PHYSICAL GEOGRAPHY

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INTRODUCTION TO LANDFORM STUDY

Introduction to Landform Study

- The Study of Landforms
- The Structure of Earth
- The Composition of Earth
- Some Critical Concepts

The Study of Landforms

- Geomorphology – the study of the characteristics, origin & development of landforms
- Topography is the surface configuration of the earth.
- A landform is an individual topographic feature of any size, e.g. a sand dune, mountain, river meander, the Grand Canyon, etc.

The Study of Landforms

- Basic elements
  - Structure
    - Geologic underpinning of a landform, e.g. the nature, arrangement and orientation of materials, say in a sedimentary rock.
  - Process
    - Actions that produced the landform, e.g. glaciers
    - Geologic, hydrologic, atmospheric, biotic processes
  - Slope
    - Angle represents a balance between structure (material type) and process "experience", which produces those characteristic slopes.

The Study of Landforms

- Drainage
  - Movement of water over and beneath Earth’s surface (e.g. underground streams in Kentucky’s karst regions).
  - Influenced by climate and the other basic elements

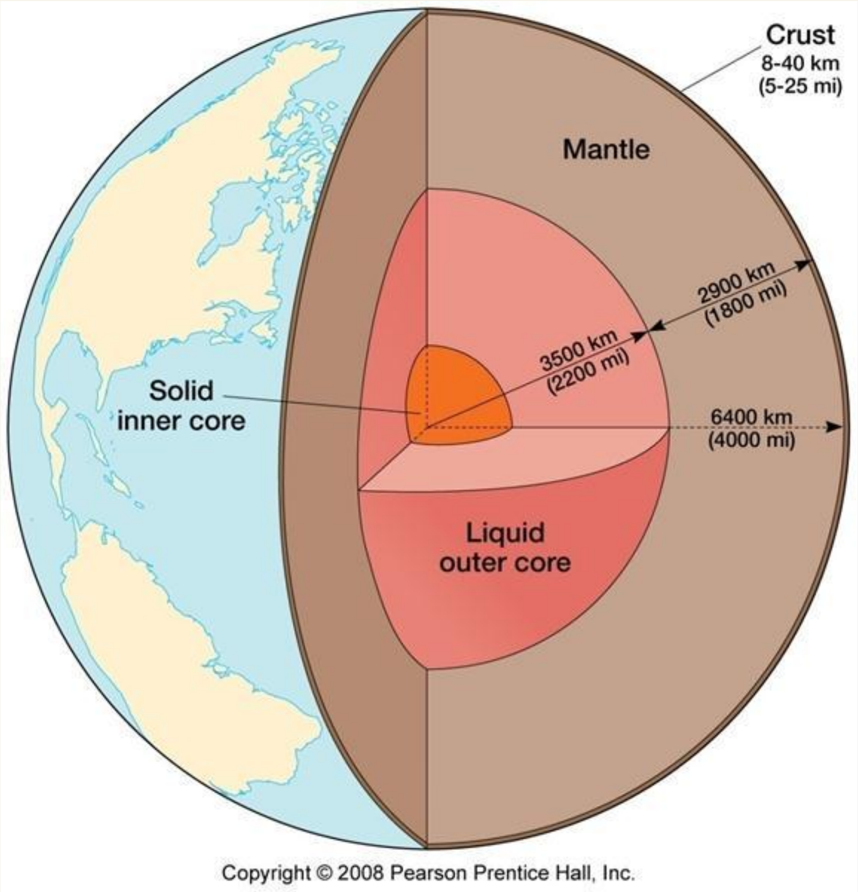
Fundamental questions of geographic inquiry:

- **What?** The form of the feature or features
- **Where?** The distribution and pattern of the landform assemblage
- **Why?** An explanation of the origin and development
- **So what?** The significance of the topography in relationship to other elements of the environment and to human life and activities.

The Structure of Earth

Introduction:

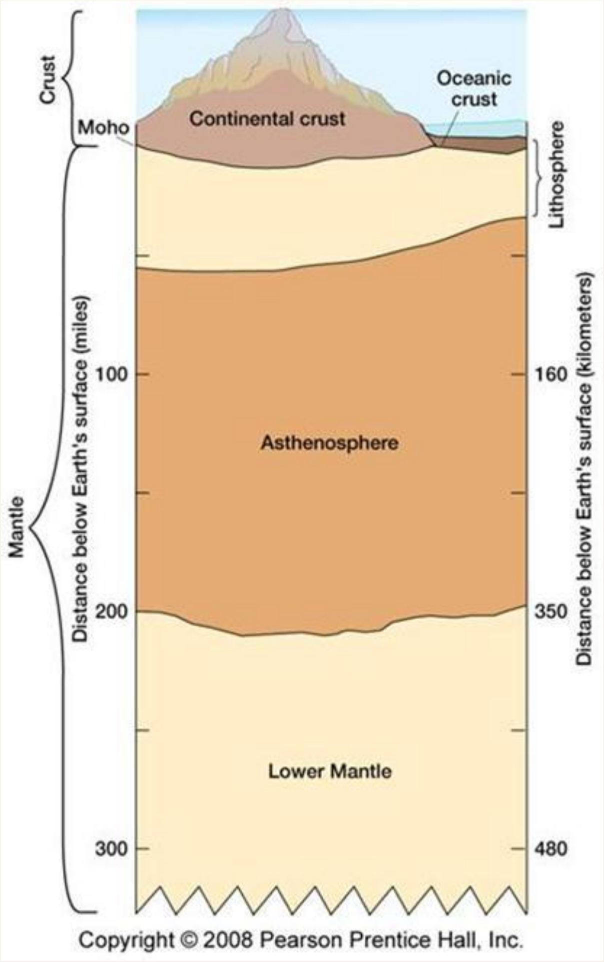
- Crust
- Mantle
- Core
  - Outer core
  - Inner core
- We only care about the interior of the earth because it helps us to understand the processes that shape its surface.



The Structure of Earth

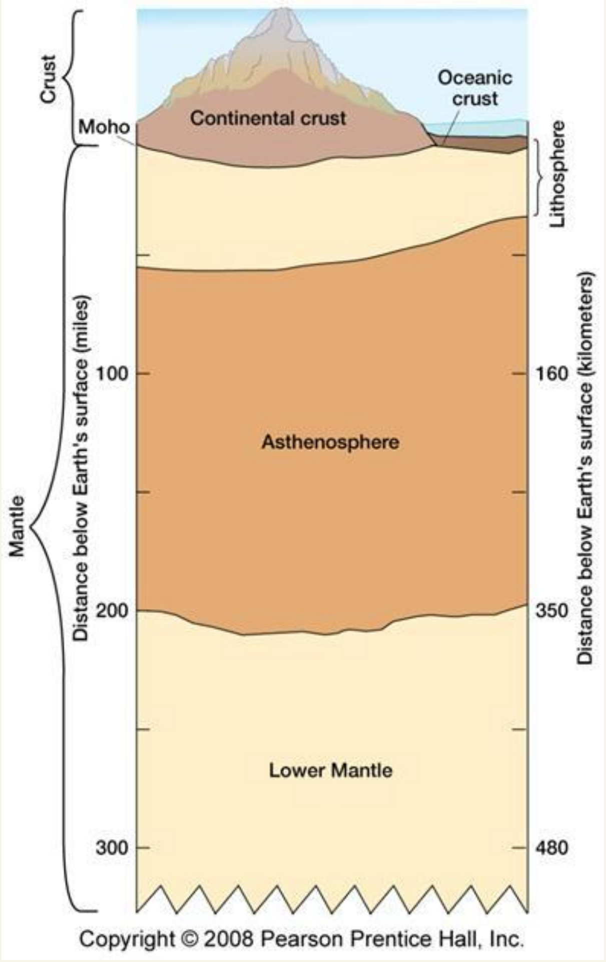
- The Crust
  - Part of lithosphere
  - Depth; thicker under continents (at least 15 miles), than under oceans (3 miles). The crust makes up less than 1% of the Earth's volume.

  Base
    - Moho (Mohorovičić discontinuity). "čić" is pronounced, "jik".
    - This is the part where there is significant change in mineral composition at the base of the crust.



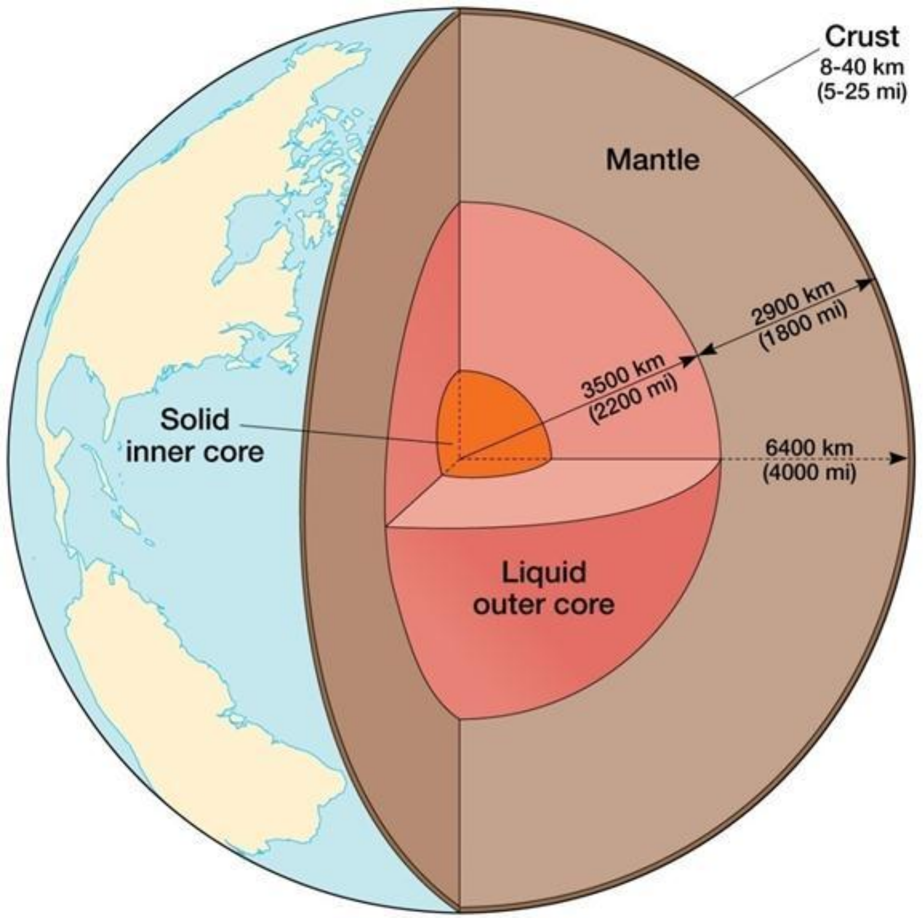
The Structure of Earth

- Mantle
  - Depth; about 1800 miles deep, largest of the 4 shells (when it comes to volume), so it is 84% of the earth's volume. It has 3 layers.
  - The crust + upper mantle = Lithosphere.
  - 1) Part of lithosphere
    - Upper mantle
    - Rigid
  - 2) Asthenosphere
    - 2nd layer of the mantle
    - "weak sphere"
    - Plastic quality; hot, **soft & easily deformed**
  - 3) Lower mantle
    - Mainly rigid



The Structure of Earth

- Core
  - Depth; both cores make up 15% of the Earth's volume. Inner core is 900 miles, outer is 3100 miles (together 4000 miles) –
  - Composition of both cores
    - Iron/Nickel or Iron/Silicate
  - Outer core
    - Molten / Liquid
    - Magnetic field of earth is generated here.
  - Inner core
    - Solid



The Composition of Earth

- **Minerals** – naturally formed compounds & elements of the earth.
- They are the building blocks of rocks, which in turn are the building blocks of the landscape.
  - Common characteristics needed for a substance to qualify *as a mineral*:
    - Solid
    - Found in nature
    - Inorganic
    - Must have specific chemical composition, regardless of where it's found
    - Atoms arranged in a regular pattern to form solid crystals
  - There are 7 principal categories (we will discuss each).

The Composition of Earth

- Silicate Minerals (largest group)
  - Combine two most common elements in lithosphere (oxygen and silicon)
  - Feldspars and quartz are the most abundant silicate minerals

The Composition of Earth

- Oxide Minerals
  - Oxide – when an element is combined with oxygen
    - Iron oxides most common (FeO_x)
  - Examples: hematite, magnetite, limonite
    - These are major sources of iron ore
- Sulfide Minerals
  - Sulfur plus one or more other elements
  - Many important ore minerals like:
    - Galena (lead)
    - Sphalerite (zinc)
    - Chalcopyrite (copper)
    - Pyrite (combination of iron & sulfur)

Iron pyrite crystals (FeS_2)

The Composition of Earth

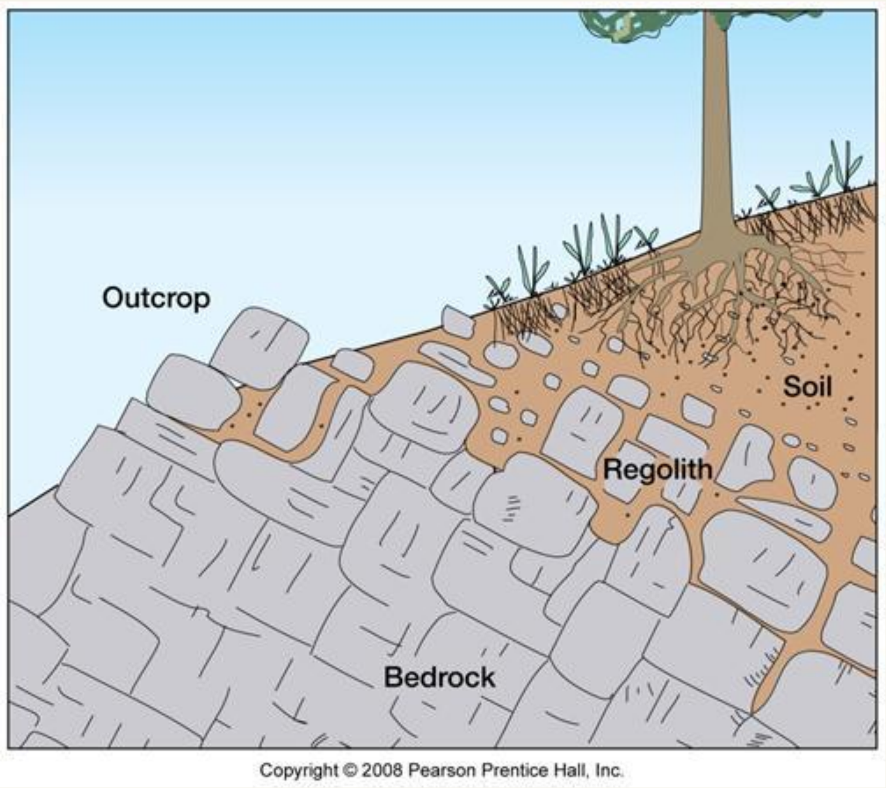
- Sulfate Minerals
  - Sulfur and oxygen in combination with some *other* element
    - Calcium is principal combining element
    - Gypsum is an example of a sulfate mineral
  - Light colored
  - Mostly in sedimentary rocks

The Composition of Earth

- Carbonate Minerals
  - When you have one or more elements in combination with carbon and oxygen, e.g.
    - Calcite (Calcium carbonate – $CaCO_3$), the main mineral in limestone
- Halide Minerals (e.g., common table salt), the least widespread minerals.
- Native elements – minerals that do not appear chemically combined with another element (e.g., gold and silver)

Rocks

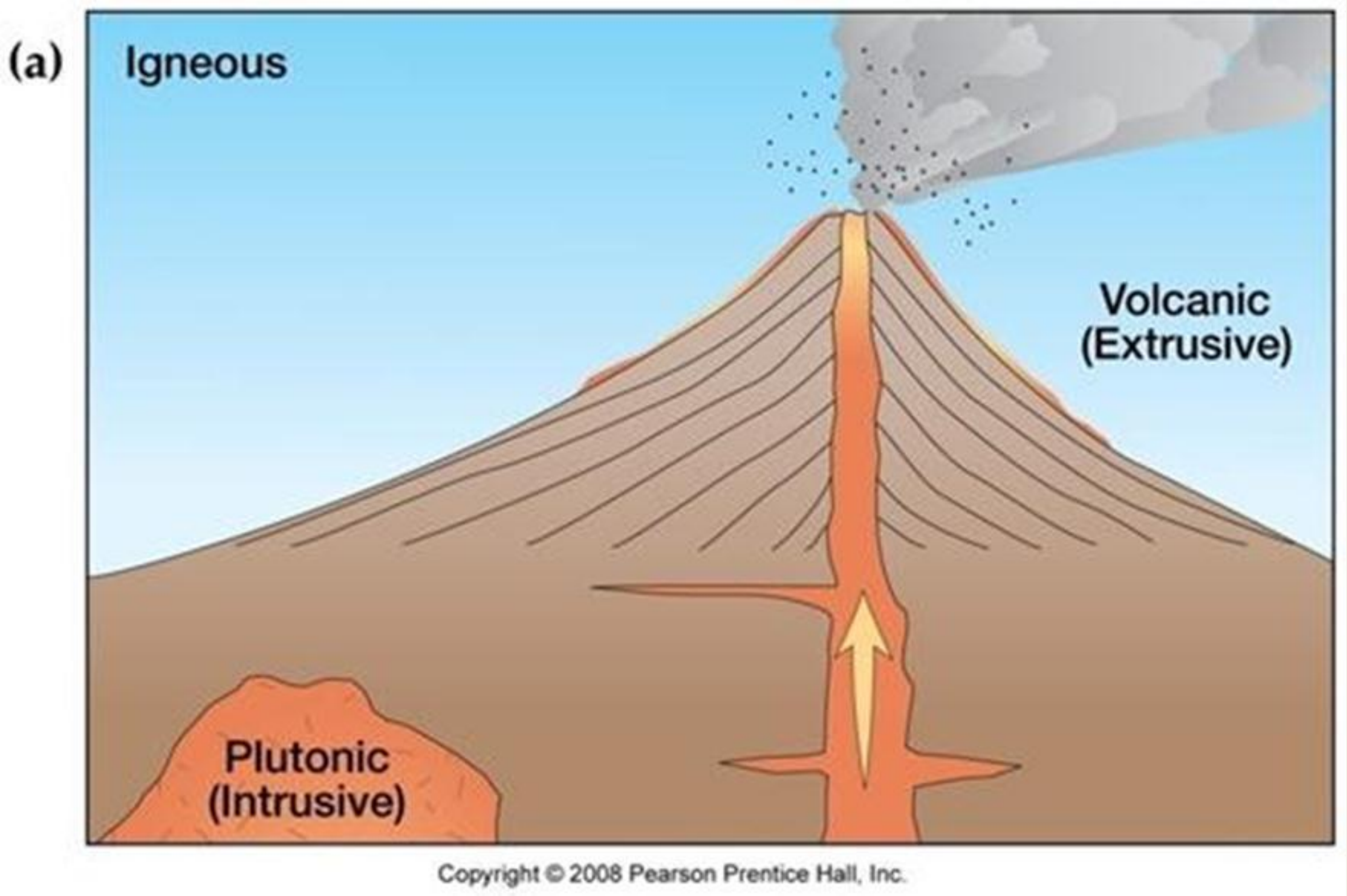
- Composed of mineral matter (usually more than one kind of mineral)
  - Fewer than 20 minerals make up 95% of Earth's crust
  - Outcrop
  - Bedrock exposure



Three Types of Rock

- Igneous
- Sedimentary
- Metamorphic

Igneous Rock

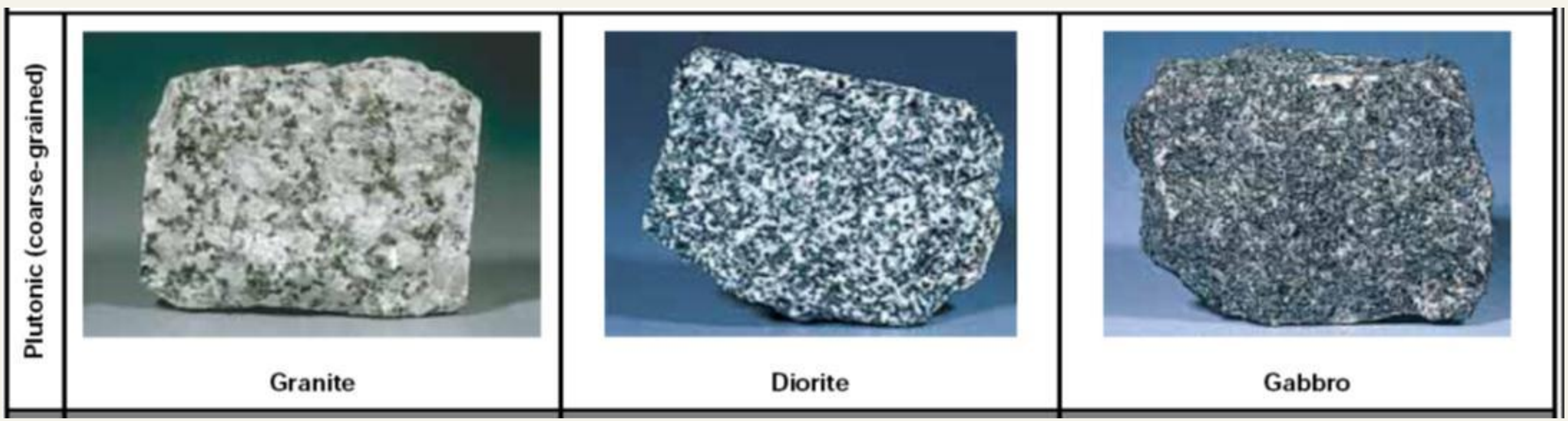


Igneous Rocks

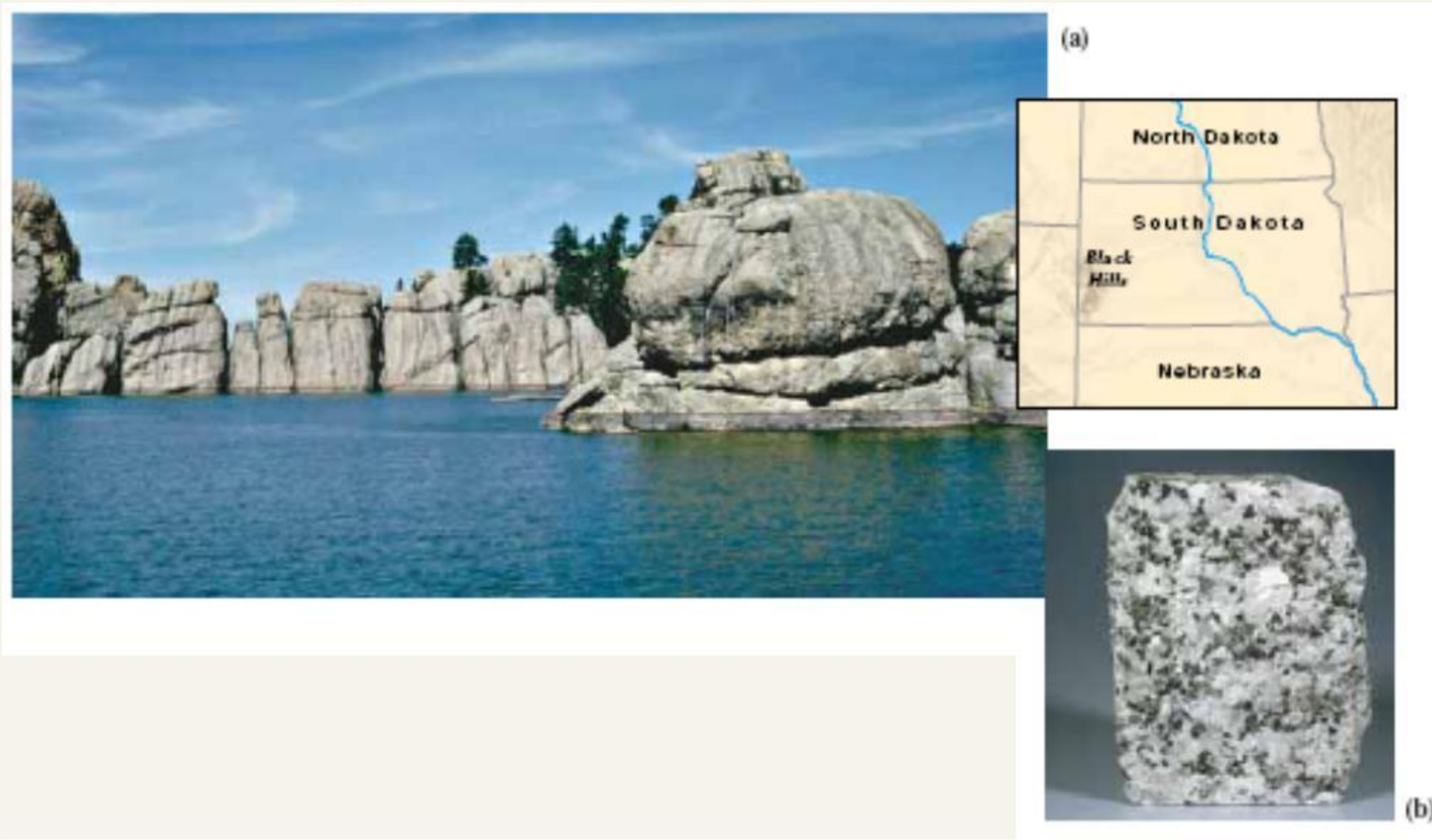
- Igneous Rocks
  - These are rocks formed from the cooling and solidification of molten rock ("fiery inception").
  - **Magma** is molten rock *below* the ground.
  - **Lava** is molten rock reaching the surface
  - Pyroclastics (or pyroclasts) are tiny pieces of volcanic rock that have been explosively ejected by a volcanic eruption. Sometimes, these also weld together to form rocks.
  - There are 2 types of igneous rocks: intrusive & extrusive.

Plutonic (intrusive) Rocks

- These are formed by magma cooling *slower, underneath* the earth
- Leading to large mineral structure (coarse-grained)
- Light-colored, generally
- Granite – most common type of rock formation



Granite



Volcanic (Extrusive) Rocks

- These form by lava cooling *faster, above* the earth
- This leads to small mineral structure (fine-grained)
- Dark-colored, generally
- Basalt most common type of rock formation (extensive seafloor bedrock)

Basalt

(a)

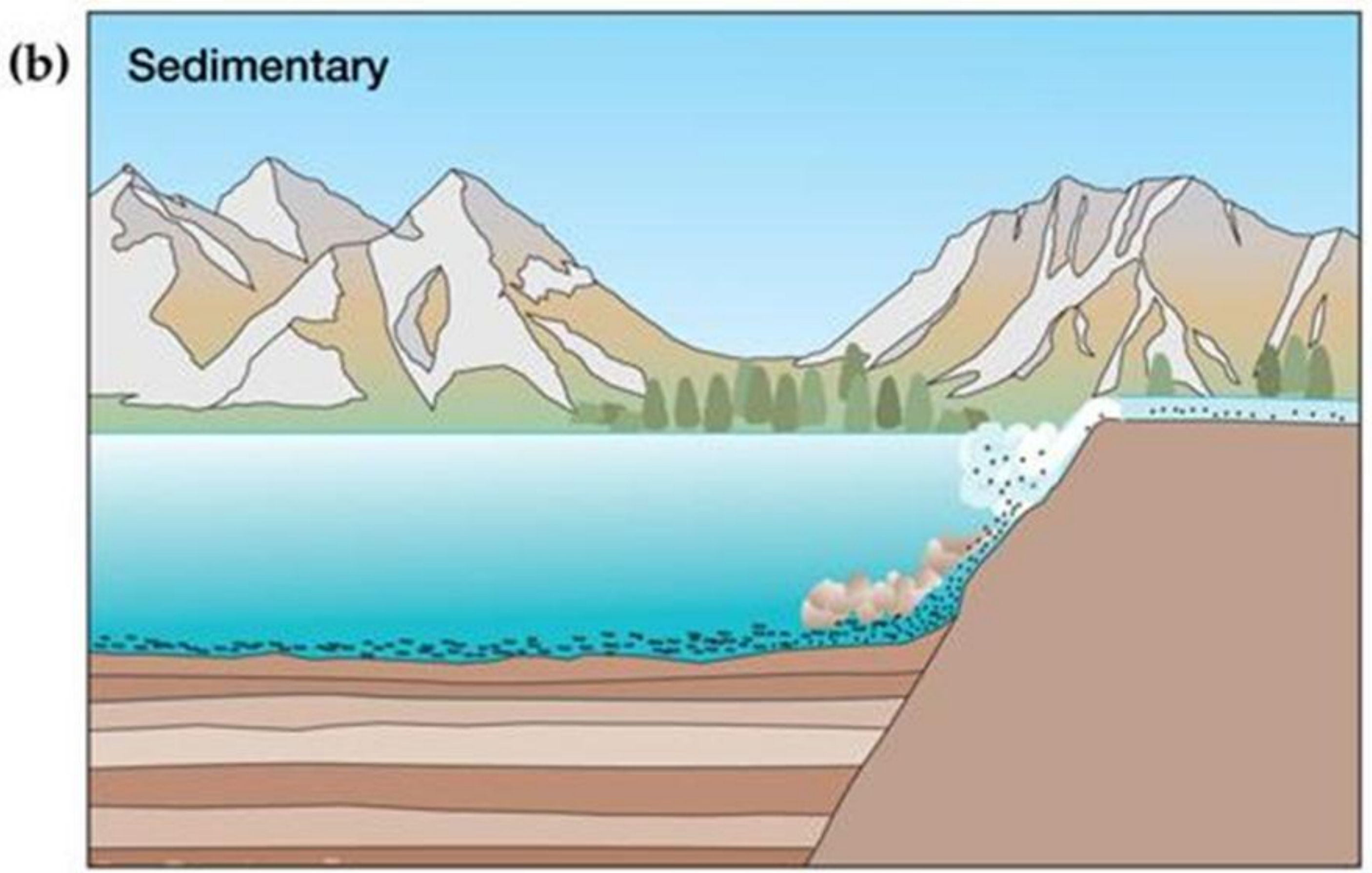
(b)

- Snake River Canyon, Idaho.

Basalt

E.g. of Basalt, pg 395 – seems to have been put down in layers by the volcano.

Sedimentary Rock



Sedimentary Rocks

- These are rocks that form from rock fragments that disintegrated and then got moved and deposited as **sediments** by either water (rivers), ice (glaciers), wind, gravity or a combination.
  - Rock fragments
  - Organic matter
  - Transportation
  - Deposition
  - Stratification

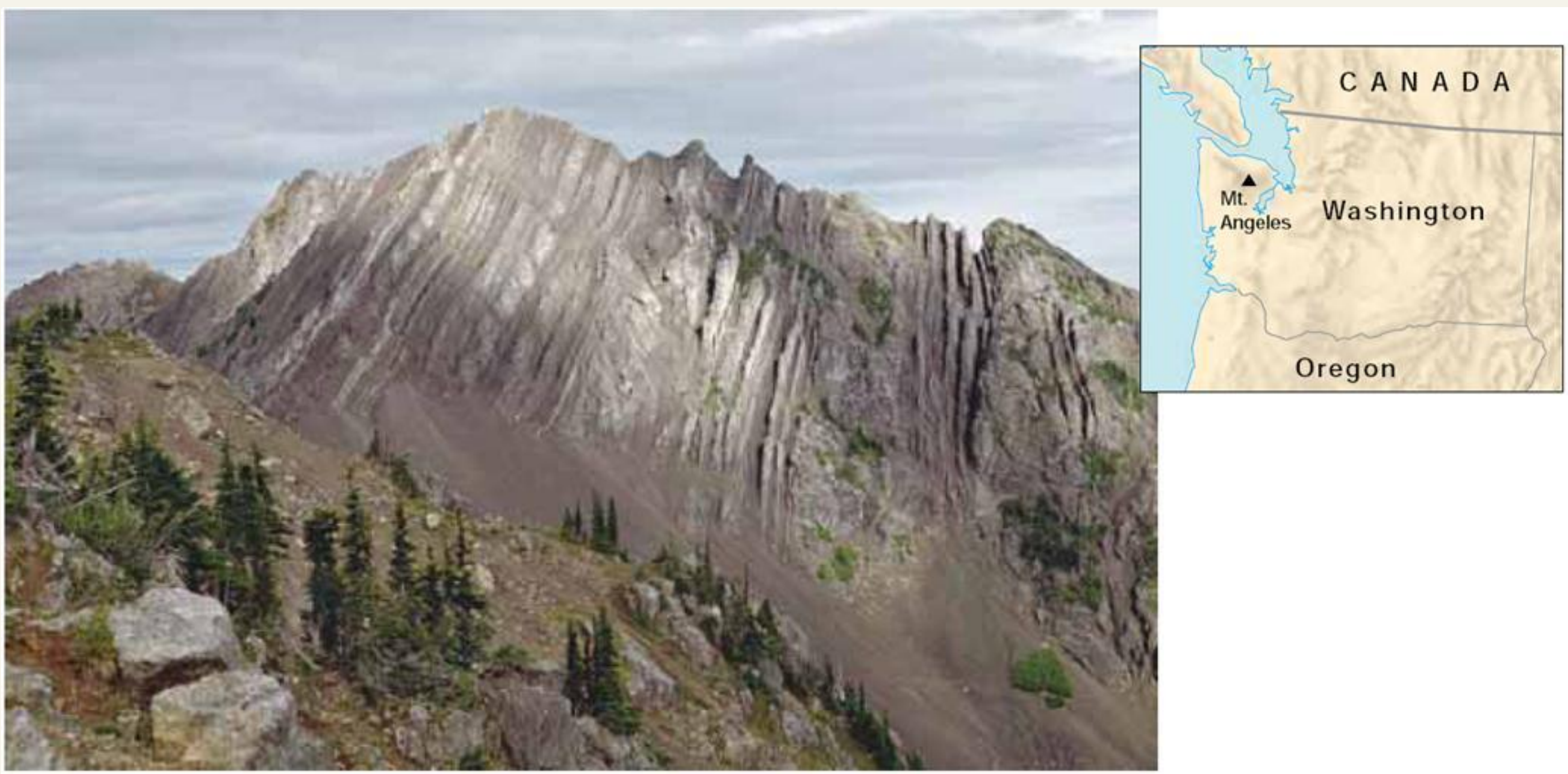
  (the above are the main themes when discussing sedimentary rocks)

Stratification

- Stratification (horizontal layering) is the distinguishing characteristic, except where the sediments are deposited by wind.
- Nearly horizontal strata of limestone and shale

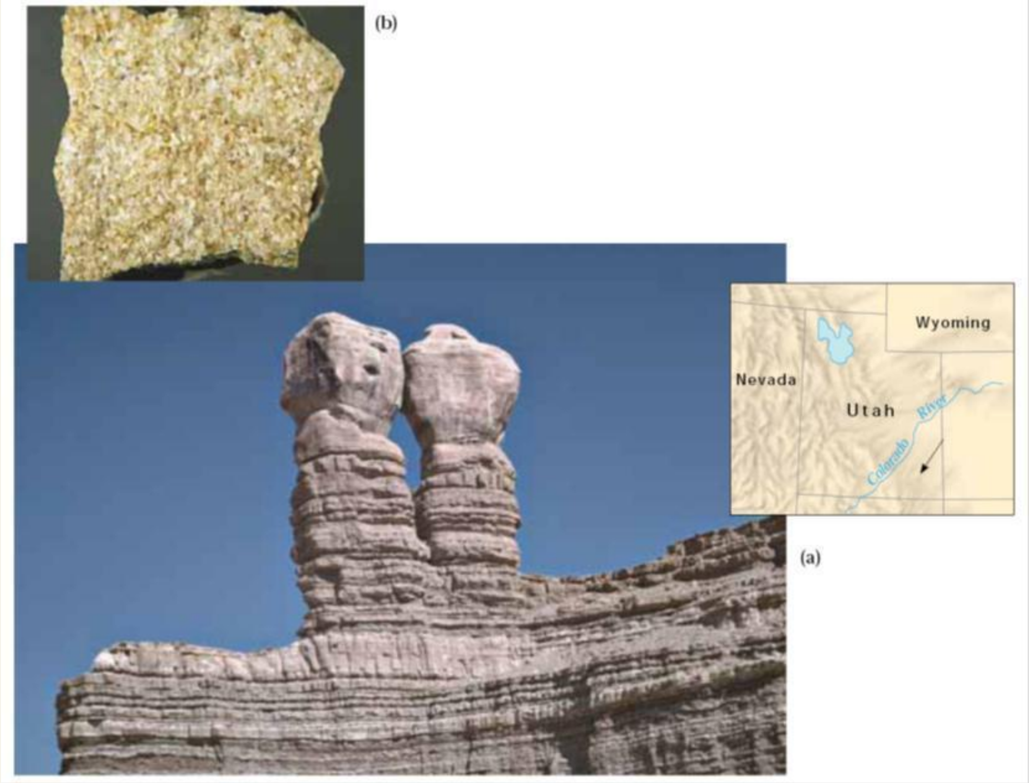
Stratification

- Almost vertically tilted sedimentary strata (limestone and shale, mostly). This tilting occurs through internal forces.



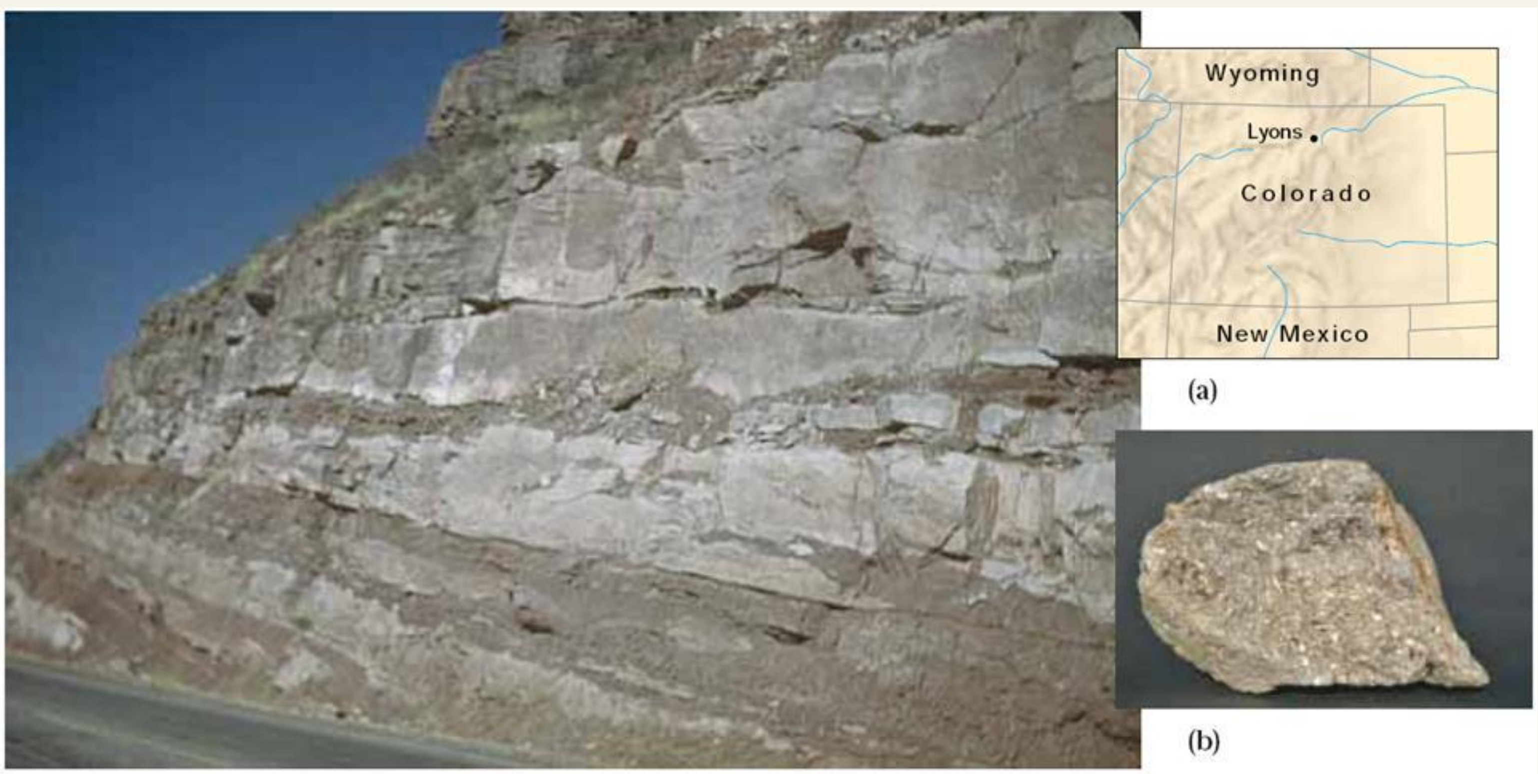
Clastic or Detrital Sedimentary Rocks

- These are formed from the remnants/ fragments of pre-existing rocks.
- The most common are shale (comprised of very fine silt and clay) and sandstone (comprised of sand-sized grained).

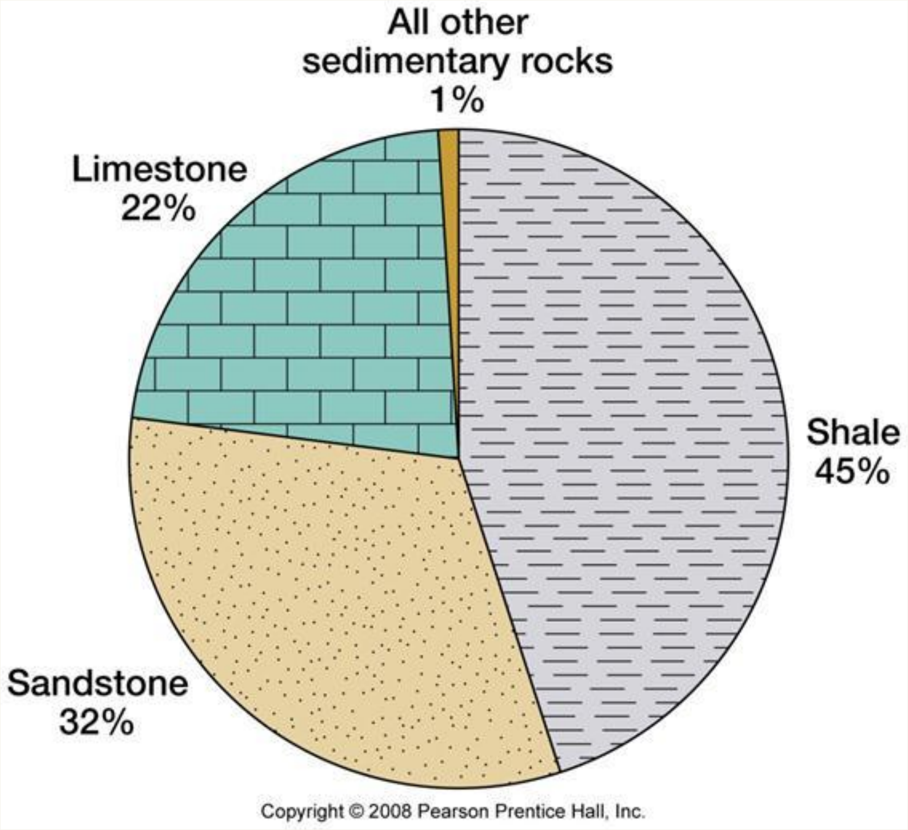


Chemical & Organic Sedimentary Rocks

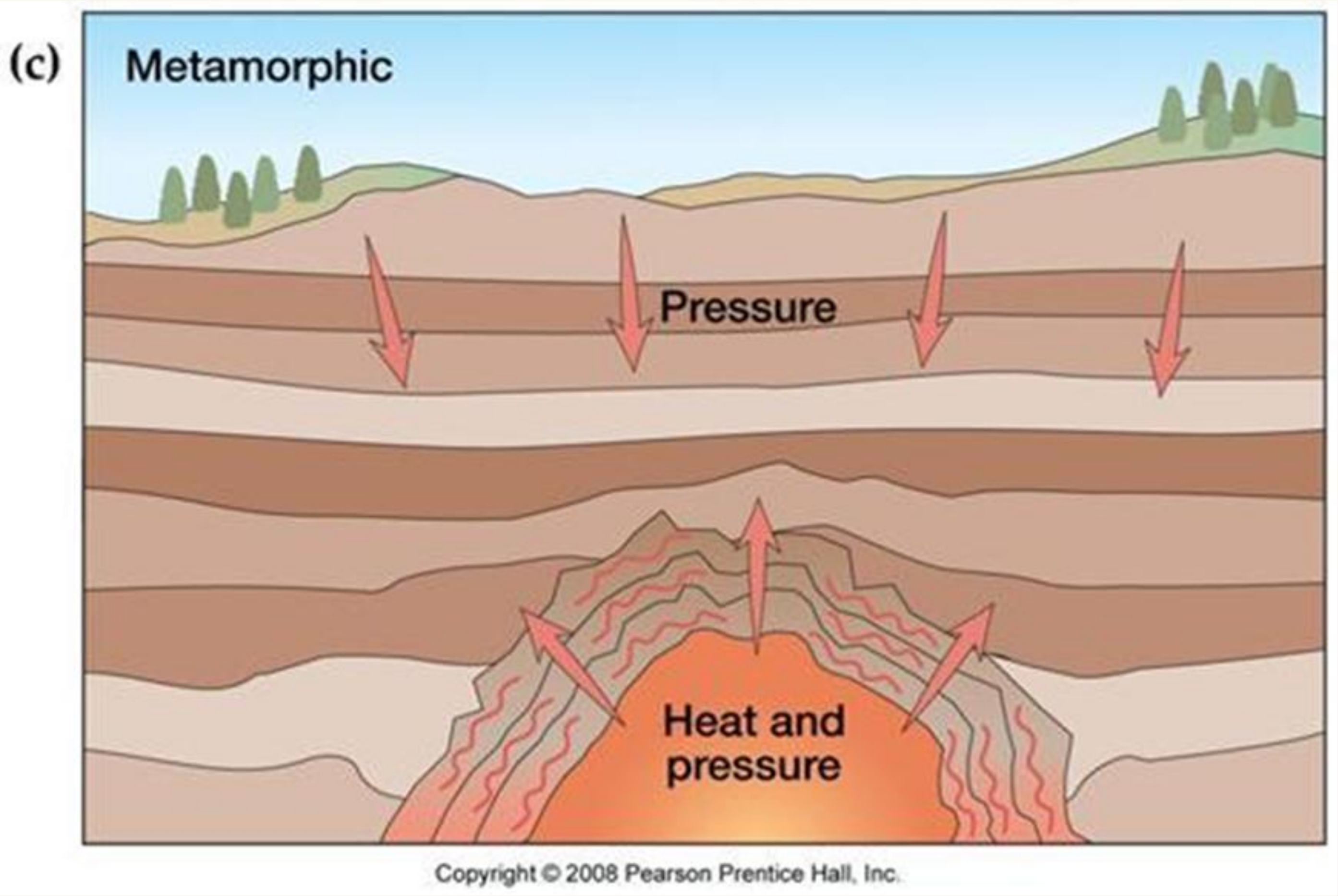
- Chemical Precipitation (Limestone most common result)
- Compaction of organic sediments (also, limestone and coal formations)



The most common types of sedimentary rocks



Metamorphic Rocks

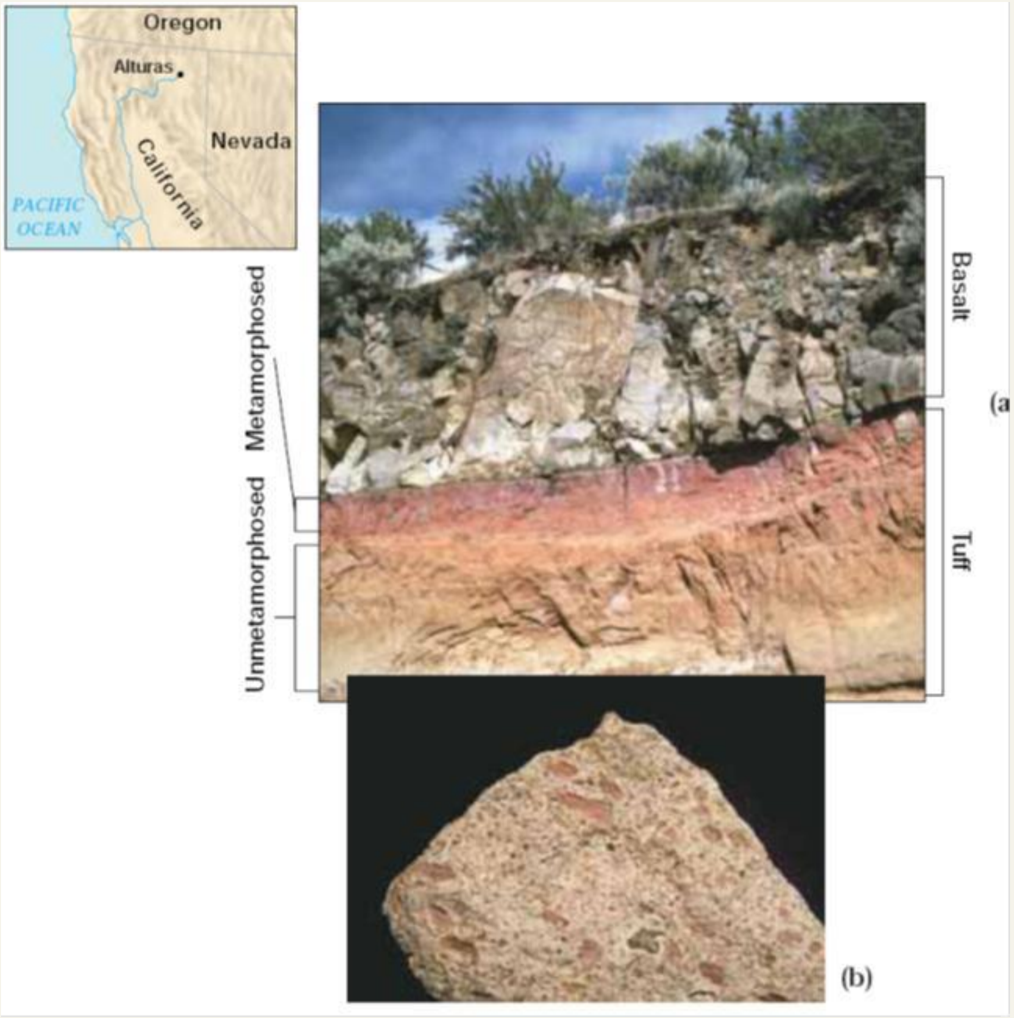


Metamorphic Rocks

- Heat and pressure
  - Foliation
- Types
  - Contact metamorphism
  - Regional metamorphism

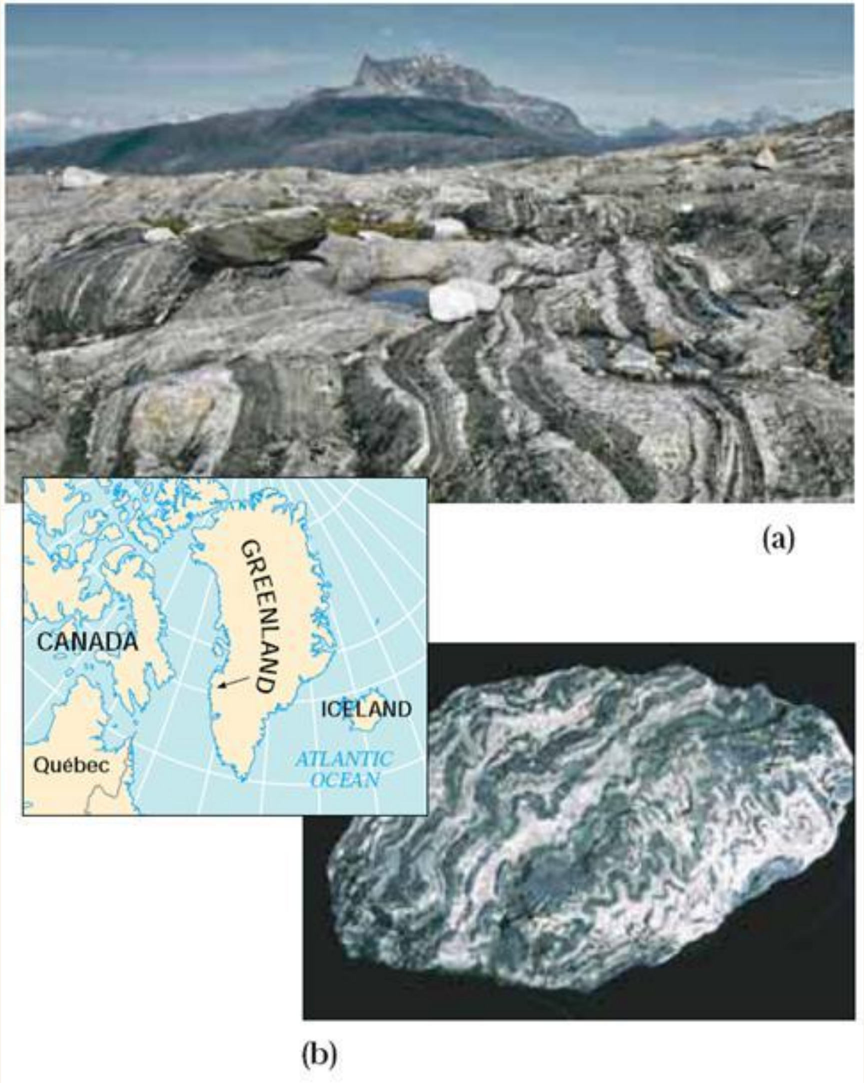
Contact Metamorphism

- Formed when magma comes in contact with surrounding rocks



Regional Metamorphism and Foliation

- When large volumes of rock deep with the crust are subjected to heat/pressure for long periods of time

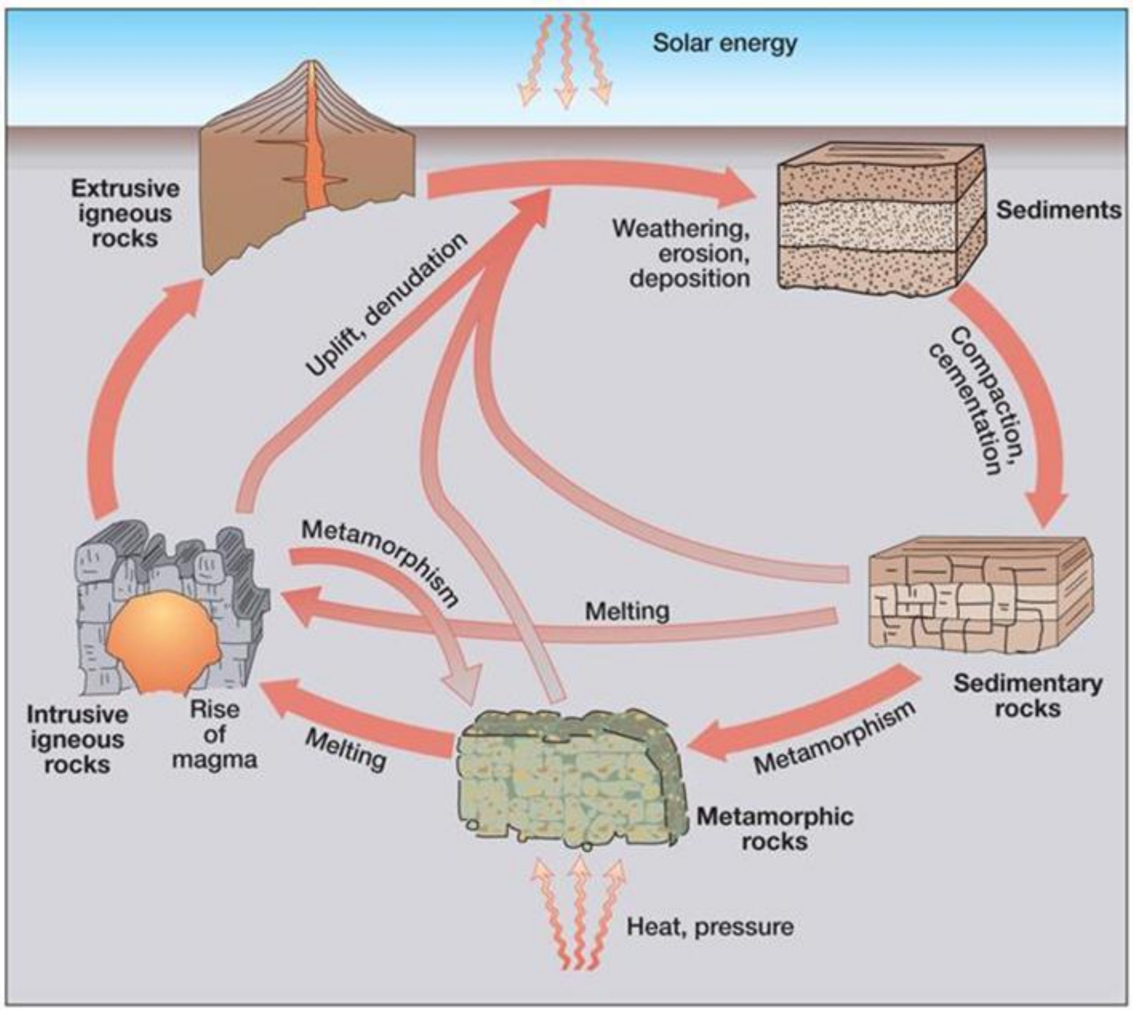


Metamorphism

- The kinds of original rock that became metamorphic rocks:
  - Marble ⇐ limestone
  - Quartzite ⇐ sandstone
  - Slate ⇐ Shale
- Some metamorphic rocks are so changed that it's hard to tell which original rocks they came from. E.g.
  - Gneiss
  - Schist

- Slate

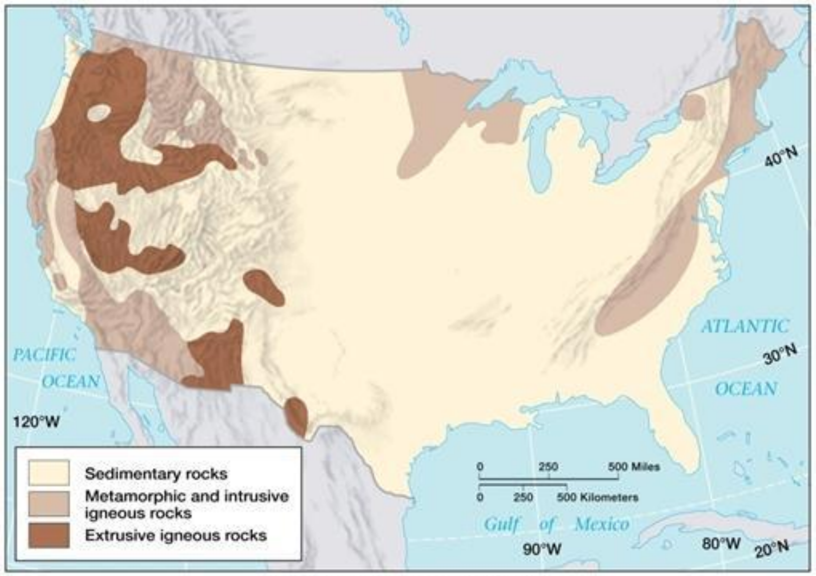
Rock Cycle



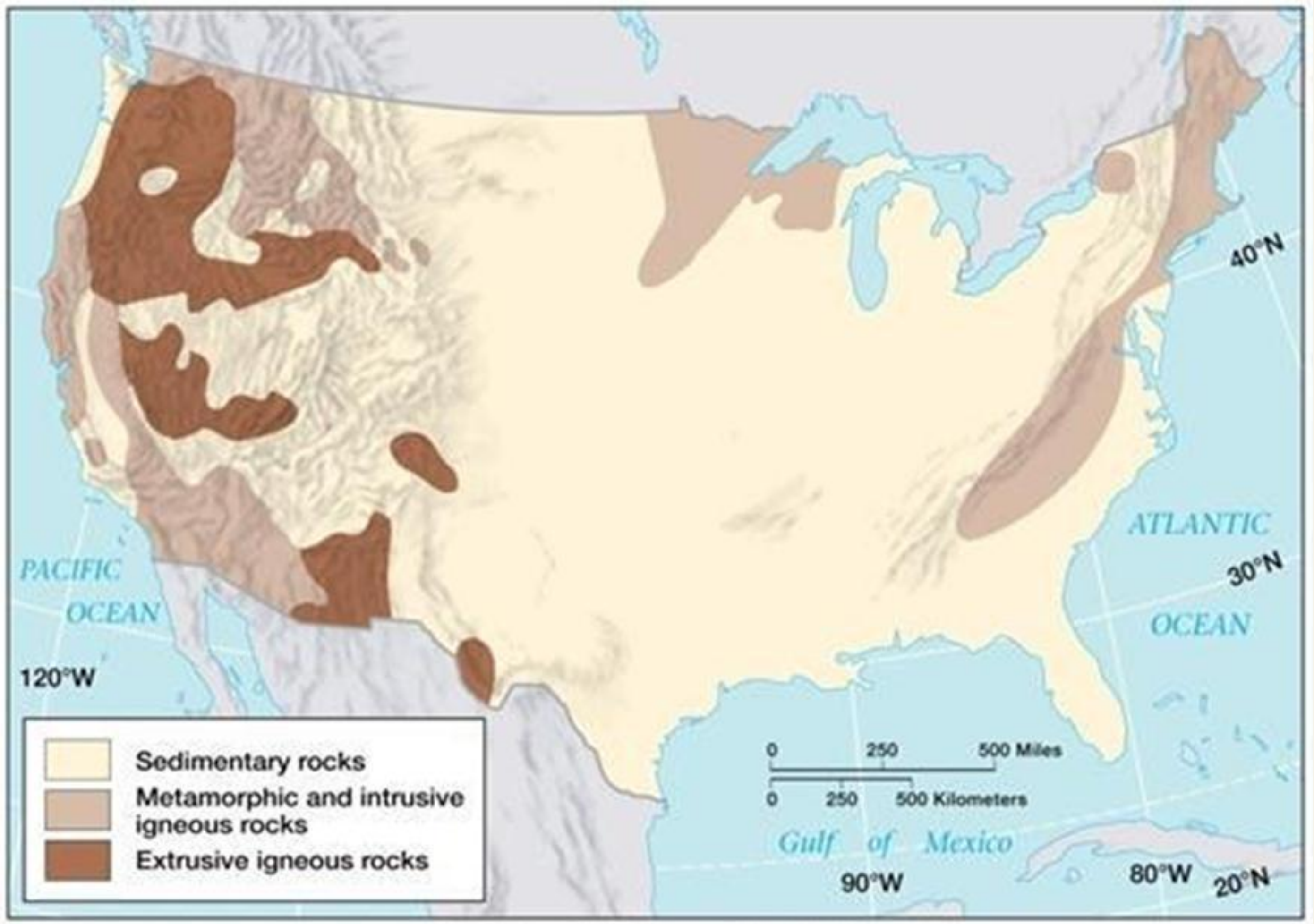
Solar energy
Extrusive igneous rocks
Weathering, erosion, deposition
Sediments
Uplift, denudation
Compaction, cementation
Metamorphism
Melting
Sedimentary rocks
Intrusive igneous rocks
Rise of magma
Melting
Metamorphism
Metamorphic rocks
Heat, pressure

Continental and Ocean Floor Rocks

- Continental Rocks
  - The continental crust is mainly igneous rock, esp. granite (in the bedrock), and an unknown amount of metamorphic rock. But sedimentary rock is the most common surface rock.
  - Continental crust is also called *sial (silica and aluminum)*



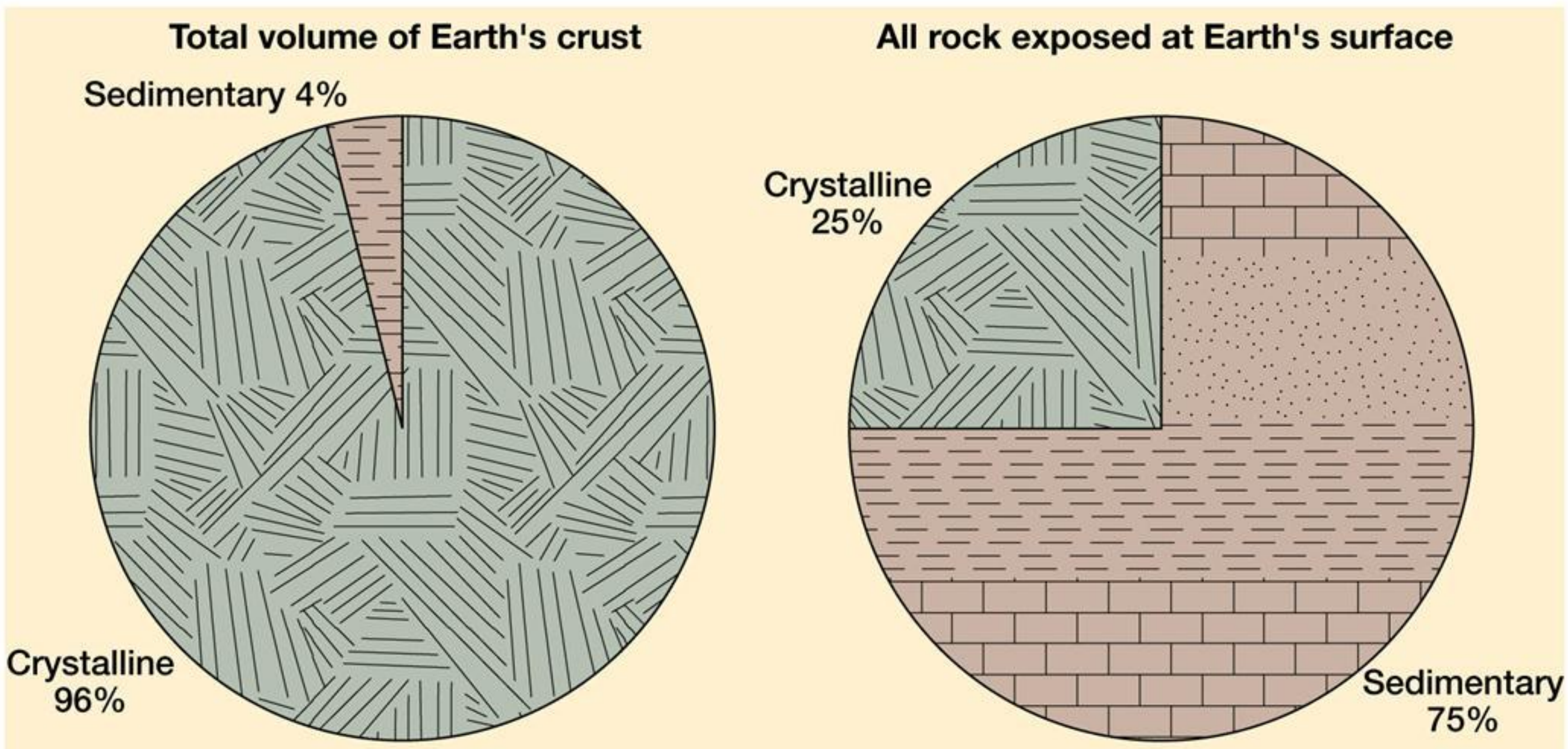
Continental and Ocean Floor Rocks



Continental and Ocean Floor Rocks

- Continental Rocks (continued)
  - It is less dense than the oceanic crust, which is mainly basalt.
  - So continental crust “floats” on the denser asthenosphere.
- Ocean Floor Rocks
  - Basalt covered with thin layer of oceanic sediments
  - The oceanic crust is dense enough that it can get pushed under the asthenosphere (i.e. subducted). Also, see Lab Ex. 28.
  - Oceanic crust is also called *sima (silica and magnesium*)

Rocks in Crust vis-à-vis Surface Rocks



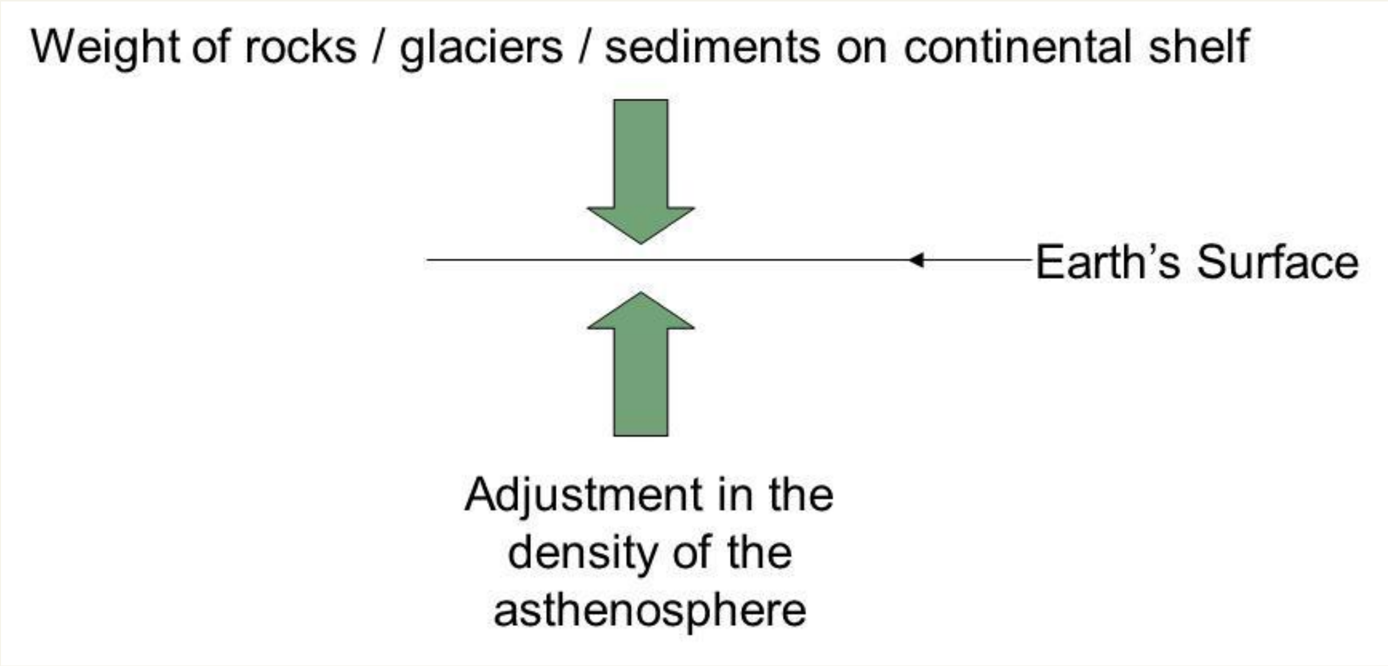
(a) Abundance of rocks in crust

(b) Abundance of rocks exposed at surface

Isostasy

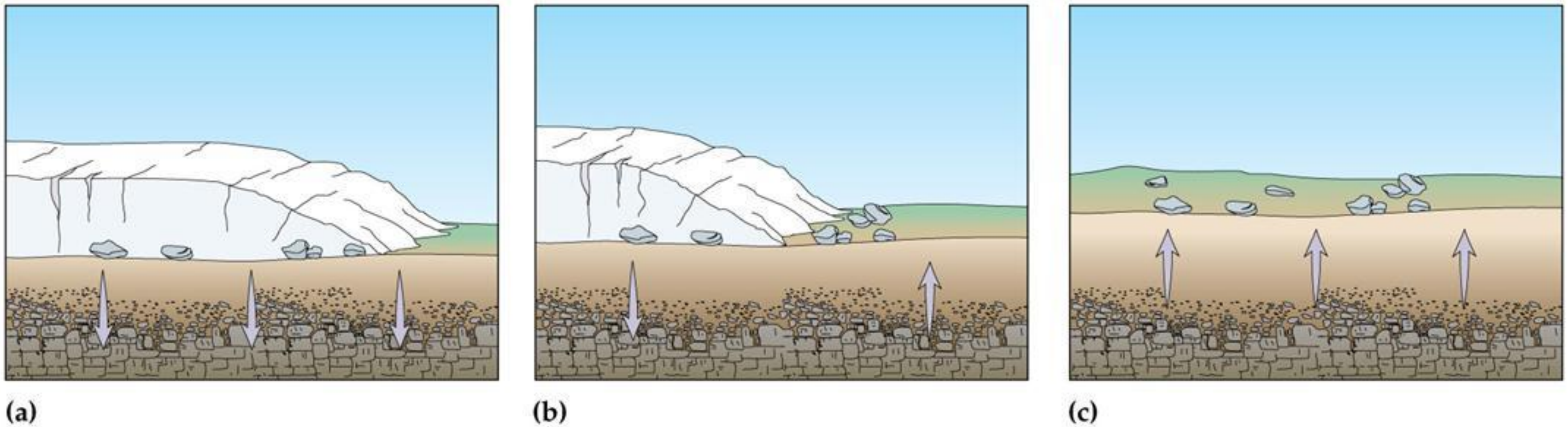
- The principle of Isostasy states that the crust gets depressed by giant weights (e.g. glaciers, water behind a dam, large amts of sediment on a continental shelf, etc) then it “bounces back” after the weight is removed.
- Geologists state that the time in which this occurs (i.e. how long it takes) is unknown.

Isostasy



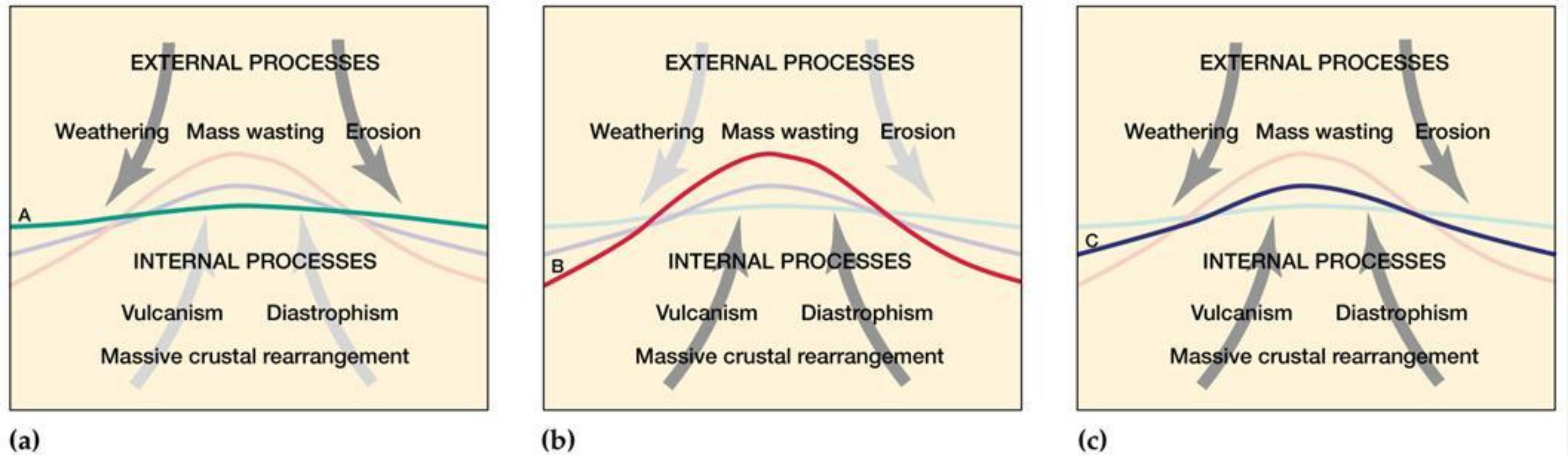
Weight of rocks / glaciers / sediments on continental shelf
Earth's Surface
Adjustment in the density of the asthenosphere

Isostatic adjustment to weight loss



Some Critical Concepts

- Internal and External Geomorphic Processes
- Schematic relationship between external and internal geomorphic processes.



Internal and External Geomorphic Processes

- **Relief** is the difference between the highest and the lowest points of a place.
  - E.g. saying that the distance btw Mt. Everest and the Mariana Trench is 20 miles.
- Both internal and external processes affect relief. Internal processes originate within the earth e.g. geothermal heat.
  - And it includes folding, faulting & volcanic activity.
  - They lead to <u>constructive</u>, uplifting, building processes that <u>increase the relief</u> of a place.

Internal and External Geomorphic Processes

- External processes on the other hand, are those that are caused by the influence of the atmosphere and oceans.
  - It constitutes a <u>destructive</u> process or a “wearing down” of the earth’s surface and it <u>reduces the relief</u> of a place.

Summary of Geomorphic Processes

TABLE 13-3 A Summary of Geomorphic Processes

Internal

- Crustal rearrangement (plate tectonics)
- Vulcanism
  - Extrusive
  - Intrusive
- Diastrophism
  - Folding
  - Faulting

Summary of Geomorphic Processes

External

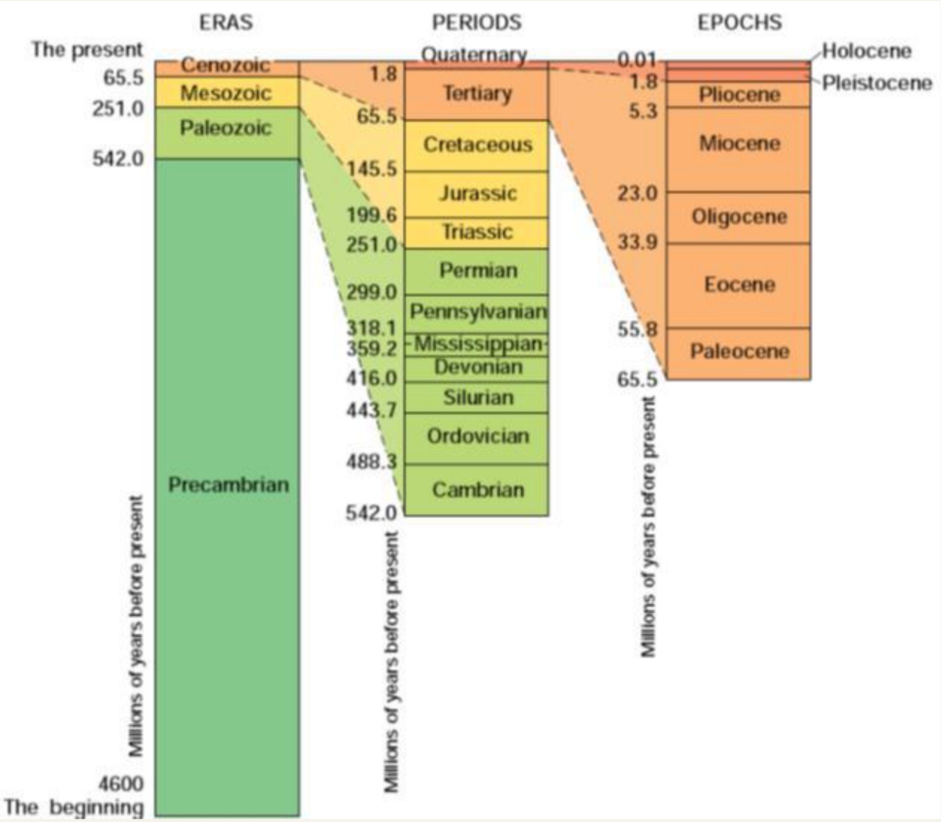
- Weathering
- Mass Wasting
- Erosion/deposition
  - Fluvial (running water)
  - Aeolian (wind)
  - Glacial (moving ice)
  - Solution (ground water)
  - Waves and currents (oceans/lakes)

The Doctrine of Uniformitarianism

- "The present is the key to the past." It holds that processes that formed the topography of the past are the same as those functioning today.

Geologic Time

- Vast periods of time over which geologic processes operate. The reason why Geologists use inordinate amounts of time is that the doctrine of uniformitarianism will be **useless** otherwise.



Geologic Time

- Since they state the processes are *so slow* that shape the earth. E.g. the Grand Canyon, Mt Everest, the Rift Valley System of East Africa, Canada’s Hudson Bay, etc. Based on geologic time, the **Earth is 4.6 billion yrs old**