

## Introduction to Mineral Equilibria

On the triangular diagram below, plot each of the following mineral compositions. Show locations with dots:

grossular  $\text{Ca}_3\text{Al}_2\text{Si}_3\text{O}_{12}$

quartz  $\text{SiO}_2$

anorthite  $\text{CaAl}_2\text{Si}_2\text{O}_8$

wollastonite  $\text{CaSiO}_3$

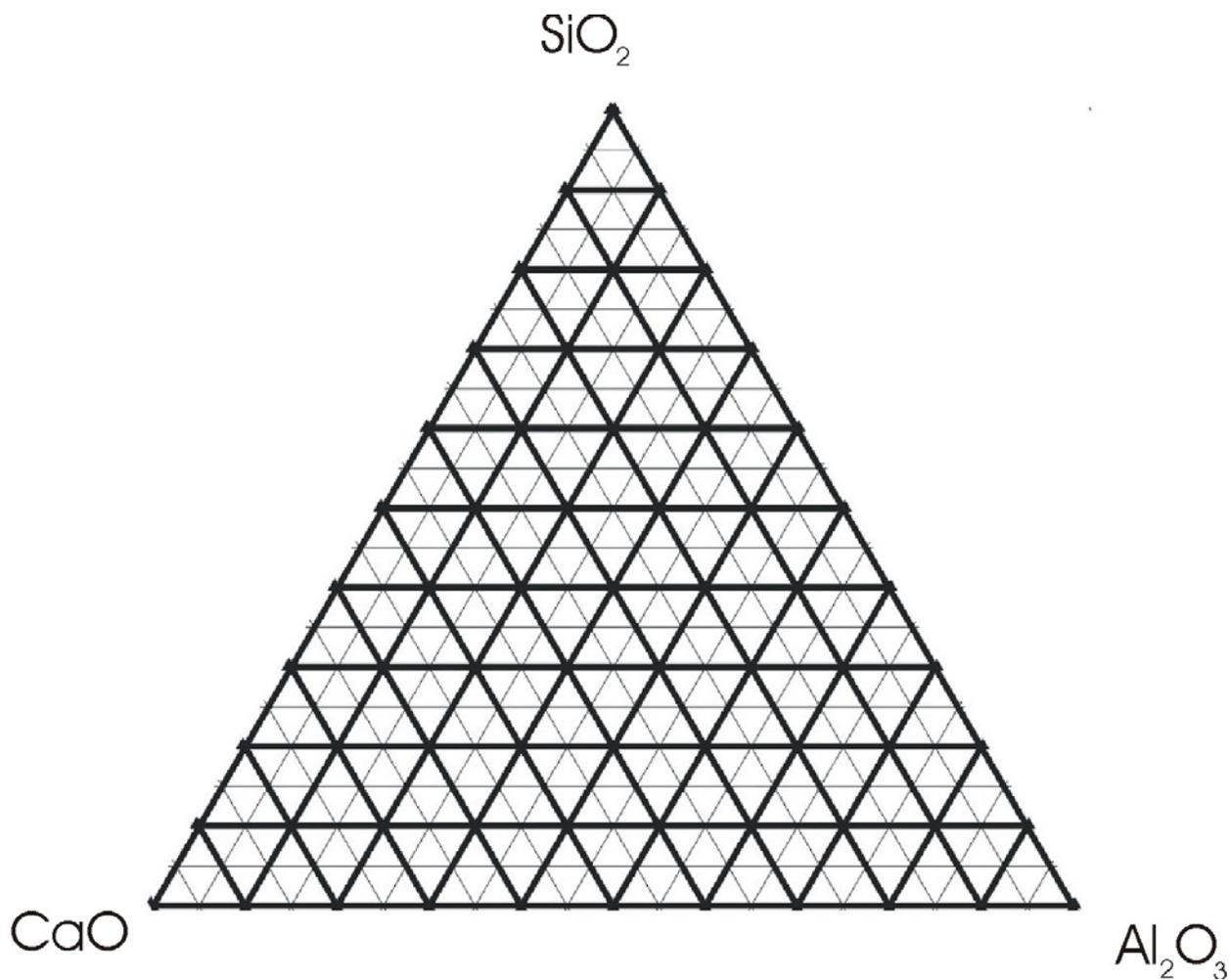
kyanite  $\text{Al}_2\text{SiO}_5$

larnite  $\text{Ca}_2\text{SiO}_4$

corundum  $\text{Al}_2\text{O}_3$

lime  $\text{CaO}$

gehlenite  $\text{Ca}_2\text{Al}_2\text{SiO}_7$



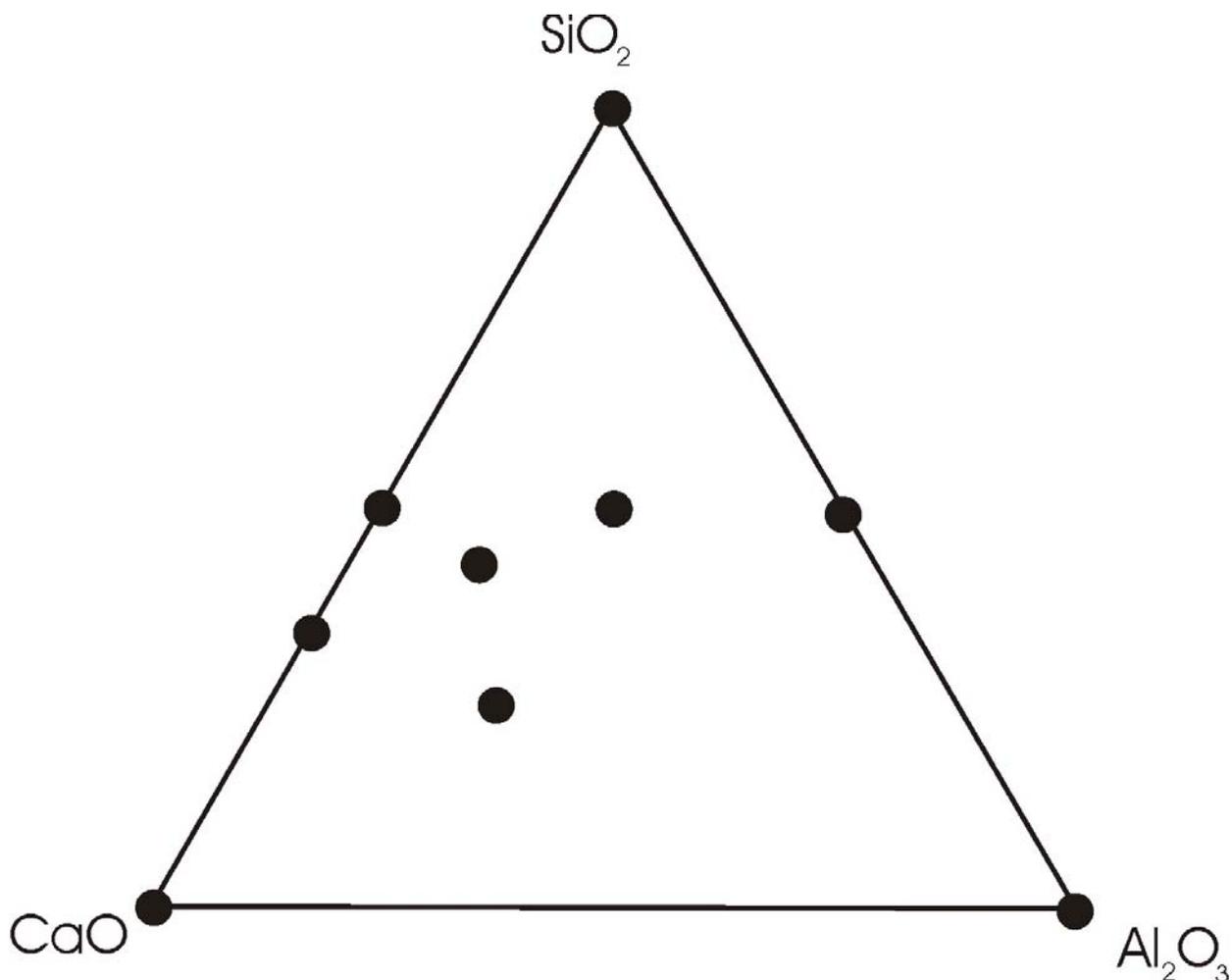
The diagram at the bottom of this page shows where you should have plotted the minerals. If this is not what you found, then make sure you know why.

The phase rule says that  $C + 2 = P + F$ . The system we are considering has 3 components ( $C=3$ ). If we consider a general region of P-T space, the degrees of freedom is 2 ( $F=2$ ). Therefore, only three phases can exist together.

We can show possible three phase assemblages by drawing lines on the diagram below. Draw lines between the dots until the entire diagram is broken up into triangles. The lines cannot cross.

Each triangle on your diagram represents a possible 3-phase assemblage. If you drew your triangles correctly, any rock with composition that falls within a given triangle will contain the minerals at the corners of the triangle. So, different compositions yield different mineral assemblages.

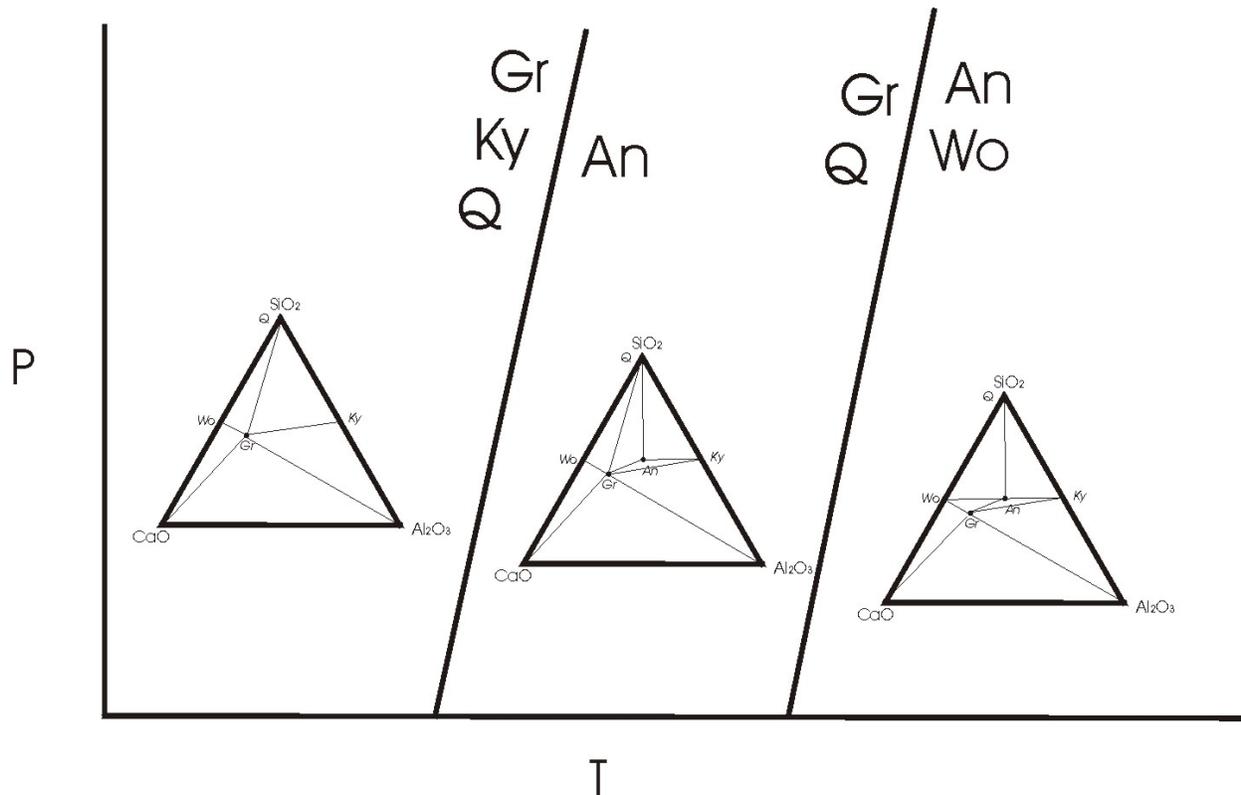
Of course, if every student worked independently, you will find that you do not all get



the same answers. Maybe someone has the correct drawing, but the drawing will change depending on what part of P-T space you are considering.

Different mineral assemblages are stable in under different conditions. The assemblages change by way of metamorphic reactions. So, the tie lines in the triangular diagrams will change.

Here are some results depicting only reactions involving Gr-Ky-Q-An-Wo. The triangles show which mineral assemblages are stable in the three different parts of PT space.



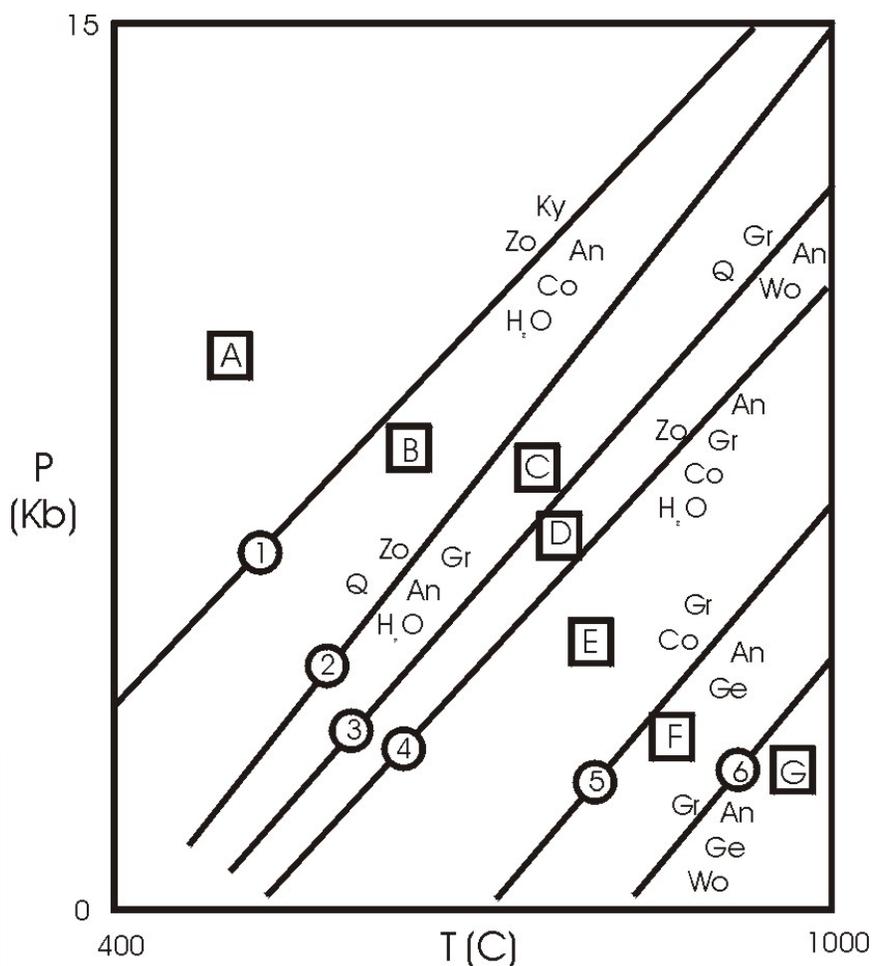
Now, let's take a look at a more complicated phase diagram.

This figure shows a phase diagram involving minerals in the CASH ( $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2\text{-H}_2\text{O}$ ) system. It includes some of the same phases you considered above, plus a couple of new ones.

There are six reactions (numbered 1 through 6) which divide PT space into seven fields (A through G).

Note, this is a 4 component system. Fill in the following table:

degrees of freedom	# of phases that may coexist
0	
1	
2	



For each of the following 15 assemblages, tell in what zones or on what reactions it is stable. Some may be stable nowhere, some everywhere.

Co	Gr-An-Co-H <sub>2</sub> O
Zo	An-Ge-Wo-Zo
Ge	Zo-Ky-Co-Gr-H <sub>2</sub> O
Zo-An	Gr-An-Zo-Q-H <sub>2</sub> O
An-Ge	An-Co-Gr-Ge-H <sub>2</sub> O
Zo-An-Ge	An-Co-Gr-Q-H <sub>2</sub> O
Gr-An-H <sub>2</sub> O	
An-Wo-Q	
Gr-Co-An-Ge	

What general observation can you make about the stability field (range of PT space where something is stable) and the number of minerals in an assemblage?