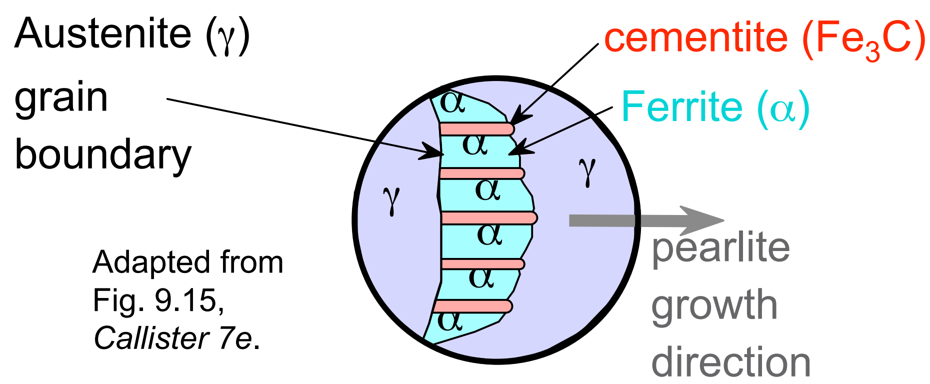
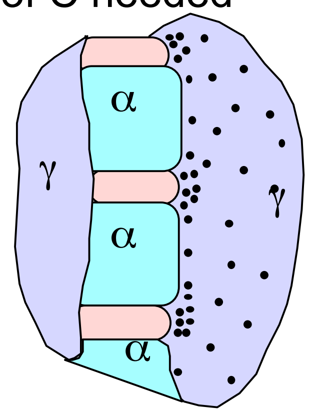
Eutectoid transformation rate

- Growth of pearlite from austenite:

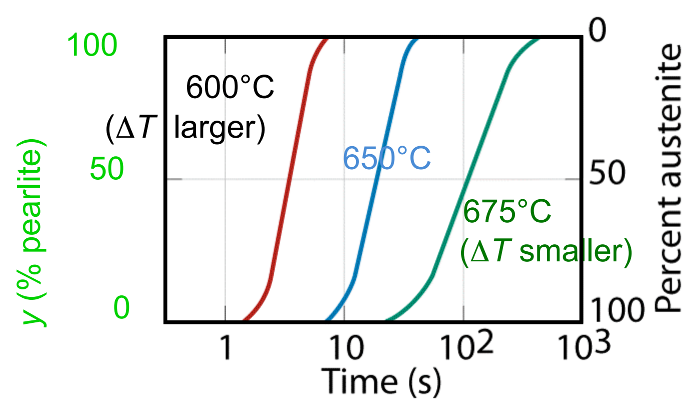


Adapted from Fig. 9.15, *Callister 7e*.

Diffusive flow of C needed



- Recrystallization rate increases with ΔT.



Adapted from Fig. 10.12, *Callister 7e*.

Transformations and undercooling

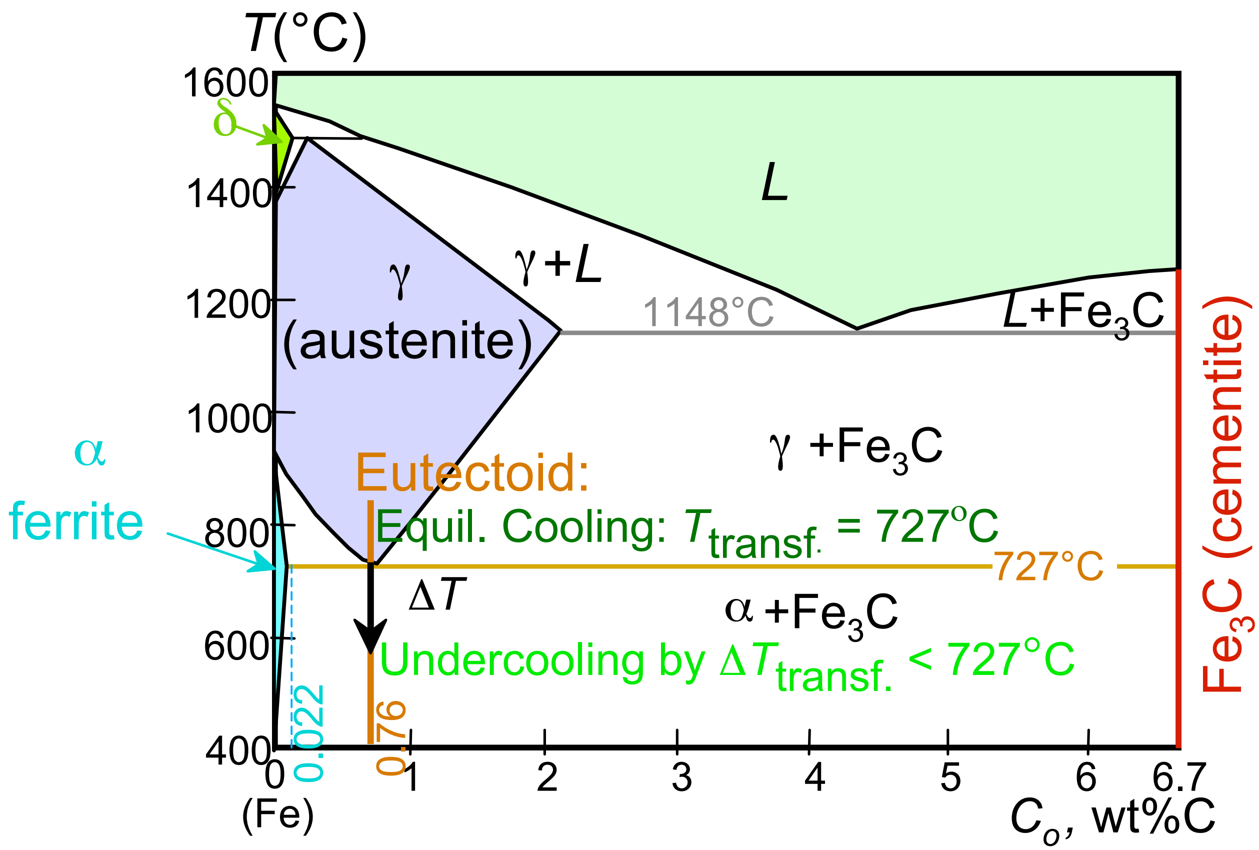
- Eutectoid transformation (Fe-C System):
- Can make it occur at:

  ...727ºC (cool it slowly)

  ...below 727ºC ("undercool" it)

$$\gamma \Rightarrow \alpha + Fe_3C$$

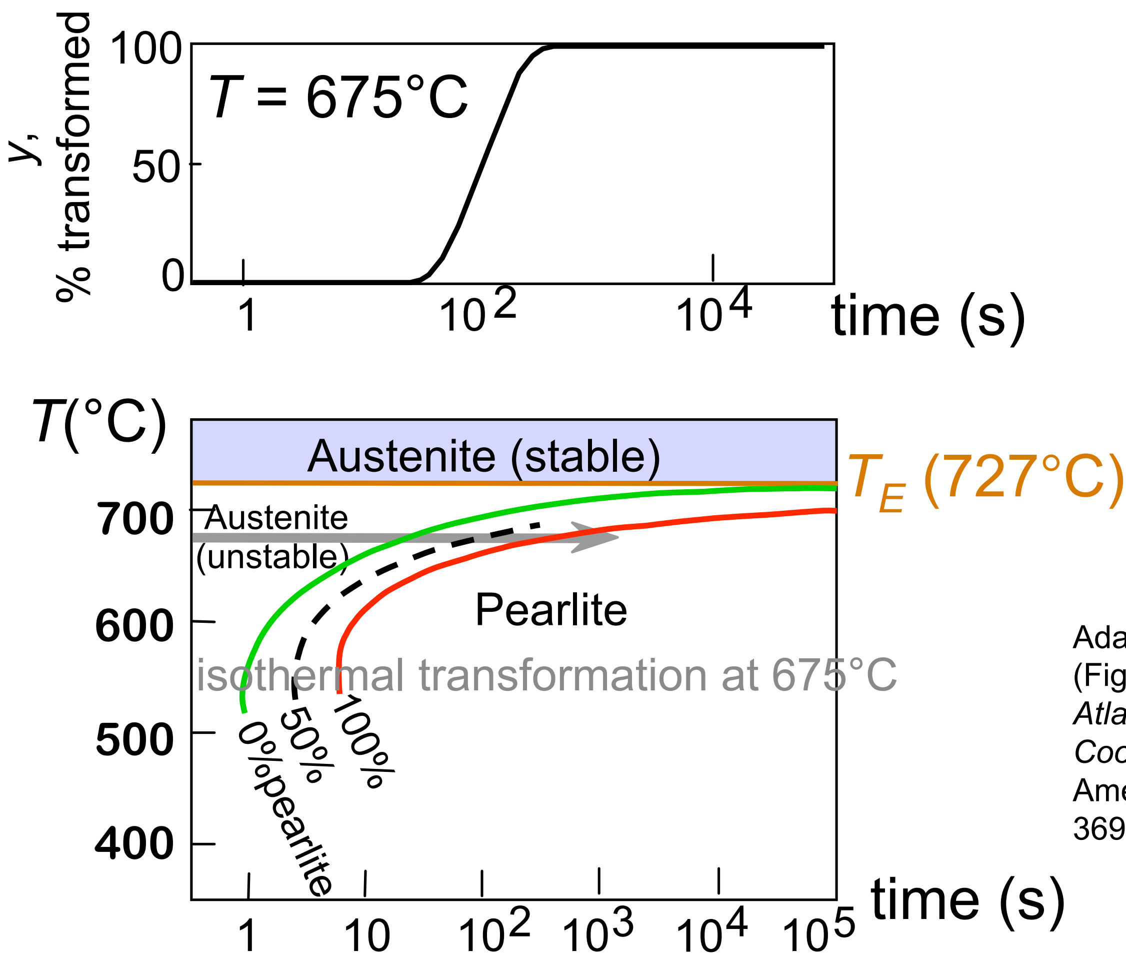
0.76 wt% C → γ; 0.022 wt% C → α; 6.7 wt% C → Fe_3C



Adapted from Fig. 9.24, *Callister 7e*. (Fig. 9.24 adapted from *Binary Alloy Phase Diagrams*, 2nd ed., Vol. 1, T.B. Massalski (Ed.-in-Chief), ASM International, Materials Park, OH, 1990.)

Isothermal transformation diagrams

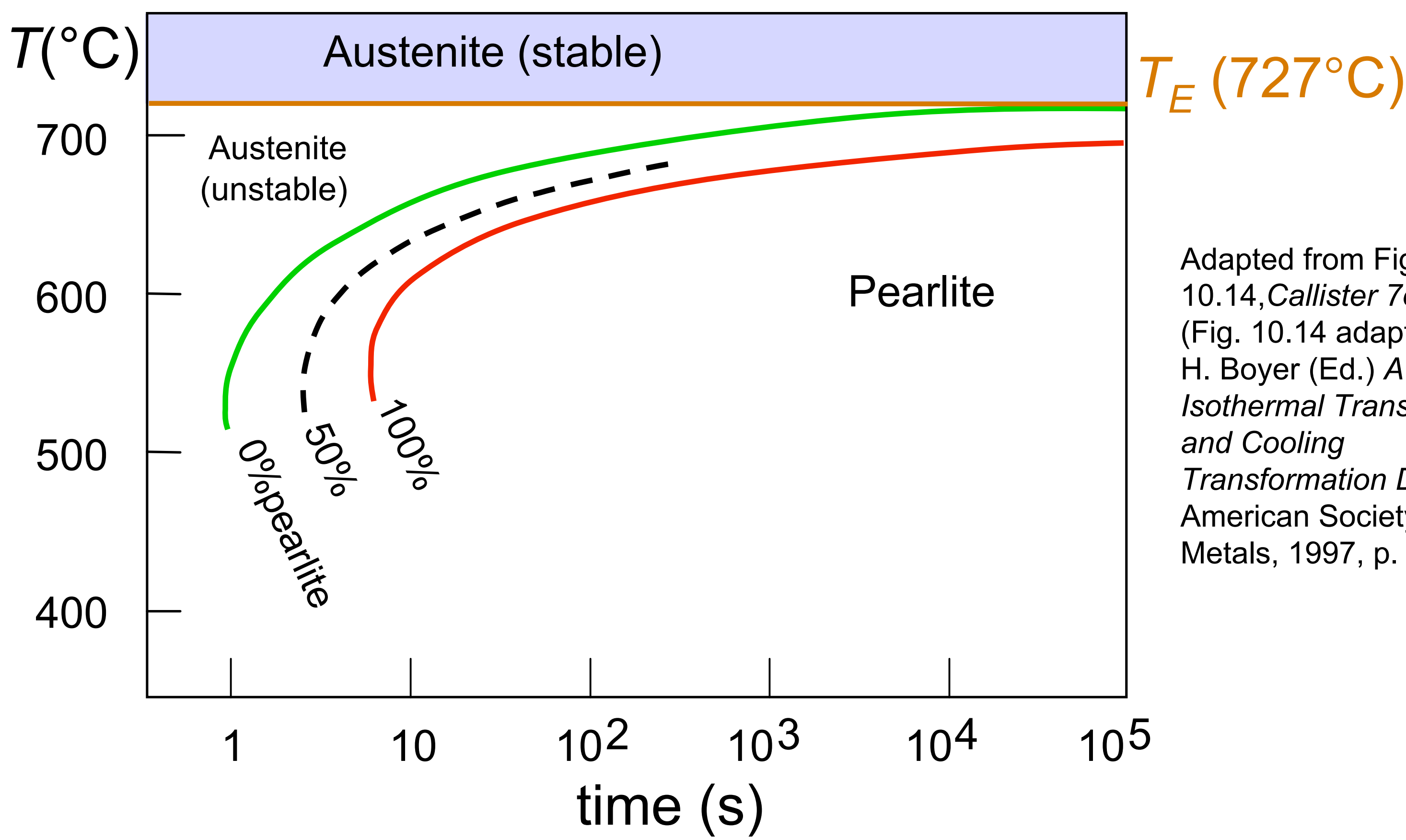
- Fe-C system, C_o = 0.76 wt% C
- Transformation at T = 675°C.



Adapted from Fig. 10.13, *Callister 7e*. (Fig. 10.13 adapted from H. Boyer (Ed.) *Atlas of Isothermal Transformation and Cooling Transformation Diagrams*, American Society for Metals, 1977, p. 369.)

Effect of cooling history

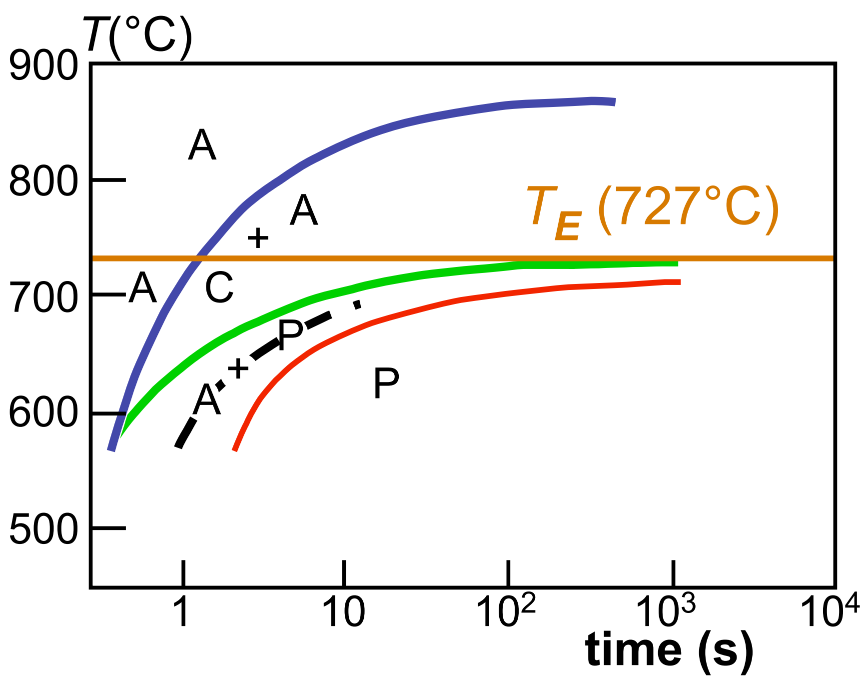
- Eutectoid composition, C_o = 0.76 wt% C
- Begin at T > 727°C
- Rapidly cool to 625°C and hold isothermally.



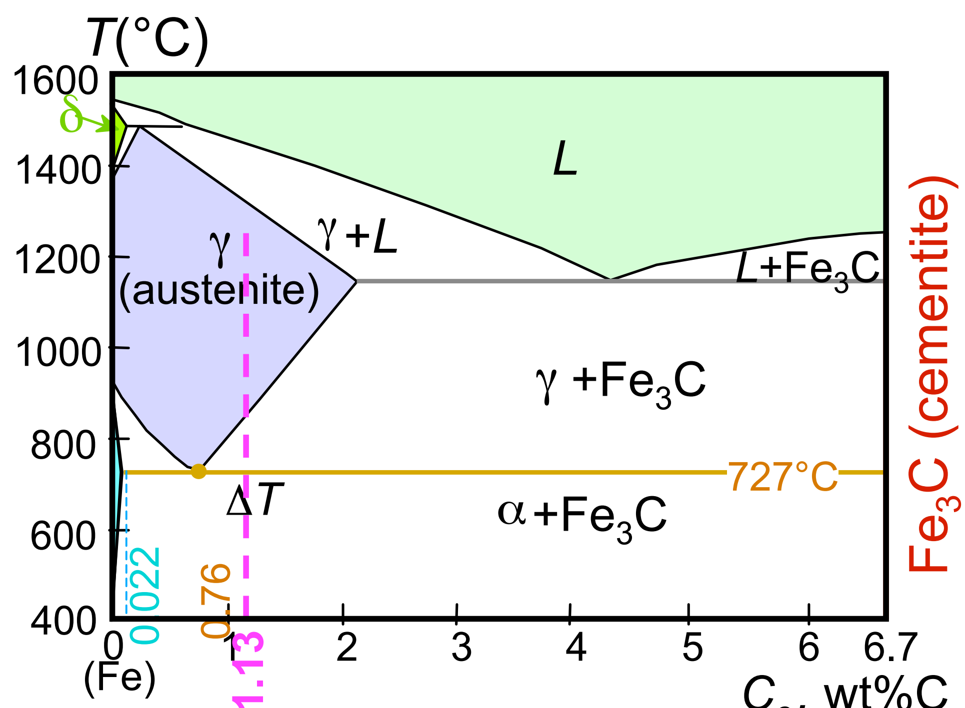
Adapted from Fig. 10.14, *Callister 7e*. (Fig. 10.14 adapted from H. Boyer (Ed.) *Atlas of Isothermal Transformation and Cooling Transformation Diagrams*, American Society for Metals, 1997, p. 28.)

Transformations with proeutectoid materials

C_o = 1.13 wt% C



Adapted from Fig. 10.16, *Callister 7e*.

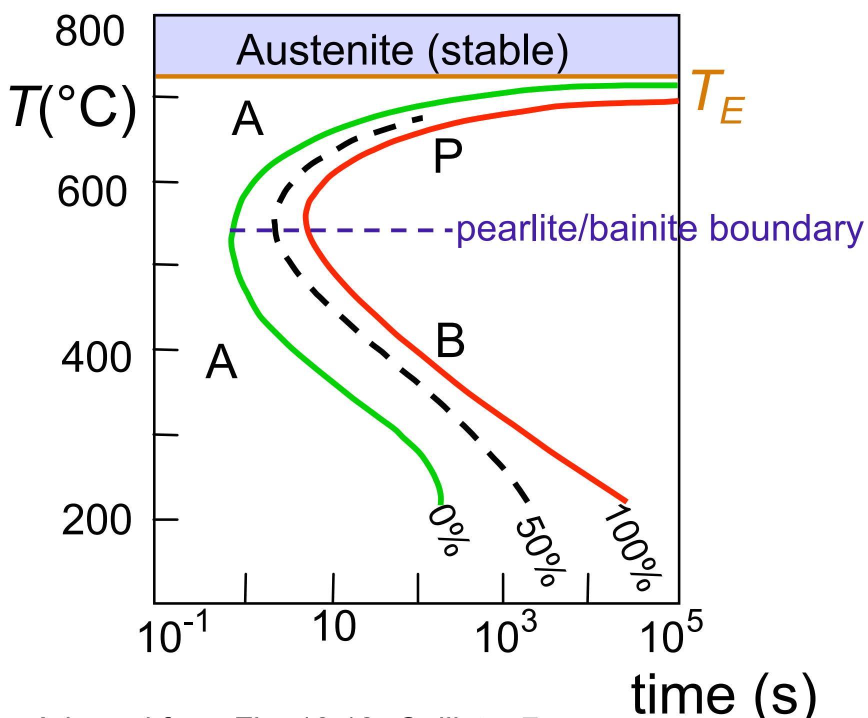


Adapted from Fig. 9.24, *Callister 7e*.

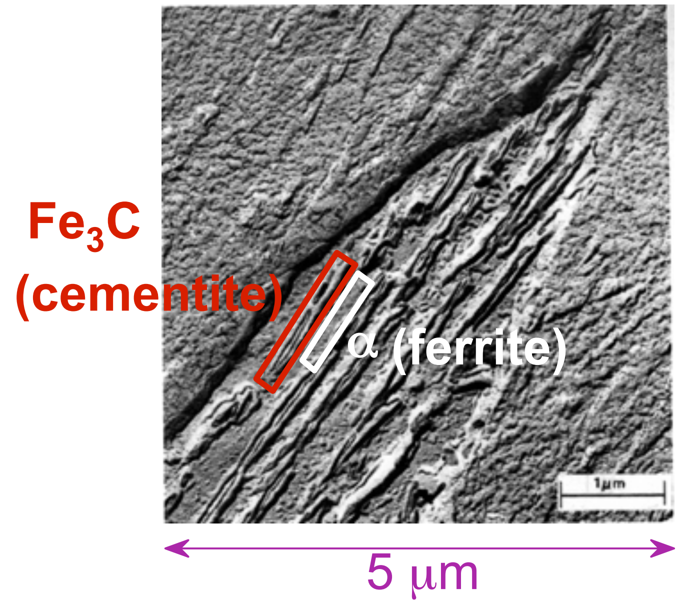
Hypereutectoid composition – proeutectoid cementite

Nonequilibrium transformation products

- Bainite:
  --α lathes (strips) with long rods of Fe_3C
  --diffusion controlled.
- Isothermal Transf. Diagram



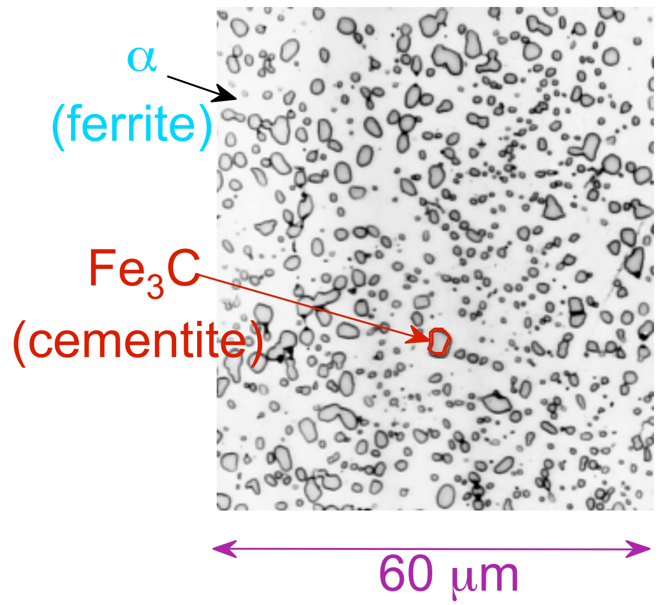
Adapted from Fig. 10.18, *Callister 7e*.
(Fig. 10.18 adapted from H. Boyer (Ed.) *Atlas of Isothermal Transformation and Cooling Transformation Diagrams*, American Society for Metals, 1997, p. 28.)



(Adapted from Fig. 10.17, *Callister, 7e*. (Fig. 10.17 from *Metals Handbook*, 8th ed., Vol. 8, *Metallography, Structures, and Phase Diagrams*, American Society for Metals, Materials Park, OH, 1973.)

Spheroidite

- Spheroidite:
  --α grains with spherical Fe_3C
  --diffusion dependent.
  --heat bainite or pearlite for long times
  --reduces interfacial area (driving force)

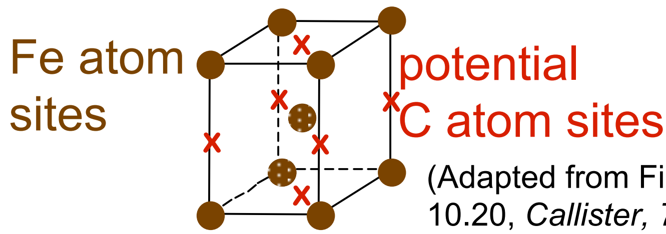


(Adapted from Fig. 10.19, *Callister, 7e*. (Fig. 10.19 copyright United States Steel Corporation, 1971.)

Martensite

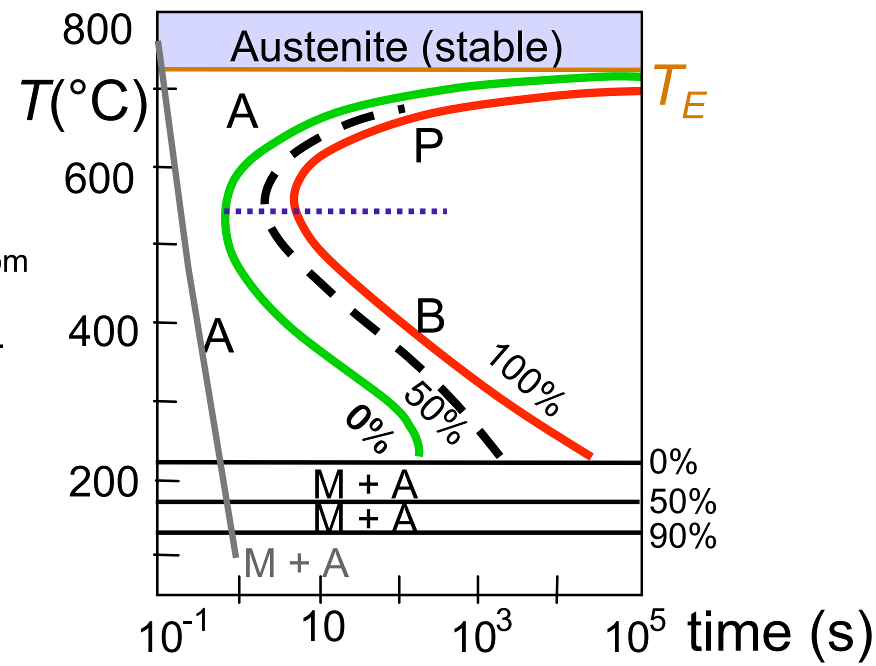
- Martensite:
  --γ(FCC) to Martensite (BCT)

(involves single atom jumps)

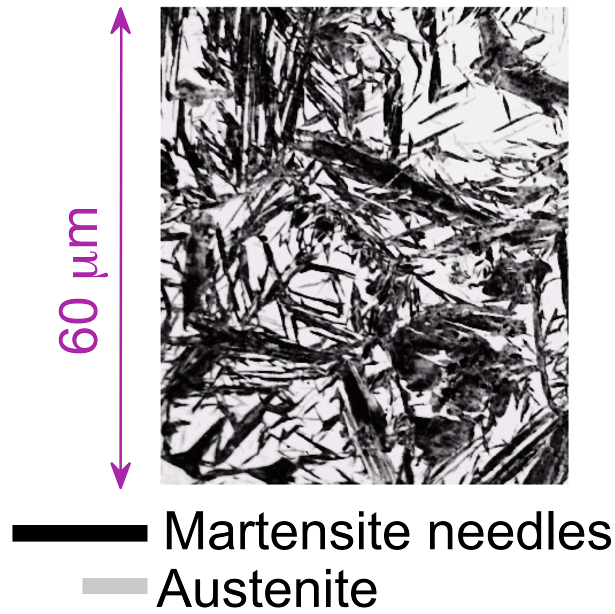


(Adapted from Fig. 10.20, *Callister, 7e*.

- Isothermal Transf. Diagram



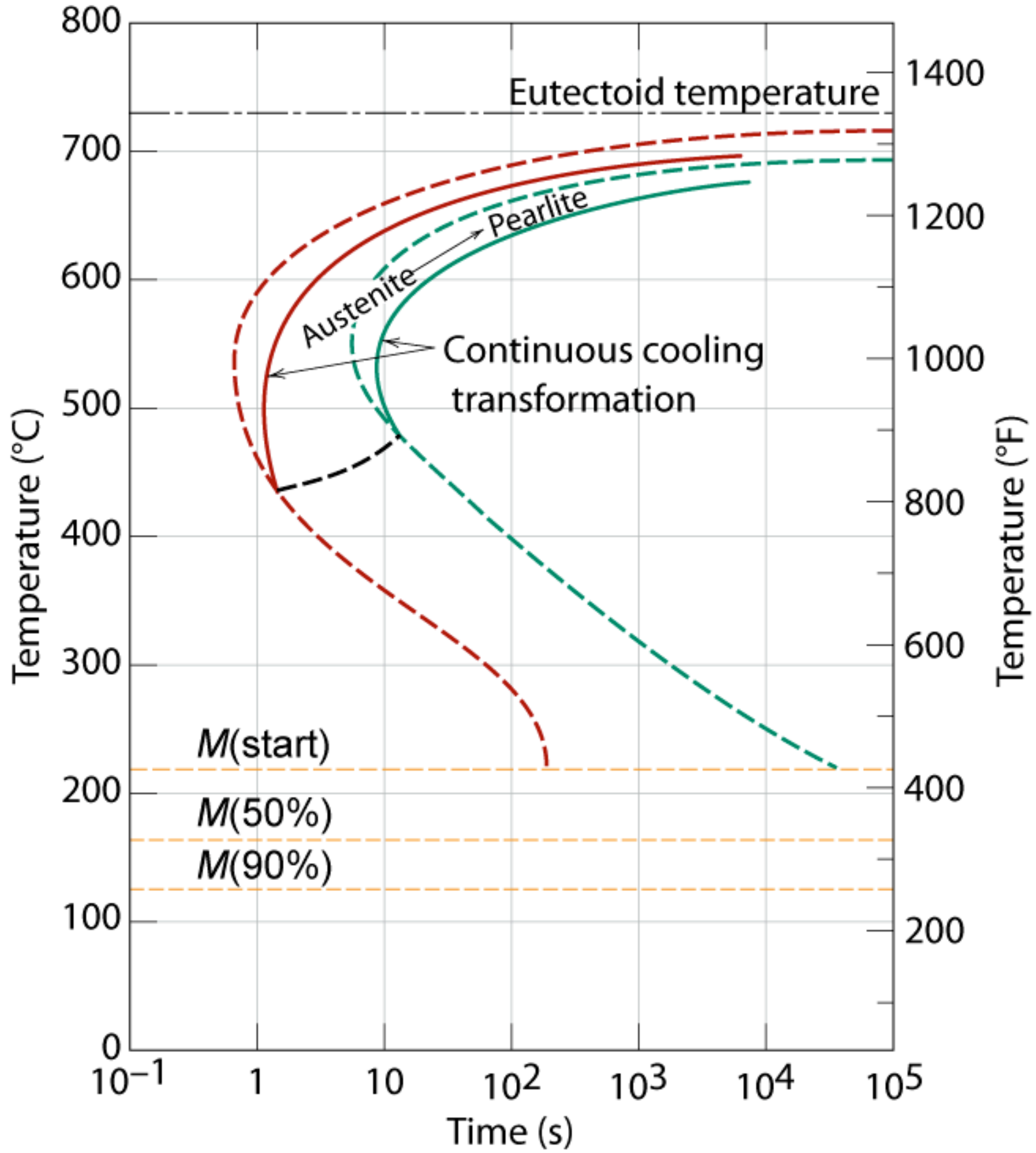
Adapted from Fig. 10.22, *Callister 7e*.



(Adapted from Fig. 10.21, *Callister, 7e*. (Fig. 10.21 courtesy United States Steel Corporation.)

Cooling curve

plot temp vs. time

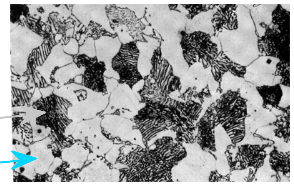


Adapted from
Fig. 10.25,
Callister 7e.

Mechanical properties 1

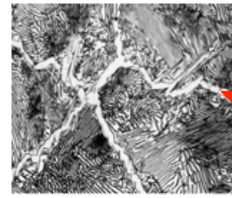
- Effect of wt% C

Pearlite (med)
ferrite (soft)



C_o < 0.76 wt% C
Hypoeutectoid

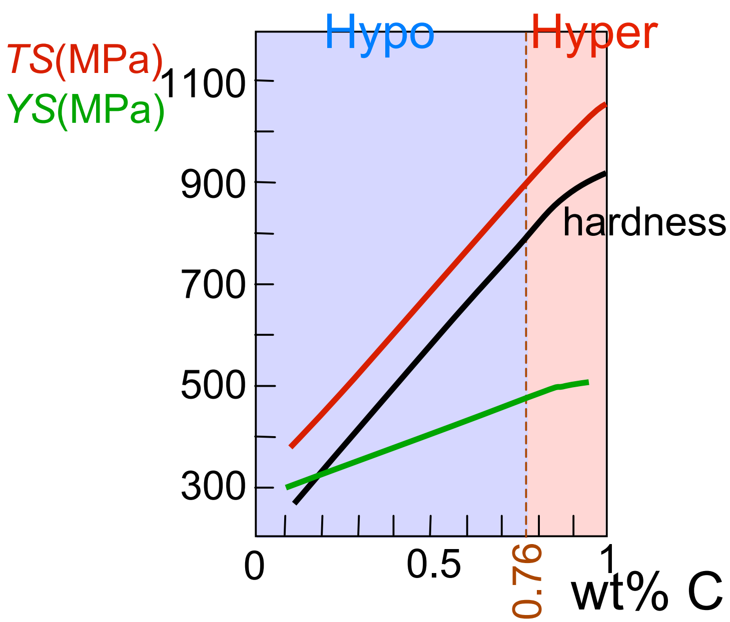
Adapted from Fig. 9.30, *Callister 7e*. (Fig. 9.30 courtesy Republic Steel Corporation.)

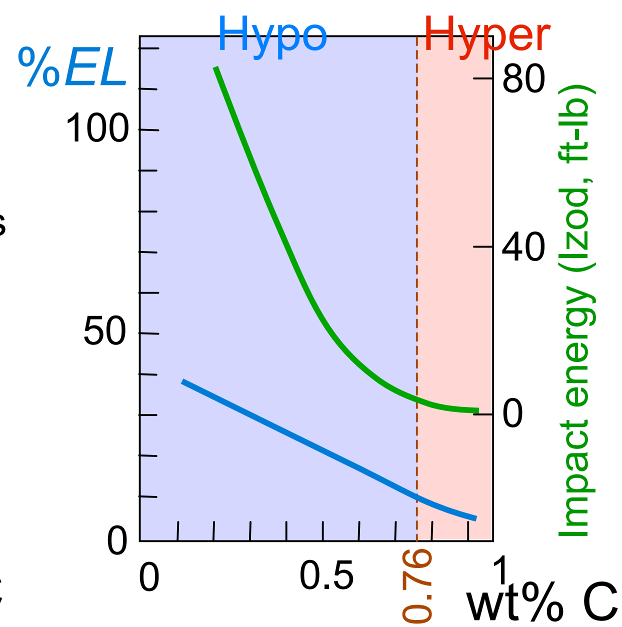


Pearlite (med)
Cementite (hard)

C_o > 0.76 wt% C
Hypereutectoid

Adapted from Fig. 9.33, *Callister 7e*. (Fig. 9.33 copyright 1971 by United States Steel Corporation.)

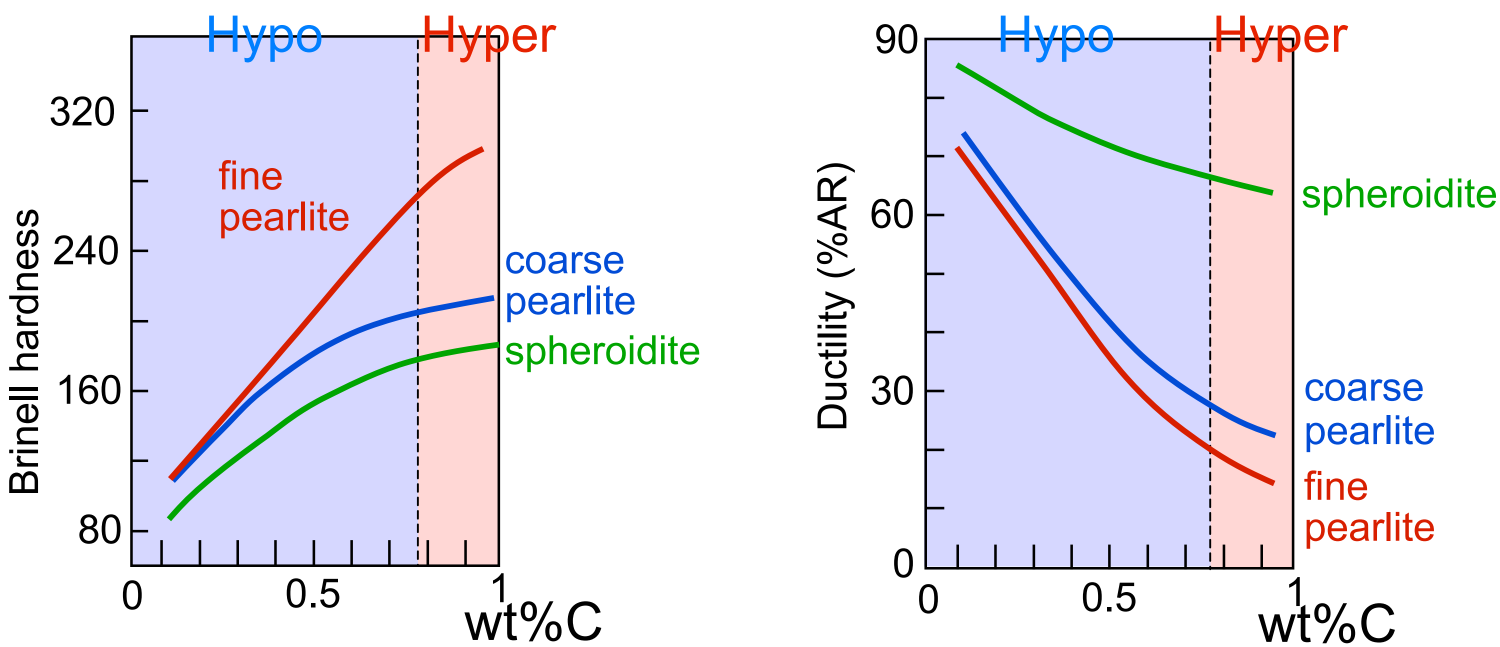




Adapted from Fig. 10.29, *Callister 7e*. (Fig. 10.29 based on data from *Metals Handbook: Heat Treating*, Vol. 4, 9th ed., V. Masseria (Managing Ed.), American Society for Metals, 1981, p. 9.)

Mechanical properties 2

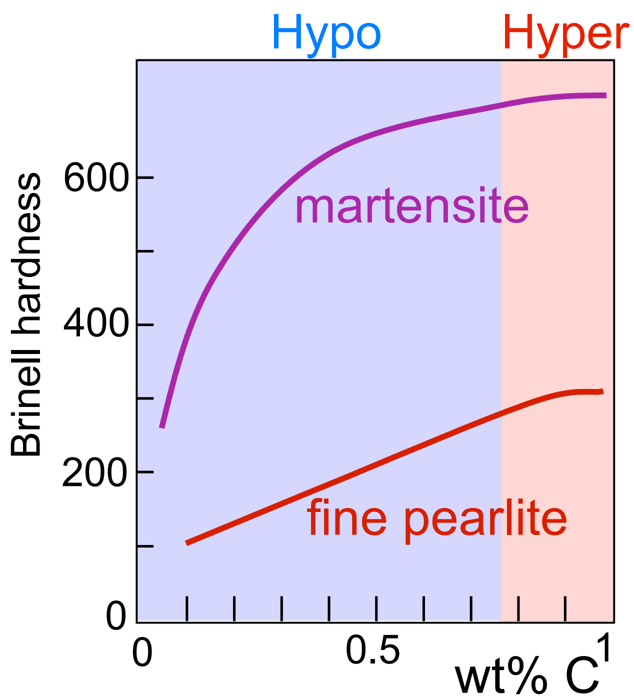
- Fine vs coarse pearlite vs spheroidite



Adapted from Fig. 10.30, *Callister 7e*. (Fig. 10.30 based on data from *Metals Handbook: Heat Treating*, Vol. 4, 9th ed., V. Masseria (Managing Ed.), American Society for Metals, 1981, pp. 9 and 17.)

Mechanical properties 3

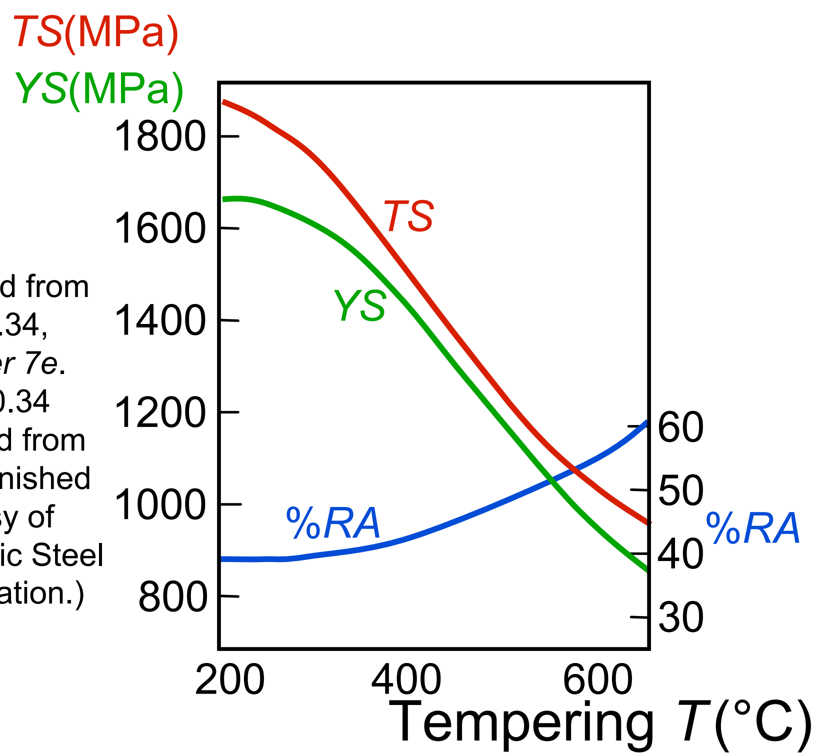
- Fine Pearlite vs Martensite:

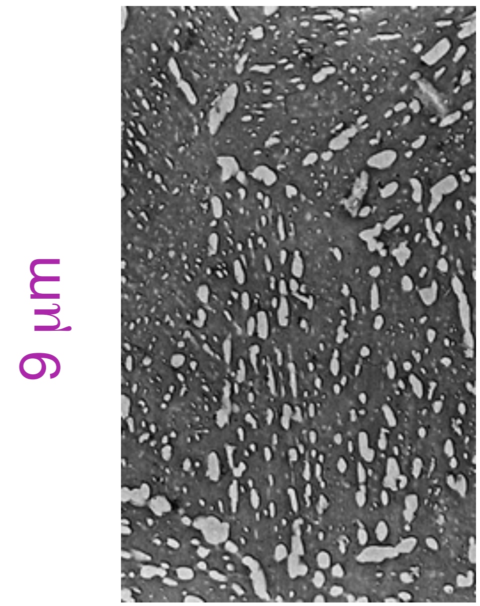


Adapted from Fig. 10.32, *Callister 7e*. (Fig. 10.32 adapted from Edgar C. Bain, *Functions of the Alloying Elements in Steel*, American Society for Metals, 1939, p. 36; and R.A. Grange, C.R. Hribal, and L.F. Porter, *Metall. Trans. A*, Vol. 8A, p. 1776.)

Tempered martensite

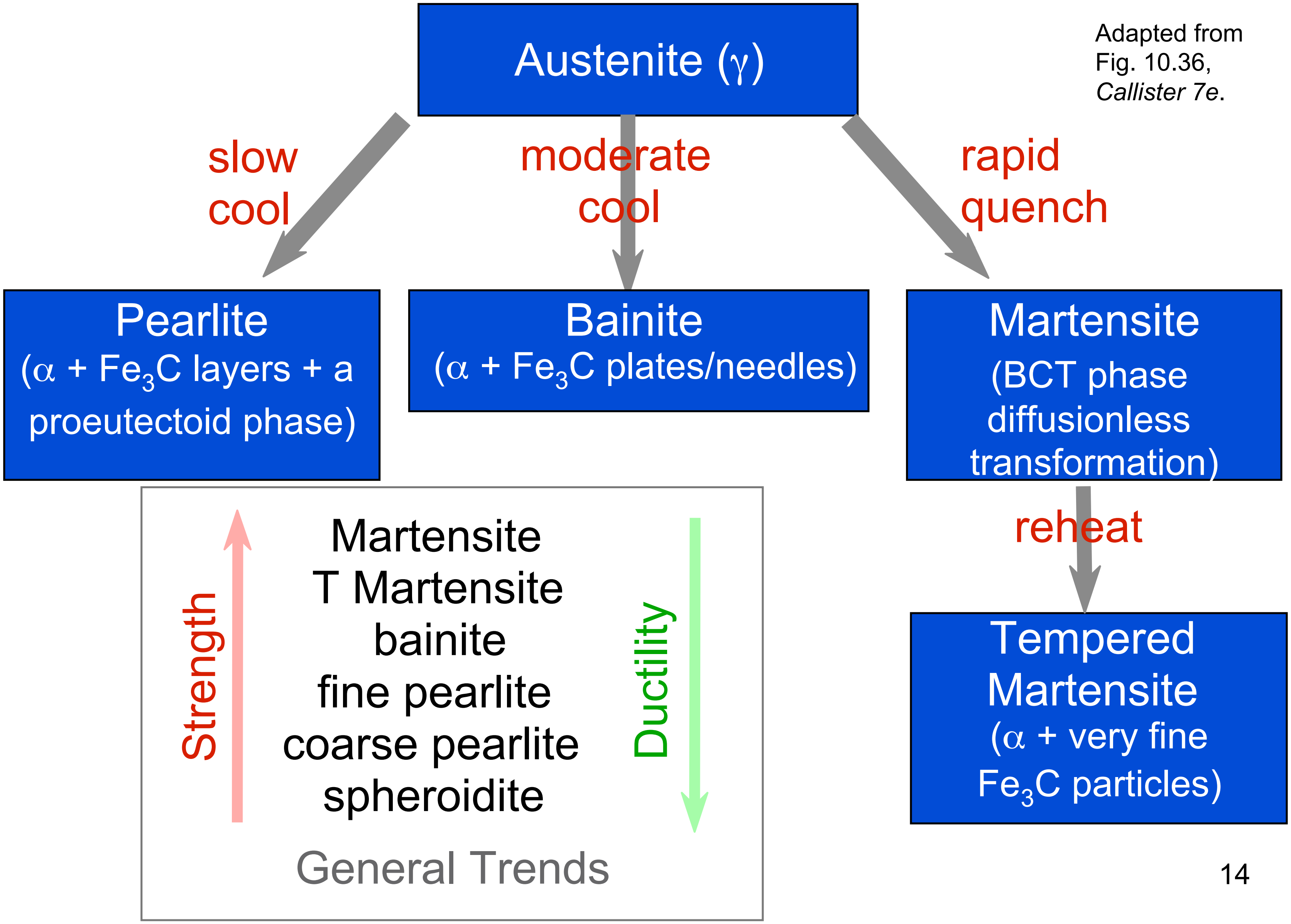
Adapted from Fig. 10.34, *Callister 7e*. (Fig. 10.34 adapted from Fig. furnished courtesy of Republic Steel Corporation.)





Adapted from Fig. 10.33, *Callister 7e*. (Fig. 10.33 copyright by United States Steel Corporation, 1971.)

Summary



Adapted from Fig. 10.36, *Callister 7e*.