

BOOK REVIEW

H.C. Bhardwaj, *Metallurgy in Indian Archaeology*, Tara Book Agency, Varanasi, 217 pages, 2000; Rs. 300/-.

Men and metals have relationship as old as the human civilisation. It is not very surprising that the division of various ages in the early era of civilisation has been done on the basis of metals. A large number of metallic objects have been discovered during the archaeological excavations throughout the World. They not only shed light on the social and cultural aspects of the civilisation of that era, but also on the state of the technological development. The present book focusses on the metallurgical aspects of the metallic objects found from various archaeological excavations within India. The book is divided in eight chapters, viz. Introduction, Copper and Bronze Metallurgy, Archaeo-Metallurgy of Gold, Metallurgy of Silver and Lead in Indian Archaeology, Metallurgy of Zinc and Brass, Metallurgical Studies of Ancient Indian Coinage, Iron and Steel in Indian Archaeology, and Socio-Economic Aspects of Metallurgy.

The author has given details, in particular of the chemical composition of a large number of artefacts of different metals found from archaeological excavations throughout the book. Readers can find the chemical analysis of important artefacts of different metals at once place. He has also tried to speculate the possible manufacturing techniques used for making many of these artefacts throughout the book. For example, he says that the method used for the famous Bronze figure of dancing girl from Mohenjo-daro is *cire-perdue* (lost wax) process (p. 19). The literary evidences giving the detailed description cited by the author are of much later period. Do we assume that there is no such reference of earlier period! The author mentions that lost wax process was used to make images as large as of 1 ton weight (p. 49). Was there any difference in the mould making for small and big objects ? The author has also given details of various furnaces used for extraction of metals in antiquity, which is an important aspect of the book.

Maximum number, about sixty, pages have been devoted to copper metallurgy. The author has rightly remarked that with the advent of iron age, the status of copper was raised to that of a 'deluxe' metal (p. 49). It must be remembered that the discovery of iron or in a strict sense iron-carbon alloy, revolutionised the socio-economic condition of the society of that time, and a more suitable alloy with respect to hardness and strength became available to the society which was not as scarce as copper. The author has classified the copper alloys discovered from the excavations, and has discussed them in detail. An interesting section in the discussion of copper metallurgy is on the arsenical copper and its comparison with tin bronzes. The reasons put forward are sound, but needed a more clear representation. Another interesting observation made by the author is on the absence of sulphur in Ganeshwar copper objects. He states that these objects could have been manufactured from native copper or copper derived from oxidised ores. This fact indirectly confirms that weathered copper ore obtained from open-cast mining was used, which appears reasonable. It has been stated that lead was added to copper alloys to increase the fluidity at a lower temperature (p. 31). It could also be possible that lead was added during melting or smelting for the fluxing purpose. In this context it is interesting to add that a small piece of lead was found along with a piece of copper ore in a brick lined pit in a house at Mohenjo-daro.

The source of gold in India in various periods has been discussed. The author is correct in saying that it was alluvial placer gold, which was the main source of gold in antiquity (p. 78). The author is right in his remarks that : "...it is hazardous to guess regarding the source of gold in Indian antiquity. It is an over simplification that Harrappans got their supply of gold from South Indian mines Harappan gold might have been partly from alluvial sources, e.g. sands of river Indus" (p. 95). It is not surprising to note that the river Indus (Sindhu) has been designated as *hirṇayayī* and *hirṇyavartani*, i.e., containing gold, in the *R̥gveda*. In this context, I wish to add the remarks made by Kauṭilya in which he states that among the land routes the Northern route (*Uttarāpatha*) had been better than the Southern route (*Dakṣiṇāpatha*), as superior quality of elephants, horses, musk, elephant teeth, skin of deer, silver and gold are available in plenty. But then Kauṭilya explains that it is not so, and except woolen rug, skin of

deer, and horses, huge quantities of conches, diamond, pearls, precious stones and gold are available in the Southern route. It is clear from this reference that in the time of Kautilya, Southern route had occupied an important place for the availability of gold, which corroborates the archaeological findings of South India. (The reviewer has discussed this and other aspects of ancient Indian gold metallurgy in his paper published in the monograph "Metallurgy in India—A Retrospective").

The author gives the method of gold refining as stated by Theophilus, Agricola, Agatharchides from secondary source of Forbes, but it is rather disappointing that he does not discuss the process for gold refining as described by Kautilya. At no stage of his discussion on gold metallurgy (p. 87), the author states the use of mercury in gold extraction and refining in ancient India. Crucibles used for gold extraction have been discovered from the area near Wandalli and Honkunni workings of South India. It has been most interesting that in both instances the presence of mercury was observed, which indicates that amalgamation process was used at some stage of the extraction of the gold from the ground ore.

The author has discussed in detail the archaeological artefacts made from silver and lead. He is of the opinion that there is a strong possibility that Harappan silver came from outside though indigenous sources can not be ruled out (p. 108). He has brought to our notice the word 'Gauḍa country' as a source of silver as stated by Kautilya. He has very rightly correlated the Burmese silver mines with it, as the country of Gauḍa was spread very extensively. However he has not considered other sources of silver as mentioned by Kautilya, viz. *tutthodgatam*, *kāmbukam*, and *cakravālikam*. Out of all these *tutthodgatam* appears to be interesting, as *tuttha* is widely used for denoting copper sulphate.

Metallurgy of zinc and brass have been adequately discussed by the author. He has used all the important references on this subject and has very rightly concluded that India was the first country to have invented the extraction of zinc metal from its ores.

The author has extensively discussed the iron and steel artefacts found from various archaeological excavations. The author has outlined the various phases of the development of iron and steel technology in India.

He has successfully presented the Indian contribution on wootz steel. However, he has not included the superplastic aspect of such a high carbon steel, which has been extensively studied by O.D. Sherby of Stanford University and his co-workers. Delhi iron pillar has also been discussed and various theories put forward for its excellent corrosion resistance have been outlined. The manufacturing technique used for it has not been dealt with adequately.

The statement of the author that the iron (sponge iron) produced upto 900°C is very porous and can not be forged (p. 157) appears to be faulty. In modern times, a new manufacturing technology known as 'Powder Forging' has been developed, in which porous metal preforms are forged to full density and is being used commercially to manufacture engineering products. Actually iron ore can not be fully reduced to metallic sponge iron at temperatures upto 900°C and would contain unreduced iron ore particles which makes it unworkable.

In short, the present book is a successful attempt to present the metallurgical knowledge as known in different eras of the Indian antiquity, derived mainly from artefacts obtained from archaeological excavations. The present study also indirectly high-lights the general drawback of Indian efforts in studying the metallurgical aspect of archaeological artefacts. This subject is an interdisciplinary in nature and requires a combined effort from archaeologists, historians, metallurgists, chemists, physicists and linguists. Now-a-days a large number of modern techniques such as neutron activation analysis, point source X-ray fluorescence spectrometer, solid state non-dispersive X-ray spectrometer, electron probe micro analysis etc. are available. Their use in the chemical analysis of archaeological artefacts may bring to light many other interesting features.

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