

GLY261 Igneous Petrology practical 2: Phase Diagrams refresher (MEMO)

Note that my lines are sometimes a little inexact- blame Word. Approximate values are then used

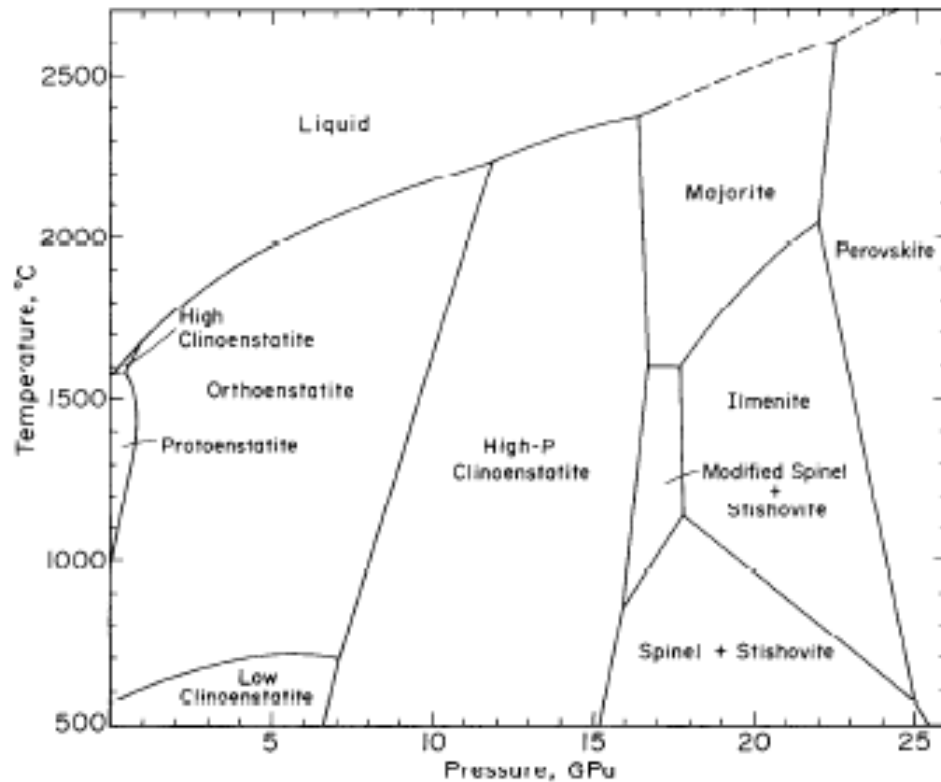


Fig. 8. Isopleth for the composition MgSiO_3 [7. 9. 35. 45. 56. 57. 65. 76. 92. 127. 140. 169]. For additional data at pressures above 15 GPa, see also Sawamoto [147]. Not shown is a singular point at about 0.13 GPa below which enstatite melts incongruently to forsterite + liquid [45]. Position of dashed curve is inferred. For additional data on melting temperatures up to 58 GPa, see Zerr and Boehler [177].

1. Consult the accompanying P-T diagram for MgSiO_3 .
 - a) If the upper mantle has temperatures of 1200 -1500 degrees C, and pressures of 17- 22 GPa, what is the stable Mg-silicate? Ilmenite
 - b) How does this differ from the conditions in a subducted slab at 10-15 GPa and upper mantle temperatures? Stable Mg form is clino-enstatite in subducted slab
 - c) What is the lowest T at which a Mg-silicate liquid can exist? 1600 deg C
 - d) What is the lowest P at which a Mg-silicate liquid can exist? 0 GPa
 - e) Perovskite exists in some mantle xenoliths. Where would these xenoliths originate from? Xenoliths must come from deeper in the mantle than the Upper Mantle- need higher T and P

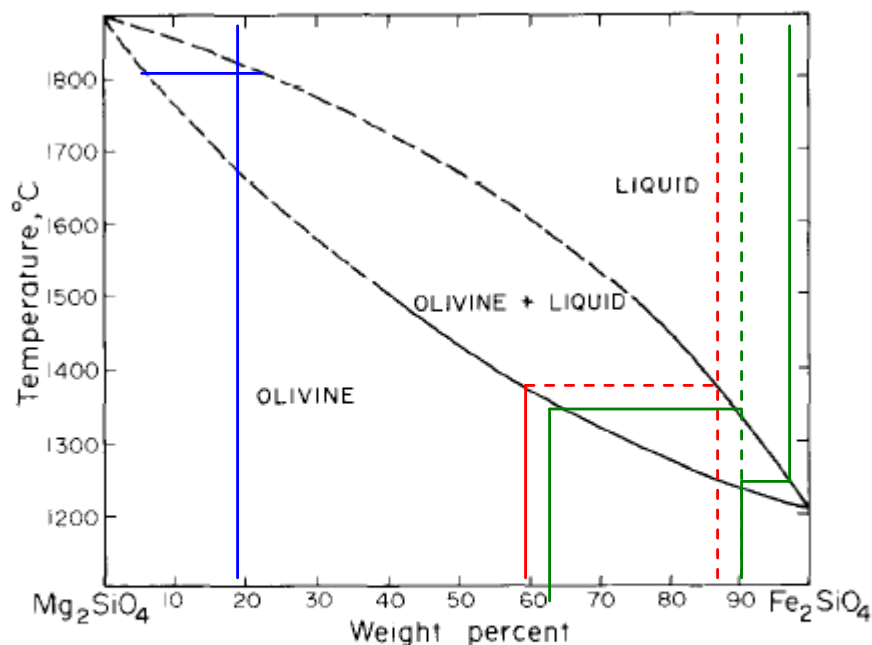


Fig. 15. Phase relationships for the system Mg_2SiO_4 (forsterite) - Fe_2SiO_4 (fayalite) in equilibrium with Fe at 1 atm [27]. Locations of dashed lines are inferred.

2. Consult the accompanying phase diagram for olivine.
 - a) If the first olivine crystals to form have a composition of 40% Fo, what was the original magma composition? 88% Fa (12% Fo)
 - b) If a magma started with 80% Fo, but only 20% liquid crystallized before the magma reached the surface and underwent quench cooling, what composition will the olivine crystals in the resulting rock have? How much glass will be present? 80% glass will be present. Crystals will be approximately Fo 8-10%
 - c) A dunite consisting of olivine crystals with a composition of 10% Fo. This rock experiences heating in a subduction zone. What is the composition of the first liquid to form? What will be the composition of the last crystals to melt? First liquid will be approximately 98% Fa (2% Fo) in composition. Final crystals to melt will be approximately Fa 65% in composition

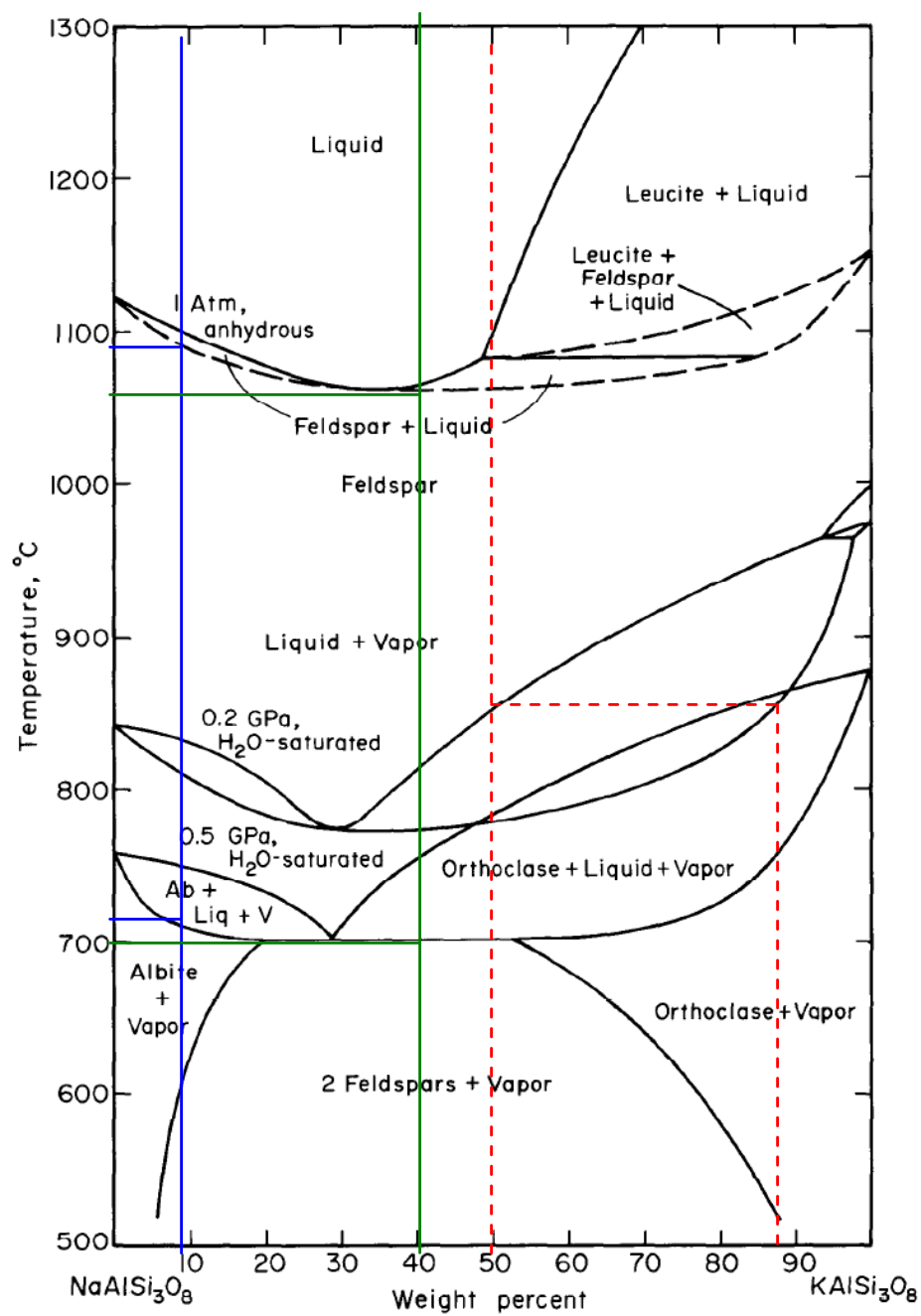


Fig. 7. Temperature-composition sections for the join NaAlSi₃O₈ (albite) - KAlSi₃O₈ (orthoclase) under anhydrous conditions at 1 atm [148], and under H₂O-saturated conditions at 0.2 GPa [29] and 0.5 GPa [119, 175]. Ab, albite; Liq, liquid; V, vapor. Locations of dashed lines are inferred.

3. Consult the phase diagram for K-feldspars.

- a) A magma is at 1000 degrees C, and has a composition of 50% Or. If the magma is water saturated and at 0.2 GPa, what will be the composition of the first crystals formed? _____ **First crystals will be 85% Or**
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- b) A magma is at 1200 degrees C and has a composition of 10% Or. At what T will this magma be completely solid is it is anhydrous, or if it is water saturated and at 0.5GPa? _____ **Anhydrous: just below 1100 deg C. Water saturated: just above 700 deg C.**
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- c) We have a solid rock of composition 40% Or. If the rock is water-saturated, what temperature will the rock start to melt? If anhydrous, what T will the rock start to melt? _____ **Water saturated rock starts to melt at 700 degrees C. Anhydrous rock starts to melt at 1050 degrees C.**
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4. Consult the phase diagram for $\text{Mg}_2\text{SiO}_4\text{-SiO}_2$.

- a) What mineral is destroyed at the peritectic point? _____ **Forsterite**
- b) If a liquid of composition X crystallises, how much Fo will be present in the final rock? _____ **50% Fo**
- c) If a liquid of composition Y crystallises, how much Fo will be present in the final rock? _____ **0% Fo**
- d) If a liquid of composition Z crystallizes, how much Fo will be present in the final rock? _____ **0% Fo**
- e) How much Fo is destroyed during the crystallization of liquid X? _____ **Final amount of Fo = 50%. Amount at Peritectic is 57-60% Fo. Therefore, Final-Peritectic= amount destroyed= 10%**
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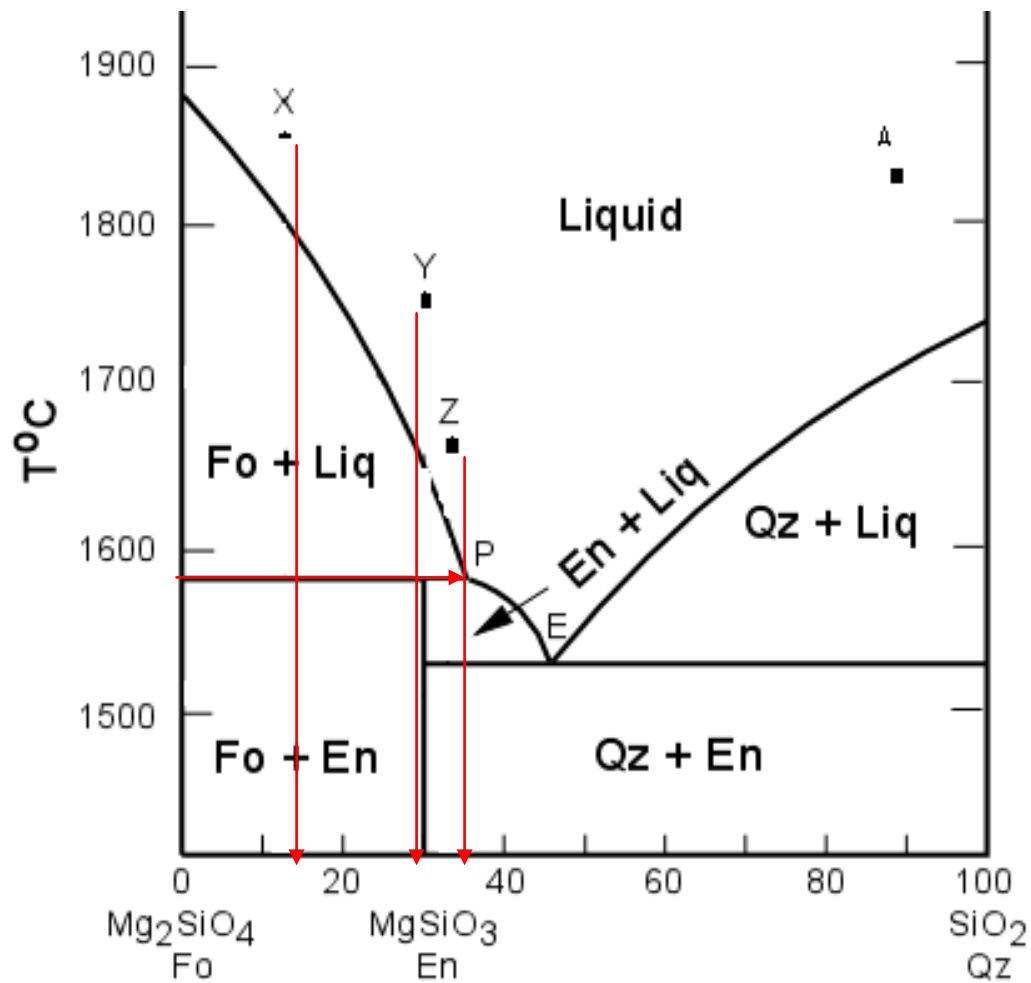
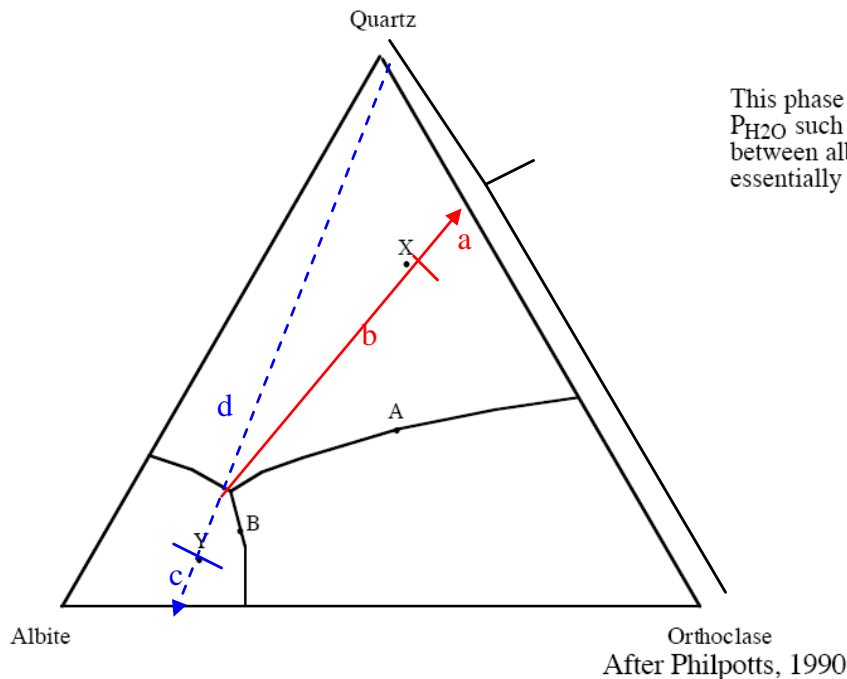


Figure 2

5. Consult the ternary diagram involving quartz, albite and orthoclase.

- What mineral crystallizes first from a magma of composition X? **Quartz**
- What mineral crystallizes 2nd? **Orthoclase**
- As the eutectic is reached, how much liquid is left in the system, and what are the relative amounts of crystals in the system? **Approx 20% liquid (a/(a+b)). Xtls consist of 25% Orthoclase and 75% Quartz**
- Consider composition Y. What crystallizes first? **Albite**
- How much quartz crystallizes at the eutectic for composition Y? **Final rock must have approx. 10% qtz (c/(c+d)). No qtz crystallizes before eutectic, therefore, 10% qtz must crystallize at eutectic.**

Q-Ab-Or system at high P_{H_2O}



This phase diagram is at high P_{H_2O} such that the relationship between albite and orthoclase is essentially a binary eutectic.

6. Consider the An-Fo-Qtz phase diagram

- Draw in your Alkemade line. Which two triangles does this line divide the diagram into? An-Fo-En and An-En-Qtz
- Which of the 3 liquids will contain Fo when fully crystallized? Liquid 2
- What is the sequence of crystallization for liquid 3? Fo, then Fo and En. Then Fo is destroyed while An and En crystallize at the peritectic. Then An and En form along the cotectic. Then Qtz, An and En crystallise at the eutectic.
- What is the sequence of crystallization for liquid 1? En, then En and An, then En, An, and Qtz.
- How much olivine is destroyed during the crystallization of liquid 2? Final rock must have approx. 60% Forsterite. At Peritectic, we have 10% liquid and 90% crystals. Ratio of Fo to En in crystals is 75% Fo, 25% En, so % Fo in system is $90\% \times 75\% = 67.5\%$. Therefore, Final-Peritectic= amount destroyed, so $60\% - 67.5\% = 7.5\%$ Fo destroyed.

