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VARNES LANDSLIDE CLASSIFICATION (1978)

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VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

The landslide classification based on Varnes' (1978) system has two terms:

- the first term describes the material type,

- the second term describes the type of movement.

http://www.ukgeohazards.info/pages/eng_geol/landslide_geohazard/eng_geol_landslides_classification.htm

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

The material types used by the various schemes are Rock, Earth, Soil, Mud and Debris, being classified as follows:

Rock: is “a hard or firm mass that was intact and in its natural place before the initiation of movement”.

Soil: is “an aggregate of solid particles, generally of minerals and rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil”.

Earth: “describes material in which 80% or more of the particles are smaller than 2mm, the upper limit of sand sized particles”.

Mud: “describes material in which 80% or more of the particles are smaller than 0.06mm, the upper limit of silt sized particles”.

Debris: “contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2mm, and the remainder are less than 2mm”.

http://www.ukgeohazards.info/pages/eng_geol/landslide_geohazard/eng_geol_landslides_classification.htm

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

The five kinematically distinct types of movement are described in the sequence:

- **fall,**
- **topple,**
- **slide,**
- **spread,**
- **flow.**

Combining the two terms gives classifications such as:

Rock fall, Rock topple, Debris slide, Debris flow, Earth slide, Earth spread etc.

http://www.ukgeohazards.info/pages/eng_geol/landslide_geohazard/eng_geol_landslides_classification.htm

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS (1978)

Varnes, D. J. 1978. Slope movement types and processes. In: *Special Report 176: Landslides: Analysis and Control* (Eds: Schuster, R. L. & Krizek, R. J.). Transportation and Road Research Board, National Academy of Science, Washington D. C., 11-33.

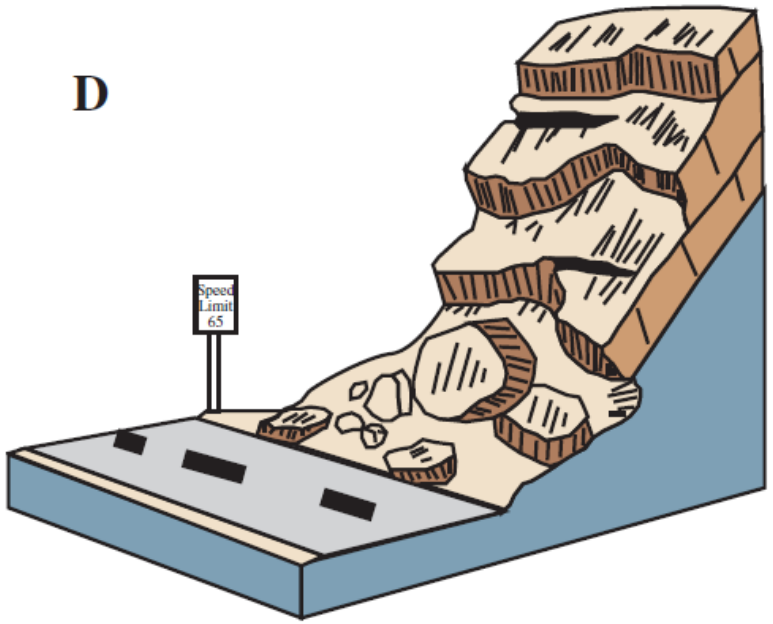
TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly coarse	Predominantly fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (deep creep)	Debris flow (soil creep)	Earth flow
COMPLEX		Combination of two or more principal types of movement		

Abbreviated version of Varnes´ classification of slope movements (Varnes 1978)

http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

Falls are abrupt movements of masses of geologic materials, such as rocks and boulders, that become detached from steep slopes or cliffs. Separation occurs along discontinuities such as fractures, joints, and bedding planes, and movement occurs by free-fall, bouncing, and rolling. Falls are strongly influenced by gravity, mechanical weathering, and the presence of interstitial water.

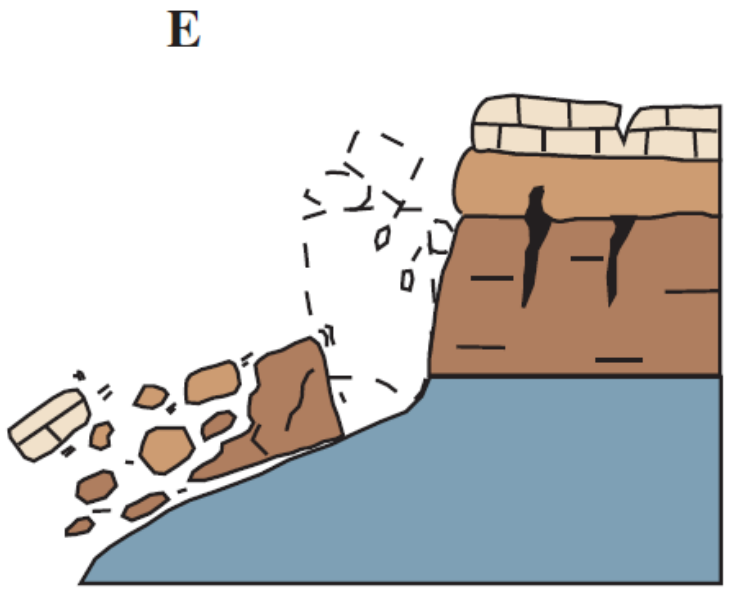


Rockfall

http://pubs.usgs.gov/fs/2004/3072/

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

TOPPLES: Toppling failures are distinguished by the forward rotation of a unit or units about some pivotal point, below or low in the unit, under the actions of gravity and forces exerted by adjacent units or by fluids in cracks.



Topple

http://pubs.usgs.gov/fs/2004/3072/

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

TOPPLES

Photo: J. Novotný

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

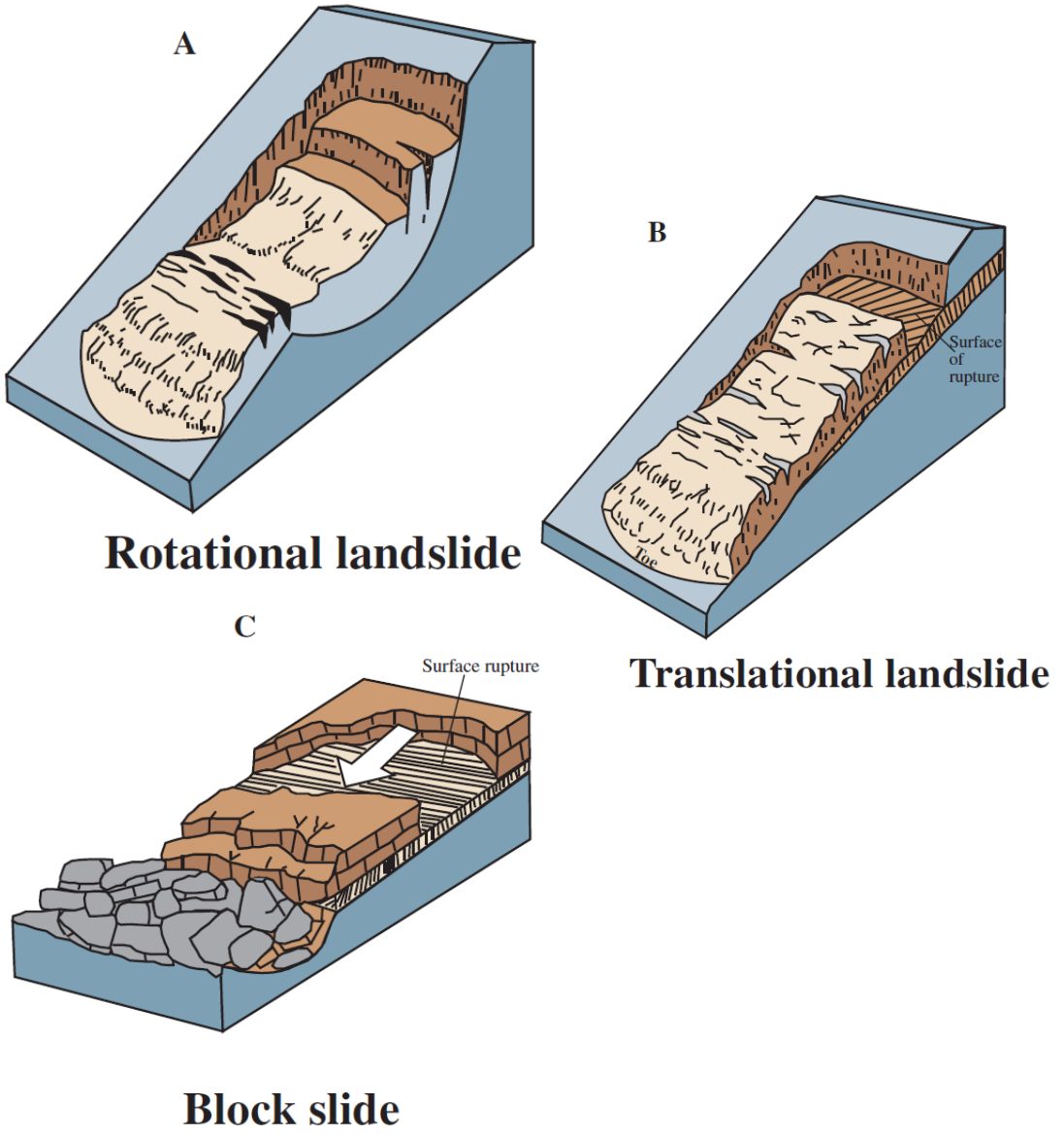
SLIDES: Although many types of mass movements are included in the general term “landslide,” the more restrictive use of the term refers only to mass movements, where there is a distinct zone of weakness that separates the slide material from more stable underlying material. The two major types of slides are **rotational slides** and **translational slides**.

http://pubs.usgs.gov/fs/2004/3072/

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

***Rotational slide*:** This is a slide in which the surface of rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface
and transverse across the slide).

Translational slide*:** In this type of slide, the landslide mass moves along a roughly planar surface with little rotation or backward tilting. **A *block slide is a translational slide in which the moving mass consists of a single unit or a few closely related units that move downslope as a relatively coherent mass



http://pubs.usgs.gov/fs/2004/3072/

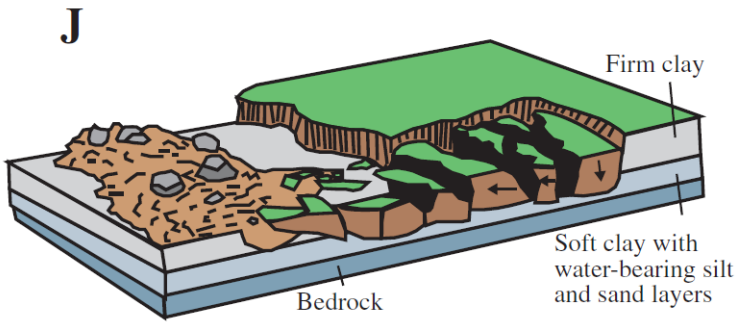
VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

A translational landslide that occurred in 2001 in the Beatton River Valley, British Columbia, Canada. (Photograph by Réjean Couture, Canada Geological Survey.)

Highland, L.M., and Bobrowsky, Peter, 2008, The landslide handbook—A guide to understanding landslides: Reston, Virginia, U.S. Geological Survey Circular 1325, 129 p.

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

LATERAL SPREADS: Lateral spreads are distinctive because they usually occur on very gentle slopes or flat terrain. The dominant mode of movement is lateral extension accompanied by shear or tensile fractures. The failure is caused by liquefaction, the process whereby saturated, loose, cohesionless sediments (usually sands and silts) are transformed from a solid into a liquefied state.



Lateral spread

Failure is usually triggered by rapid ground motion, such as that experienced during an earthquake, but can also be artificially induced. When coherent material, either bedrock or soil, rests on materials that liquefy, the upper units may undergo fracturing and extension and may then subside, translate, rotate, disintegrate, or liquefy and flow. Lateral spreading in fine-grained materials on shallow slopes is usually progressive. The failure starts suddenly in a small area and spreads rapidly. Often the initial failure is a slump, but in some materials movement occurs for no apparent reason.

http://pubs.usgs.gov/fs/2004/3072/

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

LATERAL SPREADS:

Sunset Lake, WASHINGTON, USA, 2001
(triggering factor – earthquake)

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FLOWS: There are five basic categories of flows that differ from one another in fundamental ways.

a. Debris flow: A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as a slurry that flows downslope. Debris flows include <50% fines. Debris flows are commonly caused by intense surface-water flow, due to heavy precipitation or rapid snowmelt, that erodes and mobilizes loose soil or rock on steep slopes. Debris flows also commonly mobilize from other types of landslides that occur on steep slopes, are nearly saturated, and consist of a large proportion of silt- and sand-sized material. Debris-flow source areas are often associated with steep gullies, and debris-flow deposits are usually indicated by the presence of debris fans at the mouths of gullies. Fires that denude slopes of vegetation intensify the susceptibility of slopes to debris flows.

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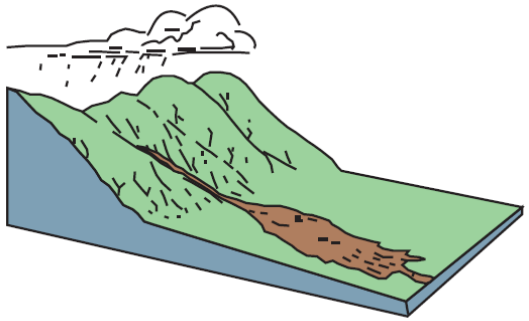

Debris flow

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FLOWS:

b. Debris avalanche: This is a variety of very rapid to extremely rapid debris flow.

c. Earth flow: Earth flows have a characteristic “hourglass” shape. The slope material liquefies and runs out, forming a bowl or depression at the head. The flow itself is elongate and usually occurs in fine-grained materials or clay-bearing rocks on moderate slopes and under saturated conditions. However, dry flows of granular material are also possible.

d. Mud flow: A mudflow is an earth flow consisting of material that is wet enough to flow rapidly and that contains at least 50 percent sand-, silt-, and clay-sized particles. In some instances, for example in many newspaper reports, mudflows and debris flows are commonly referred to as “mud slides.”

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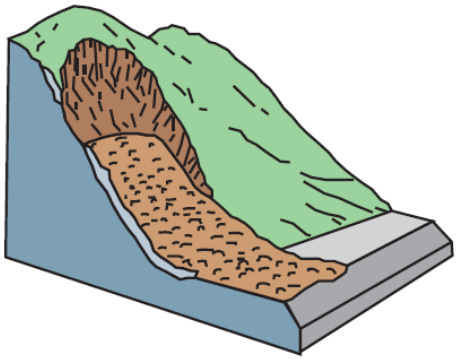

Debris avalanche

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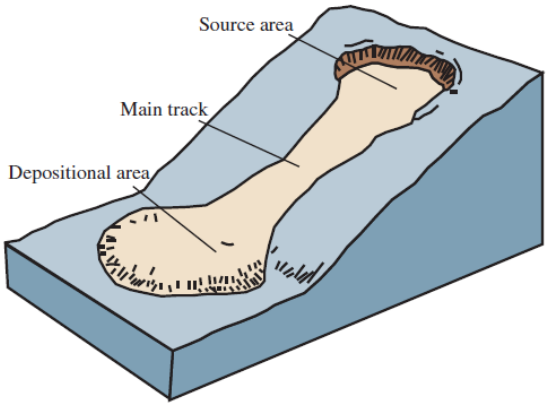


Earthflow

http://pubs.usgs.gov/fs/2004/3072/

VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

FLOWS:

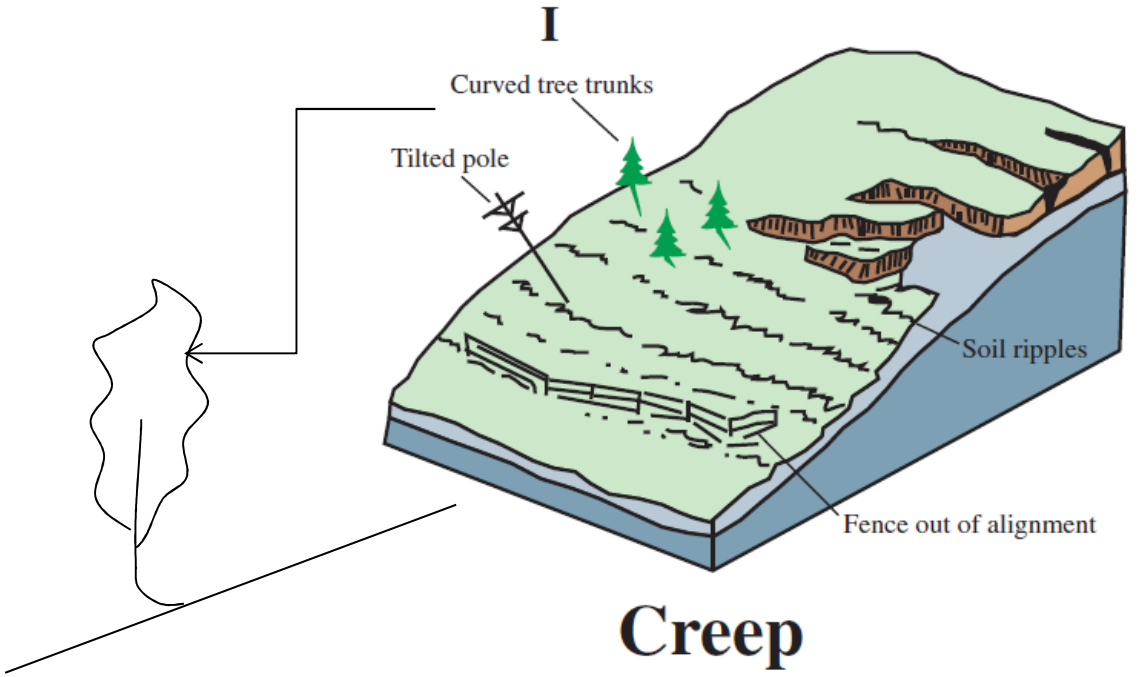
e. Creep: Creep is the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress sufficient to produce permanent deformation, but too small to produce shear failure. There are generally three types of creep:

(1) seasonal, where movement is within the depth of soil affected by seasonal changes in soil moisture and soil temperature;

(2) continuous, where shear stress continuously exceeds the strength of the material;

(3) progressive, where slopes are reaching the point of failure as other types of mass movements.

Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

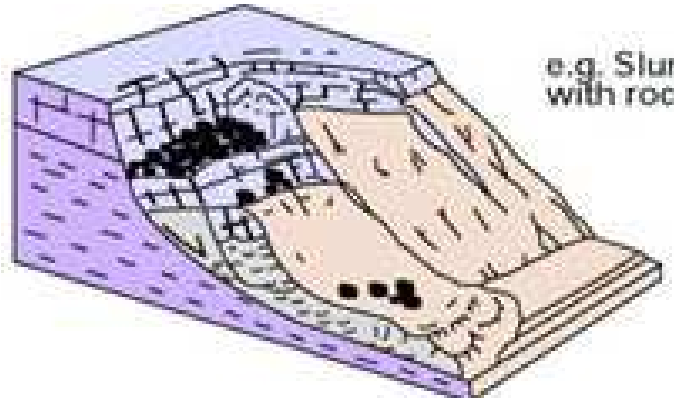


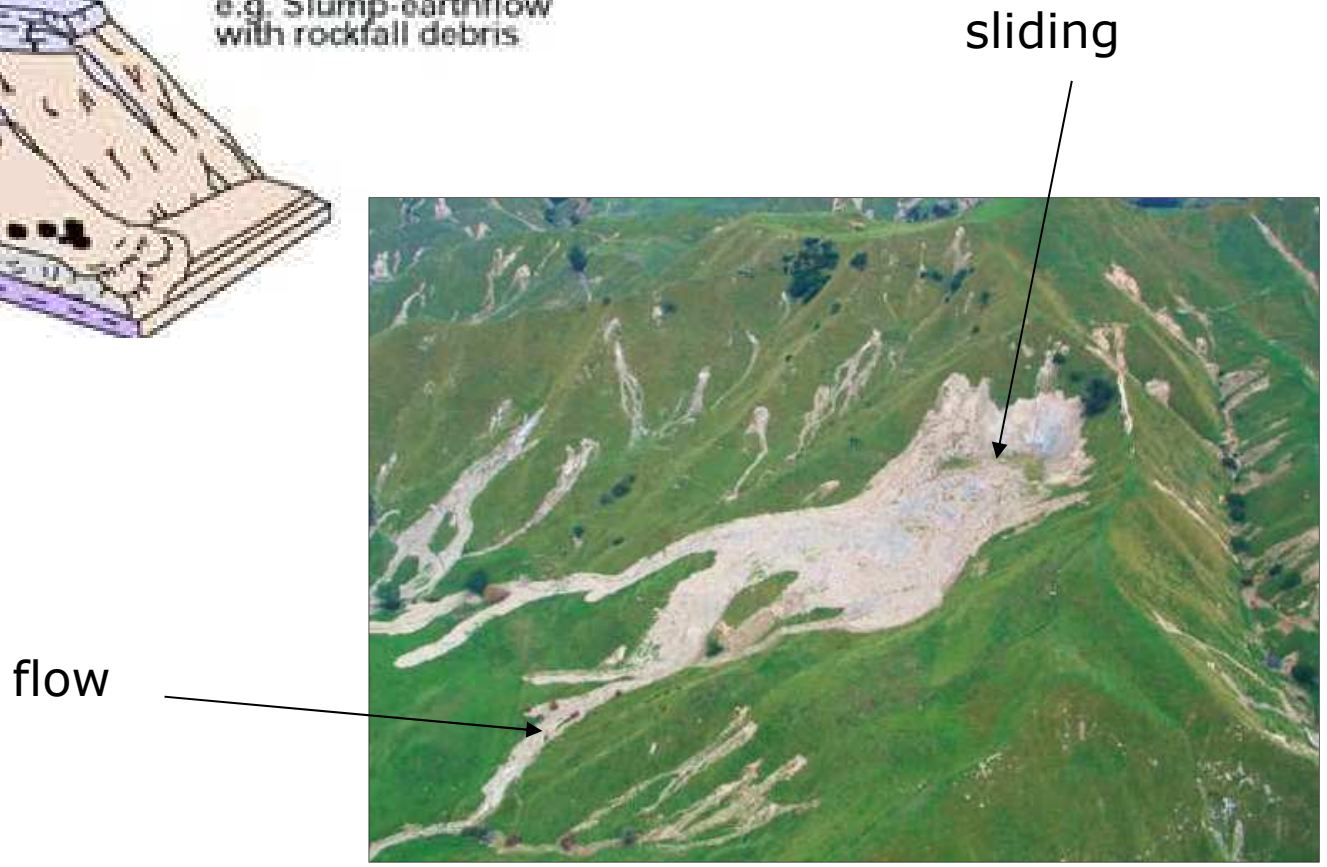
Creep

http://pubs.usgs.gov/fs/2004/3072/

COMPLEX:

Combination of two or more of the above types is known as a **complex landslide**.





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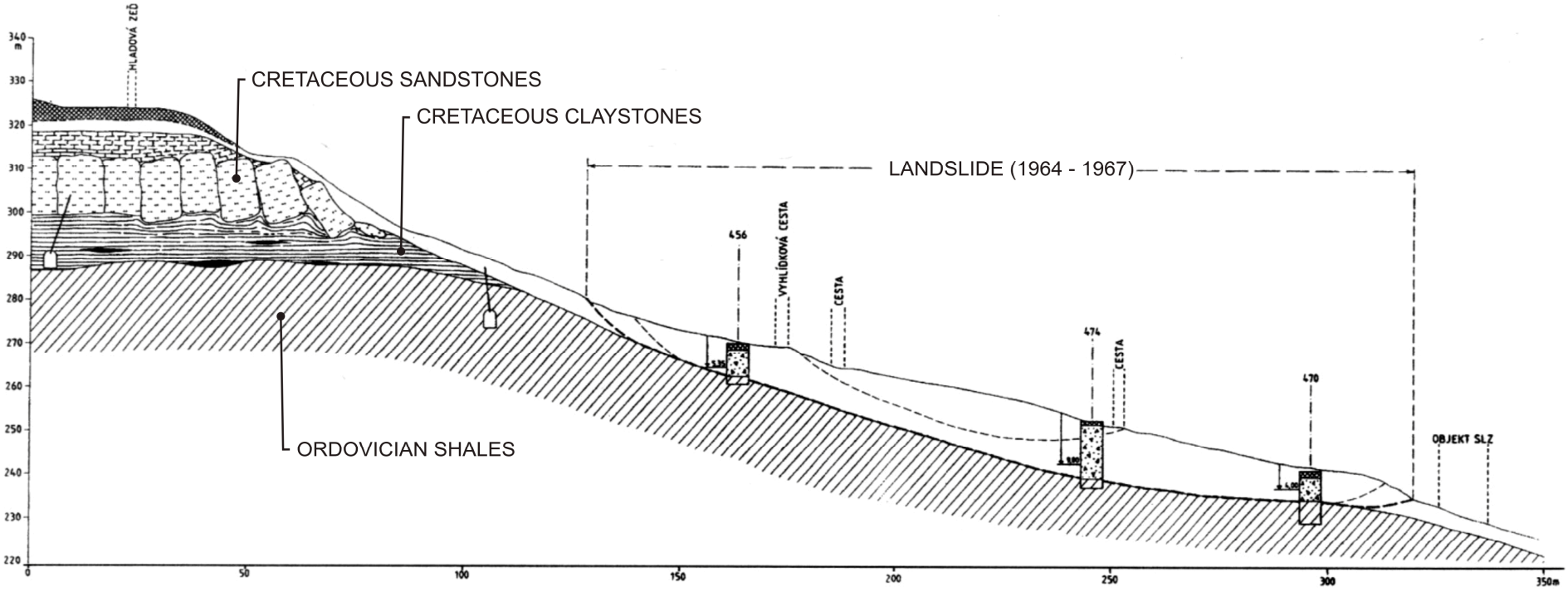

Petřín, Prague, Czech Republic

After J. Voltr 1992

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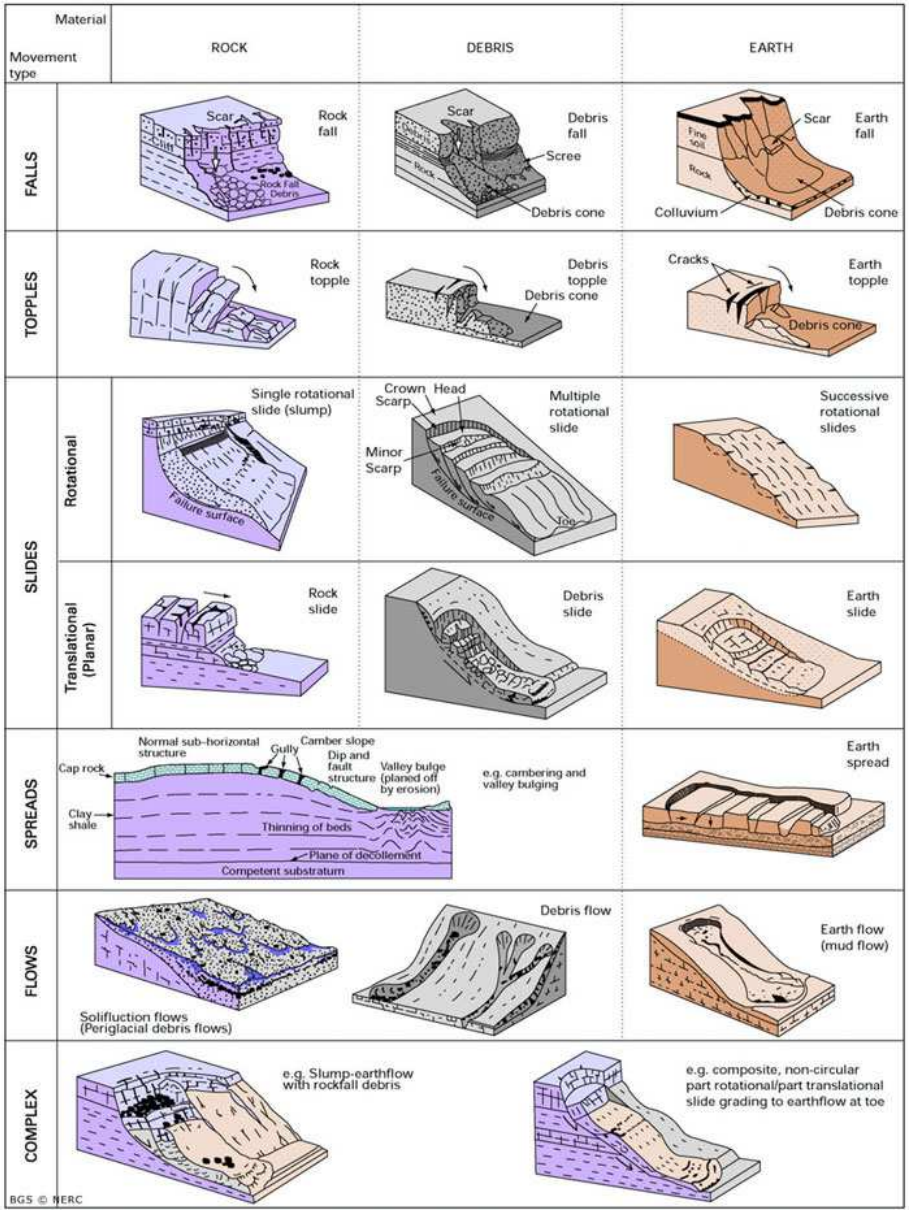

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