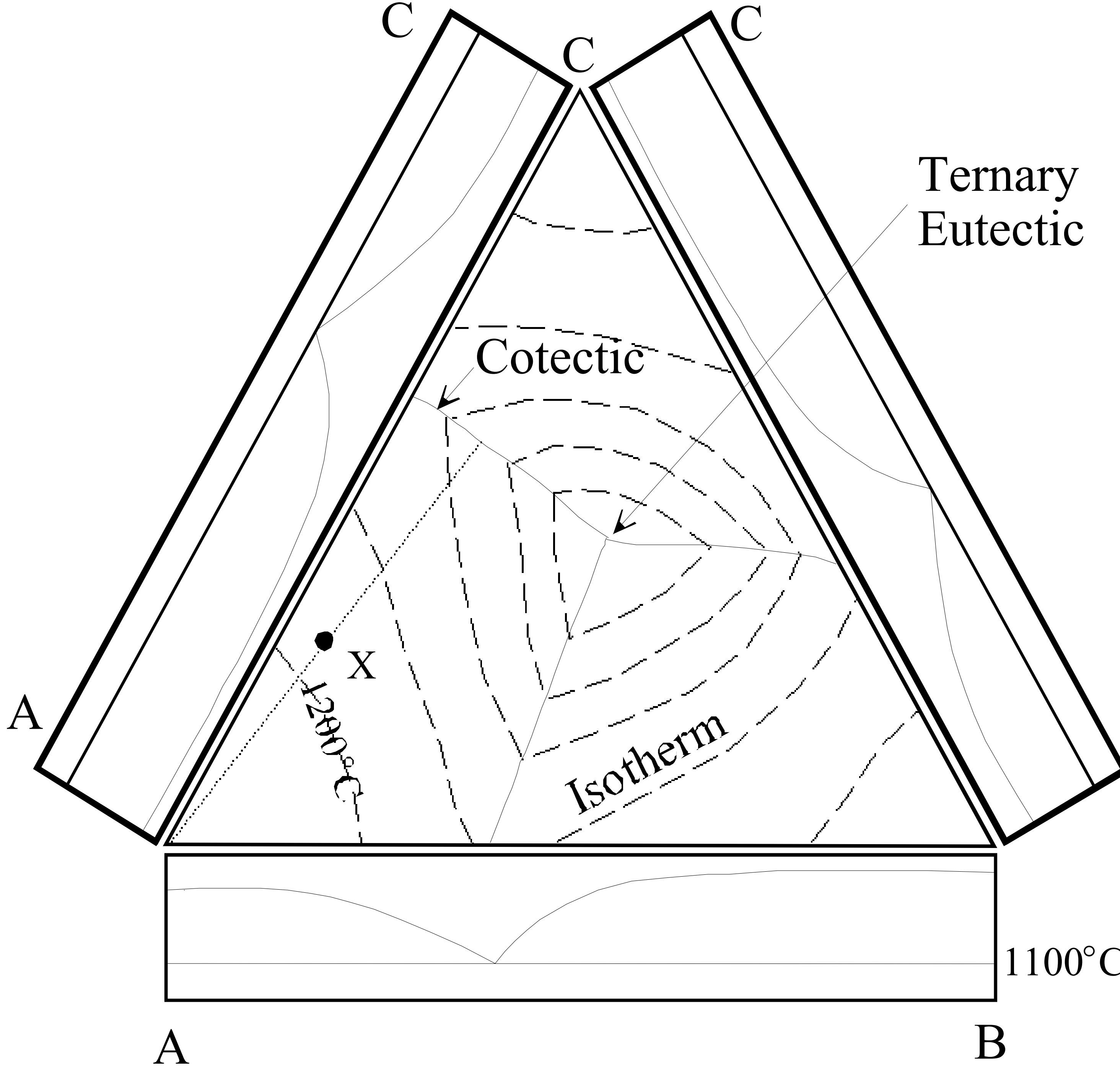
# Ternary Phase Diagrams

- Single Eutectic
- Two Eutectic Points
- Peritectic and Eutectic Points
- Solid solution
- More accurately represent real igneous rocks


C
C
C
Ternary
Eutectic
Cotectic
X
1200°C
Isotherm
A
B
1100°C
A
B

# Ternary Eutectic Phase Diagram

## Equilibrium crystallization of Y

Melt path (red markers)

Solid path (blue markers)

### Temperature 1

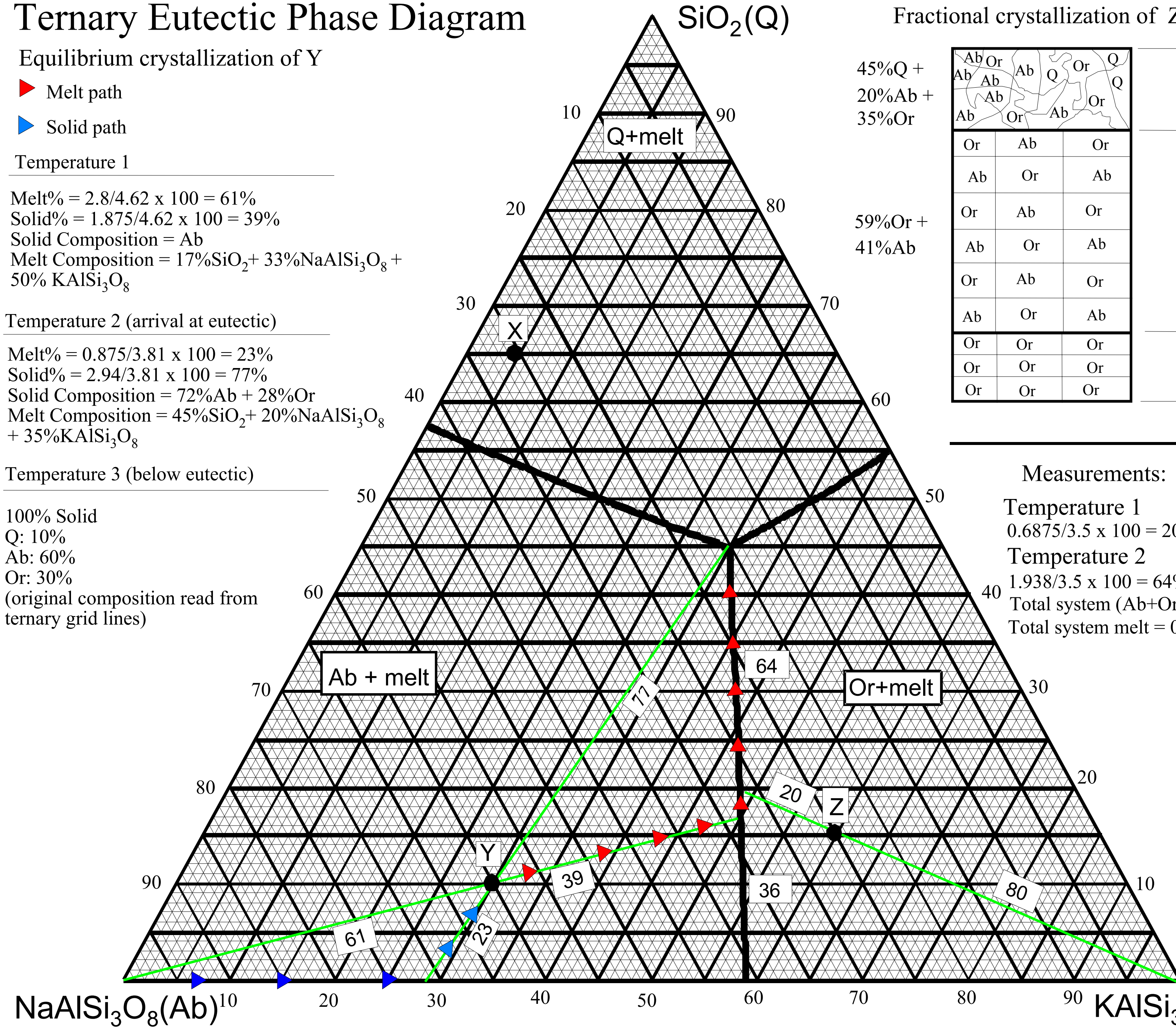
Melt% = 2.8/4.62 x 100 = 61%
Solid% = 1.875/4.62 x 100 = 39%
Solid Composition = Ab
Melt Composition = 17%$SiO_2$+ 33%$NaAlSi_3O_8$ + 50% $KAlSi_3O_8$

### Temperature 2 (arrival at eutectic)

Melt% = 0.875/3.81 x 100 = 23%
Solid% = 2.94/3.81 x 100 = 77%
Solid Composition = 72%Ab + 28%Or
Melt Composition = 45%$SiO_2$+ 20%$NaAlSi_3O_8$ + 35%$KAlSi_3O_8$

### Temperature 3 (below eutectic)

100% Solid
Q: 10%
Ab: 60%
Or: 30%
(original composition read from ternary grid lines)




## Fractional crystallization of Z

45%Q + 20%Ab + 35%Or (29%)

59%Or + 41%Ab (51%)

Or (20%)

## Measurements:

### Temperature 1

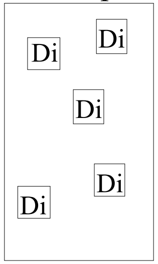
0.6875/3.5 x 100 = 20% Solid

### Temperature 2

1.938/3.5 x 100 = 64% Solid
Total system (Ab+Or) = 0.64 x 80% = 51%
Total system melt = 0.36 x 80% = 29%

Equilibrium crystallization of composition X

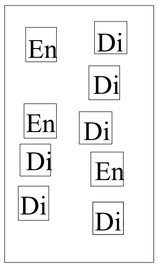
T1 Composition X




Solid = 1.2/5.5x100 = 22%
All solid = Di

Melt = 4.3/5.5x100=78%
Mg2SiO4=19%
SiO2=58%
CaMgSi2O6=23%

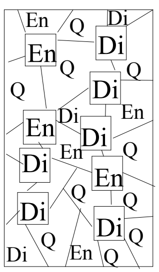
T2 Composition X




Solid =2.1/5.05x100 = 42%
Di = 5.3/7x100 = 76%
En = 1.7/7x100 = 24%

Melt = 2.95/5.05x100 = 58%
Mg2SiO4=13%
SiO2=73%
CaMgSi2O6=14%

T3Composition X

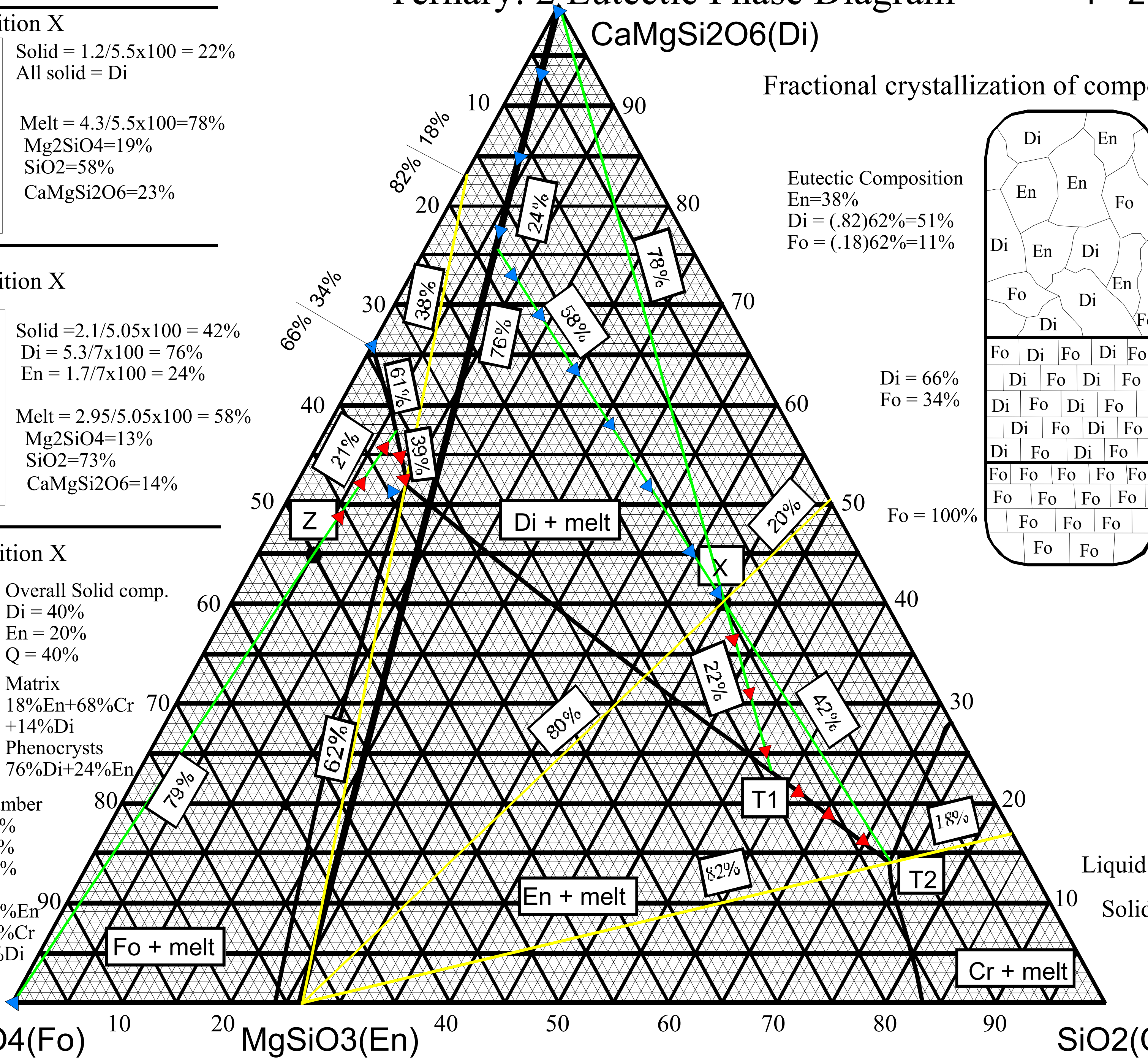



Overall Solid comp.
Di = 40%
En = 20%
Q = 40%
Matrix
18%En+68%Cr
+14%Di
Phenocrysts
76%Di+24%En

% of Entire Chamber
Phenocrysts=42%
76%Di(.42)=32%
24%En(.42)=10%
Matrix=58%
18%En(.58)=11%En
68%Cr(.58)=39%Cr
14%Di(.58)=8%Di

# Ternary: 2 Eutectic Phase Diagram

P=20Kbars




Fractional crystallization of composition Z

Eutectic Composition
En=38%
Di = (.82)62%=51%
Fo = (.18)62%=11%

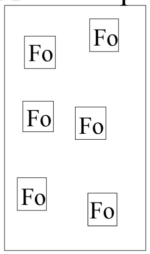
48%
Di = 66%
Fo = 34%
31%
Fo = 100%
21%

Liquid path
Solid path

# Ternary Peritectic Phase Diagram

P=2Kbars

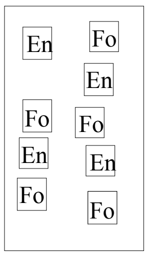
T1 Composition A




Solid = 1.7/4.1x100 = 41%
All solid = Fo

Melt = 59%
$Mg_2SiO_4$=40%
$SiO_2$=25%
$CaMgSi_2O_6$=35%

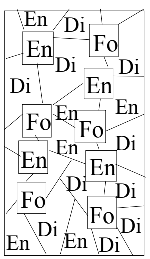
T2 Composition A



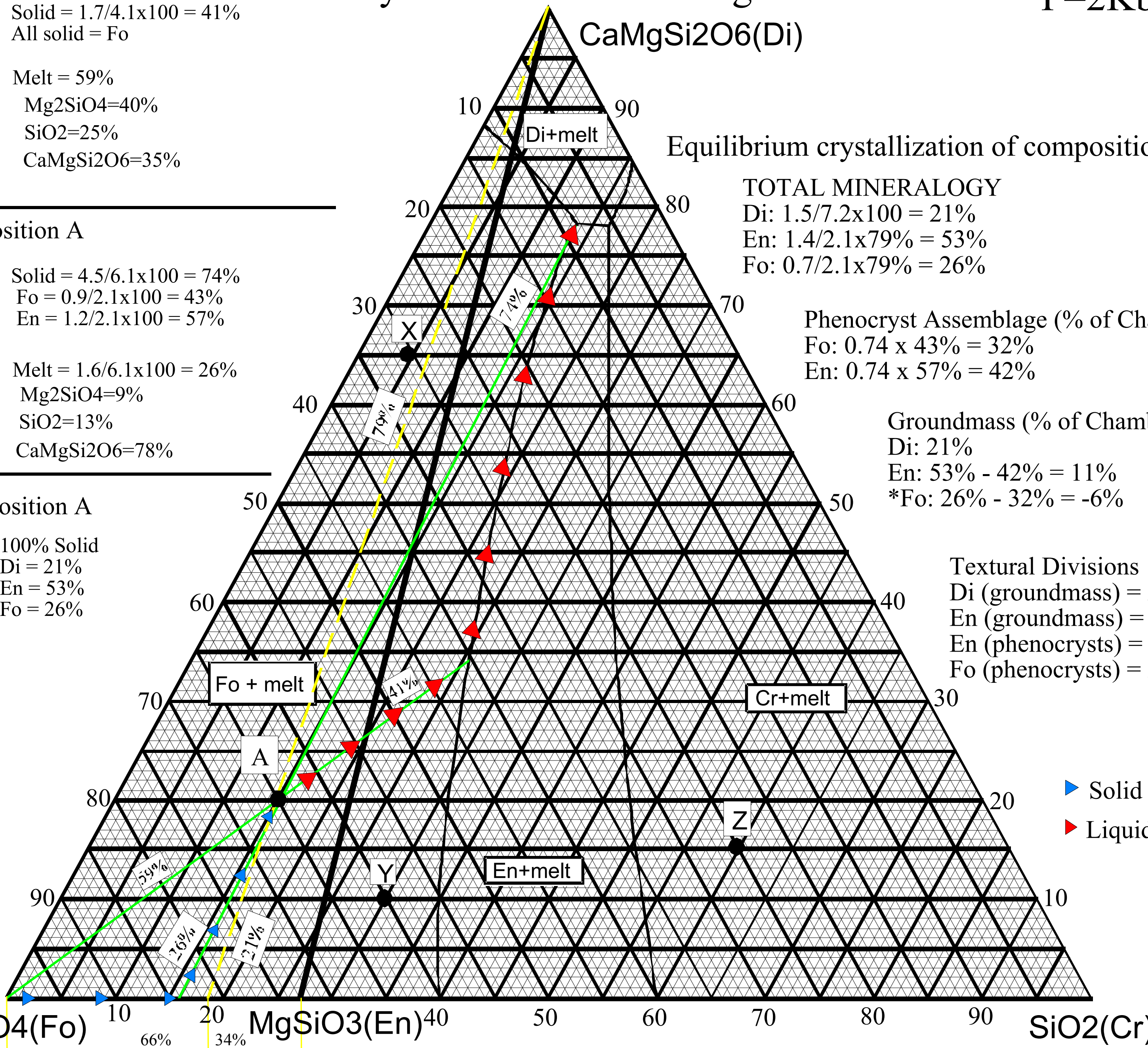

Solid = 4.5/6.1x100 = 74%
Fo = 0.9/2.1x100 = 43%
En = 1.2/2.1x100 = 57%

Melt = 1.6/6.1x100 = 26%
$Mg_2SiO_4$=9%
$SiO_2$=13%
$CaMgSi_2O_6$=78%

T3 Composition A




100% Solid
Di = 21%
En = 53%
Fo = 26%




Equilibrium crystallization of composition A

TOTAL MINERALOGY
Di: 1.5/7.2x100 = 21%
En: 1.4/2.1x79% = 53%
Fo: 0.7/2.1x79% = 26%

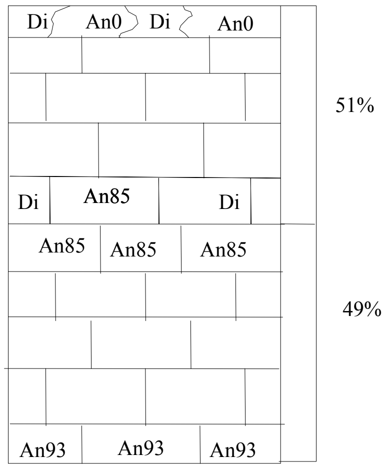
Phenocryst Assemblage (% of Chamber)
Fo: 0.74 x 43% = 32%
En: 0.74 x 57% = 42%

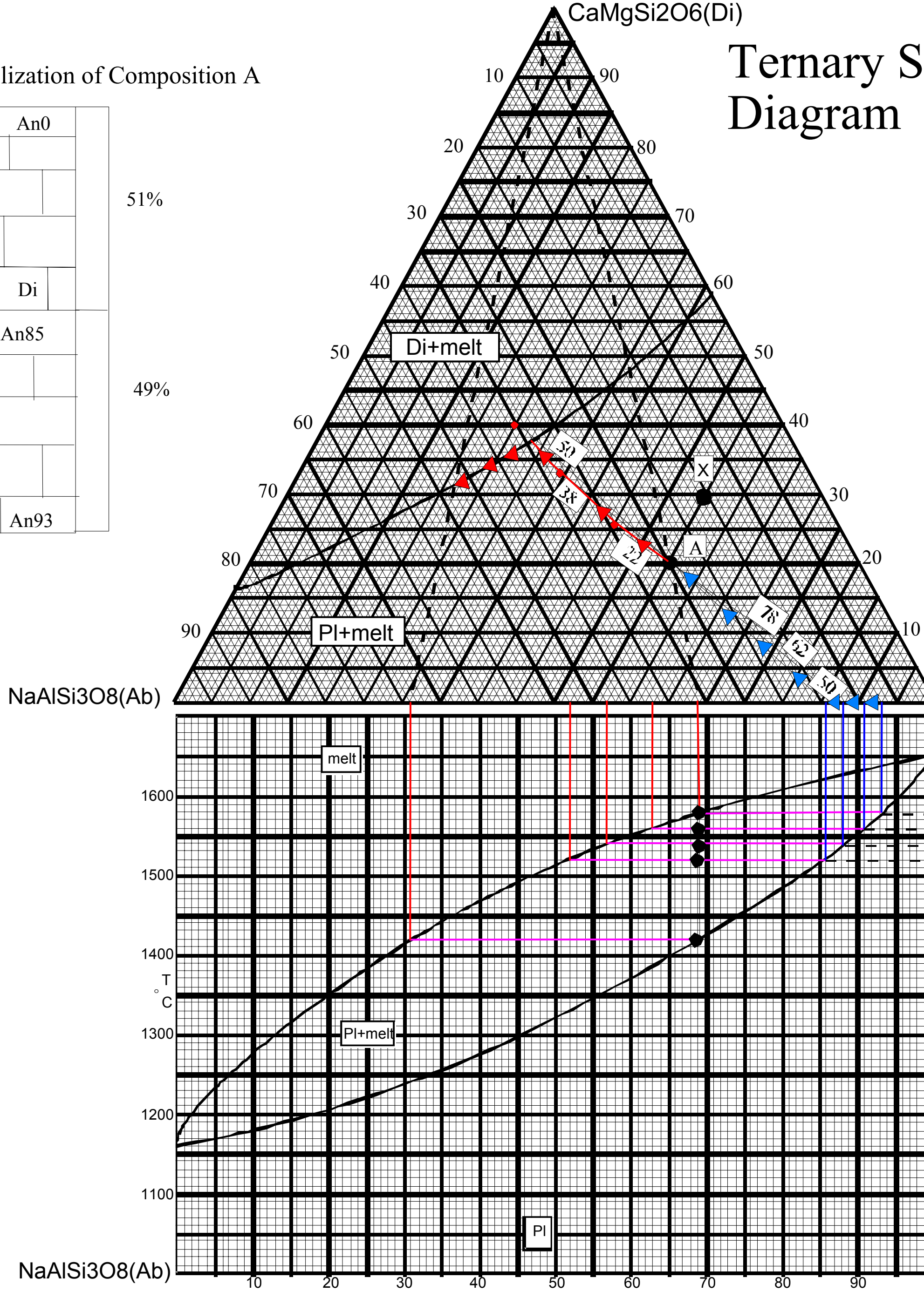
Groundmass (% of Chamber)
Di: 21%
En: 53% - 42% = 11%
*Fo: 26% - 32% = -6%

Textural Divisions
Di (groundmass) = 21%
En (groundmass) = 11%
En (phenocrysts) = 42%
Fo (phenocrysts) = 26%

# Ternary Solid Solution Phase Diagram

Fractional Crystallization of Composition A




Equilibrium Crystallization of Composition A

Liquid path

Solid path

| M% | S% | An% |
|---|---|---|
| 100 | 0 | 93 |
| 78 | 22 | 91 |
| 62 | 38 | 88 |
| 50 | 50 | 85 |

Iterations

(1) $78/1.9 = 100/x$

(where x = total ternary tie line length)

$x = 2.4$

(2) $62/1.75 = 100/x$

$x = 2.8$

(3) $50/1.6 = 100/x$

$x = 3.2$ (this extended past the cotectic)

# Phase Rule "Re-visited"

- On binary and ternary systems we don't have a pressure axis visible so the phase rule becomes modified:
  - dF = C – P + 1
- Example: ternary eutectic
  - dF = 3 – 4(melt & 3 solids) + 1 = 0 (invariant point)
- Example: ternary cotectic
  - dF = 3 – 3(melt & 2 solids) + 1 = 1 (univariant curve)

# Phase Diagram Summary

- Be familiar with all of the phase diagram assignments
- Know the “modified” phase rule for igneous phase diagrams
- Be able to explain why an invariant point on a phase diagram is a peritectic or eutectic.
- Be able to explain the difference between a regular cotectic and reaction cotectic