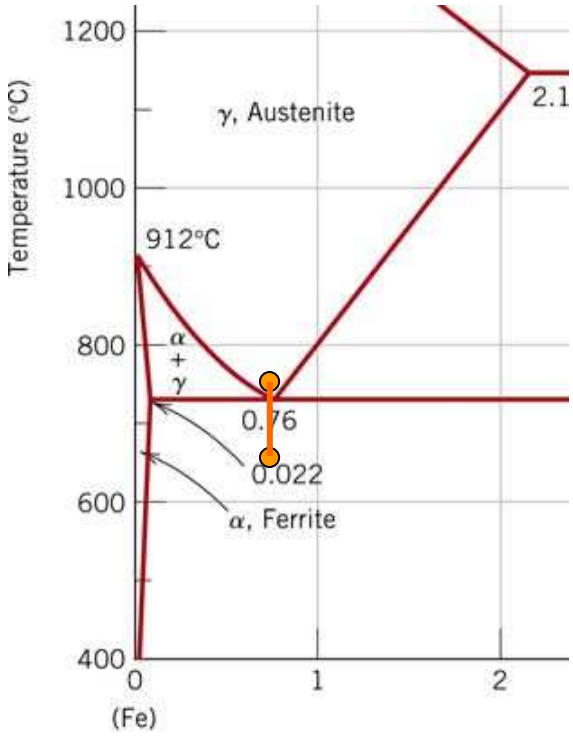
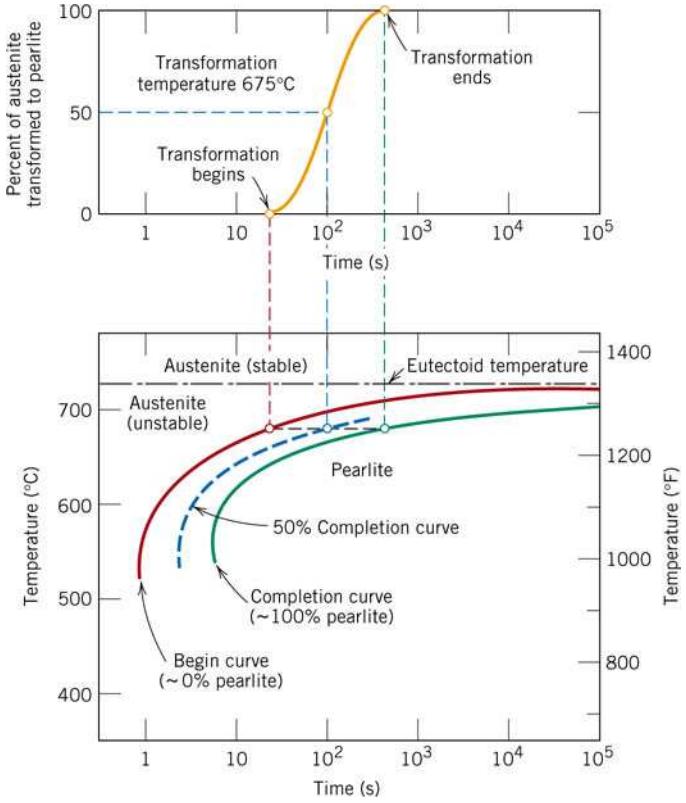
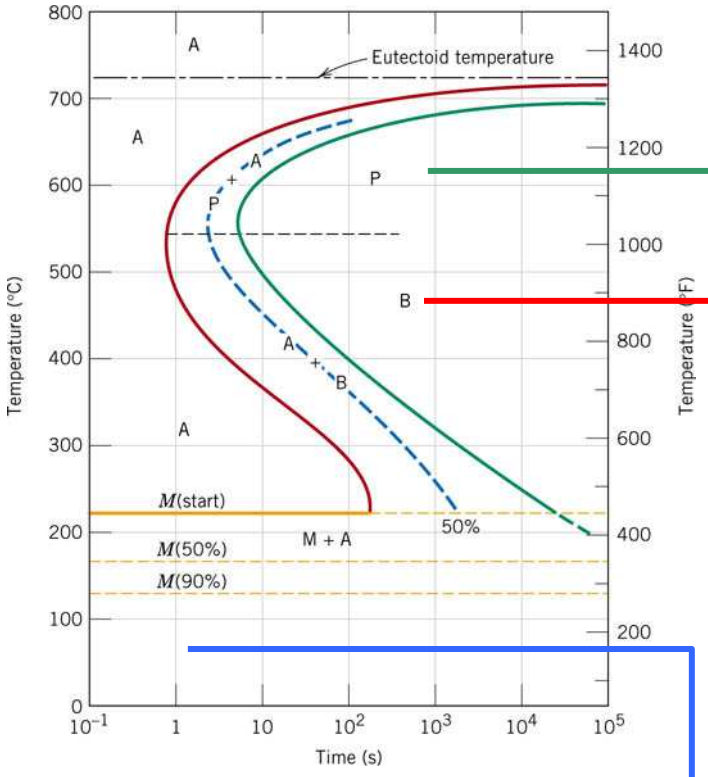
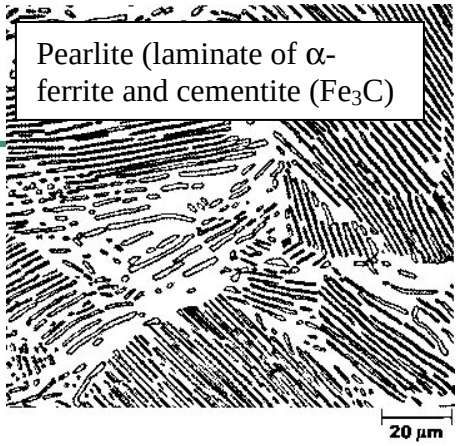


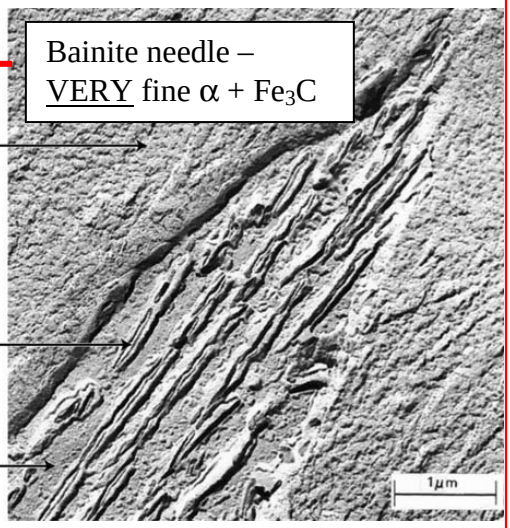
Phase diagrams assume phases are at equilibrium. Time is not relevant to phase diagrams. However, it does take time for phase transformation (to change from one phase to another).



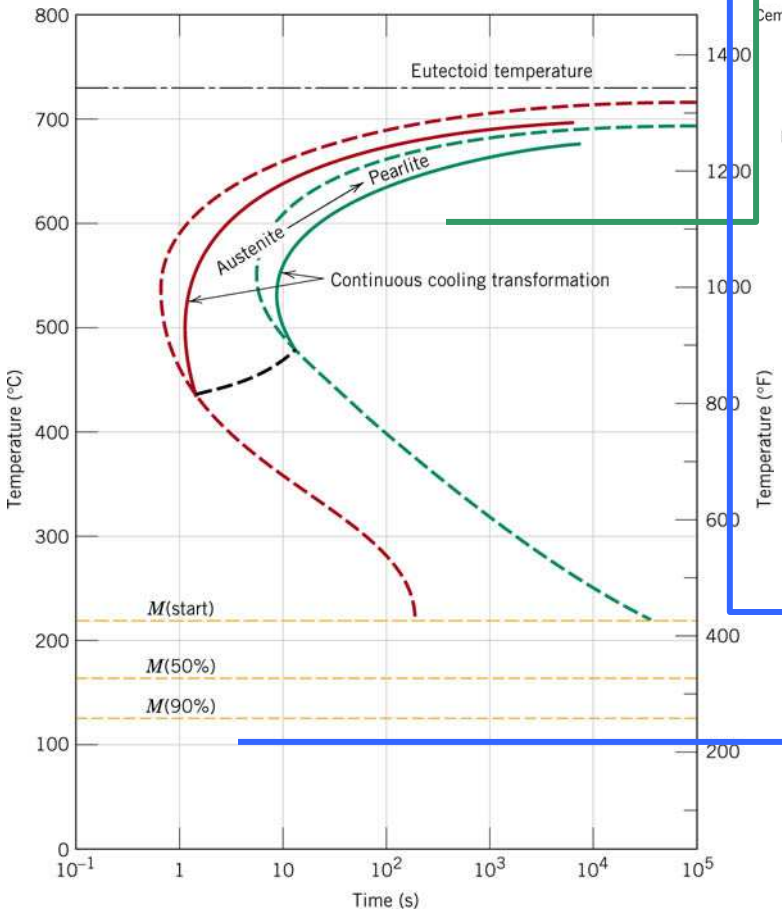




Pearlite (laminate of α-ferrite and cementite (Fe_3C)



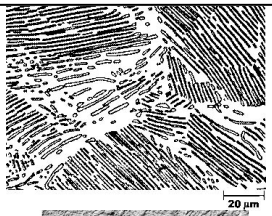
Bainite needle – <u>VERY</u> fine α + Fe_3C

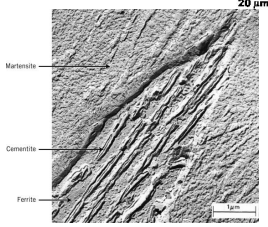


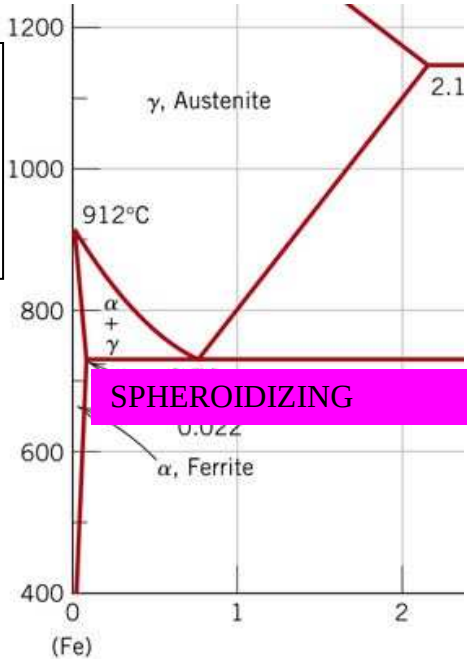
Martensite: BCT iron with C between corners.

Harder, Stronger, Less Tough

Heat pearlite (can also heat bainite or martensite) to just below eutectoid temperature for 24 hours

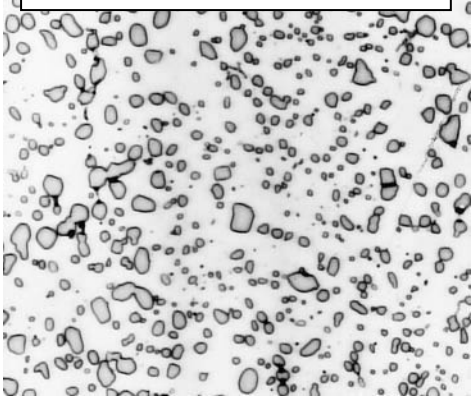


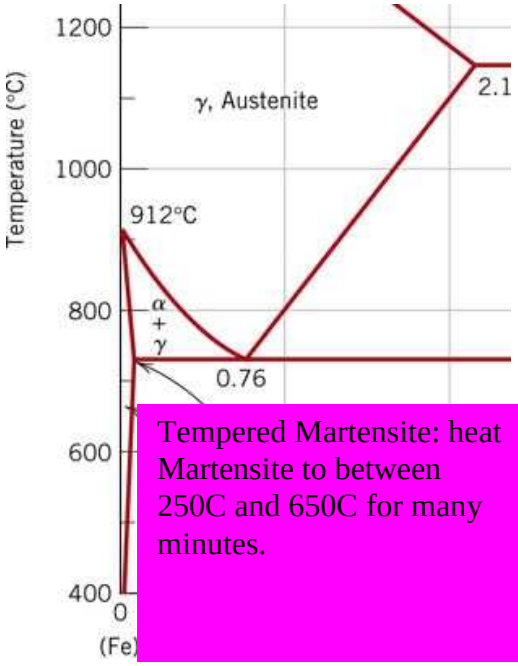




SPHEROIDIZING

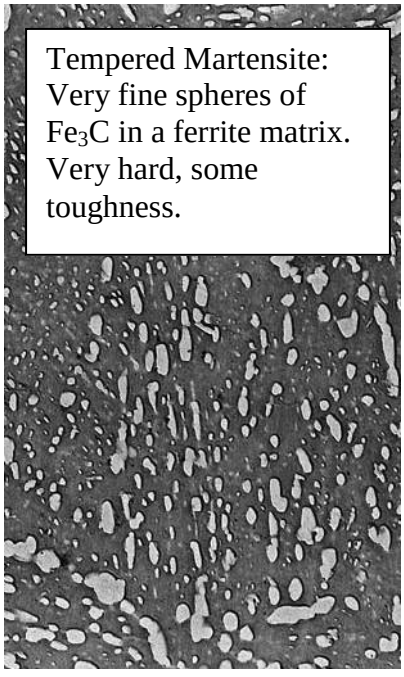
Spheroidite: spheres of Fe_3C in a ferrite matrix. Very soft, ductile, weak.





Tempered Martensite: heat Martensite to between 250C and 650C for many minutes.

Tempered Martensite: Very fine spheres of Fe_3C in a ferrite matrix. Very hard, some toughness.



$$\gamma \xrightarrow[\text{Rapid cooling}]{} \text{BCT (martensite)} \xrightarrow[\text{Heating (tempering)}]{} Fe_3C + \alpha\text{-ferrite}$$

SUMMARIZE

Step 1:
Austenitize (heat sufficiently to form γ, austenite (FCC)

Step 2: Cool

a) Slowly cooling results in pearlite (layers of α + Fe_3C)
b) Rapid cooling to 250-500C results in bainite (very fine needles of Fe_3C embedded in an α-ferrite matrix).
c) Very rapid cooling to room temperature results in martensite – a metastable phase, BCT iron with carbon between corner Fe atoms. Very hard, very brittle (no toughness).

Step 3: Reheating

a) Heating pearlite (or bainite or martensite) to 700C and hold for 24 hours results in spheroidite – very soft, ductile, weak. Good for machining, but is usually subsequently reheat treated to form pearlite or other. (Spheres of Fe_3C in α -ferrite matrix).
b) Heating martensite (tempering) to between 250-650C for many minutes produces tempered martensite (very fine spheres of Fe_3C in α -ferrite matrix).

Microstructure	Phase(s)	Produced	Properties
Pearlite	Layers of Fe_3C + α	γ, slow cool	Moderate strength, toughness, hardness
Bainite	Very fine needles of Fe_3C + α	γ, cool and hold (250-500C)	Hard, strong, some toughness
Martensite	BCT iron, C between corner Fe	γ, rapid cool to room temperature	Very hard, very brittle
Spheroidite	Spheres of Fe_3C in α matrix	Heat to 700C for 24 hours	Very soft, weak, ductile
Tempered martensite	Very fine spheres of Fe_3C in α matrix	Martensite, then heat 250-650C for minutes	Very hard, some toughness