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PERIGLACIAL FEATURES IN PENNSYLVANIA

by

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INTRODUCTION

The objective of this paper is to present a brief interim report on the occurrence and genesis of periglacial features in Pennsylvania. An extensive paper on this subject will be presented in the near future.

DISCUSSION

Periglacial features

The term periglacial is used here in the same sense as it was used by Washburn (1980): it applies to cold climate environments both with and without permafrost. The products of the periglacial environment included here are: patterned ground (stone polygons and stone stripes), involutions, ice wedge casts, grezes litees (shale-chip deposits), boulder fields, pingos, and gelifluction (solifluction) deposits. The term gelifluction is used by Washburn (1980) in preference to solifluction because he states that it is "unequivocally periglacial." The environments and processes of formation of periglacial features have been discussed by Carson and Kirby (1972), Washburn (1976; 1980), and Pewe (1983). These authors indicate that a climate with a mean annual air temperature (MAAT) of less than $0^{o}C$ is needed for the development of permafrost and periglacial features. The presence of ice wedge casts and pingo scars (Table 1) in central Pennsylvania indicates the previous existence of a periglacial climate with a MAAT of -5 to $-10^{o}C$ (Washburn, 1980; Pewe, 1983). The most recent periglacial climate was associated with the Wisconsian glacial stage (10,000 to 75,000 YBP; Crowl and Sevon, 1980). Stratigraphic evidence in western Pennsylvania (White et al., 1969) indicates that 3 earlier glacial advances occurred in Pennsylvania. These advances presumably had associated periglacial climates. The present MAAT in central Pennsylvania (at State College) is $10^{o}C$, thus there has been a 15 to $20^{o}C$ rise in MAAT since the late Wisconsinan. This change in MAAT has had a major effect on the fauna (Guilday et al., 1964) and flora (Watts, 1979) as well as the soils of Pennsylvania. Some of the effects on soils are discussed by Carter (1983), Cronce (1987), and Waltman (1985).

Maps of periglacial features of the United States given by Washburn (1980) and Pewe (1983) indicate only a small number of these features in Pennsylvania. However, the occurrence of periglacial features in Pennsylvania is more extensive than noted on these maps and a more complete map summarizing both published and unpublished occurrences is given in Fig. 1. The lack of periglacial-feature sites in western Pennsylvania is due probably not so much to their absence as to a lack of investigations in that area. The distribution of known sites indicates that the periglacial 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 former presence of a wide belt of periglacial environment adjacent to the continental ice. The actual width of this belt is speculative. Temperature projections made using a presumed Woodfordian (late Wisconsinan) MAAT of $-10^{o}C$ at State College and modern temperature gradients of latitude and altitude for the central Appalachians (Carter and Ciolkosz,1980) extend the periglacial zone to an unrealistic southern margin. This suggests that the Woodfordian temperature gradient was steeper than that of today. The present mesic-thermic soil temperature boundary in Virginia marks a position of soil changes and may be an indicator of the former extent of the periglacial environment. This boundary runs from Washington, D.C. west to the Blue Ridge and then southward. Similar landforms and lithologies are

Table 1. Periglacial Phenomenon in Pennsylvania (See Fig. 1 for location)

Code#	USGS 7 1/2' Quadrangle* and/or General Location	Source or Reference and Remarks
B-1	Hickory Run, Northern Carbon Co.	Smith (1953); Sevon (1975b)
B-2	Lehighton*; SE of Bowmanstown	Sevon (1967)
B-3	Bald Eagle Mt.	Kirkby (1965)
B-4	Hamburg*; 5 miles NW of Hamburg; Devils Potato Patch and Blue Rocks	Potter and Moss (1968)
B-5	Ringing Rocks, eastcentral Bucks Co.	Psilovikos and Van Houten (1982); Peltier (1945)
B-6	Iron Springs*; Devils Racecourse; 1 mile W of Glade Hill	Stose and Bascom (1929)
B-7	Montoursville South*; 2 1/2 miles S of Montoursville on U.S. 15	Ciolkosz (1974); Faill (1979)
G-1	Roaring Springs*; U.S. 22, 1 mile N of East Freedom	Ciolkosz (1974)
G-2	Centre County, numerous locations	Jobling (1969)
G-3	Delaware River Valley, numerous locations	Crowl (1971)
G-4	Broadheadsville* and Pohopoco Mt.*	Gardiner (1966)
G-5	Broadheadsville*; U.S. 209, 1 mile NE of Kresgeville	Ciolkosz (1974)
G-6	Williamsport	Sevon (1974)
G-7	U.S. 15 Harrisburg-Williamsport	Sevon (1974)
G-8	Hartleton*; 1 mile N of Laurelton	Marchand and Ciolkosz (1975)
G-9	Beavertown*; 1 1/2 miles SW of Benfer	Marchand and Ciolkosz (1975)
G-10	Mifflinburg*; 1 mile SE of Dice	Marchand and Ciolkosz (1975)
G-11	Auburn*; Junction of Pa. 610 & 895	Ciolkosz (1975)
G-12	Meadow Grounds*; 2 miles S of Harrisonville on Pa. 655	Ciolkosz (1975), buried soil at 6'

Table 1. Periglacial Phenomenon in Pennsylvania (cont'd.)

Code#	USGS 7 1/2' Quadrangle* and/or General Location	Source or Reference and Remarks
G-13	Plainfield*; 2 miles S of Bloserville	Ciolkosz (1975)
G-14	Alfarata*; 1/4 mile SSE of Lawvers church	Ciolkosz (1977)
G-15	Allenwood*; 1 1/4 miles NNW of Kelly Crossroads	Ciolkosz (1974)
G-16	Lehighton* and Palmerton* Eastern Schuylkill Co.	Epstein et al. (1974)
G-17	Bloomsburg* and Mifflinville*	Inners (1981)
G-18	Linden* and Williamsport*	Sevon (1977a)
I-1	Schellsburg*; 1 1/2 miles SE of New Paris on Chestnut Ridge	Ciolkosz (1974)
I-2	Pine Grove Mills*; Penn State Univ. Agronomy Farm	Ciolkosz (1974)
I-3	Muncy*; Allenwood Terrace	Ciolkosz (1974)
I-4	State Gamelands, NW Lycoming Co.	Ciolkosz (1974)
I-5	Northcentral Clinton County	Tedrow (1972)
I-6	Dalmatia*; 1 mile NE of McKee Half Falls	Millette (1955)
I-7	Leighton*; near Beltsville Lake	Ciolkosz (1975)
I-8	State College*; 2300 m W of Rt. 64 and Rt. 144 intersection	Cronce (1987) 4 casts described
I-9	State College*; Penn State stadium	Cronce (1987)
I-10	Madisonburg*; 550 m E of Green Grove	Cronce (1987)
I-11	Spring Mills*; 1100 m NW of Farmer Mills	Cronce (1987)
I-12	Centre Hall*; 600 m N of Sprucetown church	Cronce (1987)

Table 1. Periglacial Phenomenon in Pennsylvania (cont'd.)

Code#	USGS 7 1/2' Quadrangle* and/or General Location	Source or Reference and Remarks
I-13	Pine Grove Mills*; Penn State Univ. Agronomy farm	Cronce (1987)
I-14	Mifflintown*; 1100 m E of Mt. Pleasant	Cronce (1987)
I-15	State College*; Penn State Univ. Campus	Cronce (1987)
I-16	State College*; 1 km N of State College	Cronce (1987)
I-17	Madisonburg*; 800 m S of Penns Cave	Cronce (1987)
I-18	Centre Hall*; 1.5 km SE of Tusseyville	Cronce (1987)
O-1	Hartleton*; 1 1/2 miles NE of R. B. Winter State Park	Marsh (1985)
P-1	Markleton*; Mt. Davis Summit	Clark (1968) polygons
P-2	Markleton*; Negro Mt.	Clark (1968) polygons
P-3	Broadtop Mt.*	Clark (1968) polygons
P-4	Mill Hall*; Risansares Mt. Lookout Tower	Clark (1968) polygons
P-5	Beaverdale*; 2 miles SE of Krayn	Clark and Ciolkosz (1974) polygons and stripes
P-6	Vintondale*; on Laurel Ridge S of U.S. 22	Clark and Ciolkosz (1974) polygons and stripes
P-7	Elliott Park*; 2 miles SW of junction I-80 and Pa 153	Clark and Ciolkosz (1974) polygons and stripes
P-8	Huntley*; 1 mile N of four mile road at Panther Rocks	Ciolkosz (1974) polygons and stripes
P-9	Portland Mills*; 6 miles NW of Ridgeway	Ciolkosz (1974) polygons and stripes
P-10	McAlevys Fort*; Whipple Dam	Ciolkosz (1974) stripes
P-11	Palmerton*; Lehigh Water Gap	Ciolkosz (1974) stripes
P-12	McAlevys Fort*; 1/2 mile SW of Bear Meadows	Hodgson (1967) polygons and stripes

Table 1. Periglacial Phenomenon in Pennsylvania (cont'd.)

Code#	USGS 7 1/2' Quadrangle* and/or General Location	Source or Reference and Remarks
P-13	McAlevys Fort*; 1 mile SE of Bear Meadows	Troutt (1971) polygons
P-14	Berwick*; Nescopeck Mt.	Crowl (1974) stripes
P-15	Newburg*; three square hollow	Ciolkosz (1975) polygons and stripes
P-16	McConnellsburg*; Big Mt. Lookout Tower, Tuscarora Mt.	Ciolkosz (1975) polygons and stripes
P-17	Caledonia Park*; Big Flat Ridge	Ciolkosz (1975) stripes
P-18	Potter County	Denny (1956) polygons and stripes
P-19	South Mt. area	Smith and Smith (1945) boulder streams
S-1	Woodward*; 1 1/2 miles NE of Woodward	Carter and Ciolkosz (1986)
S-2	Newton Hamilton*; 1 mile S of Airydale	Hoover (1983)
V-1	Hershey*; 1 mile N of Hershey	Ciolkosz (1974)
V-2	Central Berks Co.	Carey (1974)
V-3	Carlisle*; 1 mile N of Carlisle	Ciolkosz (1975)
V-4	St. Thomas*; 1 1/2 miles SE of Sandy Hook	Ciolkosz (1975)
V-5	State College*; 650 m SW of Rt. 26 and Rt. 64 intersection	Cronce (1987)
V-6	State College*; 750 m SW of Rt. 64 and Rt. 144 intersection	Cronce (1987)
V-7	Central Cambria Co.	Ciolkosz (1974)

#B = boulder fields
G = grezes litees
I = ice wedge casts
O = pingo scars
P = patterned ground
S = solifluction lobes
V = involutions

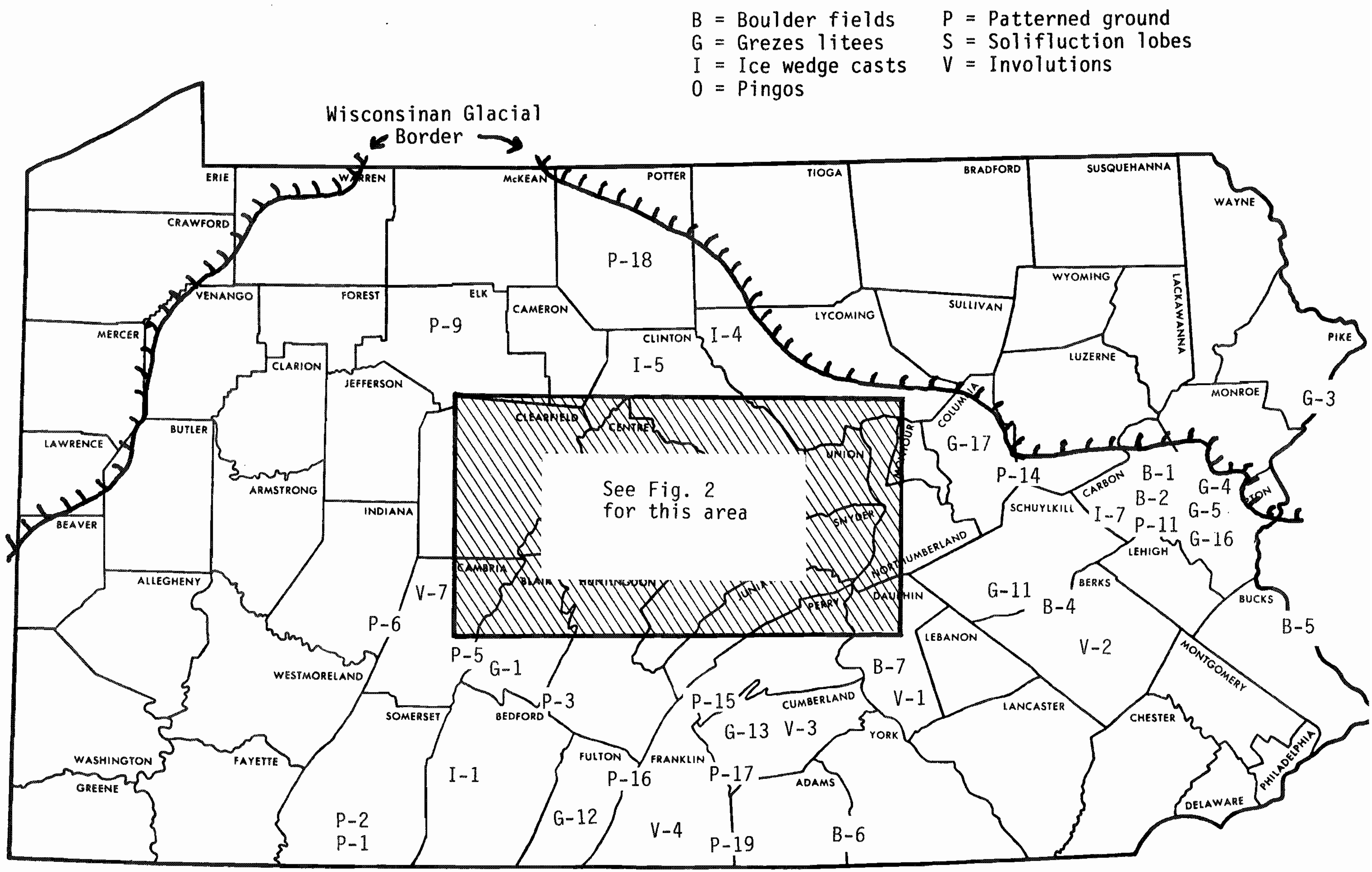
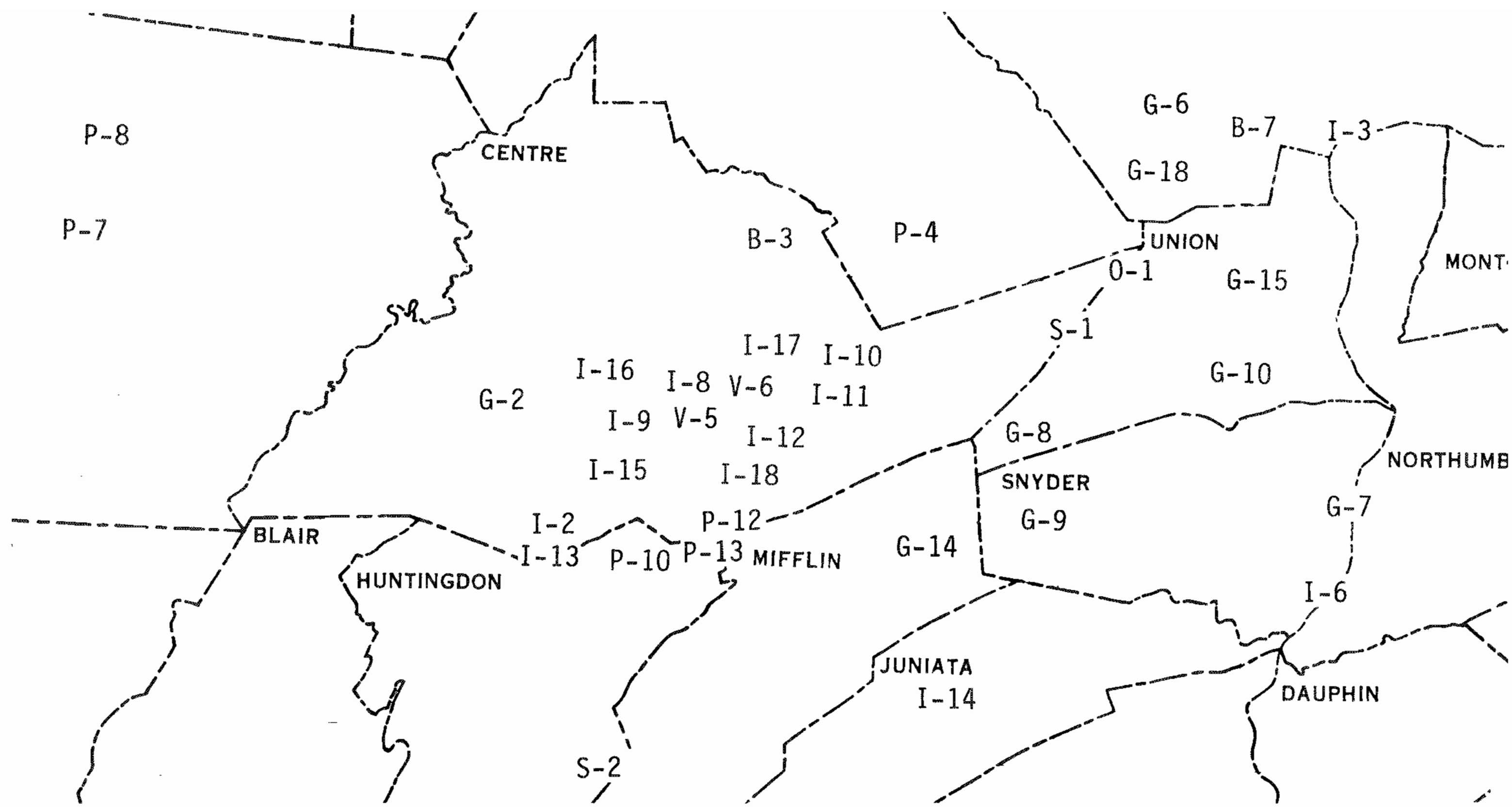


Figure 1 General location map of periglacial features in Pennsylvania (colluvium is found throughout the unglaciated area).



B = Boulder fields
G = Grezes litees
I = Ice wedge casts
O = Pingos
P = Patterned ground
S = Solifluction lobes
V = Involutions

Figure 2. General location map of periglacial features in central Pennsylvania (see Fig. 1)

present both north and south of the boundary. Thick, well-developed soils are found south of the boundary while thin, less well-developed soils are found north of the boundary (Simpson, 1984). Apparently the soils north of the line were truncated by periglacial erosion while those south of the line were not.

The recognition of periglacial features in Pennsylvania is important for several reasons. From a perspective of soil genesis these features identify soils and soil materials that were present on the landscape prior to and following the periglacial event. Thus these features indicate a minimum age of the landform and soil within which the forms are found. In addition, some soil characteristics observed today may be related to a climate that predated the periglacial event and therefore are relic with respect to present soil forming processes. This fact may be important in making meaningful soil interpretations based on the presence of certain soil characteristics. Periglacial activity in soils has created a more heterogeneous soil material than was present prior to the periglacial event. This variability in soils has only recently been recognized (Cronce, 1987). This fact has practical meaning when assumptions about an area of soil are made on the basis of one observation. This variability is also an important consideration when collecting a soil sample as representative of a particular soil area.

Colluvium

Deposits of hillslope colluvium are the most extensive of the various types of periglacial features in Pennsylvania, but they are seldom mentioned as such. They are the most important because they cover the largest area. All of the major ridges in the ridge and valley have a mantle of colluvium on the lower 1/2 to 3/4 of their slopes. The colluvium ranges from less than 1 foot to more than 100 feet in thickness. The deposits form both simple side slope and more complex fan deposits. The simple slope deposits extend 1/2 mile from the ridge crests on the average and the fan deposits commonly extend 1/4 to 1/2 mile beyond the simple slope deposits. The soils in these deposits show moderate development and have argillic horizons and fragipans. A discussion of the genesis of these soils is presented by Ciolkosz et. al. (1978; 1986).

The occurrence of colluvium is not restricted to the ridge and valley area: colluvium is also extensive in the Appalachian Plateau area. The data in Table 2 indicates that a typical county in the ridge and valley has about 27% of its area covered by colluvium. Only about 13% of a typical county is covered by colluvium in the plateau. In addition to soil mapping, detailed geologic mapping of colluvium has taken place in many areas particularly in the eastern part of the state (Berg, 1975; Hoskins, 1976; Inners, 1978; Root, 1977; Sevon, 1975, 1977b; and Wells and Bucek, 1980).

The chronology of deposition of the colluvium is difficult to ascertain. The authors are not aware of any radiocarbon dates from colluvial material in Pennsylvania. Similar soil development on similar colluvium (same lithology) in different parts of the state suggests a similar age for the colluvium. The soils developed in the colluvium are similar in some respects, particularly the occurrence of fragipans, to soils developed in glacial till of Woodfordian age. However, these colluvial soils also have argillic horizons which may indicate an age somewhat older than Woodfordian (late Wisconsinan). Therefore, much of this colluvium may represent periglacial solifluction deposits of possibly Altonian (early Wisconsinan) age. A speculative chronology might start with the early Woodfordian or possibly Altonian.

Table 2. Percentage of Colluvial, Fluvial (Floodplain and Terrace) and Residual Soils in Four Counties in Pennsylvania, (Ciolkosz, 1978).

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

As the ice moved forward a periglacial climate with tundra vegetation triggered down slope solifluction movement. 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 than soils developed in Woodfordian glacial till. 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 Woodfordian Age glacial till of similar lithology. In addition, Hoover (1983) and Waltman (1985) have shown that a large amount of pre-Wisconsinan colluvium occurs beneath the Wisconsinan colluvium. The pre-Wisconsinan colluvium is generally distinctive because of its red high chroma colors and its well developed buried soils. Observations by the authors indicate that the older colluvium is widespread throughout at least the eastern half of the state. Hoover (1983) suggested that the pre-Wisconsinan colluvium might have been deposited during the Illinoian and weathered during the Sangamonian. However, Pierce (1966) raises the possibility that some of this colluvium could be older than Pleistocene. Regardless of the age of the pre-Wisconsinan colluvium at least a part of it would have been included in the formation of younger colluvium. Clearly, much work remains to be done before we have a clear understanding of the genesis of colluvial deposits in Pennsylvania.

At the present time Pennsylvania colluvial slopes appear stable except where the toe of the slope has been disturbed. There is no direct evidence that material is moving down undisturbed colluvial slopes. Little or no deformation of trees occurs on most colluvial slopes and the presence of argillic horizons and fragipans in the colluvial soils is indicative of slope stability. These colluvial slopes may be in a "super stable" condition at present because the angle of repose of the deposits has been inherited from periglacial times. The angle of repose of the colluvial slopes is less than that possible under present climatic conditions thus making the slopes "super stable" to natural downslope movement.

Loess

Loess is not strictly a periglacial deposit, but it is discussed because of its presumed association with glaciation in Pennsylvania. Loess occurs adjacent to the Delaware, Susquehanna, and Allegheny rivers. The loess varies from less than 1 foot to 3 to 5 feet in thickness on gentle slopes. Greater accumulationa are found in footslope areas and locally elsewhere (Millette and Higbee, 1958). Loess less than 1 foot thick is very difficult to identify in soil profiles and it is quite likely that more loess is present in Pennsylvania than has been reported. Loess does not extend laterally away from the major river valleys for any appreciable distance in Pennsylvania, particularly where the slopes are steep. The loess was apparently eroded--either contemporaneous with or subsequent to its deposition. This is well illustrated in Bucks County adjacent to the Delaware River. In the central part of the county soils on slopes less than 8% are developed in brown loess. Soils on steeper slopes in the same area are developed in red Triassic sandstone and shale material that underlies the loess (Carey, 1978). The brown and red soils contrast strongly and are easy to identify on these landscapes.

The works of Carey et al. (1976), Carey (1978), and Peterson et al. (1972) along the Delaware River and that of Millette and Higbee (1958) and Peltier (1949) along the Susquehanna River provide the only meaningful information about loess in Pennsylvania. There is a particular dearth of information for western Pennsylvania. Field observations indicate that loess is very extensive in many areas of western Pennsylvania, but there is no documentation of its distribution or character.

All of the loess in Pennsylvania appears to be of late Wisconsinan (Woodfordian) Age. The placement of the loess as Woodfordian Age is based on similar soil development in the loess in unglaciated areas (Bucks and Lycoming counties) and in glaciated areas (Bradford county). In the glaciated area the loess is found on top of Woodfordian till. Altonian and pre-Wisconsinan loess must have been deposited, but no unequivocal loess deposits of these ages have been reported nor have any been observed by the authors. Such deposits presumably exist and may be identified during future investigations.

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No. 25	Cunningham et al. 1972. Laboratory Characterization Data and Field Descriptions of Selected Pennsylvania Soils. (This publication gives all the Pennsylvania soil characterization data up to 1972. Following 1972, data was published in the PA Ag Expt. Station Progress report series Characteristics, Interpretations, and Uses of Pennsylvania Soils: Number 290, Dauphin Co.; 295, Northampton Co.; 300, Huntingdon Co.; 306, Warren Co.; 316, Armstrong Co.; 320, Bradford Co.; 323, Bedford Co.; 324 Bucks Co.; 326, Butler Co.; 341, Soils Developed from Cherty Limestone Material; 344, Soils Developed from Colluvium; 355, Soils Developed from Redbeds and Calcareous Material; 362, Soils Developed from Acid Shale; 381, Minesoils. All of the data listed above plus subsequent data obtained is now in the following computer database: Ciolkosz, E. J. and N. C. Thurman. 1993. Pennsylvania State University Soil Characterization Laboratory Database, Agronomy Dept., Pennsylvania State University, University Park, PA.)
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