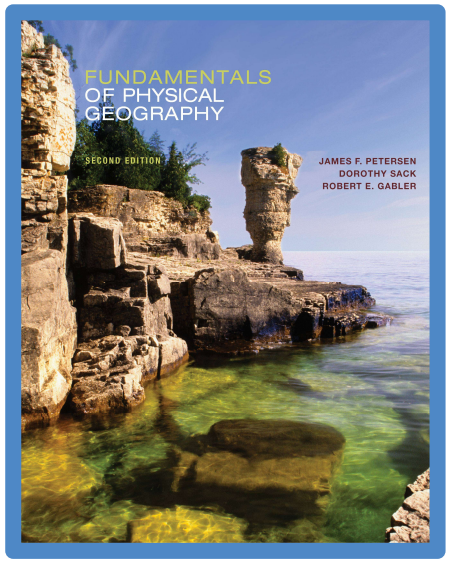
Fundamentals of Physical Geography 2e

Tectonic and Volcanic Processes and Landforms

11



- Peterson
  - Sack
    - Gabler

Introduction

- Topography
  - Distribution of landscape highs and lows
- Landforms
  - Tectonic and igneous processes
  - Dynamic, beautiful, diverse, and sometimes dangerous
- Geomorphology
  - Scientific study of landforms

Landforms and Geomorphology

- Relief
  - Difference in high and low elevations
- Endogenic processes
  - Originate within Earth; increase relief
- Exogenic processes
  - Originate at Earth's surface; decrease relief
  - Weathering: erosion, transportation, and deposition
  - What are common geomorphic agents?

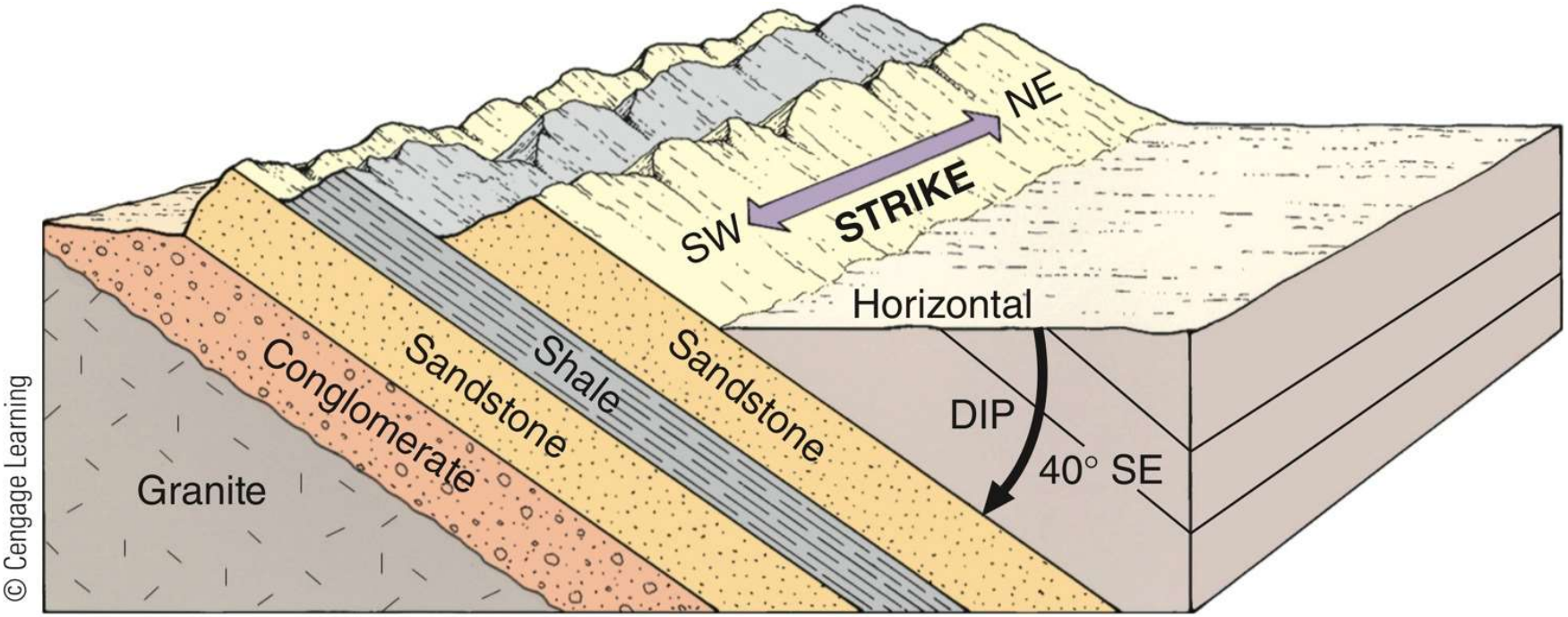
D. Sack

D. Sack

National Park Service/Kimberly Finch, D. Sack

Tectonic Forces, Rock Structure, and Landforms

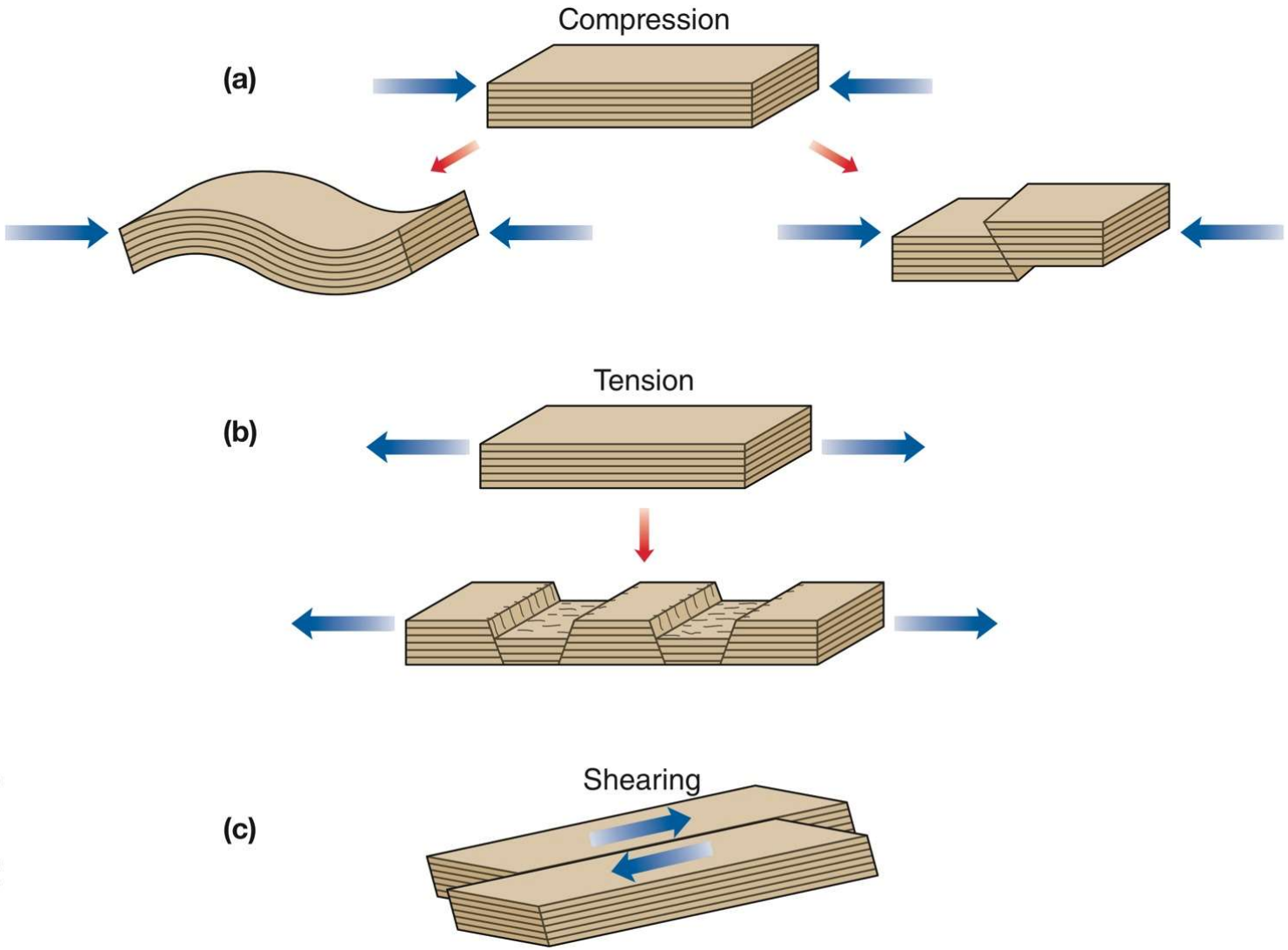
- Tectonic forces
  - Documentation of deformation
    - Nature, orientation, inclination, and arrangement of affected rock layers
  - Describe orientation of inclined rock layers by measuring:
    - Strike
    - Dip



Does a strike to the southwest differ from a strike to the northeast?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Types of tectonic forces
  - Compressional forces
    - Push crustal rocks together
  - Tensional forces
    - Pull parts of the crust away from each other
  - Shearing forces
    - Slide parts of Earth's crust past each other



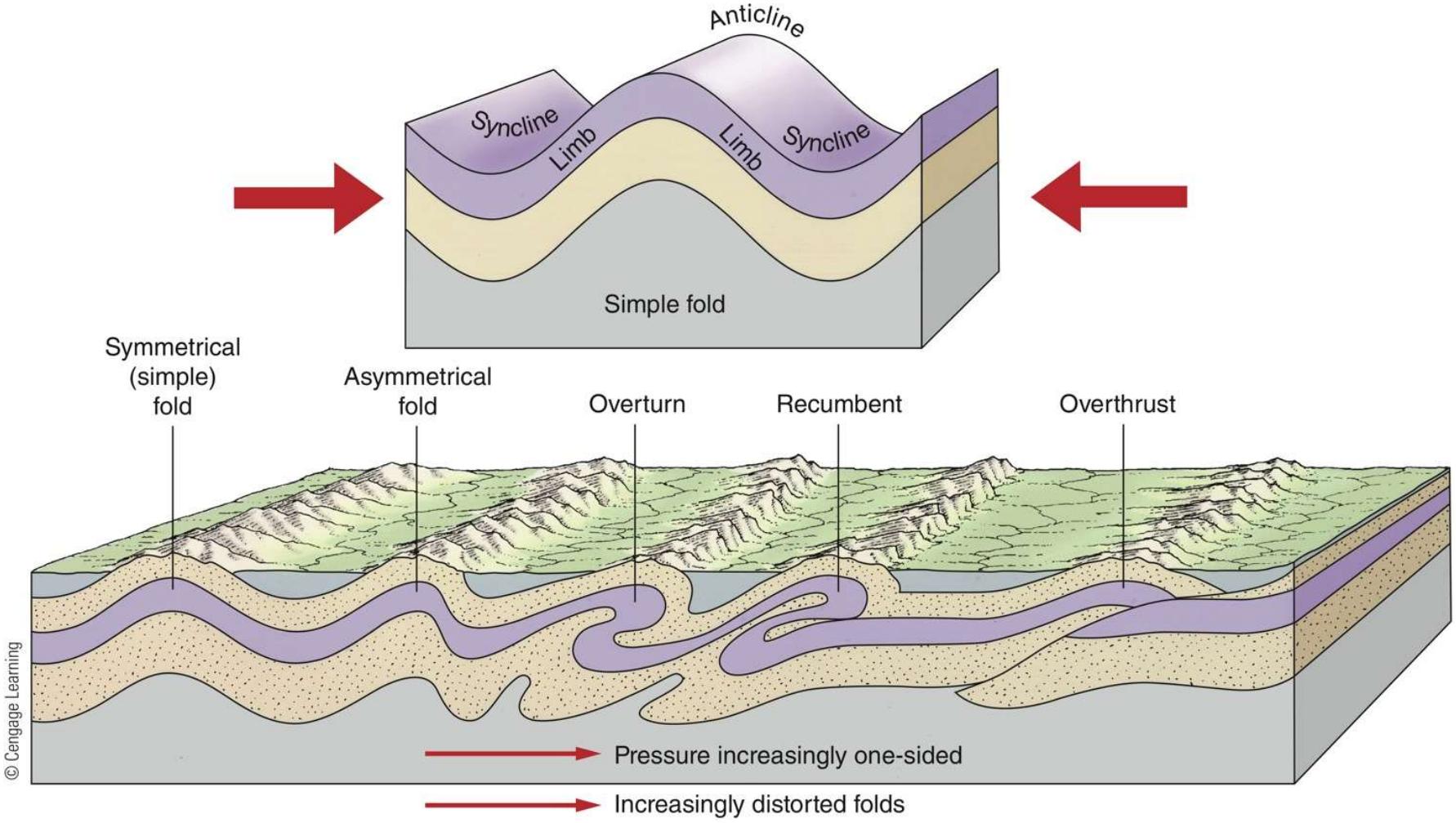
When you stretch a rubber band, are you subjecting it to compressional, tensional, or shearing forces?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Compressional tectonic forces
  - Folding: bending or crumpling where rocks are ductile
  - Anticlines: upfolds
  - Synclines: downfolds
  - Where can one find large-scale examples of folding?

J. Petersen

How can solid rock be folded without breaking?


Anticline
Syncline
Limb
Limb
Syncline
Simple fold
Symmetrical (simple) fold
Asymmetrical fold
Overturn
Recumbent
Overthrust
Pressure increasingly one-sided
Increasingly distorted folds
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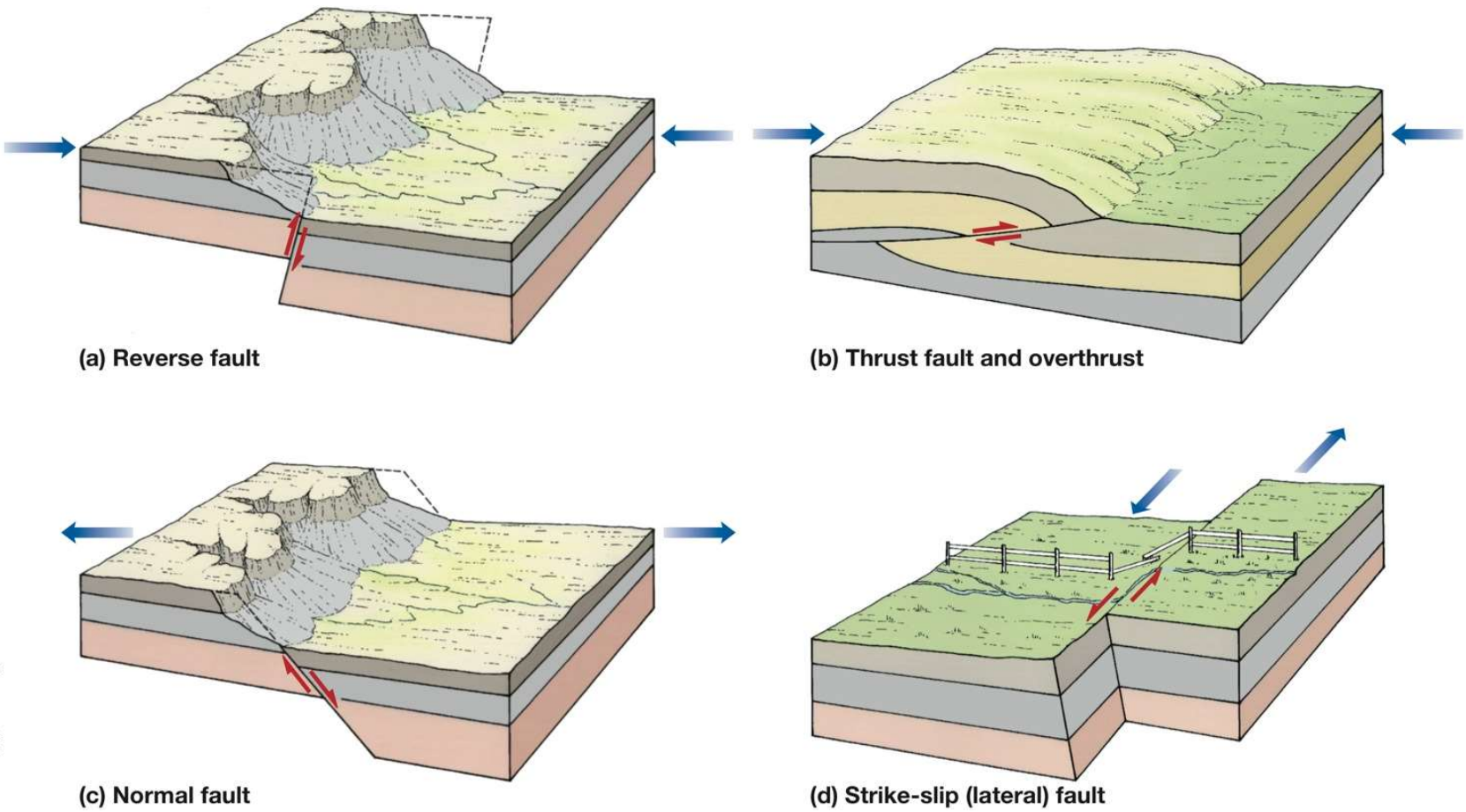
Tectonic Forces, Rock Structure, and Landforms (cont'd.)

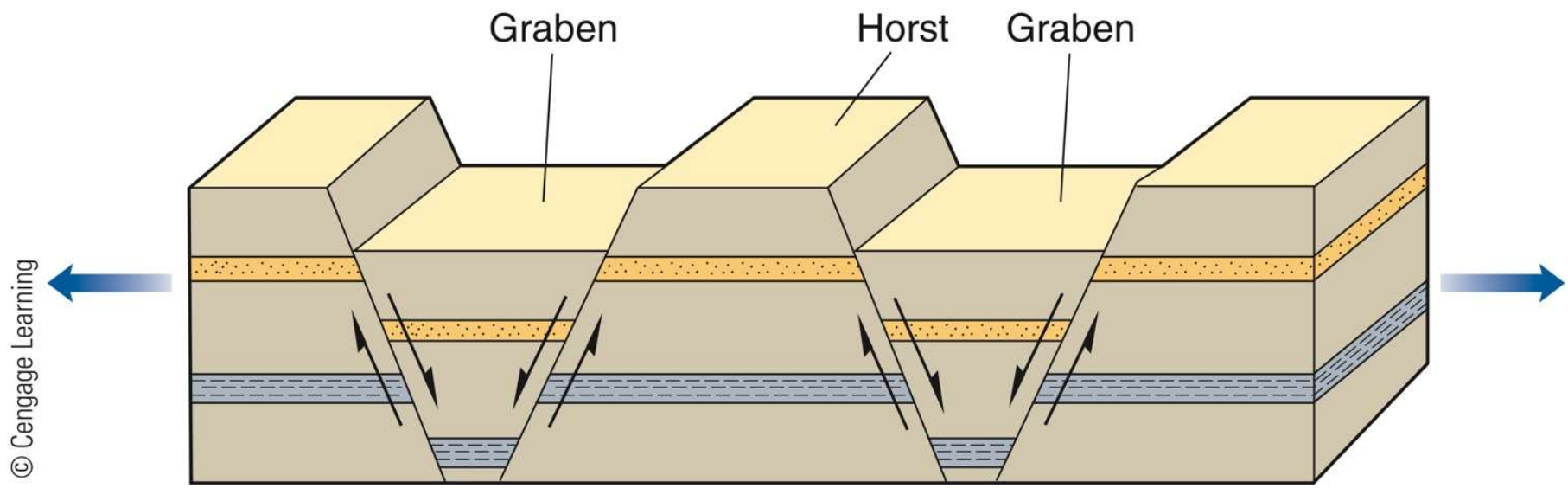
- Compressional tectonic forces
  - Faulting: slippage or displacement of rocks along a fracture
    - Fault
    - Reverse fault
    - Thrust fault
    - Overthrust



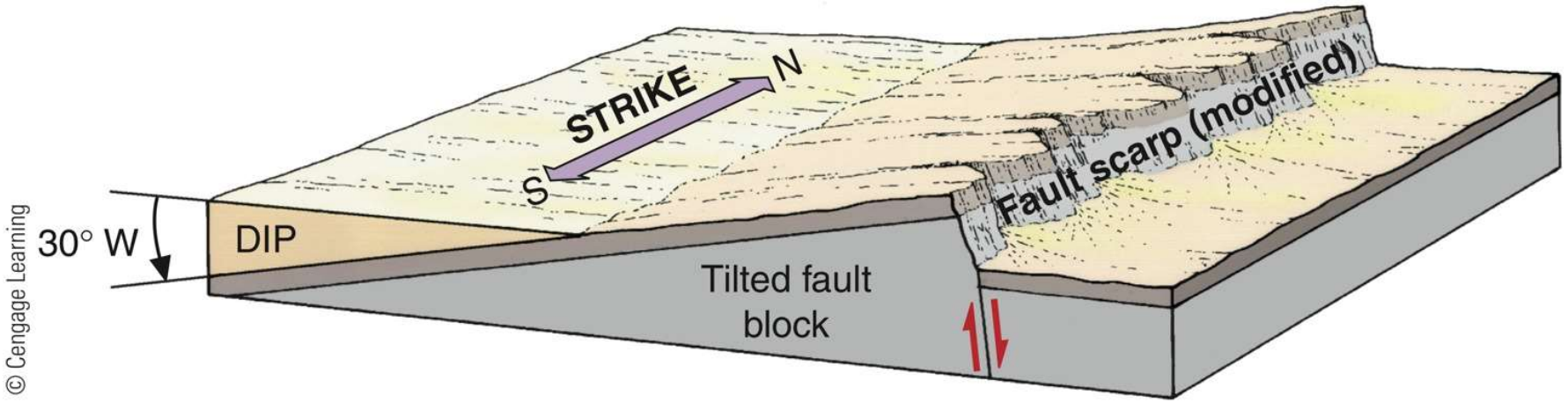
How does motion along a normal fault differ from that along a reverse fault?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Tensional tectonic forces
  - Fault blocks
    - Separated by normal faults
  - Identified by the nature of the offset of rock units along normal faults
    - Grabens
    - Horsts



What tectonic force causes these kinds of fault blocks?



Is erosion an endogenic or an exogenic process?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

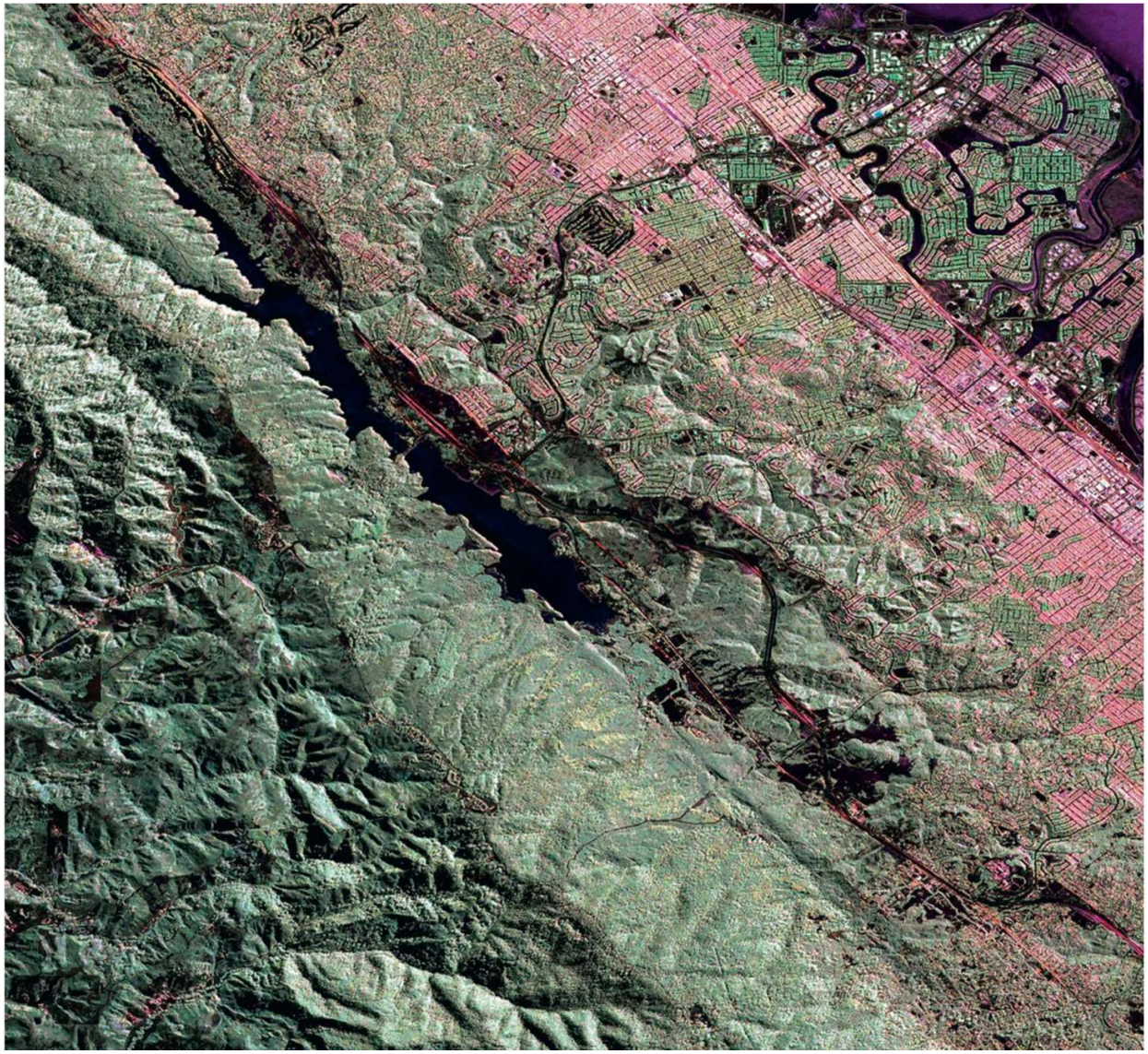
- Tensional tectonic forces
  - Rift valley
    - Long but relatively narrow zones of crust downdropped between normal faults
  - Escarpment (scarp): steep cliff
    - Fault scarp: results from movement along a fault
    - Piedmont fault scarp

D. Sack

On which side of the fault scarp does the horst lie?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Shearing tectonic forces
  - Strike-slip (lateral) fault
    - Direction of motion: left lateral or right lateral
    - Amount of offset varies

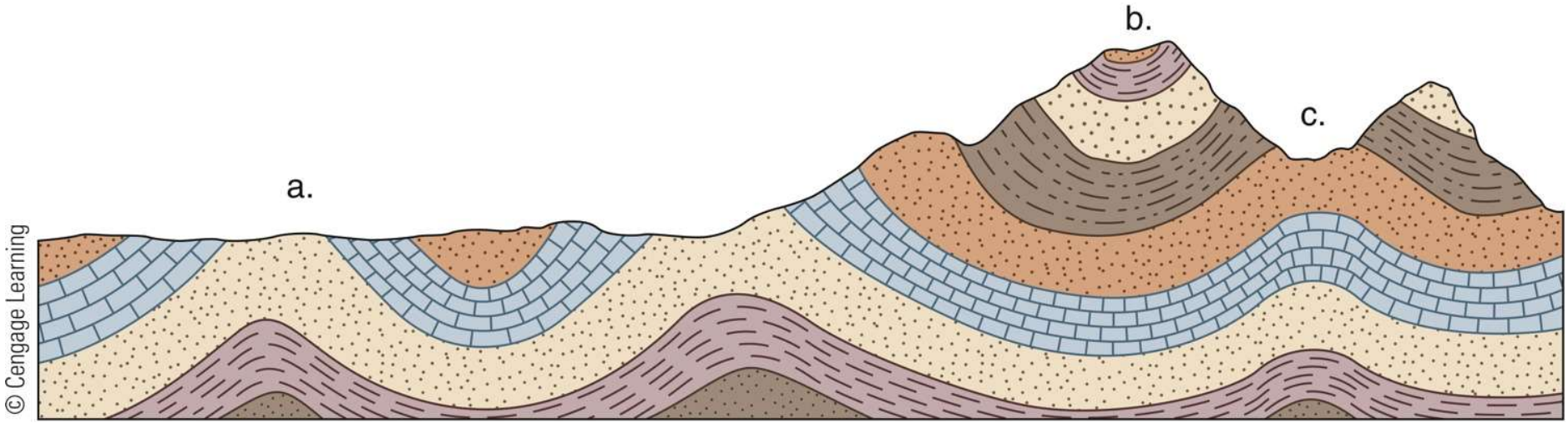


NASA/JPL

Is the San Andreas a left or right lateral fault?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Relationships between rock structure and topography
  - Why is it important to distinguish between elements of rock structure and topographic features?



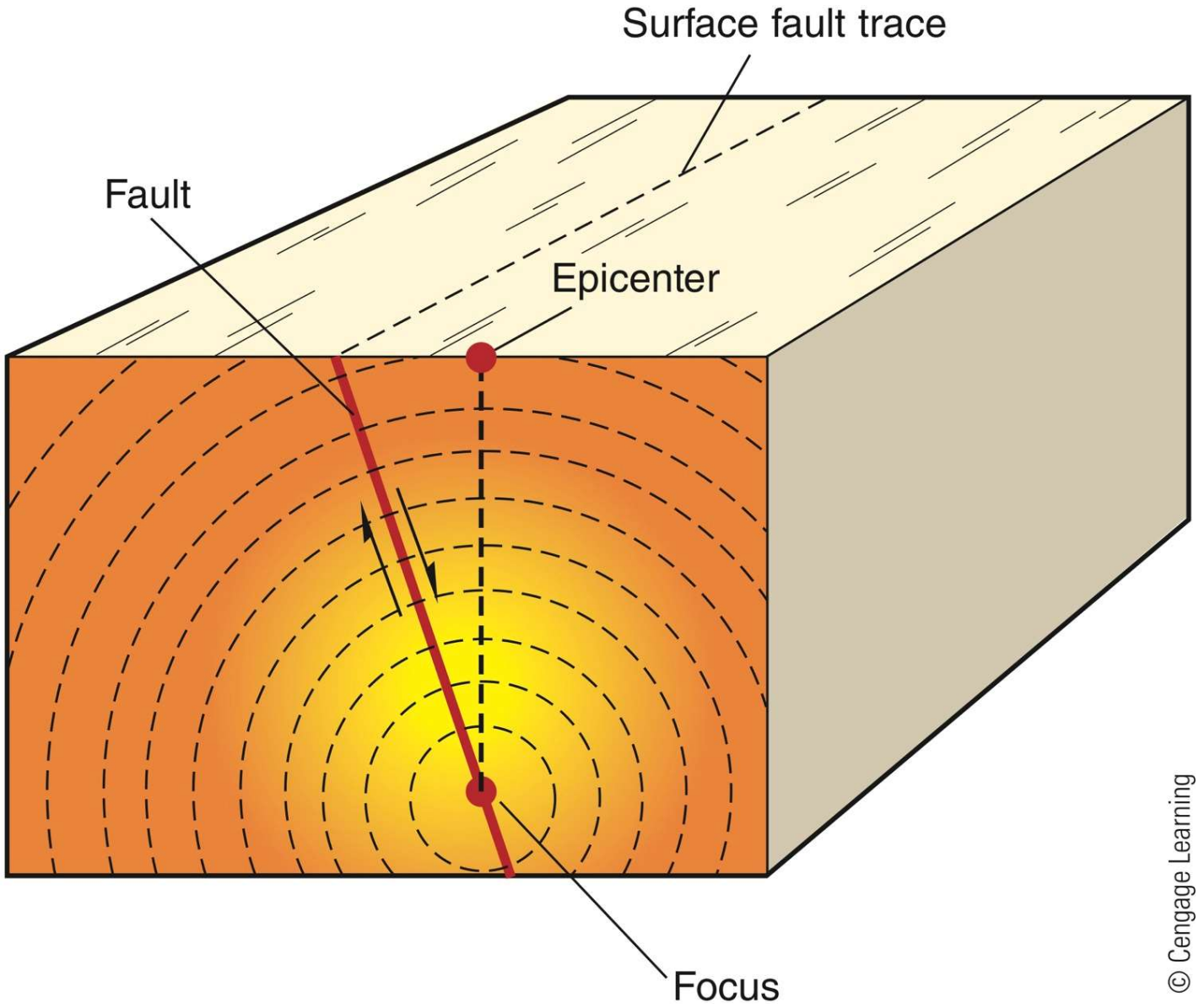
Why don’t all anticlines form hills or mountains?

Tectonic Forces, Rock Structure, and Landforms (cont'd.)

- Relationships between rock structure and topography
  - Topographic variation on Earth's surface is a result of:
    - Endogenic processes
    - Exogenic processes
    - Relative strength or resistance of different rock types to weathering and erosion

Earthquakes

- Accumulating tectonic stress
  - Suddenly relieved by displacement of rocks along a fault
- Seismic waves
- Focus
- Epicenter



Earthquakes (cont'd.)

- Measuring earthquake size
  - Severity of an earthquake
    - Size of the event
    - Degree of its impact on humans
- Earthquake magnitude
  - Scale developed by Charles F. Richter (1935)
    - Measured released energy with seismographs
  - Moment magnitude

USGS/Dr. Guy Gelfenbaum

Earthquakes (cont'd.)

- Earthquake intensity
  - Damage caused by an earthquake
  - Degree of its impact on people and their property
  - Modified Mercalli scale
    - Refer to Table 11.1
    - Twelve categories: I to XII
    - What are the benefits of mapping the variations in intensity levels?

Earthquakes (cont'd.)

- Earthquake hazards
  - Japan (2011): 9.0 magnitude
    - 28,000 people missing or confirmed dead
  - Haiti (2010): 7.0 magnitude
    - 225,000 killed, 300,000 injured, and 1.3 million people displaced
  - Factors affecting impact
    - Structural collapse
    - Number of people

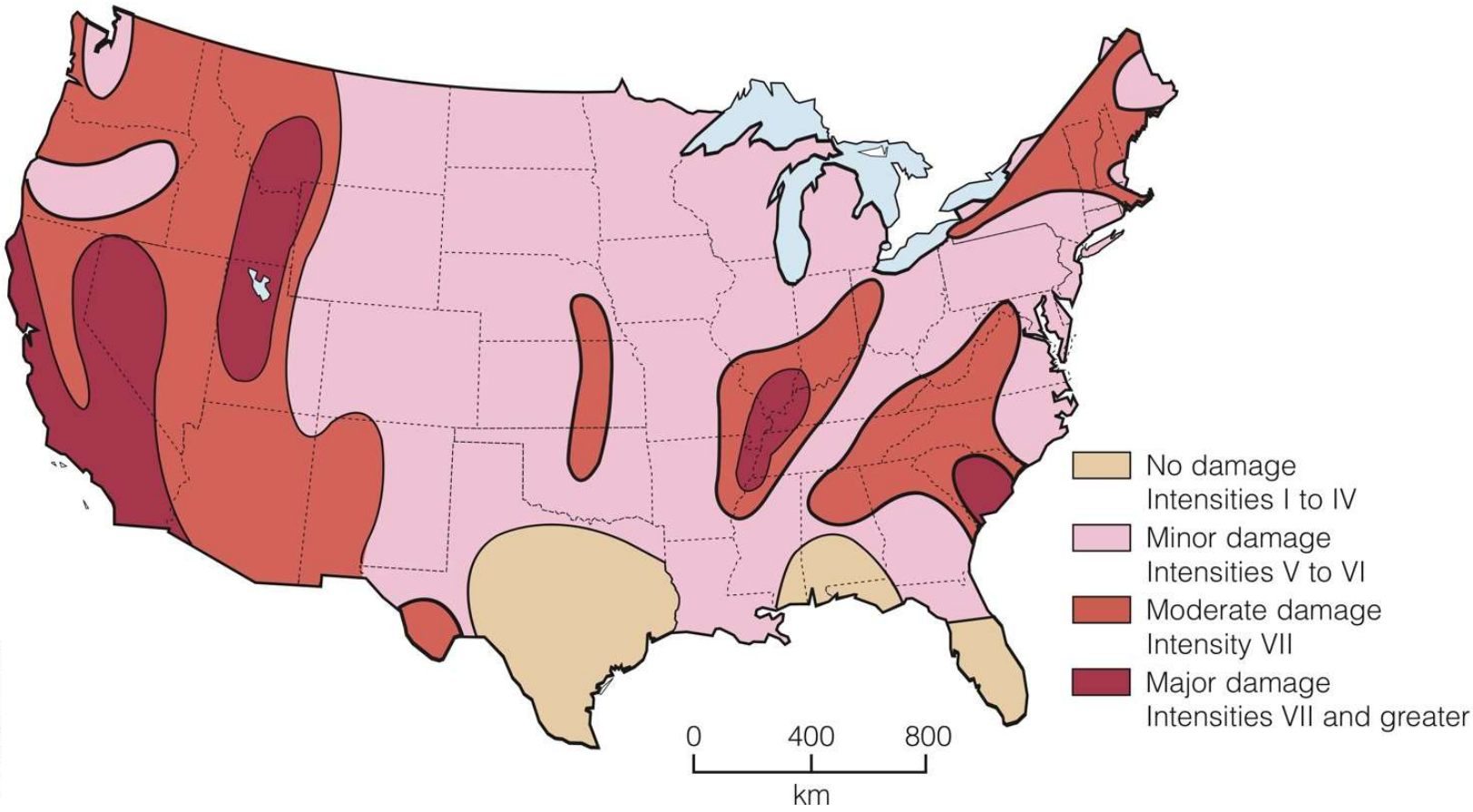
Department of Defense

What factors contributed to the large death toll from this earthquake?

USGS

Earthquakes (cont'd.)

- Earthquake hazards
  - In addition to structural collapse, what other factors influence loss of life?



What is the earthquake hazard potential where you live, and what does that level of intensity mean according to the Mercalli scale in Table 11.1?

Earthquakes (cont'd.)

- Mapping the distribution of earthquake intensity
  - Magnitude: logarithmic scale
    - Larger magnitude: more damage and human suffering
  - Mercalli Scale: earthquake intensity (I–XII)
    - Earthquake's impact: people and built environment
    - Isoseismals: equal impact levels
    - San Francisco earthquake (1906) analysis

Igneous Processes and Landforms (cont'd.)

- Volcanism
  - Extrusive
- Plutonism
  - Below Earth's surface
- Volcanic eruptions
  - Types
    - Explosive
    - Effusive

Igneous Processes and Landforms (cont'd.)

- Volcanic eruptions
  - Viscosity of magma
    - Felsic: thick
    - Mafic: less viscous
  - What is the effect of the viscosity on gas pressure during an eruption?
  - Pyroclastic materials (tephra)
    - Volcanic ash

NASA/Visible Earth

Igneous Processes and Landforms (cont'd.)

- Volcanic landforms
  - Depends primarily on explosiveness
  - Kinds (least to most explosive)
    - Lava flows
    - Shield volcanoes
    - Cinder cones
    - Composite cones
    - Plug domes
    - Calderas

Igneous Processes and Landforms (cont'd.)

- Lava flows
  - Basalt: most common composition
  - Small potential for explosive eruption
  - Joints (fractures)
  - Surface characteristics
    - Pahoehoe and aa
  - Fissures
  - Basalt plateaus

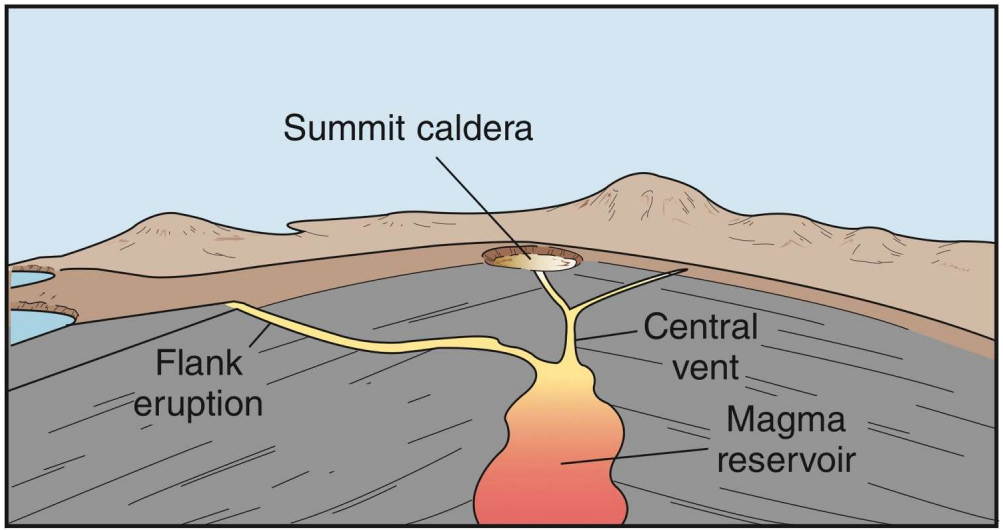
National Park Service

Why are the cliffs shown in this photograph so steep?

D. Sack

Igneous Processes and Landforms (cont'd.)

- Shielded volcanoes
  - Largest type of volcano
  - Major feature: outpouring of fluid basaltic lava flows



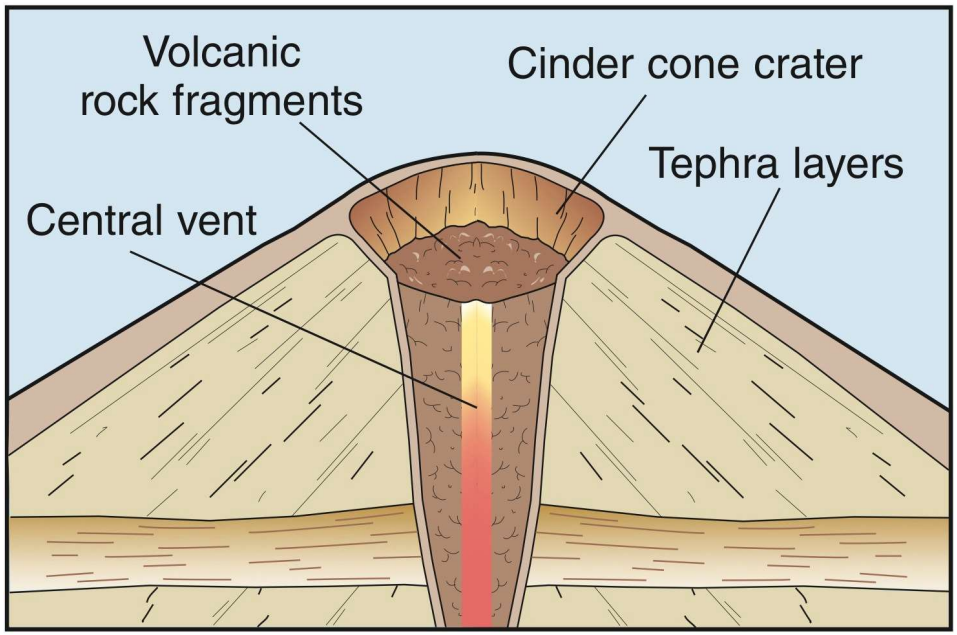
(a)

D. Sack

Why do Hawaiian volcanoes erupt less explosively than volcanoes of the Cascades or Andes?

Igneous Processes and Landforms (cont'd.)

- Cinder cones
  - Smallest type of volcano
  - Typically, rhyolite composition
  - Steep, straight sides and a large crater in the center
  - What are examples of cinder cones?



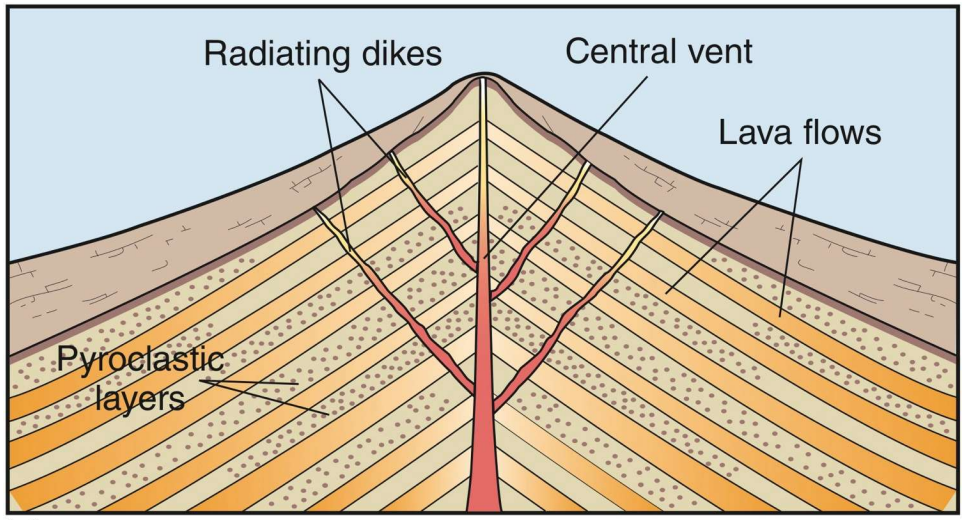
(b)

Crandell/USGS

Why is the crater so prominent on this volcano?

Igneous Processes and Landforms (cont'd.)

- Composite cones
  - Effusive or explosive
  - Stratovolcanoes
    - Layers of pyroclastics and lava
  - Classic volcano shape
  - Andesite composition



(c)

USGS Alaska Volcano Observatory/J. Adleman

USDA Forest Service

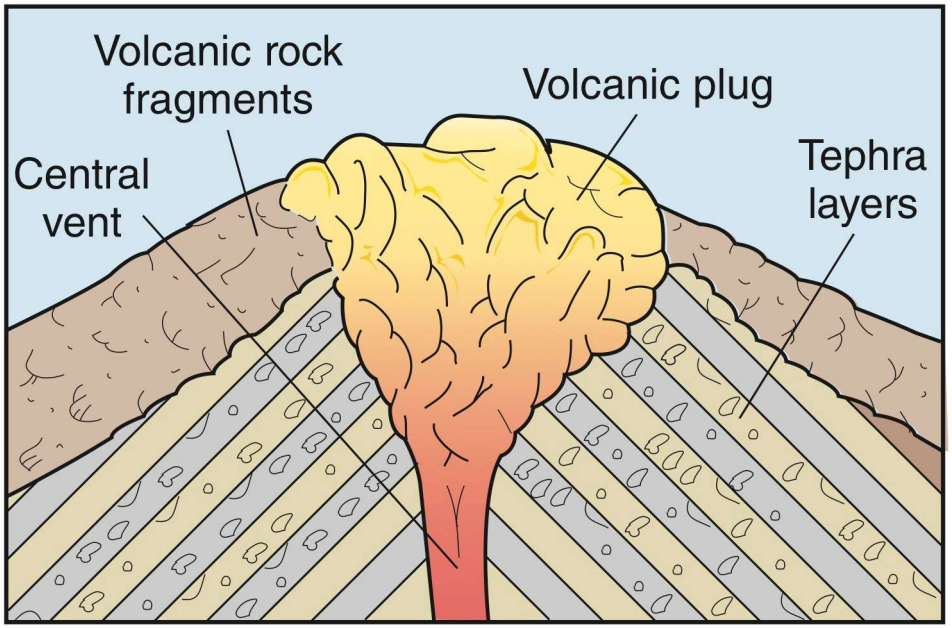
USGS/J. Rosenbaum

USGS/Lyn Topinka

Could other volcanoes in the Cascade Range, such as Oregon's Mount Hood, erupt with the kind of violence that Mount St. Helens displayed in 1980?

Igneous Processes and Landforms (cont'd.)

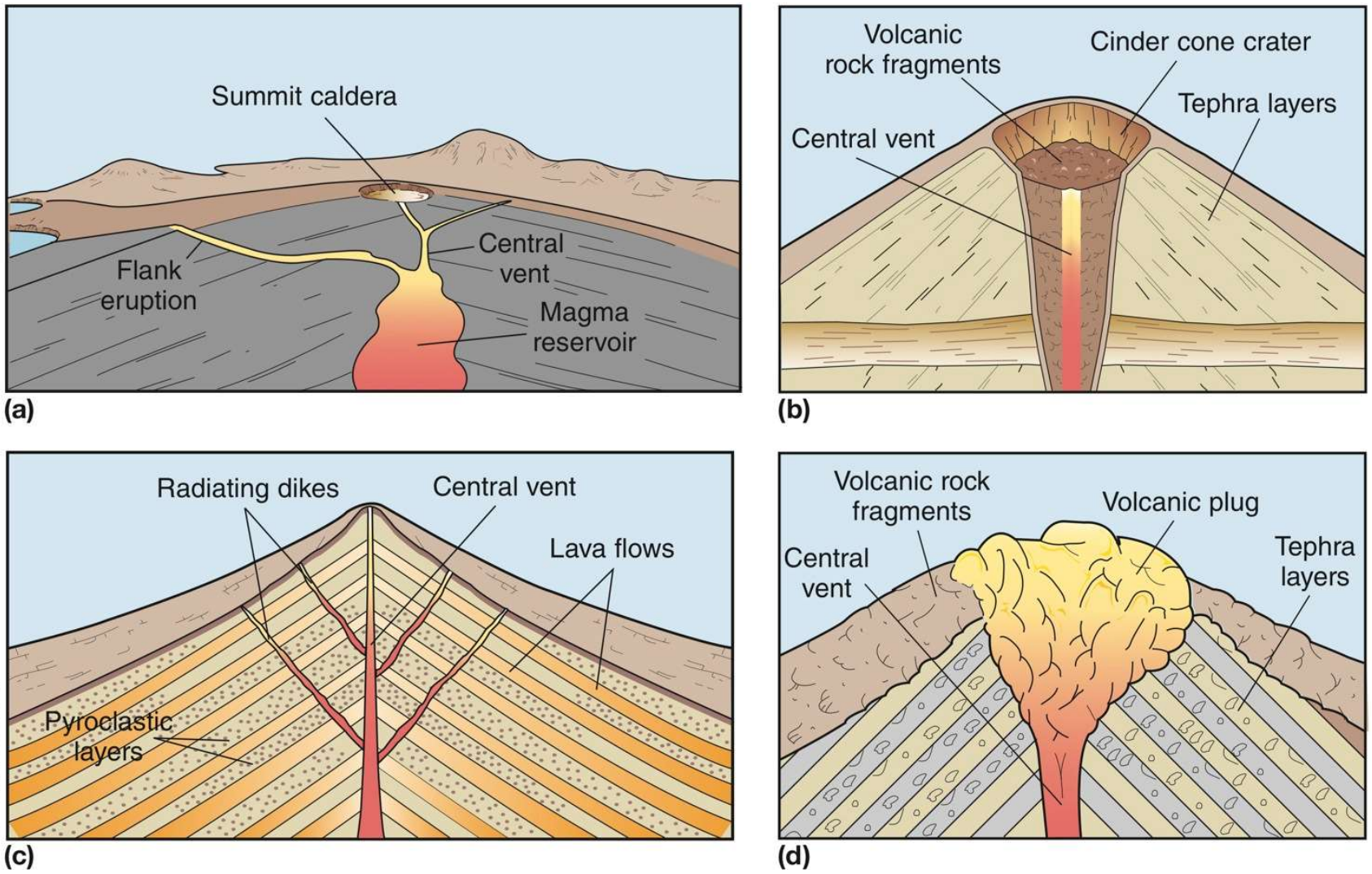
- Plug domes
  - Viscous silica-rich magma pushed into a vent
  - Potential for extremely violent explosive eruptions



(d)

USGS/Cascades Volcano Observatory

Why are plug dome volcanoes considered especially dangerous?



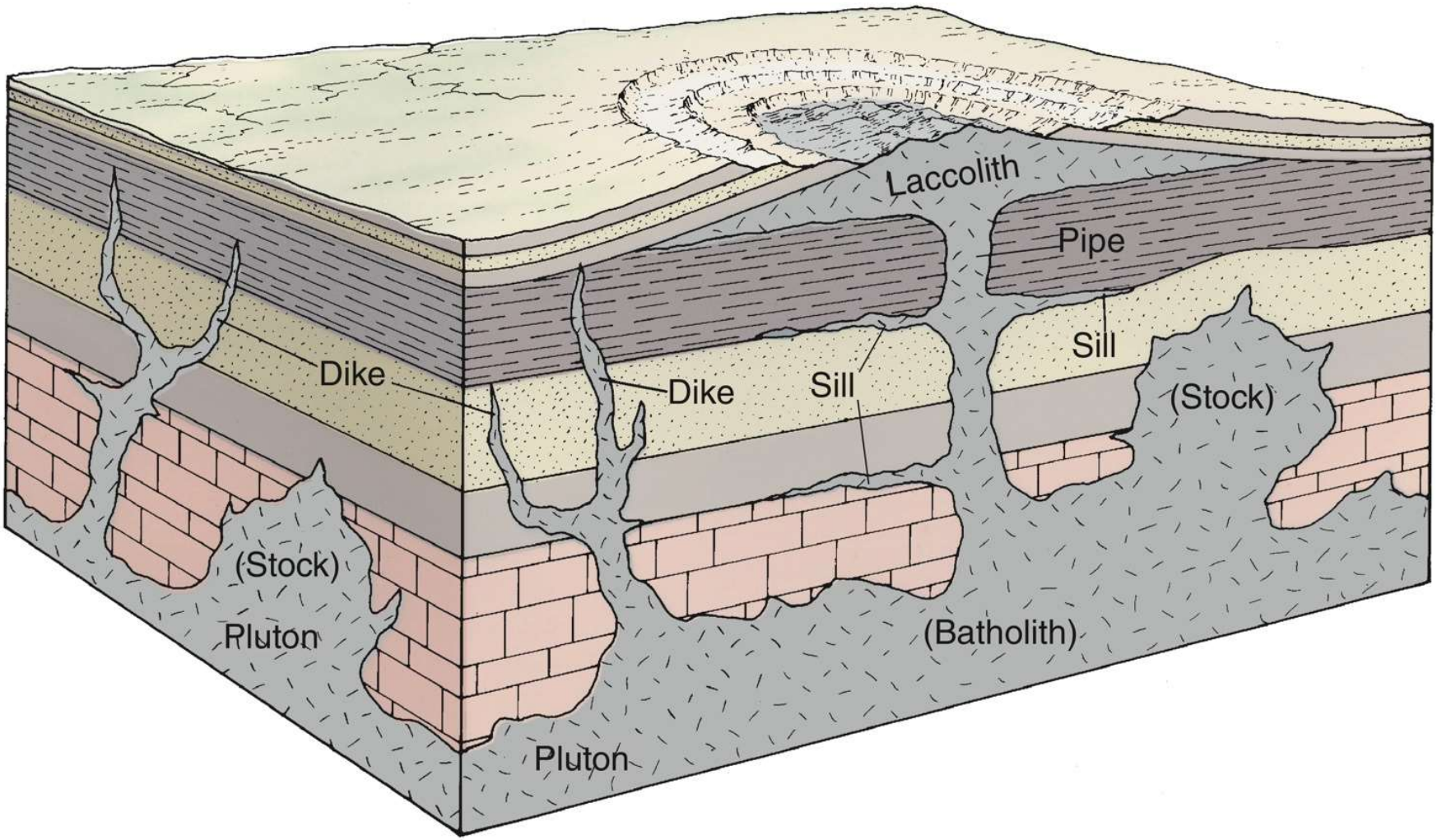
What are the key differences in the shapes of these volcanoes?

Igneous Processes and Landforms (cont'd.)

- Calderas
  - Large and deep depression in place of the summit following an eruption
  - Crater Lake
    - Wizard Island: secondary volcano
- Plutonism and intrusions
  - Igneous intrusions (plutons) result from intrusive igneous activity (plutonism)

Igneous Processes and Landforms (cont'd.)

- Plutonism and intrusions
  - Classified by size, shape, and relationships to surrounding rocks
    - Stock
    - Batholith
    - Laccolith
    - Sill
    - Dike
    - Volcanic neck



Igneous Processes and Landforms (cont'd.)

- Distribution of tectonic and volcanic activity
  - Along the boundaries of lithospheric plates
  - Some hazard prone regions are densely populated

Fundamentals of Physical Geography 2e

Tectonic and Volcanic Processes and Landforms

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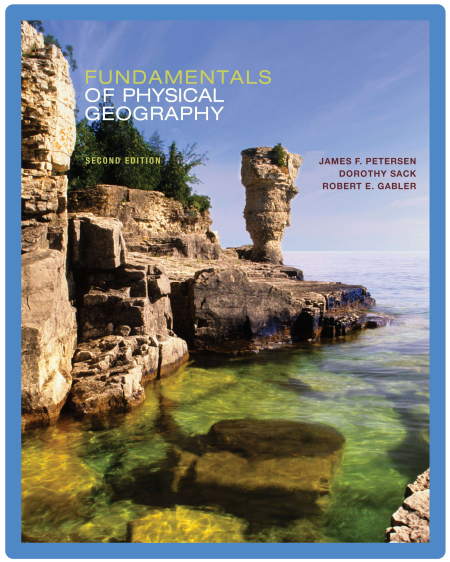

- Peterson
  - Sack
    - Gabler