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Ohio Geology Newsletter

Division of Geological Survey

WHEN THE HILLS COME TUMBLING DOWN— LANDSLIDES IN OHIO

by Michael C. Hansen

Which city in the United States has the highest per-capita cost for repair of landslides? Certainly, the images of mud oozing through California homes that periodically grace the 6 o'clock news must indicate that Los Angeles or San Francisco can claim this dubious honor. Perhaps a mountainous eastern state such as West Virginia would be a likely candidate to have such a plagued city. Wrong! The surprising answer is Cincinnati, Ohio.

Statistics on landslide damages are difficult to acquire because repairs and maintenance of these features are borne by a variety of federal, state, and local agencies and by private individuals. However, a 1980 report by the U.S. Geological Survey assembled the statistics for U.S. cities that experience major landslide problems. This study determined that between 1973 and 1978 the total cost of landslide damage in Hamilton County (Cincinnati and vicinity), Ohio, was $30,990,000, or an average of $5,165,000 per year. These figures yielded an annual per-capita cost of $5.80 for Hamilton County residents. For comparison, landslide damages in the San Francisco Bay area averaged $1.30 per person per year; in Los Angeles, $1.60 per person per year; and in Pittsburgh and vicinity, $2.50 per person per year.

Areas of most severe slope failure in Ohio.

Rotational slump in Conemaugh (Pennsylvanian) red beds, Athens County.

These statistics are perhaps stunning to many Ohioans who may have never seen a landslide in the state. And seldom do these slope failures make statewide headlines. The massive, sometimes instantaneous landslides that commonly take many lives or wipe out an entire town are not of the same genre as those in Ohio. However, as pointed out in the statistics noted above, landslides in Ohio can be costly in terms of dollar amounts of property loss, loss of property from the tax base, disruption of transportation and business, and the statistically unquantifiable commodity of human anxiety and suffering brought about by the loss of a home. Perhaps the good news is that most of the landslides in Ohio are not life threatening and many of them are preventable with proper understanding of local geologic conditions and knowledge of triggering mechanisms.

Statewide statistics on annual damages from landslides are unavailable, principally because of the difficulties in assembling such figures from a wide variety of agencies. As an index of the problem in Ohio, the Ohio Department of Transportation calculates that the average cost to repair landslides on state highways was about $1.5 million annually for the period 1981 through 1985. These figures do not include repair costs of about $25 million for the Mt. Adams landslide in Cincinnati.

Although Ohio landslides can be tremendously expensive, no deaths and few injuries have resulted from them. The potential does exist, however, for catastrophic death from a type of downslope movement known as rockfall. In 1942, in Beaver County, Pennsylvania, 150 cubic yards of rock fell on a bus, killing 22 people and injuring four others. There have been several close calls in Ohio; these are discussed later in this article.

continued on next page

ODNR
OHIO DEPARTMENT OF NATURAL RESOURCES

Richard F. Celeste, Governor • Joseph J. Sommer, Director

Chief's corner by Horace R. Collins

Place names have always held a certain fascination for me. Place names tell us much about what was important to early settlers. The words lick and salt, for instance, are often used as a place name in Ohio, telling us that natural brine seeps probably occurred somewhere in the area. The original American Indian population most likely had located these seeps (led there by deer and other animals anxious to lick the salty water) and had produced salt from them. European settlers quickly identified these sites as important for the production of this scarce and valuable frontier product; hence names such as Salt Creek, Scafford Lick, and Lick Creek.

Recently, while reviewing the manuscript of Division of Geological Survey Information Circular No. 53, *Place names directory: southern Ohio*, I was curious as to the origin of many of the names given to communities. What, I wondered, was on the minds of the namers. Some were fairly apparent. In Adams County, animals were apparently on the mind of some early Ohioans, leading to community names such as Catbird, Lynx, Squirrel Town, and Beaver Pond. Towns have often taken their names from some element of the local flora, and in Hamilton County Cherry Grove, Fernbank, Oakdale, and Walnut Hills obviously followed this pattern. Mineral resources have led to the naming of communities for some commodity produced in the vicinity. Southern Ohio has a strong tradition in this regard; in Lawrence County, for example, we find Coal Grove, Firebrick, and Ironton.

Other names have less clear though not necessarily obscure origins. Many of these allow for speculation as to their origin, or, for the student of place names, lead to serious research. In Adams County the communities of Sunshine, Tranquility, and Unity suggest a need on the part of the founder to establish a positive state of mind. On the other hand what about Needfull in Highland County or Polkadotte and Getaway in Lawrence County? In Clermont County we have Bantam, Modest, and Hamlet, which is virtually the American equivalent for small. Was the founder telling the world something? How about Eureka in Gallia County, Omega in Pike County, Slickaway in Brown County, or Cebee in Lawrence County? Although it pains me to say so because of personal friends from there who will never let me forget I said it, I believe Ross County must lead the state for unusual community names; who or why would anyone have come up with such jaw crunchers as Kinnikinnick, Knockemstiff, and Lickskillet?

If you are interested in names for historical or genealogical research purposes, or if you just like to speculate on the origin of place names, *Place names directory: southern Ohio* is for you.

1987 will mark 150 years since the creation of the Survey in 1837. Sesquicentennial activities will be announced in future issues of *Ohio Geology*.

OHIO GEOLOGY

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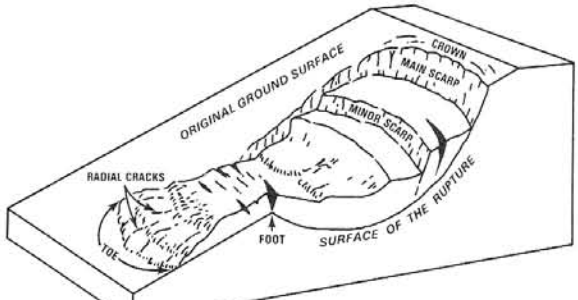
TYPES OF LANDSLIDES

The term landslide is a generalized designation for a variety of downslope movements of earth materials. Some slides are rapid, occurring in seconds, whereas others may take hours, weeks, or even longer to develop. The types of landslides commonly encountered in Ohio are listed below.

Rotational Slump

Rotational slumps are characterized by the movement of a mass of weak, incompetent rock or sediment as a block unit along a curved slip plane. These slumps are the largest type of landslide in Ohio, commonly involving hundreds of thousands of cubic yards of material and extending for hundreds of feet.



Major components of a rotational slump.

Rotational slumps are easily recognized by their characteristic form, consisting at the upper part (crown or head) of one or more transversely oriented zones of rupture (scarps) that form a stair-step pattern of displaced blocks. The upper surface of these rotated blocks commonly has a reverse slope, forming depressions along which water may accumulate to create small ponds or swampy areas. Trees on these rotated blocks may be inclined upslope, towards the top of the hill.

The lower, downslope end (toe) of a rotational slump is a fan-shaped, bulging mass of material characterized by radial ridges and cracks. Trees on this portion of the landslide may be inclined at strange angles, giving rise to the descriptive terms "drunken" or "staggering" forest. Rotational slumps may develop comparatively slowly, commonly requiring several months or even years to reach stability; however, on occasion, they may move rapidly, achieving stability in only a few hours. These landslides are one of the most common types in Ohio.

Earthflow

Earthflows are perhaps the most common form of downslope movement in Ohio and many of them are comparatively small in size. Characteristically, earthflows involve a weathered mass of rock or sediment that flows downslope as a jumbled mass, forming a hummocky topography of ridges and swales. Trees may be inclined at odd angles throughout the length of an earthflow.

Earthflows are most common in weathered surface materials and do not necessarily indicate weak, incompetent rock. They are also common in unconsolidated glacial sediments. The rate of movement of an earthflow is generally quite slow.

Rockfall

Rockfalls are an extremely rapid, and potentially dangerous, type of downslope movement of earth materials. In this type of landslide large blocks of massive bedrock suddenly become detached from a cliff or steep hillside and travel downslope in free fall and/or a rolling, bounding, or sliding manner until a position of stability is achieved.

Most commonly, massive beds of sandstone or limestone are involved in rockfalls. Joints or cracks in the rock permit entry of surface water, which increases the weight of the rock and causes expansion of joints when frozen, thus prying blocks of rock away from the main cliff. Weak, incompetent, and easily eroded clay or shale beneath the massive bed is an important contributing factor to rockfall; undercutting in this horizon removes basal support.

CAUSES OF LANDSLIDES

Landslides are not random, totally unpredictable phenomena. Certain inherent geologic conditions are a prerequisite to the occurrence of a landslide in a particular area. The presence of one or more of the following conditions can serve as an alert to potential landslide problems.

1) Steep slopes—All landslides move downslope under the influence of gravity; therefore, steep slopes, cliffs, or bluffs are a requirement for development of a landslide, especially in conjunction with one or more of the conditions listed below.
2) Jointed rocks—Vertical cracks in rocks, known as joints, permit penetration of surface moisture with a consequent weakening of the rock. During periods of cold weather, this moisture freezes and causes the rock masses to be pried apart along the joint. Joints are thus planes of failure, especially in massive rocks.
3) Fine-grained, permeable rock or sediment—Earth materials possessing these characteristics are particularly susceptible to landslides because large amounts of moisture can easily enter them. An excess of moisture, particularly common during periods of heavy rain or snow melt, increase the weight of the rock or sediment and reduce the bonding strength of individual grains. If the cement bonding individual grains is soluble, ground water will decrease the strength of the rock.
4) Clay or shale units subject to lubrication—Ground water penetrating these materials can lead to loss of strength and subsequent failure. Excess ground water in the area of contact between susceptible units and underlying materials can lubricate this contact and thus promote failure.
5) Large amounts of water—Periods of heavy rainfall or excess snow melt can saturate the zone above the normal water table and precipitate a landslide.

Although many areas of the state possess one or more of the above conditions, a landslide requires a triggering mechanism to initiate downslope movement. Events or circumstances that commonly trigger landslides in Ohio include:

1) Vibrations—Human-induced vibrations such as those from blasting, or even the passing of a heavy truck in some circumstances, can trigger a landslide. Natural vibrations from earthquakes are well-documented as triggering mechanisms for landslides in many parts of the world. In Ohio, however, there have been no documented cases of a landslide being triggered by seismic events, although the state periodically experiences small-to moderate-intensity earthquakes.
2) Oversteepened slopes—Undercutting of a slope by natural processes such as wave or stream erosion causes many landslides in the state. The most important cause of oversteepening of a slope is manmade excavations. Removing the base of a slope can cause the natural equilibrium to be exceeded and thus directly promote failure of an otherwise stable mass. The angle of stability of the slope can also be exceeded by the addition of fill to the upper part of the slope.
3) Increase of weight on a slope—Addition of large amounts of fill, the construction of a building or other structure, or an unusual increase in precipitation, either from heavy rains or from artificial alteration of drainage patterns, can trigger a landslide.

The inherent geologic conditions and triggering mechanisms listed above all contribute to landslides in Ohio. Landslides are complex phenomena which involve a variety of conditions and triggering mechanisms, and no two events are exactly alike. However, knowledge of these characteristics can alert anyone to the potential for slope failure at any particular site.

LANDSLIDE-PRONE AREAS OF OHIO

Landslides are rare or nonexistent events throughout much of Ohio because of a lack of steep slopes and/or lack of geologic units prone to failure. Several areas of the state, however, experience frequent and costly landslides.

Eastern Ohio

This area of the state is located in the Appalachian Plateaus physiographic province and is unglaciated, except along the northern and northwestern borders. This area is the "hill country" of Ohio and is characterized by local relief of several hundred feet. Many of the hill slopes are steep, a condition that makes this area particularly prone to slope failures.

Bedrock in this area consists of rocks belonging to the Mississippian, Pennsylvanian, and Permian Systems. Soils are thin in the region, although thick colluvium (highly weathered bedrock), thick lake silts, and outwash deposited by meltwater from Pleistocene glaciers locally contribute to the landslide problem.

Slope failures are relatively common in thick colluvium developed on Mississippian shales, particularly the Bedford Shale, in the lower Scioto River valley. Although most of these landslides are not extremely large, they have caused significant damages locally. Also present in this general area of southern Ohio are thick deposits of lake clays and silts that accumulated when Pleistocene glaciers dammed north-flowing streams of the preglacial Teays River system. Such deposits are also prone to failure.

The most slide-prone rocks in eastern Ohio are those of the Pennsylvanian System, particularly those known as the Conemaugh and Monongahela Groups, in the upper part of this sequence of rocks. A detailed study of landslides in a several-county area of southeastern Ohio determined that 85 percent of the slope failures were in Conemaugh and Monongahela rocks. Only 5 percent of the failures were in the lower part of the Pennsylvanian sequence (Pottsville and Allegheny Groups). The remaining 10 percent of the failures were in the overlying rocks of the Permian System (Dunkard Group), a sequence of rocks similar to those in the upper part of the Pennsylvanian System.

Pennsylvanian and Permian rocks are characterized by repetitive sequences of coal, shale, limestone, sandstone, and clay. Not all of these horizons are subject to landslides. The Conemaugh, Monongahela, and Dunkard Groups are typified by an abundance of red mudstones ("red beds"), horizons that appear to be particularly prone to failure because they tend to slake and lose strength when they become wet.

Research in southeastern Ohio has determined that 41 percent of the landslides in this area were confined to just two red-bed horizons, the Round Knob and the Clarksburg mudstones. It is obvious that detailed county maps, such as those being prepared by the Survey in the statewide county-mapping program, can be used as a guide to the location of potentially troublesome geologic units. With such maps, construction and building projects can be forewarned of possible slope failures.

Landslides in these red-bed horizons are most commonly rotational slumps or earthflows. There are literally hundreds of documented examples throughout this region of the state, but overall losses are not as high in this area as in some other parts of the state because the region is not densely populated. Two landslides in eastern Ohio are of particular note.

In 1967, during construction of Interstate 77, a large landslide began to develop in a cut slope in Conemaugh rocks on the east side of the highway near Dexter City, Noble County. A large rotational slump with a 40-foot-high scarp developed at the head of the slide, and the toe caused considerable damage to the highway grade. More than one-half million cubic yards of material was removed in an attempt to stabilize the slope; however, movement of this unstable mass has continued periodically through the years, necessitating extensive repairs to the interstate highway. More than $2.5 million was initially expended to correct the problems at this site.

One of the most dramatic landslides in eastern Ohio occurred in November 1972 at the Monticello apartment complex on the east side of Athens. This complex originally consisted of 16 multi-unit apartment buildings constructed in 1968 on a hill overlooking the city of Athens. The level area on which the apartment buildings were constructed was fashioned from a cut on the hillside in the Clarksburg red bed. The mudstone removed in this cut was used as fill on the edge of the hill in order to expand the level area for apartment construction.

Soon after occupancy in 1969 one of the buildings constructed on this fill material was abandoned because of cracks

Landslide at Monticello Apartments, Athens, 1972. Photo by David Kantner.

in the masonry and other structural problems that were associated with the beginning of slope failure. This building was razed just prior to a November 1972 massive failure of the fill material that necessitated the emergency evacuation of the residents of four apartment buildings. The toe of the slide destroyed a 500-foot section of a county road below the apartment complex, shifting it more than 40 feet from its original location. This massive slide occurred after a day of heavy rain.

Eventually, eight apartment buildings were torn down as continued movement of the slide rendered them uninhabitable. Those apartment buildings located farthest from the slide, at the back of the flat bench, and seemingly out of danger from the slope failure at the lip of the hill, were plagued by rockfall from boulders spalled from the massive Connellsville sandstone overlying the Clarksburg red bed. Construction of a retaining fence and removal of hazardous portions of this sandstone cliff averted major problems with this landslide.

Rockfall is an additional hazard in eastern Ohio, and several near disasters have occurred. The presence of massive, cliff-forming sandstones in this region, the presence of steep slopes, and the rapidity with which such failures occur makes this type of landslide a serious concern. Two rockfalls in this area serve to illustrate the nature of such downslope movements.

At 2:00 a.m. on December 2, 1971, approximately 830 cubic yards of sandstone, principally in the form of large blocks, fell from a cliff in Pomeroy, Meigs County. Several of these blocks bounded into the mail-sorting room and parking lot of the Pomeroy post office, destroying a corner of the building and filling the parking lot with rock. Had this rockfall taken place during regular business hours at the post office, injury and loss of life would certainly have occurred.

The sandstone cliff at this location is cut by joints that run parallel to the cliff face. Beneath the sandstone is a weak

Post office partially destroyed by rockfall of massive sandstone in 1971 at Pomeroy, Meigs County.

shale that has been eroded, thus providing little basal support for the overlying sandstone. Apparently, surface water penetrated into the joints, expanding them during the freeze-thaw cycle and triggering the failure.

Another rockfall that perhaps narrowly averted disaster occurred during the early morning hours of January 7, 1978, at the Lower Falls at Old Mans Cave in Hocking Hills State Park, Hocking County. A large block of Black Hand sandstone (uppermost member of the Cuyahoga Formation, Mississippian), with a volume of approximately 500 cubic yards, was detached along a cross joint and fell into the plunge pool of Lower Falls. At this point in the valley the 40-foot-thick lower portion of the Black Hand sandstone forms a rock-shelter cave, approximately 200 feet long and 50 feet deep. The Fairfield Shale Member of the Cuyahoga Formation is a weak, incompetent unit beneath the Black Hand Sandstone Member; erosion of the shale removed basal support.

This rockfall occurred after a heavy rain the preceding day that was followed by subfreezing weather. It is probable that increase in weight of the sandstone by saturation from rainfall and freezing of moisture in the cross joint were responsible for failure of the overhanging sandstone at Lower Falls. Another rockfall had occurred at this site in 1940. Fortunately, no one was injured in the 1978 rockfall. Had it occurred during the day, especially in summer, the results would have not been so fortunate. This particular portion of the gorge normally receives a large number of visitors.

Cincinnati region

As noted in the introductory portion of this article, the

Rockfall of Black Hand Sandstone at Lower Falls, Old Mans Cave, Hocking Hills State Park, Hocking County, January 1978.

Cincinnati area experiences numerous and costly landslides. The Cincinnati region includes not only the city of Cincinnati and Hamilton County but also portions of surrounding counties in southwestern Ohio where bedrock of Ordovician age is exposed. These rocks are characterized by alternating thin beds of limestone and shale. Also present in the area are glacial tills and clays and silts deposited in glacially associated lakes. Certain units within the Ordovician bedrock and the unconsolidated glacial sediments are prone to slope failure in this hilly region that has a maximum relief of about 500 feet.

The majority of the slope failures in bedrock in this region are confined to the Kope Formation and to a lesser degree to the Miamitown Shale in northwestern Hamilton County. Most of the landslides in this region are rotational slumps, but earthflows are common also.

Small slump in colluvium of the Kope Formation, Hamilton County. Photo by E. Mac Swinford.

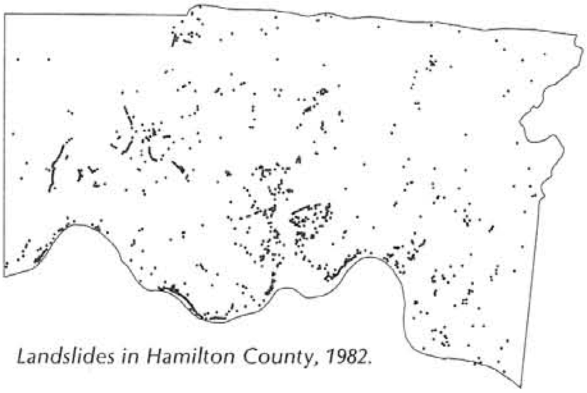
The Kope Formation, which is the unit most prone to failure in this region, averages about 220 feet in thickness and is composed of about 80 percent shale and about 20 percent interbedded limestone. Slope failures in the Kope Formation occur in colluvium, formed by the in-place weathering of the shale. This colluvium tends to slake when it is exposed to wetting and drying cycles. Landslides occur along the contact of the colluvium and unweathered bedrock when excessive hydrostatic pressure builds up in this zone.

Interestingly, studies of landslides in the Kope Formation indicate that most, if not all, of them were triggered by human activities. In addition, 92 percent of the studied landslides were on north-facing slopes, a fact that is probably related to the retention of excess moisture on these more shaded slopes. Another study concluded that the roots of vegetation on hillsides of thick Kope Formation colluvium increased the slope stability by about a factor of nine.

As abundant as slope failures in the Kope Formation in the Cincinnati region are landslides in glacial sediments. These clay and silt deposits tend to fail where cut-and-fill activities have taken place.

The landslide problem in the Cincinnati region is one of significant proportions. In 1984 the Cincinnai Department of Public Works estimated that there were approximately 100 landslides in the city that directly affected public property and that it would cost approximately $15 million to correct them. Of course, the landslide problem in Hamilton County and vicinity is, in part, due to the density of population in the area.

Probably the most famous and certainly the most costly Cincinnati-region landslide is the Mt. Adams slide. This



Landslides in Hamilton County, 1982.

failure began in colluvium of the Kope Formation in November 1973 during construction of entrance ramps to Interstate 471 in Cincinnati. Repair and stabilization efforts on this landslide continue to the present, with at least $25 million having been spent.

Cuyahoga Valley

The valley of the Cuyahoga River between Cleveland and Akron, in Cuyahoga and Summit Counties, is an area famous for landslide activity. Landslides in this area are mostly of the rotational-slump variety and occur in clays and silts deposited in lakes formed when ice from glaciers of the Pleistocene ice age blocked various segments of the valley. The modern Cuyahoga River has cut through these deposits, leaving steep bluffs of unstable sediments along the valley walls. As noted for southwestern Ohio, many slides appear to be concentrated on north-facing slopes where moisture retention is higher.

Landslide in Cuyahoga Valley lake sediments near Boston Mills, Summit County. Photo by Sherry L. Weisgarber.

Although many slope failures in this area are apparently triggered by natural processes, human activities have been responsible for some of the major slides. Many landslide problems were encountered during the construction of Interstate 80 (Ohio Turnpike) where it crossed the Cuyahoga Valley in Summit County.

Perhaps one of the more spectacular slides in the Cuyahoga Valley occurred in the early morning hours of February 7, 1950, near Brecksville, Cuyahoga County. A rotational slump with a scarp 500 feet long and 50 feet high occurred suddenly with a sound reported as a hollow booming. The slide endangered a house at the top of the scarp, forcing evacuation of the residents and eventual relocation of the structure to another site. A portion of a road and railroad tracks was destroyed. The largest loss, however, was a county highway garage that was nearly demolished as it was buckled by the toe of the slide. Estimates at the time placed the damages at $500,000. The triggering mechanism for this slump is uncertain, although heavy rains in the days preceding the slide were undoubtedly a contributing factor.

Lake Erie shoreline

The eastern half of the Ohio portion of the Lake Erie shoreline, from Cleveland to Ashtabula, is characterized by bluffs of glacial till and glacially associated lake clays and silts. These unconsolidated sediments are highly susceptible to wave erosion at the base of the bluff, with consequent slope failure as basal support is removed. Such erosion is particularly accentuated during periods of high lake levels accompanied by large storms. When sufficient undercutting has occurred, large blocks rotate downward and outward into the lake, where they are rapidly eroded and disseminated by the waves, thus removing the possibility of achieving natural stability of the slope.

This problem has long been of interest to the Survey and was a subject of investigation by Ohio's first State Geologist, W. W. Mather, in 1837. Investigations of this significant problem continue to occupy the attention of the Survey's Lake Erie Section, located in Sandusky.

Bluffs overlooking Lake Erie are desirable building sites because of their scenic view; however, many homes that were hundreds of feet from the bluff edge a few decades ago have now been destroyed or are imminently threatened by destruction. Many lakeshore roads and other structures also have been destroyed or threatened by this alarming rate of bluff recession, which has been calculated to be as high as 7 feet per year in portions of Lake and Ashtabula Counties.

Bluff recession on the Lake Erie shoreline threatening a home near Huron, Erie County. Laminated clays such as these are very susceptible to undercutting by waves.

For the 5-year period from 1972 through 1976, the U.S. Army, Corps of Engineers estimated that the cost of erosion along the southern shore of Lake Erie from Sandusky to Erie, Pennsylvania, averaged $23,500 per mile per year. This figure includes costs related to the loss or relocation of buildings and roads and the construction of shore-protection structures.

HOW TO AVOID LANDSLIDES

Construction activities in any area of the state that has steep slopes should be undertaken with prior thought as to

Road destroyed by landslide in bluff of glacial till along Lake Erie shoreline, Lake County.

the landslide potential of the site. It should be noted that within areas of steep slopes, not every slope or geologic horizon has a high potential for landslides.

Site selection for a home or other structure in problem areas of the state should include a determination of geologic materials present at the site. Geologic maps are available from the Survey for many counties in the state. The presence of old landslides at the site should also be noted. Hummocky topography with seeps of water or swampy areas, steplike scarps, and trees or fence posts inclined at unusual angles are all signs that a slope has undergone failure at some time in the past.

Precautions against slope failure can also be undertaken at the time of construction and thereafter. Cuts at the base of a slope should be avoided, as should placement of large quantities of fill on the upper part of a slope. Removal of established vegetation should be avoided also as the roots tend to anchor surface materials. Vegetation also dissipates considerable subsoil moisture. Natural drainage patterns should not be disturbed and water from downspouts or discharge from septic tanks should be channeled away from failure-prone slopes.

In questionable areas, the services of a consulting geologist or a civil engineer familiar with problems of slope failure may, in the long term, be worth the added expense. Many landslides in Ohio could have been avoided by following relatively simple precautions. Unfortunately, it is unlikely that the problem will be greatly diminished in the state in the near future.

FURTHER READING

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DALE LIEBENTHAL RECEIVES EMPLOYEE OF THE YEAR AWARD

Dale Liebenthal (right) receives award from Division Chief Horace R. Collins.

Dale Liebenthal, boat captain in the Lake Erie Section, was the 1985 recipient of the Survey's "Employee of the Year" award. This honor recognizes superior efforts and contributions by a Division employee and carries a particular distinction because recipients are selected by a committee of Survey staff from nominations submitted by fellow employees.

Dale is the captain of the Survey's 48-foot research vessel, the *GS-1*, and is noted for his skills in these duties and for his mechanical abilities in keeping the boat and research equipment of the Lake Erie Section in good working order.

Dale is a Sandusky native and has been with the Survey since 1964, except for a three-year hiatus with private industry. He is a 20-year member of the Ohio National Guard, where he is a major in an engineer battalion. Dale is married, has two children, and, during the evening hours of the summer months, is captain of the Cedar Point ferry.

SURVEY STAFF NOTES

Mary Lou McGurk

Larry Wickstrom

Mary Lou McGurk is the secretary for the Lake Erie Section in Sandusky and has been with the Survey since 1981. In addition to typing, filing, and other such duties, Mary Lou maintains the section's library and works with Lake Erie water-level records. She particularly enjoys the variety in her job.

Mary Lou lives in Huron with her husband and has three children. She enjoys the theater, music, and needlework as hobbies.

Larry Wickstrom is a geologist in the Subsurface Geology Section and came to the Survey in 1983 after completing B.S. and M.S. degrees in geology at Kent State University. Larry is particularly interested in Cambrian-Ordovician stratigraphy and computer applications in geology. Currently, he is working on projects on the Trenton Limestone and the Devonian shales.

Larry is from Canton and is president of the Ohio chapter of the Computer Oriented Geological Society. Larry lives in Columbus and enjoys photography and customizing cars as hobbies.

QUARTERLY MINERAL SALES, OCTOBER—NOVEMBER—DECEMBER 1985

Compiled by Sherry L. Weisgarber

Commodity	Tonnage sold this quarter[1]	Number of mines reporting sales[1]	Value of tonnage sold[1] (dollars)
Coal	9,189,887	238	291,461,964
Limestone/dolomite[2]	8,604,535	97[3]	28,432,497
Sand and gravel[2]	5,745,960	195[3]	17,662,231
Salt[2]	1,258,456	5[4]	12,919,992
Sandstone/conglomerate[2]	468,146	20[3]	5,842,192
Clay[2]	225,472	24[3]	1,557,838
Shale[2]	259,267	19[3]	570,411
Gypsum[2]	66,518	1	631,921
Peat[2]	7,866	3	22,034

[1]These figures are preliminary and subject to change.
[2]*Tonnage sold* and *Value of tonnage sold* include material used for captive purposes. *Number of mines reporting sales* includes mines producing material for captive use only.
[3]Includes some mines which are producing multiple commodities.
[4]Includes solution mining.

1985 OHIO MINERAL SALES[1]

Compiled by Sherry L. Weisgarber

Commodity	Tonnage sold in 1985[2]	Number of mines reporting sales[2]	Value of tonnage sold[2] (dollars)	Percent change of tonnage sold from 1984[2]
Coal	35,392,529	297	1,144,225,264	-9.3
Limestone/dolomite[3]	37,013,024	115[4]	127,116,587	+1.3
Sand and gravel[3]	27,298,305	255[4]	84,799,767	-10.6
Salt[3]	4,339,571	5[5]	43,277,374	+13.5
Sandstone/conglomerate[3]	2,073,784	26[4]	25,017,916	-3.7
Clay[3]	968,547	33[4]	5,486,681	+11.6
Shale[3]	1,328,580	26[4]	1,886,810	-44.8
Gypsum[3]	247,963	1	2,355,648	+16.7
Peat[3]	29,584	5	125,275	+42.0

[1]The sums of previously reported quarterly totals may not necessarily equal the annual totals reported here owing to the receipt of additional information or corrections to previously published figures.
[2]These figures are preliminary and subject to change.
[3]*Tonnage sold* and *Value of tonnage sold* include material used for captive purposes. *Number of mines reporting sales* includes mines producing material for captive use only.
[4]Includes some mines which are producing multiple commodities.
[5]Includes solution mining.

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