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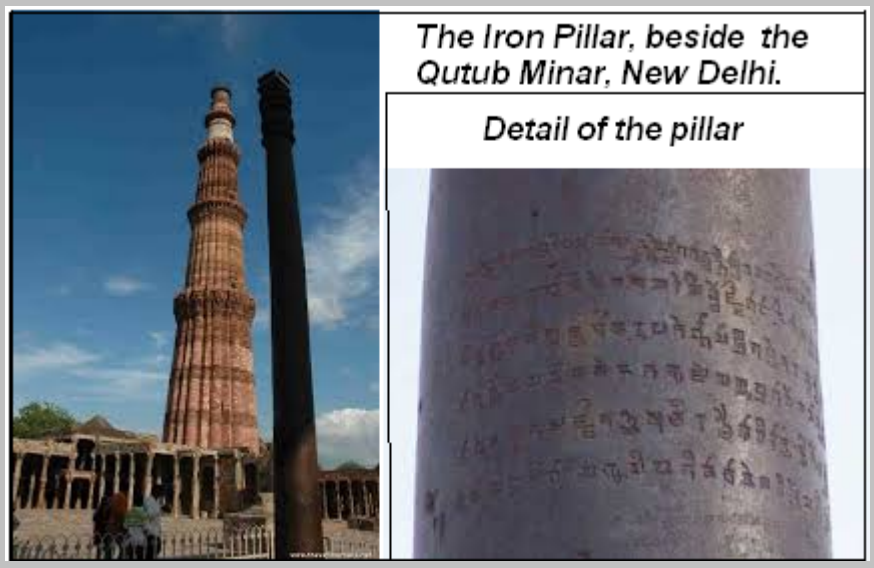
Nanotechology in ancient India

Ancient Indian metallurgical prowess has featured in this week's ***Nature***, says S.Ananthanrayanan.

The Iron pillar in the Kutub Minar premises near Delhi has withstood corrosion for over 1600 years. The pillar is made of 98% wrought iron and was made by ***forge welding***, a process where a bit of a metal is folded and welded to itself, using temperatures possible in a coal fire. A similar method was used to manufacture the ***Damascus*** steel for the sabers that clashed with the crusaders and also for the Japanese ***Katana*** and the ***Kris***.



Damascus Steel

Damascus steel or ***Wootz steel***, as it is also known, was developed in India somewhere between 200 BC and 300 AD. The word, 'wootz' is derived from 'steel' in South Indian languages and it got the name of 'Damascus' because it was exported to the Middle East. It is made from wrought iron from a specific iron ore, along with charcoal and a number of additives, which include glass and a specific wood, of the evergreen shrub, *cassia auriculata* and leaves of *calotropis gigantean*, a weed common in the tropics. 'Buttons' of the steel formed in the furnace are forged into ingots and then 'forge welded' and worked into implements. A characteristic of Wootz steel is high carbon content (1.5%) and that the matrix is abundant with metallic carbides, which show as bands, which are visible on its surface. Swords of Damascus steel were renowned for their sharpness and toughness. Their use died down after the 1700s, perhaps because the sources of the ores, which had the right mix of impurities, needed for their manufacture, became depleted.

Metallurgy

The specific ores used were rich in tungsten and vanadium and the technique used charcoal, herbs that may have just the right catalysts, and also, according to oral tradition, a piece of hematite (mineral form of iron ore). The result was the separation of metallic carbides, or a material where the crystals have carbon and metal atoms, giving the ingot the support for the legendary hardness of carbides. Carbides are well known for their uses as drill bits for ultra-hard duty, and their abundance in these ingots and plates account for their remarkable cutting edges.

In the case of the Iron Pillar, scientists of IIT, Kanpur attribute the remarkable resistance to corrosion to a thin layer ***misawite***, a compound of iron, oxygen and hydrogen that protects the cast iron from rust. It is suggested that the formation of this film is catalysed by a high phosphorus content of the steel – a feature or the product of the traditional process. In the reduction of iron ore to iron using carbon, which takes place all in the solid form, the result is steel with phosphorus content in place. The modern method uses limestone and works in the melt, which leads to phosphorus being depleted.

Current research

Peter Paufer and colleagues in Germany examined samples of Damascus steel with high resolution electron microscopy and found carbon nanotubes and cementite nanowires. Cementite is a compound of iron and carbon, which forms crystalline structures, and is found in steel with 1-2 % of carbon. The medieval process somehow overcame the brittleness of cementite and also introduced the characteristic banding, and hardiness which cementite produces.

Carbon, with its unique manner of combining with four neighboring atoms, is versatile in its chemical and crystallographic action. Hence the millions of *organic* chemicals, the magic of polymers, the hardness of diamond and the properties of graphite. Collections of carbon atoms are also able to form structures, like tubes and these molecule level physical shapes are the stuff of nanotechnology and the prospects of electric connections at the dimension of atoms and all of nano-electronics.

Well, the discovery reported on line by Nature on 16th Nov is that those metallurgists in India, two millennia ago, did nanotechnology in developing a technique to create nanotubes which may be protecting the nanowires of cementite. Maybe unwittingly, with the help of just the right fix of trace elements that helped the process, in the specific ores that were used.

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