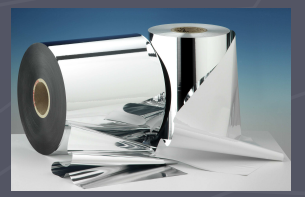
Metals and alloys

Adjustable spanner
made of steel

Josep Poch March 07

Metals and alloys

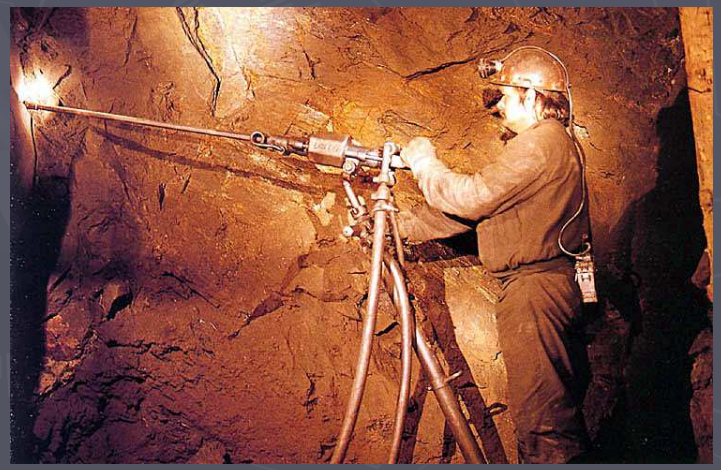
- The major proportion of naturally occurring elements are metals and they form ¼ of the earth's crust by weight
- Metals are divided into 2 categories:
  - FERROUS: the group which contains mainly iron (Fe). Iron is the most important metal in industrialized countries
  - NON-FERROUS: other metallic materials containing no iron like copper (Cu) or aluminium (Al)



Mining

- In order to obtain the metals in any useful form, they have to be extracted from the ore
- Mining removes the ore from the ground

Working deep underground in an English mine in the 1890s. Not long after this picture was taken, a roof collapsed here causing seven fatalities

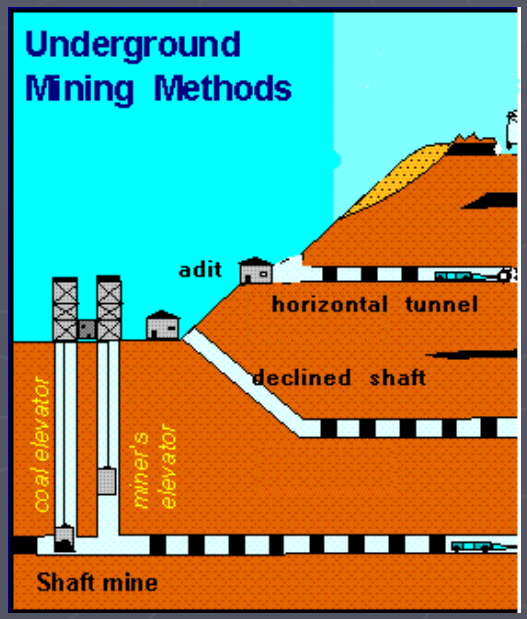


Modern mine in Czech Republic. Miners use machines to work

Mining

- There are two types of Mining Methods: Surface and Underground

Surface copper mine



Underground mine

Surface Mining

- Surface mining methods start from the earth's surface and maintain exposure to the surface throughout the extraction period
- The excavation usually has stepped slopes and can reach depths as low as 500 m

Bingham mine, Utah (USA), the largest copper mine in the world

Underground mining

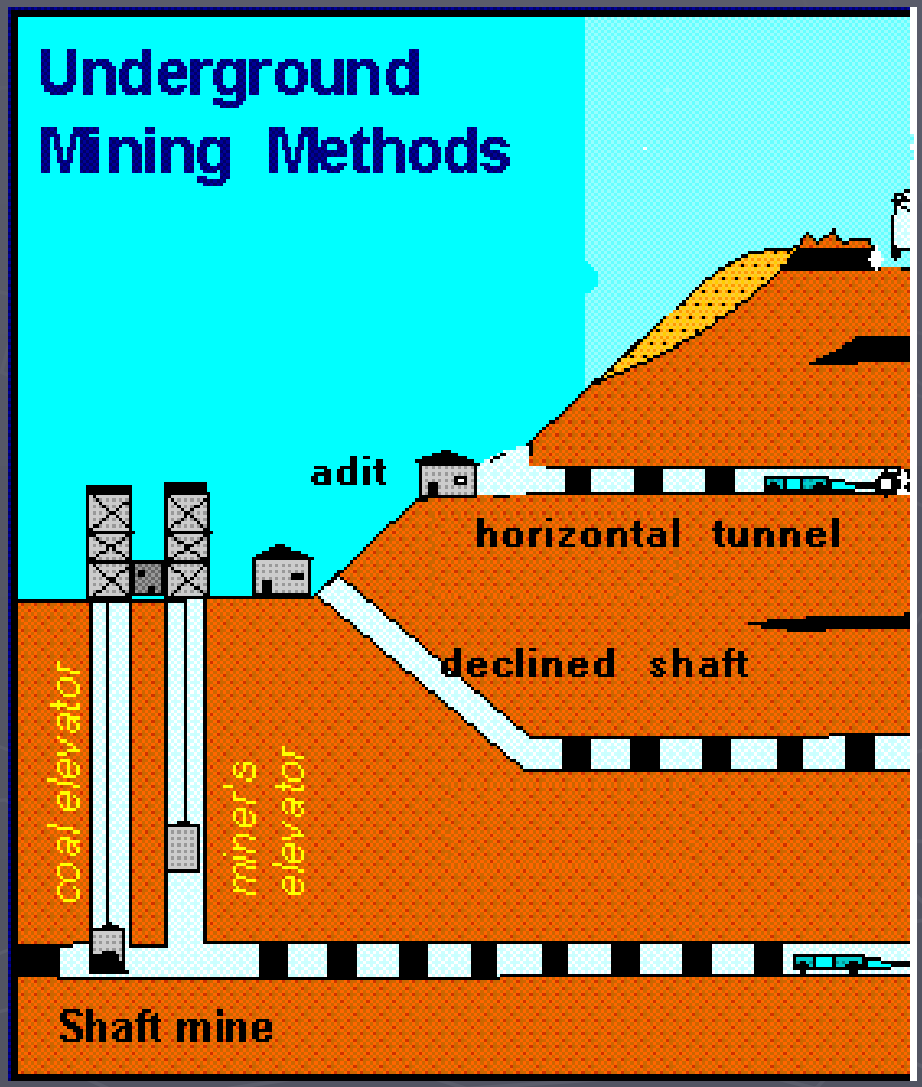
- The objective of underground mining is to extract the ore below the surface of the earth safely, economically, and with as little waste as possible
- A modern underground mine is a highly mechanized operation requiring little work with pick and shovel

pick and shovel are not used anymore – machines do the job

Underground mining

- The entry from the surface to an underground mine may be through an adit or horizontal tunnel, a shaft or vertical tunnel, or a declined shaft

Adit



Alloys

- An **alloy** is an uniform mixture. It is composed of two or more chemical elements, of which at least one of is a metal. An alloy has different properties from its constituent metals

COPPER + ZINC =

= BRASS

Brass is an alloy made of copper and zinc

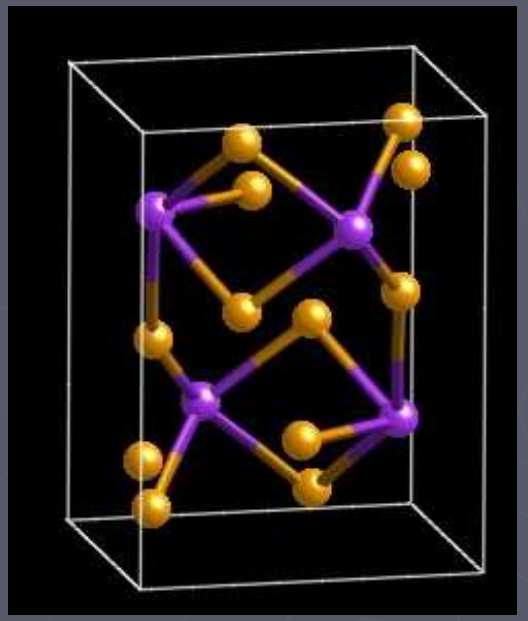
Alloys

- An **alloy** can be a physical mixture or a product of a chemical reaction
- When it's a physical mixture it is called solid solution
- When a chemical reaction has occurred, it is called intermetallic compound

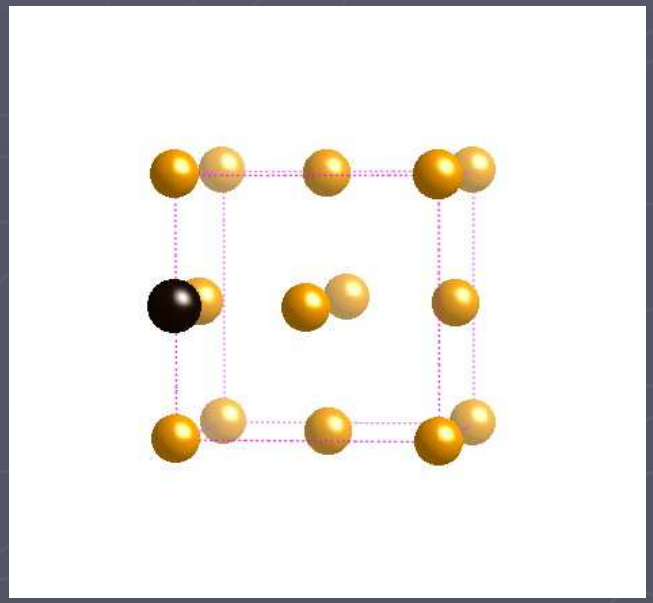
Aluminium alloy wheels are very popular: they are light, attractive and durable

Alloys

- Cementite (Fe_3C) is an intermetallic compound (Fe in brown, C in blue)

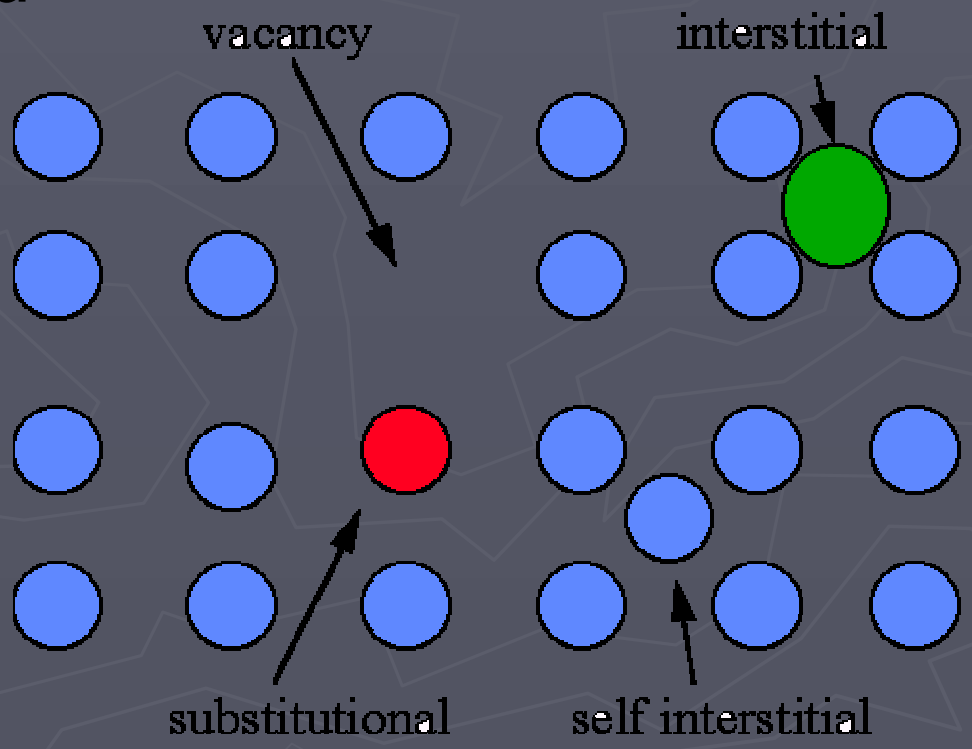


- Austenite is a solid solution (Fe + C). The crystal structure of the solvent (iron, brown) remains unchanged by addition of the solute (carbon atoms, black)

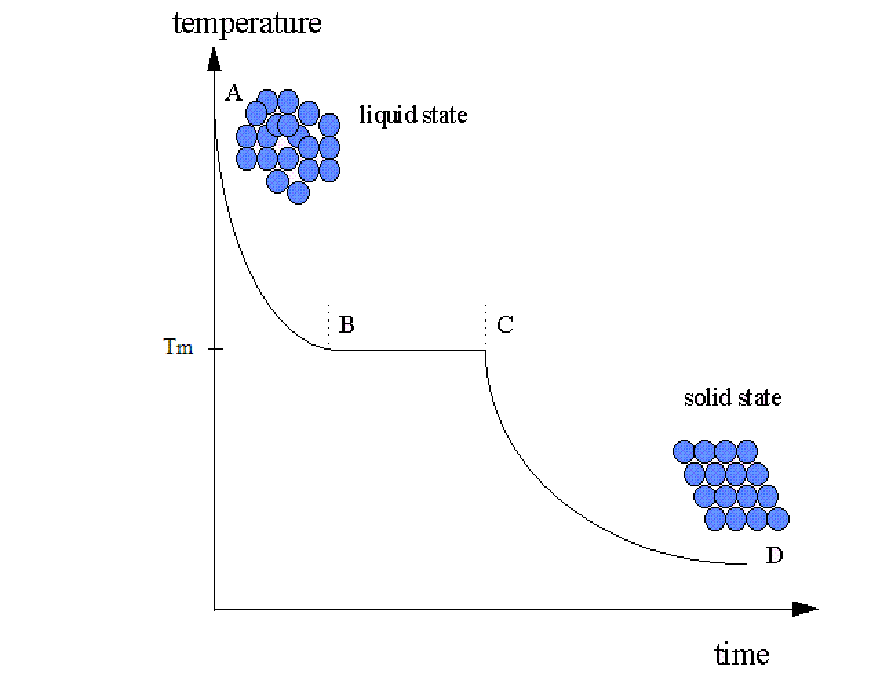


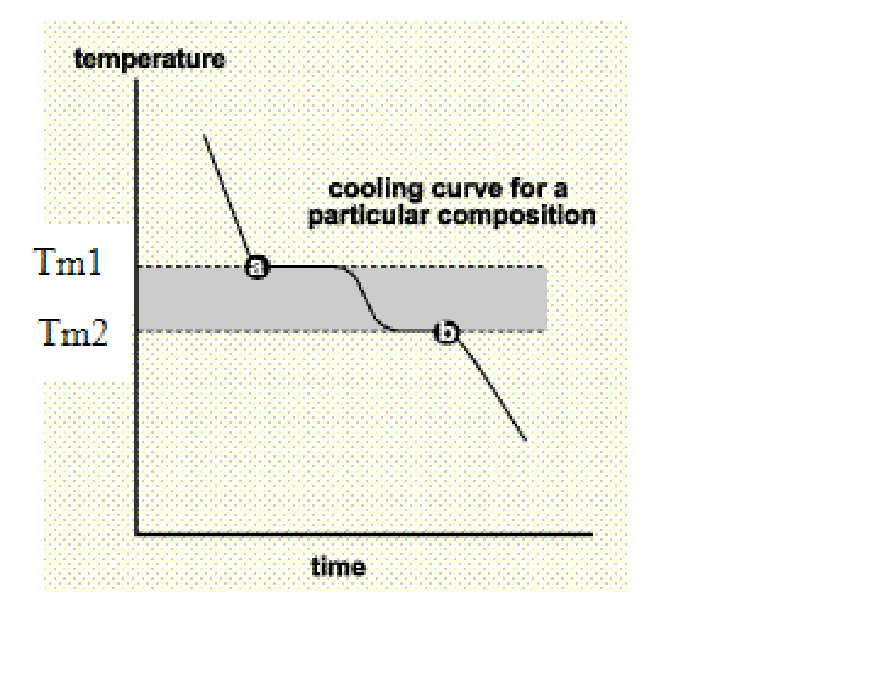
Alloys

- A solid solution can be a substitution or interstitial one, depending on where the particles of solvent are located



Cooling curves

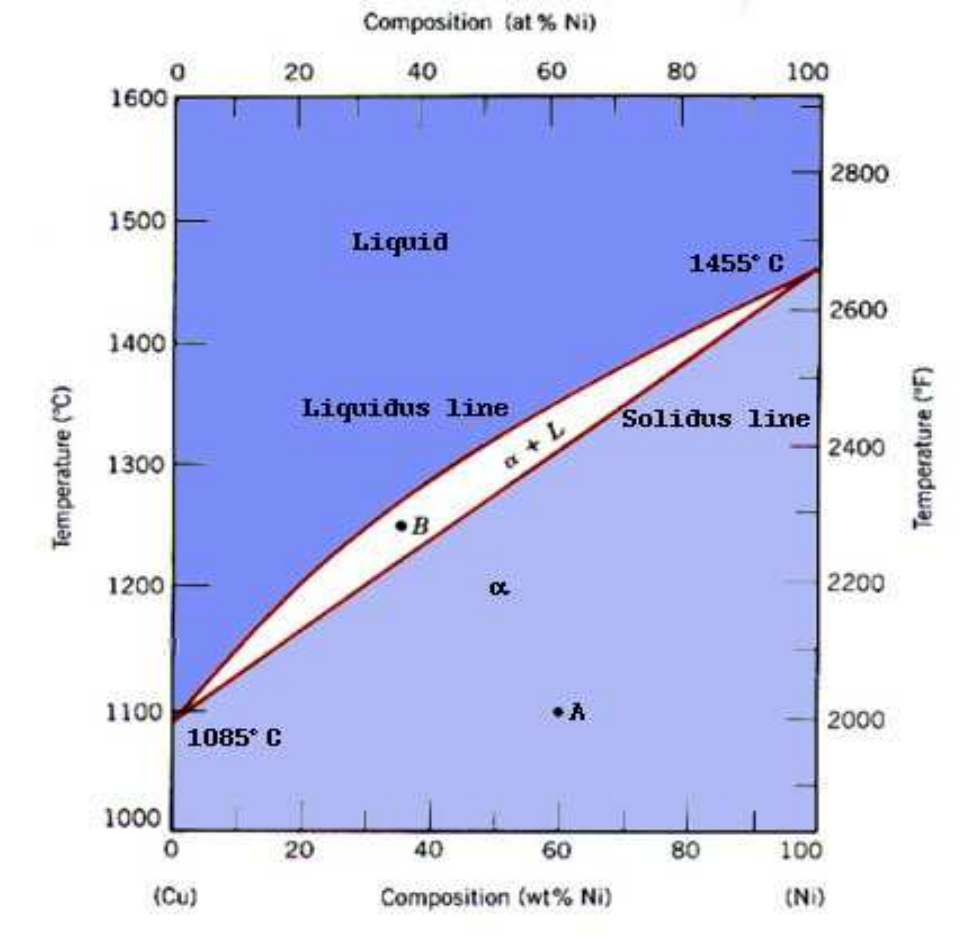




Cooling curve of a pure metal: below Tm (melting point) the metal solidifies

Cooling curve of an alloy: Tm1 and Tm2 are the melting points. The alloy is solid below Tm2 and it is molten over Tm1. Between Tm1 and Tm2 the 'liquid + solid state' occurs

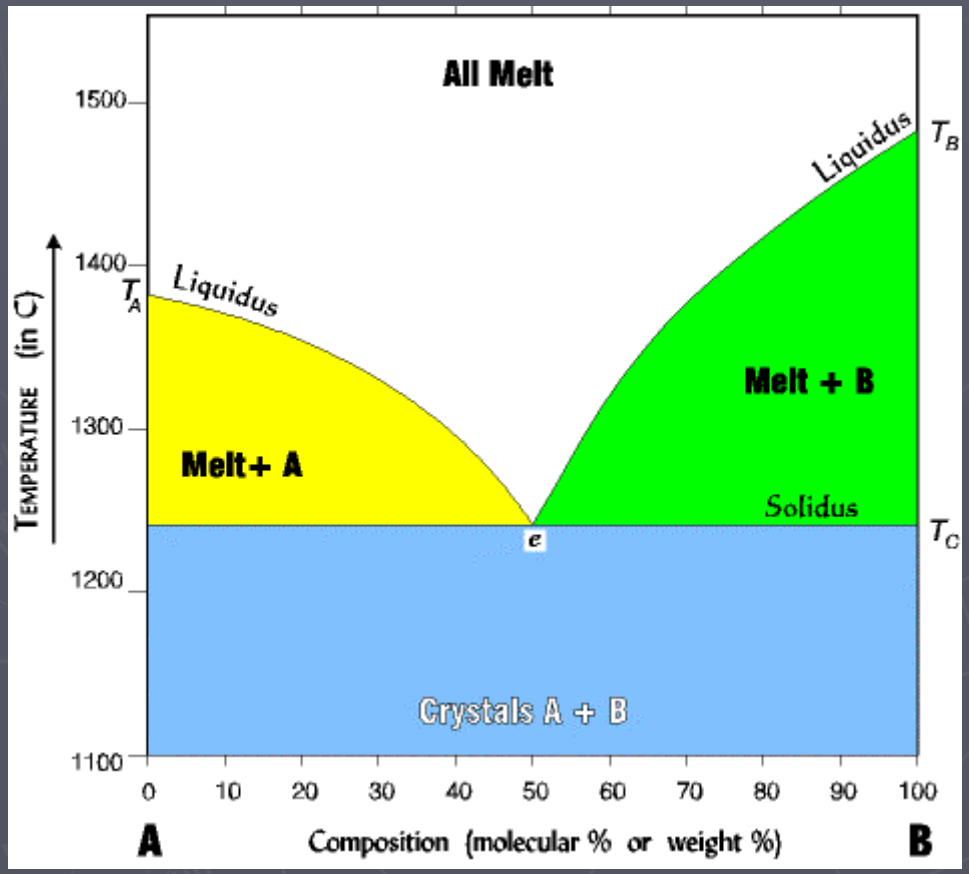
Phase diagram of an alloy (1)



Binary phase diagram of an alloy

- This is the phase diagram of copper-nickel alloy. It has 3 phases: liquid region, alpha region (solid) and alpha + liquid region
- The lines separating the regions are called liquidus line and solidus line

Phase diagram of an alloy (2)



Binary eutectic phase diagram of an alloy

- This is a binary eutectic phase diagram
- At the eutectic point, and only at the eutectic point (e) the molten alloy becomes directly solid if temperature drops. That occurs only at a concrete temperature and composition

Aluminium alloys have lower density and lower strength compared with steel alloys. Aluminium can, however, be used to build a frame that is lighter than steel