Crystallization and Melting of Diopside - Anorthite

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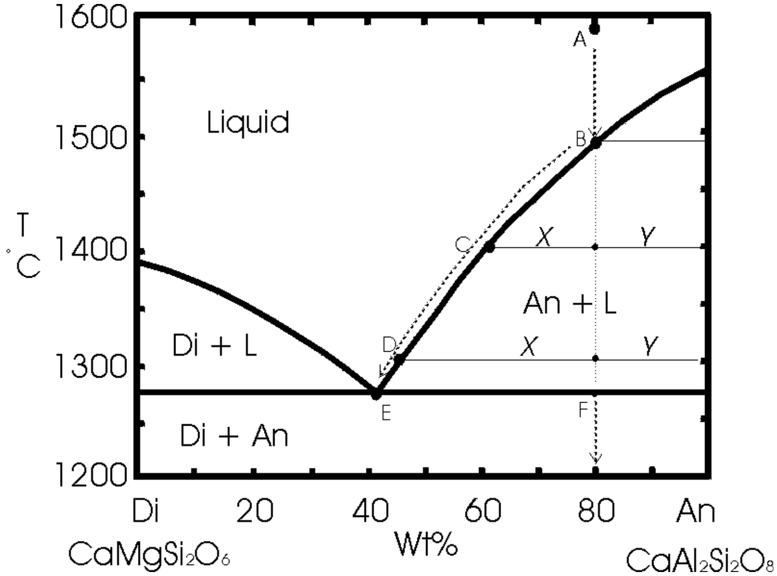
Crystallization



The diagram at left shows what happens to a liquid of composition A as it cools. Composition A is about 80% $CaAl_2Si_2O_8$ - 20% $CaMgSi_2O_6$, abbreviated $An_{80}Di_{20}$.

At point B, about 1490°C, the first crystals (of anorthite) begin to crystallize. Temperature continues to get lower and anorthite continues to crystallize.

As more and more anorthite crystallizes, the liquid composition becomes depleted in $CaAl_2Si_2O_8$ and thus richer in $CaMgSi_2O_6$. It follows the path B=>C=>D=>E as it cools. This is a type of <u>continuous reaction</u> because cooling continues as temperature falls.

E is called the eutectic point. Point E represents the temperature (about 1275 °C) and composition ($An_{42}Di_{58}$) of the last drop of liquid.

When the temperature reaches the eutectic, diopside (finally) begins to crystallize along with the anorthite. The two crystallize together and the temperature will not drop below 1275 °C (the eutectic temperature) until all the liquid is gone. We call this a <u>discontinuous reaction</u> (because cooling stops until the liquid is gone). Above the eutectic, all crystals are anorthite. Now, as diopside and anorthite crystallize together, the ratio of anorthite to diopside decreases from 100:0 until it finally reaches 80:20, the composition of the original melt (point F). Further cooling leads to no more changes.

Note that the % of crystals (compared to the total amount of crystals plus melt) at any temperature can be calculated using the length of line segments *X* and *Y*. The % of crystals = 100 $X/(X+Y)$ (lever rule). At 1490 °C (point B) it is 0% (because crystallization is just beginning). At 1400 °C (point C) the amount of crystals is about 50%; at 1300 °C (point D) it is about 65%, and as temperature reaches the eutectic it is about 70%.

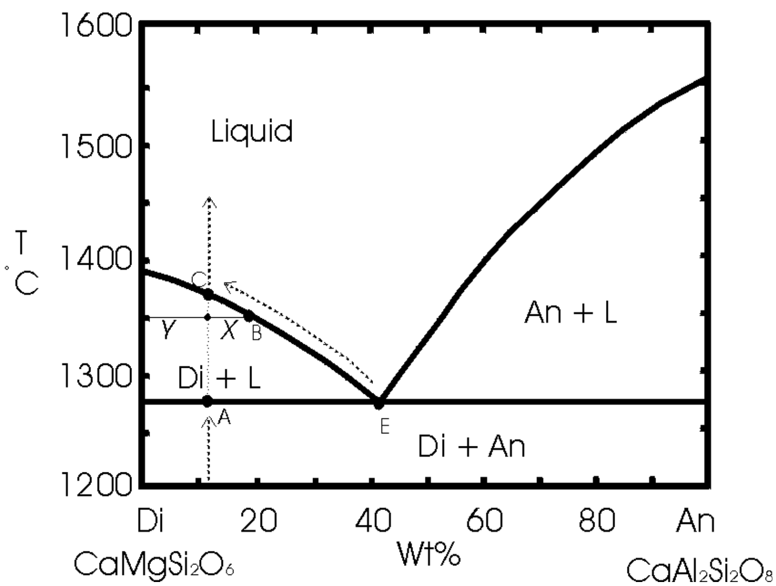
1. Suppose you have a melt of composition $An_{90}Di_{10}$.

When it cools, at what temperature will it become half crystals and half melt?

What will the composition of the crystals be at that temperature?

What will the composition of the melt be at that temperature?

Melting



Melting relationships are just the opposite of those described above.

Consider a rock that contains 12% anorthite and 88% diopside. If we heat it, melting commences at point A, about 1275 ^{o}C (equal to the eutectic temperture). The first liquid has the composition of the eutectic (point E). It forms as anorthite and diopside melt together. Temperature will not rise above 1275 ^{o}C until all the anorthite has melted.

Above the eutectic temperature, the composition of the melt changes from E==>B==>C.

At point C, about 1375 ^{o}C, all the crystals are gone, and the melt has the same composition as the original rock.

Note that the lever rule still applies. At temperatures between the eutectic and point C, the ratio of melt to solid is Y:X. The % crystals is 100 $X/(X+Y)$.

2. Suppose you have a rock that is 90% anorthite and 10% diopside. You heat it up.

At what temperature will it begin to melt?

What will be the composition of the melt?

What happens as you continue to add heat?

What will you have when the temperature reaches 1300 ^{o}C? (Be specific about ratio crystals:melt. Also, specify the compositions of the melt and crystals.)

What will you have when the temperature reaches 1400 ^{o}C?

What will you have when the temperature reaches 1500 ^{o}C?

What will you have when the temperature reaches 1600 ^{o}C?