QUATERNARY DEPOSITS AND SOILS OF THE CENTRAL SUSQUEHANNA VALLEY OF PENNSYLVANIA

Quaternary Deposits and Soils of the Central Susquehanna Valley of Pennsylvania[1/]

by

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Agronomy Series Number 52
Agronomy Department Pennsylvania State University
University Park, Pennsylvania 16802
May, 1978

[1/] Guidebook prepared for the 41st annual reunion of the Northeast Friends of the Pleistocene held at Lewisburg, Pennsylvania on May 5-7, 1978.

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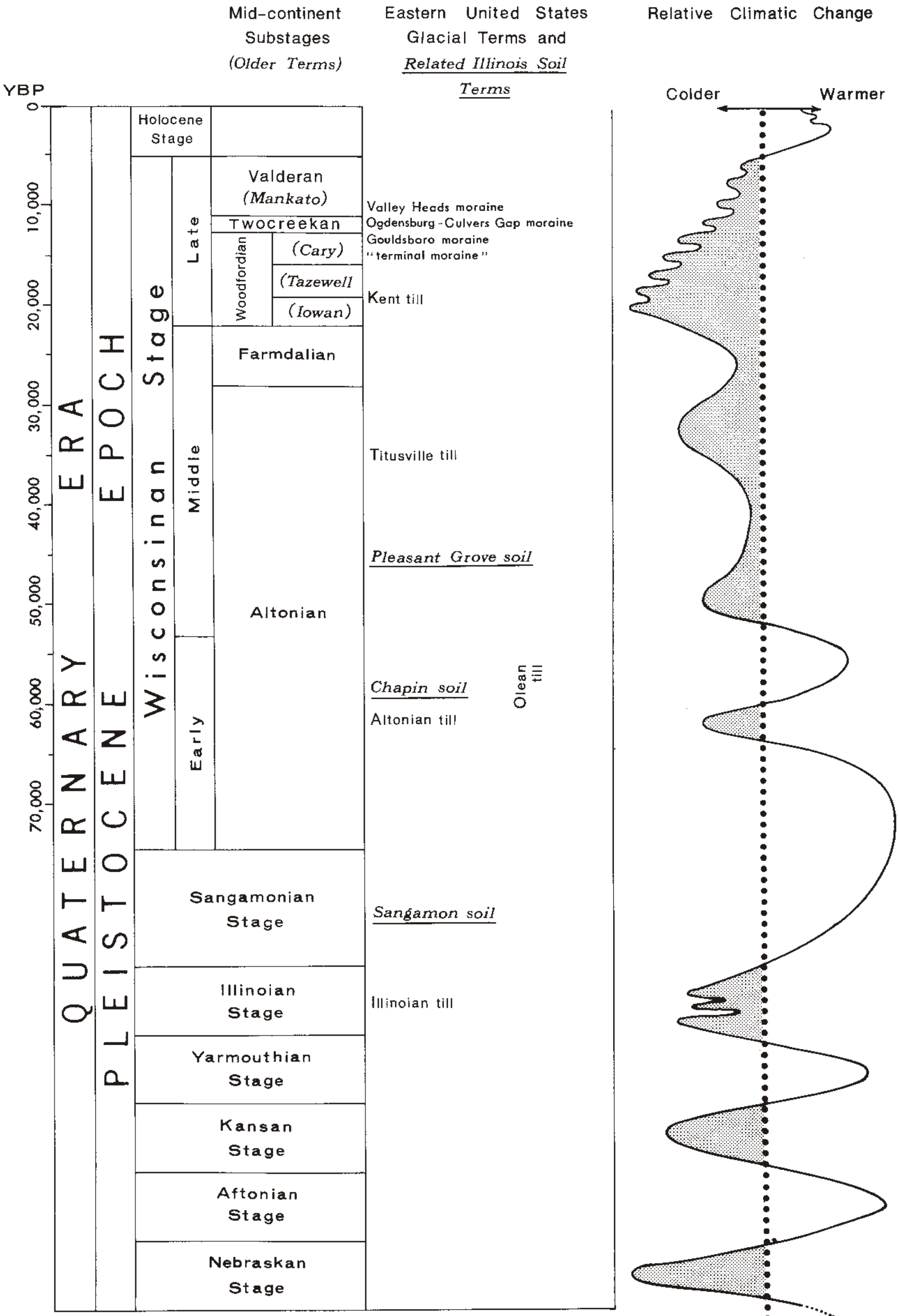

Frontispiece

ACKNOWLEDGMENT

The authors wish to thank Ed Cotter and Dick Nickelsen of Bucknell University who handled virtually all of the trip logistics, including lodging, meals, buses, and meeting facilities, as well as comments in the road log. Thanks are also extended to Bill Sevon of the Pennsylvania Geological Survey, Brian Carter of the Penn State University Agronomy Department, and Jake Eckenrode, Paul Parrish and Cliff Kohler of USDA Soil Conservation Service. These gentlemen provided considerable advice and assistance in the preparation of this field trip. Additional thanks are extended to Bill Sevon for furnishing the Figure that is used in the frontspace of the guidebook.

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* Penn State soil characterization number.

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Quaternary Deposits and Quaternary History

by

Denis E. Marchand

Introduction

The Central Susquehanna Valley lies within the Valley and Ridge physiographic-geologic province of Pennsylvania (Figure 1.1), south of the Appalachian Plateau to the north and west. Ordovician, Silurian, and Devonian sedimentary rocks (Table 1.1) underlying the region have been folded into a complex system of northeastward plunging folds, subsequently eroded to produce ENE-trending ridges and valleys (Figure 1.2). The folds display several orders, from first and second order folds involving the competent sandstones and conglomerates of the Tuscarora, Bald Eagle, Pocono and Pottsville Formation to third and fourth order folds involving less competent shales and limestones. Resistant units such as the Tuscarora, Bald Eagle, Pocono, and Pottsville form the highest ridges. Somewhat resistant thin sandstones, siltstones, and siliceous shales and cherts of the Mifflintown, Bloomsburg, Wills Creek, Oldport, Mahantango, and Catskill Formations form lower, secondary ridges, separated by valley-forming limestones and shales. The strike ridges and valleys are interrupted by the transverse courses of the Susquehanna River and its major tributaries, originally ascribed to superposition from peneplains. Some of the transverse drainage, however, may be attributable to stream piracy along directions of systematic jointing. In central Pennsylvania, at least some of the cross drainage (lower Penns Creek, for example) appears to have resulted from ice blockage during Pre-Wisconsin time. The secondary strike valleys and ridges are also interrupted where thick colluvial or glacial deposits occur. These areas of 'cross topography' are marked in many places by closed depression, poorly drained soils, and, in a few areas, ponds and marshes.

The central Susquehanna region is characterized by a moist, temperate, continental climate (Humid Continental of Strahler; CfA of Koeppen). Mean annual precipitation ranges from about 35-45 inches, evenly distributed throughout the year with a slight summer maximum. No months show soil moisture deficits. Snow depth rarely exceeds 1-2 feet in the valleys. Mean annual temperatures range from about 48-52°F. Soils are frozen to depths of several feet for about 3-5 months of the year. The high ridges experience slightly cooler temperatures and slightly higher precipitation than the valleys, a significantly larger percentage falling in the form of snow. Snow cover is also retained there over a longer period during the winter.

The composition of the original vegetation in the region is not well known. Some of the valleys were probably at least partly open, but most of the region was probably mixed deciduous forest. The present second-growth forest consists predominantly of hardwoods, with pines becoming more evident on high ridgecrest and hemlocks becoming more frequent along streams draining the high ridges. Principal deciduous trees are chestnut oak, maple, and red oak. Elm, beech, white oak, birch, hickory, and poplar are somewhat less abundant but common. Most of the gently rolling topography of the valleys has been under cultivation for more than a century.

The surficial deposits of the central Susquehanna region have never been mapped in detail and have not been systematically studies in nearly 30 years. The soils, however, have been subjected to greater study in recent years (Bilzi and Ciolkosz, 1977; Ciolkosz et al. 1971; Cunningham et al. 1974; Matelski, 1975; Parrish, 1967; Steputis, Zimmerman and Henry, 1966) and many counties are presently remapping their soils (Parrish and Derr, 1971). Early Quaternary geology in the region includes that of Chamberlin (1883), Branner (1886), Bashore (1896), Darton (1914), Hill (1886), Lewis (1884), Stose (1928), White (1883), Williams (1895; 1898; 1902), and Wright (1892). A renewed interest during the 1930s and 1940s in the glacial history of the region is reflected in the studies of Leverett (1934), Mackin (1934, 1936), Lohman (1938, 1939), Crosby (1945), and Peltier (1949). The works by Leverett and Peltier are of particular significance and will be referred to frequently during the field conference. In more recent years, studies along the Wisconsin border and within the Wisconsin drift by Denny (1956a, 1956b), Denny and Lyford (1963), Moss and Ritter (1962) and Aber and Dort (1977) have brought into question some of the earlier hypothesis concerning the number and nature of Wisconsin climatic events in southern New York and northern Pennsylvania. The work of Nelson (1963), Marchand (1973), Sevon (1973, 1974), Sevon et al. (1975), Bucek (1976), and Hoskins and Sevon (1976) clearly show that the Pleistocene history of the area outside the Woodfordian drift border is complex and requires further attention. George Crowl is presently remapping the Wisconsin drift border and has shown that the terminus in Pennsylvania is probably younger than it is in New England (Crowl and Stuckenrath, 1977). Marchand will shortly release new 7 1/2' quadrangle maps and a 1:125,000 compilation map (USGS open-file reports in press) covering

COMMONWEALTH OF PENNSYLVANIA
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Figure 1.1 **PHYSIOGRAPHIC PROVINCES of PENNSYLVANIA**

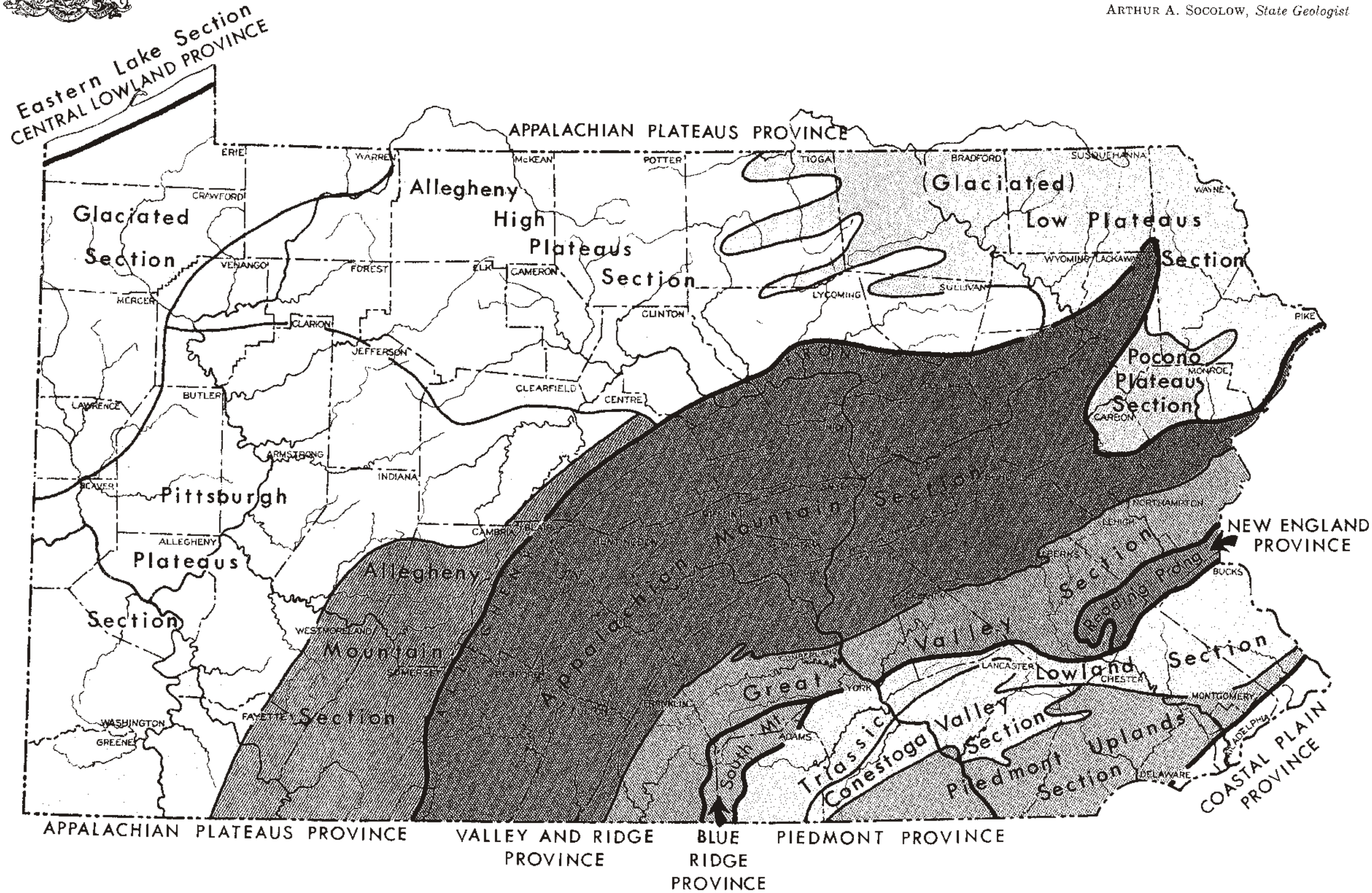
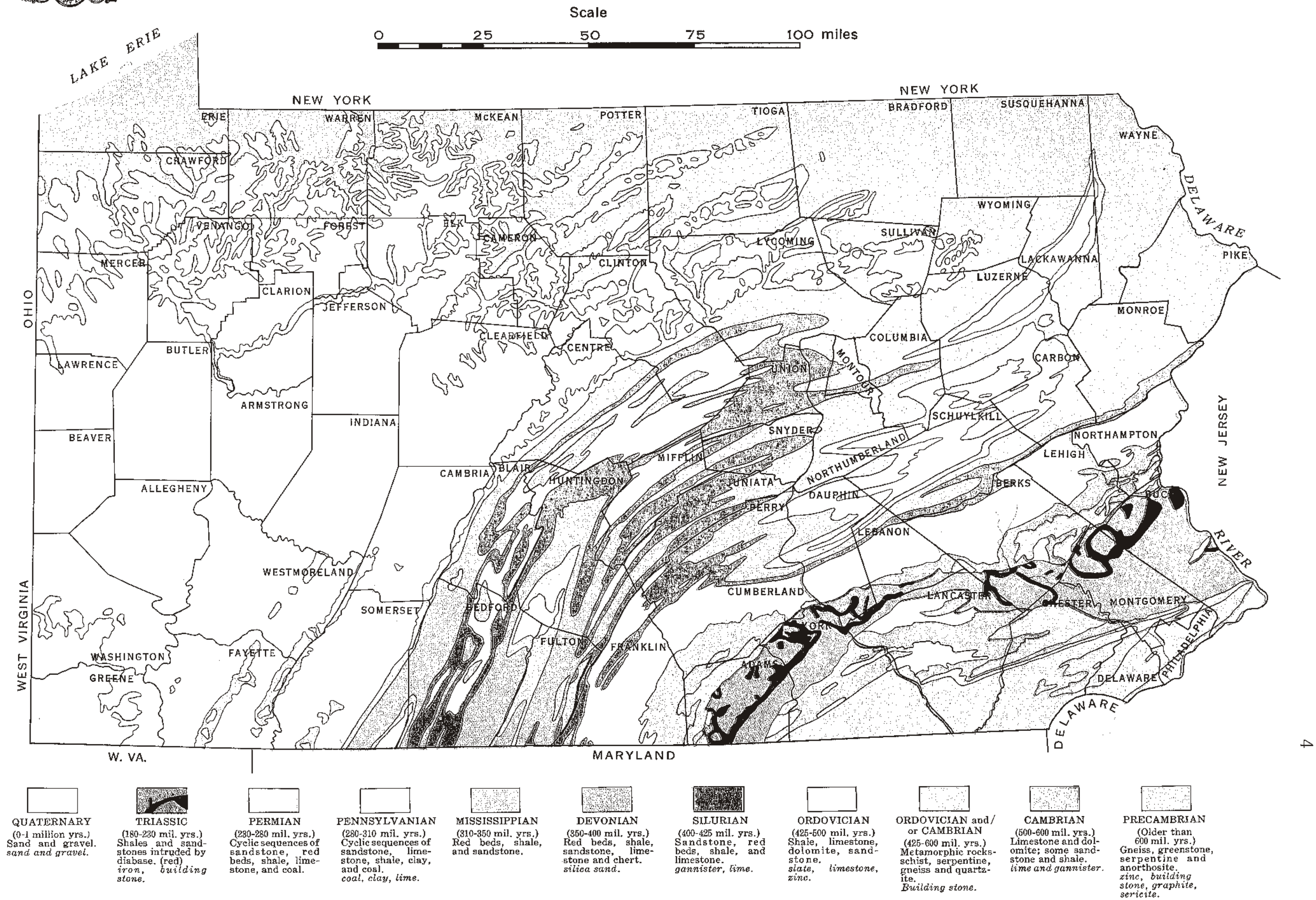


Figure 1.2 GEOLOGIC MAP OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC & GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist



much of the area outside the Woodfordian border. Periglacial deposits and processes outside the Wisconsin border have been studied by Denny (1951), Smith (1948, 1953), Kirby (1965), Rapp (1967), Potter and Moss (1968), Jobling (1969), Troutt (1971) and Clark and Ciolkosz (1975). The purpose of this field conference is to bring to attention some findings of geologists and soil scientists presently working in the central Susquehanna Valley along and outside the Woodfordian border.

Quaternary Deposits

Surficial deposits in central Pennsylvania include glacial till, ice contact stratified drift, outwash, nonglacial alluvium, eolian sand, loess, and colluvium. Designation of till is based on the following criteria: 1) presence of lithologies which could only have been transported to the observed site by ice (as opposed to fluvial or slope transport), 2) presence of semi-rounded, faceted, or polished boulders, 3) presence of a tight matrix of silt and clay; extremely poor sorting. Surficial deposits can be subdivided in this area on the basis of weathering, soil development, degree of erosional dissection and preservation, superposition, and geographical distribution into at least six mappable stratigraphic units which appear to differ significantly in age (Table 1.2: Holocene, Woodfordian, Altonian, White Deer, Laurelton, and Penny Hill). The latter three designations are informal, local terms used by Marchand for deposits outside the Altonian border in the Susquehanna Valley. The six stratigraphic units and their distinguishing characteristics are discussed in order of increasing age below and are summarized in Table 1.2.

Holocene

Deposits of Holocene age include channel, point bar, levee, and floodplain alluvial deposits along the Susquehanna River and its major tributaries. Areas of minor Holocene colluvium in secondary valleys are generally too small or narrow to map. Extensive Holocene erosion on steep slopes is demonstrated by dissection and truncation of Woodfordian deposits, including colluvium. Holocene deposits and erosional surfaces bear very weakly developed soils which in many places lack B horizons but which may show indications of incipient soil development in soils about 2,000 years old (Bilzi and Ciolkosz, 1977).

Woodfordian

Woodfordian deposits include till and ice contact deposits along the glacial border, outwash, loess and eolian sand downstream from the border, and extensive colluvial and alluvial deposits over the entire region. As many as six or seven

Table 1.1 Bedrock Stratigraphic Units of Central Pennsylvania 1/

System and Series		Formation, Members and Thickness in Feet		General Description
Pennsylvanian	M & U	Llewellyn Formation 2000'+		Cycles of conglomerate or sandstone; underclay coal, shale
Pennsylvanian	L & M	Pottsville Formation* 1400'		Cycles of conglomerate or sandstone; underclay coal, shale
Mississippian	M	Mauch Chunk 5000'		Grayish red and gray shale
Mississippian	Lower	Pocono* 1600'	Mount Carbon 940'	Gray to buff, medium grained, cross-bedded sandstone
			Beckville 225'	Gray to buff, medium grained, cross-bedded sandstone
			Spechty Kopf 435'	Gray, fine and medium grained sandstone conglomerate near middle and base
Devonian	Upper	Catskill 7250'	Duncannon 2000'	Asymmetric, upward-fining fluvial cycles, basal nonred, locally conglomeratic sandstone is overlain by grayish red sandstone and siltstones
			Sherman Creek 2400'	Interbedded grayish red claystone and fine grained, cross-bedded sandstone
			Irish Valley 2850'	Interbedded, grayish red and olive gray sandstone, siltstone, shale, overlain upward-fining cyclic deposits of gray sandstone and red siltstone
		Trimmers Rock 2000'		Medium gray siltstone and shale, with fine grained sandstone in upper part; graded bedding common
		Harrell 200'		Olive and medium light gray shale
	Middle	Mahantango 1600'	Sherman Ridge* 600'	Olive gray, fossiliferous, claystone with inter-bedded fine sandstones which coarsen upward
			Montebello 600'	Olive gray, medium grained, locally conglomeratic, fossiliferous sandstone, interbedded with siltstone and claystone in upward-coarsening cycles
			Fisher Ridge* 700'	Laminated gray silty shale
			Dalmatia 300'	Light olive gray sandstone
			Turkey Ridge 100'	Light gray, fine to medium grained sandstone
		Marcellus 106'		Highly fissile, dark gray to black shale; weathers yellowish orange
		Onondaga 165'	Selinsgrove 80'	Medium to dark gray, fossiliferous argillaceous fine grained limestone
	Lower		Needmore 85'	Medium gray, fissile shale
		Old Port* 100'		Dark gray, whitish weathering chert, underlain by shale limestone beds, and locally overlain medium to coarse grained sandstone
		Keyser 200'		Medium gray, fossiliferous, lumpy, fine to coarse grained limestone
Silurian	Upper	Tonoloway 600'		Medium gray, laminated thin-bedded, fine grained limestone
		Wills Creek 700'		Gray calcareous shale with interbedded light gray, calcareous, fine grained sandstone, limestone and red silty claystone
	Middle	Bloomsburg* 500'		Red claystone shale with fine grained, argillaceous, hematitic sandstone at base and near top
		Mifflintown 160'		Dark gray, silty, calcareous shale; bioclastic, f. gr. thin bedded, limestone

Table 1.1 Continued

System and Series		Formation, Members and Thickness in Feet	General Description
Silurian	Middle	Keefer* 40'	Red claystone shale with fine grained, argillaceous, hematitic sandstone at base and near top
		Rose Hill 950'	Light olive gray, shale, calcareous in upper part; grayish red, fine to coarse grained, hematitic sandstone near top
	L	Tuscarora* 600'	Light gray, fine to medium grained quartz sandstone
Ordovician	Upper	Juniata 750'	Grayish red, fine to medium grained, cross-bedded, graywacke sandstone; grayish red siltstone
		Bald Eagle* 730'	Gray, cross bedded, medium to coarse grained sandstone, quartz pebble conglomerate
		Reedsville 900'	Olive gray silty shale, with increasing interbeds of graded gray sandstone in upper part
	Middle	Antes Gap Shale 200'	Very dark gray fissile, carbonaceous shale graptolite trilobite fauna
		Coburn Limestone 275'	Well-bedded, dark gray, fine to medium grained fossiliferous limestone with very dark shale interbeds
		Salona Limestone 175'	Dark gray fine grained limestone, less fossiliferous than Coburn and containing five or more metabentonites
		Nealmont Limestone 70'	Medium gray, coarse grained highly fossiliferous (crinoids, bryozoans) limestone
		"Quarry Limestones" including:	
		Linden Hall 150'	Medium gray, thick bedded, fine grained pure limestone
		Snyder 70'	Light gray, mudcracked, fine to coarse grained, thin bedded commonly fossiliferous and dolomitic limestone
		Hatter 60'	Medium gray, fine grained, thick bedded limestone
		Loysburg 400'	Medium gray, fine grained, 1 footbedded "striped" limestone and dolomite
	Lower	Bellefonte Dolomite 1200'	Yellowish gray, fine grained microcrystalline dolomite
		Axeman Limestone 400'	Gray, slightly fossiliferous, fine grained, limestone with layers of dolomite
		Nittany Dolomite 1200'	Dark gray, cherty, coarsely crystalline dolomite
		Stonehenge Limestone 600'	Gray, well bedded limestone
Cambrian	Upper	Mines Dolomite 250'	Thick bedded, cherty, oolitic dolomite
		Gatesburg Sandstone & Dolomite* 1600'	Dolomitic sandstone or sandy dolomite
		Warrior Limestone 1200'	Thin bedded, gray limestone
	M	Pleasant Hill Limestone 250'	BLUE RIDGE-GREAT VALLEY SEQUENCE Elbrook Limestone
	L	Waynesboro Formation	Waynesboro Formation Tomstown Dolomite Antietam Quartzite*
Eo-Cambrian			Harpers Formation (Montalto Quartzite Member) Weverton Quartzite* London Conglomerate
Pre-Cambrian	U		Catocton Volcanics Swift Run Formation
	L		Gneissic Basement

1/ This data was provided by Dick Nickelsen and Ed Cotter of Bucknell University.

* Ridge Makers

Table 1.2. Quaternary stratigraphic units and their characteristics.

Age	Ice extent, thickness	Landform preservation in subdued terrain	Provenance of clasts	Clast weathering	Depth to fresh parent material
Holocene	None	Excellent	Locally derived	Little or no weathering; limestone present	3-4'
Woodfordian	Least ↑	Good	Plateau sediments	Shales relatively unweathered; limestone partly weathered	4-6'
Altonian	│	Difficult to assess: terrain is usually rugged	Plateau sediments, especially Catskill	No rubefication; shales weathered, limestone strongly weathered	6-8'
White Deer	│	Fair	Mixed Plateau and Valley and Ridge, high proportion of limestone and limey shale	Minor rubefication; shales strongly weathered	Uncertain, >8'
Laurelton	↓	Fair to poor	Mixed; high proportion of resistant sandstone, especially quartzites	Substantial orangish rubefication; sandstone strongly weathered	Uncertain, >12'
Penny Hill	Greatest	None	Similar to Laurelton	Extensive red rubefication; only quartzites not weathered	∿20-30' or more

Table 1.2. continued

Age	Nature of B horizon	B horizon color	Clay films	Clay content of B*	Free iron oxides in B and upper C*
Holocene	No B or thin color B	Variable, largely controlled by parent material	Absent	--	--
Woodfordian	Cambic B	Variable, usually 10YR except on red parent materials; 4 chroma or less	Some clay filling pores	Variable, usually 8-20%	0.5-1.2
Altonian	Thin, distinct argillic B, 1-2' thick	10YR except on red parent materials; chroma about 5	Moderately thick, continuous films in pores on some ped faces, and as coatings on clasts	15-30%	2.9-5.0**
White Deer	Moderately strong argillic B several feet thick	7.5YR, 6 chroma (blonde, yellowish-brown)	Moderately thick, continuous clay films in pores and on some ped surfaces to depths of about 4-5 feet	no data	no data
Laurelton	Strong argillic B about 4-6' thick	5YR-2.5YR 6 chroma (orangish-brown)	Moderately thick, continuous films on all ped surfaces; thin films extend to depths of 6-10 feet	20-46%	2.5-6.3
Penny Hill	Very strong argillic B >6' thick where not eroded	5YR-2.5YR, 7-8 chroma (reddish-brown to red)	Very thick, continuous clay films; discontinuous films extend to depths of more than 10-12 feet	35-50+%	4.8-8.8

*Till soils only.

**Probably high due to presence of iron oxides in parent material (detritus from Catskill Formation) outwash terraces can be recognized in places (Peltier, 1949; Bucek, 1976, Marchand, 1973). For mapping purposes these have been grouped into three groups: low terrace/floodplain, intermediate terrace, and high terrace. On gently sloping surfaces Woodfordian deposits are well preserved and display fresh primary landforms such as kames, kame terraces, and kettle holes. End moraines are difficult to trace over irregular topography.

Woodfordian deposits bear soils with weak color (chroma 4 or less) and textural B horizons and, in imperfectly drained areas, weak to moderately developed fragipans. In till, outwash, and eolian materials these soils lack argillic horizons. Colluvium which may be as young as Woodfordian shows argillic horizon development (Laidig soil series) and stronger fragipans in off-drained soils (Buchanan, Andover). Fresh, unweathered parent material is normally encountered within 4-5 feet of the surface.

Altonian

Deposits mapped as Altonian encompass till, ice contact deposits, outwash, loess, and colluvium. Of these, only the till and ice contact material is extensively exposed, the outwash and loess being severely eroded and the colluvium largely eroded or reworked during Woodfordian time. Altonian ice appears to have extended beyond the Woodfordian border throughout most of central Pennsylvania, pushing lobes down the West Branch of the Susquehanna as far as the New Columbia area north of Lewisburg and down the North Branch to Shamokin Dam and Sunbury.

The post-Altonian soils have weak to moderate argillic horizons 12-24" thick. Depth to fresh parent material is about 6-8 feet. Clay content of the Bt horizon is about 15-30%. Hues strongly reflect the parent material, in many places maroon sandstone and shale from the Catskill Formation along the edge of the Appalachian Plateau give the soil its color. Soil chroma is about 5. The Bt horizon displays continuous clay films in pores and over ped faces which becomes discontinuous with depth. Soil structure is generally fine to medium subangular blocky and peds are much weaker than those of Pre-Wisconsin till soils.

White Deer

Only till and loess deposits have as yet been recognized as belonging to the White Deer drift. Some of the extensive colluvium which mantles ridge slopes beneath Wisconsin colluvium may eventually be assigned to the White Deer upon further study. The White Deer drift is named for extensive deposits in the White Deer Valley north of Allenwood. The drift is well preserved here and extends as a group of remnants down the West Branch valley at least as far as Watsontown and

New Columbia, slightly beyond the Altonian border. A southern ice lobe moving west and south down the valley of the North Branch apparently reached a point a few miles west and north of Selinsgrove. The extent of White Deer ice here was also slightly greater than that of the Altonian. White Deer drift tends to be more continuous than the Laurelton and many kettle holes filled with water or marshes are still well preserved. At several locations in the White Deer Valley, White Deer till is in obvious or apparent superposition over Laurelton and Penny Hill till, separated by well developed buried soils indicative of at least one major interglacial period.

The post-White Deer soil displays a thick argillic horizon with moderately thick, continuous clay films in pores, around clasts, and to some extent on ped surfaces. No cuts deep enough to reveal fresh parent material have yet been found, but the depth exceeds 6-8 feet. Hues are usually 7.5YR and chromas about 6, giving a blonde or yellowish-brown appearance in roadcuts and in plowed fields.

Laurelton

Laurelton drift includes till, ice contact, fluvial, and probably colluvial deposits. Provenance of the drift varies with location, but is always mixed sandstone and shale. Large clasts are commonly quartzitic sandstone, usually from the Tuscarora. Any limestone fragments originally present have been weathered to clay. Laurelton ice extended west of the West Branch of the Susquehanna River nearly to the confining ridges in the White Deer and Buffalo Valleys and to a position just west of Benfer and Troxelville in the valley north of Shade Mountain. Laurelton deposits are named for the terminus immediately west of the town of Laurelton in the western end of the Buffalo Valley (Stop 8, Day 2). They are preserved only in a few locations where there apparently were stillstands of the ice and thick accumulations of drift. Elsewhere behind the Laurelton terminus, only scattered erratics can be found. Considering the sparse occurrence of drift remnants, it is not difficult to understand why Leverett (1934) queried his older drift boundaries and why the existence of ice in the valleys west of the Susquehanna has long been a subject of controversy. The moraine-like remnants which do exist, however, display shallow kettle holes filled by clayey sediments bearing poorly drained soils (Shelmadine, Alvira, Watson soil series). In places water stands in these depressions.

The post-Laurelton soils are significantly redder than the post-White Deer soils (5YR or occasionally 2.5YR, vs 7.5YR) and generally show higher chromas

(6-8 vs 6). The result is a soil which appears orangish brown in roadcuts and in plowed fields where the B horizon has been tilled. Argillic B horizons range up to 4-6 feet thick and display moderately thick, continuous clay films around clasts and continuous, moderately thick coatings over ped surfaces. Soil structure is generally strong, medium angular blocky. Fresh parent material is almost never encountered, even in deep cuts, but oxidized, loose sand or till may be found at depths of 8-10 feet, or shallower where sand underlies till or the soil profile has been eroded. Many shale and sandstone fragments within the soil show orangish rubefication and thick weathering rinds.

Penny Hill

The term Penny Hill, named for exposures in the Route 15 roadcut at Penny Hill north of Allenwood, has been applied to till, ice contact, fluvial, and eolian deposits which commonly lie outside or above the Laurelton drift border or occur as isolated remnants over bedrock where Laurelton or younger drift has apparently been stripped away. Penny Hill till also frequently can be found beneath Wisconsin or older colluvium along valley margins. Outcrops are small and often widely separated. Remnants of what may have been ice terminuses show little evidence of constructional topography. Provenance is generally similar to that of the Laurelton. Penny Hill ice apparently filled the entire White Deer Valley, perhaps up to more than 1000 feet in elevation. It also extended the length of the Buffalo Valley and west along both sides of Shade Mountain as far as Mifflintown and perhaps beyond Lewistown. Along the valley of the Susquehanna it reached a point near McKee Half Falls (Hoskins and Sevon, 1976) where the Pocono Sandstone ridges halted further movement to the south. At the Beavertown Quarry west of Middleburg (Stop 10, Day 2), old, strongly weathered till underlies colluvium bearing a soil similar to the post-Laurelton soil. West of Selinsgrove, a basement exposure showed till having Penny Hill characteristics underlying a till thought to be Laurelton. The Penny Hill drift would therefore appear to be significantly older than the Laurelton and to represent an earlier glacial advance.

The post-Penny Hill soils are generally redder and brighter in color than post-Laurelton soils (chromas of 7 to 8 and hues of 5YR to 2.5YR). Very thick, continuous clay films around clasts and over ped surfaces extend to depths of more than ten feet in relatively uneroded profiles. Soil structure is commonly coarse angular blocky. Fresh parent material occurs at a depth of about 25 feet in a U.S. 220 roadcut east of Montoursville, exposed during highway construction but now obscured by ground cover. Many till fragments show bright red rubefication.

Beyond the Laurelton border are several localities where the till displays characteristics somewhat intermediate between the Laurelton and Penny Hill, as described above. It is presently uncertain as to whether these deposits are of intermediate age between Penny Hill and Laurelton, or whether limey parent materials have kept the soils somewhat yellower and duller in color and lower in clay content than typical Penny Hill till. For mapping purposes, these deposits have been included with the Penny Hill drift.

Quaternary History

The Penny Hill glaciation was the first ice advance into the central Susquehanna Valley for which there is a depositional record. Penny Hill ice advanced down both branches of the Susquehanna, down the main valley to McKee Half Falls, and filled the major east-west-trending valleys as far west as Mifflintown, Lewistown, and the high ridge complex of Jacks, Bald Eagle and Nittany Mountains. Ice thicknesses near Allenwood may have exceeded 700 feet. Accumulations of till between the Penny Hill and Laurelton drift borders may represent Penny Hill recessional positions or positions of ice readvance during a separate glaciation. Penny Hill glacial meltwater may have created the disproportionately wide valley of East Licking Creek, west of Mifflintown, and the wind gap in Bald Eagle Mountain south of Williamsport.

The Penny Hill glaciation was followed by at least one major interglacial period during which a very strongly developed, thick, red soil formed on all stable parts of the landscape, including bedrock surfaces as well as on surficial deposits. The contrasts between post-Penny Hill and post-Laurelton soils and the strong colors and clay content of post-Penny Hill soils exposed beneath White Deer and Laurelton deposits suggest that the Penny Hill/Laurelton interglacial was longer or the soils formed more rapidly than during later interglacial periods. Laurelton ice then reinvaded the Susquehanna Valley, again proceeding down both branches, joining at Sunbury, and extending westward into the Buffalo Valley and the valleys north and south of it. The Laurelton ice lobes, however, were thinner (perhaps no more than 200-300 feet thick along the valley of the West Branch) and extended no further south than Selinsgrove and no further west than the Benfer-Troxelville area. Laurelton ice did, however, fill virtually all of the Buffalo and White Deer Valleys. During Laurelton ice retreat, a number of recessional moraines were deposited, near Port Ann, Penns Creek, Hartleton, and Lewisburg, for example. Some of the transverse course of lower Penns Creek may date from Laurelton ice diversion of meltwater. An anomalous amphitheater-like landform southwest of New Berlin could be an erosional feature produced by debris-laden Laurelton meltwater. During the Laurelton/White Deer interglacial stage, soils again formed across the landscape.

The White Deer represents the latest Pre-Wisconsin ice advance. Its extent and thickness was much less than the Laurelton: White Deer ice barely reached the Buffalo Valley, did not fill the entire White Deer Valley, and probably extended down the North Branch valley only slightly south of the West Branch confluence. Although White Deer ice was not entirely confined to the channelways of the Susquehanna, it was not much thicker than 100-150 feet in the vicinity of Allenwood and Montgomery.

Following the Sangamon interglacial, during which the post-White Deer soil began to form, Altonian ice pushed narrow lobes down both branches of the Susquehanna River, almost but not quite to the White Deer drift border. The Altonian ice sheet in the central Susquehanna area was carrying a high proportion of red Catskill sandstone and shale fragments from the edge of the Appalachian Plateau. Slope colluviation may have been extensive during the Altonian, but preserved records of colluvium demonstrably older than Woodfordian are rare. If the clot of soil in the kame east of Nescopeck (optional Stop 1, Day 1, Berwick area) and a buried soil formed in shale chip colluvium underlying Woodfordian shale chip colluvium in a borrow pit south of Mifflinburg are Altonian in age, a time gap significantly longer than post-Woodfordian time existed between the Altonian and Woodfordian in this area. We have no present evidence of Altonian recessional moraines in the central Susquehanna Valley, so Altonian ice retreat may have proceeded without major stillstands or readvances in the area beyond the Woodfordian terminus.

Woodfordian ice advanced about 15-16,000 carbon-14 years ago (Sevon et al. 1975; Crowl and Stuckenrath, 1977) to a rather irregular border extending diagonally across northern and northeastern Pennsylvania from the Salamanca Reentrant in New York to Berwick and eastward into the Pocono Mountains. During ice retreat, valley train outwash was laid down along the North and West Branches of the Susquehanna and its glaciated tributaries. Multiple outwash terraces indicate seven stages (three major stages) of ice stillstand during retreat, at which times meltwater produced new benches by cut-and-fill or by erosion (strath cuts on pre-existing outwash). Periglacial processes were exceedingly active throughout the entire region and south into Virginia and West Virginia at high elevations (Clark and Ciolkosz, 1975), producing periglacial features such as polygonal and patterned ground, ice wedge casts, and a widespread mantle of colluvium, including the shale chip or grezes litees deposits and block fields like the one on Bald Eagle Mountain along U.S. 15 south of Williamsport. Silt and sand were blown off exposed outwash surfaces and deposited close to the Susquehanna and its major tributaries as eolian sand (common only in the Milton-Montandon area, east of the West Branch) or loess (more widespread, but still restricted to narrow bands along the two branches of the Susquehanna. Wind direction appears to have been predominantly from the west and northwest, except in the Bloomsburg area, where a high pressure cell caused by proximity to the North Branch ice lobe may have produced local easterly winds.

Holocene time in this region has been characterized by relative land stability and incipient soil development in more stable positions on the landscape. Erosion has largely been confined to steep slopes and along river courses. Eolian and colluvial processes do not appear to have been of significance during the Holocene, certainly in no way comparable to their pervasive importance during the Woodfordian. By inference, conditions of relative slope stability, soil formation, and localized erosion probably also existed during previous interglacial times in the central Susquehanna, alternating with glacial intervals of ice advance, meltwater erosion and deposition, and extensive eolian and colluvial activity.

References

Aber, J. S., and Dort, Wakefield, 1977, Stratigraphic evidence for a middle Wisconsin interstade in the Binghamton-Montrose region of New York and Pennsylvania [abs.]: in Northeastern Section, 12th annual meeting, Abstracts Vol. 9, no. 3, p. 233.

Bacon, S. R., Taylor, David, Boileau, Alfred, and Yoder, Gerald, 1946, Soil survey of Union County, Pennsylvania: U. S. Dept. Agric., Bureau of Plant Industry, Soil, and Agric. Eng., ser. 1940, no. 2, 115 p.

Bilzi, A. F., and Ciolkosz, E. J., 1977, Time as a factor in the genesis of four soils developed in recent alluvium in Pennsylvania: Soil Sci. Soc. Am. J. 41:122-127.

Bucek, Melina F., 1976, Pleistocene geology and history of the west branch of Susquehanna River Valley near Williamsport, Pennsylvania: Ph.D. dissertation, Geology Department, The Penn State Univ., 238 p.

Chamberlin, T. C., 1883, Terminal moraine of the second glacial epoch: U. S. Geol. Survey, 3rd Ann. Rept., p. 291-402.

Ciolkosz, E. J., Latshaw, G. J., Cunningham, R. L., and Sevon, W. D., 1971, Parent material, topography, and time as soil forming factors in east-central Pennsylvania: Soil Sci. Soc. Am., Div. S5, Soils Tour Guidebook, 55 p.

Clark, G. M., and Ciolkosz, E. J., 1975, Distribution, characteristics and origin of selected Appalachian sorted patterned ground localities south of the glacial border (Data on file).

Crosby, I. B., 1945, Glacial erosion and the buried Wyoming Valley of Pennsylvania: Geol. Soc. Am. Bull., v. 56, p. 389-400.

Crowl, G. H., 1971, Pleistocene geology and unconsolidated deposits in the Delaware Valley, Matamoras to Shawnee-on-Delaware, Pennsylvania: Pa. Geol. Survey Gen. Geol. Rept. G60, 40 p.

Crowl, G. H., and Stuckenrath, R., Jr., 1977, Geological setting of the Shawnee-Minisink Paleoindian archeological site (36-Mr-43): Annals New York Acad. Sciences, v. 288, p. 218-222.

Cunningham, R. L., Ciolkosz, E. J., Matelski, R. P., Petersen, G. W., and R. Pennock, Jr., 1974, Characteristics, interpretations and uses of Pennsylvania soils developed from colluvium: Penn State Univ. College of Agri., Agricultural Expt. Sta., Progress Rept. 344, 48 p.

Darton, N. H., 1914, Some features of the Quaternary deposits in the Wyoming Valley region (a.): Wyoming (Pa.) Hist.-Geol. Soc. Proc., v. 13, p. 41-64.

Denny C. S., 1951 Pleistocene frost action near the border of the Wisconsin drift in Pennsylvania: Ohio Jour. Sci., v. 51, p. 116-125.

Denny C. S., 1956a, Wisconsin drifts in the Elmira region, New York, and their possible equivalents in New England: Am. Jour. Sci., v. 254, p. 82-95.

Denny C. S., 1956b, Surficial geology and geomorphology of Potter County, Pennsylvania: U. S. Geol. Survey Prof. Paper 288.

Denny, C. S., and Lyford, W. H., 1963, Surficial geology and soils of the Elmira-Williamsport region, New York and Pennsylvania: U. S. Geol. Survey Prof. Paper 379, 60 p.

Higbee, H. W., Footprints of the ice ages in Pennsylvania: colored map, privately published.

Hill, F. A., 1886, Description of the Wyoming buried valley between Pittston and Kingston: Ann. Rept., Geol. Survey Penn. for 1885, p. 637-647.

Hodgson, D. A., 1967, The morphology of an area of patterned ground in central Pennsylvania: Penn. State Univ., M.S. Thesis, 62 p.

Hoskins, D. M., and Sevon, W. D., 1976, New Illinoian till(?) locality and river terraces in the Millersburg area, Susquehanna River Valley, Pennsylvania [abs]: _in_ Northeastern Section, 11th Annual Meeting, Abst. vol. 8, no. 2, p. 200.

Jobling, J. L., 1969, The origin of shale chip deposits in southeastern Centre County, Pennsylvania: Penn. State Univ., M.S. Thesis.

Kirkby, A. V. T., 1965, Boulder fields on Bald Eagle Mountain, Pennsylvania [abs.]: Annals Assoc. Amer. Geogr., v. 55, p. 626.

Leverett, Frank, 1934, Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania: Pa. Geol. Surv., 4th ser., Bull. G-7, 123 p.

Lewis, H. C., 1884, Report on the terminal moraine in Pennsylvania and western New York: Pa. Second Geol. Surv., v. 2, 299 p.

Lohman, S. W., 1938, Ground water in south-central Pennsylvania: Pa. Geol. Survey, ser. 4, Bull. W5, 315 p.

Lohman, S. W., 1939, Ground water in north-central Pennsylvania: Pa. Geol. Survey, ser. 4, Bull. W6, 219 p.

MacClintock, Paul, 1940, Weathering of the Jerseyan till: Geol. Soc. Am. Bull., v. 51, p. 103-116.

MacClintock, Paul, and Apfel, E. T., 1944, Correlation of the drifts of the Salamanca Re-entrant, New York: Geol. Soc. Am. Bull., v. 55, p. 1143-1164.

Mackin, J. H., 1934, Terraces in the Susquehanna Valley below Harrisburg, Pa.: Science, n.s., v. 80, p. 140-141.

Mackin, J. H., 1936, Susquehanna River terraces: Cong. Internat. Geographic Warsaw, 1934, Trav. Sec. II, T. 2, p. 524-528.

Marchand, D. E., 1973, Pleistocene history of the central Susquehanna Valley--a preliminary report [abs.]: in Northeastern Section, Geol. Soc. Am. 7th Annual Meeting, Abstr. v. 5, no. 2, p. 194.

Matelski, R. P., 1975, Soil series of Pennsylvania - catena diagrams: Penn. State Univ., Dept. of Agronomy, Univ. Park, 8th ed., 98 p.

Moss, J. H., and Ritter, D. F., 1962, New evidence regarding the Binghamton substage in the region between the Finger Lakes and Catskills, New York: Am. Jour. Sci., v. 260, p. 81-106.

Nelson, J. G., 1963, Pre-Illinoian glaciation in central Pennsylvania: Canadian Geographer, v. VII (3), p. 145-147.

Nelson, J. G., 1965, Some effects of glaciation on the Susquehanna River valley: Assoc. of Am. Geog. Annals, v. 55, p. 404-448.

Parrish, P. H., 1967, Soil survey of Columbia County, Pennsylvania: U. S. Dept. Agric., Soil Cons. Service, ser. 1967, 139 p.

Parrish, P. H., and Derr, B. D., 1971, Interim soil survey report, Snyder County, Pennsylvania: U. S. Dept. Agric., Soil Cons. Service, v. 1, Soil Interpretations, 133 p.

Peltier, L. C., 1949, Pleistocene terraces of the Susquehanna River, Pennsylvania: Penna. Geol. Surv., 4th ser., Bull. G-23, 158 p.

Pierce, K. L., 1966, Bedrock and surficial geology of the McConnellsburg quadrangle, Pennsylvania: Pa. Geol. Surv. Atlas 109a, 120 p.

Potter, Noel, Jr., and Moss, J. H., 1968, Origin of the Blue Rock block field and adjacent deposits of Berks County, Pennsylvania: Geol. Soc. Am. Bull., v. 79, p. 255-262.

Rapp, A. A., 1967, Pleistocene activity and Holocene stability of hill slopes with examples from Scandinavia and Pennsylvania: Les Congre et collques De L' University de Liege, v. 10, p. 230-244.

Sevon, W. D., 1967, The Bowmanstown boulder field, Carbon County, Pennsylvania: Pa. Acad. Sci., v. 40, p. 90-94.

Sevon, W. D., 1973, "Early" Wisconsinan drift in Lycoming County, Pennsylvania [abs.]: Geol. Soc. Am., Northeastern Sec., 7th Annual Meeting, Abstr. v. 5, no. 2.

Sevon, W. D., 1974, Relative age and sequence of glacial deposits in Carbon and Monroe Counties Pennsylvania [abs]: <u>in</u> Northeastern Section Geol. Soc. Am., 8th Annual Meeting, Abstr. v. 5, p. 71.

Sevon, W. D., G. H. Crowl and T. H. Berg, 1975, The late Wisconsinan drift border in Northeastern Pennsylvania. Guidebook for the 40th Annual Field Conference of Pennsylvania Geologists. Pa. Geol. Survey, Harrisburg, 108 p.

Steputis, W. J., Matticks, R. E., Zimmerman, Robert, and Henry, Robert, 1966, Soil survey of Clinton County, Pennsylvania: U. S. Dept. Agric., Soil Cons. Service, 141 p.

Stevens, E. H., Hendrickson, B. H., Manifold, C. B., Degan, C. G., and Patrick, A. L., 1923, Soil survey of Lycoming County, Pennsylvania: U. S. Dept. Agric., Bur. Chem. and Soils, no. 32, 1043-1093.

Stose, G. W., 1928, High gravels of Susquehanna River above Columbia, Pennsylvania: Geol. Soc. Am. Bull., v. 39, p. 1073-1086.

Taylor, David, Bacon, S. R., and Yearick, L. G., 1955, Soil survey of Montour and Northumberland Counties, Pennsylvania: U. S. Dept. Agric., Soil Cons. Service, ser. 1942, no. 11.

Taylor, F. B., 1925, Moraines of recession between Indiana and New England [abs.]: Geol. Soc. Am. Bull., v. 36, p. 172-173.

Troutt, W. R., 1971, An occurrence of large scale, inactive, sorted patterned ground south of the glacial border in central Pennsylvania: Penn. State Univ., M.S. thesis.

White, I. C., 1883, Report on the geology of Wyoming, Lackawanna, Luzerne, Columbia, Montour, and Northumberland Counties: Pa. Second Geol. Surv., v. G-7, 464 p.

Williams, E. H., 1895, Notes on the southern ice limit in eastern Pennsylvania: Am. Jour. Sci., v. 49, p. 174-185.

Williams, E. H., 1898, Notes on Kansan drift in Pennsylvania: Am. Phil. Soc. Proc., v. 37, no. 157, p. 84-87.

Williams, E. H., 1902, Kansan glaciation and its effects on the river systems of northern Pennsylvania: Wyoming (Pa.) Hist-Geol. Soc. Proc., v. 7, p. 21-28.

Williams, E. H., 1917, Pennsylvania glaciation, first phase: Woodstock, Vt., 101 p.

Wright, G. F., 1892, Extramorainic drift in the Susquehanna, Lehigh, and Delaware Valleys: Proc. Acad. Nat. Sci., Philadelphia.

CHAPTER 2

The Woodfordian Border

by

George H. Crowl

The Woodfordian glacial boundary in Pennsylvania trends N60°W from Belvidere, New Jersey, on the Delaware River to Salamanca, New York. Lobes and indentations are controlled by bedrock topography. Major lobes lie in the Delaware Valley, the Stroudsburg lowland north of Kittatinny Mountain, and the Muncy Creek lowland at Picture Rocks. The principal re-entrants are at Kittatinny Mountain and Camelback Mountain near Stroudsburg, and at Huckleberry Mountain and North Mountain at the margin of the Appalachian Plateau northwest of Benton. Drift deposits are thick and nearly continuous in the east; west from the Lehigh River, drift thins and areas of colluvium and young residual soils become steadily more extensive within the border. This condition apparently reflects the decreasing intensity of glaciation from east to west.

Eight radiocarbon dates from basal organic sediments in lakes and bogs along the border from Delaware River to the New York state line range from 14,200 B.P. to 12,520 B.P. A date of 12,560 B.P. was obtained from a bog in New York 25 miles from the border of the Olean drift on the east side of the Salamanca re-entrant. On the west side of the re-entrant a bog date on Woodfordian drift is 14,000 B.P. On the basis of these dates and youthful soil profiles, I judge the glacial border in eastern Pennsylvania is Woodfordian in age. Ice probably began to retreat from the border about 15,000 years ago.

CHAPTER 3

Glacial History of the West Branch of Susquehanna River Near Williamsport

by

Milena F. Bucek

Glacial history of the West Branch of the Susquehanna river valley in the vicinity of Williamsport is characterized by repeated ice advances that resulted in the deposition of three distinct groups of deposits (Muncy, Warrensville, and Rose Valley Drifts). Each drift includes glacial, proglacial, and ice-contact deposits and is characterized by the presence of tills that differ in color and composition. Soils developed in the drifts differ in degree of weathering and can be used as key markers in mapping the drift. This is especially true in the case of soils developed on the Muncy Drift. These soils are characterized by high chroma red colors and weathering profiles with thickness in excess of 30 feet. The intensity of the soil profile development coincides with the degree to which the drifts were subjected to colluviation and erosion. The Muncy Drift with the thickest weathering profile is the most eroded unit, while the constructional landforms associated with the Rose Valley Drift are only slightly modified by post-glacial erosion. The soils developed on the Rose Valley Drift show weak, shallow weathering profiles.

Table 3.1 shows a stratigraphic succession of glacial and periglacial deposits that has been established for the West Branch of the Susquehanna river valley near Williamsport. The names used for designation of the rock-stratigraphic units were derived from local names to emphasize that these units characterize the conditions prevailing in the study area. Table 3.1 also gives a tentative correlation of these units with the stratigraphic section established for Northwestern Pennsylvania by White et al. (1969).

The Warrensville Drift has been tentatively assigned to the Early Wisconsinan Age. The drift occurs south of the Woodfordian constructional end moraine, forming a thin cover on the uplands of the Plateau and a thick and continuous accumulation in a belt south and along the Plateau escarpment. South of this belt, the drift occurs in isolated erosional remnants of various thickness.

The overall composition of the Warrensville Drift shows that the glacier was rather erosive and it transported material predominantly of local origin. The Warrensville Till has a very high content of lithologies derived from the Pocono, Pottsville, and Catskill Formations. The color of an unoxidized, unweathered till is reddish brown (5YR 5/3 to 5YR 4/3) or weak red (2.5YR 4/2).

Table 3.1 Tentative correlation of rock-stratigraphic units of Northwestern Pennsylvania with those of the West Branch of the Susquehanna river valley near Williamsport.

C-14 years B.P.		Northwestern Pennsylvania Grand River Ice Lobe: Time-stratigraphic units (Frey and Willman, 1960)	Northwestern Pennsylvania Grand River Ice Lobe: Rock-Stratigraphic units (White et al, 1969)	West Branch of Susquehanna river valley, Williamsport area, Ontario Ice Lobe: Rock-stratigraphic units Paleosols	
10,000		HOLOCENE		Alluvium	
20,000	WISCONSINAN	Valderan Twocreekan Woodfordian	Ashtabula Till Hiram Till Lavery Till Kent Till	Rose Valley Till	Eolian silts and sands Fluvial deposits Colluvium
	WISCONSINAN	Farmdalian	Paleosol	Post-Warrensville paleosol	
30,000 40,000	WISCONSINAN	Altonian	Titusville Till	Warrensville Till	
Time scale tentative only		SANGAMONIAN	Thick Paleosol	Post-Muncy poleosol	
		ILLINOIAN	Mapledale Till	Muncy Till	
		YARMOUTHIAN	Thick Paleosol	Thick paleosol on bedrock	
		KANSAN			

The till is not calcareous, it is well compacted, and sandy. Paleofabric measurements of four 50-pebble samples indicate a southwest direction of ice movement during the till deposition. The soils that define the drift upper boundary are moderately well developed. The drift is colluviated and no original constructional landforms were found.

The Warrensville Drift will be seen in the Montoursville quarry (Stop 2). In the quarry a sequence of varved sediments overlain by glaciofluvial sands and gravels is capped with a sheet of Warrensville Till.

The Muncy Drift is believed to be the oldest drift recognized in the study area. It has been tentatively assigned to the Illinoian age. Although the drift generally occurs in thin and patchy erosional remnants, it was also preserved in a thick and relatively continuous fill in the West Branch of Susquehanna river valley between Montoursville and Muncy. Numerous exposures were provided in this fill during construction of Route 220 in 1974-1975. The field trip will be passing through this area when traveling on Route 220 towards Montoursville (cumulative mileage 22.4 to 28.2). Slides of some of the exposures will be shown during the pre-meeting session on May 5.

An exposure of the unweathered Muncy Till was opened at one of the roadcuts approximately 2.3 miles east of Montoursville. The color of the unweathered till is dark greyish brown (10YR 5/2). The deposit is extremely well compacted and calcareous. Paleofabric measurements of two 50-pebble samples taken at this locality show that the ice moved generally to the west. The till, exposed in thickness of about 25 feet, was overlain by about a 30 feet thick sequence of glaciofluvial gravels and lacustrine clays and silts. The weathering profile developed in these deposits was 30 feet thick and characterized by an abrupt and well defined lower boundary. The soil was buried by another diamicton, possibly of glacial origin.

Two sheets of the Muncy Till separated by 15 feet of varved clays and silts and cross-bedded sand and gravels were uncovered in an exposure opened during a bridge construction north of the Trinity Memorial Park. The upper till sheet, 17 feet thick, was intensely weathered throughout its entire thickness with notable changes to high chroma red colors. The lower till sheet was only slightly oxidized.

The occurrence of lacustrine deposits, often found in juxtaposition with till sheets, indicates that the ice transgression into the valley resulted in the formation of a proglacial lake. The existence of such a lake was postulated by Williams (1895) who named it Lake Lesley. The ice moved westward through the valley, against the regional slope and drainage direction. The shape of the lake was adjusted to the topography of the area and was characterized by a relatively narrow body of water extending from the Williamsport area to the west, possibly as far as Milesburg. During the highest lake level, its elevation is believed to have been at 700 feet, and the lake was at least 40 miles long.

The Rose Valley Drift is the youngest of the glacial deposits. It underlies the constructional end moraine shown in Figure 3.1 as the Rose Valley End Moraine. The moraine is believed to mark the terminal position of the Woodfordian ice and it lies approximately 15 miles north of Williamsport.

Thick ice-contact and outwash deposits that fill Wallis Run and Loyalsock Creek valleys were deposited during deglaciation of the Woodfordian ice. Three fluvial ice-contact and one lacustrine ice-contact deglacial morphologic sequences were recognized here. The deglacial morphological sequence refers to a downstream progression of landforms composed of meltwater deposits and deposited in front of and in contact with the retreating ice. The deposition of these units within a sequence is contemporaneous and represents a time interval between two successive recessional positions (Koteff, 1974).

The lacustrine ice-contact and the oldest fluvial ice-contact sequence are associated with the terminal position of the Woodfordian ice. The two younger fluvial ice-contact sequences are correlative with two recessional ice positions northeast of the Rose Valley End Moraine. The glaciofluvial aggradation during each of the recessional stillstands was controlled by the same base level, that of the West Branch of the Susquehanna River. This caused the downstream convergence of the valley train surface (SI,SII, and SIII) of each successive sequence as shown in Figure 3.2. The terrace surfaces eventually merge into one surface of the Rose Valley terrace. The terrace is about 30 to 40 feet above the present river. The depositional gradient of each valley train steepens upstream toward the original ice-contact position where a notable thickening of the drift as well as coarsening of the materials can be observed.

Some of the kames, alluvial fans, and valley train terraces of the deglacial sequence discussed above will be seen when the trip passes through the Loyaslock Creek and Wallis Run valleys on the way to Rose Valley Lake (Stop 1) and again when traveling back to Montoursville.

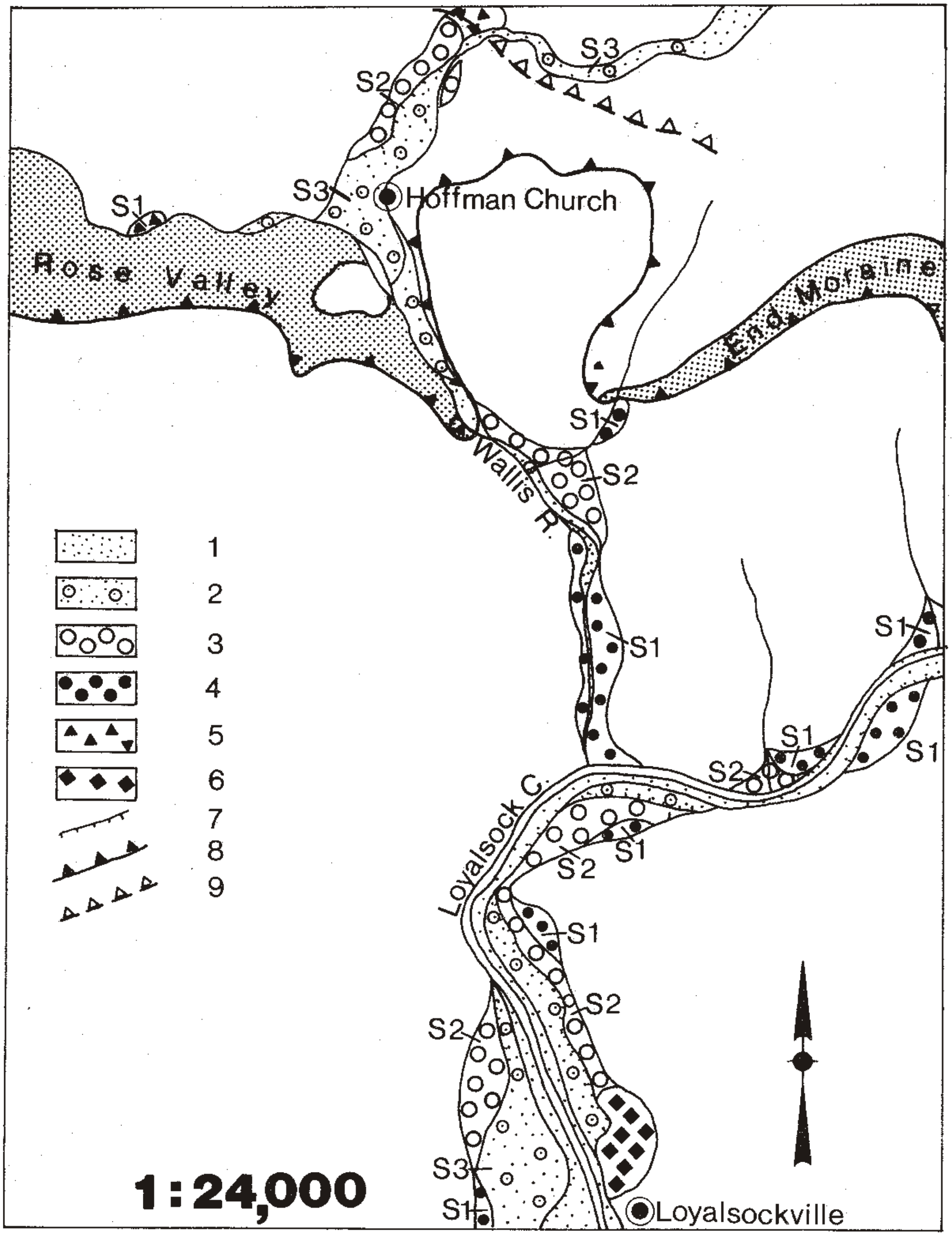


Figure 3.1. Deglacial morphological sequences (S 1,2,3) in Wallis Run and Loyalsock Creek valleys.
Explanations: 1. Post-glacial alluvial silt and sand, 2. outwash gravels - S3, 3. outwash gravels - S2, 4. outwash gravels - S1, 5. ice-contact deposits - S1,2, 6. Muncy Drift, 7. terrace escarpment, 8. ice terminal position, 9. first ice recessional position.

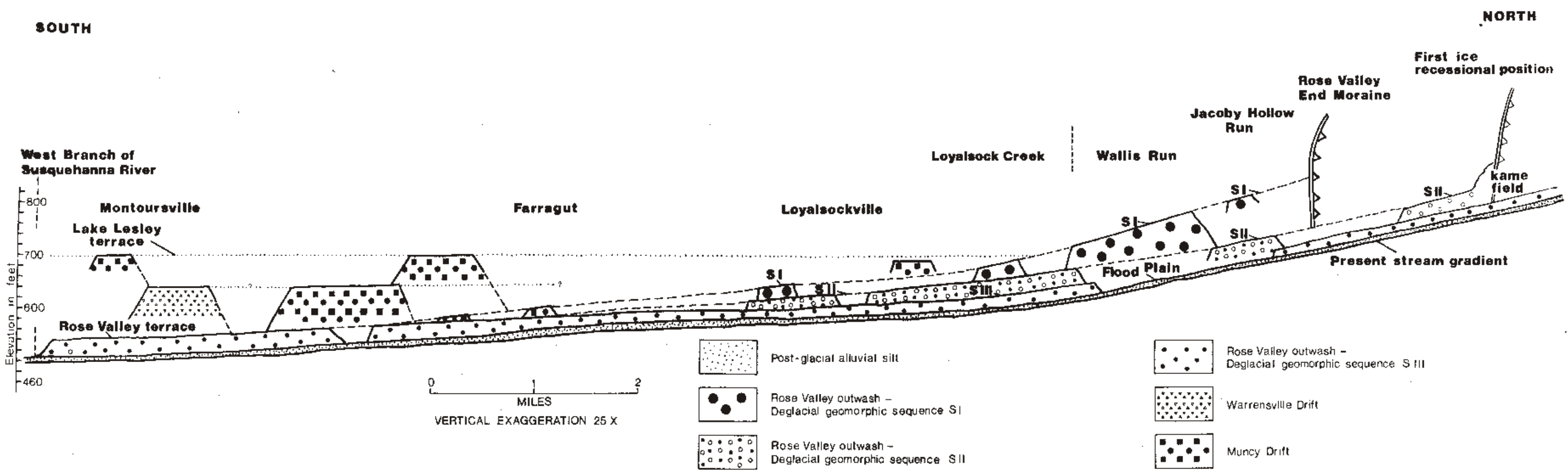


Figure 3.2 Pleistocene terraces of Loyalsock Creek valley.

Literature Cited

Frey, J. C. and H. B. Willman, 1960, Classification of the Wisconsinan Stage in the Lake Michigan Glacial Lobe: Illinois Geol. Surv. Circ. 285, 16 pp.

Koteff, C., 1974, The morphological sequence concept and deglaciation of Southern New England: Glacial Geomorphology, Publications in Geomorphology (Editor - D. Coates) Binghamton, N. Y., p. 121-144.

White, G. W., S. M. Totten and D. L. Gross, 1969, Pleistocene stratigraphy of Northwestern Pennsylvania: Pa. geol. Survey, General Geol. Report G55, 88 pp.

Williams, E. H., 1895, Notes on southern ice limit in Eastern Pennsylvania: Am. Jour. Sci., 3rd ser., v. 47, p. 174-185.

CHAPTER 4

Soils of the Central Susquehanna Valley

by

Edward J. Ciolkosz

The major soils found in the Central Susquehanna Valley are given in Table 4.1. This table arranges these soils according to parent material and the natural soil drainage classes. This is a handy way to think of and discuss soils.

The major soils found on the floodplains of the area are Linden, Barbour and Basher. These soils are classified as Inceptisols (Soil Survey Staff, 1975) which means that they have cambic horizons (color and/or structural B2 horizons). This weak soil development is what one would expect to find in soils on floodplains. The age of the floodplain of the Susquehanna river is not known with any certainty but radiocarbon dates from floodplains of smaller streams in Central Pennsylvania (Bilzi and Ciolkosz 1977, Cunningham et al., 1971) give a range of 200 to 2000 year B.P. for the upper 2 to 4 feet of material. The floodplain of the Susquehanna in this area is complex and has 3 to 4 levels which can be observed in various places and the soils on some of these levels have been sampled for a soil characterization study (Ciolkosz et al., 1978). Although there may be some differences in the soils between levels 2, 3 and 4 all were flooded by Agnes and other floods of comparable size.

The soils of the terraces in this area are even more complex than the soils of the floodplains. As a part of the study of Ciolkosz et al., (1978) soils on various terrace levels near Montgomery and Jersey Shore were sampled. This study indicates that the lowest terrace which was not flooded by Agnes had Wheeling soils on them. These soils are classified as Alfisols which means they have an argillic horizon (B2t) and a moderate to high base status in the lower B2 horizon. The Wheeling profiles characterized had very weak to weak argillic horizon development. This would indicate that they are older than the soils of the floodplains but not that much older. Above the Wheeling level there are numerous terrace levels. At Montgomery 3 levels were sampled above the Wheeling surface. These surfaces were all loess mantled and appear to have Pre-Wisconsinan fluvial or till material below the loess. The loess ranges from 1 to 4 or 5 feet in thickness, and where the loess is thick enough Duncannon soils are mapped. Duncannon soils are classified as Alfisols like the Wheeling soils, but in the Montgomery transect the Duncannon soils showed stronger argillic horizon development than the Wheeling soils. This again may indicate that they are older soils.

As is noted in chapter 5, colluvium mantles all of the slide slopes in the ridge and valley area. The soils developed in this colluvium are primarily Laidig and Buchanan (Figure 4.1). These soils are Fragiudults, which means they have fragipans (Bx or Cx horizons), an argillic horizon (B2t) and low base saturation in the lower B2 and Bx horizons. The central concept of Ultisol soils is a soil very low in base status due to leaching. Many Ultisols in Pennsylvania do not fit this concept because they are "Parent Material Ultisols". They have a low base status because their parent material was very low in base content before soil formation started. This may be the case for Laidig and Buchanan soils.

The soils developed in glacial till are of prime interest in this trip. They are of four or possibly five different ages. The soils developed in Woodfordian age glacial till can be of various colors e.g., red, brown or gray. These colors are primarily inherited and not pedogenic (Ciolkosz et al., 1971). Data from a Bath soil (brownish gray) and Lackawanna soil (red) are given in the Appendix. Additional data for these and associated soils is also available (Cunningham et al., 1972, Ranney et al., 1972). These data indicate that these soils do not have an argillic horizon (Figure 4.2) but that they do have a fragipan (Bx or Cx horizons). Considerable research has been conducted on the genesis of fragipans (Grossman and Carlisle, 1969). Despite this research there is still controversy on the genesis of Fragipans (Ranney et al., 1975). In Pennsylvania certain things can be concluded about fragipans. Firstly they are found primarily in non-calcareous transported parent materials of medium texture (not too coarse and not too fine) but not in recent floodplain deposits. Secondly in a parent material drainage sequence, the fragipan comes progresively closer (Petersen et al., 1970) to the surface from the well drained to the somewhat poorly drained soil. Also the Fragipan seems to increase in development from the well to the somewhat poorly drained soils. And lastly it apparently takes between 2,000-12,000 years to form a fragipan in Pennsylvania (Bilzi and Ciolkosz, 1977).

Soils developed in older glacial till are much less extensive than soils developed in Woodfordian age till. Data from two soils (Leck Kill) that are

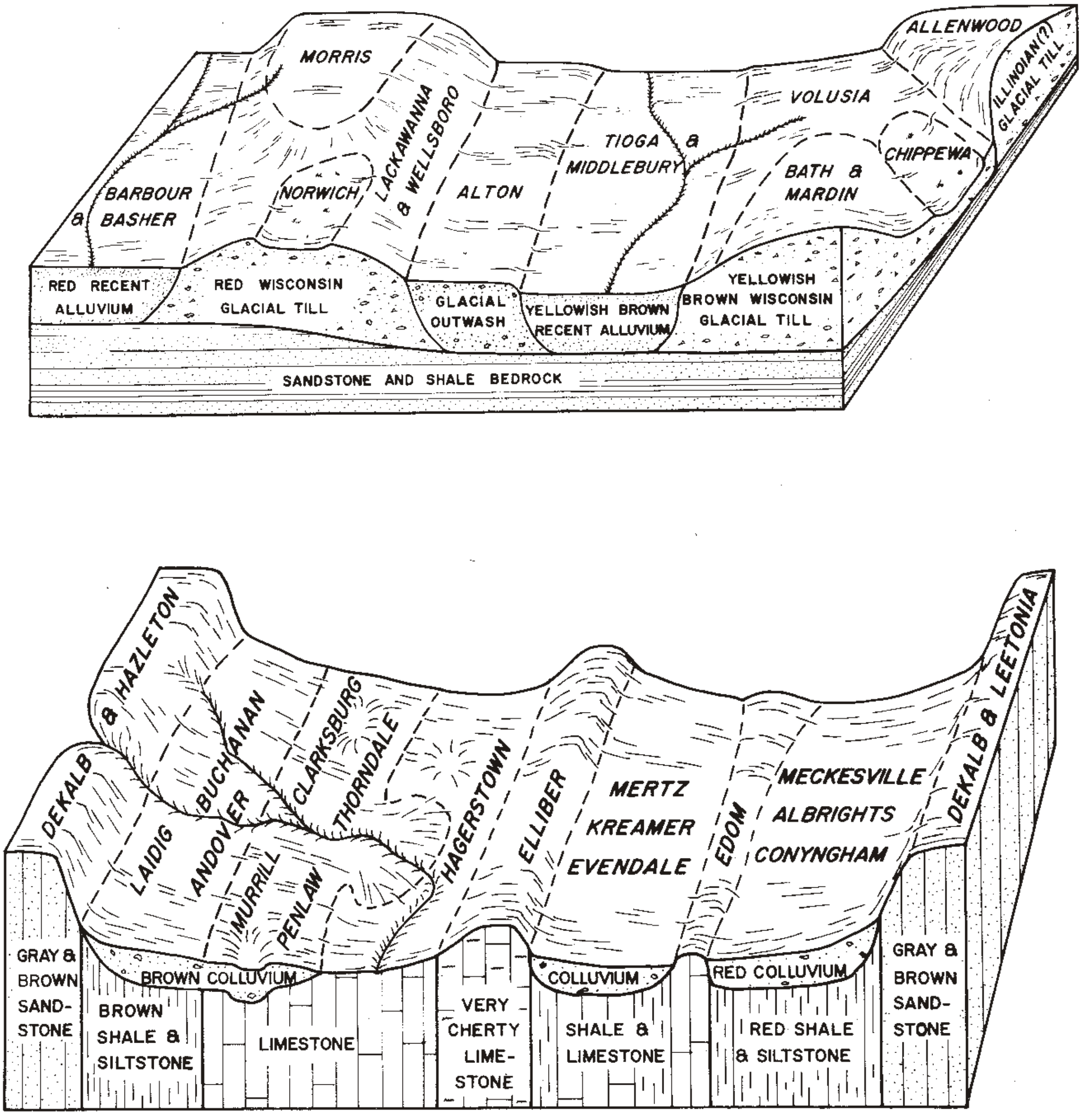


Figure 4.1. Soil-landscape relations of some major soils of northcentral and central Pennsylvania.

Table 4.1 Major Soils of Central Pennsylvania Arranged According to Parent Material and Drainage.*

Parent Material	(Shallow) <20" to bedrock	(Moderately Deep) 20-40" to bedrock	(Deep >40" to consolidated bedrock)				
	Drainage Class and Depth to Mottling						
	Well Drained >40"			Moderately Well Drained (20-40")	Somewhat Poorly Drained (10-20")	Poorly Drained 0-10 "; some gleying	Very Poorly Drained (0-10"; strong gleying)
Residual							
Gray and brown acid shale and siltstone	Weikert Lithic Dystrochrept; loamy-skeletal	Berks Typic Dystrochrept; loamy-skeletal	Bedington Typic Hapludult; fine-loamy	Comly Typic Fragiudalf; fine-loamy --------)		Brinkerton Typic Fragiaqualf; fine-silty	
Gray and brown acid sandstone	Ramsey Lithic Dystrochrept; loamy-skeletal†	Dekalb Typic Dystrochrept; loamy-skeletal	Hazleton Typic Dystrochrept; loamy-skeletal	Cookport Aquic Fragiudult; fine-loamy --------)		Nolo Typic Fragiaquult; fine-loamy	Lickdale Humic Haplaquept; fine-loamy
			Leetonia Entic Haplorthod; sandy-skeletal, siliceous				
Very cherty limestone			Elliber Typic Hapludult; loamy-skeletal				
Relatively pure limestone	Opequon Lithic Hapludalf: clayey		Hagerstown Typic Hapludalf; clayey**	Clarksburg Typic Fragiudalf; fine-loamy	Penlaw Aquic Fragiudalf; fine-silty	Thorndale Typic Fragiaqualf; fine-silty	
Colluvium							
Gray and brown acid sandstone and shale			Laidig Typic Fragiudult; fine-loamy	Buchanan Aquic Fragiudult; fine-loamy --------)		Andover Typic Fragiaquult; fine-loamy	
Very cherty limestone and shale			Mertz Typic Hapludult; loamy-skeletal	Kreamer Aquic Hapludult; clayey	Evendale Aeric Ochraquult; clayey --------)		
Alluvium							
Recent alluvium from acid red shale, siltstone and sandstone uplands; dull red chroma 4 or less on floodplains			Barbour; Linden Fluventic Dystrochrept; coarse-loamy	Basher Fluvaquentic Dystrochrept; coarse-loamy --------)		Holly Typic Fluvaquent; fine-loamy	Papakating Mollic Fluvaquent; fine-silty
Old alluvium on terraces			Wheeling Ultic Hapludalf; fine-loamy	Sciotoville Aquic Fragiudalf; fine-loamy --------)		Ginat Typic Fragiaqualf; fine-loamy	
Eolian							
Wind blown silts (loess) on terraces and uplands			Duncannon Ultic Hapludalf; coarse-silty	Lawrenceville Typic Fragiudalf; fine-silty	Chalfont Aquic Fragiudalf; fine-silty	Doylestown Typic Fragiaqualf; fine-silty	
Wind blown sands			Plainfield Typic Udipsamment				
Glacial Till							
Red acid shale and sandstone till of Woodfordian Age	Arnot Lithic Dystrochrept; loamy-skeletal	Oquaga Typic Dystrochrept; loamy-skeletal	Lackawanna Typic Fragiochrept; coarse-loamy	Wellsboro Typic Fragiochrept; coarse-loamy	Morris Aeric Fragiaquept; coarse-loamy	Norwich Typic Fragiaquept; fine-loamy	Alden Mollic Haplaquept; fine-loamy
Red acid shale, siltstone and fine grain sandstone; dull red chroma 4 or less; Altonian Age			Leck Kill Typic Hapludult; fine-loamy	Albrights Aquic Fragiudalf; fine-loamy --------)		Conyngham Unclassified	
Gray and brown shale and sandstone till (deeply weathered) of Pre-Wisconsinan Age			Allenwood Typic Hapludult; fine-loamy	Watson Typic Fragiudult; fine-loamy	Alvira Aeric Fragiaquult; fine-loamy	Shelmadine Typic Fragiaquult; fine-loamy	
			Washington Ultic Hapludalf; fine-loamy				

* Almost all soils are also mixed, mesic.

** These soils are classified in the fine family but for the purpose of this table clayey will be used.

† In Pennsylvania most pedons are skeletal.

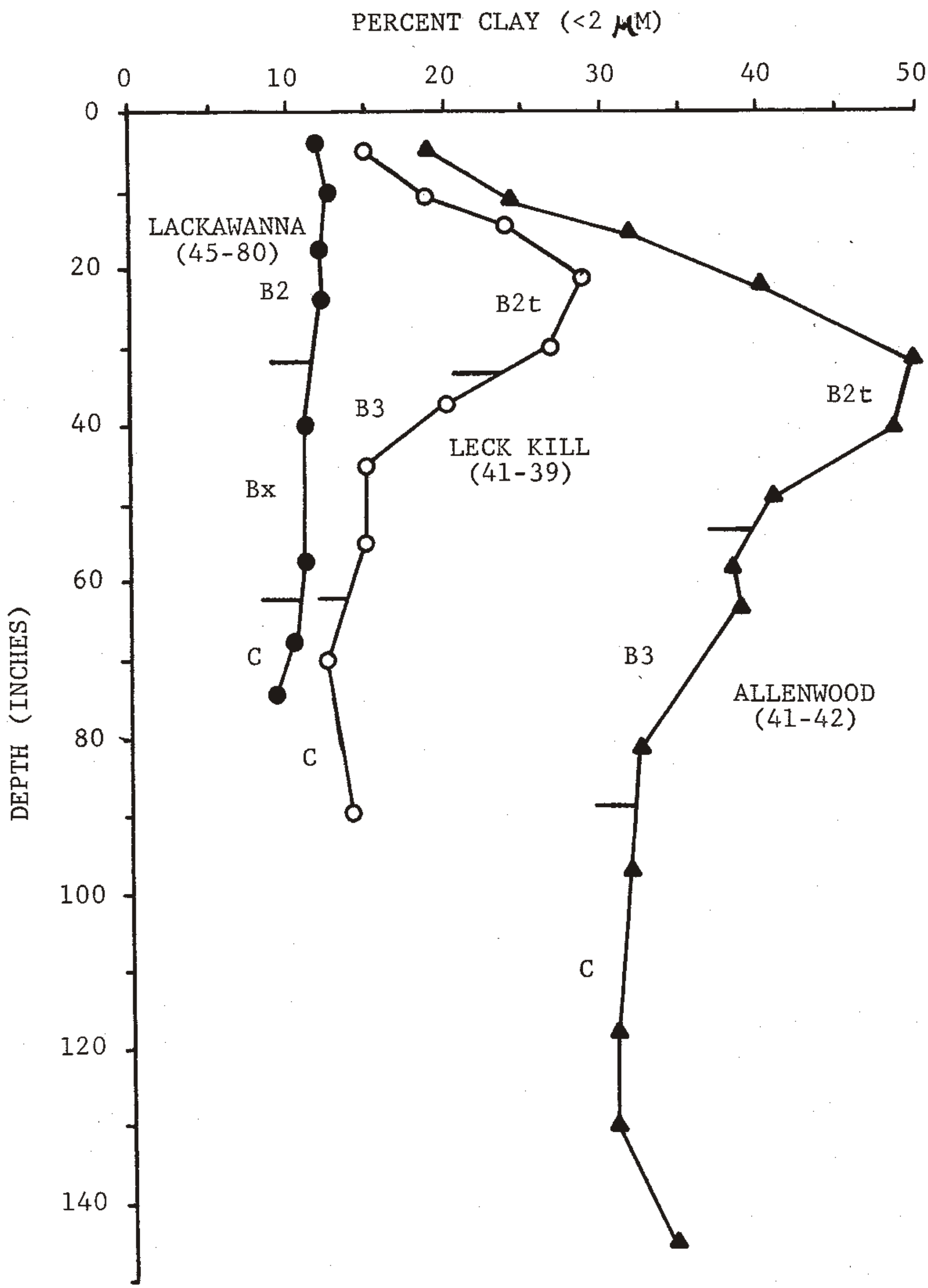


Figure 4.2. Clay content with depth of the Lackawanna, Leck Kill and Allenwood soils.

believed to be Altonian in age are given in the Appendix. These two Leck Kill soils show moderate development in that they show a very slight reddening in the B2 horizon and a moderately well developed argillic horizon (Figure 4.2). The thickness of the A and B horizons (soil solum) as well as the distinctness of the soil horizons also indicates that the Leck Kill is more developed and therefore an older soil than the Lackawanna. The Leck Kill soil does not have a fragipan. This may indicate as some have proposed that as soils get older the fragipan is destroyed by the development of the argillic horizon.

The soils developed in Pre-Wisconsinan till are more complex and the present data does not give a completely clear picture of the age relationships of these soils. In recent soil mapping soils developed in Pre-Wisconsinan fluvial and till deposits have been combined and have been called Allenwood and Washington. In some older reports the soil name Germania was used for the soils developed in Pre-Wisconsinan fluvial deposits.

Allenwood and Washington soils have been sampled in various places in northeastern Pennsylvania. Unfortunately with the exception of two Allenwood profiles (60-8 and 41-42) the sampling was not deep enough. Consequently the lower parts of these profiles were inadequately studied. Some future sampling is being planned to rectify this shortcoming. The data from the Allenwood soils at sites 60-8 and 41-42 (see Appendix for data and descriptions) indicate that these soils show much more development than the Leck Kill soils. The argillic horizons (Figure 4.2) and solums are thicker and the oxidation is more intensive (higher soil chromas) and extensive (deeper in the profile). It appears that there are at least two different age soils developed in Pre-Wisconsinan deposits, but more study is needed to quantify these differences.

Literature Cited

Bilzi, A. F. and E. J. Ciolkosz. 1977. Time as a Factor in the Genesis of Four Soils Developed in Recent Alluvium in Pennsylvania. Soil Sci. Soc. Amer. J. 41:122-127.

Ciolkosz, E. J., G. J. Latshaw, R. L. Cunningham and W. D. Sevon. 1971. Parent Material Topography and Time as Soil Forming Factors in Eastcentral Pennsylvania. Guidebook Div. S5 Soil Sci. Soc. Amer. Soils Tour Aug. 1971. Agronomy Series No. 21, Agronomy Dept., Penn State University, University Park, PA.

Ciolkosz, E. J., R. L. Cunningham, G. W. Petersen and R. Pennock, Jr. 1978. Characteristics, Interpretations and Uses of Pennsylvania Soils Developed on Floodplains and Terraces of the Susquehanna River. Pa. Agr. Exp. Sta. Prog. Report. (In preparation).

Cunningham, R. L., E. J. Ciolkosz, R. P. Matelski, G. W. Petersen and R. W. Ranney. 1971. Characteristics, Interpretations and Uses of Pennsylvania Soils: Armstrong County. Pa. Agr. Exp. Sta. Prog. Rep. 316.

Cunningham, R. L., G. W. Petersen, R. P. Matelski, R. W. Ranney and E. J. Ciolkosz. 1972. Laboratory Characterization Data and Field Descriptions of Selected Pennsylvania Soils. Pennsylvania State University, Agronomy Dept. Series No. 25. University Park, PA.

Grossman, R. B. and F. J. Carlisle. 1969. Fragipan soils of the eastern United States. Advan. Agron. 21:237-279.

Petersen, G. W., R. W. Ranney, R. L. Cunningham and R. P. Matelski. 1970. Fragipans in Pennsylvania Soils: A Statistical Study of Laboratory Data. Soil Sci. Soc. Amer. Proc. 34:311-722.

Ranney, R. W., G. W. Petersen, R. P. Matelski, R. L. Cunningham and E. J. Ciolkosz. 1972. Characteristics, Interpretations and Uses of Pennsylvania Soils: Bradford County. Pa. Agr. Exp. Sta. Prog. Rep. 320.

Ranney, R. W., E. J. Ciolkosz, R. L. Cunningham, G. W. Petersen, and R. P. Matelski. 1975. Fragipans in Pennsylvania Soils: Properties of Bleached Prism Face Material. Soil Sci. Soc. Amer. Proc. 39:695-698.

Soil Survey Staff. 1975. Soil Taxonomy. USDA Agriculture Handbook No. 436. U. S. Government Printing Office, Washington,D. C.

CHAPTER 5

Periglacial Features of Pennsylvania

by

Edward J. Ciolkosz

The objective of this presentation is not to present an extensive paper on periglacial features in Pennsylvania. Such a paper is being prepared and thus only a few highlights will be presented.

Periglacial as used by Washburn (1973) includes features caused by cold environments both associated with and without permafrost. These features include patterned ground (stone nets and stone stripes), involutions, ice wedge casts, grezes litees, boulder fields, and geliflu ction deposits. Washburn prefers the term geliflu ction to solifluction because he states that gelifluction is "unequivocally periglacial". The environments and the processes of formation of periglacial features are reviewed elsewhere (Washburn, 1973; Washburn, 1976; and Carson and Kirby, 1972) and will not be discussed here.

The occurrence of periglacial features in Pennsylvania has been noted by many investigators. The map presented below (Figure 5.1) is a preliminary summary of the published and unpublished occurrences of these features. This map indicates that these features extend to the southern border of Pennsylvania which is 100 miles south of the ice margins of the Wisconsinan and Pre-Wisconsinan ice advances. This indicates the presence of a wide belt of periglacial environment adjacent to the continental ice.

One of the periglacial features that is seldom mentioned in Pennsylvania is the gelifluction or solifluction deposits. These colluvial deposits are probably the most important of the various types of periglacial features in Pennsylvania. The reason they are the most important is that they are the most extensive of the periglacial features in area coverage. All of the major ridges in the Ridge and Valley area have the lower one-half to three-fourth of their slopes mantled with colluvium. The colluvium ranges from less than one foot to more than 100 feet in the thickness, and it forms simple side slope as well as more complex fan deposits. The simple slope deposits extend on the average one-half mile from the ridge crests while the fan deposits commonly extend one-quarter to one-half mile beyond the simple slope deposits. The soils in these deposits show moderate development and have argillic horizons and fragipans. A more complete discussion of the genesis of these soils is presented elsewhere (Ciolkosz et al., 1971; Ciolkosz et al., 1978).

The occurrence of colluvium is not restricted to the Ridge and Valley area; it is also extensive in the Appalachian Plateau area. The data in Table 5.1 indicates that in the Ridge and Valley area a typical county has

Table 5.1 Percentage of Colluvial, Fluvial (Floodplain and Terrace) and Residual Soils in Four Counties in Pennsylvania.*

Physiographic Area and County	Colluvial	Fluvial	Residual
Ridge and Valley			
Fulton	27.2	6.2	66.6
Huntingdon	27.3	6.4	66.3
Plateau			
Fayette	14.3	4.6	81.1
Westmoreland	12.5	8.5	79.0

*Data from Churchill (1969), Kopas (1973), Merkel, and Taylor et al.,(1973).

about 27% of its area covered by colluvium while on the Plateau colluvium occupies an area of about 13% of a typical county. These data indicate the extensive nature of this material in Pennsylvania.

The chronology of deposition of the colluvium is difficult to ascertain. To the author's knowledge there are no radiocarbon dates available to date the colluvium. The colluvium seems to be of a similar age in that soils developed in the same kind (same lithology) of colluvium throughout the state have similar soil development. The soils developed in the colluvium are similar in some respects to Woodfordian age soils developed in glacial till in that they have fragipans, but in addition to fragipans they have argillic horizons. This may indicate that they are older than late Woodfordian, possibly middle or early Woodfordian or even Altonian in age. A speculative chronology might start with the early Woodfordian or possibly Altonian and as the ice moved forward a periglacial climate with tundra vegetation (H. E. Wright, personal communication) triggered solifluction movement down slope. As the climate warmed and the ice retreated soil formation progressed on the stabilized slopes. Because the colluvial material was derived from weathered material and was not fresh rock material the soils in the colluvium may have developed an argillic horizon more rapidly. Another possibility is that the bulk of the solifluction took place in the early Woodfordian and soil formation progressed through most of Woodfordian time. This may also explain the differences noted between soils developed in colluvium and glacial till of similar lithology. Some additional

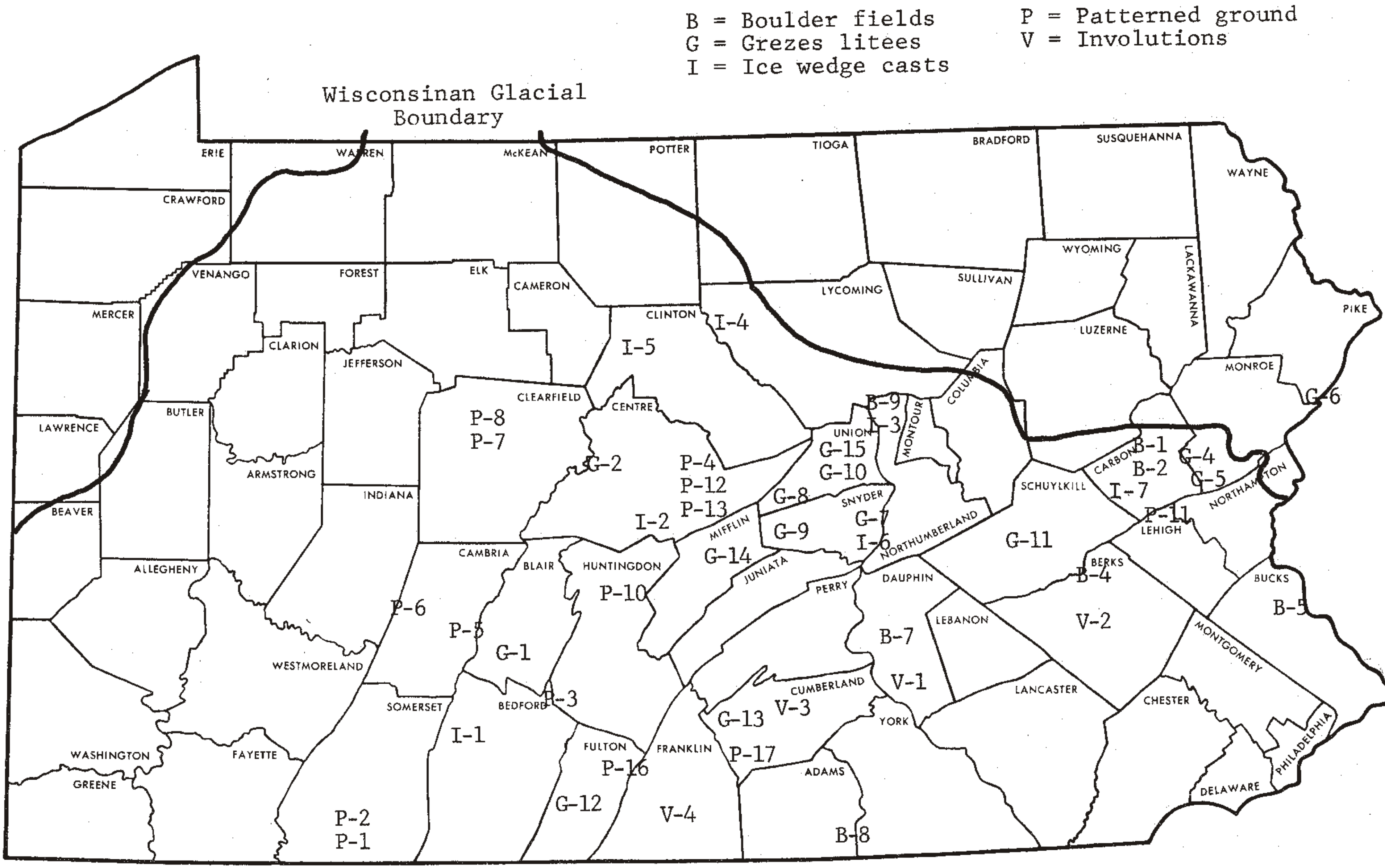


Figure 5.1 Preliminary location map of periglacial features in Pennsylvania (colluvium is found throughout the unglaciated area).

detailed soils work may shed some light on this interesting problem.

One last item. The colluvial slopes today appear to be stable unless the toe of the slope is undercut. The material on these slopes does not appear to be moving down slope. Little if any deformation of trees is noted and the argillic horizons and fragipans in these soils seems to indicate landscape stability. This condition may well be a "super stable" condition. Under periglacial conditions the angle of repose of this material was lower than under today's conditions. This would indicate that the present slopes are less than the angle of repose of this material under present conditions making these slopes "super stable" to natural downslope movement.

Literature Cited

Carson, M. A. and M. J. Kirkby. 1972. Hillslope Form and Process. Cambridge University Press. London.

Ciolkosz, E. J., G. J. Latshaw, R. L. Cunningham and W. D. Sevon, 1971. Parent Material, Topography, and Time as Soil Forming Factors in Eastcentral Pennsylvania. Guidebook Division S5 Soil Science Society of America Soils Tour August 1971. Agronomy Series No. 21. Agronomy Dept., Penn State University, University Park, PA.

Ciolkosz, E. J., G. W. Petersen, R. L. Cunningham and R. P. Matelski. 1978. Soils Developed from Colluvium in the Ridge and Valley Area of Pennsylvania. Proceedings of 1973 International Geobotany Conference. Univ. Tennessee Press (In Press).

Churchill, N. J. 1969. Soil Survey of Fulton County Pennsylvania. USDA-SCS. U. S. Government Printing Office, Washington, D. C.

Kopas, F. A. 1973. Soil Survey of Fayette County, Pennsylvania. USDA-SCS. U. S. Government Printing Office, Washington, D. C.

Markel, E. J. Soil Survey of Huntingdon County, Pennsylvania. USDA-SCS. U. S. Government Printing Office, Washington, D. C. (In Press).

Taylor, D. C. et al. 1965. Soil Survey of Westmoreland County, Pennsylvania. USDA-SCS. U. S. Government Printing Office, Washington, D. C.

Washburn, A. L. 1973. Periglacial Processes and Environments. St. Martins Press. New York.

Washburn, A. L. 1976. Periglacial Indicators of Permafrost (a six paper symposium). Quaternary Res. 6:1-124.

CHAPTER 6

The Agnes Flood

by
Edward J. Ciolkosz

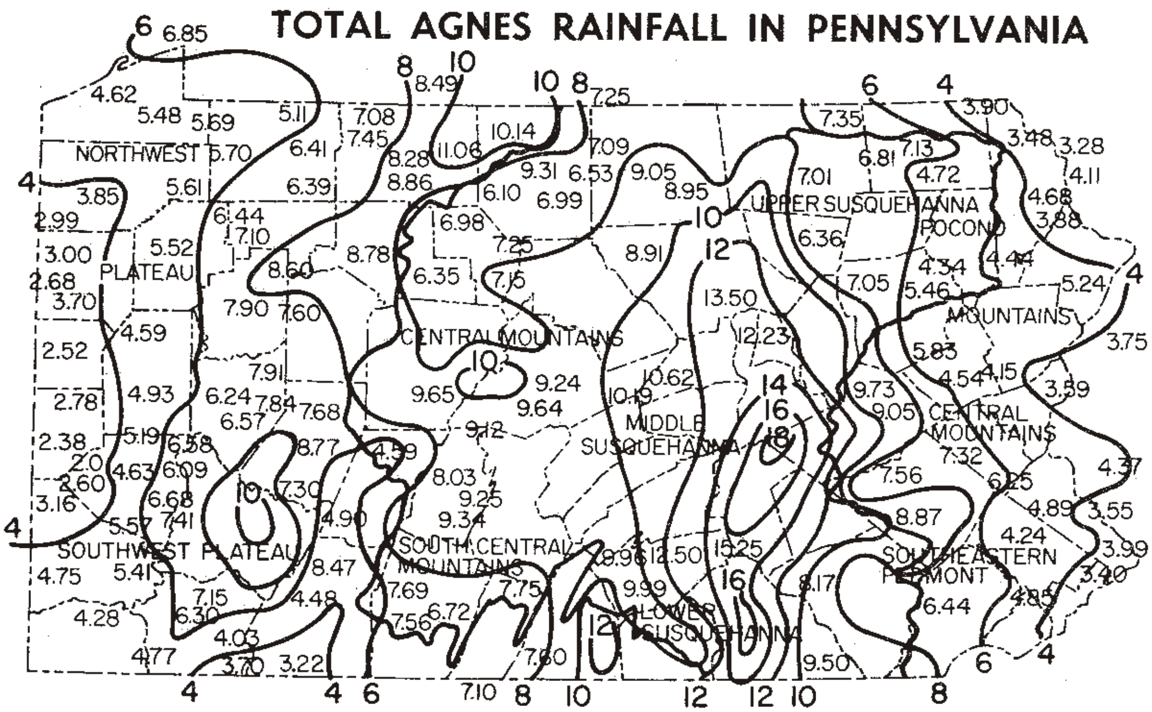
The following is from the abstract of Bailey et al. 1975:

"Hurricane Agnes originated in the Caribbean Sea region in mid-June. Circulation barely reached hurricane intensity for a brief period in the Gulf of Mexico. The storm crossed the Florida Panhandle coastline on June 19, 1972, and followed an unusually extended overland trajectory combining with an extra-tropical system to bring very heavy rain from the Carolinas northward to New York. This torrential rain followed the abnormally wet May weather in the Middle Atlantic States and set the stage for the subsequent major flooding.

The record-breaking floods occurred in the Middle Atlantic States in late June and early July 1972. Many streams in the affected area experienced peak discharges several times the previous maxima of record. Estimated recurrence intervals of peak flows at many gaging stations on major rivers and their tributaries exceeded 100 years. The suspended-sediment concentration and load of most flooded streams were also unusually high. The widespread flooding from this storm caused Agnes to be called the most destructive hurricane in United States history, claiming 117 lives and causing damage estimated at $3.1 billion in 12 States. Damage was particularly high in New York, Pennsylvania, Maryland, and Virginia."

The following figure and tables provide additional information on the Agnes Flood.

Figure 6.1



This map shows rainfall in inches for Pennsylvania from June 20 through June 25, 1972. The period measured begins with the evening of the 20th or the morning of the 21st and ends with the evening of the 25th or the morning of the 26th.

Table 6.1
U.S. deaths and damage attributed to Agnes (De Angelis, 1972; See Bailey et al., 1975)

State	Damage	Deaths
Pennsylvania*	$2,119,269,000	48
New York	702,502,000	24
New Jersey	15,000,000	1
Maryland	110,186,000	19
Ohio	6,818,000	0
Delaware	Light	1
West Virginia	7,753,000	0
Virginia	125,987,000	13
North Carolina	6,558,380	2
South Carolina	50,000	0
Georgia	205,000	0
Florida	8,243,000	9
Total	$3,102,571,380	117

*68,000 homes and 3,000 businesses were destroyed

Table 6.2
The 10 most destructive tropical cyclones in the United States since 1930 (De Angelis, 1972; See Bailey et al., 1975)

Storm	Year	Damage (millions of dollars)	Deaths
Agnes	1972	$3,102.6	117
Camille	1969	1,420.7	258
Betsy	1965	1,420.5	75
Diane	1955	831.7	184
Carol	1954	461.0	60
Celia	1970	453.8	11
Carla	1961	408.3	46
New England Hurricane	1938	387.1	600
Donna	1960	386.5	50
Hazel	1954	251.6	95

Table 6.3. Flood levels at Williamsport*

March 17, 1865	30 ft.	May 28, 1946	30.1 ft.
June 1, 1889	32.4 ft.	June 22, 1972	34.7 ft.
May 1894	30 ft.	Sept. 26, 1975	27.9 ft.
March 18, 1936	33.9 ft.		

*Information from the USDA-SCS Williamsport. Flood stage is 20.0 feet at Williamsport. Prior to 1972 only floods of 30 feet or more are listed.

Literature Cited and References

Bailey, J. F., J. L. Patterson, and J. L. H. Paulhus. 1975. Hurricane Agnes Rainfall and Floods, June-July 1972. USGS Prof. Paper 924.

Shank, W. H. 1972. Great Floods of Pennsylvania (1972 Flood Edition). Buchart-Horn Inc. York, PA.

Miller, R. A. 1974. Hydrologic Data of the June 1972 Flood in Pennsylvania. Pa. Dept. Environ. Resour. Water Resour. Bull. 9. Harrisburg, PA

Road Log for First Day - Saturday May 6, 1978

Mileage Cumu-lative	Incre-ment	
0.0	0.0	Intersection of US 15 and PA 45 in Lewisburg. This intersection was under 3 feet of water during the June 1972 Agnes flood; it lies on the low terrace/floodplain surface of Limestone Run (Bull Run). Most of Lewisburg, however, is situated on the intermediate terrace at the confluence of Buffalo Creek and the West Branch of the Susquehanna River and it was above the flood level (See chapter 6 for more information on the Agnes flood). Proceed east on PA 45.
0.2	0.2	Market St. (PA 45) crosses Bull Run at 6th St. During Agnes this intersection was a roaring torrent as Bull Run dropped from a higher level north of Market St. to a lower level to the south. Two lives were lost in this torrent as a rescue boat capsized. Water in this area was about 9 feet deep.
0.6	0.4	Major downtown area of Lewisburg that was an isolated island during the Agnes flood.
0.7	0.1	Cross the West Branch of the Susquehanna River. The Agnes flood water was at about the deck level of the bridge.
1.0	0.3	Cross the broad floodplain east of the Susquehanna River. This area was seriously inundated during the Agnes flood. The soils of the floodplain are Linden and Barbour. Beneath the capping of the overbank deposits are coarse Pleistocene outwash gravels.
1.8	0.8	Start of Pleistocene dune field showing numerous undrained depressions. Just ahead is a railroad crossing. The age of the dune field is probably late Woodfordian or Holocene.
2.2	0.1	Turn left on LR (Legislative Route) 49053 at the flashing yellow light. The approximate limit of Agnes flood was 0.1 mile farther east on US 45.
2.5	0.3	Better view of dune topography in farm fields adjacent to road.
2.8	0.3	Bus pauses for view of dunes. The dune material varies from 0 to 12 feet deep with some deeper accumulations locally, and an average depth of about 5 feet. There are about 1650 acres of this material in this area, and a few hundred additional acres in other places along the river. The wind direction was from the northwest and the sand was blown off of the stream deposits along the Susquehanna river (see Chase, C. M. 1977. Central Pennsylvania Sand Dunes. Pennsylvania Geology Vol. 8#3:9-12). The Plainfield soils are found developed in these deposits. These soils are weakly developed with an A and a color or structural B2 horizon (See pedon description and data in the Appendix). The Plainfield soil is mapped only in this area in Pennsylvania.

3.0	0.2	Turn right at secondary road.
3.3	0.3	At the edge of the woods is the approximate east edge of dune field, Note the beginning of poor drainage and a change in land use. Holly soils are found in this area.
3.8	0.5	Stop sign. Turn right onto LR 49118.
3.9	0.1	Left turn onto PA 147 and proceed north through upland area.
5.5	1.6	Siluro-Devonian Tonoloway and Keyser Limestones at the intersection with PA 642, Opequon and Hagerstown soils, continue on PA 147.
6.0	0.5	Asymmetric minor anticline in Wills Creek Shale (Silurian) on left side (west). Edom soils.
6.4	0.4	Cross PA 254.
6.8	0.4	Bloomsburg Formation, red shale and sandstone of Silurian age, dipping south on left side of road. This begins a sequence of low, hummocky outcrops in this formation for the next 3 miles. This topography results from a series of small folds, Klinesville and Calvin soils.
8.4	1.6	Interstate Route 80 underpass.

Optional Side Trip to Berwick

0.0	0.0	New mileage on I 80 onramp. Note the clean topography between here and the Buckhorn exit (next 20 miles), almost entirely free of surficial deposits other than alluvium of small streams and thin colluvium. This area lies beyond the Woodfordian, Altonian, and White Deer ice margins, but behind the Laurelton and Penny Hill drift boundaries.
3.3	3.3	Exit 32
5.6	2.3	Cross Chillisquaque Creek
5.8	0.2	Road cuts in black Devonian shales
7.0	1.2	Rest Area
9.4	2.4	Note Montour Ridge to south, first high ridge of Valley and Ridge Province in this area. Anticlinal ridge cored by Tuscarora sandstone (lower Silurian).
13.1	3.7	Exit 33, Danville. Note water gap to south (right).
15.7	2.6	I 80 now passes between relatively flat-lying rocks of the plateau to the north and Montour Ridge to south.

21.5	5.8	Buckhorn Exit. Laurelton or Penny Hill drift is fairly abundant in this area, visible in cuts on left (north) side over shale, just past the exit. This area has not yet been mapped in detail.
22.4	0.9	Cross Fishing Creek. Note low terrace/floodplain, which grades to the corresponding surface on the North Branch at Bloomsburg. Intermediate and high-level Woodfordian can also be traced down from the glacial border, a few miles to the north.
24.3	1.9	Quarry on right (south) in Woodfordian sandy outwash and loess associated with intermediate level terrace on Fishing Creek.
24.9	0.6	Roadcut gully exposes strongly oxidized Pre-Wisconsin (Laurelton or Penny Hill) fluvial deposits, originally capped by Woodfordian loess prior to road excavation and surface stripping.
25.1	0.2	Exit 35. Lightstreet.
27.1	2.0	Altonian(?) till over Bloomsburg in exposure to right (south).
29.9	2.8	Take US 11 North exit, proceed eastward, toward Berwick.
30.2	0.3	Route travels along intermediate outwash terrace surface along the North Branch of the Susquehanna River. Lower terrace/floodplain surface visible to right (south).
31.7	1.5	Intersection, road south to Mifflinville. Enter Briar Creek, proceed east on US 11.
32.6	0.9	Descend onto low terrace/floodplain of Briar Creek, tributary to the North Branch.
33.0	0.4	Cross Briar Creek
33.3	0.3	Ascend onto lowest of the intermediate terrace group
33.7	0.4	Ascend riser onto second surface
34.2	0.5	Ascend riser onto third surface
34.7	0.5	Ascend riser onto highest surface in the intermediate terrace group, all mapped together for convenience.
35.5	0.8	Ascend major riser onto high level terrace, on which central Berwick is situated. A slightly higher surface, mapped along with this level for convenience, can be found on both sides of the North Branch at Berwick. The high and intermediate level terraces bear soils with color B horizons and well developed fragipans, where internal drainage is restricted. The low terrace/floodplain surface is characterized by soils with significantly less profile development. The high outwash terraces at Berwick are Woodfordian in age and the low terrace/floodplain surface is believed to be a Holocene erosional and

		depositional surface developed over Woodfordian outwash sand and gravel.
35.8	0.3	Turn right at second stop light in Berwick on PA 93 south. Cross North Branch of the Susquehanna.
36.3	0.5	Ascend from low terrace/floodplain onto lowest of several intermediate terrace group levels. Enter Nescopeck.
37.1	0.8	Descend briefly onto low terrace/floodplain channelway which swings south of Nescopeck. Nescopeck was an island during the 1972 Agnes flood. Cross railroad tracks and reascend intermediate level terrace.
37.5	0.4	Ascend riser onto high level terrace, lower sublevel.
37.7	0.2	Note Woodfordian kame terrace associated with Berwick terminus ahead and to right (south).
38.5	0.8	Ascend onto kame-kettle terrace complex.
38.7	0.2	Note constructional topography of kames and kettle holes to left (north). We are now behind the Woodfordian ice margin.
39.7	1.0	Orange-brown residual soil on left, probably outside Wisconsinan border.
40.1	0.4	Ridgecrest. Wisconsinan border immediately to east (rolling hills are kames).
40.8	0.7	Proceed diagonally left on paved side road.
41.0	0.2	Till boulders in plowed fields. Altonian or Woodfordian.
41.1	0.1	Turn left on PA 239. Road passes through Woodfordian ground moraine.
41.9	0.8	Turn left on PA 239. Proceed northward.
42.3	0.4	Berwick Side Trip Stop 1, D. Marchand. Small quarry in Woodfordian kame. Examination of weak soil formed in stratified and unstratified stagnant ice deposits. A large clot of an older soil (post Altonian?), incorporated into the kame deposit, may still be visible in the east wall if it has not been quarried away by the time of the field conference. Proceed northward on PA 239.
44.1	1.8	Turn left at bottom of hill. Proceed west along south side of North Branch.
44.4	0.3	Road descends onto terrace/floodplain surface.
44.7	0.3	Quarry to left (south) in ice-contact stratified drift.

45.4	0.7	Cross railroad tracks.
45.5	0.1	Berwick Side Trip Stop 2, D. Marchand. Large quarry in Woodfordian kame terrace. Relatively high percentage of crystalline erratics and large boulders. Continue westward.
45.8	0.3	Quarry in high terrace level outwash, which fills an incision into the kame terrace of the Woodfordian border. These and the lower terrace gravels presumably are related to recessional terminuses upstream from Berwick, but no correlation has yet been made.
46.2	0.4	Descend to lower sublevel of the upper terrace group.
46.5	0.3	Descend major escarpment onto intermediate level terrace group.
47.0	0.5	Stop sign. Turn right on PA 93. Retrace route west to Nescopeck.
47.9	0.9	Turn left on PA 339 (Broad Street) in Nescopeck.
48.2	0.3	Turn right (west). Stay on PA 339.
48.3	0.1	Cross Nescopeck Creek
48.9	0.6	Slope break to right, from remnant of intermediate level outwash terrace to low level/floodplain.
49.6	0.7	Ascend onto high-level Woodfordian terrace, partially loess-mantled.
50.4	0.8	Enter Mifflinville, descend onto intermediate level terrace, partly mantled by Woodfordian loess. South of Mifflinville lies an abandoned Pre-Wisconsinan(?) diversion channel of the North Branch, which joins the present river course near Catawissa.
51.6	1.2	Leave Mifflinville.
51.8	0.2	Turn right onto I 80 west onramp, retrace route to PA 147, north of Milton.
54.0	2.2	Altonian till over Pre-Wisconsinan (White Deer?) loess in roadcuts just north of I 80, visible from the highway.
57.8	3.8	Lightstreet exit. Bus pullover to view gully exposure of oxidized Pre-Wisconsinan fluvial deposits just west of interchange. No stop.
81.8	24.0	Turn right onto PA 147 North onramp.

<u>Return to Original Road Log Mileage of 8.4</u>

10.5	2.1	Wills Creek Formation (clayey dolomitic limestone) dipping south on right side of road, Edom soils.

11.8	1.3	Silurian Tonoloway Limestone on left side of road, Hagerstown soils.
12.8	1.0	Devonian Marcellus black shale on right.
13.4	0.6	Pass PA 54 exit. Continue on PA 147. Pre-Wisconsinan kame on the right. From here to the Muncy Hills there are small patches of Pre-Wisconsinan till material on the uplands (Allenwood and Washington soils).
14.1	0.7	View ahead to the Muncy Hills, held up by a broad syncline in Upper Devonian sandstones and interbedded shales. About 4 1/2 miles west of here adjacent to the Susquehanna River there are old (Pre-Wisconsinan?) eolian sand deposits. They are 140 feet above the river and cover a small area (about 600 acres). There is also a small area of old eolian sands in Lycoming County near Jersey Shore.
16.4	2.3	Exposures of Devonian Trimmers Rock Formation dipping to the north. These are prodelta turbidites in advance of the Catskill "Delta". The soils of the Muncy Hills are Weikert, Berks and Hartleton.
17.0	0.6	More Trimmers Rock Formation, now dipping south.
19.1	2.1	Marcellus black shale (Devonian) on left side of road.
19.8	0.7	PA 405. Two miles west of here (on the west side of the river) is the location of the Linden, Wheeling Duncannon soil transect mentioned in chapter 4.

Optional Side Trip to Hughesville

0.0	0.0	New mileage at PA 405 offramp.
0.3	0.3	Stop sign. Turn right on PA 405. On outwash terrace of Muncy Creek.
0.9	0.6	Turn left at PA 442 junction, stay on Pa 405. Cross Muncy Creek.
2.6	1.7	Enter Hughesville. Turn left on LR 41066. On broad Muncy Creek outwash terrace.
3.4	0.8	Back edge of terrace. Road bends left.
3.7	0.3	Road bends right.
3.8	0.1	Turn right. Stay on LR 41066.
4.8	1.0	Turn right on West Cemetery Street (T 519). Note Penny Hill(?) fluvial deposits in low road cuts.
4.9	0.1	Turn right again.

5.1	0.2	Hughesville Side Trip Stop 1, D. Marchand. Walk straight ahead 100 feet and down to excavation. Penny Hill(?) stratified drift. Note extreme degree of soil development, deep oxidation, preservation of primary stratification. Material at surface is less well sorted, but contains well rounded clasts. Return to West Cemetery Street.
5.3	0.2	Turn right on West Cemetery Street (T 519).
5.5	0.2	Back edge of intermediate level terrace.
6.1	0.6	Turn right on PA 405 (S. Main Street).
6.8	0.7	West edge of Hughesville. Retrace route to PA 147 North.
9.4	2.6	PA 147 North onramp. Complete Hughesville loop.

Return to Original Road Log Mileage of 19.8

20.9	1.1	Cross Muncy Creek, Linden and Barbour soils on the floodplain.
22.4	1.5	PA 147 becomes US 220 South. Stay on freeway.
22.8	0.4	Views of Allegheny front to the right (north) - relatively flat-lying Devonian strata capped by Mississippian Pocono sandstone. To the left is the Bald Eagle mountain underlain by the Silurian Tuscarora formation. The mountain is the northeast end of the White Deer Anticline. This anticline is the last fold in the Folded Appalachians. Just ahead Altonian till is found on uplands.
27.3	4.5	Pass Fairfield Road Exit. Continue on US 220.
28.2	0.9	Exit right at PA 87 offramp.
28.5	0.3	Turn left (north) at stop sign onto PA 87. Route will be north up the valley of Loyalsock Creek.
29.2	0.7	The Loyalsock Creek outwash terraces and floodplain are well displayed on the left. Several terrace levels can be observed in the Loyalsock Creek and Wallis Run valleys between Montoursville and Calvert (cumulative mileage 28.5 to 40.2). These terraces are part of three deglacial morphological sequences developed during the melting of the Woodfordian ice on the Allegheny Plateaus. Several older terrace remnants underlain by deeply weathered deposits can be also seen here. A discussion of the terrace development will be given at STOP 1 and is presented in chapter 3. Linden and Barbour soils are on the floodplain and Tunkhannock soils on the terraces.
30.0	0.8	Entering community of Farragut
30.3	0.3	Ascend higher terrace underlain by weathered sand and gravel followed quickly by descent.

31.3	1.0	Rise onto higher terrace.
32.5	1.2	Turn left onto PA 973, cross Loyalsock Creek, then immediately past bridge turn right (north) on LR 41050.
34.7	2.2	Outcrop of Devonian Catskill Formation on left. In this part of the field trip all red strata are part of Catskill Formation.
34.8	0.1	Bridge where Wallis Run enters Loyalsock Creek. Terrace remnant on right. Follow road up Wallis Run.
37.8	3.0	Turn left on road to village of Calvert. This is an area of Woodfordian drift.
38.7	0.9	Cross bridge.
39.1	0.4	Another minor bridge.
39.5	0.4	Road fork. Keep left.
40.2	1.1	Left turn in Calvert on Township (T) 854.
41.1	0.9	Bridge where road comes in from right side; continue straight ahead on T854.
41.5	0.4	<u>STOP 1</u>. Rose Valley Lake. George Crowl and Ed Ciolkosz. At this stop there is Woodfordian till in a small area of end moraine within the glacial border east of Rose Valley Lake (see chapter 2 for a general discussion of the border). The till here is reddish brown (5YR 4/4), stoney, with a loam matrix. It is derived from the underlying Devonian Catskill formation with some admixture of Pocono sandstone from the north. It is typical of Woodfordian till in this region. Till is widespread in the valleys of Wallis Run and Murray Run and as far west as the end of Blessing Mountain, south of Stop 1. Rose Valley Lake, an artificial lake, lies in an ice block depression a short distance to the west, at the margin of the Woodfordian ice. Most of the till has been removed from steep mountain slopes by colluviation but the boundary must be on the north slope of Blessing Mountain just south of here because Altonian till, older residual soils, and colluvium are exposed on the broad mountain top to the south. The soils of this area are Oquaga, Lackawanna, and Wellsboro. These soils show weak to moderate development with no argillic horizon but a fragipan in the Lackawanna and Wellsboro soils. Descriptions and data for two soils developed in Woodfordian till (Bath and Lackawanna) are given in the Appendix. Terraces of Loyalsock Creek by Milena F. Bucek. See chapter 3 for this discussion. Turn around and retrace route back towards Calvert, and US 220.
41.9	0.4	Road to left at bridge. Continue straight ahead up hill.
42.8	0.9	Right turn in village of Calvert, onto LR 41050 toward Loyalsockville.

45.2	2.4	Turn right along Wallis Run toward Loyalsockville.
48.2	3.0	Bridge where Wallis Run enters Loyalsock Creek.
50.5	2.3	At bridge over Loyalsock Creek (PA 973) turn left across the creek, then right onto PA 87 south.
54.7	4.2	Go under US 220.
54.8	0.1	Turn left onto Fairview Drive.
55.6	0.8	Church on left (Faith United Methodist)
55.8	0.2	STOP 2, Montoursville Quarry. Melina F. Bucek. Walk up along north face of quarry. Warrensville till of Altonian age overlies glaciofluvial and lacustrine deposits. Leck Kill soils are developed on the till. The Leck Kill soil shows moderate profile development and has an argillic horizon. Profile descriptions and data are given in the appendix for two Leck Kill soils that were sampled 2 to 4 miles north of the quarry. The underlying bedrock is the Lower Devonian Needmore shale and Oriskany sandstone. Discussion of Warrensville till and other glacial deposits found in Williamsport area is given in chapter 3. Leave quarry. Retrace route along Fairview Drive to US 220.
56.7	0.9	Stop sign. Turn right, go under freeway.
56.9	0.2	Left turn onto US 220 South onramp.
58.5	1.6	Bridge across Loyalsock Creek.
59.3	0.8	Roadcuts in Siluro-Devonian Tonoloway and Keyser Limestones.
59.9	0.6	Pass Loyal Plaza shopping center on right.
60.6	0.7	Turn left at the beginning of two road jogs to stay on US 220 South.
61.8	1.2	Right turn, followed by left turn one block later.
62.0	0.2	Left turn. Follow signs indicating US 220 South.
62.3	0.3	Bear right.
62.4	0.1	Turn right onto US 15 South onramp. In this area during the 1936 flood before the dike was built, there was about 9 feet water in this area. During the Agnes flood (1972) the water came within 1 foot of over topping the dike.
62.6	0.2	Join US 15 South. Continue south across West Branch of Susquehanna River.
63.5	0.9	US 15 bends eastward

63.9	0.4	Pass Little League Headquarters on left. Laidig and Buchanan soils on the side slopes.
65.4	1.5	Opposite adult book store. Exposure of uppermost Tuscarora Formation (Castanea member) in steeply northward dipping strata on right side of road.
66.2	0.8	Left turn into Scenic View parking lot. View of the valley of the West Branch of the Susquehanna River, Williamsport, Montoursville, Appalachian Plateau and the tributary valley of the Loyalsock. Proceed south on US 15.
67.1	0.9	STOP 3, Lunch. Crest of hill. Turn right into Roadside Rest This is in a fine example of a "wind gap". Across Bald Eagle Mountain on US 15 and also about 0.5 mile to the south are examples of blockfields. Proceed south on US 15.
67.7	0.6	Bus slows for view of blockfield to right. This blockfield is similar in many respects to Hickory Run and other blockfields in the area, but smaller and on a somewhat steeper slope.
68.1	0.4	Tuscarora Formation on left, now dipping to south.
70.4	2.3	Entrance to Allenwood Federal Prison Farm.
71.4	1.0	Penny Hill road cut. Exposure of Penny Hill till on right (west). This was the Allenwood soil study site of Denny and Lyford (1963).
73.7	2.3	White Deer till in cut on left (east) at gravel road intersection.
75.4	1.7	Intersection, PA 44 in village of Allenwood. Proceed south on US 15.
75.8	0.4	Cross White Deer Hole Creek
76.0	0.2	Rose Hill shale exposed in roadcuts, dipping north on north flank of first order White Deer anticline. From here to the new Columbia exit, note on the left the intermediate Woodfordian terrace (Olean terrace of Peltier, 1949) on West Branch of the Susquehanna River. This terrace is mantled in many locations by Woodfordian loess and overbank silt and includes as many as four separate levels in some locations. Also note the break onto lower terrace/floodplain surface along the West Branch (Binghamton terrace of Peltier, 1949). This surface appears to be a complex of Holocene landforms and deposits, superimposed on eroded or reworked outwash deposits, containing coarse cobble and boulder gravel in many locations. This surface does not normally bear a loess or eolian sand mantle, as does the next higher level (intermediate terrace). Wheeling and Duncannon soils on the terraces.
76.6	0.6	Crest of anticline. Tuscarora sandstone exposed in core.

76.9	0.3	Rose Hill shale, dipping south.
79.4	2.5	Cross beneath I 80. Continue south on US 15.
79.7	0.3	Borrow pit on left (east). Eolian sand and silty sand (Woodfordian) over Laurelton till and underlying fluvial deposits.
80.2	0.5	Take New Columbia exit, turn right at base of offramp.
80.4	0.2	Turn right again, almost immediately, on dirt road heading north.
80.8	0.4	STOP 4, New Columbia, D. Marchand. White Deer loess and till over Bloomsburg Formation. Characteristics of the White Deer drift are discussed in chapter 1. Washington soil. We are at the margin of the White Deer drift, which also occurs on the east side of the West Branch as far south as Watsontown. White Deer ice apparently did not reach down the valley of the West Branch to Milton and Lewisburg. Proceed north on dirt road, which eventually bends left (west).
81.6	0.8	Stop sign. Turn right on LR 59024. Laurelton till (thin) over Wills Creek shale.
82.5	0.9	Note relatively clean topography, good expression of strike ridges and valley.
82.7	0.2	Turn right (north) on Gray Hill Road (T514).
83.2	0.5	Entering area of Laurelton till.
83.5	0.3	Bear left, staying on Gray Hill Road.
87.7	0.2	Turn left, parallel to I 80 on T 417.
84.0	0.3	STOP 5, I 80 Borrow Pit, D. Marchand. Laurelton till over fluvial sand and gravel. Characteristics of the Laurelton drift are described in chapter 1. Allenwood soil. Retrace route back to Gray Hill Road. Turn right.
84.5	0.5	Intersect better paved road. Turn left immediately on Huff Road (T 413). Note clean topography.
85.0	0.5	Borrow pit in shale on right.
85.1	0.1	Enter area of Laurelton till.
85.8	0.7	Turn left on Dietrick Road (T520).
86.0	0.2	Pass under I 80.
86.1	0.1	Intersection, Showers Road on left. Altonian till poorly exposed in roadcuts. Proceed straight ahead.
86.2	0.1	Altonian till exposed in roadcut on left.

87.0	0.8	Pass under US 15.
87.0	0.1	Turn left on paved road (old 176).
88.0	1.0	Stop sign. Go straight ahead onto US 15 North.
90.5	2.5	Enter village of Allenwood.
90.8	0.3	Entering extensive area of White Deer till.
93.5	2.7	Brighter orange soil in plowed fields along base of hills may be B horizon of post-Laurelton soil, exposed on erosional slopes underlying the White Deer till.
96.0	2.5	Being ascent of Penny Hill. Laurelton(?) till on right (east).
96.4	0.4	Penny Hill till on left (west) at crest of hill. No stop.
97.3	0.9	Turn left at entrance to Allenwood Federal Prison Camp on LR 41005. The Allenwood Prison occupies 4,000 acres in the White Deer valley. It is one of the five U. S. Bureau of Prisons minimum-security camps and is referred to by some as a "country club prison". The prison has about 500 inmates and in recent years has housed Watergate figures Egil Krogh, Jr., James McCord, Jeb Stuart Magruder, E. Howard Hunt and G. Gordon Liddy.
97.8	0.5	Enter Prison gate.
98.2	0.4	Turn left, then bear left again, skirting around behind prison buildings.
98.5	0.3	Turn left onto gravel road, take first left and ascend hill.
98.8	0.3	<u>STOP 6</u>, Allenwood Prison Hill Site, D. Marchand. Remnant of Penny Hill till, overlying Devonian shale, exposed on high ridgecrest. Extremely red clay-rich Allenwood soil. See chapter 1 for characteristics of Penny Hill drift. After stop, turn around, retrace route toward prison entrance.
99.3	0.5	<u>STOP 7</u>, Allenwood Prison Pond Site, D. Marchand. White Deer till overlying older till, probably Penny Hill. The superposition of older tills in the White Deer Valley and valleys to the south and possible ages and correlations of these old drift bodies will be discussed. Allenwood characterization site 41-42 is located 3/4 mile southwest of this site (See appendix for data). Leave pond site, return to US 15 via LR 41005.
100.4	1.1	Turn right (south on US 15) toward Lewisburg.
110.2	9.8	School and Texaco station on left (east). Poor exposures (eroded?) of Laurelton or Penny Hill fluvial sand, perhaps associated with a remnant of an outwash terrace about 70 feet above the level of the West Branch.

111.3	1.1	Cuts in Bloomsburg redbeds (middle Silurian).
111.7	0.4	Pass West Milton
112.9	1.2	The next several road cuts are in the Wills Creek shale (upper Silurian).
113.4	0.5	Road intersection to left (west). Quarry visible from US 15 exposes Laurelton till overlain by Wisconsin and perhaps older (White Deer?) loess.
114.7	1.3	Evangelical Hospital on left (west). Sitauted on what may be a high level Altonian or Pre-Wisconsinan strath surface.
115.3	0.6	Cross Buffalo Creek, which drains much of the eastern part of the Buffalo Valley. Just north of the creek, US 15 crosses intermediate Woodfordian terrace which grades eastward onto an outwash terrace along the West Branch. Laurelton till is locally exposed on eroded bluffs beneath the alluvium.
115.7	0.4	Intersection, PA 192. Keep straight ahead on US 15.
116.1	0.4	Intersection, PA 45 and US 15, Lewisburg.

End of first day.

Road Log for Second Day - Sunday May 7, 1978

Mileage Cumulative	Mileage Increment	
0.0	0.0	Intersection PA 45 and US 15, Lewisburg. Proceed west on PA 45, toward Mifflinburg. Note clean topography, prominence of strike ridges and valleys. This area lies west of the Lewisburg area, where scattered remnants of Laurelton till suggest the former existence of a Laurelton terminus representing a recessional position or a readvance.
4.9	4.9	Entering Vicksburg. The soils along the route between here and Hartleton are Edom with some Mertz and Kreamer associated with cherty ridges.
7.5	2.6	Entering Mifflinburg; area of thin till (Laurelton).
9.2	1.7	Junction PA 104 South, Keep straight (west) on PA 45.
10.1	0.9	Bear right, stay on PA 45 West.
12.7	2.6	Area of Laurelton till, thin and discontinuous in places, possibly associated with a recessional moraine, now extensively eroded.
12.8	0.1	Enter Hartleton.
12.9	0.1	Paved road to right (north) leads into area of extensive Laurelton till.
13.6	0.7	Ridgecrest. Area of relatively clean topography.
14.1	0.5	Area of thin Laurelton till.
15.1	1.0	Turn left on LR 59003 towards Laurelton.
15.2	0.1	Shale chip colluvium (Woodfordian?) over bedrock on right. Strong soil locally preserved on older colluvium or residuum at base of shale chip colluvium. Note merging of Woodfordian colluvial surface and intermediate terrace surface to left (south). Lower terrace/floodplain is incised into the intermediate terrace.
15.5	0.3	Stop sign. PA 235. Jog left, then right (west) on LR 59003. Cross gravelly alluvium of Laurel Run intermediate terrace which merges westward with colluvial slopes.
15.9	0.4	Area of clean topography, good expression of strike ridges and valleys.
16.1	0.2	Area of Laurelton till begins. Note loss of strike topography, presence of closed, poorly drained depressions.
16.6	0.5	Turn left (south) on T 306.

16.7	0.1	Small ponds in depressions on both sides of road represent incompletely filled kettle holes in Laurelton end moraine.
16.9	0.2	Turn right (west) on LR 59001.
17.1	0.2	STOP 8, End Moraine, D. Marchand and E. Ciolkosz. Laurelton end moraine in the west end of the Buffalo Valley. Discussion of distribution of Laurelton deposits in the Buffalo Valley, preservation of constructional topography, and potential for paleomagnetic and palynological studies. Allenwood characterization site 60-8 is located at this site (see appendix for data). Continue straight ahead.
17.3	0.2	Road junction on right. Keep straight ahead. Note clean topography, reemergence of strike ridges and valleys.
18.1	0.8	Chapel Road (T 307). Vehicles turn around to retrace last part of route.
18.5	0.4	Note cross topography ahead. This is the Laurelton end moraine just seen at STOP 8.
19.1	0.6	Pass location of STOP 8.
19.2	0.1	Turn right on Paddy Mountain Road (T 306).
19.6	0.4	Lincoln Chapel. Turn left onto LR 59032. Area of thick till, hummocky topography, orange-brown soils in plowed fields along crest of Laurelton terminus. Strike valleys and ridges absent here but visible to the east. After turning left, Laurelton till is to right and Woodfordian colluvium mantles the side-slopes of the small bedrock ridge on the left.
20.0	0.4	Turn right on Long Lane (T 308). Note colluvial fan emerging from gap in north side of Jacks Mountain (ahead and to left after turning). Soils developed in the colluvium are Laidig and Buchanan.
20.7	0.7	Junction PA 235. Turn right (south) on PA 235.
20.9	0.2	Cross Penns Creek. Note low terrace/floodplain. Begin ascent of Jacks Mountain.
21.1	0.2	Red, clay-rich soil formed in colluvium on both sides of the road. Soil structure looks more like Woodfordian, but color and clay content suggest presence of inherited soil material from old drift or colluvium.
21.8	0.7	Outcrop of red Tuscarora(?) sandstone.
22.1	0.3	Blocky colluvial slope to left.
23.6	1.5	Ridge crest. Residual soils (Leetonia and Hazleton) formed on the quartzitic sandstones of the Tuscarora and Bald Eagle

Formations are Inceptisols and Spodosols, developed on high ridges with cooler temperatures and somewhat higher moisture regimes and a larger percentage of coniferous cover than soils formed in the valleys below.

24.6	1.0	Sandstone outcrop on right.
26.6	2.0	Intersection of PA 235 and LR 54029 on the outskirts of Troxelville, follow PA 235. In this valley there are many cherty ridges (Elliber soils) with cherty colluvium on their sideslopes (Mertz and Kreamer soils). The soils developed on the gray shale material are primarily Weikert and Berks.
26.9	0.3	Go straight (west); leave PA 235 and follow T 469.
27.1	0.2	Turn right, stay on paved road (T 469).
27.5	0.4	Regraded alluvial surface over Laurelton till.
28.9	1.4	Thin till over Bloomsburg Formation.
29.1	0.2	Turn left on T 576. Laurelton terminus in this valley. Note closed depressions.
29.5	0.4	Road intersection at crest of terminus. Turn left on LR 54023.
29.8	0.3	Turn right on T 467. Still in Laurelton till.
30.2	0.4	Turn right on T 576 return to intersection at crest of terminus.
30.6	0.4	Turn left at intersection on LR 54023.
30.9	0.3	Leave area of till.
31.1	0.2	Note benches cut on bedrock to left, now incised by small stream. Road lies on similar surface on the north side of the strike valley. These benches bear no obvious old fluvial deposits, but may represent strath surface cut by debris-laden proglacial meltwater emerging from the Laurelton terminus immediately to the east. Some of the valleys west of here are very large in proportion to their present streams, suggesting the presence of former meltwater channels.
32.4	1.3	Road intersection on right (T 469). Go straight ahead.
32.7	0.3	Turn left on LR 54026 to Middle Creek.
33.5	0.8	Turn left (east) on T 467. Note broad valley, drained only by small streams. Also note absence of till, prominence of strike valleys and ridges.
34.8	1.3	Turn right (south) on T 574.
35.1	0.3	STOP 9, Benfer Shale Pit, E. Ciolkosz. Thick Wisconsinan shale chip colluvium (grezes litees) showing remarkable bedding,

		exposed in large quarry cut. Weakly developed Rushtown soil at surface. Evidence of truncation within the deposit with the lower unit showing very large prisms. Frost features preserved in exposures at upper quarry level. Discussion of periglacial features outside the Wisconsinan boundary and of soils formed on colluvial deposits (see Chapter 4). Continue south on T 574.
35.5	0.4	Turn left (east) on LR 54026.
36.8	1.3	Junction PA 235. Turn right (south) on PA 235 toward Beaver Springs.
38.3	1.5	Pass orchard.
38.8	0.5	Turn left (east) on US 522 north.
39.0	0.2	Enter area of till (Penny Hill?) outside the Laurelton terminus. Note high chroma of B horizon in plowed fields. Till exposures south and west of Beaver Springs bear Allenwood soils having very high clay contents, thick clay coatings around clasts, and reddish colors (hues 5YR to 2.5YR, chromas 6 to 8).
39.7	0.7	Pass church (Beaver Lutheran).
40.3	0.6	Cross bridge as Beavertown is entered. Just past bridge turn right on T 425, recross the creek, then turn left (south) on T 588.
40.6	0.3	Bear left on T 425. Recross creek.
40.9	0.3	Bear left on gravel road.
41.0	0.1	STOP 10, Beavertown Borrow Pit, D. Marchand. Old colluvium (Laurelton?) bearing well developed soil overlying significantly older till (Penny Hill?). Bloomsburg bedrock exposed at base of pit. Discussion of Laurelton-Penny Hill differentiation, distribution of the Penny Hill drift. Turn around, return to US 522 via same route.
41.7	0.7	Intersection US 522. Go straight ahead on T 588.
42.2	0.5	Cobbly alluvium of low terrace to right.
42.5	0.3	Pass paved road intersection on left.
42.6	0.1	Stop sign. Turn left at T intersection on LR 54030.
43.3	0.7	Cross Middle Creek. Note low terrace/floodplain.
43.8	0.5	Turn left at intersection on to LR 54023.
43.9	0.1	Roadcuts on right in Devonian sandstone.

44.2	0.3	Entering area of eroded (Penny Hill?) till within the probable limits of the Laurelton ice. (A profile description and data from an Allenwood soil characterization site (55-12) which was located behind the house on the left is given in the Appendix).
44.5	0.3	Thin till exposed in roadcuts above shale.
44.5	0.1	Cross North Branch of Middle Creek.
45.2	0.7	Intersection. Turn right on PA 235. Road lies on intermediate level terrace of Middle Creek.
45.8	0.6	Descend onto lower terrace/floodplain level.
47.1	1.3	Turn right in Troxelville. Stay on PA 235.
47.5	0.4	Leave Troxelville. PA 235 goes left. Stay straight on LR 54029 toward Penns Creek.
50.2	2.7	Ridgecrest. Note water gaps in Jacks Mountain to the north. Slope break on lower slopes marks the approximate contact between Tuscarora sandstone above and Rose Hill shale below and also markes the beginning of thick colluvial cover on lower slopes.
50.7	0.5	Turn right just past Port Ann on LR 54033.
51.2	0.5	Cross North Branch of Middle Creek, flowing west from a drainage divide in Laurelton till. The shortest exit for runoff here would be eastward into Penns Creek.
51.8	0.6	Turn left (east) on paved road (LR 54028).
52.9	1.1	Keep straight at intersection.
53.4	0.5	Gray silts and clays in shallow depressions in valley to left (north) appear to be kettle hole fillings. The basal sediment in these depresssions should date back to Laurelton time. Shelmadine and Alvira soils.
53.8	0.4	Sandstone exposed in roadcuts to right (south).
54.4	0.6	Turn left on unsurfaced road (T 626). Note blockfields on south side of Jacks Mountain.
54.6	0.2	Colluvium mantling Laurelton till.
55.2	0.6	Ponds and closed depressions on both sides of the road, marking position of Laurelton recessional(?) moraine extending across valley west of Penns Creek. Some of these larger ponds might yield old pollen records.
55.6	0.4	Turn right on LR 54029 toward Penns Creek.
56.6	1.0	Hummocky topography in Laurelton till. Allenwood soil

characterization site (55-7) lies just north of here (see Appendix for description and data).

57.2	0.6	Intersection with PA 104 in Penns Creek. Go straight ahead.
57.3	0.1	Turn right at first intersection on LR 54052.
58.2	0.9	Corner. Proceed straight ahead on T 503.
58.9	0.7	Partially filled kettle holes in Laurelton till. When fields are freshly plowed, color contrasts between orange-brown Allenwood soils on topographic highs and gray, clayey poorly drained Watson, Alvira, or Shelmadine soils in depressions is very evident.
59.4	0.5	Corner. Turn left. Road here passes through an 'amphitheater' which disrupts the trend of outcropping Devonian rocks along the south margin of the valley. This 'amphitheater' may be an erosional feature, produced by meltwater escaping from Laurelton ice southward into the Penns Creek area. The lower course of Penns Creek itself may date from Laurelton or Penny Hill time.
59.6	0.2	Corner. Turn right. Stay on T503 from here to LR 54036.
59.8	0.2	Corner. Turn right. Borrow pit in sandstone.
60.3	0.5	Turn left at T 666 junction. Remain on T 503.
60.6	0.3	Bend right. Penns Creek low terrace lies to left (north).
61.0	0.4	Bear left (north) at corner. T 558 junction.
61.1	0.1	Basher soils on low terrace-fan graded to Penns Creek. Soils are immature. Red color is inherited from the Catskill redbeds in the source area to the south. Turn right on T 503.
61.6	0.5	Corner, turn right, proceed eastward.
61.8	0.2	Corner, bear left.
62.1	0.3	Turn left on LR 54036.
62.2	0.1	Turn left again, stay on LR 54036. Till boulders in fields.
62.7	0.5	Bear left onto PA 204, going north across Penns Creek.
63.0	0.3	Turn right on PA 304 in New Berlin.
63.3	0.3	Bear left, continue on PA 304.
64.6	1.3	Penns Creek on right.
65.5	0.9	Till boulders on left (north)

67.0	1.5	Dry Valley Crossroads. PA 304 parallels Shamokin Ridge to the north, which was probably overtopped by Penny Hill ice but not by Laurelton and later advances. Dry Valley itself contains significant patches of Laurelton drift, but not White Deer drift. Some White Deer appears to be present west of Selinsgrove, probably marking the margin of White Deer ice in that area. Altonian ice apparently reached as far down the North Branch valley as Sundury, but not significantly beyond.
70.0	3.0	Winfield Quarry on right (south) in Keyser and Tonoloway limestones. Scattered patches of Laurelton till lie south of the quarry.
70.4	0.4	Enter Winfield. Bear left on PA 304.
70.6	0.2	Turn left on US 15, head north.
71.2	0.6	Crossing axis of Shamokin Mountain anticline. Intermediate and low level terraces of the West Branch, Susquehanna River to right (east).
71.5	0.3	Cross low terrace/floodplain of Turtle Creek.
72.9	1.4	Pass National Guard Armory to right. Thin patch of Laurelton till over Bloomsburg Formation. Till thickens appreciably to the east.
73.5	0.6	Pass Bucknell University on right, Moore Avenue. Thick Laurelton till underlies most of the Bucknell campus and is overlain by up to ten feet or more of loess, presumably Woodfordian and derived from the Susquehanna River and Buffalo Creek terraces in the Lewisburg area.
74.1	0.6	Intersection US 15 and PA 45.

End of field trip.

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