Plotting Compositons in 2- and 3-Component Systems

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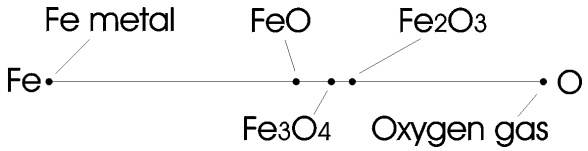
1. Plotting Compositions on A Line

We can easily depict two component chemical systems by plotting compositions on a line. For example, the drawing below shows the system Fe-O. Dots on the line show several different compositions corresponding to metallic iron (Fe), wustite (FeO), magnetite (Fe_3O_4), hematite (Fe_2O_3), and oxygen gas (O_2).



Once you get the basics down, it is not difficult to plot compositions in the correct places. For example, Fe-metal plots at the left hand end of the line because it is 100% Fe. Wustite plots at the center because it is 50%Fe and 50%O. Magnetite is 57% (=4/7) O, and so plots 57% of the way from Fe toward O. The key is to remember that if a composition is richer in Fe than in O, it must plot closer to the Fe end of the line. If it is richer in O, then it must plot toward the O end of the line.

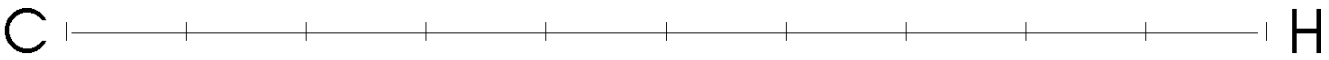
Note also that because magnetite plots between wustite and hematite, we can write a reaction:

magnetite	=	wustite	+	hematite
Fe_3O_4		FeO		Fe_2O_3

Similarly, we can write and balance the reaction between hematite, magnetite and oxygen, but in this case the reaction coefficients are not all 1:

3 hematite	=	2 magnetite	+	oxygen
3 Fe_2O_3		2 Fe_3O_4		½ O_2

Question 1.1 - The line drawn below shows the system carbon - hydrogen (C-H). I added tic marks to help you with plotting. Put dots on the line, and label clearly, to show the compositons of graphite (C), hydrogen gas (H_2), methane (CH_4), ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}).



Question 1.2 - Write and balance a reaction that involves methane, ethane, and propane.

2. How to use Triangular Diagrams to Show Compositions Involving Three Components

Triangular diagrams are a convenient way to plot compositions if we are dealing with three components.

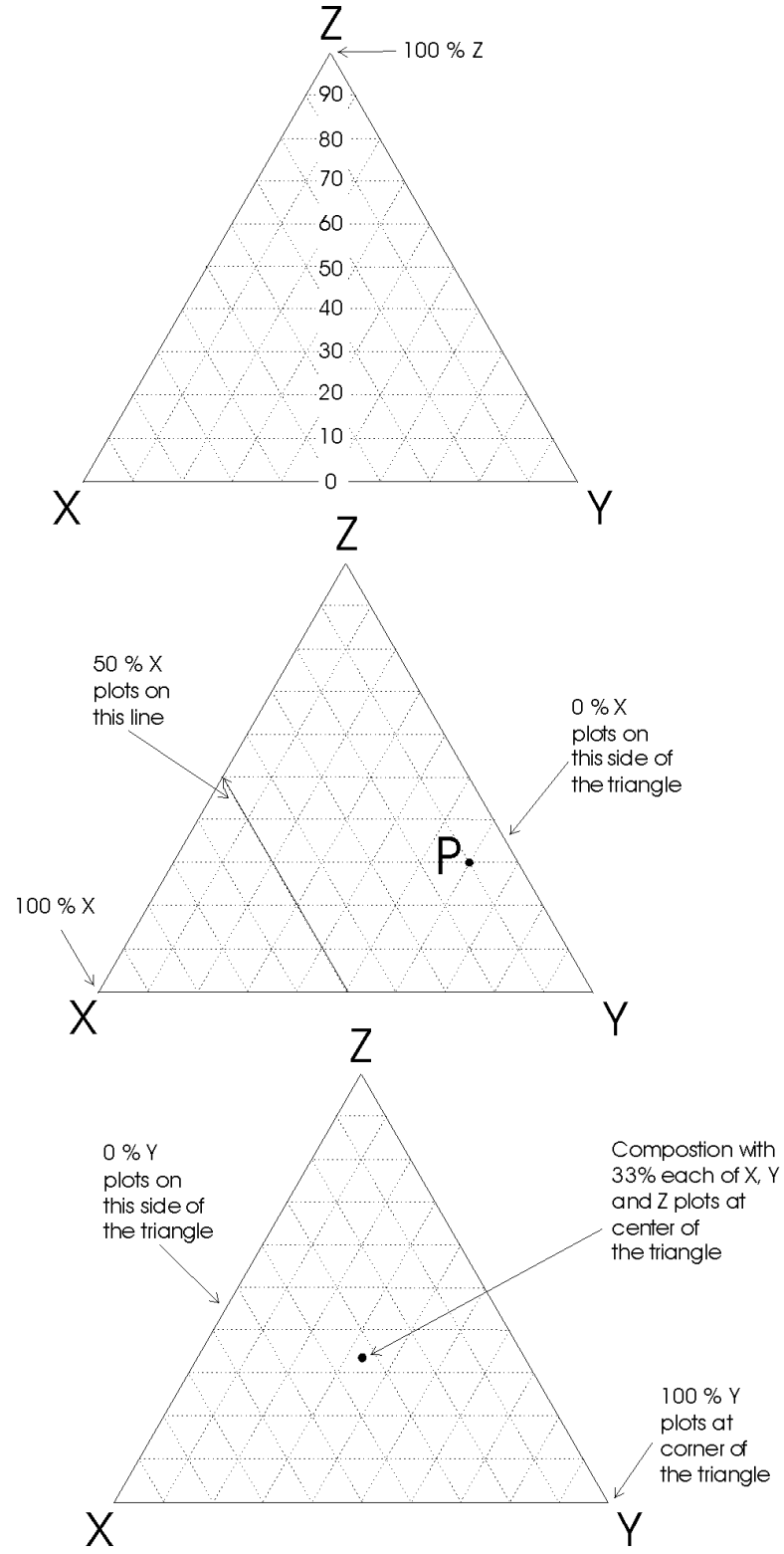
The drawings at the right show triangles for hypothetical components X, Y and Z.

The top drawing shows horizontal lines indicating the amount (%) of Z present. 0% on the bottom edge of the triangle. 100% at the top (Z) apex.

Diagonal lines show the amounts of X and Y. Northwest-southeast diagonals for X and southwest-northeast diagonals for Y. The composition at point P, therefore, is 10% X, 60% Y, and 30% Z.

Note that if a composition has 0% of one component (X, for example) it must plot on the side delineated by the other two components (Y-Z side if there is 0% X).

Of course if a composition has equal amounts of X, Y and Z, it plots right in the middle of the triangle, as shown on the bottom drawing.



An Alternative Way to Plot Compositions

Often we do not have the grid lines. Say for example we wish to plot the composition of bredigite ($Ca_7MgSi_4O_{16}$) on the CaO-MgO-SiO_2 diagram below.

We start by observing that bredigite = $Ca_7MgSi_4O_{16}$ = 7CaO + 1MgO + 4SiO_2.

So, the ratio of MgO/MgO+CaO = 1/8 = 12%.
The ratio of MgO/MgO+SiO_2 = 1/5 = 20%.
And the ratio of CaO/CaO+SiO_2 = 7/11 = 64%.

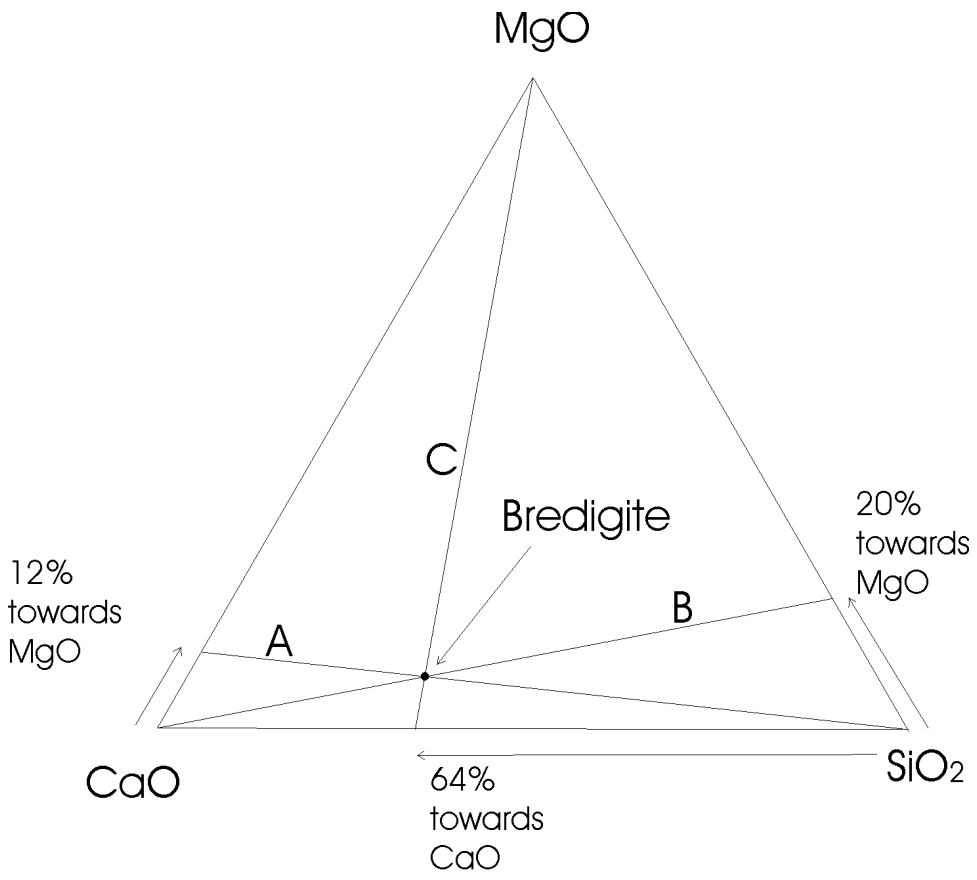
We use the percentages to draw the lines labeled A, B, and C to plot bredigite's composition. (We really only need two of lines, but the third acts as a check to see if we did it correctly.)

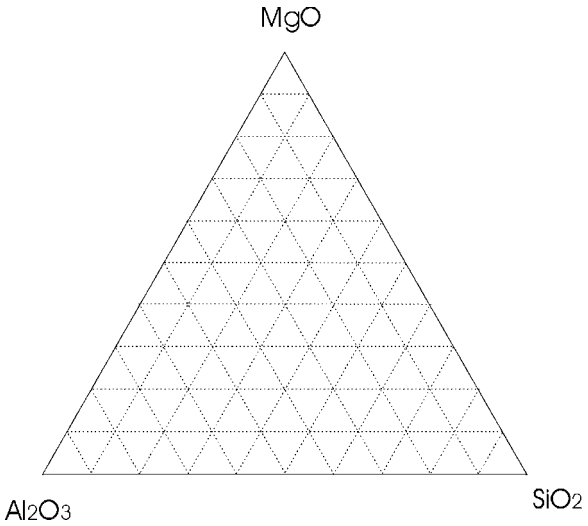
All compositions for which MgO/MgO+CaO = 1/8 = 12% must plot on line A.

All compositions for which MgO/MgO+SiO_2 = 1/5 = 20% must plot on line B.

And all compositions for which CaO/CaO+SiO_2 = 7/11 = 64% must plot on line C.

So, the three lines intersect at the composition of bredigite.



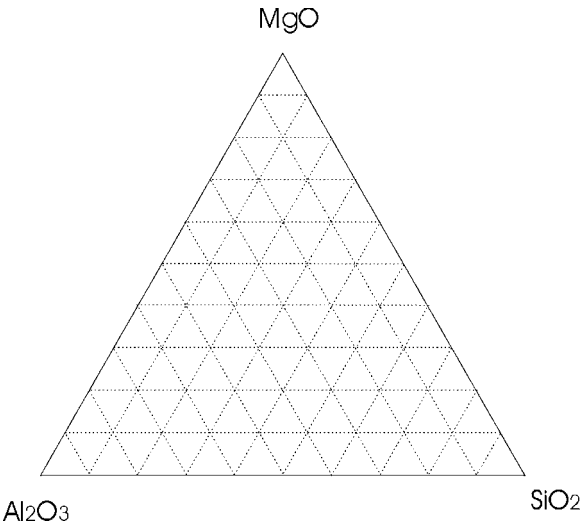


Question 2.1 - On the triangle to the left, plot the following compositions (and be sure to make it clear which point is which composition):

MgO
Al_2O_3
$MgAl_2O_4$

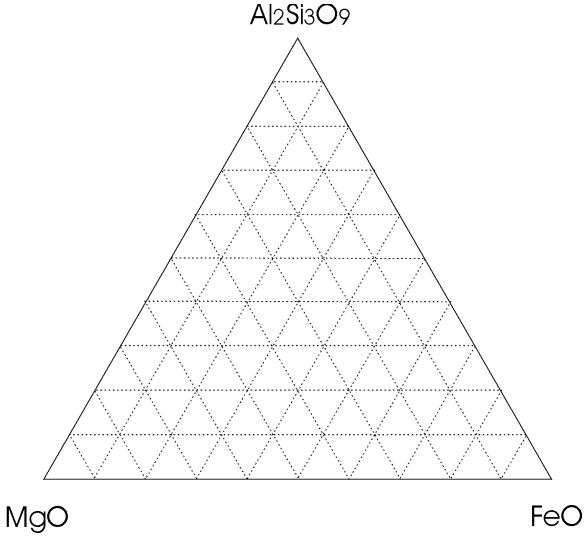
If you plot the three correctly, you will be able to draw a line through all three points. This is because all three minerals belong to the binary system MgO-Al_2O_3. That binary is included within the Mg-Al-O ternary. So, remembering what we did in the first part of this handout, we can write the reaction:

$MgO + Al_2O_3 = MgAl_2O_4$



Question 2.2 - On the triangle to the left, plot the following compositions:

MgO
Al_2O_3
$MgSiO_3$
$Mg_3Al_2Si_3O_{12}$



Question 2.3 - On the triangle at the left, plot the composition of almandine and of pyrope. (You may not like the composition at the top apex, but it works just as well as any other.) Natural garnets are often mixtures of these two end members. Where on the triangular diagram do such mixtures plot?

Question 2.4 - All the compositions given on this page have mineral names. For extra credit, what are the mineral names?

Question 2.5 - On the triangular diagram below, plot the following compositions (without adding percentage grid lines - use the alternative plotting method):

wollastonite ($CaSiO_3$)
anorthite ($CaAl_2Si_2O_8$)
gehlenite ($Ca_2Al_2SiO_7$)
CaTs (a pyroxene with composition $CaAl_2SiO_6$)
quartz (SiO_2)