The study of early and traditional metallurgy in India: a review of some recent publications

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Minerals and Metals in Ancient India Vol 1 by A K Biswas; Vol 2 A K & S Biswas. *D K Printworld, New Delhi, 1996. xxx+524pp and xviii+259pp. 44 lurid plates, many figures, maps, tables and index. ISBN 81-246-0048-1. Rs 3500 (=c.£70, but outside India costs $225).*

Copper and its Alloys in Ancient India by D K Chakrabarti and N Lahiri. *Munshiram Manoharlal, New Delhi, 1996. xii+228pp. Many figures, maps, tables and index. ISBN 81-215-0767-3. Rs 475 (= c.£9).*

The study of early metallurgy in India is uneven. On the one hand there has been a steady stream of really quite substantial works on various aspects of the subject over the past few years, but on the other hand there is a certain sterility both of new material as well as of new ideas and approaches.

Since 1989 alone the following major works, known to the reviewer, have appeared in addition to the two most recent publications listed above:

Ancient Indian Mining, Metallurgy and Metal Industries by G Kuppuram. *Sundeep Prakashan, Delhi 1989. xv+512pp. 40 plates, many maps, figures & tables. ISBN 81-85067-287.*

An Introduction to Ancient Indian Metallurgy by K T M Hegde. *Geological Survey of India, Bangalore 1992. vi+86pp. Maps, figures, tables and plates. ISBN and price not stated.*

The Early Use of Iron in India by D K Chakrabarti. *Oxford University Press, Delhi 1992. xiv+200pp. 16pp figures. ISBN 0 19 562992 2. Price not stated but about £12.*

The Early History of Gold in India by R Nanda. *Munshiramm Manoharlal, New Delhi, 1992. vii+254pp. Figures, maps and plates. ISBN 81-215-0548-6. £27.95.*

All to some degree display both the achievement and problems of Indian archaeometallurgy.

There is of course enormous scope for the study of both ancient and surviving traditional metallurgy in all its stages. The Indian Subcontinent has been home of major civilisations for over 5,000 years and metallurgy is attested, at least in the north, for several thousand years before that at sites such as Mehrgarh, now in northern Pakistan. During this enormous span many interesting developments in copper metallurgy took place, the precocious use of tin bronze by the Harappans in the third millennium BC, the enigmatic copper hoards, typically containing large numbers of massive but crude castings of copper that are often highly ferruginous (Yule 1989). From the beginning of the historical period in the second half of the first millennium BC brass is attested at sites across northern India, although tin bronze apparently remained prevalent in the south until almost two thousand years later. Clearly such a huge centrally placed land mass had important trade relations with the rest of the world, and the possibility and extent of trades in various metals such as copper in the third millennium BC with Mesopotamia; of gold and iron with the Classical world; of tin with South-East Asia; of zinc and cupro-nickel with China; and of iron and steel with the Islamic world are just some of the areas to be explored.

Along with the general development of metallurgy, India saw two unique metallurgical developments of world importance: the production of zinc and of liquid steel.

Thus the range of problems is very broad. Fortunately this is matched by very well preserved mines and associated smelting sites for a wide range of metals to be found throughout the subcontinent. This has been realised from the outset by mining engineers and geologists, and recently reassessed by members of the Historical Metallurgy Society, with the Society's support (Willies 1987 and 1992).

Some traditional metallurgical industries still survive throughout India such as gold-panning, direct reduction iron smelting, and even an extraordinary recent introduction, or at least official support of, low technology tin streaming and smelting by local tribals at Bastar in Madhya Pradesh (Babu 1994, 182-91), as a 'cottage industry'. Some ancient mining techniques such as firesetting also survive although only now in quarries (Craddock 1996). Metalworking industries are much more numerous, and a wide range of ferrous and non-ferrous products are made, with many metallurgically important specialities such as the casting of life-size images at Swami-Mali in Tamil Nadu, the wrought high-tin bronzes and the cast high-tin bronze mirrors both from Kerala, the bidri makers of the cities of the Deccan, and of course the jewellers working towns and cities all over India.

Thus there is a very wide field of study, and much of this has attracted the attention of travellers, mining engineers and geologists from the early 19th century to the present

day. The reports of Buchanan, and slightly later, those of Voysey on the crucible steel industry of southern India in the early 19th century are well known, and such reports by both European and Indian officials continue through the century (Krishnan 1953, Bronson 1986) to the cessation of the industry at the very end of the century (Sambasiva Iyer 1900-01). The extensive use made by Percy in all of his four books on metallurgy of reports of traditional Indian metallurgical practices are similarly well-known. Indeed it has been argued that much of our perception of ancient smelting techniques and furnace types, especially bowl and shaft furnaces, is indirectly based on the experience of 19th century India via Percy (Clough 1985, Craddock 1995, 171).

There is a very extensive literature in the geological reports as well as official government annual reports and gazetteers, describing many ancient remains and surviving mining and metallurgical practices. This tradition carried on through the 20th century to the present, as exemplified by the excellent 1961 census report, published in 1964, on the indigenous smelting of iron, which contains a detailed account of the surviving traditional industry. Similarly, geological field reports often contain excellent first hand accounts of surviving traces of earlier workings, which we have found invaluable in our work. Thus, for example, the best introduction to the ancient gold mines of southern India is contained in the excellent report of the Geological Survey of India for 1974.

Studies devoted to early metals and metallurgy also have a long tradition in India, notably the two books by the chemist Neogi, *Iron in Ancient India* (1914) and *Copper in Ancient India* (1917). These are amongst the earliest specific studies on one region to be published anywhere. However even in these volumes one notices the problems that were to become more pronounced as the century progressed. This is the over reliance on earlier reports giving the impression that the particular sites and objects discussed had never actually been seen let alone studied by the author. This was often coupled with a reluctance to question or criticise the earlier sources or to initiate new areas of enquiry, giving the volumes a rather tired, second hand feel that regrettably has persisted through most of the succeeding publications.

To some degree this is part and parcel of the problems with Indian archaeology generally. During the 20th century there has been great archaeological activity, but one sometimes feels that the main objectives were firmly set by mid century and have not substantially changed since. Furthermore none of these objectives have included the investigation of mines or the sites of metal production. However, the discovery of the Harappan civilisation initially at Harappa (Vats 1940), Mohenjo-Daro (Marshall 1931, Mackay 1938) and latterly at such sites as Lothal in Gurjarat (Rao 1979 and 1985), and to a lesser extent excavations at later urban sites, notably at Taxila (Marshall 1951) in the north of Pakistan, did provide a great deal of very interesting metal, even if only limited evidence of metalworking activities. Even here it must be pointed out that these major excavations, with the exception of Lothal, were reported by the 1950's, and the excellent little volume of Prakash and Rawat, bringing together the analytical results of a selection of the finds from these excavations was published in 1965, but these analytical data still provide the majority of the material for the succeeding works including those reviewed here.

Minerals and Metals is an ambitious work, being a survey of the whole range of inorganic materials used in India from the sixth millennium BC to AD 1200. It has to be said that the work concentrates heavily on metals, and on precious stones, but with relatively little of ceramics or glass. The majority of the book's chapters follow the course of Indian archaeology chronologically with, predictably, chapters with titles such as 'The story of material splendour at Mohenjo-Daro' and 'Metals and minerals at Taxila through the centuries'. In these chapters Biswas tries to extract the relevant technical material from the original, now very old, publications. Unfortunately this is done in a non-critical fashion with the excavators' opinions given without comment or qualification, the author seemingly distancing himself from his subject. This can be very exasperating, for example, A K Biswas is a noted materials scientist, does he really have to rely on Gordon Childe as the appropriate authority for the melting point of bronze (p.58)? Similarly we are solemnly told on p.149 that the microscopic examination of a copper axe had revealed that it was cast from molten metal. In the chapters on the Harappan civilisation Mackay's 1938 report is very extensively and totally uncritically quoted even where the technical and metallurgical opinions quoted are at best now totally outdated and in some instances, frankly nonsensical. Thus on p.114, paraphrasing Rao's discussion of the source of the gold found at Lothal, it states that 'As gold has been found associated with silver in these objects, so it would therefore not be unreasonable to assume that alluvial gold was not used by the goldsmiths of Lothal'.

This great reliance on the statements of others inevitably leads to contradictions. Thus on p.53 we are informed the sulphur content of the Harappan metal means the ores used were themselves sulphidic, but on p.60 the sulphur content in a lump of cuprite copper ore from the site means that oxidised ores were used. Similarly the solution to the old problem of the gold digging ants of Kashmir, mentioned in both the *Mahābhārata* and by Herodotus, is solved in Vol I, on p.284, where the huge furry ants were in reality the fierce dogs kept by the gold

miners (following McCrindle 1896); it is solved again in Vol II, on p.63, where these same ants were in reality the skin tents of the gold miners (following Ball 1881). The relatively recent book devoted to the subject by Peissel (1984) is, of course, not mentioned in either.

Often the weirder ideas are not acknowledged, thus the relatively good condition of the iron from Sirkap when compared to the rest of the ironwork from Taxila is attributed to their having been in an intense fire and then buried in the ashes. A statement which flies in the face of common experience, even if it was originally propounded by the excavator!

The later chapters of the first volume deal with more specific topics, mining, zinc and brass, and iron and steel, and in the first two of these the work of HMS members feature very strongly. Regrettably there are still frequent errors of fact and misunderstanding of principles. Perhaps the single worst error concerns the occurrence of crucible steel at Taxila. The metallurgical reports of Hadfield, contained in Marshall's excavation report, are picked up, and the items variously described as three swords (wrong) or two swords and an axe (correct), together with 108 (actually 105) ingots of wrought iron (Vol 1, p.261). But when these reappear in Vol 2, p.52 they have been transformed into 'about 108 such ingots (of cast steel) ... each weighing 3 to 4 pounds, it is claimed they contain 1.2 to 1.7% of carbon' (wrong, 0.1% is published for the one example examined by Hadfield). If the statement had been correct, such a mass of crucible steel ingots dating from the first century AD would have been of the first importance, but neither the error or its potential significance seem to have been noticed.

Overall this work is very old fashioned in concept and material, and suffers badly from numerous mistakes in writing, editing and proof reading, which severely compromise its usefulness. We are firmly in the Empire, with regions still having names such as the Madras Presidency, the Western Presidency, Rajputana and Mysore, even the boundaries of the map of India includes not just India and Pakistan but Myanmar and Sri Lanka (sorry, Burma and Ceylon). But the reiteration of ideas already outdated and corrected in some cases over a century ago is a far more serious anachronism. Sir John Evans opines that the Gungeria hoard 'was the most important ever found in the Old World', this may be of some historical significance (unfortunately here as elsewhere the text reference doesn't appear in the bibliography), but the major technical study on this and the other copper hoards by Yule (1989) is not mentioned.

Professor Chakrabarti's two books are more limited in their scope and are rather more useful, especially *The Early Use of Iron in India,* published in 1992. This a synthesis, starting with a history of research into iron in India. This is 22 pages long, the first phase from 1795 to 1850 gets six pages but the phase from 1976 to date gets just two pages, which in itself is a fairly damning comment on the state of research in India. There then follow chapters dealing with the ores, the archaeological evidence for iron, the latter being basically just lists of artifacts culled from the relevant excavation reports. These are followed by the literary sources, and then the Pre-Industrial Iron-smelting Tradition, which is basically a compilation of 19th century European reports on iron and steel making. Only in the final chapter does Chakrabarti allow himself any observations, but even so the volume as a whole is a very useful compilation of sources and material with an extensive, if old fashioned bibliography.

Copper and its Alloys in Ancient India, written with N. Lahiri, is less successful although it follows very much the same scheme as the volume on iron, namely ores, significant archaeological finds of metal, literary sources, and the pre-industrial tradition. One reason why, overall, the volume is less successful is that the same sterile approach, relying so heavily on 19th century sources, doesn't work as so many of the non-ferrous craft-based industries still survive in India, but were apparently not reported in the 19th century. Some of the more famous of these, often utilising alloys that are peculiar to India, and which one would have thought should have been emphasised here, are largely ignored. Thus there is very little on the high zinc bidri alloys of the Deccan, and nothing at all on the high tin cast bronze mirror makers of Kerala, published by Srinivasan and Glover in this journal, or on the high tin wrought bronzes of southern India. The earlier counterparts of the latter, the wrought bronze bowls from the nearby Nilgiri Hills *are* mentioned, but they were reported in the 1870's.

The mines at Zawar are mentioned, but there is nothing at all on the production of zinc in medieval India, surely its most important contribution to non-ferrous metallurgy. The authors reveal that they are very unfamiliar with the technical material, often quoting unlikely statements with no comment at all, for example on p.162 it recommends that if the copper ore was of poor quality then iron metal should be added during the smelting.

The authors treat all the various alloying elements in the copper as straight metallic additions with no apparent appreciation of how an arsenical copper or a brass might have been produced in antiquity.

The authors themselves undertook a little investigation of some craft industries, mainly involved in the casting of brass images, but unfortunately little technical detail is given, and there are neither photographs nor drawings to

illustrate the processes.

The scene presented by the books under review here is one of sterility, but in fact they do not accurately reflect the progress made by archaeometallurgy in India. The periodic literature has a continuing series of excellent articles as a glance through the back numbers of *Historical Metallurgy* will show. The works of the geologists often contain invaluable first hand and informed reports on old workings and smelters and these can extend to a full archaeological and historical description. This can be exemplified by the excellent account of the crucible steel industry by Krishnan (1953), and by far and away the best account of the early operations at Zawar before the joint British Museum/Hindustan Zinc investigations was made not by the archaeologists, but by the geologists Straczkk and Srikantan (1967). Many of the reports of the Geological Survey of India are invaluable for the study of early metallurgy in India, in fact it must be said that any serious study of early metal production in India would derive more real benefit from the various works of the geologists than from the works more formally dedicated to archaeometallurgy. Similarly the various government reports on craft industries, both past and present give a more detailed and immediate picture on the metal working processes than the art history-orientated works.

Even so it has to be admitted that the study of early metallurgy in India is in urgent need of new directions, initiatives and above all of new field projects directed towards metallurgical questions. For example, the crucible steel industry has been endlessly discussed, usually invoking the same 19th century reports with all their contradictions and shortcomings (Bronson 1986), yet the sites of the most famous producers are well known and characterised by large heaps of debris; when will they be excavated?

The remarkable discoveries of early wind blown iron smelting furnaces in Sri Lanka (Juleff 1996) show what can be achieved with a carefully coordinated programme of survey, excavation, scientific study and experimental replication. Chakrabarti and Lahiri in the conclusion to *Copper and its Alloys* also lament this lack of directed research into mines and smelting places; as they so correctly conclude on p.196, that ultimately 'The matter is much more of an issue of attitude than money for research'.

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