ROAD LOG AND STOP DESCRIPTIONS

DAY 1—PENNSYLVANIA

Mileage Int.	Cum.	Description
0.0	0.0	Leave from circle in front of Shawnee Inn. The Inn and golf course are located on postglacial stream terraces that reach a maximum elevation of 330 ft (101 m), about 35 ft (11 m) above the mean annual elevation of the Delaware River. An Early Archaic occupation site excavated on Shawnee Island (Stewart, 1991) was dated at 9330 + 545 yr B.P. (Uga-5488).
0.3	0.3	Turn left onto River Road. The road passes over a variety of Silurian and Devonian rocks that are covered in many places by thin, late Wisconsinan till. The rocks were laid down in a variety of depositional environments, including sub-tidal marine, tidal flats, and beaches. They are complexly folded and have different tectonic characteristics than rocks above and below (Figure 1).

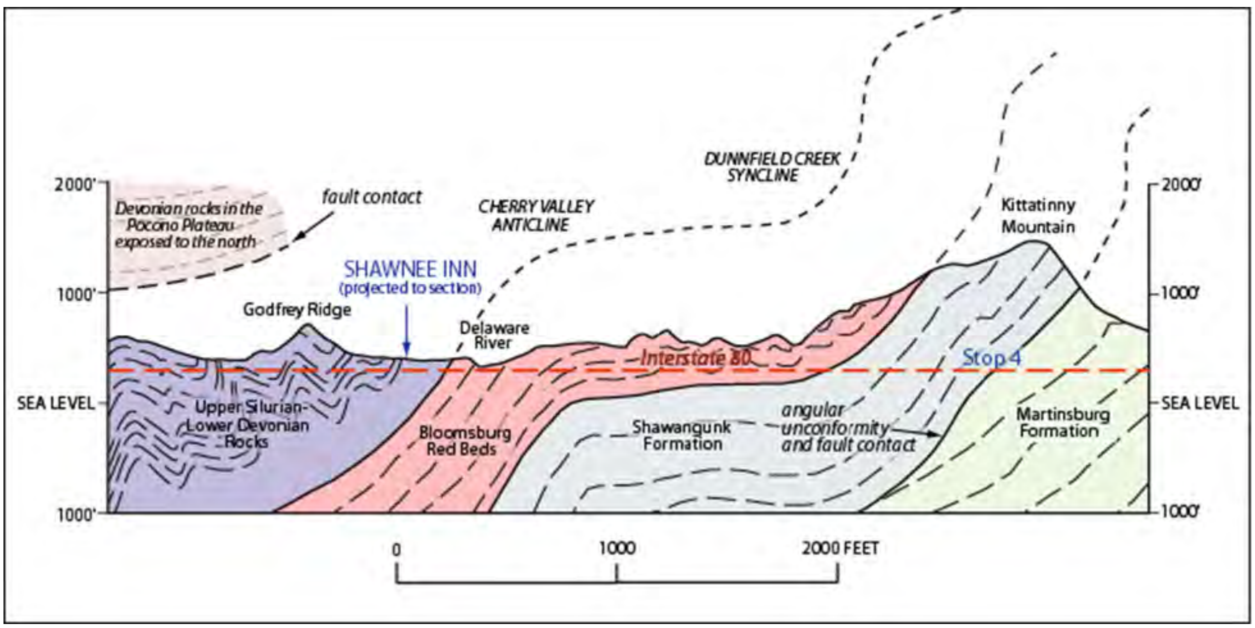


Figure 1. Cross section through Delaware Water Gap showing structural differences between packages of rocks. The position of Shawnee Inn is projected to the section. Vertical exaggeration: 2X. Location of Stop 4, Point of Gap Overlook, is indicated. Note the undulations in the Bloomsburg Red Beds that will be see at mileage 143.1.

0.1	0.4	Limestone of the Shawnee Island Member of the Coeymans Formation on right (measured section 14-b of Epstein, A.G., and others, 1967). The Stormville Member capping the top of the Coeymans Formation is seen in the private driveway to the right (Figure 2).
0.3	0.7	Fossiliferous New Scotland Formation in slope to right.
0.1	0.8	Traffic light at Buttermilk Falls Road. Continue straight.
0.7	1.5	Minimart on left, and Smithfield School on right sit on a late Wisconsinan

outwash terrace. The terrace lies at an elevation of 400 ft (122 m), about 100 ft (31 m) above the Delaware. Based on its position near the mouth of Marshalls Creek, it was probably laid down by a meltwater stream flowing down the Marshalls Creek valley.

0.1 1.6 Gap View Road on right. 0.3 mi (0.5 km) to the north is the location of an extinct sand and gravel pit in which deltaic deposits were exposed (Figure 3).

0.4 2.0 Village of Minisink Hills. Follow curve to left. Exposures of Coeymans Formation through Esopus Formation along abandoned railroad grade to right. On the crest of the hill northeast of the railroad grade is an imposing ledge of cherty Ridgeley Sandstone (the Indian Chair) from which Amerinds extracted a good-quality flint (Phillip La Porte, personal communication, 2001). Postglacial stream terraces of Brodhead Creek on right. Late Wisconsinan outwash terraces form the higher ground on the left.

0.2 2.2 Historical Marker on left: The Shawnee-Minisink Paleoindian site (McNett and others, 1985) is located on a postglacial stream terrace about 20 ft (3 m) above the Delaware. Work here in the 1970s revealed a very rich and diverse, stratified cultural assemblage of Woodland, Archaic, and Paleoindian components. Radiocarbon dating of organic material collected from a hearth about 9 ft (3 m) deep yielded a date of 10,590 + 300 yr B.P. The hearth is located in cultural zone containing Paleoindian components (clovis point, scrapers, hammerstones). Glacial ice left this area about (15,000 years ago).

Question: Were the native Americans (Lenapi/Delaware Indians) here at the time of glacial retreat? There are several references that indicate that the word Minisink suggests a legendary memory of floods that possibly resulted from the retreat and melting of the Wisconsinan glacier. Brodhead (1870) noted that The Indian name of Minisink—meaning the water is gone—given by the aboriginals to the level country north of the Gap, and extending up the river many miles (kilometers), would seem to indicate some tradition confirming the theory of a lake at some remote period of time (Brodhead, 1870 p. 2); and She (Princess Winona of the Lenni Lenape tribe, about 1670) spoke of the old tradition of this beautiful valley having once been a deep sea of water, and the bursting asunder of the mountains at the will of the Great Spirit, to uncover for her the home of her people the vale of the Minisink; the mighty chasm in the mountains, and the twin giants overlooking the vast extent of country to the rising sun, as far as the eye can reach (Brodhead, 1870, p. 27).

0.2 2.4 Cross Brodhead Creek.

Figure 2. Stormville Member of the Coeymans Formation at mileage 0.4. Parallel to cross-bedded conglomeratic arenaceous limestone with quartz pebbles as much as 0.5 in (1.3 cm) long. Abundant brachiopods (*Gypidula coeymanensis*; pencil) and crinoid columnals indicate a high-energy marine environment, such as an offshore bar.

Figure 3. Coarse topset beds overlying finer foreset beds in sand and gravel (removed by pit operations in 1967) along Gap View Road 0.33 mi (0.53 km) north of River Road. Foreset beds dip due west, probably fed by streams that deposited an esker immediately to the east. See Epstein (1969, fig. 5).

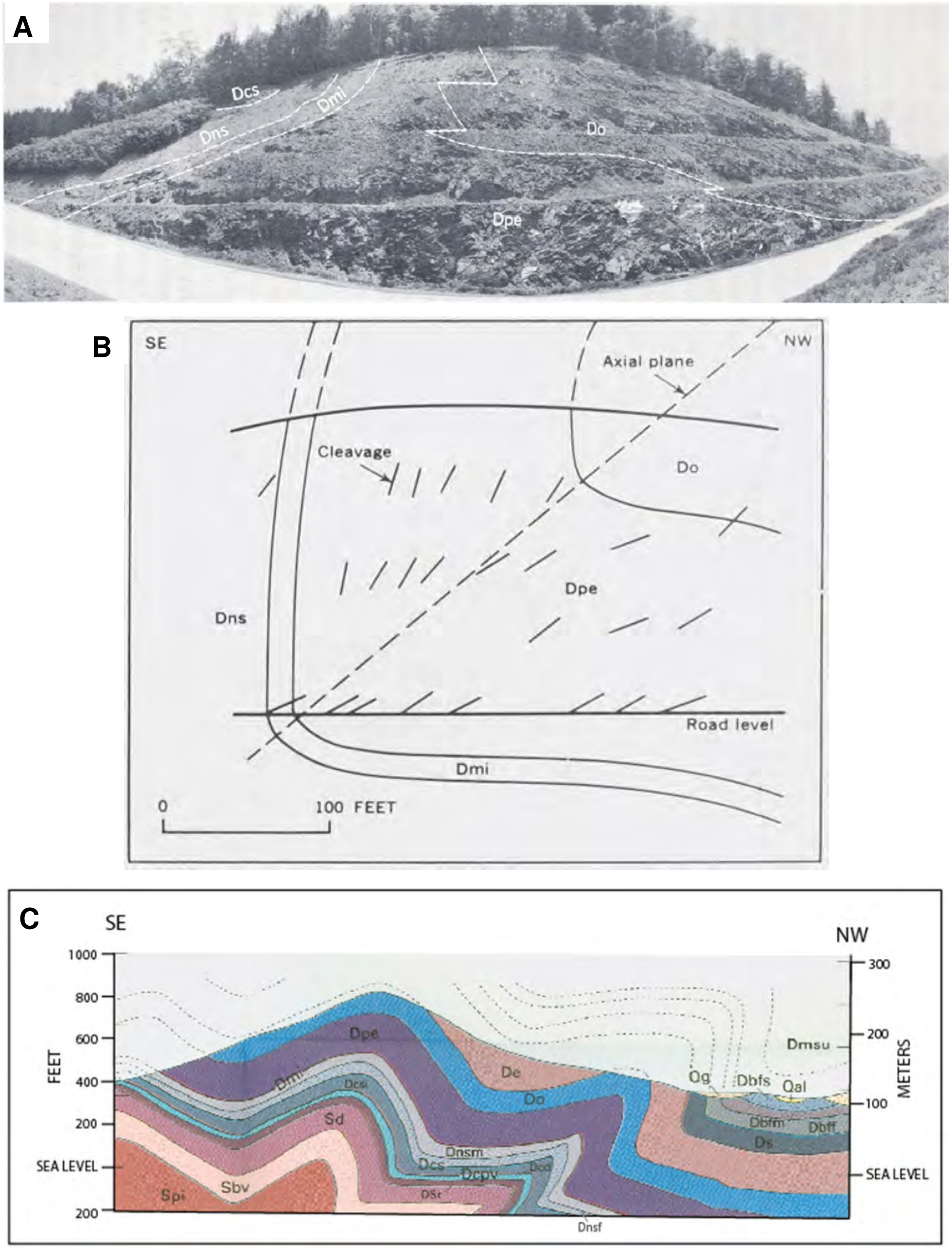


Figure 4. A—Overturned syncline exposed along I-80. Dcs, Stormville Member of the Coeymans Formation; Dns Flatbrookville and Maskenozha Members of the New Scotland Formation; Dmi, Minisink Limestone; Dpe, Port Ewen Shale; Do, Oriskany Formation. Dashed lines are bedding traces. Overturning seems greater because of foreshortening in photo. From Epstein and others (1967, fig. 11); B—Geologic section showing divergent fanning of cleavage in the Port Ewen Shale along I-80. Do, Oriskany Group; Dpe, Port Ewen Shale; Dns, New Scptland Formation; Dmi, Minisink Limestone. From Epstein and Epstein (1969). This fold is part of a complex fold train in Godfrey Ridge; C—Geologic section through Godfrey Ridge at mileage 3.1. Dbfa, Foxtown Member of the Buttermilk Falls Limestone of Epstein (1984), now identified as the Edgecliff Member of the Onondaga Limestone of New York (Ver Straeten, 2001). De, Esopus Formation; Do, Oriskany Group; Dpe, Port Ewen Shale; Dmi. Minisink Limestone; Dnsm, Maskenozha Member of New Scotland Forma-tion; Dnsf, Flatbrookville Member of New Scotland Formation; Des, Stormville Member of Coeymans Formation; Dcsi, Shawnee Island Member of Coeymans Formation; Dcpv, Peters Valley Member of Coeymans Formation; Oed, Depue Limestone Member of Coeymans Forma-tion; Sr, Rondout Formation; Sd, Decker Formation; Sbv, Bossardville Limestone; Spi, Poxono Island Formation.

0.1	2.5	Cross Norfolk Southern (originally, Delaware, Lackawanna & Western) Railroad.
0.2	2.7	Pass under I-80.
0.1	2.8	Traffic light. Turn right onto ramp to I-80 West.
0.3	3.1	Overturned syncline in Lower Devonian rocks on left (Figure D1). Well-developed cleavage fans the fold (Figure D2). This fold is part of a train of complex folds throughout Godfrey Ridge (Figure D3).
0.4	3.5	Cross Brodhead Creek. Note the flat-lying Oriskany Sandstone bluff above the creek. Rumor has it that the Lenape Indians used this fort to shoot arrows down on enemies below.
0.2	3.7	Continue straight at exit 309.
0.2	3.9	Onondaga Limestone on left.
0.9	4.8	Continue straight at Exit 308
0.7	5.5	Cross Brodhead Creek again.
0.2	5.7	Continue straight at Exit 307
1.1	6.8	Onondaga Limestone (Seneca Member) on left
0.6	7.4	Continue straight at Exit 305
0.2	7.6	Exit 304. Bear right onto PA 33S/US 209.
0.9	8.5	Road passes through ridge of stratified drift. During late Wisconsinan deglaciation, proglacial lakes formed in the ice-dammed, northeast-draining valley. Several ice-contact deltas mark ice retreat (Epstein, 1969).
0.8	9.3	Traffic light. Continue straight.
1.0	10.3	Topset and foreset beds in a glacial delta exposed in sandpit to left.
1.4	11.7	Exposure of Marcellus Shale on right. The Marcellus in this area is a medium dark-gray to grayish-black, laminated to poorly bedded, shale and silty shale. It lies more than 4,000 ft (1,219 m) above the Martinsburg Formation. Cleavage is present, but not as well-developed as in the Martinsburg. Folding here is not as profound as in the rocks below. Bedding parting, which is nearly flat, is prominent. Cleavage dips about 38o to the southeast (Figure 5). Pencil cleavage is well developed, formed by splitting along bedding, cleavage, and joints. This property makes it valuable as road fill. The Marcellus was deposited in an anoxic

Figure 5. Marcellus outcrop at mileage 11.7. Cleavage dips moderately to the southwest; bedding is flat; steeper joints interrupt the outcrop. Note "pencil" cleavage in scree in lower left. Small brachipodod on flat bedding surface at bottom of exposure.

(oxygen-starved) marine basin. Because of the reducing environment it is sparingly fossiliferous and contains a depauperate brachiopod fauna, few in numbers and variety. Whereas the Marcellus is a very active gas play in the Alleghany Plateau in northern Pennsylvania, the Marcellus here has reached temperatures too hot to pass gas.

0.9 12.6 Snydersville exit. Continue straight.

0.8 13.4 Pass through road cut in the Schoharie Formation in Godfrey Ridge.

0.2 13.6 Eureka Stone quarry in Schoharie Formation on left. Eureka-Pocono Sandpit in ice-contact delta to right. Over time the pit has exposed excellent examples of deltaic sedimentary structures (Figure 6). This delta marks the first major retreat

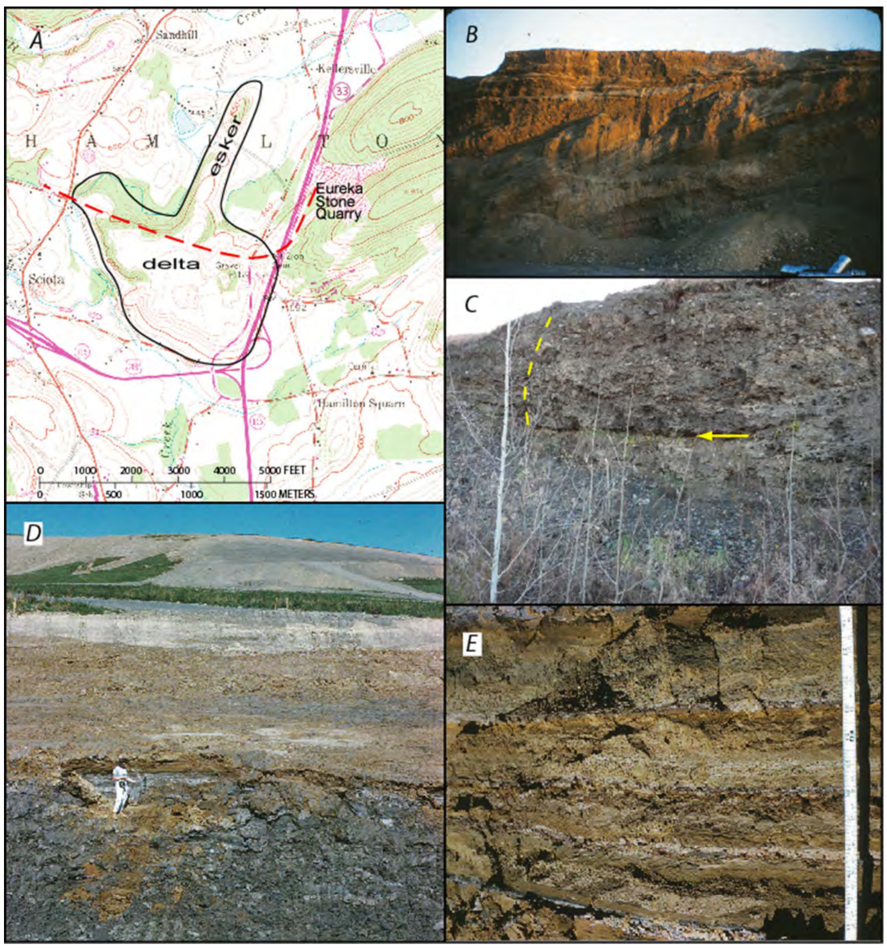


Figure 6. Map and transitory exposures in the glacial delta at Sciota, PA. A—Map showing lobate delta and feeding esker. Dashed red line suggests position of ice front when the delta was deposited. Note kettle hole depressions. From US Geological Survey 7.5-minute quadrangle, 1960 edition, photo-revised 1970; B—Topset and foreset beds during pit operations in 1966. Foresets dip to the south; C—Collapse gravel at the kettle hole near "G" in "Gravel Pit" in A, exposed in 2009. Merges into poorly stratified gravel and sand to the left. These sediments overlie compact gravelly till (at arrow) with abundant clasts derived from the underlying Marcellus shale; D—Frontal foreset slope of the delta with varves exposed at the base during construction of the PA 33 overpass in 1962; E—Varves of clay, silt, and fine sand exposed in base of slope in D.

position of the Wisconsinan glacier from its terminus at Saylorsburg, 2 mi (3 km) to the south (Epstein and Epstein, 1969).

0.4 14.0 Cemetery in stratified sand and gravel to right. Note the lobate southern front of the delta. The foreset slope of the delta merges into flats underlain by varved clay, silt, and sand (see Figure 6).

2.9 16.9 Exposures in Cherry Ridge to right. There are significant facies changes in Lower and Middle Devonian-age rocks from Godfrey Ridge 3 mi (5 km) to the north (Epstein, 1990). The Esopus and Schoharie Formations become thinner; while the upper part of the Buttermilk Falls Limestone (Onondaga) becomes sandy and becomes the Palmerton Sandstone. More than 200 ft (61 m) of the lower part of the Buttermilk Falls has been leached to a varied-colored clay, which has been exploited previously for whitener in cement (Figure 7).

0.2 17.1 Exit to Saylorsburg. Continue straight.

0.4 17.5 Glacial till in Wisconsinan terminal moraine.

0.3 17.8 Start of scattered exposures of Bloomsburg Red Beds beneath pre-Wisconsinan till.

0.7 18.5 Curve in highway follows form of the upright Wind Gap anticline (Epstein, 1990) in the Bloomsburg Red Beds.

0.7 19.2 Bloomsburg Red Beds outcrop on left.

0.7 19.9 Continue straight past exit to town of Wind Gap. The floor of Wind Gap is at 980 ft (274 m) altitude, about 700 ft (213 m) higher than the bottom of Delaware Water Gap, 13 mi (21 km) to the northeast. A tributary of the Delaware probably robbed the Wind Gap River in the geologic past leaving its gap high and dry (Epstein, 1966).

0.2 20.1 Near-vertical sandstone, conglomerate, and shale in the Minsi Member of the

Figure 7. Early-Middle Devonian rocks exposed in 1962 during construction of PA 33. The rocks are overturned and dip 30-55^{o} southeast. The Schoharie and Esopus Formations (Dse) thin from about 280 feet in Godfrey Ridge to about 150 ft (46 m) in Cherry Ridge. The Palmerton Sandstone (Dp) is absent in Godfrey Ridge and attains 66 ft (20 m) in thickness in Cherry Ridge. The rocks have been affected by deep pre-Wisconsinan weathering, especially the 263 ft (80 m) of Buttermilk Falls Limestone (Dbf) which have been mined locally for whitener in cement (Epstein and Hosterman, 1969). The Buttermilk Falls is presently totally overgrown. Red 1996 Mustang convertible for scale—I shouldn't have sold it!.

Shawangunk Formation exposed on right.

1.3 21.4 Slate dump in Pen Argyl Member of the Martisburg Formation on right. Bedrock is poorly exposed in this area, being covered by pre-Wisconsinan (Illinoian?) drift.

0.5 21.9 Continue straight past exit to PA512 (Wind Gap/Bath). Surrounding low hills are held up by graywackes in the Ramseyburg Member of the Martinsburg Formation.

4.0 25.9 Continue straight past exit to Belfast.

1.4 27.3 Break in slope in hill to right marks the contact between the slate of the Bushkill Member of the Martinsburg Formation from the less resistant calcareous shale and shaley limestone of the Jacksonburg Limestone. The contact between the two is well exposed along Bushkill Creek, 800 ft (244 m) to the west. Here, dolomite beds in the lower Bushkill form mullions due to shortening along cleavage (Figure 8).

0.1 27.4 Cross Bushkill Creek. For the next 27 mi (43 km) we will be travelling on Cambrian and Ordovician carbonate rocks in the Great Valley section of the Ridge and Valley Province.

Figure 8. Silicoeus dolomite mullions, as much as 4 ft (1.2 m) long, in basal Martinsburg on Bushkill Creek, north of Stockertown, PA. Shortening approaches 100%.

0.2 27.6 Continue straight past exit to Stockertown.

0.4 28.0 Hercules Cement quarry and plant to right. The Jacksonburg Limestone is quarried for cement rock. It immediately overlies the Epler Formation of the Beekmantown Group (Epstein 1990).

0.3 28.3 PA33 crosses Brodhead Creek, site of extensive sinkhole collapse due to sinkhole collapse in the Epler Formation, which disrupted traffic along PA 33 in 2001 (Figure 9).

Figure 9. Sinkholes in Bushkill Creek, tilted concrete pier, and sagging roadway of PA 33 in 2001. See Kochanov (p. 139 of this guidebook) for details.

0.7 29.0 Scattered sinkholes along both sides of highway in the Epler Formation.

1.9 30.9 Continue straight past PA248 exit to Wilson.

1.2 32.1 Continue straight past Hecktown exit.


WARMER
IN Sports BANNER SEASON FOR NCC WOMEN /C-1
IN Local SPARKS FLYING OVER EXPANSION AT PPL PLANT /B-1
EASTON AREA EDITION
The Express-Times
SERVING PENNSYLVANIA AND NEW JERSEY SINCE 1855
Tuesday, February 13, 2001

Specter sending in an army to fix sinkholes

Ridge urges action on sinkholes
Governor has asked PennDOT to work on sinkholes plaguing Bushkill Creek

Sinkholes set to gobble sewer line

Boscola wants to enlist PennDOT
The Army Corps of Engineers needs help to fix sinkholes

THE DETAILS
◆ This set of sinkholes is less than a mile from the batch that has plagued a Palmer Township neighborhood where 10-foot wide sinkholes have opened overnight.

0.8	32.9	Bear right onto US22W towards Bethlehem/Allentown.
0.8	33.7	Merge onto US22W.
1.8	35.5	Outcrops of Rickenbach Dolomite on right (Aaron and Drake, 1997).
0.3	35.8	Continue straight past Exit to PA191/Nazareth Pike.
2.6	38.4	Continue straight past PA512/center Street.
1.6	40.0	Continue straight past exit to Schoenersville Road.
0.6	40.6	Continue straight past exit to PA378S.
0.5	41.1	Continue straight past PA987Airport Road.
0.4	41.5	Continue straight past PA987S/Airport Road, unless going to Ollies.
1.5	43.0	Road cuts in Richenback Dolomite (Drake, 1996).
0.5	43.5	Cross Lehigh River.
0.2	43.7	Continue straight past Fullerton Avenue exit.
0.6	44.3	Continue straight past McArthur Rd/7th Street exit.
1.0	45.3	Continue straight past 15th Street exit.
1.8	47.1	Continue straight past Cedar Crest exit.
1.7	48.8	Continue straight past exit to US 309/Quakertown.
0.8	49.6	Continue straight past exit to PA Turnpike.
0.4	50.0	Continue straight past Kuhnsville exit.
0.8	50.8	Merge onto I-78W.

1.3 52.1 Continue straight past PA100, exit 49A and B.

1.2 53.3 Hills straight ahead and to the right underlain by the Martinsburg Formation.

1.7 55.0 Upgrade in I-78 marks contact between the Martinsburg Formation and the Epler Formation of the Beekmantown Group. Sherwood (1964) noted that the Jacksonburg Limestone was missing between the two units and interpreted the structure here and nearby as a series of isocloinal recumbent folds with characteristic slaty cleavage that were formed by gravity tectonics during an early period of deformation that are overprinted by smaller open folds and crenulation cleavage. He did not assign an age to the earlier folding, but noted recumbent folds in Silurian and Devonian rocks north of Blue Mountain. Drake (1987) mapped the contact as a folded thrust fault that bounds an overturned recumbent synform in the Epler Formation which is separated from a recumbent overturned limb in the Martinsburg Formation. The Martinsburg is shown as a series of NNE-trending overturned folds that cut across the older synform.

0.7 55.7 Approximate contact between the Martinsburg Formation and Weisenberg Member of the Windsor Township Formation of the Hamburg klippe sequence (Drake, 1987).

1.3 57.0 Continue straight past exit to PA863.

1.0 58.0 Windsor Township Formation outcrops on right (Lash, 1985).

1.0 59.0 Windsor Township Formation outcrops.

0.8 59.8 Graywackes in the Windsor Township Formation.

2.1 61.9 Continue straight past PA737 exit.

1.0 62.9 Windsor Township Formation outcrops on right.

2.9 65.8 Small outcrop on I-78 to right and larger outcrop on Old US 22 to the south in the Windsor Township Formation comprise rippled calcisiltite and shale with an early Early Ordovician conodont assemblage (Figure10).

1.2 67.0 Continue straight past the PA145 Lenhartsville exit.

2.6 69.6 Exposures of greywacke on right in the Windsor Township Formation (Lash (1987a).

2.3 71.9 Continue straight past Exit 30 to Hamburg.

0.7 72.6 Cross Schuylkill River.

0.1 72.7 Take exit 29B to right onto PA 61.

0.3 73.0 Cabela’s on left.

0.7 73.7 Traffic light. Continue straight. Graywacke in the Windsor Township Formation

Figure 10. Ripple-bedded calcisiltite (light lenses) and calcareous shale, 0.9 mi (1.4 km) east of Lenhatrstville, PA, along old US 22. These are in slide blocks in the Hamburg klippe (Epstein and others, 1972). They contain North Atlantic Province conodonts of early Early Ordovician age (lower Arenigian) (Bergstrom and others, 1972).

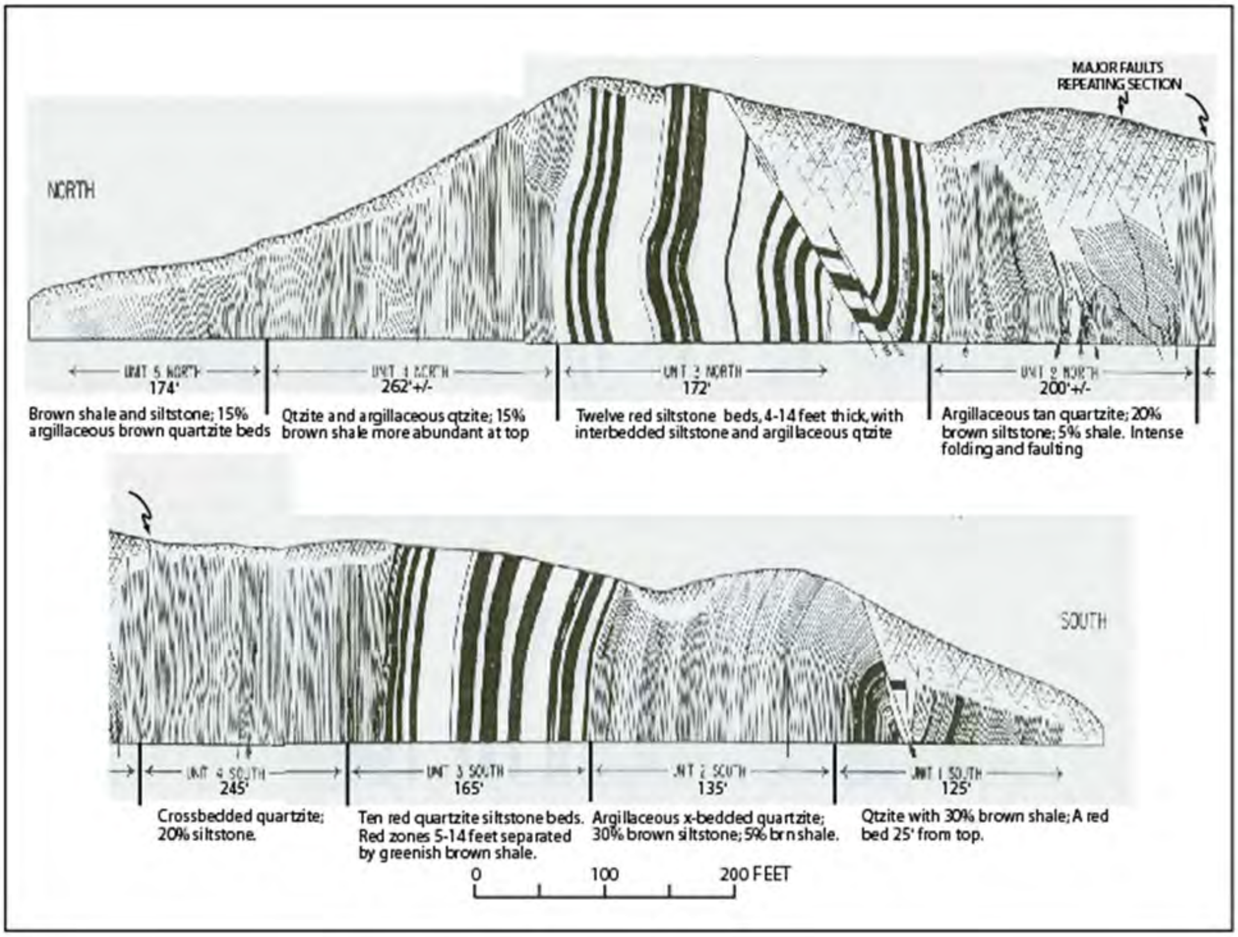


Figure 11. Section of the Clinton Formation along PA 61 just north of the Schuylkill River. Modified from Burtner and others (1958). Section is 2X original.

		on right.
0.8	74.5	Cross Schuylkill River. The river flows on the Tuscarora Sandstone here which is exposed in railroad cuts on both sides of the river.
0.2	74.7	Two-thousand-foot-long outcrop in the Clinton Formation on right, comprising near vertical, faulted and crumpled, interbedded siltstone, quartzite, and red beds (Figure 11), described in detail by Burtner and others (1958).
0.3	75.0	Turn LEFT onto Broad Street in Port Clinton.
0.2	75.2	Cross Little Schuylkill River and park in lot to left.
		STOP 1: SCHUYLKILL GAP
		See detailed stop description on p. 217.
		Leave Parking lot and return to PA61.
0.2	75.4	Turn right (south) on PA 61.
0.5	75.9	Cross Schuylkill River.
0.8	76.7	Traffic light. Continue straight.
0.2	76.9	Traffic light. Continue straight.

0.3	77.2	Traffic light. Continue straight. Do not turn right onto I-78/US22W.
0.3	77.5	Turn right onto I-78/US22E.
0.6	78.1	Cross Schuylkill River.
0.3	78.4	Continue straight past Exit 30/Hamburg.
0.4	78.8	Outcrop of Windsor Township Formation on right.
5.0	83.8	Turn right at Exit 35 onto PA143/Lenhartsville.
0.2	84.0	Stop sign. Turn left. We will be passing through exposures within the Windsor Township Formation in the Hamburg klippe for the next 4.8 mi (7.7 km), including thick greywacke and red claystone.

Figure 12. Slickensided overturned greywacke interbedded with shale with two cleavages. These are shown as strain-slip and fracture cleavages with an implied Alleghanian age of deformation (Lash, 1987a).

0.5	84.5	Graywacke on left.
0.3	84.8	Zettlemoyers Bridge over Maiden Creek on Long Road to right. Overturned greywacke and shale of the Windsor Township Formation with two cleavage and slickensides along Mountain road to the left (Figure 12). Beds immediately to the north dip south and are upright in the northern limb of the overturned syncline.

Spitzenberg, a 500-foot-high hill 1 mi (1.6 km) to the northeast (Figure 13), consists of about 150 ft (46 m) of gently dipping red and green, partly cross-bedded sandstone and carbonate-clast conglomerate unconformably overlying steeply dipping rocks of the Windsor Township Formation (Lash, 1985). Whitcomb and Engle (1934) named the Spitzenberg Conglomerate and believed

Figure 13. Spitzenberg hill, 2 mi (3 km) northeast of Lenhartsville, PA. The top is capped by 150 ft (46 m) of red and green, horizontally bedded to cross bedded sandstone and polymictic conglomerate with limestone clasts as much as 10 in (25 cm) long.

Figure 14. Location map and view of the Blue Rocks boulder field. Intersection of Long/Mountain Road and PA 143 is at mileage 9.6.

it was an erosional remnant of Triassic age. A late Ordovician to Early Silurian age was preferred by Stephens (1969) and Platt and others (1972) because a similar sequence of rock, however without the limestone conglomerate, underlies the Tuscarora Sandstone in Sharps Mountain 2.5 mi (4 km) to the west (Lash, 1985, 1987a). Lash (in Lash and others, 1984) expounded the sedimentology of the Spitzenberg rocks.

The road to the left (Blue Rocks Road) leads to the 2,000-foot long Blue Rocks boulder field (Figure 14), 1 mi (1.6 km) to the northwest,whose origin has been discussed by Potter, 1968. We will not be visiting the boulder field. The map gives directions for post-field trip visitation.

0.5	85.3	Overturned graywacke and shale of the Windsor Township Formation with abundant load casts on left.
0.2	85.5	Enter Albany Township.
0.2	85.7	Spitzenburg (pointed mountain) straight ahead (see Figure 13) .
0.5	86.2	Inverted red and gray shale grading up into greywacke of the Windsor Township Formation on left.
0.5	86.7	Little Roundtop Road to right leads to Spitzenburg.
0.3	87.0	Resistant Tuscarora conglomerate and sandstone caps nose of syncline at the Pinnacle.
0.3	87.3	Long exposure of greywacke
0.1	87.4	Interbedded red claystone and greywacke.
0.3	87.7	Excellent exposures of wildflysch, consisting of boudinaged sandstones and shales with scaly cleavage. Site of Stop 4 of the 49th Annual Field Conference of Pennsylvania Geologists (Lash and others, 1984). These broken formations were characterized by boudinaged and lozenge-shaped/isolated sandstone pods in a sheared shale with scaly cleavage. They developed at the frontal edge of the Greenwich slice in a convergent margin setting. (Lash, 1987b; Codegone and others, 2012).
0.2	87.9	Hawk Mountain Road to left. A visit to the Hawk Mountain Sanctuary is most rewarding (**http://www.hawkmountain.org/**). Continue straight.

0.4	88.3	PA737. Kempton with the WK&S Railroad (Hawk Mountain Line) displays vintage locomotives and offers local train rides by men with their big toys. Continue straight on Pa143, entering the Slatedale quadrangle
0.5	88.8	The Kistler Valley Fault separates rocks of the Windsor Township Formation from those of the Shochary Ridge sequence (Epstein and Lyttle, 1993), which holds up Shochary Ridge, rising to nearly 700 ft (213 m) above the valley floors to our right. The New Tripoli Formation forms the lower part of the sequence, consisting 4,000 ft (1,219 m) of fossiliferous, calcareous greywacke interbedded with thick slate. The overlying Shochary Sandstone, ranges to more than 4,000 ft (1,219 m) thick, comprising thin- to thick-bedded calcareous greywacke and interbedded slate. These two units form the singular Shochary syncline, a deep overturned syncline bounded by faults and with no complementary anticline. For the next 5.8 mi (9.3 km) we will be traversing rocks that make up Shochary Ridge,
0.5	89.3	Shochary sandstone on left.
0.7	90.0	More sandstone. Trough of the Shochary syncline.
1.0	91.0	Village of Wannamakers
0.4	91.4	Leaser Road on left leads to Leaser Lake
0.8	92.2	Village of Jacksonville.
0.2	92.4	Pleasure Ct leads to Leaser Lake on left.
0.3	92.7	Ontelaunee Rd leads to Leaser Lake on left.
0.4	93.1	Hills to right are in the north limb of the Shochary syncline.
0.3	93.4	Village of Lynnport.
1.2	94.6	Buried contact between the Martinsburg Formation and New Tripoli Formation along the Eckville fault.
0.1	94.7	Slate dump in Pen Argyl Member of the Martinsburg Formation. We will visit the Member at the next stop.
1.4	96.1	Turn left onto Mosserville Road.
0.4	96.5	Several abandoned slate quarries and dumps in the Pen Argyl Member of the Martinsburg Formation for the next 2,000 ft (610 m) on left in a series of short wavelength folds (Figure 15).
0.5	97.0	Stop sign. Continue straight.
0.6	97.6	Poor exposures of greywacke in the Ramsyeburg Member

Figure 15. Abandoned slate quarry in the Pen Argyl Member of the Martinsburg Formation along the Mosserville Road. Bedding dips gently to the left (southwest) and cleavage dips more steeply in the same direction. Behre (1933, p. 347)

of the Martinsburg Formation on right. About 1 mi (1.6 km) to the west, these graywackes become rarer in a series of folds and the Ramseyburg is no longer mappable (Epstein and Lyttle, 1993, p. 7).

0.4 98.0 Stop sign. Juntction with US 309. Continue straight. Road becomes Mountain road.

0.2 98.2 Ground covered with veneer of pre-Illinoian till making mapping of bedrock difficult.

1.9 100.1 Irregular topography atop Blue Mountain to left due to a series of northwest dipping thrust faults cutting overturned beds in the Shawangunk Formation and Bloomsburg Red Beds. (Epstein and others, 1974).

2.7 102.8 Turn right on Brown Street, leading to Slatedale.

0.8 103.6 Turn right into parking area of Penn Big Slate Company Manhatten Quarry (Figure 16). Note the large slate dump ahead and to the left (Figure 17).

Figure 16. Sign outside the Penn Big Bed Slate Company quarry.

Figure 17. Slate dump east of the Penn Big Bed slate quarry, a typical mound of waste slate common throughout northeast Pennsylvania, some of which exceed 200 feet in height.

STOP 2: PENN BIG BED SLATE COMPANY QUARRY (MANHATTAN MINE)

See detailed stop description on page 237.

Leave parking lot of Penn Big Bed Slate Quarry, turning left onto Brown Street.

0.8 104.4 Stop sign. Turn right on PA143/Mountain Road.

0.9 105.3 Cross over northeast Extension of the Pennsylvania Turnpike. Lehigh Tunnel through Blue Mountain to left. See discussion for Stop 3.

1.9 107.2 Talus covered slope in Lehigh Gap straight ahead.

0.3 107.5 Stop sign at junction with PA873. Bear leftish towards PA248, crossing the Lehigh River.

0.2 107.7 Lehigh River. Note fencing and other fetaures used to stabilize the slope.

0.1	107.8	Traffic light. Turn right onto 248E.
0.1	107.9	Traffic light. Continue straight on PA248E.
0.1	108.0	Gravel road to stop 3 on left. Continue straight for 0.7 mi (1.1 km) to turn-around point.
0.7	108.7	Turn left at Gulf Station and re-trace route along PA248.
0.8	109.5	Carefully turn right after blinking light onto gravel road.
0.1	109.6	Park in parking area and settle down with LUNCH. After eating, burping, and farting, proceed northward towards the Martinsburg-Shawangunk contact.

STOP 3 AND LUNCH: LEHIGH GAP.

See detailed stop description on page 248.

Leave Parking area at Stop 3.

0.1	109.7	Carefully turn left onto PA243E.
0.2	109.9	Turn left on Timberline Road.
2.7	112.6	Stop sign. Turn left on PA946 towards Danielsville.
1.1	113.7	Traffic light. Turn left on Blue Mountain Drive and ascend Blue Mountain.
0.8	114.5	Coarse-pebble conglomerate in the Weiders Member of the Shawnagunk Formation is overturned 50o to the southeast (Figure 18).
0.6	115.1	Devil's Potato Patch on right, a boulder field.
0.2	115.3	Cross Appalachian Trail.
0.1	115.4	Blue Mountain Ski slope to right.
0.2	115.6	Sand pits in Chestnut ridge in middle ground to left are in weathered Palmerton and Oriskany Sandstones.
0.3	115.9	Bloomsburg Red Beds on right in southeast limb of recumbent fold that has been rotated past the horizontal (Figure 18).
0.9	116.8	Blue Mountain Lodge on right. Entering village of Little Gap.
0.3	117.1	Bear left on Lower Smith Gap Road towards Palmerton.
0.2	117.3	Turn right on Covered Bridge Road. Buses may have to detour to the left around the bridge.

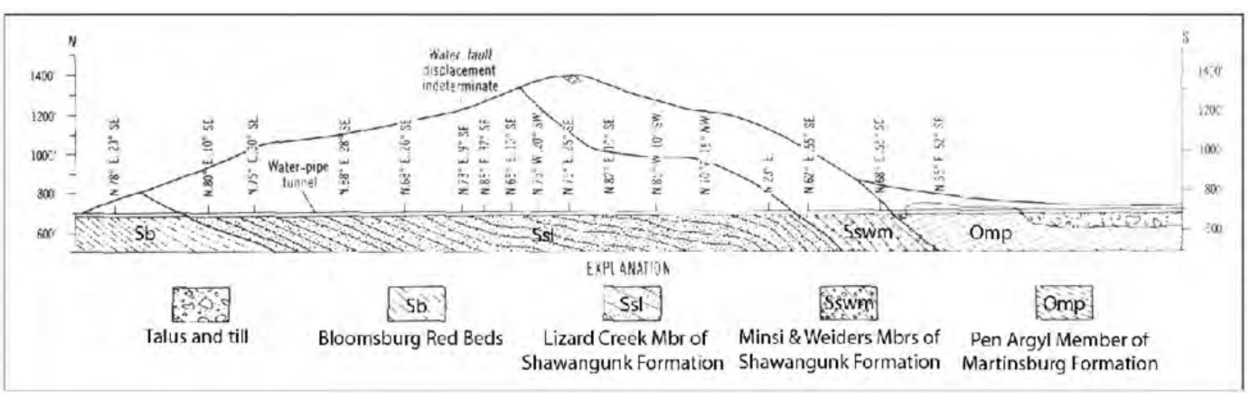


Figure 18. Cross section through Blue Mountain at Little Gap along water tunnel for the city of Bethlehem, PA., from Epstein and others (1974, fig. 142). Dips plotted are corrected to tunnel direction. Actual dips and strikes are recorded above section. All dips are overturned to southeast except northwest dips which are in beds that have been rotated more than 180°. Modified from unpublished data by B.L. Miller, 1940.

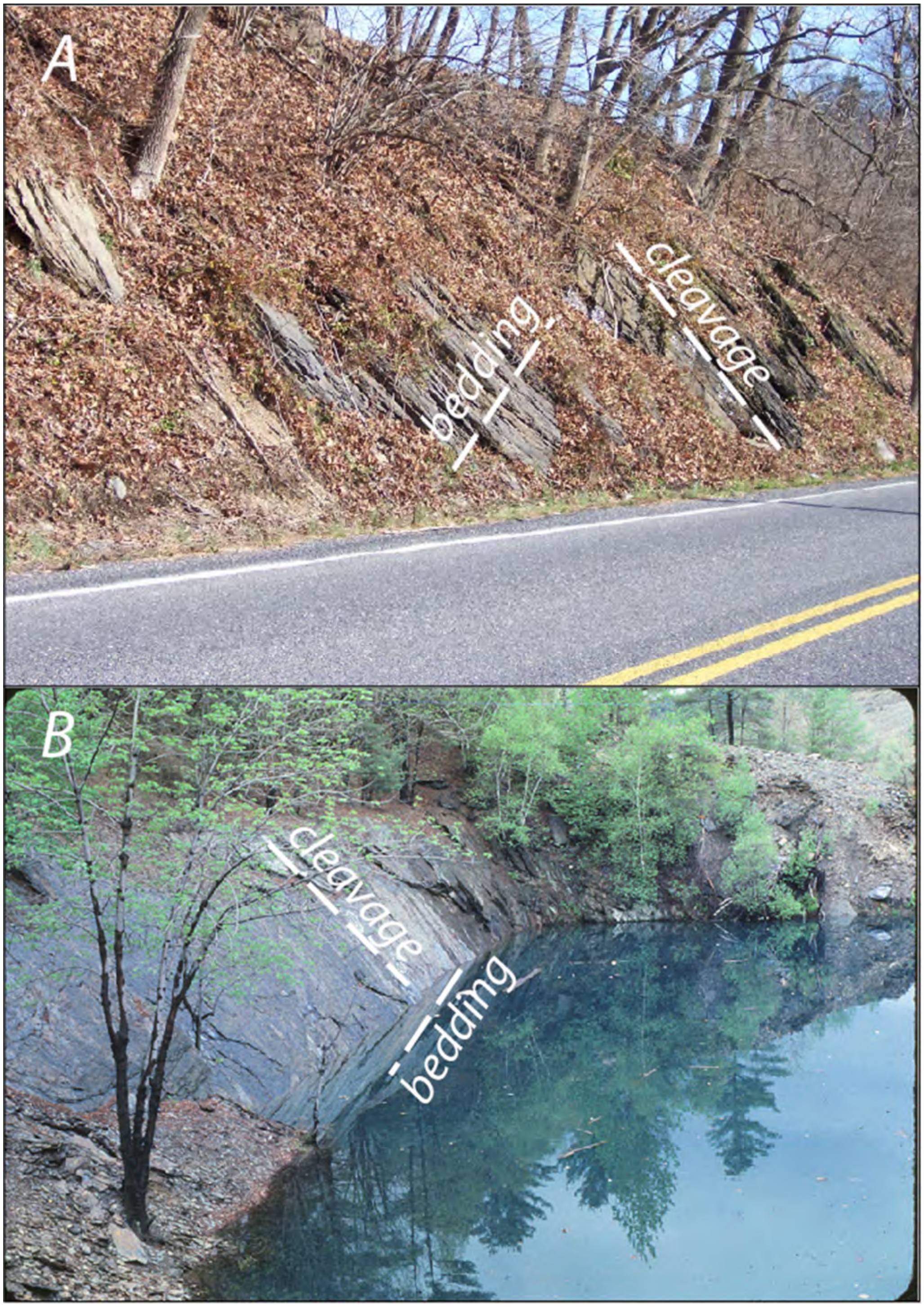


Figure 19. A—Well-developed slaty cleavage in the Mahantango Formation exposed in a series of road cuts about one mile east of Little Gap, PA; B—Bray Quarry No.1 (Behre, 1933, p. 125), a slate quarry in the Mahantango Formation just north of the village of Aquashicola, PA, 3 mil (5 km) west of Little Gap. The prominent cleavage dips 65^{o} southeast; bedding dips 69^{o} northwest. Behre (1933) noted that slate production ceased about 1915. This observation supports the conclusion that the regional slaty cleavage, prominent in the Martinsburg Formation, passes through all rocks at least into those of Middle Devonian age. Picture taken in 1981.

0.5 117.8 Cross Aquashicola Creek through covered bridge.

0.1 117.9 Village of Little Gap. Turn right on Little Gap Road.

0.3 118.2 Mahantango Formation on left. For the next 0.6 mi (1 km) uniform siltstones have pronounced slaty cleavage that dips 40-50^o southeast towards the road. Beds dip 40-80^o to the northwest on the south limb of the Weir Mountain syncline (Stop 3, Figure 5). The cleavage in these Devonian rocks are as well developed as those in the Martinsburg Formation and has allowed quarrying for slate nearby (Figure 19).

0.1 118.3 Cleavage in the Mahantango Formation on left.

0.3 118.6 Mahantango outcrop on left.

0.6 119.2 Mahantango outcrop on left. Little Gap Road becomes Kunkletown Road as we pass eastward from Carbon County into Monroe County.

2.1 121.3 Continue straight towards Kunkletown, do not turn left on Silver Spring Blvd..

0.9 122.2 Village of Kunkletown. Continue straight.

0.2 122.4 Continue straight on Kunkletown road. Do not turn left on Fiddletown Road.

3.0 125.4 Sand and clay pits on Chestnut Ridge to right (Epstein and Sevon, 1978). Deep weathering of the Palmerton Sandstone of Devonian age has removed much of its cement, making for an easily excavated sand resource. Weathering of Lower and Middle Devonian shaley limestones, such as the Buttermilk Falls (now Onondaga) and New Scotland, has produced clay as much as 300 ft (91 m) deep that is used as a whitener in cement (Epstein and Hosterman, 1969.

0.2 125.6 Hill in middle ground to right underlain by the Nis Hollow Sandstone Member of the Mahantango Formation (Epstein and Sevon, 1978).

1.7 127.3 Shale chip gravel derived from the Marcellus Shale in slope to left.

0.7 128.0 Shale borrow pit to left.

0.6 128.6 Stop sign. Continue straight on Kunkletown Road.

1.5 130.1 Stop sign. Saylorsburg. Turn right onto Old Pa115.

0.5 130.6 Turn left on Cherry Valley Road (County 2004) towards PA33.

0.3 130.9 PA33 is a quick alternate route to Stop 4, Delaware Water Gap. We will continue straight on Cherry Valley road.

0.1 131.0 Many abandoned clay pits in Chestnut Ridge to right (geologic discussion given in Figure 7).

0.4 131.4 Camel Back Mountain in distance to left.

0.2 131.6 County 949/South Easton Belmont Pike to left. Continue straight on Cherry Valley Road.

0.5 132.1 Scenic/geologic view left (Figure 20).

1.6 133.7 Village of Bossardsville.

0.2 133.9 Hanson aggregate quarry on right. Excellent exposures in complexly folded Upper Silurian rocks (Poxono Island Formation, Bossardville Limestone, and Decker Formation) were examined by the 32nd Field Conference of Pennsylvania Geologists (Epstein and Epstein, 1967) and again later (Epstein and Epstein, 1969, Figure 21).

Figure 20. View looking northwest of Cherry Valley Road. The short-dashed white line is at the upper level of the topset plain of the glacial delta near Sciota, PA, described at mileage 13.6 and Figure 6. Glacial lake clays and outwash in flat fields lie in front of the delta. Camelback Mountain is held up by flat-lying Upper Devonian roack. Godfrey Ridge comprises complexly folded late Silurian to lower Middle Devonian rocks. Middle Devonian shales and siltstones make up the hills between Camelback and Godfrey.

0.5 134.4 View of Cherry Valley to northeast Figure 22).

1.0 135.4 Flat floor of Cherry Valley to right underlain by Wisconsinan glacial lake beds.

We are in the middle of the Cherry Valley National Wildlife Refuge, lying in Monroe and Northampton Counties, Pennsylvania, southwest of and adjacent to the Delaware Water Gap National Recreation Area.

Figure 21. Folds and faults in the Bossardville Limestone in the Hanson quarry.

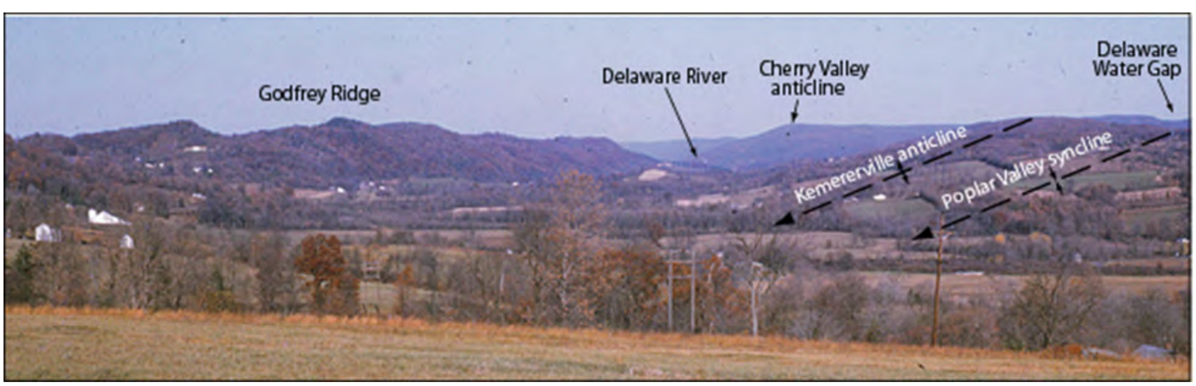


Figure 22. View to northeast from Cherry Ridge. The southwest-plunging Kemmererville anticline is nicely defined by the rounded hill in the Bloomsburg Red Beds. The bumps on Godfrey Ridge reflect complex folds in a variety of Upper Silurian through Middle Devonian rocks. The flat floor in the middle ground is underlain by Wisconsinan lake beds (Epstein, 1969).

It was approved by the Fish and Wildlife Service on December, 2008, and was established to preserve the habitat for many rare and endangered plants and animals, including the bog turtle The refuge includes two caves where White Nose Syndrome in bats is a concern. About 20 mi (32 km) of the Appalachian Trail lie atop Kittatinny Mountain in the refuge.

0.1	135.5	Laminated intertidal Bossardville Limestone outcrop on right.
1.1	136.6	Bear right at Y in road heading toward Delaware Water Gap.
0.3	136.9	Deep mudcracks in Rondout Dolomite to left (Figure 23).
0.3	137.2	Kiln on left. The Bossardville Limestone is presently crushed for aggregate, but was burnt for agricultural lime many years ago.
0.1	137.3	Coeymans Limestone outcrop on left.
1.8	139.1	Stop sign; junction with PA191. Turn left toward Delaware water Gap.
0.2	139.3	Turn right on Cherry Valley Road toward Delaware Water Gap.
0.7	140.0	Stratified sand and gravel in covered slope to left.
0.5	140.5	Turn left onto detour from Cherry Valley Road (as of July, 2012). The road was closed ahead because of a landslide in stratified drift that developed along the steep river-cut slope in stratified drift (Figure 25).
0.6	141.1	Stop sign. Turn right on Fenner/Greenbrier Road.
0.2	141.3	Stop sign. Turn left rejoining Cherry Valley Road at the duck pond.
0.3	141.6	Hummocky stratified drift underlies golf course to right.
0.4	142.0	Stop sign. Continue straight. Enter Village of Delaware Water Gap.
0.2	142.2	Stop sign. Beware heavy traffic! Continue straight.
0.2	142.4	Stop sign. Turn right on PA611S.
0.2	142.6	Northwest dipping Shawangunk Formation on right.
0.2	142.8	Crest of Cherry Valley anticline (see Figure 1).
0.1	142.9	Resort Point overlook on left. This was the site of the Kittatinny House, one of the largest of many vacation hotels visited during the mid 1800s – early 1900s. It was destroyed by fire in 1931, and was never rebuilt. Opening of the Poconos to the north with abundant new resorts and higher/cooler climate spelled the end of the Delaware Water Gap resort era. See Wilson in this guidebook, p. __. Time permitting, we may return to this locality as STOP 4a.
0.2	143.1	Passing through a series of undulations in the Bloomsburg Red Beds (see Figure 1). Note southeast-dipping cleavage.
0.7	143.8	Contact between Bloomsburg Red Beds and the Tammany member of the Shawangunk Formation dipping xxo NW.
0.7	144.5	Turn right into Point of Gap parking lot. Discussion will be at the kiosk on the small hill.

STOP 4: DELAWARE WATER GAP.

See detailed stop description on page 272.

Turn left onto PA 611N leaving parking lot to return to Shawnee Inn.

1.6	146.1	Resort Point Overlook; possible Stop 4A. See detailed description on p. 292.

Figure 23. Mudcracks more than two feet deep in the Whiteport Member of the Rondout Formation. Many laminated Silurian rocks in Pennsylvania are mudcracked. Their polygons are extended in the *b* tectonic direction. Slaty cleavage may be preferentially concentrated in these mud-crack columns along the *bc* plane, accentuating the apparent depth of the columns (Figure 24).

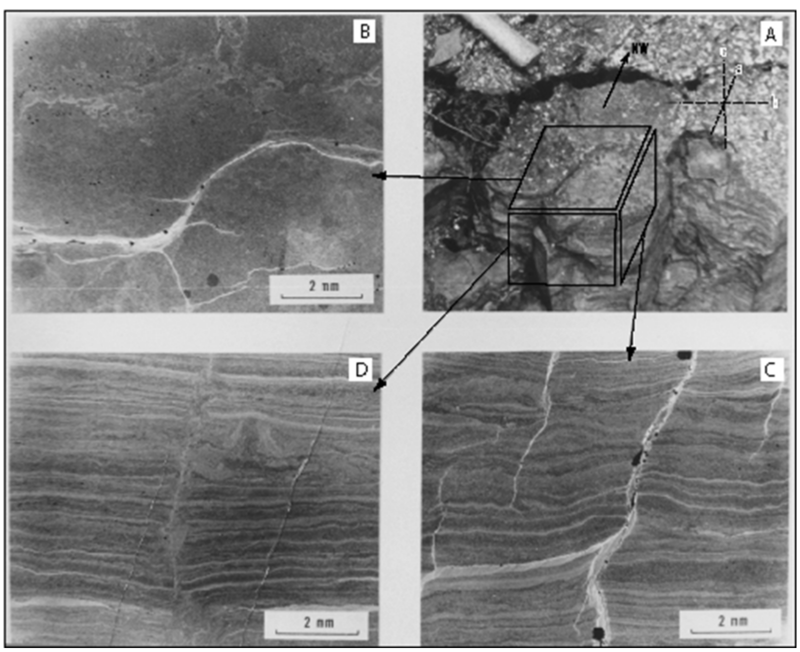


Figure 24. Deformed mud-crack polygons in laminated dolomite (A) that have been shortened in a northwest direction with a l/w ratio averaging 1.8/1. The coordinate axes are: A, direction of tectonic transport; B, direction of fold axes; C, perpendicular to *ab* plane. B, C, and D are negative prints of acetate peels showing the pronounced development of cleavage along the columns that are subparallel to *b* (B, *ab* plane; C, *ac* plane) and lack of cleavage development in the *bc* plane, D.

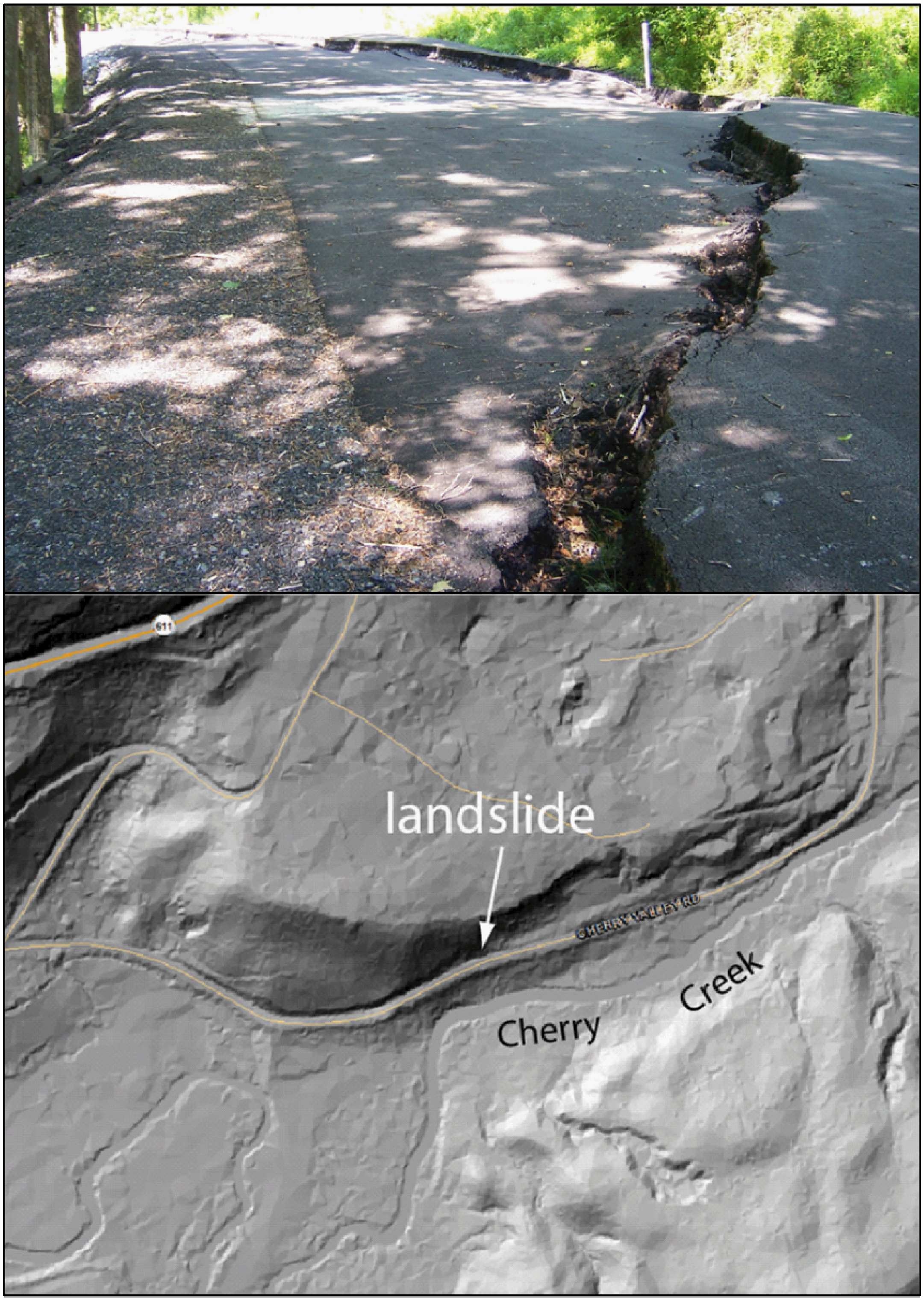


Figure 25. Landslide in freshly-laid blacktop at crest of ice-contact stratified drift north of and along the steep bank of Cherry Creek to the left (top) and lidar image showing the steep cut bank along Cherry Creek at the site of the slide (http://www.pasda.psu.edu/). Previous landsliding is evident along this stretch of the road. The slide occurred in September, 2011.

0.6	146.7	Traffic light in Village of Delaware Water Gap. Turn right onto Broad Street.
0.1	146.8	Diner on right, a favorite meeting place for geologists and other societal members of ill-repute.
0.3	147.1	Traffic light. Turn right onto River road.
0.3	147.4	Cross Brodhead Creek.
0.4	147.8	Stop sign at Village of Minisink Hills. Continue to right.
1.1	148.9	Traffic light at Buttermilk Falls Road. Continue straight.
0.5	149.4	Turn right into Shawnee Inn.
0.4	149.8	Unload at front of Inn.
		End of Day one trip. Have a beer or two.

DAY 1 ROADLOG REFERENCES

Aaron, J.M and Drake, Jr, A.A., 1997, Geologic map of the Nazareth Quadrangle, Northampton County, Pennsylvania. U.S. Geological Survey Open-File Report 97-33.

Behre, Jr., C.H., 1933, Slate in Pennsylvania. Pennsylvania Geologic Survey, 4th ser., Mineral Resource Report 16, 400 p.

Bergstrm, S.M., Epstein, A.G., and Epstein, J.B., 1972, Early Ordovician North Atlantic province conodonts in eastern Pennsylvania. U.S. Geological Survey Professional Paper 800-D, P. D37-D44

Brodhead, L.W., 1870, Excerpts from: The Delaware Water Gap: Its Legends and Early History. Sherman & Company, Printers, Philadelphia, PA from *Research of Donald R. Repsher, of Bath, Pennsylvania, Friend and Brother of the Lenape,* **http://lenapenation.org/content/Research%20of%20Don%20Repsher%20-%20Delaware%20Water%20Gap%20-%20History%20Excerpts.pdf** (accessed July 2012).

Burtner, Roger, Weaver, Richard, and Wise, Donald, 1958, Structure and stratigraphy of Kittatinny Ridge at Schuylkill Gap, Pennsylvania. Pennsylvania Academy of Science Proceedings, v. xx, p. 141-145.

Codegone, Giulia, Festa, Andrea, and Dilek, Yildirim, 2012, Formation of Taconic mélanges and broken formations in the Hamburg Klippe, central Appalachian orogenic belt, Eastern Pennsylvania. Tectonophysics, **http://www.sciencedirect.com/science/article/pii/S004019511200145X**, (accessed July 2012).

Drake, Jr., A.A., 1987, Geologic map of the Topton Quadrangle, Lehigh and Berks Counties, Pennsylvania. U.S. Geological Survey Geologic Quadrangle Map GQ-1609.

Epstein, A.G., Epstein, J.B., Spink, W.J., and Jennings, D.S., 1967, Upper Silurian and Lower Devonian stratigraphy of northeastern Pennsylvania and New Jersey, and southeasternmost New York. U.S. Geological Survey Bulletin 1243, 74 p.

Epstein, J.B., 1966, Structural control of wind gaps and water gaps and of stream capture in the Stroudsburg area, Pennsylvania and New Jersey, *in* Geological Survey Research, 1966: U.S. Geological Survey Professional Paper 550-B, p. B80-B86.

Epstein, J.B., 1969, Surficial geology of the Stroudsburg quadrangle, Pennsylvania-New Jersey. Pennsylvania Geological Survey Bulletin G-57, 67 p.

Epstein, J.B., 1974, Map showing slate quarries and dumps in the Stroudsburg quadrangle, PA-NJ, with a description of their environmental significance. U.S. Geological Survey Miscellaneous Field Studies Map MF-578.

Epstein, J.B., 1990a, Geologic map of the Saylorsburg quadrangle, Monroe and Northampton Counties, Pennsylvania._US Geological Survey Report GQ-1638.

Epstein, J.B., 1990b, Geologic map of the Wind Gap quadrangle, Pennsylvania. U.S. Geological Survey Geologic Quadrangle Map GQ-1645, scale 1:24,000.

Epstein, J.B., and Epstein, A.G., 1967, Geology in the region of the Delaware to Lehigh Water Gaps. Guidebook. 32nd Annual Field Conference of Pennsylvania Geologists, Harrisburg, PA, 89 p.

Epstein, J.B., and Epstein, A.G., 1969, Geology of the Valley and Ridge province between Delaware Water Gap and Lehigh Gap, Pennsylvania, *in* Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions. Rutgers University Press, New Brunswick, NJ, p. 132-205.

Epstein, J.B., Epstein, A.G., and Bergstrm, S.M., 1972, Significance of Lower Ordovician exotic blocks in the Hamburg klippe, eastern Pennsylvania. U.S. Geological Survey Professional Paper 800-D, p. D29-D36.

Epstein, J.B., and Hosterman, J.B., 1969, Residual clay deposits in rocks of Early and Middle Devonian age near Kunkletown, Pennsylvania. U.S. Geological Survey Professional Paper 650-D, p. D95-D105.

Epstein, J.B., and Lyttle, P.T., 1993, Geology of the New Tripoli quadrangle, Lehigh, Berks, Schuylkill, and Carbon counties, Pennsylvania. U.S. Geological Survey Bulletin, 1994, 19p., scale: 1:24,000.

Epstein, J.B., and Sevon, W.D., 1978, Preliminary Geologic Map and sections of the Kunkletown quadrangle, Pennsylvania. U.S. Geological Survey Open-File Report 78-392.

Epstein, J.B., Sevon, W.D., and Glaesser, J.D., 1974, Geology and mineral resources of the Lehighton and Palmerton 7 1/2-minute quadrangles, Pennsylvania. Pennsylvania Geological Survey 4th ser., Atlas 195 cd, 460 p.

Lash., G.G., 1985, Geologic map of the Kutztown quadrangle, Berks and Lehigh Counties, Pennsylvania. U.S. Geological Survey Geologic Quadrangle Map GQ-1577.

Lash., G.G., 1987a, Geologic map of the Hamburg quadrangle, Schuylkill and Berks Counties, Pennsylvania. U.S. Geological Survey Geologic Quadrangle Map GQ-1637.

Lash, G.G., 1987b, Diverse mélanges of an ancient subduction complex. Geology, v. 15, p. 652-655.

Lash, G.G., Lyttle, P.T., and Epstein, J.B., 1984, Geology of an accreted terrane: The eastern Hamburg klippe and surrounding rocks, eastern Pennsylvania. Guidebook, 49th Annual Field Conference of Pennsylvania Geologists, Harrisburg, PA, 151p. and folded map, scale 1:250,000.

McNett, C., Dent, R.J., Evans, J., Marshall, S.B., and McMillan, B.A., 1985, The Upper Delaware Valley Early Man Project, *in* C. McNett, ed., Shawnee Minisink: A Stratified Paleoindian-Archaic Site in the Upper Delaware Valley of Pennsylvania. Academic Press, New York, NY, p. 3-14.

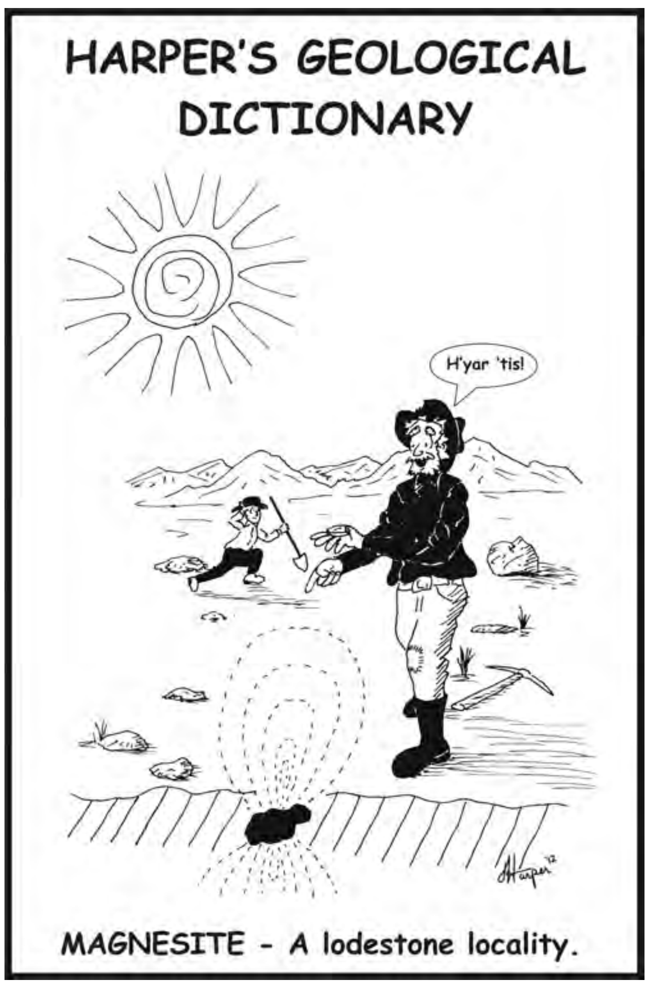
Platt, L.B., Loring, R.B., Papaspyros, A., and Stephens, G.C., 1972, The Hamburg klippe reconsidered. American Journal of Science, v. 272, p. 305-318.

Potter, Jr.,Noel and Moss, J. H., 1968, Origin of the Blue Rocks Block Field and adjacent deposits, Berks County, Pennsylvania. Geological Society of America Bulletin, v. 79, p. 255-262.

Sherwood, W.C., 1964, Structure of the Jacksonburg Formation in Northampton and Lehigh Counties, Pennsylvania. Pennsylvania Geological Survey, 4th Series, General Geology Report G45, 64p.

Stephens, G.C., 1969, Stratigraphy and structure of a portion of the basal Silurian clastics in eastern Pennsylvania. Unpublished MS thesis, George Washington University, Washington, DC, 50 p.

Whitcomb, Lawrence and Engel, J.A., 1934, The probable Triassic age of the Spitzenberg conglomerate, Berks County, Pennsylvania. Geological Society of America Bulletin, v. 53, p. 755-764.



DAY 2--NEW JERSEY AND NEW YORK

Mileage Int.	Cum.	Description
0.0	0.0	Leave from circle in front of Shawnee Inn. The Inn and golf course are located on postglacial stream terraces that reach an elevation of 330 ft 101 m), about 35 ft (11 m) above the mean annual elevation of the Delaware River. An Early Archaic occupation site on Shawnee Island (Stewart, 1991) was dated at 9330 ± 545 yr B.P.
		Turn left onto River road. The road passes over a sequence of Silurian shale, limestone and dolomite that is covered in many places by thin, late Wisconsinan till.
0.7	0.7	Traffic light at Buttermilk Falls Road. Continue straight.
0.5	1.2	Minimart on left, and Smithfield School on right sit on a late Wisconsinan outwash terrace. The terrace lies at an elevation of 400 ft (122 m), about 100 ft (31 m) above the Delaware. Based on its position near the mouth of Marshalls Creek, it was probably laid down by a meltwater stream flowing down the Marshalls Creek valley; the outwash forming an outwash fan that coalesced with the valley train in Delaware Valley.
0.6	1.8	Village of Minisink Hills. Sits on outwash terrace, 100 ft (31 m) above Delaware River. Follow curve to left.
0.2	2.0	Historical Marker on left: Shawnee-Minisink Archeological Site. About 1,500 ft (457 m) eastward (left side) is the Shawnee-Minisink Paleoindian site Island (McNett and others, 1977). It is located on postglacial stream terrace similar in elevation to the terrace at Shawnee on the Delaware. Work here in the 1970s revealed a very rich and diverse, stratified cultural assemblage of Woodland, Archaic, and Paleoindian components. Radiocarbon dating of organic material collected from a hearth about 9 ft (3 m) deep yielded a radiocarbon date of 10,590 +/- 300 (W-2994). The hearth is located in cultural zone containing Paleoindian components (clovis point, scrapers, hammerstones).
0.2	2.2	Cross Brodhead Creek. Famous fly fishing stream during the latter part of the 19th and early 20th centuries that rivaled the more famous Catskill streams. Buffalo Bill, Annie Oakley, Grover Cleveland, Benjamin Harrison, and Theodore Roosevelt were some of the more notable persons that fished these waters (Ingram, 1998). Flooding along the Brodhead in August, 1955 (Hurricanes Connie and Diane) claimed over a hundred lives including 37 campers, many of them children, whom were staying at Camp Davis on the banks of Brodhead Creek near the village of Analomink, about 6 mi (10 km) to the northwest from this position. The following is an excerpt from the Morning Call, an Allentown-based newspaper about that tragic event (reprinted in an article by Frank Whelan of the Morning Call, October 13th, 2004).
		Forty-six people, children and their mothers were spending five weeks of vacation at the religious camp. Among them were Jennie Johnson of Jersey City, N.J., and her three children. She was interviewed by The Morning Call on

Aug. 22, 1955, and said that around 6:30 p.m. on Aug. 18 she and her children were watching the creek. We watched the stream rushing past and remarked how pretty it looked. There wasn't anything to worry about, at least we didn't think so then, she said.

They were sitting in the bungalow a half-hour later when the building began to shake. Johnson remembered that it sounded as if a dam had broken. She and her children fled the shaking building for the big, solid home of camp supervisors, the Rev. and Mrs. Leon Davis. There they joined the rest of the campers. The Davises, who had left earlier to go into town, were not there. Their return had been blocked by the rising water. Although the three-story house seemed safe, water quickly began to rise. As it reached each floor, the screaming campers fled to the next. Finally they were forced to seek refuge in the attic. The campers were watching the water climb the attic stairs after them when the building shuddered and collapsed.

Johnson told The Morning Call she was hit on her head by a board and passed out. When she came to, she found herself floating. Johnson grabbed one board and then another to try to stay afloat. Eventually she drifted onto a debris pile, praying until 7 a.m., when she was rescued. She found her 19-year-old daughter, but her two sons, ages 14 and 10, had died. When the final count was made, only nine of the 46 campers who had been at Camp Davis survived.

0.3	2.5	Traffic light. Turn left on Broad Street toward I-80E.
0.2	2.7	Turn right on ramp to I-80E.
0.5	3.2	Merge onto I-80E
0.1	3.3	Bloomsburg Red Beds with fish scales on right.
0.2	3.5	Northwest-dipping sandstone and conglomerate of the Shawangunk on right in the northwest limb of the Cherry Valley anticline (Epstein, 1973).
0.2	3.7	Crest of Cherry Valley anticline.
0.1	3.8	Cross Delaware River. Glacially scoured and river-washed surface of Bloomsburg Red Beds to left. The elevation of the bedrock floor beneath the Delaware River and thick glacial-valley fill is shown in Figure 1.
0.3	4.1	Series of undulations in Bloomsburg Red Beds on left.
0.4	4.5	Late Wisconsinan outwash fan to right, laid down at the mouth of Dunnfield Creek.
0.7	5.2	Downstream entrance to Delaware Water Gap (Figure 2). Note bend in dip of Shawangunk on cliff across the river in Pennsylvania. Epstein (1966) suggested that this flexure played a part in the location of the Delaware Water Gap.
0.1	5.3	When this road crews cut this roadway some old timer named Epstein happened to be present and noted some trace fossils and mudcracks on the underside of a shale bed within the Minsi Member of the Shawangunk Formation (Epstein and Epstein, 1969, fig. 8D). The Taconic unconformity separating Shawangunk above from Martinsburg Formation below was not exposed during roadway construction.; thick talus consisting of Shawangunk boulders on left conceal the contact. It was seen by Beerbower (1956) who reported a one degree divergence in dip and three degree in strike.

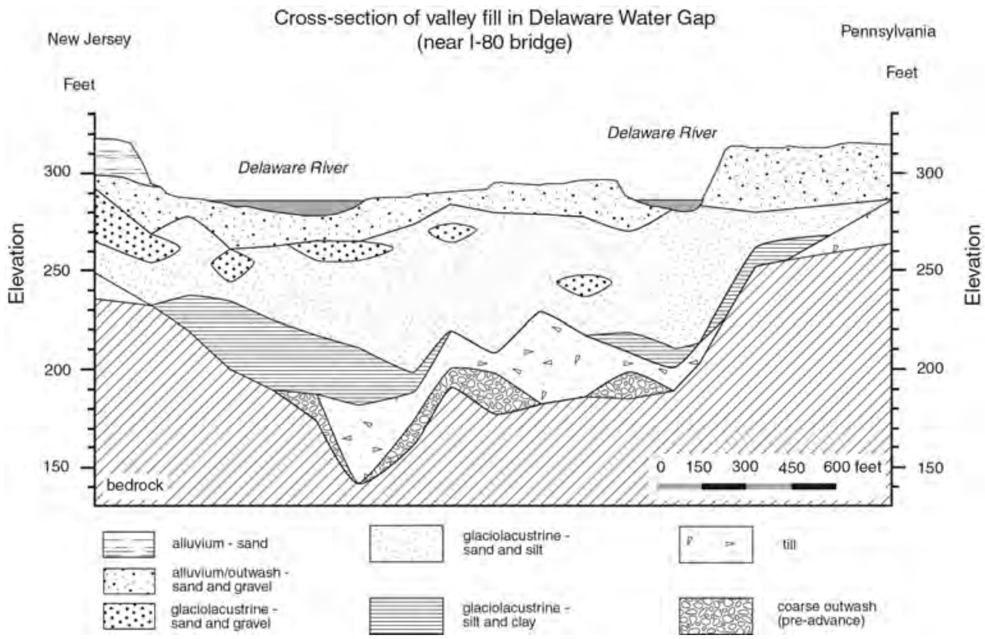


Figure 1. Interpretive cross-section of Delaware Water Gap near I-80 Bridge showing depth to rock and valley-fill stratigraphy. Thick deposits of Late Wisconsinan silt and clay, and sand presumed to be glaciolacustrine, lie in the subsurface throughout the Delaware River valley from Belvidere, NJ, to Port Jervis, NY. These materials were laid down in small proglacial lakes formed during deglaciation when slightly older outwash downvalley and in some places end moraine dammed the valley. Based on depth to rock throughout the valley and the elevation of the river channel where it flows over rock at Marble Mountain Gap (Witte and Stanford, 1995), there has been as much as 150 ft (46 m)of scour over the last two glaciations. Section based on detailed geologic logs and blow counts on file at New Jersey Geological Survey.

Figure 2. Aerial view of the Delaware Water Gap looking downstream. I-80 bridge in foreground. The meandering course of the Delaware River is congruent with plunging folds in the Shawangunk Conglomerate and Bloomsburg Red Beds. Photo by R.W. Witte, 2006.

0.3	5.6	Camp Weygadt to the right is the proposed new visitor's center for DEWA. A nearby slate quarry was opened in 1820 by Mr. Schofield. It later came to be owned by the Delaware Water Gap Slate Company and a slate factory was added. A 1860 industrial census showed that the company produced 2000 squares of roofing slates, and about 725 boxes of school slates (Clemensen, 1996; Epstein; 1974). To support the slate industry a company town called Browning was built in 1870. Operations ceased in 1904 because the remaining slate was of poor quality. The thick-bedded slate here resembles the slates of the Penn Argyl Member, but they are interbedded with graywackes of the Ramseyburg Member. The Pen Argyl forms the host rock of most eastern Pennsylvania slate quarries. It is unconformably overlapped by the Shawangunk Formation west of Delaware Water Gap (Epstein, 1973).
1.0	6.6	Traveling on postglacial stream terrace, high outwash terrace on left.
0.7	7.3	Cross Stony Brook.
2.4	9.7	Turn right at exit 4C to NJ94N toward Blairstown.
0.1	9.8	Allentown Dolomite on left. Here we are traversing an Allentown cored anticlinal structure that plunges to the southwest just across the Delaware River and west of Portland, PA.
0.1	9.9	Continue north on NJ89.
0.3	10.2	Allentown Dolomite on right. We will be traveling up the Paulinskill Valley, which is underlain by Cambrian and Ordovician carbonate rocks, such as the Allentown Dolomite, Beekmantown Group, and Jacksonburg Limestone. The valley is flanked by hills held up by slates and graywackes of the Martinsburg Formation, fault-bounded contact with the carbonates on the east valley wall and gradational contact with the Jacksonburg Limestone on the west side of the valley.
0.4	10.6	Intersection with Stark Road (village of Warrington). Ice-contact deltas in the lower part of Paulins Kill valley delineate three ice-retreat positions (Ridge, 1983). These deposits lie as much as 100 ft (30 m) above the Paulins Kill, and they form the bulk of meltwater deposits in Paulins Kill valley. These deltas were laid down in small proglacial lakes held in the south-draining valley by older outwash deposits downvalley and possibly by ice in the Delaware Valley. This stepward style of deglaciation can be traced throughout the Paulins Kill valley. Based on the morphosequence concept (Koteff and Pessl, (1981); Ridge (1983) and Witte (1988) have delineated 14 ice-retreatal positions in the valley. The meltwater? terrace deposits that cover parts of the valley floor were formed by meltwater emanating from these up valley positions. The broad meltwater terraces in the vicinity of Vail and Walnut Valley (mileage = 14.1) lie well below the ice-contact deltas. Their lower positions in the valley reflect a lowering of local base level as older outwash down valley became further incised by meltwater draining from younger retreat positions upvalley.
1.0	11.6	Pass through railroad tunnel (Conrail, formerly Delaware-Lackawanna & Western R.R.; built in 1909).
0.8	12.4	Road to Mt. Pleasant on left. Pass through village of Hainesburg. A nearly

complete skeleton of *Cervacles scotti* Lydecker (Figure 3) was recovered from a bog just southwest of the village.

0.2 12.6 Pass over Yards Creek. For next 1.5 mi (2 km) cross over large ice-contact delta that was laid down in small proglacial lake held in by older outwash downvalley.

0.1 12.7 Cemetery on left in late Wisconsinan outwash (ice-contact delta).

3.2 15.9 Enter Blairstown Township.

1.7 17.6 Turn left onto Walnut Valley Road towards Yards Creek.

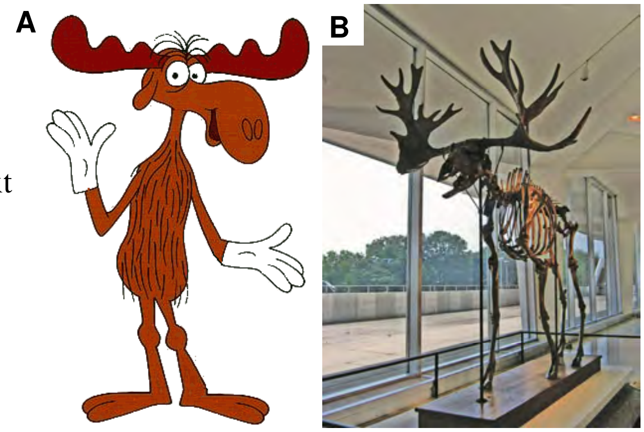


Figure 3. A—Artist's rendition of *Cervacles scotti* that was found in 1885 at Mt. Hermon, about four mi (6 km) southeast of Hainesville, New Jersey; Right—Reconstruction of the skeleton in the New Jersey State Museum.

0.1 17.7 Beekmantown Group, upper part dipping northwest on west roadside. Just above this outcrop and around the bend lies the Jacksonburg Limestone which is covered by thin till. The Beekmantown unconformity lies at the Beekmantown-Jacksonburg contact. It marks the peripheral bulge migration from present day east to west caused by thrust sheet loading from the approaching Taconic island arc complex. Most of the large erratics are the Shawangunk Formation (whitish quartz-pebble conglomerate), with lesser red sandstone boulders of the Bloomsburg Red Beds.

0.8 18.5 Pass Frog Pond Road on left.

0.1 18.6 Cross over Yards Creek. Ramseyburg Member of the Martinsburg Formation exposed in creek bed to the right. Here the Ramseyburg has a well developed southeast dipping cleavage.

0.4 19.0 Many till stones beneath power lines to right. Common in areas of thick till.

0.5 19.5 Cliffs of Shawangunk Formation to the left.

2.4 21.9 Continue straight across intersection with Mt Vernon Road to guard house at Yards Creek Generating Station (117 WalnutValley Road). Check in and continue to parking area.

0.2 22.1 Park.

STOP 5: YARDS CREEK PUMPED STORAGE HYDROELECTRIC GENERATING STATION—MARTINSBURG SLATY CLEAVAGE; TACONIC UNCONFORMITY

See detailed stop description on page 294.

Leave parking area at Yards Creek and return to guard gate.

0.2 22.3 Turn left on Mt Vernon road.

0.1 22.4 Cross Yards Creek.

1.0 23.4 Outcrop of Martinsburg on right. Note its well developed, southeast-dipping cleavage. Ravine cut by meltwater on the left.

0.5	23.9	Cross over Stony Brook. Transition to carbonate-floored valley.
0.8	24.7	Stop sign. Turn left on Buchanan Road.
0.4	25.1	Stop sign. Turn left on NJ 94N.
0.4	25.5	Exposure of the dolomite facies of the Beekmantown Group, lower part on north roadside. Behind the supermarket on the left is the type section of the Jacksonburg Limestone. It rests unconformably atop the different units of the Beekmantown Group in New Jersey depending on the amount of previous erosion. The basal Jacksonburg, commonly called the cement lime member by the quarry workers is a shallow water carbonate that is abundantly fossiliferous. As the Taconic foreland basin begins to develop the Jacksonburg shows evidence of deepening water through an increase of argillaceous content. This marks the cement rock member of the Jacksonburg. Cement quarries in eastern Pennsylvania and western most New Jersey excavate and sell this material as it has an almost perfect Portland cement-type chemistry. Thomas Edison opened a quarry in the cement rock member in Stewartsville, New Jersey. The cement rock is only found in this area as farther to the east the fossiliferous cement lime grades directly into the Bushkill Member of the Martinsburg Formation. Regional outcrop patterns suggest that this Jacksonburg depositional pattern is controlled by the original foreland basin morphology. The deeper water Penn Argyl Member of the Martinsburg displays a similar pattern cropping out in eastern Pennsylvania and just across into New Jersey along I-80. Farther to the east the upper member of the Martinsburg, the High Point Member (Drake, 1991) becomes coarser grained and more proximal to its sediment source.
0.2	25.7	Cemetery on right lies in late Wisconsinan ice-contact delta.
0.2	25.9	Cross over Jacksonburg Creek.
0.3	26.2	Outcrop on right of Beekmantown Group crops out on right (southern roadside). This exposure lies on an anticlinal hinge. The carbonate sequence that continues upsection through the woods to the south contains an abundance of chert and supported small Paleoindian workings.
0.3	26.5	Sitting on the southeastern dipping limb of the anticline is an exposure of the Beekmantown Group, lower part. Immediately south lies a southeast dipping thrust fault that traverses almost the entire Paulins Kill carbonate valley.
0.2	26.7	Enter Blairstown. Originally named Smyths Mills after Benjamine Smyth who built a small gristmill around 1760. Renamed Butts Bridge in 1795 and officially changed to Blairstown in 1839. In 1820 the village consisted of a few dwellings, store-post office, tavern, black smith shop, and a few barns (www.blairstown-nj.org/AboutUs.html).
0.4	27.1	Traffic light. Continue straight on NJ 94N towards Newton and cross over Paulins Kill.
0.4	27.5	Outcrop of Martinsburg on right.
1.0	28.5	Series of outcrops of the Ramseyburg Member of the Martinsburg on right for the next 2.5 mi (4 km). We are just into the deep-water foreland basin deposits on the southeast side of the long anticlinal structure. The ribbon slates generally dip to the southeast with a well-developed southeast dipping cleavage. Several small folds occur within the Martinsburg. A southeast dipping thrust fault to the

		north places the Upper Ordovician Martinsburg over the Lower to Middle Ordovician carbonate units
3.8	32.3	Johnsonburg Rd. on right.
1.1	33.4	Leave Warren County and enter scenic Sussex County with cowsies.
0.2	33.6	Yellow Frame Presbyterian Church (Figure 4). Completed in 1786 on the last of three sites used by the local congregation. Yes, the original structure was painted yellow.
1.1	34.7	Thin-bedded Bushkill Member of the Martinsburg Formation on slope to left. Penecontemporaneous slump folds, presumably set in motion by an earthquake, was exposed about 40 years ago in pull-off area, now covered (Figure 5).
0.5	35.2	Outcrop of Martinsburg on right. As we continue along this route the Ramseyburg, a coarser grained turbidite than the Bushkill, can be seen on both sides of the road. Ramseyburg turbidites are characterized as Tbcde, and Tcde pattern while the Bushkill is more commonly a Tde structure.
0.3	35.5	Outcrop of Martinsburg on left.
0.3	35.8	Martinsburg on left.
0.6	36.4	Martinsburg on left.
0.5	36.9	Outcrop of Martinsburg on right.
0.4	37.3	As we continue along NJ 94 we are slowly migrating across the Martinsburg units toward another Cambrian and Ordovician carbonate belt.
0.3	37.6	Traffic light. Junction with County 610 (Phil Hardin Road). Continue straight.

Figure 4. Yellow Frame Presbyterian Church, a pre-revolutionary congregation that first met in 1750 near a place called Log Gaol, now known as Johnsonburg.

Figure 5. Penecontemporaneous slump folds, presumably set off by an earthquake, in laminated beds of the Bushkill Member of the Martinsburg Formation exposed in a clearing about 200 ft (61 m) long in 1974. The interval of folding is about 4 ft (1.2 m) thick; contacts with flat-lying beds above and below are abrupt. The amplitude of some folds is as much as 1 ft (0.3 m). The axes of the folds plunge 29°, N.85°W. Folds appear to verge to the southwest (left), suggesting current flow in that direction, agreeing longitudinal flow patterns in the Martinsburg Basin suggested by McBride (1962).

2.7 40.3 Enter Newton. Originally formed as a township in 1750. The town, a regional transportation hub, was originally built around the Sussex County Court House (Figure 6) which was completed in 1765. In 1780, the courthouse was the site of a raid by James Moody. The event was described as follows by historian Kevin W. Wright of Sussex County:

Figure 6. Sussex County Courthouse, Newton, New Jersey. The original courthouse was completed in 1765 and rebuilt in 1848 after it was largely destroyed by a fire the previous year. Inset photo—Moody's Rock, a Loyalist hangout during the Revolutionary War.

On May 10, 1780, Loyalist Lieutenant James Moody led six men from Staten Island on a daring raid to free eight prisoners held in the Sussex Gaol on various suspicions and charges of loyalty to the British Crown. Hearing a knock in the dead of night, the Sheriff called down from the upper room, asking these shadowy figures their business. Lt. Moody replied that he had captured a notorious Tory, who was one of Moody's men. Though seemingly delighted, the wary jailer refused to open the door. Moody then identified himself and threatened to pull down the building. With loud Indian war hoops, his small troop alarmed the sleeping villagers. Meanwhile, Lieutenant Moody gained entry through a casement and succeeded in releasing the prisoners. Despite a spirited pursuit lasting several days, the militia failed to capture the raiders. (excerpt from (**www.revolutionarywarnewjersey.com/new_jersey_revolutionary_war_sites/towns/newton_nj_revolutionary_war_sites.htm**).

Supposedly, Moody hid out in caves and rock shelters (inset, fig. 6) located a few miles (kilometers) south of town in an area known as the Muckshaws. Geologic mapping in that area has only revealed the presence of very small caves that would hardly be suitable as a hideout for a small group of wanted men.

0.5 40.8 Outcrop of Martinsburg on right.

0.6 41.4 Enter squared circle to right. Stay in left lane as you circulate counter clockwise.

0.2 41.6 Enter Main Street.

0.1 41.7 Keep left towards US 206N.

0.1 41.7 Turn right onto US 206/94N.

0.3 42.0 Note Martinsburg outcrop on left as it plays a part in the next stop. The outcrop displays a well developed cleavage and locally a high concentration of veins cut the Martinsburg. Northwest dipping Jacksonburg Limestone is exposed just one block to the east of our present location

0.4 42.4 Turn left on North Park Drive.

0.1 42.5 Turn left towards Home Depot.

0.2 42.7 Drive into parking lot and park along outcrop on south side. Stop 2.

STOP 6: NEWTON, NJ HOME DEPOT PARKING LOT

See detailed stop description on page 302.

Return to US209/94N, right at traffic light.

0.3 43.0 Traffic light, continue straight.

0.1 43.1 Grand Union Klippe on left.

0.4 43.5 Traffic light, continue straight.

0.6 44.1 Martinsburg outcrop on left.

0.3 44.4 Traffic light, continue straight on US 209 N.

0.5 44.9 Cross over Paulinskill Valley Rail Trail.

0.1 45.0 County Rt. 626 (Halsey – Myrtle Grove Rd.) on left.

0.1 45.1 Ogdensburg-Culvers Gap moraine and ice-contact deltas on left (Figure 7). Recessional moraines in northwestern New Jersey form arcuate, nearly continuous to segmented, cross-valley ridges that mark former, stable, ice-marginal positions of the Laurentide ice sheet. These features are late Wisconsinan age, following looping courses through the Kittatinny and Minisink Valleys. They consist of noncompact, stony, silty-sandy till (diamicton) with minor beds and lenses of water-laid sand, silt, and gravel. This material is distinctly different from the more compact, and less stony ground moraine or till that lies near the moraine. Additionally, stratified drift is not a major constituent, even in places where it crosses river valleys (former glacial lake basins). Their course indicates the margin of the Kittatinny and Minisink Valley lobes was distinctly lobate at both a regional and local scale. Topography varies between ridge-and-swale and knob-and-kettle, with the former more prevalent along the outer morainal margin.

The following definition, modified from Flint (1971) describes the character of these features. An end moraine is a ridge?like accumulation of drift built along any part of the margin of an active glacier. Its topography is initially constructional, and its initial form results from (1) amount and vertical distribution of drift in the glacier, (2) rate of ice movement, and (3) rate of ablation. Flint stressed the role of active ice transporting drift to the glacier margin, and the amount of drift in the ice sheet. Presumably, the more active the glacier and the more drift it contains, the larger the end moraine it will make. In addition, syndepositional and postdepositional modification of the moraine through ice shove, collapse due to melting of buried ice, and resedimentation of supramorainal materials chiefly by mass wasting, all act to give the recessional moraines their overall form.

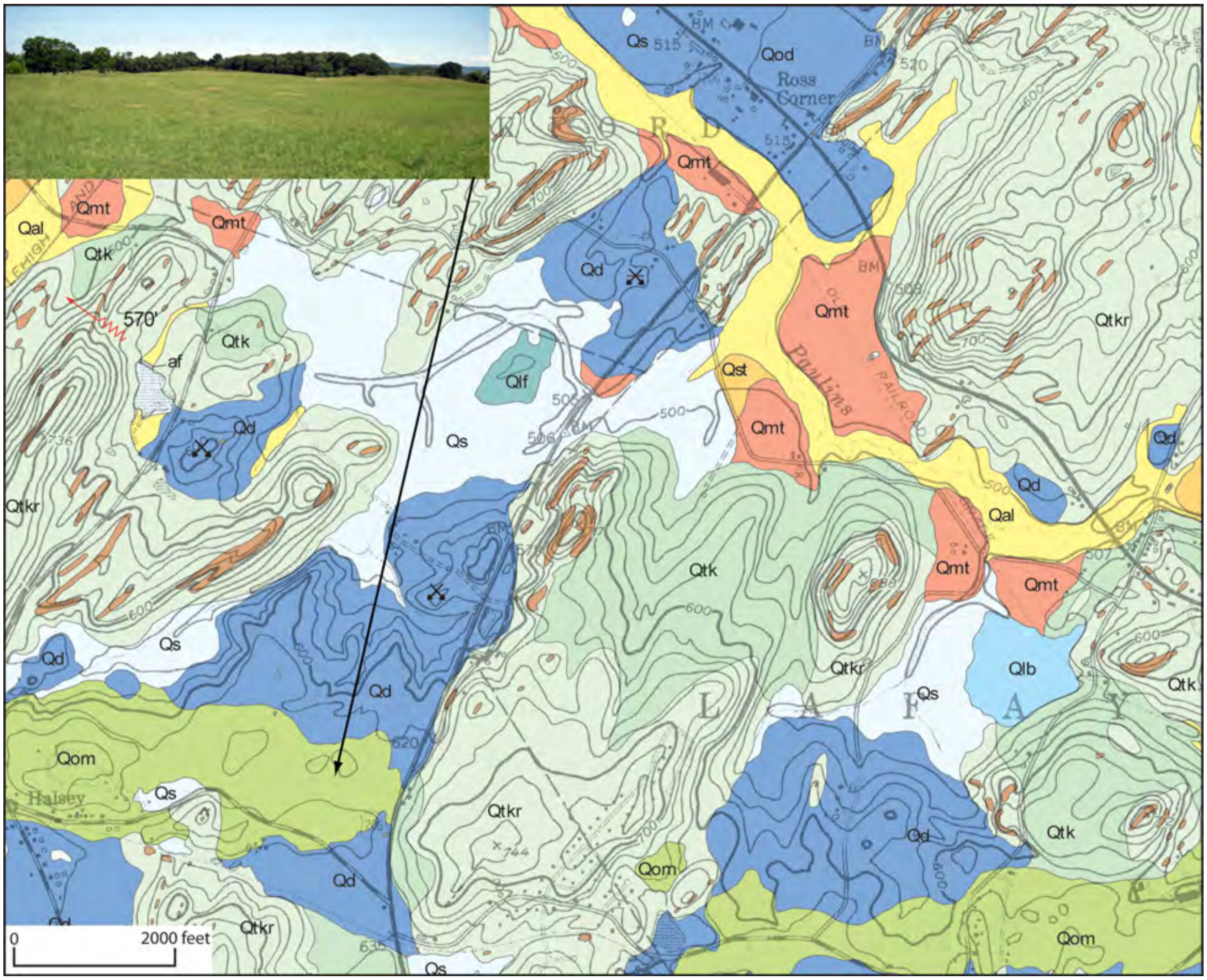


Figure 7. Surficial geologic map of part of the field trip route, Ross Corner, New Jersey. The inset photo shows the low knob and swale topography of the Ogdensburg-Culvers Gap moraine located on the west side of Route 206. List of map units: Qtk – thick till, Qtkr – thin till, Qom – Ogdensburg-Culvers Gap moraine, Qk – kame, Qd – ice-contact delta, Qlb – glacial lake-bottom deposit, Qmt – meltwater terrace deposit, Qst stream-terrace deposit, Qs – swamp and bog deposits, Qal – alluvium. Small, light brown, unlabeled unit are extensive rock outcrop. Map from Witte and Monteverde (2006).

0.4	45.5	Martinsburg on both sides of road.
0.5	46.0	Om on right.
0.4	46.4	Cross small tributary of the Paulins Kill. Discuss lowland north of Qom.
0.5	46.9	Om on right, pencil cleavage.
0.1	47.0	Cross over Paulins Kill.
0.1	47.1	Ross Corners. Traffic light. Ross Corner, intersection of Routes 206, 15, and 565. Turn left on US 206 N toward Branchville. Large outwash plain on right laid down in small unnamed glacial lake in the Paulinskill Valley.
0.2	47.3	Baseball stadium of the minor league New Jersey Cardinals on right.
0.8	48.1	Lehigh and New England Rail Road, glacial Lake Wallkill spillway. Just upvalley from the spillway lies the Augusta Moraine. Similar to the Ogdensburg-Culvers Gap moraine it also defines a major retreat position of the

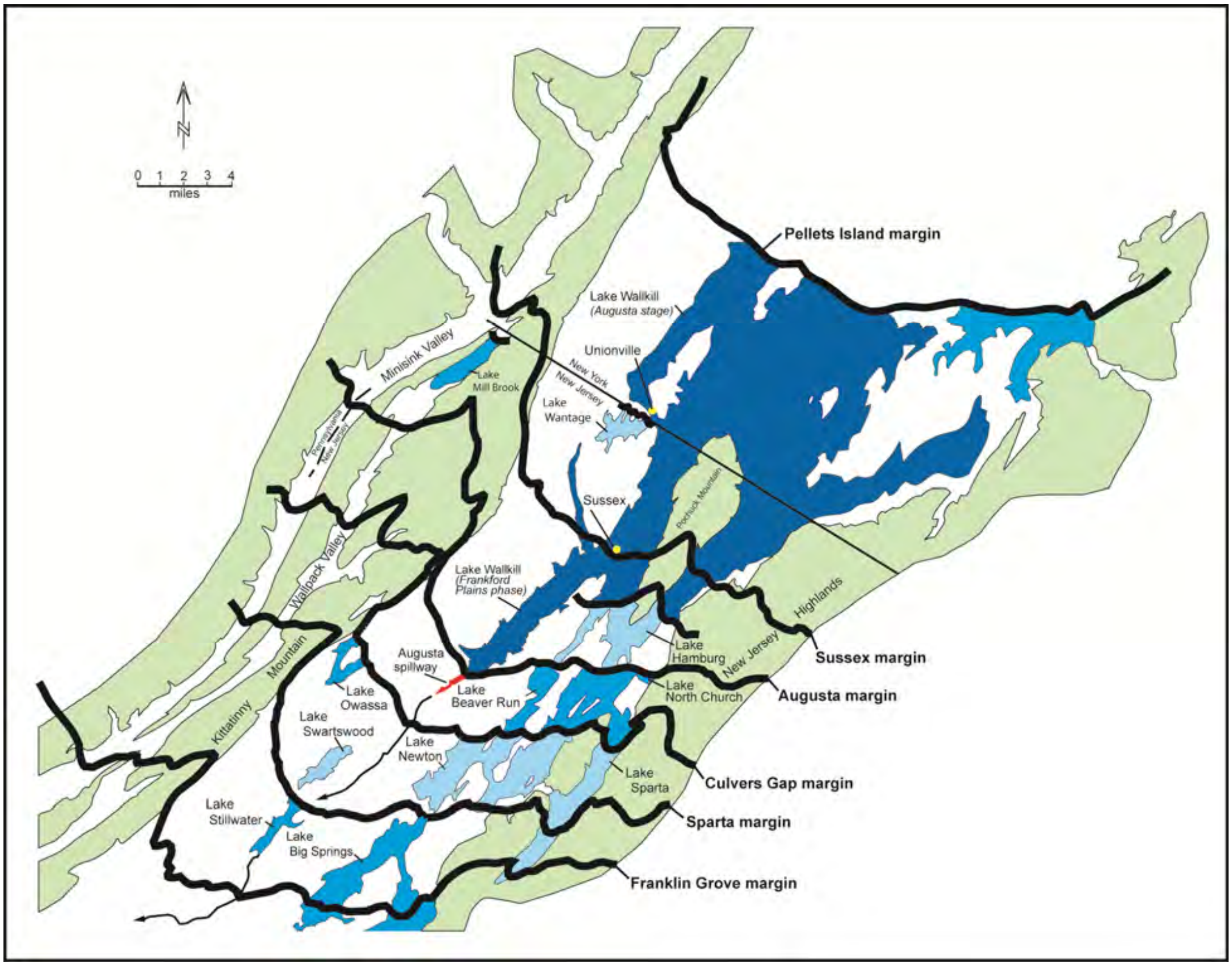


Figure 8. Late Wisconsinan ice-recession margins and glacial lakes in the upper parts of Kittatinny and Wallkill Valleys, New Jersey and New York. Retreat of the Kittatinny Valley ice lobe from the Augusta moraine resulted in the formation of glacial Lake Wallkill in Papakating Creek valley. The lake initially drained south across the moraine into the Paulins Kill valley. As the size of the lake and its drainage basin increased during retreat of the ice lobe, discharge increased and the spillway was lowered by fluvial erosion into an underlying outwash deposit. Eventually, a narrow deep channel was cut through the outwash by the outflowing stream. Erosion of the channel continued until bedrock was reached, and the level of the lake stabilized. Present elevation of this threshold, called the Augusta spillway, is estimated to be 495 ft (151 m) above sea level and the period during which Lake Wallkill utilized this spillway is called the Augusta stage. The period prior to the formation of the stable spillway is called the Frankford Plains phase of glacial Lake Wallkill. Lake Wallkill continued to expand northward into New York up until ice uncovered the northern end of the Skunnemunk Mountains, and a lower outlet was uncovered (365 ft (111 m) above sea level), the lake discharging into the Moodna Creek Valley. Figure modified from Witte (1997).

Kittatinny Valley lobe. The moraine where it crosses Papakating Creek valley overlies stratified sand and gravel, which shows it was deposited after a readvance of the Kittatinny Valley lobe. The extent of the readvance is unknown; however, based on the deglaciation history of Kittatinny Valley (Ridge, 1983; Witte, 1997) the readvance was probably minor. The retreat of the margin of the Kittatinny Valley ice lobe from the Augusta Moraine resulted in the formation of glacial Lake Wallkill in Papakating Creek valley (Figure 8). Initially, the lake's spillway was over morainal deposits of the Augusta Moraine. As the size of the lake and its drainage basin in-creased during retreat of the ice lobe, discharge increased and the spillway was lowered by fluvial erosion into the underlying coarse gravel and sand that lies beneath and south of the moraine. Eventually a narrow deep channel was cut through the sequence by the outflowing stream. Erosion of the channel continued until bedrock was reached, and the level of the lake stabilized. Present elevation of this threshold, called here the Augusta spillway, is estimated to be 495 ft (151 m) above sea level. The period antedating the formation of the stable spillway is called the Frankford Plains phase of glacial Lake Wallkill.

0.1	48.2	Traffic light. Continue straight. Plains Road on right.
1.0	49.2	Traffic light. Continue straight.
0.3	49.5	Traffic light. Turn right onto CR 519 N toward Branchville.
0.2	49.7	Bear left onto Mill Rd. (CR 519).
0.1	49.8	Cross Culvers Creek.
0.3	50.1	Branchville. At stop sign turn sharp right following Wantage Ave. (CR 519 N). Branchville was settled by William H. Beemer in 1690 who built a grist mill along Culvers Creek. Named Branchville in 1821. Back in the day of COGEOMAP, Don claims he would detour many miles (kilometers) out of the way to drive north of Branchville, just to get a glimpse of a bikini-clad, work boots wearing, raven-haired beauty who was operating a commercial, walk behind Gravelly lawn mower. Following extensive peer review, this sighting has never been verified.
0.4	50.5	Cross over Dry Brook. Start of long Martinsburg outcrop.
0.3	50.8	End of exposure.
0.5	51.3	Turn left following CR 519 N (Wantage Rd.).
0.6	51.9	Cross over Dry Brook.
0.7	52.6	Martinsburg on left.
0.3	52.9	Martinsburg on left.
0.1	53.0	Large swamp on right in Dry Brook Valley is largely the result of beaver dams.
0.4	53.4	Cross over Dry Brook again (now would be a good time for an adult beverage).
0.1	53.5	Martinsburg on right.
0.1	53.6	Martinsburg on right.
0.2	53.8	Martinsburg on both sides.
0.4	54.2	Martinsburg on both sides. (Do we really need to see more Martinsburg? Where is that drink?)
0.3	54.5	View of Sunrise Mountain to the left. Second highest point along the Appalachian Trail in New Jersey. Just below and slightly southwest of the mountain is the only known natural exposure of the Taconic Unconformity in New Jersey (Figure 9).

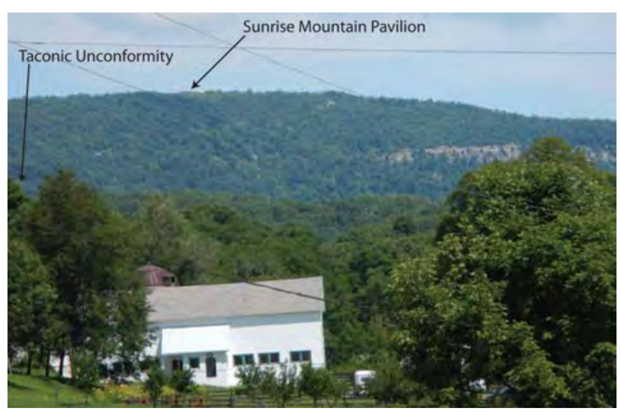


Figure 9. The only known, natural exposure of the Taconic unconformity in New Jersey located about 1 mi (1.6 km) southwest of Sunrise Mountain and 1200 ft (366 m) east of the Appalachian Trail.

Unfortunately we won't be going there due to its distance from the road and a mount of bushwacking needed.

0.5	55.0	Turn left onto Crigger Road.
0.9	55.9	Stop sign. Turn right onto Neilson Road.
1.5	57.4	Bog on left. Nothing notable about it. Just need a surficial reference to break up the monotony of "turn right" and "outcrop left"!
0.8	58.2	Syenite on left.
0.4	58.6	Martinsburg Hornfels complex.
0.7	59.3	Park busses on left alongside of road.
0.1	59.4	Trailhead to Stop 7.

STOP 7: LUSSCROFT FARM AND BEEMERVILLE SYENITE

See detailed stop description on page 314.

Continue northeast on Neilson road.

0.3	59.7	Volcanic Hill Road on right. This road leads up to the volcanic diatreme responsible for some of the material observed at the last stop. Diverse xenoliths consisting of Mesoproterozoic gneiss, Cambrian and Ordovician platform carbonates and Martinsburg can all be found within the volcanic material. Several other volcanic diatremes exposures have been mapped in the area (Spink, 1967; Drake and Monteverde, 1992).
0.4	60.1	Stop sign. Turn left on NJ519N.
0.4	60.5	Junction with Sussex County 650. Continue straight on 519N.
1.6	62.1	Stop sign. Turn left on NJ23N/519N.
0.4	62.5	Enter Colesville.
0.9	63.4	Graywacke of the High Point Member of the Martinsburg Formation on left.
0.7	64.1	Martinsburg on right.
1.0	65.1	Bear left on Sussex 23; do not turn right on 519.
0.3	65.4	Martinsburg graywacke on left.
0.4	65.8	Appalachian Trial. Do not drive on it.
0.3	66.1	Turn right into High Point State Park.
0.2	66.3	Entrance booth. Continue straight towards monument. We are riding atop a narrow exposure of the High Point Member of the Martinsburg Formation with Shawangunk Formation to both the east and west. This represents a narrow fold in the Taconic unconformity which plunges to the northeast and unfortunately is not exposed.
0.1	66.4	Shawangunk erratic at split in road.
0.2	66.6	Picnic pavilion on right and outcrop of Martinsburg (High Point Mbr.). The Martinsburg plunges out just before Lake Marcia.
0.3	66.9	Lake Marcia and High Point Monument on right (Figure 10). Supposedly, the lake was named in 1855, after Marcia Smith, fiancee` of a state geologist. It's amazing how far an excuse a geologist will use to keep going out into the field. (**http://www.njskylands.com/pkhighpt.htm**).

Figure 10. Highpoint in the Skylands Region of New Jersey, is the highest elevation in the state at 1,803 ft (550 m). The monument rests on coarse clastic rocks the Shawangunk Formation. It was built in 1930 and adds an additional 220 ft 67 m) to the altitude of New Jersey.

0.3	67.2	Shawangunk Formation dips northwestward on left side of road.
0.1	67.3	Park road to Cedar Swamp on left (only known inland occurrence of Atlantic White Cedar). Continue straight uphill toward monument.
0.9	68.2	Park below monument.
		STOP 8 AND LUNCH: HIGH POINT STATE PARK
		See detailed stop description on page 334.
		Retrace route back to Route 23.
1.5	69.7	Stop sign. Turn right onto Rte 23N.
0.1	69.8	Om on right.
0.3	70.1	Saw Mill Road on left. Borings along gas pipeline about 2.5 mi (4 km) southwest show that the overburden (mostly late Wisconsinan till) is as much as 120 ft (37 m) thick. Many of the glacial landforms in this area are drumlins.
0.3	70.4	Shawangunk outcrop.
0.1	70.5	Steeny Kill Lake on right. The lake is manmade, its earthen dam on the lake's north side, constructed in 1938.
0.6	71.1	Steeny Kill Lake moraine. Small recessional moraine that marks a minor stillstand or readvance of the Minisink Valley lobe.
0.3	71.4	Two till exposures in ravine along Clove Brook, 0.5 mi (0.8 km) to the northwest (Figure 11). Here, exposed at a recent slump, is 10 ft (3 m) of yellowish-brown quartzite-rich till (Shawangunk clasts) overlying more than 30 ft (9 m) of reddish-brown, red sandstone-rich till (Bloomsburg Red Beds clasts). This change in till lithology is consistent with an ice flow shift from southward to nearly westward that occurred during deglaciation (topic discussed at High Point Stop 8).

Figure 11. Brown quartzite-rich till overlying reddish-brown red sandstone rich till exposed along the face of a small slump located along the upper reach of Clove Brook, High Point State Park, New Jersey. The reddish-brown till, largely derived from the Bloomsburg Red Beds, represents a more southerly flow across Kittatinny Mountain. The brown till, largely derived from the Shawangunk Formation, represents a southwesterly to westerly flow. This change in till provenance is consistent other indicators of ice flow (drumlins, striae, erratic dispersal) that show a more regional southerly flow superceded by a southwesterly to westerly flow during deglaciation.

0.5	71.9	Till exposure to right. What variety? Vanilla or chocolate?
0.7	72.6	Bloomsburg Red Beds outcrop on right.
0.3	72.9	Kame consisting largely of cobble-pebble gravel on right. Probably deposited in a small reentrant formed between the glacier's margin and a small valley that drained the higher ground to the east.
0.8	73.7	Clove Road on left, lower part of Mill Brook Valley. The north-draining valley contains many small ice-contact deltas that were deposited in glacial Lake Mill Brook, an ice-dammed lake.
4.2	77.9	Traffic light. Rte 23 becomes CR 15. Enter New York.
0.1	78.0	Merge onto I-84E toward Middletown.
3.7	81.7	Shawangunk-Martinsburg unconformity exposed on right. The angular discordance at the unconformity is five degrees (see Figure 3 on p. 39 of this guidebook).
2.6	84.3	Turn right at Exit 2 to Mountain road.
0.3	84.6	Turn right onto Mountain Road/CR 35.
4.5	89.1	Intersection. Turn slight left onto Mountain road following CR 73.
2.9	92.0	Martinsburg outcrop on left.
0.4	92.4	Martinsburg outcrop on left.
0.3	92.7	Martinsburg outcrop on left.
0.9	93.6	Stop sign. Turn left onto Highland Ave/CR 11. Enter Town of Otisville on Main Street.
0.6	94.2	Stop sign. Turn left on NY 211/State Street.
0.3	94.5	Begin Shawangunk float on right.
0.2	94.7	Shawangunk outcrop on right.
0.5	95.2	Buses pull off along side of road to right just before CR 61. Cross highway and follow abandoned railroad grade to the left (southwest) to Stop 9.

The abandoned quarry in the hill to the right icontains northwest-dipping thin shales interbedded with typical Shawangunk quartzites and conglomerates (see

Epstein, 1993, fig. 5). These rocks are on line with exposures 1.2 mi (1.9 km) to the southwest to which Swartz and Swartz (1931) applied the name Otisville Shale Member of the Shawangunk Formation. This unit is out to lunch, that is, it is poorly defined, it is unmappable, and was discarded by Epstein (1993). Perhaps after this trip Epstein should be discarded. Clarke (1907) measured the rocks in the quarry and showed that shale makes up less than 3 percent of the section.

STOP 9: OTISVILLE RAILROAD CUT

See detailed stop description on page 354.

NOTE: If we do not go to Stop 10 at this point because of tourist crowding and abundant leaf peepers at the Sams Point Nature Preserve, then do not proceed on CR 61 but follow CR 211 straight ahead for 2.6 mi (4.2 km) and turn left onto US 209 and follow the road log back to Shawnee Resort. Pick up mileage 97.3 at the intersection with US 209N.

Pull out and immediately turn right onto CR 61.

0.2	95.4	Sandstone and conglomerate of the Shawangunk Formation behind retaining wall.
1.9	97.3	Stop sign. Turn right onto US 209N.
5.4	102.7	Traffic light. Intersection with NY 17. Continue straight on US 209N. Excellent exposures of units within the Shawangunk Formation and Bloomsburg Red Beds, as well as the Silurian-Ordovician unconformity (15^{o} discontinuity) are present to the east along NY 17 (Epstein, 1993).
0.8	103.5	Enter village of Wurtsboro
0.6	104.1	Traffic light. Continue straight on US 209N. Pastrami and corned beef sandwiches at Danny's on right.
2.2	106.3	Wurtsboro airport on right. Believed to be the oldest operating glider airport in the country.
2.0	108.3	Sand and gravel pit in delta to right (Figure 12).
1.1	109.4	Hill to right is in the Phillipsport moraine.
1.8	111.2	Town of Wawarsing, so the sign says. It is not! It is Summitville, which gets its name from the fact that it is the highest point on the old Delaware and Hudson Canal (Heroy, 1974).
2.3	113.5	View of northwest limb of the Ellenville arch to right.

Figure 12. Topset and foreset beds in a glacial delta in a sandpit east of US 209. This is the Phillipsport moraine of Rich (1935), a kame moraine that lay at the Hudson River-Delaware River drainage divide (see Reynolds, 2007).

0.9	114.4	Outcrop of moderately northwest-dipping gray shale, siltstone, and sandstone of the Mount Marion Formation on left (see Appendix 2 of this guidebook, p. 32).
0.8	115.2	Enter Ellenville.
0.8	116.0	Traffic light. Turn right on NY 52E/Center Street.
0.2	116.2	Traffic light. Continue straight on Center Street.
0.2	116.4	Cross Sandburg Creek.
0.2	116.6	Pass Broadhead Street/Berme Road. The Ellenville zinc?lead mine and a rock quarry in the tongue of the Shawangunk are located at the base of the mountain to the left. See Sims and Hotz (1951) and Rutstein (1987, p. 116) for descriptions.
0.2	116.8	Stop sign. Bear right on NY52E and ascend the mountain
0.1	116.9	Cross North Gully, joining NY 52. Exposures of the Ellenville Tongue of the Shawangunk Formation in roadcuts and Wurtsboro Tongue of the Bloomsburg Red Beds (see Epstein, this guidebook, Figure 3 on p. 5) in the creek bed of North Gully to the left.
0.4	117.3	Wurtsboro Tongue of the Bloomsburg Redbeds on left. The road follows this unit for several hundred feet (scores of meters).
0.4	117.7	Outcrops of uppermost Shawangunk , Ellenville Tongue, in flatirons on northwest limb of the Ellenville arch.
0.1	117.8	Cross South Gully.
1.0	118.8	There is a pull-off here where, 0.1 mi (0.16 km) below on the other side of the road, sedimentary structures in the uppermost Shawangunk are exposed (careful of high-speed traffic if you wish to stop here). The following description is from Epstein and Lyttle (1987). The full story is in Epstein (1993).
		The Ellenville Tongue of the Shawangunk Formation here consists of crossbedded and planar?bedded conglomeratic quartzite and pea?gravel conglomerates, with minor thin, lenticular light?olive?gray shale. Channels are abundant and many beds pinch out along strike. Shale drapes in crossbeds are common. Flattened silty shale balls up to 8 in (20 cm) long are seen on the lower exposed bedding surface. Crossbed trends throughout the immediate area are to the northwest. The sedimentary structures, current trends, and petrographic characteristics suggest a fluvial, braided stream environment of deposition, similar to the interpretation for the Shawangunk in eastern Pennsylvania (Epstein and Epstein, 1972).
		The beds dip about 45^{o}NW. They are interrupted by a kink fold whose axis trends 18^{o} $S56^{o}$ W., a more easterly trend than the regional strike of the beds. This fold, and scattered others in this part of the Shawangunk Mountains, may represent a later stage of Alleghanian folding than seen to the southwest in New Jersey.
		If the leaves are off the trees, you may be able to see the linear valleys in the Catskill Mountains to the north. These post-Taconic structures are discussed at Stop 10.
0.2	119.0	Small thrusts in Shawangunk to left. These have a strike similar to the kink axis at Stop 3 and may also be later structures.

0.3	119.3	Ellenville Tongue of the Shawangunk Formation; Launch site for hang gliders straight ahead.
0.3	119.6	Middle shale unit of Shawangunk on left.
0.1	119.7	Back into overlying quartzite unit.
0.2	119.9	Shale unit of Shawangunk to left, nice view at turn off to right. At this turn off you can see the flat?floored valley of Sandburg Creek underlain by glacial lake clays. In the far distance to the north the hills are underlain by sandstones of the Ashokan Formation, and in the far distance to the north are the higher Catskill Mountains underlain by Middle and Upper Devonian rocks of the Catskill Formation. The valleys in the Catskills are aligned along linears that may controlled by structural weakness. Casual observation of some o f the valleys indicate that the rocks become more intensely jointed as the center of the valleys are approached, and exposures are lacking in their centers. In this area we have been able to divide the lower part of the Shawangunk Formation into lower and upper units separated by a middle shale?bearing unit about 100 ft (31 m) thick (see Epstein, this guidebook, Figure 3 on p. 5). The shale unit underlies topographic lows, generally allowing for easy mapping. This unit can be seen at the base of the exposed section here, and consists of more than 80 ft (24 m) of interbedded, laminated, ripple laminated, olive?gray silty shale and moderate?brown and light?olive?gray very fine to medium?grained, crossbedded, lenticular sandstone, slightly conglomeratic in places. Many of the sandstones have harp channeled bases and some are ripple?topped. The shale unit is overlain by several hundred feet (scores of meters) of thin? to medium?bedded, medium?grained, partly conglomeratic, partly feldspathic, crossbedded, channeled quartzite with scattered thin and lenticular olive gray shale. The quartzites appear to be evenly bedded from a distance, but closer scrutiny shows that they are channeled, lenticular, and unevenly bedded.
1.0	120.9	Turn left on road to Cragsmoor and Ice Caves Mountain. Between here and Stop 10, the road will be mostly on glacial till, with a few scattered exposures of the Martinsburg Formation.
1.4	122.3	Village of Cragsmoore. Bear right past the post office onto South Gully Road.
0.1	122.4	Turn right onto Sams Point road.
0.2	122.6	Cragsmoor Fire Dept. on right. Martinsburg exposure on left. This exposure and a few more up the road peeking through their till cover are n the Taconic tectonic zone of broad open folds. Views of continuous cliffs of the Shawangunk Formation in the broad top of the Ellenville arch may be seen at several places along this road.
0.7	123.3	Nice exposure of till on bank to right (if you like till—reminds us of a song about glacial love: Till There Was You!).
0.4	123.7	Enter Sam's Point Preserve and park. Stop 10. Visit the displays in the Conservation Center and hike up the trail to Sam's Point atop the Shawangunk outcrop.

STOP 10: ELLENVILLE ARCH

See detailed stop description on page 362.

		Leave the Nature Preserve, following Sams Point road back to Cragsmoor.
1.2	124.9	Stop sign. Turn left onto South Gully Road.
0.1	125.0	Continue onto Cragsmoore road.
1.5	126.5	Turn right on NY 52W.
1.0	127.5	View of Catskill Mountains in skyline.
3.0	130.5	Enter Ellenville at bottom of mountain. Continue straight on NY 52/Main Street.
0.1	130.6	Turn left following NY 52 onto Center Street.
0.5	131.1	Traffic light. Continue Straight on NY 52/center Street.
0.2	131.3	Traffic light. Continue straight.
0.1	131.4	Traffic light. Turn left onto US 209S/Main Street.
0.4	131.8	Traffic light. Kohl's on left. Continue Straight
1.5	133.3	Traffic light in Wurtsboro. Continue straight toward Port Jervis.
1.5	134.8	Traffic light at NY 17. Continue straight on US 209.
5.4	140.2	Village of Deer Park.
3.2	143.4	Intersection with NY 211. Continue straight on US 209.
0.7	144.1	Neversink River. Delaware and Hudson Canal County Park on right. Possible traffic light while bridge is being repaired.
5.7	149.8	Polished and striated Onondaga Limestone on left.
0.9	150.7	Entering Port Jervis.
0.5	151.2	Continue straight on US 209.
0.4	151.6	Traffic Light. Junction with US6. Turn right following US 209/US 6W.
0.2	151.8	Traffic light. Turn left following US 209/US 6W.
0.4	152.2	Traffic light. Continue straight on US 209.
0.2	152.4	Cross Delaware River in Matamoras, PA.
0.9	153.3	Traffic light.
0.1	153.4	Junction with I-84W. Continue straight on US 209.
0.2	153.6	Traffic light. Continue straight on US 209.
0.4	154.0	Junction with I-84E. Continue straight.
0.3	154.3	Traffic light. Paddlers Point Shopping Center. Continue straight.
0.1	154.4	Traffic light. Continue straight.
0.3	154.7	Traffic light. Continue straight.
0.1	154.8	Traffic light. Continue straight.
0.1	154.9	Traffic light. Continue straight. Note cliff face above I-84 to right. The valley here has been glacially scoured resulting in many hanging valleys and waterfalls.
3.8	158.7	Enter Milford. Tom Quick Inn on left. Jim Quick, Chief Scientist of the USGS Earth Surface Processes Team (what a name!), asked Epstein if he knew of the name Ben Quick from anywhere in Pennsylvania, because he knew he was

related to such a person. So, Jim and Jack visited the Tom Quick Inn, his actual ancestor, and the legend of Indian-slayer Tom Quick, an Indian slayer was recounted. The story can be found in many places, including **http://www.genyourway.com/ss-7.html** (accessed 9/7/2012), here presented:

THOMAS QUICK was born about 1690 in New York. He married Margrieta Dekker December 22, 1713 in New York. They were the parents of at least seven children. The family eventually settled in Milford, Pennsylvania, about 1733 as the first white settlers recorded in the area. Milford is the county seat for Pike County and right on the Delaware River. During the summer of 1983 the town of Milford had a large celebration of this event, commemorating the 250 years since the first settler came to the area.

Although Thomas Quick is recorded as the first settler in the area, there probably were earlier people in the area as a number of settlers were listed as living just across the river in New Jersey as early as 1701. Since a number of Dutch related men were in the area, the Dutch Reformed Church sent their ministers into the area. For this reason the Historical Society does not feel that this Thomas Quick was the first settler and it should not be celebrated as such.

It was said that Indians were abundant in the area as it was on the Delaware River, rich in animals and fish for food and clothing. The Quicks had to live with the Indians for survival and therefore treated the Indians with respect and kindness. They supplied them with food and clothing. They were able to live with the Indians for over 20 years with only minor problems, even as more and more white settlers came to the area.

The legend goes that in 1756 while Thomas Quick and one of his sons and his son-in-law were working by the river, farming or cutting wood for their mill, they were attacked by Indians from a nearby woods. The Quicks, having no *weapons, ran for their lives for the house.*

The elder Quick was heavy and old (about 66 years old). His sons grabbed him by the arms and tried to hurry him along. He begged the boys to abandon him and flee.

One of the sons was wounded by a bullet. The boys at last had to leave their father. The boys escaped by crossing the frozen Delaware River into New Jersey. But they were able to see the Indians kill and scalp the elder Quick and cut a pair of silver buckles from his trousers.

One of his sons, Tom Quick, pledged he would revenge the death of his father. He was about 22 years old at the time. Years later he got the buckle back after killing a number of Indians in cold blood. Legend has it that he killed over 100 Indians. A number of books and articles on the internet have been written about the exploits of this Tom Quick as he became a famous frontiersman and Indian fighter. He lived until 1795, about 61 years old.

Was he history or legend? He became an official legend in 1889 when the town erected the Settler's Monument and transferred his remains there from a grave in Matamoras where he was buried.

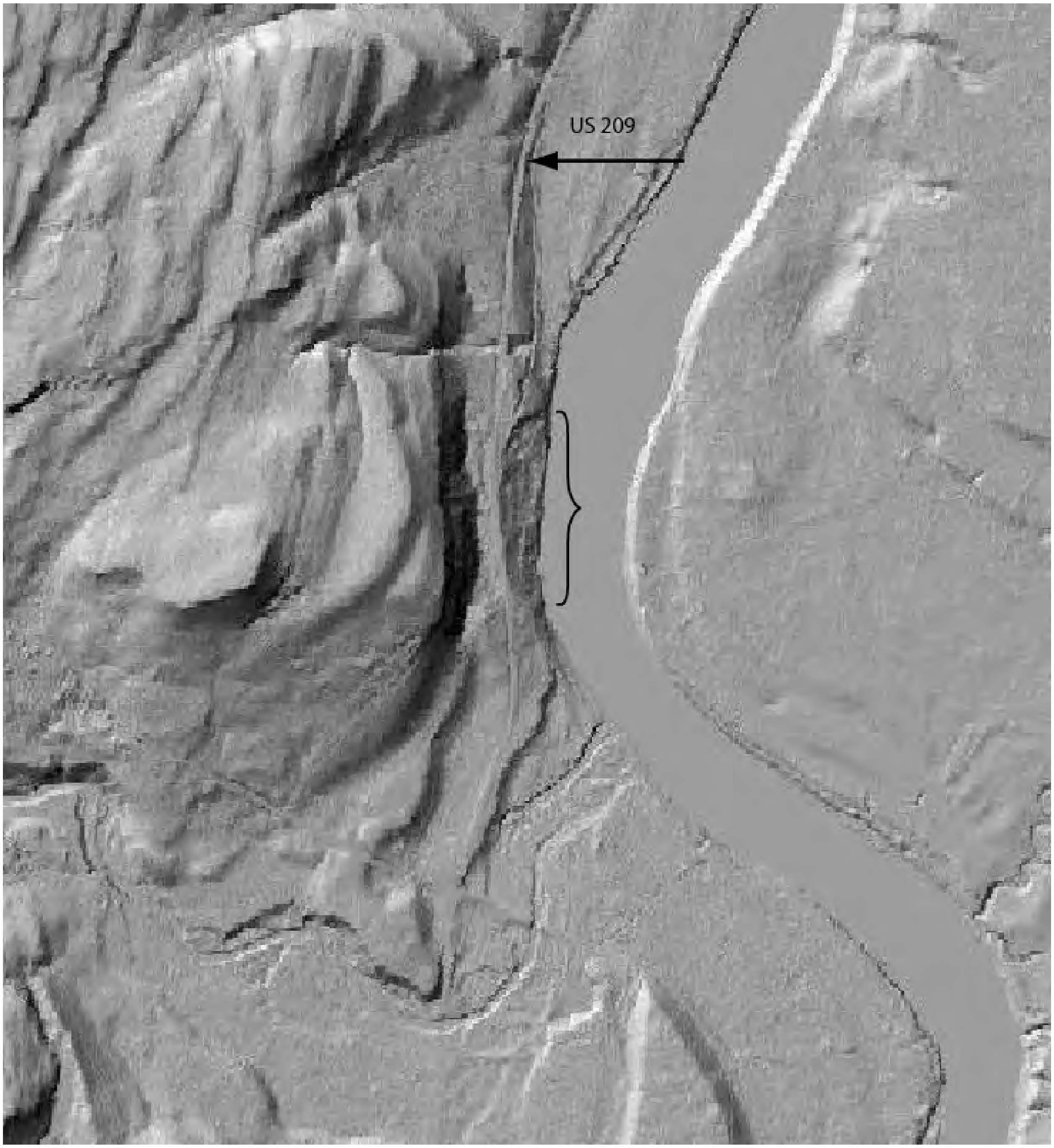


Figure 13. Lidar imagery showing landslide causing slumpage of US209 along the outside bend of the Delaware River. The slump is re-activation of the 1,000 ft- (305 m)-long landslide, affecting 560 ft (171 m) of the highway at the apex of the landslide's head. The road has been shutdown since xxx. The obvious culprit is the over-steepening of the slope in glacial till which was cut along the outside meander of the nearby Delaware River. The northward-striking, westward dipping Devonian rocks are well defined to the left in the image.

In 1997, the Quick's zinc monument on Sarah Street was vandalized with a sledgehammer. It was repaired but has not been redisplayed because of objections by native Americans.

0.5	159.2	Traffic light. Dingmans Ferry. Turn right on US 6 following detour. Normally we would turn left following US209 through Delaware Water Gap National Recreation Area. Flooding and landsliding (Figure 13) during tropical storm Lee in September 2011 resulted in closing the highway necessitating this detour.
0.2	159.4	Turn left on Mill Street and follow CR2001/Milford Road.
7.7	167.1	Turn left on RTE 739/Dingmans Turnpike.
2.5	169.6	Traffic light. Turn right on US209S, entering Delaware Water Gap National Recreation Area.
9.8	179.4	Marcellus on right.
0.9	180.3	Cliffs on right support shales of the Marcellus Formation at the base and Mahantango Formation siltstones above.
1.1	181.4	Cross Bushkill Creek in town of Bushkill.
1.1	182.5	Leaving DEWA.
0.6	183.1	Two quick traffic lights. Continue straight
1.1	184.2	Exposure of fault in basal Marcellus on right (Figure 14; see also Ver Straeten and others, 2001, p. 185).
1.7	185.9	Traffic light. Continue straight.
0.4	186.3	Traffic light. Continue straight.
0.4	186.7	Traffic light. Continue straight.
0.5	187.2	Traffic light. Continue straight.
0.8	188.0	Traffic light. Intersection with Mt. Nebo/Oak Grove Dr. Continue straight.
0.2	188.2	Enter new bypass. The Marshalls Creek Traffic Relief Project was completed and open to the public on June 12, 2012, relieving long lines of stop-and-go traffic at the bottleneck at Marshalls Creek.
0.4	188.6	Traffic light, continue straight. Onondaga Limestone outcrop.
0.2	188.8	Onondaga on left.
0.5	189.3	Large Schoharie outcrop on left.
0.2	189.5	Enter roundabout. Continue left onto US 209S.
0.6	190.1	Roadcut through interbedded shale, limestone, and chert of the Port Ewen Shale-Shriver Chert interval.
0.2	190.3	Roadcut through highly fossiliferous Port Ewen shale.

Figure 14. Two Noo Joisey geologists looking at the shear zone in the basal Martinsburg Formation (Union Springs Member) overlain by cleaved shaly siltstone of the Stoney Hollow Member of the Marcellus. The same shear zone has been seen in several scattered places all the way northeast to New York and around the northern edge of the Catskill Plateau. Has the entire Pocono-Catskill Plateau slid on this decollement? But, that's another story.

0.6 190.9 Deep road cut through the Port Ewen Shale. On the west side of the road is a 32-ft (10–m) long erratic of cherty limestone sitting on the shale (Figure 15).

0.5 191.4 Cut in south-dipping lower Onondaga Limestone, Schoharie Formation, and upper Esopus Formation. Buttermilk Falls on Marshalls Creek, the type locality of the Buttermilk Falls (=Onondaga) Limestone, is about 0.1 mi (0.16 km) to the east of here.

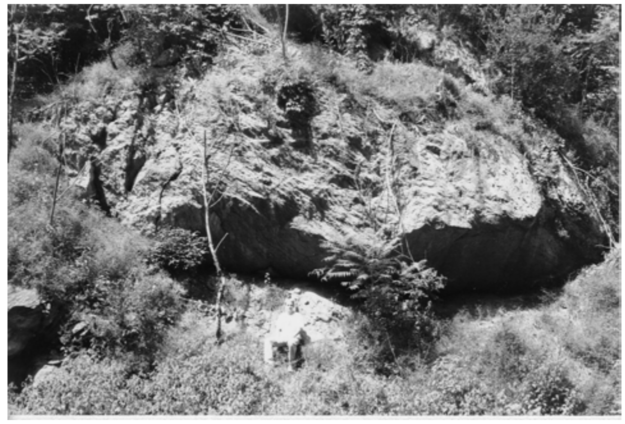


Figure 15. Humongous Onondaga erratic derived from the Edgecliff Member of the Onondaga Limestone, which has supplied scattered large erratics like this one throughout the area. (see White, 1882, p. 46-48).

0.3 191.7 Traffic light. Turn left on Buttermilk Falls road.

0.2 191.9 Outcrop of Schoharie on left.

0.5 192.4 Traffic light. Turn left on River Road. Exposure of New Scotland Formation on left.

0.3 192.7 Turn right into Shawnee Inn.

0.2 192.9 Pull into parking lot.

End of Trip.

Go Home!

Don't bother me anymore.

DAY 2 ROAD LOG REFERENCES

Clarke, J.M., 1907, The Eurypterus shales of the Shawangunk Mountains in eastern New York. New York State Museum, Bulletin 107, p. 295-326.

Clemensen, A.B., 1996, Preliminary historic resource study, Delaware Water Gap National Recreation Area, Pennsylvania/New Jersey. National Park Service, Denver Service Center, 372 p., 4 plates.

Drake, Jr., A. A., 1991, The High Point Member (Upper Ordovician) of the Martinsburg Formation in northern New Jersey and southeastern New York, *in* Drake, Jr., A. A., ed., Contributions to New Jersey Geology. U.S. Geological Survey Bulletin 1952, p. B1-B9.

Drake, Jr., A.A. and Monteverde, D.H., 1992, Bedrock geologic map of the Branchville quadrangle, Sussex County, New Jersey. U.S. Geological Survey Geologic Quadrangle Map, GQ-1700.

Drake, Jr., A.A., Volkert. R.A., Monteverde, D.H., Herman, G.C., Houghton, H.H., Parker, R.A., and Dalton, R.F., 1996, Bedrock geologic map of northern New Jersey. U.S. Geological Survey Miscellaneous Geologic Investigations Map I-2540-A.

Epstein, J.B., 1966, Structural control of wind gaps and water gaps and of stream capture in the Stroudsburg area, Pennsylvania and New Jersey, *in* Geological Survey Research, 1966.

U.S. Geological Survey Professional Paper 550-B, p. B80-B86.

Epstein, J.B., 1973, Geologic map of the Stroudsburg quadrangle, Pennsylvania-New Jersey. U.S. Geological Survey Quadrangle Map GQ-1047. Scale, 1:24,000.

Epstein, J.B., 1974, Map showing slate quarries and dumps in the Stroudsburg quadrangle, PA-NJ, with a description of their environmental significance. U.S. Geological Survey Miscellaneous Field Studies Map MF-578.

Epstein, J.B., 1993, Stratigraphy of Silurian rocks in Shawangunk Mountain, southeastern New York, including a historical review of nomenclature. U.S. Geological Survey Bulletin l839L, 40p.

Epstein, J.B. and Epstein, A.G., 1969, Geology of the Valley and Ridge province between Delaware Water Gap and Lehigh Gap, Pennsylvania, *in* Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions. Rutgers University Press, New Brunswick, NJ, p.132-205.

Epstein, J.B. and Epstein, A.G., 1972, The Shawangunk Formation (Upper Ordovician (?) to Middle Silurian) in eastern Pennsylvania. U.S. Geological Survey Professional Paper 744, 45p.

Epstein, J.B. and Lyttle, P.T., 1987, Structure and stratigraphy above, below, and within the Taconic unconformity, southeastern New York, *in* Waines, R.H., ed., Field Trip Guidebook, 59th Annual Meeting, New York State Geological Association, Kingston, NY, p. C1-C78.

Flint, R.F., 1971, Glacial and Quaternary Geology. John Wiley and Sons, Inc., New York, NY, 892 p.

Heroy, W.B., 1974, History of Lake Wawarsing, in Coates, D.R., ed., Glacial Geomorphology: State University of New York at Binghamton, Special Publications in Geomorphology, p. 277-292.

Ingram, George, 1998, Fishing the Delaware Valley. Temple University Press, Philadelphia, PA, 248 p.

Koteff, Carl and Pessl, Jr., Fred, 1981, Systematic ice retreat in New England. U.S. Geological Survey Professional Paper 1179, 20 p.

McBride, E.F., 1962, Flysch and associated beds of the Martinsburg Formation (Ordovician), central Appalachians. Journal of Sedimentary Petrology, v. 32, p. 39-91.

McNett, Jr., C.W. McMillian, B.W., and Marshall, S.B., 1977, The Shawnee-Minisink site, *in* Newman, W.S. and Salwen, Bert, eds., Amerinds and their paleoenvironments in northeastern North America. Annals of the New York Academy of Sciences, v. 288, p. 282-298.

Rich, J.L., 1935, Glacial geology of the Catskills. New York State Museum Bulletin No. 299, 180 p.

Reynolds, R.J., 2007, Hydrogeologic appraisal of the valley-fill aquifer in the Port Jervis trough, Sullivan and Ulster counties, New York. **http://pubs.usgs.gov/sim/2007/2960/sheet3.pdf** (accessed 9/6/2012)

Ridge, J.C., 1983, The surficial geology of the Great Valley section of the Valley and Ridge province in eastern Northampton County, Pennsylvania, and Warren County, New Jersey. Unpublished MS thesis, Lehigh University, Bethlehem, PA, 234 p.

Rutstein, M.S., 1987, Mineralogy of the Ellenville-Accord area, *in* O'Brien, L.E. and Matson, L.R., eds., Field Trip Guidebook for the National Association of Geology Teachers, Eastern Section, Stone Ridge, New York, p. 110-124.

Sims, P.K., and Hotz, P.E., 1951, Zinc-lead deposit at Shawangunk mine, Sullivan County, New York. U.S. Geological Survey Bulletin 978-D, Contributions to Economic Geology, 1951, p. 101-120.

Spinks, W.J., 1967, Stratigraphy and structure of the Paleozoic rocks of northwestern New Jersey. Unpublished PhD dissertation, Rutgers University, New Brunswick, NJ, 311p.

Stewart, Michael, 1991, Archaeology and environment in the upper Delaware, *in* Orr, D.G. and Campana, D.V., eds., The People of Minisink: Papers from the 1989 Delaware Water Gap Symposium. National Park Service, U.S. Department of the Interior, p. 79-115.

Swartz, C.K. and Swartz, F.M., 1931, Early Silurian Formations of southeastern Pennsylvania. Geological Society of America Bulletin, v. 42, p. 621-662.

Ver Straeten, C.A., Monteverde, D.H., and Inners, J.D., 2001, Stop 8. Fairway and US 209 shale pit: Upper Onondaga Limestone, Union Springs Formation, and basal Union Springs décollement, *in* Inners, J.D. and Fleeger, G.M., eds., 2001: A Delaware River odyssey. Guidebook, 66th Annual Field Conference of Pennsylvania Geologists, Shawnee-on-Delaware, PA, p. 232-243.

White, I.C., 1882, The geology of Pike and Monroe Counties. Pennsylvania Geological Survey, 2nd ser., Report G6, 333 p.

Witte, R.W., 1988, The surficial geology and Woodfordian glaciation of a portion of the Kittatinny Valley and the New Jersey Highlands in Sussex County, New Jersey. Unpublished MS thesis, Lehigh University, Bethlehem, PA, 276 p.

Witte, R.W., 1997, Late Wisconsinan glacial history of the upper part of Kittatinny Valley, Sussex and Warren Counties, New Jersey. Northeastern Geology and Environmental Sciences, v. 19, p. 155-169.

Witte, R.W. and Stanford, S.D., 1995, Surficial geology and earth material resources of Warren County, New Jersey: New Jersey Geological Survey Open file Map no. 15c, scale 1:48,000, 3 pl.