Absolute Geologic Time

- Radiometric Dating
- Igneous rocks contain potassium, uranium thorium and rubidium that are radioactive
- Careful measurement of ratios of these and their daughter products, or of the isotopes of them that are not radioactive can be used to calculate absolute ages

Table 10.1 Radioactive isotopes frequently used in radiometric dating.

Radioactive Parent	Stable Daughter Product	Currently Accepted Half-Life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

Radiometric dating

- Known Half-life
- Closed system
- Cross-checked for accuracy
- Yields numerical dates

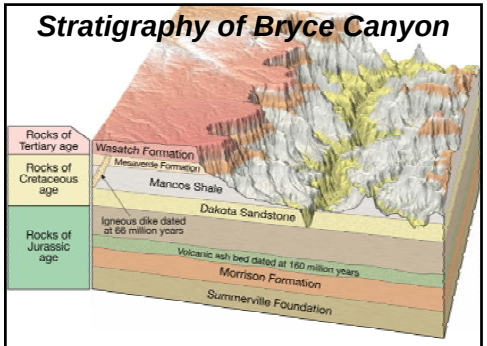
Absolute Ages

- Only possible for igneous rocks
- Need to have crosscutting relationships
- Can bracket age of sediments, geologic events like faulting, folding, erosion

Importance of radiometric dating

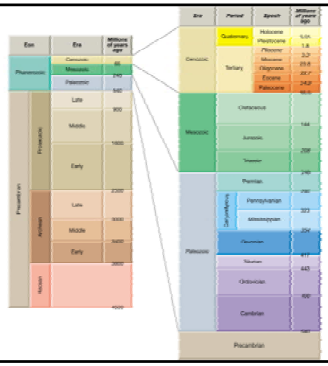
- Confirms the idea that geologic time is immense
- Rocks from several localities have been dated at more than 3 billion years
- Radiometric dating is a complex procedure that requires precise measurement

Stratigraphy of Bryce Canyon



Geologic time scale

- Divides geologic history into units
- Originally created using relative dates
- Bracket events and arrive at ages



Subdivisions

- Eons
  - –Eras
    - ➢Periods
      - –Epochs

Eon

Greatest expanse of time

- Four eons
  - –Phanerozoic ("visible life") – the most recent eon: started 543 Ma
  - –Proterozoic: 2500 – 543 Ma
  - –Archean: 3800 – 2500 Ma
  - –Hadean – oldest eon 4500 – 3800 Ma

Eras of the Phanerozoic eon

- Cenozoic ("recent life"): 65 Ma – now
- Mesozoic ("middle life"): 248 – 65 Ma
- Paleozoic ("ancient life"): 543 – 248 Ma

Mass Wasting

The downslope movement of rock, regolith, and soil under the direct influence of gravity

Gravity is the controlling force

Mass Wasting

Important triggering factors

- Saturation
- Oversteepening
- Removal of vegetation
- Ground vibrations

Important triggering factors

Saturation of the material with water

- Destroys particle cohesion
- Water adds weight

Important triggering factors

Oversteepened slopes

- Unconsolidated granular particles assume a stable slope called the angle of repose
- Stable slope angle is different for various materials
- Oversteepened slopes are unstable

Important triggering factors

Oversteepened slopes

- Undercutting by streams
- Undercutting by human interference
- Addition of material to top of slope
  - Natural—deposition
  - Human-caused--construction

Important triggering factors

- Removal of anchoring vegetation
  - Wildfires
  - Drought
  - Development, logging
- Ground vibrations
  - from earthquakes

Mass Wasting

Types of mass wasting processes

Defined by

- The material involved
- The movement of the material

Types of mass wasting processes

Defined by the material involved
- Debris
- Mud
- Earth
- Rock

Types of mass wasting processes

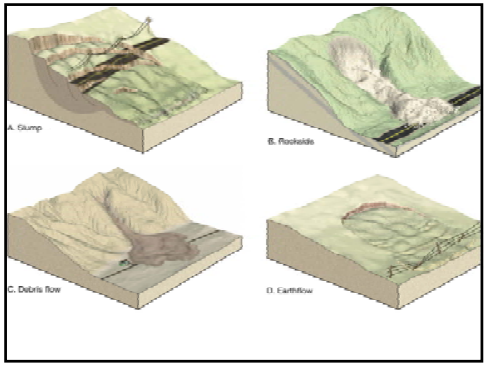
Defined by the movement of the material
The character of the movement
- Fall
- Slide
- Flow

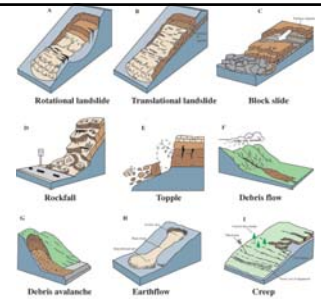
Types of mass wasting processes

Defined by the movement of the material
The rate of the movement
- Fast
- Slow

Forms of mass wasting

- Slump
- Rockslide
- Debris flow
- Earth flow
- Creep
- Solifluction

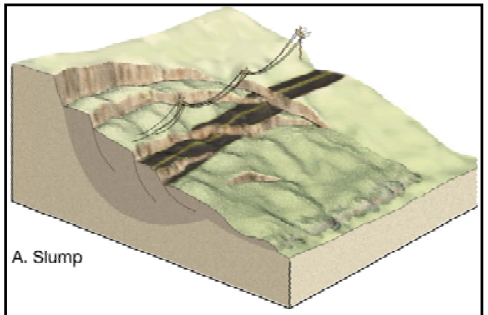




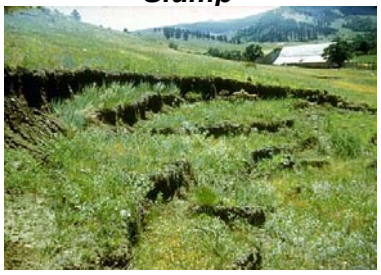
- http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html

Forms of mass wasting

Slump
- Rapid movement along a curved surface
- Occur along oversteepened slopes



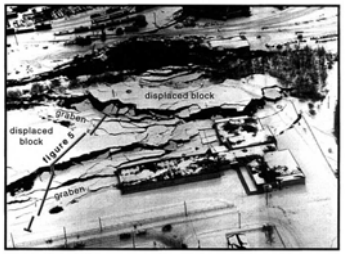
Slump



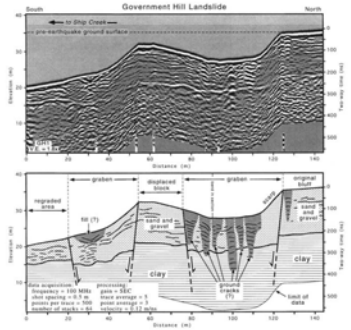
- http://www.physicalgeography.net/fundamentals/10x.html

Government Hill, AK

- 1964

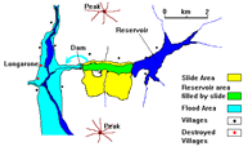


- http://walrus.wr.usgs.gov/geotech/radaraapg/fig4.html



- http://walrus.wr.usgs.gov/geotech/radaraapg/fig5.html

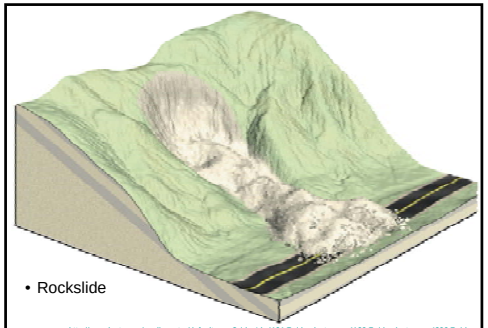
Block slide at Vaiont Dam



Forms of mass wasting

Rockslide
- Rapid
- Blocks of bedrock move down a slope

Cousin to Rockfall



- Rockslide

- http://www.kmtr.com/mediacenter/default.aspx?videoId=4191@video.kmtr.com,4199@video.kmtr.com,4200@video.kmtr.com,4195@video.kmtr.com,4189@video.kmtr.com&navCatId=5&2=2

Elkton, Oregon, March 4, 2006

ODOT Photo

- http://www.kmtr.com/news/local/story.aspx?content_id=010798AE-AF2F-41D5-93F5-120A64493D45

Elkton, Oregon, March 4, 2006

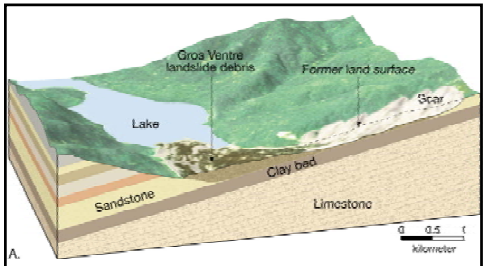
ODOT Photo

- http://www.kmtr.com/news/local/story.aspx?content_id=010798AE-AF2F-41D5-93F5-120A64493D45

Nevado Huascarán

- Peru 1970
- Buried two towns
- 18,000 killed
- Geologists warned government of potential

http://landslides.usgs.gov/html_files/landslides/slides/slide5.htm

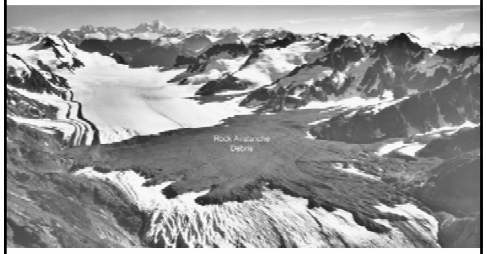


- http://www.goldengatephoto.com/WestUS/wyother.html#grosventre

Slide Lake, Wyoming

- http://www.uwsp.edu/geo/projects/geoweb/participants/dutch/VTrips/GrosVentre.HTM

Sherman Glacier Rock Avalanche, March 1964



Rock Fall

- July 1996
- Yosemite

- http://landslides.usgs.gov/html_files/landslides/slides/slide9.htm

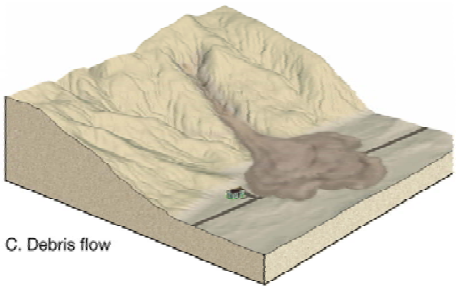
Rock Fall

- http://sts.gsc.nrcan.gc.ca/geoscape/vancouver/graphics/mountain1.gif

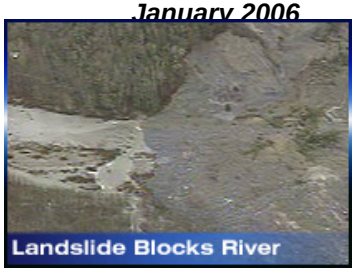
Forms of mass wasting

Debris flow (mudflow)

- Rapid flow of debris with water
- Confined to channels
- Dry areas with heavy rains
- Lahar composed of volcanic materials



Snohomish County, WA January 2006



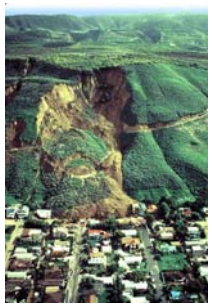
- http://www.komotv.com/stories/41527.htm

US 50, Sierra Nevadas, California 1997

http://landslides.usgs.gov/monitoring/hwy50/index.php

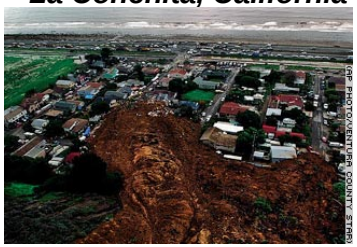
La Conchita, California

- Spring 1995
- No one injured or killed



- http://landslides.usgs.gov/html_files/landslides/slides/slide21.htm

La Conchita, California

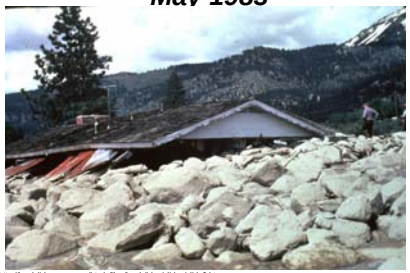


- February 2005

- http://www.cnn.com/interactive/weather/0501/gallery.storms/frameset.exclude.html

- http://www.redcross.org/article/0,1072,0_312_3943,00.html

Slide Mountain, Nevada, Mav 1983



http://landslides.usgs.gov/html_files/landslides/slides/slide2.htm

Lahar debris flow

- http://landslides.usgs.gov/html_files/landslides/slides/slide13.htm

Toutle River Debris Flow

- http://pubs.usgs.gov/fs/fs-176-97/fs-176-97.html

Nevado del Ruiz

- http://volcanoes.usgs.gov/Hazards/What/Lahars/RuizLahars.html

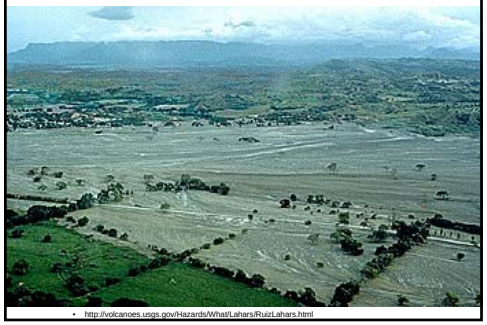
Eruption of Nevado del Ruiz

- http://volcanoes.usgs.gov/Hazards/What/Lahars/RuizLahars.html

Confluence of lahars, Nevado del Ruiz

- http://volcanoes.usgs.gov/Hazards/What/Lahars/RuizLahars.html

Armero site, Nevado del Ruiz



- http://volcanoes.usgs.gov/Hazards/What/Lahars/RuizLahars.html

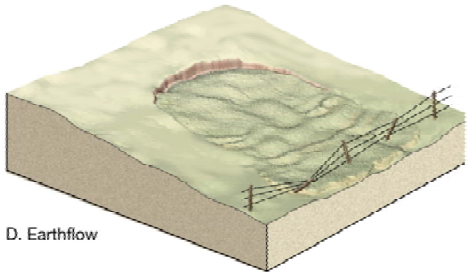
- http://www.alertnet.org/thenews/pictures/MANS2D.htm

- http://news.yahoo.com/news?tmpl=story&u=/060219/481/xbm10202190643

Forms of mass wasting

Earthflow

- Rapid or slow
- Typically occur on hillsides in humid regions
- Water saturates the soil
- Liquefaction: associated with earthquakes and clay soils



Hollywood Hills, CA

- January 2005

- http://www.cnn.com/interactive/weather/0501/gallery.storms/frameset.exclude.html

Niigata, Japan, 1964

- http://www.ce.washington.edu/~liquefaction/selectpiclique/nigata64/tiltedbuilding.jpg

Anchorage, AK

1964

- http://www.owlnet.rice.edu/~sehh/AlaskaEQ/Alaska_Sci/EQScience

- http://walrus.wr.usgs.gov/geotech/radaraapg/fig5.html

Alaska, 1964

- http://www.ce.washington.edu/~liquefaction/selectpicilique/alaska64/landslideintowater.jpg
- Hyperlink to sand boil liquefaction http://walrus.wr.usgs.gov/geotech/images/TIsandboils.mov

Sheffield Dam, 1925

Santa Barbara County, CA

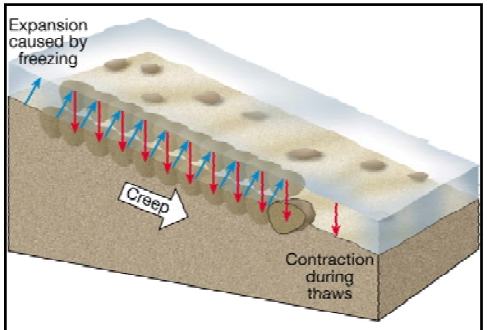
Earth-quake caused earthflow

- http://www.ce.washington.edu/~liquefaction/selectpicilique/dams/sheffielddam1.jpg

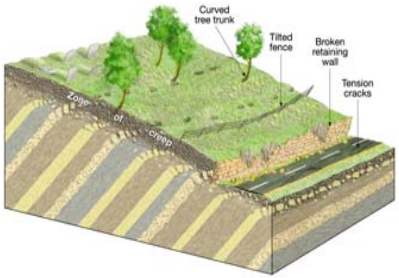
Forms of mass wasting

Creep

- Slow movement of soil and regolith downhill
- Causes fences and utility poles to tilt



Some visible effects of creep



Creep

- Bedrock curled due to creep mass wasting

- http://www.gpc.edu/~janderso/physical/massw.htm

Creep

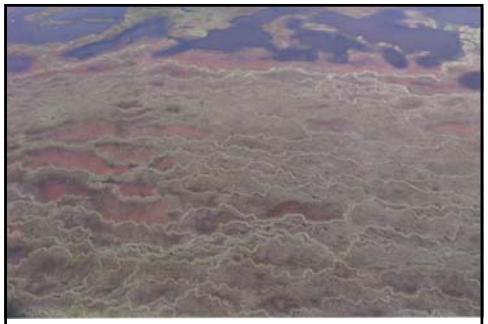
- Curved trunks due to soil creep

- http://classes.colgate.edu/dkeller/geol101/masswimages/creep1.jpg

Forms of mass wasting

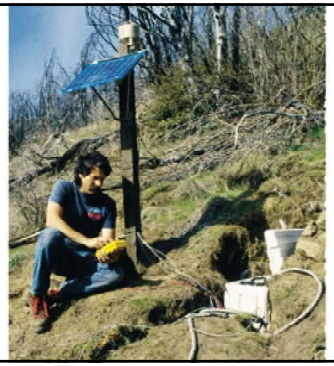
Solifluction

- Slow movement in areas underlain by permafrost
- Upper (active) soil layer becomes saturated and slowly flows over a frozen surface below

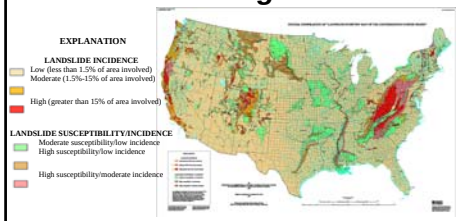


- http://piru.alexandria.ucsb.edu/collections/geography3b/misc/solifluction_lobes_jpg%5b1%5d.jpg

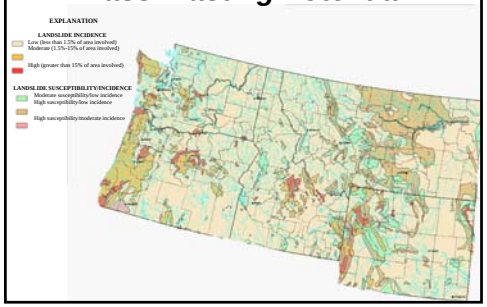
Ground subsidence in Alaska due to solifluction



Mass Wasting Potential



Mass Wasting Potential



Mass Wasting

The downslope movement of rock, regolith, and soil under the direct influence of gravity

Gravity is the controlling force

Important triggering factors

- Saturation of the material with water
- Oversteepening
- Devegetation
- Vibration