Lecture 8  More on Binary Systems

Friday, February 11th, 2005

Binary Peritectic Systems
Two components but three phases
enstatite = forsterite + SiO₂

In this system in addition to the eutectic there is a second inflection on the liquidus the peritectic. This means that under equilibrium conditions quartz could never co-exist with forsterite. They would react to produce enstatite.

Figure 6-12. Isobaric T-X phase diagram of the system Fo-Silica at 0.1 MPa. After Bowen and Anderson (1914) and Grieg (1927), Amer. J. Sci.
C. Binary Peritectic Systems

Cooling of liquid (a) results in the crystallization of cristobolite (point b) at 1550°C. Further cooling leads to crystallization of cristobolite (e) and enstatite (d) at the eutectic (c).

Liquid (f) cools to (g) at which point forsterite (h) begins to crystallize. Continuing forsterite crystallization leads to liquid (i) at the peritectic and forsterite (j) is joined by enstatite (k). With continuing crystallization the liquid remains at (i) at 1557°C (WHY?). Olivine reacts with the liquid producing enstatite (k). Eventually the liquid is exhausted leaving a mixture of olivine and enstatite.

Figure 6-12. Isobaric T-X phase diagram of the system Fo-SiO\textsubscript{2} at 0.1 MPa. After Bowen and Anderson (1914) and Grieg (1927). Amer. J. Sci.
\( i \) = “peritectic” point
1557°C have co-linear Fo-En-liq
• geometry indicates a reaction: Fo + liq = En
• consumes olivine (and liquid) \( \rightarrow \) resorbed textures

When is the reaction finished?

Here olivine has reacted with the liquid and is being rimmed by replacement enstatite
Incongruent Melting of Enstatite

- Melt of En does not $\rightarrow$ melt of same composition
- Rather En $\rightarrow$ Fo + Liq i at the peritectic

Partial Melting of Fo + En (harzburgite) mantle

- En + Fo also $\rightarrow$ first liq = i
- Remove i and cool
- Result = ?
Cool $X = n$  

**Immiscible Liquids**

- At 1960°C hit solvus exsolution
  \[ \rightarrow 2 \text{ liquids } o \text{ and } p \]
- $\phi = 2$  \( F = 1 \)
  
  both liquids follow solvus

**At 1695°C get Crst also**

<table>
<thead>
<tr>
<th>Reaction?</th>
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<tbody>
<tr>
<td>1695</td>
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<tr>
<td>Crst</td>
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<tr>
<td>Mafic-rich liquid</td>
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**Pressure Effects**

Different phases have different compressibilities

Thus $P$ will change Gibbs Free Energy differentially

- Raises melting point
- Shift eutectic position (and thus $X$ of first melt, etc.)
D. Solid Solution with Eutectic:
Ab-Or (the alkali feldspars)

Eutectic liquidus minimum

Figure 6-16. T-X phase diagram of the system albite-orthoclase at 0.2 GPa H₂O pressure. After Bowen and Tuttle (1950). J. Geology.
Effect of $P_{\text{H}_2\text{O}}$ on Ab-Or

Figure 6-17. The Albite-K-feldspar system at various H$_2$O pressures. (a) and (b) after Bowen and Tuttle (1950), J. Geol, (c) after Morse (1970) J. Petrol.