2009 fall

Advanced Physical Metallurgy

"Phase Equilibria in Materials"

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Chapter 10. Ternary phase Diagrams

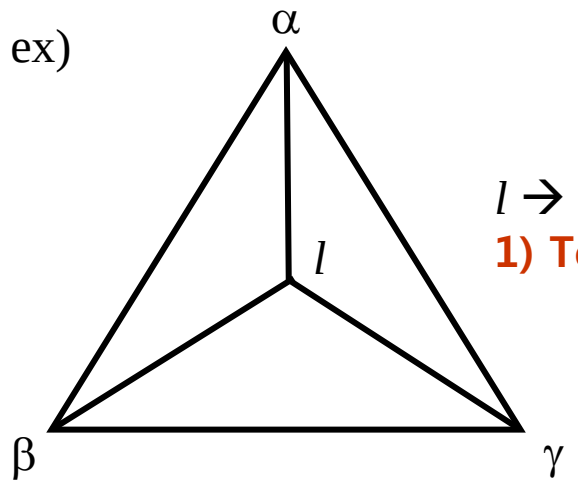
Four-Phase Equilibrium

10.1. THE EUTECTIC EQUILIBRIUM ($l = \alpha + \beta + \gamma$)

Three phase equil. (f = 1)

- eutectic, peritectic

ex)



$l \rightarrow \alpha + \beta + \gamma$

1) Ternary eutectic

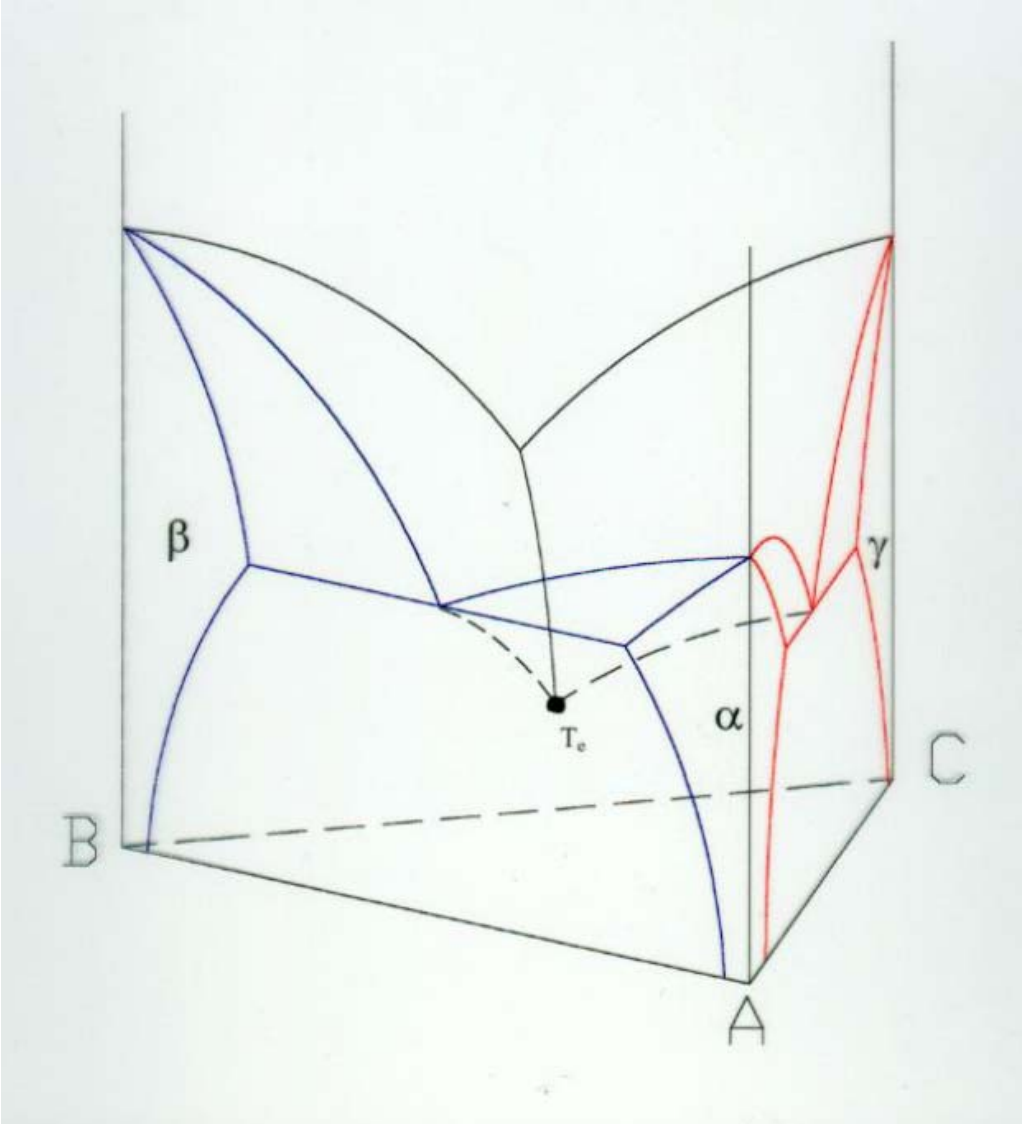
cf) $l + \alpha \rightarrow \beta + \gamma$: **2) ternary quasi-peritectic**

$l + \alpha + \beta \rightarrow \gamma$: **3) ternary peritectic**

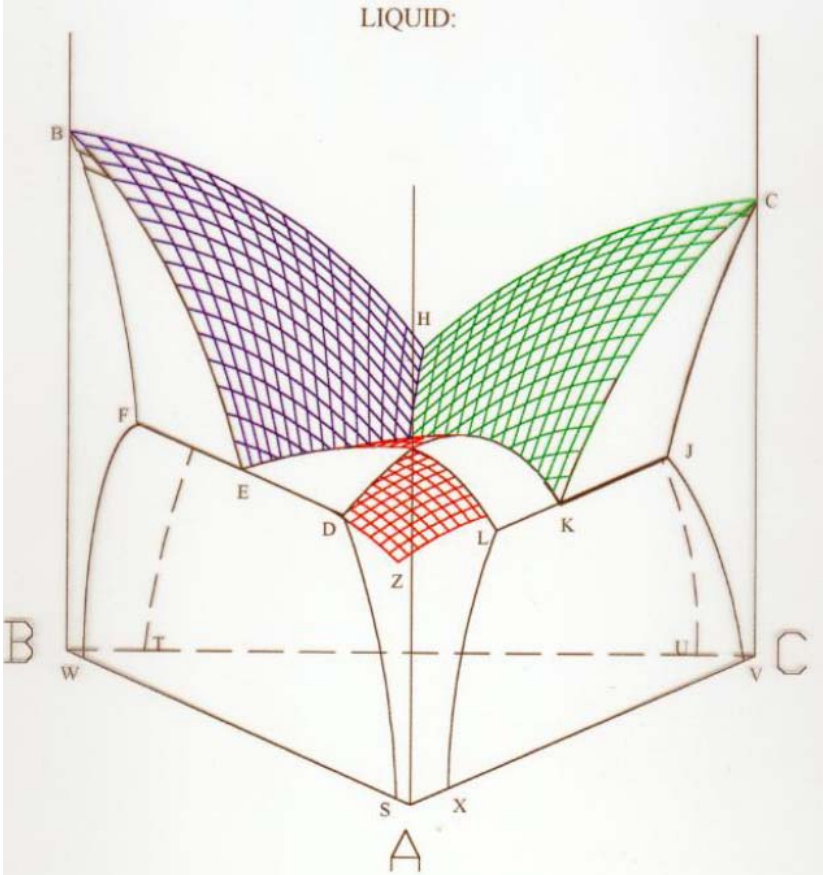
Now we consider of four equilibrium

- max N of phase
- $f = 0$: composition of four phases at temp.→ fixed
- isothermal four phase regions

Ternary Eutectic System
(with Solid Solubility)

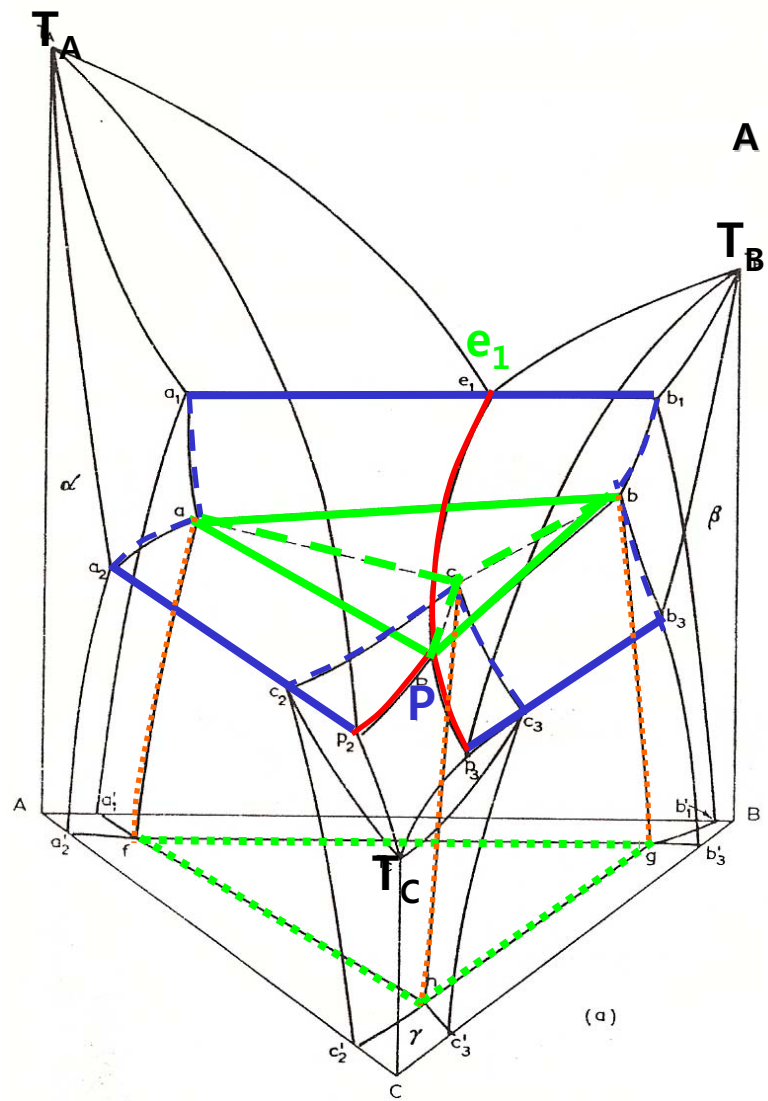


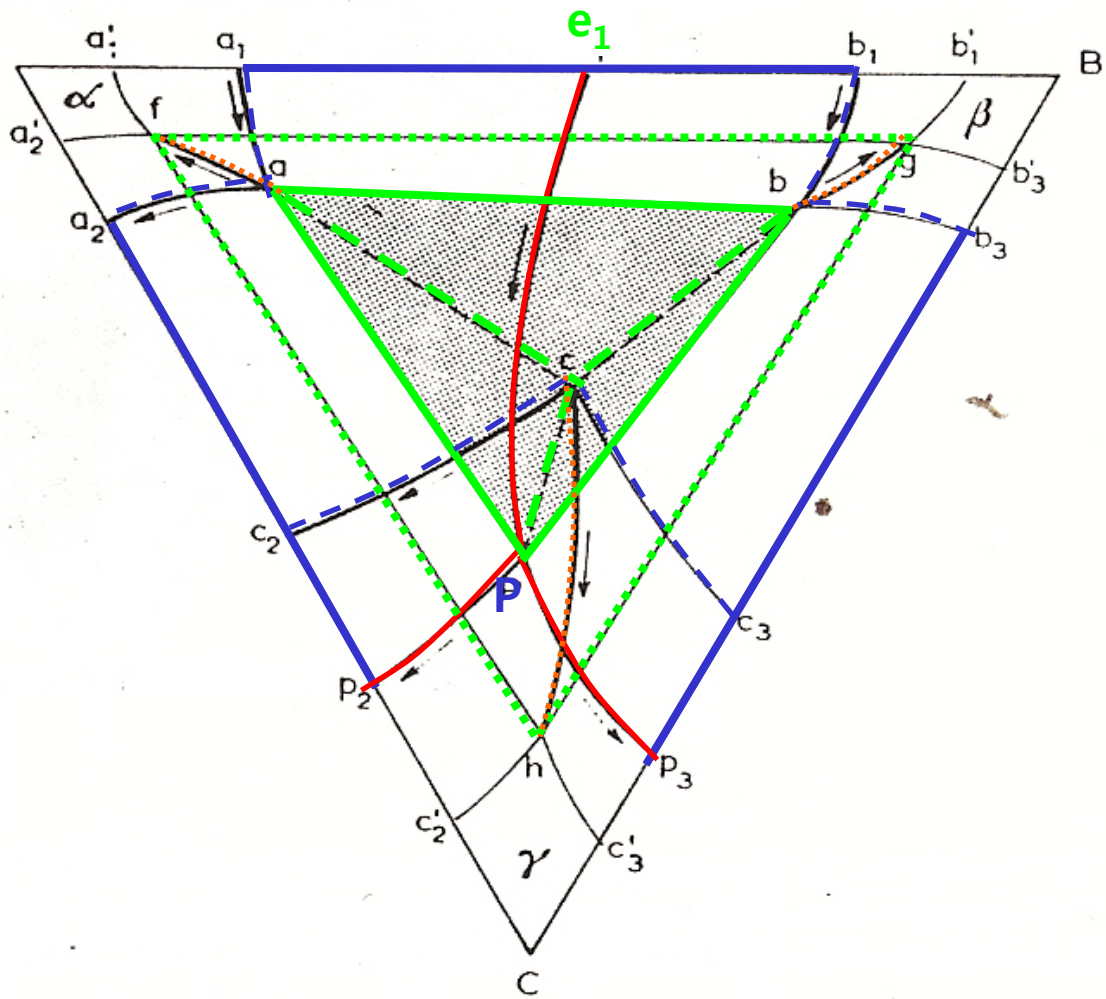
Main outline of Ternary Phase Diagram with Ternary Eutectic (T_e) and Solid Single Phase Regions Shown



All Liquidus surfaces (α+L-Red, β+L-Purple, γ+L-Green)

10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)

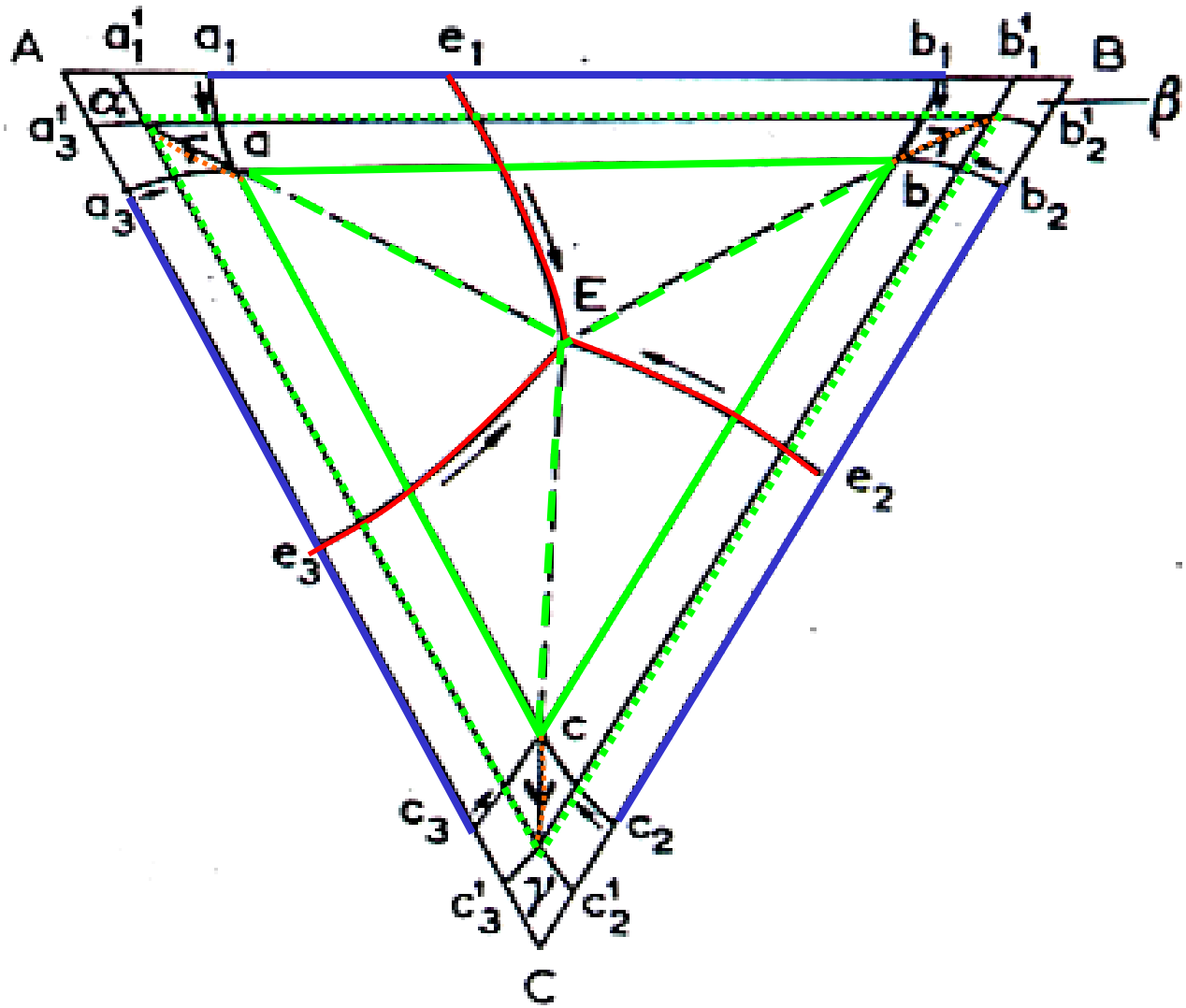


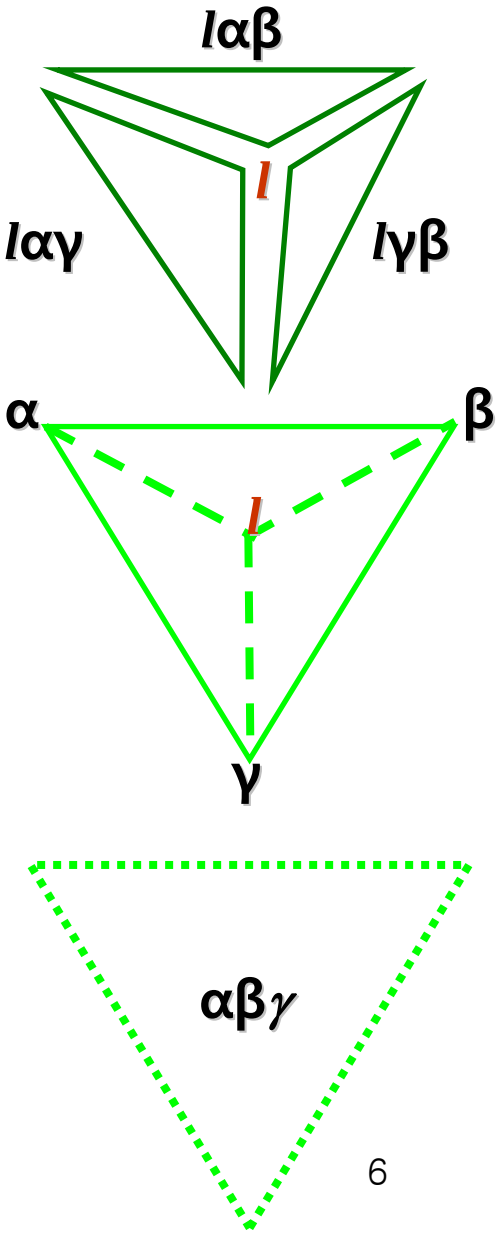


$T_A > T_B > e_1 > P > P_2 > P_3 > T_C$

THE TERNARY EUTECTIC EQUILIBRIUM ($l = \alpha + \beta + \gamma$)

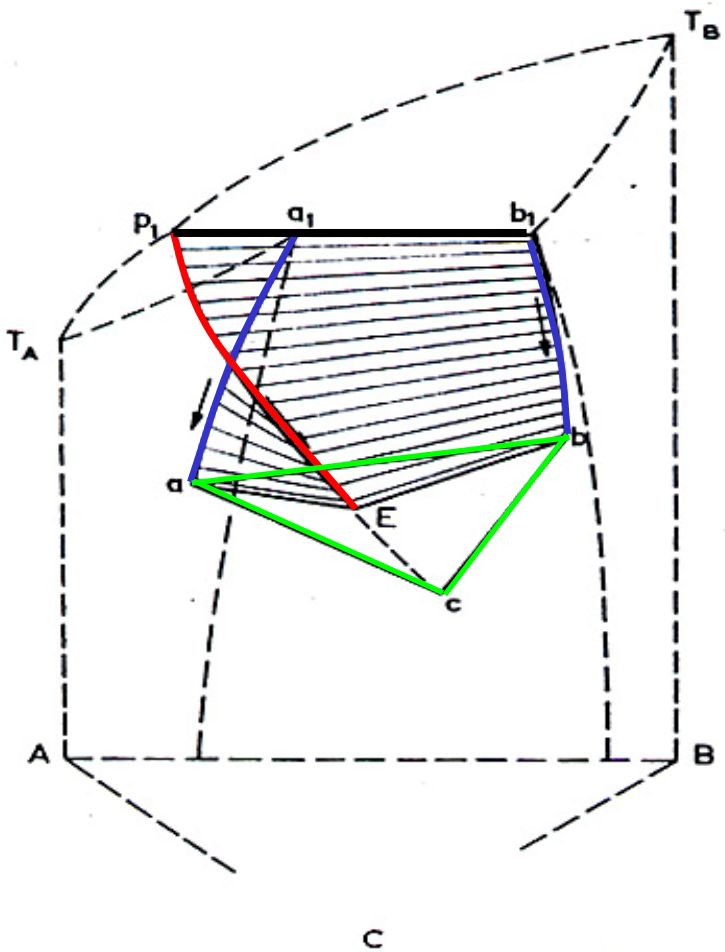
- **Projection** : solid solubility limit surface
  : monovariant liquidus curve

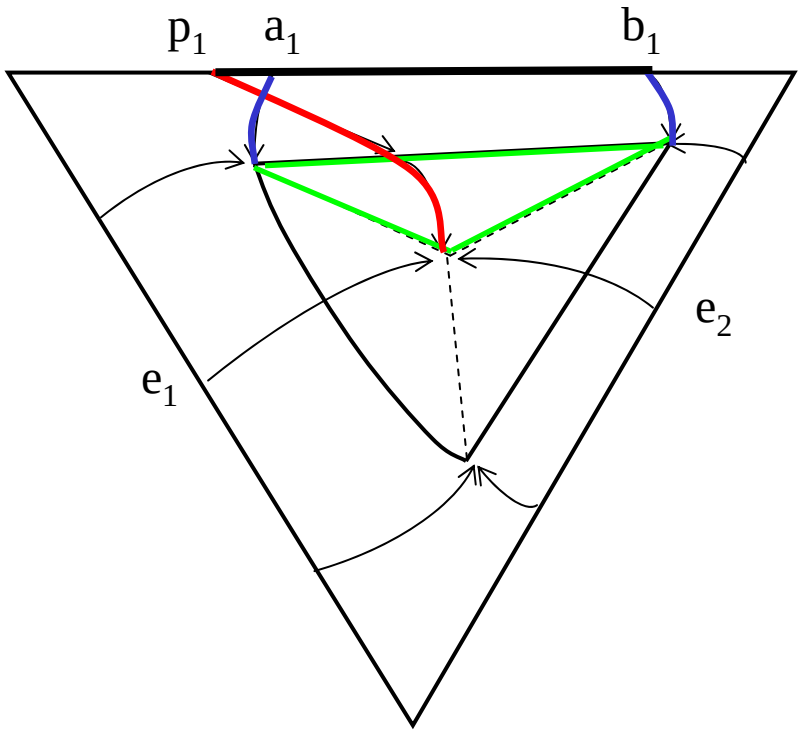




10.2. VARIANTS OF THE TERNARY EUTECTIC DIAGRAM

- **Variant of the ternary eutectic system in which one binary is a peritectic**

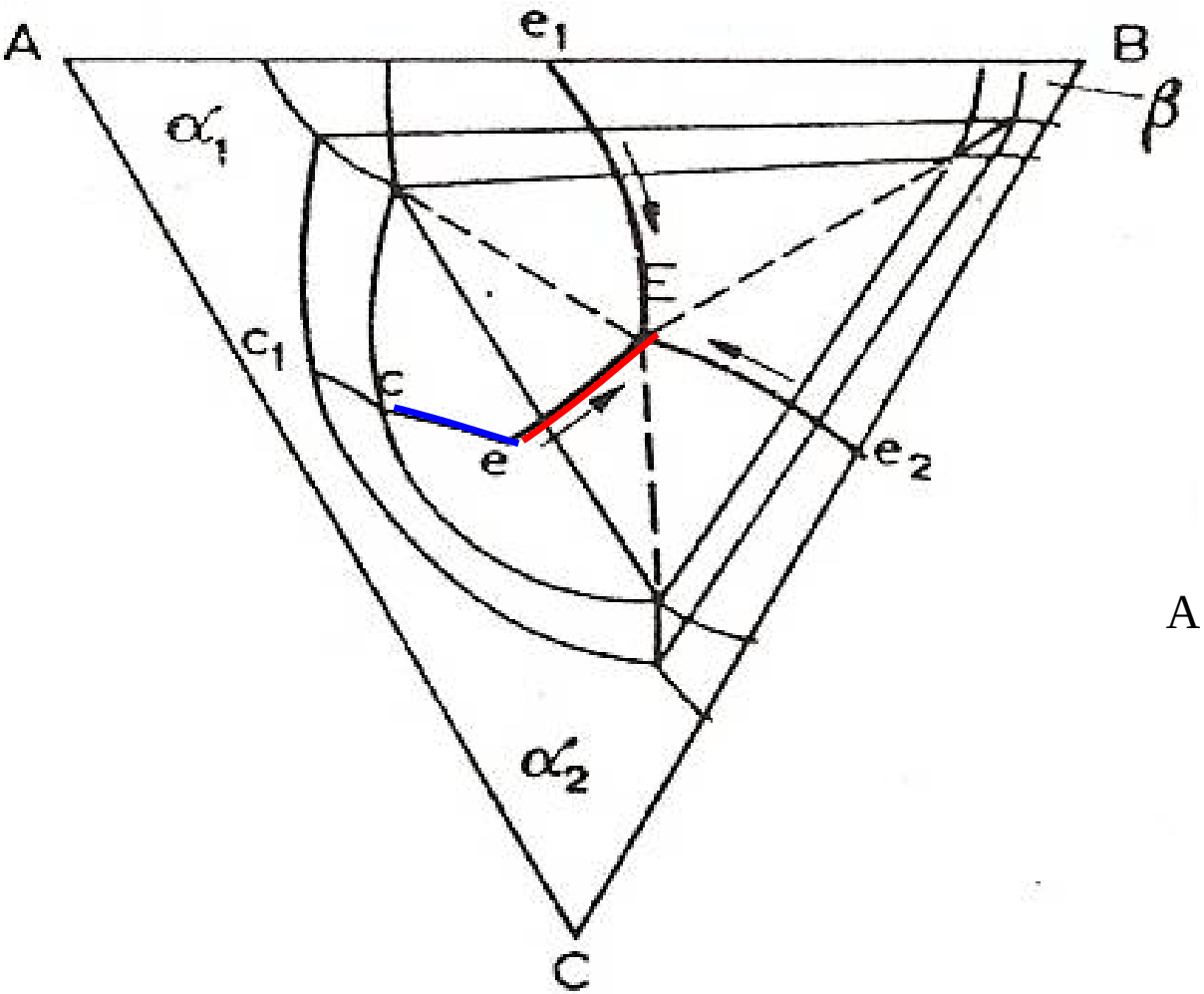


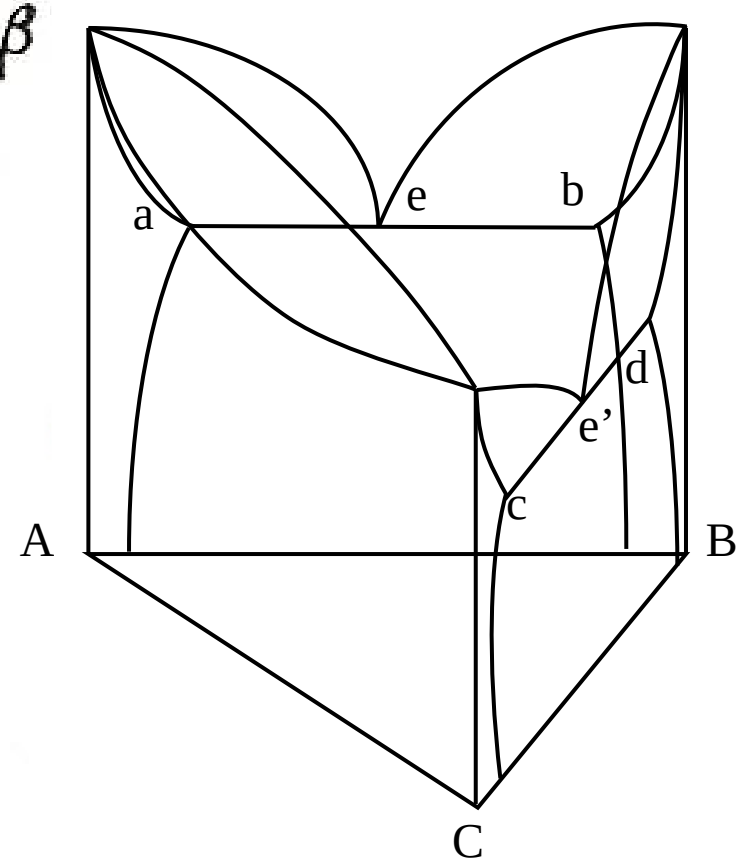


Monovariant liquidus line (P_1E) 과 monovariant solidus line (a_1a)이 앞에 있는냐 뒤에 있는냐로 삼각형 모양이 결정됨

10.2. VARIANTS OF THE TERNARY EUTECTIC DIAGRAM

- **Ternary eutectic system in which two of the binaries are eutectics.**



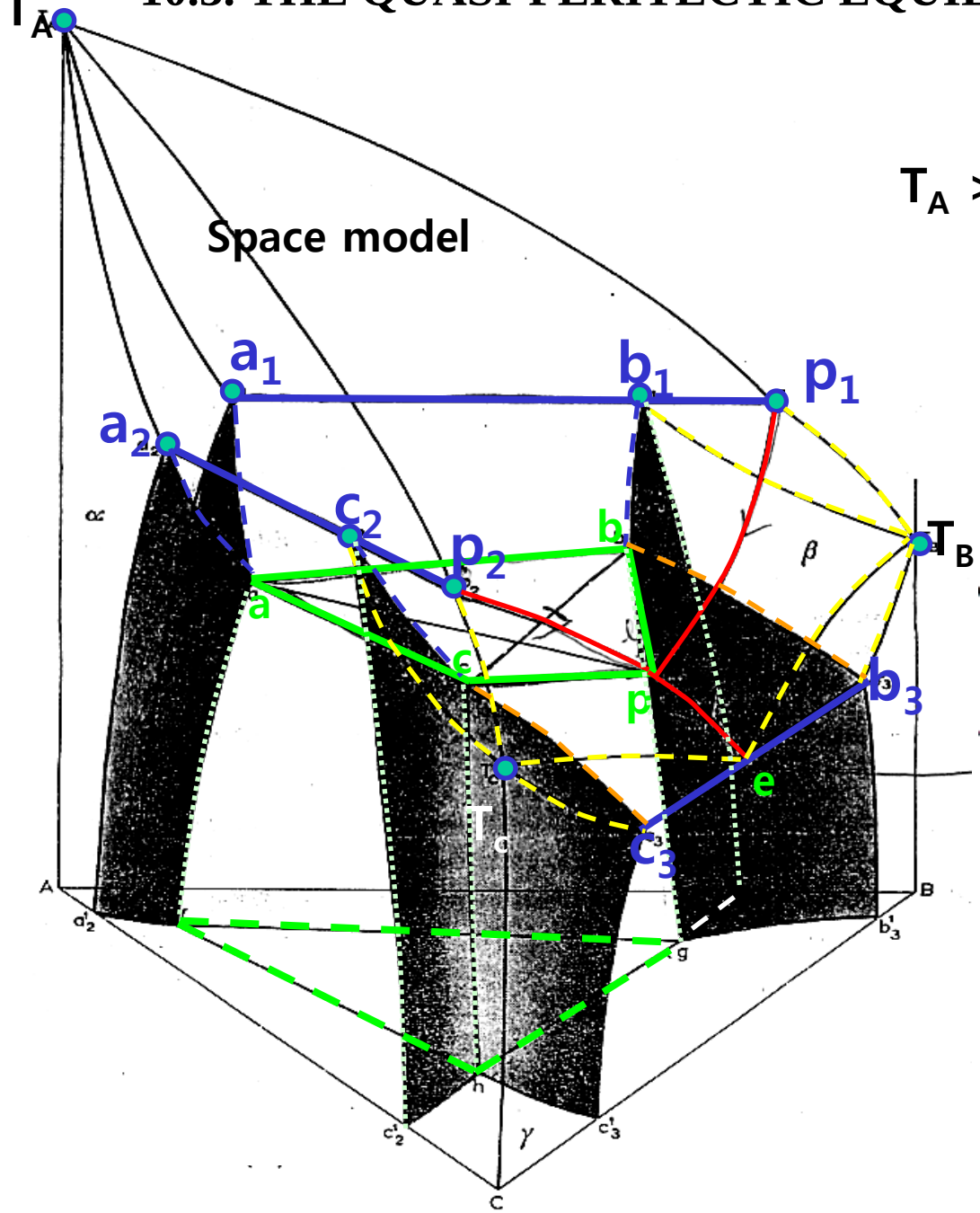


<one complete solid solution + two binary eutectic>

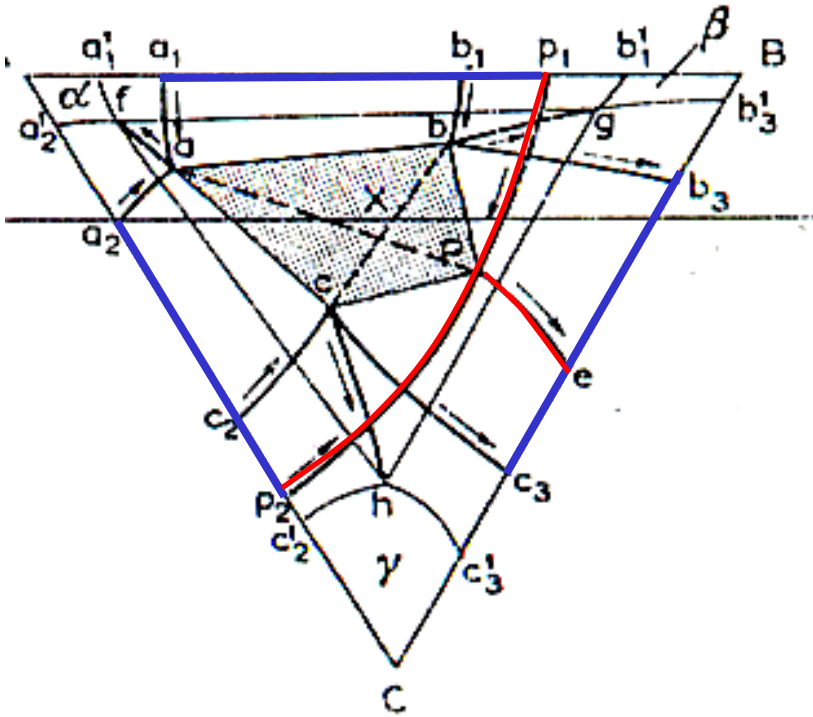
10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)

$T_A > P_1 > P_2 > T_B > P > T_C > e$

Space model

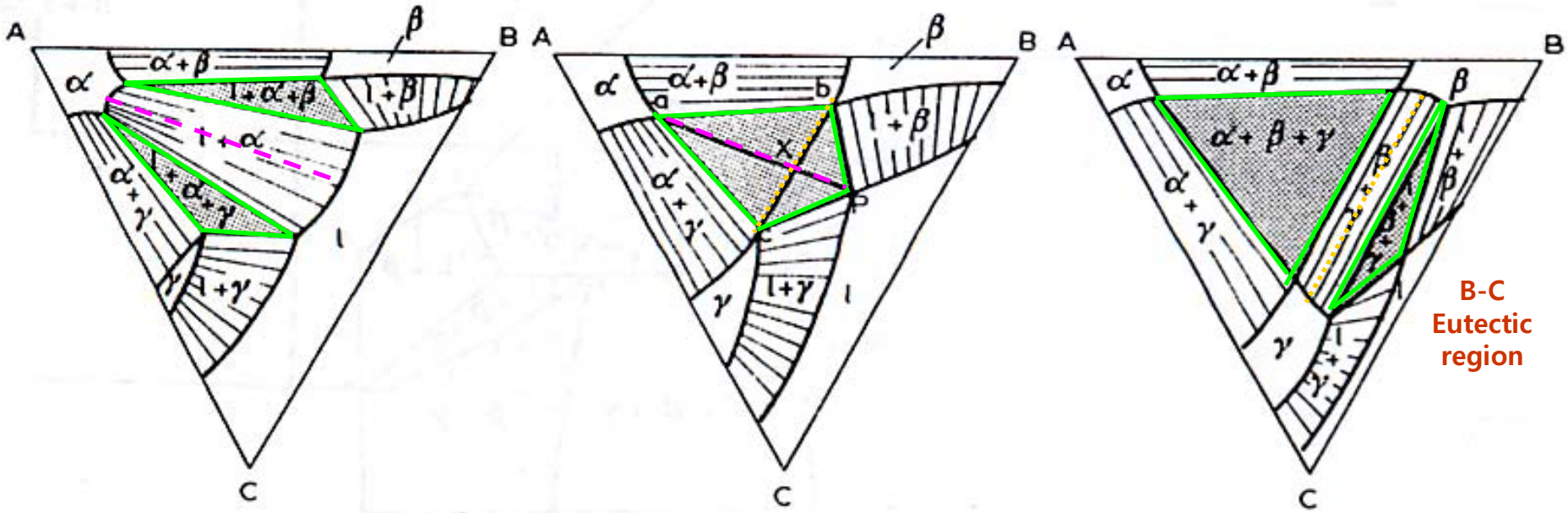


Projection



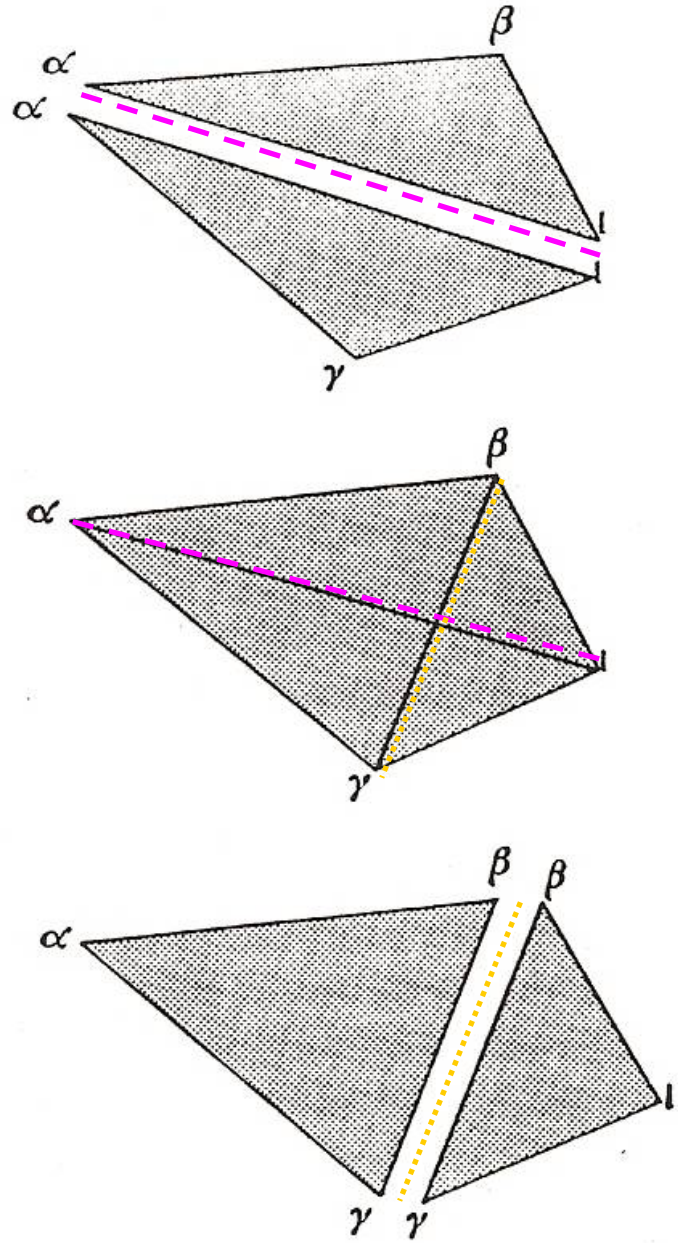
10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)

Isothermal section



$T_B > T > P$ $\qquad$ $T = P$ $\qquad$ $P > T > T_C$

10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)



abP peritectic lαβ equilibrium

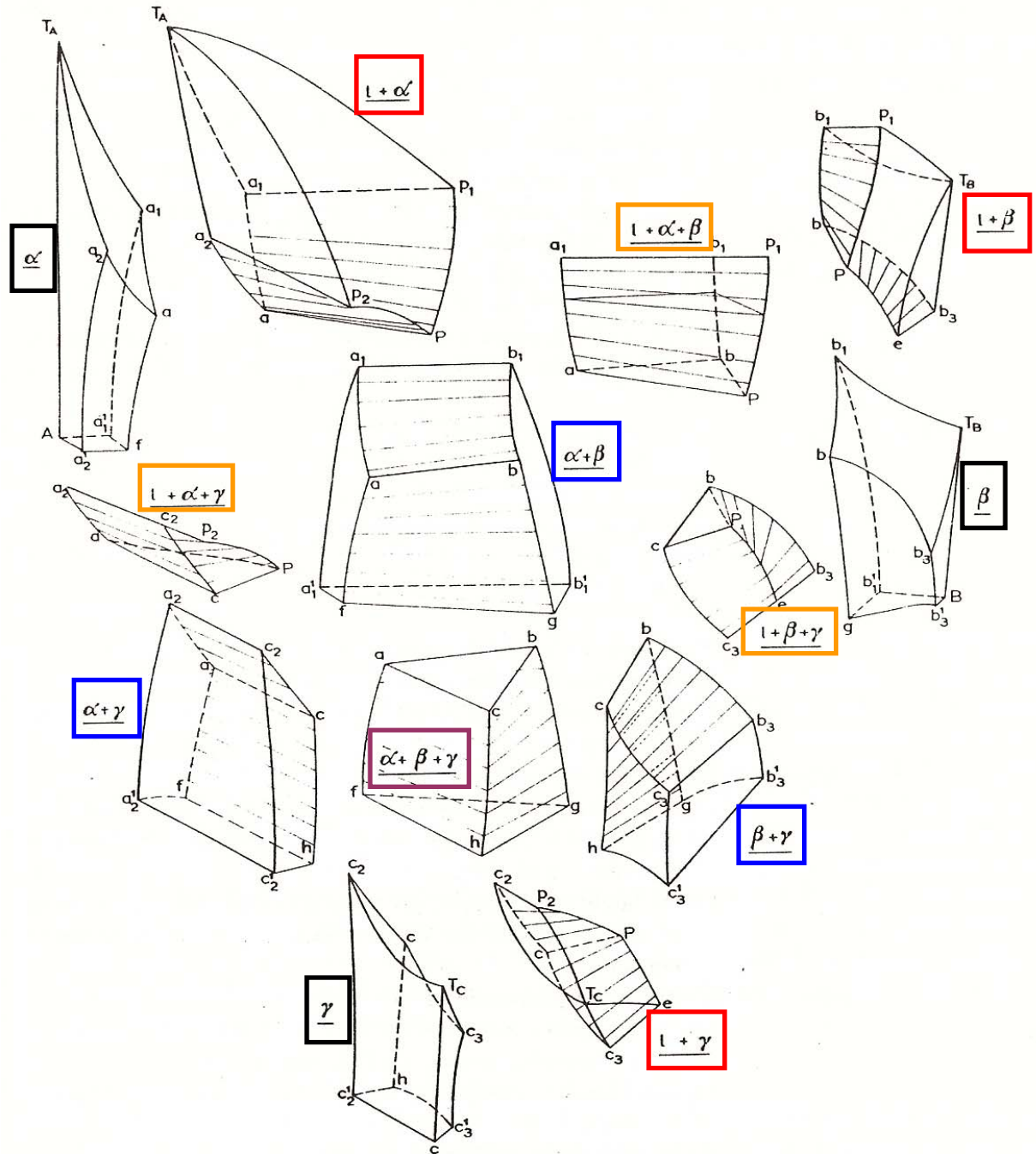
acP peritectic lαγ equilibrium

decreasing temperature

bcP eutectic lβγ equilibrium

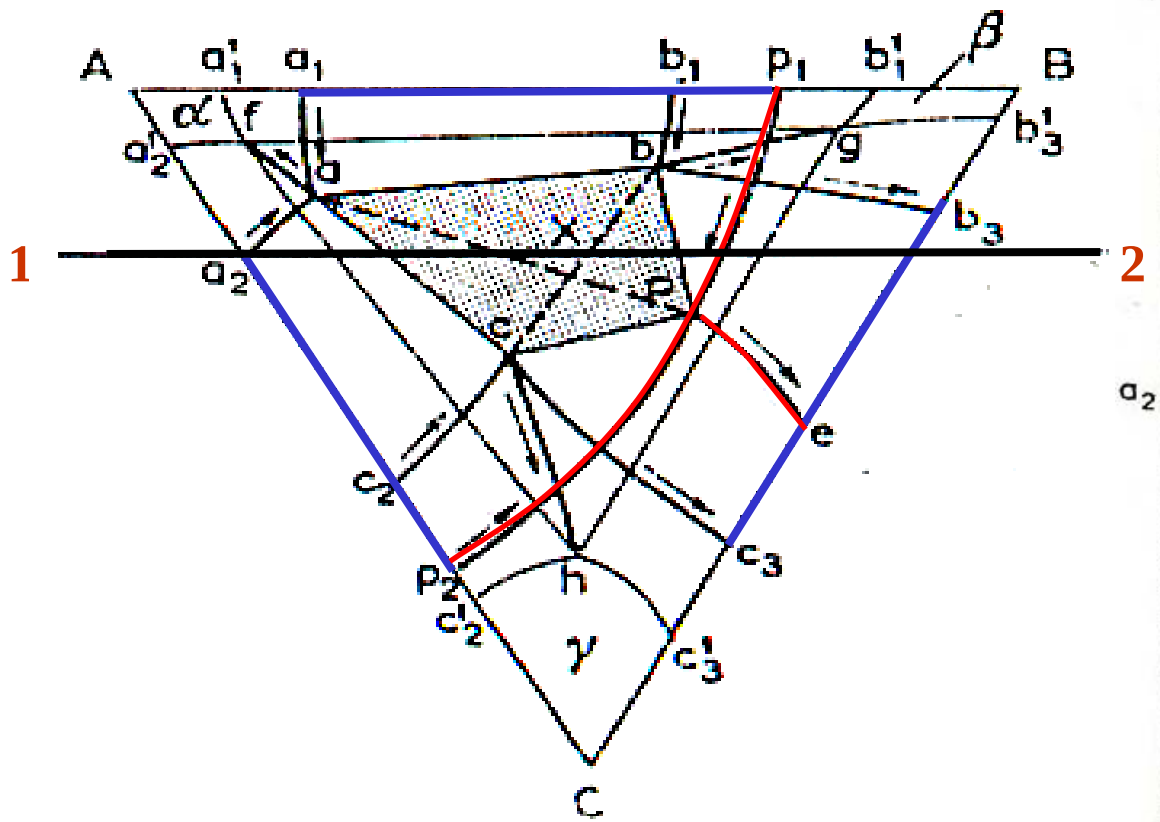
abc peritectic αβγ equilibrium

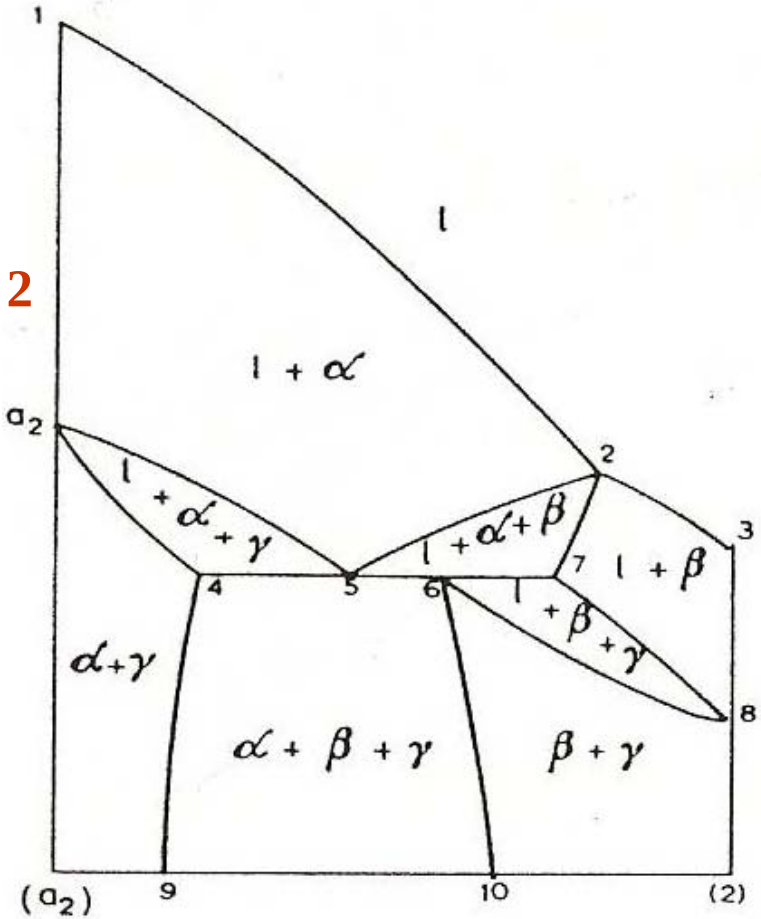
10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)



10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)

Vertical section





(a)

10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)

Vertical section

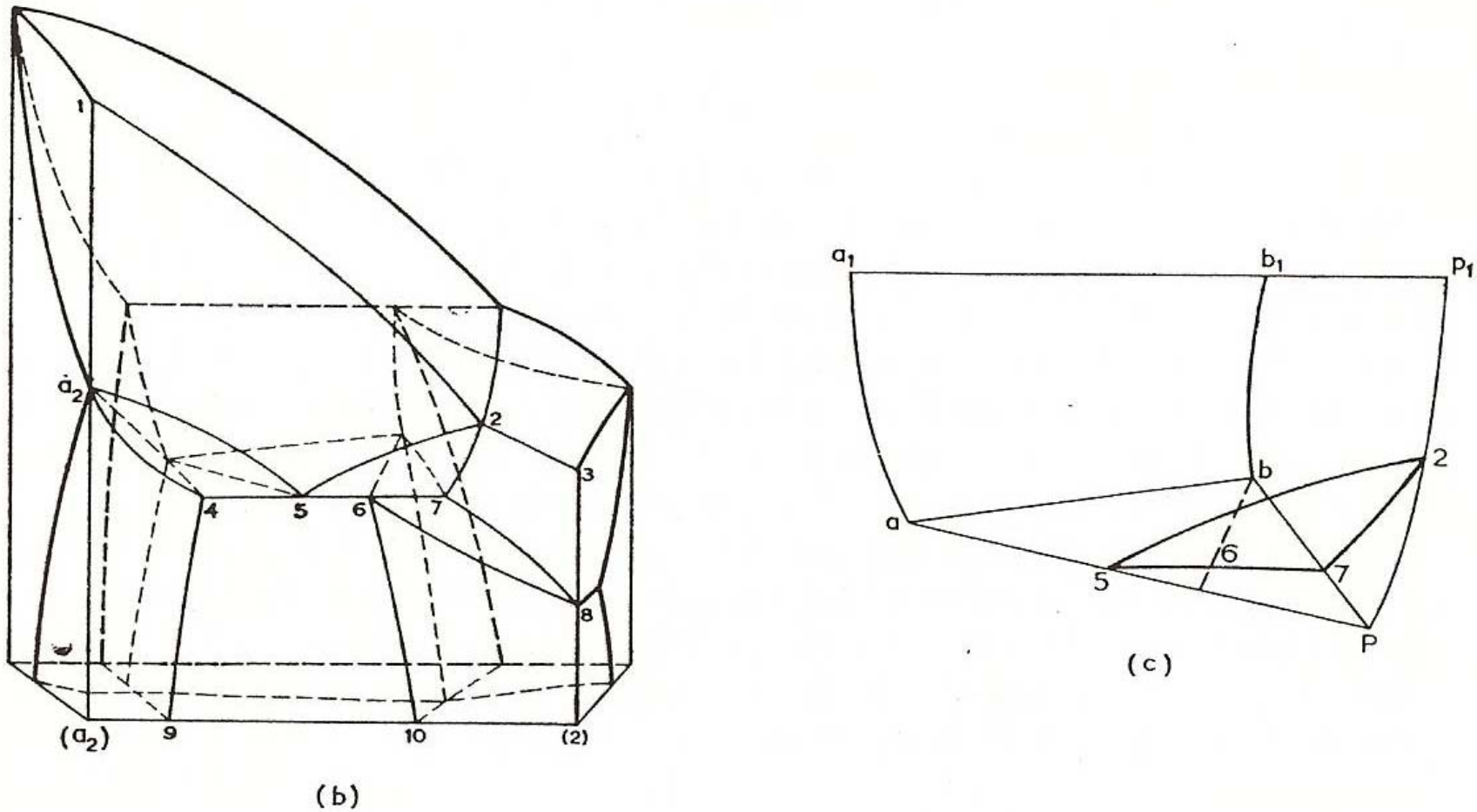
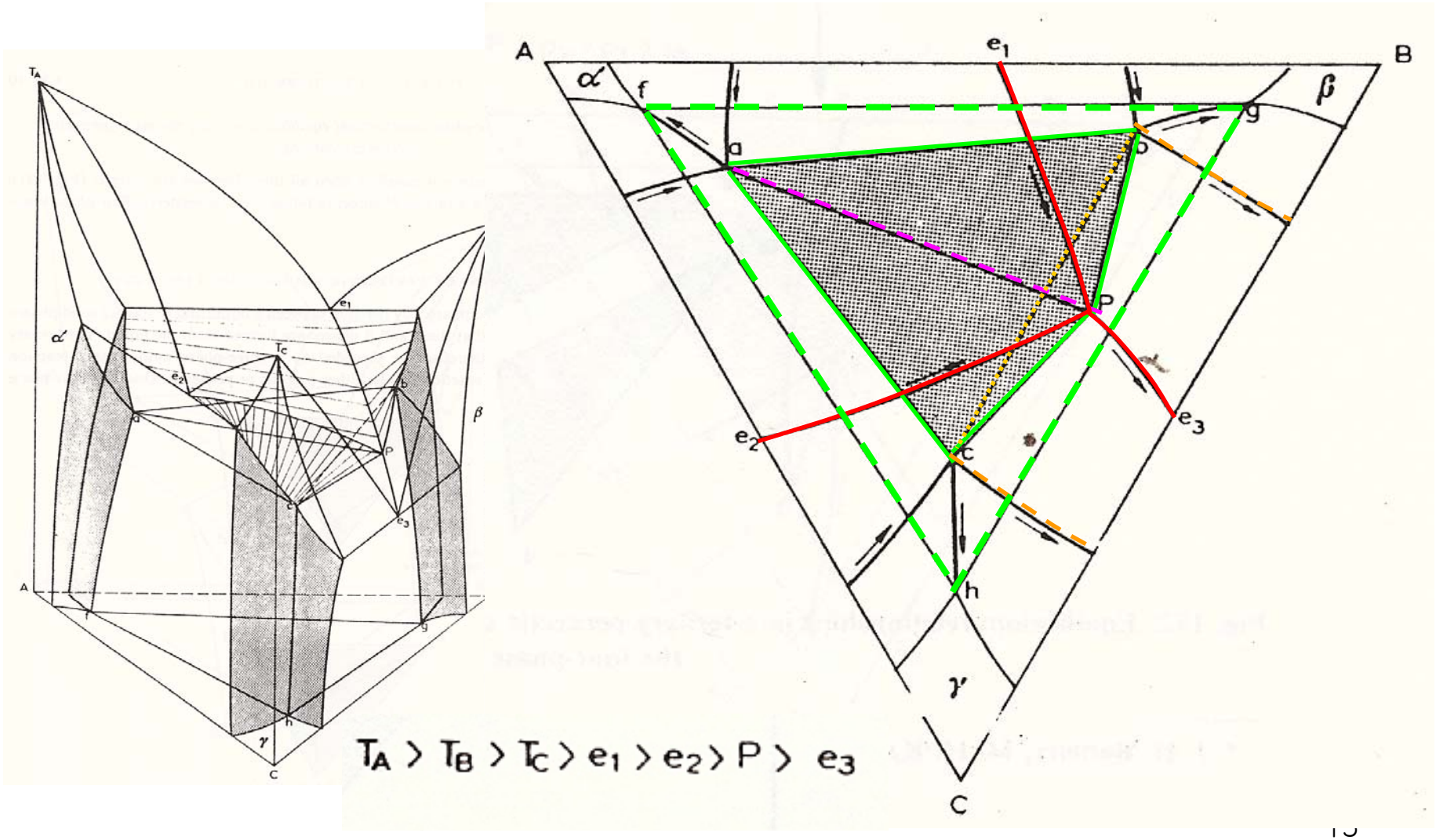


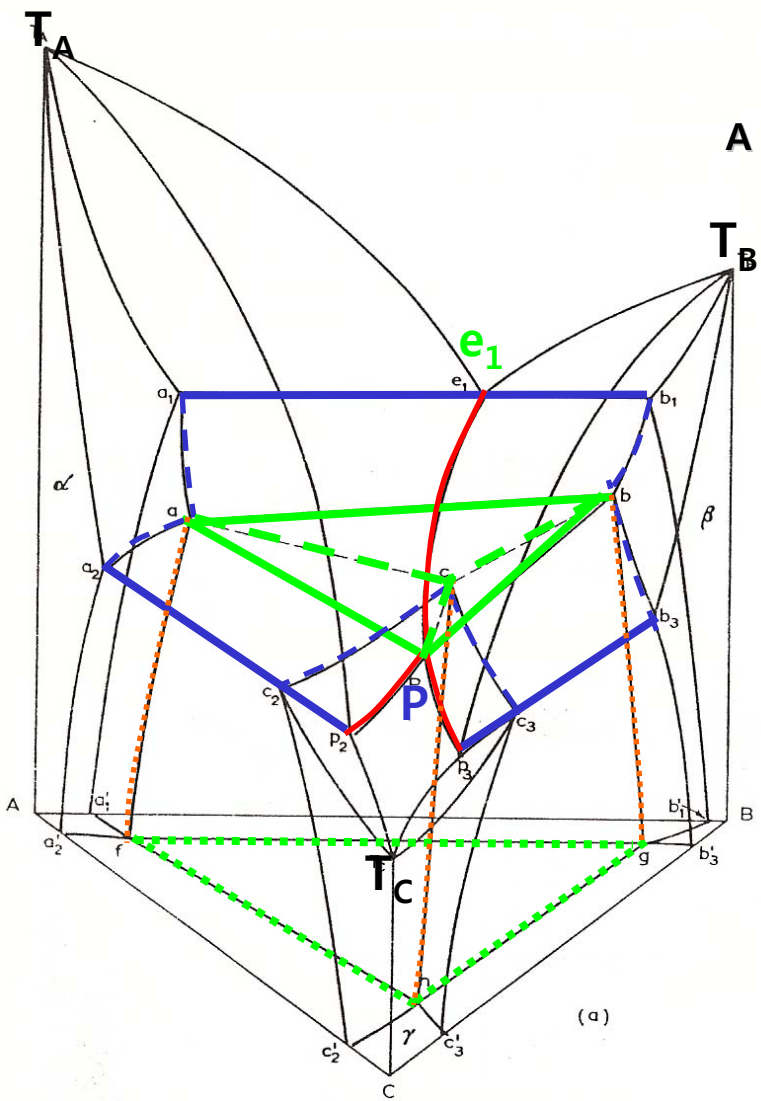
Fig. 188. A vertical section through the space model of Fig. 185a. (a) The vertical section a_2–2; (b) construction of the vertical section; (c) intersection of the vertical section with the $l+\alpha+\beta$ phase region.

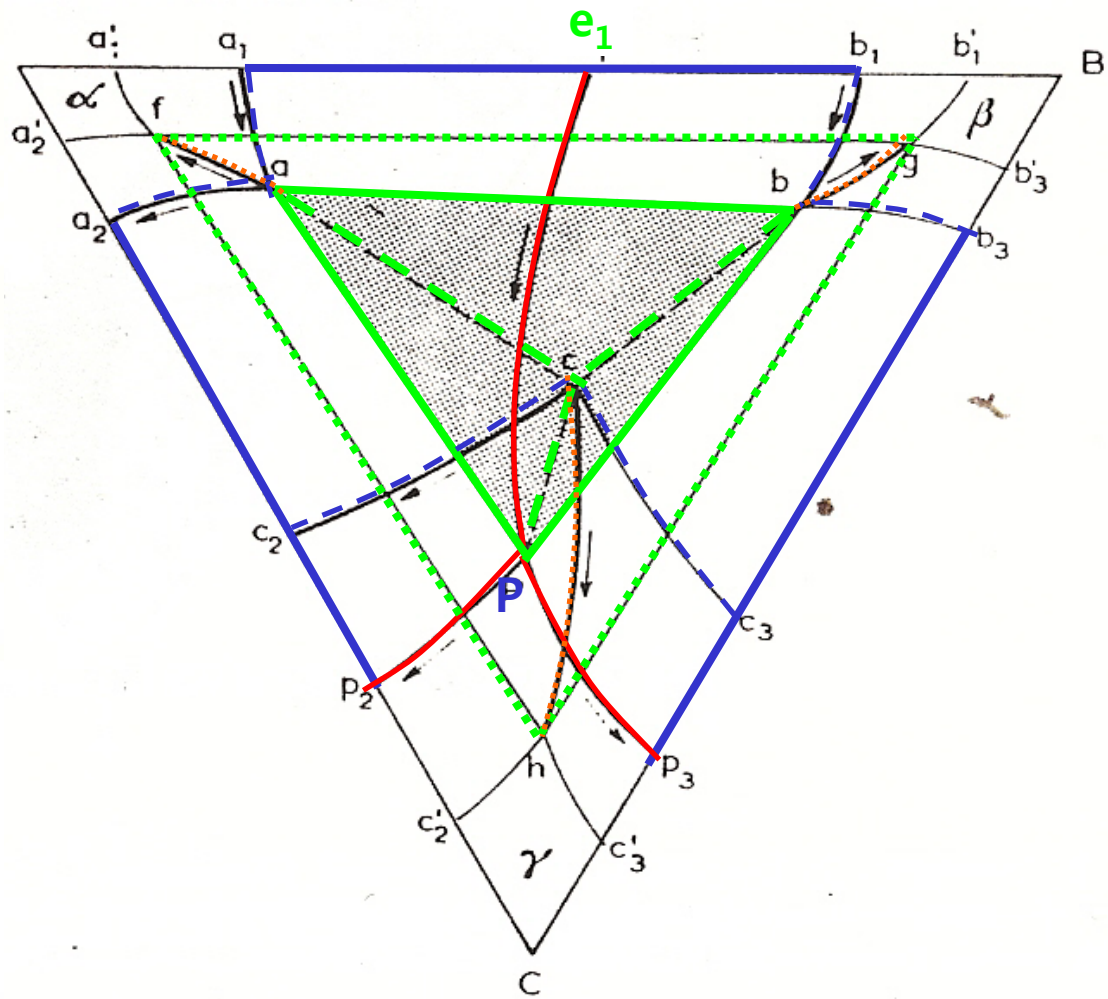
10.3. THE QUASI-PERITECTIC EQUILIBRIUM ($l + \alpha = \beta + \gamma$)

Fig. 191. The ternary quasi-peritectic system formed when all three binaries are eutectics. (a) Space model; (b) projection on the concentration triangle.



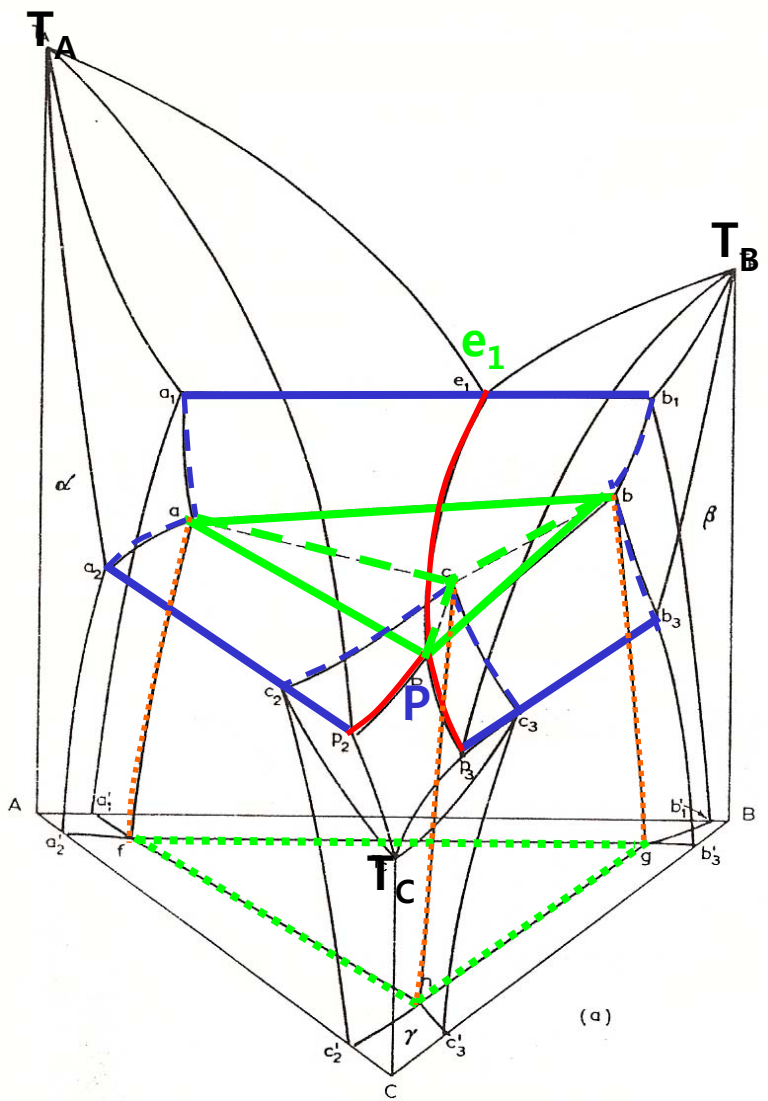
10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)

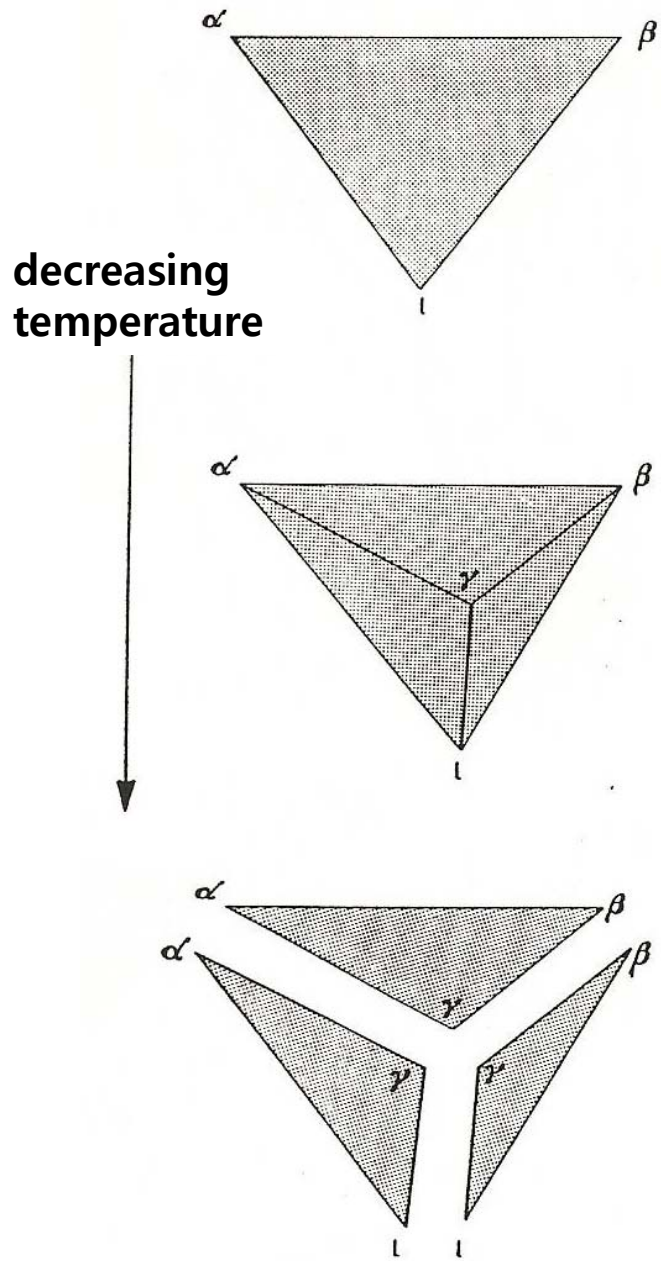




$T_A > T_B > e_1 > P > P_2 > P_3 > T_C$

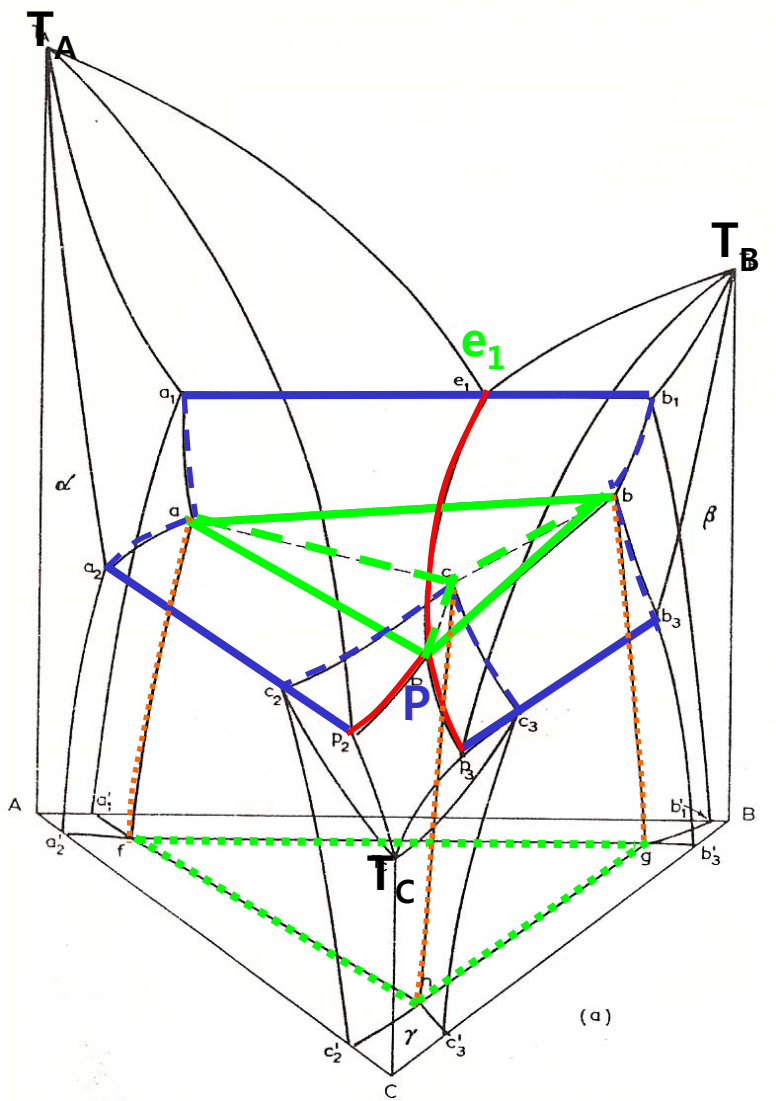
10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)

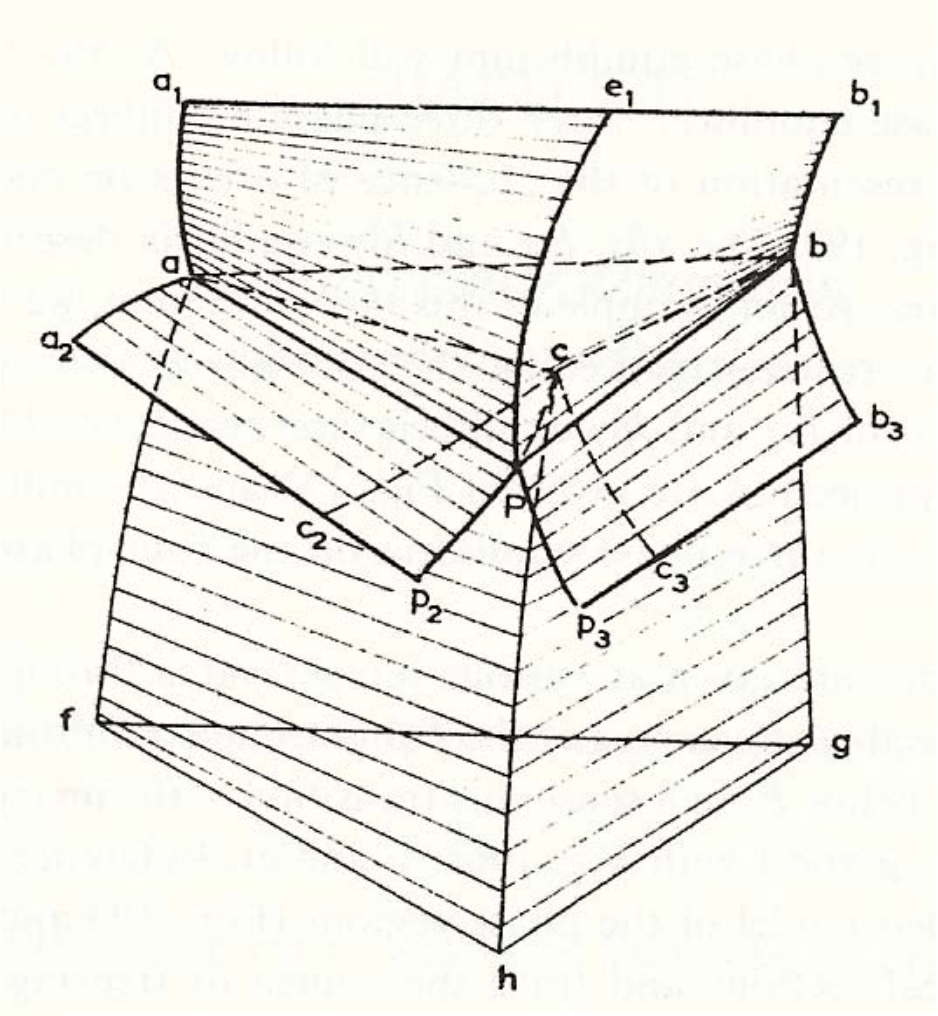




$T_A > T_B > e_1 > P > P_2 > P_3 > T_C$

10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)

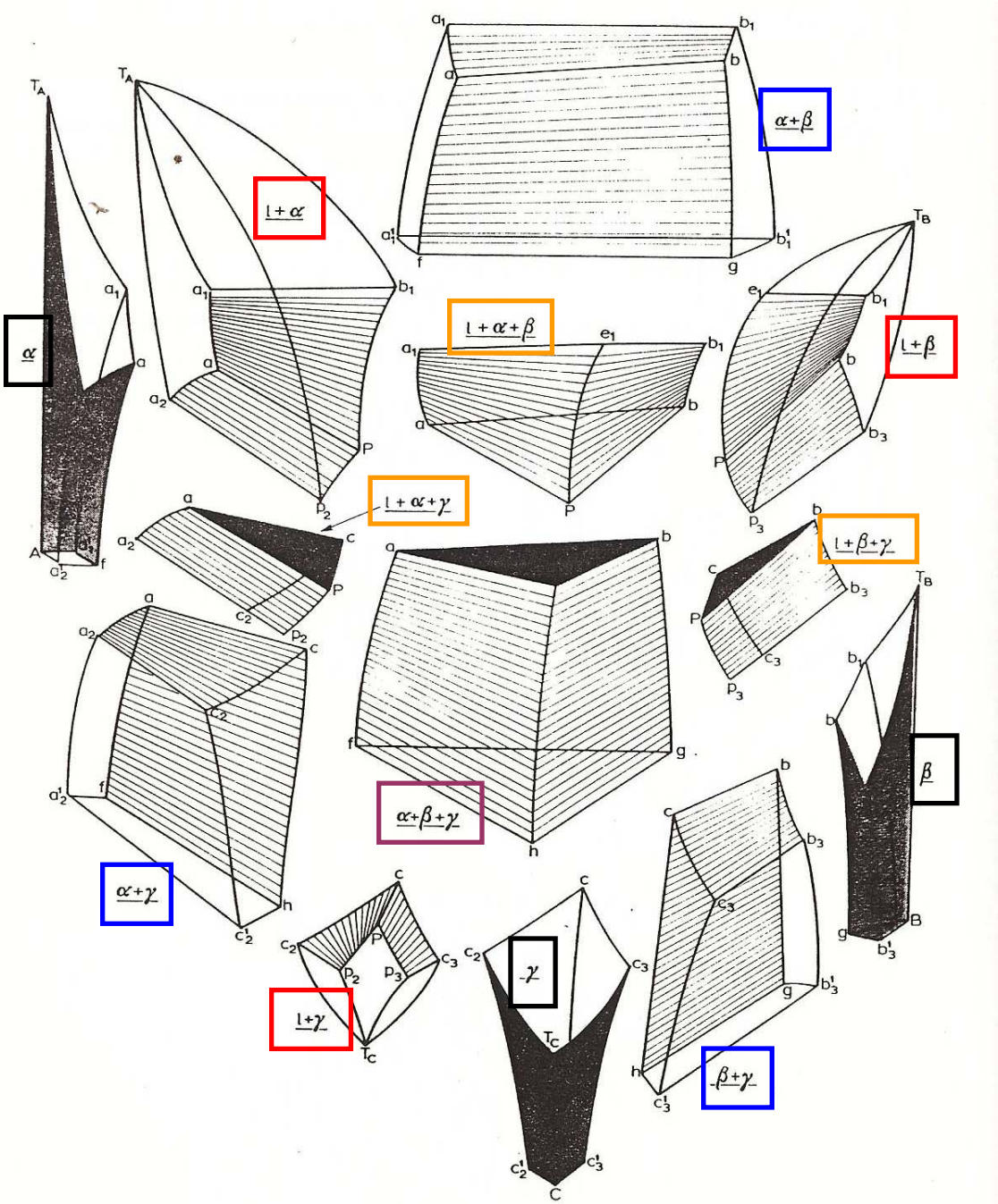




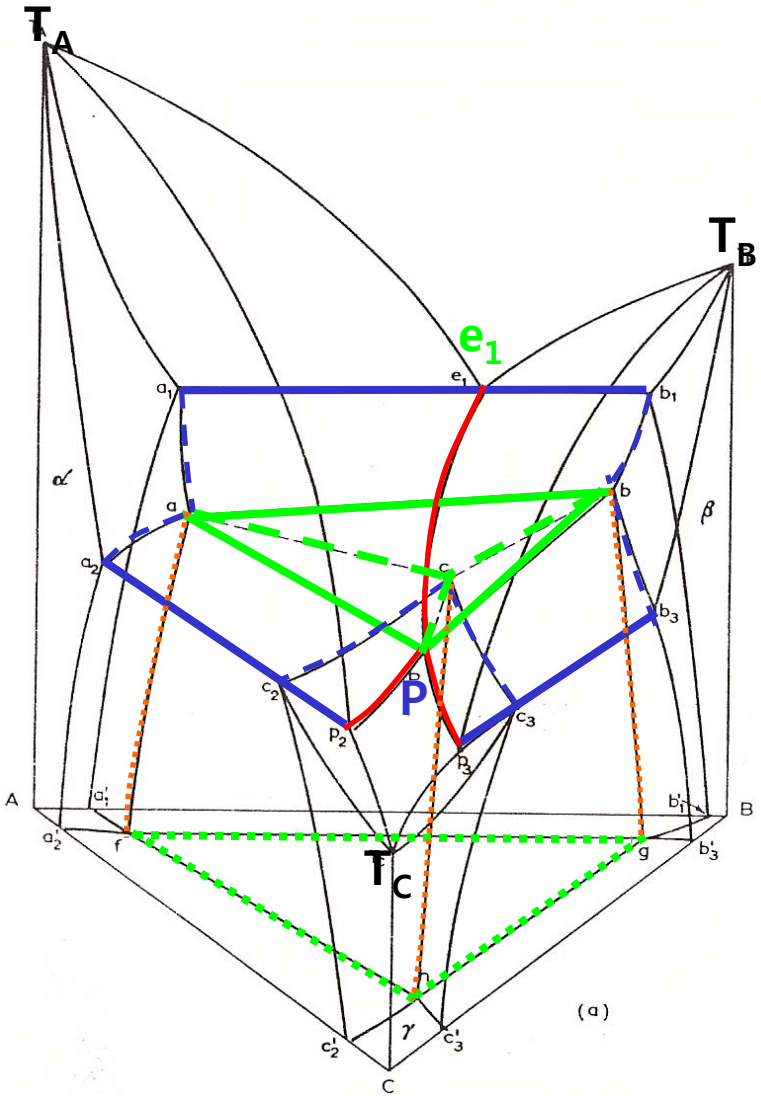
$T_A > T_B > e_1 > P > P_2 > P_3 > T_C$

The ternary peritectic four-phase plane as the junction of four tie triangles

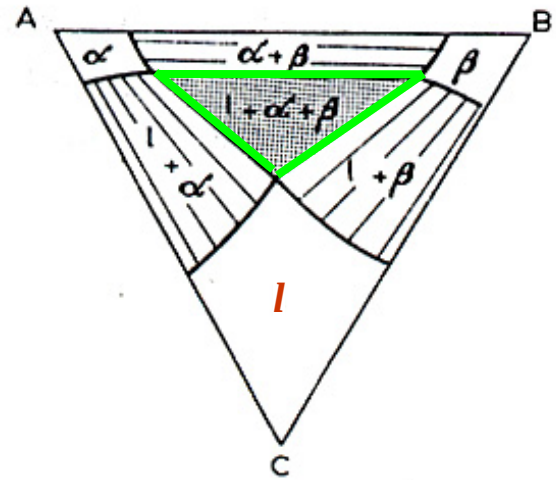
10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)



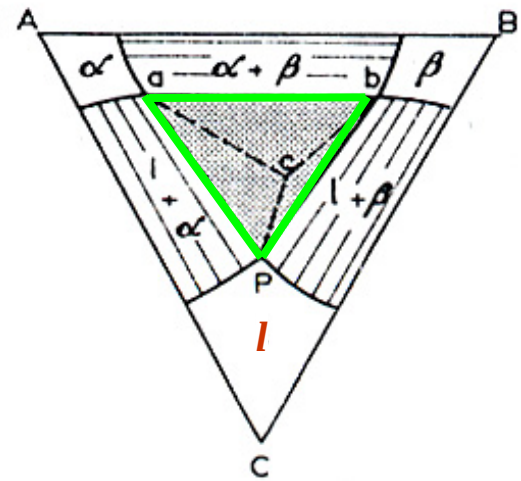
10.4. THE TERNARY PERIECTIC EQUILIBRIUM ($l + \alpha + \beta = \gamma$)



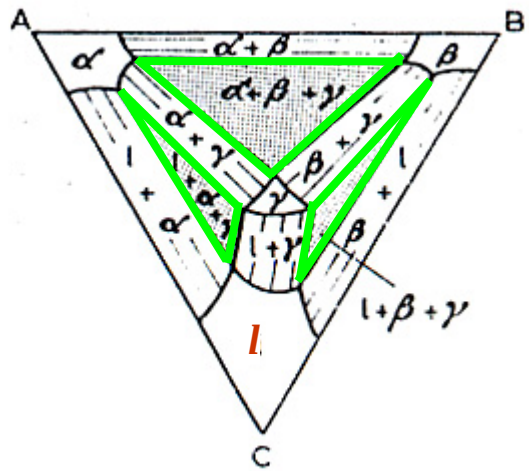
Isothermal section



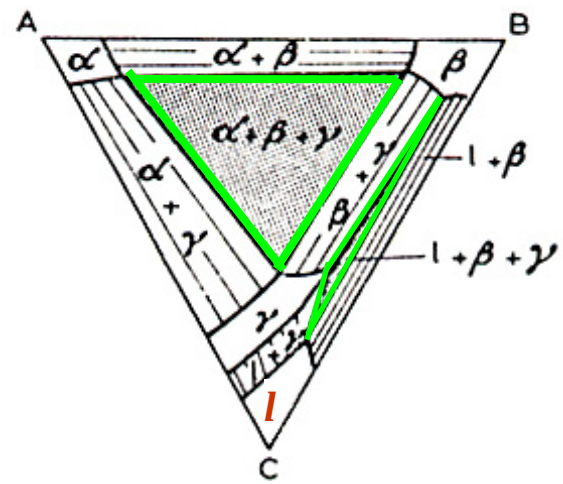
$e_1 > T > P$



$T = P$



$P > T > P_2$



$P_2 > T > P_3$

$T_A > T_B > e_1 > P > P_2 > P_3 > T_C$