

Book reviews

L'artisanat du bronze en Italie centrale (1200–725 avant notre ère): le métal des dépôts volontaires [Craftsmanship in bronze in central Italy (1200–725BC): The metal hoards] by Anne Lehoërff. *École française de Rome, Rome (Bibliothèque des Écoles françaises d'Athènes et de Rome 335)*, 2008, 280x220mm, xi+472pp, 243 figs/tables/plates (4pp in colour), ISBN 978-2-7283-0798-2, 108€ h/b. In French.

A number of studies on prehistoric Italian metalwork have been published recently, including the volumes by Anna Maria Bietti Sestieri and Ellen Macnamara (2007) and Mark Pearce (2007). When coupled with the ground-breaking work on Alpine copper deposits being undertaken by Gilberto Artioli *et al* (2008; in press), it is clearly an exciting time to be working in this area of archaeometallurgy.

This book—a study of central Italian metalwork from the late Bronze Age to the early Iron Age—is based on the author's doctoral thesis completed six years previously. At its heart is the metallurgical study of 65 samples (from 30 objects). The objects studied were mostly axes, fibulae and vases, drawn from the collections of four museums (at Tarquinia and Civit  Castellana in Italy, and in Britain, the Ashmolean and the British Museum). Objects from a number of other museums were also examined, but not sampled. However, the book appears to have considerably wider ambitions.

The beginning of the *Introduction* is written in fine prose (... a beautiful spring day ... with a river running majestically towards the south west ...) and presumably is intended to breathe a bit of life and imagination into what some may regard as a dry subject. It is certainly unusual to find such text in a non-fiction book, and it may grate with some readers.

Les lieux et les temps de l'action (Ch 1) attempts to 'set the scene', introducing the history of the archaeology of central Italy, the Etruscans, the mineral wealth of the region, and the many problems of chronologies. It has many illustrations, some of which are useful (although the first, a line drawing map of Europe rotated -135 , could be regarded as an interesting attempt to see the

world from a different perspective, as no doubt the author intended, but could as easily be regarded as quirky).

Tech n  et metallurgie (Ch 2) has a promising title but did not work for me, being somewhat general rather than specifically informative. It also suffers (as did the preceding chapter) from a vast amount of footnotes which makes it difficult to read. The footnotes do however contain many references (often to works in French). *Objets, archives et microscope. Les sources et les m thodes d' tude* (Ch 3) contains useful illustrations, especially line drawings of objects (many reproduced from earlier works) which shows the range of artefact types being considered. Some introductory metallurgy is also included.

Bilan technique des examens visuels (Ch 4) is perhaps the best chapter in the book, concentrating on methods of production and especially of decoration, and is illustrated with many black and white photographs.

  la recherche des techniques de fabrication. Les enseignements du laboratoire (Ch 5) describes the samples and acknowledges the problems associated with studying material that has been in museum collections for many years, most of it not from controlled excavations. An optical microscope was used to determine the metallurgical state of the samples and give an estimate of the degree of reduction the hammered artefacts have undergone, while an SEM+EDX provided chemical analyses. More could have been made of these results, especially for the minor and trace elements. For example, the reported analysis of a final Bronze Age winged axe from near Lake Como (BM registration no WG 1068) gives figures for the major elements, but not for the minor and trace elements which is surprising as analysis of the axe using ICP-AES (Bietti Sestieri and Macnamara 2007, 314) showed it contained 0.5% As, 0.55% Ni, 0.66% Sb among other elements, levels which should have been detectable by SEM-EDX; not detecting/reporting these elements is a concern and certainly will be a disappointment to some other analysts. The analyses are not discussed in detail and are not compared to others in the literature.

One might expect *Les modalités d'organisation et d'évolution de la production* (Ch 6) to attempt a general discussion on the organization and evolution of bronze production, but I struggled until rescued by a discussion of the LBA site at Scarceta reminded me of the importance of 'archaeo' in archaeometallurgy. *Les voies des changements techniques* (Ch 7) discusses the reasons for and the effects of the introduction of iron. It also attempts to put central Italy into context by discussing its cultural and geographical links with, for example, the Myceneans, Cypriots and Phoenicians, and Sardinia, Greece and areas beyond the Alps to the north.

The book is not the easiest to use; while there is a contents list, it is hidden at the back of the book in the French style, and the lack of an index is an irritation. Perhaps even more surprisingly is the absence of a summary in either Italian or English. Overall, I have been left wondering who the book was aimed at. I was initially expecting it to be more 'scientific' than it proved to be, and perhaps suspicious that the examination of a relatively small numbers of samples had been stretched to fill an overly-long 475 pages. I hoped that the science might have been fully integrated into a wider study but was, however, disappointed as scientific examination is hardly mentioned in the final two chapters or in the conclusions. A lot of work has gone into producing this book and one hopes it will be of some use to at least a small number of specialists working on material from this period.

There are no details on how to obtain the book on the website of the French School at Rome (where it is listed as forthcoming), and is out of stock on www.amazon.fr. The quoted price seems expensive, especially compared with the books by Pearce and Bietti Sestieri and Macnamara which retail for about £40 each.

Duncan Hook

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Die Produktion von Ferrum Noricum am Hüttenberg Erzberg [The Production of Ferrum Noricum at the Hüttenberg Erzberg] edited by Brigitte Cech. *Im Selbstverlag der Österreichischen Gesellschaft für Archäologie, Vienna, 2008, xii+294pp, A4, many plates, figures and tables, no ISBN, 35€.* In German with comprehensive English summaries.

This is the first substantial publication of a major project to study iron production from the Iron Age through to the quite recent past that has taken place at the Hüttenberg in Carinthia. The volume covers excavations that took place between 2003 and 2005 at Semlach/Eisner, the preliminary scientific examination of the production debris and the first series of experimental smelts. The excavations were directed by Brigitte Cech who is in overall charge of the project. Let it be recorded straight away that this is to some degree a strange, unbalanced compilation. The excavations are meticulously presented in accurate detail together with a comprehensive pottery report compiled by Wolfgang Artner on research which, as on so many Roman sites, produced more precise dates than the physical methods employed. Preliminary experimental smelts were carried out in 2007 and are reported by Erich Nau, Aude Mongiatti and Thilo Rehren. Then there are the preliminary scientific examinations reported by Herbert Presslinger with the reconstruction of the processes by Edmond Truffaut. The latter are also reported in meticulous detail as if based on established fact, but actually the main conclusion of the whole exercise, namely that the Romans were working an advanced blast furnace smelting process producing a liquid iron-manganese alloy from which they made steel, is based on a single chance find made well away from the excavations. Before discussing this further it is necessary to outline the project and describe this volume in a little more detail.

The Roman *Noricum* iron has always been famed and previous metallographic examination of contemporary ironwork from the important nearby cult centre at Magdalensberg has shown that many pieces were of high carbon steel, correctly heat treated to give martensitic structures that warranted the high reputation of the steel (see for example Tylecote 1987, 169), and the metallographic examination of more pieces is reported in the volume under review. The steel was smelted from the limonite ores found in Carinthia and Styria which, in common with many of the ores smelted to make the so-called natural steels in Europe, were manganese-rich (Tylecote 1987). These ores were mined by the Romans at Lolling and Feistawiese in Styria as well as at the Hüttenberg in Carinthia, and were mined again from at

least the end of the medieval period until quite recently. In the post-medieval period the ores were smelted to give the manganese-rich *Spiegeleisen* that could be resmelted to produce a good quality 'natural' steel, the famed Styrian steel. Latterly, the steel was used as the feedstock for the Austrian crucible steel industry. But what processes were used in antiquity?

Some early sites had previously been excavated (Schmid 1932) and experimental smelts carried out by Staub *et al* (1965), but this had still left a great many unanswered questions and thus a major project was set up to establish how the *Noricum* steel was produced, and to set the industry more firmly in the local and broader Roman context.

An area of some 472 sq metres at Semlach/Eisner in the Hüttenberg was excavated and revealed extensive remains of smelting and smithing. These could be dated by a variety of means between the second half of the 1st century BC and the mid 4th century AD. Although the superstructures of the furnaces were missing above the level of the Roman surface, because the furnaces were set quite deeply (typically 0.8–1.1m) in the ground to create a sunken working area in front, they were in fact quite well preserved. The slag was tapped through an opening in the furnace into the sunk area, and Cech believes that the bloom would also have been removed through this opening. There was certainly no provision for the casting of the putative cast iron from these furnaces. Above ground they were probably shaft furnaces and at ground level had internal diameters of 0.6–0.8m. There were inlets for air at ground level on the opposite side to the sunken slag-tapping area. The excavations produced no ceramic tuyeres and thus it was suggested by Truffaut (p. 94) that the furnace was not blown with bellows but instead relied on natural up-draught. Given the relatively small size and preserved height of the furnace compared to known natural draught furnaces, this seems inherently unlikely. The regularly-spaced two or three air holes in the furnaces seem more likely to have accommodated tuyeres from bellows, that presumably must then have been of iron. The previous and current smelting experiments used bellows.

Immediately alongside the furnaces were the smithing hearths where the blooms were forged into billets. As well as the ubiquitous slags two fragments of iron bloom were found in the excavation, both of which were ferritic iron with little or no carbon; this did not suggest the production of natural steel but was similar to the iron produced in the experimental smelts. The slags are mainly olivine and wustite, and contained about 50–60%

FeO, 25% SiO₂, 8% MnO and a little alumina. Thus the combined FeO+MnO content is almost 70% in some instances, which apparently gave a liquidus temperature of around 1500°C. It seems inconceivable that the body of the furnace could have been made hot enough to allow the slags to be tapped at such temperatures. These are, after all, fairly standard clay-lined bloomery furnaces, producing quite unexceptional solid blooms.

The main problem, though, concerns the overall reconstruction of the process by Truffaut where the evidence is provided by a third piece of iron. This is described as a piece of badly corroded bar iron, although apparently slag-coated. Metallographic examination showed this to have been molten and moreover to contain lamellae of graphite. It is grey cast iron, familiar all over Europe for the past three or four centuries. If, as assumed in the report, this was produced by the Romans, then it would be of great importance; however, it was found on the surface of a slag heap at some distance from the excavations. In short it was a chance find and its significance is minimal. One can be a little sympathetic for Truffaut, a retired metallurgist, for not realising the significance of this but less sympathetic with Cech, an archaeologist, for apparently being unaware of the dangers of using such unstratified and thus undateable material as the basis for the reconstruction of the process, especially as the iron excavated from secure contexts was so different. What was the point of carrying out painstaking excavation if the overall process was to be based on a chance find picked up from the surface?

Grey cast iron is typically a product of high temperature processes, usually associated with the use of fossil fuel. Under these conditions a few percent of silicon dissolves in the iron and this in turn promotes the formation of graphite. Unfortunately no chemical analysis was given for the piece but two other examples of Roman cast iron are cited in the report to support the process as described by Truffaut; these are both from Britain (Tylecote 1986, 167–8, Table 83) and have recently been re-examined by Craddock and Lang (2005). One piece of cast iron was from Tiddington just outside Stratford-upon-Avon, and was an unstratified find, and is almost certainly modern. The other piece was from Wilderspool, from the excavation of a Roman iron smelting site. The rough, corroded piece of grey cast iron contained about 0.5% sulphur, the accompanying slags also contained sulphur, and coal was found all over the site. This rather suggests the Wilderspool iron really was an attempt by the Romans to smelt iron with coal. Thus neither cited piece provides much support for the piece under discussion here, where charcoal was certainly the fuel

used. As liquid iron was produced in quantity in the Hüttenberg from the post-medieval period onwards, it seems much more likely that the piece is not Roman but more recent. In fact the postulated reconstruction of the process follows the recent processes rather closely (Stansbie 1907, 150–3; Barraclough 1984, 164–70).

A more likely explanation of the role of the manganese in the formation of the Roman *Noricum* steel is that the more stable manganese oxide formed a substantial proportion of the slag, replacing the wustite, FeO, in the slag. During the smelting and smithing processes the slag was intimately mixed with the iron and wustite had a tendency to decarburise the iron, whereas MnO would not react to decarburise the iron. The slags at Semlach seem rather low in manganese, and this is reflected in the almost carbon-free iron stratigraphically associated with them.

This is a well produced volume, excellently and comprehensively illustrated with both photographs and drawings, although an index would have helped. The text is in German, but there are very extensive summaries in English so it is quite easy for non-German readers to follow. Thus, overall, the excavations have revealed an important Roman iron smelting site, but the interpretation of the finds needs careful reappraisal based on the excavated material alone.

Paul Craddock

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The charioteer and the hunters: a masterpiece of ancient silversmithing by J Chamay, M Guggisberg and K Anheuser. *Chaman, Neuchâtel*, 2007, 236pp, 250x280mm, 135 colour figs, ISBN 2-9700435-4-8, 55€ h/b. Parallel text in French and English.

This beautifully-produced book describes both the

manufacture and the iconography of the decoration of a large, late Roman silver dish, displayed in the Musée d'art et d'histoire, Geneva. The object dates to the late 3rd or early 4th century and weighs 3.65kg (in its restored state). Its diameter is 527mm, with a foot ring on the outside and a central medallion 143mm in diameter on the inside of the base; a 42mm wide frieze runs round the horizontal rim.

The medallion shows a chariot race and the image is explained and compared with many other classical depictions on coins, gemstones, mosaics, ivories and carved stone. The frieze is made up of six hunting scenes which include 19 human figures and 27 assorted animals; it appears to be an illustrated treatise on hunting, showing the animals in their native habitats. Again there are comparative images from other media that aid our understanding of the activities depicted. Each page of the lengthy description is illustrated by the relevant scene from the dish so there is no need to constantly switch between the text and the main illustrations — of which more later.

Technical examination suggested the dish was made by casting the central medallion with a plain rim which was then hammered out into thin sheet metal; this was then lathe-turned to produce the curved profile of the dish. To this was added a separate casting of the relief-decorated rim which was probably hard-soldered to the dish. X-radiography showed the relief of both the medallion and the rim is solid metal, not repoussé work, and also demonstrated the characteristic variations in thickness of the hammered sheet metal. The figures and other decorative elements were enhanced with engraving, chasing and punching. Details of the designs were gilded by mechanically attaching gold foil, the edges of which were held in grooves cut into the silver; the magnified images clearly show how this was done.

The *piece de resistance* of this publication is however the photograph of the frieze round the rim. This has been digitally-enhanced and then enlarged to turn the narrow arc of the original into a rectangular strip 4.4m by 180mm, spread across 26 concertina-folded pages which allow the continuity of the image to be fully comprehended. Looking at it one can see details that would normally only be visible under a binocular microscope, so studying the technology and iconography can now be done from the comfort of your own armchair!

A great deal of care has gone into the design and production of this book, and it makes fully available the results of scholarly study of a spectacular piece of

late Roman silver. While applauding and enjoying the presentation, I do wonder if the resources that went into the study and publication of this one unprovenanced object could have been more usefully employed in studying other, better-provenanced archaeological finds.

Justine Bayley

Story of the Delhi Iron Pillar by R Balasubramaniam. *Foundation Books, Delhi, 2005, 220x140mm, xii+99pp, 40 plates, ISBN 81-7596-278-X, £9.99 (in UK).*

The Delhi Iron Pillar is arguably the most famous piece of archaeometallurgy in the world. It has been the subject of international debate for almost two centuries, with speculation on almost every aspect of its being. These range from where it had originally stood, its age, how and of what it was made, and perhaps most intriguing to investigators over the years, why has the iron not corroded? Hardly surprisingly the Pillar has inspired very many publications, from the mundane to the mystic, that have provided a great deal of information, but which still left many questions unresolved.

For the past few centuries at least the pillar, seven metres tall, six tons in weight, has stood in the open courtyard of the Qutub mosque complex some 15km south of Delhi. Until the 1990s it was quite unprotected and the visitor could not only touch but was encouraged to make a wish whilst grasping the Pillar. One stood, back to the Pillar with arms around it until one's fingers touched behind it, helped by the resident small boys. By the time one had been manoeuvred for the souvenir photograph one's hands and clothes had been in pretty intimate contact with the surface, ensuring that a band about 50cm wide about a metre above the ground was not just uncorroded but highly polished (and actually revealing a lot of interesting detail of weld lines and repairs etc). At last in the 1990s the Archaeological Survey of India, who have overall responsibility for the monument, decided that the pillar should be restored and then fenced off from the public. The opportunity was taken to fully examine the pillar while it was encased in scaffolding, and this was undertaken by Professor Balasubramaniam. This study has succeeded in answering the outstanding questions and resulted in a series of publications including a major monograph (Balasubramaniam 2002), all succinctly summarised in the quite excellent book reviewed here. You reviewer must start with a slight caution, the work is intended as a guide for the intelligent lay person. Prof Balasubramaniam is head of metallurgy at the renowned Indian Institute of Technology at Kanpur and is used to teaching engineering undergraduates, and one rather

suspects that these are the intelligent lay persons he unconsciously had in mind. The *Story of the Delhi Iron Pillar* is most certainly not a dumbed down tourist guide, instead it introduces and expects the reader to follow many concepts of physical metallurgy, chemistry and corrosion science; this is a serious work of scientific scholarship.

The book's five chapters take the reader logically through all aspects of the pillar. First its history is dealt with: who is likely to have ordered its construction, where did it originally stand and what could its function have been. From the inscriptions carved into the pillar's surface it is likely to have been commissioned by the Gupta monarch, Chandragupta II Vikramaditya in the middle of the 4th century AD. It was dedicated to Vishnu and was set up on a hill at a place called Vishnupadagiri, which is probably to be identified with the present day ancient shrines at Udayagiri which is about 50km to the east of Bhopal in central India, many hundreds of kilometres south of Delhi.

The second chapter is a detailed description of the pillar. The column itself has always been correctly understood as a solid shaft of wrought iron, but it is surmounted by a complex bell capital. Due to its relative inaccessibility there was much more uncertainty how this had been made; Tylecote (1984) made the not unreasonable suggestion that it could have been a casting. Detailed examination has now shown that it is made up of a number of forged rings that had been shrunk-fitted while hot over an iron cylinder set in the top of the pillar itself. On the top pedestal there is a rectangular slot that clearly once held yet another component. Balasubramaniam makes the plausible suggestion that this would have been a large nakshatra-chakra wheel. Such wheels were regularly placed on top of pillars from the time of the Mauryans, and the surviving example from Sarnath, near Varansi is familiar now as the emblem of the Republic of India.

Chapter 3 describes how the iron would have been smelted and how the lumps of solid iron would have been welded together to form the pillar. The surface was then painstakingly chiselled and polished to its present high finish, but the bottom metre or so that was always intended to be buried is still in its original roughly-hammered state.

The final chapter addresses the problem of why after over 1500 years' exposure it shows no obvious corrosion (above ground that is; the buried portion is quite corroded). This has been the subject of speculation for well over a century with explanations ranging from the supposedly dry environment in which the pillar has

stood to now-lost secret ingredients in the iron. In fact the local environment is not particularly dry; your reviewer stayed in the vicinity and even in the dry season the humidity at night is very high, causing parked cars to be covered in condensation. The iron itself is a rather pure wrought iron with about 0.1–0.2% carbon and 0.2–0.5% phosphorus as the only significant elements in the iron, plus the usual slag inclusions, a not unusual composition for bloomery wrought iron in India or elsewhere. There are several other ancient pillars and beams at locations around India, some near the sea and others deep in the tropics, that are also uncorroded. Thus most serious studies such as that by Bardgett and Stanners (1963) were previously not able to offer an explanation.

Balasubramaniam has studied the problem in great detail for a number of years and has convincingly shown that the reason for the lack of serious corrosion is the phosphorus in the iron. On exposure this rapidly forms a coherent passivating layer of hydrated iron phosphate on the surface. Observations of the areas once kept polished by tourists' embraces, but now protected, show that they initially became covered in the familiar orange-red rust but over the course of about three years the layer of iron phosphate formed and the surface began to resemble that of the rest of the Pillar. As Balasubramaniam points out, phosphoric irons, although quite common in antiquity, have been anathema to metallurgists and engineers for well over a century because of their tendency to fail in use. Thus their properties, including that of corrosion-resistance, have never been fully explored or appreciated.

This is an excellent book, produced to the best western standards and with none of the mistakes that have so often bedevilled Indian publications in the past. The work itself is clearly and well argued and presented. Prof Balasubramaniam's writing style and the clear figures and photographs make the work easy to read and understand.

Paul Craddock

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Medieval Islamic swords and swordmaking: Kindi's treatise 'On swords and their kinds' by Robert G Hoyland and Brian Gilmour. *Gibb Memorial Trust*,

Oxford, 2006, 250x175mm, vii+216pp, 12 B&W figs, plates and photographic reproductions of original manuscripts, and annotated Arabic script version of *Kindi manuscript*, ISBN 0 906094 52 6, £30 h/b.

Some years ago whilst being filmed for a TV documentary on Japanese swords I was placed under considerable pressure to provide a sound-bite that these were the finest blades ever produced. No opportunity was presented to compare them with the artistry of the Anglo-Saxon and Viking pattern-welded blades, the efficient killing power of blades from Solingen, Toledo or perhaps the late European cavalry swords. The exotic Indonesian *krises* similarly went unmentioned and likewise, perhaps the most serious rival for any such title, the swords of central Asia and the Indian subcontinent which utilized the technology of liquid crucible steel in their production—the subject of Hoyland and Gilmour's book.

Throughout history swords tended to be the weapon of the wealthy elite, who could not only afford high quality craftsmanship and artistry, but also the materials required to give a sword strength, flexibility, and hardness of edge. The wealth of information on swords from Europe and Japan contrasts with a paucity of technological information, at least until recently, on blades, and other steel artefacts from the Middle East, central Asia and the Indian sub-continent. It is a part of the world where surviving early swords are relatively rare. Ancient blades were not revered and preserved as in Japan, they were not generally deposited in burials as in pagan Europe, and in regions such as India, colonial powers actively discouraged the possession of weapons by the population. Where surviving artefacts are scarce, the opportunities and willingness to undertake 'destructive' technological analysis are also rare.

Occasional accounts by travellers exist for more recent years, but what of contemporary accounts written at a time when sword making flourished? Where literary sources do exist it takes a rare combination of translator and technologist to extract meaningful information. It is therefore a considerable pleasure to find a publication which achieves this, through Hoyland's linguistic skills and Gilmour's archaeometallurgical experience. More pleasing and perhaps surprising, given the title, is that the publication covers not only the text of Kindi's *On Swords and their kinds* treatise, but three other sources as well: a translation of F W Schwarzlose's lengthy compilation of references to swords in Arabic poetry, a brief note on the metallurgically relevant passages of Jābir ibn Ḥayyān's *Book on iron* and an extensively annotated

translation of that part of Muḥammad al-Bīrūnī's *Sum of knowledge on precious stones* which discusses iron.

Kindi was born about AD 800 and wrote for the Abbasid caliphs in Baghdad. This was an immensely fertile intellectual period, combining the translation into Arabic of earlier foreign texts with new research. Kindi was clearly a scholar of immense breadth, compiling well over 200 treatises on subjects as diverse as philosophy, arithmetic, astronomy, politics and natural phenomena together with work on more down-to-earth topics such as pigeons, bees and cooking. He produced two treatises on swords, *On swords and their kinds*, and also, *That with which swords and iron are treated so they are not broken or blunted*, which survives in one far less complete copy. Our first clue to the scope of his knowledge comes from the map on the inside cover which names the geographical regions to which Kindi refers, not only the Islamic heartlands of the Middle East and central Asia, but the Frankish Empire to the north-west, China to the north-east, and to the south the Malay peninsula, India and Sri Lanka.

In describing swords from this huge region, Kindi provides a classification that shows detailed knowledge of the methods of manufacture of the ferrous alloys used in the blade, but also of their quality. For the modern metallurgist with a scientific understanding, his terminology is unfamiliar and at first baffling, but is clearly consistent. Iron is divided into two main categories, mined (*maḍdanī*) and unmined (*laysa bi-maḍdanī*). The former refers to products of the direct production process, such as the bloomery, but could also include cast iron. The latter implies products of a secondary production process, such as the crucible process. Mined iron was further divided into hard (or male) iron (*shāburqān*) and soft (or female) iron (*narmāhan*), the hardness, or perhaps hardenability, equating to the amount of carbon present. Composite iron-steel blades are referred to as *murakkaba*. Kindi correctly identifies this as the usual method used by Frankish smiths and his description is extremely useful. Most of the swords described by Kindi are classified as *fulādh*, an 'unmined' iron produced in crucibles, and regarded as a purified form of iron. Gilmour interprets this as the product of co-melting (white) cast iron and low carbon bloomery iron. However, in one of Hoyland's notes concerning Kindi's second, more technical, text a recipe is quoted giving very precise ingredients, which suggest a significant content of organic matter, presumably present to promote carburization:

'For the Indian swords one takes a *manṇa* of *narmāhan* and the same amount of *shāburqān*, break

into small pieces, put in a furnace, and add to it one *manṇa* of magnesia, two dirhams of kernels of myrobalan, five dirhams of *andarānī* salt, the same amount of Khurasani borax, a handful of peel of bitter pomegranate sifted with egg-white'.

To denote quality Kindi divides the *fulādh* blades into three groups. The best '*Aṭīq*' translates literally as 'ancient', but clearly refers to blades of contemporary manufacture. In contrast the most basic blades are described as *muḥdath* or modern, and between these two lies a class of blade neither ancient nor modern. Interestingly, many of the poorer-quality blades are described as made from imported iron, suggesting widespread trade networks for raw materials. Certain manufacturing centres also had reputations for attempting to pass off their blades as if from more prestigious manufacturing regions, particularly as the most highly-regarded Yemeni blades. Into this typology are fitted a considerable number of swords of different origins, though how a centre maintained its quality and reputation, when presumably many smiths contributed to its output, is not considered. For each different type we often have details of the blades' physical dimensions, their heat treatment, polishing, etching and patterns visible in the watering. But the assessment of quality goes deeper, making judgments on compactness, firmness and flexibility of the metal, its polish and the purity of the fracture surfaces—qualities that predict the effectiveness of the weapon in use.

Chapter 4 comprises an English translation, by Mark Mühlhäusler and Robert Hoyland of 'The weapons of the ancient Arabs as presented in their poetry: A contribution to the history of the Arabs and to Arab lexicography' by Friedrich Schwarzlose. This is a compendium of references to swords in Arabic poetry, originally published in German in the 19th century. At first only browsing this with little expectation of any metallurgical insight, following its initial references to how swords were worn and used in battle and the widespread references to swords as metaphors and in proverbs — I particularly liked *the injustice of relatives is more painful than the sword*. We do learn of the Arabs' preference for Indian swords above all others, or perhaps for swords forged elsewhere in the Indian manner, with blades made in Yemen and the Syrian city of Aryah being particularly praised. It would seem that an Indian sword was synonymous with an excellent blade. At this point Schwarzlose unexpectedly reveals his metallurgical interests by noting that 'in India swords of excellent quality were cold-forged from so-called wootz-steel (a kind of cast steel)'

In contrast to Kindi's treatise, the poets do mention the names of particular eminent swordsmiths. They also seem to consider that old swords were not of any greater quality than more recently produced ones. However, the distinction between male iron (steel) and female iron (low-carbon iron) is in agreement with Kindi's terminology. Blades combining these two materials are termed *mudhakkar*, or made male. This class of weapons is apparently clearly contrasted with the higher-quality watered, *ma'thūr* blades, but the following discussion would seem to suggest that there was at least popular confusion between the two types, with both terms sometimes being used for a single blade. Schwarzlose also seems too cautious to wholeheartedly accept the use of crucible steel for sword manufacture, although from his notes he was well aware of Anosov's replication of watered crucible steel of the type the Russian engineer believed to have been used in oriental blades. Schwarzlose suggested that such details of manufacture would not be widely known, although the treatises included in this volume make clear that this was not the case. The poets do provide considerable detail on the filing, hardening (edge only), grinding and polishing of the blade and clearly had a fascination for the watered patterns revealed by this painstaking work.

The first appendix contains an intriguing extract from the works of Jābir ibn Ḥayyān together with a commentary from Brian Gilmour. Jābir, an alchemist, describes firstly the smelting of iron ore, together with an alkali flux, to produce what is clearly cast iron. The second part of the passage is more ambiguous; the products of the first process are subjected to prolonged heating prior to casting in the form of steel rods or 'steel like ostrich eggs'. As the authors note, the process has previously been interpreted by al-Hassan and Hill as a refining process, *ie* decarburization of cast iron only. However, Gilmour suggests the process may parallel the crucible smelting witnessed by Massalski in 1841 in what is now Uzbekistan, not least because both descriptions emphasize the bubbling or boiling noise. In such a process both low-carbon iron and cast iron would be placed in the crucible.

In the second appendix, Muḥammad al-Bīrūnī's writings on swords are presented and interpreted. These come from a chapter on iron in his treatise 'sum of knowledge about precious stones'. Bīrūnī (AD 973–1048) bases his text on a number of older references, rather than first-hand observation, and as a result sometimes lacks the clarity of meaning found in Kindi's writing. The division of iron between male (*shāburqān*) and female (*narmāhan*) is again clear. However, the latter is divided

between 'the substance itself' and its water, the *dūs*, which is evidently cast iron produced as a by-product of the smelting furnace. As a hard material, noted by Bīrūnī as being brittle, it is surprising that he does not categorize this as *shāburqān* as Kindi does. The two materials are combined in a crucible to form watered steel, *fūlādh*. Herat is particularly noted for its steel of this type where it is referred to as eggs, due to the shape of the crucible in which it solidifies, and Bīrūnī states that this is the steel used for Indian swords. When the two components are equally melted in the crucible the product is homogeneous steel, *shāburqān*, suitable for making files. It is when the two are improperly mixed, that watering (*firind*) can be seen and this is the steel sought for sword blades. In a later section we learn how watering may be hidden by heating and polishing and how people in India use iron sulphate to bring out the watered pattern. For quenching, we learn that smiths used a mixture of clay, cow dung and salt to protect the body of the blade so that the edges were preferentially hardened.

The use of watered crucible steel is contrasted with Russian pattern-welded blades, whose descriptions match metallographic studies of Viking swords. Bīrūnī described these as having *shāburqān* edges and *narmāhan* cores and a web of the two materials welded in such a way to produce 'wonderful things, just as they intended and wished for', as compared with *fūlādh* blades where the design is achieved 'not by desire, but rather by chance'.

Bīrūnī's most detailed account of crucible steel manufacture is taken from an earlier text by Mazyad ibn 'Alī, a Damascan smith, a source which he says was also used by Kindi, but which differs from the one included above in stipulating five *raṭls* of horseshoes and nails for the *narmāhan*, no mention of *shāburqān*, but ten *dirhams* weight of antimony, golden marcasite (iron sulphide) and powdered magnesia. Interestingly, the addition of 40 dirhams each of myrobalan, pomegranate peel 'the salt of dough' and pearl shells, occurs later, after the iron has melted and an hour before heating ceases and the eggs are left to cool, which again raises the question as to the effect of this organic-rich mix on the carbon content of the steel.

The final appendix comprises photographic reproductions of the two surviving manuscripts (Leiden Or. 287 and Istanbul 4832) on which Hoyland based his translation, and the volume is completed with a glossary of metallurgical terms, both Arabic, as used by the treatise writers, and modern, as used by Gilmour to explain the processes and materials in contemporary scientific terms.

To sum up the value of this book, we must consider the current state of knowledge of the forging of swords, and of the manufacture of high-quality, superior ferrous alloys needed for these weapons. The European sphere is relatively well understood from metallurgical studies of excavated material. In the Far East, Japanese blades have been extremely well researched, though Chinese and Indonesian traditions require more attention. Geographically between the two lies a region of far more advanced metallurgical technology, but one more obscured by modern myths than enlightened by sound scholarship. Some metallurgical production sites, such as Merv, have now been explored, and watered steels have been metallographically and analytically examined, particularly by Gilmour himself and by Verhoeven and his fellow researchers, respectively. However, the enormous scale and rich variety of traditions of the region of Islamic influence, where metals and finished swords were clearly widely traded, makes the few studies based solely on archaeological or later material seem very inadequate. The importance of Kindi's work, as Gilmour points out, is to enable us to construct a framework for how iron and steel were made and exploited over much of the known world around the end of the first millennium AD. In bringing his and these other texts to the attention of researchers and making them accessible, both through Hoyland's fluent translation and through Gilmour's knowledgeable interpretation, the authors deserve much praise.

Dave Starley

Meols: The archaeology of the north Wirral coast. Discoveries and observations in the 19th and 20th centuries, with a catalogue of the collections by D Griffiths, R A Philpott and G Egan. *School of Archaeology, University of Oxford (OUSA Monograph 68), Oxford, 2007, A4, xxii+498pp, many figs and plates (a few in colour), ISBN 978-1-905905-03-4, £30 h/b.*

The construction of sea defences at the end of the 19th century put an end to the erosion of the north-west coast of the Wirral peninsula around Meols. It also stopped the deposition of objects of all dates that had been continuously eroded out onto the beach. These archaeological finds had been collected throughout the 19th century, and many of them were published by Hume in his book, *Ancient Meols*, in 1863. My copy of his book is leather-bound with gold tooling—inherited some while ago from J M Keefe, then an HMS member—and handsomely illustrated by 32 plates and several hundred wood engravings.

The volume under review has updated and expanded Hume's work. It catalogues over 4000 objects, most of them now dispersed between five museum collections, and uses them to reconstruct the settlements in and around the area that has now been lost to the sea. The copious illustrations are mainly monochrome photographs which may lack the crispness of the engravings in Hume's book but do have the virtue of being printed to a known scale. The majority of the finds are metal, and belong to the medieval and post-medieval periods though smaller numbers of prehistoric and Roman objects were also found. For many object types this assemblage is among the largest in the country, outside a few major urban centres, so the book deserves consultation when parallels or identifications of 'mystery' objects are being sought.

There are only a few objects identified as evidence for metalworking: small collections of waste or scrap metal (copper alloy and lead), two crucibles, two bone-ash cupels, pieces of haematite used for polishing, parts of two pairs of blacksmiths' tongs and a pair of pincers. However, there is discussion of 'Roman manufacturing at Meols?' (p. 395), the English-imitative variety of the Hiberno-Norse coinage found is used to suggest that Meols is the most likely location for the late 10th- to early 11th-century mint that produced them (p. 349), and the small flat-bottomed crucibles (p. 262) and the cupels (p. 223) suggest some post-medieval metalworking.

The potential of accurate material identifications to contribute to the project was appreciated, and a group of objects was selected for analysis by Matthew Ponting. In Appendix 2 he reports the mainly qualitative XRF analyses of about 90 metal objects, most of later medieval date, and compares his results with those for groups from other parts of the country. Nearly two-thirds of the 46 copper-based objects were mixed alloys containing significant amounts of both tin and zinc; unalloyed tin, unalloyed lead as well as tin-rich and lead-rich pewters were found among a further group of 33 small objects, while all the six silver objects were shown to have compositions that approximated to modern sterling silver, though the higher lead and gold contents suggest earlier dates. The 60 glass beads and vessel fragments were almost all high-lead glass, containing around 70% by weight lead oxide; this composition dates the beads to the 10th–11th centuries and the vessels to the 13th–14th centuries. Though no metallography was carried out, examination of X-radiographs identified weld lines in twelve (of about 100) late medieval knives which suggest they had steel cutting edges butt- or scarf-

welded onto a softer iron back.

This re-publication of the finds from Meols shows how much information can be obtained from a carefully planned project. However, it is important to remember

that although the objects did not come from controlled archaeological excavations, the 19th-century records which link them to Meols are vital, as without them no site-specific interpretations would have been possible.

Justine Bayley