TRIM ALONG THIS LINE TO JOIN NORTHERN HALF

Base from U.S. Geological Survey, 1971

UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:50 000

5 MILES

7 KILOMETERS

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Landslides mapped by J.S. Pomeroy, 1975-76

INTRODUCTION

This map is one of a series of 1:50,000-scale county maps in the Greater Pittsburgh region; it identifies areas having potential slope stability problems. Intensive interpretation of 1975 GS-VDMO black-and-white aerial photographs (scale 1:24,000) was supplemented by field reconnaissance in late 1975 and early 1976. Some recent landslides have not been delineated as they are too small to be discerned on the aerial photographs. Furthermore, many slopes not designated as containing older landslides probably include some, but the geomorphic evidence for these has been obliterated by erosion or modified by man.

The map is essentially a guide to areas where detailed studies of slope stability would be most important to the general public. In these areas, site examinations are necessary to determine the degree to which slope instability affects a contemplated land use. The map is not intended to replace detailed geological and engineering studies of specific sites by competent technical personnel.

SOURCES OF DATA

The soil survey of Butler County (U.S. Soil Conservation Service, 1972) was used as a source of data. B. A. Breisch (Soil Conservation Service, Butler, Pa.) and Neil Hawks (Pennsylvania Department of Transportation, Indiana, Pa.) reviewed their knowledge of landslides in the county with me. The geology of Butler County is discussed by Patterson and Van Lieu (1971). The geology of the county is included in the 1:125,000-scale geologic map of the Greater Pittsburgh region (Wagner and others, 1975). Additional geologic maps for the area are listed in Briggs (1973). Modern detailed geologic quadrangle mapping is not available in Butler County. Slope stability studies in neighboring Allegheny County were conducted by Briggs and others (1975) and by Pomeroy and Davies (1975); the former publication includes recommendations and advice on slope stability for the nontechnical user. The present map supersedes a preliminary version by Pomeroy (1977a).

GEOLOGY AND SOILS AND THEIR RELATION TO LANDSLIDING

Bedrock in Butler County is composed almost entirely of coal-bearing rocks of Pennsylvanian age (figs. 1, 2) which include, from oldest to youngest, the Pocono, Pottsville, Allegheny, and Conemaugh Groups. Glacial deposits occur in the extreme northwest corner of the county.

Most landslides observed in Butler County occur in colluvial or residual clay and clayey silt soil derived from mudstone, claystone, shale, siltstone, and glacial till. Soils derived from the red claystones and mudstones of the Conemaugh Group are particularly prone to sliding (fig. 3). Soils in part designated as Gilpin-Upshur and Vandergrift-Cavode (U.S. Soil Conservation Service, 1972) largely overlie the "Pittsburgh redbeds" and an unnamed mixed red-bed and non-red-bed sequence above the Ames Limestone Member of the Glenshaw Formation (fig. 2) in the hilly southern part of the county. The "Pittsburgh redbeds" also include greenish-gray, gray, purple, and tan mudstone, claystone, and shale. This unit probably averages 9 to 14 m in thickness.

The red beds weather very rapidly to a plastic red residual clay having low shear strength on exposure to air and water. If a dried sample of the weathered red clay is immersed in water, it slakes or disintegrates within minutes into a soft wet mass. Fresh and unweathered red beds are sufficiently strong for many structural purposes.

Red clayey Upshur soil from a recent slide, adjacent to the Middlesex Presbyterian Church parking lot south of Butler and east of Pa. Route 8, possesses a moderate plasticity index of 16 (tests by S. Obermeier and M. Moore, U.S. Geological Survey). The clay minerals in the red soil, determined by X-ray diffraction techniques applied to samples from adjacent counties, include illite, kaolinite, and interstratified minerals (S. McNabb, M. Hoss, written commun., 1977). Similar clay mineralogical determinations and physical and chemical data of Upshur soil from a southern Butler County sampling site are discussed by Ciolkosz and others (1976).

Silty clay till soil (Tyler, fig. 3) in the northwestern part of the county is also prone to landsliding. One sample (analyzed by S. Obermeier and M. Moore, U.S. Geological Survey) gave a plasticity value of 23 which is in the higher limits of the moderate plasticity index range.

Generally, small slides have developed from weathered non-red claystone horizons of varying thickness beneath several coals in the Allegheny Group (particularly beneath the Upper Freeport coal, due to its great areal extent). Slides in underclays or other claystones can occur on Gilpin-Wharton, Cavode, and Wharton (fig. 3) slopes exceeding 15 percent. These soils are characterized by a moderate plasticity index and a medium to low shear strength.

The clayey materials throughout the area have a porosity as high as 40 percent, but their permeability is relatively low. As a result, only about 1 to 5 percent of the pore water drains by force of gravity (Subitsky, 1975). Susceptibility to sliding is high where excessive pore water pressure decreases the shear strength of the clay.

FEATURES SHOWN ON THE MAP

Recent Landslides

More than 95 percent of all recent slides in Butler County are small, generally less than 30 m in maximum dimension. Landslides smaller than 9 m in maximum dimension have not been plotted because of the map scale; they are considered soil slips. Slumps, earthflows, debris slides (figs. 4A-C) and combinations of the three are mostly thin-skinned in that they are generally less than 2.5 m thick. A few slides occurring in relatively thick colluvium along lower slopes involve heterogeneous unconsolidated material more than 15 m in thickness. Also, some slides occur in relatively thick manmade fill deposits which may or may not be related to mining.

Although a few recent slides have been caused by unusually heavy rainfall, most have been man-generated; these slides generally occur near roads and construction sites. Man's modifications of sensitive slopes include: excavation at the base of a slope resulting in its over-steepening, overloading a slope with fill causing instability, altering drainage conditions affecting both surface and ground water, and blasting and pile driving causing vibrations. Any one of these actions can cause slippage in earth material having low shearing strength.

Recent sliding is commonly observed along streams on the outside of curves where the slope is undercut by the water. Slides along Slippery Rock Creek at the northwestern edge of the county, southwest of Slippery Rock and slides along Connoquenessing Creek just north of Reibold and south-west of Butler are of this type.

Soil creep is the imperceptible downslope movement of soil and rock material (fig. 4D) and is not considered a landslide process; often accelerated creep precedes sliding. Creep is common on many slopes throughout the county, and on such slopes there is no ground breakage.

Most slides consist of slumps grading downslope into flows (fig. 4E). Although not shown in the diagram, springs and seeps, occasionally accompanied by the development of cattail marshes, commonly characterize the toe of a recent slide. Fresh scars not only at the head but throughout the entire landslide mass coupled with obvious frontal movement typify an active slide. About half of the slides shown as recent were active at the time of the reconnaissance. Several slides have become stabilized temporarily.

Slope failures in refuse from strip mines constitute more than 40 percent of the recent slides and are especially conspicuous in the western part of the county where the Upper Freeport coal bed has been actively strip mined. The slumps occur most commonly along spoil banks which lie along the slope adjacent to the bench. The movement has been generally restricted to the waste material itself and is largely independent of the underlying natural slope. The primary causes of sliding are poorly controlled surface and subsurface runoff and improperly compacted spoil material. Fewer slides, such as those in Brady and Allegheny Townships in northern Butler County, occur where the highwall has been cut into a colluvial slope, and the soil material lying above the highwall moves. Improper compaction and settling of backfill in one reclaimed area have led to accelerated creep along the modified slope 2.3 km east-northeast of the Lake Arthur dam. Some settling of reclaimed material at the site of the former headwall has produced small discontinuous scarps without any apparent frontal movement about 1.5 km south of Portersville.

Slumps in fill not produced by mining are few. However, one of the largest recent landslides in the county is located behind a gas station on the north side of Pa. Route 68, just northwest of Butler Area High School. Overloading by fill has caused the massive 120-m-wide recurring failure.

A relatively fresh, arcuate slide area on the east side of Interstate 79, 6 km north of the Allegheny County line, spans approximately 140 m at its maximum width; it is clearly discernible on the aerial photographs. A rock-cut bench between the highway and the bowl-shaped landform suggest a massive slope failure during or shortly after construction of Interstate 79. Field inspection indicated that a complete renovation of the slope area and substantial removal of red soil derived from the Pittsburgh red beds should stabilize the area. Neil Hawks (oral commun., 1977) informed me that failure of the slope occurred during construction in the summer of 1968. The massive slide involved an estimated 765,000 m^3 of rock and colluvium; it is exceptional because of its immense size and because the head of the slump extended into bedrock. Preconstruction aerial photographs suggest that the recent slide area was part of an older landslide.

A large earthflow (roughly 91 m wide and 60 m long) in Winfield Township, 0.8 km northeast of Leasureville, was caused by heavy rainfall according to a local resident. Red clay derived from the Pittsburgh red beds formed the slippage surface.

Small recent slumps in glacial till have occurred in the Slippery Rock area. The slides seldom exceed 12 m in width and are more properly considered soil slips. The slump material involves a relatively homogeneous bluish- to brownish-gray clay. The most notable examples observed are 4.8 km south of Slippery Rock in road cuts immediately south of Slippery Rock Creek and Big Run.

Several small landslides and soil slips occur near the Upper Freeport coal bed in the Connoquenessing drainage area east, north, and northwest of Evans City. It is very probable that slippage occurs in the plastic underclay (fireclay). Records of core holes in Butler County and adjacent Beaver County indicate that underclays in the Allegheny Group are as thick as 3.6 m (Richardson, 1936). A relatively large slide (now "buried") involving the displacement of approximately 70,000 m^3 of rock and colluvial material occurred during construction of U.S. Route 422 in 1973 about 4 km east of Butler. Neil Hawks (oral commun., 1977) believes that the slippage surface is the Upper Freeport coal underclay.

Older Landslides

More than 3,000 older landslides in Butler County have been identified in the present inventory. More than 80 percent of the older landslides are only fair to poorly defined (indefinite); the remainder of the older slides have boundaries that are better defined and geomorphic features that strongly indicate former slope movement. Hummocky ground typifies the lower slope of most slides mapped as definite older landslides. Erosion has subdued the head scarp and the hummocky lower slope of indefinite older landslides.

Generally, older landslides occur in hillside recesses that are concave both across slope and downslope (fig. 5). Instability is greater in these concave-shaped areas which collect more ground water than adjacent slopes. Colluvial material at the foot of many older landslides exceeds 10 m in thickness.

Some of the mapped landslides are individual bodies and others are a complex of slides covering areas up to 1 km in width. Most of the designated older landslide areas, whether single or complex, are progressive accumulations of deposits from landslides that probably occurred during and immediately after Wisconsin Glaciation when rainfall was considerably heavier than it is presently. Some older landslides, however, represent slope movements which have occurred within the past 100 years.

Older landslides may be presently stable but can be reactivated where modified by excavation, loading, and changes in drainage conditions.

Areas most susceptible to sliding

Areas underlain by the Pittsburgh red beds (and other thinner red mudstones of the Conemaugh Group) are more susceptible to landsliding than are other areas. A high density of definite older slides and recent slides is in a zone involving not only the Pittsburgh red beds but less persistent basal red beds in the Casselman Formation in the southern part of the County. Generally slopes located within this zone are greater than 15 percent.

The areas along a 6-km section of Slippery Rock Creek and along adjacent tributary streams are also included in this unit; they have a relatively high concentration of older landslides and mostly unmapped small recent landslides that are best designated as soil slips in the glacial till.

There is a relatively high incidence of recent small landslides and soil slips along the underclay in the Upper Freeport coal zone in the basin of Connoquenessing Creek east of Interstate 79 and west to southwest of the Butler area. Elsewhere the occurrence of recent and older landsliding at this horizon is relatively rare. The extensive outcrop of this horizon throughout the county (fig. 1) and the landslide susceptibility within the zone (fig. 2) are comparable to those of the mudstones immediately below and above the Ames Limestone Member of the Glenshaw Formation (fig. 1). The density of recent and definite older landsliding at the Freeport coal underclay, however, is minor compared to the landslide density in the mudstones. No graphic representation of this zone is shown on the map due to its thinness.

It is important to realize that landslides can occur anywhere in the geologic section when optimum conditions for slope movement are present. For example, a troublesome slide area 2 km southwest of Parker along Pa. Route 268 in the northeastern part of the county occurs in colluvium underlain by the Pottsville Group.

Slope movement problems are minimal in a broad area of little relief extending northwestward from Winfield Township in the southeastern part of the county nearly to Lake Arthur northwest of Butler. The area is largely underlain by massive sandstones in the Glenshaw Formation of the Conemaugh.

Slope stability problems in Butler County are not as severe as those in adjacent counties to the southeast, south, and southwest due to a considerably limited areal extent of the red-bed horizons, more moderate slopes, and a combination of decreased urbanization and fewer cut-and-fill operations. Significantly, the area in Butler County having the greatest susceptibility to landsliding lies in a region of moderate to relatively rapid growth (Cranberry, Middlesex, Penn, and Buffalo Townships). As development in southern Butler County continues, the knob or hill areas which afford scenic vistas will probably be utilized. It must be emphasized that red mudstone, claystone, and shale make up much of the bedrock underlying these hills. Proper engineering and judicious control of land use in these sensitive areas will be needed to control the threat of slope movement (Pomeroy, 1977b).

ROCKFALLS (not shown on map)

In an area underlain by cyclic sedimentary rocks, widely differing physical characteristics of the individual rock lithologies cause geologic engineering problems. The rockfall problem is a prime example.

Rockfalls (fig. 4F) are produced by weathering and erosion that affect mudstone and shale more readily than sandstone, siltstone, and limestone. As a result, unsupported ledges of the more resistant rocks break away by falling. In Butler County rockfalls are common only in cut slopes along main highways (Interstate 79, U.S. Route 422, north and east of Butler, Pa. Route 8, south of Butler) and along secondary roads traversing major drainage basins such as Connoquenessing Creek. However, the volume of rockfall in these localities is very small, and rockfalls have not been shown on the map. Rockfalls can occur anywhere in the geologic section. The hazard is serious in the Pittsburgh area due to greater relief and urbanization; one rockfall in Beaver County in 1942 killed 22 people (Ackenheil, 1954).

SUMMARY

More than 3,000 landslides have been identified in Butler County. Less than 3 percent of these happened in historic times. More than 40 percent of the recent slides were in coal spoil banks. Movement on natural slopes is related to specific rock sequences, primarily red claystone in the Conemaugh Group, non-red claystone and underclay in the Allegheny Group (mostly in the Upper Freeport coal zone), and in silty clay glacial till. The greatest potential for landsliding occurs on slopes underlain by the Conemaugh Group in the southern part of the county. One of the largest slides anywhere in the Greater Pittsburgh region took place along Interstate 79 during its construction; part of this slide was in bedrock. Proper engineering and judicious control of land use in sensitive areas can reduce the threat of slope movement.

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Note: This map cannot be used as a substitute for detailed onsite geological and engineering investigations of slope stability.

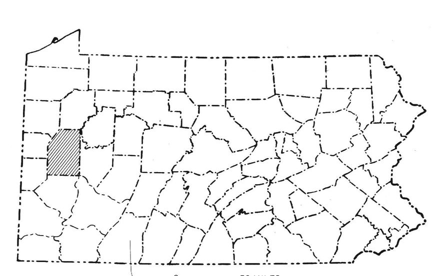
EXPLANATION
(See text for additional information)

S(P) Recent landslide--Well-defined; characterized by fresh scars; may still be active. Arrow used to point out symbol. Selected examples of slump, S; fill slump, FS; earthflow, E; mining-related slide, M. Letter in parentheses indicates geologic horizon inferred to be involved in sliding; "Pittsburgh red beds," (P), Upper Freeport coal underclay, (F)

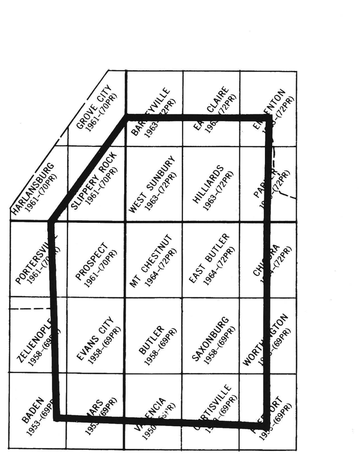
Older landslide--Approximately located. Dashed where landslides are indefinite or poorly defined

Area most susceptible to landsliding--Underlain largely by red mudstones of Conemaugh Group in southern part of county and by glacial till in northwestern part of county

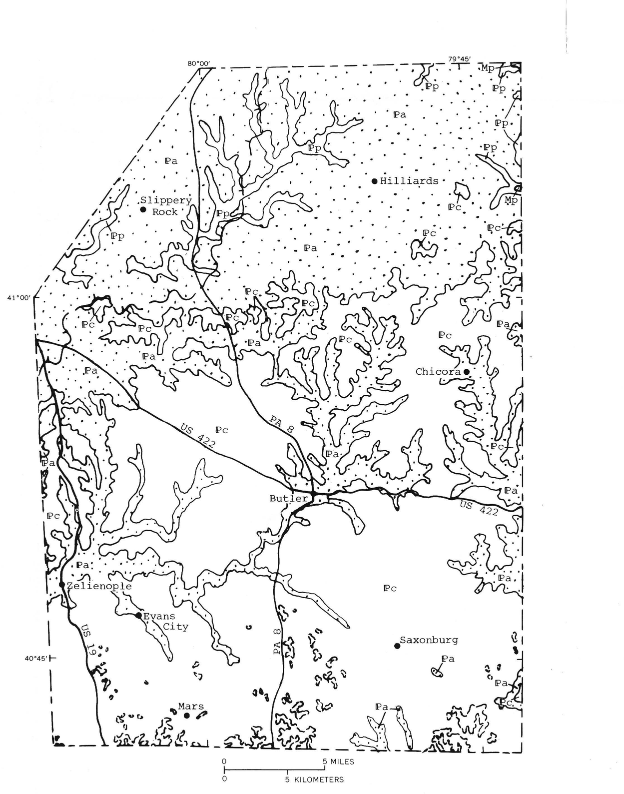
fig.5c Selected area shown in figure 5



County index map of Pennsylvania showing location of Butler County



Index to topographic quadrangle maps of the U.S. Geological Survey 7 1/2-minute series, Butler County, Pa.



EXPLANATION

Conemaugh Group--Ames Limestone Member of Glenshaw Formation indicated by dashed line

Allegheny Group--Upper Freeport coal occurs at top of group

Pottsville Group

Pocono Group

Limit of glaciation--Ticks toward glacier

Figure 1.--Generalized geologic map of Butler County, adapted from the geologic map of Pennsylvania (Pennsylvania Geological Survey, 1960).

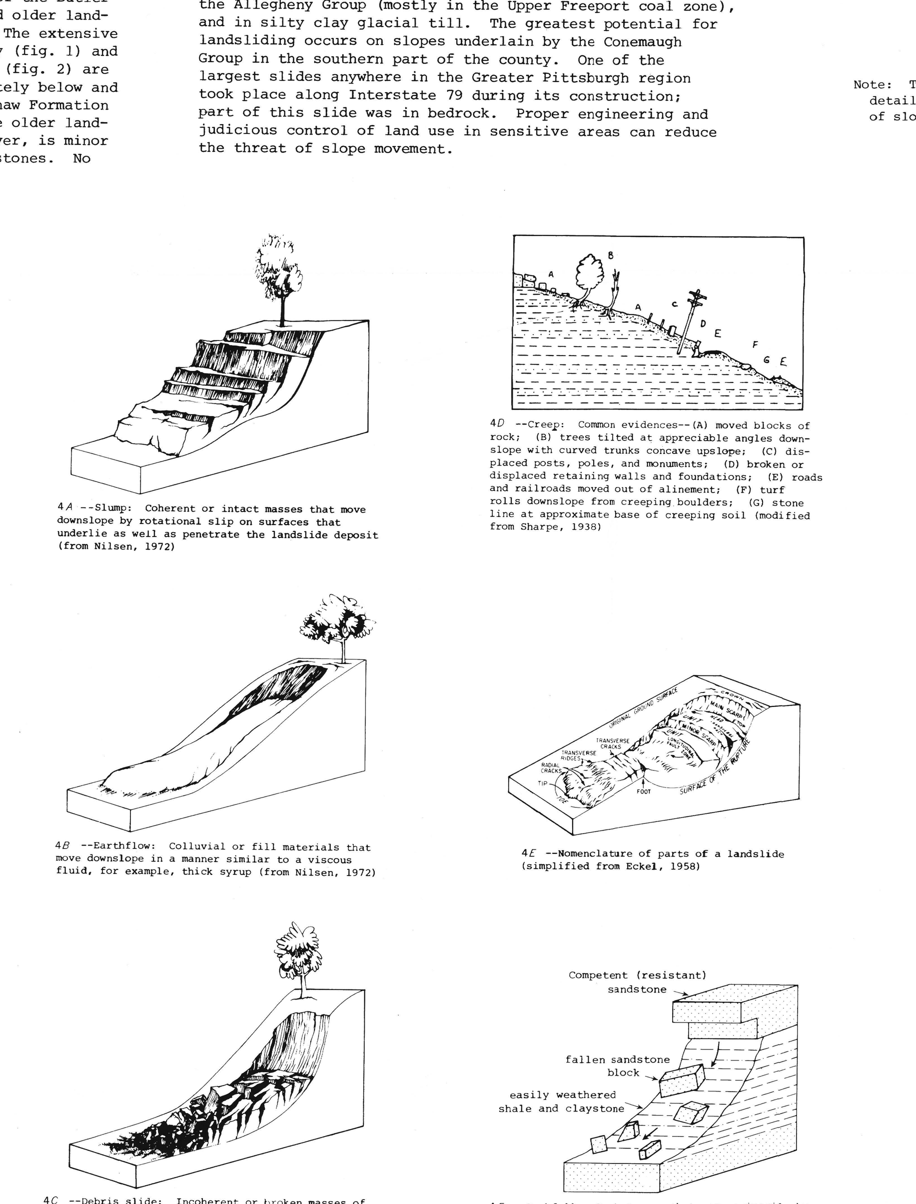
SYSTEM	GROUP	FORMATION	APPROXIMATE THICKNESS, IN METERS	LITHOLOGY SHALE--SH SHALE--SH MUDSTONE--MU CLAYSTONE--CL SILTSTONE--SI SANDSTONE--SS LIMESTONE--LS COAL--C	KEY HORIZONS UPPER--U MIDDLE--M LOWER--L	RELATIVE SUSCEPTIBILITY OF DERIVATIVE SOILS AND WEATHERED ROCK TO LANDSLIDING (assuming that rocks underlie slopes steeper than 15 percent, and that other conditions are generally equal)
Quaternary	Alluvium, terrace, and glacial deposits		0-30	Unconsolidated--clay to boulders		Negligible to low in terrace and glaciofluvial (sand-gravel) deposits. Moderate to moderately high in silty clay till
Pennsylvanian	Conemaugh	Casselman	161	SH, MU, SI, SS, CL, LS, C (cyclic)	Morgantown Sandstone Member	Low
					"redbeds" — Ames Limestone Member	Moderate to moderately high
		Glenshaw			"Pittsburgh redbeds" "redbeds"	Low to moderate
	Allegheny	Freeport	85	SS, SH, MU, SI, CL, LS, C (cyclic)	U Freeport coal — L Freeport coal	Moderate
		Kittanning			U Kittanning coal — M Kittanning coal — L Kittanning coal	Low to moderate
		Vanport Limestone			Vanport Limestone	
		Clarion			Clarion coal	
	Pottsville	Homewood	51	SS, SH, C		Low
		Mercer				
		Connoquenessing				
Mississippian	Pocono		60	SS, SH		Negligible

Figure 2.--Generalized stratigraphic section, Butler County, Pa. (modified from Patterson and Van Lieu, 1971), and relative susceptibility of derivative earth material to landsliding.

SOIL NAME	STRATIGRAPHIC INTERVAL OF PARENT MATERIAL	LITHOLOGY OF PARENT MATERIAL
Gilpin-Upshur	Conemaugh Group	Largely red mudstone, claystone, and shale
Vandergrift-Cavode	Conemaugh Group	Red and non-red mudstone, claystone, and shale
Tyler	Pleistocene deposits	Silty clay till
Gilpin-Wharton	Conemaugh and Allegheny Groups	Largely non-red shale, mudstone, and claystone
Cavode	Allegheny and Conemaugh Groups	Non-red shale, mudstone, and claystone
Wharton	Conemaugh and Allegheny Groups	Non-red shale, mudstone, and claystone

NOTE: Soils shown above are highly plastic and have a moderate or high shrink-swell potential (U.S. Soil Conservation Service, 1972). Landslides have been identified on all soils listed above.

Figure 3.--Major landslide-prone soils, Butler County.



4A.--Slump: Coherent or intact masses that move downslope by rotational slip on surfaces that underlie as well as penetrate the landslide deposit (from Nilsen, 1972)

4B.--Earthflow: Colluvial or fill materials that move downslope in a manner similar to a viscous fluid, for example, thick syrup (from Nilsen, 1972)

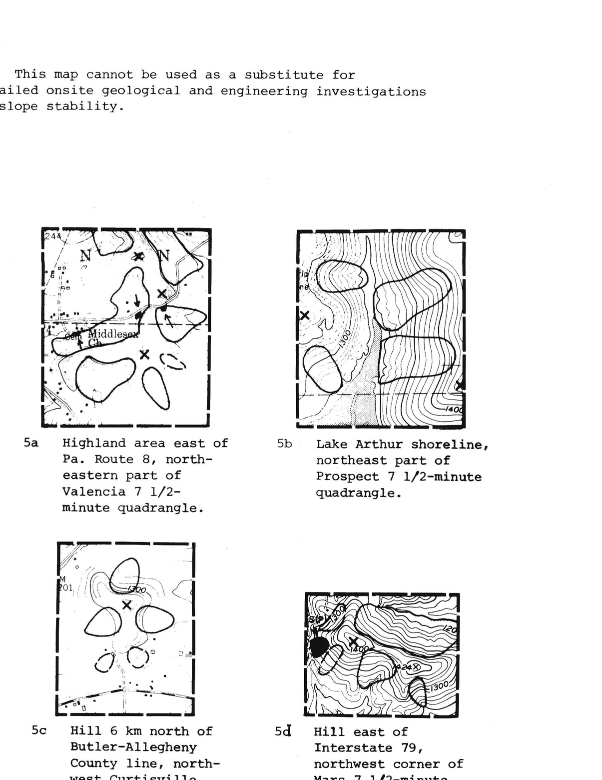
4C.--Debris slide: Incoherent or broken masses of rock and other debris that move downslope by sliding on a surface that underlies the deposit (from Nilsen, 1972)

4D.--Creep: Common evidence--(A) moved blocks of rock; (B) trees tilted at approximate angles downslope with curved trunks concave upslope; (C) displaced posts, poles, and monuments; (D) broken or displaced retaining walls and foundations; (E) roads and railroads moved out of alignment; (F) turf rolls downslope from creeping boulders; (G) stone line at approximate base of creeping soil (modified from Sharpe, 1938)

4E.--Nomenclature of parts of a landslide (simplified from Eckel, 1958)

4F.--Rockfall: Rock masses that move primarily by falling through the air (from Nilsen, 1972)

Figure 4. Diagrammatic representation of mass movement phenomena.



5a Highland area east of Pa. Route 8, northeastern part of Valencia 7 1/2-minute quadrangle.

5b Lake Arthur shoreline, northeast part of Prospect 7 1/2-minute quadrangle.

5c Hill 6 km north of Butler-Allegheny County line, northwest Curtisville 7 1/2-minute quadrangle.

5d Hill east of Interstate 79, northwest corner of Mars 7 1/2-minute quadrangle.

Contour interval, 20 feet

1 MILE

1 KILOMETER

EXPLANATION

Definite older landslide

Indefinite older landslide

Recent landslide

Top of hill

Figure 5.--Selected areas at 1:24,000 showing relation of older landslides to topography. Boundaries of older landslides are inferred to approximate.

MAP SHOWING LANDSLIDES AND AREAS MOST SUSCEPTIBLE TO LANDSLIDING, BUTLER COUNTY, PENNSYLVANIA

By
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1978

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