# C. Binary Peritectic Systems

## Three phases enstatite = forsterite + $SiO_2$

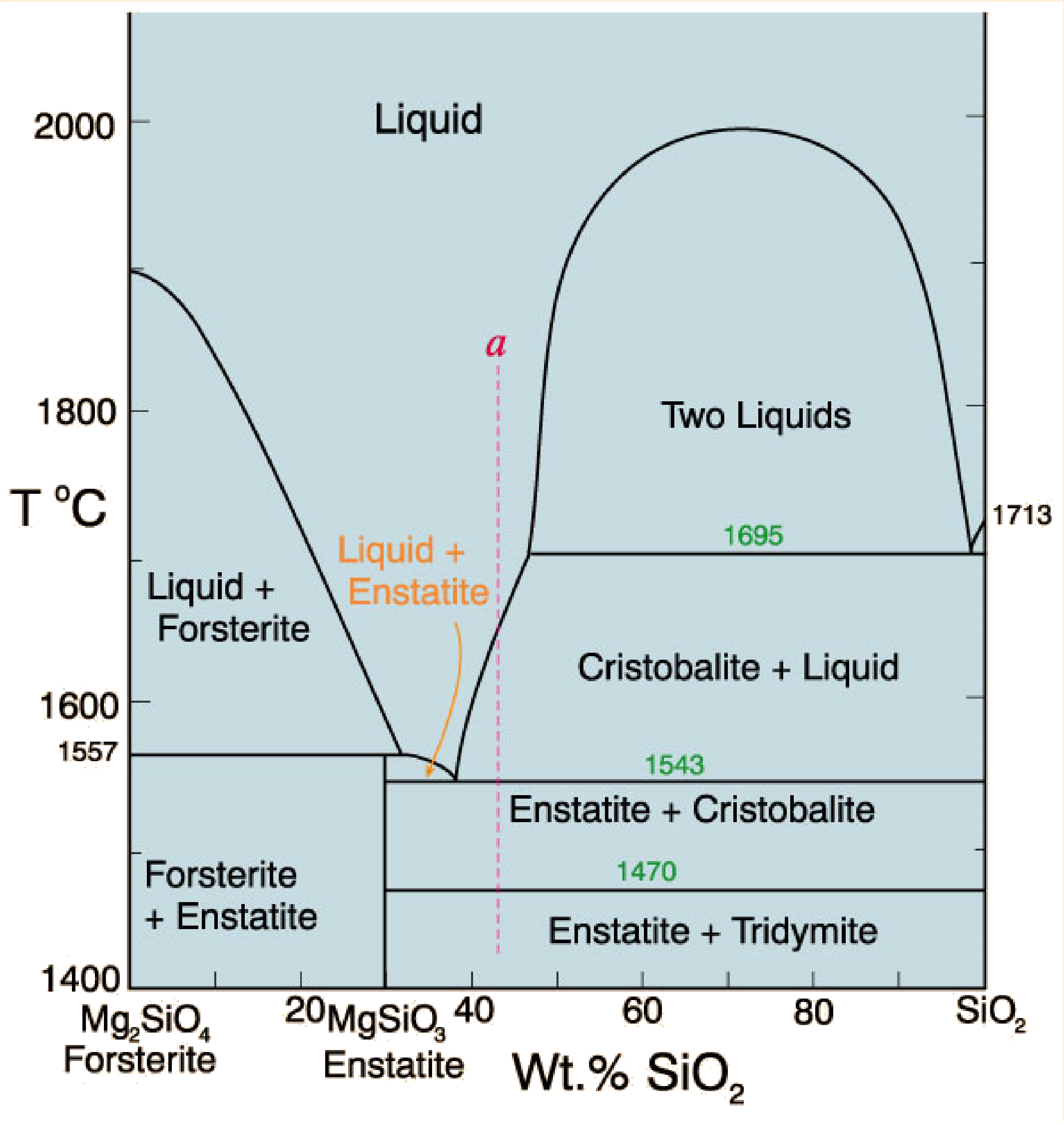



**Figure 6.12.** Isobaric T-X phase diagram of the system Fo-Silica at 0.1 MPa. After Bowen and Anderson (1914) and Grieg (1927). Amer. J. Sci.

# C. Binary Peritectic Systems

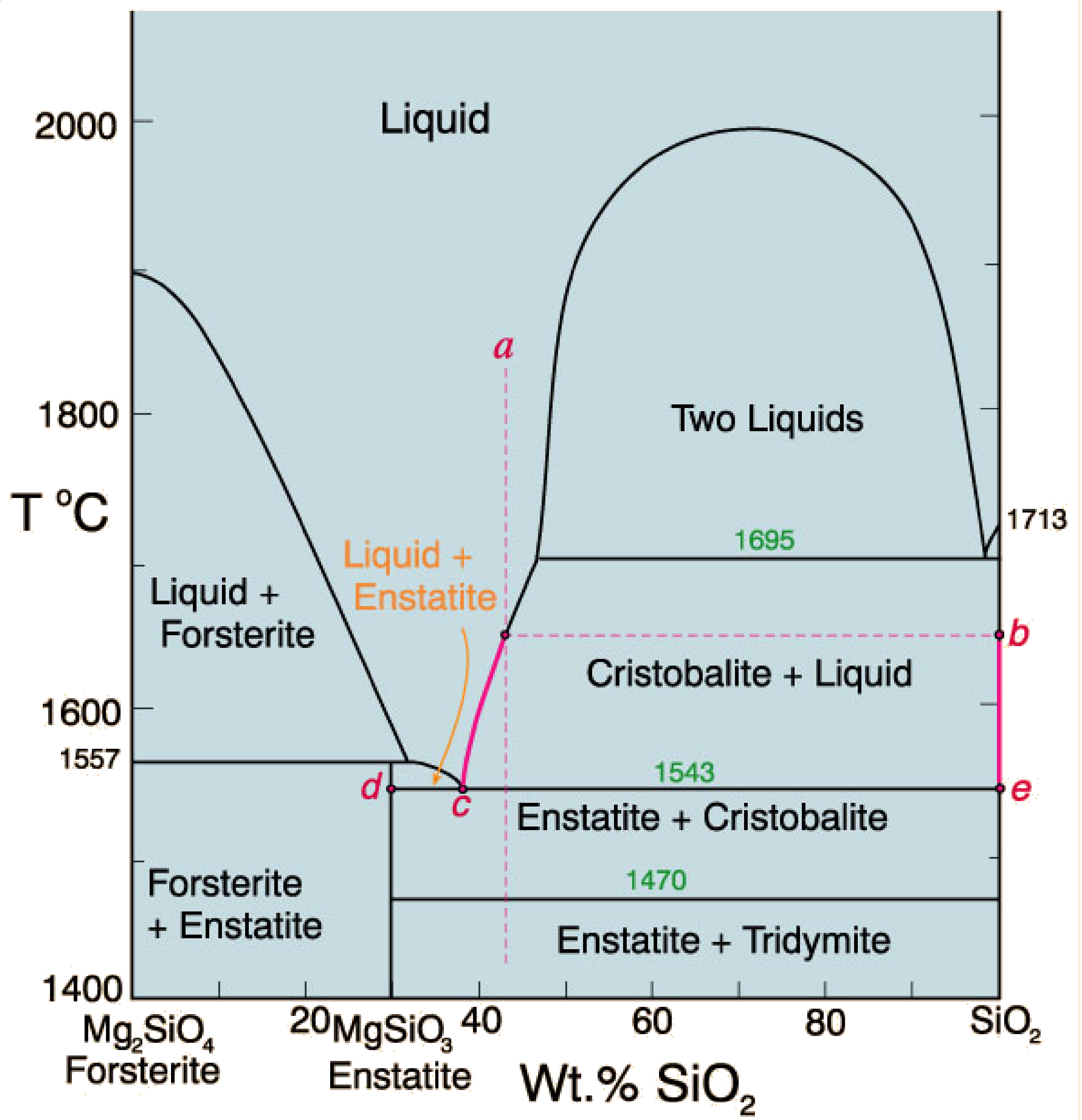



**Figure 6.12.** Isobaric T-X phase diagram of the system Fo-Silica at 0.1 MPa. After Bowen and Anderson (1914) and Grieg (1927). Amer. J. Sci.

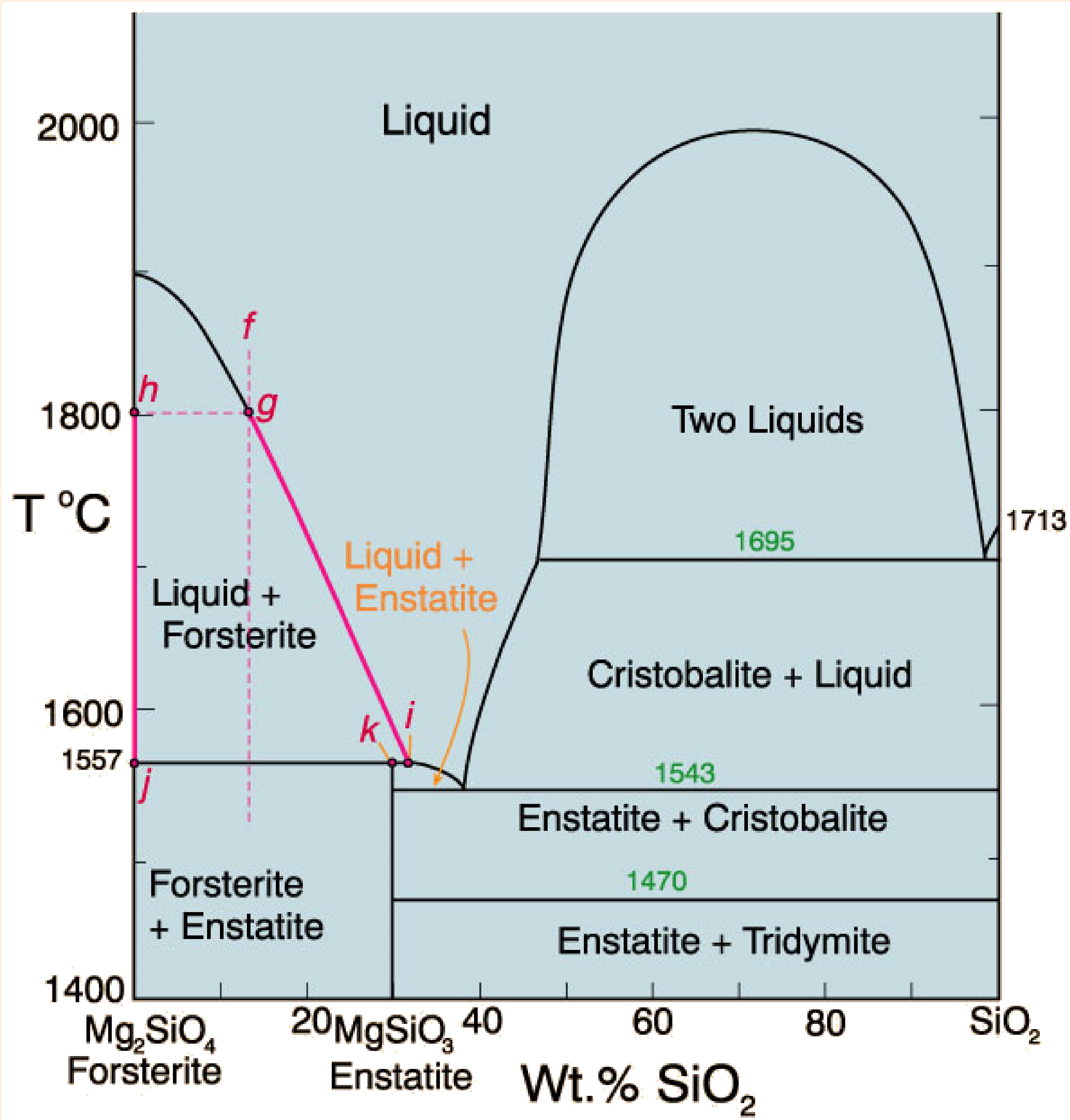


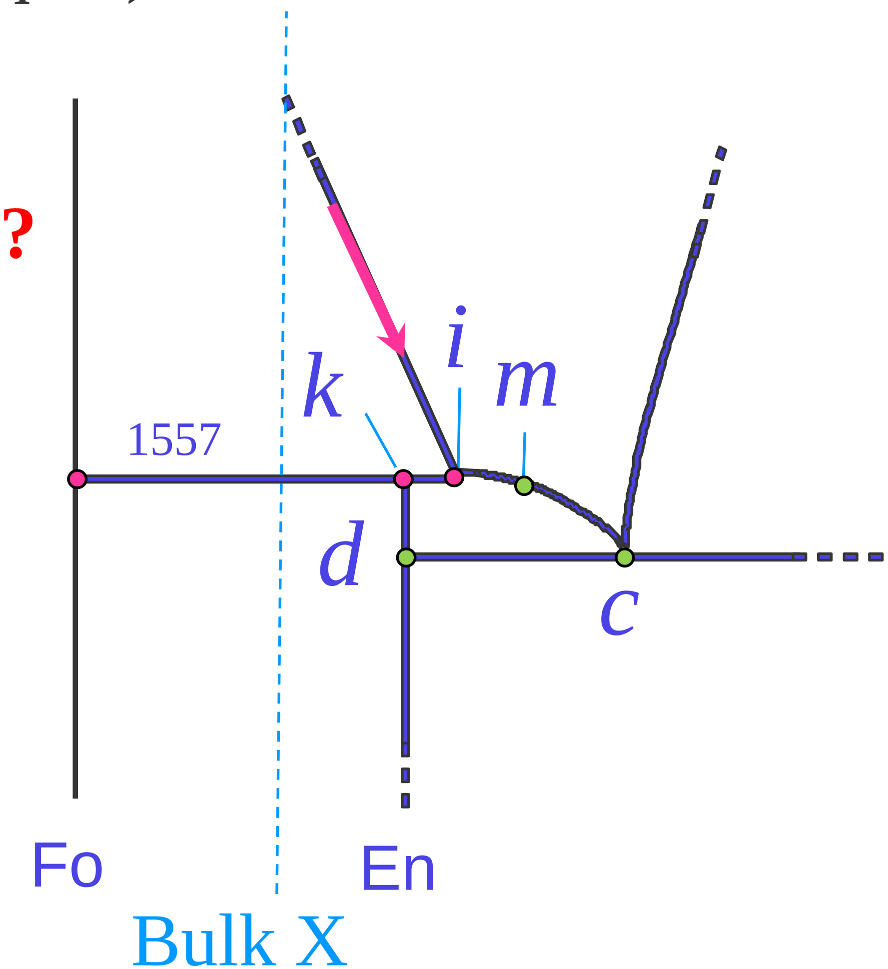

**Figure 6.12.** Isobaric T-X phase diagram of the system Fo-Silica at 0.1 MPa. After Bowen and Anderson (1914) and Grieg (1927). Amer. J. Sci.

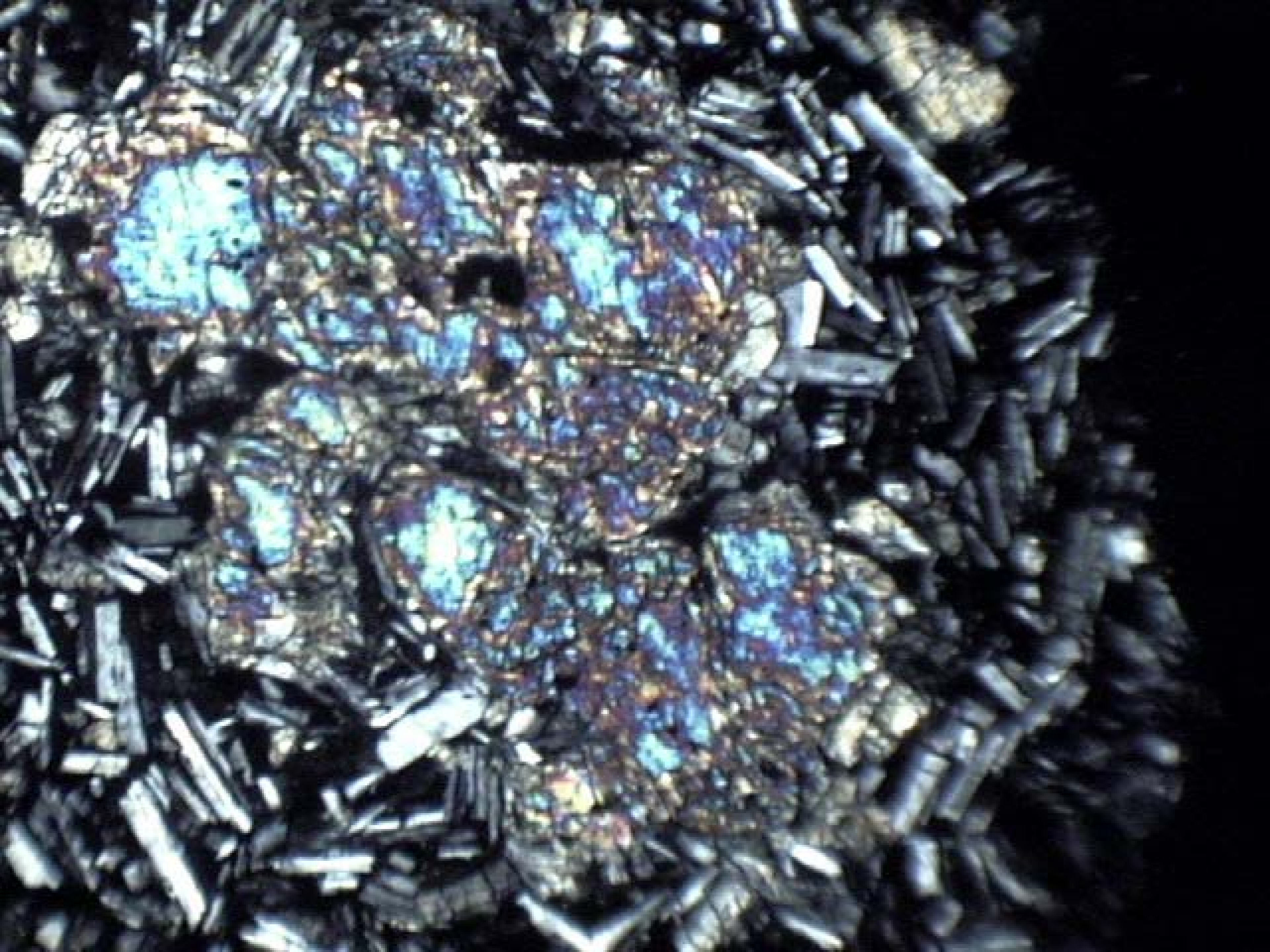
*i* = "peritectic" point

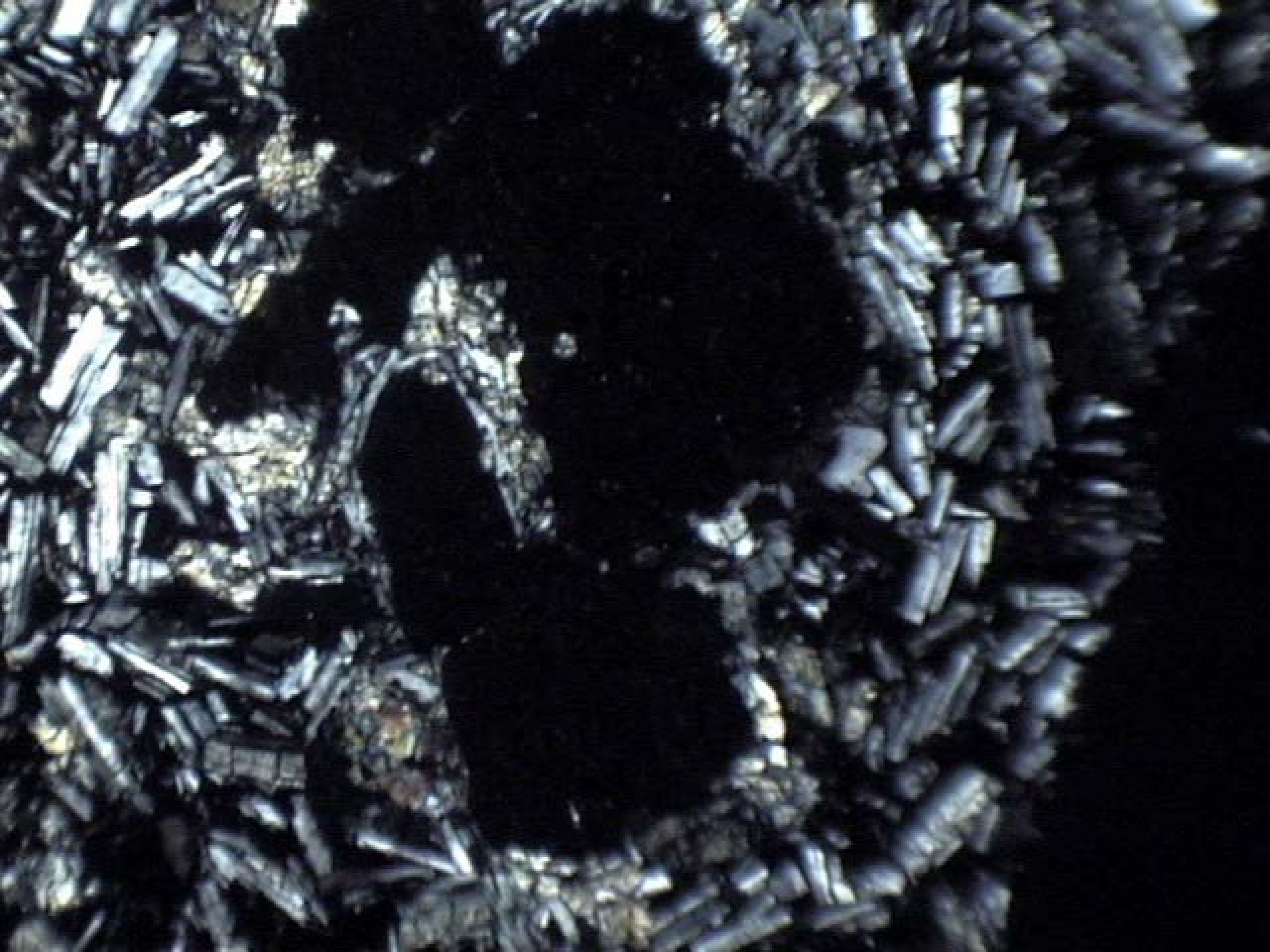
1557°C have colinear Fo-En-liq

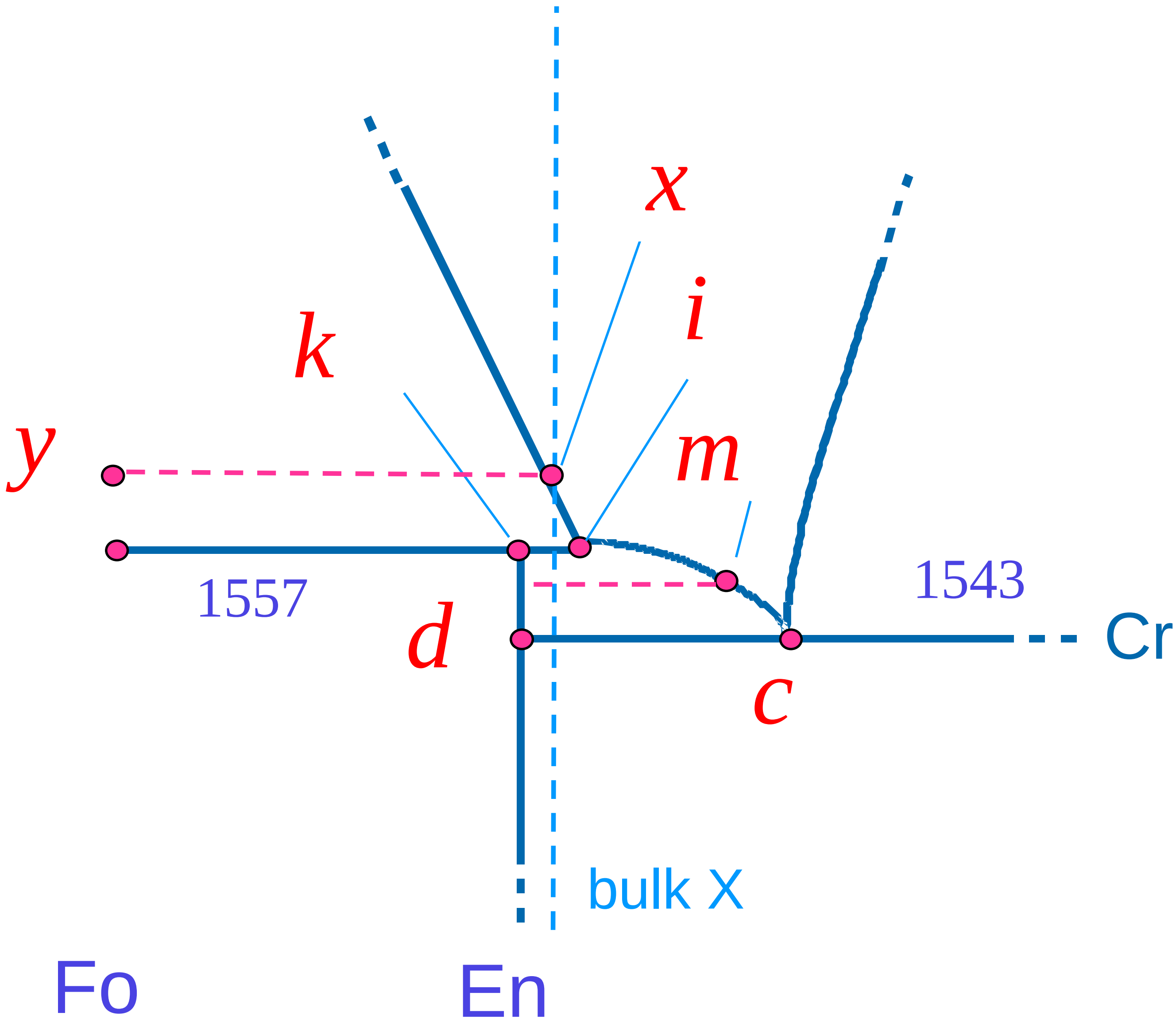
- ☞ geometry indicates a reaction: Fo + liq = En
- ☞ consumes olivine (and liquid) → resorbed textures

**When is the reaction finished?**







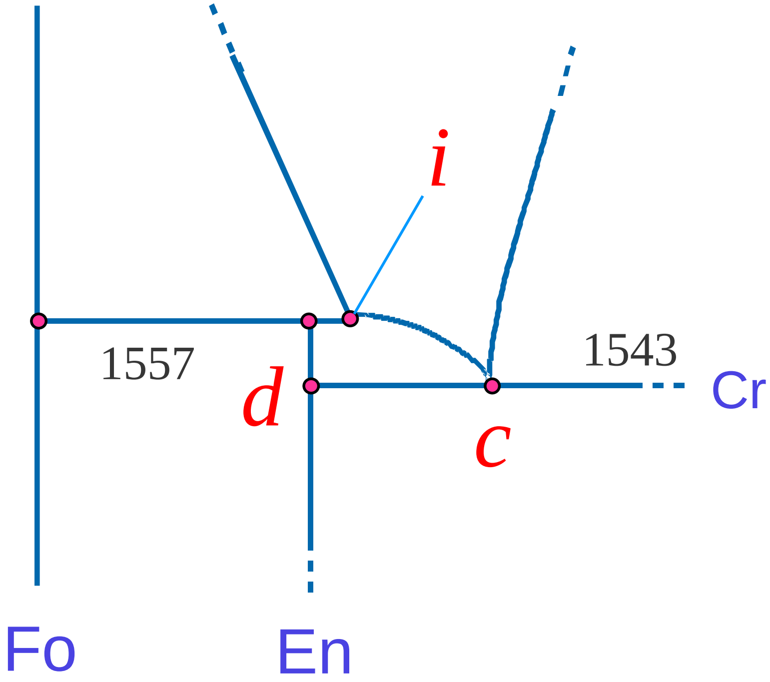

x
i
k
m
y
1557
1543
d
Cr
c
bulk X
Fo
En

# Incongruent Melting of Enstatite

- Melt of En does not → melt of same composition
- Rather En → Fo + Liq *i* at the peritectic

## Partial Melting of Fo + En (harzburgite) mantle

- En + Fo also → first liq = *i*
- Remove *i* and cool
- Result = ?



Cool X = n

# Immiscible Liquids

- At 1960°C hit solvus

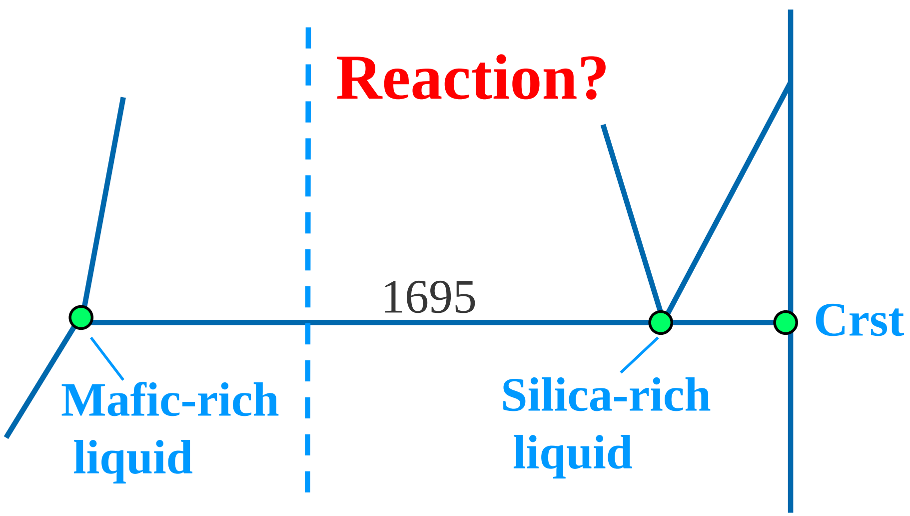
  exsolution

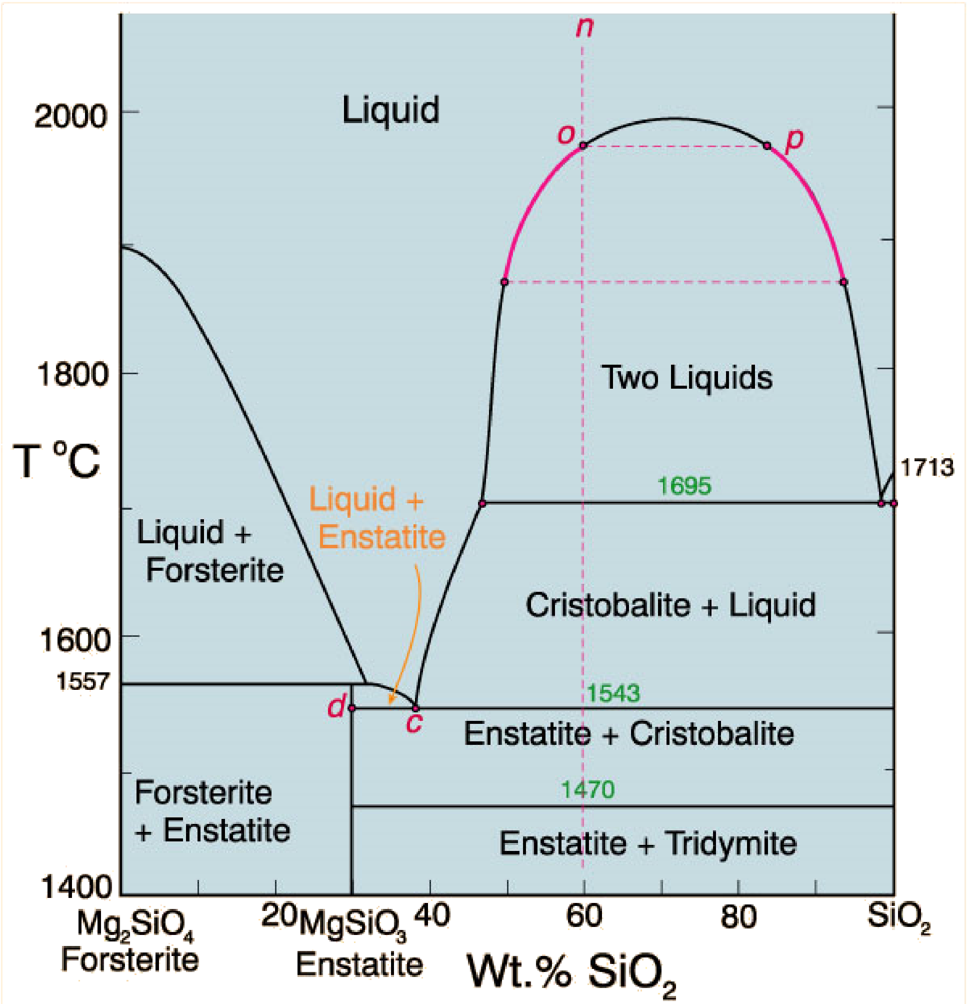
  → 2 liquids o and p

  $\phi = 2 \quad F = 1$

  both liquids follow solvus

At 1695°C get Crst also



# 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.)

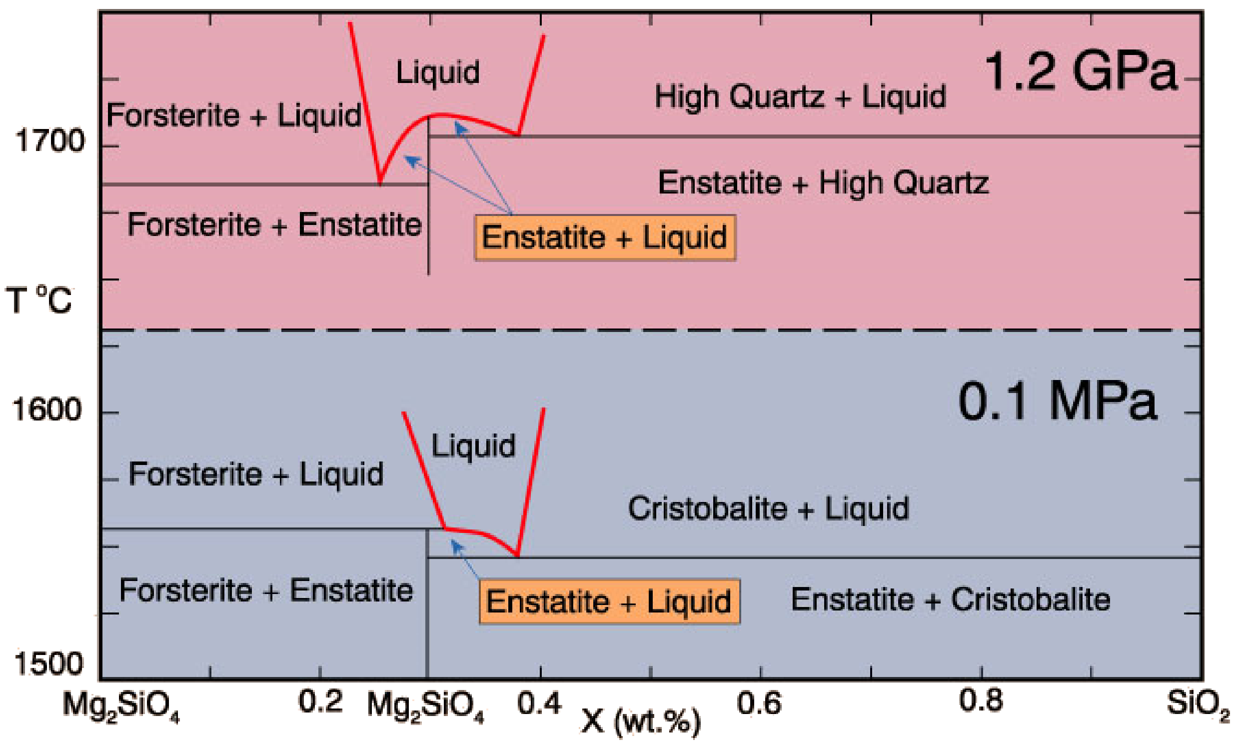



**Figure 6.15.** The system Fo-$SiO_2$ at atmospheric pressure and 1.2 GPa. After Bowen and Schairer (1935), Am. J. Sci., Chen and Presnall (1975) Am. Min.

# D. Solid Solution with Eutectic: Ab-Or (the alkali feldspars)

**Eutectic liquidus minimum**

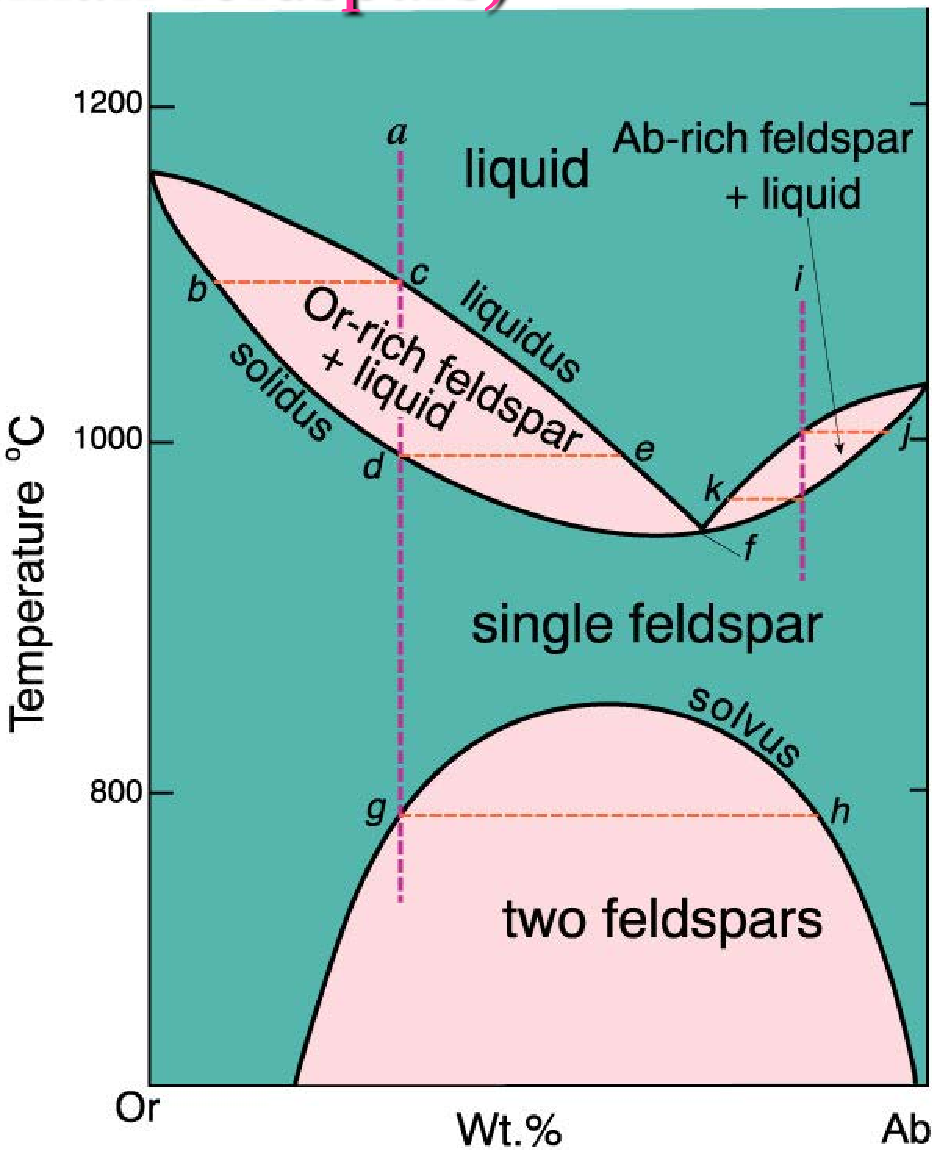
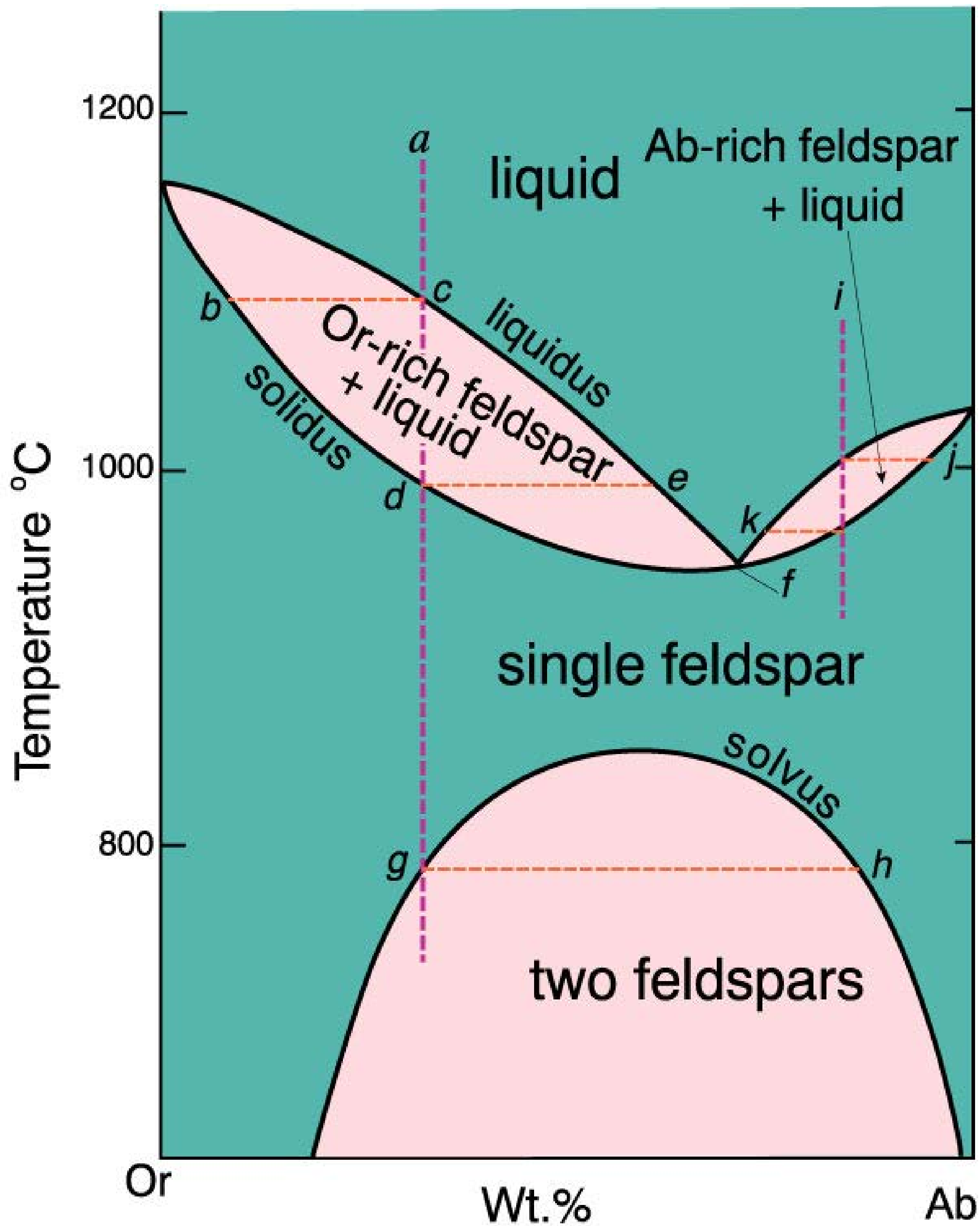



**Figure 6.16.** T-X phase diagram of the system albite-orthoclase at 0.2 GPa $H_2O$ pressure. After Bowen and Tuttle (1950). J. Geology.



Temperature °C
1200
1000
800
Or
Wt.%
Ab
a
liquid
Ab-rich feldspar
+ liquid
c
b
liquidus
i
Or-rich feldspar
+ liquid
solidus
e
d
j
k
f
single feldspar
solvus
g
h
two feldspars

# Effect of $P_{H_2O}$ on Ab-Or

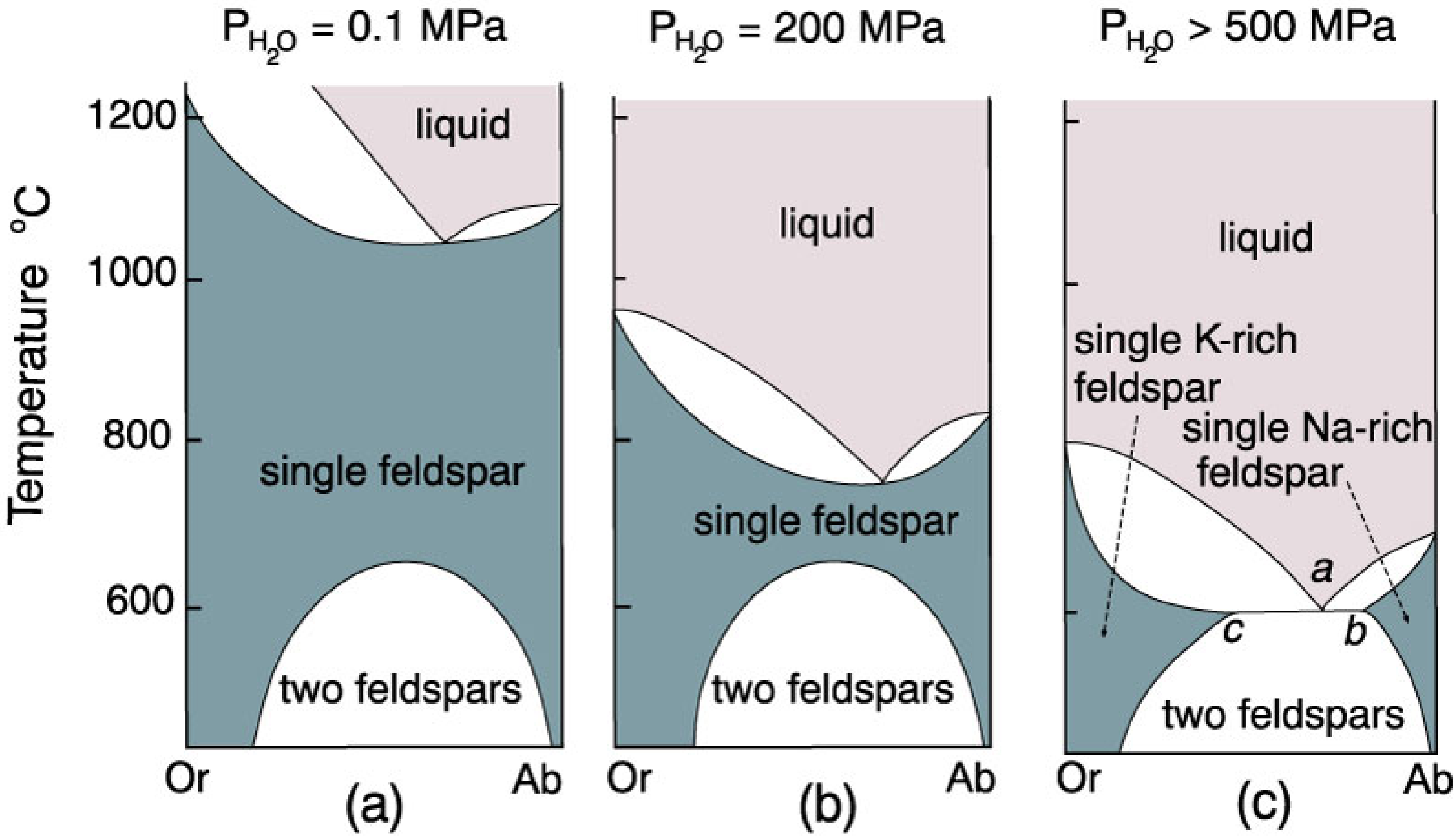



**Figure 6.17.** The Albite-K-feldspar system at various $H_2O$ pressures. (a) and (b) after Bowen and Tuttle (1950), J. Geol, (c) after Morse (1970) J. Petrol.

# C = 3: Ternary Systems:

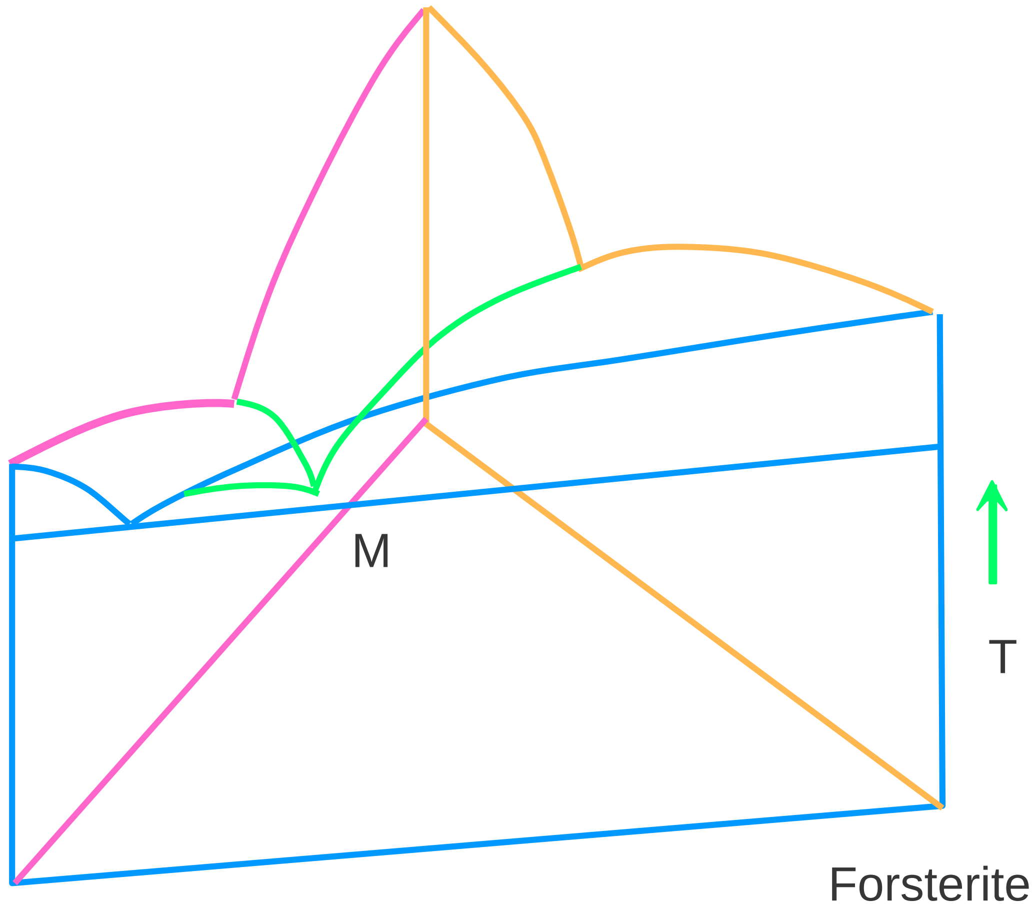
## Example 1: Ternary Eutectic

## Di - An - Fo

Note three binary eutectics

No solid solution

Ternary eutectic = M



# T - X Projection of Di - An - Fo

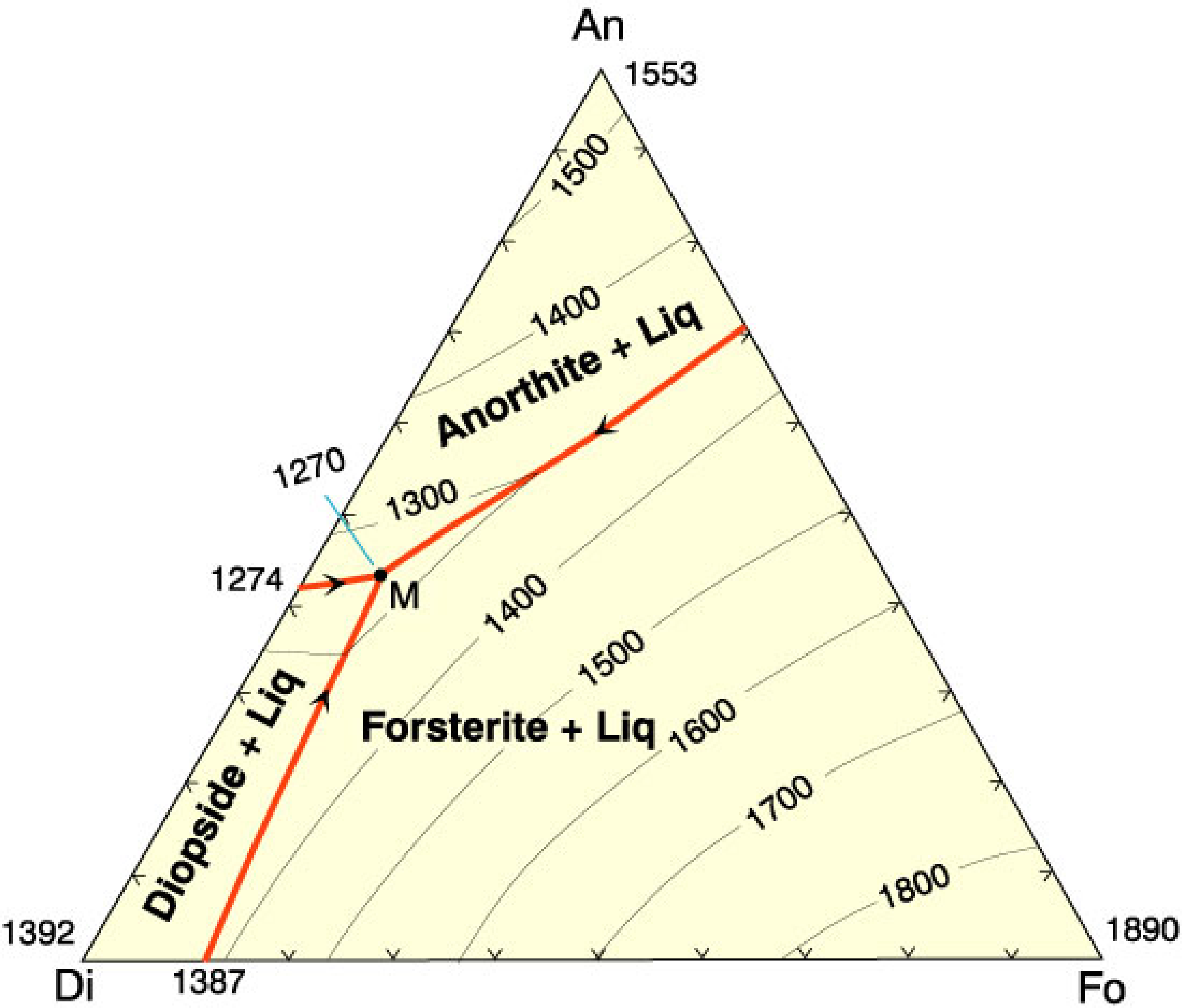
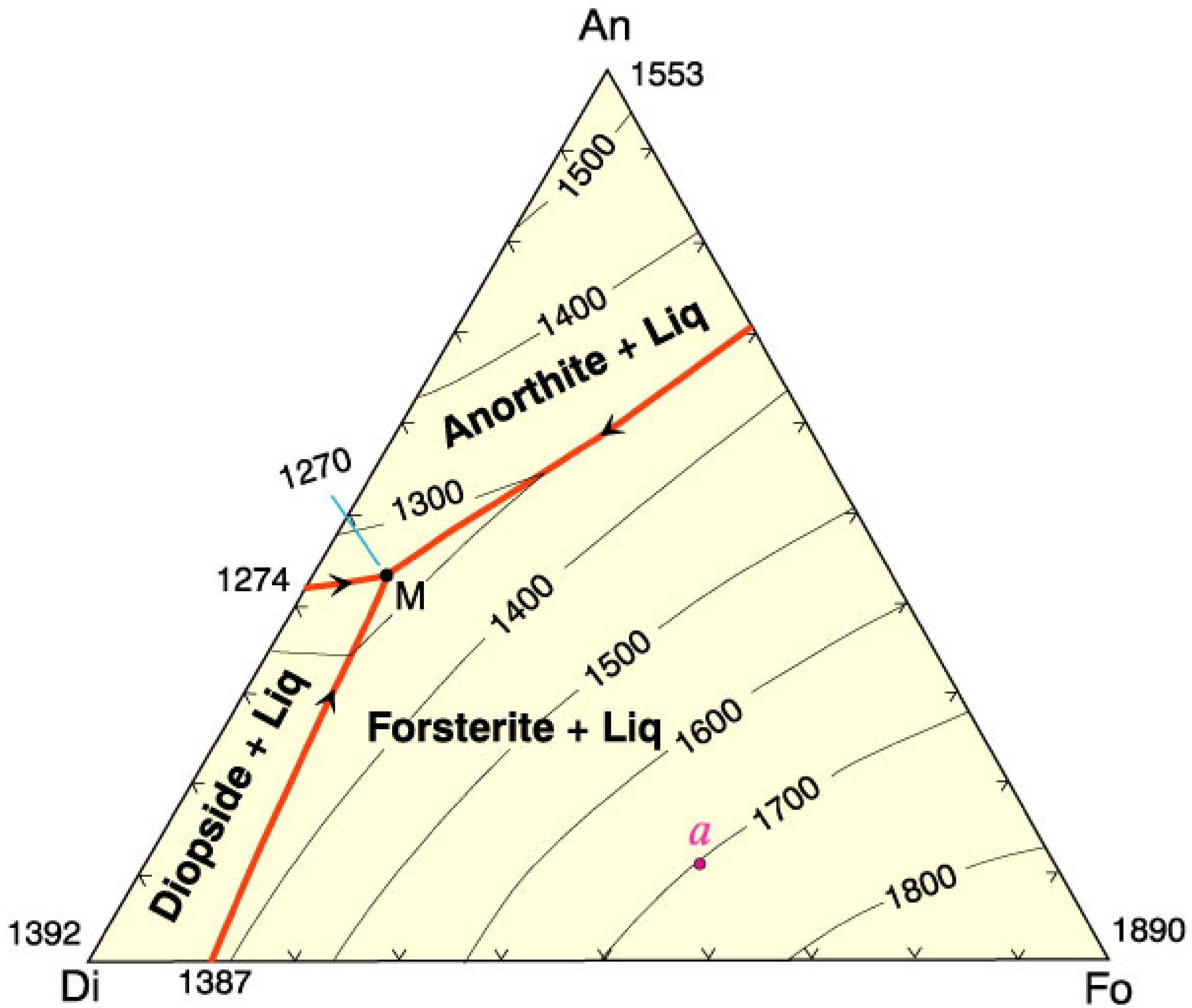
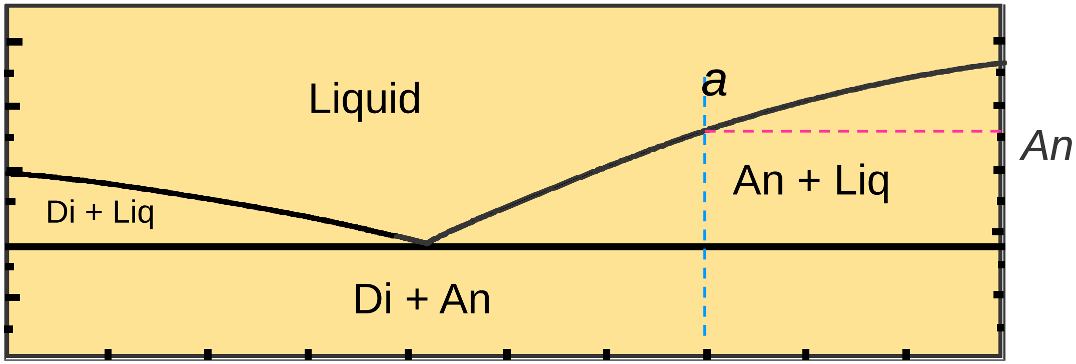



**Figure 7.2.** Isobaric diagram illustrating the liquidus temperatures in the Di-An-Fo system at atmospheric pressure (0.1 MPa). After Bowen (1915), A. J. Sci., and Morse (1994), Basalts and Phase Diagrams. Krieger Publishers.

# Crystallization Relationships



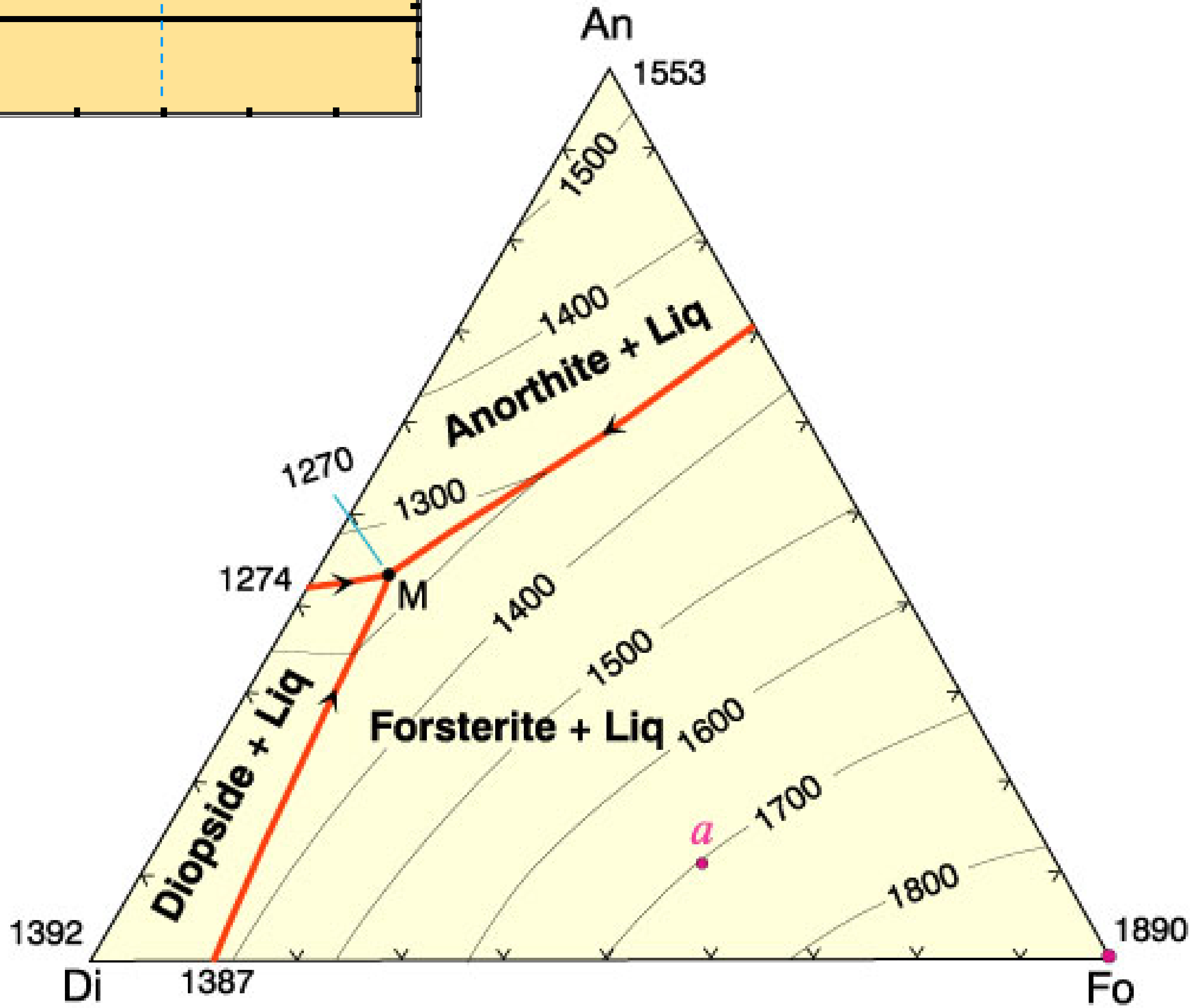



Pure Fo forms

Just as in binary

$\phi = ?$

$F = ?$

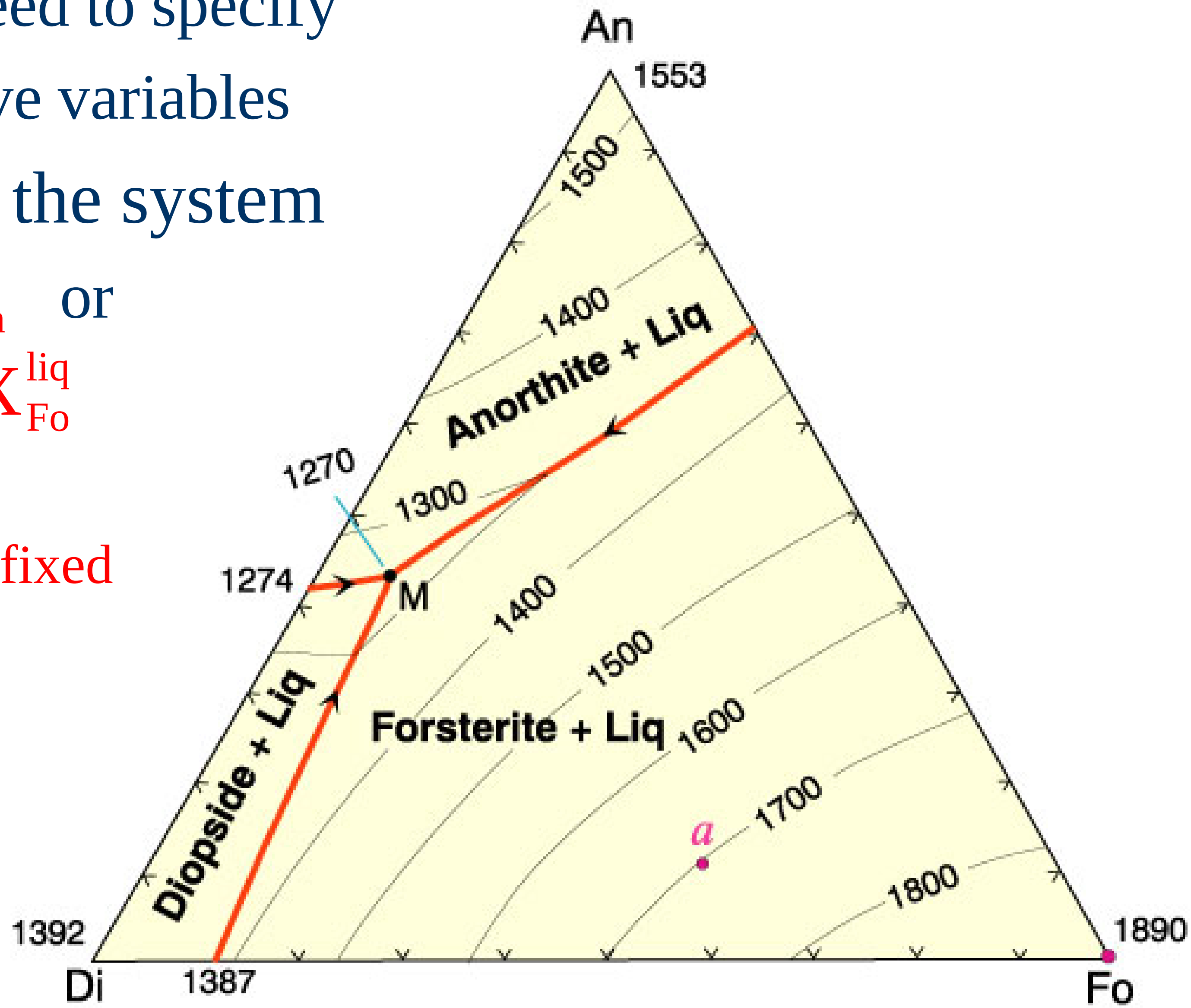


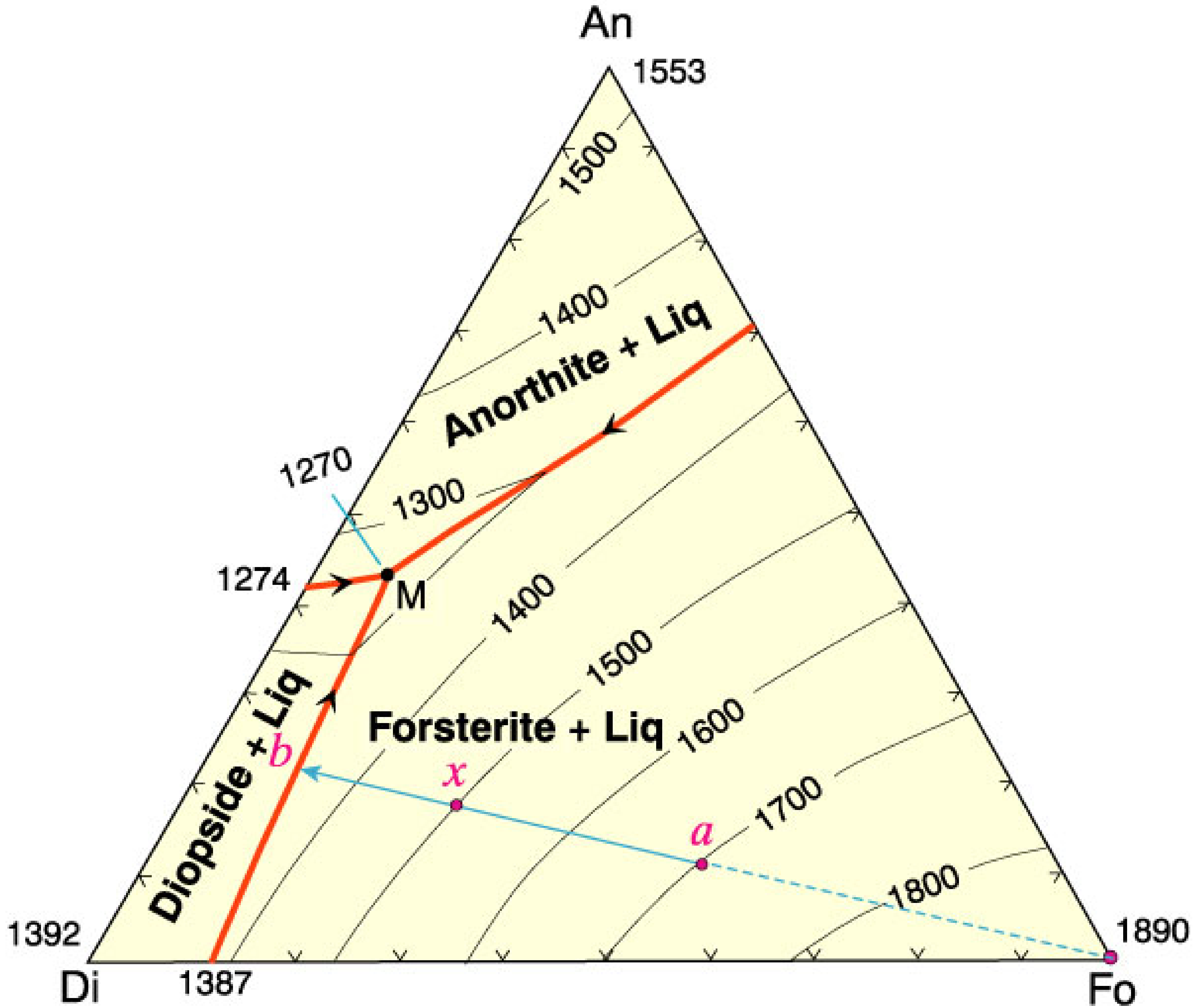
- ☞ $\phi = 2$ (Fo + Liq)
- ☞ $F = 3 - 2 + 1 = 2$

If on liquidus, need to specify only 2 intensive variables to determine the system

- ☞ T and $X_{An}^{liq}$ or
- ☞ $X_{An}^{liq}$ and $X_{Fo}^{liq}$

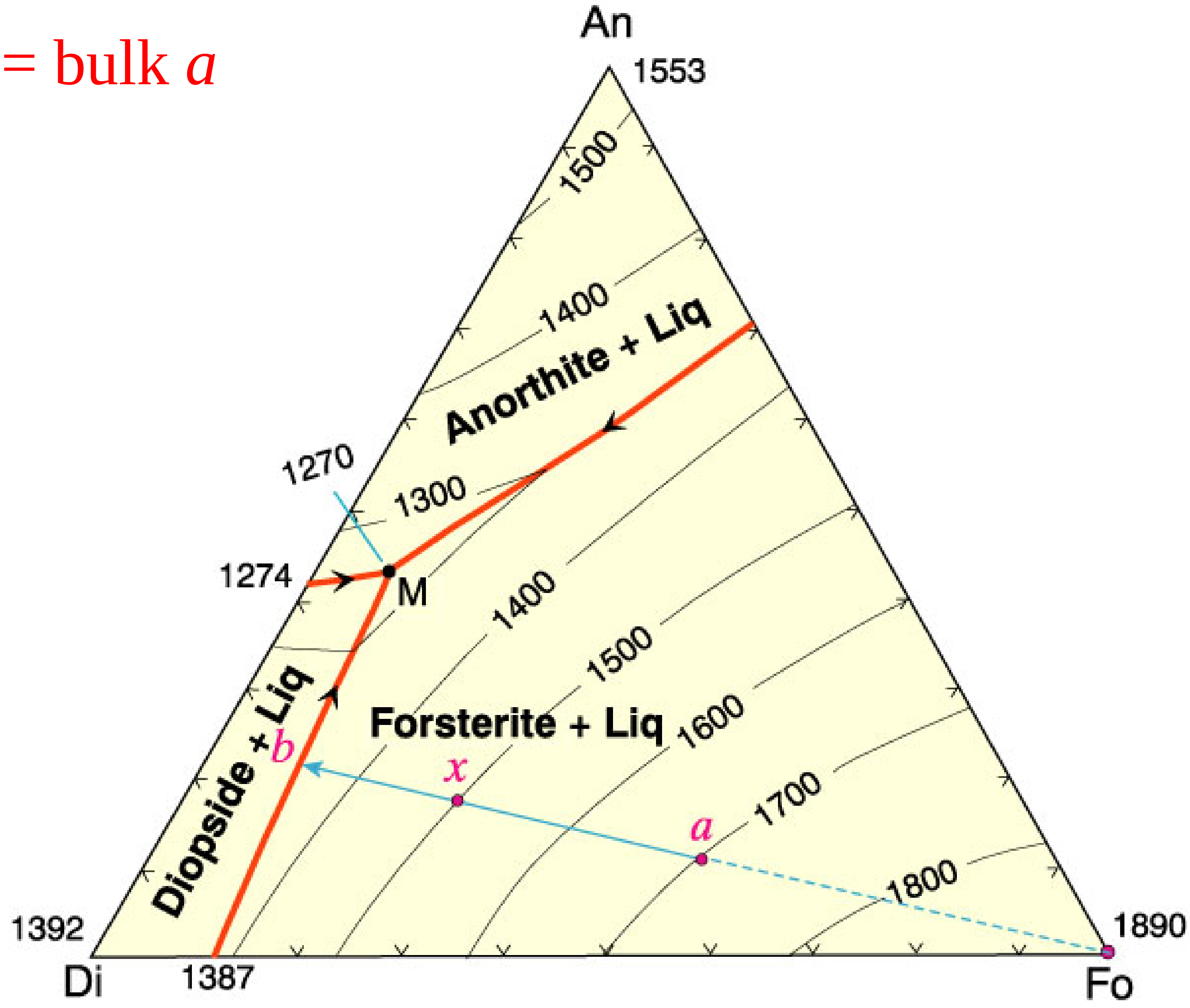
X of pure Fo is fixed

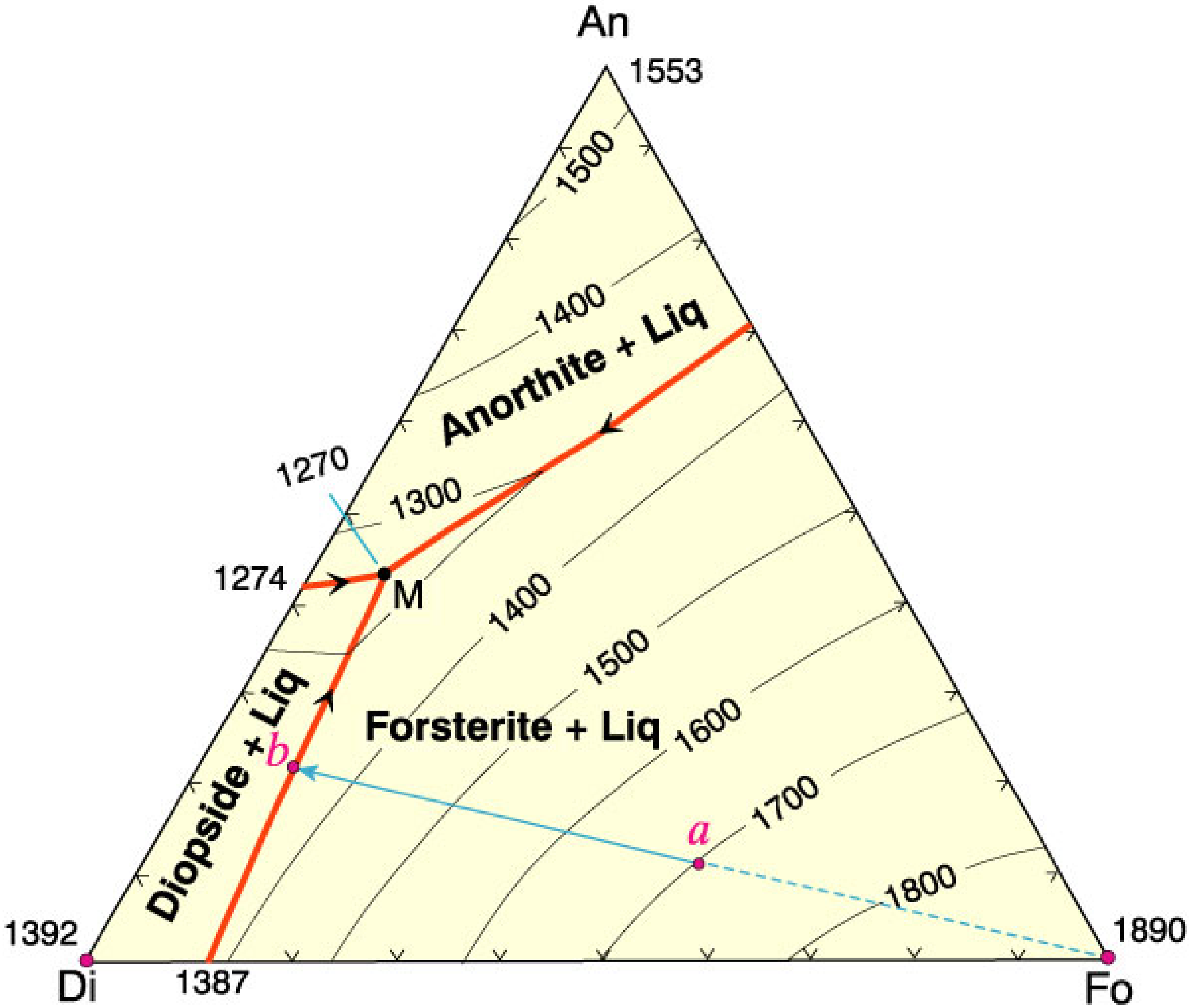



An
1553
1500
1400
Anorthite + Liq
1270
1300
1274
M
1400
1500
Diopside + Liq
Forsterite + Liq
1600
b
x
1700
a
1800
1392
1890
Di
1387
Fo

# Lever principle → relative proportions of liquid & Fo

- At 1500°C
  - ☞ Liq *x* + Fo = bulk *a*



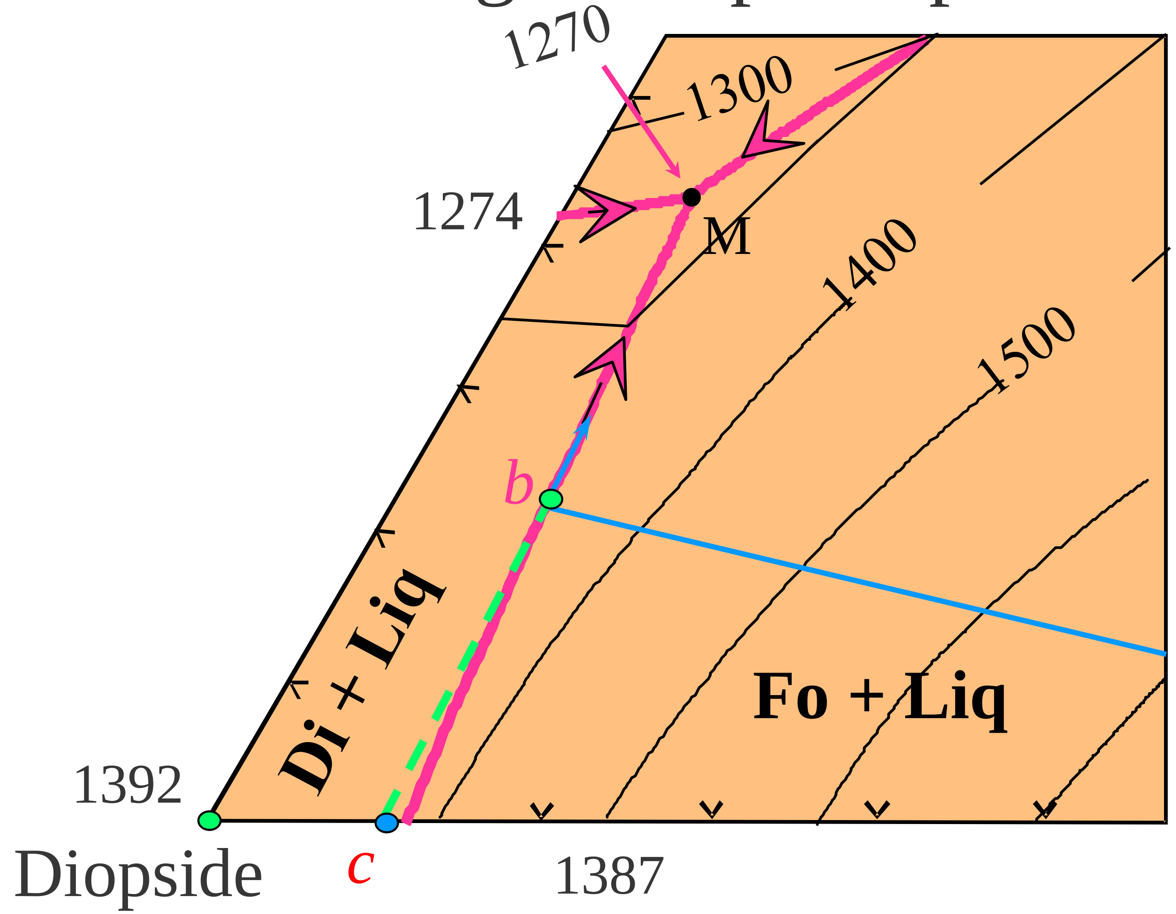


An
1553
1500
1400
Anorthite + Liq
1270
1300
1274
M
1400
1500
Diopside + Liq
Forsterite + Liq
1600
b
1700
a
1800
1392
1890
Di
1387
Fo

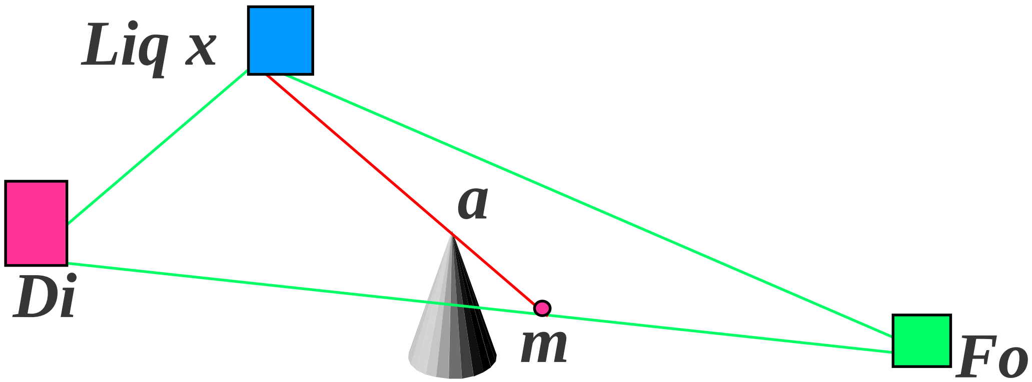
- New continuous reaction as liquid follows cotectic:

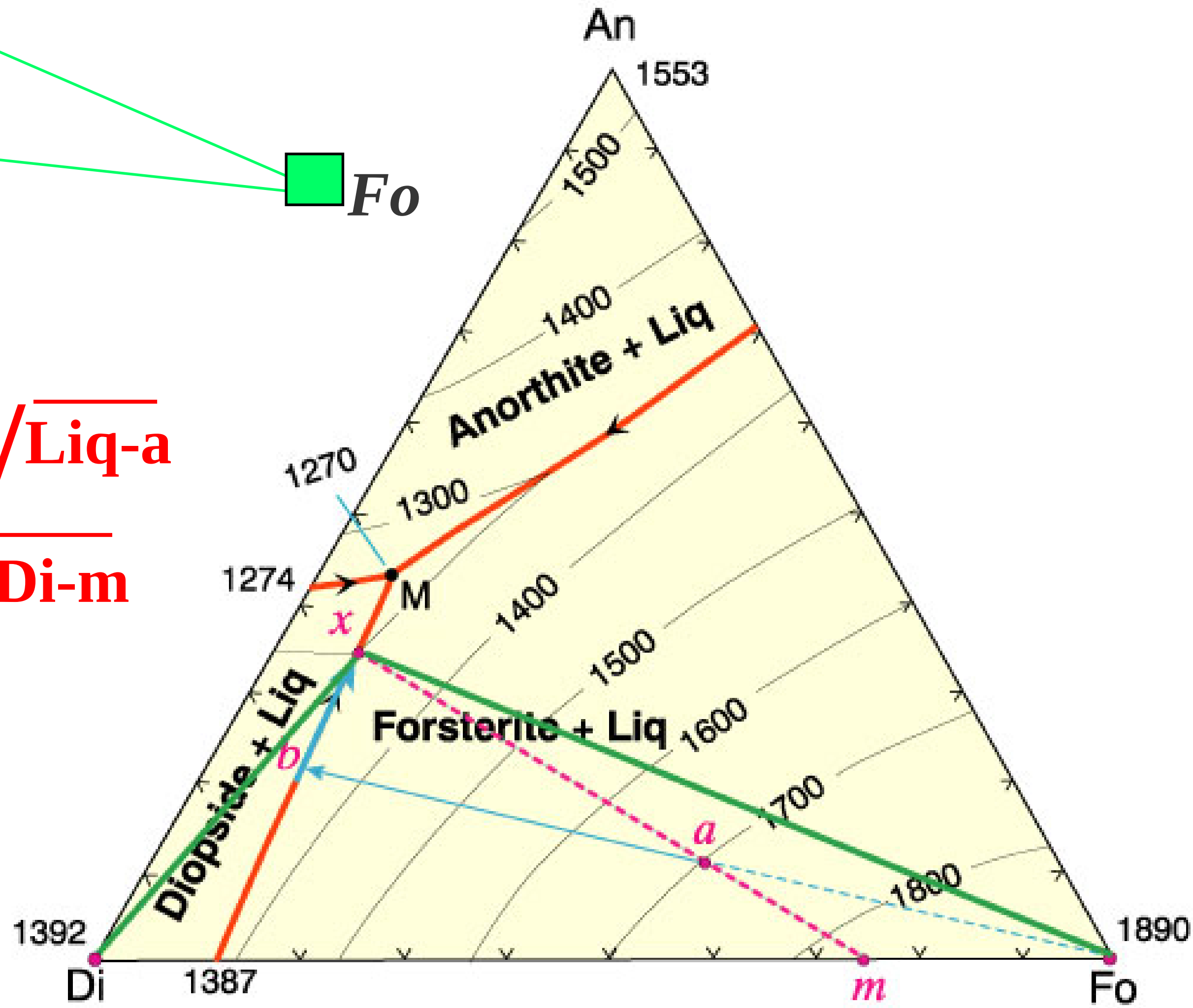
  $Liq_A \rightarrow Liq_B + Fo + Di$

- Bulk solid extract
- Di/Fo in bulk solid extract using lever principle



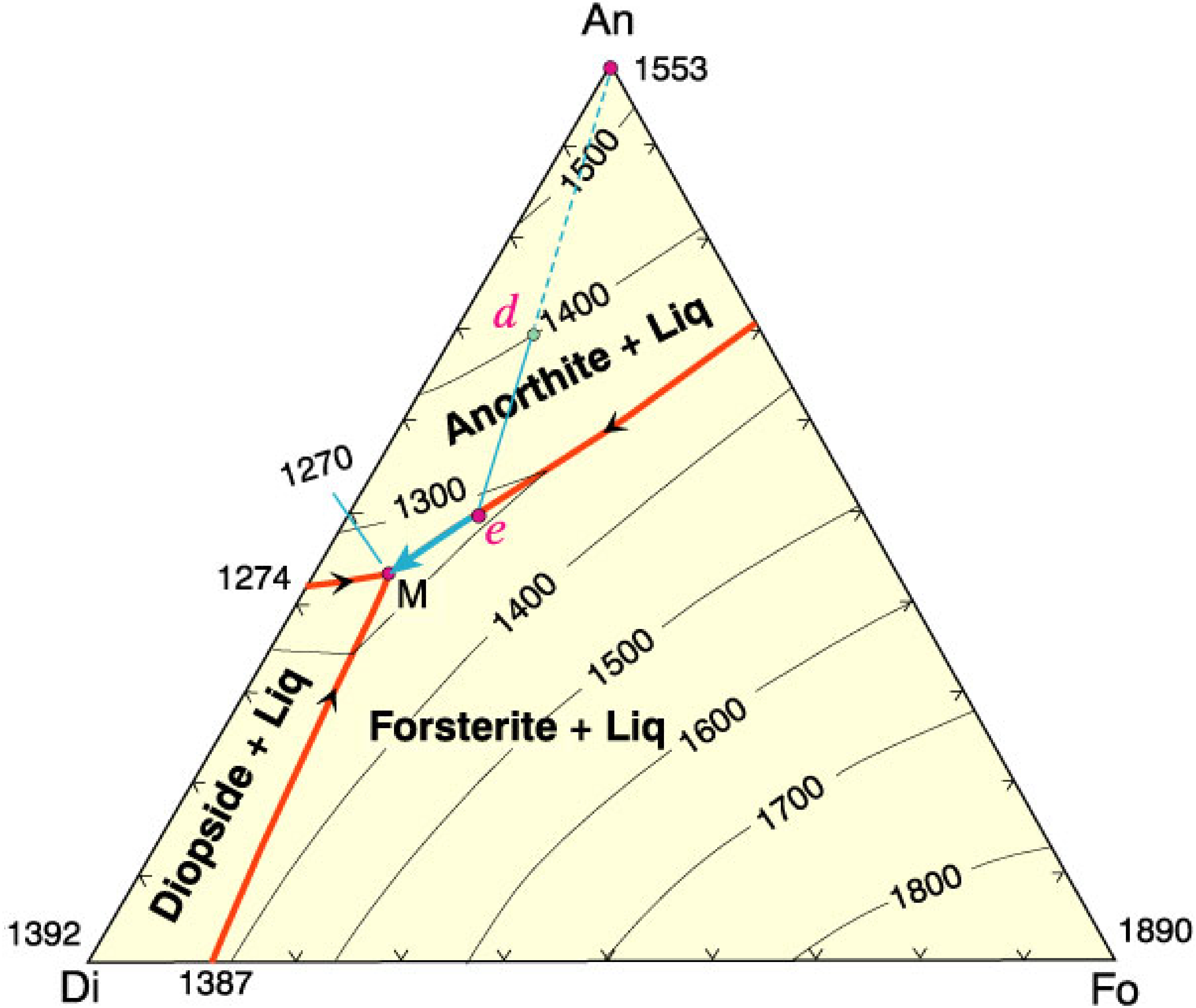
- At 1300°C liquid = X
- Imagine triangular plane X - Di - Fo balanced on bulk *a*



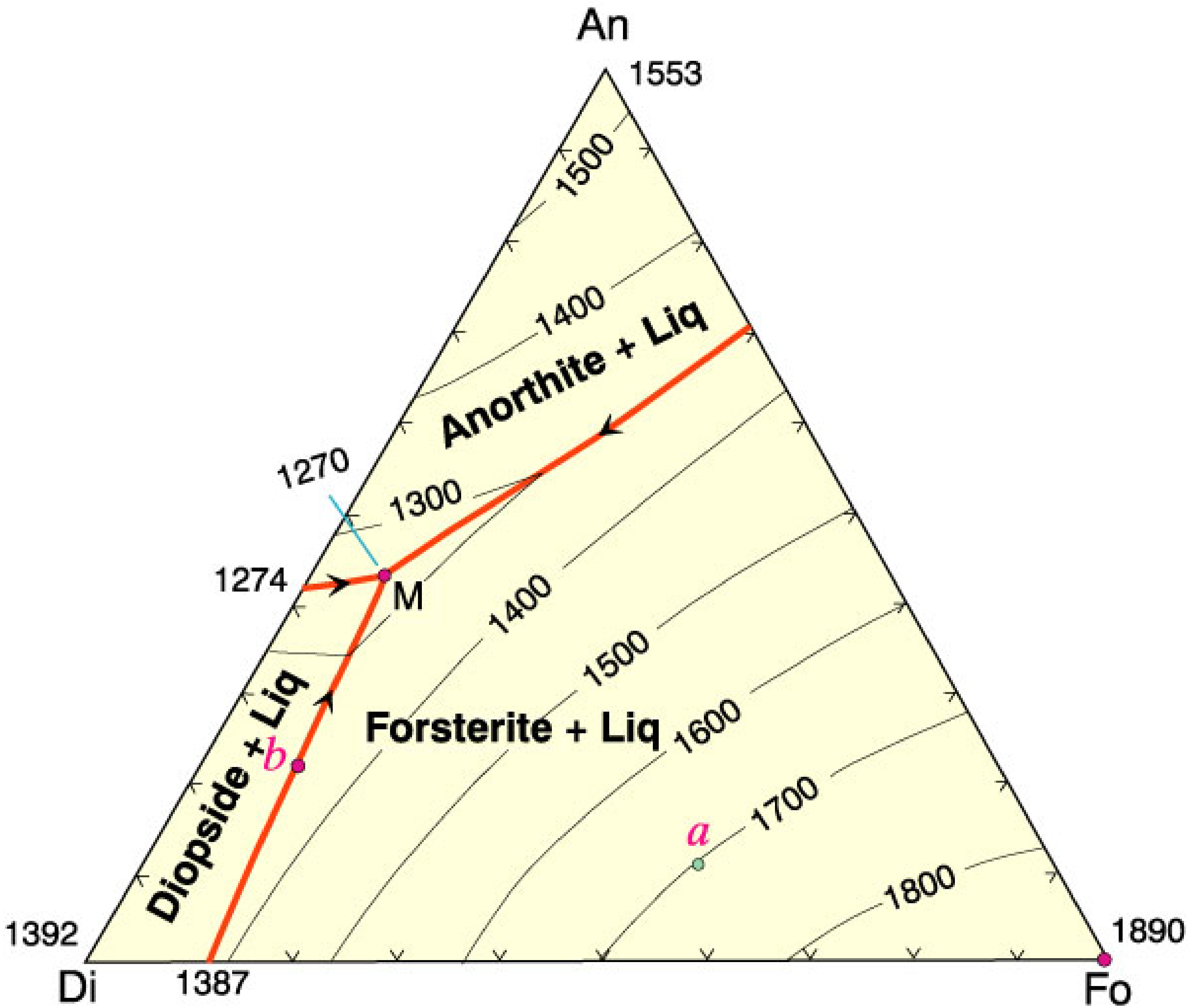

**Liq/total solids = $\overline{a\text{-}m}/\overline{Liq\text{-}a}$**

**total Di/Fo = $\overline{m\text{-}Fo}/\overline{Di\text{-}m}$**



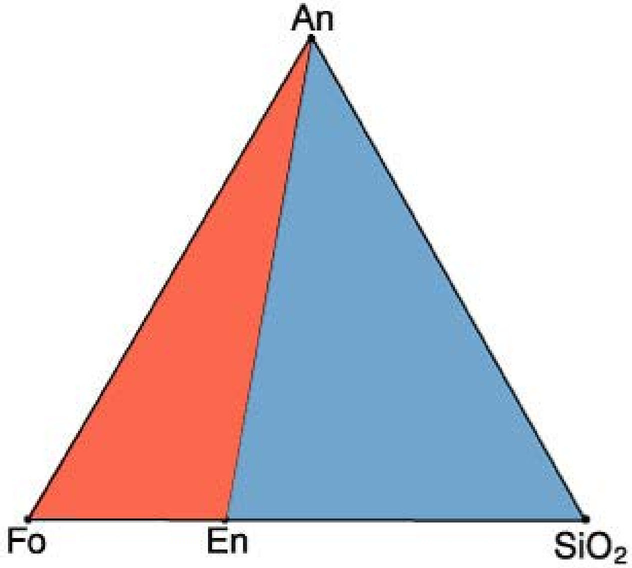
An
1553
1500
1400
d
Anorthite + Liq
1270
1300
e
1274
M
1400
1500
Diopside + Liq
Forsterite + Liq
1600
1700
1800
1392
1890
Di
1387
Fo

# Partial Melting (remove melt):



# Ternary Peritectic Systems:

(at 0.1 MPa)




3 binary systems:

Fo-An eutectic

An-$SiO_2$ eutectic

Fo-$SiO_2$ peritectic

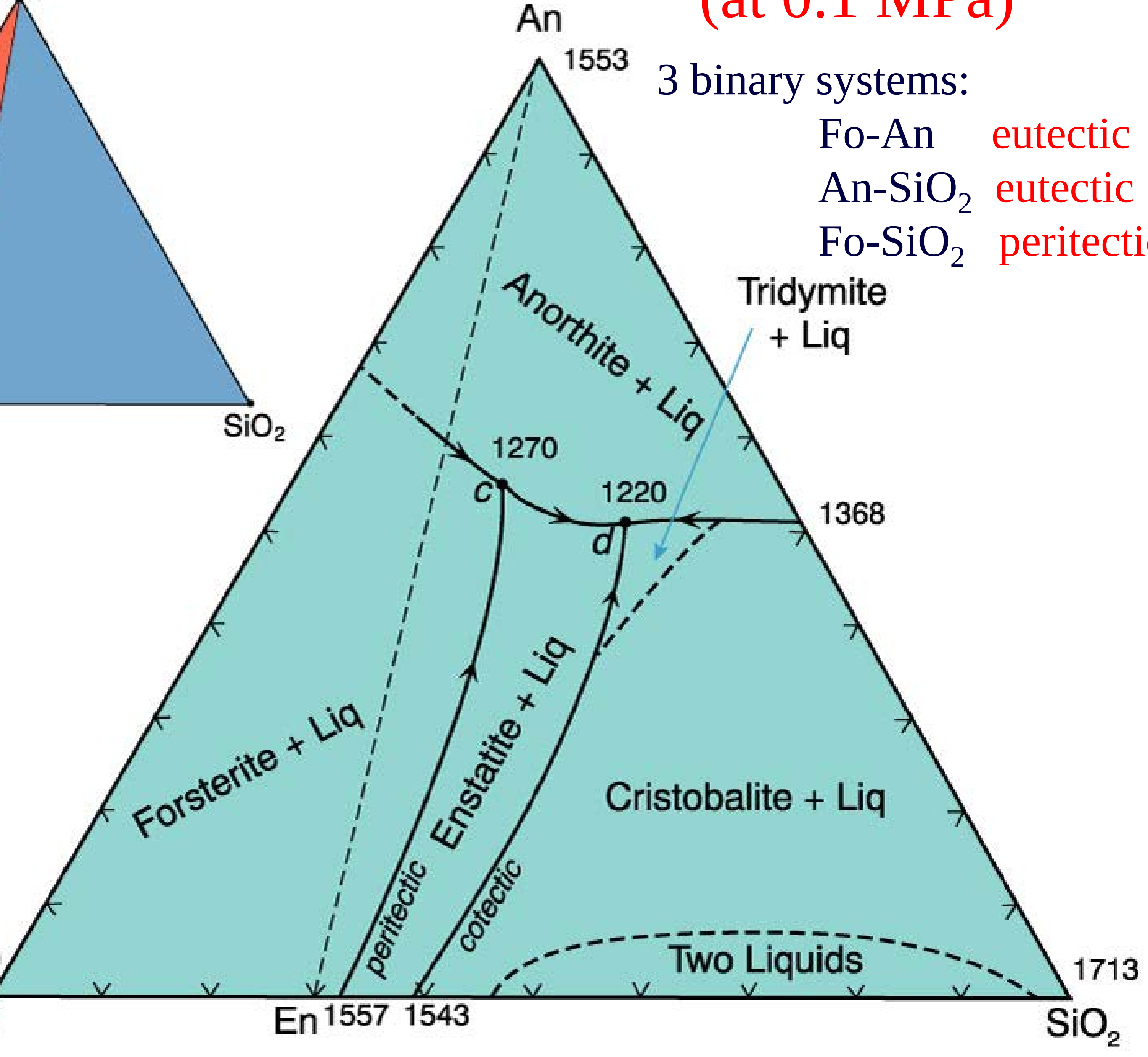
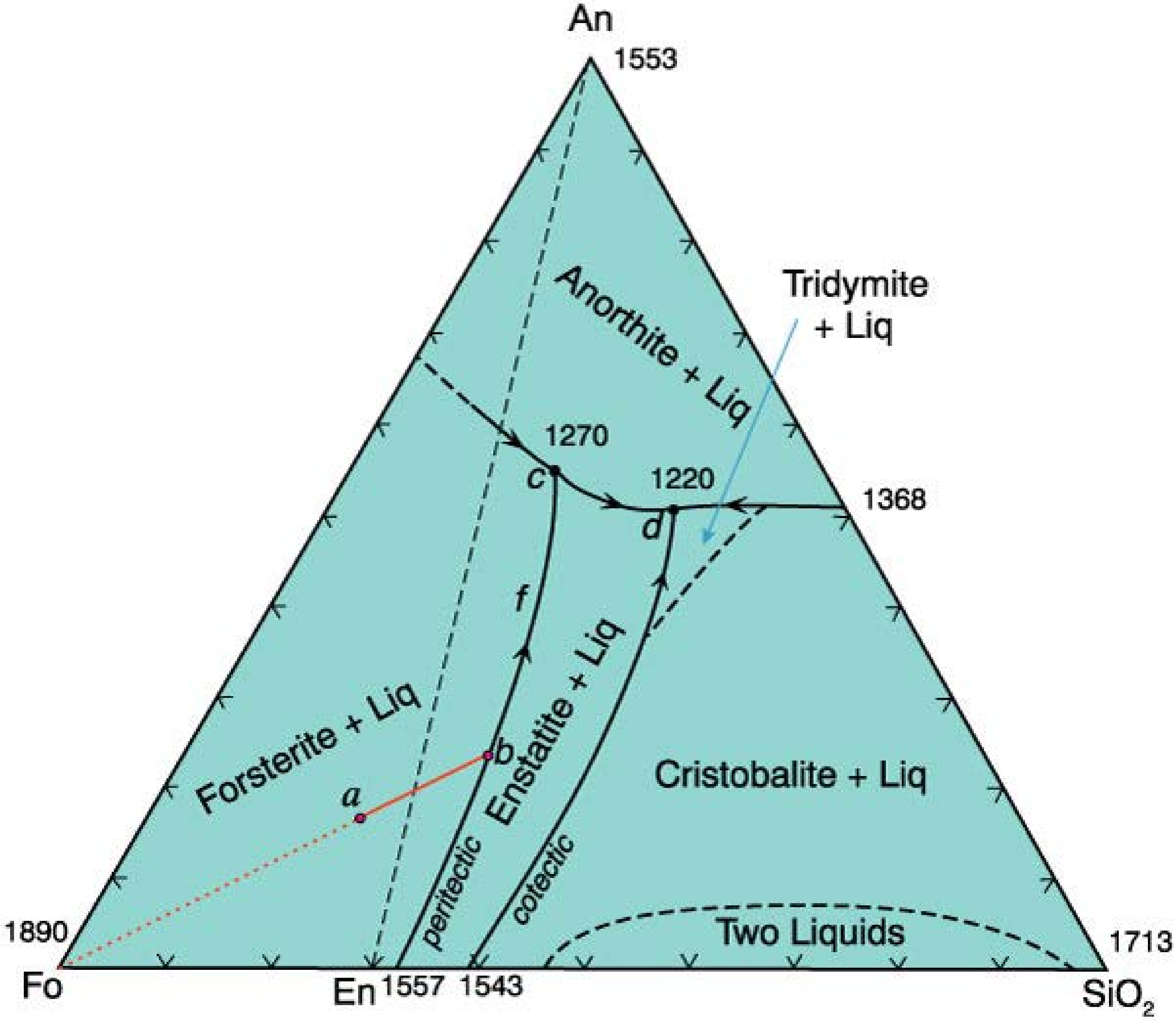
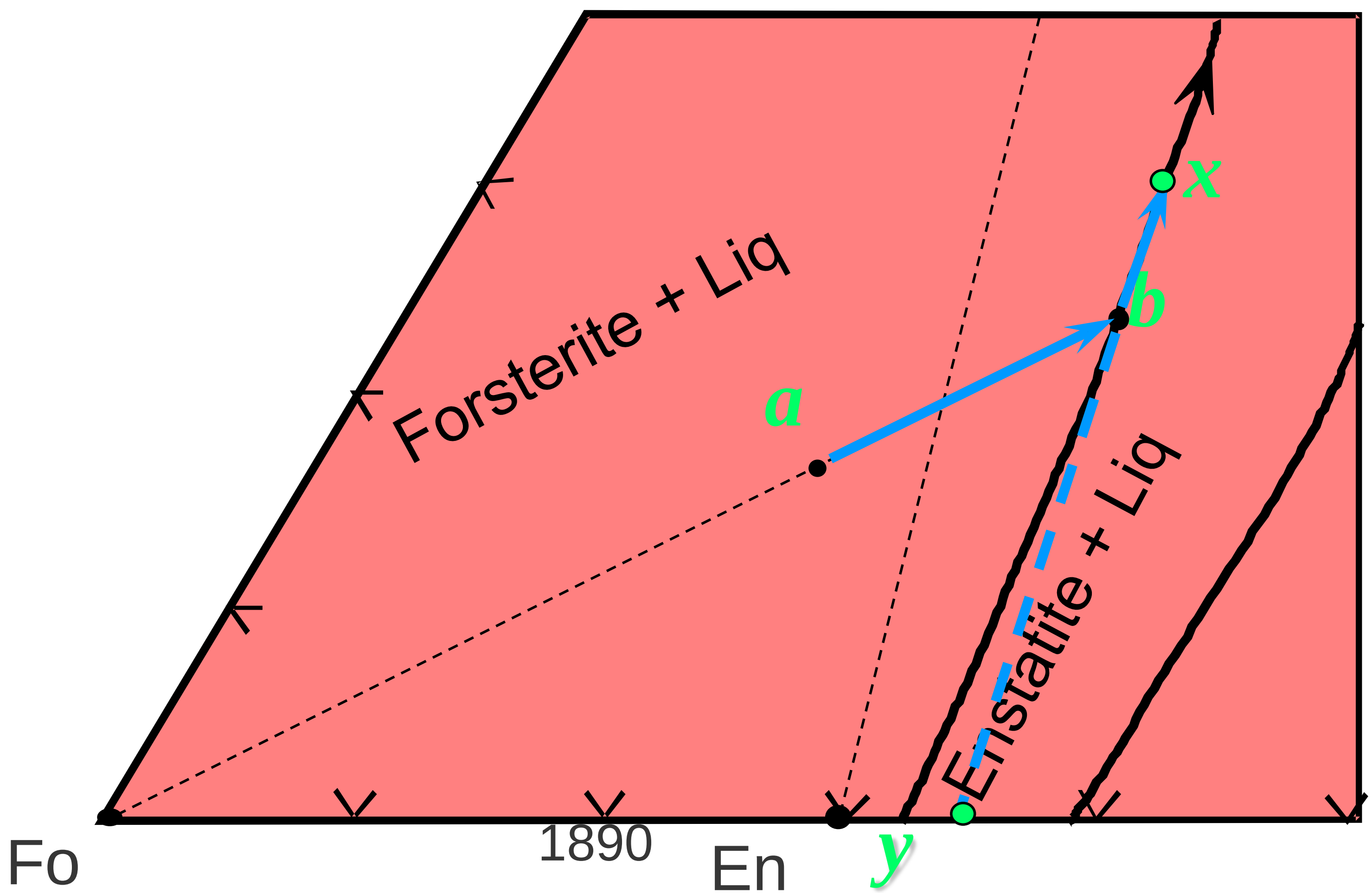
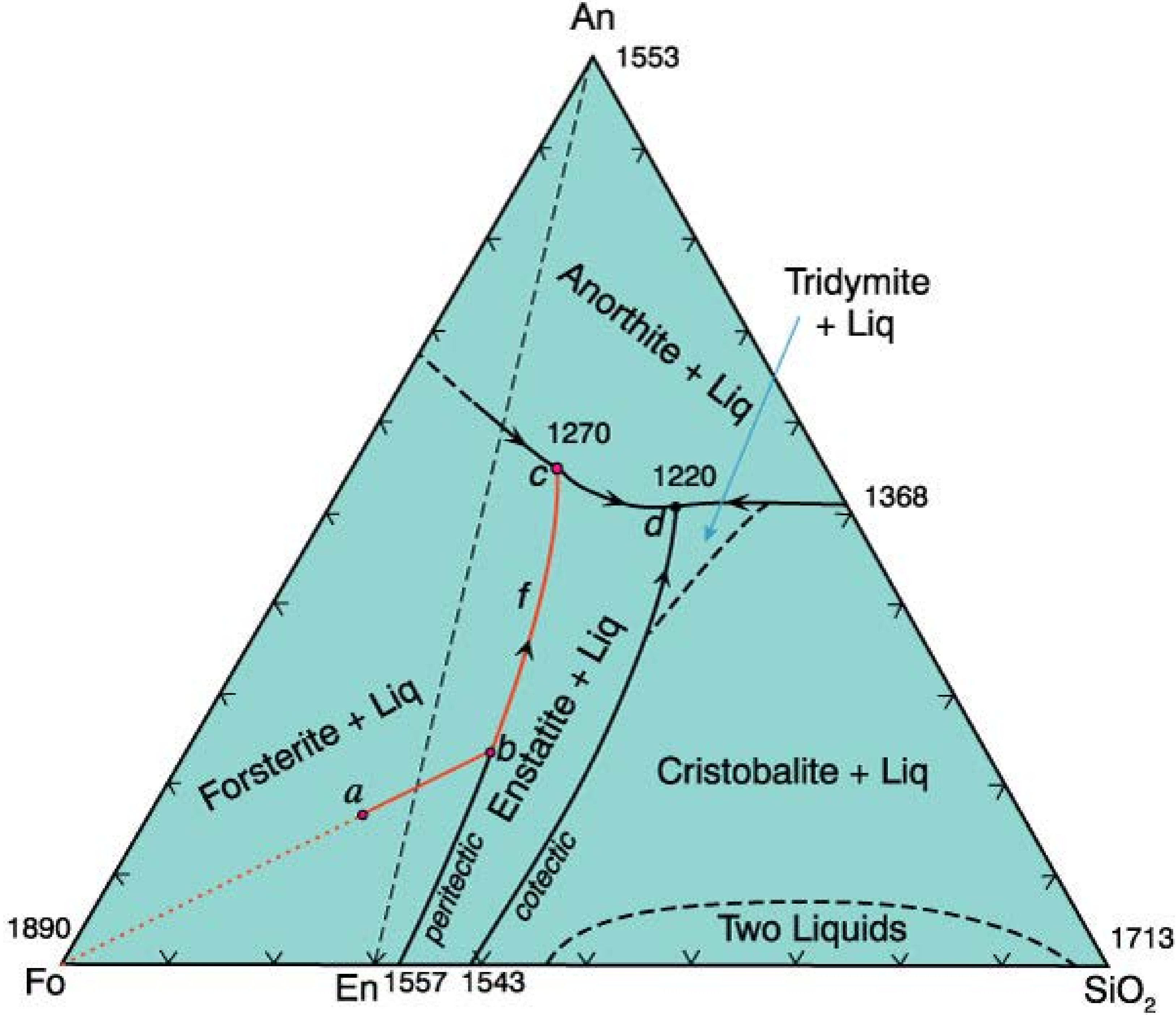



**Figure 7.4.** **Isobaric diagram illustrating the cotectic and peritectic curves in the system forsterite-anorthite-silica at 0.1 MPa. After Anderson (1915) A. J. Sci., and Irvine (1975) CIW Yearb. 74.**


An
1553
Anorthite + Liq
Tridymite
+ Liq
1270
c
1220
d
1368
f
Forsterite + Liq
Enstatite + Liq
b
a
Cristobalite + Liq
peritectic
cotectic
Two Liquids
1890
1713
Fo
En
1557
1543
SiO2

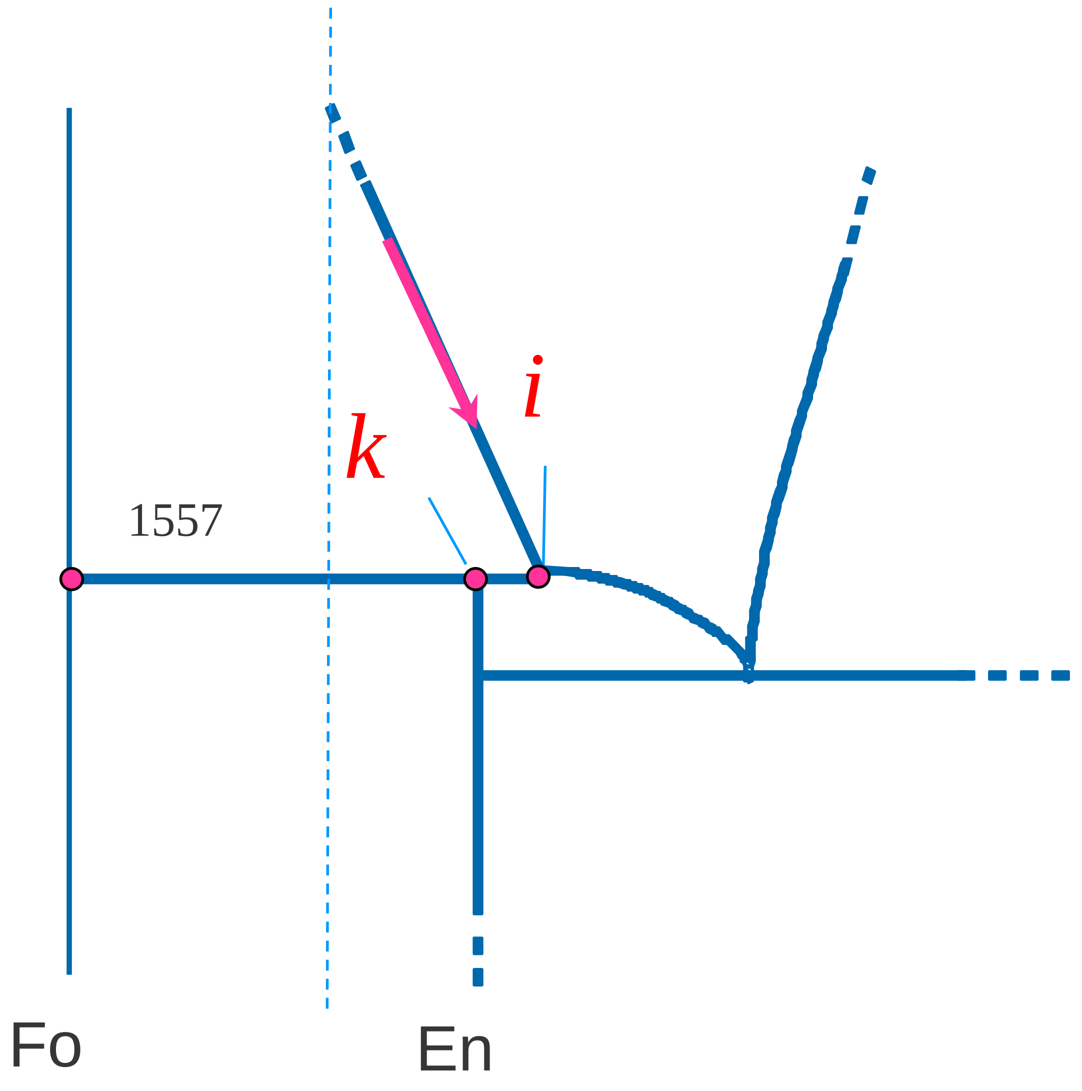


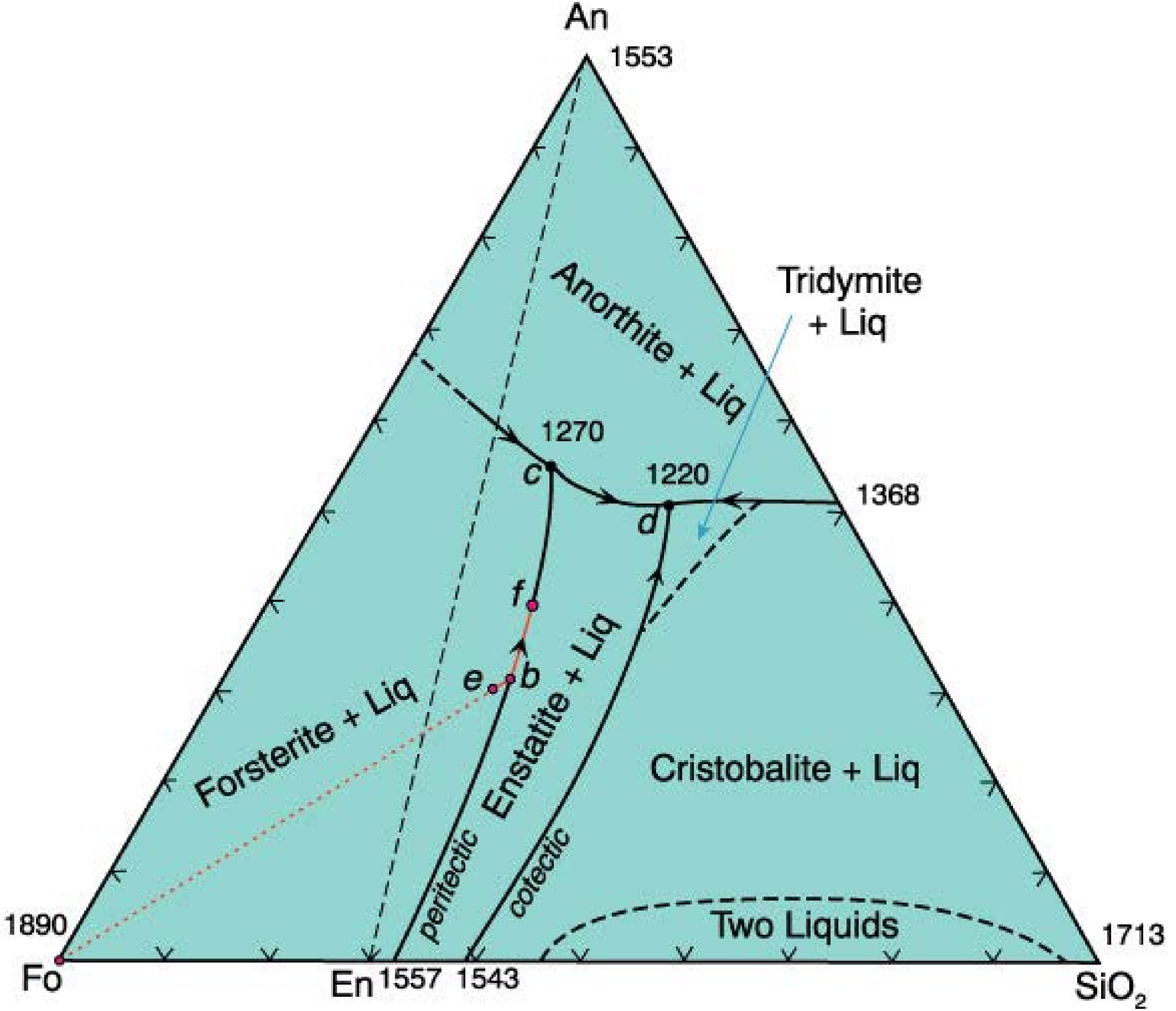
Forsterite + Liq
Enstatite + Liq
a
b
x
y
Fo
1890
En



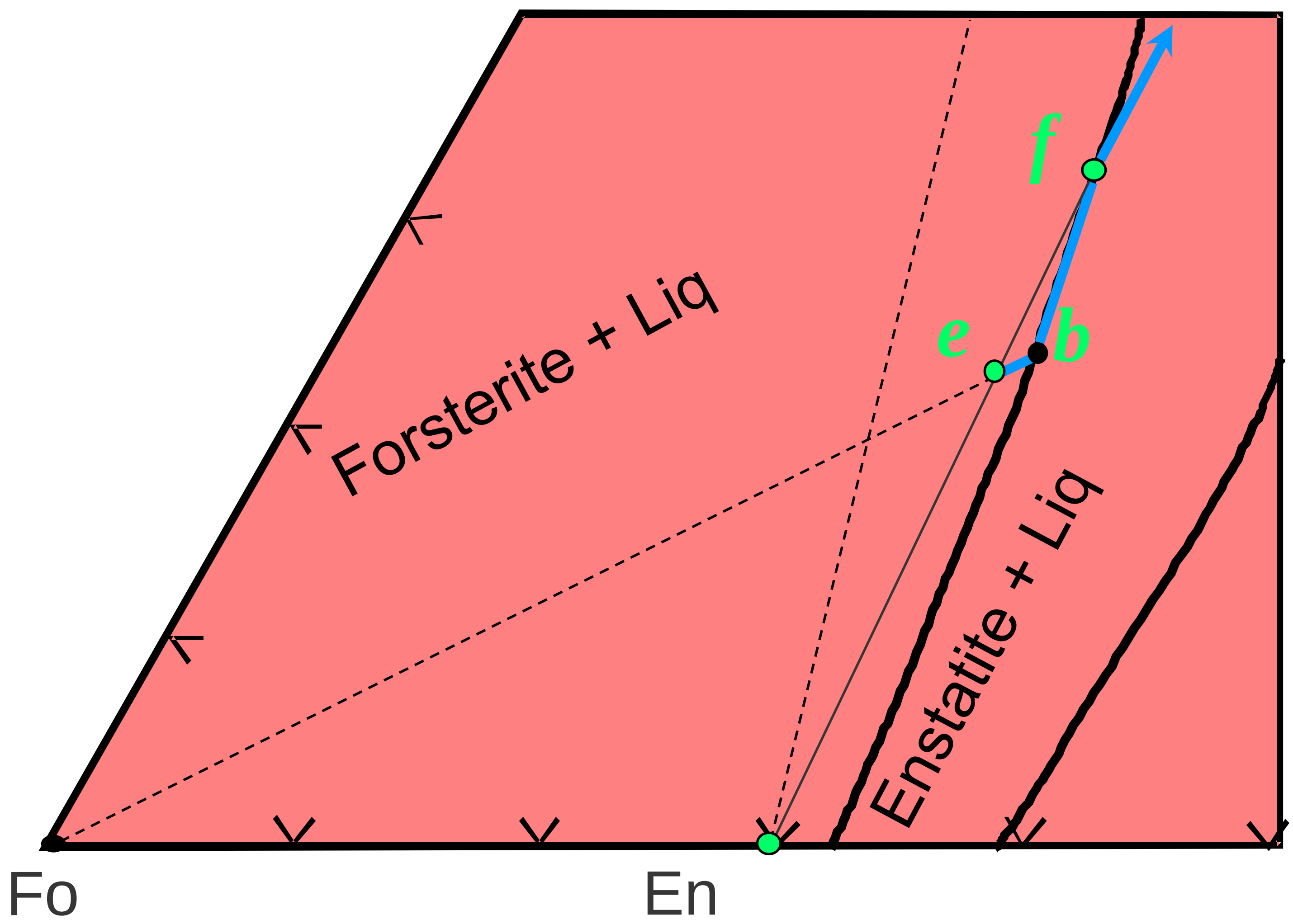
An
1553
Anorthite + Liq
Tridymite
+ Liq
1270
c
1220
1368
d
f
Forsterite + Liq
Enstatite + Liq
b
a
Cristobalite + Liq
peritectic
cotectic
Two Liquids
1890
1713
Fo
En
1557
1543
$SiO_2$

# Works the same way as the Fo - En - $SiO_2$ binary

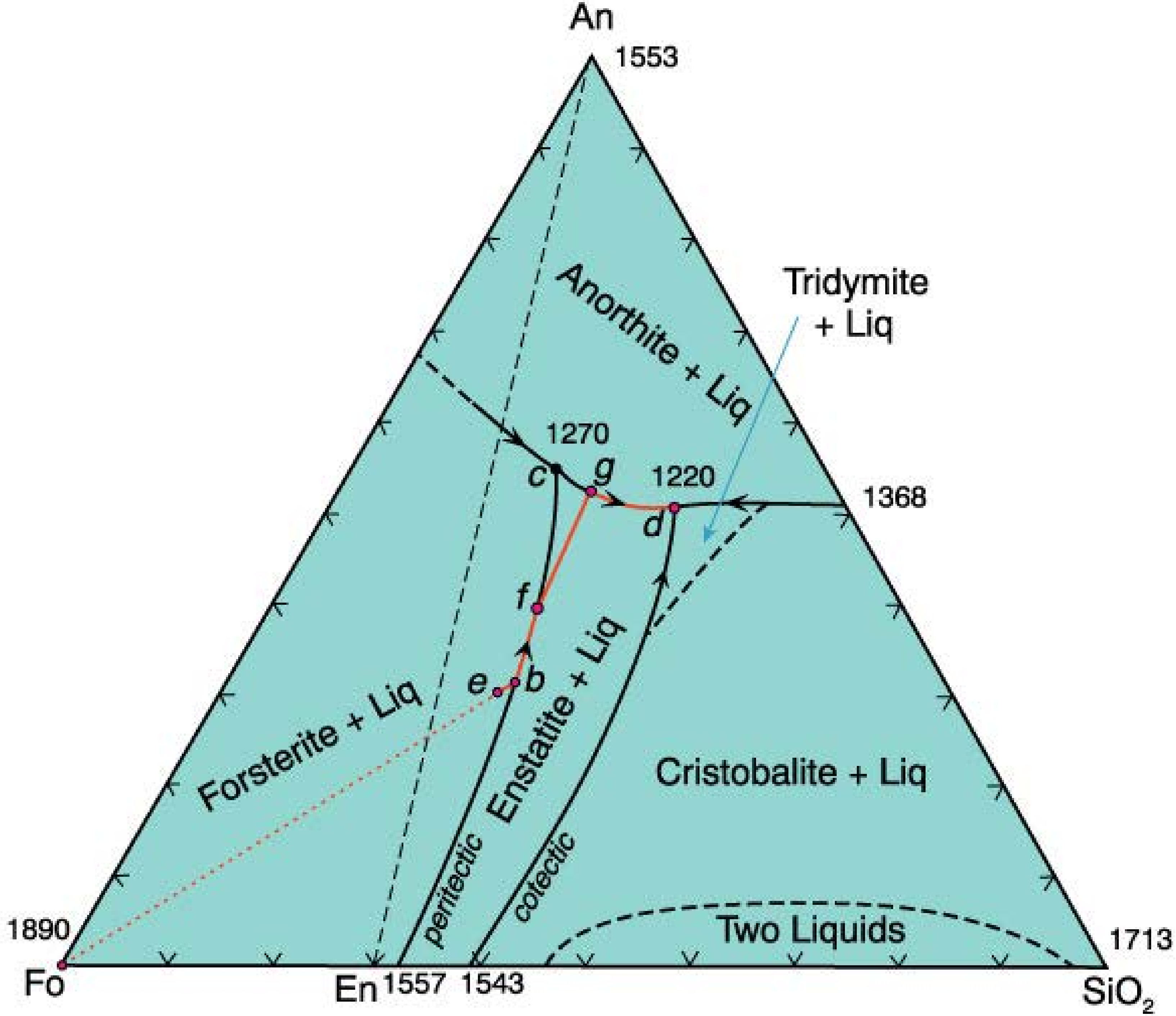




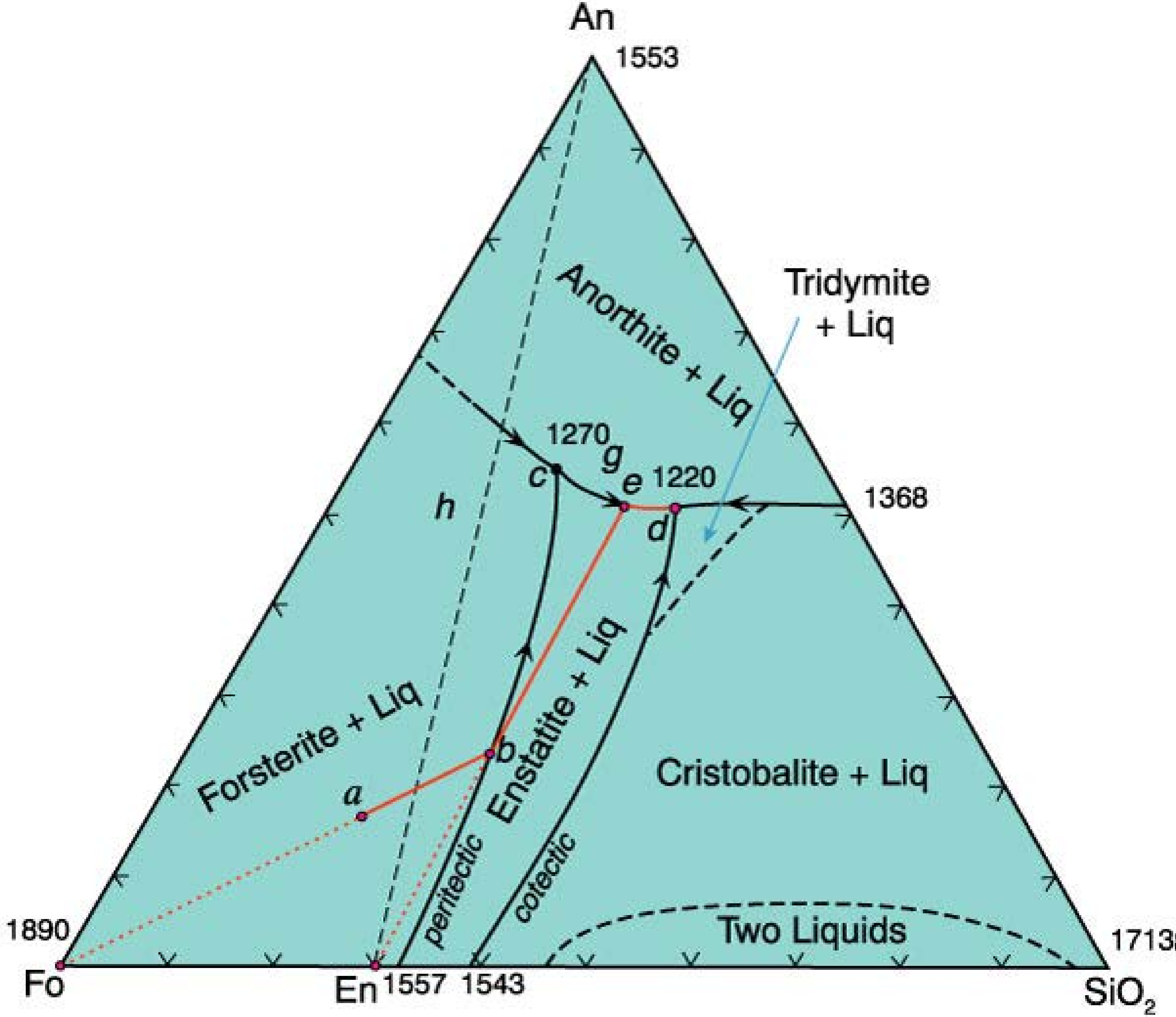
An
1553
Anorthite + Liq
Tridymite
+ Liq
1270
c
1220
d
1368
f
e
b
Forsterite + Liq
Enstatite + Liq
Cristobalite + Liq
peritectic
cotectic
Two Liquids
1890
1713
Fo
En
1557
1543
SiO2



Forsterite + Liq
Enstatite + Liq
f
e
b
Fo
En



An
1553
Anorthite + Liq
Tridymite
+ Liq
1270
c
g
1220
d
1368
f
b
e
Forsterite + Liq
Enstatite + Liq
Cristobalite + Liq
peritectic
cotectic
Two Liquids
1890
1713
Fo
En
1557
1543
SiO2


An
1553
Anorthite + Liq
Tridymite
+ Liq
1270
g
e
1220
c
h
1368
d
Forsterite + Liq
Enstatite + Liq
b
a
Cristobalite + Liq
peritectic
cotectic
Two Liquids
1890
1713
Fo
En
1557
1543
$SiO_2$