Phase Diagrams

Best, Chapter 14

Gibbs Phase Rule

$$F = 2 + C - \varphi$$

F = degrees of freedom (P-T-X)

C= components

φ = phases

Degrees of Freedom

- **Rule applies to a phase or assemblage**
- **Divariant indicates two degrees of freedom**
- **Univariant means one degree of freedom**
- **Invariant means there are no degrees of freedom**

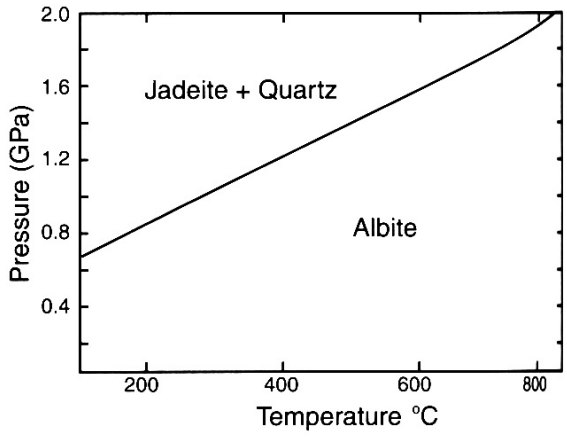
Petrogenetic Grid

- **The grid define stability limits**
  - **End-member minerals**
  - **Mineral assemblages**
- **More thermodynamic data is needed to construct a useful grid**

Anhydrous Phase Diagrams

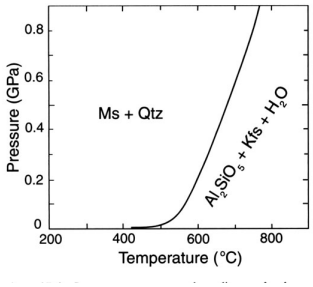
- Solid-solid reactions
- Governed by Clapeyron equation
  - dP/dT = 10 ΔH/T ΔV = ΔS/ΔV
  - ΔH is the heat of reaction
  - ΔS is the change in entropy
  - ΔV is the change in volume
- The slope of the stability is dP/dT

Jadeite + Quartz = Albite



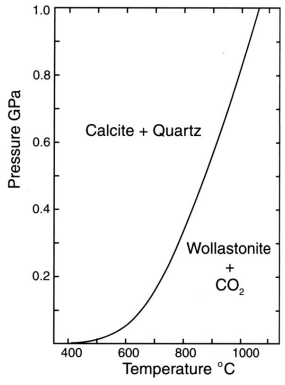
System Open to H_2O

- Dehydration curves
- Example of the general case
- Specific minerals
  - Breakdown of chlorite, muscovite, biotite, etc



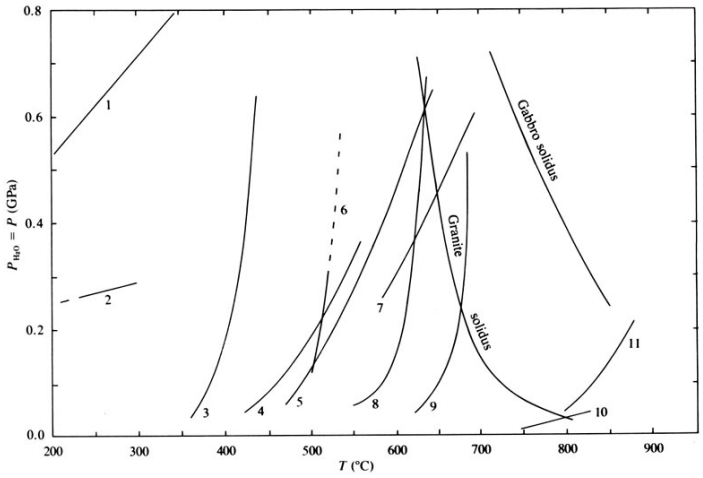
System Open to CO_2

- Decarbonation curves
- General case example
- Specific minerals
  - Breakdown of calcite, dolomite, etc



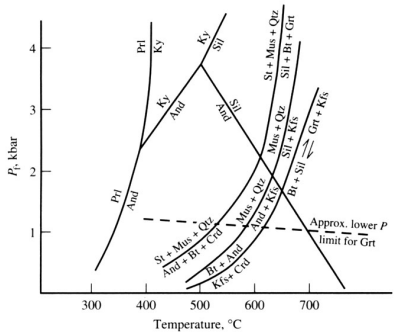
Univariant Curves

- Curves that define reactions with one degree of freedom
- In P-T space this means that if T is changed, than P must also change to maintain equilibrium
- Many important metamorphic reactions are defined by these curves



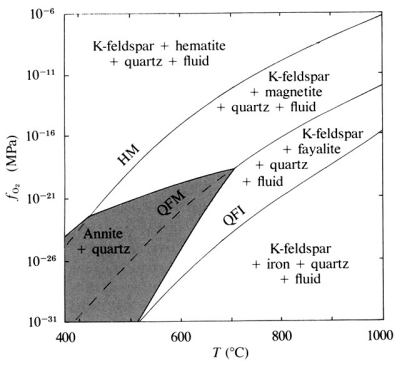
Important Reactions

- Al_2O_3 phase stability
- Dehydration curves



Stability of Iron Oxides

- $\mathbf{P_{O2}}$ (f_{O2}) vs. Temp.
- Main phases
  - Hematite
  - Magnetite
  - Fayalite
  - Native Iron/Wustite

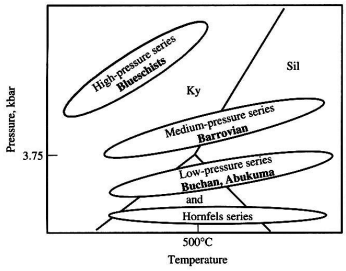


Miyashiro's Facies Series

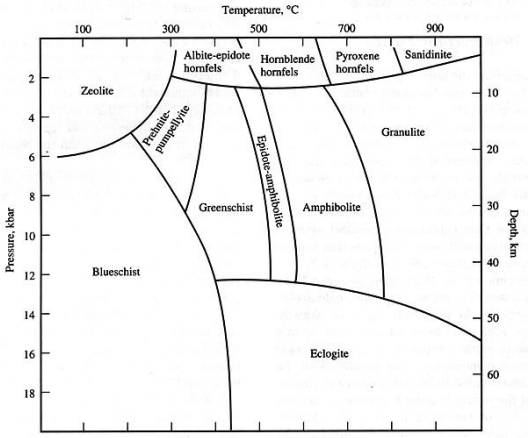
- Low geothermal gradient
  - Zeolite, pumpellyite-prehnite, blueschist
- Intermediate geothermal gradient
  - Barrow's zones
- High geothermal gradient
  - Andalucite present in pelitic rocks

Relation to Geotherms

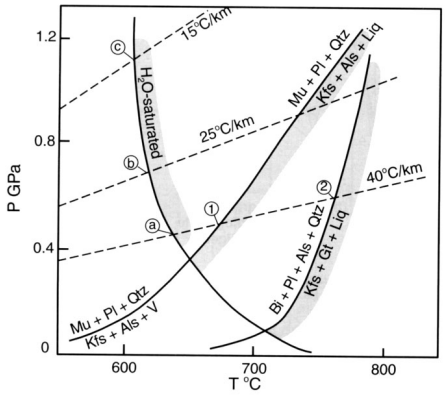
- High pressure series
- Medium P/T series
- High temperature series

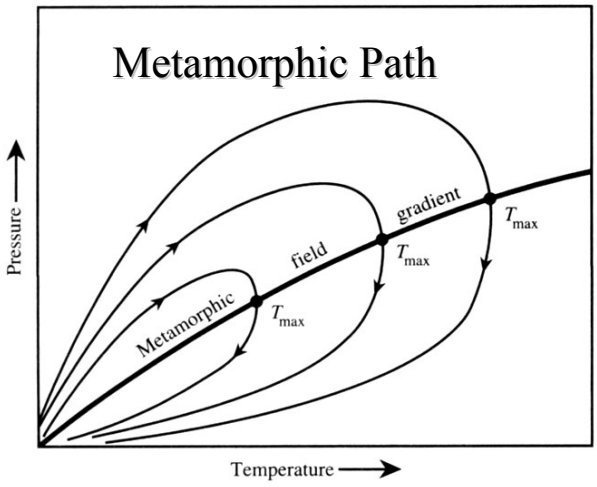


Facies in P-T Space



Granite Solidus (Wet)





Polymetamorphism

- Sometimes there are repeated episodes of metamorphism
- The last event may be weak or of short duration
- Polymetamorphism is common in post tectonic environments and in contact aureoles

Material Transport

Diffusion

Infiltration

Diffusion

- Materials move through crystal lattices or a stationary pore fluid
- Rate of movement controlled by a diffusion coefficient (Fick's Law)

$$Q = k (\delta C / \delta x)$$

- Material moves about 1 cm/m.y.

Infiltration

- Passive mass transport of a solute in a moving fluid medium
- Driven by fluid pressure
- Microfractures are important
- Reaction-enhanced permeability
  - Volume reduction due to reactions
- Dilatency pumping

Reaction Textures

olivine + plagioclase = hypersthene + diopside+ spinel