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LANDSLIDES

By
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to Lilly alias "the Debris slide" from the "Soil Creep" Herb

Introduction - This past winter excessive slope failures in the Northwest have focused more than usual interest on landslides. Public interest has led to the preparation of this article designed to explain in a general way the causes, danger signs, and corrections for a few of the most common types of slides occurring in the Portland area.

Landslide damage - Landslides are far more common than is generally realized. Lack of information about them is probably due to their intermittent occurrence and the relatively small number of people directly affected. The following cost estimates of slide damage in Oregon are given to illustrate their importance and to call attention to the need for further slide study.

The winter of 1955-1956 cost the Multnomah County road department an estimated $125,000 for slide repair, four times the normal yearly cost. Slides in that county, which numbered 109, are exclusive of those on highways and streets maintained by city governments and the State Highway Department. The Portland city water department reported a slide damage this past winter to the main water supply system which will cost an estimated $100,000 to repair. According to the city engineer's office, repairs to Portland city streets and parks necessitated by recent slides will cost about $100,000.

The Oregon State Highway Department reports that slides have cost an average of more than $400,000 yearly for the 4-year period ending November 30, 1955. Since that date, damage has occurred which may greatly exceed this yearly average. Federal agencies concerned with relocation of the Willamette Highway in the vicinity of Lookout Point Dam reported that slides increased the cost of construction by at least $500,000, but that other similar Federal projects were less affected. In addition the cost of landslides to counties in Oregon other than Multnomah County, cities besides Portland, the Forest Service, logging companies, railroads, power and telephone companies, corporations, and individuals throughout the State makes the total far greater than may be realized.

Causes of landslides - Slopes remain standing only because they possess the internal strength to have withstood the most severe conditions to date. The fact that slides occur is evidence that either weather conditions affecting the soil have become more severe or other factors have made the slopes more susceptible to sliding.

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A slide is precipitated when the shearing stress exceeds the shearing strength of the soil. Shearing stress in a soil mass is increased by external causes while a loss of shear strength of the soil is caused by internal changes.

External causes of landslides are due to the undercutting of the toe of a slope (over-steepening), addition of weight from embankment material or waste deposited along the upper edge of the slope, and from added weight of increased moisture content. Earthquakes or vibrations can be a cause and there is no doubt that vibrations from any source may "trigger" a slide.

Internal causes of landslides are due to water in the ground. The ground water produces both immediate and progressive decrease in shear strength of the soil. Immediate decrease of shear strength is generally caused by increase in pressure from water in the voids. This pressure is analogous to the forces exerted by a hydrostatic head. Seapage pressure is a force exerted by ground-water flow due to the viscosity of water moving through minute passages in the soil. Continued seepage through slopes expels the air and apparent cohesion between the soil particles is eliminated, further weakening the soil. Although this mainly concerns conditions of rapid drawdown in reservoirs and stream channels it is also true of saturated soils below the water table. Progressive decrease in shear strength results from removal of the soil binder and chemical decomposition of the mineral grains by ground-water action.

A deep frost greatly increases the susceptibility of a slope to fail. Frost heaving or the expansion of the soil by formation of ice crystals and the freezing of water pockets results in increase of void spaces in the soil. This increased moisture capacity of the soil is sometimes sufficient to start liquefaction* and slide action on fairly steep slopes. The deep frost early in the fall of 1955 is unquestionably a major factor in the large number of slope failures in the Portland area during the past winter.

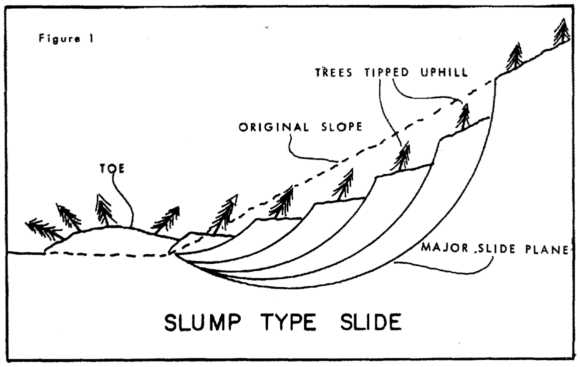
Slide development - As the shearing forces approach the shear strength of a soil mass, certain sections fail by rearrangement of the soil grains and the formation of hairline cracks. Excess water in the disturbed soil is forced into other sections of the soil and failure of the soil mass continues as if by chain reaction. When the shear strength along a possible slide plane is reduced sufficiently the entire mass becomes mobile and a slide occurs. At the moment a slide begins the shearing forces are but slightly greater than the shear strength of the soil, but sliding causes a reduction in strength of 20 to 90 percent depending on the sensitivity** of the soil (Terzaghi, 1950, p. 112). Movement of the slide rapidly increases as the soil loses its strength. As the slide progresses, the driving force is reduced through reduction in slope and mixing of the slide material with more stable foreign soil. When the resisting force again is equal to the shearing force of the soil the movement passes from sliding into slow creep. The surface of an old slide is particularly susceptible to the effects of excessive rainfall, since numerous deep fissures provide easy entrance for water and drainage is greatly disrupted.

Varieties of landslides - Landslides occur in so many types of material under such a wide variety of conditions that a classification could include dozens of categories. For the student of landslides, various classifications have been prepared (Ladd, Sharpe, Terzaghi, and others)

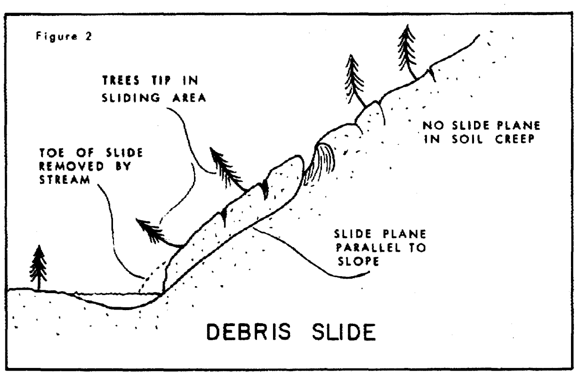
* Action of a saturated soil which becomes fluid when disturbed.

**Sensitivity refers to changes in soil strength under variations of moisture content.

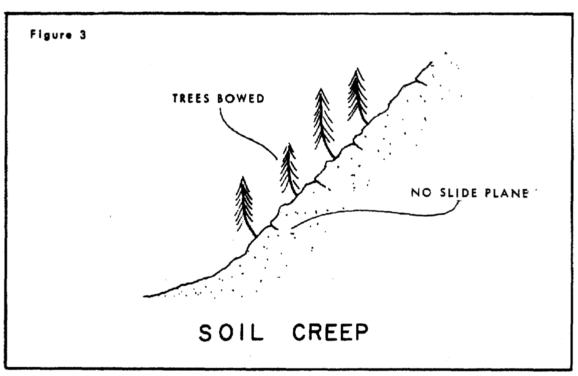
based on the appearance, the mechanics, the type of material, and the speed at which failure takes place. No attempt is made here to present a classification of landslides other than to name and describe the most general types occurring on earth slopes.



Slump: This term is used (Sharpe, 1938) for landslides having a curved slide plane occurring in relatively homogeneous material such as unbedded silts and clays. A slump-type slide is recognized by the exposed main slide plane at the head of the slide, a series of successive slump blocks resembling terraces having exposed sliding surfaces, and the bulged toe of the slide due to compression from the sliding mass. Trees standing on the individual blocks are nearly vertical at the top but near the base they lean upslope, due to rotation (see Fig. 1). On the toe, however, the trees lean downhill. When the toe of a slump occurs on steep slopes the slide may continue as a debris slide or mudflow depending on moisture conditions and sensitivity of the sliding material to minor moisture changes. As an example of high sensitivity, a silt soil, which is stable at a certain moisture content, loses its strength rapidly with slight increase of moisture.



Debris slide: Debris slides are characterized by a straight slide plane and generally occur in a weathered zone such as clay or silt resting on unweathered resistant beds. The sliding mass tears away from the soil upslope, forming deep irregular cracks normal to the direction of sliding. Trees tip downhill due to forward rotation of the soil mass by friction at the slide plane (see Fig. 2). If material accumulates at the toe of a debris slide a curved sliding plane will develop, producing a more stable condition (Baker, 1953, p. 10).



Soil creep: Creep is similar to a debris slide except that no slide plane is developed. The surface of a creep area consists of a series of humps or rolls; cracks are developed in an irregular pattern but do not outline the sliding area as in a debris slide. Trees and normally vertical objects tilt downslope. Creep often develops into slump or debris slides as continued movement produces a sliding surface (see Fig. 3).

Mudflow: Mudflows occur when the soil flows downslope as the result of oversaturation. Rearrangement of the soil grains in this type of material by shock or movement when the soil is saturated decreases the void space, which in effect creates an excess of water in the soil mass. The excess water gives buoyancy and mobility to the soil mass and can carry along material in its path ranging from soil to boulders. Mudflows are recognized by the jumbled mass of unsorted materials, generally fan shaped, at the toe.

Treatment and prevention - Both critical slopes and landslides offer serious problems and should be equally considered. In general both will require the same extensive treatment before stability is assured.

The corrective methods used depend on degree of slope, size of area, type of soil, and degree of safety required. All slides and unstable slopes have in common the force of gravity and shear strength of the soil. Both are appreciably affected by moisture. Any treatment to be successful must counteract the effective force of gravity or increase the shear strength of the soil.

Since even gentle slopes may be subject to sliding they should be examined for signs of failure. Old landslide scars are obvious signs of dangerous slopes. Although these may have affected only a small part of the area, the entire slope should be considered susceptible to failure. According to Terzaghi (1950, p. 110) all slides except those due to earthquake and spontaneous liquefaction will show signs of progressive failure prior to sliding. Indications of progressive slope failure are bent trees, vertical objects such as fence posts tipped downhill, and tension cracks along the upper edge of the unstable area.

Although some slopes have not failed, any steepening such as addition of material at the top or the removal of material at the toe, may change the conditions sufficiently to cause sliding. Failure, however, will probably not occur until there is a decrease of soil strength and addition of weight during a period of excessive moisture.

The treatment of slides and critical slopes depends upon acquiring a satisfactory degree of safety within economical limits. In the case of highway slides it is sometimes more economical to clean up a slide after it occurs rather than prevent it. Occasionally moderate expenditure will make a slope questionably safe; however, this type of treatment is impractical if a slide might result in excessive damage, possible injury, or loss of life. The magnitude of a slide that warrants being made absolutely safe depends on the value of the property involved. Slides affecting most dwellings must be made unquestionably safe, therefore only sliding on a small scale can be economically corrected. Generally stabilization can be effected by unloading the top of the slide and placing material on the toe and draining the slope by good surface drainage and by horizontal pipes placed to intersect subsurface water. All sources of surface and ground water leading into the slide area should be located and their effects lessened or eliminated. Control of long slopes is difficult, expensive, and often economically impossible, especially if the slide occurs part way up the slope.

Piling driven through the moving layer of soil into stable material may add stability but it should not be attempted without a study of the forces involved. Piling of proper strength must be driven sufficiently deep in firm, stable material to resist being pushed over or broken off by the force exerted by the unstable soil mass. The effects of piling or a retaining wall should not be expected to overcome the entire force of a large soil mass but should be used in conjunction with other procedures such as drainage or resloping.

Close spacing of homes on small hillside lots affected by a slide may prevent the most satisfactory correction such as diversion of surface water away from the slide and resloping. Proper treatment in this case can be accomplished only by cooperation on the part of all persons involved.

Landscaping of homes located on steep hillsides should take into consideration the possibility of creating or alleviating slides. Care should be taken when retaining walls are built on slopes below the level of the house and filled with soil to provide level or nearly level yards. This system if properly designed is satisfactory; however, most trouble lies in underdesigned retaining walls, poor foundations in which to anchor the wall, little or no drainage facilities for water pressure building up behind the wall, and, probably the greatest cause of failure, poorly compacted fill material composed of sensitive silt or clayey silt. Persons familiar with design of retaining walls should be given the responsibility. The problem of compaction and type of material is extremely important. The body of the fill should be made of a well-graded soil which when compacted will have a minimum of void space, thereby providing as little volume for moisture as possible. It should be placed at a computed moisture content and compacted to at least 90 percent maximum by hand or pneumatic tampers. The fill should be placed and compacted in layers not exceeding a depth of 6 inches to insure sufficient compaction.

Acknowledgments - Gratitude is extended to the persons and organizations that gave assistance in the preparation of this report. Mr. W. C. Hill, Soils Engineer for the Oregon State Highway Department, read the report and made helpful suggestions. Mr. H. F. Kerslake provided a map and list of slides occurring on Multnomah County roads. The State Highway Department, the Multnomah County Road Department, and the Street, Park, and Public Works departments of the City of Portland provided information on occurrences and costs of the numerous slides in the Portland area.

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LAND DETERMINATION AREAS IN OREGON

The U.S. Forest Service and Bureau of Land Management have notified the Department the following areas will be examined this summer for determination of surface rights under Public Law 167 (see The Ore.-Bin, April 1956 and August 1955).

U.S. Forest Service

1.-Deschutes National Forest (field examination started May 1956): Secs. 29 through 36, T. 25 S., R. 8 E.; secs. 24, 25, and 36, T. 26 S., R. 7 E.; secs. 1 through 36, T. 26 S., R. 8 E.; secs. 1 through 30, 34, 35, 36, and part of sec. 31, T. 27 S., R. 8 E.; secs. 1, 2, 3, 10, 11, 12, 13, 14, 24, 25, 35, and 36, T. 28 S., R. 8 E.; and sec. 1, T. 29 S., R. 8 E.

2.- Willamette National Forest (field examination to be started as soon as snow conditions permit): Little North Fork Santiam River area and Quartzville area.

3.- Siskiyou National Forest (to be examined this spring): Lawson Creek drainage of Curry County.

U.S. Bureau of Land Management

The letter from the Bureau of Land Management states:

> "We have selected T. 34 S., Rs. 5 and 6 W., as the first experimental or test area. This is an area of intermingled O&C and vacant public lands and known to contain a number of mining claim locations. We expect to examine and advertise the vacant public land under Public Law 167 within the next three months. It is also quite likely it will also be necessary to examine and advertise the O&C lands. The reason being that the O&C Mining Act of 1948 (62 Stat. 162) does not provide road rights of way across mining claims located either prior or subsequent to the act of August 28, 1937 (50 Stat. 874).
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> "If any claims are found on O&C lands which were located prior to August 28, 1937, and which appear, upon examination, to be locations without a valid discovery, it is quite likely adverse proceedings will be brought under the old procedure with the object of cancelling such locations. The effect of such a procedure would be to save for the counties (75%) and the Government (25%) of the timber values now and hereafter growing on the area occupied by a claim or claims located prior to August 28, 1937, the same as if such locations were made subsequent to the act of April 8, 1948, supra."

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DRILLING PERMIT ISSUED

Permit No. 18 to drill an oil test well was issued April 30, 1956, to Riddle Gas and Oil Producers, Oreg., Ltd. The permit showed that the drilling was to be done 601 feet south of the north line and 34.9 feet west of the east line of sec. 28, T. 30 S., R. 6 W. The lessee was given as F. H. Wollenberg, Alameda, California, and the lessor as W. M. Parnell, Riddle, Oregon.

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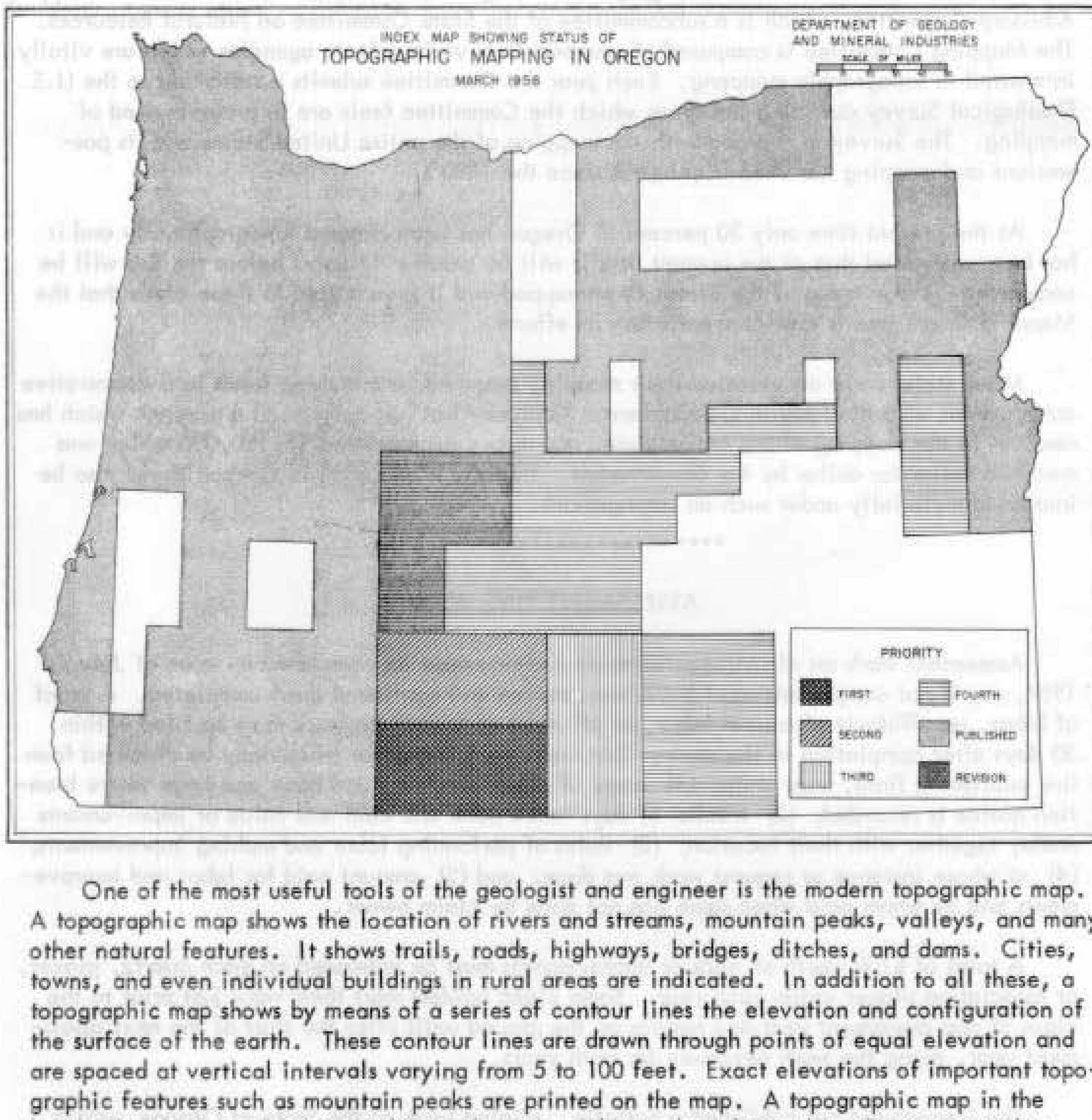
TOPOGRAPHIC MAPPING



One of the most useful tools of the geologist and engineer is the modern topographic map. A topographic map shows the location of rivers and streams, mountain peaks, valleys, and many other natural features. It shows trails, roads, highways, bridges, ditches, and dams. Cities, towns, and even individual buildings in rural areas are indicated. In addition to all these, a topographic map shows by means of a series of contour lines the elevation and configuration of the surface of the earth. These contour lines are drawn through points of equal elevation and are spaced at vertical intervals varying from 5 to 100 feet. Exact elevations of important topographic features such as mountain peaks are printed on the map. A topographic map in the hands of a person trained in reading it shows at a glance the relationship of one geographic point to another, both vertically and horizontally. The usefulness of such maps is not limited, however, to the professional, and increasing numbers are sold annually to vacationists and others interested in the out of doors who wish the most accurate information of the countryside available.

From an engineering standpoint, a topographic map is a "must" in the planning and execution of any project such as a pipeline, highway, transmission line, or dam. Oftentimes the feasibility of a proposed site can be determined readily from an examination of a topographic map. Geologists require topographic maps as a base on which to plot their findings. It is impractical to do any geologic mapping in areas not previously mapped topographically. The growing demand for water points up the need for topographic maps since adequate studies can not be made without them.

The accompanying map shows the status of topographic mapping in Oregon. Included on this map are the areas for which topographic coverage has been requested by the State Mapping Advisory Committee, which is a subcommittee of the State Committee on Natural Resources. The Mapping Committee is composed of members from various State agencies which are vitally interested in topographic mapppng. Each year the Committee submits a statement to the U.S. Geological Survey outlining the areas which the Committee feels are in greatest need of mapping. The Survey is charged with the mapping of the entire United States and its possessions and mapping has been in progress since the 1880's.

At the present time only 30 percent of Oregon has been mapped topographically and it has been estimated that at the present rate it will be another 17 years before the job will be completed. Large areas of the State are unmapped and it is in regard to these areas that the Mapping Committee is now concentrating its efforts.

Many states have accelerated their mapping programs by matching funds in a cooperative arrangement with the Federal Government. Kentucky has just completed a program which has resulted in the mapping of the entire state. Kentucky appropriated $3,180,000 which was matched dollar for dollar by the Government. The rate of mapping in Oregon could also be increased materially under such an arrangement.

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ASSESSMENT TIME AGAIN

Assessment work on all unpatented mining claims must be completed by noon of July 1, 1956, or, if not completed, must have been started and continued until completed. A proof of labor, an affidavit of annual labor, or affidavit of assessment work must be filed within 30 days after completion of the work. This instrument, forms for which may be obtained from law publishing firms, must state: (1) name of claim or claims and book and page where location notice is recorded; (2) number of days' work done and kind and value of improvements made, together with their location; (3) dates of performing labor and making improvements; (4) at whose instance or request work was done; and (5) amount paid for labor and improvements and by whom paid when same was not done by claim owner.

A total of $100 worth of work or improvements must be expended on each quartz, placer, or association placer claim each year. Some claim holders start their work just prior to the close of one assessment year and remain on the ground until after the start of the next assessment year, doing the work necessary for both years.

The Department has published a bulletin, Mining Laws of the State of Oregon, which contains the rules and regulations of the State of Oregon pertaining to location and assessment work on quartz and placer mining claims. Copies of this publication may be obtained from the Department office at Portland or from the Grants Pass and Baker field offices at a cost of 50 cents per copy.

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FLASH

It has been reported but not confirmed that the Office of Defense Mobilization will announce the extension of several strategic mineral programs in the near future. Chrome is one of the minerals reportedly included in the extensions.

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