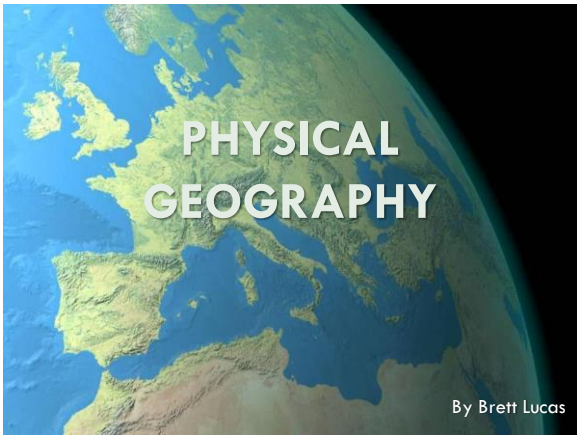


INTRODUCTION TO LANDFORM STUDY

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

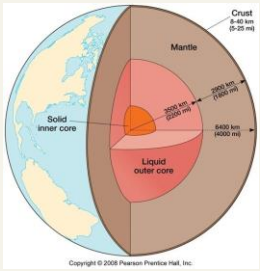
Fundamental questions of geographic inquiry:

- **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:

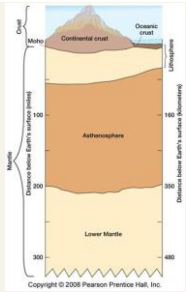
- Crust
- Mantle
- Core
  - Outer core
  - Inner core
- We only care about the interior of the earth because it helps us to understand the processes that shape its surface.



The Structure of Earth

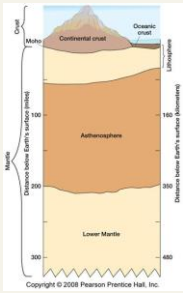
- The Crust
  - Part of lithosphere
  - Depth; thicker under continents (at least 15 miles), than under oceans (3 miles). The crust makes up less than 1% of the Earth's volume.

  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.



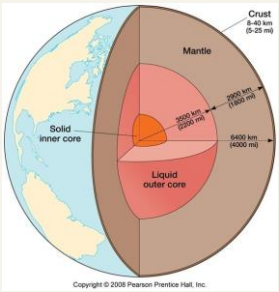
The Structure of Earth

- 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 <u>rocks</u>, 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

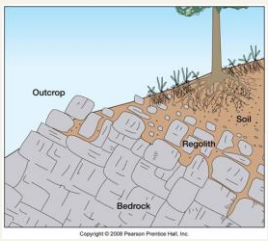
- Sulfate Minerals
  - Sulfur and oxygen in combination with some *other* element
    - Calcium is principal combining element
    - Gypsum is an example of a sulfate mineral
  - Light colored
  - Mostly in sedimentary rocks

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

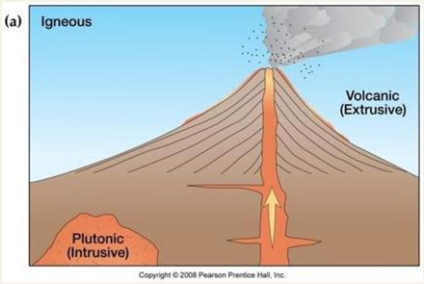
- Composed of mineral matter (usually more than one kind of mineral)
  - Fewer than 20 minerals make up 95% of Earth's crust
  - Outcrop
  - Bedrock exposure



Three Types of Rock

- Igneous
- Sedimentary
- Metamorphic

Igneous Rock

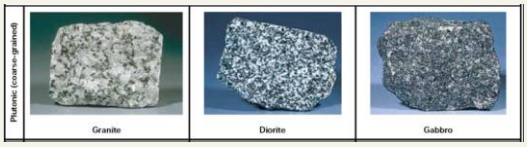


Igneous Rocks

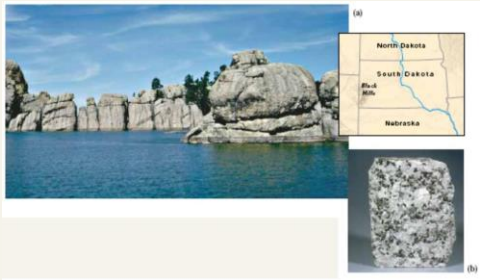
- Igneous Rocks
  - These are rocks formed from the cooling and solidification of molten rock ("fiery inception").
  - **Magma** is molten rock *below* the ground.
  - **Lava** is molten rock reaching the surface
  - Pyroclastics (or pyroclasts) are tiny pieces of volcanic rock that have been explosively 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



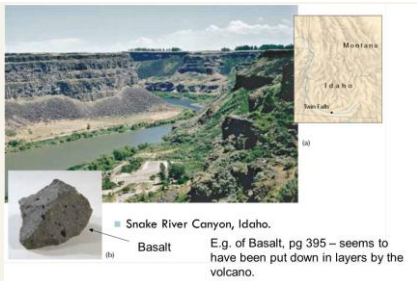
Granite



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)

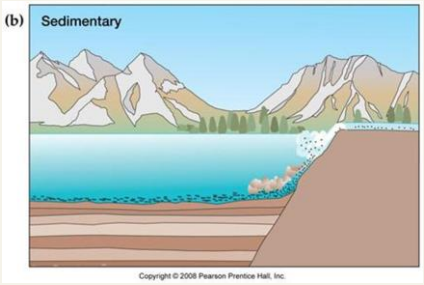
Basalt



- Snake River Canyon, Idaho.

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

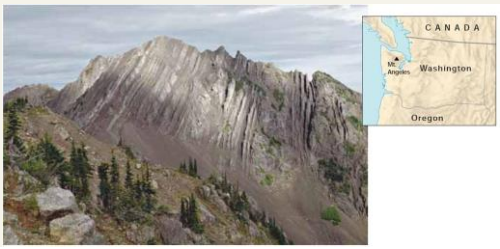
  (the above are the main themes when discussing sedimentary rocks)

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.



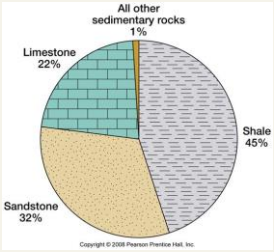
Clastic or Detrital Sedimentary Rocks

- 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).

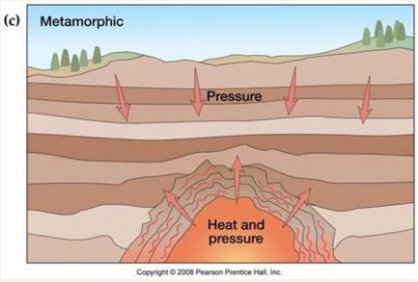
Chemical & Organic Sedimentary Rocks

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

The most common types of sedimentary rocks



Metamorphic Rocks

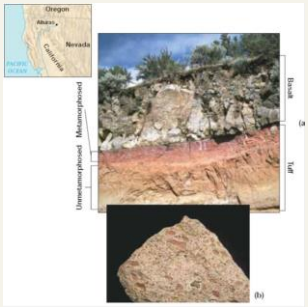


Metamorphic Rocks

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

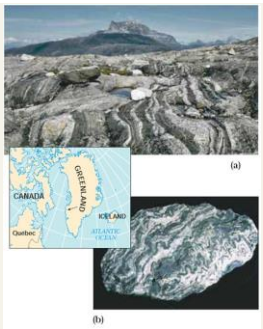
Contact Metamorphism

- Formed when magma comes in contact with surrounding rocks



Regional Metamorphism and Foliation

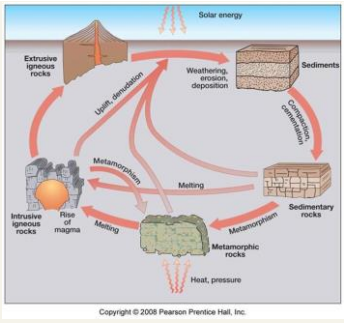
- When large volumes of rock deep with the crust are subjected to heat/pressure for long periods of time



Metamorphism

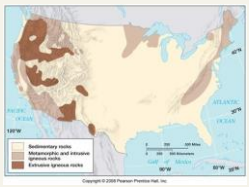
- The kinds of original rock that became metamorphic rocks:
  - Marble ⇐ limestone
  - Quartzite ⇐ sandstone
  - Slate ⇐ Shale
- Some metamorphic rocks are so changed that it's hard to tell which original rocks they came from. E.g.
  - Gneiss
  - Schist
- Slate

Rock Cycle

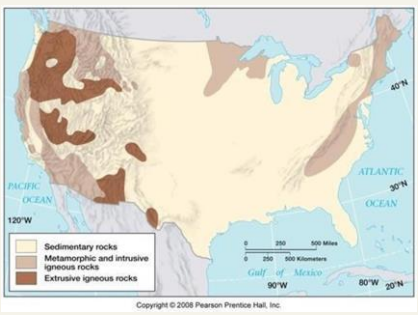


Continental and Ocean Floor Rocks

- 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)*



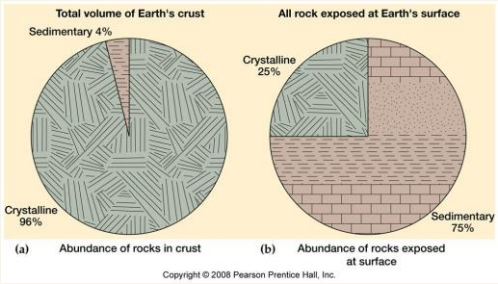
Continental and Ocean Floor Rocks



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)*

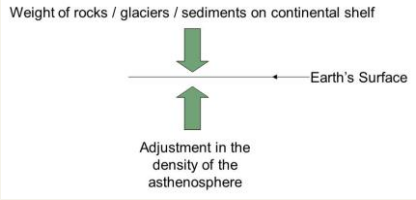
Rocks in Crust vis-à-vis Surface Rocks



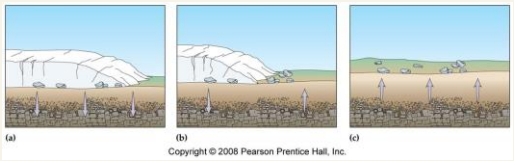
Isostasy

- 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

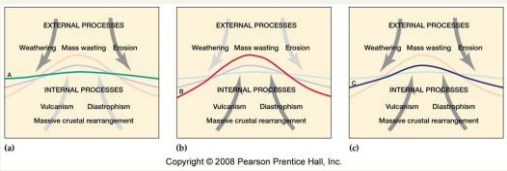


Isostatic adjustment to weight loss



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 constructive, uplifting, building processes that increase the relief 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 destructive process or a "wearing down" of the earth's surface and it reduces the relief 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

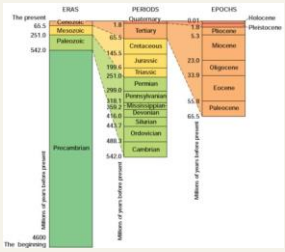
External
- Weathering
- Mass Wasting
- Erosion/deposition
  - Fluvial (running water)
  - Aeolian (wind)
  - Glacial (moving ice)
  - Solution (ground water)
  - Waves and currents (oceans/lakes)

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**