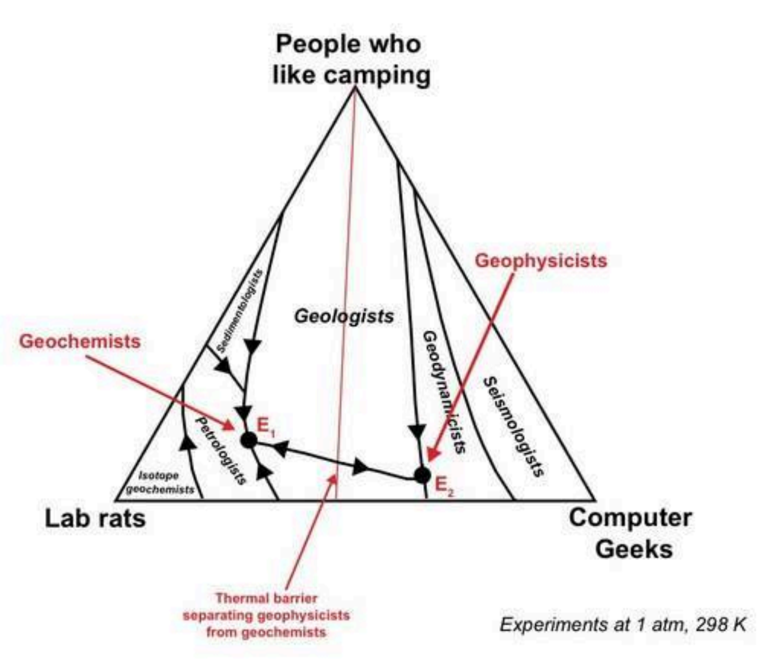
Sarah Lambart - 2016

LECTURE 10-12: THREE COMPONENT SYSTEMS



Recap Lecture 6-9

- Work at const. P $\Rightarrow$

Reduced Gibbs phase rule: $f = c + 1 - \Phi$

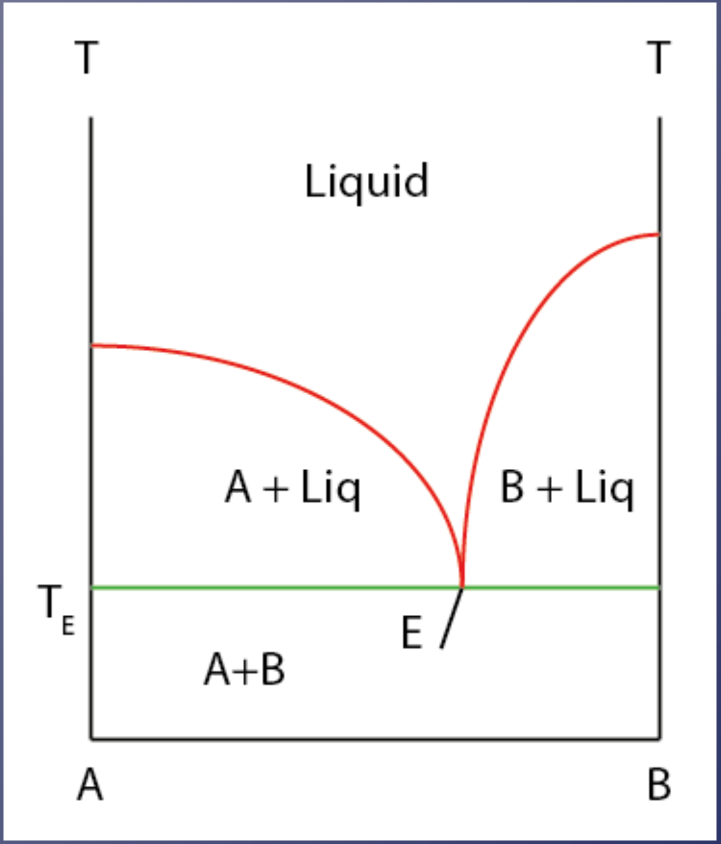
- Two component systems $\Rightarrow$ $\Phi_{max} = 3$

- 2 different cases:
  - System with eutectic
  - System with solid solution

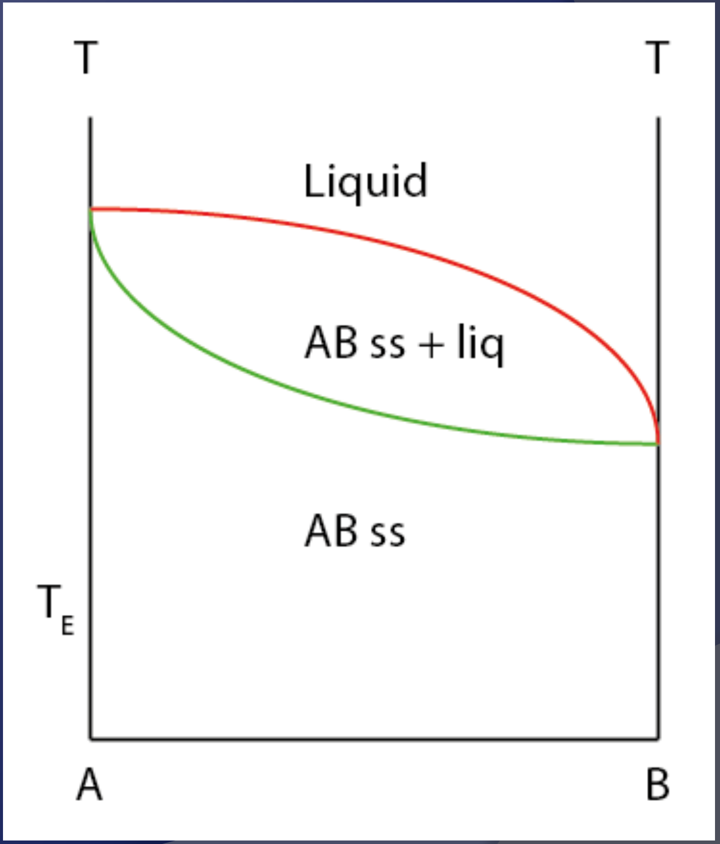
Note: most of the lecture material has been presented on board and is not included here

Recap Lecture 6-9

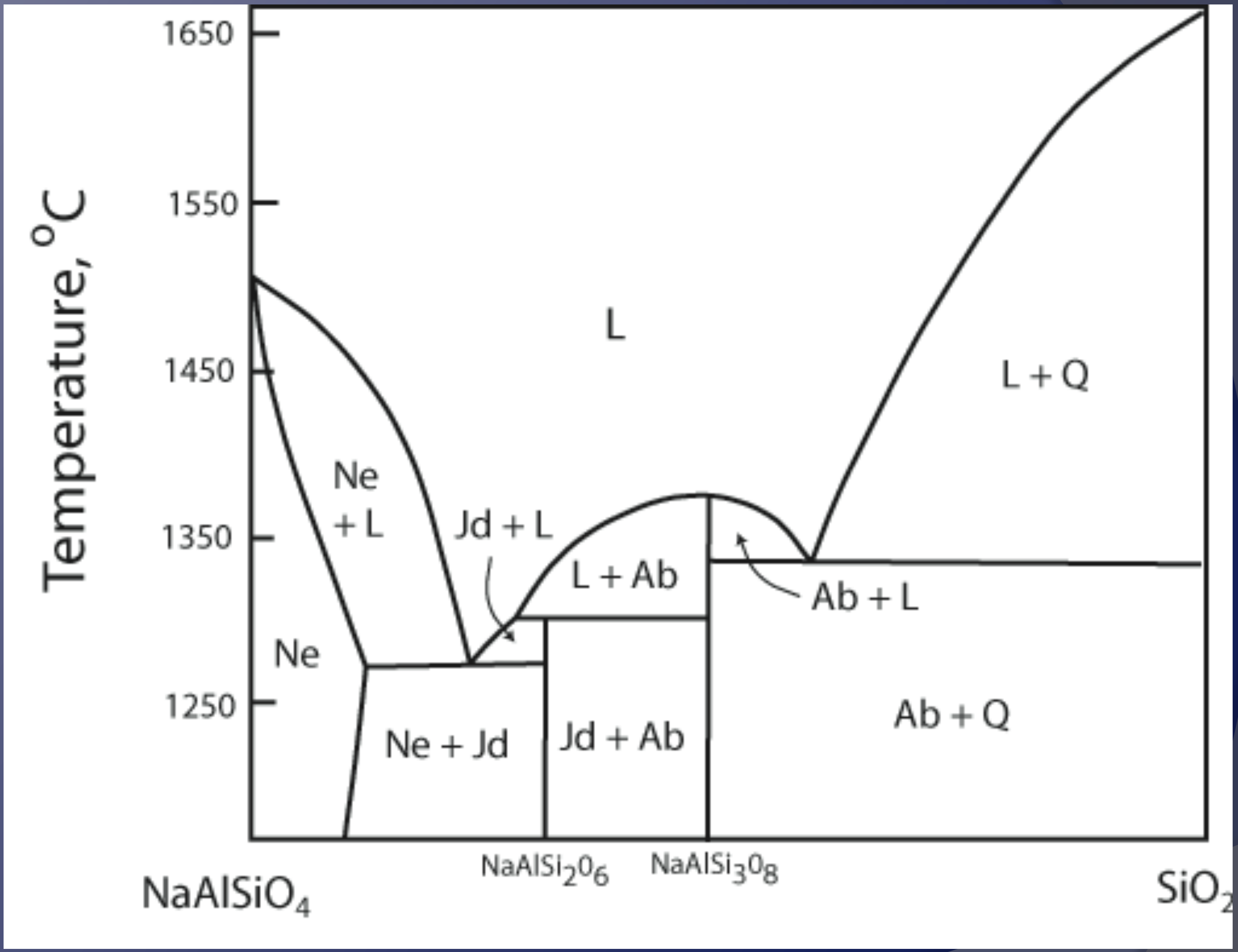
Syst. With Eutectic



Syst. With Solid solution



Recap Lecture 6-9



Recap Lecture 6-9 – Definitions (1/4)

Liquidus: separate the field with only liquid from the other fields

Solidus: separate the field with only solid phase(s) form the other fields

Eutectic point:

- separate the field with only solid phase(s) form the other fields
- lowest T at which liquid is stable
- Φ_{max} / invariant point

Lever rule: to calculate phase proportions

Recap Lecture 6-9 – Definitions (2/4)

Congruent melting: liquid has the same composition than the solid: $A_{solid} \rightarrow A_{liquid}$ (ex.: $Fo_{solid} \rightarrow Fo_{liquid}$)

Incongruent melting: solid melt into a liquid with NOT the same composition AND produce another solid: $A_{solid} \rightarrow B_{liquid} + C_{solid}$ (ex.: $En_{solid} \rightarrow Liq + Fo_{solid}$)

Peritectic point:

- Φ_{max} / invariant point
- reaction point: $A_{solid} \leftrightharpoons B_{liquid} + C_{solid}$

Intermediate compound: phase with intermediate composition

Recap Lecture 6-9 – Definitions (3/4)

Thermal divide: thermal maximum between two part of the same phase diagram – composition from one side of the phase diagram cannot produce melts (or solids) by melting (or crystallization) that plot on the other side. A thermal divide indicate the presence of a stable intermediate solid phase.

Solvus: separate two immiscible solids

Exsolution: subsolidus reaction: when a solution stable at high T becomes unstable at low T

Recap Lecture 6-9 – Definitions (4/4)

Equilibrium crystallization/melting: the solid phases and the melt stay together all along the process and reequilibrate at each step - the process is slow enough to allow this reequilibration (diffusion of the elements through the solid and the liquid) – the P/T path of the product of an equilibrium process is erased

Fractional crystallization/melting: the solid/liquid is instantaneously removed from the liquid/solid at each step – the extraction is fast enough for the solids and the melt to not reequilibrate – will generate “magmatic series”, i.e., a range of different compositions all produced by differentiation of the same bulk composition – the PT path can be reconstructed by looking at the compositional range.

Pressure effect

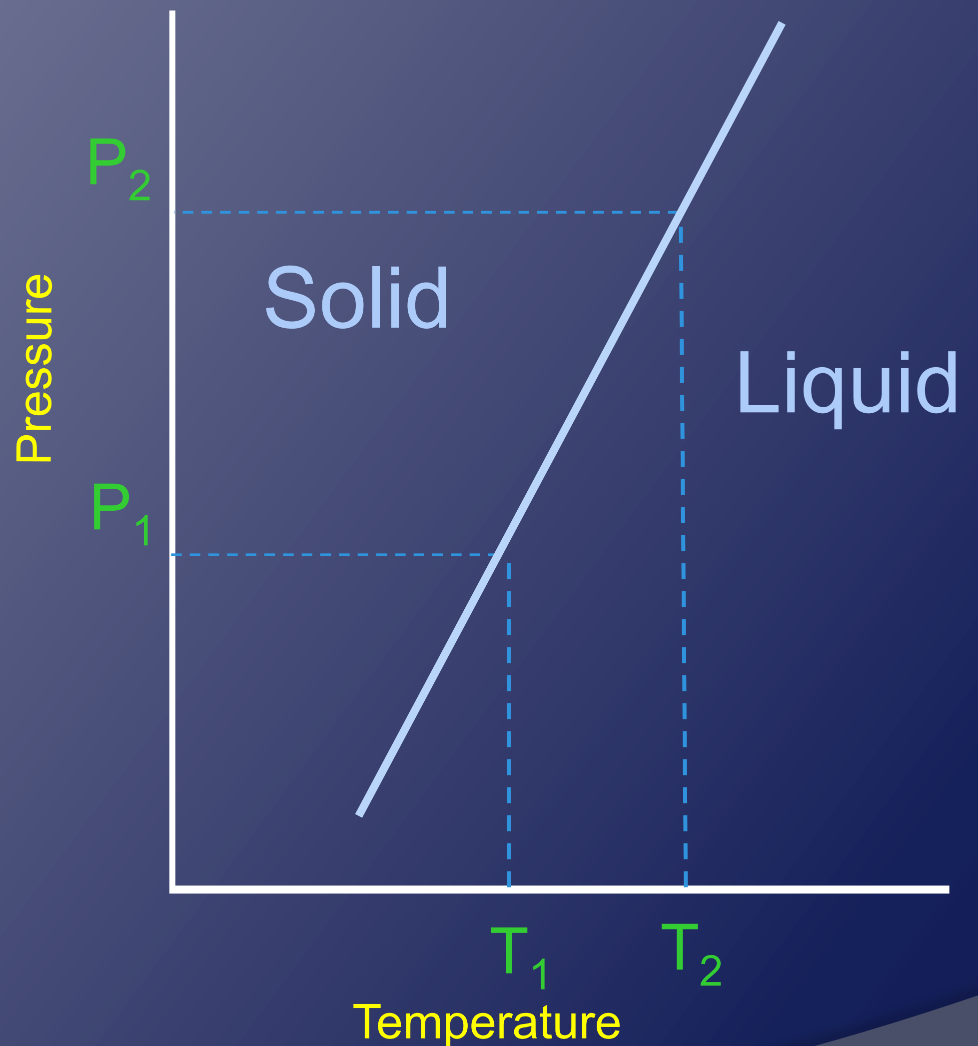


Fig. 7.15 Winters

Pressure effect

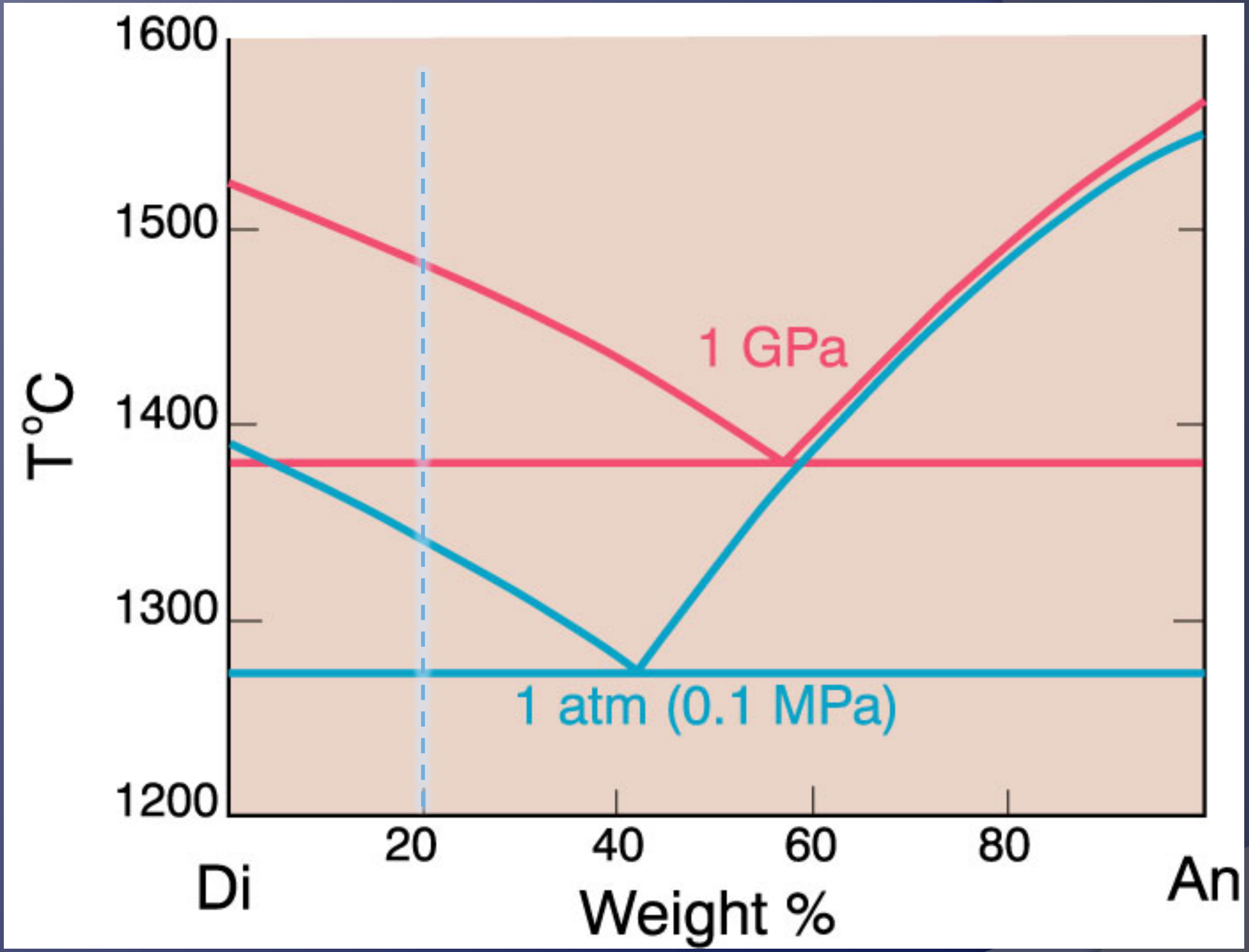


Fig. 7.16 Winters

Pressure effect

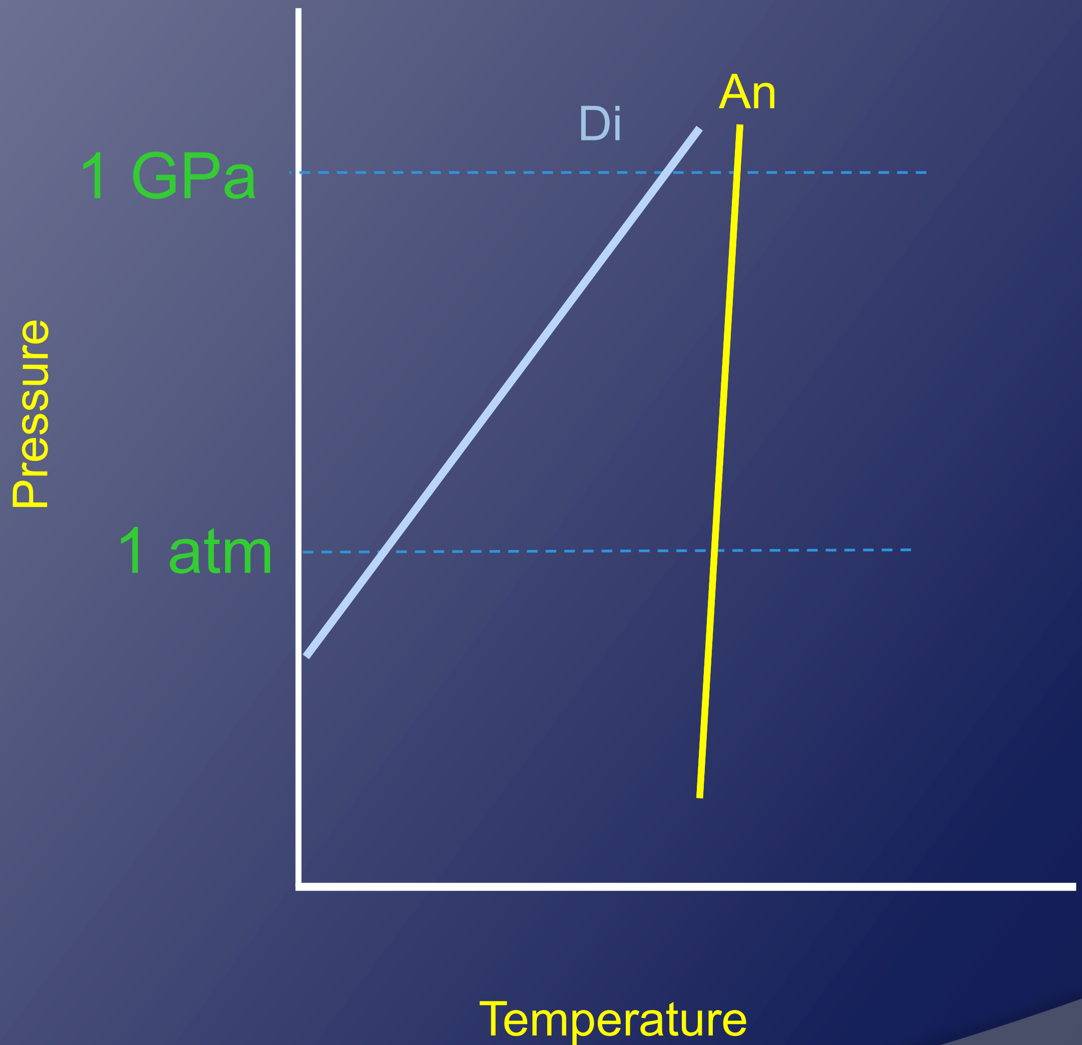
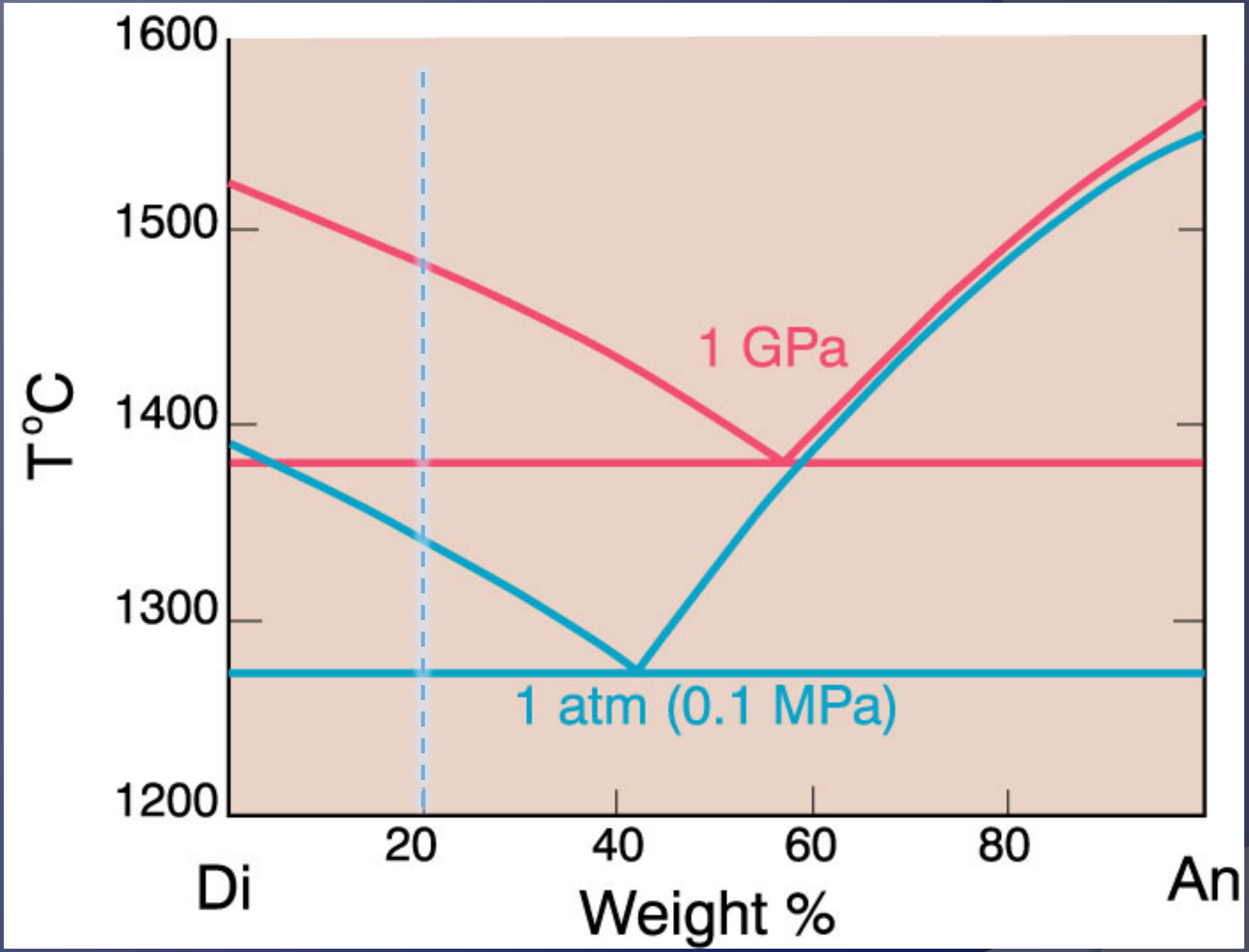


Fig. 7.15 Winters

Pressure effect



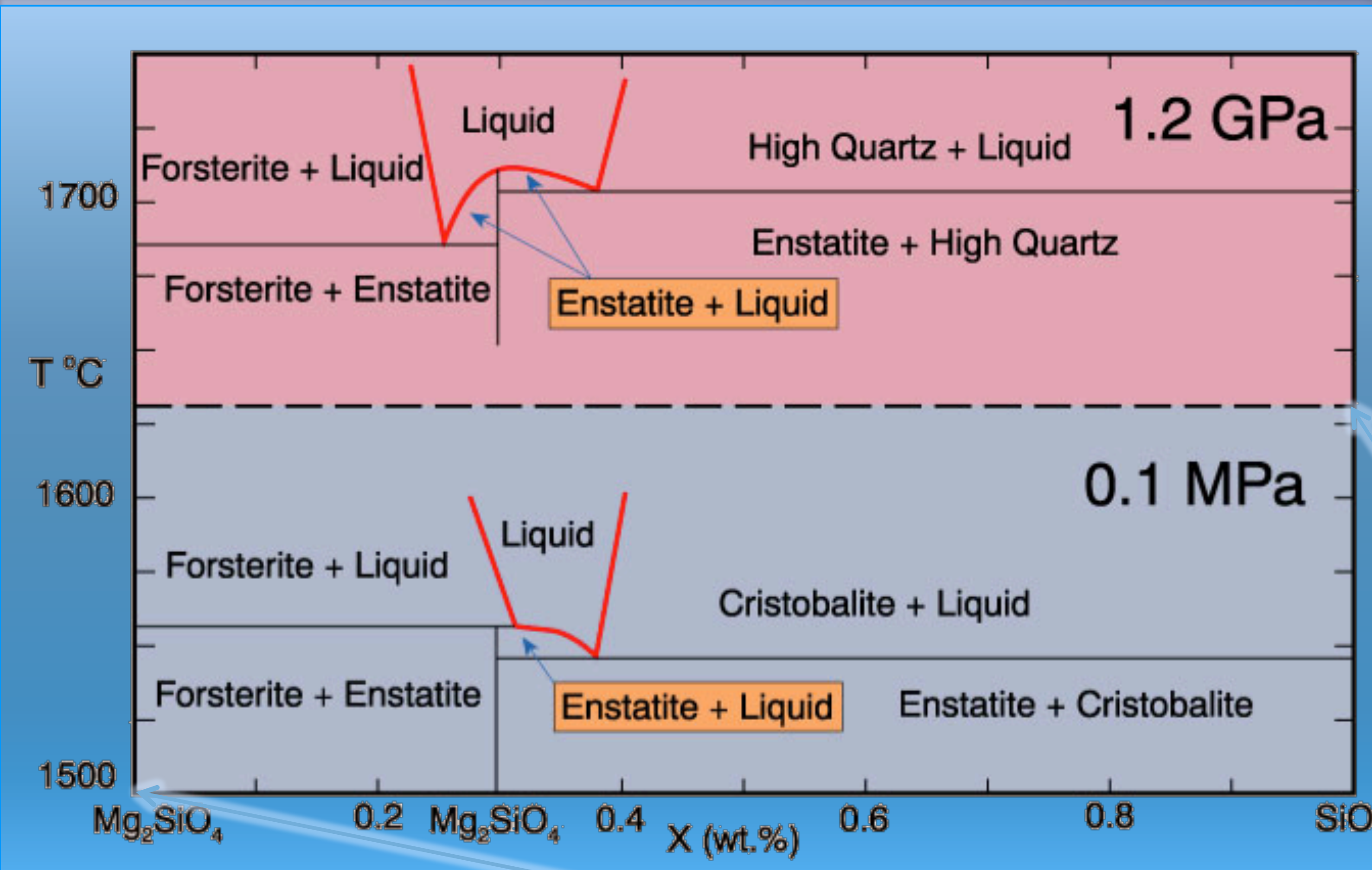
Increase of P ⇒ Increase of melting T

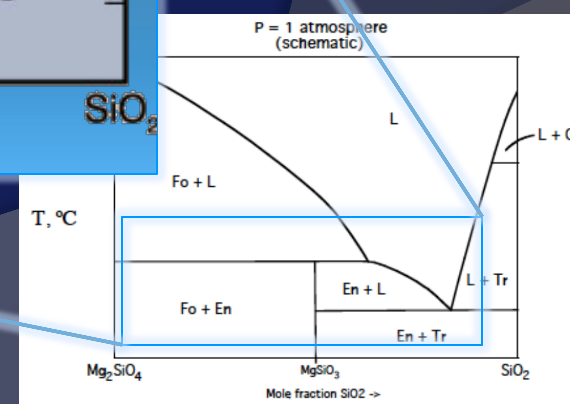
Fig. 7.16 Winters

Pressure effect

Fig. 6.15 Winters

Change of the phase relations!

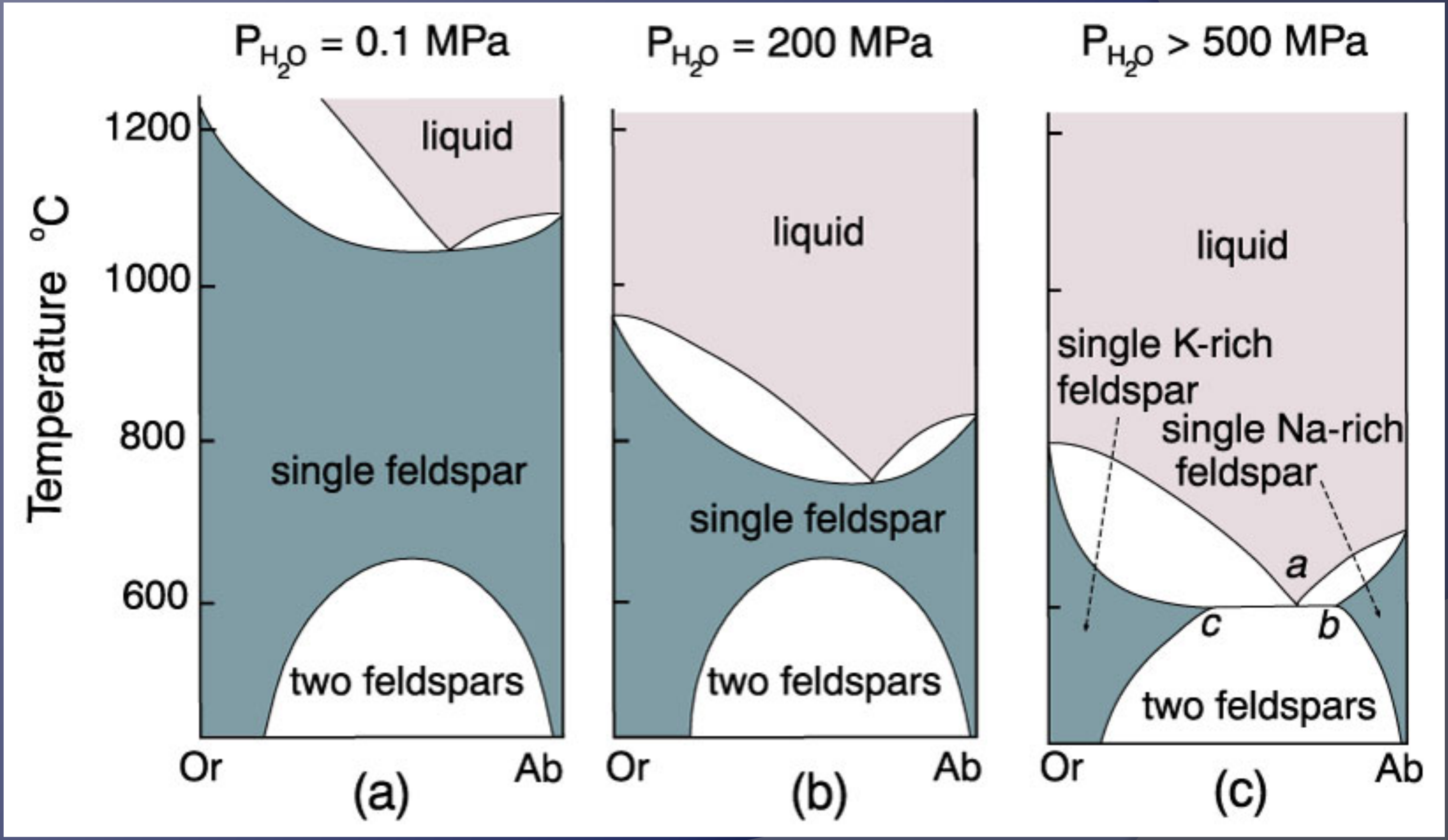




Water pressure effect

Increase of *water* P ⇒ Decrease of melting T

Fig. 6.17 Winters



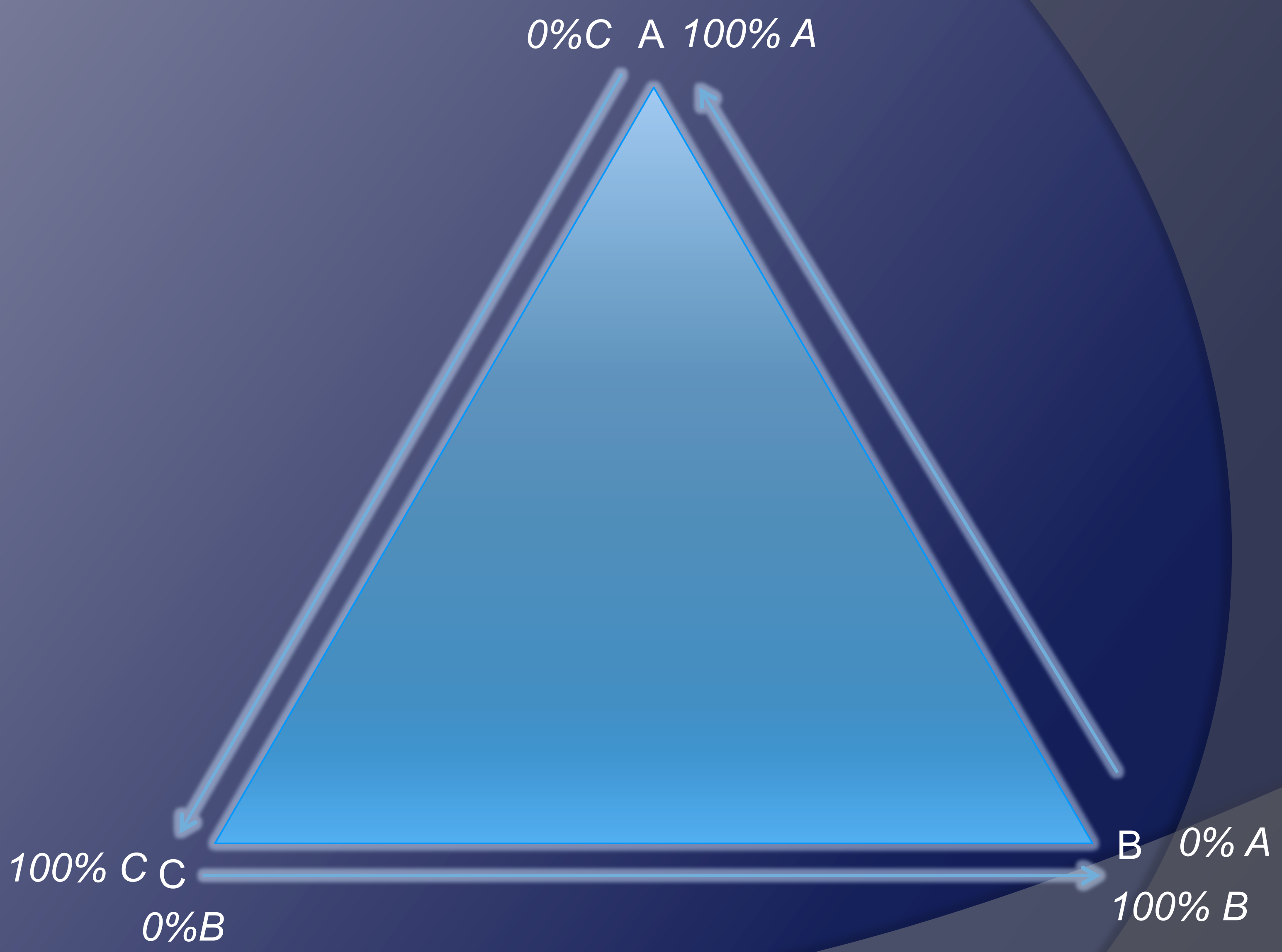
Three component systems

- Work at const. P $\Rightarrow$

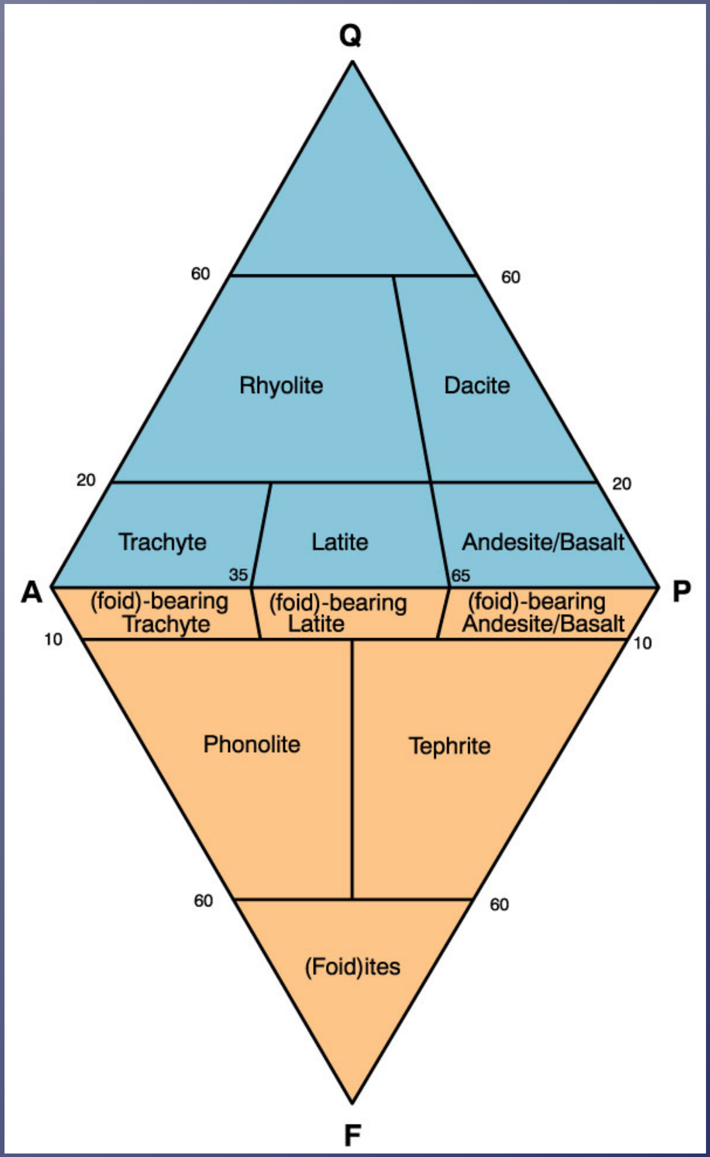
Reduced Gibbs phase rule: $f = c + 1 - \Phi$

- $c = 3 \Rightarrow \Phi_{max} = 4$
- 2 different cases:
  - System with eutectic
  - System with solid solution

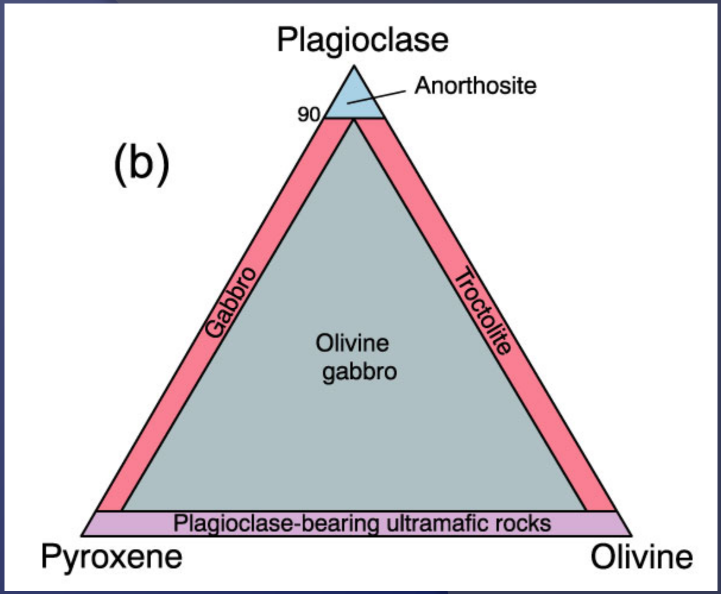
Ternary diagrams



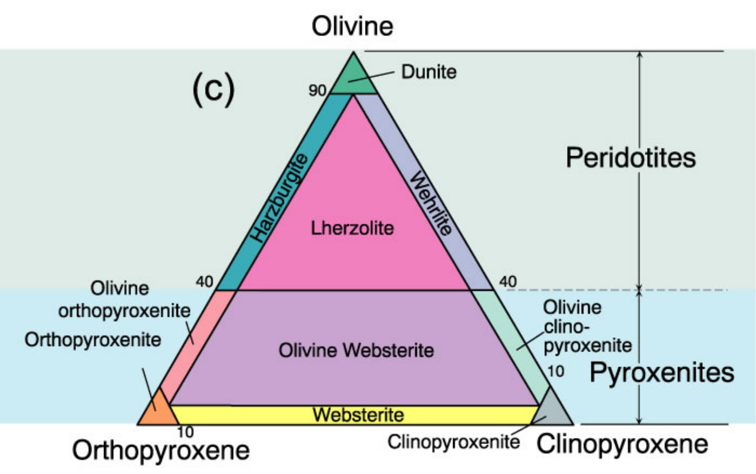
Ternary diagrams



Volcanic rock classifications
Fig. 2.3 - Winters



"Gabbro classification"
Fig. 2.2b - Winters



Ultramafic rock classifications
Fig. 2.2c - Winters

Ternary diagrams - principles

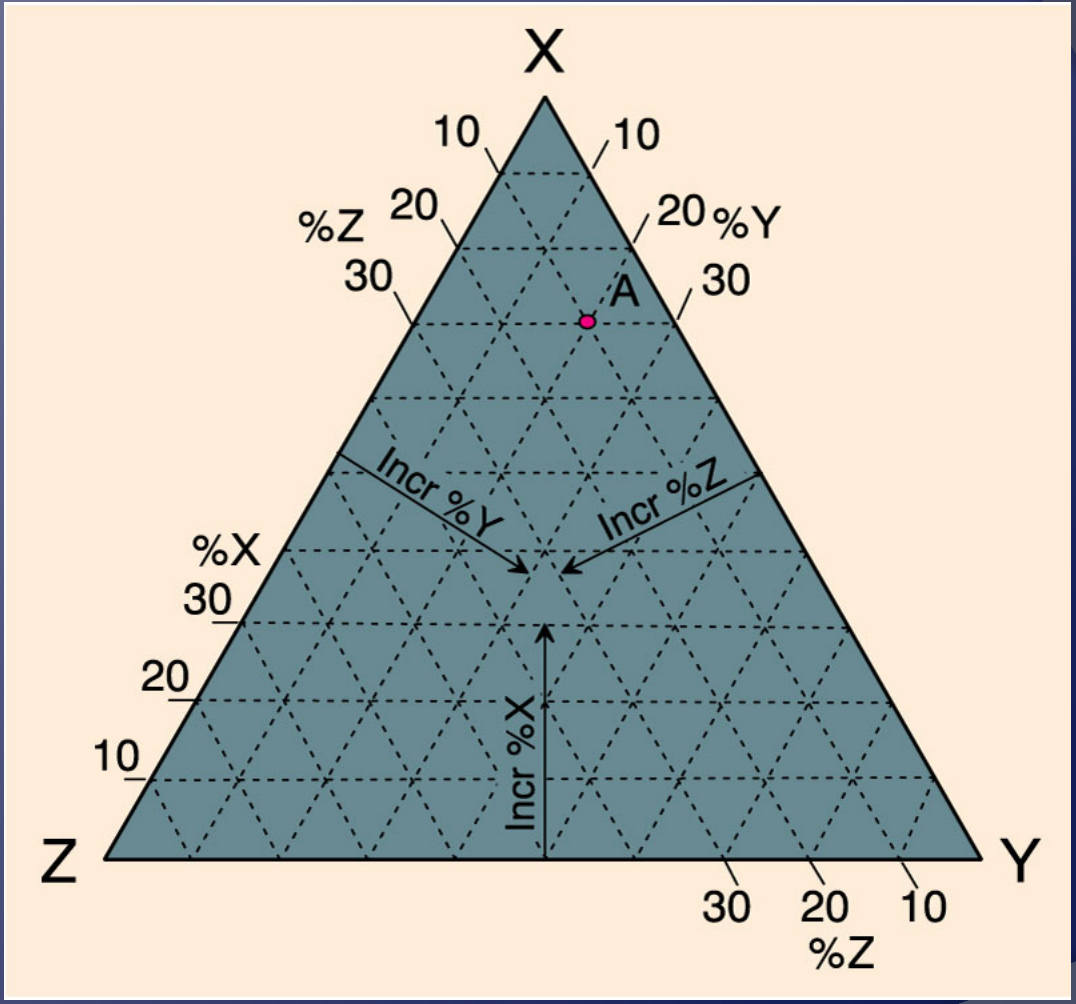


Fig. 2.1a - Winters

Ternary phase diagrams

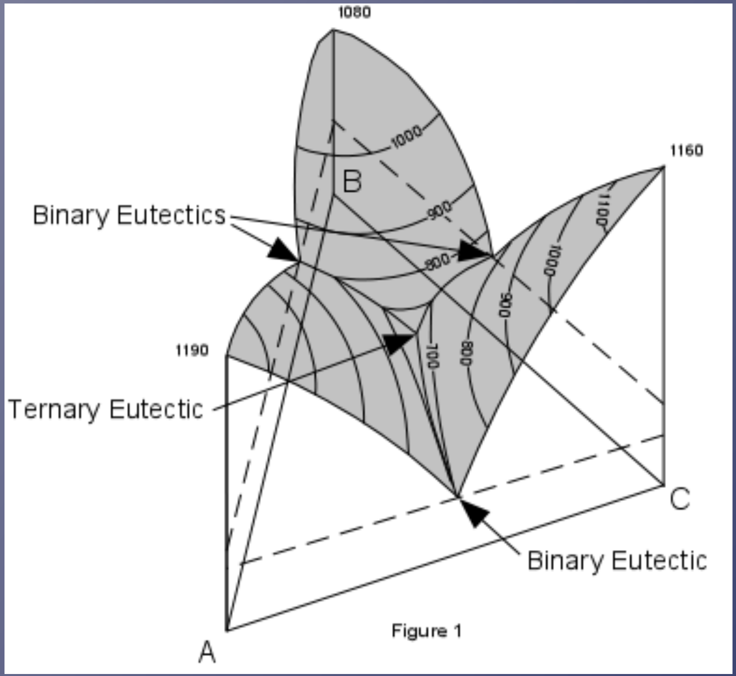


Figure 1

http://www.tulane.edu/~sanelson/eens212

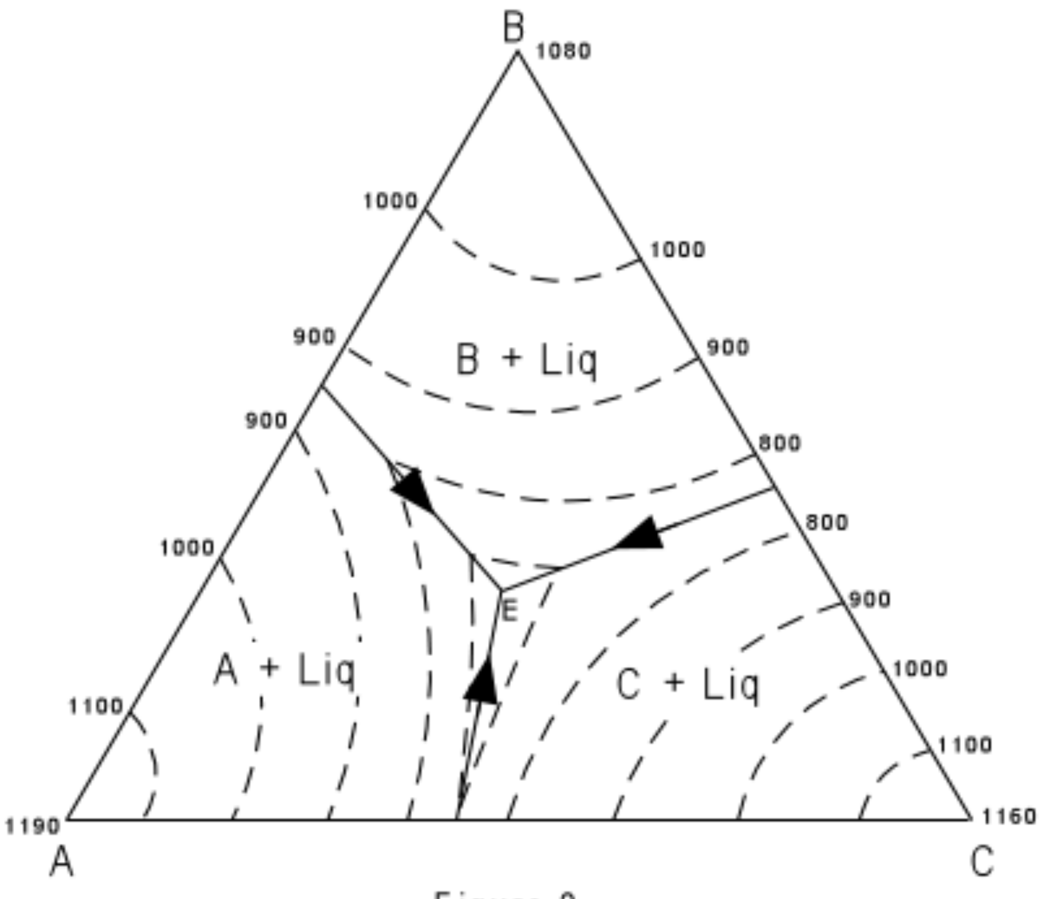
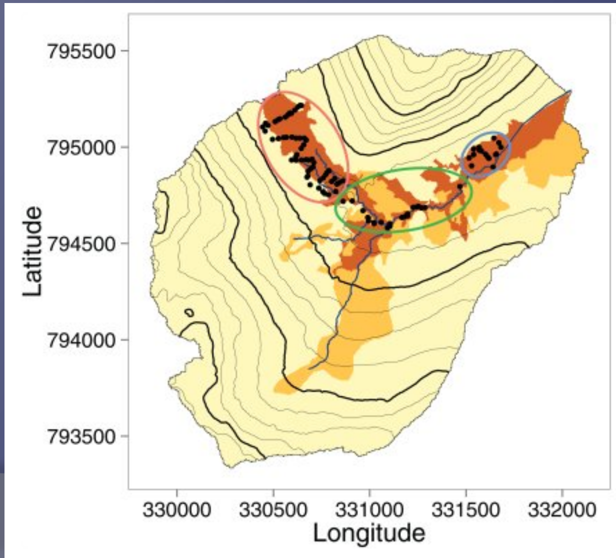
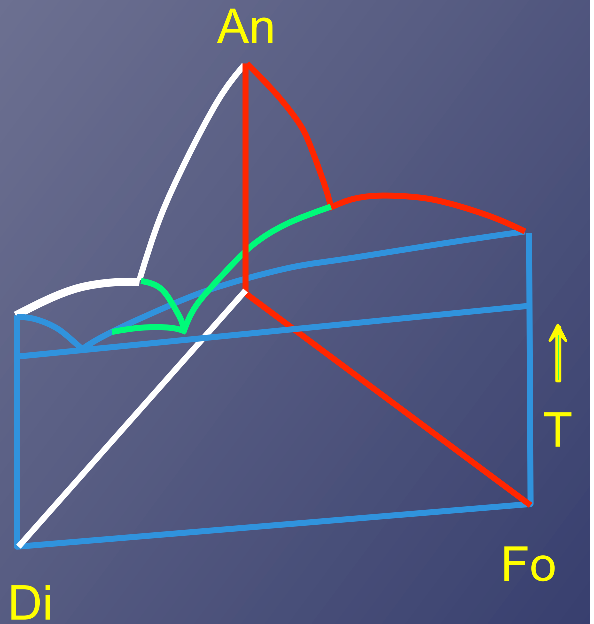


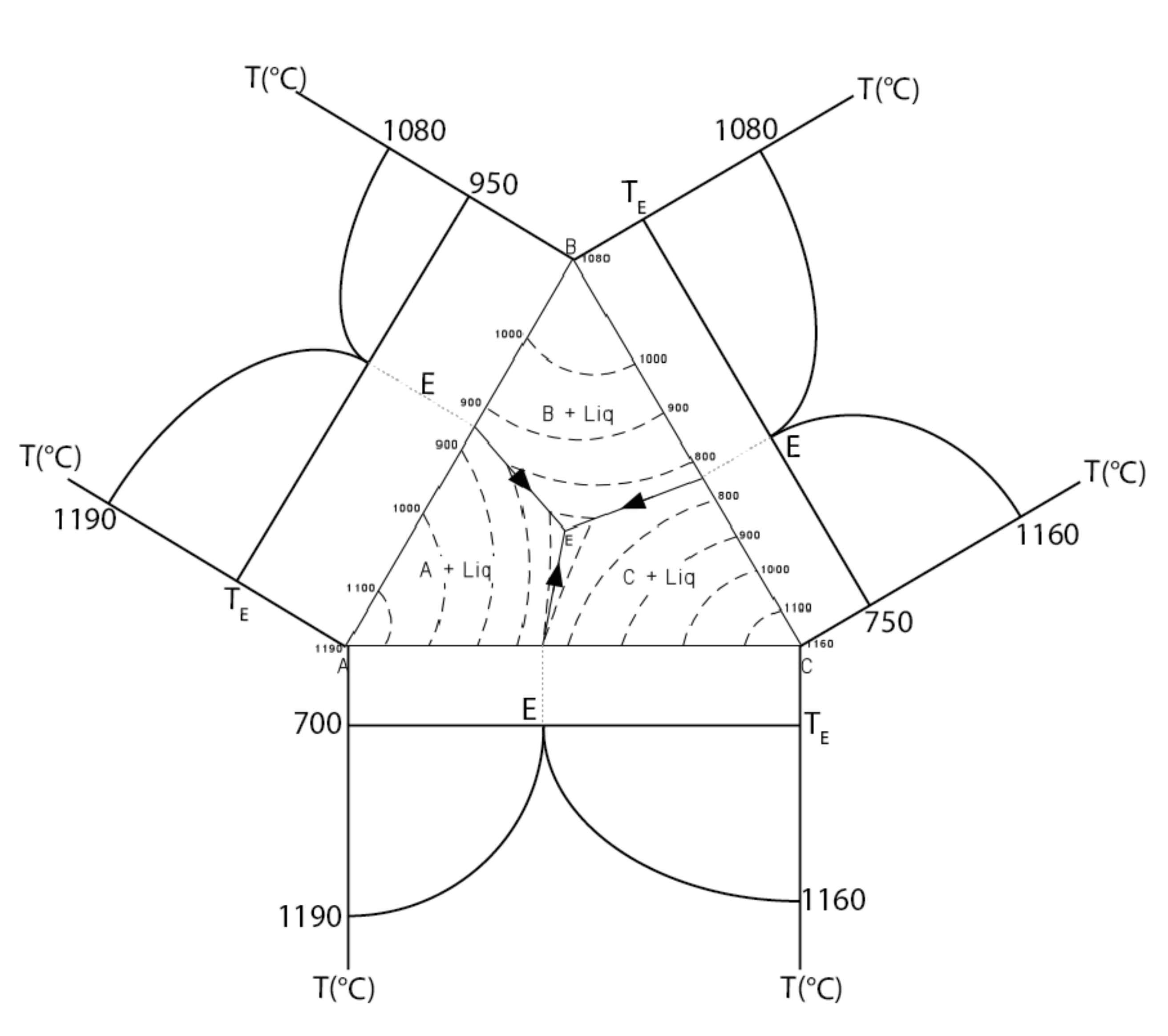
Figure 2



Lessels et al. 2016

Ternary phase diagrams





Ternary phase diagram: representation of the liquidus surface

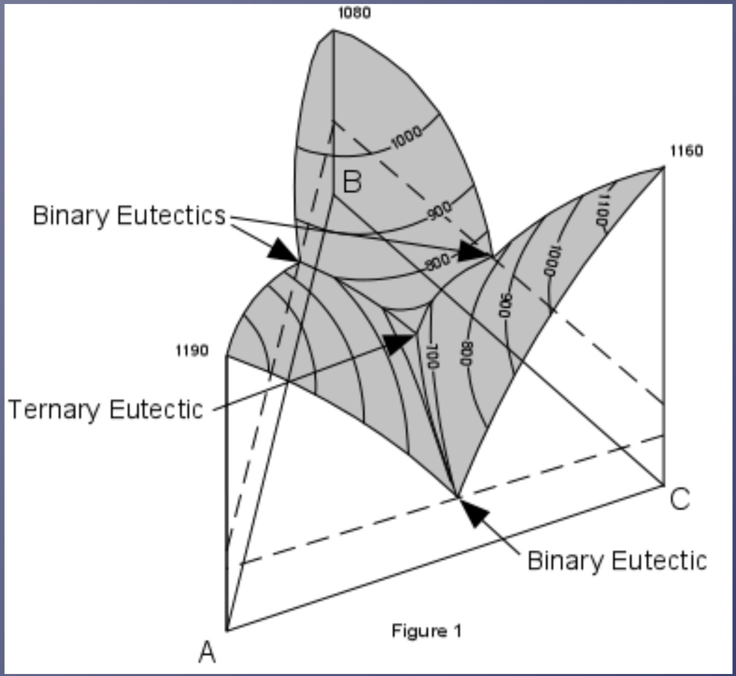


Figure 1

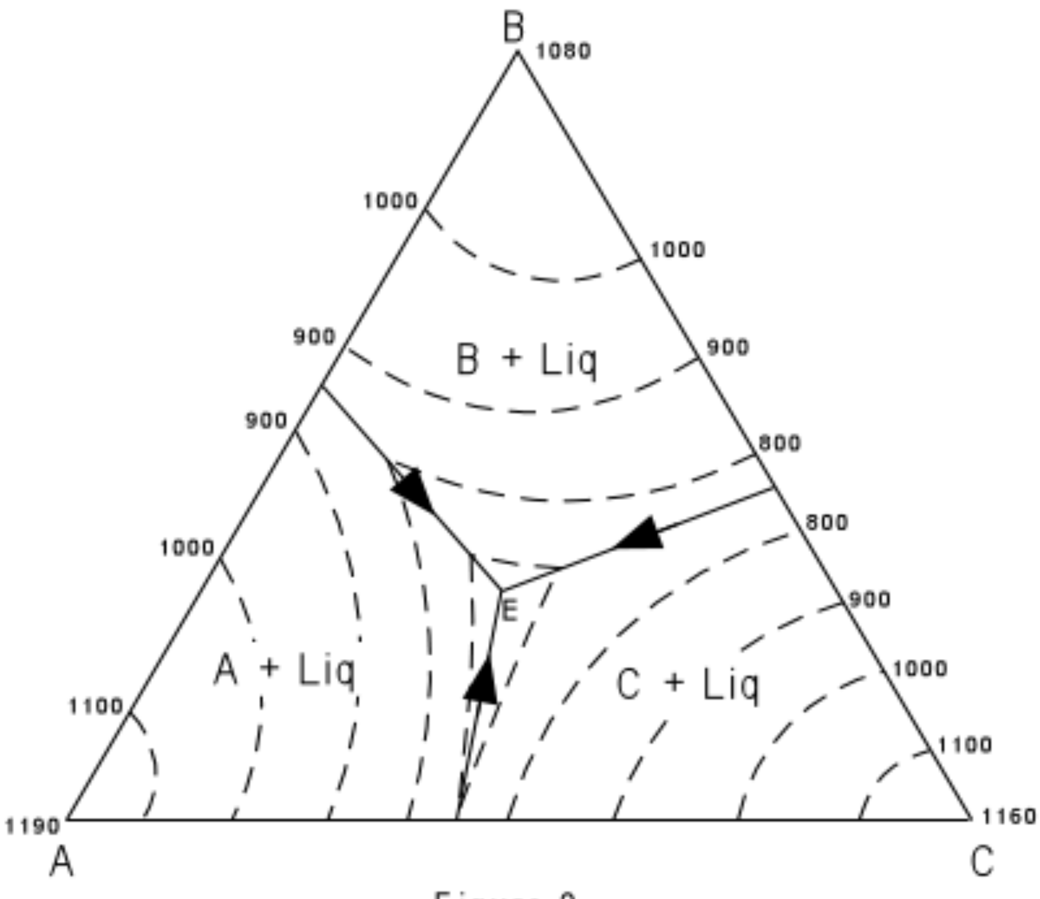
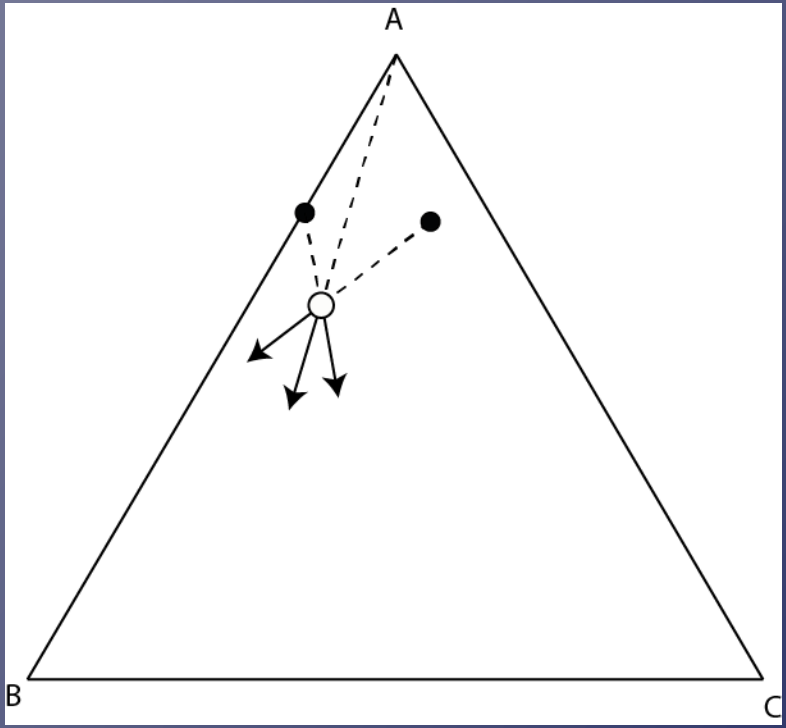


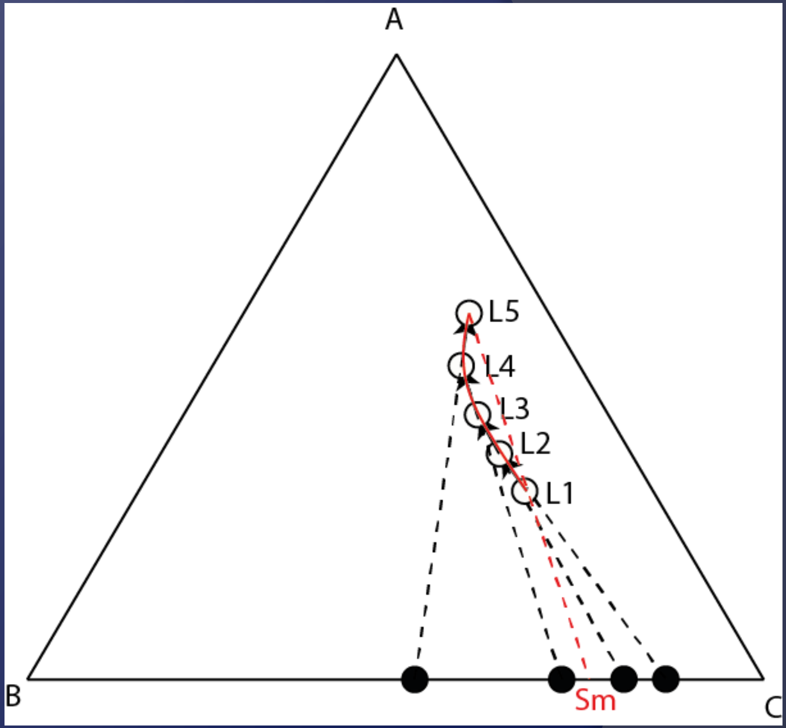
Figure 2

Binary eutectic = cotectic curve
Ternary eutectic = eutectic point

Modification of the composition

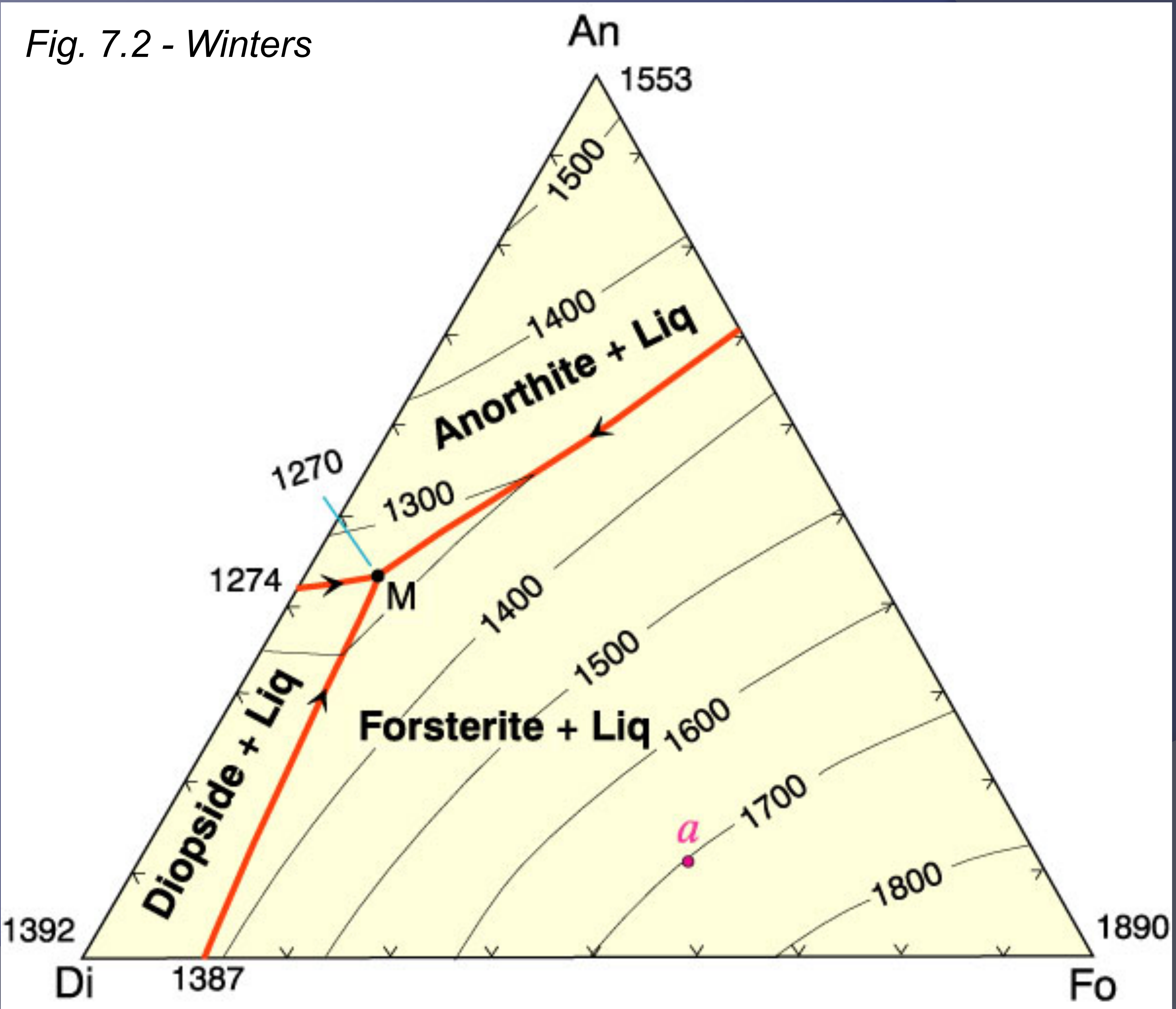


Crystallization of solids with constant composition

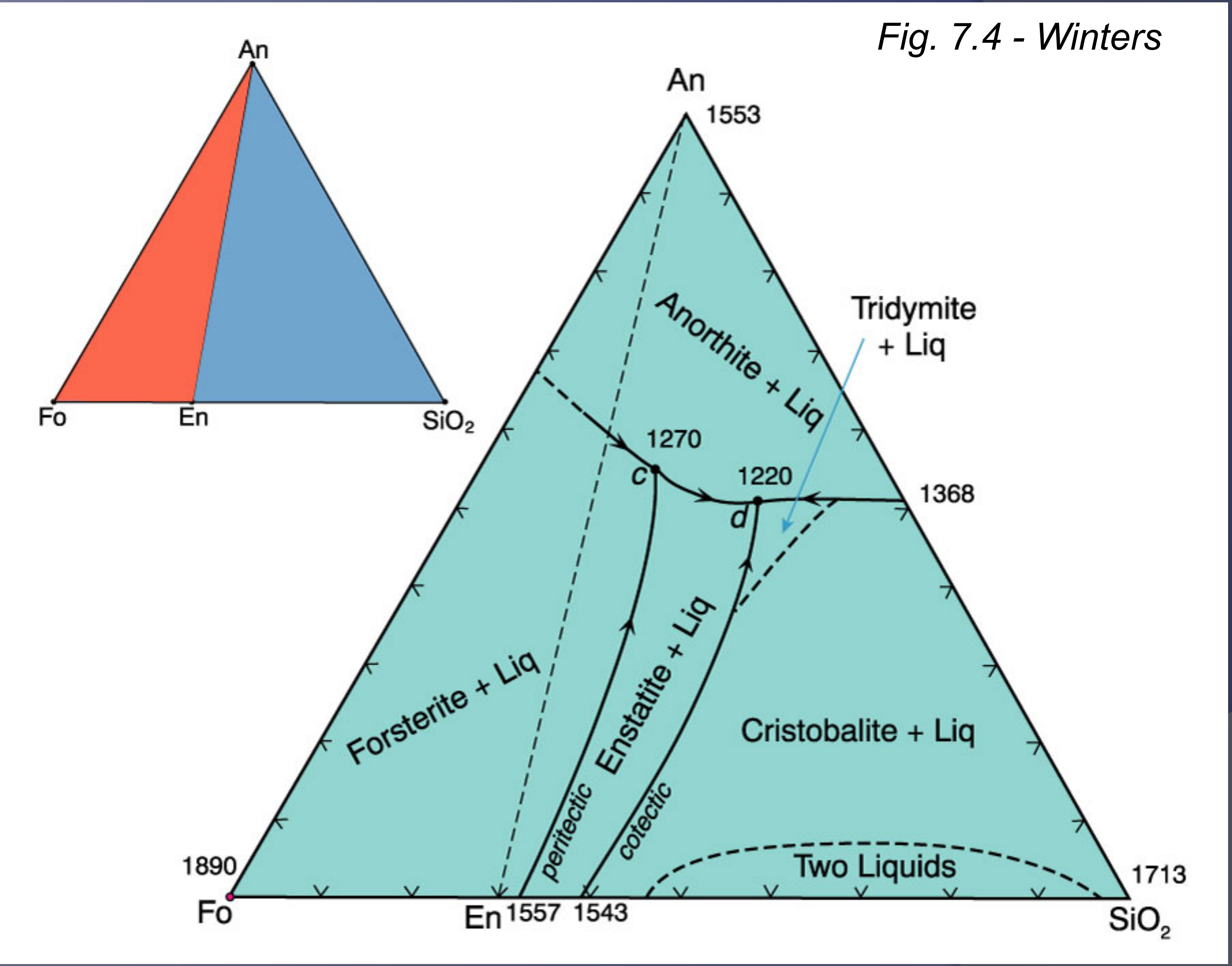


Crystallization of solids with variable composition

Ternary diagram with a single eutectic

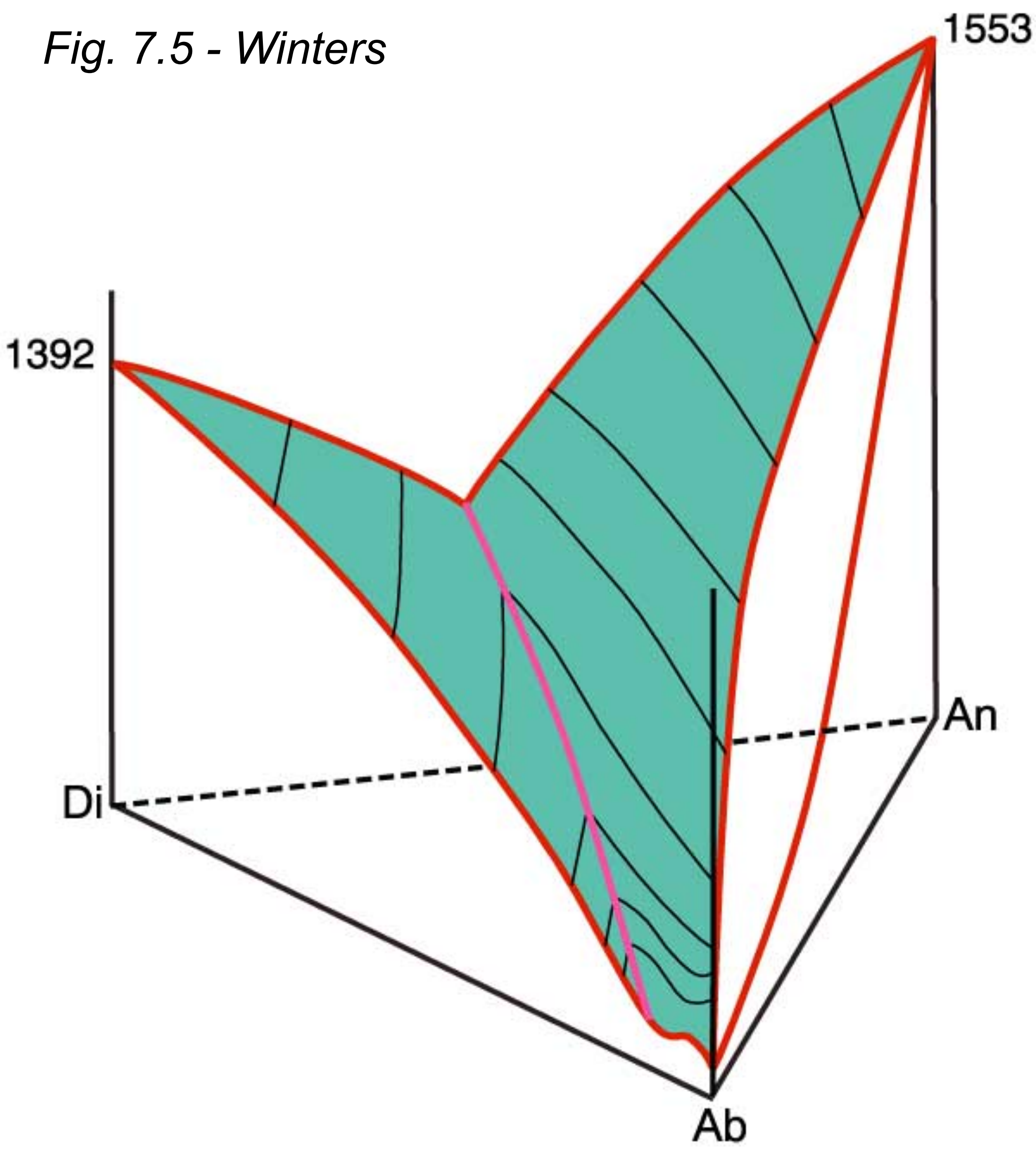


Ternary diagram with a peritectic



Ternary diagram with solid solutions

System Di-Ab-An



Ternary diagram with solid solutions

Di-An

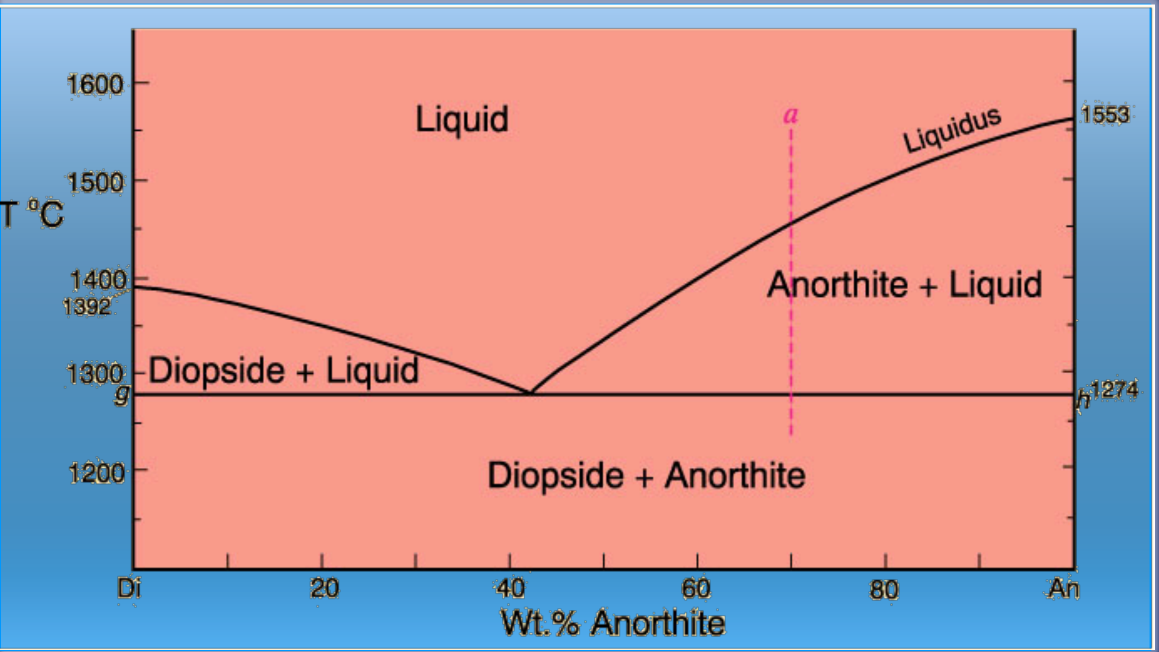


Fig. 6.11 - Winters

Di-An

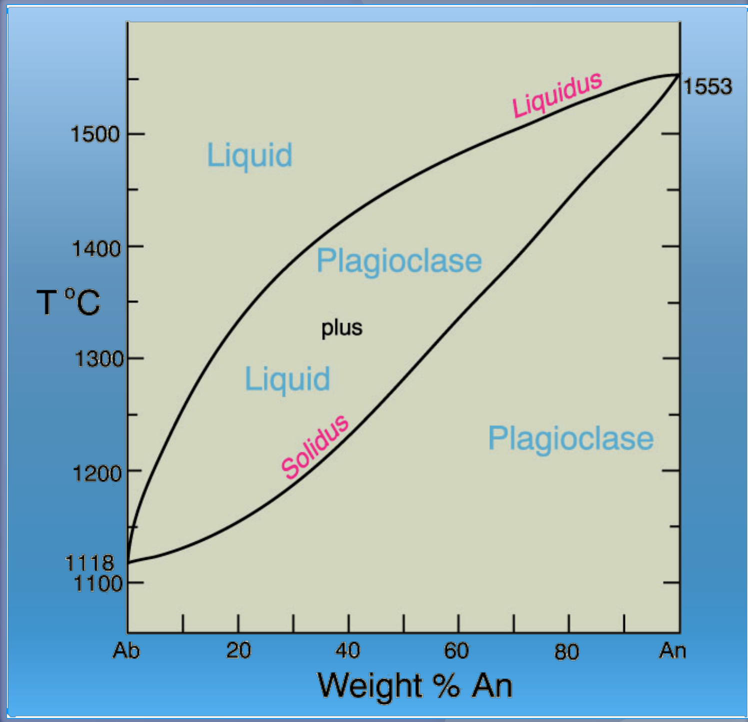
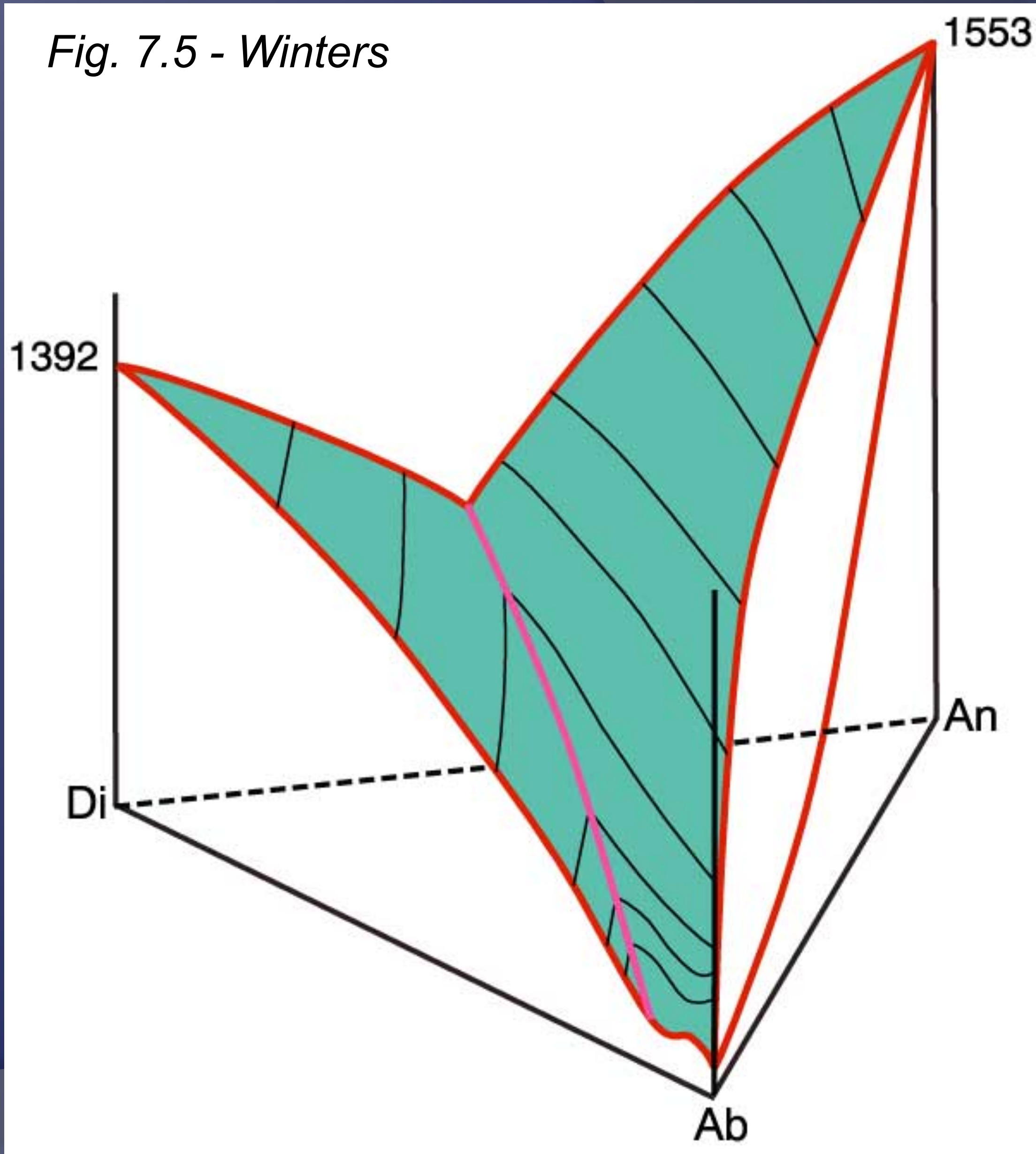


Fig. 6.8 - Winters

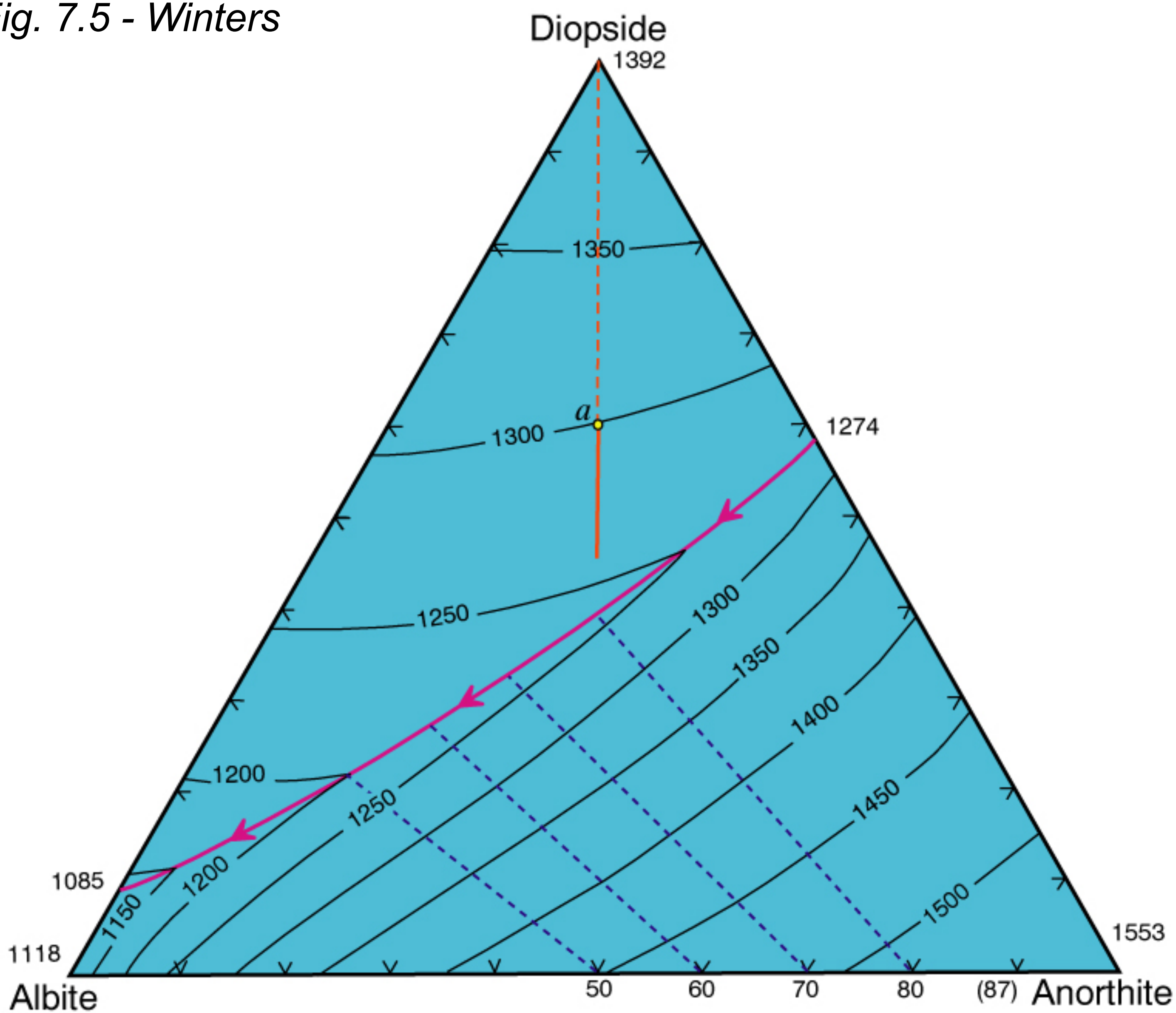
Ternary diagram with solid solutions

System Di-Ab-An



System Di – Ab – An

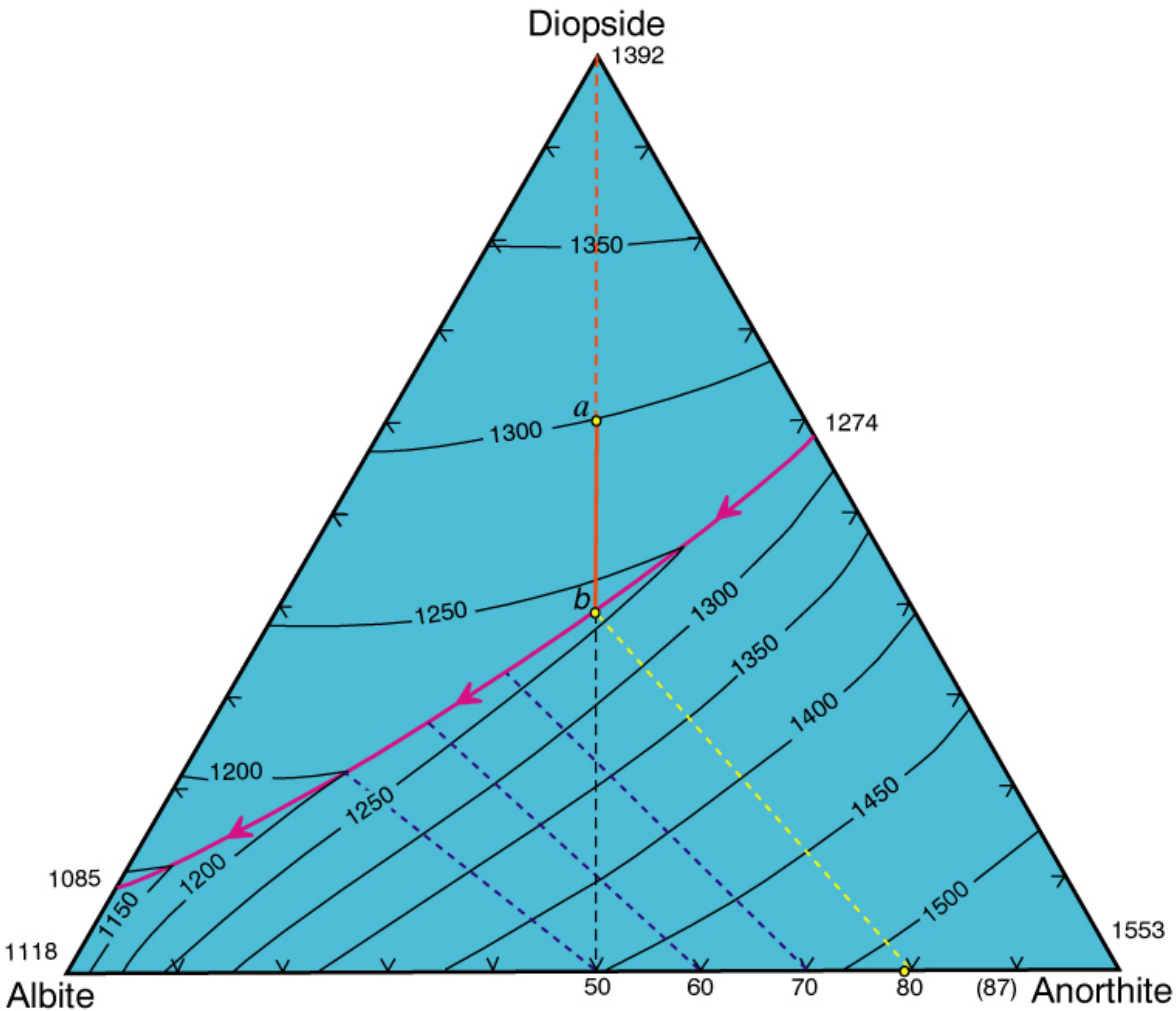
Fig. 7.5 - Winters



Bulk comp. a:

- Starts to crystallize Di at 1300°C

System Di – Ab – An

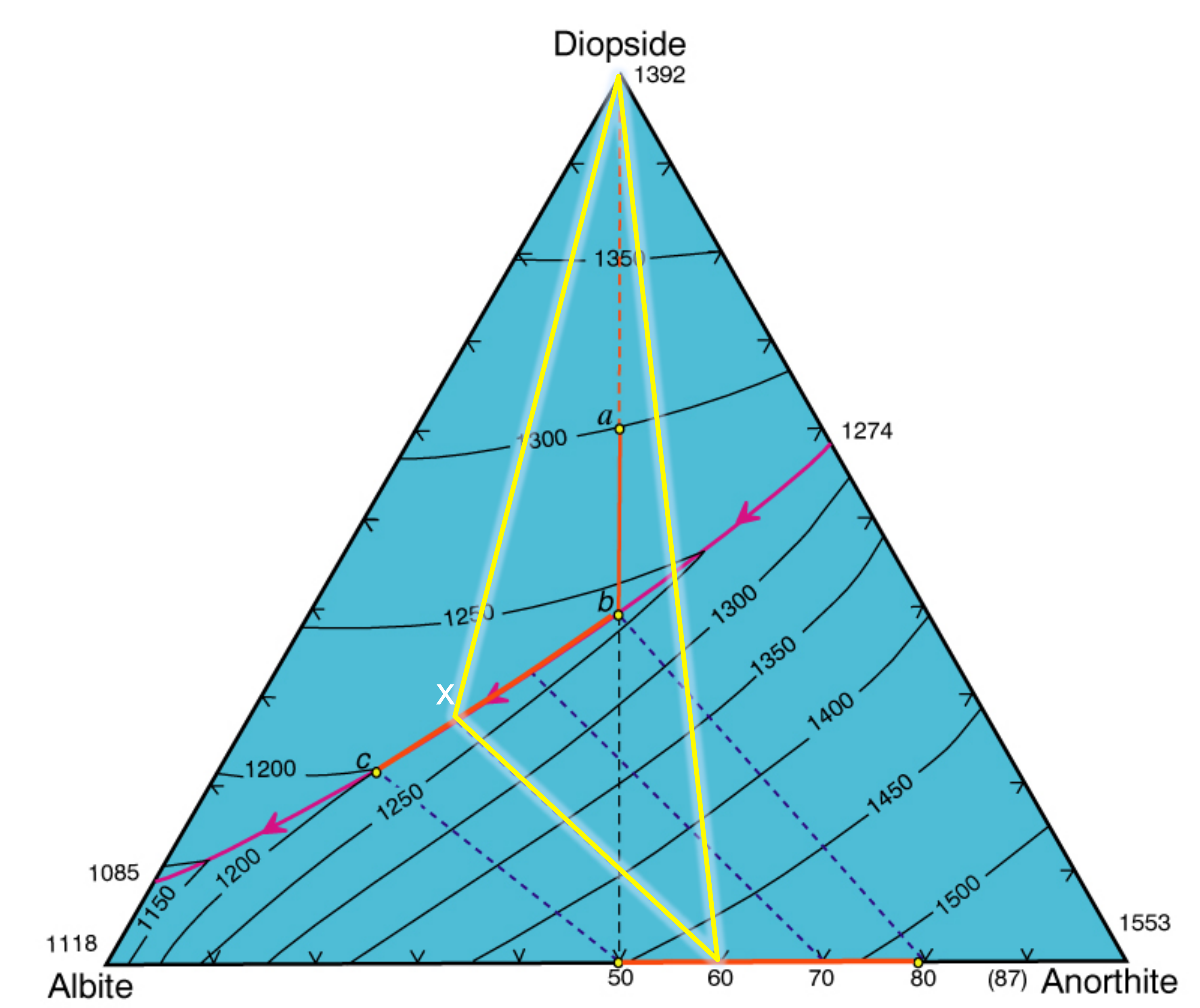


Bulk comp. a:

- Starts to crystallize Di at 1300°C
- Reaches the cotectic around 1240°C and start to crystallize plg (in b).

  Compo of the plg can be read using the tie-line: (80% An)

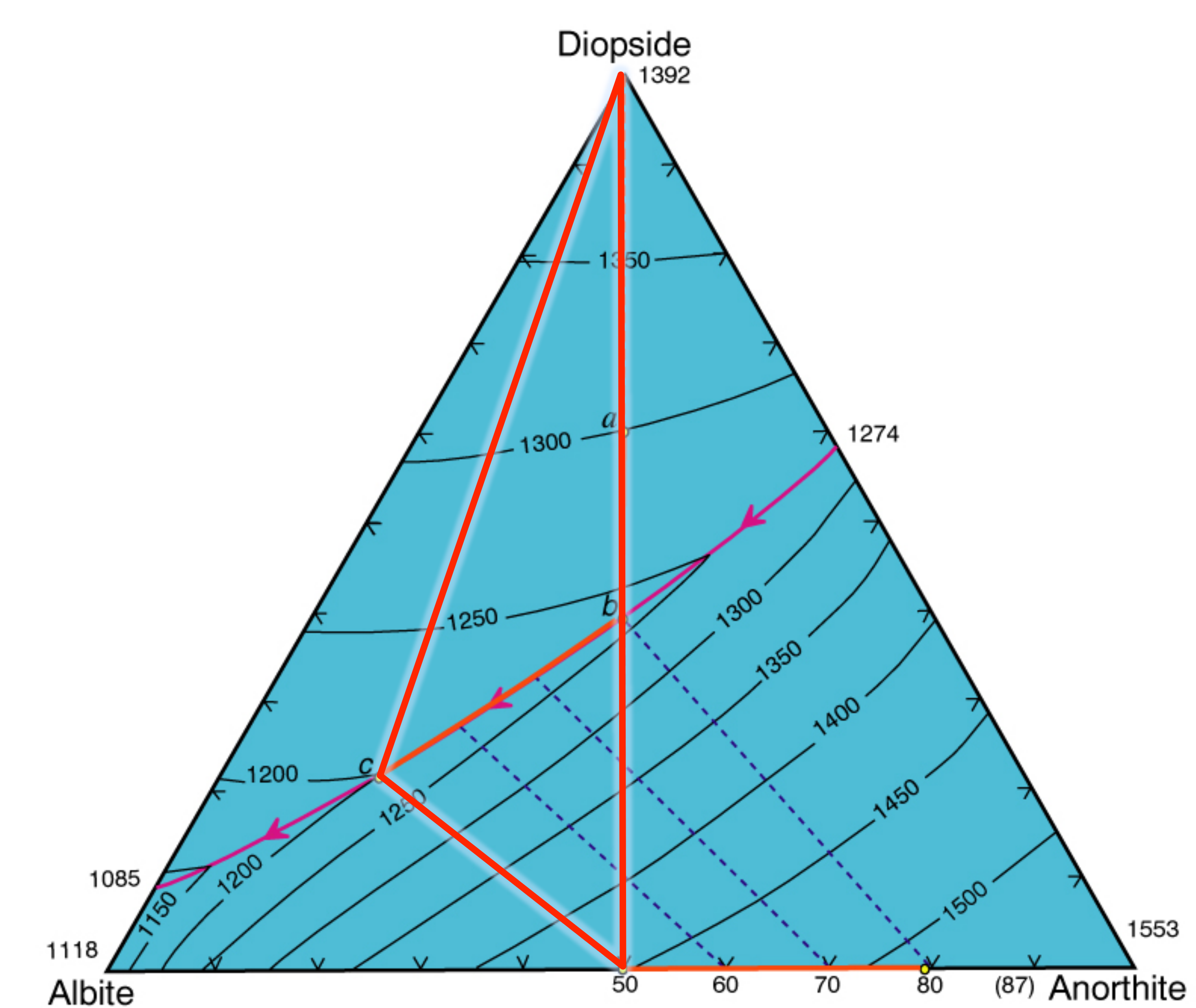
System Di – Ab – An



Bulk comp. a:

- Starts to crystallize Di at 1300°C
- Reaches the cotectic in b.
- In x, T ≈1225°C, 3 phases: liq – plg – di ⇒ bulk compo a in the triangle defined by the 3 phases

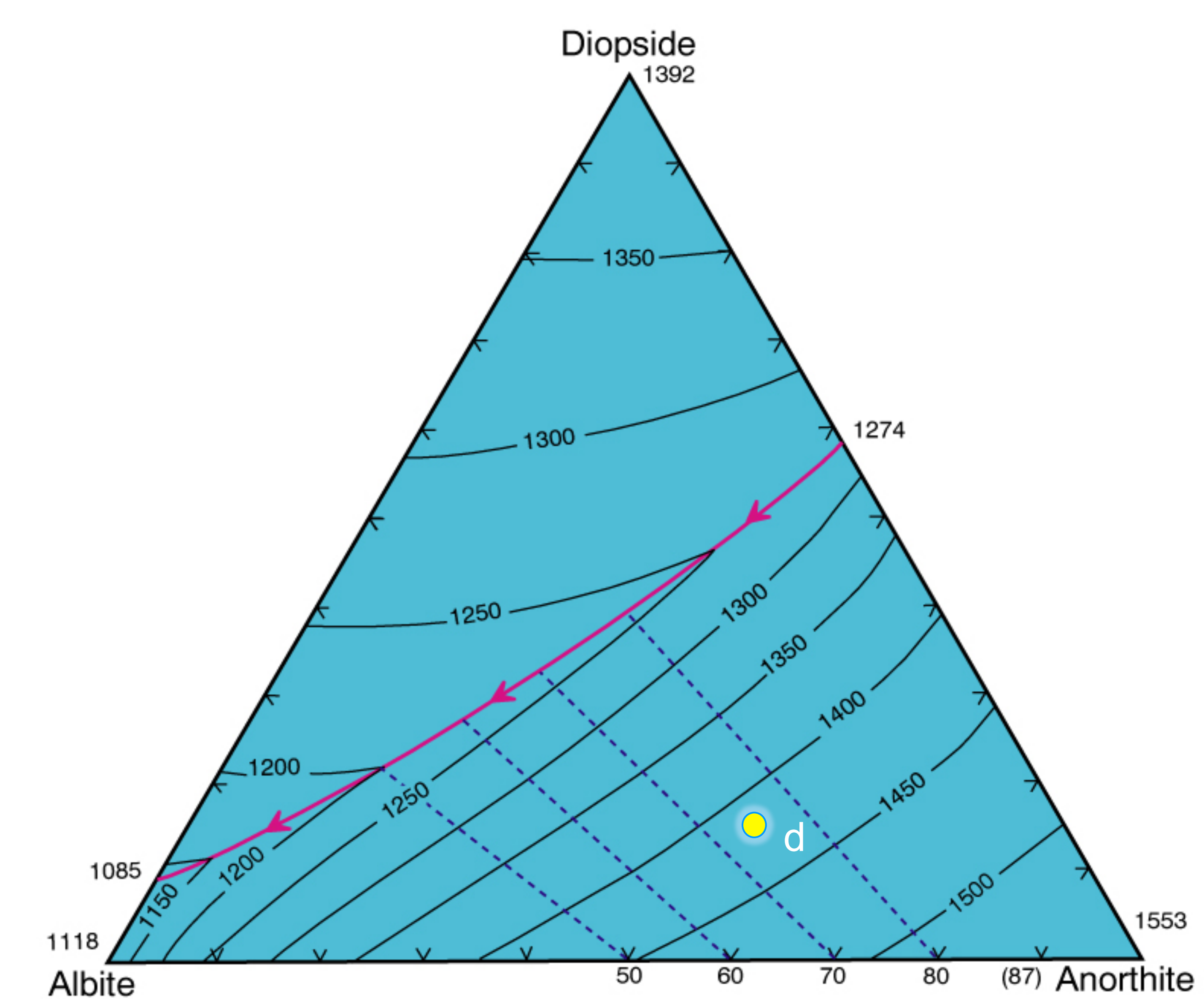
System Di – Ab – An



Bulk comp. a:

- Starts to crystallize Di at 1300°C
- Reaches the cotectic in b.
- In x, T ≈1225°C, 3 phases: liq – plg – di
- When liquid reaches c: bulk compo aligned with Di and plg ⇒ do not need liquid anymore to define the system ⇒ c = last drop of liquid

System Di – Ab – An

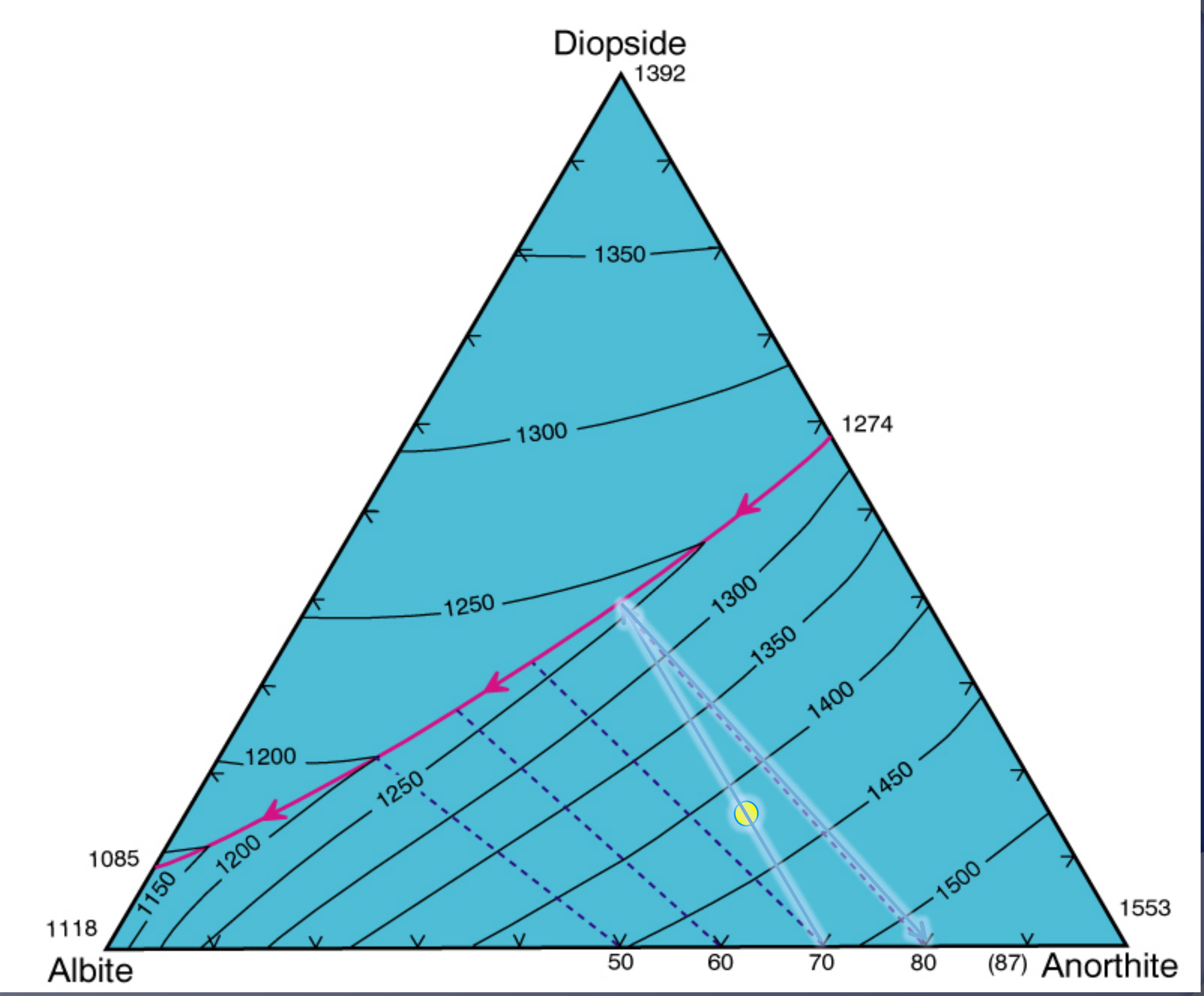


Bulk comp.d:

- Starts to crystallize plg at ≈1420°C

Compo plg unknown

System Di – Ab – An

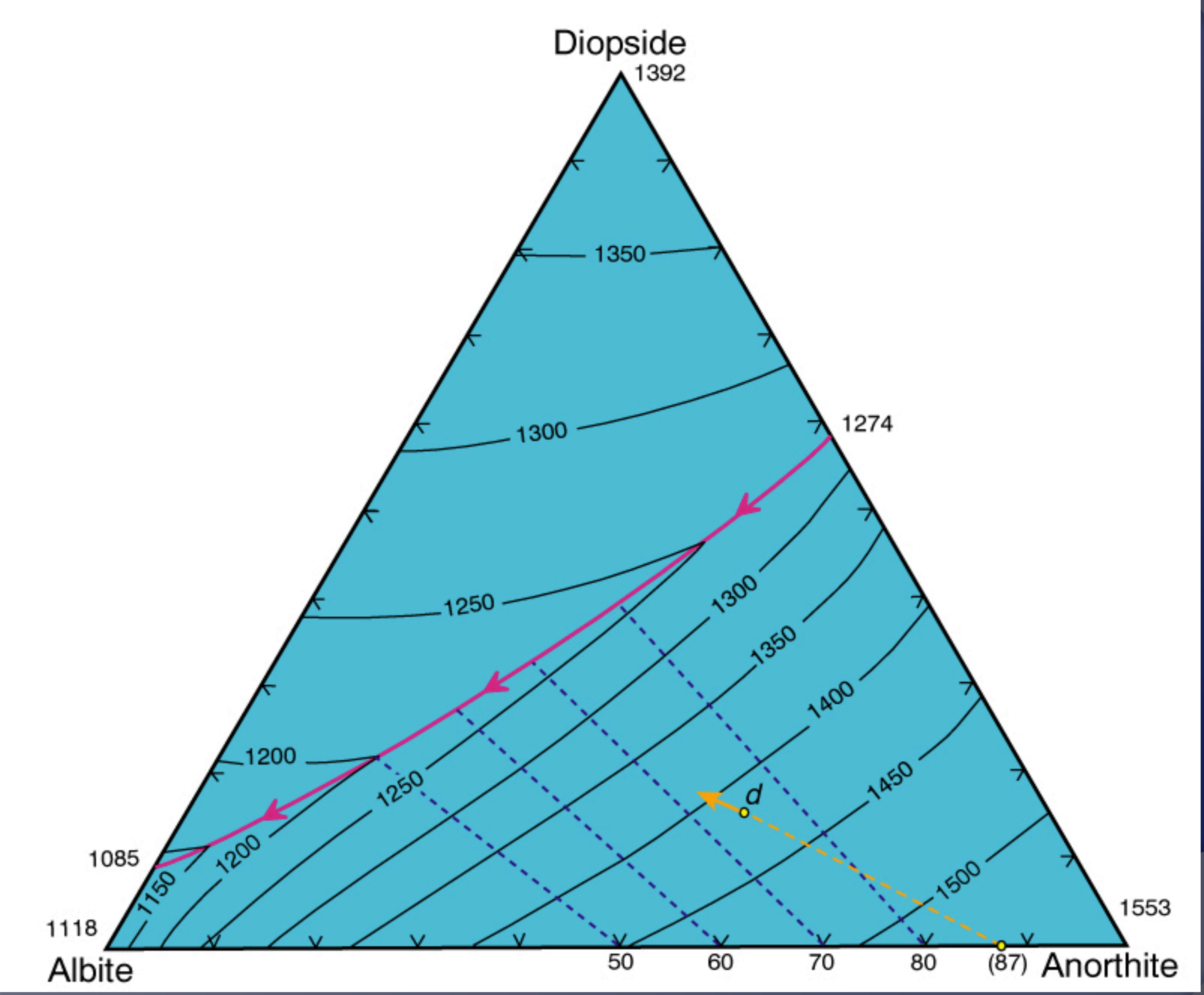


Bulk comp. d:

- Starts to crystallize plg at ≈1420°C

Compo plg unknown but >75%, otherwise the An content of plg will be lower at 1420 that at the cotectic (≈1230°C): NOT POSSIBLE

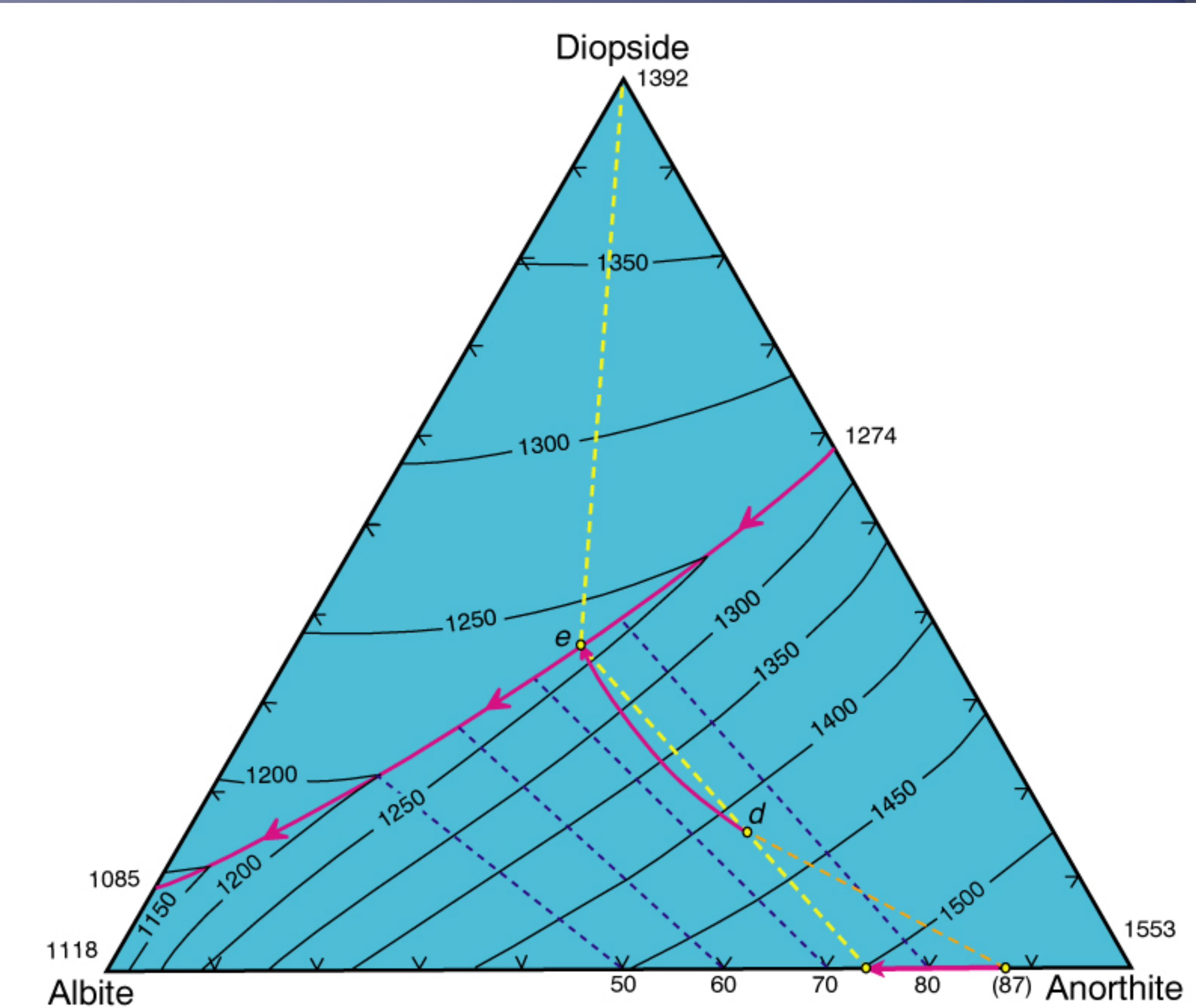
System Di – Ab – An



Bulk comp. d:

- Starts to crystallize plg at ≈1420°C
- Compo plg given: 87An ⇒ liquid goes away form plg

System Di – Ab – An

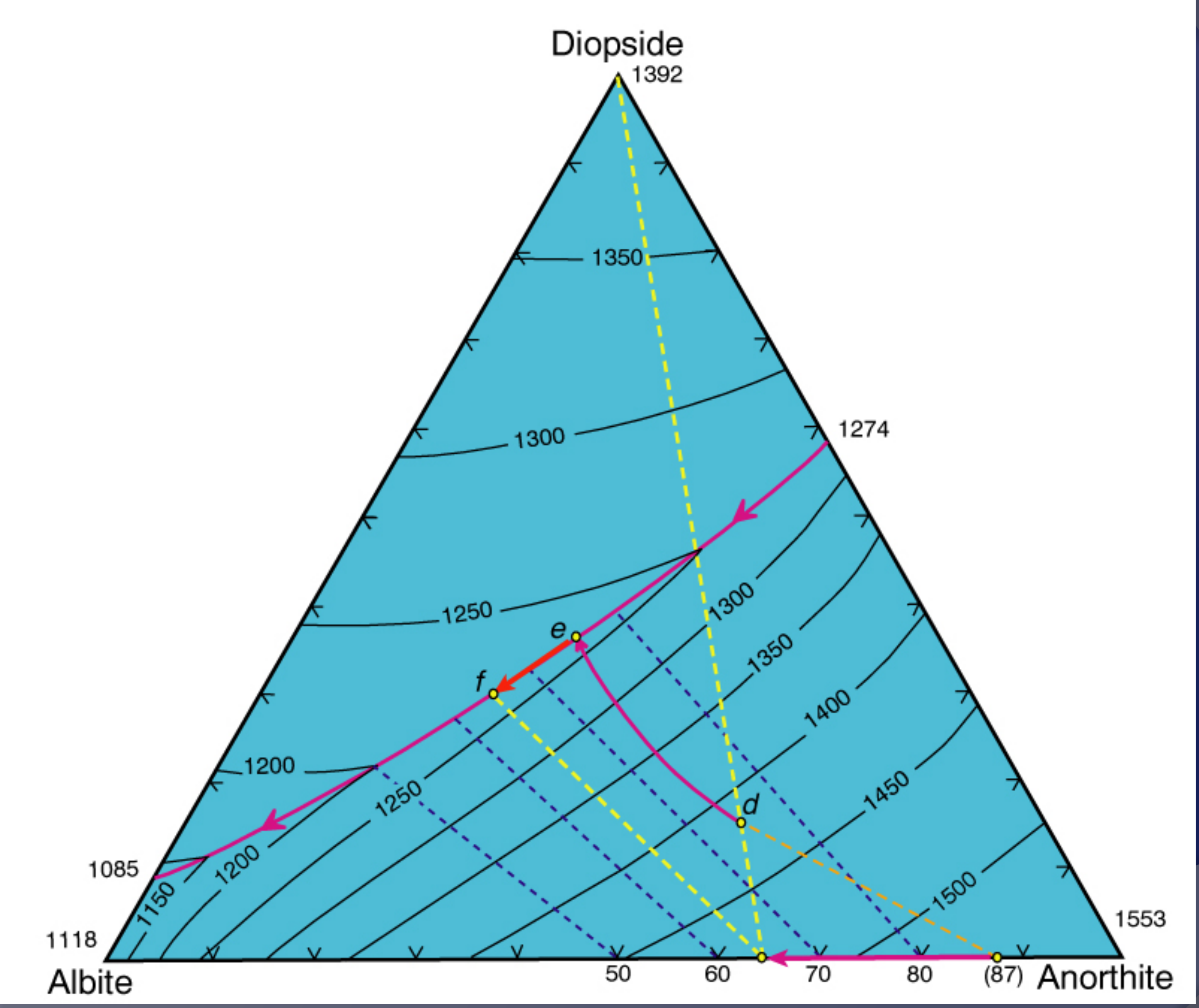


Bulk comp. d:

- Starts to crystallize plg at ≈1420°C
- Compo plg given: 87An ⇒ liquid goes away form plg
- But compo plg change during melting ⇒ liquid path is not a straight line
- Reaches the cotectic in e: starts to crystallize Di

  Compo of plg in equilibrium at the cotectic given by tie-line

System Di – Ab – An



Bulk comp. d:
- Starts to crystallize plg at ≈1420°C
- Compo plg given: 87An ⇒ liquid goes away form plg
- But compo plg change during melting ⇒ liquid path is not a straight line
- Reaches the cotectic in e: starts to crystallize Di
- Liq path stops in f (when d, plg and Di are aligned)

NEXT TIME

Major elements

TO READ:

Chapter 8

FIGURE PRESENTATION