VARNES LANDSLIDE CLASSIFICATION
(1978)

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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
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
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.
VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS (1978)


<table>
<thead>
<tr>
<th>TYPE OF MOVEMENT</th>
<th>BEDROCK</th>
<th>TYPE OF MATERIAL</th>
<th>ENGINEERING SOILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALLS</td>
<td>Rock fall</td>
<td>Debris fall</td>
<td>Predominantly coarse</td>
</tr>
<tr>
<td>TOPPLES</td>
<td>Rock topple</td>
<td>Debris topple</td>
<td>Predominantly fine</td>
</tr>
<tr>
<td>ROTATIONAL</td>
<td>Rock slide</td>
<td>Debris slide</td>
<td>Earth slide</td>
</tr>
<tr>
<td>TRANSLATIONAL</td>
<td>Rock flow</td>
<td>Debris flow</td>
<td>Earth flow</td>
</tr>
<tr>
<td>LATERAL SPREADS</td>
<td>Rock spread</td>
<td>Debris spread</td>
<td>Earth spread</td>
</tr>
<tr>
<td>FLOWS</td>
<td>Rock flow</td>
<td>Debris flow</td>
<td>Earth flow</td>
</tr>
<tr>
<td>COMPLEX</td>
<td>Combination of two or more principal types of movement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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.

http://pubs.usgs.gov/fs/2004/3072/
**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.
VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

TOPPLES

USA, Utah, Canyonlands

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

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.

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.
LATERAL SPREADS: Sunset Lake, WASHINGTON, USA, 2001 (triggering factor – earthquake)

Photo: S. Kramer
VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

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.
VARNES´ CLASSIFICATION OF SLOPE MOVEMENTS

path of debris flow

new bridge, old bridge was broken by debris flow

Photo: J. Novotny

Brazil
new village was built on debris flow accumulation which buried older village

Photo: J. Novotny
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.”
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.

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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
# Varnes´ Classification of Slope Movements

<table>
<thead>
<tr>
<th>Material</th>
<th>Rock</th>
<th>Debris</th>
<th>Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Type</td>
<td>Falloff</td>
<td>Slump</td>
<td>Slide</td>
</tr>
<tr>
<td>Falls</td>
<td>Rock falls</td>
<td>Debris slides</td>
<td>Earth falls</td>
</tr>
<tr>
<td>Topses</td>
<td>Rock topples</td>
<td>Debris topples</td>
<td>Earth topples</td>
</tr>
<tr>
<td>Rotational</td>
<td>Single rotational slide (slump)</td>
<td>Crowned scarp</td>
<td>Multiple rotational slides</td>
</tr>
<tr>
<td>Slides</td>
<td>Rock slide</td>
<td>Head scarp</td>
<td>Suscussive rotational slides</td>
</tr>
<tr>
<td>Translational (Planar)</td>
<td>Normal translational slide</td>
<td>E.g. caving and valley widening</td>
<td></td>
</tr>
<tr>
<td>Spreads</td>
<td>Earth spread</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flows</td>
<td>Debris flow</td>
<td>Earth flow (mud flow)</td>
<td></td>
</tr>
<tr>
<td>Complex</td>
<td>e.g. Slump earth flow with coherent debris</td>
<td>E.g. composite, non-circular part rotational/part translational slide grading to earth flow at toe</td>
<td></td>
</tr>
</tbody>
</table>