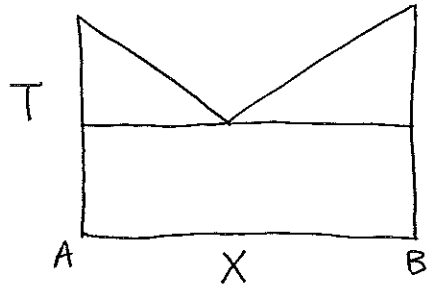
Difficulty Scale

1 10

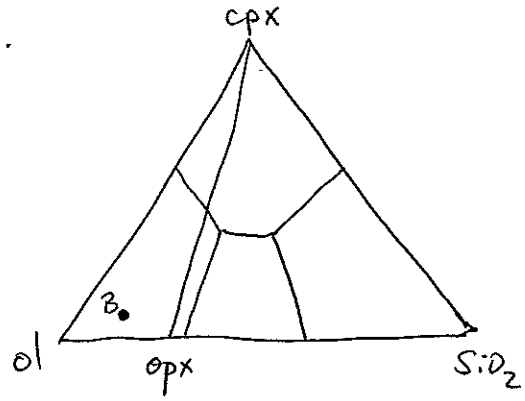
1. Consider the following phase diagram. ☺



① Label the eutectic

② Consider batch melting of a bulk composition that is fertile and one that is infertile. Draw their melting paths on this T-X diagram.

③ Plot (qualitatively) melt fraction as well as fraction of phase A and B as a function of temperature for a fertile and infertile bulk composition. How do they differ?

2. 

☺

Consider a peridotite with bulk composition B. Draw the melting relationship by showing how melt composition and mineral modes change as temperature increases

3. Consider a $K_{D(Fe^{2+}/Mg)} = \frac{(Fe^{2+}/Mg)_{OL}}{(Fe^{2+}/Mg)_{melt}} = 0.3$ for ☺ olivine melt.

① Calculate (show in a graph) how $Mg\# = \frac{Mg}{Mg+Fe}$ in the melt varies with Forsterite content of olivine it is in equilibrium with. Do it for different K_D to evaluate sensitivity

② What is the Mg# of melt in equilibrium with a mantle with Forsterite 89 olivine? What is the typical observed Mg# of mid-ocean ridge basalt?

3. (3) CONSIDER again $K_{D\,Fe^{2+}/Mg} \sim 0.3$

Now consider a melt with whole-rock $\frac{Mg}{Mg+Fe_T}$ of 0.72

where Fe_T refers to all Fe. If 30% of the Fe_T is Fe^{3+}, what would the Forsterite content of the olivine be. Make a plot of $\frac{Mg}{Mg+Fe_T}$ versus Fo for different $\frac{Fe_{3+}}{Fe_T}$.

4. For a closed system, an element is distributed btwn melt and solids as follows

$$\frac{C_L}{C_0} = \frac{1}{F+D(1-F)} \qquad \frac{C_S}{C_0} = \frac{D}{F+D(1-F)}$$

where C_0 = composition of bulk system

C_L = conc. in liquid

C_S = conc. in solid

D = solid/liquid partition coefficient.

F = liquid fraction

Convince yourself that the above equation is correct

Show that $$\frac{(C_{Fe}/C_{Mg})_L}{(C_{Fe}/C_{Mg})_0} = \frac{F + D_{Mg}(1-F)}{F + D_{Fe}(1-F)}$$

Show that $$\frac{(C_{Fe}/C_{Mg})_S}{(C_{Fe}/C_{Mg})_0} = K_{D(Fe/Mg)} \cdot (C_{Fe}/C_{Mg})_L$$

Here, we will assume that for a peridotite, composed of opx, cpx, ol ... the $K_{DS(Fe/Mg)}$ of these phases are all ~0.3

Using $D_{Mg\ ol/L}$ and $D_{Fe\ ol/L}$ from Roeder + Emslie as a function of T, and combining with the previous equations, show how Fe and Mg in a melt vary with T, F. D_o same for peridotite residue.

assume MgO_o = 38% by weight
FeO_o = 8% by weight
no Fe^{3+} for simplicity.

plot FeO vs MgO contoured for T, and F.
Discuss. *** note that we have made some approximations

5. MELTS THERMODYNAMIC PROGRAM

Pick a primitive mantle major element composition (McDonough+Sun 1995)
At 1 GPa, conduct a batch melting "experiment"
Use fO_2 at FMQ buffer

1. estimate solidus and liquidus T at 1 GPa
2. Plot phase proportions as a function of T
3. plot chemistry of melt as a fcn of T
4. Plot bulk chemistry of solids as fcn of T
5. PLOT olivine Fo as function of T and F.