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

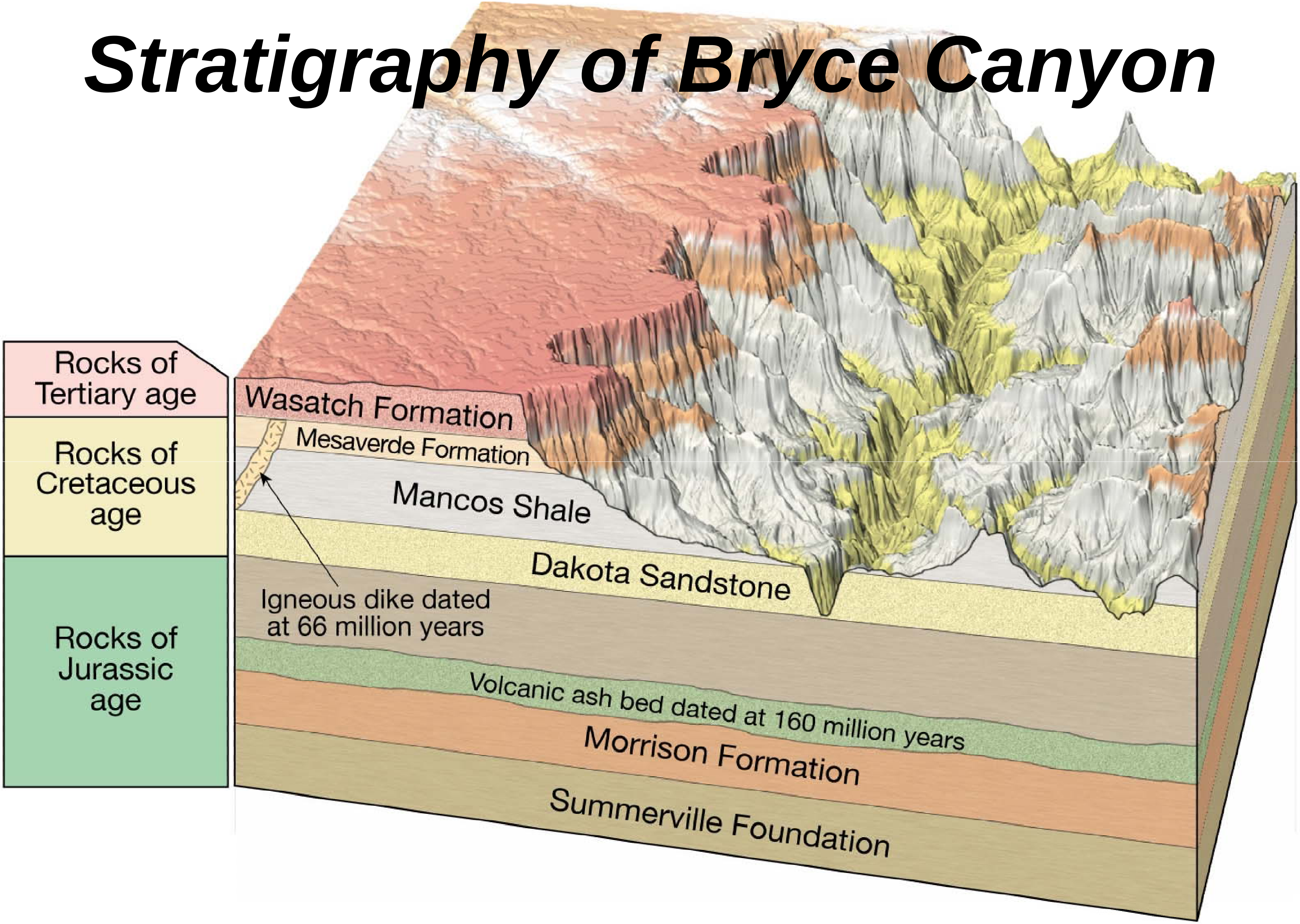
Absolute Ages

- 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

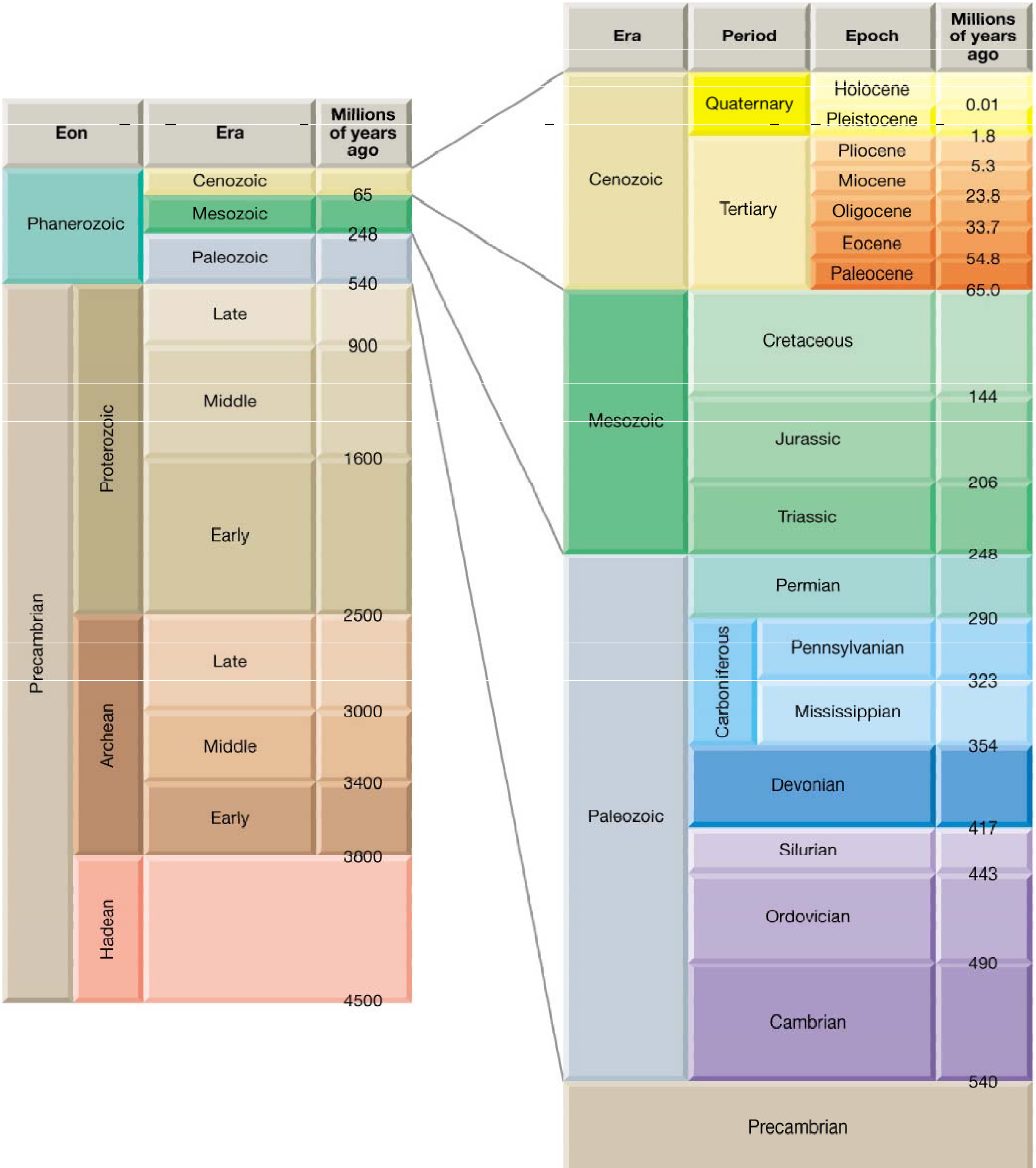
- Confirms the idea that geologic time is immense
- Rocks from several localities have been dated at more than 3 billion years
- Radiometric dating is a complex procedure that requires precise measurement

Stratigraphy of Bryce Canyon



Geologic time scale

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



Eon
Era
Millions of years ago
Phanerozoic
Cenozoic
65
Mesozoic
248
Paleozoic
540
Precambrian
Proterozoic
Late
900
Middle
1600
Early
2500
Archean
Late
3000
Middle
3400
Early
3800
Hadean
4500
Era
Period
Epoch
Millions of years ago
Cenozoic
Quaternary
Holocene
0.01
Pleistocene
1.8
Tertiary
Pliocene
5.3
Miocene
23.8
Oligocene
33.7
Eocene
54.8
Paleocene
65.0
Mesozoic
Cretaceous
144
Jurassic
206
Triassic
248
Paleozoic
Permian
290
Carboniferous
Pennsylvanian
323
Mississippian
354
Devonian
417
Silurian
443
Ordovician
490
Cambrian
540
Precambrian

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

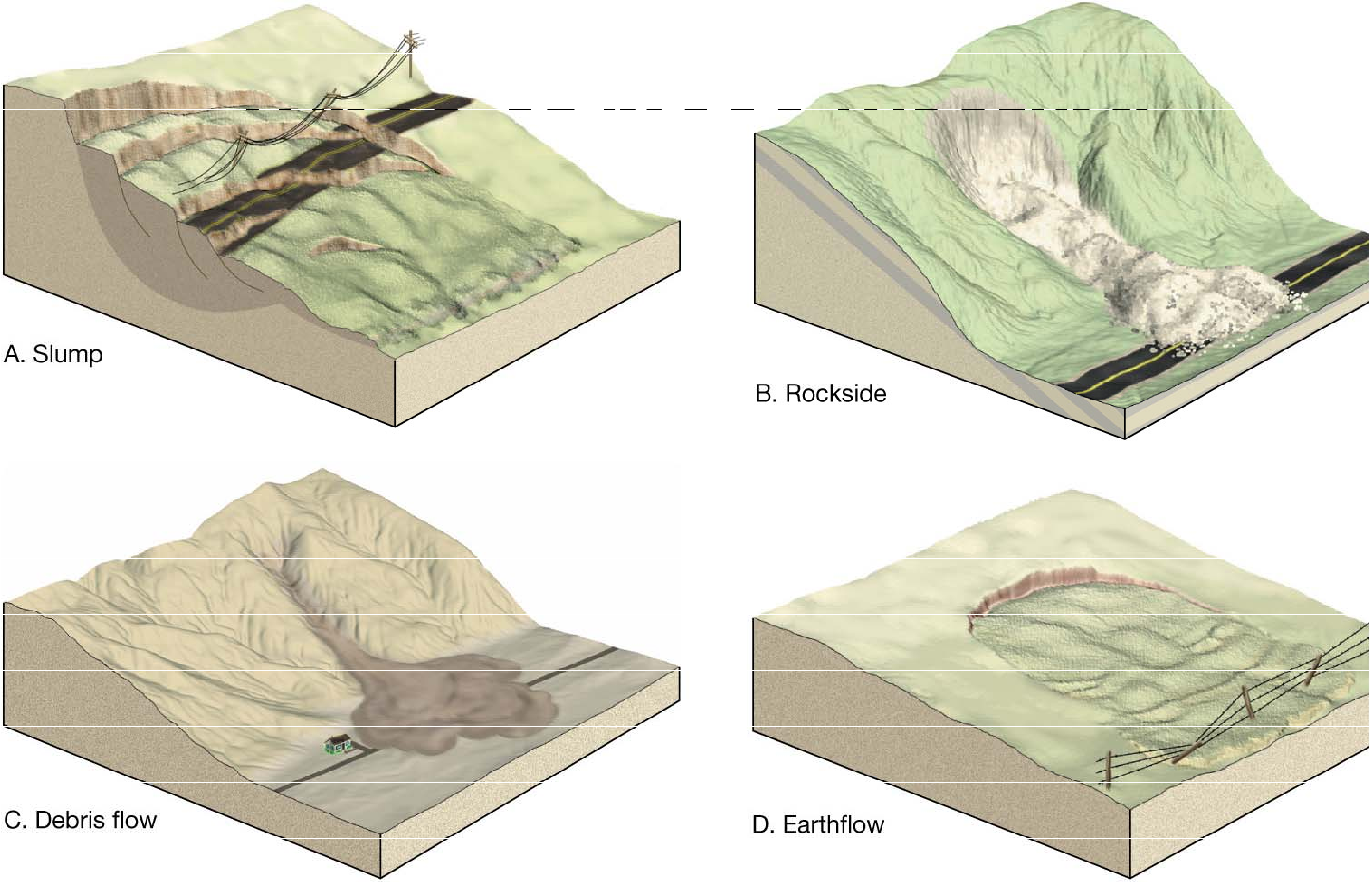
Defined by the movement of the material

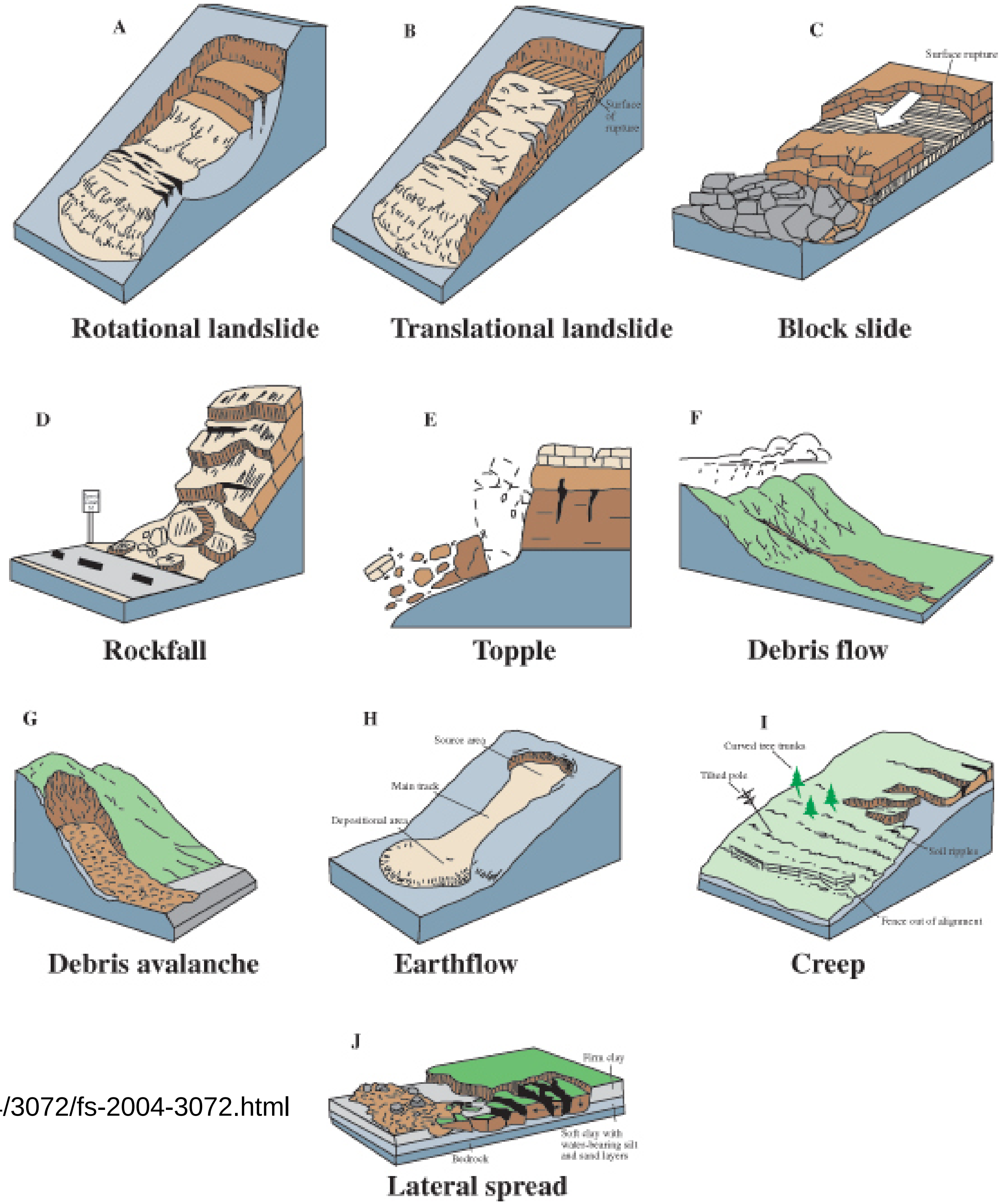
The rate of the movement

- Fast
- Slow

Forms of mass wasting

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


A. Slump
B. Rockside
C. Debris flow
D. Earthflow

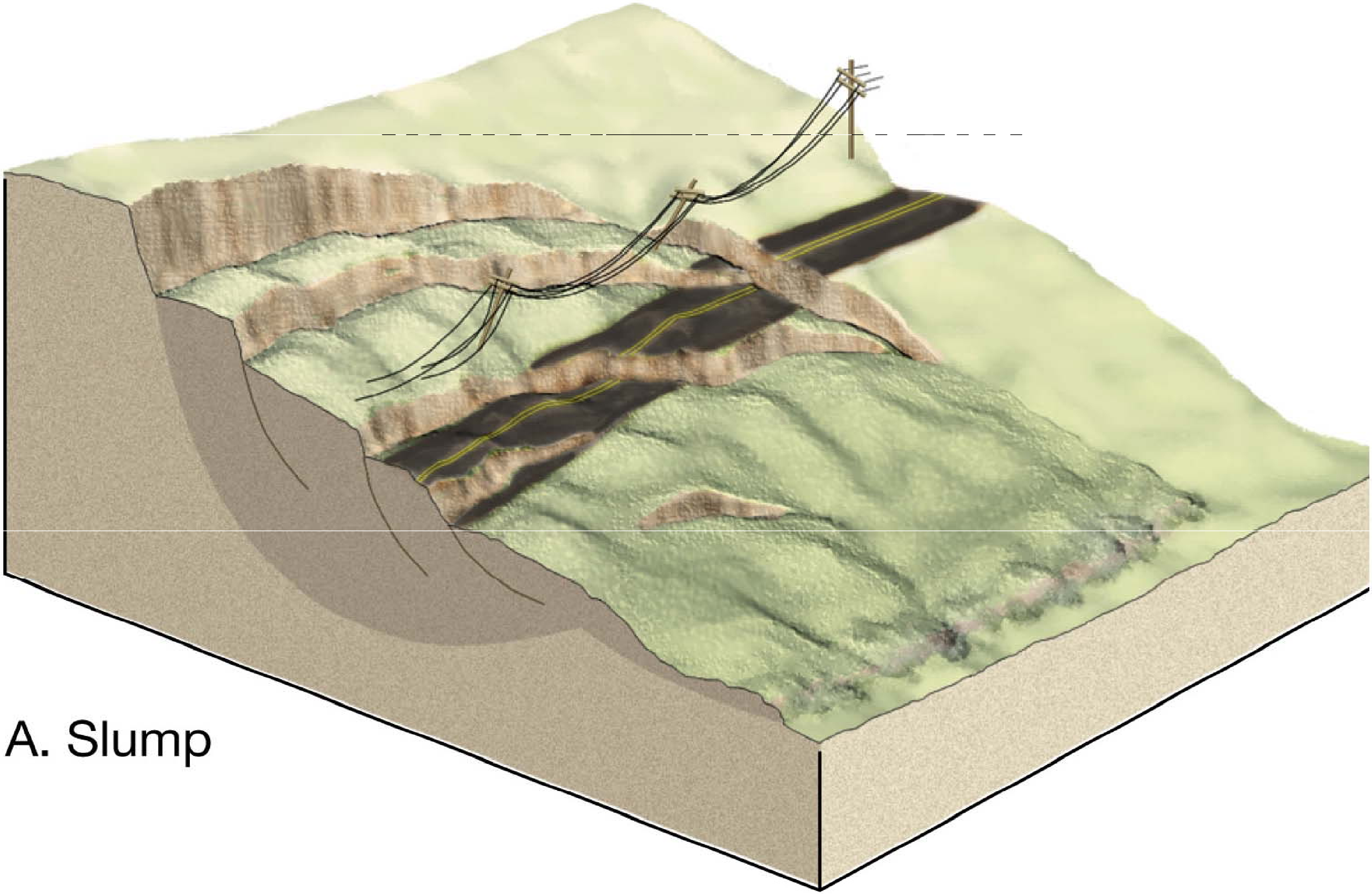


- http://pubs.usgs.gov/fs/2004/3072/fs-2004-3072.html

Forms of mass wasting

Slump

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



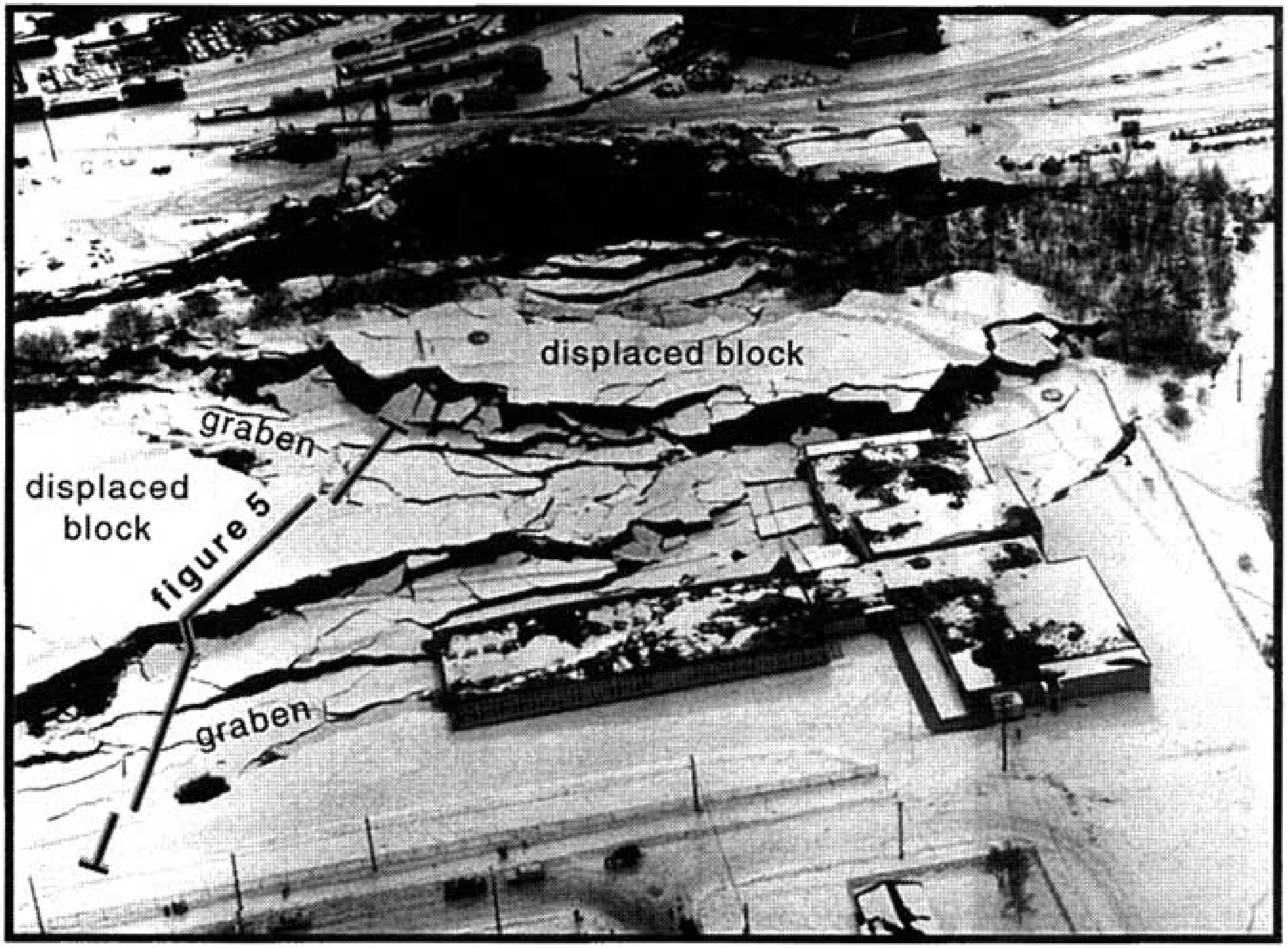
A. Slump

Slump

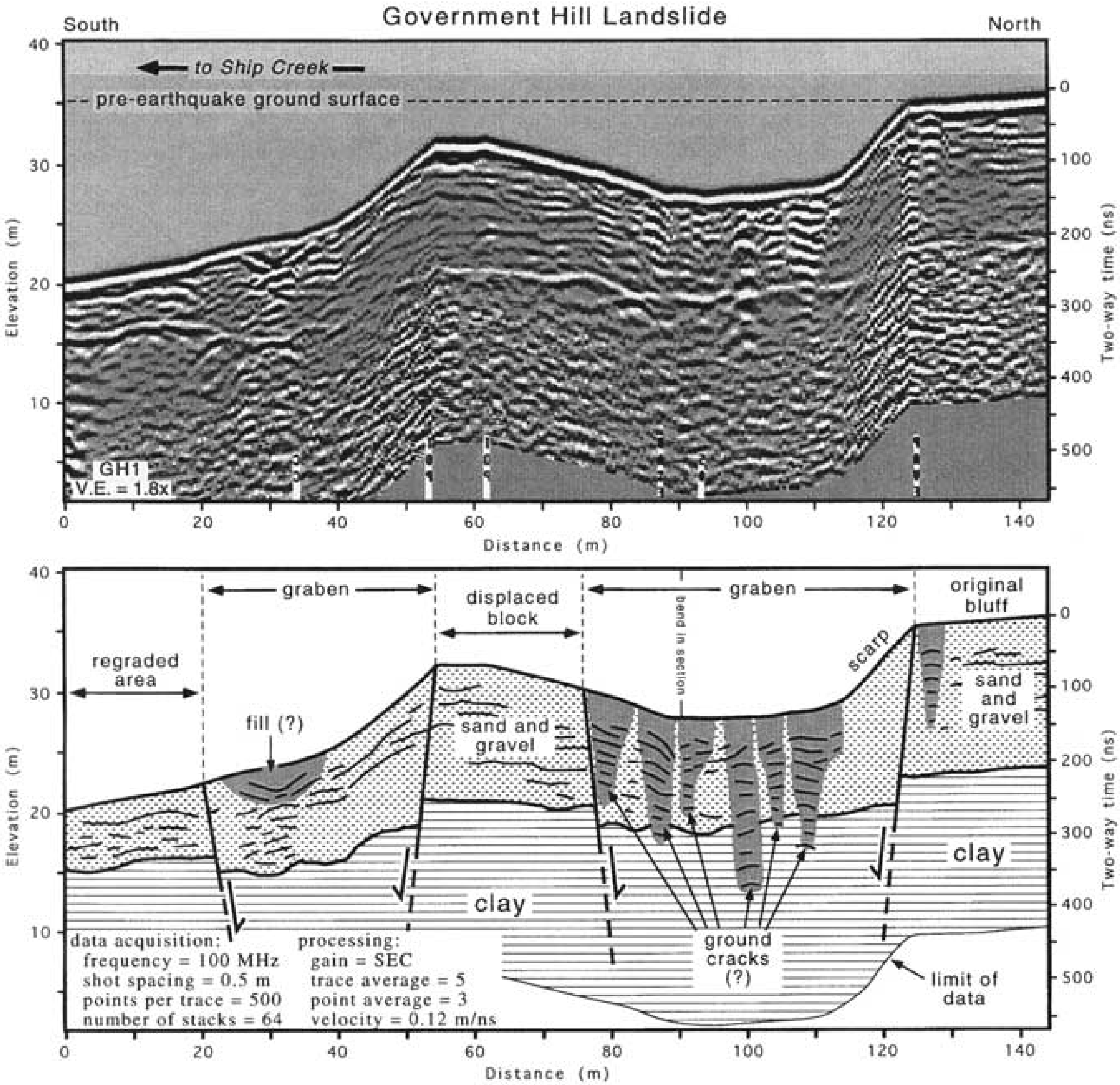
- http://www.physicalgeography.net/fundamentals/10x.html

Government Hill, AK

- 1964

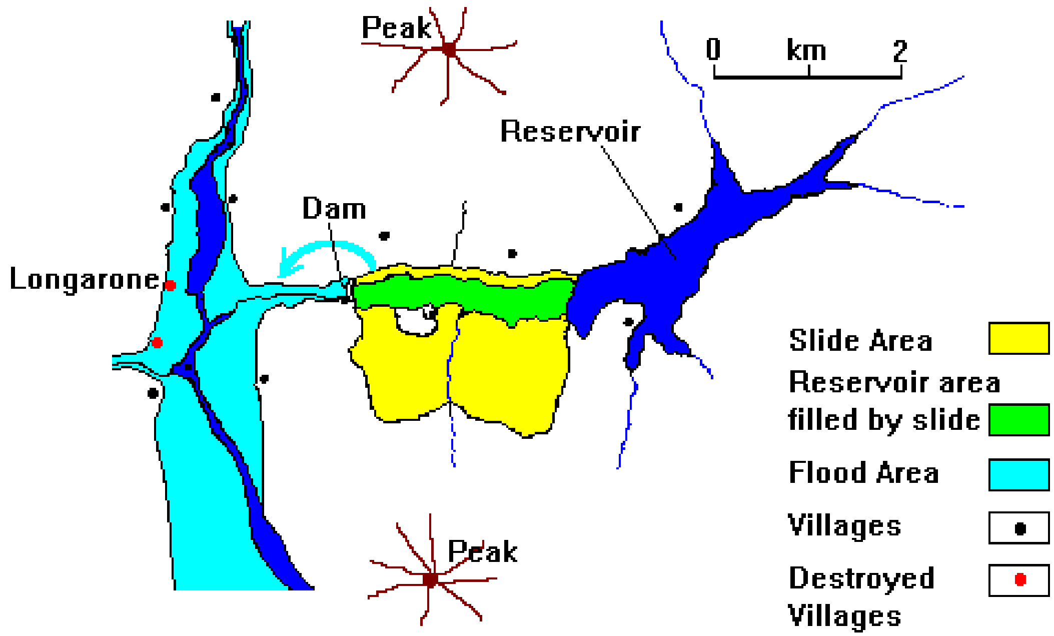


- http://walrus.wr.usgs.gov/geotech/radaraapg/fig4.html



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

Block slide at Vaiont Dam

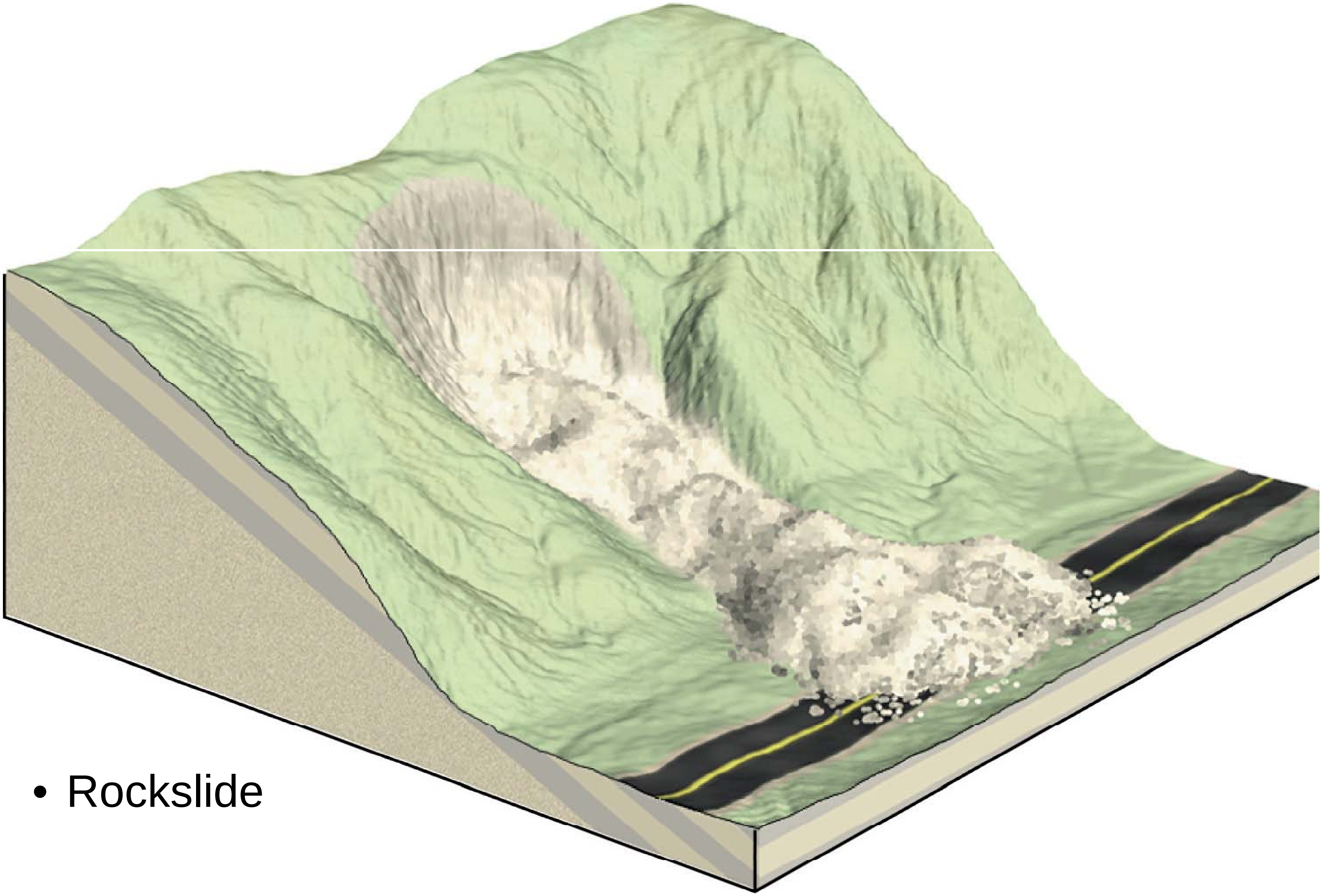


Forms of mass wasting

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

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

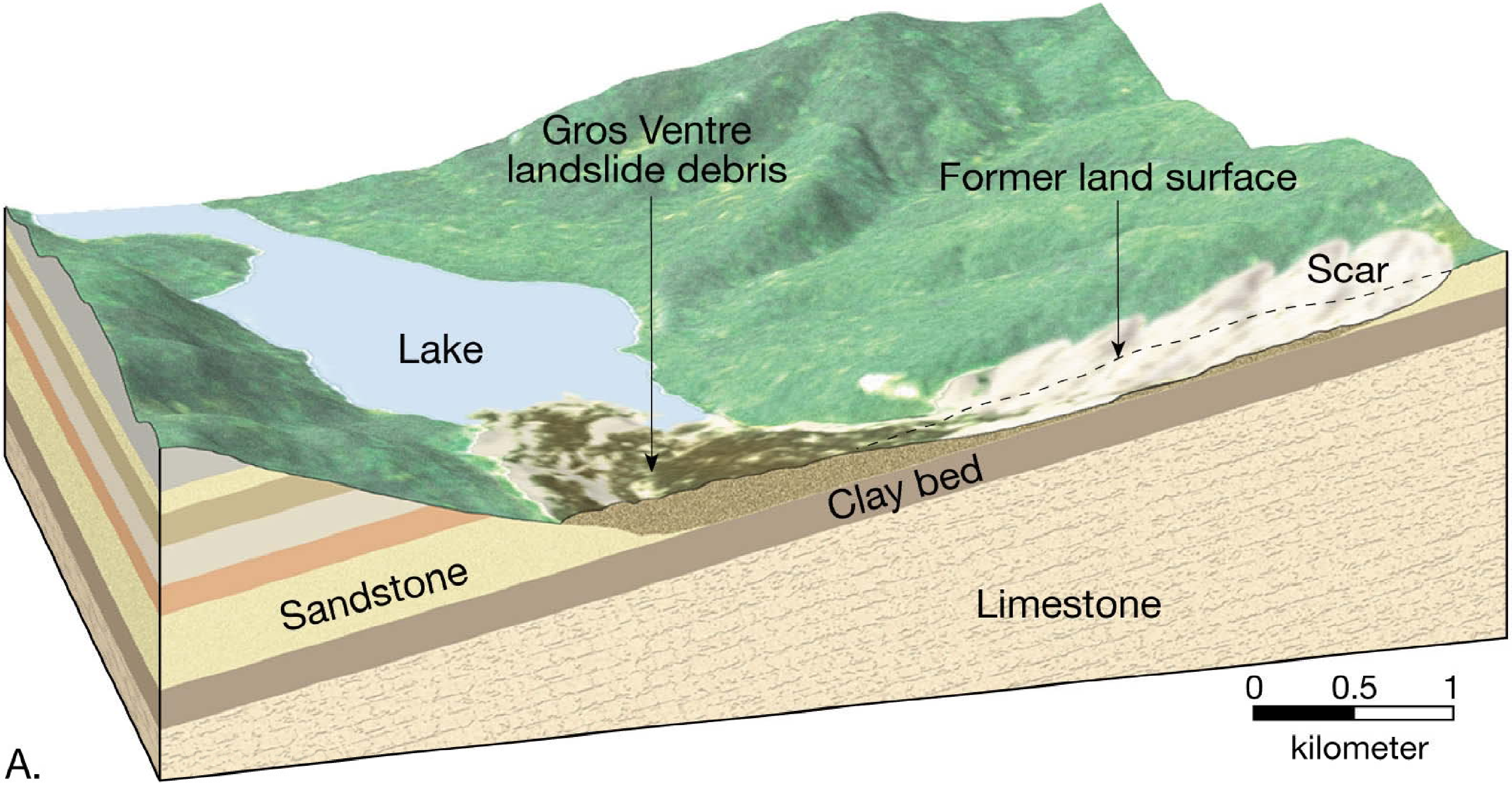
Elkton, Oregon, March 4, 2006

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

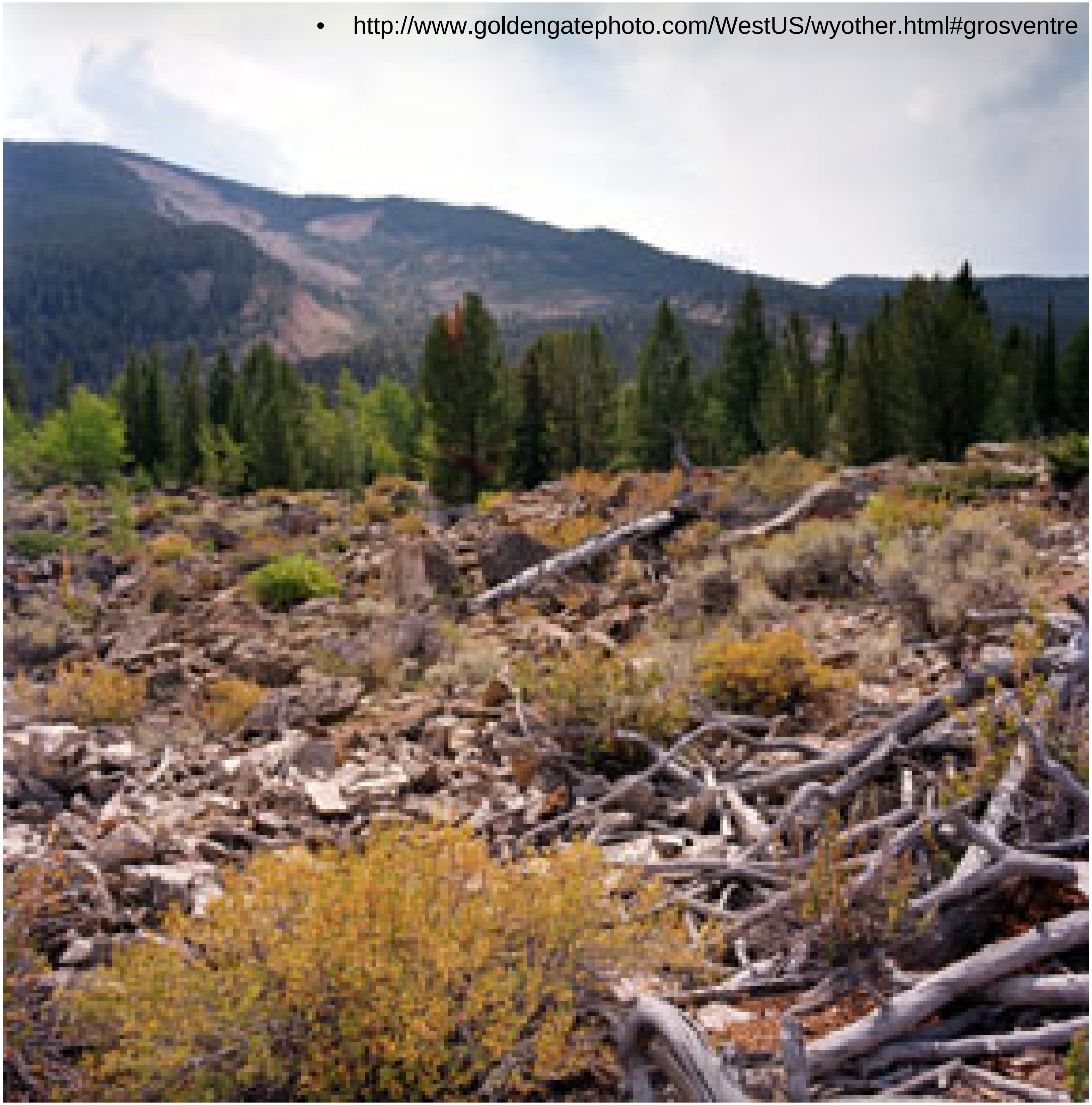
Nevado Huascarán

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

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


Gros Ventre
landslide debris
Former land surface
Scar
Lake
Clay bed
Sandstone
Limestone
0
0.5
1
kilometer
A.

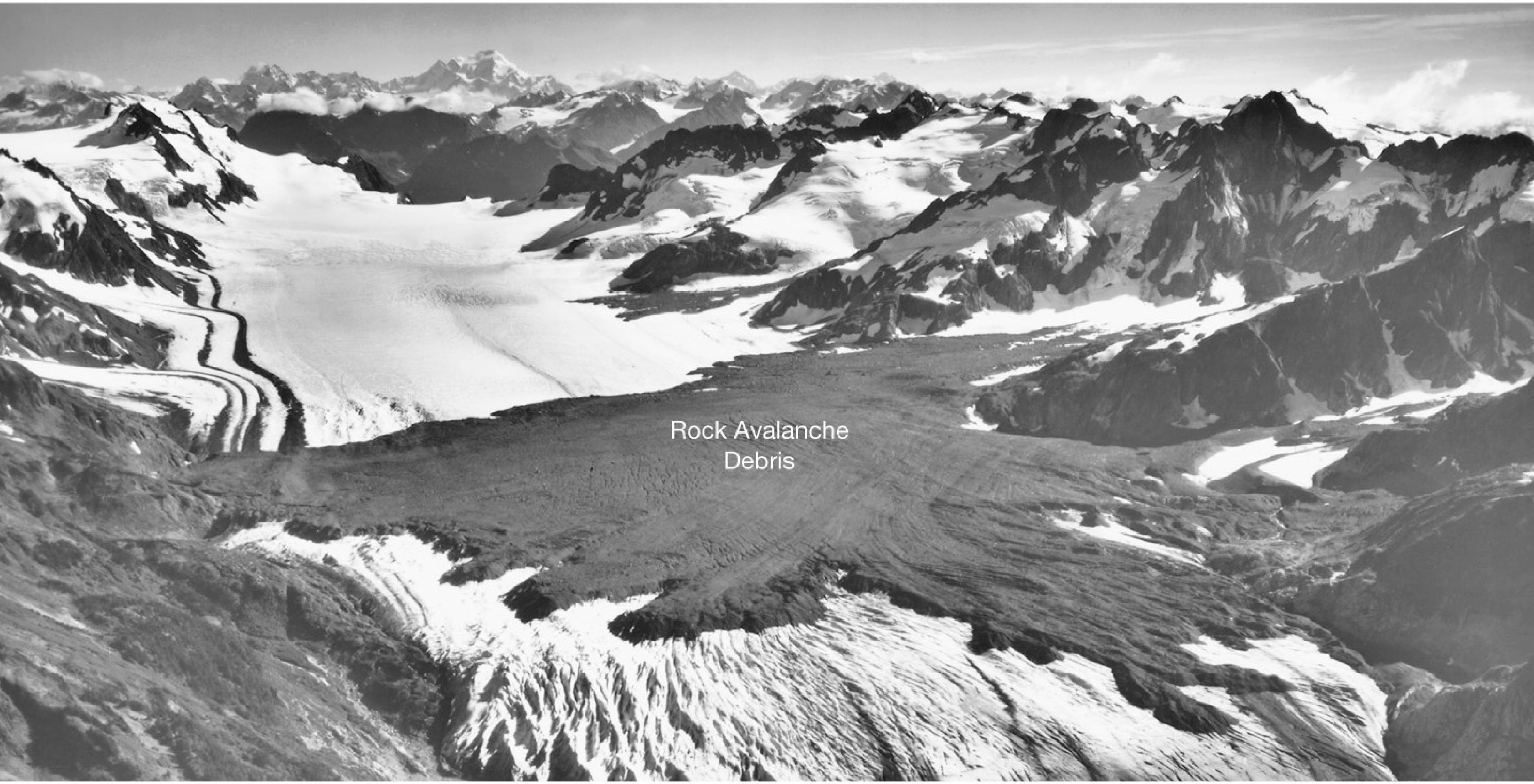
- http://www.goldengatephoto.com/WestUS/wyother.html#grosventre



Slide Lake, Wyoming

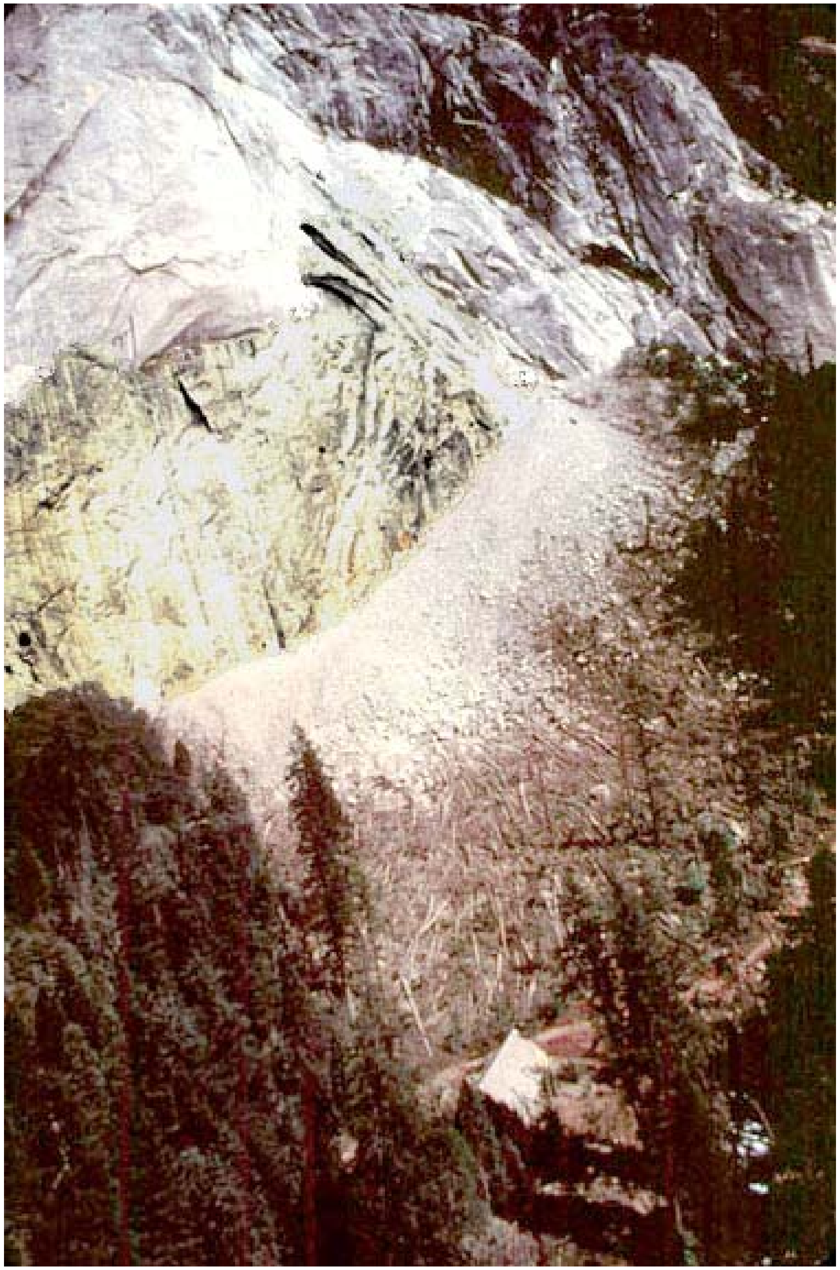
- http://www.uwsp.edu/geo/projects/geoweb/participants/dutch/VTrips/GrosVentre.HTM

Sherman Glacier Rock Avalanche, March 1964



Rock Fall

- July 1996
- Yosemite



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

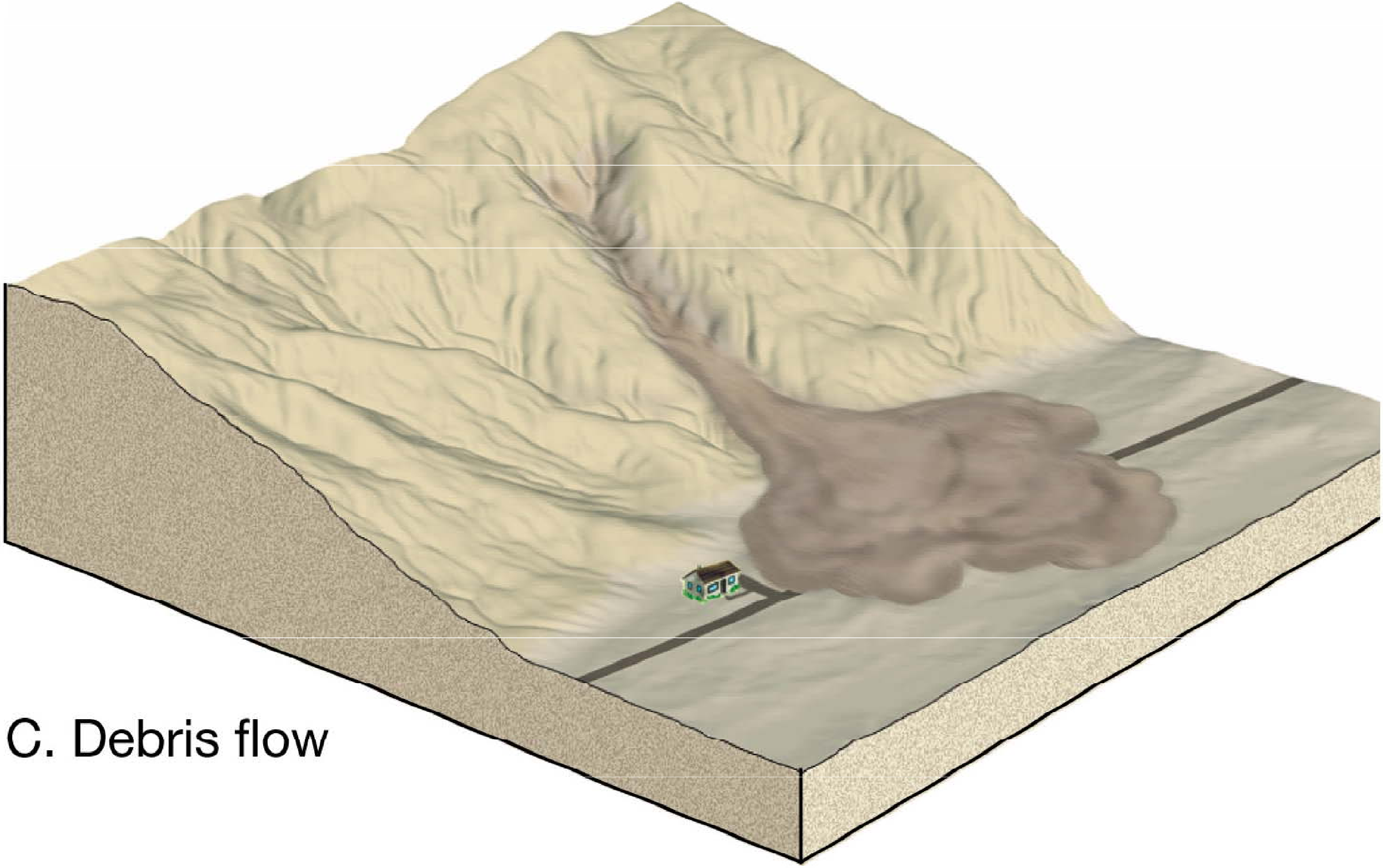
Rock Fall

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

Forms of mass wasting

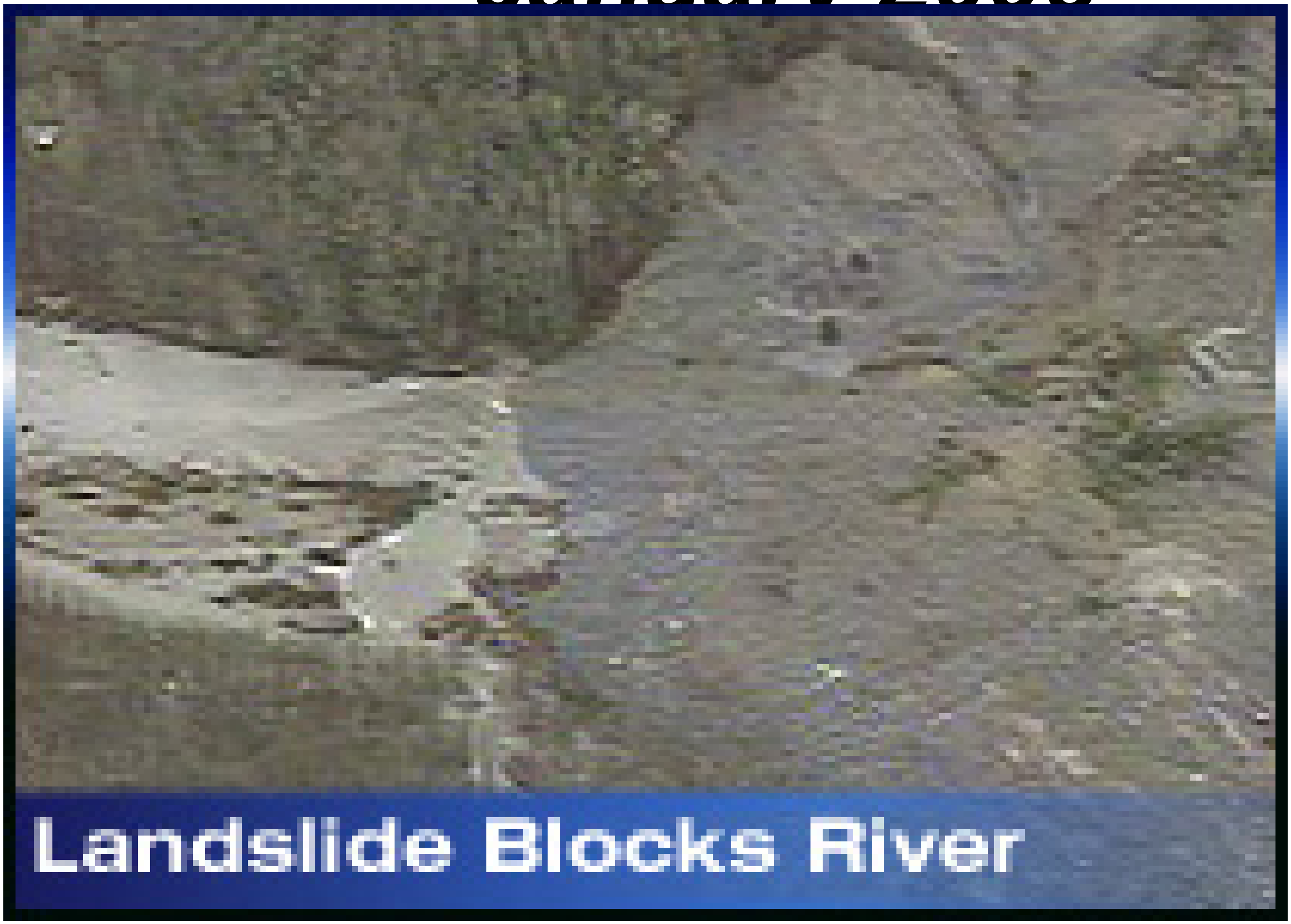
Debris flow (mudflow)

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



C. Debris flow

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, May 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

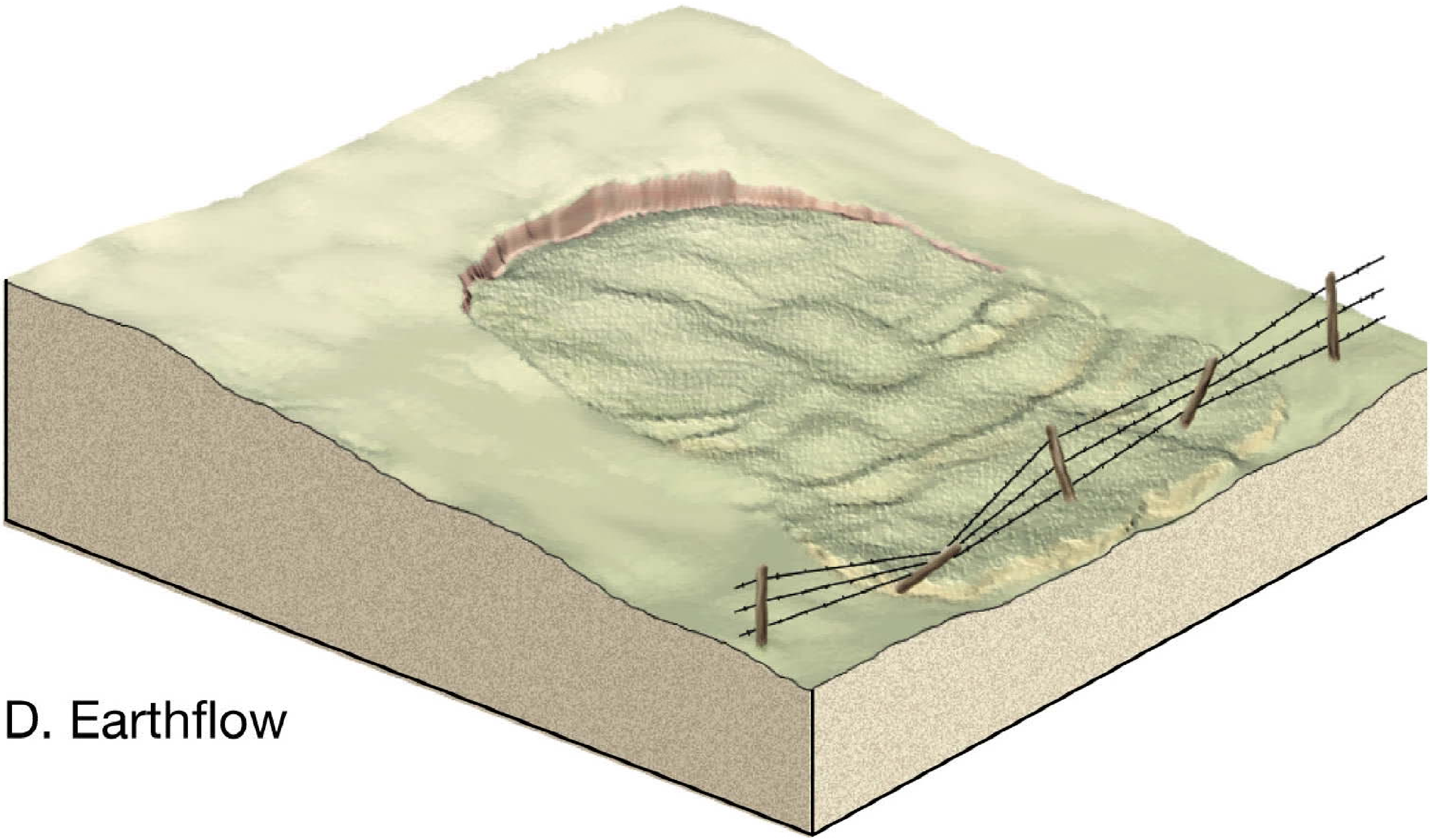
- http://www.alertnet.org/thenews/pictures/MAN52D.htm

- 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



D. Earthflow

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/selectpiclique/alaska64/landslideintowater.jpg

- Hyperlink to sand boil liquefaction http://walrus.wr.usgs.gov/geotech/images/TIsandboils.mov

Sheffield Dam, 1925

Santa Barbara County, CA

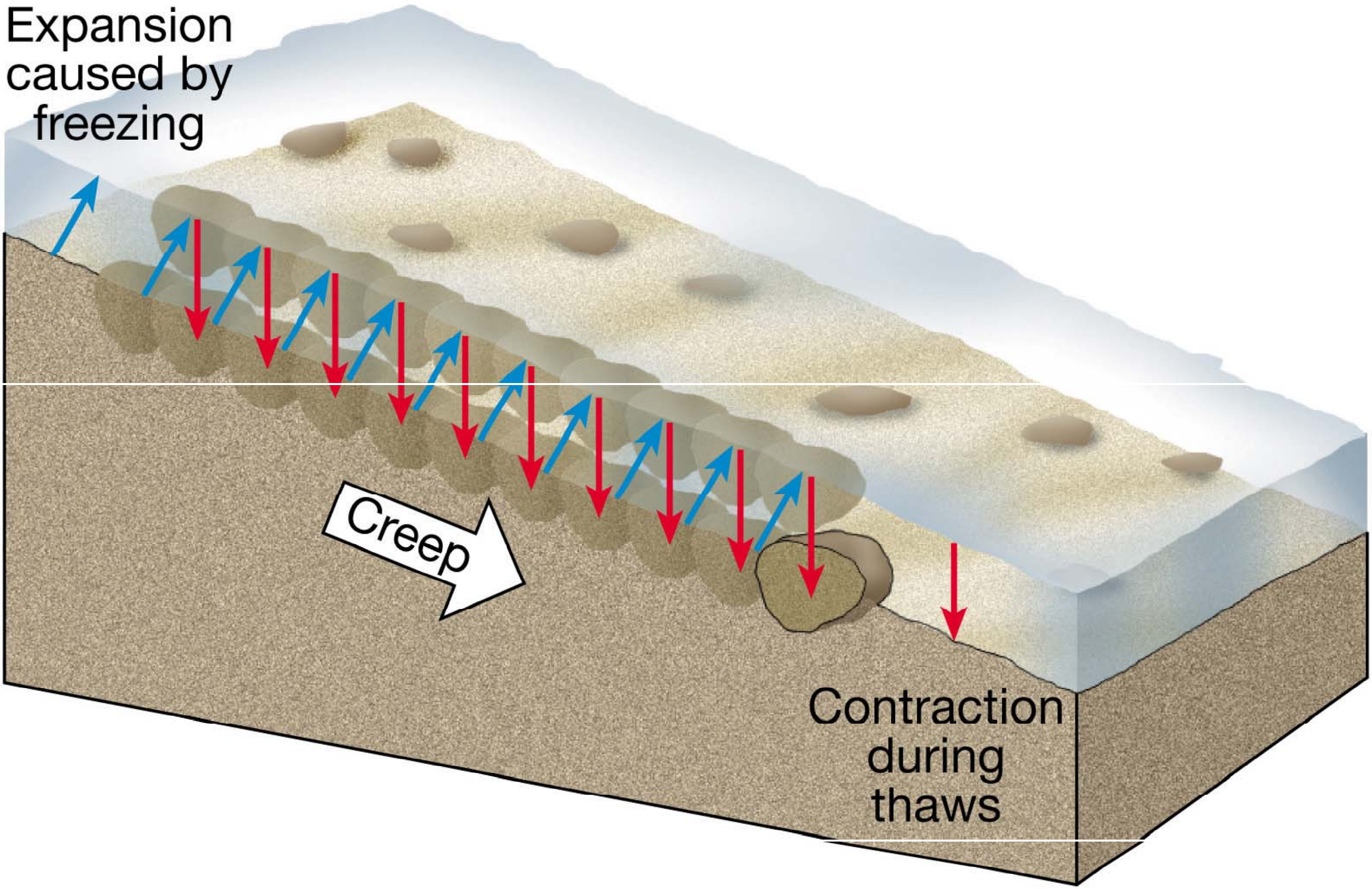
Earth-quake caused earthflow

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

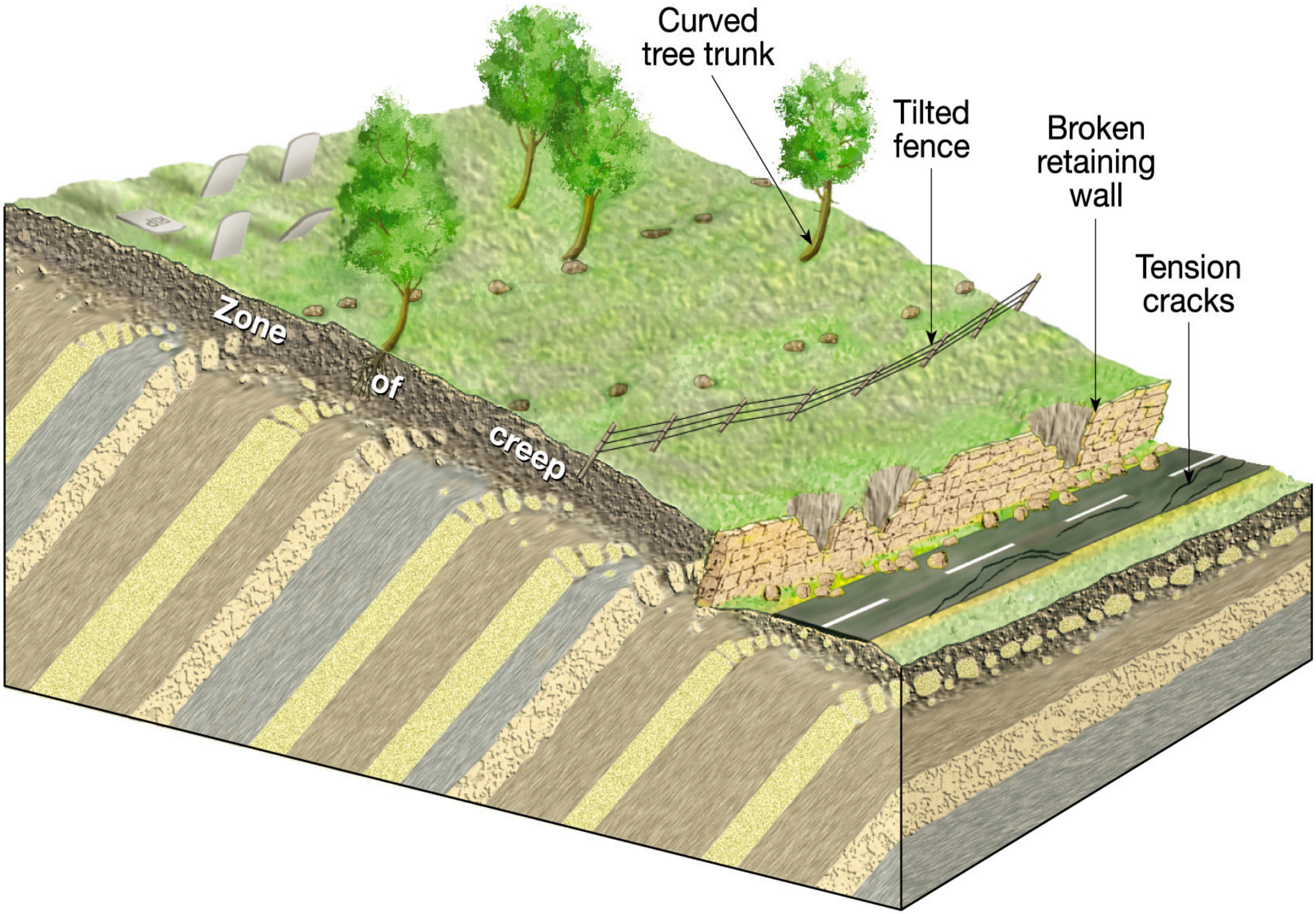
Forms of mass wasting

Creep

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


Expansion caused by freezing
Creep
Contraction during thaws

Some visible effects of creep



Creep

- Bedrock curled due to creep mass wasting

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

Creep

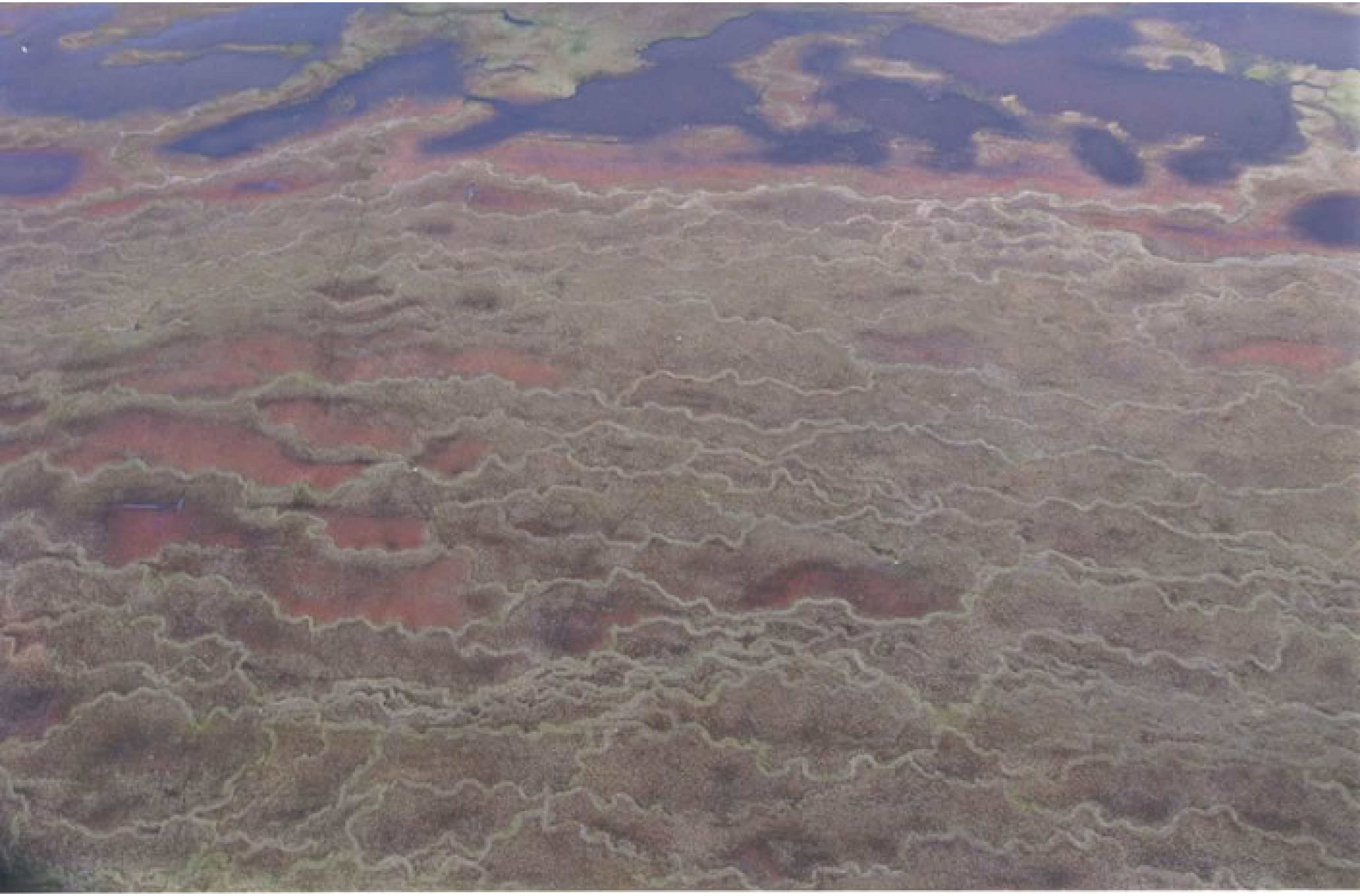
- Curved trunks due to soil creep

- http://classes.colgate.edu/dkeller/geol101/massw/images/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

EXPLANATION

LANDSLIDE INCIDENCE

Low (less than 1.5% of area involved)

Moderate (1.5%-15% of area involved)

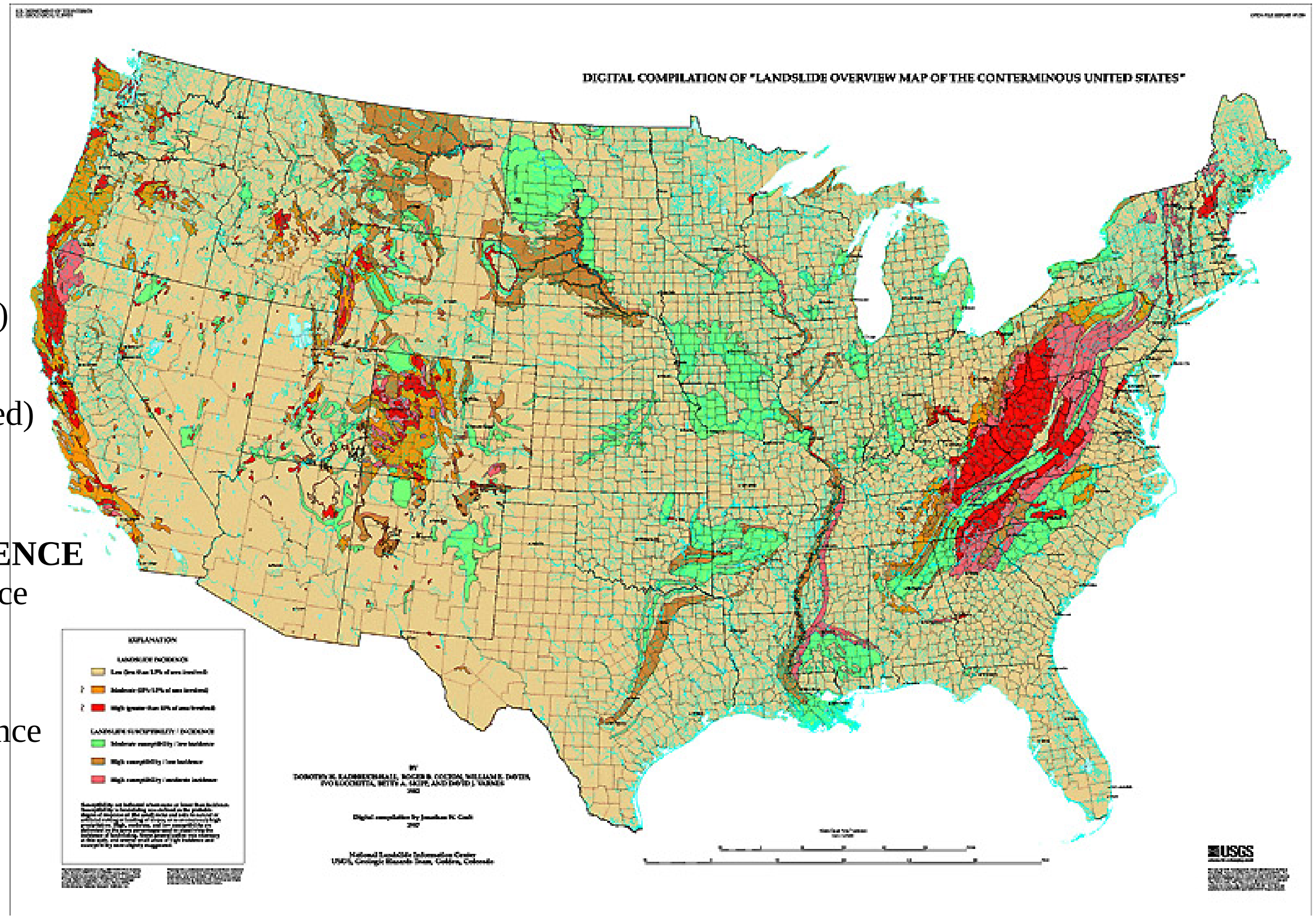
High (greater than 15% of area involved)

LANDSLIDE SUSCEPTIBILITY/INCIDENCE

Moderate susceptibility/low incidence

High susceptibility/low incidence

High susceptibility/moderate incidence



Mass Wasting Potential

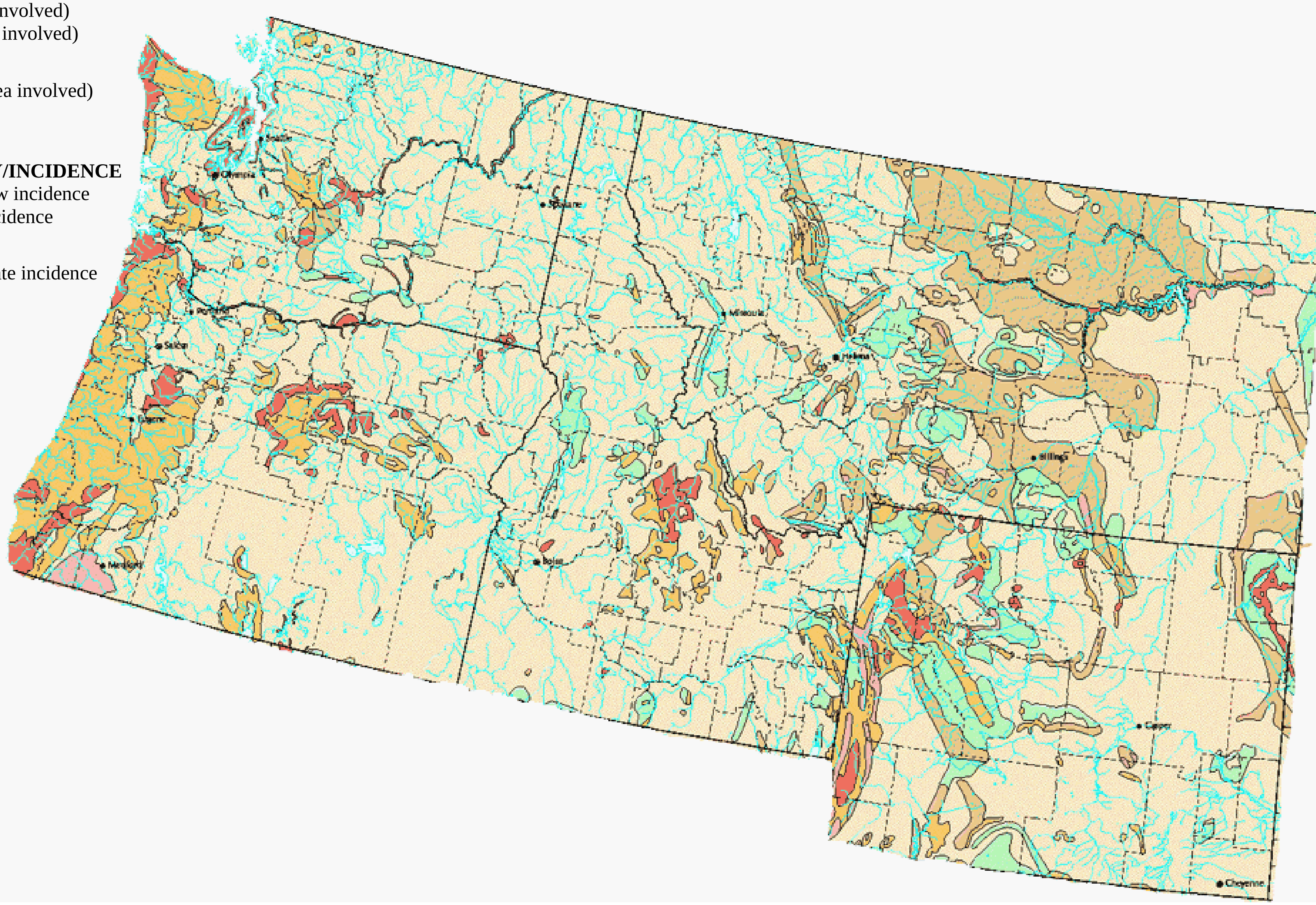
EXPLANATION

LANDSLIDE INCIDENCE

- Low (less than 1.5% of area involved)
- Moderate (1.5%-15% of area involved)
- High (greater than 15% of area involved)

LANDSLIDE SUSCEPTIBILITY/INCIDENCE

- Moderate susceptibility/low incidence
- High susceptibility/low incidence
- High susceptibility/moderate incidence



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