

12.104 Using Phase Diagrams

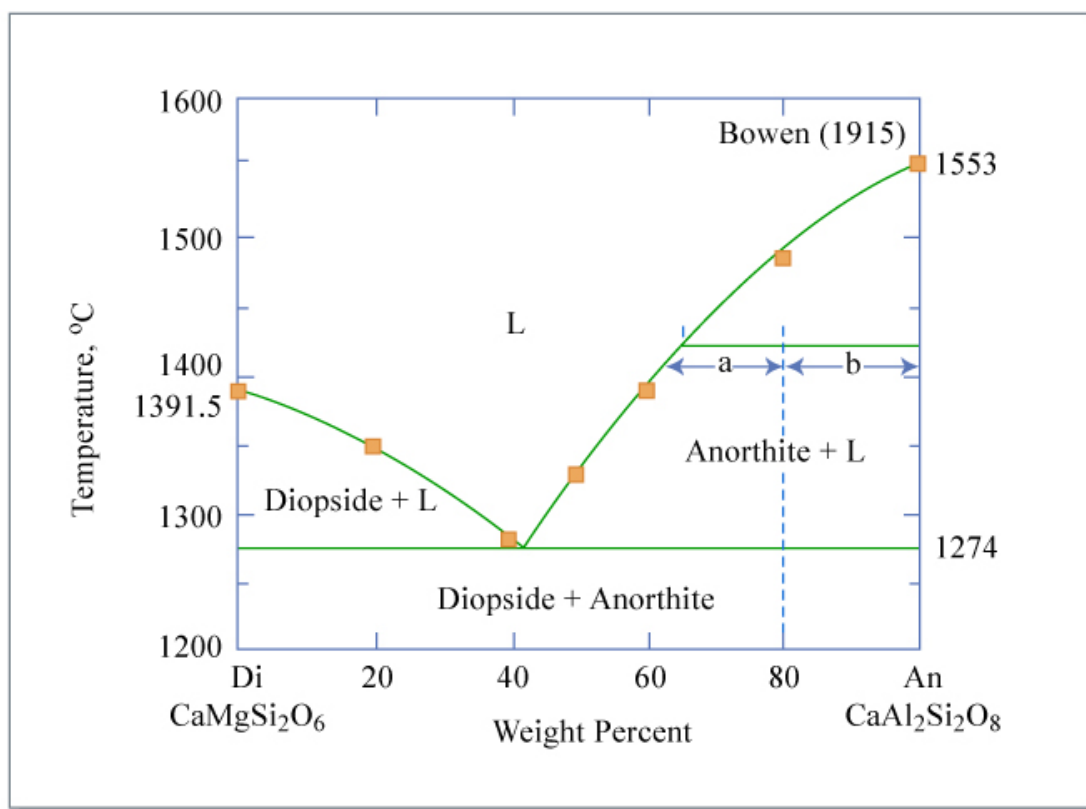
Some useful terminology:

Liquidus – region above which liquid is the only stable phase for the entire system

Solidus – region below which solids are the only stable phases in the system

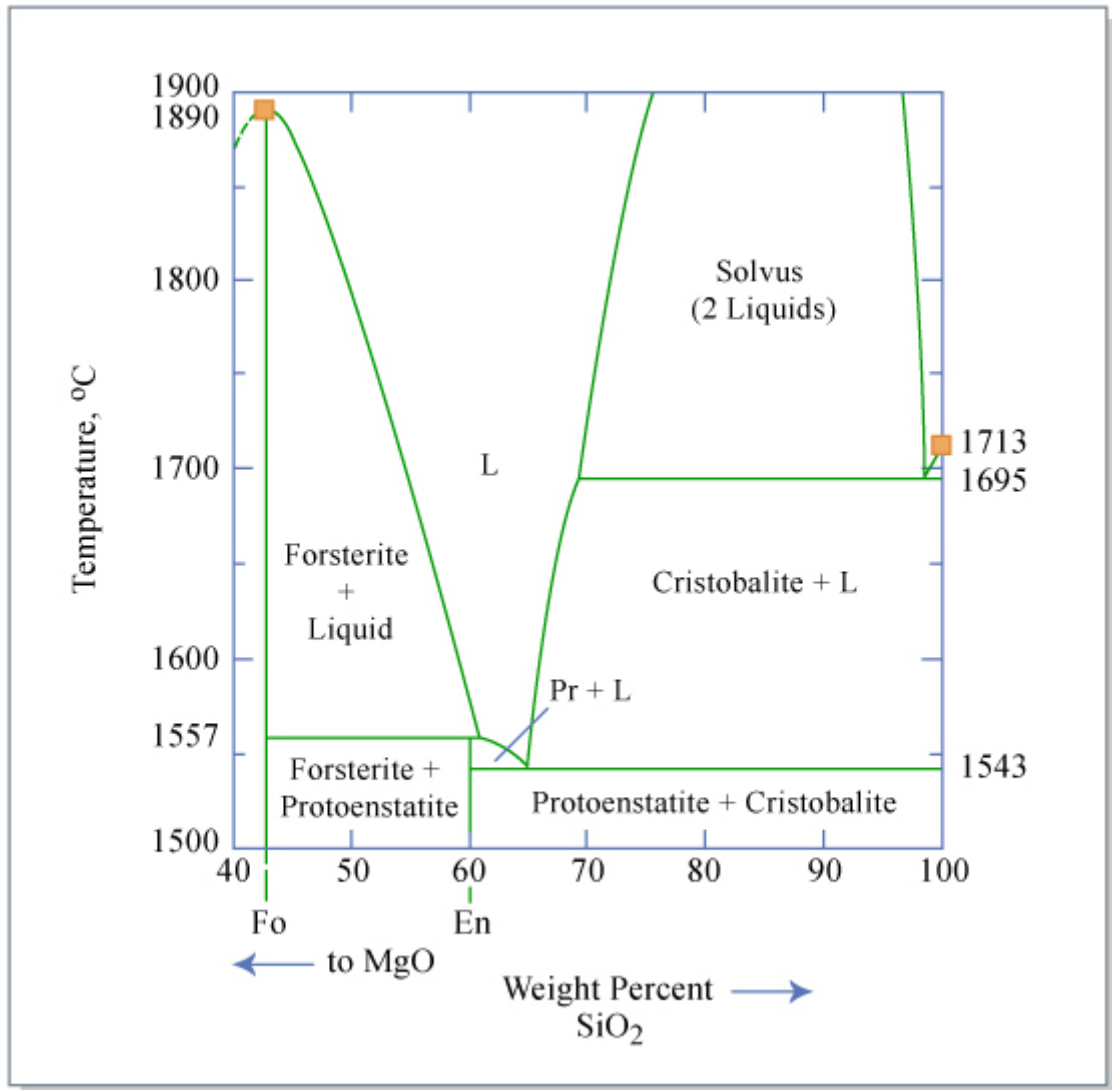
The lever rule – For a given bulk composition you use the lever rule to calculate the amount of the phase that will be present in a two-phase assemblage. For the example below, $b/(a+b) = \% \text{ liquid}$ and $a/(a+b) = \% \text{ anorthite}$.

Binary system with a eutectic



This is an example of congruent melting. The idea is that the two things melt to some intermediate composition, but you need to know the phase diagram or the thermodynamic properties to determine the composition of the melt. Eutectic means “occurring together.”

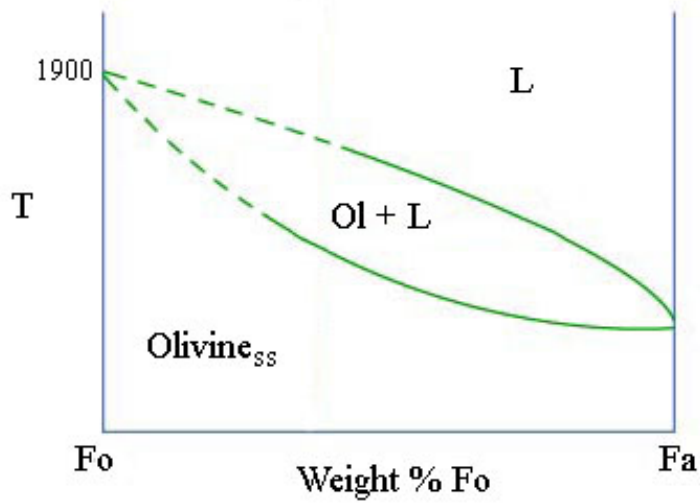
System showing incongruent melting



In this system, enstatite melts incongruently to forsterite and liquid. This type of melting reaction is called a peritectic reaction. Peritectic means “built around”.

A peritectic is not a point terminal to the coexistence of liquid and crystals. Instead, one of the solids disappears. This type of reaction is also referred to as a discontinuous reaction, because one of the solid phases reacts out.

System showing continuous solid solution

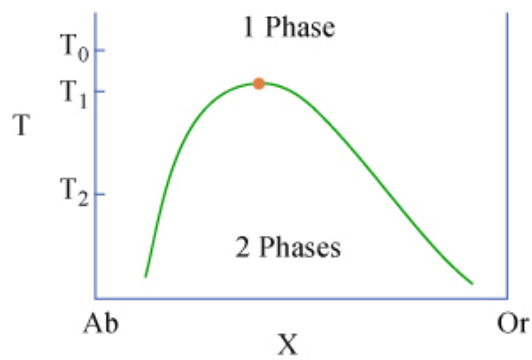


A continuous change in compositions of crystal and coexisting liquid occurs with decreasing temperature.

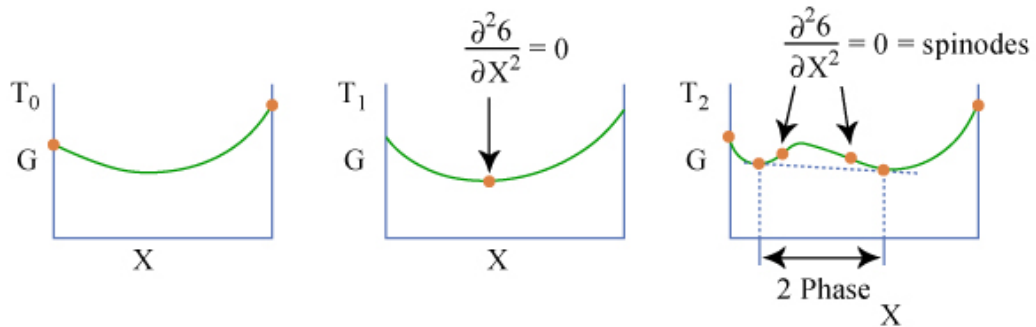
More on 2 component Systems

Solution exhibiting critical behavior – solvus
Miscibility gaps

More on 2 Component Systems



Solution
exhibiting critical behavior
- Solvus



Several mineral solutions exhibit this behavior –

Alkali feldspars $\text{KAlSi}_3\text{O}_8 - \text{NaAlSi}_3\text{O}_8$

Orthoclase - Albite

Pyroxenes $\text{MgSiO}_3 - \text{FeSiO}_3 - \text{CaSiO}_3$

Feldspathoids $\text{KAlSiO}_4 - \text{NaAlSiO}_4$

Kalsilite – Nepheline

Methods of Melting

Batch melting – an equilibrium process – a bulk composition is raised to a specific temperature above its solidus, the system comes to equilibrium, and the melt is removed.

Fractional fusion – the opposite of fractional crystallization – melt is removed from contact with solid residue as it is produced.

Continuous melting with incomplete melt withdrawal – in this case, melt is generated by partial melting, then some of the melt is removed, but some is left in contact with the solid residue.

In both the fractional fusion and continuous melting with incomplete melt withdrawal cases, the composition of the residue changes continuously as melt is withdrawn.

Fractional Crystallization

Types of fractional crystallization

Perfect fractionation – Crystals are removed from contact with melt as soon as they are formed.

Overgrowth zoning fractionation – Crystal grows from melt and overgrown rims on crystals remove the interior of the crystal from reaction with the melt. The extent to which this process can occur will be governed by diffusion rates in the crystal, because these rates are generally much slower than diffusion in the liquid.

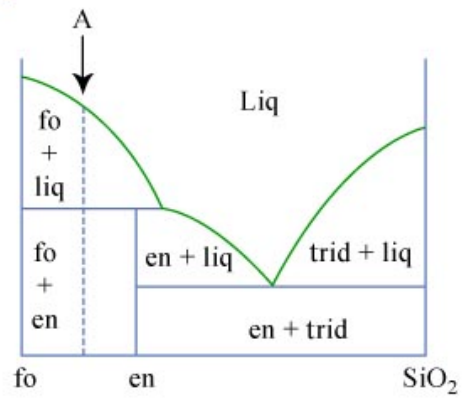
In contrast, during equilibrium crystallization, crystals and liquid continually react.

Some examples – In ex. 1, composition A (under equilibrium conditions) crystallizes completely to Fo and En at the reaction point. All liquid is used up in reacting Fo + liq → En. Under conditions of fractionation, liquid can reach the En + Trid eutectic.

In ex. 2 (under equilibrium conditions), composition A crystallizes initial feldspar B. The plagioclase and the liquid change composition continually as temperature drops until the liquid reaches C and the feldspar reaches A. Here all liquid is used up and we are left with a homogenous solid with composition A.

For fractionation, feldspar is removed from contact with liquid and zoning develops. The liquid can evolve to pure albite residue.

Example 1



Example 2

