Review of:
Biswas, Arun Kumar. 2005. *Science in Archaeology and Archaeo-Materials*. Delhi: DK Printworld. Pp. 374. Price Rs. 1800/=.

By D P Agrawal
Lok Vigyan Kendra
Almora 263601

Biswas has made a very important contribution to the literature on the uses of scientific techniques in Archaeology. It raises many basic issues regarding the very nature of archaeology as a discipline. It revives the age old controversy of the Two Cultures made so famous by C P Snow. In this age of interdisciplinary studies the old compartments of disciplines have hardly any relevance. A subject like molecular biology cuts across the boundaries of physics, biology and mathematics. Real life problems do not respect the boundaries of different disciplines. Such compartments are a result of the limitations of the human mind rather than of physical reality.

The book, however, is comprehensive only to a limited extent. Though in one case it goes to the details of microelectronics of remote sensing, on the other it does not even discuss important areas of lapidary technology or for that matter the technologies of reconstructing environment. Similarly, there is a discussion of the AMS C-14 dating but not of normal gas C-14 dating, TL dating or a variety of other dating techniques. Nor does it discuss how one distinguishes between domesticated and wild varieties of plants and animals. Ethnobiology today is more important a discipline than many other disciplines as it tells us about the socio-economy of the society.

AK Biswas is a name to reckon with in the field of scientific archaeology. He has made great contributions to scientific archaeology, especially to archaeometallurgy. Now he has come out with an interesting and useful volume on science in archaeology, with a good number of essays by various experts covering diverse themes related to dating, survey, artefact analyses techniques, genetic evolution etc.

In the introductory essay Biswas himself sets the stage by delving deep into the nature of archaeology, and gives a brief glimpse of the various techniques that are advantageously used in archaeology. It is followed by an essay by Bhattacharya on sequence dating. Although, It can be seen as a good introduction to dating in archaeology, nothing much of significance is there.

The next essay by Chowdhury on radiocarbon dating by Accelerator Mass Spectrometry (AMS) is quite informative, yet one would have liked to know more about the Accelerator Mass Spectrometry facility, based on 3 MV Pelletron, at the Institute of Physics at Bhubaneshwar. We have been hearing about it for a long time now but have not heard of any substantial results so far. Chowdhury explains that AMS has become a sensitive, efficient, powerful and versatile analytical tool for the radiocarbon dating of samples in archaeological research. The AMS technique requires a very small amount of sample (few tens of micrograms) and takes 2-5 hrs for each measurement. This is particularly important in archaeology where many rare specimens are available only in small quantity. He further informs us that in the last 20 years, the AMS systems have been developed at more than 50 laboratories around the world for radiocarbon dating in archaeology, anthropology and the other branches of science. The AMS facility based on 2.5 MV Tandetron accelerator was developed at Groningen University, The Netherlands,which is fully dedicated to radiocarbon dating measurements. This AMS facility has been in operation since 1994 and thus far, a grand total of about 16000 ^{14}C targets have been analysed.

The essay is followed by Chakrabarti et al who discuss the ~~R~~role of Remote Sensing in archaeological survey. They have provided a very useful summary of GIS applications also. They explain that in the primary stage of archaeological investigation, GIS may play a facilitator role to identify possible sites. The database to be used in GIS environment includes:

- Various theme maps [viz., drainage (including palaeo-channels) and surface waterbodies map, geomorphological and geological maps, landuse/landcover maps, transport network, settlement maps with heritage points and administrative boundaries up to *mouza* level.
- Historical maps.
- Non-spatial collateral attribute data.

They further tell us that terrain analysis and classification through applied geomorphological studies with morphogenetic approach provide baseline geo-spatial information to enhance the visualization and conceptualization processes of the researcher for selection of archaeological sites in the planning phase. The GIS technology helps to generate well-formulated geo-information through integration and analysis of spatial and related non-spatial data for a structured approach towards solving the specific problems. They however warn that RS and GIS applications should not be considered as a panacea. Good use of these new technologies largely depends on the "fitness for use" and "truth in labelling" which includes meaningful full-featured spatial data, positional accuracy, attribute accuracy, logical consistency and completeness.

In this age of microelectronics, Sen, in the next article, explains its importance in remote sensing, though the essay does not seem ~~too~~ much relevant to archaeology. We are informed that much progress has been made in respect of the use of SAR-based interferometry which is relevant to some hazard-related problems, e.g. earthquake detection and prediction. Sen further tells us that significant advances in science and related algorithm design also involve:

a) Instantaneous rainfall evaluation, by passive micro-wave data analysis;
b) Aggregated rainfall estimation, through infrared data analyses;
c) Mapping and monitoring of snow areas, depth and/ or water equivalences, using multi-spectral visible/infrared, and microwave data;
d) Soil moisture status, particularly when the ground surface is flooded over wide areas, using passive microwave Surface Wetness Indices;
e) Vegetation health (or lack of it) using improved multi-spectral Vegetation Indices;
f) The identification and monitoring of frosts based on infrared imagery;
g) Surface changes related to earthquakes and volcanic activity, through interferometric processing of active microwave imagery;
h) Passive microwave imagery has also proved useful in respect of broad-scale reconnaissance of marine pollution, e.g., associated with major oil spills.

Roychoudhury and Roy, in their essay, discuss ‘Genetic Perspective of Origin and Evolution of Indian Population’. They inform us that now genetics is playing a significant role in understanding evolution. These molecular tools are now tackling several evolutionary questions such as the origin and dispersal of modern man. One important inference which came out of such studies is the fact that despite such enormous morphological, cultural and linguistic diversities among different population groups of the world there is very little genetic difference between these population groups.

Biswas in his interesting article, “Remains, Residues and Slags in Indian Archaeology” discusses the useful information that can be gathered on plant, animal and human remains, ash residues, metallurgical tailings and slag etc., and what modern science and sophisticated analytical techniques can do to harness such information leading to many valuable conclusions. Biswas warns that not even the soil is to be discarded during the course of excavation. Even the seemingly "trivial" matters need to be subjected to rigorous scientific investigation.

Krishnan and Shah in their interesting essay on ‘Petrographic Perspective on Ancient Indian Pottery’ discuss the issue of the Black and Red Ware, the cultural identity of which is quite controversial. They advise that a petrographic analysis of this ware along with the associated ware at three Chalcolithic sites in north Gujarat and Rajasthan revealed that at each of these sites, the Black and Red Ware occupied different positions and therefore to club them into a single identity would lead to loss of potential information. The subsuming of conventional ware categories into similar fabric groups has revealed that the ancient potters were able to use the same paste recipe to make very different forms, which demanded different surface treatment and firing and gave rise to different physical properties. At Nagwada, petrographic groupings revealed a multiplicity of paste-preparation techniques where typologically similar wares were found to have been produced differently. At least four different modes of production were discernible for Fine Red Wares and Gritty Red Wares each. Amongst these, Black and Red Ware represented a distinct technological tradition in terms of both the mode of production and raw material procurement.

They suggest some exciting possibilities for the study of the Northern Black Polished Ware (NBPW). The NBPW is commonly believed to have evolved, with technological refinement, from the archaeologically earlier Black Slipped Ware. By a comparison of the Fe^{2+} /Fe^{3+} ratios and elemental carbon in the NBPW, Painted Grey Ware (PGW) and Black Slipped Ware (BSW), Gogte and others had concluded that NBPW was nothing but PGW with a black polished slip on its surface and BSW cannot be thought of as an intermediate step in its evolution.

The essay emphasises that such studies are all classic examples of how petrographic classification, by cutting across conventional ware boundaries, has been able to look beyond the external criteria of wares and shapes into more "real" paste differences to provide insightful relationships to address a range of cultural issues, such as organization of production, trade etc.

Das et al in the next essay, ‘Pottery Technology and Provenance Studies from the Site of Chandraketugarh’, conclude that the site may not have been the centre of pottery production in this region. The clays, distributed within a radius of 10 km are of the same nature but not responsible for these types of pottery-making. This is contrary to the views expressed by Gogte who contends that pottery was being produced at the site of Chandraketugarh and was being exported to other regions and countries.
They report that the elemental analysis along with X-ray diffraction study of the fired pottery gave a very detailed picture of the inside mechanism about the mineral pattern. The most significant finding in these studies is the conclusions about the firing temperatures of these Wares. They contend that though the firing temperature of the pottery concerned could not have crossed the 500^0C mark yet they remain preserved in an excellent condition throughout the centuries. The ancient potters not only produced such hardy materials in a very low firing atmosphere by choosing a fine quality of clay, but they probably mixed it with other fluxing materials so that the lustre, shape and quality survived even after nearly 3000 years.

Ramachandrarao and Mandal discuss the method of casting and working of metallic objects. They explain that the cast microstructures will have dendritic morphology, in contrast, a cold-worked material (mostly for bronzes and brasses) will have many distorted and twin grains. The composition of these materials can be known for each of the grains through SEM having an EDAX attachment. For all these we need a small piece of specimen from the artefacts. They further explain that composition of a phase and crystal structure can be studied by the transmission electron microscope.

Discussing ‘Copper and Copper Alloys in an Archaeological Perspective’, Datta states that the first copper metal was definitely native copper, available near copper mines. Forging, drawing and annealing native copper changed the forming techniques of materials from earlier destructive hammering process to constructive shaping processes. Along with native copper, man also developed the extractive metallurgy of copper to get a suitable supply of copper for the human society. Firstly, they tried oxide ores or carbonate ores (Malachite) probably, but later they extracted copper from widely available sulphide ores. Datta informs us that the Indian metal workers used quartz as a flux in copper extraction and made fluid slag, which they made to run through a slag notch to get pure copper.

Balasubramaniam et al discuss ‘Characterization of Rust on Ancient Indian Iron’. In recent times, Balasubramaniam, of IIT, Kanpur has made seminal contributions to the archaeometallurgy of monumental iron technology. In this essay they explain that different kinds of oxides, oxyhydroxides, oxychlorides are formed on iron depending on the conditions and medium. They explain that the study of nature of rust is essential because the corrosion product layer determines further ingress of water and oxygen to the metal surface resulting in the continuation of the processes. Rusting of iron in atmospheric and soil environments has been briefly reviewed in this essay. In this interesting article, techniques for micro-structural (scanning electron microscopy and optical microscopy) and compositional analyses (EDS, EPMA and PIXE) have been discussed. Detailed description of important spectroscopic methods (like Raman spectroscopy, infrared spectroscopy and Mossbauer spectroscopy) has also been provided.

Pranab Chattopadhyay has done extensive work on Indian archaeometallurgy. In his essay given here, ‘Basic Principles and Modern techniques in the Studies of Archaeo-Materials in Eastern India’, he gives hints as to what is to be done for archaeometallurgical sample collection and analysis. The probable sources of ore-minerals are to be identified first. The details of composition of ore-minerals and slag are to be established. The furnace remains are to be analysed for its ceramic phases, which may establish the types of soils utilized for the making of tuyeres and furnaces. Based on the chemical results, a model may be established to calculate the yield, efficiency and the slag/ore ratio. The use of flux, if any, is to be identified.

Adequate analysis is the only way to reveal our ancient technologies meaningfully. About iron he says that there ~~are~~ enough evidence~~s~~ that iron technology was independently discovered in eastern India. The study revealed that the smiths of Pandurajar Dhibi, during the third century BC, knew about the addition of carbon to iron. They further hardened this carburized iron by heating it to red-hot and then quickly cooling (quenching) in water. To make the hardened iron less brittle, they reheated it to an intermediate temperature (tempering).

Raj et al in their essay on ‘Non-destructive Evaluation for Characterization of

Archaeo-Metallurgy Objects' point out that non-destructive testing methods are appropriate for investigating archaeo-metallurgy objects such as south Indian bronzes, Delhi Iron Pillar, silver coins of Sailgam and Roman periods. They discuss and explain the laser-based techniques for scientific characterization, conservation and restoration of works of art. The advantages and disadvantages of these NDT methods for the purpose of studying these antiquities have been highlighted.

To Sum Up

In such a rich volume, the editor only collects essays and edits them properly to integrate them in a wholesome book. I was however pained to read the following types of sentence right in the opening para of the book, which cry out for copyeditors sharp scissors!

"Additionally or knowledge of the historical period acquired which is through the written word can be further illuminated by the aid of archaeological investigations." What does the sentence mean?

Otherwise it's a useful addition to the literature on science & archaeology, which we has grown fast during the last decade. The volume could be more representative and useful, and less skewed in the selection of topics, if 50% of the essays were not commissioned from only one state, and the remaining 50 % from the other 26 states of India!

Though it does not cover all the important fields where science has been applied to resolve Indian archaeological problems, it does give a glimpse into some important techniques and that itself makes it an invaluable reference work and a book worth acquiring.