. High Street.
81.4 Traffic light. TURN LEFT onto Cherry Street.
81.5 Stop Sign. CONTINUE STRAIGHT AHEAD. Immediate RIGHT into parking lot. End of trip.

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