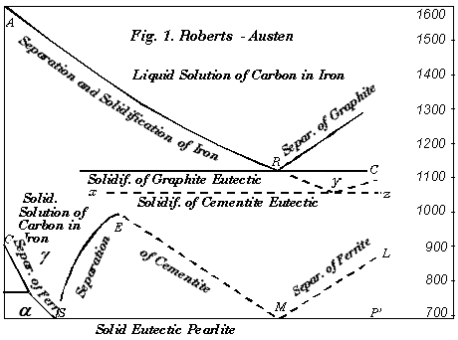
Names around Iron and Steel

Advanced

- Here is the list of all those more or less weird *names* we encountered around iron and steel with an explanation of the origins.
  - **Cementite** (German: **Zementit**). The stoichiometric **Fe_3C** phase. It is a compound with a complicated lattice and rather hard and brittle.
  - **Ferrite** (German: "**Ferrit**). The α-phase with the **bcc** lattice and very little dissolved carbon.
  - **Austenite** (German "**Austenit**). The γ-phase with the **fcc** lattice and some dissolved carbon.
  - **Pearlite** (German: **Perlit**), the pseudo-phase (correctly a two-phase mixture; ferrite and cementite, at a certain concentration relation) obtained right below the eutect*oid* point at **0.8 % C** concentration with the typical "zebra" appearance.
  - **Ledeburite** (German: **Ledeburit**); the pseudo-pseudo-phase (correctly a mixture of cementite with the pseudo-phase pearlite at a certain concentration relation) obtained right below the eutect*ic* point at **4.3 % C** concentration.
  - **Martensite** (German: **Martensit**); a kind of metastable version of *austenite* + carbon; but with a tetragonal lattice and different mechanical properties (it is very hard and brittle). Martensite is always contained in retained austenite; it cannot exist by itself.
  - **Bainite** (German: **Bainit**); a mixture of α **- ferrite** (to some extent supersaturated with carbon) and *cementite*, but with a fine-grained structure quite different from *pearlite*.
  - **Graphite** (German: Graphit) the ultimate stable hexagonal carbon phase in iron-carbon systems.
- How did those names come into being? Let's see:
- The name *Cementite* - you might have guessed it - has something to do with the English word "*cement*", meaning something that binds or glues things together in this context.
  - In the words of a dictionary. "In **1885**, Osmond and Werth published their "Cell-Theory", in which not only the existence of allotropic forms of iron was proposed (now known as austenite and ferrite), but in which also a new look at carbide formation was given. Their research on high-carbon steels showed that the matrix consisted of grains or cells of iron, encapsulated by a thin layer of iron carbide. During solidification, iron globules, or cells, are formed first and continue to grow. The remaining melt solidifies as iron carbide. In this way, the carbide-phase actually *glues* or *binds* the previous formed cells together. This view makes it understandable why Osmond called the iron-carbide thus formed, "*Ciment*" (French for binder or cement)".
    Well - we know now that this is not exactly what happens, but never mind. They did well for their time.
  - Since English and German have words quite similar to the french *ciment*, the French name did not stick but became "*cementite*" in English and "*Zementit*" in German.
- *Ferrite* is practically self-explaining:
  - *Ferrum* is the Latin root for many modern words around iron and iron compounds. The word ferrum is possibly of Semitic origin.
- *Austenite* was named after Sir William Chandler **Roberts-Austen**, a British metallurgist (**1843–1902**).
  - Roberts-Austen published the first iron-carbon phase diagram; in preliminary form **1897** (below), and in a "final" form in **1899**.



First phase diagram of iron - carbon by Roberts-Austen
Redrawn as close as possible to the (rather fuzzy) original with some minor omissions of (unreadable) letters

- It is obviously not "correct" but it was a major achievement, attacked by his peers. One should not forget that the ruling dogma stated that no reactions could take place in solids. If you find iron carbide or graphite in iron, it must have been there in the liquid and just got "frozen-in", for example.
  It is also necessary to point out that those early metallurgists were mainly concerned with cast-iron, where cementite or graphite could be found. It is hard for us now to imagine what a hopelessly complex task it must have been to bring some systematic science into to the world of iron, steel and cast-iron. There were countless observations, measurements and analyses, some wrong, some good - and no way to tell.

Pearlite has its name form the pearl-like luster and iridescence of its appearance. I have yet to see that for myself or find a picture substantiating that claim. I also could not yet find out, who coined this name and made it stick.

- However, quite recent research can provide an explanation why this particular structure is pearl-like in appearance: The regular spaced lamellae of optically quite different materials form a kind of "photonic crystal" with optical properties quite different from those of the constituents. About this I know quite a bit; see the link. Real pearls get their luster from the same mechanism; the name "Pearlite" thus is more fitting than its inventor could have known.

Ledeburite is named after Adolf **Ledebur** (**1837-1916**). It is only important for cast-iron.

- *Ledebur* was the first Professor for "Eisenhüttenkunde" (iron smelting lore) at the (famous) Bergakademie Freiberg. In **1882** he discovered the iron-carbon "Mischkristalle" and became rather famous. "Ledeburite" as a name for the iron - cementite eutectic was adopted in honor of his achievements.

Martensite was named after Adolf **Martens** (**1850 - 1914**).

- One needs to be careful here: Around 1900, what we call austenite now was called martensite then!
- Martens started as an engineer, made it to the director of the royal mechanical laboratory, which evolved into the "Staatliche Materialprüfungsamt" in Berlin. In Germany, a prestigious prize is now awarded in his name.

Bainite is named after the American chemist E. C. **Bain**. In the words of an **US** source:

- "The history of austempering begins in the **1930**'s, when Grossman and Bain, working for the United States Steel Laboratories, were evaluating the metallurgical response of steels cooled rapidly from **1450°F (788C)** to intermittently high temperatures and held for various times. The outcome of their pioneering research is what we now commonly call the "isothermal transformation diagram" Grossman and Bain were familiar with the conventional metallurgical structures of ferrite, pearlite and martensite. What they discovered, however, was another structure, formed above the martensite start temperature (Ms) and below the pearlite formation region. In steels, this structure took the form of an acicular (plate-like) structure with a feathery appearance. X-ray diffraction later identified this structure as a combination of ferrite and metal carbide. The resultant structure, termed "*Bainite*" was found to be stronger and tougher than a comparable "quenched and tempered" structure.