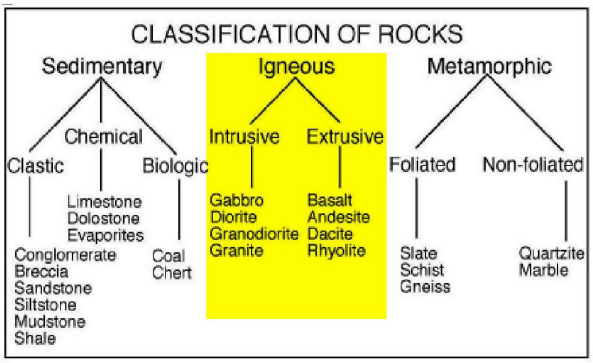
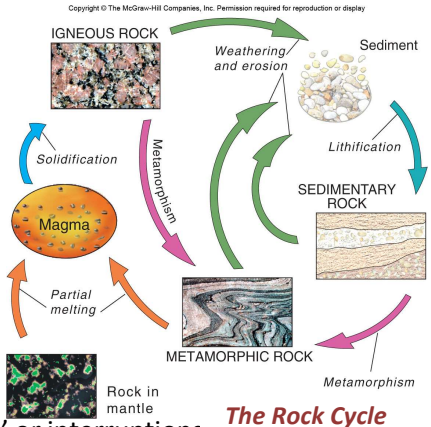
Chapter Outlines



NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>

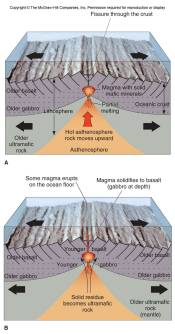
Igneous Rocks

The defining characteristic of **igneous rocks** is that at one time they were molten and part of magmas or lavas. A **magma** is a body of molten rock that occurs below the surface of the earth ***(intrusive).*** When magma rises along a deep fault and pours out on the earth's surface, it is termed **lava** ***(extrusive).*** This material then cooled to form a variety of intrusive and extrusive igneous rocks.



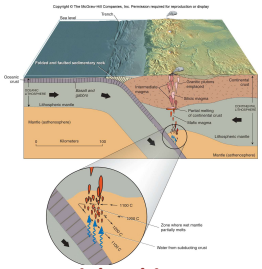
The Rock Cycle

- **The rock cycle**
  - Shows the interrelationships among the three rock types
  - Although usually very slowly, crustal rock endlessly continues to be reworked and changed to different types of rock. When a rock finds itself in a new environment due to erosional or tectonic processes *(therefore physically or chemically unstable),* changes will take place in that rock making it 'stable' in its new environment.
  - The full cycle does not always follow the same path owing to 'shortcuts' or interruptions
- Where are intrusive igneous rocks?
  - Grand Tetons, Sierra batholiths, Canadian Shield, bottom of Grand Canyon, etc. etc.
- Earth's crust is normally solid. But, in many locations not far beneath the surface rock is near its melting temperature. Rock in Earth's subsurface is made hot by:
  - Heat transferred from Earth's core to the surface by conduction *(geothermal gradient)* & convection.
  - Heat from Earth's core carried upward by slowly rising plumes of hot mantle material (also convection).
  - Friction from mountain building processes, and decay of radioactive materials within Earth.



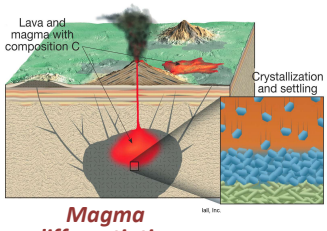
Partial melting at a divergent boundary

- Unusual condition must exist for this high temperature rock to melt. Some conditions that can lower the melting point of rock and begin melting are:
  - **Decompression melting** – lowering pressure also lowers the melting point. This occurs when very hot rock rises towards Earth's surface into areas of less pressure due to shallower depth.
  - **Added water** – melting temperature lowers when H_2O is mixed with hot rock.
  - Mixing of mineral types.



Partial melting at a subduction zone (convergent boundary)

- Origin of magma… The mantle and crust are solid. Melting does occur in some locations but is commonly partial melting. It can occur…
  - At a divergent plate boundary from decompression melting.
  - At a convergent plate boundary from raised water content.
  - Over a mantle plume *(plume origin being near the core*) from the heat of the plume.
- Crystallization of magma. **Bowen's Reaction Series** explains the crystallization sequence of a magma and the resultant compositional change of a magma body over time.
  - As it cools, some magma begins to crystallize in stages – not all at once. These first crystals can be carried along in the magma or drop to the bottom of the magma body.
  - Mafic minerals crystallize first. As the crystallizing mafic minerals remove mafic materials, the lava composition from a magma likely changes from basalt to andesite to rhyolite.
  - In reverse, felsic magma is produced first when partial melting occurs.
  - Magma composition will also evolve due to assimilating surrounding felsic crustal rock as the magma ascends, or mixing with other bodies of magma.



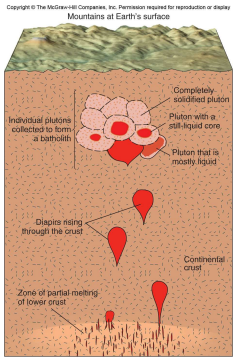
Magma differentiation through crystal settling

- Igneous texture is primarily controlled by rate of cooling.
  - Slow cooling = large crystals, Rapid cooling = fine texture, Quench = glassy texture
- Igneous rock texture *(primarily intrusive)*
  - **Phaneritic** *(coarse grained)* = mineral grains are visible to unaided eye
  - **Aphanitic** *(fine grained)* = mineral grains can't be seen with unaided eye
  - **Glassy** = like glass
  - **Porphyritic** = large crystals in a fine grained groundmass
  - **Pegmatitic** = very large crystals

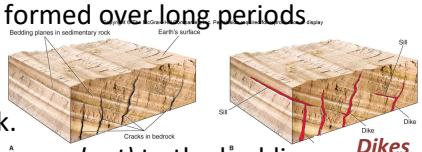
Porphyritic texture

D. Porphyritic

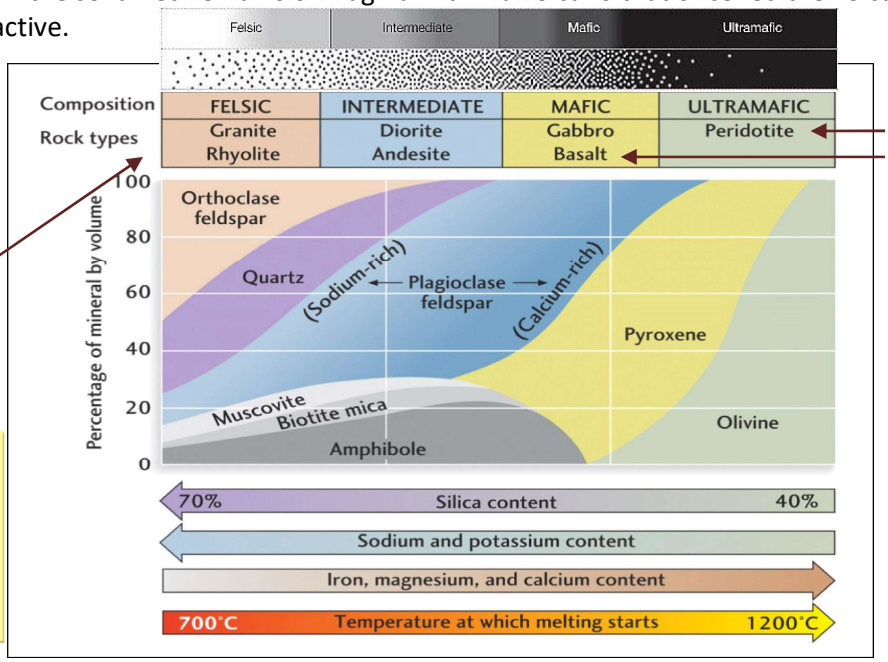
- Igneous rock classification. Continents are mostly felsic while ocean floors are mostly mafic.
  - **Ultramafic** are **less than 45% silica**, only intrusive, thought to compose the mantle. The rock is peridotite.
  - **Mafic** is **45% to 52% silica**, dark gray or dark green, olivine, pyroxene, calcium plagioclase, etc. Rock is basalt and gabbro.
  - **Intermediate** is **53% to 65% silica**, medium gray, amphibole, intermediate plagioclase, biotite, etc. Rock is andesite and diorite.
  - **Felsic** is **greater than 65% silica**, light colored, quartz, potassium feldspar, sodium plagioclase, biotite, etc. Rock is rhyolite and granite.
  - Generally, <u>mafic</u> rocks are <u>darker</u> color, while <u>felsic</u> rocks are <u>lighter</u> color.
- Intrusive rock bodies
  - **County rock** – is the surrounding rock that the magma invades.
  - **Plutons** – discordant intrusive rock that formed at great depth. If it occupies less than 100 sq km *(60 sq mi)* it is a **stock**; larger than this is termed a **batholith**. They are formed over long periods through accumulation of smaller rising magma blobs called **diapirs.**
  - **Dike** – an intrusive body of magma occupying a discordant *(cross-cutting)* crack or fissure that crosses the layering in country rock.
  - **Sill** – a body of magma formed by entering the country rock parallel *(concordant)* to the bedding
  - **Volcanic neck** – the solidified remains of magma within a volcano that once fed the volcano when it was active.



Intrusive igneous bodies



Dikes & sills



Intrusive (plutonic)
Extrusive (volcanic)

Common igneous rock types

- Plate tectonics
  - Igneous activity occurs primarily at or near tectonic plate boundaries.
    - **Mafic** *(rich in magnesium and iron)* igneous rocks commonly form at divergent boundaries.
    - **Intermediate** igneous rocks are commonly formed at convergent boundaries.
    - **Felsic** *(rich in feldspar and silica)* igneous rock commonly result from hot rising intermediate magmas mixing with felsic continental rock.
  - Rising mantle plumes can produce localized **hotspots** and volcanoes when they produce magmas that rise through oceanic or continental crust *(Hawaii & Yosemite are examples).*