Minerals and Metals in Ancient India, Vol. 1 **Archaeological Evidence**, by Arun Kumar Biswas (524 + xxix pp); Vol. 2 **Literary Evidence**, by Arun Kumar Biswas and Sulekha Biswas (259 + xvii pp). D. K. Print World (P) Ltd., New Delhi 110 015. 1996. Price: Rs. 3500 (US $ 225) per set.

The writing of History involves a reconstruction of the past, through a process of research, making use of a variety of source materials. The sources of information may be in the form of written material (inscriptions, travellers' accounts, the literature of the period), material objects and structures (as handed down from the past, or as unearthed through the work of archaeologists), and even traditions (in the form of practices, folklore). The historical researcher draws upon all the available evidence, and exercises his/her reason and judgement to construct a coherent picture of the happenings in the past, consistent with the available evidence, and with the best of objectivity. It is a continuing process, where every painstaking and careful effort is valuable.

The construction of Indian history is beset with many problems. The civilization itself had its beginnings several millennia back, before the appearance of any literature or documentation. Through the ages, a good portion of the material achievements has been destroyed as a consequence of natural calamities and even more, the insensitive and brutal ravages by invaders and aggressions from outside. At the same time, it is so important to reconstruct and recapture the cultural and intellectual heritage of India's past, particularly from the point of view of the younger generation in the country, to give them a sense of legitimate pride and meaningful belonging to the motherland. Fresh discoveries by archaeologists, modern scientific techniques of dating and materials characterization, and the capabilities offered by the computer have all added new dimensions to the study of history.

One of the illustrious and earliest attempts to write a history of Indian science was by the late Acharya Prafulla Chandra Ray, who published his 'monumental work', *the History of Hindu Chemistry*, in two volumes during the period 1902 to 1908. This classic was later republished with additions, in 1956, under the title *History of Chemistry in Ancient and Medieval India* as edited by P. Ray (then Professor of Chemistry at the Indian Association for the Cultivation of Science, Calcutta). The enlarged edition has covered the period from pre-Harappan days (4th millennium BC) till the end of the Moghul period. It has included extensive references to the Sanskrit literature of the Vedic and Ayurvedic period, the literature of alchemy and also a section on metallurgy and working of metals.

There has been a natural and growing interest in research on the history of Indian science, since the time of our political independence (1947) and various initiatives have been taken by the Government and the science academies. Arising out of the recommendations from a symposium on the History of Sciences in South-East Asia, held in Delhi in 1950, the Indian National Science Academy set up a History of Science Board, which in 1964–65 became the National Commission for the Compilation of the History of Sciences in India. As a major step in stimulating academic and professional interest in this field, the commission had brought out in 1971, *A Concise History of Science in India* – a comprehensive volume encompassing the disciplines of astronomy, mathematics, medicine, chemistry and metallurgy, agriculture, botany and zoology – with contributions from specialists, and edited by D. M. Bose, S. N. Sen and B. V. Subbarayappa. This concise History surveyed the ground from pre-historic times up to the British period.

The present two-part monograph – a collaborative effort of Arun Kumar Biswas and Sulekha Biswas – has also been sponsored by the Indian National Science Academy, History of Sciences Division. The work that has been devoted to the subject of minerals and metals, their production and applications in ancient and medieval India, presents a detailed analysis of archaeological evidence and literary evidence (as available in Sanskrit), for the period up to 1400 AD.

The Biswas couple have brought their wide-ranging academic experience and scholarship to the formidable task they had set for themselves – of collection, collation, evaluation and construction of a vast body of historical material, to present substantial and valuable conclusions. A. K. Biswas, who is presently Mahendralal Sircar Research Professor in History of Science, at the Asiatic Society, Calcutta, had been on the Faculty of IIT, Kanpur for over three decades (1963–95). His professional interests have been in the areas of applied chemistry, surface chemistry, mineral engineering and hydrometallurgy. He has had a long-standing interest in archaeo-metallurgy and the history of science. His deep appreciation of India's cultural heritage has inspired him to author several books, including one on *Science in India*, and another on *Profiles in Indian Languages and Literatures*. Sulekha Biswas is a scholar in Sanskrit and has been a fellow-collaborator with Biswas, assisting him in the selection and interpretation of Sanskrit texts and treatises on science and religion.

Notwithstanding the overpowering volume and detail of material presented in the two volumes, what facilitates the reader and sustains the interest is the structured presentation. Volume 1 which presents the archaeological evidence is conveniently divided into 21 chapters. Both the preface to the volume and the introductory chapter outline the logic and methodology, and the research motivations. Following chapters two to seven,– dealing with the splendrous variety of minerals, gem stones, metals, ornaments, tools and metal ware, and the associated technologies as unearthed at various excavation sites like Mehargarh (Baluchistan) (pre-Harappan), Mohenjo-Daro (Sindh, Pakistan), Harappa (Ravi basin), Chanhu-Daro (Sindh), Lothal (between Ahmedabad and Bhavanagar, India), and Ahar (near Udaipur, India) – chapters 8 and 9 are devoted to the Chalcolithic cultures of Peninsular India and Eastern India, and chapter 10 to a critical evaluation of copper technology in ancient India. Iron technology in ancient India is covered in chapter 12 and again in chapter 19 (the Delhi pillar, wootz steel and Damascening). There are individual chapters devoted to particular topics: Minerals and metals in the Mahabharata epic sites, in Taxila through the centuries, India's trade in minerals and metals, and mining in ancient India.

Arising out of his own analysis of all the source material, Biswas makes bold to express the firm views that there was

a continuity of the civilization from the pre-Harappan to the post-Harappan era (there was no invasion from outside), and that both copper technology and iron technology were indigenous developments and not the result of any diffusion from other civilizations. He has asserted that he has been very objective in making these assessments and no chauvinistic sentiment has clouded his judgement.

One of the amazing achievements of ancient Indian metallurgy is the carbothermic reduction of roasted zinc blende (sphalerite) to distil zinc vapour and recover the condensed metal. A collaborative project among M/s Hindustan Zinc Ltd, the Department of Archaeology, Baroda University (K. T. M. Hegde) and the British Museum Research Laboratory (P. T. Craddock and colleagues) involving archaeological excavations in the Zawar region of Rajasthan, brought to light extensive debris of the ancient zinc smelting furnaces and retorts. Through techniques of ^{14}C dating, the activity has been placed in the first millennium BC. The primacy of India's contribution to zinc smelting is now well accepted. It was not till 1730 AD that a similar technology for zinc extraction was successfully attempted in the Western world (in England). Biswas, who had carried out investigations on the characterization of Zawar zinc retort residues, has dwelt at length on the scientific basis of the Indian process, in his chapter on 'Antiquity of zinc and brass in ancient India' (chapter 18).

Volume 2 is a search for and survey of references to minerals, metals, processes and related concepts in Vedic and Sanskrit literature up to fourteenth century AD. It is an eloquent illustration of the versatility of the Sanskrit language to develop an extensive vocabulary to distinguish various minerals and metals in relation to their appearance and properties, to develop scientific concepts, and to deal with the subtleties of materials technology. At the same time, the Biswas team has made the observation that the references to minerals and metals in the Sanskrit literature are surprisingly scanty and scattered, the exceptions being the cases of Panini's *Asthādhyāyi*, Kautilya's *Arthasāstra* and the *Rasasastra* texts.

As interesting examples of etymology, for cat's eye or beryl Panini uses the description *Vaidūrya* (derived from the city of Vidura where the gem was cut). While *ayas* was used as a general name for metal, *Kālāyasa* or black metal referred to iron and *lohitāyasa* or red metal referred to copper. *Padārtha* (which literally meant the meaning of a word) was also adopted to mean a material or substance.

Arthasāstra is an important sourcebook on the economic importance attached to materials and metals in ancient India. While there has been some controversy on the date of the *Arthasāstra* – placing it between 4th century BC and third century AD – Biswas accepts the traditional view that it was the work of Kautilya (also known as Chānakya or Vishnugupta), in the time of Chandragupta Maurya whose reign commenced around 321 BC. Apart from giving details on metal processing, the *Arthasāstra* also defines the duties and responsibilities of the director of mines (*Ākarādhyaksha*) and the director of metals (*Lohādhyaksha*).

Volume 2 devotes a long chapter to gemmology literature (a millennium of *Ratnasāstra*) and a short chapter to non-gem minerals and metals in ancient Indian texts. Alchemy was pursued for a long time in India, perhaps even from the Ayurvedic period, but more prominently between fourth century AD till as late as the 14th century AD – but with greater emphasis on the use of minerals and herbs in health and medicine. Literature on Indian alchemy is voluminous, in the form of the *Rasasāstra* texts and is discussed in chapter 8 in this volume.

Rasaratnasamuccaya (compiled during the 14th century AD) has been described by the authors as 'a pinnacle in the Indian latro-chemistry'. It is interesting for the detailed descriptions related to mineral and metal processing. Extensive extracts referring to zinc extraction, brass and lead, and different kinds of iron are included in chapter 9, but the text is in Sanskrit, and the authors have not considered it necessary to provide English translations.

There is a closing chapter titled 'The future of the past' in volume 1, and a resume in Volume 2, where the authors have summarized the major conclusions from their work, and made suggestions for future work. Maps showing the sites of archaeological excavation, the chronological presentations of historical information, the large number of tables giving the chemical analysis and other significant details of ancient objects, and the beautiful colour plates of jewellery, seals, implements, icons, metal work, stone sculpture, etc. all add great value to the presentation.

It is undisputed that Indian civilization – in the ancient and medieval periods – had touched great heights in the aesthetic application of minerals and metals, and in metallurgical accomplishments of a high order and pioneering quality. The authors have raised the familiar question why such a vibrant civilization did not maintain its leadership in the subsequent eras and did not proceed to develop modern science and large-scale technologies. (There are many aspects to this question as explained by B. M. Udgaonkar in his comprehensive article 'Scientific traditions and other traditions', *Curr. Sci.*, 1995, **69**, 197–206.) The authors place particular emphasis on the stratification that had crept into society, where specific skills (like working with different metals: iron, zinc or gold) remained confined to particular castes and tribes, the intellectual class largely stayed aloof, and there was no effective cross-communication and discussion of experience.

The Biswas couple have produced a very impressive and valuable compendium of information, that should serve as a consolidated sourcebook for future historians and research workers.

C. V. SUNDARAM

National Institute of Advanced Studies, Bangalore 560 012, India

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Parasitic Infections of Domestic Animals: A Diagnostic Manual, Johannes Kaufmann. Birkhauser Verlag, Basel, P.B.No. 133, CH-4010. SFr 68. 1996. 423 pp. Price: DM 78.

Several textbooks on parasitology and parasitic infections of domestic animals are available. These mainly focus on the parasites grouped according to zoological classification; give detailed descriptions of morphology and life-cycle; and small notes on pathology, symptoms and control. Some of the books contain