GEOLOGY 303

LEHIGH VALLEY FIELD TRIP

November 4, 2000

THEMES OF THE TRIP:

glacial sediment, both till and outwash

moraines and other glacial landforms

topographic expression of glacial materials

topographic expression of rocks of differential resistance

cold-climate features and processes in sub-glacial regions

sedimentary deposits of ancient rivers - both braided and meandering

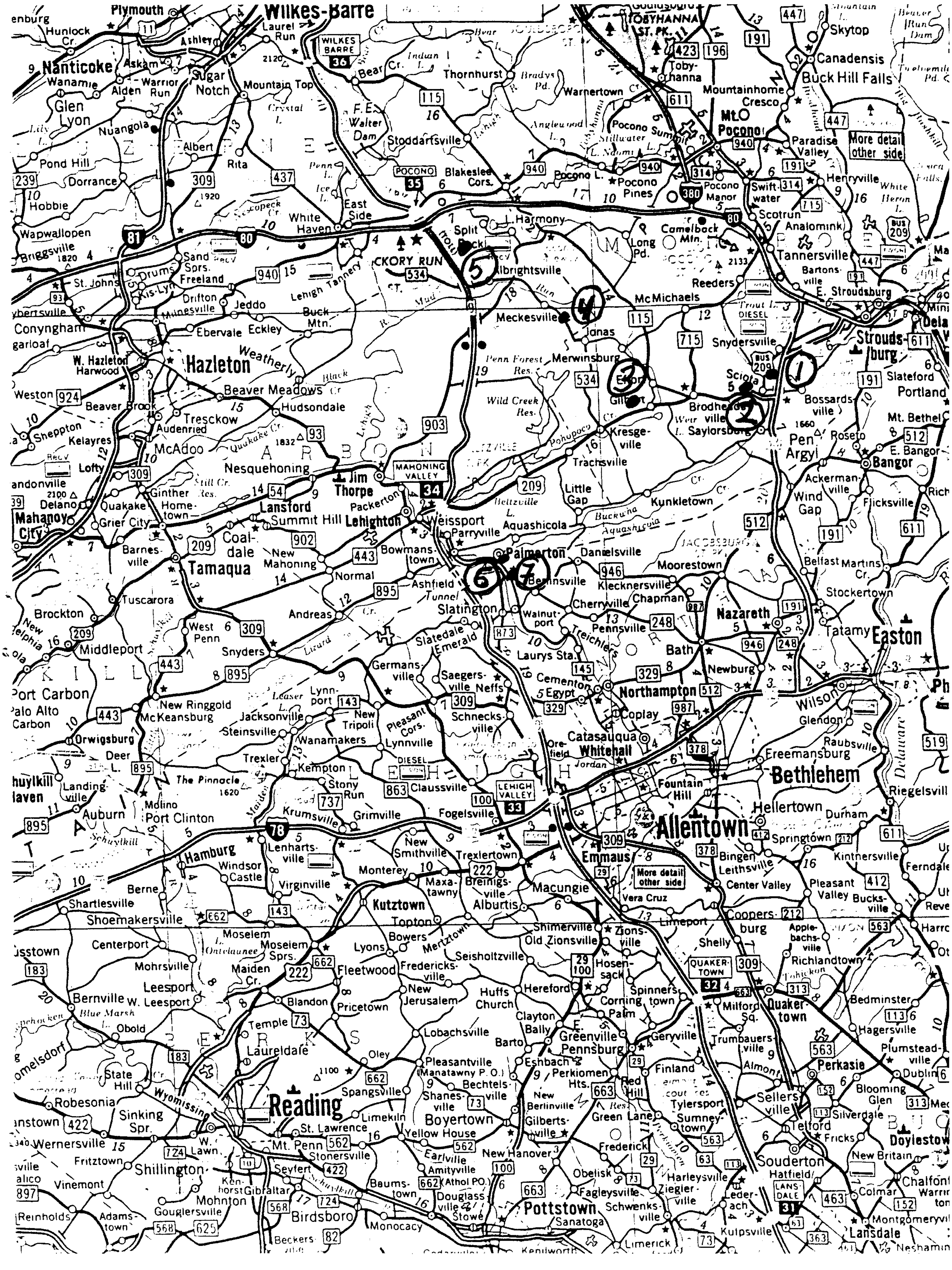
primary sedimentary structures

deposing sedimentary rocks

STOPS:

1. Eureka Stone Co. sand pit, Sciota, PA; 1 hour
2. Jeff Horacek property: glacial till; 20 minutes
3. Earl Beers property: outwash? soil? Brodheadsville, PA; 20 minutes
4. Mountain top: colluvium field; 15 minutes
5. Hickory Run State Park: boulder field; 1 hour
6. Silurian fining-upward cycles, Palmerton, PA: 45 minutes
7. Silurian braided-river sandstones and conglomerates, Palmerton PA: 45 minutes

return to Newark 1900



Wilkes-Barre
Plymouth
Hunlock Cr.
Nanticoke
Ashley
Laurel Run
Wanamie
Askam
Warrior Run
Sugar Notch
Alden
Mountain Top
Glen Lyon
Nuangola
Albert
Rita
Pond Hill
Dorrance
Hobbie
Wapwallopen
Briggsville
Bear Cr.
Thornhurst
F.E. Walter Dam
Stoddartsville
Blakeslee Cors.
White Haven
East Side
Warnertown
Tobyhanna
Tobyhanna St. Pk.
Pocono Summit
Mountainhome
Cresco
Mt. Pocono
Skytop
Canadensis
Buck Hill Falls
Paradise Valley
More detail other side
Henryville
Swiftwater
Pocono Manor
Pocono Pines
Pocono L.
Scotrun
Analomink
Tannersville
Camelback Mtn.
Long Pd.
Harmony
Split Rock
Hickory Run
Albrightsville
Sand Sprs.
Drums
Freeland
Kis-Lyn
St. Johns
Drifton
Jeddo
Milnesville
Lehigh Tannery
Buck Mtn.
Conyngham
Ebervale
Eckley
Meckesville
Jonas
McMichaels
Reeders
Bartonsville
E. Stroudsburg
Stroudsburg
Snydersville
Merwinsburg
Effort
Gilbert
Sciota
Brodheadsville
Saylorsburg
Bossardsville
Slateford
Portland
Mt. Bethel
W. Hazleton
Harwood
Hazleton
Weatherly
Penn Forest Res.
Wild Creek Res.
Weston
Beaver Meadows
Beaver Brook
Hudsondale
Tresckow
Audenried
Sheppton
Kelayres
McAdoo
Nesquehoning
Jim Thorpe
Mahoning Valley
Kresgeville
Trachsville
Pen Argyl
Roseto
E. Bangor
Bangor
Lofty
Delano
Mahanoy City
Quakake
Ginther
Hometown
Lansford
Summit Hill
Lehighton
Packerton
Weissport
Parryville
Little Gap
Kunkletown
Wind Gap
Ackermanville
Flicksville
Grier City
Barnesville
Tamaqua
Coaldale
New Mahoning
Normal
Bowmanstown
Aquashicola
Palmerton
Danielsville
Moorestown
Belfast
Martins Cr.
Tuscarora
Brockton
Ashfield
Andreas
Slatington
Bennsville
Kecknersville
Chapman
Cherryville
Stockertown
Walnutport
Nazareth
Tatamy
Easton
Middleport
West Penn
Snyders
Pennsville
Treichlers
Laurys Sta.
Bath
Newburg
Germansville
Slatedale
Emerald
Saegersville
Neffs
Cementon
Egypt
Northampton
Wilson
Port Carbon
Palo Alto
New Ringgold
McKeansburg
Jacksonville
Lynnport
New Tripoli
Pleasant Cors.
Schnecksville
Coplay
Glendon
Orwigsburg
Steinsville
Wanamakers
Lynnville
Catasauqua
Whitehall
Raubsville
Freemansburg
Deer L.
Trexler
Kempton
Stony Run
Claussville
Orefield
Fountain Hill
Bethlehem
Schuylkill Haven
Landingville
The Pinnacle
Lehigh Valley
Riegelsville
Auburn
Molino
Port Clinton
Krumsville
Grimville
Fogelsville
Allentown
Hellertown
Durham
Hamburg
Lenhartsville
New Smithville
Trexlertown
Emmaus
Bingen
Leithsville
Springtown
Kintnersville
Windsor Castle
Virginville
Monterey
Maxatawny
Breinigsville
Macungie
Vera Cruz
Center Valley
Pleasant Valley
Bucksville
Berne
Shartlesville
Kutztown
Alburtis
Coopersburg
Shoemakersville
Topton
Shimerville
Zionsville
Limeport
Old Zionsville
Moselem
Moselem Sprs.
Lyons
Bowers
Mertztown
Seisholtzville
Shelly
Applebachsville
Richlandtown
Centerport
Mohrsville
Maiden Cr.
Fleetwood
Fredericksville
Hosensack
Quakertown
Bedminster
Bernville
Leesport
W. Leesport
Blandon
Pricetown
New Jerusalem
Huffs Church
Hereford
Spinnerstown
Milford Sq.
Corning
Palm
Hagersville
Blue Marsh L.
Obold
Temple
Lobachsville
Clayton
Bally
Greenville
Pennsburg
Geryville
Trumbauersville
Plumsteadville
Laureldale
Oley
Barto
Eshbach
Perkiomen Hts.
Red Hill
Finland
Almont
Perkasie
Dublin
State Hill
Pleasantville
Manatawny P.O.
Bechtelsville
Spangsville
Shanesville
Sellersville
Blooming Glen
Robesonia
Reading
Wyomissing
Sinking Spr.
Limekiln
Boyertown
New Berlinville
Gilbertsville
Green Lane
Tylersport
Sumneytown
Silverdale
Telford
Fricks
Doylestown
Wernersville
W. Lawn
St. Lawrence
Mt. Penn
Yellow House
Earlville
New Hanover
Frederick
Souderton
New Britain
Fritztown
Shillington
Stonersville
Amityville
Athol P.O.
Obelisk
Harleysville
Hatfield
Chalfont
Vinemont
Kenhorst
Gibraltar
Seyfert
Baumstown
Douglassville
Stowe
Fagleysville
Ziegler ville
Lederach
Colmar
Mohnton
Gouglersville
Adamstown
Birdsboro
Monocacy
Pottstown
Sanatoga
Schwenksville
Montgomeryville
Lansdale
Reinholds
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The Glacier

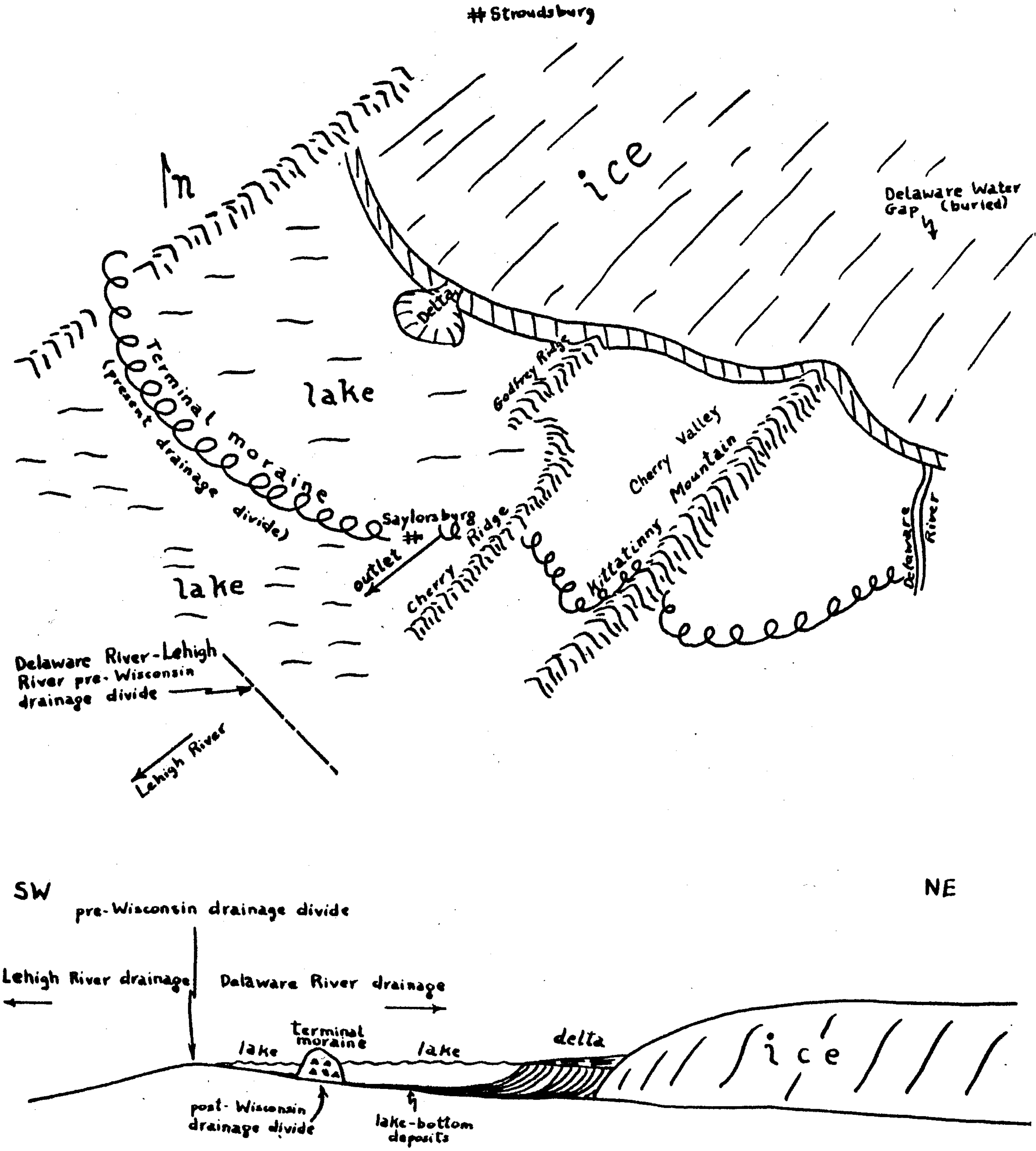
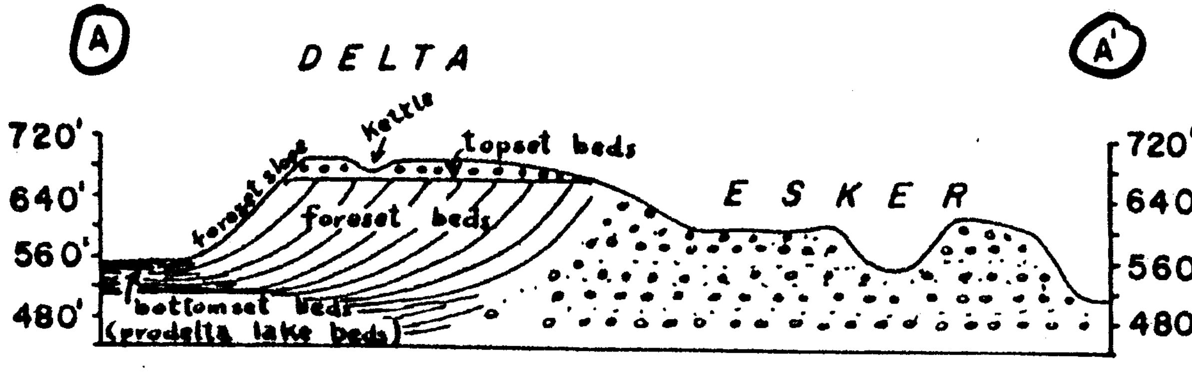


Figure 10. Diagrammatic sketch and section showing pre-Wisconsin drainage divide and position of Wisconsin glacier at the time of deposition of delta seen at stop 1, first day, in Lake Sciota. The terminal moraine marks the present Delaware River-Lehigh River drainage divide.

The Delta



VERTICAL EXAGGERATION X5

STOP 1: ***SCIOTA SAND PIT***

- Consult the two diagrams on the following pages for orientation to the glacier, and the delta.

- Describe the character of the sand. Sorting? Average grain size? Any specific grain size prominently represented?

- Describe the bedding. Not the cross-bedding, but the bedding. Do you think the deposit qualifies as “stratified”?

- Draw some sketches of any cross-bedding, ripples, ripple bedding, slump structures and other structures that you might find.

- Describe any glacial erratics that you might encounter. What aspects of the erratics don't make sense to you? How could explain away those contradictions?

- What do you think was the major mode of sediment transport in this sand body?

- Draw a sketch of the delta, and label topset, foreset and bottomset beds.

- Are the erratics in any consistent place in relation to the geometry of the delta itself?

Places to stop –

– By the Office – – Esker cliffs
– Slug el bdg.

– Right bank –
Far end – Earthflow pit, on right.
– Foreset beds, fossil, granite flow bdg
– Large soft sed fold, + TFB bdg

– Left fork – to turnaround.
– F-B bdg.

STOP 2: ***JEFF HORACEK PROPERTY***.

If we're lucky, we will be able to get behind the wall of the store Jeff is building, and we'll be able to see glacial till in place, unmoved and uneroded. A rare event. This is the Olean Till, named for exposures in Olean, (western) New York, which are part of the same moraine system. If the construction has gone too far, we may be able to locate some moved till in the dirt piles.

- Describe the sedimentary character of the till - sorting, average grain size, angularity of particles, and inferred mode of deposition.

- Compare and contrast the glacial sediment exposed here with the glacial sediment exposed in the sand pit.

STOP 3: ***EARL JONES PROPERTY***

An exposure of soil and/or glacial sediment is seen on the north side of Highway 209. I have not examined this stop before, and there's no telling what we may find.

No questions here.

STOP 4: ***COLLUVIUM FIELD***

This stop shows large boulders of resistant rock (probably sandstone) littered about on the surface, poking out of the weeds and soil. These boulders are COLLUVIUM. They are in creep transit down the gentle slope, and will end up at the base of the mountain and out across the low valley slopes. You've been seeing colluvium all day so far, and will see more of it this afternoon; here's a chance to examine it up close and personal.

- Describe the overall angularity of the boulders - smooth? Jagged? Are the boulders equidimensional or irregular in shape?

- What evidence, if any, of weathering do you see here? Describe:

STOP 5. ***HICKORY RUN BOULDER FIELD***

Read the included material on the next two pages for an introduction to Hickory Run.

This boulder field is at once truly amazing and truly puzzling. There are no easy answers to questions about where the boulders came from, how they were transported, how they were deposited, why the upper surface is even, why the upper surface is so gently inclined, why there isn't much inter-boulder sediment, how they were deposited, how the boulder field grew (from the front back or from the back forward), and on and on.

– Write down some specific questions you have formulated in response to examining the boulder field.

– Propose your own scenario for how the boulders arrived here.

– This location was probably out in front of the glacier, and was not buried by ice. But it must have been very cold here, probably year round. Does this new awareness cause you rethink your scenario? How so?

Hickory Run Boulder Field

The boulder field at Hickory Run State Park is one of the most remarkable relics of the ice ages in Pennsylvania. Take Exit 41 to the park entrance.

The boulder field covers a flat segment of Hickory Run valley, about 1600 feet long east-west and 400 feet wide north-south; the layer of boulders is probably at least 12 feet deep. East-west-trending bedrock ridges rise about 200 feet above the field. A shallow, marshy drainage divide lies about one mile east of it. You can sometimes hear water flowing in the open spaces between the boulders of the field on its way down to Hickory Run.

In addition to its large size, the most striking and unexplained aspect of this field is its flatness. The boulders vary widely in size; a few of the largest are 25 feet long, yet the view over the length of the field reveals an exceptionally level, boulder-top horizon. The rocks are almost entirely reddish-gray sandstones and conglomerates of the Catskill formation from the cap rock of the nearby ridges. How do you suppose the boulders got down from the ridges?

Let's look at several other similar boulder fields in the state: Blue Rocks, Devil's Race Course, Devil's Potato Patch, and Devil's Turnip Patch. All are in the Valley and Ridge province near ridges capped by resistant sandstone and conglomerate, the sources of the boulders. all are near the terminal moraine of the last ice age, except for Devils Race Course, which is only 15 miles southeast of it. Their proximity to the terminal moraine suggests that all the boulder fields formed at the climax of the last glaciation, about 20,000 years ago. Temperatures then were colder than they are now. A lot of meltwater was issuing from the glacier, and frost heave was very active. Talus that accumulated on the sides of the ridges migrated downslope to fill the valley bottoms.

Each freeze-thaw cycle carried the talus a little farther downslope. Judging from the large size of the moraine, the ice front remained stationary for a long time, maintaining the cold climate necessary for the boulder field to form. Perhaps boulder fields are poorly developed within the glaciated region north of the moraine because the receding glacier did not stabilize in any one position long enough.

from "Roadside Geology of PA", 1990

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SEPTEMBER 1953

THE HICKORY RUN BOULDER FIELD, CARBON COUNTY, PENNSYLVANIA*

H. T. U. SMITH

ABSTRACT. The Hickory Run boulder field is located in the Pocono Plateau region of northern Carbon County, northeastern Pennsylvania, along a valley flat near the headwaters of Hickory Run. It lies within an area mapped as Illinoian drift, just beyond the border of the Wisconsin drift. The boulder field is irregular in outline and roughly 400 by 1800 feet in extent. The surface of the field is a bare expanse of unsorted, loosely packed boulders up to 20 feet or more in length. Despite minor irregularities, the overall appearance of the field is one of striking flatness, and the surface gradient is close to 1°. The boulders are composed of quartzitic sandstone and conglomerate of local derivation. Many boulders show splitting, pitting, rounding, and discoloration by weathering in place. Scattered excavations show a complete absence of any finer interstitial material down to water level, at a depth of several feet. Bordering the boulder field are wooded slopes of moderate declivity, with scattered blocky patches and numerous blocks projecting through the forest floor.

The morphology and lithology of the boulder field, together with its present aspect of stagnation and decay, are best explained as resulting from periglacial climatic conditions during the near approach of the Wisconsin ice sheet, inferred to have effected a marked interruption of the stream erosion cycle, with frost action in a major role. The bouldery material is believed to have been supplied by intensified mechanical weathering, to have been carried downslope onto the valley flat by accelerated mass movement, and then to have been left immobile when deglaciation brought climatic amelioration. Subsequent resumption of the normal processes of weathering and erosion now observable has worked toward gradual breakdown of the boulders in place and gradual flushing of interstitial soil material.

INTRODUCTION

THE Hickory Run boulder field, the largest of its kind on record in the Appalachian region, is unusual both scenically and geologically. It is located in the Hickory Run State Park, in the Pocono Plateau region of northern Carbon County, northeastern Pennsylvania (fig. 1). The designation "boulder

* Publication authorized by the Director, U. S. Geological Survey.

APPALACHIAN BASIN STRATIGRAPHY

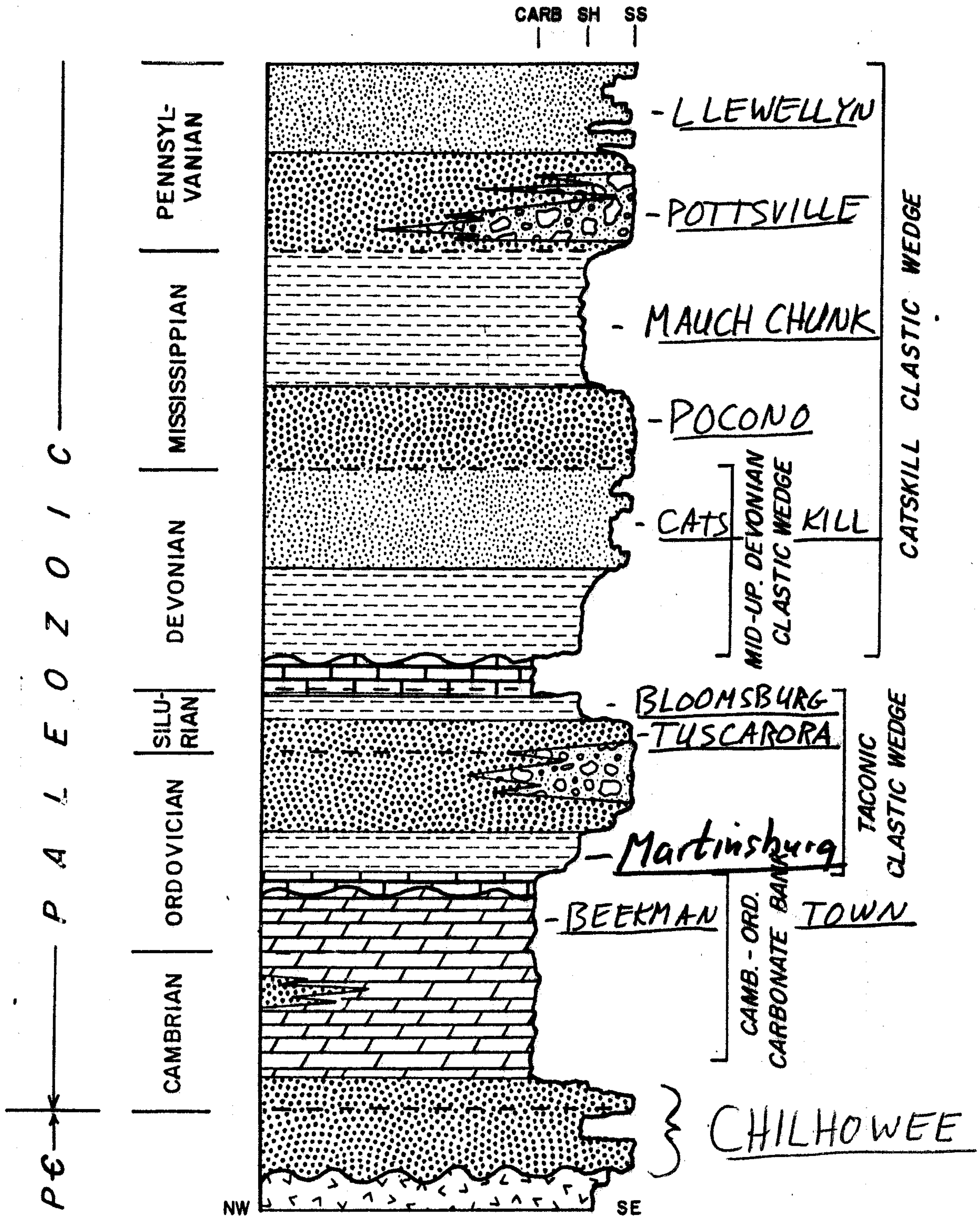


FIGURE 5. GENERALIZED STRATIGRAPHY OF THE NORTHEASTERN APPALACHIAN BASIN IN CENTRAL AND EASTERN PENNSYLVANIA.

from Thompson + Sevon, 1983

Valley + Ridge Sequence Stratigraphy

TABLE 1—(Concluded)

System	Series	Lithotectonic Unit	Formation	Member	Description	Thickness (feet)	Localities where unit will be seen on field trip and economic use
SILURIAN	Middle and Upper	2	Bloomsburg Red Beds		Red, green, and gray conglomeratic sandstone, sandstone, siltstone, and shale partly in upward-fining sequences. Fifty percent sandstone, 45 percent shale and siltstone, and 5 percent conglomerate. Crossbedded and laminated, mud cracks; cut-and-fill structure; scattered ferroan dolomite concretions. Fish scales locally. Partly burrowed. Upper contact gradational.	about 1,500	Quarried for fill and road metal. Stop 4, 2d day.
	Lower and Middle		Shawangunk Conglomerate	Upper quartzite-conglomerate member	Medium-gray to medium-dark-gray fine- to coarse-grained planar-bedded to crossbedded, limonitic, pyritic, conglomeratic (quartz and argillite pebbles as much as 2 in. long) evenly to unevenly bedded quartzite containing about 2 percent dark-gray argillite. Rare ferroan dolomite beds and calcite and ferroan dolomite concretions. Upper contact gradational.	816	Stop 4, 2d day.
				Middle quartzite-argillite member	Medium-light-gray to medium-dark-gray and light-olive-gray fine- to coarse-grained, laminated to planar-bedded, and crossbedded, evenly to unevenly bedded, rippled and flaser-bedded, limonitic, pyritic, and graphitic (rare), quartzose sandstone containing burrows and trails and rare ball-and-pillow structure, interbedded with medium-dark-gray to dark-gray laminated, flaser-bedded, evenly to unevenly bedded, burrowed siltstone and shale containing rare fossils (eurypterids and Dipleurozoa (reported) and *Lingula*). Rare beds of collophane (carbonate fluorapatite), siderite, and chlorite nodules and quartz pebbles.	273	Stop 4, 2d day.
				Lower quartzite-conglomerate member	Light-gray to medium-dark-gray and light-olive-gray medium- to coarse-grained crossbedded and planar-bedded, limonitic, pyritic, unevenly to moderately evenly bedded thin- to thick-bedded quartzite, conglomeratic quartzite, and quartz-, chert-, and shale-pebble conglomerate (quartz pebbles as much as 2 in. long). About 7 percent dark-gray irregularly bedded laminated locally mud-cracked argillite. Upper contact gradational.	300	Stop 4, 2d day.
ORDOVICIAN	Middle and Upper	1	Martinsburg Formation	Pen Argyl Member	Dark-gray to grayish-black, thick- to thin-bedded, evenly bedded claystone slate, rhythmically intercalated with beds of quartzose slate or subgraywacke and carbonaceous slate. Upper contact abrupt and unconformable.	3,000–6,000	Quarried for slate, lightweight aggregate, and fill. Stops 2 and 3, 1st day.
				Ramseyburg Member	Medium- to dark-gray claystone slate alternating with beds of light- to medium-gray, thin- to thick-bedded graywacke and graywacke siltstone. Graywacke composes about 20–30 percent of unit. Upper contact with Pen Argyl Member gradational.	about 2,800	Upper part quarried for slate in Bangor-Pen Argyl area.
				Bushkill Member	Dark- to medium-gray thin-bedded claystone slate containing thin interbeds of quartzose and graywacke siltstone and carbonaceous slate. Upper contact gradational.	about 4,000	Formerly quarried for slate.

from Epstein (1969)

Structural Relations

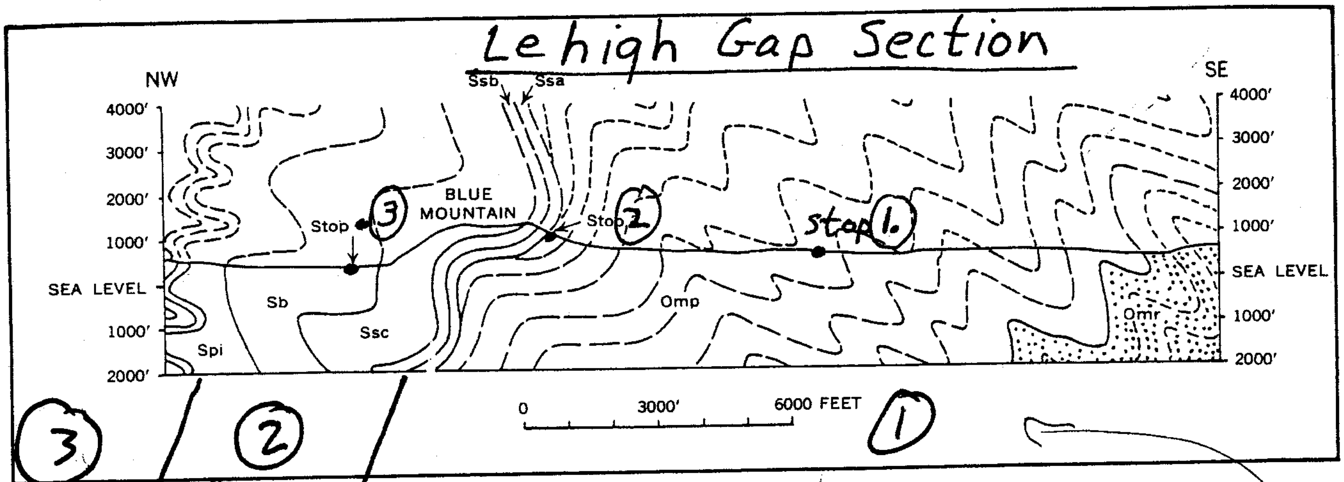


Figure 47. Geologic section 2,000 feet east of Lehigh Gap. Spi, Poxono Island Formation of White (1882); Sb, Bloomsburg Red Beds; Ssc, quartzite-argillite unit of Shawangunk Conglomerate; Ssb, lower quartzite-conglomerate unit of Shawangunk Conglomerate; Ssa, conglomerate unit of Shawangunk Conglomerate; Omp, Pen Argyl Member of Martinsburg Formation; Omr, Ramseyburg Member of Martinsburg Formation.

TABLE 3. LITHOTECTONIC UNITS IN THE DELAWARE RIVER-LEHIGH RIVER AREA, PENNSYLVANIA. MODIFIED FROM FIELD CONFERENCE OF PENNSYLVANIA GEOLOGISTS (1967).

Litho-tectonic unit	Age of lithotectonic unit and stratigraphic sequence (see tables 1 and 2)	Lithologic characteristics	Style of folding	Average size of folds
4	Upper and Middle Devonian Marcellus Shale and younger rocks	More than 10,000 feet of sandstone, conglomerate, siltstone, and shale	Nearly symmetric, concentric, predominantly flexural slip	Two major folds in the area (Weir Mountain syncline and Lehighton anticline—fig. 3); half-wavelengths of more than 5 miles; amplitudes diminish from 4,200 feet near Kunkletown to zero near Bossardsville
3	Middle Devonian to Upper Silurian Buttermilk Falls Limestone of Willard (1938) to upper part of Poxono Island Formation of White (1882)	700 to 1,500 feet of limestone, shale, siltstone, sandstone, and dolomite; heterogeneous stratigraphic units between 3 and 180 feet thick	Asymmetric, concentric, and similar, flexural slip and flow, passive slip and flow. Cascade folds in the east (fig. 23A, B) and flaps (antiformal synclines and synformal anticlines) in the west (fig. 23C)	Wavelengths 1,000 to 1,500 feet; amplitudes about 250 feet in the east increasing to about 1,500 feet in the west
2	Upper to Lower Silurian Lower part of Poxono Island Formation of White (1882) to Shawangunk Conglomerate	3,100 feet of sandstone, siltstone, shale, and conglomerate; coarser toward base of sequence	Asymmetric, concentric; flexural slip with minor passive slip and flow. Extensive bedding slip and wedging in the Bloomsburg Red Beds. Folds tighter in western part of area with development of faulted-out cores of anticlines west of Lehigh River	Wavelengths about 1 mile; amplitudes 1,500–5,000 feet
1	Upper and Middle Ordovician Martinsburg Formation	About 12,000 feet of thick monotonous sequences of slate and graywacke	Asymmetric, similar nearly isoclinal, nearly recumbent in eastern section (fig. 24); mainly passive flow and slip, flexural slip near contact with Shawangunk Conglomerate. Folds probably superimposed on upright limb of large regional nappe	Wavelengths 1,000 to 3,000 feet; amplitudes 400 to 2,000 feet. Small-scale imbricate faults and major thrusts with possible displacements in miles south of field-trip area

competence and thickness control wavelength.

STOP 2: LEHIGH GAP

the rocks:

Shawangunk (pronounced " Shawngum") Conglomerate: well sorted quartz-pebble conglomerate and sandstone; Lower Silurian

Martinsburg Formation, Pen Argyl member: thick-bedded slate and graywacke; Middle Ordovician

FEATURES TO LOOK FOR AT LEHIGH GAP:

- slaty cleavage in Martinsburg, and fanning of cleavage around folds.
- refraction of cleavage
- control of cleavage spacing by rock competence
- cleavage-bedding relations, and changes in it across outcrop
- Taconic unconformity, and relations of bedding on either side
- evidence for faulting (decollement) along unconformity
- evidence for extension or compression within Shawangunk conglomerate
- competence control of fold shape and geometry

Use the Brunton to measure strike and dip of cleavage in the Martinsburg.

Measure the strike and dip of bedding in the Martinsburg.

Sketch a cleavage fan across a small fold in the Martinsburg.

Sketch the relation of cleavage to bedding in the Martinsburg away from the Shawangunk contact.

Sketch the relation of cleavage to bedding in the Martinsburg near the Shawangunk contact.

Sketch tension gashes and conjugate fractures in the Shawangunk, and show stress orientations consistent with those structures.

Using only the width of this page, draw a scaled cross-section of the geologic relations in the gap as we walk through it. Put the Martinsburg-Shawangunk contact at the midpoint of the page. Put topography on your section; estimate it. This is an exercise in keeping track of scale, of scaling things down to a given width.

Stop 2. Lehigh Gap 12

STOP 3. I, MARTINSBURG-SHAWANGUNK CONTACT ALONG ABANDONED RAILROAD GRADE IN LEHIGH GAP
II, STRATIGRAPHY AND SEDIMENTATION OF THE LOWER SHAWANGUNK CONGLOMERATE

The bedrock structure near the Lehigh River is shown in figure 47. A syncline and anticline occur in Blue Mountain at Lehigh Gap. These die out rapidly to the west. At this stop we will see the unconformable contact between the Martinsburg Formation and Shawangunk Conglomerate. Detailed structural relations are shown in figure 48. Southeast-dipping slaty cleavage is well developed in the Martinsburg, 200 feet (stratigraphically) below the contact. The cleavage disappears 120 feet below the contact and bedding-plane slickensides become prominent. Steps on the slickensides indicate northward movement of the overlying beds. The uppermost 8 inches of the Martinsburg is heavily slickensided and contains fault gouge and breccia with internal structures also indicating northwest movement (fig. 22). Evidence, listed in the section on the Taconic orogeny in eastern Pennsylvania, indicates that the prominent cleavage in the Martinsburg was not produced during the Taconic orogeny and is an Appalachian feature. A steep northwest-dipping faint cleavage is seen in thin section in the area where the prominent southeast-dipping cleavage is absent. It is not certain what the age or origin of the cleavage is, but recent work by I. B. Alterman (written commun., October 1968) has shown that in other places there is an early cleavage, generally obliterated by later deformation that she believes developed during the emplacement of the nappe of Taconic age in the Great Valley discussed earlier (section on the Taconic orogeny in eastern Pennsylvania). Perhaps the northwest-dipping cleavage at this stop is the one described by Alterman. The Martinsburg-Shawangunk contact, which also separates lithotectonic units 1 and 2 (see section on structural geology and fig. 27), is interpreted as a décollement.

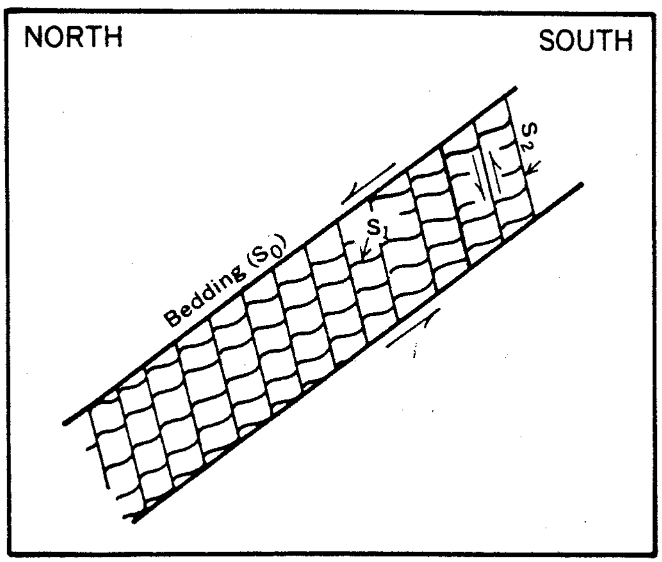


Figure 49. Diagrammatic sketch showing a 2-inch-thick argillite bed in conglomerate unit of Shawangunk Conglomerate. S_0, bedding; S_1, slaty cleavage; S_2, slip cleavage. The first cleavage (S_1) may have formed in response to interbed shear with overriding beds moving to the north as indicated by bedding-plane slickensides. Compare with figure 29B.

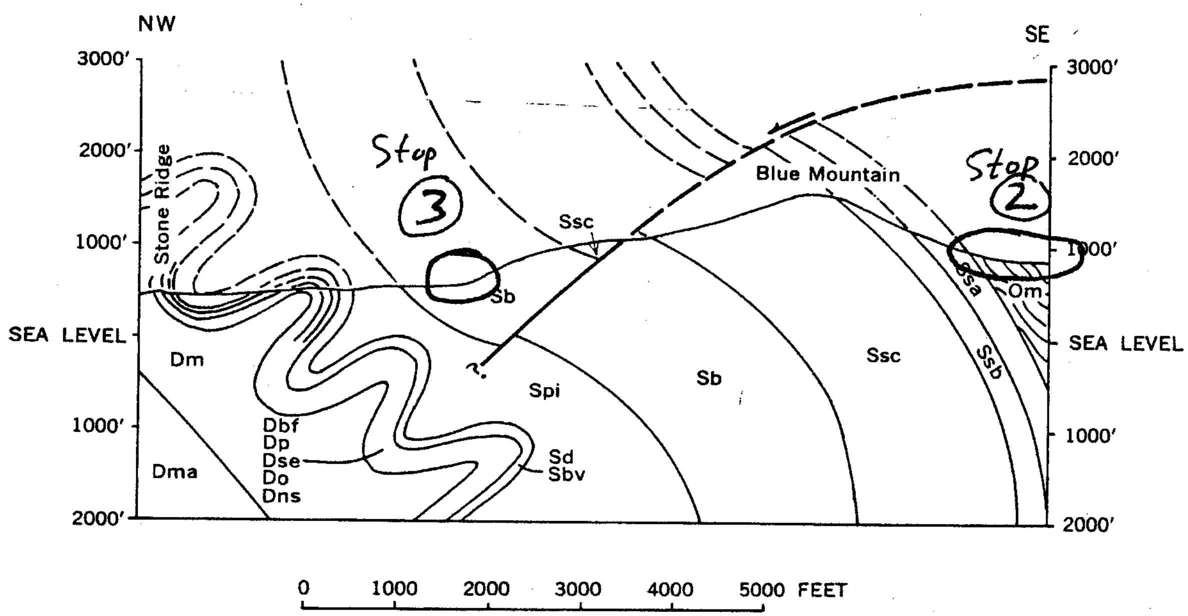
Quartz, chert, and quartzite pebbles in the basal conglomerate unit of the Shawangunk indicate that the Martinsburg was breached and underlying rocks were being eroded and supplying pebbles during early Shawangunk time. The sharp contact and angular relationship between the Shawangunk and Martinsburg, and the very different environments of deposition under which these two units accumulated, indicate an unconformable relationship. The contact is a folded and faulted unconformity.

Two cleavages (one a slip cleavage) occur in a 2-inch-thick argillite bed in the Shawangunk Conglomerate about 50 feet north of the contact (fig. 49).

The contact between the conglomerate unit and overlying lower quartzite-conglomerate unit may be seen about 250 feet north of the Shawangunk-Martinsburg contact. The planar-bedded conglomerates and crossbedded sandstones seen in the lower Shawangunk is indicative of fluviatile sediments deposited by streams of great competency, high gradient, and low sinuosity (see section on geographic and tectonic environments of deposition). These streams flowed to the northwest off the highlands uplifted during the Taconic orogeny. A possible antidune will be seen in the conglomerate unit (fig. 50).

A few miles to the south, a partly dissected Illinoian(?) outwash terrace along the east side of Lehigh River can be seen from this stop.

from Epstein (1969)



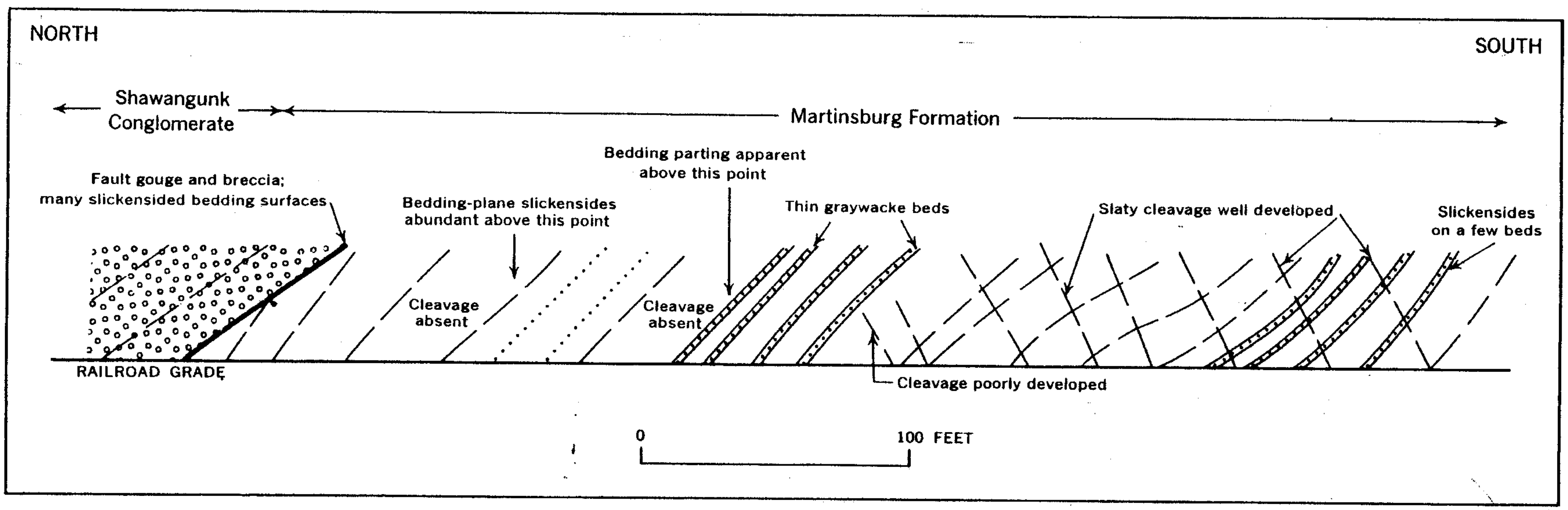


Figure 48. Diagrammatic geologic section through the Shawangunk–Martinsburg contact at Lehigh Gap, showing the dying out of the prominent slaty cleavage in the Martinsburg as the contact is approached.

STOP 3: PALMERTON

the rocks: Bloomsburg Formation: interbedded red and gray sandstones, and red shales: middle Silurian

FEATURES TO LOOK FOR AT PALMERTON:

- fining-upward cycles in sandstones and shales
- layer-parallel shortening, and evidence for it.
- cleavage in shales, and its orientation
- refraction of cleavage in sandstones
- drag of cleavage along faults
- tension gashes in sandstones, and stress orientation
- fiber fillings and extension directions in tension gashes
- wedge thrusts and flattened reduction spots.

THE CENTRAL PROBLEM TO BE ADDRESSED HERE IS THIS: WHAT IS THE DIRECTION OF TECTONIC TRANSPORT OF THESE ROCKS?

Sketch a wedge thrust fault in the sandstones.

Measure the displacement on one wedge fault.

QUESTIONS TO ANSWER:

8. Draw a diagram showing the relations between bedding, wedge thrusts, cleavage, flattening of reduction spots, and σ_1.

9. How many stages of deformation have these rocks undergone? What is the evidence?

Stop 3. Palmerton

Stratigraphy

The Bloomsburg, as seen at Lehigh Gap, stop 4, first day, consists predominantly of red sandstone, siltstone, and shale which occur in poorly to well-defined upward-fining cycles (fig. 12). These cycles are as much as 14 feet thick and consist of, from bottom to top:

(1) Very fine to coarse-grained, large-scale cross-bedded to planar-bedded sandstone that may contain red shale clasts as much as 3 inches long. The basal contact is a sharp erosion surface of very low relief that cuts into underlying finer grained beds. The lower few inches of the sandstone may be gray. The abruptness of the basal contact may be accentuated by bedding slippage described at stop 4, first day.

(2) Finely interbedded and irregularly interlaminated siltstone and very fine grained sandstone containing small-scale ripples. Mud clasts are occassionally found in the sandstone beds.

(3) Shaly siltstone that is extensively burrowed, may be indistinctly mud cracked and contain scattered irregular dark-yellowish-orange concretions averaging about 1 inch in length. These were suggested by N. D. Smith (oral commun., 1968) to be calcareous nodules characteristic of overbank deposits (Bernard and Major, 1963; Moody-Stuart, 1966). X-ray diffraction analysis and staining techniques show that the nodules in the Bloomsburg are ferroan dolomite.

The cycle described above is idealized and does not represent all rocks in the Bloomsburg.

These fining-upward cycles are generally considered to have been deposited by meandering streams (e.g., Allen, 1965b). The coarse basal sands were deposited in stream channels and point bars through lateral accretion as the stream meandered. The mud clasts were derived from bank caving. Large-scale crossbedding and planar-bedding are indicative of the upper lower and lower upper flow regimes, respectively. These basal beds grade up into laminated sandstone and siltstone containing small-scale crossbedding that indicates decreasing flow regime. These are interpreted to be levee and crevasse-splay deposits (Allen, 1965b). Next in succession are the fine overbank or flood-plain deposits that accumulated by vertical accretion. Burrowing animals obliterated stratification in many of these beds in this low-energy tranquil environment. Mud cracks show that subaerial exposure was common. Evaporation at the surface may have caused the precipitation of calcareous concretions, but, as mentioned previously, the concretions in the Bloomsburg are ferroan dolomite. It is possible, for reasons mentioned below, that the Bloomsburg rivers were not far above the strandline, and the dolomite concretions may have formed in a high tidal flat environment by a mechanism similar to the one described for the dolomitization of calcium carbonate later in this section.

Fossils are very rare in the Bloomsburg. Fish have been found in the lower part of the Bloomsburg near Delaware Water Gap which Beerbower and Hart (1959) believe lived in a fluvial or lagoonal environment.

Cyclicity in the Bloomsburg is readily explained by vertical and lateral accretion from migrating streams concomitant with basin sinking. Each fining-upward cycle represents superposition of beds of successively lower flow regime.

I, ILLINOIAN(?) OUTWASH
II, STRATIGRAPHY AND SEDIMENTATION OF THE UPPER SHAWANGUNK AND BLOOMSBURG RED BEDS
III, BEDDING SLIPPAGE, WEDGING, AND TELESCOPING IN THE BLOOMSBURG RED BEDS

from Epstein (1969)

In the small valley above the transitional contact between the Bloomsburg Red Beds and the quartzite-argillite unit of the Shawangunk Conglomerate is a deeply weathered deposit consisting of rounded pebbles and boulders in a clay to very fine sand matrix. Two miles to the south, along the Lehigh River, a similar but better exposed deposit is horizontally stratified. The terrace form, stratification, and rounded pebbles show that this is an alluvial deposit (an outwash terrace or valley train), possibly of Illinoian age. A pebble count indicates a north and northeast source area.

At this locality 900 feet of red beds are exposed. The Bloomsburg is estimated to be 1,500 feet thick. In the exposed section, 128 planes of bedding slippage were counted, so that the total number of such planes in the Bloomsburg may be 1,500/900 x 128, or 213. For purposes of discussion, it is estimated that there has been about 2 feet of downdip displacement along 100 feet of slippage surface. Therefore, for each 100 feet, in a northwest direction parallel to bedding in the Bloomsburg, there could have been 213 x 2, or 426 feet of displacement. Because northwest-dipping beds are at least 6,000 feet deep at this locality (fig. 47), the minimum estimated telescoping is 426 x 6,000/100, or 25,560 feet, or nearly 5 miles. The actual depth of northwest-dipping beds may be more than 10,000 feet, so that total telescoping could be more than 8 miles. If similar wedging and bedding slippage extends up into the Poxono Island Formation of White (1882), where the structural style between lithotectonic units 2 and 3 changes, then the amount of displacement could be even greater.

Note the fining-upward cycles of crossbedded sandstones with mud clasts at the base, rippled to unevenly bedded shaly siltstones and sandstones in the middle, and indistinctly mudcracked bioturbated shaly siltstones with dolomite concretions at the top. These have been interpreted as meandering stream deposits of a low alluvial coastal plain (see section on geographic and tectonic environments of deposition at the beginning of this report). The transitional continental-marine environment of the argillite-quartzite unit of the Shawangunk Conglomerate will also be discussed. Note, in particular, the rather unique beds of nodular phosphate, siderite, and chlorite.

The near-vertical beds at this stop are in the northwest limb of an overturned anticline (fig. 47). Many bedding planes are slickensided, and the steps indicate northwest movement of the overriding beds. Small-scale wedging corroborates this direction of movement (figs. 25, 51). The net telescoping must have been considerable.

The glide zones between all the lithotectonic units in the field-trip area may extend to the northwest where they may shear upward, producing folds similar to those described by Gwinn (1964).

From the bend in the road, three sags can be seen in Blue Mountain above the Pennsylvania Turnpike Extension 2 miles to the west. The sags occur where a northwest-dipping fault emerges from the tightened core of an overturned anticline (figs. 27, 52), showing that the intensity of deformation in lithotectonic unit 2 increases to the west. The antiforms and synforms shown in figure 52 were first described by Dyson (1956).

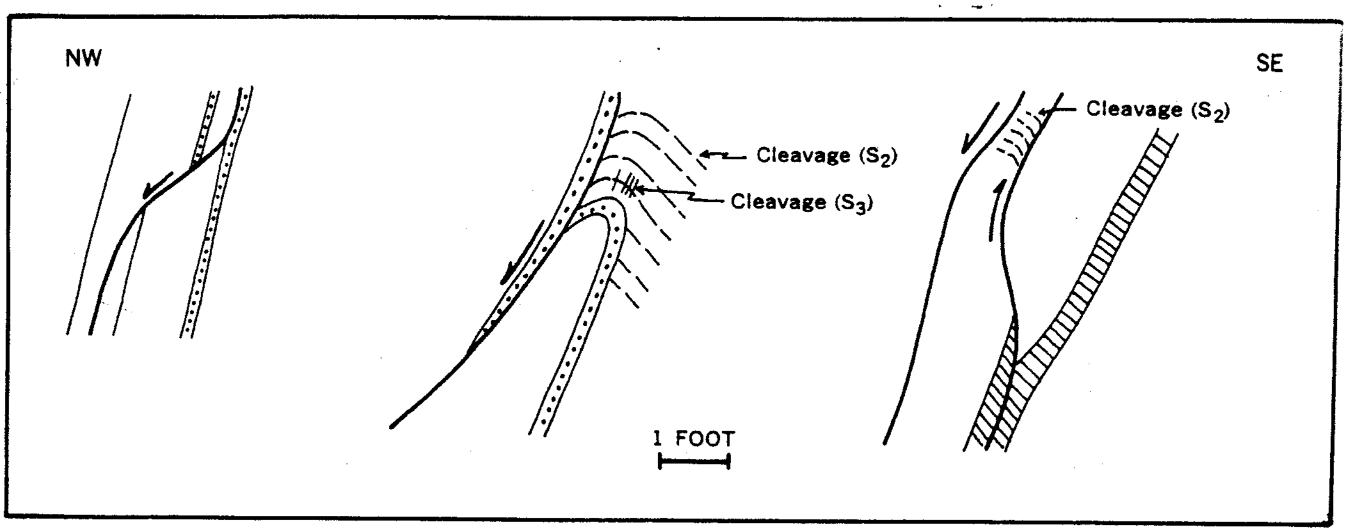


Figure 51. Diagrammatic sketch of wedges and bedding-plane slips in the Bloomsburg Red Beds, Lehigh Gap, stop 4, second day.