Minerals Give Clues To Their Environment Of Formation

- Can be a unique set of conditions to form a particular mineral or rock
- Temperature and pressure determine conditions to form diamond or graphite (polymorphs)
  - Diamonds require pressures and temperatures equivalent to those in the mantle at least 150 km below Earth's surface.
  - Diamond is metastable

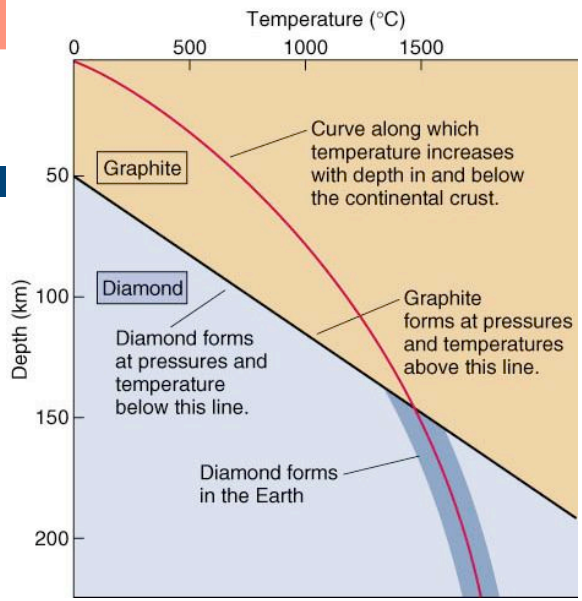


Figure 3.31

Also

- Clues to climate:
  - Some minerals form during weathering processes.
  - Past climates can be determined from the kinds of minerals preserved in sedimentary rocks.
- Clues to seawater composition:
  - The content of past seawater can be determined from minerals formed when the seawater evaporated and deposited its salts.

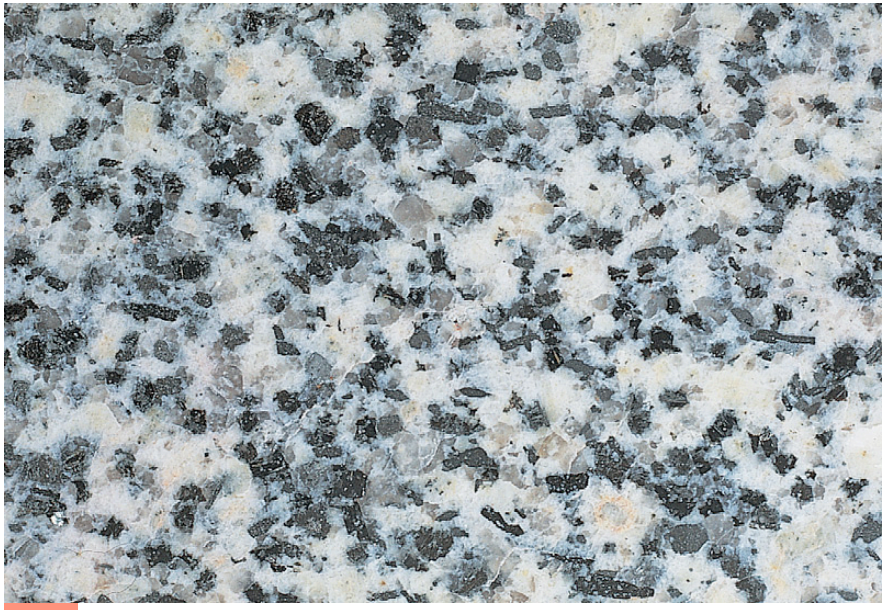
Rocks: Mixtures of Minerals

- Igneous rocks
  - Formed by solidification of magma.
- Sedimentary rocks
  - Formed by sedimentation of materials transported in solution or suspension.
- Metamorphic rocks
  - Formed by the alteration of preexisting sedimentary or igneous rocks in response to increased pressure and temperature.

Distinguishing The Three Rock Types

The differences among rock types are identified by two features.

- **Texture:**
  - —**The overall appearance of a rock due to the size, shape, and arrangement of its constituent mineral grain.**
- **Mineral assemblage:**
  - —**The type and abundance of the minerals making up a rock.**

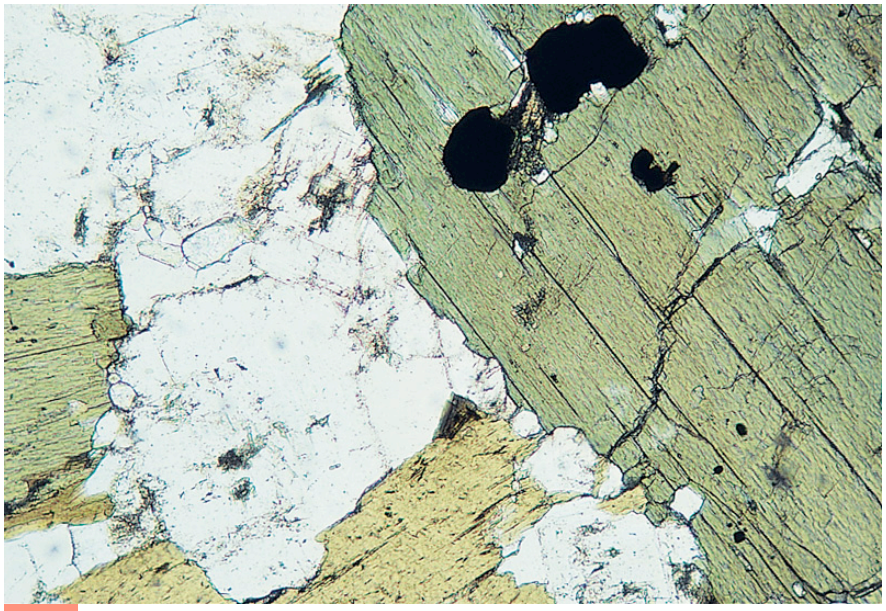


Fig

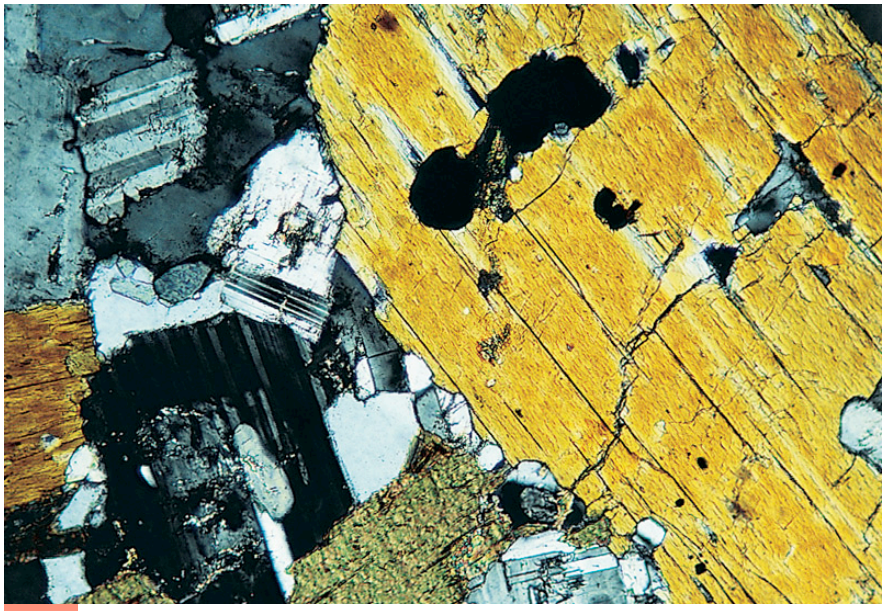
Texture and Mineral Assemblage

- **A systematic description of a rock includes both texture and mineral assemblage.**
  - **Megascopic textural features of rocks are those that we can see with the unaided eye.**
  - **Microscopic textural features of rocks are those that require high magnification to be viewed.**

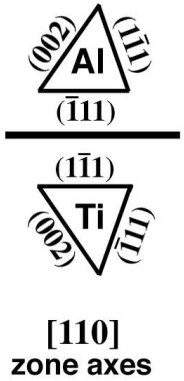
Fig



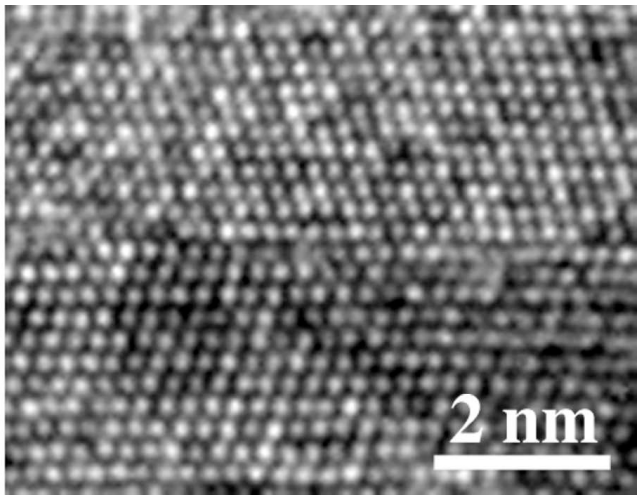
Fig



Fig



[110]
zone axes



Mineral Concentration

- Two common processes of concentration:
  - Fluids released by a cooling body of magma.
    - Veins of minerals - pegmatite
  - Hydrothermal circulation
    - Hot water reacts with and alters a rock
    - Extracts the scarce metals.
    - Solution cools and metals are deposited in veins.

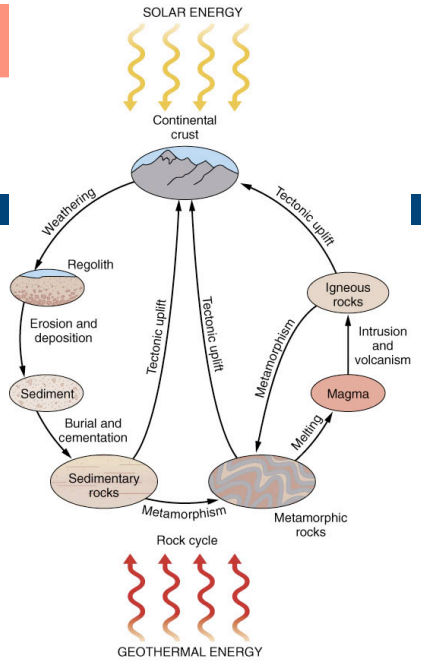


Figure 3.33

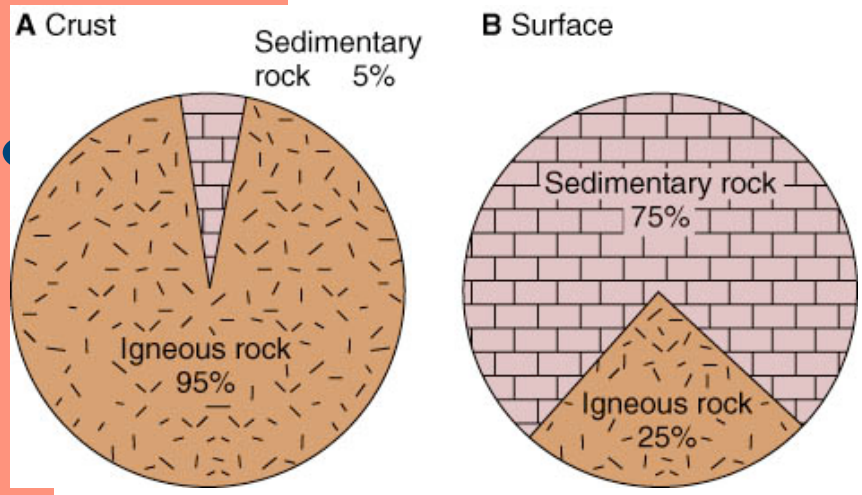


Figure 3.34

Igneous Rocks: Product of Earth's Internal Fire

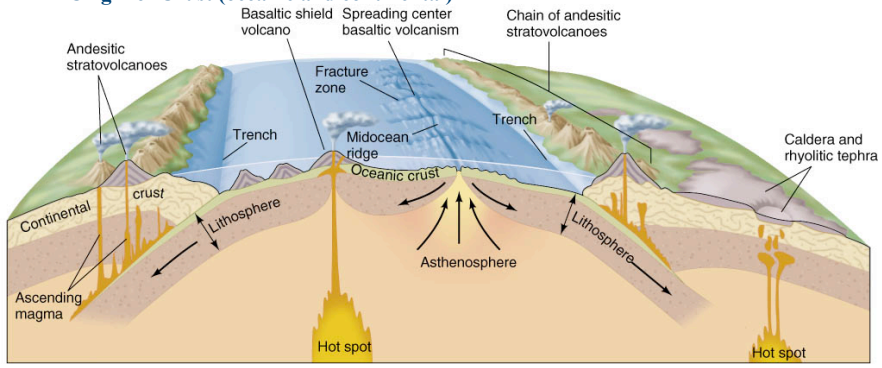
Summary

- Igneous rock forms by the solidification and crystallization of magma.
- Igneous rock may be intrusive (meaning it formed within the crust) or extrusive (meaning it formed on the surface). The grain sizes of igneous rocks indicate how and where the rocks formed.
- Igneous rocks rich in quartz and feldspar, such as granite, granodiorite, and rhyolite, are characteristically found in the continental crust. Basalt, which is rich in pyroxene and feldspar, is derived from magma formed in the mantle and is common in the oceanic crust.
- All bodies of intrusive igneous rock are called plutons. Special names are given to plutons based on shape and size.

- Volcanic activity is concentrated along plate margins. Andesitic volcanoes are found at subduction margins, and basaltic volcanoes are concentrated along spreading margins. Rhyolitic volcanoes occur at collision margins and in places where rising basaltic magma causes the continental crust to melt
- Magma forms by the partial melting of rock. (Complete melting, if it happens at all, is rare)
- Basaltic magma forms by dry partial melting of rock in the mantle. Andesitic magma forms during subduction by wet partial melting of mantle rock as a result of water being released from heated oceanic crust. Rhyolitic magma forms by wet partial melting of rock in the continental crust.

- Processes that separate remaining melt from already formed crystals in a cooling magma lead to the formation of a wide diversity of igneous rocks.
- Magmatic mineral deposits, which form as a result of magmatic differentiation, are the world's major sources of nickel, chromium, vanadium, platinum, beryllium, and a number of other important industrial metals.

Cooling and solidification of magma (intrusive or extrusive)
Characteristic of plate tectonic environments
Classification related to origins
Origin of Crust (oceanic and continental)



Igneous Rock Classification

Why?

Relate name to processes that created them

Texture – size of crystals and way packed?

Mineralogy – proportions of which minerals?

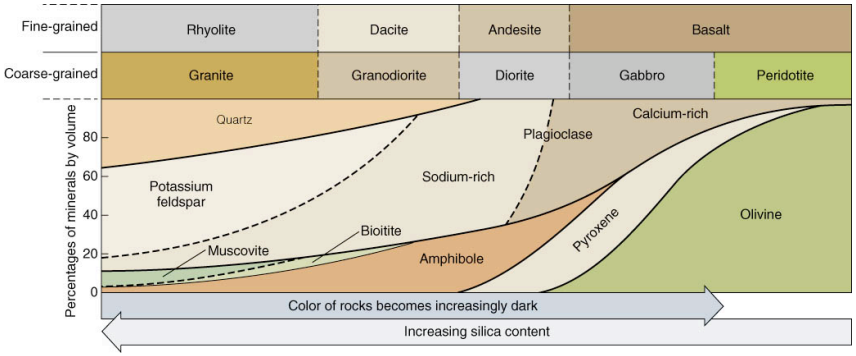


Figure 4.6

Texture In Igneous Rocks

- **Extrusive rocks are fine-grained.**
  - Magma that solidifies on the surface usually cools rapidly, allowing insufficient time for large crystals to grow.
  - **Obsidian**: with no crystals – a glass.
  - **Pumice** and volcanic **ash**
- **Phanerite** (from the Greek word meaning visible)- course grained. **Aphanite** –fine grained
- **Pegmatite -** contains unusually large mineral grains (2cm or larger)
- **Phenocrysts:** large isolated grains
- **Porphyry:** 50% or more of the rock is coarse mineral grains scattered through a mixture of fine mineral grains.

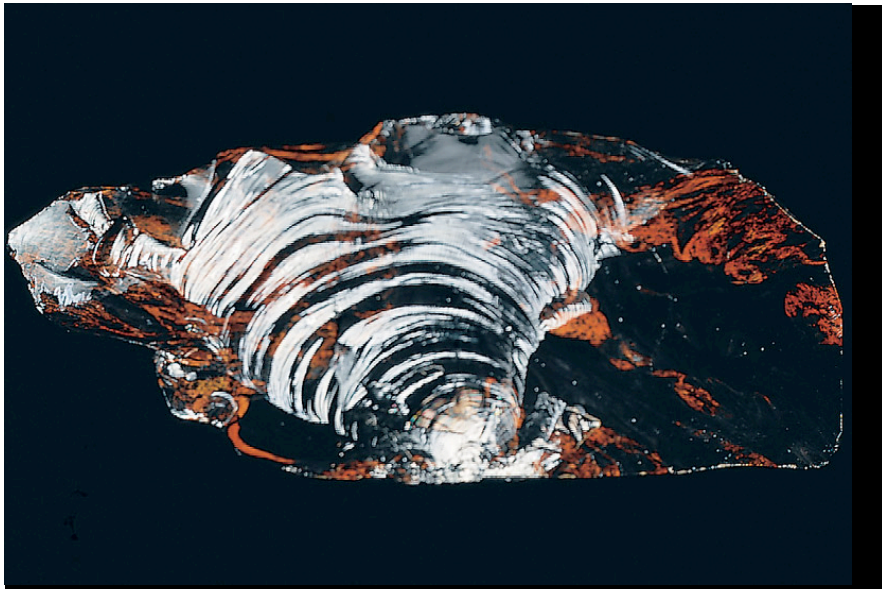


Figure 4.5

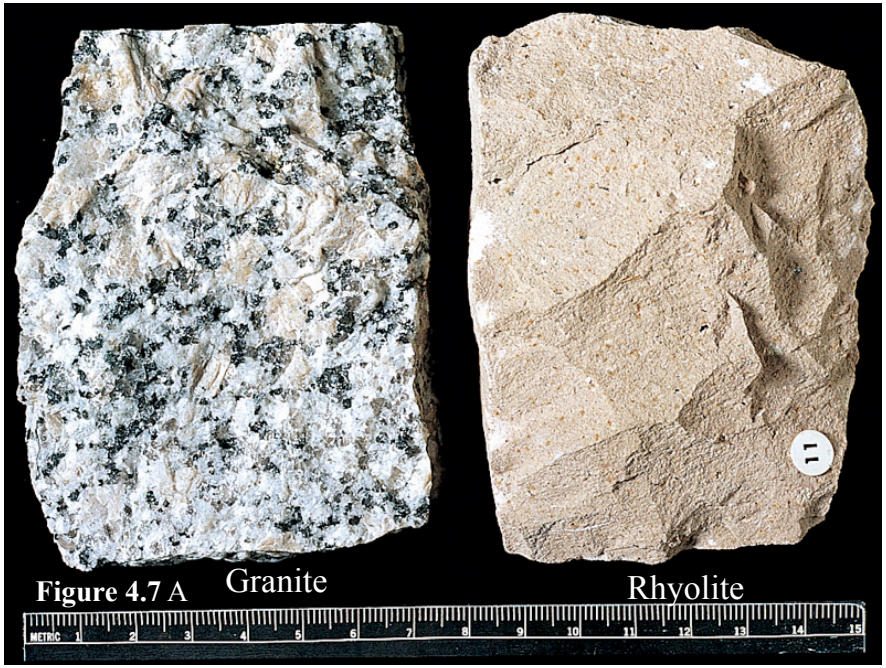


Figure 4.7 A

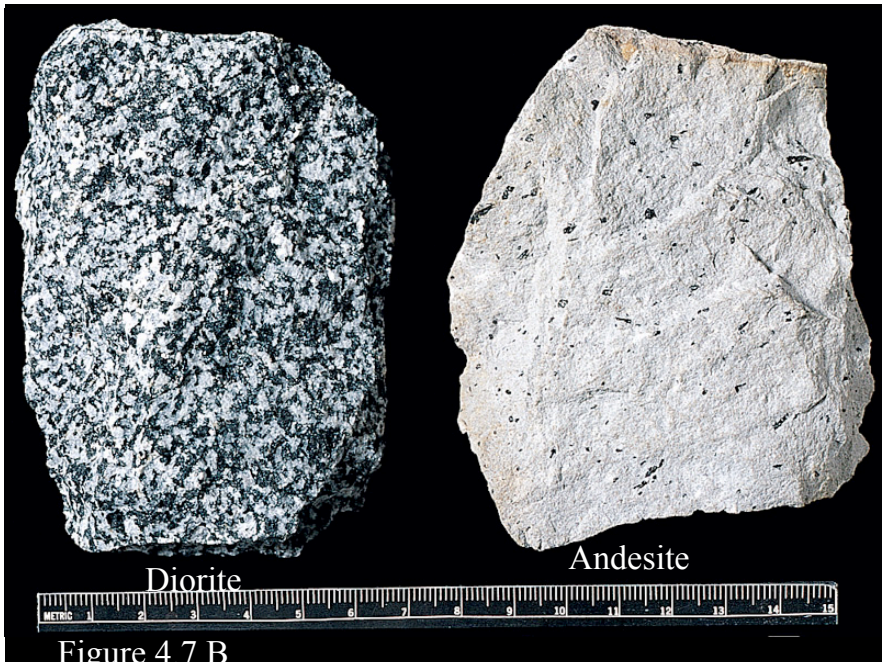


Figure 4.7 B

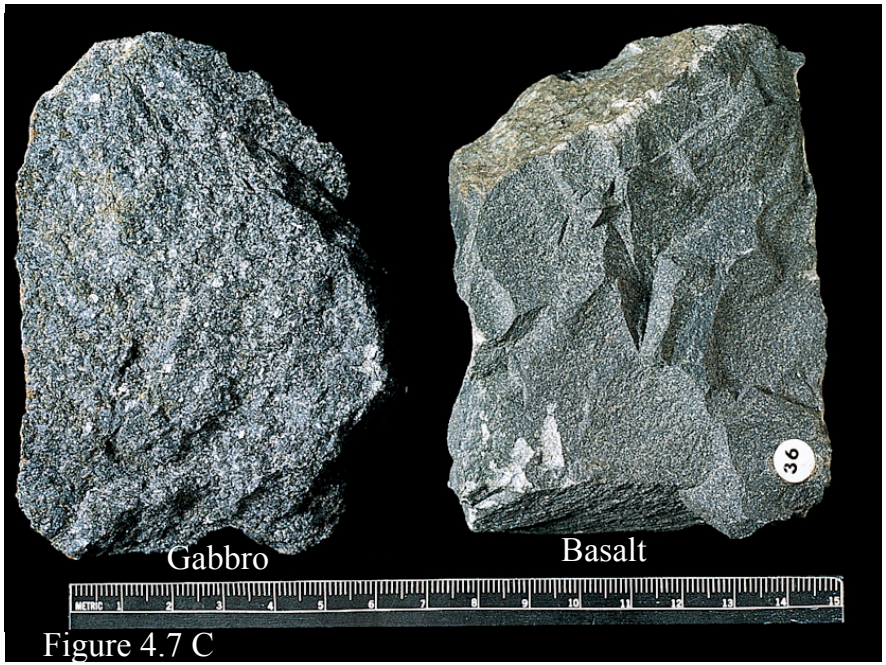


Figure 4.7 C

Explosive Volcanism products

- **Pyroclast:** fragment of rock ejected during a volcanic eruption – deposited as **tephra**
  - large: **bombs,** fine grained: **ash**
- **Tephra** is converted into **pyroclastic rock:**
  - Through the addition of a cementing agent, such as quartz or calcite, introduced by groundwater**.**
  - Through the welding of hot, glassy, ash particles.
    - **Welded tuff.**

Plutons

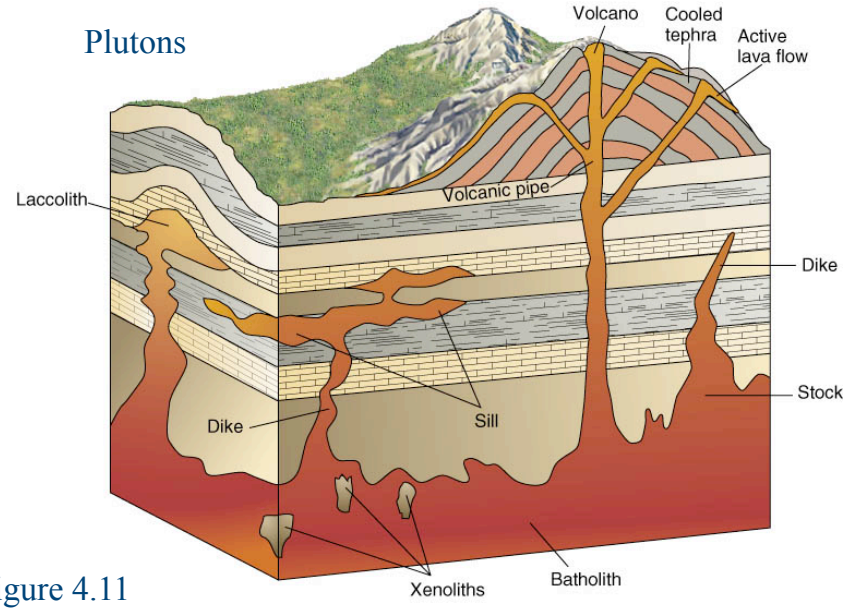


Figure 4.11

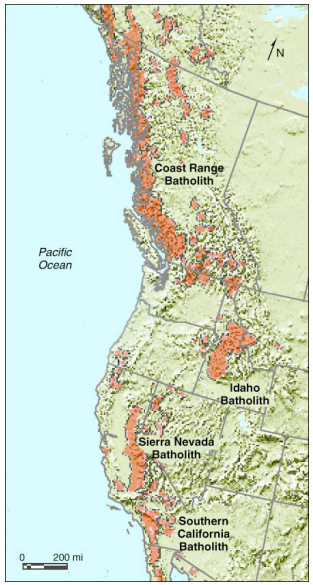


Figure 4.14

Distribution of Volcanoes

- Rhyolitic magma:
  - rhyolitic volcanoes are restricted to areas with continental crust.
- Andesitic magma:
  - The most common volcanism of subduction zones
  - Composition is close to average continental crust
- Basaltic magma:
  - Mid-ocean ridges and hotspots
  - Direct product of melting the mantle

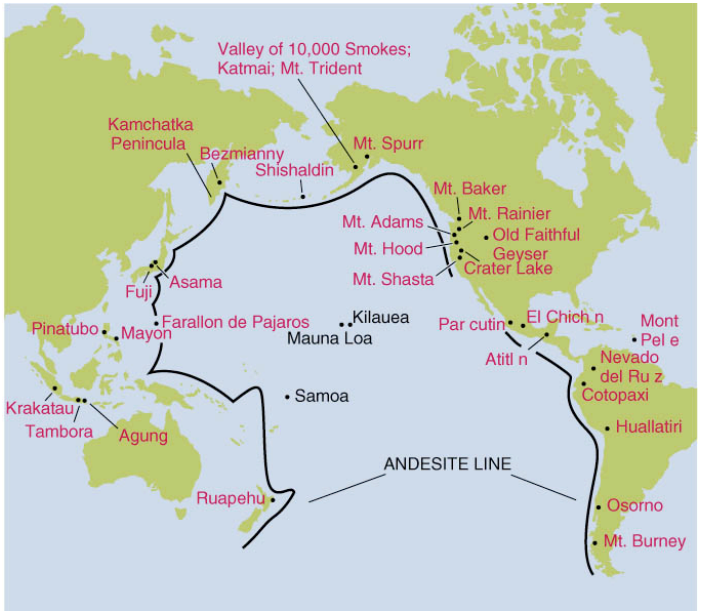


Figure 4.17

Origin of Magma

- Rocks are collections of different minerals each with different melting points –
  - within mineral groups, melting temperatures also vary with composition
  - Water depresses mineral melting temperatures
- Magmas: partial melting of a parent rock
  - Composition depends on degree of partial melt
    - Large fraction melt: magma has composition of parent
    - Low fraction melt: magma is very different from parent
- Primary parent is mantle
  - Primary magma type is basalt: 10% partial melt of mantle

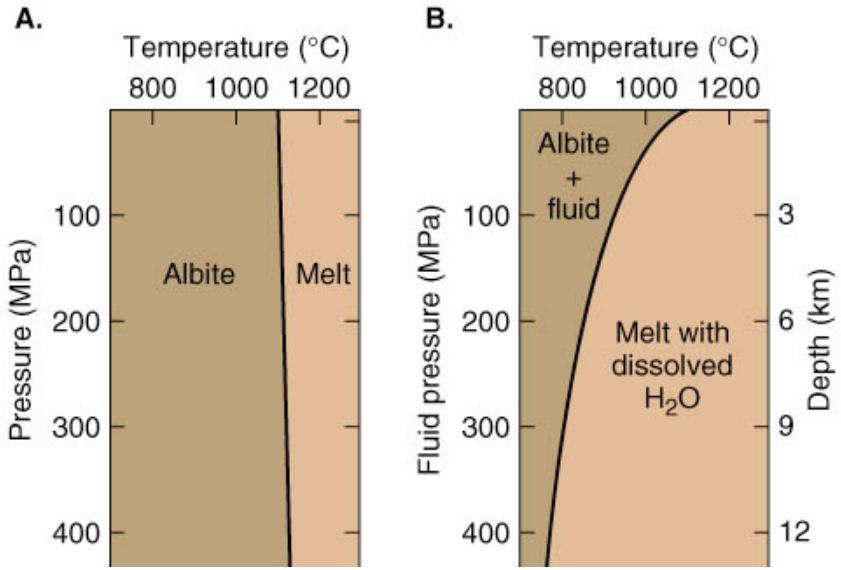


Figure B4.1

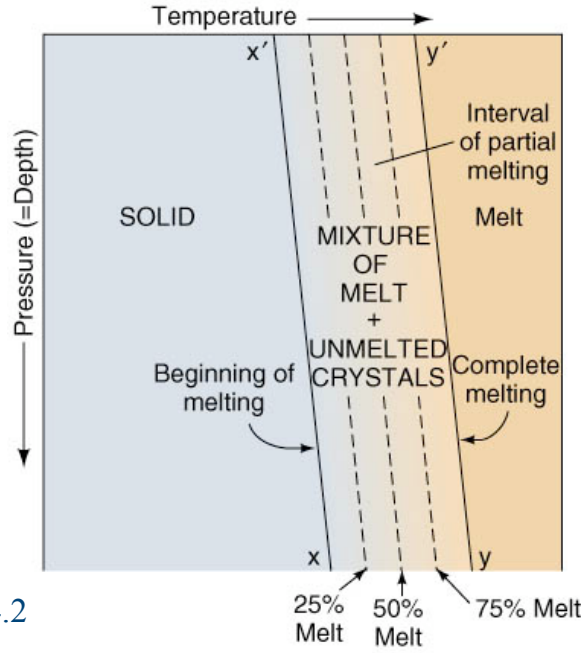


Figure B4.2

Bowen's Reaction Series

- **Canadian-born scientist N. L. Bowen (1887-1956) first recognized the importance of magmatic differentiation by fractional crystallization.**
- **Bowen argued that a single magma could crystallize into both basalt and rhyolite because of fractional crystallization.**

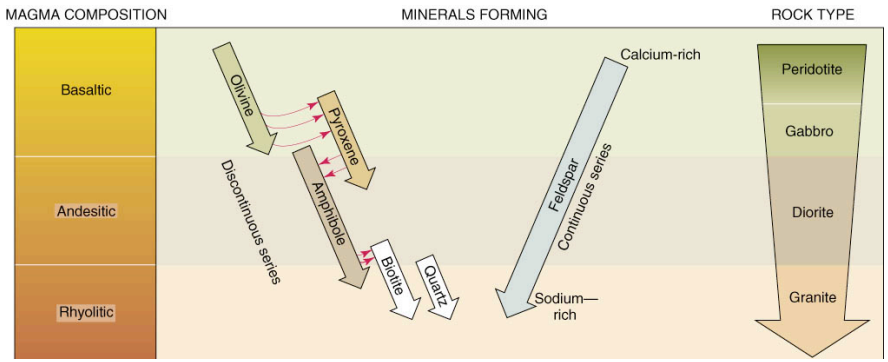


Figure 4.20

Ocean Crust revisited: MORB
(if section is landlocked: Ophiolite)

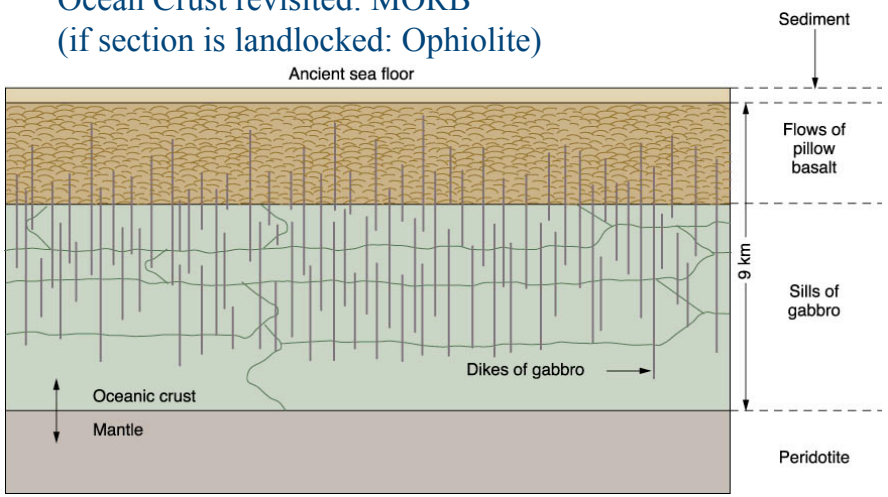


Figure 4.23

Igneous Rock And Life on Earth

- **Life requires nutrients such as potassium, sulfur, calcium, and phosphorus.**
- **Magma, which is less dense than the rock from which it forms by melting, rises buoyantly upward, bringing with it the nutrients on which life depends.**
- **A continent unaffected by any process of surface renewal, such as uplift or volcanic eruptions, but subjected to erosion for a hundred million years, would finish with low relief and almost barren soils.**