Summary

- Mass wasting is the down slope movement of rock debris under the pull of gravity without a transporting medium. Mass wasting occurs both on land and beneath the sea.
- The composition and texture of debris, the amount of air and water mixed with it, and the steepness of slope influence the type and velocity of slope movements.
- Mass-wasting processes include sudden slope failures (slumps, falls, and slides) and down slope flow of mixtures of regolith, water, and air
- Failures occur when shear stress reaches or exceeds the shear strength of slope materials. High water pressure in rock voids or sediment reduces shear strength and increases the likelihood of failure.
- Slumps involve a rotational movement along a concave-up surface that results in backward-tilted blocks of rock or regolith.
- Falling and sliding masses of rock and debris are common in mountains where steep slopes abound.
- Rock fall debris accumulates at the base of a cliff to produce a talus with slopes that stand at the angle of repose.
- Slurry flows involve dense moving masses of water-saturated sediment that form non-sorted deposits when flow ceases. Flow velocities range from very slow (solifluction) to rapid (debris flows).

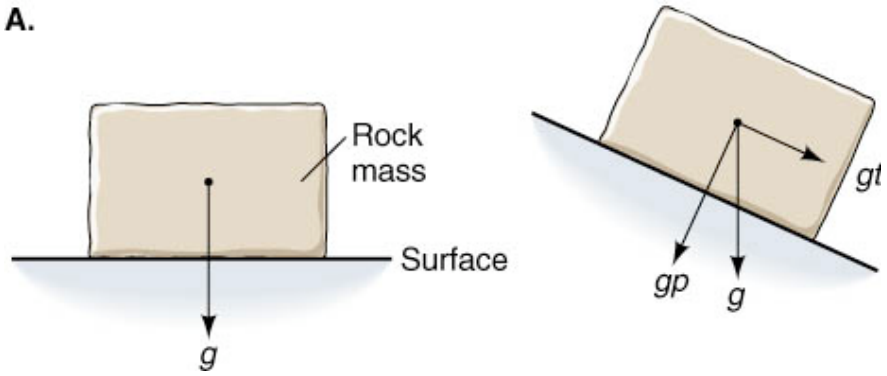
- In granular flows, sediment is in grain-to-grain contact or grains constantly collide. The sediment may be largely dry, or it may be saturated with water that can escape easily.
- Although creep is imperceptibly slow, it is widespread and therefore quantitatively important in the down slope transfer of debris.
- Large, rapidly moving debris avalanches are relatively infrequent but potentially hazardous to humans.
- In regions of perennially frozen ground, frost heaving, creep, and gelifluction are important mass-wasting processes.
- Large areas of seafloor on the continental slopes show evidence of widespread slumps, slides, and flows. Mass wasting on submarine slopes was especially active during glacial ages, when sea level was lower and large quantities of stream sediment were transported to the edge of the continental shelves.
- Slope failures can be triggered by earthquakes, undercutting by streams, heavy or prolonged rains, or volcanic eruptions. Subaqueous slope failures are frequently related to earthquake shocks and to over-steepening of slopes caused by rapid deposition of sediments.
- Loss of life and property from mass-wasting events can be prevented or mitigated by adequate assessment and planning based on geologic studies of previous occurrences.

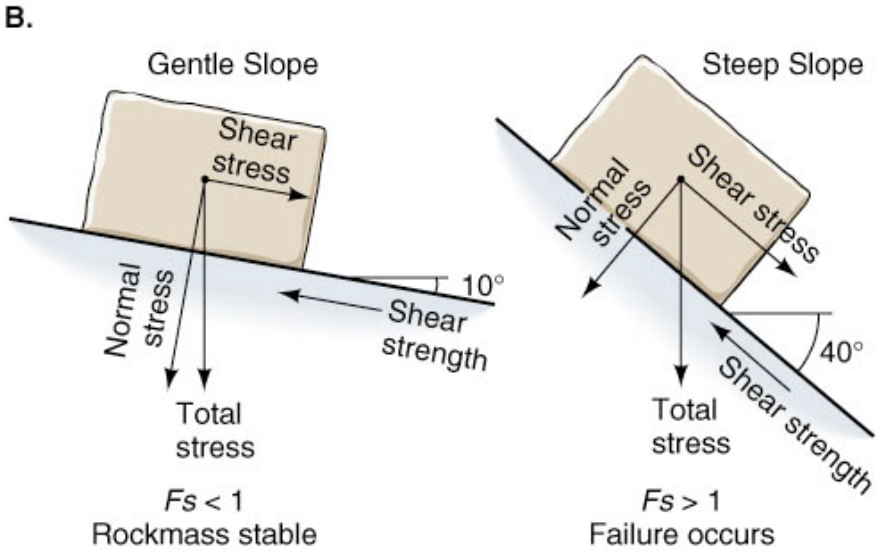
Mass wasting:

- Downslope movement of regolith and masses of rock
  - under the pull of gravity.
- Part of the rock cycle.
  - Weathering, mass-wasting, erosion:
    - a continuum of interacting processes.

Basic Physics:

- **Steady-state**: slope at an angle where flux of regolith is constant
- Define normal and tangential forces of gravity
  - Normal stress holds object in place
  - Shear stress acts to move object down hill



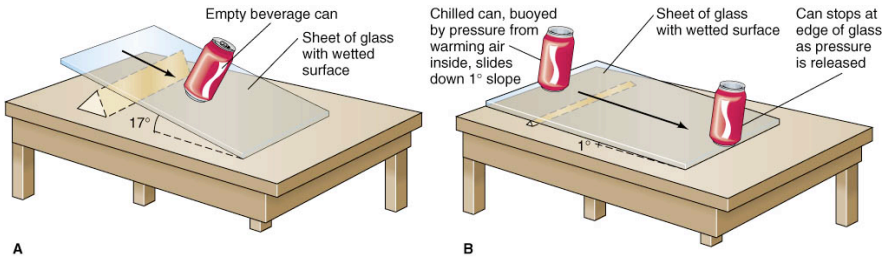


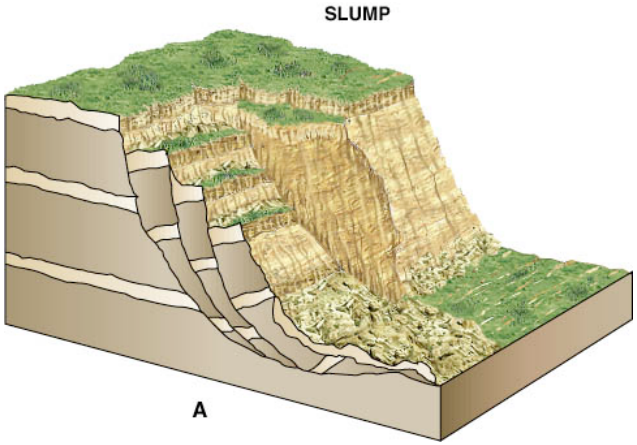
Role of Water

- Almost always present within rock and regolith near the Earth's surface.
- If sand, silt, or clay becomes saturated with water, and the fluid pressure of this water rises above a critical limit, the fine-grained sediment will lose strength and begin to flow.
- If the voids along a contact between two rock masses of low permeability are filled with water, the water pressure bears part of the weight of the overlying rock mass, thereby reducing friction along the contact.

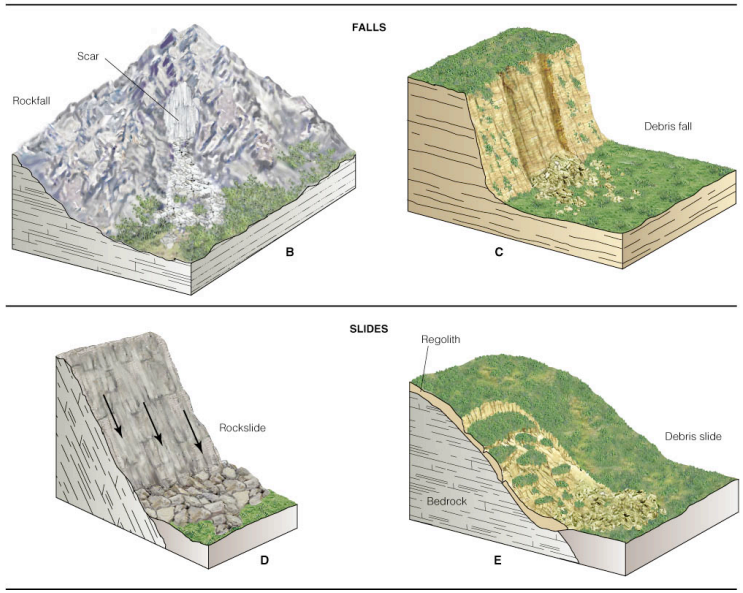
Slope Failures

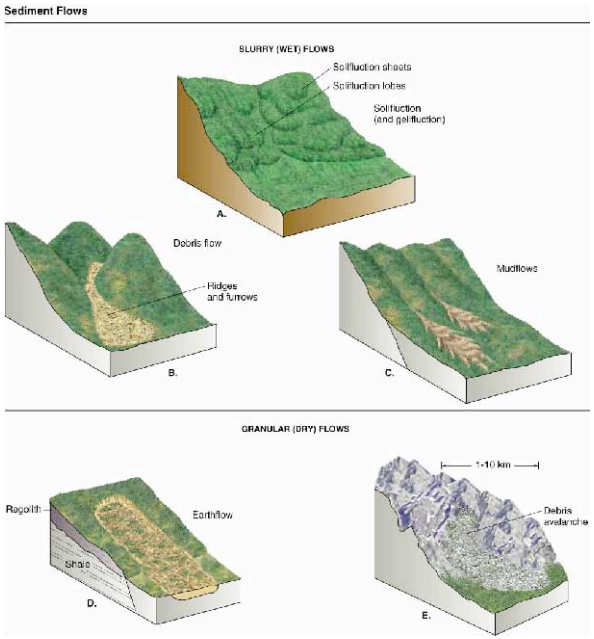
- Slumps
- Falls
- Slides

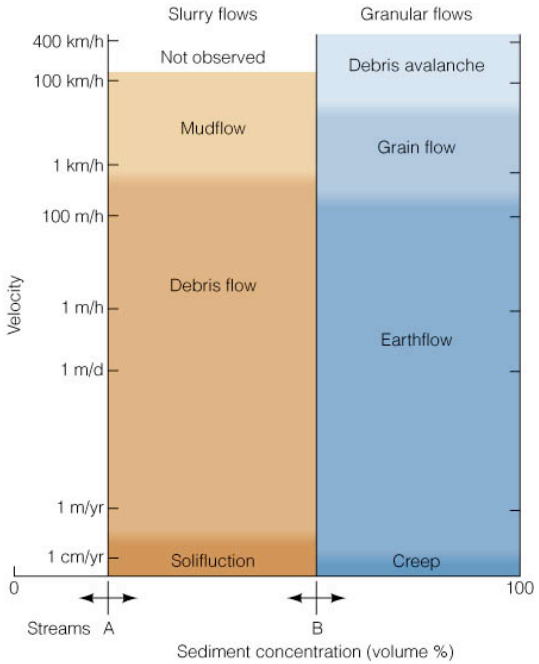


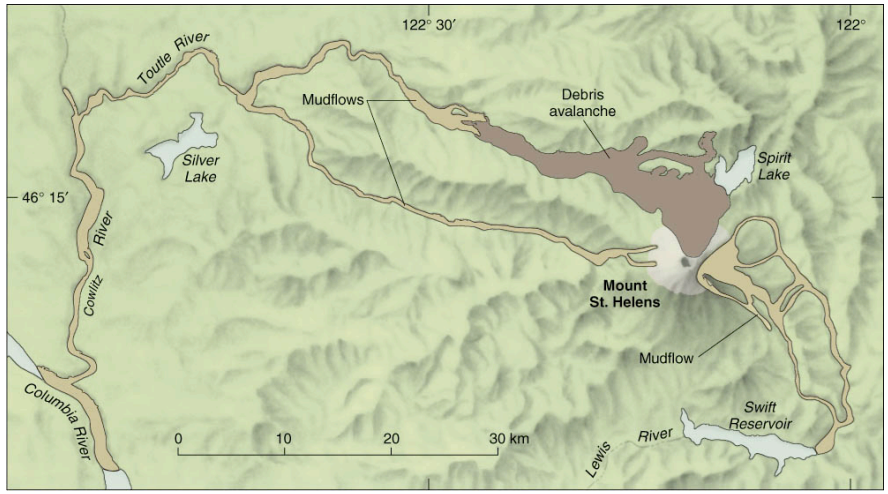


•downward and outward rotational movement
•curved concave-up surface
•top usually tilted backward,
  • producing a reversed slope


FALLS
Scar
Rockfall
B
Debris fall
C
SLIDES
Rockslide
D
Regolith
Bedrock
Debris slide
E


Sediment Flows
SLURRY (WET) FLOWS
Solifluction sheets
Solifluction lobes
Solifluction
(and gelifluction)
A.
Debris flow
Ridges
and furrows
B.
Mudflows
C.
GRANULAR (DRY) FLOWS
Regolith
Earthflow
Shale
D.
1-10 km
Debris
avalanche
E.


Slurry flows
Granular flows
400 km/h
100 km/h
1 km/h
100 m/h
1 m/h
1 m/d
1 m/yr
1 cm/yr
Velocity
Not observed
Mudflow
Debris flow
Solifluction
Debris avalanche
Grain flow
Earthflow
Creep
0
100
Streams A
B
Sediment concentration (volume %)


122° 30′
122°
Toutle River
Mudflows
Debris
avalanche
Silver
Lake
Spirit
Lake
46° 15′
Cowlitz River
Mount
St. Helens
Mudflow
Columbia River
Swift
Reservoir
0
10
20
30 km
Lewis River

Rockfalls and Debris Falls

- Rockslides:
  - Rapid displacement of masses of rock or sediment along an inclined surface, such as a bedding plane.
  - Common in high mountains where steep slopes abound.
  - Typically range in size from sand grains to large boulders.
  - Forms talus, a body of debris sloping outward from the cliff.
- The **angle of repose** (the angle at which the debris remains stable) typically lies between 30^{o} and 37^{o}.

Solifluction:

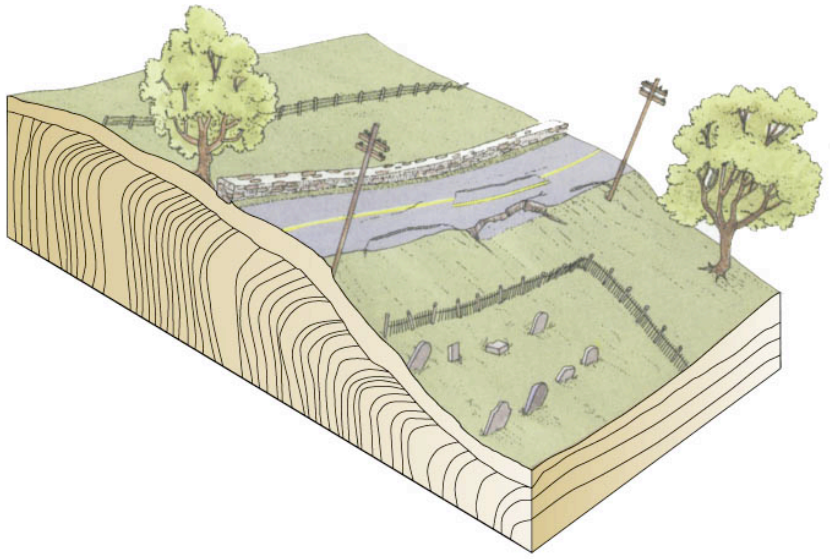
- The very slow downslope movement of saturated soil and regolith.
- Rates of movement are less than about 30 cm/yr.
- Creates distinctive surface features:
  - Lobes.
  - Sheets of debris.
- Occurs on hill slopes in temperate and tropical latitudes,
- Regolith remains saturated with water for long intervals.

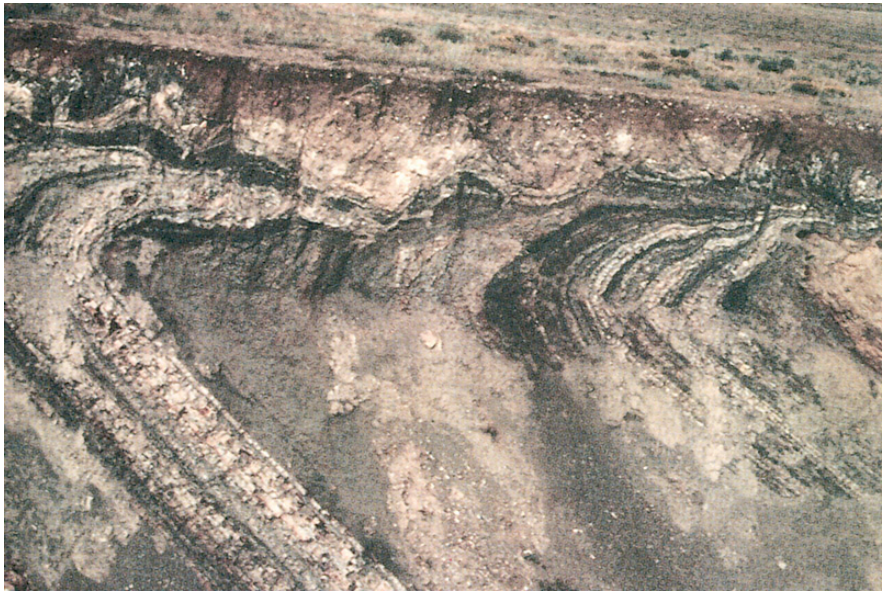
Debris Flows

- The downslope movement of unconsolidated regolith, the greater part being coarser than sand.
- Rates of movement range from only about 1m/yr to as much as 100 km/h.
- Debris flow deposits commonly have a tongue-like front.
- They are frequently associated with intervals of extremely heavy rainfall that lead to saturation of the ground.

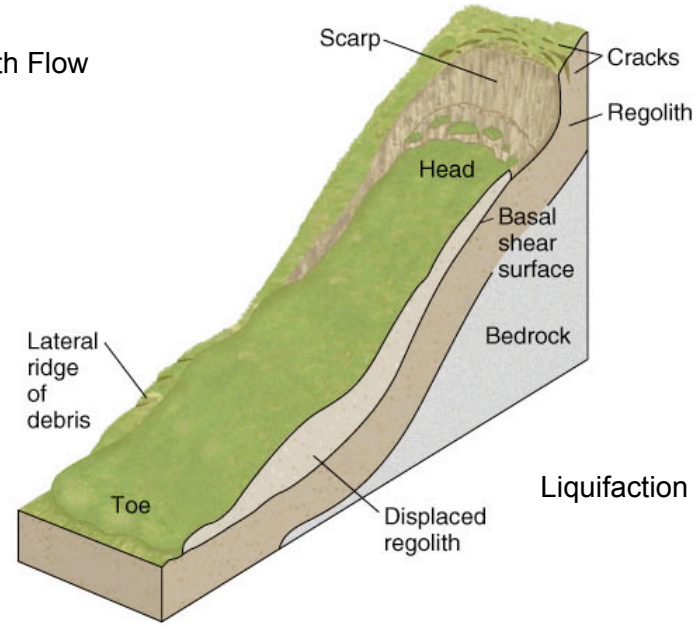
Mud Flows

- Rapidly moving debris flow with a water content sufficient to make it highly fluid.
- Most mudflows are highly mobile.
- After heavy rain in a mountain canyon, a mudflow can start as a muddy stream that becomes a moving dam of mud and rubble.
- Mudflows produce sediments fans at the base of mountain slopes.
- A particularly large mudflow originating on the slopes Mount Rainier about 5700 years ago traveled at least 72 km.
- Mount St Helens has produced mudflows throughout much of its history.





Earth Flow



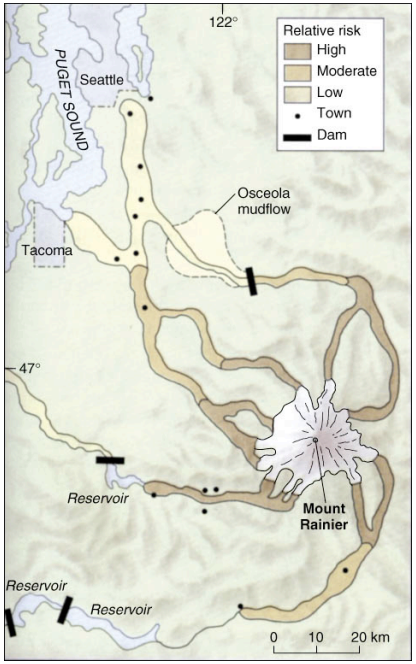
Liquifaction

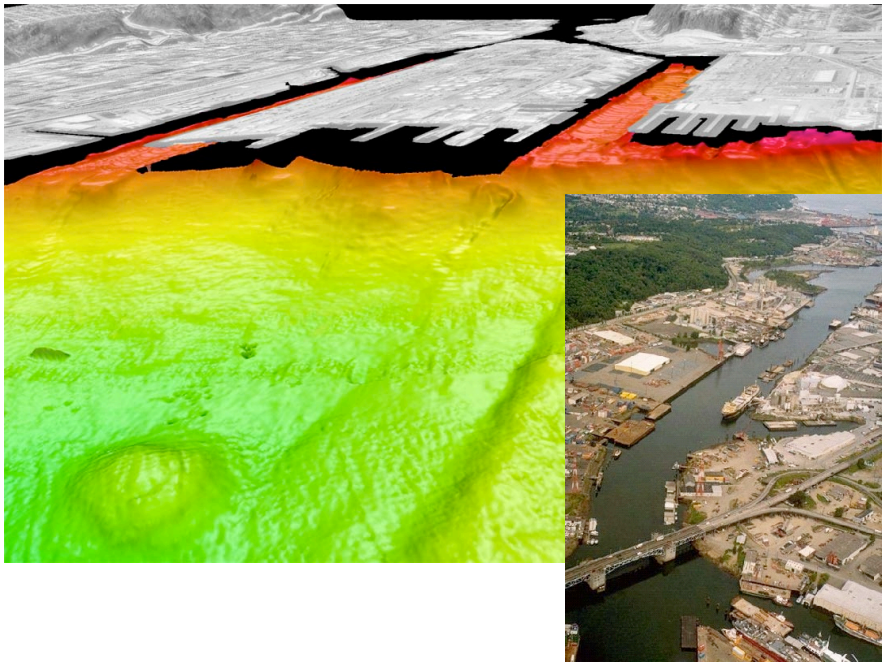
Debris Avalanches

- huge mass of falling rock and debris that breaks up, pulverizes on impact, and then continues to travel downslope
- Steep stratovolcanoes are especially susceptible to collapse that can lead to the production of debris avalanches
  - Debris - > Lahar


USGS


122°
Kent
Puget Sound
Auburn
Lowland
Osceola Mudflow
~5,600 years old
Tacoma
Sumner
Puyallup
Enumclaw
Sound
Orting
RANGE
Fork
White R.
Electron Mudflow
~500 years old
17°
Puget
Puyallup R.
West
Mount Rainier
CASCADE
WASHINGTON
Seattle
0
20 Kilometers
Area of Map
U.S.Geological Survey


122°
Relative risk
High
Moderate
Low
Town
Dam
PUGET SOUND
Seattle
Osceola mudflow
Tacoma
47°
Reservoir
Mount Rainier
Reservoir
Reservoir
0
10
20 km

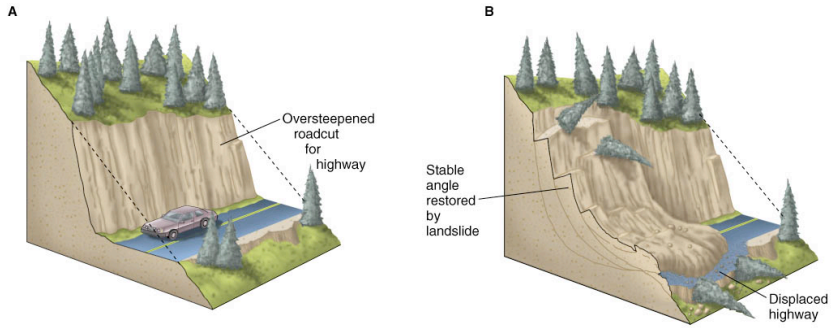


Mass Wasting In Cold Climates

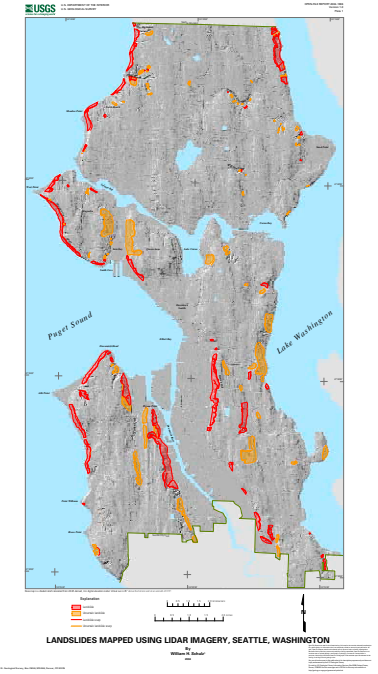
- Frost Heaving
- Gelifluction
- Rock Glaciers

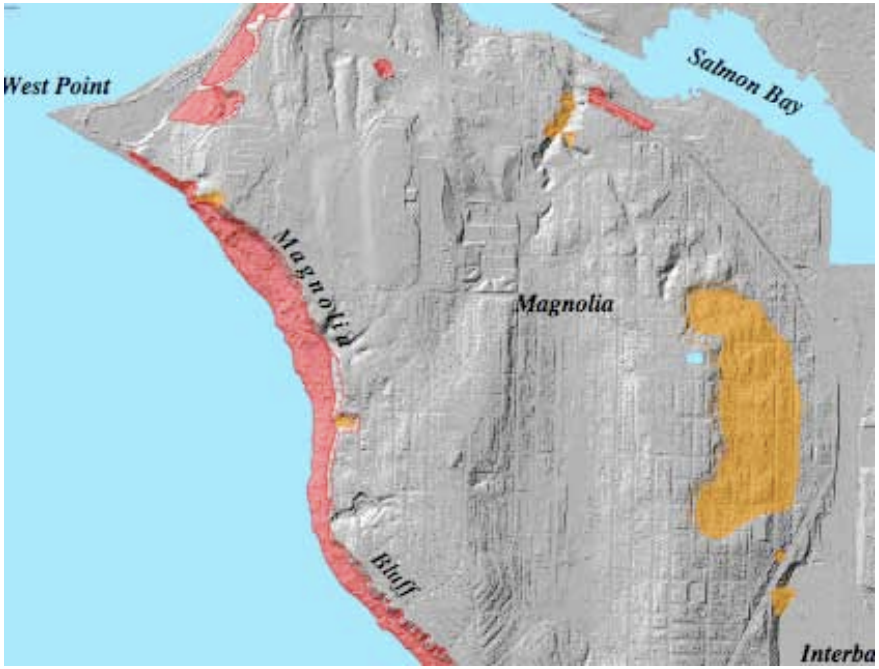
Triggers?

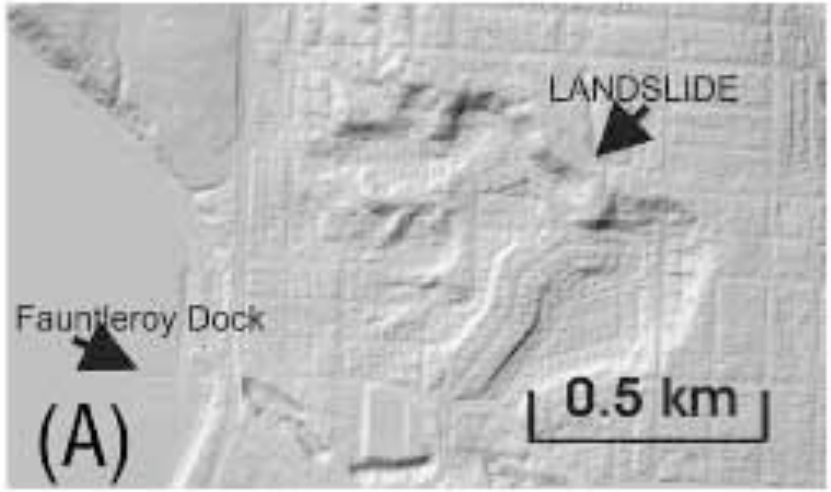
- Earthquakes may release so much energy that slope failures of many types and sizes are triggered simultaneously
- Volcanic eruptions
- Slope modification by human activities, such as occurs in road cuts, creates artificially steep slopes that are much less stable than the more gentle original slopes.
- Undercutting action of a stream along its bank or surf action along a coast can trigger landslides.
- Exceptional precipitation

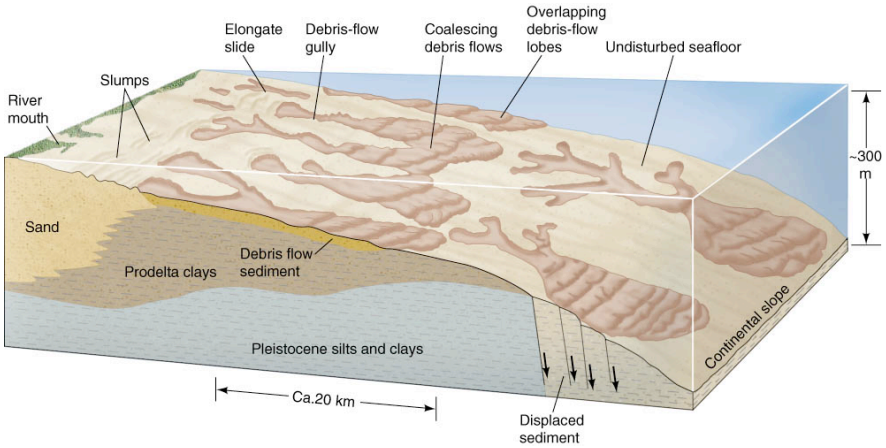


Seattle Landslide Hazards

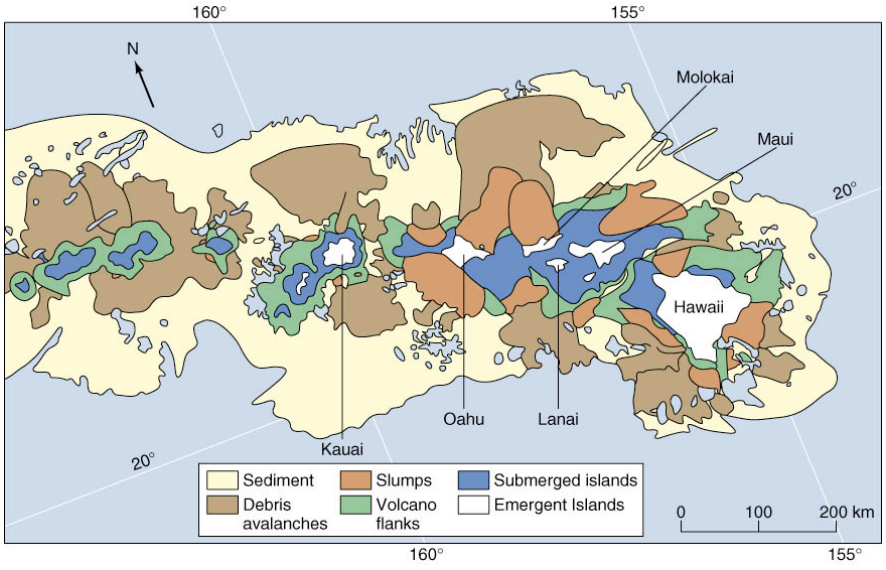


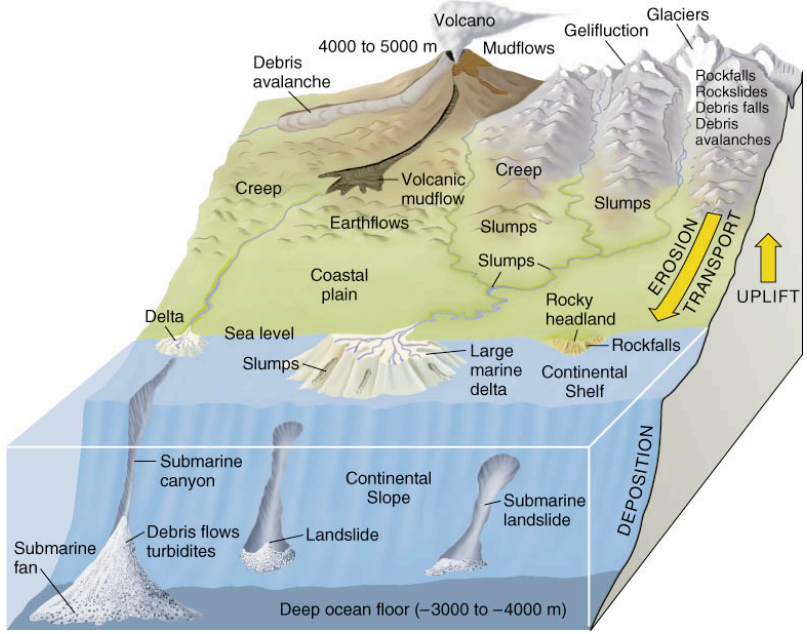





Elongate slide
Debris-flow gully
Coalescing debris flows
Overlapping debris-flow lobes
Undisturbed seafloor
Slumps
River mouth
~300 m
Sand
Prodelta clays
Debris flow sediment
Pleistocene silts and clays
Continental slope
Ca.20 km
Displaced sediment


HAWAIIPICTURES.COM


160°
155°
N
Molokai
Maui
20°
Hawaii
Oahu
Lanai
Kauai
20°
Sediment
Debris avalanches
Slumps
Volcano flanks
Submerged islands
Emergent Islands
0
100
200 km
160°
155°


Volcano
4000 to 5000 m
Mudflows
Gelifluction
Glaciers
Debris avalanche
Rockfalls
Rockslides
Debris falls
Debris avalanches
Creep
Volcanic mudflow
Creep
Slumps
Earthflows
Slumps
Slumps
EROSION
TRANSPORT
UPLIFT
Coastal plain
Rocky headland
Delta
Sea level
Rockfalls
Slumps
Large marine delta
Continental Shelf
Submarine canyon
Continental Slope
Submarine landslide
DEPOSITION
Debris flows turbidites
Landslide
Submarine fan
Deep ocean floor (−3000 to −4000 m)