### Magma Composition

References:
*Encyclopedia of Volcanoes*, pp. 115-190

### Constitution of Magmas
- Hot molten rock
- $T = 700 - 1200$ degrees C
- Composed of ions or complexes
- Phase
  - Homogeneous
  - Separable part of the system
  - With an interface

### Chemical Composition
- Most components
  - Low vapor pressure
  - Designated by mole fraction ($X_i$)
- Volatile components
  - Mainly exist as a gas
  - Designated by vapor pressure ($p_i$)
- Fluid pressure = sum of partial pressures
  $$P_f = \sum p_i$$

### Gas law
- Important to understand explosive volcanism
- Volume proportional to temperature
- Volume inversely proportional to pressure
  $$V = \frac{RT}{P}$$

### Atomic Structure of Magma
- Quenched to form a glass
- Si & Al are polymerized with O
- Forming networks of Si-O chains
- Short-range structural order

### Structural Model
- Network formers
  - Si, Al
- Network modifiers (cations)
  - Ca, Mg, etc
- Dissolved water has a strong effect
  $$H_2O + O^2 = 2(OH)^-$$
**Magma Generation**

- Magmas form at perturbations in P,T,X
- Convergent plates
- Divergent plates
- Peridotite mantle source

**Source Regions**

- Must originate in the mantle or crust
- At Hawaii source is 60 km deep
- Only 1 to 3% melt exists in peridotite

**Magma From Solid Rock**

- Basalt & peridotite sources for magma
  - Plagioclase, Olivine, Pyroxene, Fe-Ti oxides
- Granite sources for magma
  - Quartz, K-spar, albite, biotite, hornblende

**Basalt & Peridotite Sources**

- Equilibrium fusion
  - Solid and liquid remain in equilibrium
  - Continuous but limited composition range
- Fractional fusion
  - Liquid is immediately removed from host rock
  - Melts are both oversaturated & undersaturated with respect to Si

**Influence of Pressure**

- Pressure strongly influences the cotectic
- Partial melts of mantle peridotite are basalts
- At higher pressures partial melts are more silica deficient

**Water Saturation**

- Saturated granite melts have 10 to 15% $\text{H}_2\text{O}$
- Natural granite melts have about 4% $\text{H}_2\text{O}$
- Therefore most silicic melts are undersaturated at depth
**Water Undersaturation**

- Common granitic mineral assemblage
  - Biotite, K-spar, Fe-Ti oxide

\[
\frac{1}{2} O_2 + \text{biotite} = \text{K-spar} + \text{Fe}_3\text{O}_4 + \text{H}_2\text{O}
\]

- Excess water drives this reaction to the left
- Hence, most granites are not water saturated

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**Basalt Classification**

- Phases:
  - Augite (Cpx)
  - Hypersthene (Hy)
  - Olivine (Oliv)
  - Plagioclase (Plag)
  - Nepheline (Ne)

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**Ultramafic Classification**