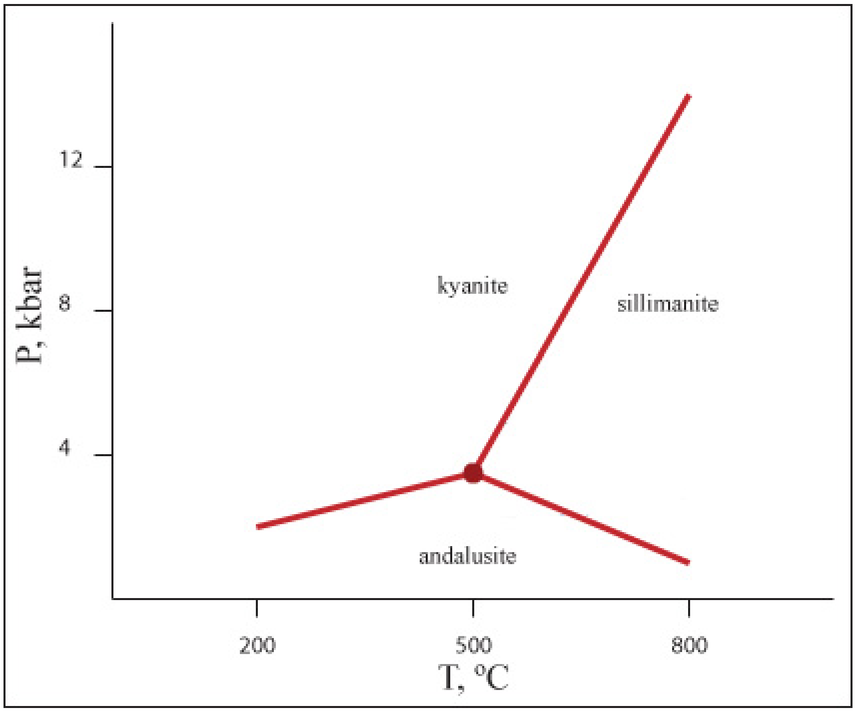
November 29, 2005

Metamorphic Thermometry and Barometry

See Spear Ch. 15



Pelitic rocks commonly have garnet-biotite-plagioclase assemblages. Those minerals, along with an aluminosilicate and quartz can be used to calculate T + P.

Reactions:
garnet-biotite Fe-Mg exchange, T sensitive
garnet + plag + aluminosilicate + quartz, P sensitive

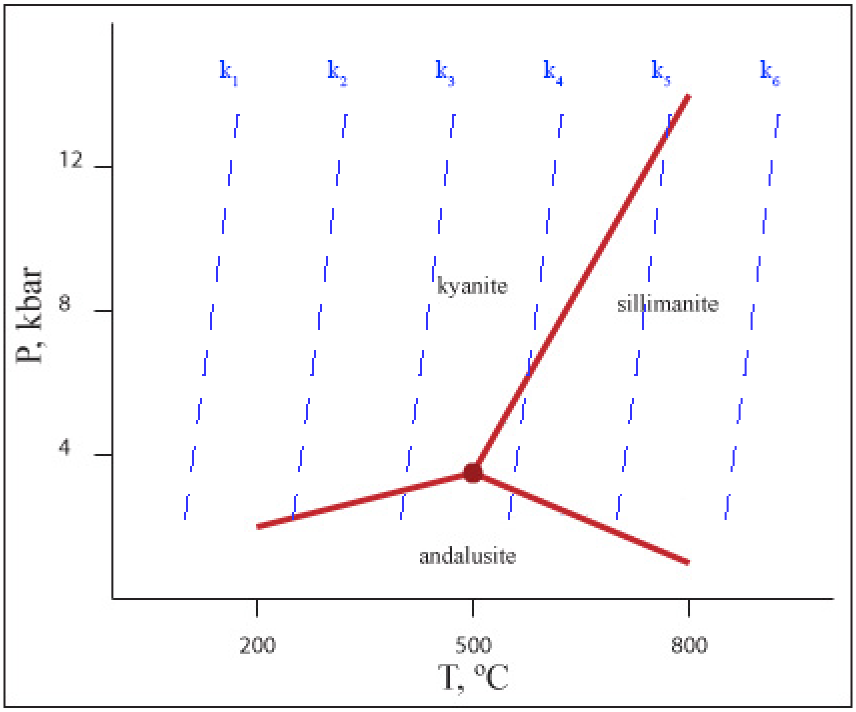
1) exchange reaction: GARB

$$Fe_3Al_2Si_3O_{12} + KMg_3AlSi_3O_{10}(OH)_2 \rightleftharpoons Mg_3Al_2Si_3O_{12} + KFe_3AlSi_3O_{10}(OH)_2$$

Almandine Phlogopite Pyrope Annite

$$\ln K_{eq} = -\frac{\Delta G_{rxn}}{RT} = \frac{(a_{pyr}^{gt})(a_{ann}^{bt})}{(a_{alm}^{gt})(a_{phl}^{bt})} = \frac{-\Delta H_{rxn} + (P-1)\Delta V_{rxn}}{R}\frac{1}{T} + \frac{\Delta S_{rxn}}{R}$$

If you can calculate lines of constant K, plot on the aluminosilicate graph:



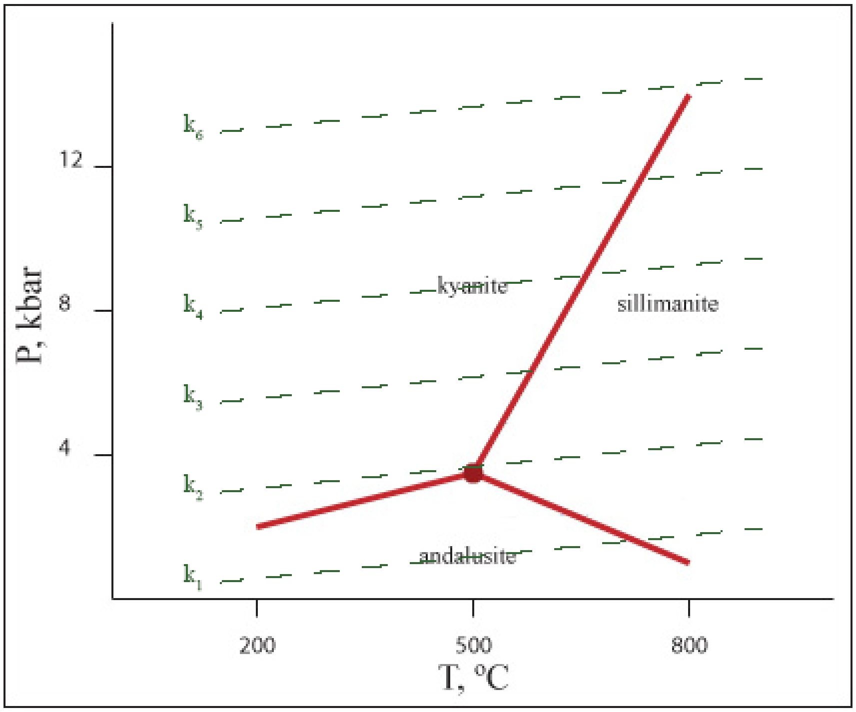
$$\left.\begin{array}{l}\Delta S\\ \Delta H\end{array}\right\}\text{large}$$
ΔV small

→ K more sensitive to T than P

2) GASP

$$Ca_3Al_2Si_3O_{12} + 2Al_2SiO_5 + SiO_2 \rightleftharpoons 3CaAl_2Si_2O_8$$
Grossular Alumino Qtz Plagioclase (Anorthite)

$$\ln K = \frac{\Delta G}{RT}$$
$$\frac{dP}{dT} - \Delta V \text{ both terms large}$$



Low slope → more sensitive to P than to T
Ky, qtz assumed to be pure phases
a ≈ 1

Check compositions of garnet, biotite, and plag to find both P + T!

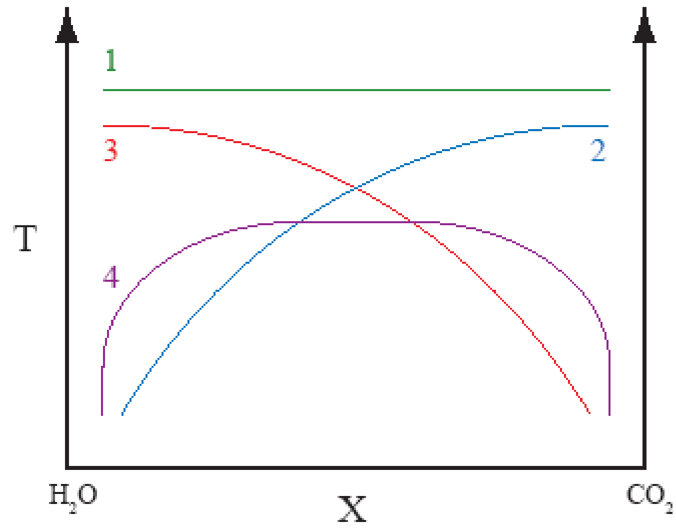
<u>Mixed Volatile Metamorphism</u>

See Spear Ch. 12

Rocks with both CO_2 and H_2O important components

- calc-silicates (including siliceous dolomites)
- ultramafic rocks, when CO_2 present in fluid
- also basic rocks, when CO_2 present in fluid

Visualization: $T - X_{CO_2}$ diagrams
Examine effects of T and variable fluid composition

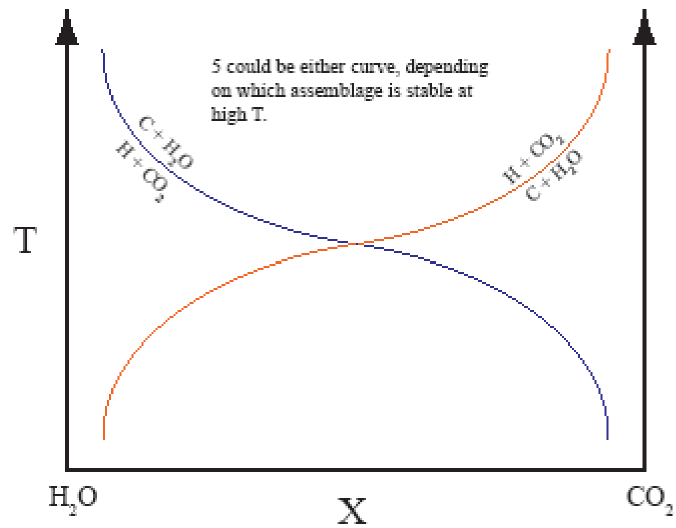


1) A=B, volatile absent

2) Decarbonation
$C = A + x(CO_2)$

3) Dehydration
$H = B + x(CO_2)$

4) Both components removed
$C + H = A + x(CO_2) + y(CO_2)$



5) $H + x(CO_2) = C + y(CO_2)$

1) $\left.\dfrac{\partial \Delta G}{\partial T}\right|_P = -\Delta S_{rxn}$ ← change in G such that high entropy assemblage is stabilized. Gas has high S, mineral has low S.

2) le Chatelier's principle
Take a $C = A + CO_2$ reaction
If we add H_2O, dilute CO_2, drives reaction to the right

4) the sum of 2 and 3 – volatiles always released
Pure CO_2 phase can't be in equilibrium with pure CO_2 fluid

$CaO - MgO - SiO_2 - CO_2 - H_2O$ siliceous dolomite
5 components: $F = 7 - \varphi$

Triangle diagrams for siliceous dolomites: