<table>
<thead>
<tr>
<th>Constitution of Magmas</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hot molten rock</td>
<td>- Most components</td>
</tr>
<tr>
<td>- T = 700 - 1200 degrees C</td>
<td>- Low vapor pressure</td>
</tr>
<tr>
<td>- Composed of ions or complexes</td>
<td>- Designated by mole fraction (X_i)</td>
</tr>
<tr>
<td>- Phase</td>
<td>- Volatile components</td>
</tr>
<tr>
<td>- Homogeneous</td>
<td>- Mainly exist as a gas</td>
</tr>
<tr>
<td>- Separable part of the system</td>
<td>- Designated by vapor pressure (p_i)</td>
</tr>
<tr>
<td>- With an interface</td>
<td>- Fluid pressure = sum of partial pressures</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gas law</th>
<th>Atomic Structure of Magma</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV = nRT</td>
<td>- Quenched to form a glass</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural Model</th>
<th>Magma Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Network formers</td>
<td>- Magmas form at perturbations in P,T,X</td>
</tr>
<tr>
<td>- Si, Al</td>
<td>- Convergent plates</td>
</tr>
<tr>
<td>- Network modifiers</td>
<td>- Divergent plates</td>
</tr>
<tr>
<td>- Ca, Mg, etc</td>
<td>- Peridotite mantle source</td>
</tr>
<tr>
<td>- Dissolved water has a strong effect</td>
<td>H_2O + O^2 = 2(OH)^-</td>
</tr>
</tbody>
</table>
**Source Regions**

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

**Melting**

- Heat of fusion
  - About 300 times the rock’s specific heat
  - Melting of rock consumes much heat
- Mechanisms for melting
  - Temperature increase by mass transfer
  - Decompression
  - Changes in composition reducing melting point

**Temperature Increase**

- Mechanical deformation
  - Friction generates heat
- Mass transfer of rock
  - Descending oceanic lithosphere
  - Basaltic underplating of continental crust

**Decompression**

- Upwelling mantle
  - Beneath oceanic or continental rift
- Adiabatic system
  - Pressure causes all temperature change

**Changes in Composition**

- Increase in water pressure
- Lowers the solidus
- Subduction zones
  - Peridotite wedge
  - Over subducting oceanic crust

**Magma From Solid Rock**

- Basalt & peridotite systems
- Granite systems
### Basalt & Peridotite

- **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

### Role of CO₂

- Polymerizes melt
- Contracts olivine field
- Favors silica-poor alkali melts
- Repeated melting episodes favors incompatible element enrichment

### Role of H₂O

- Depolymerizes melt & stabilizes olivine
- Partial melts more silica rich
- Favors tholeiitic basalts

### Mantle-derived Primary Melts

- Wide range of melt compositions possible
- Fractional crystallization vs. Partial melting
- Primary melt
  - Segregated from peridotite source rock
  - First crystallized minerals similar to mantle source zone
- Derivative melt
  - Modified after leaving the source region

### Granitic Systems

- Impossible to generate granites by partial melting of mantle peridotite or subducted oceanic floor basalt
- Their origin is related to older sialic crust
- Granites concentrated along old subduction zones
**Water Saturation**

- Saturated granite melts have 10 to 15% H₂O
- Natural granite melts have about 4% H₂O

**Water Undersaturation**

- Common granite mineral assemblage
  - Biotite, K-spar, Fe-Ti oxide
  
  \[ \frac{1}{2} \text{O}_2 + \text{biotite} = \text{K-spar} + \text{Fe}_3\text{O}_4 + \text{H}_2\text{O} \]
- Excess water drives this reaction to the left
- Hence, most granites are not water saturated

**Origin of Granites**

- Partial Melting of lower crust
- Source in mica-amphibolites
- Contain 1-2% H₂O
- Lowest T melts are K-rich granite
- Higher T, deeper melts are Ca-rich granodiorite

**Subduction Zone Magma**

- Subducted slab
  - Mafic primary melts
- Peridotite mantle wedge
  - Mafic primary melts

**Dehydration Beneath Orogen**

- Large amount of water in oceanic slab
  - Water in pore space
  - Water in alteration minerals
- Heating dehydrates the slab
- Liberated water promotes partial melting of peridotite
- Composition is Si-saturated tholeiite
Magma Diversification

- Magmatic differentiation
- Gravitational settling
- Liquid immiscibility

Crystal-liquid Fractionation

- Regular pattern of compositional variation
- Variation of MgO is a good measure of olivine fractionation
- Computer mixing programs can be used

Magma Mixing

- Two different magmas may blend to produce a hybrid
- Common with calc-alkali magma
- Blended magmas should have linear composition with the parents