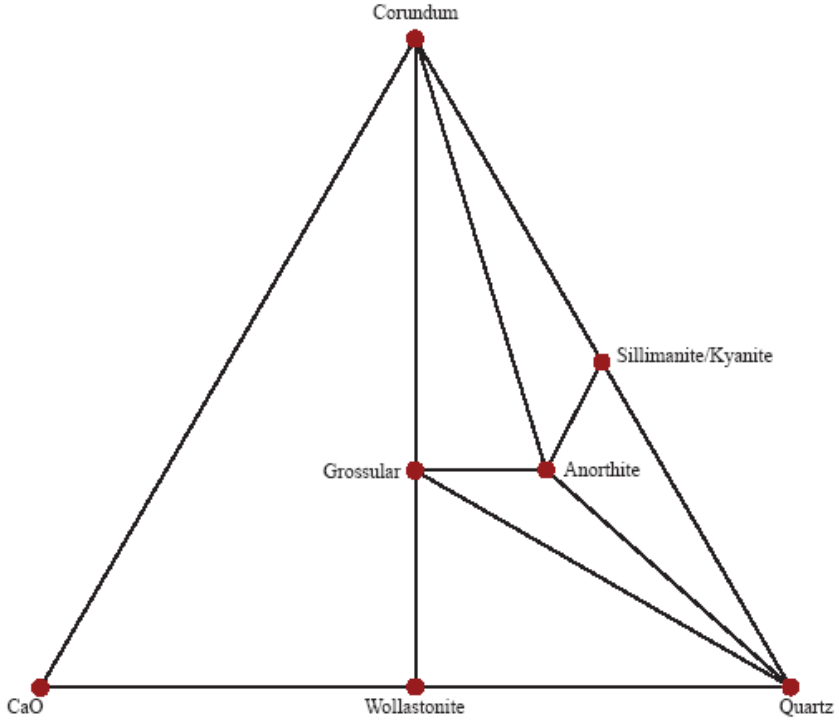
November 17, 2005

Metamorphic isograds – Barrow
See Spear ch. 10, Spear ch. 4 for more on metamorphic minerals

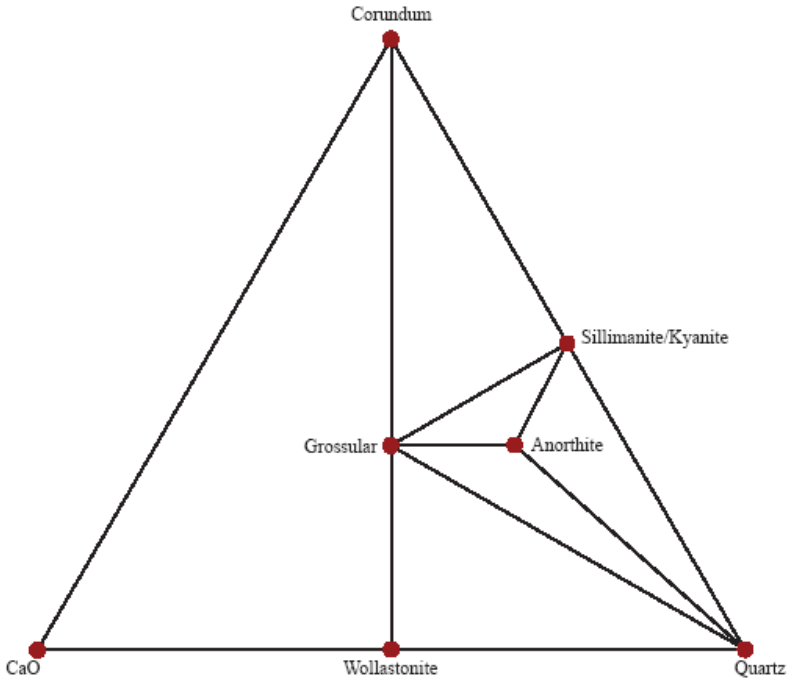
Graphical representations

1) useful for visualizing chemical reactions
2) reinforce the idea that bulk composition of your rock is important

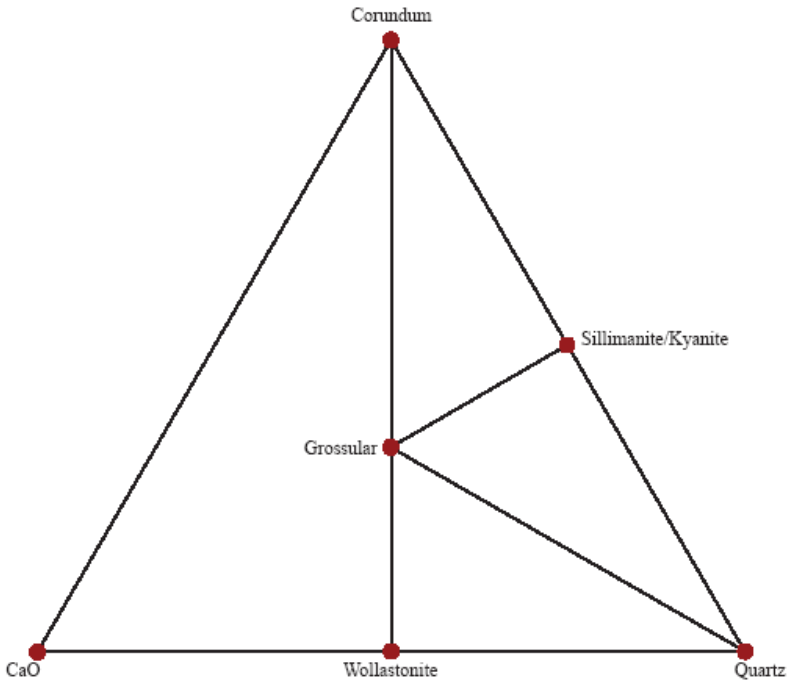
Plot bulk composition to find stable phases:



Grossular + kyanite $\rightleftharpoons$ anorthite + corundum
Tie line switch – non-terminal reaction

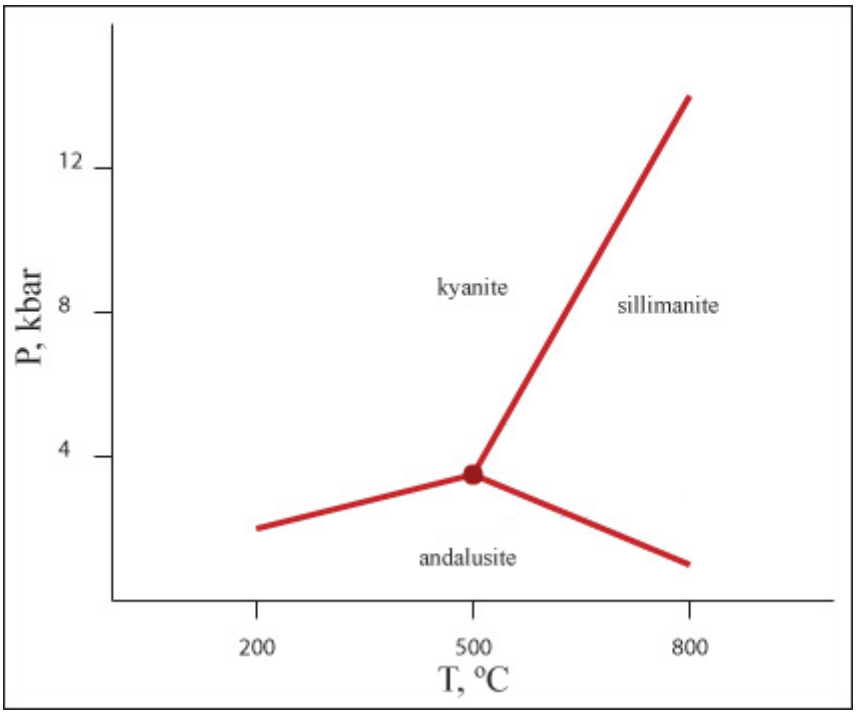


Anorthite $\rightleftharpoons$ grossular + kyanite + quartz
Terminal reaction – end of P-T stability of a phase



Reactions in simpler, lower variance systems

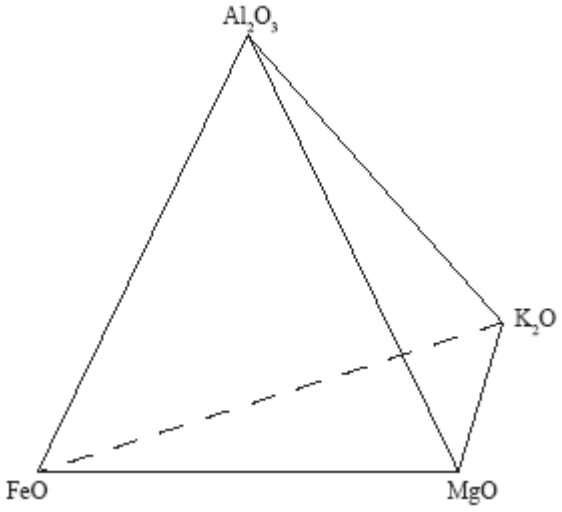
Kyanite ⇌ sillimanite
c = 1



Barrow's metamorphic grades

Pelites – J B Thompson (1957) developed an approach for understanding reactions in pelites. The system is: $SiO_2 – Al_2O_3 – K_2O – MgO – FeO – H_2O$. He took advantage of some simplifying features in these rocks:

1) quartz assumed always present
2) H_2O assumed present as fluid phase



+ H_2O + SiO_2

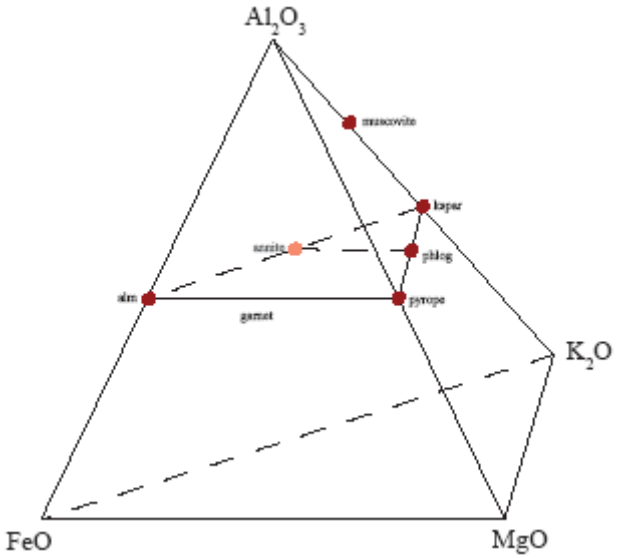
Can further simplify if muscovite is always present to the two-dimensional FMA diagram (F = FeO, M = MgO, A = Al_2O_3)

Minerals

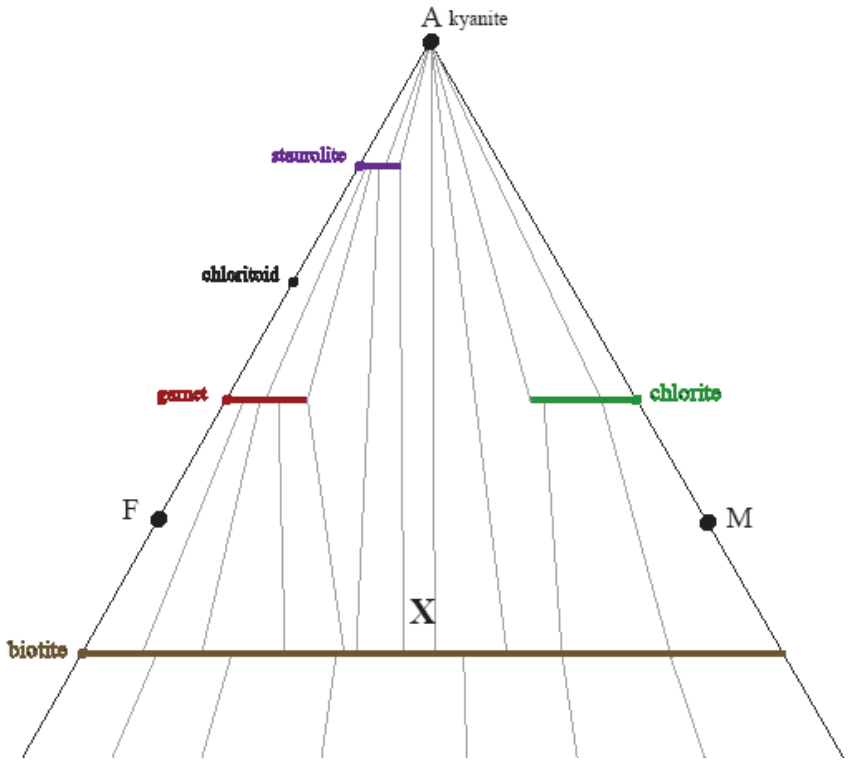
Muscovite		$KAl_2AlSi_3O_{10}(OH)_2$	
Sillimanite-Andalusite-Kyanite		Al_2SiO_5	
Quartz		SiO_2	
K-Feldspar		$KAlSi_3O_8$	Stable at low T + P and again at high T + P
Garnet	Pyrope	$Mg_3Al_2Si_3O_{12}$	
	Almandine	$Fe_3Al_2Si_3O_{12}$	
Biotite	Phlogopite	$KMg_3AlSi_3O_{10}(OH)_2$	
	Annite	$KFe_3AlSi_3O_{10}(OH)_2$	
Staurolite		$Fe_2Al_9Si_4O_{22}(OH)_2$	
Chloritoid		$(Fe,Mg)_2Al(OH)_4Al_3O_2(SiO_4)_2$	
Chlorite		$(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$	
Cordierite		$Mg_2Al_4Si_5O_{18}$	Low P indicator mineral

To plot minerals in projection:

1) start with chemical analysis in wt % of oxides
2) divide each wt % by gm mol wt, renormalize → calculate mol % or mol fraction



Project through muscovite onto FMA face, for example:



Reactions when you have solid solution minerals:
Continuous, 3 phase triangles move across the diagram

Isograds – mineral appearances – depend on P, T, and the bulk composition