LANDSLIDE INVENTORY OF ILLINOIS

Myrna M. Killey Jennifer K. Hines Paul B. DuMontelle

CIRCULAR 534 1985
Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

Cover: Road crew surveys damage from 1972 rock fall in Monroe County, Illinois. (Photo courtesy of the Waterloo Republic-Times, Waterloo, Illinois)

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Frontispiece Aftermath of a 1972 rockfall in Monroe County. (Photo: The Waterloo Republic-Times, Waterloo, Illinois)

ABSTRACT

In 1982 the Illinois State Geological Survey, with the cooperation and partial support of the U.S. Geological Survey, initiated a program to identify, map, and classify all known landslides in Illinois and make this information readily accessible to builders, engineers, architects, geologists, planners, and the public. The Landslide Inventory Program includes (1) a state map (scale, 1:500,000) showing locations and types of all known landslides and landslide-prone areas in Illinois; (2) a table giving estimates of damage and actual repair costs reported for specific landslides; and (3) a bibliography of published information on Illinois landslides. A computer-assisted data file facilitates retrieval and updating of this information.

Although most Illinois landslides are not serious or life-threatening, they have caused millions of dollars of property damage over the years. They occur throughout the state, but are concentrated primarily in areas adjacent to major rivers and lakes. On the basis of geologic materials and type of movement, Illinois landslides are classified and described in this report and on the accompanying state map as rock falls, rock slumps, earth slumps, earth slumps on bedrock, earth flows, and rock creeps. Geologic conditions, other natural factors, and human use of land determine whether a landslide will develop. In landslide-prone areas, geologic conditions associated with landslide development include bedrock at ground surface, shallow bedrock overlain by loess and/or glacial tills, glacial deposits or loess, and saturated soils at ground surface. Other natural factors affecting landslide occurrence are slope angle, precipitation rate, freeze-thaw cycles, and vegetation. Human activities that may trigger a landslide include removing material at the toe, overloading the top, increasing water infiltration into the slope, or changing the character of the geologic materials in the slope. Unloading the top of the slope, increasing support at the bottom, draining or lowering the water table within the slope, preventing additional infiltration, and treating clay materials to improve their strength may help prevent or stabilize a landslide. The cause of slope failure must be determined before a slope can be successfully stabilized.

ACKNOWLEDGMENTS

Generous support from many sources made this study possible. Earl E. Brabb of the U. S. Geological Survey suggested the project and obtained partial financial support from the U. S. Geological Survey. Alan Goodfield, geologist with the Illinois Department of Transportation (IDOT) Division of Highways, provided locations and descriptions of landslides associated with highway construction and maintenance. IDOT highway engineers and geologists from several districts gave us information on landslides within their districts. Peter Waldo, geologist with the U. S. Department of Agriculture Soil Conservation Service, contacted regional soil conservationists in Illinois who provided much information and assistance. Robert Gibson of the Abandoned Mines Lands Reclamation Council and Richard C. Anderson of Augustana College reported on several landslides they had observed, and Susan Carol Bradford of the Survey's staff spent several days helping to field check and photograph landslides in the state. Many staff members of the Illinois State Geological Survey reported landslides encountered during their own field work.

Many Illinois residents—particularly those who live in flat areas—may be surprised to learn that landslides have caused millions of dollars of property damage in the state over the years.

Although most Illinois landslides are not serious or life-threatening, they are often troublesome to engineers, community planners, construction firms, and individual landowners, especially in years of heavy precipitation. The misconception that landslides do not occur in Illinois can produce a disregard for landslide potential and the use of precautionary measures. Subsequent landslide damage can then lead to delay or abandonment of construction projects and to considerable damage to private property.

According to the U.S. Geological Survey (1982) landslide potential is considered medium to high in parts of Illinois (fig. 1). Although landslides occur throughout the state, they are concentrated primarily in areas adjacent to major rivers and lakes.

Landslides have been observed by a number of researchers in various parts of the state and have been mentioned in their reports. Stratigraphic studies conducted at the Illinois State Geological Survey (ISGS) have included references to landslides, and stratigraphers have assigned formal stratigraphic names to landslides and related features. Willman and Frye (1970) gave the name Lacon Formation to " . . . gravity-initiated deposits, such as landslides, slumps, slips, and rock falls . . . " and the name Peyton Colluvium to " . . . the widely distributed but narrow belts of poorly sorted debris that have accumulated on the lower slopes and at the base of slopes by processes of creep, slopewash, and mudflow." But until recently there was no systematic procedure in the state for collecting information on landslides and landslide-prone areas that could be used to make preliminary assessments of site stability.

In 1982 the ISGS, with the cooperation and partial support of the U.S. Geological Survey, initiated a program to identify, map, and classify all known landslides in Illinois and make this information easily accessible to builders, architects, geologists, planners, and the public. The ISGS landslide inventory program now includes the following components:

- *a state map (scale, 1:500,000) showing (1) locations and types of all landslides on file as of March 1983 and (2) landslide-prone areas (plate 1).*
- *a table providing estimates of damage and actual repair costs reported for specific landslides in the state.*
- *a bibliography of published information on Illinois landslides available when this study was begun.*
- *a computer-assisted data file providing a quick means of searching and evaluating landslide inventory information.* (Information can be retrieved by county or by the unique landslide number assigned to each landslide.) The file is updated periodically.

The bibliography, damage/repair cost table, and a table summarizing types of landslides in Illinois are included in the appendix of this report.

Landslide information used in this project was compiled from several sources:

- *a literature search of published references to landslides in Illinois.*
- *responses to landslide report forms.* These forms, developed at the ISGS to encourage standardized reporting and mapping of landslides, were sent to district and field offices of the Illinois Department of Transportation and Soil Conservation Service to obtain information from personnel familiar with landslide problems in their local areas.
- *reports from ISGS scientists who observed landslides in the course of their field work.*

LANDSLIDE CLASSIFICATION

The landslide inventory map (plate 1) accompanying this publication was published in cooperation with the U.S. Geological Survey. The solid areas on the map are regions where Lineback (1979) mapped landslides, slumps, and rock falls as Lacon Formation and slopewash, creep, and mudflow deposits as Peyton Colluvium. In future stratigraphic classification of landslides mapped as part of this project, all landslide types except rock creep and earth flow will be classified as Lacon Formation; rock creep and earth flow will be classified as Peyton Colluvium.

In preparing this inventory map, we used a landslide classification system developed by Varnes (1978), adapting it slightly to suit geologic conditions in Illinois. Earl Brabb of the U.S. Geological Survey provided us with a standard set of symbols to classify landslides on the map by the geological materials involved (such as bedrock, glacial materials), major cause of the landslide (natural processes or human-induced), and by status (active or inactive). A symbol for "unclassified" was used to indicate landslides that could not be classified geologically because of a lack of data.

GEOLOGIC CLASSIFICATION

On the basis of the geologic materials and type of movement involved, Illinois landslides can be classified as rock falls, rock slumps, earth slumps, earth slumps on bedrock, earth flows, and rock creeps.

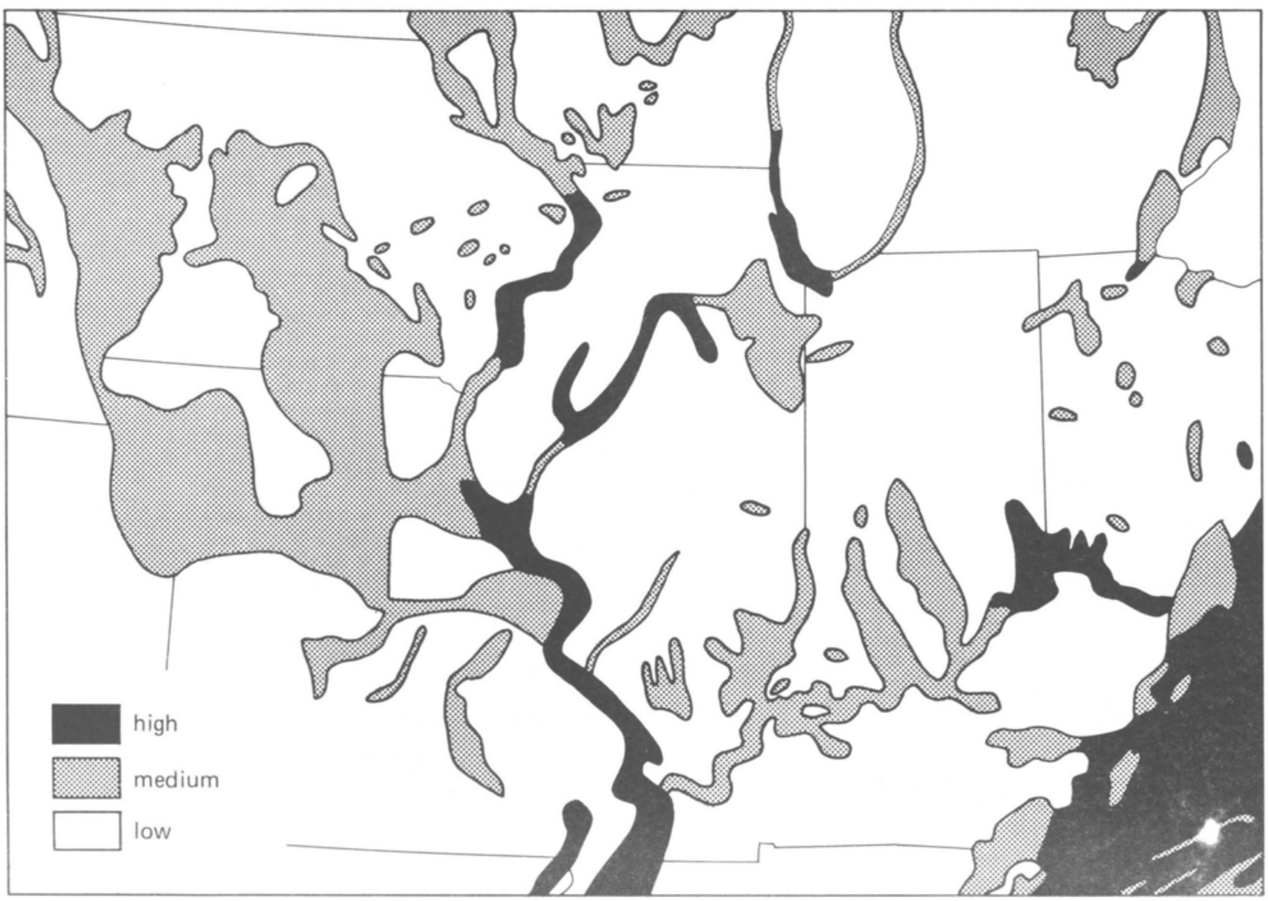

Figure 1 Landslide potential in Illinois (modified from USGS Circular 880, 1982).

A block of rock that falls freely (often precipitously) from a steep slope or cliff, or a block of well-drained loess or till in a competent bluff face that fails when undercut by erosion (fig. 2).

Rock falls occur primarily in areas of steep bedrock bluffs (usually Mississippian limestone) in western and southern Illinois along major stream and river valleys, especially the Mississippi River.

A landslide of this type occurred in July 1972 along the river bluff road in Monroe County (see frontispiece and fig. 2). Large limestone boulders fell approximately 200 feet from the jointed limestone bluff to the county road below, knocking down a power pole and lines and completely blocking the road. The bluffs consist of jointed limestone.

Stress relief fracturing associated with the erosion of the valleys may have contributed to this failure. As valleys are eroded, lateral support for the valley walls is lost; the walls then move in slightly toward the valley, producing vertical joints that parallel the valley. At the Monroe County site, repeated cycles of freezing and thawing of water in the joints over periods of years resulted in gradual detachment of blocks of rock from the bluff face, which then toppled. Roots growing between the joint faces helped force the blocks apart, allowing water and debris to infiltrate.

Although natural processes (valley stress relief, fracturing, root growth, freeze-thaw cycles, and periods of excessive rainfall) contributed to the failure, this slide was categorized in the inventory as a man-induced slide; during construction of a road at the toe of the talus pile, some of the underlying support for the bluff was probably removed during borrowing, and the loss of support was probably the most significant factor in triggering this landslide.

Toppling glacial material is common in the thick loess (windblown silt) region of southwestern Illinois. If excavation for construction sites or borrow materials undercuts the base of the Mississippi River valley bluffs, the overlying loess blocks may then fall down the slopes. A similar process occurs along the Lake Michigan shoreline, where glacial till (pebbly silt, sand, and clay) is underlain by sand deposits. If waves erode the sand, the overlying glacial till loses its support and topples—in large blocks—into the lake.

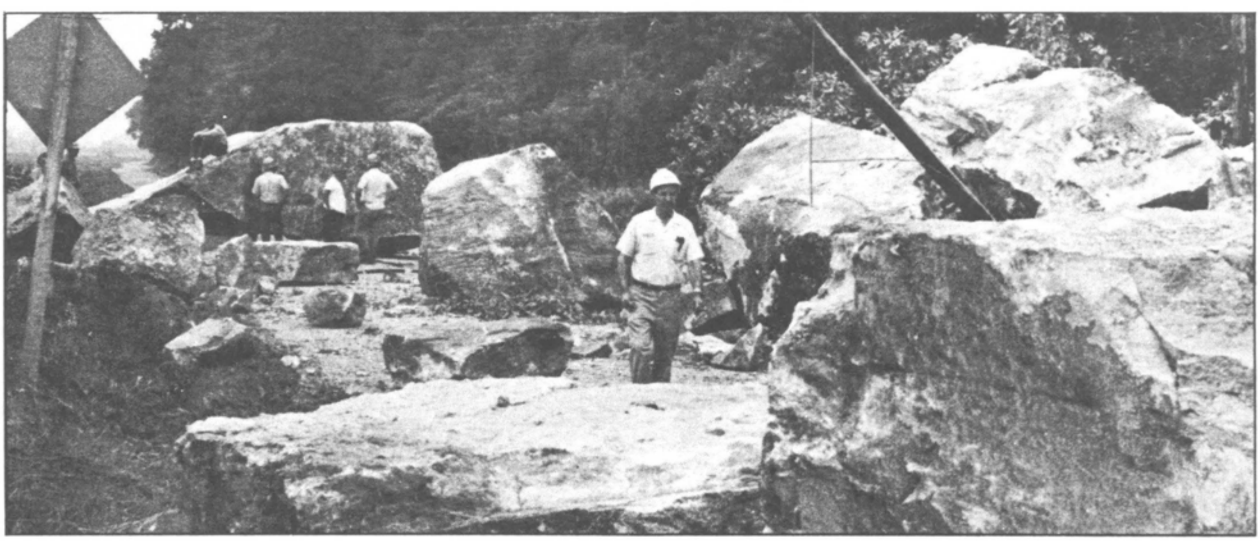

Figure 2 Huge limestone boulders crashed down from a limestone bluff in Monroe County in 1972, blocking a county road. (Photo: The Waterloo Republic-Times, Waterloo, Illinois)

SLUMP

A mass of rock or earth that moves down along one or more buried failure planes within the unit or between units. Such movement commonly involves some backward rotation of the slump block along a horizontal axis, generally parallel to the slope.

Nearly 60 percent of the landslides inventoried so far in Illinois are slump-type landslides. These landslides can be recognized by one or more of the following characteristics (fig. 3):

□ *a sharp cliff (the main scarp) several inches to several feet high,* resulting from the initial downward movement.

□ *one or more secondary scarp faces* resulting from successive slumps downslope.

□ *ponding or marshy areas that develop on the tops of individual slump blocks* because of the rotational backward tilting of the blocks.

□ *poor drainage in places throughout the slide area,* because cracks and depressions on the surface, and shear planes along the sides and under slump blocks, may disrupt normal drainage of rainfall and groundwater.

□ *dead trees (resulting from root damage or excess moisture)* and tilted trees (fig. 4), fence posts, and utility poles.

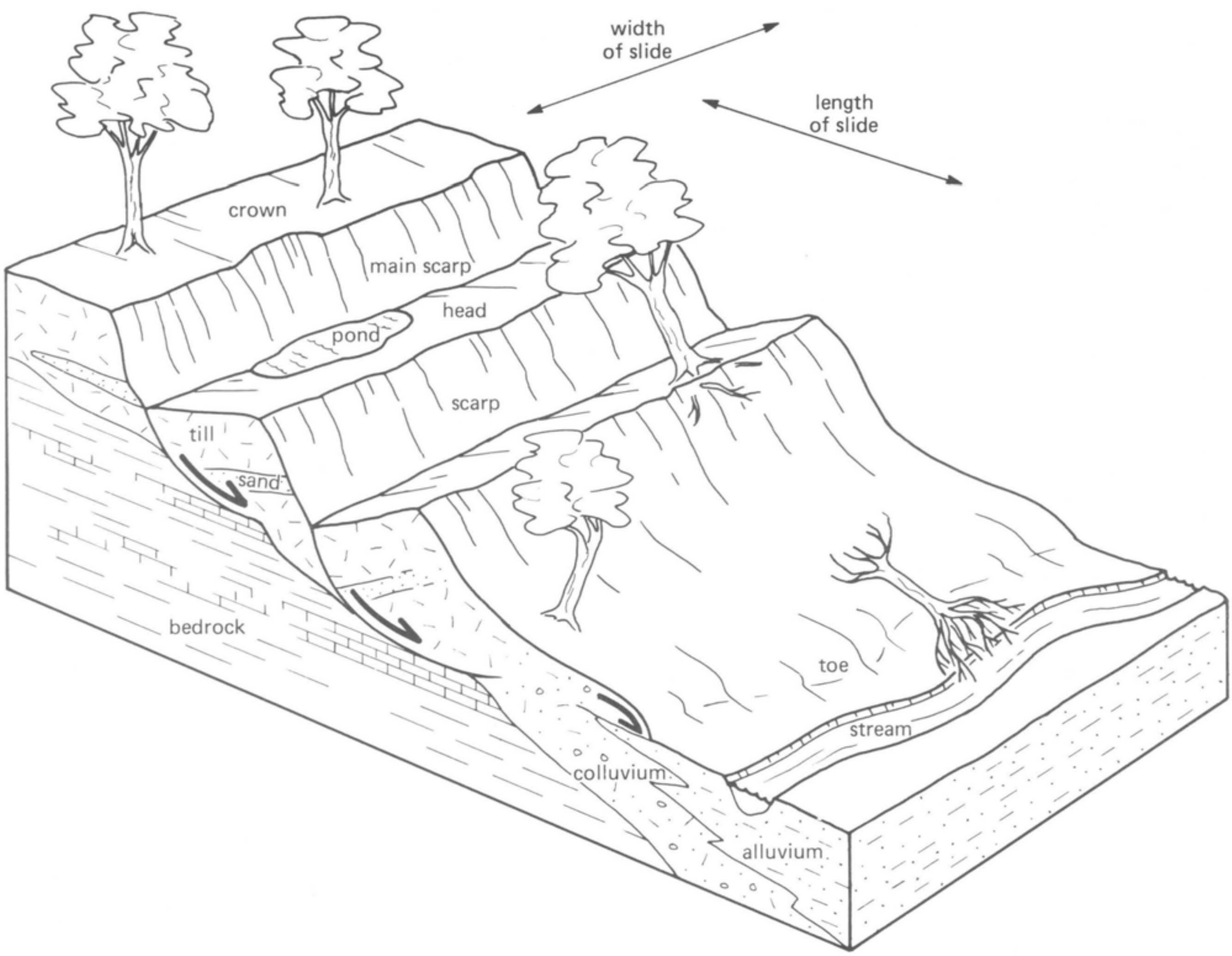

Figure 3 Major components of a slump-type landslide (modified from Fairbridge, 1968). Upper two arrows indicate backward rotation of blocks; lowest arrow indicates roll-over motion at toe.

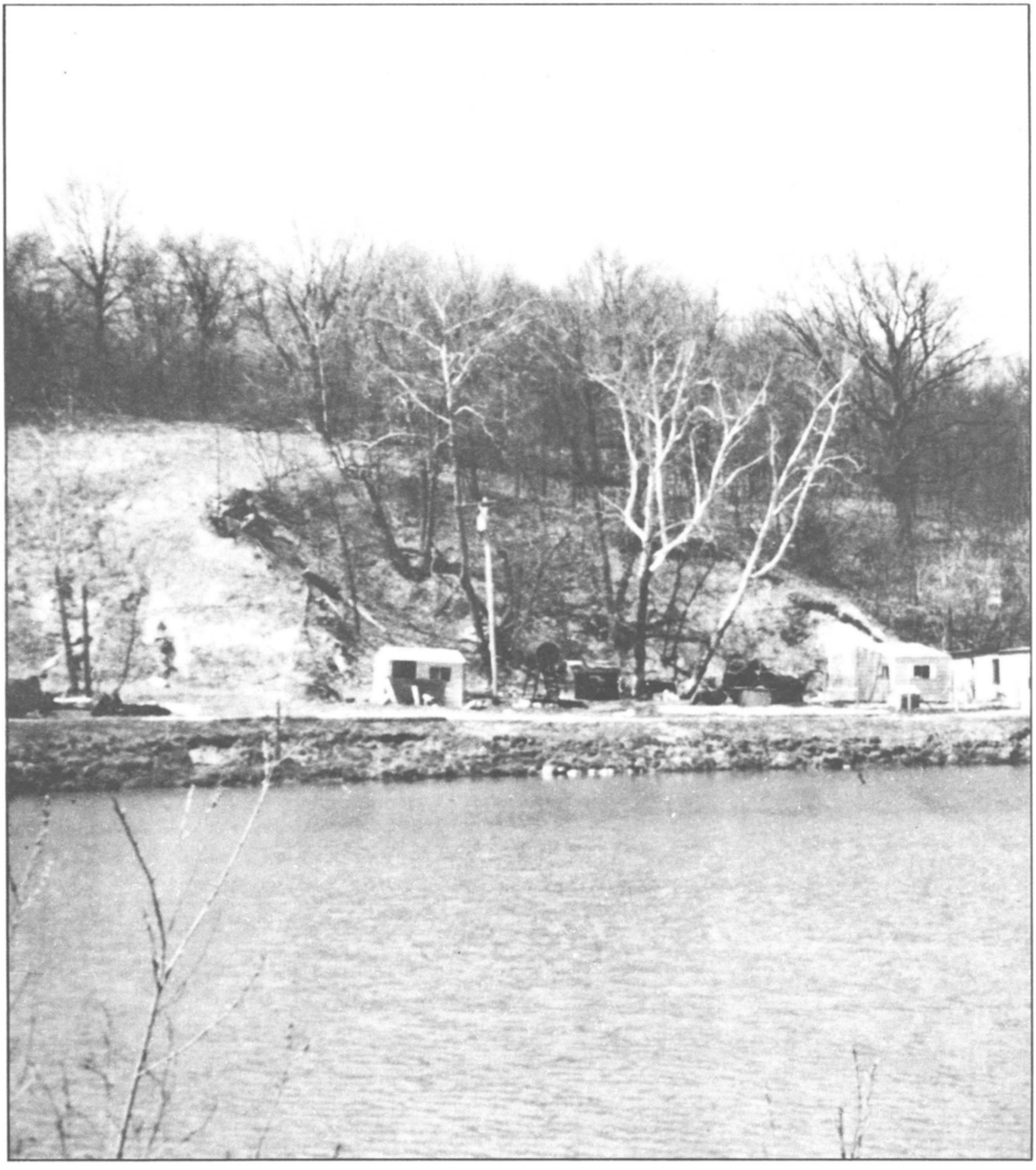

Figure 4 Tilted trees are characteristically found on slump-type landslides.

ROCK SLUMP

Blocks of bedrock and any overlying glacial material that slide on underlying rock (frequently blocks of competent limestone sliding on underlying shale). Water seeping down through the relatively permeable limestone collects at the contact between this rock and the underlying relatively impermeable shale, and contributes to the instability of the slope by increasing pore-water pressure and lubricating the contact, thus reducing friction to the point that slumping finally occurs (fig. 5).

Several examples of rock slumps can be found in Rock Island and Carroll Counties along the Mississippi River (fig. 6).

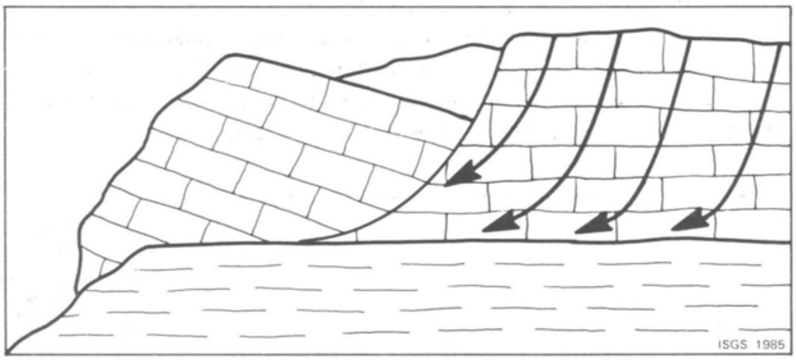

Figure 5

Figure 6 Pennsylvanian shale and overlying river alluvium have slumped here along Case Creek in Rock Island County. The entire block (extending from the foreground to the scar beyond the figures in the upper right) has moved toward the creek and has broken into several smaller blocks. Arrows show movement of the block. (Photo: Anderson, 1980)

Moderately consolidated, fine-textured (silty, sandy, clayey) glacial materials that slide when failure planes develop in them.

Earth slumps are the most widespread type of landslide in the state. A good example of an earth slump can be seen in figures 7 and 8; stream undercutting and an exceptionally wet spring resulted in successive earth slumps that damaged this road near Copperas Creek in Fulton County. The slope above the road was benched in an effort to stabilize it (fig. 9).

A photograph taken in 1974 of an area just south of the Lake Bluff sewage disposal plant in Lake County, Illinois shows the recession that had taken place in the bluff since failure of a bulkhead in 1970 (fig. 10). Wave erosion at the base of the bluffs and surface seepage (where downward-percolating water flows laterally along contacts with underlying, less permeable materials) contribute to slumping in this area (fig. 11). Figure 12 is a stratigraphic section of glacio-lacustrine sediments exposed on the Lake Michigan shoreline south of the Lake Bluff sewage disposal plant.

Figure 7 Slumping along the bank of Copperas Creek, Fulton County.

Figure 8 Road damage from additional slumping that had taken place by the time the authors revisited the same site 2½ weeks later. This photograph was taken from a spot behind the van (fig. 7). Slumping has also occurred on the hillside above the road.

Figure 9 This slope (along the same road shown in figs. 7 and 8) has been benched in an attempt to stabilize it.

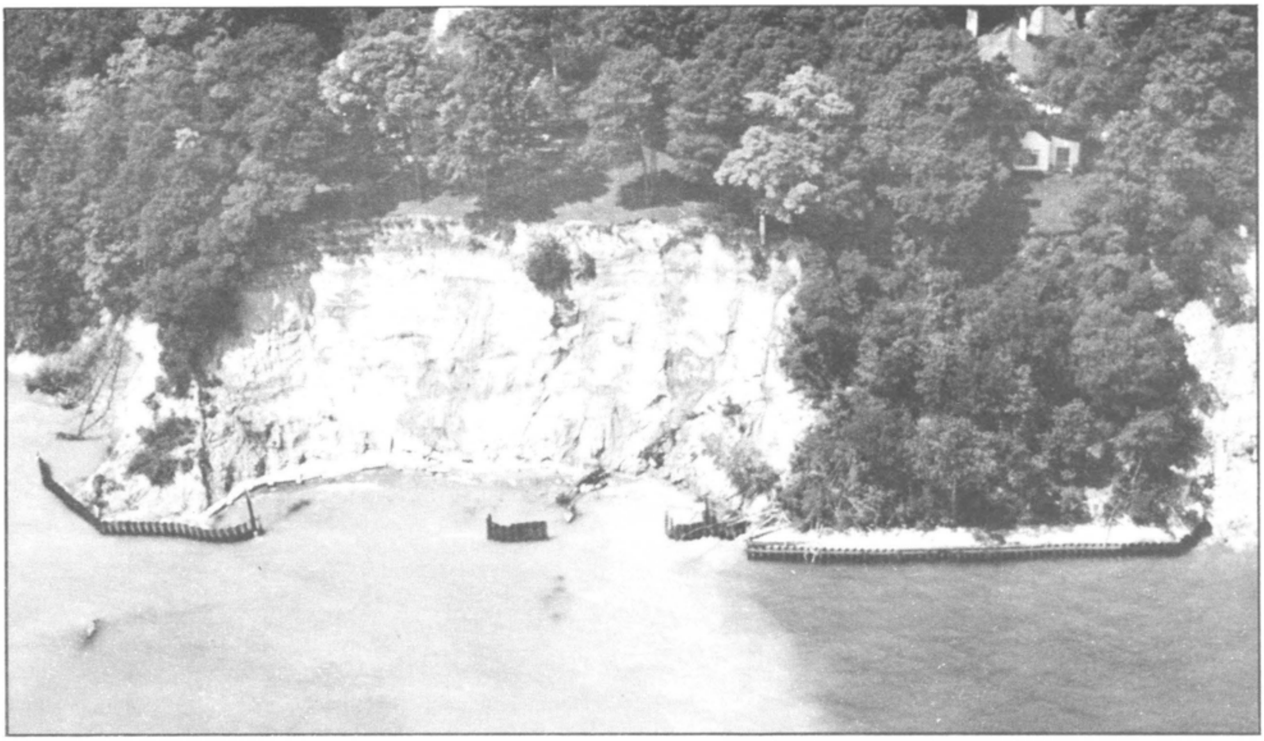

Figure 10 Lake Michigan shore just south of the Lake Bluff Sewage Disposal Plant (1974). The bluff remained vegetated and stable where the bulkhead was maintained. The houses on top of the bluff are less than 50 feet from the bluff edge. In 1975 the bluff toe was protected with riprap and the scarp was filled; the bluff scarp was revegetated and appears stable at the present time (Berg and Collinson, 1976).

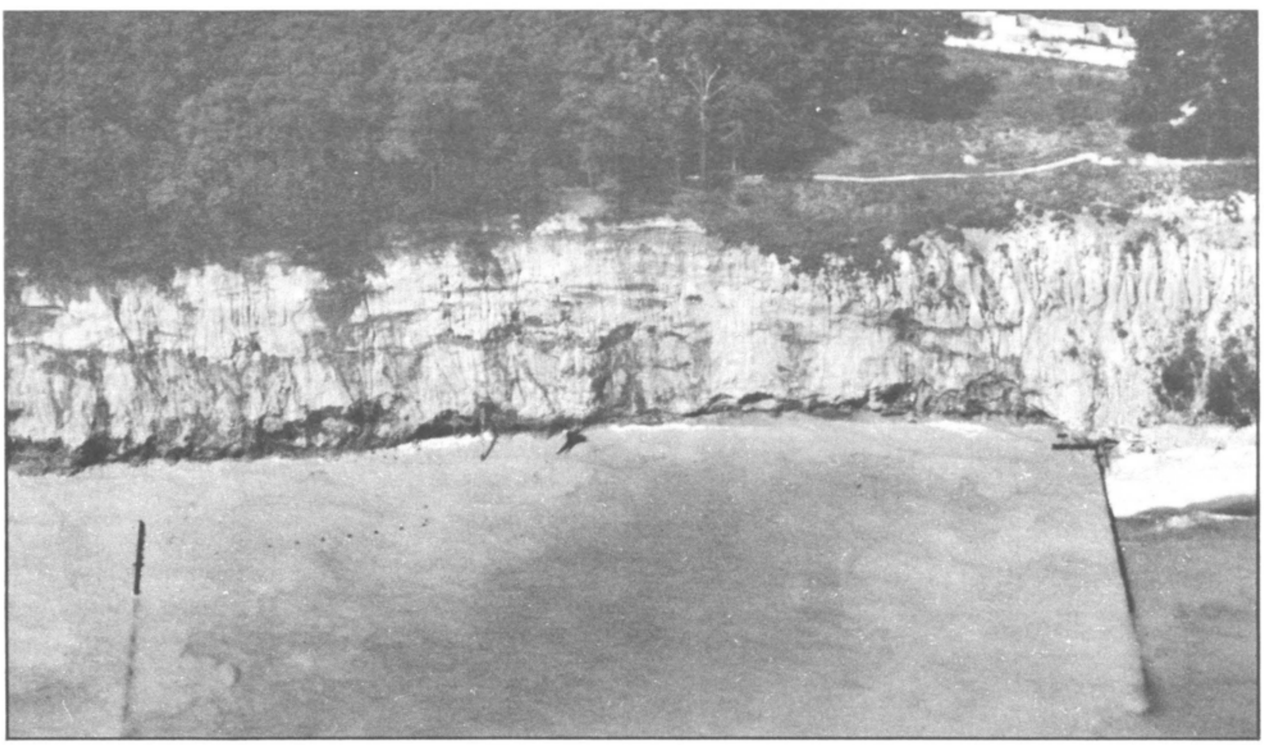

Figure 11 The irregular, dark line halfway up the face of this 70-foot bluff scarp in south Lake Bluff is the contact between the homogeneous glacial till and the weak, silty till, sand, silt, and clay sediments above it. Dark streaks indicate surface seeps. Surface waters drained over the bluff face, causing the vertical fluting of the bluff, and wave action undercut the foot of the bluff. The bluff receded 39 feet between 1964 and 1974, when this photograph was taken. Clay derived from the bluff is suspended in the water (Berg and Collinson, 1976).

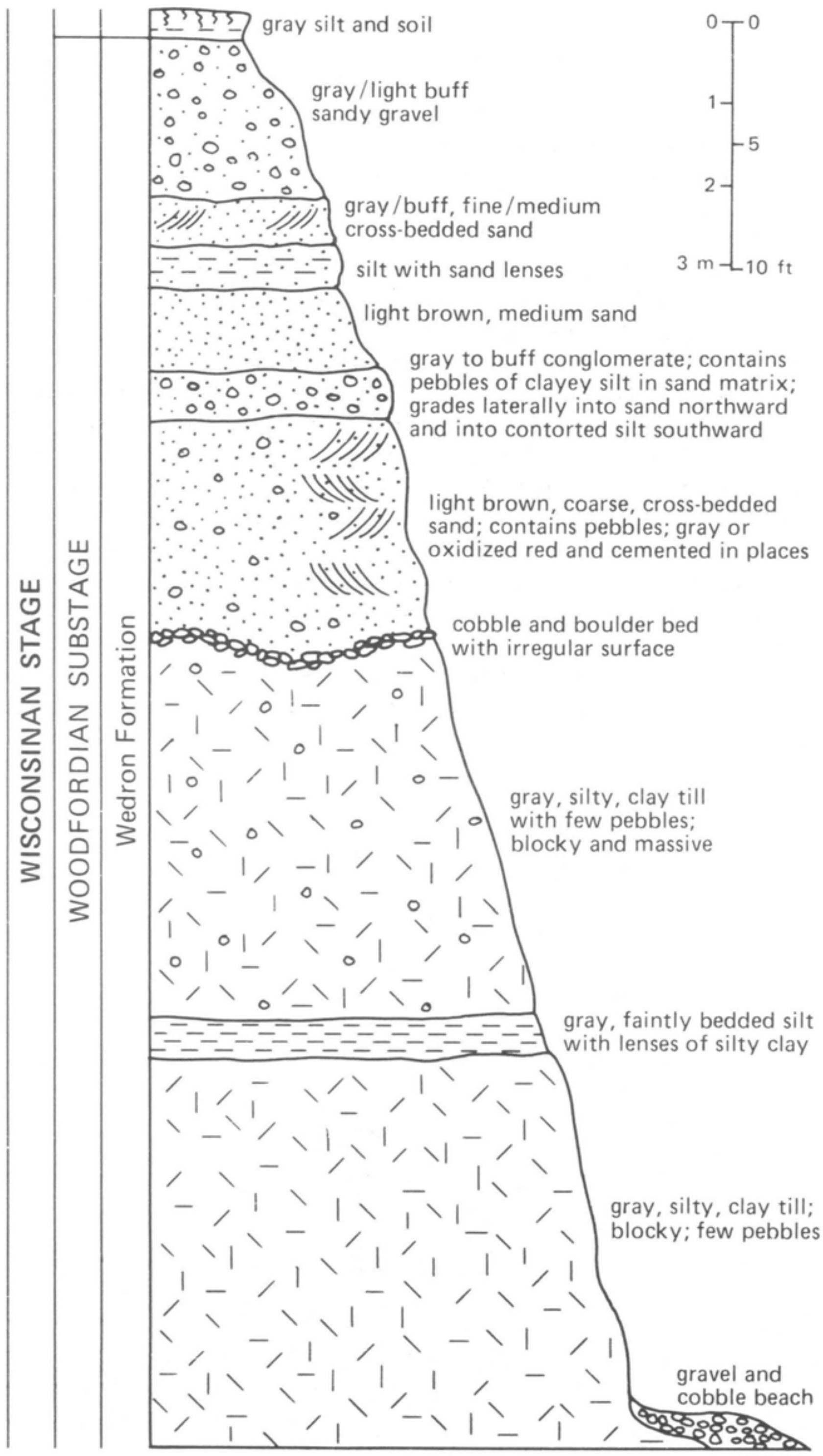

Figure 12 Stratigraphic section (described by DuMontelle, Stoffel, and Brossman, 1975) just south of the Lake Bluff Sewage Disposal Plant (Berg and Collinson, 1976).

A mass of glacial material that slides on a bedrock surface, often shale. This kind of slump usually occurs when water percolates through a somewhat more permeable glacial material (commonly till) until it reaches a less permeable bedrock surface (often shale); the accumulation of water increases the pore-water pressure and lubrication that induce slumping.

This type of landslide is quite common in several areas of Illinois (plate 1), especially near Chester in Randolph County and in Rock Island County. Figures 13 and 14 show striations left on the failure plane by glacial materials that slid down the bedrock on bluffs west of the Illinois River.

Several good examples of this type of landslide in the La Salle-Peru area along the Illinois River Valley have been described by DuMontelle, Hester, and Cole (1971). Figure 15 shows a geologic column and a cross section of a typical landslide in this area. To ensure the stability of buildings under construction for the Illinois Valley Community College south of La Salle, changes were made in the original foundation design and landscaping plans. Drainage is diverted from the slopes, collected, and piped to an elevation well below the site. These measures have successfully stabilized the slopes and building site. Residents in the area have taken various steps to prevent slope failures that threaten their homes: they have built retaining walls, covered the slopes with plastic sheets to prevent water infiltration, and installed collection pipes for controlling infiltration and runoff.

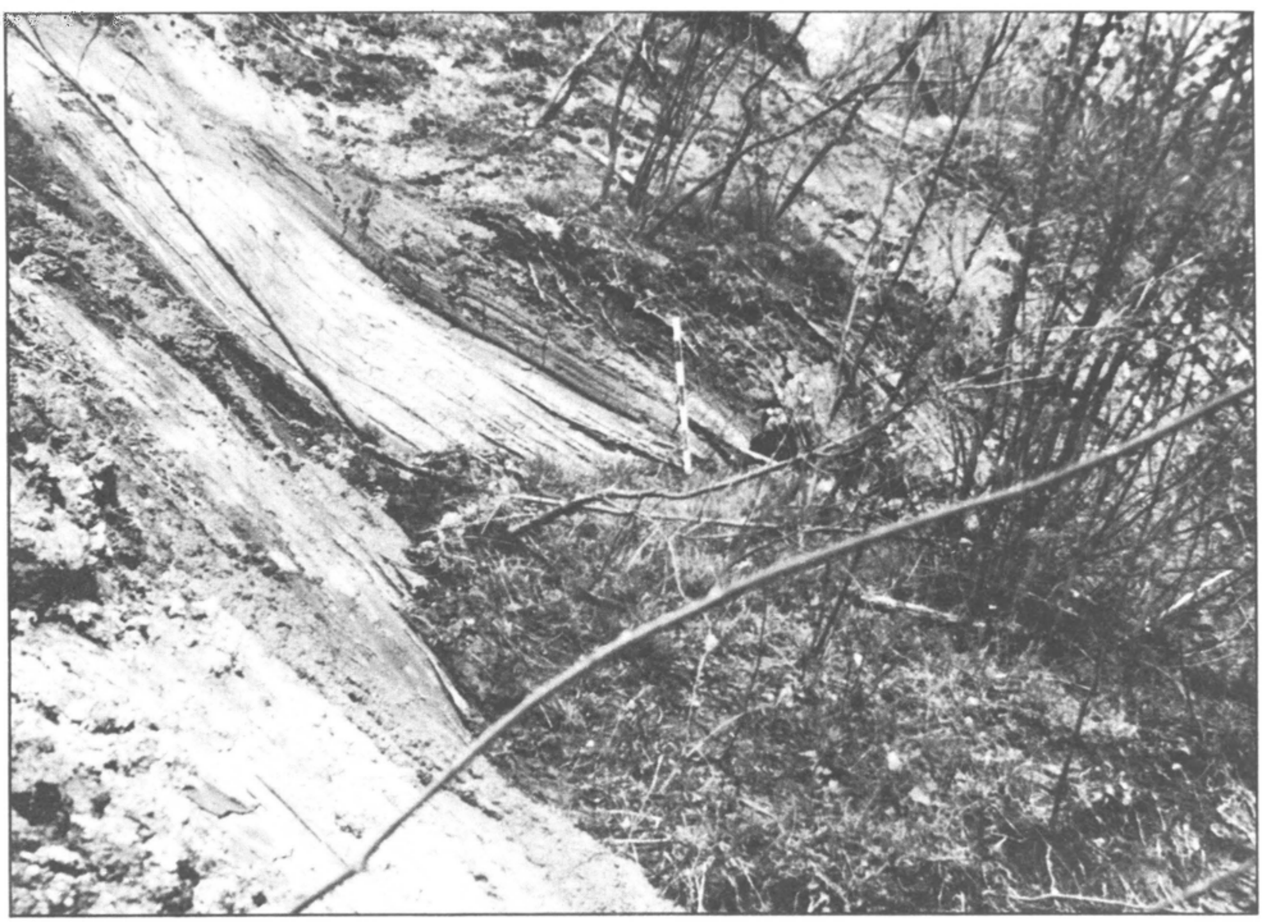

Figure 13 Islands of vegetation have slid down the slope; the young trees are tilted but apparently are otherwise undisturbed. (Photo: R. A. Bauer, ISGS)

Figure 14 The knobby upper section (siltstone) and the smooth, striated lower part (shale) are both units of Pennsylvanian age. (Photo: R. A. Bauer, ISGS)

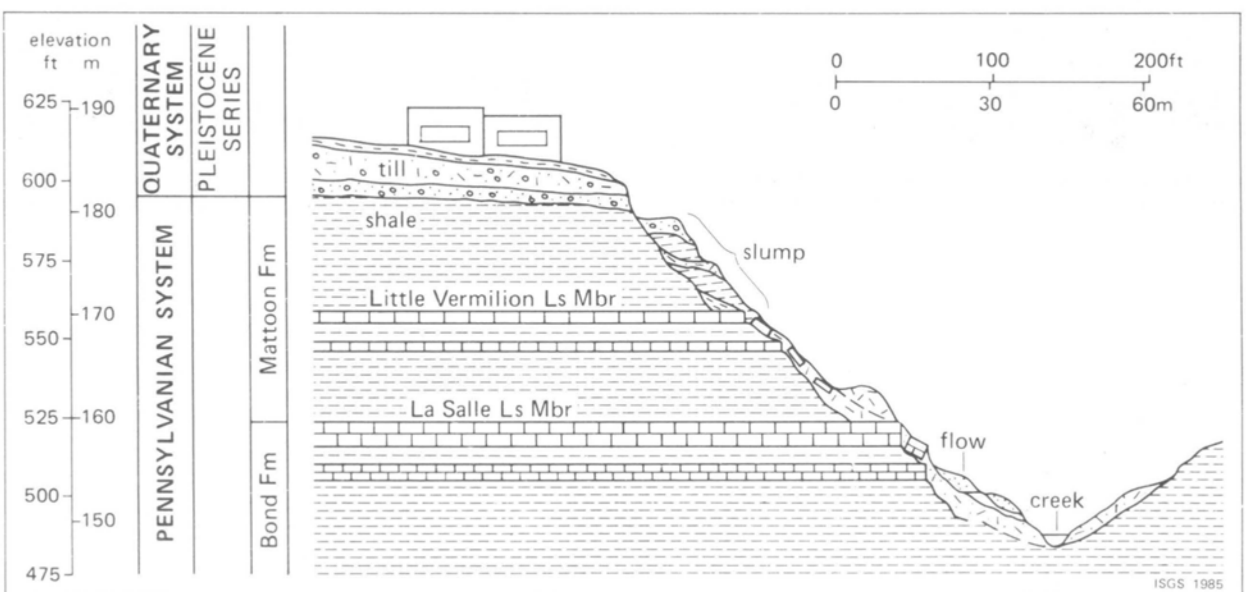

Figure 15 Geologic column and cross section of landslide in tributary valley adjacent to the Illinois Valley Community College campus (modified from Cady, 1919; Willman and Payne, 1942; and DuMontelle, Hester, and Cole, 1971).

Any flow of sand or other relatively unconsolidated earth material, regardless of rate of movement. In general, the more consolidated or cohesive the material, the slower the rate of flow. Sand or very sandy materials flow more quickly than do materials having a high clay content. The rate of flow is also increased when pore-water pressure and degree of saturation are high; thus the velocity increases during periods of high precipitation or flooding.

An earth flow frequently occurs as an extension of an earth slump at the toe of a landslide (fig. 16); only 10 landslide sites have been mapped where an earth flow is the dominant feature, rather than part of an earth slump. Three types of earth flows found in Illinois are shown in figure 17. Sand flows commonly occur in places in southwestern Illinois where dune deposits are exposed during the excavation of bluffs.

Figure 16 Earth flow occurring as the toe of a large earth slump on bedrock in the bluffs west of the Illinois River. Note the tilted trees on and below the toe. Dashed line shows original ground surface; arrow shows direction of flow. Range pole with 1-foot markings provides a scale.

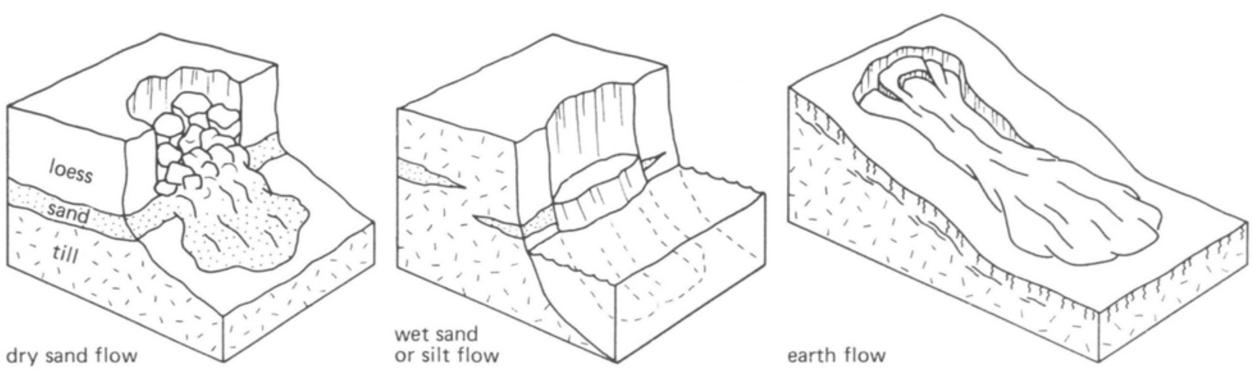

Figure 17 Three types of earth flows found in Illinois (modified from Varnes, 1978).

ROCK CREEP

Blocks of rock that slide slowly along a gentle slope. The downslope movement is generally so slow that it can be detected only over a period of years.

The only rock creep mapped so far in Illinois is in Jo Daviess County, where dolomite blocks are creeping downward on a shale slope (fig. 18).

Figure 18 Slabs of Silurian dolomite have gradually broken off and are creeping slowly downslope on underlying Ordovician shale in the Driftless Area of northwestern Illinois. (Photo: D. L. Reinertsen, ISGS)

□ *active or inactive.* An inactive landslide is one in which no movement has taken place for at least 100 years. The only landslide mapped in this category so far is an earth slump in Pulaski County. Kolata, Treworgy, and Masters (1981) noticed offsets in glacial and some preglacial bedrock formations at two gravel pits just west of Mounds in Pulaski County (fig. 19). They observed that these offsets generally parallel the Ohio bluffs and have a cumulative displacement toward the valley. This observation and findings from geophysical studies in exploration trenches strongly suggest that landslides were responsible for the offsets. Kolata, Treworgy, and Masters (1981) mention that "the exact cause of the landslide is unknown, but the evidence suggests that the Ohio River in the adjacent valley undercut the bluff. Less severe disturbances such as caving of stream banks and local fissuring were evident in this part of southern Illinois following the 1811-12 New Madrid earthquake (Fuller, 1912). Because the landslide at the Mounds site has no surface expression today the event probably predates the New Madrid events." Other ancient landslides have been reported to the authors but have not yet been verified or mapped.

□ *natural or man-induced.* Many landslides result from a combination of natural processes and human activity at the slope site, but in most cases we have been unable to determine which of these factors was the dominant cause.

□ *unclassified.* A landslide reported but not described in enough detail to permit classification into one of the categories on the Landslide Inventory Map. In some cases, records indicated whether the landslide was natural or man-induced but gave little additional information.

Figure 19 Offset between a younger loess deposit (left) and older sand (right) on the wall of a gravel pit near Mounds, Pulaski County. Meter stick shows scale (Kolata, Treworgy, and Masters, 1981).

FACTORS CONTRIBUTING TO LANDSLIDE POTENTIAL

A number of factors—some related to geological conditions, others to human use or abuse of land—determine whether or not a landslide will develop in a particular area.

Natural forces acting upon the landscape for thousands of years have produced much of the terrain as we now view it in Illinois. In most places, the slopes are gentle, resulting from gradual, grain-by-grain erosion of relatively soft earth materials. However, the effects of dynamic erosion can be observed along gullies, creeks, and rivers; the erosive action of waves and high water levels along lake shores is evidence of a powerful system at work that disrupts the gentle slopes of the terrain. The major effect of these forces is to steepen the slopes by transporting material away from their bases. How the slopes adjust to this undercutting depends upon the composition of the slopes (the geology) and the interplay of the geology with other natural and man-induced factors.

GEOLOGIC CONDITIONS

Landslide prone areas in Illinois are found where one or more of the following geologic conditions exists:

Bedrock at ground surface. Bedrock—usually limestone, dolomite, sandstone, shale, or coal—exposed at ground surface or covered only with a thin veneer (usually less than 5 ft) of loess, alluvium, sand and gravel, or soil formed from weathering of the bedrock. This type of geology is found in three major regions of Illinois:

- *along the major river valleys*—especially the Mississippi and Illinois Rivers—where Mississippian and Pennsylvanian rocks are exposed (fig. 20).
- *in southern Illinois,* beyond the margin of glaciation, where rocks ranging in age from Ordovician to Tertiary are exposed in the driftless area.
- *in the northwestern corner of the state,* where Ordovician and Silurian rocks are exposed.

These areas are shown in white and labeled as bedrock on the Quaternary Deposits of Illinois map (fig. 21). Bedrock is also found at or near ground surface in many other scattered localities not large enough to be shown on the map. Rock falls, rock slumps, and rock creep may occur in such areas, depending on how particular geologic conditions interact with other factors.

When shale underlies limestone or sandstone units in areas where bedrock is near the land surface, landslide potential is generally increased. Rock falls may occur because shale is usually more easily eroded than are the more resistant overlying limestones and sandstones, and such erosion removes support from these rocks; rock slumps and rock creeps are likely because the top surface of the shale provides a wet, slippery surface on which overlying blocks of rocks may slump and slide (or creep if the angle is low).

Shallow bedrock overlain by loess and/or glacial tills. Bedrock close enough to the surface to provide a slippage plane for overlying material such as loess or glacial till. This condition is found primarily along the Mississippi and Illinois River valleys, but also in many other places where the bedrock surface intercepts a slope at land surface. Landslides categorized as "earth slump on bedrock" are likely to be found in such areas.

Pennsylvanian shale is the most frequently encountered bedrock in this type of landslide-prone area (fig. 20); however, the more clayey weathered bedrock surfaces may provide a barrier to downward water movement. Once the overlying units become saturated and the upper surface of the bedrock becomes lubricated, slumping is likely to occur.

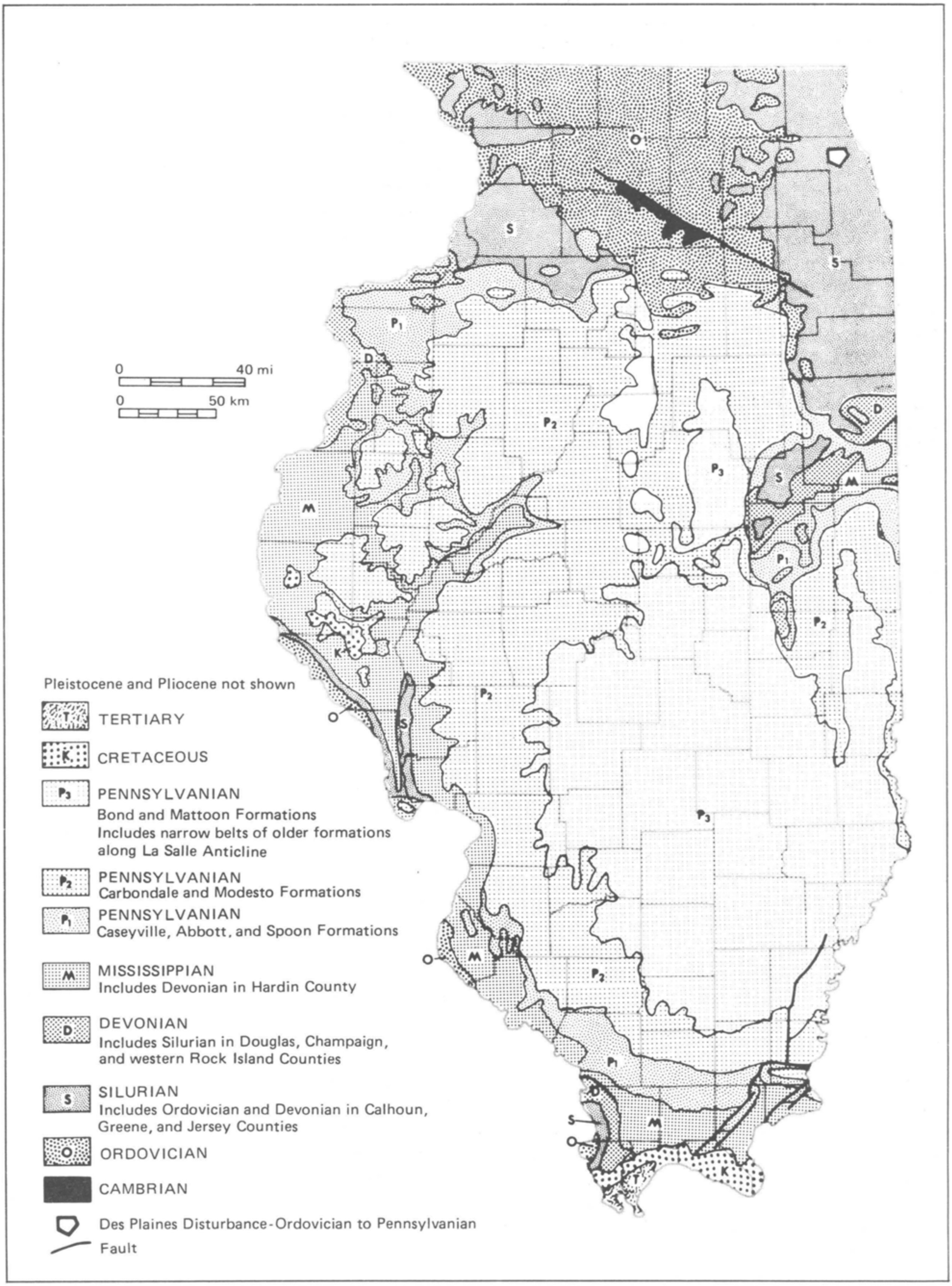

Figure 20 Bedrock geologic map (Willman and Frye, 1970).

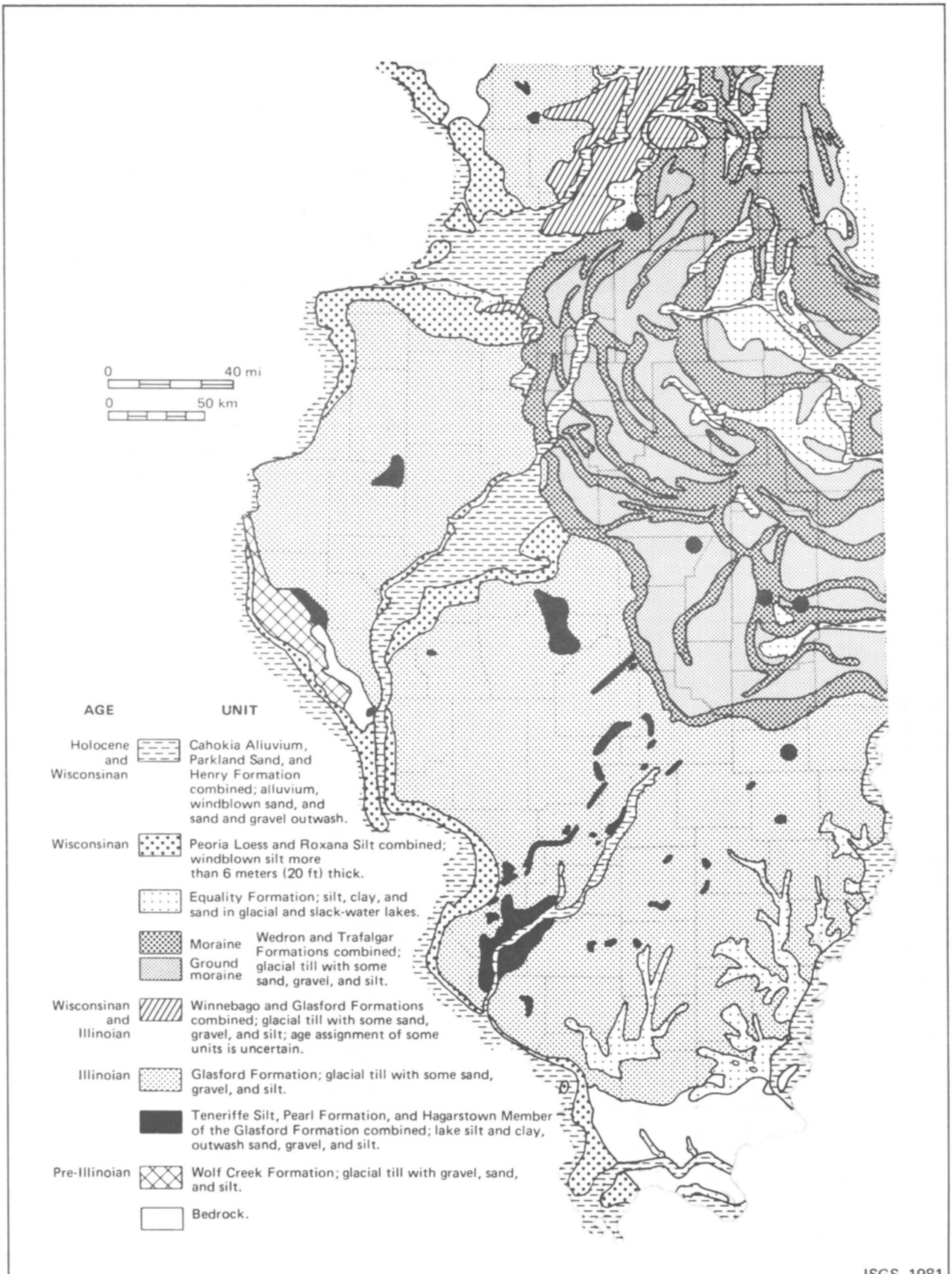

Figure 21 Quaternary deposits of Illinois map (modified from Lineback, 1979).

Glacial deposits and loess. Loess overlying glacial till (or less commonly, sand and gravel). This sequence of materials is found widely throughout the state. Earth slumps are likely to be found where loess or younger tills overlie ancient soil horizons (paleosols) in older glacial deposits. These paleosols can act as barriers to downward water movement because of an increase in their clay content due to soil development processes. Water will move by gravity laterally along the interface of the paleosol and the overlying materials if there is a slight incline. Changes in clay composition resulting from soil development processes may also weaken the material, resulting in failure.

Saturated soils at ground surface. This geological condition, which depends on the interaction of precipitation and topography, can occur nearly anywhere in the state; it is responsible for any landslide categorized as an "earth flow." An earth flow generally is found in Illinois as an extension of an earth slump at the toe of the landslide. Miniature earth flows—often called "skin" slides because they involve only the uppermost soil layer—can be seen along many of the major highways in Illinois. Saturated surface soils seem to turn to a viscous liquid and flow downslope (fig. 22).

Sand deposits underlying the loess bluffs in southwestern Illinois and sand lenses within till units in places along the Lake Michigan shoreline tend to flow when exposed at the face of a slope; these sand flows are also a type of earth flow.

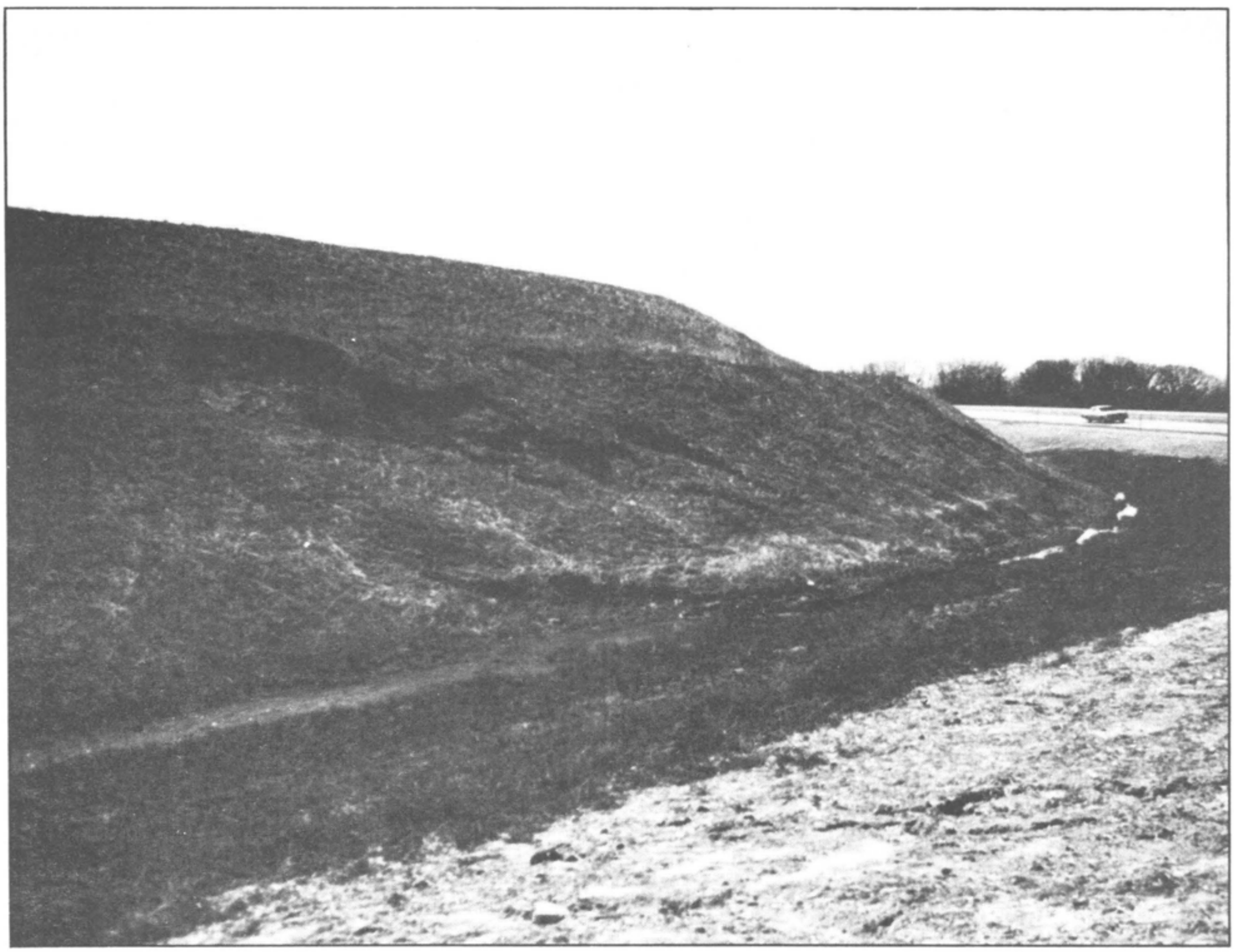

Figure 22 Shallow landslides ("skin" slides) occasionally develop along newly constructed highways where the uppermost layer of saturated soils turns into a viscous liquid and flows downslope.

OTHER NATURAL FACTORS

Slope angle, precipitation rate, freeze-thaw cycles, and vegetation also affect slope stability. These factors are closely interrelated, even though a particular factor may appear to be dominant at a specific location.

Slope angle. The maximum slope inclination (grade) that the soils and rock materials constituting a slope can support without failure—under existing conditions of geology, climate, vegetation, and land use—is called the *critical slope angle*; this angle is different for different geological materials. Usually, the more resistant the geologic materials, the steeper the critical slope angle, and therefore the steeper the natural slope. For example, sand dunes have little strength, fail easily, and form very gentle slopes. On the other hand, bluffs consisting of glacial till have relatively high strengths and stand in high, steep cliffs similar to the rock bluffs along the Mississippi River valley in the southwest part of the state. Very few slope faces are of uniform geological composition, and therefore, very few slopes have the same angle of stability from top to bottom along the face.

Precipitation rate. Precipitation rates vary from place to place, season to season, and year to year. Precipitation can affect slope stability by causing a rise or fall in the water table (the approximate depth at which water saturates the ground). As the water table rises, the pore-water pressure between the grains of soil increases, pushes the particles apart, and gradually reduces the cohesiveness of the earth materials. Once slip planes form and failure occurs, water may accelerate the rate of movement. Increased pore-water pressure tends to increase the velocity of some landslides by lowering the viscosity of the debris and/or lubricating the debris or the slip plane. Even after a slope stabilizes, renewed movement may take place if pore-water pressures are not maintained at a reduced level by installation of drains.

Cycles of freezing and thawing. Rocks subjected repeatedly to freezing and thawing may split apart eventually and tumble downslope. Water in existing joints in rocks expands during freezing, creating larger cracks that water, roots, and other materials can penetrate. This continuous process contributes to increased slope instability. When bluff faces freeze, normal drainage of the slope is impeded, and the water table may rise in the slope. In some places (especially on artificial slopes such as highway embankments), frost forms in the cover soil overlying compacted materials. When the frost thaws, the saturated soils turn to liquid and flow as debris slides—the "skin" slides discussed earlier. These slides can also occur when thawing takes place only at the surface.

Vegetation. Deep roots of trees and some grasses cling to the rocks and soil that hold the slope—so vegetation is usually credited with increasing the stability of slopes. Plants that require a great deal of water tend to lower the water table and increase stability. However, vegetation is not always beneficial. Some grasses tend to hold the water in the ground and keep it from running off, increasing infiltration rates and raising water table levels. Roots of trees and brush may also force apart large blocks of rock that may finally tumble downslope.

Many of the landslides in Illinois can be classified as man-induced landslides. Most natural slopes (even those that have moved in the past) are at least temporarily in balance—but this balance can be upset by:

□ *removing material at the toe of a slope.* Loss of support at the base of a slope—often the result of road construction—is the major cause of Illinois landslides.

□ *overloading the top of a slope.* The addition of any load (a building, or piles of rock, for instance) at the top can cause slope failure. Several existing landslides in Illinois were aggravated when loads of stone were added to fill in the slumped area at the top (figs. 23, 24, and 25). The extra load caused the movement to accelerate, and the stone moved downslope. In sloping terrain, sites for buildings and locations must be designed carefully with landslide potential in mind.

□ *increasing water infiltration into slopes.* Clearcutting tree-covered slopes, expanding row-crop farmland too near the crest of slopes, directing surface drainage or locating septic fields without regard to slope conditions, or simply overwatering lawns in slope areas can trigger slope failures.

□ *changing the character of the geologic materials constituting the slope.* Effluent from septic tanks, brine ponds, landfills, and other concentrated sources of chemicals can cause stable clays to become weak and unstable (White and Kyriazis, 1968).

Figure 23 Crown and main scarp of a large earth slump on bedrock in bluffs west of the Illinois River. Note load of stone dumped on the main scarp along the crown in foreground. The trees were probably bent by the stone.

Figure 24 This earth slump in western Illinois was aggravated when a load of stone was placed on the uppermost slump unit to fill the area. Subsequent movement caused additional damage to the road.

Figure 25 A close-up view (from the opposite direction) of the slide's main scarp. Blocks of asphalt roadway appear in the foreground. The crushed rock in the background, added to stabilize the slide, overloaded the uppermost slump unit and contributed to additional sliding. (Photo: S. C. Bradford, ISGS)

STABILIZING OR PREVENTING LANDSLIDES

The first step in attempting to stabilize a landslide is to determine the cause of the slope failure. (If more than one landslide exists at a site, each slide should be examined individually.) Once the cause of the failure is known, some relatively simple measures can be taken to stabilize the landslide:

□ *unload the top of the slope.* Grade the earth materials so that the final slope has less load at the top.

□ *load the bottom of the slope.* If the landslide is active, load the toe area, preferably with heavy, porous material that will permit drainage. Because toe material usually consists of fine-grained material, filters should be installed or constructed to prevent subsurface erosion (piping) of the fine material. Filter fabric is being used successfully at many sites.

□ *prevent additional water from entering the slope.* Reduce infiltration by (1) installing backslope longitudinal drains—the Illinois Department of Transportation does this to provide supplementary drainage behind major highway cuts; (2) covering the top and upper part of the slope with plastic sheeting; (3) regrading slopes to stable angles and installing adequate drains or placing materials at the toe of the slope; (4) drilling horizontally into slopes and installing permanent perforated drain pipes; and (5) planting vegetation that will provide leaf cover over the slope and root penetration into the slope and absorb large amounts of groundwater.

□ *improve the strength of clay minerals.* Clays that have lost strength can usually be restabilized by applying chemicals to the surface, drilling holes and injecting chemicals, or electrically charging the affected clay zones.

Some landslides may be difficult to stabilize because of difficulties posed by the working site; slopes are often wet and marshy in places, and heavy equipment is hard to maneuver if the slope angle is steep.

RETRIEVING LANDSLIDE DATA

Quick access to data on all known landslides in Illinois is made possible through the Illinois State Geological Survey's Landslide Inventory Program.

A computer-assisted data file at the Survey allows for rapid retrieval of landslide information by county or by unique landslide number; eventually, retrieval will also be possible by specific criteria (such as type of slide, geology of the site), and it will be possible to relate this information to other parameters, including geographic and tabular data, by transferring information to a mainframe computer.

The program includes an entry and update system. Written in BASIC for an IBM-Personal Computer, the program allows the user to display or print the output. The program and information files are stored on magnetic diskettes; a copy of the program and sample printout are available upon request.

As more landslide information is added to the Landslide Inventory Program it will become increasingly valuable to Illinois citizens who want to prevent or minimize damages that can result from landslides.

The 1:500,000-scale state map will be updated periodically as more landslide information becomes available.

ACTIONS ILLINOIS CITIZENS CAN TAKE

Be aware of landslide potential when you are evaluating sites for roads and buildings in sloping terrain.

Contact the Illinois State Geological Survey if a landslide or a slope that could be unstable occurs near an existing building or a potential construction site on your land.

Do not attempt to stabilize a landslide until you find out the cause of the landslide. Survey staff members will check the Landslide Inventory file for any pertinent data on specific landslides in your area and will provide you with information about the general geology of the region, indicate the type of materials expected to be present in the area and suggest the possible cause of the problem. (For instance, loess thickness or depth to the top of the bedrock—well-defined in most regions of Illinois—is commonly the key to determining where the pore-water pressure causing a landslide is highest.)

Hire a consultant (engineering geologist or geotechnical engineer) if necessary. Survey staff members will work with you and your consultant to define the geology at the site, determine the probable area and depth of the landslide, and develop remedial measures to stabilize the landslide. Specific decisions concerned with aspects of engineering and construction techniques are, of course, the responsibility of the owners and their consultants, and not the State Geological Survey.

Let the Survey know about landslides you encounter by filling in the landslide report form in the appendix. The information will be added to the Landslide Inventory Map when it is next updated. Good photographs of landslides and any reports of costs of damage or repairs are also welcomed.

BIBLIOGRAPHY

Anderson, R. C., 1980, Geology for planning in Rock Island County, Illinois: Illinois State Geological Survey Circular 510, 35 p.

Ball, J. R., 1952, Geology and mineral resources of the Carlinville Quadrangle: Illinois State Geological Survey Bulletin 77, 110 p.

Berg, R. C., and C. Collinson, 1976, Bluff erosion, recession rates, and volumetric losses on the Lake Michigan shore in Illinois: Illinois State Geological Survey Environmental Geology Notes 76, 33 p.

Cady, G. H., 1919, Geology and mineral resources of the Hennepin and La Salle Quadrangles: Illinois State Geological Survey Bulletin 37, 136 p.

Collinson, C., P. L. Drake, and C. K. Anchor, 1975, Inventory of the physical characteristics of the Illinois shore north of Chicago, *in* Illinois coastal zone management program: First Year Work Product, v. 2, 72 p.

DuMontelle, P. B., N. C. Hester, and R. E. Cole, 1971, Landslides along the Illinois River Valley south and west of La Salle and Peru, Illinois: Illinois State Geological Survey Environmental Geology Notes 48, 16 p.

Ekblaw, G. E., 1929, Cause and prevention of potential rockfalls north of Savanna, Illinois: Illinois State Academy of Science, v. 22, p. 450–454.

Ekblaw, G. E., 1952, Embankment and base slide failure, Clark County, Illinois: unpublished report on file at the Illinois State Geological Survey.

Fairbridge, R. W., 1968, The encyclopedia of geomorphology: Encyclopedia of Earth Sciences Series, v. III, Reinhold Book Corporation, New York, 1295 p.

Fuller, M. L., 1912, The New Madrid earthquake: U.S. Geological Survey Bulletin 494, 119 p.

Illinois Division of Highways (IDOT), Department of Public Works and Buildings, Landslide data, 1954: prepared by Bureau of Materials for Landslide Committee, Highway Research Board.

Kolata, D. R., J. D. Treworgy, and J. M. Masters, 1981, Structural framework of the Mississippi Embayment of southern Illinois: Illinois State Geological Survey Circular 516, 38 p.

Krumm, R. J., 1984, Investigation of a slump-type landslide, southwestern Illinois: master's thesis, Southern Illinois University, Edwardsville.

Lineback, J. A. [compiler], 1979, Quaternary deposits of Illinois: Illinois State Geological Survey map (scale 1:500,000).

Railway Engineering and Maintenance, 1934, Drainage system overcomes serious slides, January, 1934, 3 p.

Schuster, R. L., and R. J. Krizek [eds.], 1978, Landslides, analysis and control: National Academy of Sciences Transportation Research Board Special Report 176, Washington, D.C., 234 p. (This publication was the source of the landslide classification used in this project.)

U.S. Geological Survey, 1982, Goals and tasks of the landslide part of a ground-failure hazards reduction program: U.S. Geological Survey Circular 880, 49 p.

U.S. President, 1983, Economic report of the President: U.S. Government Printing Office.

Varnes, D. J., 1978, Slope movement types and processes, *in* R. L. Schuster and R. J. Krizek [eds.], Landslides, analysis and control: National Research Council, Transportation Research Board, Washington, D.C., Special Report 176, p. 11–13.

Wanless, H. R., 1957, Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont Quadrangles: Illinois State Geological Survey Bulletin 82, 233 p.

White, W. A., and M. K. Kyriazis, 1968, Effects of waste effluents on the plasticity of earth materials: Illinois State Geological Survey Environmental Geology Notes 23, 23 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204 p.

Willman, H. B., and J. N. Payne, 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator Quadrangles: Illinois State Geological Survey Bulletin 66, 388 p.

Willman, H. B., E. Atherton, T. C. Buschbach, C. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

APPENDIX

SUMMARY OF LANDSLIDE TYPES

Landslide Type	Natural	Man-induced	Totals
Earth slump	15*	25	40
Earth slump on bedrock	9	18	27
Rock slump	2	16	18
Rock fall	1	11	12
Earth flow	5	5	10
Rock creep	1	0	1
Unclassified	1	36	37
Total	34	111	145

*One earth slump has been inactive for more than 100 years.

COST-OF-DAMAGE INFORMATION REPORTED ON ILLINOIS LANDSLIDES

County	Landslide type	Date of landslide	Damage or repair costs (converted to 1982 dollars)*
Bureau (1)	Earth slump	Spring 1973	$980,000 for road replacement
Carroll (1)	Rock slump with some talus	1928	$170,000 damage and repair costs for road and seven homes
Carroll (2)	Rock falls and slumps	1928	$30,000 for corrective measures during road construction
Clark (1)	Earth slump	1951	$90,000 damage
Cumberland (1)	Earth slump	1938	$70,000 damage
Cumberland (2)	Earth slump	1950	$14,000 damage
Fulton (1)	Earth slump on shale	1943	$235,000 estimated damage
Fulton (6)	Earth slump	1943	$30,000 cost of repair
Fulton (7)	Earth slump on bedrock	1972	$400,000 - 500,000 cost of repair
Hancock (7)	Earth slump	Summer 1982	$750,000 cost of repair
Henry (1)	Earth slump on bedrock	1977	$2,220,000 estimated cost of repair
Jackson (1)	Earth flow	1982	$27,000 proposed remedial measures
Jackson (2)	Earth slump	(unknown)	$38,000 remedial measures
Jo Daviess (1)	Earth slump on bedrock	April 1981	$635,000 cost of repair
La Salle (1)	Rock slump	1928	$100,000 damage and repair costs
La Salle (2)	Earth slump on bedrock	1944	$560,000 damage
La Salle (4)	Earth slump on bedrock	1972	$60,000 - 70,000
Randolph (1)	Earth slump	1945	$38,000 damage/$14,000 for similar slides in immediate area
Randolph (6)	Earth slump on shale	1952	$1,070,000 damage
Rock Island (4)	Rock slump	1974	$360,000 cost of repair
Rock Island (6)	Earth slump on bedrock	1974	$180,000 cost of repair
Schuyler (3)	Earth flow	1975	$8,000 damage repair
Schuyler (3)	Earth slump	1978(?)	$28,000 damage repair and slope stabilization
Warren (1)	Sand flow	July 1982	$10,000 damage repair
Warren (2)	Rock and earth slumps	1970	$4,000 damage repair
Winnebago (1)	Sand flow	still active	$150,000 estimated cost of repair
			Total — $8,271,000 minimum cost

*All damage information was provided by Illinois Department of Transportation, except for Clark County, provided by Ekblaw (1952); La Salle (4), provided by a local foundation engineer; and Schuyler (3), provided by the U.S. Soil Conservation Service. Number following county name is the number next to the landslide symbol on the map. All cost figures have been converted to 1982 dollars, using price deflators provided in the yearly report of the President (U.S. President, 1983, table B-5); figures have been rounded to the nearest $1,000 or $10,000. Landslide costs are arbitrarily allocated to the year the landsliding occurred.

LANDSLIDE INFORMATION REPORT FORM

Illinois State Geological Survey
615 East Peabody Drive
Champaign, Illinois 61820

YOUR NAME ______________________________

YOUR ORGANIZATION ______________________

TELEPHONE NUMBER _______________________

DATE ________________

LOCATION OF SLIDE (Please indicate as precisely as possible, such as NW/SW/NE SEC. 23-T4N-R2E; Interstate mile marker number; road junction; etc.)

____

COUNTY ______________________ TOPOGRAPHIC MAP ______________________

(Attach a copy of quadrangle topographic map; indicate quad name; show location if possible.)

SOURCE OF INFORMATION (Personal observation, publication, newspaper article, thesis, etc.)

____

____

LANDSLIDE TYPE (Check the type that fits best)

____ Rock fall
____ Rock slump
____ Earth slump
____ Earth slump on bedrock
____ Earth flow
____ Rock creep
____ Unclassified

GEOLOGY (Type of geologic materials; use stratigraphic names if known)

____

____

IS THE SLIDE:

______ Active?
______ Inactive?
______ Natural?
______ Man-induced?

DATE OF LAST MOVEMENT, IF KNOWN ______________________________

ESTIMATED SIZE

Length: from top of slide to toe at lower part of slope ______________________

Width: measured perpendicular to length at widest place ______________________

CAUSE OF SLIDE (For example, stream cut, road construction, etc.)

____

____

ESTIMATED COST OF DAMAGE ________________ REPAIR ________________

ADDITIONAL COMMENTS OR INFORMATION:

FOR OFFICE USE ONLY				
M	CN	UN	RN	CF

SEAL OF THE STATE OF ILLINOIS

AUG. 26TH 1818

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1691

Table 1.--Illinois landslides for which cost-of-damage information is available. All damage information provided by Illinois Department of Transportation except for Clark County, provided by Ekblaw (1952); Lasalle-4, provided by a local foundation engineer; and Schuyler-3, provided by the U.S. Soil Conservation Service. Number following the county name is the same as number next to the landslide symbol on the map. All cost figures have been converted to 1982 dollars using price deflators provided in the yearly report of the President (U.S. President, 1983, Table B-5), figures rounded to the nearest $1,000 or $10,000. Landslide costs are arbitrarily allocated to the year the landsliding occurred.

County and Map No.	Landslide	Date of landslide	Damage or Repair costs reported
Bureau - 1	Earth slump	Spring 1973	$980,000 for road replacement
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Cumberland - 1	Earth slump	1938	$70,000 damage
Cumberland - 2	Earth slump	1950	$14,000 damage
Fulton - 1	Earth slump on shale	1943	$235,000 estimated damage
Fulton - 6	Earth slump	1943	$30,000 cost of repair
Fulton - 7	Earth slump on bedrock	1972	$400,000-500,000 cost of repair
Hancock - 7	Earth slump	Summer 1982	$750,000 cost of repair
Henry - 1	Earth slump on bedrock	1977	$2,220,000 estimated cost of repair
Jackson - 1	Earth flow	1982	$27,000 proposed remedial measures
Jackson - 2	Earth slump	Unknown	$38,000 remedial measures
Jo Daviess - 1	Earth slump on bedrock	April 1981	$635,000 cost of repair
La Salle - 1	Rock slump	1928	$100,000 damage and repair costs
La Salle - 2	Earth slump on bedrock	1944	$560,000
La Salle - 4	Earth slump on bedrock	1972	$60,000-70,000
Randolph - 1	Earth slump	1945	$38,000 damage 14,000 for similar slides in immediate area
Randolph - 6	Earth slump on shale	1952	$1,070,000 damage
Rock Island - 4	Rock slump	1974	$360,000 cost of repair
Rock Island - 6	Earth slump on bedrock	1974	$180,000 cost of repair
Schuyler - 3	Earth flow	1975	$8,000 damage repair
	Earth slump	1978(?)	$28,000 damage repair and slope stabilization
Warren - 1	Sand flow	July 1982	$10,000 damage repair
Warren - 2	Rock and earth slumps	1970	$4.000 damage repair
Winnebago - 1	Sand flow	Still active	$150,000 estimated cost of repair
		Total	$8,271,000 minimum cost

References

Anderson, R. C., 1980, Geology for planning in Rock Island County, Illinois: Illinois State Geological Survey Circular 510, 35 p.
Ball, J. R., 1952, Geology and mineral resources of the Carlinville quadrangle: Illinois State Geological Survey Bulletin 77, 110 p.
Berg, R. C., and Collinson, C., 1976, Bluff erosion, recession rates, and volumetric losses on the Lake Michigan shore in Illinois: Illinois State Geological Survey Environmental Geology Note 76, 33 p.
Collinson, C., Drake, P. L., and Anchor, C. K., 1975, Inventory of the physical characteristics of the Illinois shore north of Chicago: Illinois Coastal Zone Management Program, First Year Work Product, v. 2, 72 p.
DuMontelle, P. B., Hester, N. C., and Cole, R. E., 1971, Landslides along the Illinois River Valley south and west of La Salle and Peru, Illinois: Illinois State Geological Survey Environmental Geology Note 48, 16 p.
Ekblaw, G. E., 1929, Cause and prevention of potential rockfalls north of Savanna, Illinois: Illinois State Academy of Science, v. 22, p. 450-454.
—— 1952, Embankment and base slide failure, Clark County, Illinois: unpublished report on file at the Illinois State Geological Survey
Illinois Division of Highways, 1954, Landslide data: prepared by Bureau of Materials for Landslide Committee, Highway Research Board.
Kolata, D. R., Treworgy, J. D., and Masters, J. M., 1981, Structural framework of the Mississippi Embayment of southern Illinois: Illinois State Geological Survey Circular 516, 38 p.
Krumm, R. J., in preparation, Investigation of a slump-type landslide, southwestern Illinois: Southern Illinois University, Edwardsville, M.S. thesis.
Lineback, J. A. (compiler), 1979, Quaternary deposits of Illinois: Illinois State Geological Survey map, scale 1:500,000,
Railway Engineering and Maintenance, 1934, Drainage system overcomes serious slides, January 1934.
Schuster, R. L., and Krizek, R. J., eds., 1978, Landslides, analysis and control: National Academy of Sciences Transportation Research Board, Special Report 176, 234 p.
U.S. President, 1983, Economic report of the President: U.S. Government Printing Office.
Varnes, D. J., 1978, Slope movement types and processes: in Krizek, R. J. and Schuster, R. L.,eds., Landslides, analysis and control: National Academy of Sciences, Transportation Research Board, Special Report 176, p. 11-33.
Wanless, H. R., 1957, Geology and mineral resources of the Beardstown, Glasford, Havana, and Vermont quadrangles: Illinois State Geological Survey Bulletin 82, 233 p.
Willman, H. B., and Frye, J. C., 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204 p.
Willman, H. B., and Payne, J. N., 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator quadrangles: Illinois State Geological Survey Bulletin 66, 388 p.

EXPLANATION

Area of slumping and landsliding where individual slides are too numerous to map. Symbol within outlined area indicates dominant type of landslide in area and location of prominent individual slide (see classification)

Area of Peyton Colluvium and Lacon Formation (Willman and Frye, 1970) mapped by Lineback (1979): deposits resulting from creep and slope wash (Peyton Colluvium) and from slumps and landslides (Lacon Formation)

I — Landslide inactive for past 100 years

2 — Number next to symbol refers to report (filed by county in which landslide is located) on open file at Illinois State Geological Survey

Landslide classification (adapted from Varnes, 1978)

NATURAL	MAN-INDUCED	TYPE OF LANDSLIDE
■	□	Rock fall—Mostly rock; may include some glacial material
▼	▽	Rock slump—Slump block consisting of rock and any overlying glacial material
▲	△	Earth slump—Slump block consisting of glacial material
		Earth slump on bedrock surface
◆	◇	Earth flow—Any flow of earth or sand, regardless of rate of movement
●	○	Unclassified landslides
*		Rock creep—Continual movement of boulders at barely perceptible rates

Scale 1:500,000
1 inch equals approximately 8 miles

10 0 10 20 30 40 Miles
10 0 10 20 30 40 50 Kilometers

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

ILLINOIS LANDSLIDE INVENTORY MAP

Compiled by
M. M. Killey, J. K. Hines, P. B. DuMontelle
Illinois State Geological Survey
and
Earl Brabb
U.S. Geological Survey
1984

Base map compiled, edited, and published by the U.S. Geological Survey. 1927 North American datum. Lambert conformal conic projection based on standard parallels 33° and 45°

Landslide data compiled in 1983

Interior—Geological Survey, Reston, Va.—1984

For sale by Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202