HEAT TREATMENT OF CAST-IRON

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INTRODUCTION

- Cast iron is a generic term used to designate a family of metals with a wide variety of properties. All cast irons contain more than 2% carbon and an appreciable amount of silicon (usually 1-3%). The high carbon and silicon content means that they are easily melted, have good fluidity in the liquid state and have excellent pouring properties. The basic types of cast iron are best differentiated by their microstructure as opposed to their chemical analysis because the various types overlap.
- The metallurgy of cast iron is more complex than its economics and, in fact, is one of the more complex metallurgical systems [Fig 2]. Iron-carbon alloys with less than 2% carbon are metastable; the true stable system being iron-graphite (Fe-C). The general term cast iron includes pig iron, gray iron, malleable iron, chilled iron, white iron, and nodular or ductile iron. If an iron alloy exceeds about 2% carbon, the carbon does not have to nucleate from decomposition of austenite, but instead, it can form directly from the melt by a eutectic reaction. Note that cementite (Fe_3C) can still nucleate at the eutectic more readily than graphite, but on sufficiently slow cooling, graphite itself is able to form and grow.

- Consider the solidification of a 3% carbon cast iron (Fig. 3). At a rapid cooling rate, dendrites of austenite form as the alloy cools below the liquidus and grow until the eutectic temperature is reached. At the eutectic, graphite formation is suppressed, but austenite and cementite precipitate to form ledeburite, **a form of eutectic that consists of spheres of austenite embedded in cementite**. Ledeburite forms at the Fe-Fe3C eutectic (solid line "nm"). On further cooling, the cementite grows as the austenite decreases in carbon content (along the solid line "no") At the eutectic (point "o"), the remaining austenite transforms to pearlite. At room temperature, the iron is hard and brittle and is called white iron because the surface of a fractured piece of iron is white and (somewhat) lustrous. Upon slow cooling of a 3% carbon cast iron, austenite forms from the melt, but eutectic freezing is now slow enough so the products of the eutectic reaction are austenite and graphite (the reaction takes place at the dotted line "nm").

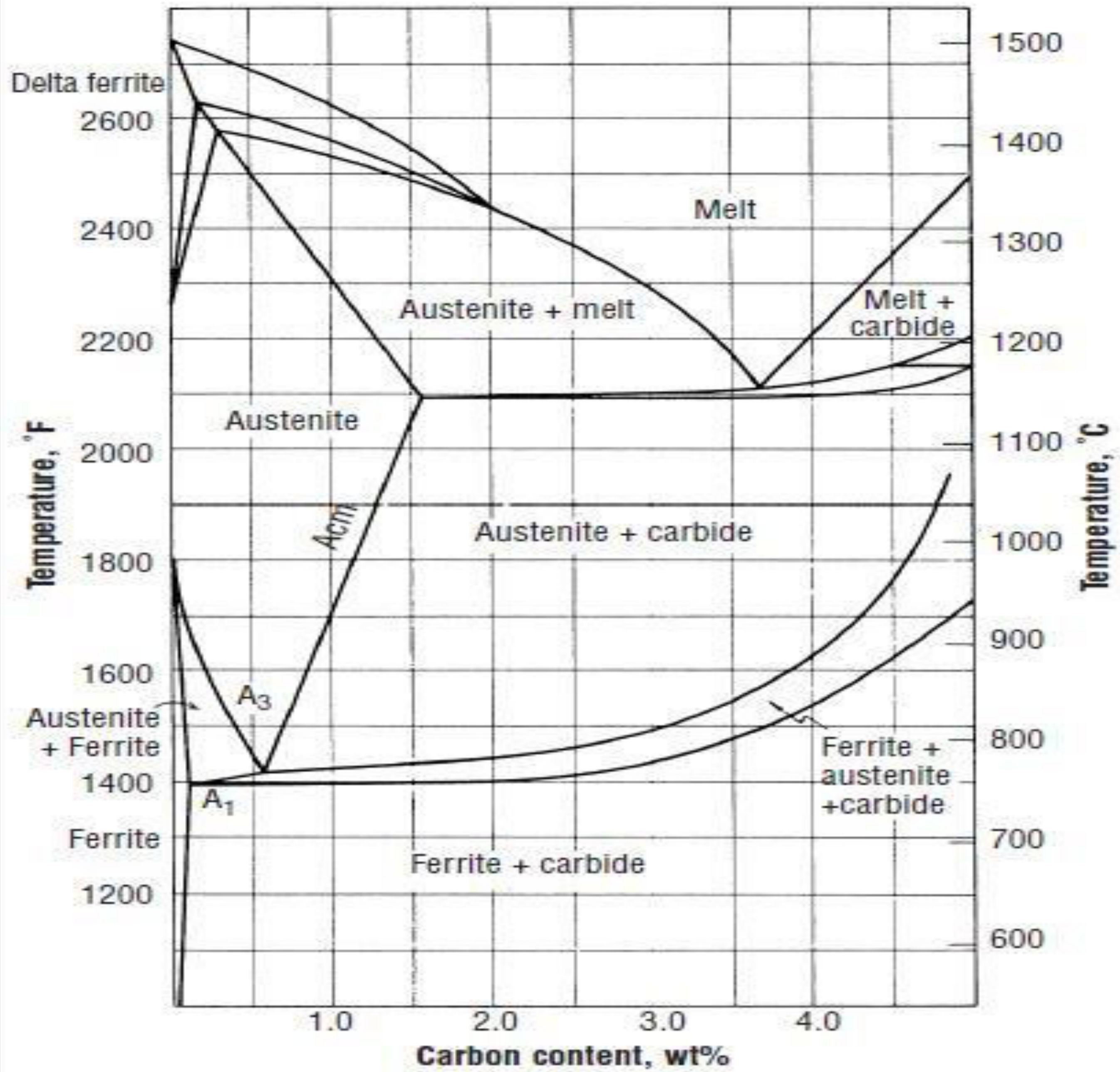

Fig 2. Fe-C-Si diagram at 2% silicon.
Silicon strongly promotes graphite formation.

- The eutectic graphite tends to form flakes surrounded by eutectic austenite. As cooling continues, the austenite decreases in carbon content (along the dotted line “no”), while the remaining austentite transforms to pearlite. Because the fracture surface appears dull gray the material is known as gray iron (or pearlitic gray iron).
- Cooling at an extremely slow rate results in phase changes similar to those of a slow cooled component, except the eutectoid cooling is sufficiently slow to permit graphite to precipitate rather than pearlite. No new graphite flakes will form, but the ones present will increase in size. The final microstructure consists of graphite flakes embedded in a ferrite matrix. The resultant material is called ferritic gray iron (cooling of actual castings cooling is seldom slow enough to obtain this structure).

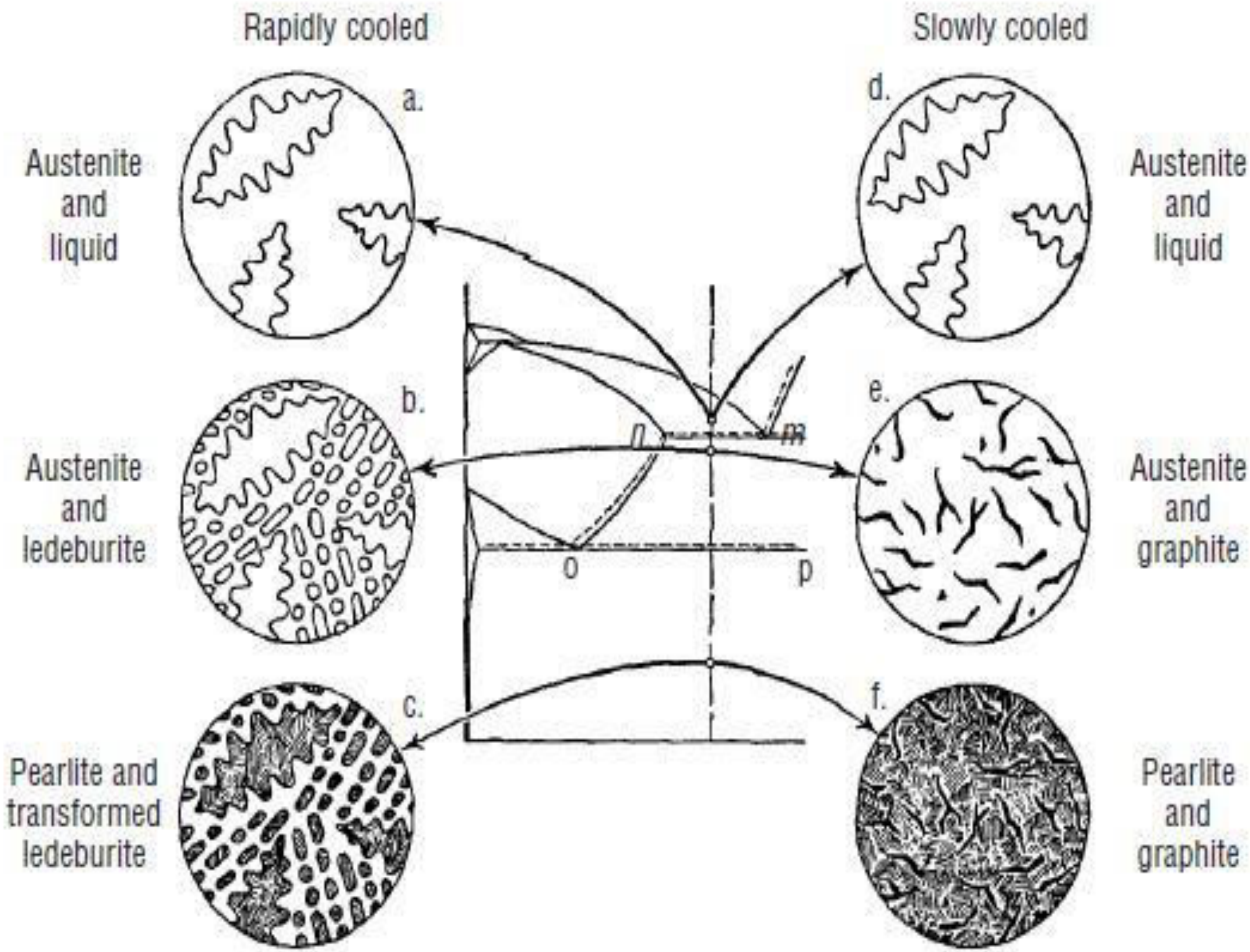

Fig 3. Iron-graphite phase diagram [4]. Microstructures obtained by cooling and solidification of cast iron; white iron (left) and gray iron (right).