Book reviews

Mining and Metal Production through the Ages edited by Paul Craddock and Janet Lang. *British Museum Press, 2003. 296pp, 283x225mm, 49 colour and 170 black and white figures, ISBN 0 7141 2770 1. £65-00.*

This volume began life nine years ago (1995) as the proceedings of an international conference on the Prehistory of Mining and Metallurgy organised jointly by The British Museum and the Early Mines Research Group. The core of original conference papers are augmented in most cases by the inclusion of participants' more recent work and additional contributions by other leading experts in the field. Among the varied topics are the early development of copper smelting technology as exemplified at Feinan, Jordan; the recognition of Bronze Age copper mining in the British Isles; and the important discovery of Bronze Age tin mining and processing at Kestel and G^ltepe in Turkey. Perhaps more importantly, the first group of papers in the volume serve to demonstrate how the study of prehistoric mining and metallurgy has recently developed to now encompass studies of its environmental impact (Mighall) and the realisation of how crucial an understanding of the underlying mineralogy is to the interpretation of prehistoric mining (Ixer and Pattrick). Timberlake's overview of early mining research in Britain shows how these various approaches can be brought together to provide an invaluable contribution to archaeology in its broadest sense. Traditional approaches still remain, and are well exemplified in the paper by Herdits.

The excavation of ancient smelting sites, so often only in Europe and the Near East, is now occurring in other parts of the world, and refreshing and challenging work is reported on the origins of copper metallurgy in India, China and South Africa. The identification of a change from arsenical copper to tin-bronze with the rise of Harappan culture around 2000 BC (Babu) seems curiously to mirror developments in Britain and demonstrates the huge gaps in our understanding of the technological development of the Indian sub-continent. In the Xinjiang region of China similar gaps in our knowledge are identified, although evidence for the same sort of early use of arsenical copper has been identified during the first millennium BC, and its production appears to have involved the addition of arsenic ores to a complex matte smelting process (Jianjun and Yanxiang). By contrast, new research on the development of metallurgy in sub-Saharan Africa (Miller) eloquently demonstrates how the European and Near Eastern developmental pattern is not universally applicable, and is particularly interesting in demonstrating how external contacts can impact and modify indigenous technological development for a variety of non-technical reasons.

Detailed examination and reconstruction of more complex extraction processes are covered in other papers and include the treatment of silver-rich jarosite ores in Phoenican Spain (Kassianidou), a variety of crucible based processes (Rehren), and the production of brass by direct processes (Craddock and Eckstein). The latter paper brings together the results of recent research and presents an important and well clarified overview of this technologically and culturally important topic from a world perspective. Research into the issue of liquid iron production is also brought up to date in the following paper (Craddock) which serves to dispel some deeply rooted biases and (hopefully) provoke some interesting discussion. Craddock presents evidence for the intentional production of liquid crucible steel in the Middle East, Central Asia and India as much as 2000 yrs ago, and the mass-production of liquid iron in China in the mid-first millennium BC. A case is also made for documentary evidence for crucible steel production in the Classical world in the third century AD. This paper is appropriately followed by the presentation of the archaeological evidence for crucible steel production in 9th century Turkmenistan (Feuerbach *et al*).

The final paper presents the results of the intrepid Craddock's expedition to Guizhou province in China (Craddock and Weirong) where a modern, small scale traditional zinc distillation industry successfully competes with modern electrolytic extraction plants. This work presents a rare opportunity to document change and innovation in traditional craft metal extraction processes, as exemplified by the change in furnace technology initiated in the 1950s, and to study the nature and effect of external pressures on this sort of industry; crucial factors, yet ones that are usually denied to the archaeologist.

The breadth of topics covered, both geographically and chronologically, make this a seminal publication, but it is the reflective and integrated approaches of many of the papers that are the real highlight. Craddock perhaps sums this up when talking about liquid iron production, with a comment that is applicable to all technical studies of archaeological material: 'By making comparisons based on superficial similarities and forcing the technological achievements into mere anticipations of modern technology, there is a danger of distorting our perception of the very real achievements of Ö early technologies' (Craddock, 238).

Contents: Introduction; Copper-arsenic ores and Bronze Age mining and metallurgy, with special reference to the British Isles (*R A Ixer and R A D Pattrick*); Early mining research in Britain: the developments of the last ten years (*S Timberlake*); Geochemical monitoring of heavy metal pollution and prehistoric mining: evidence from Copa Hill, Cwmystwyth, and Mount Gabriel, County Cork (*T M Mighall*); Hafted stone mining hammer from Chuquicamata, Chile (*B R Craddock, C R Cartwright, P T Craddock and W B Wray*); Bronze Age smelting site in the Mitterberg mining area in Austria (*H Herdits*); Spatial organization of mining and smelting at Feinan, Jordan: mining archaeology beyond the history of technology (*G Weisgerber*); Developments in copper metallurgy during the fourth and third millennia BC at Feinan, Jordan (*A Hauptmann*); Indigenous copper mining and smelting in pre-colonial southern Africa (*D Miller*); Early copper technology in Xinjiang, China: the evidence so far (*Mei Jianjun and Li Yanxiang*); Early metallurgy in Bulgaria (*N H Gale, Z Stos-Gale, A Raduncheva, I Panayotov, I Ivanov, P Lilov and T Todorov*); Advent of the Bronze Age in the Indian subcontinent (*T M Babu*); Analyses of metalliferous residues, crucible fragments, experimental smelts and ores from Kestel tin mine and the tin processing site of G^ltepe, Turkey (*K A Yener, A Adriaens, B Earl and H ÷zbal*); Early extraction of silver from complex polymetallic ores (*V Kassianidou*); Crucibles as reaction vessels in ancient metallurgy (*Th Rehren*); Production of brass in antiquity by direct reduction (*P T Craddock and K Eckstein*); Cast iron, fined iron, crucible steel: liquid iron in the ancient world (*P T Craddock*); Early Islamic crucible steel production at Merv, Turkmenistan (*A M Feuerbach, D R Griffiths and J F Merkel*); Traditional zinc production in modern China (*P T Craddock and Zhou Weirong*). Matthew Ponting

Hutnictwo Świętokrzyskie Oraz Inne Centra I Ośrodki Starożytnei Metalurgii Żelaza Na Ziemiach Polskich [The Świętokrzyskie region metallurgy and other centres of ancient iron smelting in Polish territories] edited by S Orzechowshiego. *Świętokrzyskie Stowarzyszenie Dziedzictwa Przemyslowego, Kielce, 2002, 203pp, A4, many illustrations (in colour and black and white) and distribution maps, ISBN 83-7217-128-9. Price not stated.*

This collection of 17 papers presented at a conference are all written in Polish, but English summaries are provided and the figure captions are bilingual. K Bielenin sets the scene by mentioning the many sites with evidence of ancient and early medieval bloomery smelting in the Świętokrzyskie region, Mazovia and Silesia. The archaeological finds are largely slag, with some charcoal and ore; metal and furnaces are rare. In a second paper the need for collaboration between archaeology and metallurgy is highlighted. Analyses of slag block surfaces has led to doubts about accepted reconstructions of slag-pit furnaces. It is concluded that the scale and organisation of production in the Świętokrzyskie Mountains must have been for an external market, south of the Carpathians or within the Roman provinces.

S Orzechowski discusses the distribution of settlements and iron-smelting sites in the Świętokrzyskie Mountains in the late pre-Roman and Roman Iron Ages (3rd century BC to early 3rd century AD). The earliest settlements are in the east of the area, with Roman period settlements further west. A huge production complex, spread over 800 km^2, with over 6000 smelting sites and 50 smelters' villages has been recorded. In other areas no settlements have been found though there is a high density of production sites, suggesting their seasonal operation. Roman finds are more frequent in the Kamienna valley than in the adjacent metal working areas, suggesting it was an important exchange area and trading route.

A Przychodni describes the excavation of 79 slag pits in two clusters at the site of Bilcza, in the Nida valley. Other structures included a charcoal pit and many fragments of furnaces were found. Bloomery slag has been recorded on 35 sites in the valley, showing it was an iron production centre in the Roman period that utilised local bog ores.

P Madera surveys the chronological and spatial distribution of iron working in Silesia. 687 sites were recorded, 136 of them have been excavated. The date range is Hallstatt to the early migration period but 628 of the sites belong to the Przeworsk culture (late Iron

Age to Roman periods). The metal production sites cluster within the settlement divisions known from the literature. Initially production was almost exclusively in Lower Silesia but it later spread to Upper Silesia, and eventually was concentrated there. E Tomczak focuses on iron metallurgy in Upper Silesia where there was dense settlement from the later 2nd to early 5th centuries AD. The workshops consisted of furnaces and auxiliary structures and are found within settlements, unlike the slag-pit furnace clusters of the Świętokrzyskie Mountains. Iron production was to satisfy local needs.

S Pazda's paper on the complete excavation of a workshop in Przylesie Dolne is copiously illustrated with plans and sections of the bases of furnaces and photos of tuyere and furnace shaft fragments. The furnaces are reconstructed as standing above ground with an internal diameter of 0.9–1.1m. Notable among the finds were burnt bone bellows tips. The sites dates to the later 4th century AD and is typical for the Brzeg region.

L Berdula and M Dobrakowski describe a smelting settlement of the Roman period, found during rescue excavation on the line of the A-4 motorway in Lower Silesia. A total of 253 structures relating to iron working included 180 furnace pits, concentrated in two clusters, as well as 60 furnaces for roasting bog ores, six charcoal pits, six clay mines and a store for bog ore. Many settlement features were also found. Another site of the early Roman period at Namyslów is described by A Kosicki. There were five bloomery furnaces, several bog ore roasting hearths, two charcoal pits and 14 lime kilns. The furnaces were buried about 0.6m deep and had a maximum internal diameter of 0.5–0.6m. The results presented justify the claim that iron production was technologically closely related to lime production. Metal production was limited and for local use.

S Woyda describes the discovery of the Mazovian Metallurgy Centre, spread over 1600 km^2 to the west of Warsaw. A dense group of nearly 50 late La Tène and Roman period sites has been found in the 300 km^2 eastern part of the area. At the best-researched site of Biskupice 3,700 furnaces have been found and there are an estimated 15,000 at Milanówek. There may be around 120–150,000 furnaces in the Mazovian Centre. The single-use furnaces were up to 1.5m high, partly underground with a clay shaft. They were accompanied by smithy forges, lime kilns and wells. The iron production peaked in the 1st–2nd centuries AD and collapsed in the 3rd century though the Przeworsk culture continued, suggesting these organized metal-working centres were not serving local needs. In the 3rd century huge iron smelting sites begin to appear in northern Germany and Jutland, using similar technology and organisation to that of the earlier Polish centres. This dislocation reinforces the hypothesis relating it to political events in barbarian Europe and its contact with the Roman Empire.

W Nowakowski writes on the problem of iron acquisition in the Mazury Lake District in the Roman period. Tacitus says the *Æstii*, who lived in this area, infrequently used iron. Archaeologists have believed his statements, despite the numerous iron finds. Little evidence of Roman ironworking have been found although the readily available bog iron ores were exploited on an industrial scale in the 19th century.

P Luczkiewicz describes a number of bloomery furnaces from the late pre-Roman and Roman site of Sobieszyn. The best preserved was a shaft pit furnace. L Żygadlo maps sites that have produced a range of Przeworsk culture ironworking tools. These are illustrated and are mainly hammers, tongs, anvils and rasps. W Slawiński describes the range of techniques used by blacksmiths in the Roman period. The information comes from examination of archaeological finds and replication experiments. I Suliga *et al* examined and analysed bowl-shaped slags. The chemical and phase compositions are attributed to the incorporation of iron scale in these smithing slags. M Karbowniczek and I Suliga report the results of partially-successful smelting experiments using a slag-pit bloomery furnace. The final paper, by W Weker, investigates the theoretical model of bloomery iron production in the light of the many reported smelting experiments. The failure to accurately replicate ancient processes points to a need for further systematic research.

Justine Bayley

Archaeometallurgy in India: Studies on technoculture in early Copper and Iron Ages in Bihar, Jharkhand and West Bengal by Pranab Kumar Chattopadhyay. *K P Jayaswal Research Institute, Patna, 2004, vii+183pp, 245x170mm, 10 figures, 78 plates, 45 tables. No ISBN. 155 rupees.*

In 1996 the present reviewer wrote a critical appraisal of the state of archaeometallurgy in South Asia on the basis of recent publications (Craddock 1995) It seems appropriate to review the literature of the past eight years as a preamble to a more detailed discussion of the present work. General studies of archaeometallurgy include Agrawal (2000) and the conference proceedings edited by Tripathi (1998), the latter, although uneven, does contain some interesting papers. The chapters in Vol 4 of the encyclopaedic *History of Science, Philosophy and Culture in India*, on metals by Sundaram et al (1999) and alchemy by Subbarayappa (1999) are useful summaries. Bhardwaj and Sharma (1997) adopt a new approach with a compilation of illustrations, from a variety of sources, of tools and apparatus for a variety of tasks, in which all aspects of metallurgy are depicted. There have been major publications on more specialised topics of some significance. These include Juleff's (1998) work on iron production in Sri Lanka, which is of great importance to our understanding of early iron smelting processes generally, and is by far and away the most significant study of wind-blown furnaces. The Iron Pillar of Delhi has attracted a steady stream of publications for many years which usually contrive to say nothing new, often at considerable length. The work of Balasubramaniam (2000) is a notable exception in which a detailed scientific examination (including excavation) of the pillar is backed up by a sensible discussion on how it was made and why it is corrosion-resistant. Reedy's (1997) excellent monograph on the bronze statuettes of the Himalayan region is not just a comprehensive scientific survey of the metalwork, but has advanced the whole subject of the scientific and technical examination of metal castings, and the integration of these aspects into their broader study. The belated publication of the 1988 conference 'The 4th USA-USSR Archaeological Exchange/Symposium: The Development of Ancient Metallurgy in the Old World' contains papers by Kenoyer and Miller (1999) on the metallurgy of the Harrapan civilisation and by Possehl and Gullapalli (1999) on the inception of iron work, that are both of great importance in sorting out some of the problems surrounding these controversial subjects in South Asia archaeology.

As the title suggests, the book under review here addresses the archaeometallurgy of the prehistoric period in the Indian states of Bihar and West Bengal (rather confusingly Jharkhand is a region of Bihar). This part of India contains the remains of many ancient cultures, notably being the heartland of the great Mauryan Empire of the later part of the 1st millennium BC. More specifically, the area includes the Singhbhum district which is rich in both precious and base metals of all kinds, and which together with Aravalli Hills in the west of India were probably the main source of metal for the whole of northern India in antiquity. Dr Chattopadhyay trained in the material sciences and spent most of his career working as a scientist in the steel industry, but has also studied archaeology and has been publishing papers on the early history of metals in the east of India for many years (Chattopadhyay 2003 and Singh and Chattopadhyay 2003 being two recent examples in western publications).

The book follows the general pattern of others on the subject, with the first chapters being on archaeometallurgy generally and the history of metals throughout India at all periods. These are followed by a chapter on the archaeological sites in the region that have revealed important metallurgical information, usually finds of metalwork. The succeeding chapters on archaeometallurgy pursue the familiar themes of Indian prehistoric archaeological investigation generally, namely the Chalcolithic and the Copper hoards and the inception of iron into South Asia. Bluntly speaking, these have been confused issues for many years and the present work does little to clarify the situation, even within Bihar-West Bengal, although it does present a considerable amount of new metallurgical data on the metalwork itself.

Very many hoards of copper artefacts have been found in considerable numbers for many years from a wide region centred on the central Ganges valley but extending considerably beyond (see Yule 1989 for the most comprehensive study on the Copper hoards). The hoards contain massive artefacts, often in the form of crude tools, weapons or ritual items, but most apparently unfinished, unused and very often patently unusable. They are generally found in isolation and so are difficult to date or assign culturally. They hang about in a sort of cultural 'Chalcolithic' twilight somewhere between the end of the Bronze Age Harrapan civilisation and the inception of the Iron Age and date vaguely to the 2nd millennium BC for want of anywhere better to place them. The one thing that is certain is that together they constitute a great amount of metal, leading to questions of where the metal could have come from. A favourite pastime of archaeometallurgists over the years has been analysis to try and match the trace element content of the metal to known ore sources. This approach, discredited in Europe for many years now, suffers even more in India because the number of artefacts sampled has usually been pitifully small, with analytical techniques that are often at best semi quantitative, and with comparative material from the ore sources being usually based on a very few published results from modern mining companies, in default of any dedicated archaeological sampling programme. Coupled with the provenancing work there have been attempts to determine the original ore type, based on work published a paper published by Friedmann *et al* (1966). The original project might or might not be viable when applied to a large number of samples with the wide range of trace elements required accurately determined, but it is most unconvincing when based on the incomplete analysis of a single corroded bronze. Chattopadhyay (p.80) tries in rather a half-hearted manner to link the artefacts that he has analysed, semi-quantitatively by emission spectrography for the most part, to the sources in Singhbhum, but admits that 'unfortunately the sample was very much restricted'. However, he still felt, for no very good reason, that the copper in the hoards was local. Perhaps fortunately, lead isotope analysis has not yet been widely been applied to trace Indian copper sources, with the exception of the work of Srinivasan (1999) who used the technique to try and establish some of the copper sources used in the bronzes of southern India.

The inception of iron in India and whether it is likely to have been an indigenous discovery or introduced from Iran has generated a huge literature, largely based on the study of poorly stratified metal artefacts, often themselves in a poor state of preservation. Quite recently our understanding of this question has been transformed by the excavation of a number of sites in eastern Uttar Pradesh in the central Ganges Valley, where iron artefacts and slag have been found together with pottery previously regarded as Chalcolithic and thus dating through the 2nd millennium BC (Tewari 2003). This dating is confirmed by a series of radiocarbon dates from the layers containing the iron work which again span the 2nd millennium BC. These are not only by far the earliest dates for iron in India, they are also currently amongst the earliest dates anywhere for the sustained use of iron. This rather upsets Chattopadhyay's scheme of iron inception in the lower Ganges valley at around 1000 BC (see also Chattopadhyay 2003). It seems that the book developed over a number of years and the Tewari references to sites just over the Bihar border in eastern Uttar Pradesh, although going back to 1997, are a latter addition to the book. There is a numbered reference system, with a secondary 'A' system superimposed upon it (which unfortunately sometimes does not make it back to the reference pages). Thus one is confronted by the carefully argued original scheme with the 'A' listed Tewari references displacing it by over half a millennium.

Chattopadhyay and his associates have also been conducting some interesting metallographic work on a series of early high tin bronze bowls from eastern India that have been hot forged and then quenched and tempered (Singh and Chattopadhyay 2003), in the same manner as the more familiar bowls from the Nilgiri Hills of southern India (Srinivasan and Glover 1995). This work is reported here with good micrographs of the structures, and clearly Chattopadhyay is more at home in the metallographic examination and interpretation of artefacts than with archaeological sites.

The 1995 review castigated the Indian archaeometall-urgical literature for over reliance on very old and stale references and a lack of new material. In both these respects this current work is a considerable improvement, with much more evidence of direct involvement at least on the examination of artefacts. As perhaps befits his professional skills as a metallurgist, this book includes many new chemical analyses, performed by a variety of techniques but mainly by emission spectrography. Unfortunately there are no estimates of precision or of detection limits which are indispensable when comparing analyses performed by different methods. There are also many metallographic examinations on both metals and slags, resulting in about 50 good micrographs printed separately on art paper and thus reasonably clear. This greatly increases the number of published metallographic sections of Indian material, including martensite and widmanstätten structures of some interest.

The work also contains a wealth of references clearly collected over the years, dating from the 19th century to the present, which the reviewer has already found useful in his own work. Many of them are from mineralogical and geological sources which, by and large, are likely to be more useful for archaeometallurgical work, as well as being more reliable and better informed on metallurgical matters, than purely archaeological sources.

The book as a whole, it must be stated, is poorly produced. As with so many Indian publications careless mistakes abound which the most elementary proof reading should have picked up. This means that one cannot place too much confidence in any particular number, spelling or even identification. On p.92, for example, the table of analyses has one item with, amongst other elements, 3.5% of antimony and 0.05% of tin. In the discussion immediately beneath, it states that 'it is clear it was made of an alloy of bronze with 3.5% of tin' (and incidentally there was claimed to be a 99.06% probability that the copper originated from a sulphidic ore). There are also many other blunt and unsubstantiated statements throughout the book, for example, on p.64 we learn that the presence of cuprite in copper metal indicates that it has been poled, and on p.106 that in the protohistoric period borax was used as the flux in copper smelting. A major drawback in a book containing so much data and so many places and cultures which are referred to repeatedly, is the absence of any cross references and of an index. Thus overall the book contains a great deal of new information but is sadly compromised by poor reliability and presentation.

Paul Craddock

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The lead legacy: the prospects for the Peak District's lead mining heritage by J Barnatt and R Penny. *Peak District National Park Authority, Bakewell, 2004, 120pp, A4, many illustrations and maps (in colour and black and white). No ISBN or price stated.*

This report has been prepared by the Peak District National Park Authority Lead Rakes Project in partnership with English Heritage and English Nature, funded by the Aggregates Levy Sustainability Fund. It highlights the ongoing losses of nationally, and in some cases internationally, significant lead mining remains, showing that only about a quarter of the original surface remains now survive in good condition. Its main aims are to provide inventories of regionally and nationally important lead mining sites and landscapes, to highlight the conservation challenges and opportunities they provide, and to explore ways of achieving their sustainable management for the future.

The report includes is a summary of the geological origins and the history of lead mining in the Peak District. This was one of the largest, richest and longest-worked orefields in Britain and was a major European supplier for many centuries. Lead has been mined at least since Roman times and exploitation was at its height in the 17th and 18th centuries, declining sharply in the later 19th century and effectively ending with the closure of the last big mine in 1939. Surviving remains include the workings and spoil heaps (lead rakes), ore-processing structures and ruined mine buildings such as engine houses that contained pumping engines. These are described and illustrated, with below- and above-ground photos, including aerial photos which clearly show the extent of the surviving lead-mining features. Nearly half the text comprises the tabulated inventories, location maps of the sites, descriptions of the archaeologically significant features at each site and a glossary.

This publication is a welcome initiative. It clearly sets out the extent of the surviving evidence for lead mining and processing in the Peak District, while at the same time assessing its vulnerability to current land use practices. It offers no panacea but is explicit about the need to educate and enthuse landowners and the wider public if this unique industrial landscape is to have a long-term future.

Justine Bayley