Chapter 4

INTRUSIVE IGNEOUS ROCKS

Polymerization of Silica
- Each Si atom is surrounded by 4 oxygens.
- Polymerization is the degree to which the oxygens are shared with other Si atoms.
- Polymerization is the number of Si-O-Si bonds.
  - Olivine has none: isolated SiO_4 groups
  - Pyroxene has one third: SiO_3 chains
  - Mica has has 40% shared: Si_4O_{10} sheets
  - Quartz and feldspar have 100% (Si,Al)O_2 framework.

MAGMA
- Magma is the term for any molten silicate material, whether below the surface or on top.
- Volcanic rocks are erupted on the surface.
  - Volcanic rocks are fine-grained (<1 mm)
- Intrusive igneous rocks crystallize from magma below the surface.
  - Intrusive igneous rocks are coarse-grained (> 1 mm)
  - Pegmatites are very coarse grained (> 1 cm)

Intrusive Igneous Rocks
- Composition
- Mineralogy
- Geologic Setting
  - Mantle
  - Oceanic Crust
  - Continental Crust
- Igneous Fractionation
  - How the chemistry evolves
Igneous Rock Compositions

- Rock compositions are described in weight percents of oxides.
- The principal variation in igneous rock compositions is silica (SiO$_2$) content.
- The degree of polymerization of silica increases with silica content (both in crystals and melt).

Igneous Rock Compositions

- Igneous rocks vary in composition from
  - ultramafic (~40 wt%) (peridotite)
  - mafic (48-55%) (gabbro)
  - intermediate (55-65%) (diorite)
  - silicic (65-75 wt %) (granite)
- The mantle is peridotite (ultramafic).
- The ocean basins gabbro (mafic).
- The continents are granite (silicic)

Igneous Rock Names and Compositions

- Composition
  - Ultramafic
  - Mafic
  - Intermediate
  - Silicic (felsic)
- Intrusive
  - Peridotite
  - Gabbro
  - Diorite
  - Granite
- Volcanic
  - Komatiite
  - Basalt
  - Andesite
  - Rhyolite

Igneous Rock Mineralogy

- Peridotite (Ultramafic)
  - Olivine ((Mg,Fe)$_2$SiO$_4$
  - Pyroxene ((Mg,Fe,Ca)SiO$_3$
- Gabbro (Mafic)
  - Feldspar (CaAl$_2$Si$_2$O$_8$
  - Pyroxene
  - Garnet (Mg$_3$Al$_2$Si$_3$O$_12$
- Diorite (Intermediate)
  - Feldspar (CaAl$_2$Si$_2$O$_8$
  - Pyroxene
  - Mica
- Granite (Silicic)
  - Quartz (SiO$_2$
  - Feldspar (NaAlSi$_3$O$_8$
  - Mica (biotite)
  - Mica (muscovite)
  - Mica (KAl$_2$(Si,Al)$_4$O$_10$(OH)$_2$

Geologic Settings

- Compositions
  - Ultramafic
  - Mafic
  - Intermediate
  - Silicic (felsic)
- Where?
  - Mantle
  - Oceanic
  - Subduction Zones
  - Continental Mass
**Geologic Settings:**

- Mantle
- Mid-ocean ridges
- Oceanic Islands
- Island arcs
- Continental

There appear to be 13 major plates that cover the globe.

**Igneous Fractionation:**

*Peridotite-basalt-granite*

- **Partial Melting**
  - Rocks have a melting interval of several hundred degrees C.
  - First melt is rich in silica, water and trace elements.

- **Fractional Crystallization**
  - First-formed crystals low in silica settle to the bottom.
**Intrusive forms**

- **Pluton**: Any large discordant intrusion at depth
  - **Batholith**: large > 100 km$^2$
  - **Stock**: small < 100 km$^2$
- **Dike**: Tabular non-conformable
- **Sill**: Tabular conformable
**Small Pluton: Stock**

**Intrusive forms**
- **Pluton**: Any large discordant intrusion at depth
  - Batholith: large > 100 km²
  - Stock: small < 100 km²
- **Dike**: Tabular non-conformable
- **Sill**: Tabular conformable

**Terms**
- Polymerization
- Magma
- Pegmatite
- Igneous Fractionation
- Partial melting
- Fractional Crystallization
- Ultramafic
- Mafic
- Intermediate
- Silicic
- Peridotite
- Gabbro
- Diorite
- Granite
- Pluton
- Stock
- Batholith
- Dike
- Sill