Antique Texts Concerning Crucible Steel

> We may presume that the indigenous Indian historical sources have been thoroughly searched for references to early steel. The fact that no such references have appeared in the metallurgical literature can tentatively mean that few exist.
> **Bennet Bronson**

Advanced

Very Early to Roman Times

- In what follows I'm going to list what I found in chronological order as far as that can be done. The contents are based on Bennet Bronsons invaluable 1986 paper [1)] where he debunks a lot of the myths around the role of crucible steel in ancient and not-so-ancient writings, the rather recent book of Alan Williams, and many papers; foremost the ones from Anna Feuerbach and Sharada Srinivasan.
  As an addition further down I will give a quick look at wootz steel in ancient China, based compltely on the papr of Wliilam Lox [2)].

- The possibly first indirect reference to crucible steel appears in the writing of **Ctesias of Cnidus**. He was a Greek physician at the court of the Persian King Artaxerxes II (404 BC - 398/397 BC) and wrote several (lost) books about Persia and India. Another not-so-ancient author, St. Photios the Great (Ecumenical Patriarch of Constantinople from 858 to 867 and from 877 to 886) quoted from Ctesias books in the 9th century AD or about 1300 years later. From this we know of two wonderful if not magical swords of (maybe) Indian iron that Artaxerxes gave to Ctesias.
  - Whatever that means. One should not forget that long before one can forge swords from crucible steel, the making and forging of bloomery iron needs to be well established. Swords from this stuff could have been quite remarkable too in 400 BC. Maybe the hilts and scabbards were encrusted with gemstones and made with lots of gold - and that can make a sword wonderful, too.
    From other writings it appears that Ctesias was given to tall tales. Maybe Artaxerxes mother (she appears to have been involved too) just cleared out all the junk that tends to accumulate in the living room, and let her physician have a few surplus swords. All in all: *Forget it!*
- Quintus Curtius Rufus was a Roman historian, writing probably during the reign of the Emperor Claudius (41 AD - 54 AD) or Vespasian (69 AD - 79 AD). His only surviving work "Historiae Alexandri Magni" is a biography of Alexander the Great in Latin. According to him **Alexander the Great** received hundred talents (about 2 tons) of "ferrum candidium", meaning bright or white iron, when he toured India in 326 BC. He also received valuable horses, chariots, lions, and so on (but not the usual assorted virgins; Alex was probably gay) in order to make him go away. Since crucible steel cakes are reported to appear white due to the whitish cementite on the surface (I have not yet seen a picture of this), this may be taken as a hint that crucible steel was made as early as 350 BC in India.
  - This is very weak. Normal iron also looks bright if polished. Superior steel is useless for a world conqueror if you don't make superior swords from it. While Alexander supposedly cut the Gordic knot with his sword, there seem to be no references to particularly good swords around Alexander. There are hints, however, that he used iron for rather unmanly pursuits.
- **Pliny the Elder** (**23 AD– 79 AD**), who we have encountered before, writes in his "Natural History":
  "Among varieties of iron that of the Seres carries of the palm and is exported by them together with garments and pelts, while the second best comes from Parthia".
  He continues with his assessment of Ferrum Noricum and so on.
  - This is a good start to once more point out some of the problems we have even with authentic writings from well-known guys:

    - Who are the *Seres*? The Chinese as Alan Willams suspects? Or does Pliny mean the "Southern kingdom of the Cheras", whoever they are? An ancient Tamil dynasty in India, ruling in the early centuries of the Common Era as many assume? Or some other guys?
    - Is "Seric Iron" crucible steel? Or just particularly well-made and well-forged bloomery steel? Or just iron from a source with a good public relation department?

    As long as we do not get new data, e.g. by finding "lost" manuscripts or digging up iron marked for shipment to the Romans in some "seric" place, we simply won't know.
- From about the same time (40 AD - 70 AD) we have the **Periplus of the Erythraean Sea** (or Periplus of the Red Sea). A periplus, in case you (like me) do not know this, is literally "a sailing-around" guide. It is a kind of navigation book that lists ports, landmarks, distances, and what is going on in various places. The Periplus of the Red Sea does mention "sideros indicos kai stomona" = Indian iron and steel as freight that was routinely shipped around.

- Does this allude to Indian crucible steel? Maybe - but there is no way of knowing. Iron and steel are just two items mentioned in a long list containing a lot of trivial stuff, too. The periplus also mentions iron from Somalia, for example, if we can trust my quick scanning of a German version. All we can learn is that iron and steel was made in India around this time - but that need not have been crucible steel. The Indians had plenty of woods for making charcoal and easy access to iron ore, both items being rather scarce in Arabia.
  The satellite picture tells it all. It probably didn't look much different 2000 years ago.

Why the "Arabs" (and Egyptians) tended to import iron / steel

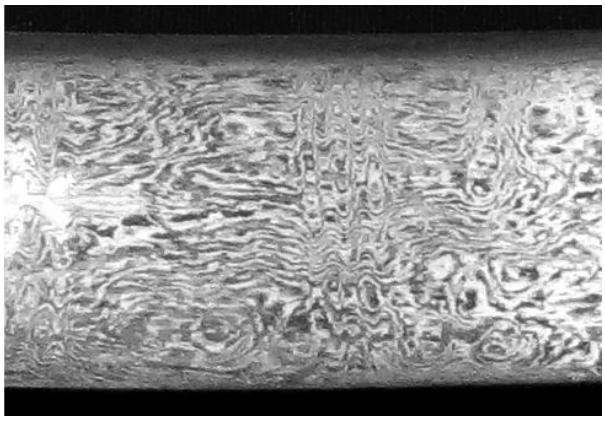
Source: Google

- In the law books of the Roman Emperor *Marcus Aurelius* (2nd century AD) "ferrum Indicum", Indian iron, is mentioned as an item for which duty needs to be payed.
  - That makes clear once more that in Roman times there was some trade with India that included iron. It does not prove, however, that this iron had been made in a crucible. Or, to quote Bronson[1)]: "We are not justified in concluding that Indian steel was made in crucibles during the Roman period, or that it was outstanding in quality, or that it had more than a marginal importance at the time to anyone outside India".
    It's not that India is rarely mentioned in antique text - quite the opposite. It is just very rarely associated with iron or steel but with other things like gemstones, fabric, spices, etc.

Late Roman to Middle Age

- The next written record is from **Zosimos** (a. 350 AD - ca. 420 AD) who was born in Panoplis (present-day Akhmim in the south of Egypt). He worked as an early alchemist in Alexandria and has written a lot. Some of his writings have survived in more or less weird ways. As far as crucible steel is concerned, he states:
  "The tempering of Indian Iron: Take 4 pounds of soft iron, and the skins of myrobalans, called elileg, 15 parts; belileg, 4 parts; and two parts of glassmakers magnesia. Then place it into a crucible amd make it level. .... Put on the charcoal and blow the fire until the iron becomes molten and the ingredients become united with it. ... Such is the premier and royal operation, which is practiced today and by means of which they make marvellous swords. It was discovered by the Indians and exploited by the Persians".
  It helps to know that "glassmakers magnesia" was manganese dioxide, and that myrobalans are a kind of plume, associated then and now with healing powers.
  - Looks rather convincing? Yes, it is. The recipe, after all, is coming close to the making of good crucible steel. It is, indeed - but it might not be from around 400 AD but from the 9th - 10th century AD. The text is part of a larger codex, compiled around 1000 AD, and authorship is often uncertain.
- The "**Hamasa**" (valor, rapture, ?), is a pre-Islamic anthology of arabic poetry. It was compiled by one Abu Tammam in the 9th century but the texts go back to the 6th - 8th century AD. Some of the poems refer to swords of "AI-Hind" or "Hinduwani" from India. AI-Hind or Hinduwani were arabic words for what we now call wootz or bulad.
  - So there! We can be rather sure that remarkable swords made from crucible steel did exist by 800 AD - 900 AD. We do not learn, however, if those swords showed the "water" pattern.
- **Jabir ibn Hayyan** (ca. 721 AD – ca. 815 AD), is one of the most notable early Islamic alchemists, pharmacist, philosopher, astronomer, etc. "His original works are highly esoteric and probably coded, though nobody today knows what the code is. On the surface, his alchemical career revolved around an elaborate chemical numerology based on consonants in the Arabic names of substances and the concept of takwin, the artificial creation of life in the alchemical laboratory", says an Iranian source. His latinised name was "Geber", and the word "gibberish" might have been derived from his name.
  Be that as it may, he seems to have written that steel from India and Sri Lanka was used in many places for sword making.

- No we need to look at **Al-Kindi** (ca. 800 AD - 873 AD) or more precisely Abu Ya'qub ibn Ishaq al-Kindi (there should also be the proper *diacritics*, those little cute things above or below some letters in many strange languages), is known as "the Philosopher of the Arabs" and unanimously hailed as the "father of Islamic or Arabic philosophy". Al-Kindi was the first of the Muslim *peripatetic* philosophers, meaning follower of Aristotle , and thus has much to answer for. Since he also might have been the first distiller of alcohol, he shall be forgiven, though.
  Al-Kindi wrote "A Treatise *(Addressed*) to some of His Brethren Concerning Swords" where he has much to say about swords. He distinguishes between "shaburqan, the male, hard iron which can be heat-treated by its nature, and narmahin (narm-ahin), which is the female soft iron which cannot be heat-treated by its nature. [Swords] can be forged from either of these two kinds or from both combined. Thus, all kinds of swords made of natural iron fall into three kinds: shaburqani, narmahani, and those made of a combination of both."
  He mentions white swords, swords produced and forged in Khurasan, and swords called "Zaydiya (that) were forged by a man called Zayd, and hence they were attributed to his name".
  More important, he described the essentials of the crucible process and uses the name **pulad** or fualdh for the product. He also mentions that swords made from pulad exhibt a pattern (known then as "firind" or "jawhar") and that might be the *first* description of the "water" pattern obtainable with some crucible steel:
  "The iron that is not natural, is steel (fulad). It is understood to have been purified. It is produced out of natural iron into which one throws something that cleans and hardens it, so that it becomes strong and flexible, and the "firind" (waterpattern) appears on it". Aristotle at work!
- **Al-Biruni** , or more precisely Abu al-Rayhan Muhammad ibn Ahmad al-Biruni (973 AD - 1048 AD), is known as one of the greatest scholars of the medieval Islamic (Persian) era. In 1017 AD he traveled to the Indian subcontinent and became the most important interpreter of Indian science to the Islamic world.
  He seems to write that Indian steel makes for superior swords but I couldn't find any direct quote. He is the one who mentions pomegranate peels as an ingredient in the crucible charge. Crucible steel is perceived by him as the mixing of soft "female" and hard "male" iron (see above) , yielding a product that contains characteristics of either parent. That might be a hint that in his time crucible steel was also made by mixing bloomery iron with cast iron instead of organic matter.
  He also comments on the "water" pattern that could be produced.



Water pattern

Source: Photographed in the Metropolitan; had to sacrifice three bottles of wine for that.

  - Al-Beruni also used the term "**pulad**" for crucible steel and gives some idea about the meaning of names. He points our, for example, that the denomination "Mashrafyiyah" in connection with a sword might refer to an ironsmith named Mashraf or to a village called Mazarif.
    Especially enticing in this context is a swordsmith called "**Damasqui**" who is mentioned by Al-Beruni, and who made swords of crucible steel. Maybe that's the root of all the misunderstanding about "damascus steel", which, as you know, has nothing to do with the city of Damascus.
- Then we have guys like *Murda al-Tarsusi*, a *12th-century* writer and expert on military matters around Saladin, *Fakhr-i-Mudabbir* (or Fakr-e Modabber) author of two prose works in Persian from the late 12th - 13th century AD and many more who comment on crucible steel making and sword made from this material.
  - It was in the 11th / 12th century AD that the misleading term "damascus steel" came up, e.g. in the writings of *al- Jaubari* (died 1232 AD) and *Ibn-al Uhkuwwa* (died 1329 AD).

Wootz in China

- In the short module on iron and steel in China I haven't mentioned wootz steel at all, simply because I haven't read anything about that when I wrote that module. However, old Chines sources seem to mention wootz steel and that's why I will give some information about that here; based exclusively on William Lox's paper.
  - The mist important point in this context is that historical documents of the Beiwei dynasty (386 AD - 534 AD) mentioned "**bintie**" steel several times, a particular hard and good steel supposedly from Persia.
    Bintie steel was famous (and costly) in China for many centuries. We may safely assume that bintie steel is crucible steel, and that bintie made it from India / Persia to China sometime in the 4th century AD or even earlier. That corroborates nicely the evidence we have form other sources.
  - In later times like during the reign of the Tang dynasty (618 - 907), swords form "bintie" were mentioned for their quality and price (three times that of a normal sword). We might speculate that these swords were "wootz" in the sense that the showed a water pattern but that is far from certain.
- Production of bintie along the traditional recipes and the special techniques of forging it eventually made it to China proper - via the Mongolian conquest, it seems. Bintie products, however, were never mainstream and probably scarce. Almost none, it appears, have survived to our times. The Chinese, however, always had an alternative to traditional UHCS crucible steel. They had mastered the techniques of making cast iron by smelting and wrought iron by fining cast iron. To make steel, including high and ultra-high carbon steel, all you needed to do was to mix the two in whatever relation would produce the right carbon concentration.
  - It's not quite as easy as it sounds - refer to this module for some more details. But i is not all that difficult either and there are numerous sources referring to some special process along this general. The products might have been called "bintie", too, and the meaning of the word shifted considerably through the millennia (it was neve quite clear anyway).
    A little anecdote has it that Chines troops in 1933 fought the Japanese invaders with crucible-steel bintie swords that cut so many Japanese in half that these sword connoisseurs learned to fear the Chinese blades and demanded special protection gear from their superiors. .
- I now would like to show you a picture of an old Chinese bintie / wootz sword. Alas, I couldn' t find any. Sorry.

- Enough! It is clear that - roughly - since around 500 AD crucible steel and swords made from it were prominent in the pre-Islamic Persian and Arabic world and stayed so ever since. One might assume that they were also prominent in India and Central Asia but written records about that have not yet come to my attention. That does not mean that all swords were made from Indian crucible steel; not all jewelry at present is made of pure gold or platinum either. It also does not mean that swords actually made from crucible steel showed the "water" pattern we associate with "wootz" swords. Several Indian investigators who looked into their history of iron technology are of the opinion that prior to the 6th century AD all iron in India was bloomery iron, as stated in William's book. Others disagree, of course.
  The crusaders , doing their thing between 1095 AD and 1272 AD, thus did encounter crucible steel swords. They might have been impressed but not too much. They could produce plenty of damage with their swords, too.
  Before the Crusaders went "down south", Islamists came "up north". The Islamic conquistadores or invaders under Emir Abdul Rahman Al Ghafiqi Abd al Rahman of the Caliphate of the Abbasids, who lost in a major way against the Caralongian "Franks" under Charles Martel in 732 when they tried to invade what now is France, can testify to that. They outnumbered the Franks by 5:1 and carried some protective armor. If they were wielding wootz swords, it obviously did not impress the (unarmored) Franks very much, who most likely carried pattern welded swords themselves.
  - What the crusaders did not encounter was a secret technology. The writers mentioned above gave precise recipes for making crucible steel, and not just one but several. There was no mystery concerning crucible steel beyond the general mystery concerning the difference between iron and steel.
    The real mystery, to quote Bronson[1] once more is "why wootz-type processes were ever a mystery to Europeans. It is hard to believe that no European craftsman or intellectual ever had close enough contact with Islamic countries not to be informed of what appears to have been a commonplace industrial process there".
    This statement might need to be a bit modified now. There are some recent indications that some of the famous "Ulfberht" swords have been made from (imported) crucible steel. More to that in the link
- Maybe Indian (and other) crucible steels were not always superior to "normal" steel? While al-Kindi from above did not rate "European" swords to highly, he implies that they were in common use among Arabs and that very good swords were made (in Arabic countries) from normal steel, too.

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[1] Bennet Bronson: "The making and selling of wootz, a crucible streel of India", Archeomaterials, Vol1, No. 1 (1986) p. 13 - 51.

[2] Wliiam Lox: "*Bintie*: The Wootz Steel In Ancient China", Indian Journal of History of Science, 44.3 (2009), 369 - 388. Lenny Lantsman from "Arms and Antiques" alerted me to this paper; Thank You, Lenny!