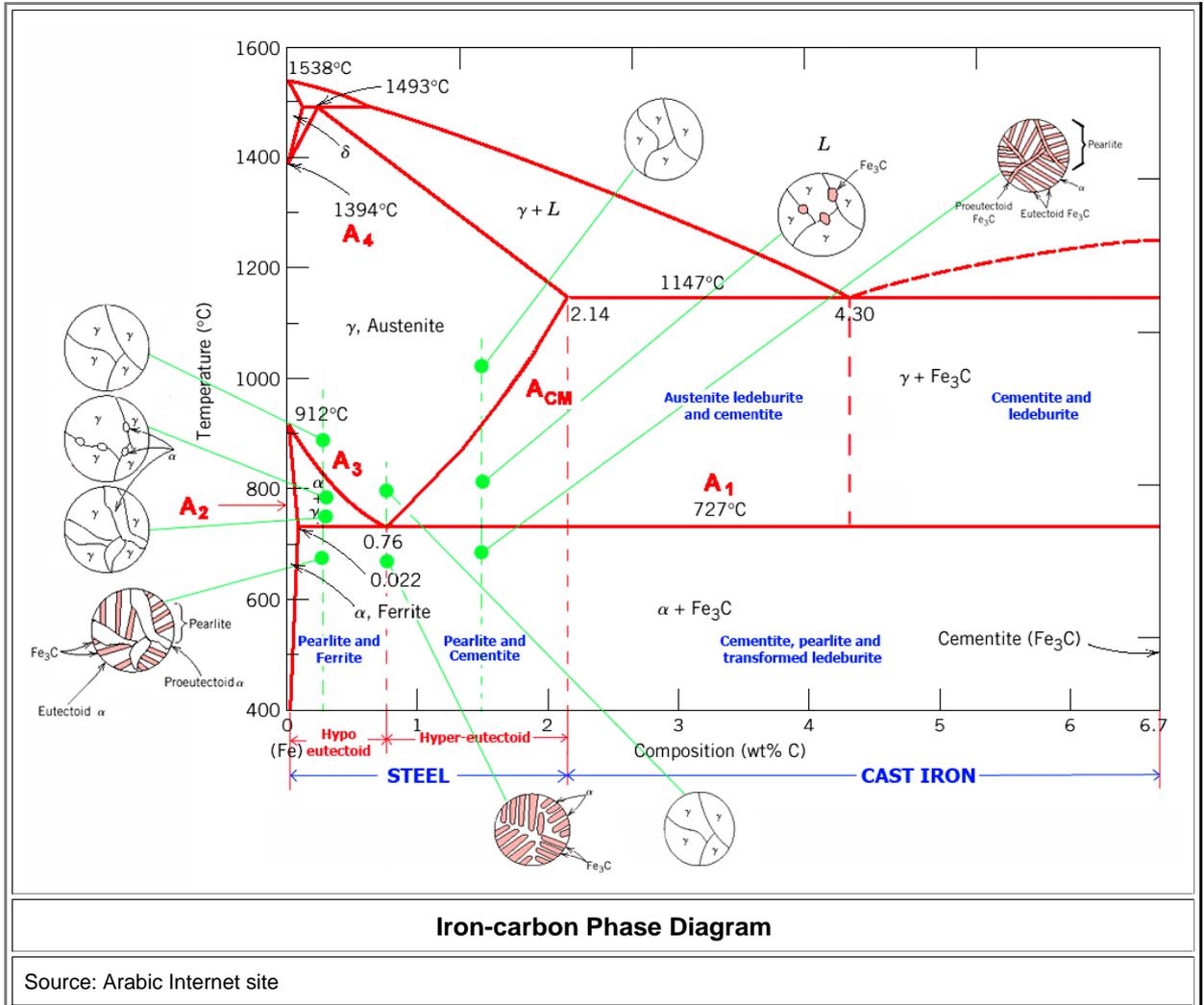


The Iron Carbon Phase Diagram

Science

There is more to the iron-carbon phase diagram than related in the backbone. In particular, there is some nomenclature that I avoided in the main text but that is important for understanding other writings about iron and steel. So let's start with a phase diagram that contains maximal information:



The important boundaries (the lines) separating phases have some universally used abbreviations:

- **A₁**: The upper limit of the ferrite / cementite phase field (horizontal line going through the eutectoid point).
- **A₂**: The temperature where iron loses its magnetism (so-called **Curie temperature**). Note that for pure iron this is still in the α -phase.
- **A₃**: The boundary between the γ austenite and the austenite/ ferrite field.
- **A₄**: The point in this case where α changes to δ at high temperatures.
- **ACM**: The boundary between the γ austenite and the austenite / cementite field.

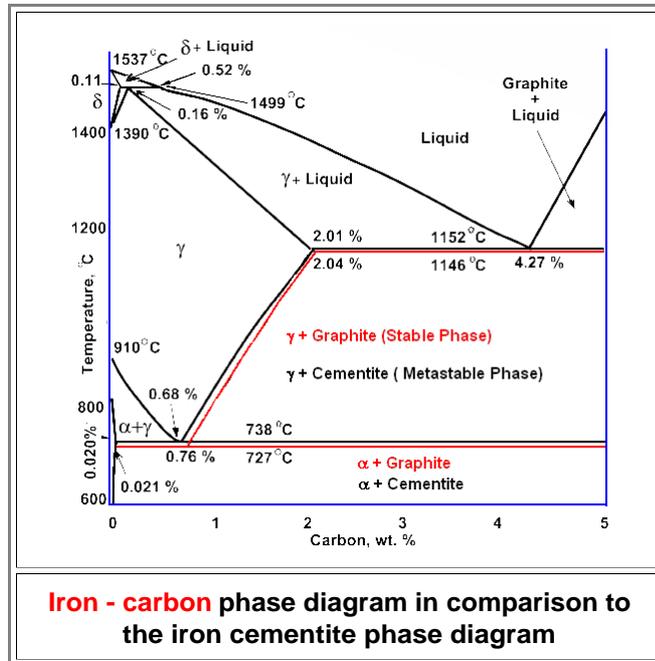
Why would anybody abbreviate a temperature with the letter "A"? Well, it stands for "arrest", something that happens in the slope of [dilatometric or thermal curves recorded](#) whenever phase diagrams were first measured. Statements like "the addition of x lowers A₃" are now clear.

The circular insets give a schematic idea of what the structure would like at the compositions and temperatures indicated.

The next thing to know is that the phase diagrams above is actually *not* the true iron-carbon phase diagram. [I lied to you](#). Some mixture of *cementite* and iron is *not* the configuration that allows the system to achieve total nirvana. That would be a iron - *graphite* mixture.

All the cementite forming is just a transient phase on the way to nirvana; it will decay into pure carbon (graphite) and iron *in due time*. Due time, however, means millennia and more at room temperature for plain carbon steel. Cementite, in other words, is a very long-lived [metastable phase](#) under normal conditions. It thus makes sense to use it for something that is *not* a true phase diagram for purists, but that sane normal folks will call "phase diagram" anyway.

We are also justified in doing this because the "real" iron - graphite phase diagram looks almost exactly like the iron - cementite "phase diagram". Here is the proof:



Does that mean that we don't have to worry about graphite being formed? Yes and no. Like almost always, it depends:

- For *plain carbon* steel with carbon concentrations below 2 %, you needn't worry, indeed. Graphite is *never* formed and the usual phase diagram covers everything nicely.
- For *cast-iron*, with carbon concentrations up to a few percent you need to worry. Graphite might form, depending on conditions.
- For *alloy steel*, the usual thing nowadays, you need to worry, too. Some alloying elements, in particular silicon (Si) but also nickel (Ni), promote graphite formation.