Book reviews

Dansk Jern: En kulturhistorisk analyse af fremstilling, fordeling og forbrug. [Danish Iron: A cultural analysis of production, distribution and consumption] by Henriette Lyngstrøm. *Det Kongelige Nordiske Oldskriftselskab, København, 2008, 242pp with many figures and tables, ISBN* 9878787483866.

This book covers the entire iron-working process from iron production to distribution and consumption. Even though it is written in Danish, there is a substantial 16-page summary in English and a 21-page summary in Russian. In addition, all figures and tables have trilingual captions in Danish, Russian and English.

The book is divided into seven sections, the first of which 'Danish Iron' defines the iron alloys available, *ie* pure iron, carbon steel and phosphoric iron. There is some discussion as to how each was created and used during the Iron Age and Viking Period. Slag is also discussed including that created during smelting and smithing processes, as well as slag inclusions trapped within iron artefacts. The next section, 'Danish Iron Research', reviews research carried out prior to the author's study and includes data from excavations, slag and artefact research, and also results from past experiments.

The following section provides an excellent introduction to Danish iron production, investigating the raw materials required and different smelting furnaces, drawing on archaeological evidence from known Danish sites. There are also some results from iron-smelting experiments and a comparison between Iron Age and Viking Danish iron production and that of other parts of Scandinavia.

Section four is entitled 'Distribution' and considers the process of primary smithing, converting blooms into bars, and describes the slag residues formed during this process; there are also detailed descriptions of the different types of bars found at Danish sites. As before, the author draws on data from Danish excavations and experiments but also compares Danish evidence with the rest of Europe and Scandinavia.

Danish iron consumption is then considered. The section first examines the evidence for secondary smithing slag from Danish excavations but also includes data from experiments. After introducing the various methods of manufacturing knives, the metallographic analysis of 64 iron knives, ranging in date from the Early Iron Age to the Viking period is discussed. There is a detailed comparison with other knives found on sites across Europe and Scandinavia. This section also reports on smithing experiments that used bar iron to create finished knives.

This is followed by 'Farmers, smiths and smelters' which provides a short summary of the previous chapters. The final section is a catalogue of archaeometallurgical results from the analysis of both slag and iron artefacts, predominately knives. For each sample there is a sketch of the artefact, artefact dimensions, a sketch and/or photo of the section showing microstructures and, for the iron artefacts, plots showing the amount of carbon and phosphorus present.

The sections are logically laid out and in each the iron product, as well as the slag residues, is discussed. The use of archaeological material and experimental data has allowed the author to fully investigate the processes involved. My only issues with the book are related to the metallographic analyses. While the identification of manufacturing methods is important, there is little mention of heat-treatment, which is equally important technologically. In addition to this, there are no hardness values for any of the artefacts in the catalogue and no summary elsewhere in the book, without which it is difficult for those doing similar research to make useful comparisons. Despite these omissions this is an excellent basic reference book to Danish iron production and use.

Eleanor Blakelock

Joseph Needham: Science and Civilisation in China. Volume 5: Chemistry and Chemical Technology. Part 11: Ferrous Metallurgy by Donald B Wagner. Cambridge University Press, Cambridge, 2008, 245x185mm, xxxiii+478pp, 48 plates, 139 figures, ISBN 13 978 0 521 87566 0, £120 h/b.

This long-awaited study, superseding the author's *Iron and Steel in Ancient China* (1993), is written in a style

which makes for an ease of reading not always achieved in the Needham series. The core of the book is made up of six chronologically-arranged chapters: the earliest evidence of iron making in China (wrought not cast—at variance with some earlier studies); the 3rd and 2nd centuries BC; the Han state monopoly; the late Han through Tang; the Song, emphasising the use of mineral fuel; the Ming. It ends with a summary of Chinese contributions to modern iron making. The theme which is emphasised throughout is the importance of iron goods to the Chinese economy, particularly for agricultural equipment and, within this, the extent of use of cast iron, with its superior durability, inconceivable in the West before the end of the Middle Ages. Semi-centralized production, in blast furnaces at ironworks large by early western standards, is shown as potentially dangerous to the state were such operations to fall into anti-government hands, explaining the creation of the Han state monopoly of iron production of 117 BC. Discussion of foundry practice is divided: the most detailed coverage, starting with the earliest methods, inherited from bronze casting, is in Section 4 (3rd-2nd centuries BC) with a brief discussion of cupola furnaces in Section 5 (the Han state monopoly). The chronological sections are preceded by a chapter entitled 'Preliminary orientations: the traditional Chinese iron industry in modern times'. This will be valuable not only to archaeometallurgists but to students of modern China, for it helps to explain the continuation or resurrection of traditional small-scale industrial methods during the Cultural Revolution.

The book is of particular interest for sections on malleable cast iron and co-fusion steel. One reason for the extensive use of cast iron in China was the development of heat-treatment which made the iron less brittle, namely the packing of castings into pots or chests, which were heated, probably for several days. Within this section the author summarizes evidence for the early development of such heat treatment in the West for, as he says, a history of western malleable iron production has yet to be written. This brief consideration (pp 159–170) is a useful first step, comparing European evidence from the 17th and 18th centuries with archaeological material from China.

The production and use of steel is covered in most detail in Section 6 (the late Han period), for it is thence that the best evidence for production comes. The co-fusion method, heating high- and low-carbon iron together in a crucible, is discussed, citing as evidence excavated crucibles considered to have been used for this purpose. The spread of the process beyond China is outlined, citing material from recent excavations in Turkmenistan and Uzbekistan. The author has found no evidence for the melting of steel in crucibles, as developed in the West in the 18th century, although he accepts that excavated ceramic fragments could have withstood the necessary temperatures.

A brief final chapter seeks connections between iron making in China and late-medieval western metallurgy, a section to which economic historians will turn. The author summarizes present knowledge of early blast-furnace technology in Carolingian Europe, in Sweden, Austria, Germany, Italy and, with some emphasis, northern Iran. He makes the case that with Sweden and Italy, at least, it is reasonable to suppose that merchants trading overland would be acquainted with the products if not the methods of Iranian ironworking, which are seen as derived, in turn, from further east. He concludes that cast iron was being made in the region in the 10th century, emphasizing the description of co-fusion by the writer al-Bīrūnī (AD 973-1048). This, and the recent archaeological research which has shown that such steel making was widespread in medieval central Asia, infers that cast iron was available, from blast furnaces. However, it has to be said that direct archaeological evidence from this region for a blast furnace of the size seen in China, or later in Europe, is still lacking, and it has to be asked whether the high-carbon irons used for co-fusion were in fact being produced in furnaces of bloomery size, with high charcoal-to-ore ratios in the charge. As always, there is the problem of definition, as to what constitutes a blast furnace or a bloomery. What the author does not address—even if only to provide a reasoned dismissal—is the question of whether Venetian merchants, who took advantage of the opening of direct overland trade routes from the Levant to China in the 13th and 14th centuries, had any role in observation and transmission of Chinese blast furnace operation and products.

The book is well illustrated. There are 48 plates, mostly in colour, bound together: particularly valuable and well reproduced are the selections from the gouache paintings of Chinese ironworks in the Bibliotheque Nationale, Paris. Of the 139 figures, the early-20th-century half-tones are understandably limited in definition; however, reproduction of the photograph of the medieval Swedish blast furnace at Lapphyttan, under excavation in 1985 (fig 136), is also poor, which is surprising and suggests that originals of some of the earlier material may not have been as bad as their appearance here might suggest.

There are two substantial (75pp) bibliographies. One

includes pre-modern Chinese and Japanese texts, the other lists modern publications in all languages. As Wagner's coverage of such a wide subject inevitably leads to summary treatment of some topics, these listings are vital, although one wonders about the accessibility of some of their contents. What they do show is how much work has been done by Chinese archaeologists over the last *c* 30 years, often under difficult conditions. The index is comprehensive and accurate.

David Crossley