Book reviews

Metal Plating & Patination edited by Susan La Niece and Paul Craddock. *Butterworth-Heinemann Ltd, Oxford. x+305pp, figs, illustrations and index. ISBN 0 7506 1611 3. £49.50.*

There has been a growing trend in recent years for the surfaces of artefacts, their visual appearance, texture and colour, to be given greater consideration. After all, as Craddock points out in the preface to the book, inevitably one's first impression of any artefact is its surface and from antiquity to the present day the finish and colour of artefacts has often equalled the importance of function. This dwelling on surface appearance is almost subconscious but is a reflection of the status and individuality of the owner as well as changing fashion.

The perceived interest in the surface finishing of artefacts in antiquity prompted the organisation of a meeting on the subject in June 1990, mainly of invited speakers. This book is the product of that meeting but it is no ordinary conference proceedings. It is a comprehensive, well-produced volume which includes photographic illustrations of excellent quality with 12 pages of colour plates (a vital component for a book concerned so much with colour). The publishers have a good track record of authoritative books on archaeological science or conservation themes.

The main theme of the book, as the title indicates, is concerned with surface finishes applied to metals. The finishes considered are principally of inorganic materials although some organic coatings, *eg* lacquering, are covered by Birnie. They range from subtle or superficial chemical treatments to applied platings. Treatments from the 2nd millennium BC through the medieval period to the 19th century and from the Mediterranean, the Near and Far East and the Americas are considered. Inlaying as such is not included unless this forms part of the overall decorative process as in the case of silver inlaying of Bidri ware and Wu Tong. The primary 'function' of many of the processes considered is decorative although in one case, bower-barffing, the main intention was protective but the finish was nevertheless considered aesthetically pleasing.

The volume opens with a review by Hughes of the concepts, intentions and practicalities of patination, both natural and artificial, mainly on copperbased metalwork. It is notable that the principal chemical constituents of patina developed by various artificial techniques, including the direct application of chemicals, immersion and packaging, are often the same as those produced under natural conditions. The more exotic sulphate and nitrate compounds are however less common on artefacts from buried environments and often the structure of such natural patinas, when seen in section, will be different. This paper, but particularly the following two papers by Born and by Craddock and Giumlia-Mair, also consider the intentional patination and colouring of Classical statuary. Were such artefacts kept in their natural metallic state or were they patinated or toned artificially? Conflicting conclusions are apparently possible from the evidence provided by contemporary description and illustration and also by the composition of the patination on artefacts. The difficulty with relying on the surviving or current patination are of course the unknown effects of the environment and thus this must be unreliable evidence. On balance, deliberate patination of Roman statuary does not seem to have been normal practice. The overall evidence would suggest that no consistent policy was practised; some statues were kept clean and possibly toned with oil whereas others were allowed to develop a natural patination according to individual taste.

Ogden next deals with ancient goldwork, particularly jewellery, considering the various methods which could have been used to modify its colour and texture. Although he finds plenty of evidence for the use of different coloured gold alloys there is no clear cut evidence of deliberate surface enrichment and he considers that in general this is a natural effect. This would not apply to the base gold alloy *tumbaga* from South America however which was intentionally enriched (see Bray). He concludes that most ancient goldwork was intended to have a shiny surface finish. Ogden also presents results of the examination of an example of one of the Mycenaean daggers with gold inlaid into a black panel. After many years of speculation about the nature of the black finish of the central panel of these daggers the panels are shown to be alloys analogous in composition with shakudo-type alloys with a typical cuprite finish.

We return to copper-based alloys with two papers by Zhu and He, and Meeks on mirrors and their patination, particularly the black patina observed on Chinese mirrors. Both conclude that this is a natural phenomenon of a tin-rich surface, but whereas Zhu and He postulate applications of tin to the surface, Meeks finds no evidence for this.

A group of four papers now consider related black-patinated copper alloys: Hsmn-Km, Corinthian bronze, wu tong and shakudo and other analogous Japanese alloys. Craddock and Guimlia-Mair bring together the literary and artefactual evidence for black patination in antiquity reconsidering and refining translations of some of the texts and adding new analyses. All these materials can be shown to be compositionally related, relying on a copper-based alloy containing 3-5% gold often with small amounts of silver and arsenic, although wu tong is constructionally somewhat different being a composite material. Craddock and Guimlia-Mair explore the possibility of a developmental link in the geographical dissemination of knowledge about its production and suggest that it had a single origin in the 2nd millennium BC in the western Mediterranean. From here it gradually spread both eastwards and westwards.

Another black-patinated material, Indian bidri, is described by Stronge, with an appendix on contemporary production by Craddock. This material, being a zinc-based alloy, is of course quite different from shakudo-type alloys and seems to be confined to very restricted areas of the Indian subcontinent. There are as yet no known examples of the copper-based shakudo type alloys from India although the early literature describes similar materials.

Patinated metalwork of more recent manufacture are considered by Birnie (scientific instruments), Goodway (19th century bower-barffing process for iron) and Rudoe (oxidised 19th century silver). The latter describes the toning of silver predominantly brought about by the production of, amongst other specie, a surface film of silver sulphide. Calling this 'oxidation' sounds a misnomer but to a chemist this is an entirely appropriate term for describing any reaction which leads to the loss of an electron, in this case the conversion of Ag to Ag^+ as a result of forming Ag_2S.

The remaining papers consider the application, or formation, of metal platings and include gilding (Oddy; Bray, who also describes platinum cladding; Jett), silvering (La Niece; Turner, Sheffield plating; Zwicker *et al,* on coin forgeries), tinning (Meeks), copper on iron (Corfield) and the history and development of electro-plating (Raub; Child).

Oddy reviews all forms of gilding to the end of the Roman period but it is interesting to note the early history of fire-gilding in the west. Whilst there is little doubt that fire-gilding originates in China in about the 4th century BC, the earliest regular use in the west was assumed to be Roman, from about the 2nd century AD. However, evidence is growing, from the examination of contemporary coin forgeries and jewellery, that the Celts were using fire-gilding before the Romans, possibly from the late 1st century BC. Further investigations of fire-gilding on China metalwork are presented by Jett who discusses both artefactual and experimental evidence of the successful gilding of leaded bronze figurines.

La Niece presents a comprehensive review of silvering and we see that mercury silvering also has its origins in China (*c* 1st century AD) but that its regular use in Europe (from about the 13th century AD) substantially postdates the introduction of mercury gilding. As in the case of fire-gilding, the use of mercury silvering in Europe is pioneered by coin forgers, the earliest example being from the 8th century AD. Why the regular use of mercury silvering is so much later than mercury gilding is unclear. La Niece points out that silver does not amalgamate as readily as gold but another reason may be cost. It is possible that mercury was too expensive to use with silver but could be justified for the more valuable gold. The paper by Turner on the history and development of Sheffield plating brings the use of this material into the 20th century with an interesting account of its application in the supercharger intercooler of the Rolls Royce Merlin aero engine series requiring its combined properties of strength and conductivity.

After a paper by Zwicker *et al* on silver-plated Roman coins, including the examination of artefacts and plating experiments, there is a comprehensive review of the interpretation of tin-rich (and also some arsenic-rich) surfaces on copper-based artefacts by Meeks. Deciding whether or not an artefact has been tinned is not solved by simply detecting tin at the surface if the artefact is made of tin bronze. However, Meeks shows that by identifying the presence or absence of the three intermetallic compounds of copper-tin (δ, ε and η), from the microstructure or using X-ray diffraction,it is often possible to confirm the use of tinning.

Corfield then describes the variety of methods which were used to plate copper, or copper-based alloys, on iron and the volume concludes with two papers on electroplating, its history and modern application. The rapid developments which took place in the process are exemplified by the specification for a church dome in Moscow in the 1850s, only a little over a decade after regular commercial electroplating started, which demanded 28.44g of gold per square metre (equivalent to about 1.5 micron thickness) with a maximum deviation of only 20%.

The volume is provided with a useful and comprehensive index. If I had to provide some criticism it would be that some of the contributions would have benefitted from sub-headings to give them a clearer structure but this is a small point to make about a

volume which is certain to be an invaluable work of reference for some time to come.

Mike Cowell

The Celtic Sword by Radomir Pleiner. *Oxford University Press, 1993. 196pp, £55.*

This book tackles the subject from the point of view of how and from what material swords were actually made. This is a regrettably rare approach to an object-based study, particularly in the case of iron where the often severely corroded nature of the metal may not allow a very satisfactory morphological and typological approach. The reason why the technological approach is such a potentially important and productive one should, however, have been stated and explained in the introduction as it is not clear to most people what iron objects, especially high status things like swords, have to offer from this kind of study. Belatedly it is starting to be realised that metal objects, especially ones made of iron, contain a great deal of information about how and from what they were made. This information is readily extractable and any gaps left by sampling can be easily restored, little impairing the potential for future academic study or display.

The first four chapters cover different aspects of the archaeology of the sword, mainly the long sword, since the majority of European swords outside the classical southern zone were over 70cm long, and the development of these is traced from some of the early examples such as those found in graves in Asia Minor (3rd millennium BC) and Mycenae (2nd millennium BC). Unfortunately the book is let down by an outdated view of the overall archaeological development of Europe particularly during the 1st millennium BC. The view taken is the old invasion hypothesis in which the population of northern and western Europe was seen as Celts who originated in a limited area of Central Europe, and who spread out from this 'ethnic' central area in successive invading waves. In this model successive invasions accompanied by migrations of people were used to explain the appearance of new types of material and styles of object. Increasingly this idea has had to be abandoned as it has become clear that it was the styles or the objects themselves that travelled rather than the people. In a way the title of the book adds to this misleading impression as originally the term Celt *(Keltoi)* was used by Julius Caesar to describe one of the three main tribes of Gaul, who occupied the region between the rivers Seine and Marne to the north and Garonne to the south. This region extended from the Greek colonies along the Mediterranean coast where the use of the term Celt as an uncritical reference to all the occupants of Gaul appears to have originated. In fact there seems no reason to suppose that the population of northern and western Europe was not fairly stable from before the Bronze Age.

Pleiner places great emphasis on the wars and raiding campaigns of the Gallic tribes against the urbanised classical Mediterranean countries of southern and south-eastern Europe and he sees the start of these as a possible reason for the re-introduction of the long sword in the 5th century BC. Whilst the Gallic wars and related raids were clearly important events their 'savage' nature is over-emphasised and there is no evidence that these influenced the design or possible re-introduction of the Celtic long sword.

Chapter 2 examines various accounts, virtually all classical written sources, relating to these wars and the effectiveness — or rather ineffectiveness according to the classical writers — of the Celtic long sword. Also mentioned are some of the references to swords in early Irish and Welsh literature which preserve earlier traditions even though they only date from about the 5th century AD and were mostly compiled later. The mythical King Arthur's sword is mentioned twice, one source describing the image on the blade of two snakes spitting flames. It should be mentioned, however, that references to snakes on swords during the 1st Millennium AD are not confined to Celtic literature. They occur in Anglo-Saxon and Viking written sources and such swords, although very rare, have been found as far afield as England (West Heslerton, 6th century) and Finland (9th-10th century). A surprising omission here also is the significant reference in the early Welsh poem, the Gododdin (which is thought to date from about the 7th or 9th century AD), which refers to 'their clean blue swords' in the lament for a young warrior and which is very relevant to the surface finishing of swords discussed in chapter 8.

The distribution of swords in cemeteries is discussed in Chapter 3 which includes just a short final section mentioning the mass deposition of weapons in water at La Tène and a few other sites. This last section should have been stressed more as the votive deposition of weapons (and other objects) was very common and widespread through the Iron Age and was a continuation and development of Bronze Age practices. Many swords, shields and the like continue to be found in sites such as the old beds of rivers, although individually the numbers are quite small and are perhaps not quite as obvious as the huge votive deposits like those from La Tène.

Chapter 4 forms a good summary of mid-late Iron Age sword types found across northern and western Europe with illustrations of hilt types and scabbard decorations. It is a pity that this section could not have included the last of the swords found at Orton Longueville in

Cambridgeshire. This wonderfully preserved sword with its clearly visible early form of proto pattern-welding and scabbard with interlocking bronze frame must surely rank as the most exceptional sword find, at least of this period, from this country. Unfortunately, although it was found about 10 years ago, this sword has not been published or metallographically examined and it was stolen in 1994 and not yet recovered.

The short chapter 5 describes experimental trials using modern mild steel to show how a roughly blade shaped ingot or currency bar could have been forged into a sword blade. So far, however, there is no evidence that this was how any swords were actually made — that would require matching the structures found in currency bars with those found in swords which has yet to be done.

The main core of the book and the reason why it is a very important and useful publication lies in the information presented in Chapters 6-8. Chapter 6 is presented as a catalogue of the results of the metallographic and chemical analysis of 27 swords examined by Pleiner in Czechoslovakia and found in that region of eastern central Europe. The catalogue entries are concise and well thought out with all the main structural details listed under the relevant sub-headings (macro and micro structure, hardness, chemical analysis etc). This catalogue is continued in Chapter 7 which adds the results of a further 92 swords found and published elsewhere. Most of these come from sites further west, extending to the west coast of France but also include material from Britain and Ireland. To fit in with the format of the catalogue the original descriptions have been rationalised and partially brought up to date. This cannot have been an easy task although I think it might have been better to remove archaic or misleading terms such as *hardenite* (martensite) and put in footnotes where this had been done. Although he includes an extra 92 sword examinations in the catalogue he mentions that a further 85 swords (making a further 177 swords in all) have been examined although in these cases the details were too brief or too poorly recorded to include here.

In Chapter 8 he discusses the results of the examinations described earlier — 122 are mentioned although 119 actually appear in this book — and the various blade structures are discussed and divided into groups which are listed in a series of tables. It is well illustrated with the main cross-sectional types shown, as well as maps showing their distribution. The individual numbering of the table is different to that of the catalogues and the two are not cross-referenced which makes life harder for the reader. What is also confusing is that only 93 swords are featured in this series of tables which leaves 26 unaccounted for from the catalogue of examinations. One small further point is that a sub-heading appears to be missing on p.156 between the summary on scabbards and the brief overall conclusions on sword dating and technology. Editorial problems such as these should have been sorted out before publication.

One potentially confusing piece of terminology concerns the use of the terms *hard steel* and *soft iron.* There are no such terms as *hard steel, medium steel* and *soft iron* and where these terms appear what is meant by *soft iron* is plain ferritic iron low in any alloying elements such as phosphorus or carbon. *Medium-hard steel* seems to have been used instead of medium-high carbon steel. Although harder than plain iron, this is only relative as medium-high carbon steel itself becomes much harder (and more brittle) after quenching. Hardened steel is the standard way of referring to the medium-high carbon steel that has been quenched and (sometimes) tempered.

Chapter 9 discusses the possible effectiveness of swords as battle weapons and includes the results of some reconstruction experiments to test the kinds of damage that might have inflicted on the blades. The summary and conclusions trace the early development of the sword as a fighting weapon as well as giving an overall assessment of the main types of blade structure found during the examinations reported here. Pleiner is probably too cautious in emphasising the widespread skills of the smiths during much of this period (*c* 500-1 BC). Although little earlier material is represented, if the dating is correct then high levels of technical expertise were attained earlier on, with pattern-welding, for instance, being introduced earlier (perhaps by the 5th century BC) than has previously been thought. This decorative technique of sword manufacture actually survived beyond the Middle Ages (see p.167) but not in most of Europe. It continued in the Ottoman Empire and elsewhere in the Middle East and further afield. It was this continuation that led to its reintroduction and use in the late 18th and 19th centuries for some swords, although mainly for gun barrels, hence the misnomer 'Damascus barrels' applied to these.

One of the clearest results that seems to emerge from the 119 examinations presented here is that the swords varied very widely in structural complexity and (apparent) quality. The author understandably has difficulty attempting to explain this in terms of the battle effectiveness of these weapons. Exactly the same problem is encountered when trying to explain the structure of north-western European swords of the Anglo-Saxon era, particularly during the 5th-8th centuries AD. The answer may lie in the interpretation of the sword itself, the prime importance of which may have been — possibly right though from early in the

Bronze Age or before — as a symbol of power or rank rather than a fighting weapon although it may have been used as such to a greater or lesser extent at various times.

One final point is that I have referred to one author here, although it is clear that Dr Brian Scott has made a significant contribution to the publication of this book. The extent of the various comments given here might be seen as an adverse indicator of the measure of achievement of this book. This is not intended to be the case as Dr Pleiner is to be applauded for the immense amount of work that clearly has gone into producing a pioneering and long needed technological study of the central and western European swords of this period. It is a pity, however, that the book is so expensive as this must put off many potential buyers. Also, for an important book produced by a leading publisher, the reader might reasonably expect a better level of editorial input and more illustrations, given the wealth of decorated Iron Age sword-related material that has been found.

Brian Gilmour

Bloomery Ironmaking During 2000 Years. Volume II West Nordic Region – Middle ages edited by Arne Espelund. *Budalseminaret, Metallurgisk Institutt, Universitetet i Trondheim 1992. 250x170mm. 132pp. ISBN 82-992434-1-6. £15.* and **Volume III International Contributions. Smelting and excavation in Budalen** edited by Arne Espelund. *Budalseminaret, Metallurgisk Institutt, Universitetet i Trondheim 1993. 250x170mm. 173pp. ISBN 82-992434-2-4. £15. (3 volume set £40 including postage).*

These two volumes complete the series of proceedings from the Bloomery Ironmaking During 2000 Years Seminar held in Budalen, Sør-Trøndelag, Norway in August 1991. Volume II brings together a number of studies of iron production and working the West Nordic region during the medieval period and thus provides a useful comparison with the more widely published Swedish surveys, and better studied Iron Age production sites.

Contributions in Volume II start with Thorbjörn Á Fridriksson and Margrét Hermanns-Audardóttir's paper, Ironmaking in Iceland, which argues that the major limiting factor on iron production in Iceland was the availability of charcoal. Although deforestation of the country generally occurred rapidly, this may actually have been slower in those areas where iron making formed a major part of the economy. Three categories of extraction site were proposed, based on their location at isolated sites, summer farms or as part of smithies, *raudasmidja,* at the permanently occupied farms. Dependence on imported iron became complete after the cessation of iron smelting in the 16th century.

Símun V Arge: Iron in the Faroe Islands, demonstrates the importance of iron in the economy of the early Faroese settlers and provides preliminary evidence for iron smithing in the form of hearth stones and slags. The possibility of local iron smelting is considered, although no evidence of this is currently known.

In considering south Danish sites, Vagn Buchwald and Olfert Voss: Iron Production in Denmark in Viking and Medieval Times, highlight the problem of locating Viking and medieval iron extraction sites, which are considerably less conspicuous than the Iron Age sites which produce slag blocks of up to 200kg. A paucity of sites between the 12th and 14th centuries AD compares with a total absence between the 8th and 11th and during the 15th and 16th centuries. Documentary evidence, however, suggests that smelting did continue until 1600 and three examples of the intermediate products of production, the distinctive *klode* (a bloom partially spit into four fingers) have been recovered as isolated finds. Metallographic examination of these kloder revealed a slag content of 50% by volume and microprobe analysis showed a phosphorus content as high as 1wt% in the metal and 12wt% in the glassy matrix of the slag inclusions.

Anders Ödman: Iron and Castles in Scania, presents the result of the excavation of a series of castles built and occupied during an interval of Swedish occupancy of the region which lasted until 1360. It is argued that a major role of these castles was the control of an iron tax. Iron smelted on farmsteads passed through the castles on its way to refining centres, such as the contemporary workshops identified in the medieval city of Va.

Irmelin Martens: Iron in Southeastern Norway in the Medieval Period, uses the results of two major archaeological landscape studies, at Møsstrond and Dokkfløy, to explain the influence of iron extraction on the settlement pattern in marginal areas up until the depopulation brought about by the Black Death. It is argued that expansion in both regions was associated with the ability to produce a surplus of iron. Some contrasts were made between the two regions. However, similarities were evident in both the decentralised mode of production and the type of furnace used.

More detail from the second of the two sites above is provided by Jan Henning Larsen: Iron Production at Dokkfløy in Oppland, Norway. This archaeological survey carried out in advance of a hydro-electric project in a low-lying mountain valley located 35 iron extraction sites. Three distinct phases were identified.

The earliest, dated between 100 and 550/600 AD utilised shaft furnaces of approximately 1.5m internal diameter and an underlying slag pit. Slag blocks from these site measured up to 1m across. Shaft furnaces of the Viking period, dated 800-1000 AD are narrower (0.5-0.6m) and allowed slag to be tapped from the furnace into a ditch. Furnaces built between 1200 and 1400 are narrower still, having an internal diameter of only 0.35-0.45m and are set within a framework of flagstones. These medieval furnaces are invariably associated with house sites and charcoal pits, and typological subgroups, based on the numbers of each feature, are suggested.

Perry Rolfsen: Iron Production in the Upper Part of the Valley of Setesdal, Norway. This further survey provides additional support for Martens and Larsen's suggestions for the importance of iron extraction in regions considered marginal for agriculture. It is estimated that about 15000 monuments in this mountainous region are associated with iron extraction, most of which are charcoal pits. Radiocarbon dates suggest that the smelting 'industry' here may have continued later than the other two regions, at least into the 15th century. Again it would appear that the blooms were transported out for refining at centralised workshops.

A total of 121 iron extraction sites are included in a survey described in a short paper by Tom Bloch-Nakkerud: Iron Production in Hallingdal. It is stressed that the larger numbers of medieval furnaces do not necessarily imply greater production when compared with the fewer, but larger Iron Age sites. The location of the furnaces does however show a geographical shift; Iron Age furnaces are found only in the lower valleys and it is not until about 900 AD that furnaces are built above 900m. The move to higher altitudes culminates in a 14th century site at 1145m, far above the present tree line.

Finally, Arne Espelund: The Mellager site in Trondheim: a Complex of Metal Workshops, and its Role in Medieval Iron Metallurgy, describes the results of the excavation of an iron smithing workshop on the river-front in Trondheim. The site, dated between 1150 and 1350, produced large quantities of smithing hearth bottoms of largely fayalitic composition (analyses presented) and is interpreted as being a centralised workshop, operating under a single authority, which received blooms of iron from inland regions. These were then refined into bar iron or, possibly, finished iron artefacts prior to redistribution along the coast to adjoining regions.

Volume III contains the 'international' contributions and comprises an interesting diversity of approaches and areas of study. The first paper, by Carl Blair: The Operational Characteristics and Production Capacities of the Burgenland Style Iron Smelting Furnace, describes his experimental smelting using a large furnace. The design was based partly on archaeological evidence from Austrian and German Roman Iron Age sites and partly on ethnographic evidence. The most successful cycle lasted approximately 22 hours, produced a 50kg iron bloom and 100kg of slag, some of which was tapped from the furnace. The 2.7m shaft assisted convection but did not obviate the need for a forced draught.

Peter Crew and Chris Salter: Currency Bars with Welded tips, is based on experience gained from over 40 iron working experiments. The production of currency bars from iron smelted in a reconstructed bloomery furnace showed that requirements for manpower and fuel, and the iron losses involved in smithing, are likely to be greater than has been anticipated by other researchers. Suggested total requirements for smelting and smithing are 25 man days and 100kg of charcoal for each kg of currency bar produced. Metallographic and analytical studies showed appreciable quantities of carbon (up to 0.7%) and phosphorus (averaging 0.4%) within the heterogenous structure of one bar, with an unexpected degree of overlap between the two elements.

H Laumann: Rohstoffe und Energie auf Latènezeitlichen Hüttenplatzen des Siegerlandes (Westfalen) Versuch einer Berechnung. This paper attempts to calculate the local production capability of La Tène settlements based on assumptions derived from archaeological excavation and pollen studies. Gossan ores and coppiced oak and birch charcoal provided the raw materials for localised smelting. Whilst stressing the difficulty in calculating figures it is cautiously suggested that in each valley site an annual clearance of 1ha coppice would provide 40t of wood. This could be converted, successively, to 8t of charcoal, 1.2t of iron blooms and finally to either 800 flanged axes or 200 adze-axes. Such production surplus may provide an explanation of the richness of contemporary grave goods.

Rosemarie Leineweber: Römerzeitliche Eisenverhüttung in der Altmark Archäologischer Befund und Rekonstruktion. Experimental furnaces were reconstructed based on excavated late Roman period bloomery furnaces from the Altmark, central Germany. The furnaces were free-standing with a tubular or bowl shaped pit below, to which a narrow tunnel led from the ground surface. Air appeared to have been supplied by natural draught. Four smelts using very different conditions met with mixed success. Despite the low grade limonite ore (35%Fe, 32%SiO_2), some metallic iron was produced along with a distinctive

'schlackenklotz' slag block.

Michel Mangin's paper, La Production du Fer dans l'Est des Gaules: L'Example des Zones Siderurgiques de Franche-Comte et du Morvan, provides an update on work to date, carried out primarily by doctoral students, at the University of Besançon. Whilst work in the region of Franche-Comte is still in its early stages, the study of the iron industry of the smaller Morvan-Auxois region has now identified the main mining and iron production sites. Further work needed includes the excavation of some of these sites and the investigation of ore deposits within Morvan.

Jüri Peets: Über die Eisenverhüttung in Ostestland und auf Saaremaa im XI.-XIV. Jh. contrasts evidence from furnace excavations from northern and eastern Estonia with more variable sites on the island of Saaremaa and concludes that differences result from Saaremaa's contacts with Scandinavia and its local traditions whilst the mainland sites were influenced by the influx of settlers from the east.

Radomir Pleiner's Punch Marks on High Medieval Iron Artefacts, uses an assemblage of 250 14th-15th century iron objects from excavations in Wenceslas Square, Prague as the basis for discussion of the practice of marking tools in this way. Documentary evidence is quoted for Guilds (and the king) conferring the right for individual smiths to use specific marks and it is suggested that further studies could provide evidence for the export of knife blades from Bohemia.

Alain Ploquin: A Propos des Scories Legeres et Laitiers Associes aux Dechets Paleosiderurgiques en France, Quelques Apports de la Base de Donnees Artemise-Scories. Through the French program 'Artemise-scories' chemical analysis and other data on bloomery slags has been collected in a data base and used to define specific types of 'light' slags. The element beryllium was found useful in discriminating between slags deriving from vitrified furnace lining and the more highly siliceous of the smelting slags.

J Simon and E Thomàs's paper, entitled A Study of a Metal Fragment Adhering to Forge Debris, Presumably from the Escabie Forge in Areu, examines the debris from a Catalan hearth. Results from metallography and SEM-based analysis show that a highly carburised fragment of iron had cooled from a molten state.

Alan Williams' contribution, Slag Inclusions in Armour Plate (1400-1640), describes attempts to extend his studies of the metallography of defensive armour by the use of SEM-based analysis of entrapped slag inclusions. Compositionally, armour of most dates and provenances shows a broadly similar range of 'mixed silicates', iron silicates and iron oxides. However, two exceptional groups were found; late munition armour and expensive late Milanese armours. It is suggested that the former derive from indirectly smelted iron whilst the latter may possibly be examples of Brescian steel.

The volume concludes with another two articles by Arne Espelund. The first, co-written with L F Stenvik, provides the background to one of the sites visited during the conference. The bank of four furnaces of Storbekken I are dated to the Roman Iron Age and are typical of about 100 sites in the Trøndelag region. The furnace remains include stone-lined, horseshoe-shaped, slag pits over which clay shafts had been constructed. Slag weights on site are estimated at 24-48 tons, with an iron output of at least 15 tons for the four furnaces, which appear to have been worked simultaneously. A second article summarises the demonstration, at the conference, of a 'Nordic' bloomery according to the description in Evenstad's 1790 paper. The pinewood-fuelled furnace produced a low carbon, but phosphorus-rich bloom of 7kg in 5 hours. Smithing of the bloom to a bar reduced its weight by a little over half.

Taken as a whole, the three volumes provide a valuable insight into the approaches, limitations and progress achieved by archaeologists studying iron production. This is particularly welcome for Scandinavia, which, with the exception of Sweden, has seen remarkably little published internationally. The depth of the studies varies considerably, some comprise only preliminary observations of previously neglected areas, such as the Faroes, whilst others derive from impressive large-scale archaeological projects or in-depth analytical studies. For the latter cases the written contributions, like the 20 minute presentation slots at the seminar, are necessarily restricted to only brief summaries of the work undertaken. Whilst these papers serve as a useful introduction, in English, to the work of the authors, researchers requiring more detail of the methodology or data will need to follow up the further references. These volumes will undoubtedly serve as a very convenient source of information for researchers working in the broader field of European iron production for years to come.

David Starley

The Story of Ironmaking in Northamptonshire 200 B.C. to 1980 A.D. by James Sanders. *Towcester Bookshop, 42 Watling Street East, Towcester, Northamptonshire, 1994. 42pp. including appendix and bibliography. ISBN 0 952351501. £3.95.*

This little book was published to record the ironmaking activities of Northamptonshire for local students. The first short chapter provides a brief description of the

geology of Northamptonshire and its ironstone. The author progresses to a description of early smelting, which suggests that iron was made before bellows were devised. This is presently thought to be unlikely. The chemistry is suspect at this point too. Very little of the iron ore will be reduced by solid carbon as is suggested. Reduction is largely by carbon monoxide in all methods of smelting. The account of the development of the bloomery is sketchy and ignores the existence of large waterpowered bloomeries. The description of the early blast furnaces is good, but it is not clear that the dimensions are internal. There is no mention of the massive square tower that most people could recognise. There is also an assumption that wrought iron was not made by the indirect process (in the finery) before Cort invented puddling.

There is some discussion towards the end of the chapter about the use of coke in the blast furnace. The author contends that the reason coke replaced charcoal was purely metallurgical, its higher strength permitting the use of taller furnaces. While the use of coke did enable taller furnaces to be used it seems unlikely that this was the original reason. There is no doubt that everyone thought that the iron furnaces were using too much wood in the South East. This was the reason for the Acts of Parliament. It was also difficult to collect and store enough charcoal to work for more than about nine months in the year. The early coke furnaces were converted charcoal furnaces and new furnaces were built to similar designs. The increase in height and number of tuyeres came with experience. Coke was not an immediate success, as the author suggests in chapter 3, taking more than 50 years to replace charcoal for making forge iron.

Chapter 3 gives an account of the beginnings of modern ironmaking in Northamptonshire. The diagram of a furnace is very clear but when discussing the shape of the furnace the author ignores the expansion of the charge due to heating it up. He correctly describes the deposition of carbon, but does not explain why it happens. In a book for students this must be an oversight. He does not explain why the furnace contracts in the boshes. He also seems not to know of the coal fired pipe stoves that preceded the regenerative stoves for heating the blast. His assertion that the boshes were water cooled from the early days of hot blast is also not supported by the furnaces still in existence from that time and the drawings in Percy's *Metallurgy*. The tuyeres were water cooled but there is no evidence of bosh cooling before the mid 18th century.

Chapter 4 gives an account of the reactions. Again the diagram is very clear but the text suggests that reduction of the ferric oxide starts at 200°C. Between 200°C and 400°C only the hydroxides are decomposed, which is shown in the diagram. Chapter 5 forms about half of this little book; it is the important part. It gives brief histories of the ironworks. A sketch map would have helped me, as a stranger to the area, to see where they were but this is not important. The histories are accompanied by interesting photographs of some of the works. Chapter 6 is a brief epilogue summarising the present position. A short appendix tells us a little of the Butlins, who founded the industry.

On the whole this is an interesting little book but marred by errors that make it difficult to recommend.

Peter Hutchison

The Anglian helmet from Coppergate by Dominic Tweddle. *The Archaeology of York, Vol 17/8, 1992. Council for British Archaeology, London. xxi+350 pp, 230 plates, 25 tables, 11 full size unbound illustrations. 242x184mm p/b. ISBN 1 872414 192. Price £40.*

This volume records the discovery, excavation, technological examination and conservation of the Coppergate Helmet as well as a discussion of its significance and context. It is a type known as a crested helmet of which numerous examples have been found in Scandinavia, but only seven, including the Sutton Hoo helmet, have been found in England. The helmet is a complex construction of iron plates reinforced and decorated with brass bindings. The neck of the wearer was protected by a mail curtain which survived intact inside the helmet. To create the helmet a range of metallurgical techniques were used, these are comprehensively explored in the publication.

It is rare for a single object from an excavation to be studied in such detail but it is a measure of the helmet's archaeological importance that so much time and effort has been expended. Its importance rests on the fact that it is the most complete and the best preserved helmet of its type to be found in England, and the first to have been found at a time when the full resources of modern investigatory conservation and technical examination could be brought to bear from the moment of discovery.

Before any conservation was undertaken a range of radiographic techniques were applied. Computer-aided tomography (CAT) and conventional tomography were selected to determine the nature of the soil filling the helmet, this had not been removed at the time of excavation to avoid the possible loss of any helmet parts contained within it. The CAT scans, provided useful information, including the identification of the mail skirt, but were of insufficient quality to resolve the detail of the contents; clearer images were obtained by transferring the computer images to negative film and viewing them as conventional radiographs.

Conventional tomography showed some of the detail of the structures in the helmet but did not allow for detailed analysis of the contents.

After the excavation of the soil filling the helmet, industrial quality radiographs were taken which enabled a detailed study to be made of the helmet's structure; the radiographs provided a wealth of information about the helmet's manufacture and decoration as well as showing wear and contemporary repairs. The mail was later further examined by high-intensity microfocus radiography. The lavish publication of radiographs show how valuable these techniques have become to the technological study of archaeological finds.

The preservation of the iron of the helmet resulted from its burial in an anaerobic deposit. This prevented the normal oxidation of the iron; the corrosion present on the iron was identified by X-ray diffraction as siderite, ($FeCO_3$) and that on the copper alloy as chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4). Metallography of important artefacts is rarely possible as curators become more reluctant to allow sampling. The inclusion of the section on the examination of the iron plates and mail rings is therefore welcome.

The preservation of the mail curtain was equally good. Sonia O'Connor provides much detail of the techniques used in its manufacture. From the radiographic evidence O'Connor concludes that wire of a higher quality was used for the welded rings and suggests that the higher proportion of slag in the iron would facilitate the welding. In order to better understand the techniques involved in the fabrication of the mail experimental production of rings was undertaken by Peter Gardner.

Lang, Craddock & Hook, who undertook metallographic examination of a ring of each type, do not comment on this in their detailed report, but they do show that the welded ring examined is made from an inhomogeneous wire while the lapped and welded ring is homogeneous.

It is rare that an iron object which has been thus damaged can be restored, the corrosion of the metal usually rendering it too brittle for any manipulation to be contemplated. It has already been noted that the preservation of the helmet in the ground had been unusually good; the care given following excavation prevented any major post excavation corrosion, and as a consequence it was agreed that reshaping should be undertaken to return the helmet to its original form. The work was done at the British Museum and is described by McIntyre, Newey and Oddy. The careful manipulation of the damaged iron components without any use of heat is testimony to both the quality of the metal and the skill of the conservators involved.

The publication has been drawn together by Dominic Tweddle who presents a considerable body of archaeological and art historical evidence; the English and continental parallels are described and reference is made to contemporary documentary evidence. The volume is lavishly illustrated with 230 illustrations in the text, 54 of which are in colour and 27 are radiographs. There are 8 metallographic sections and 11 full size drawings in an accompanying folder.

The wealth of metallurgical information contained in this volume will make it a valuable addition to the corpus of archaeometallurgical knowledge. The organisation of the volume does have some discontinuity, the technical data in particular is a little disjointed however this does not distract from the usefulness of the volume and is perhaps inevitable with 22 contributors. As a whole the study shows the value of close collaboration between archaeologists, conservators, scientists and art historians in the study of complex finds. The Coppergate Helmet can be seen in the York Castle Museum, for those seeking a better understanding of its technology this publication will meet their every need.

Mike Corfield

Fell, V, 1992, Review of *Anglo-Scandinavian ironwork from 16-22 Coppergate* by Patrick Ottaway, *Historical Metallurgy* 27(1), 40-41.

Wilson, D M, 1976, Craft and Industry. in D M Wilson (ed) *The Archaeology of Anglo Saxon England.*

Gunfounding in the Weald in the sixteenth century by Edmund B Teesdale. *Royal Armouries Monograph 2, Trustees of the Royal Armouries, London, 1991. 142pp, tables and maps. ISBN 0 948092 17 3. Price (incl P&P) £8.95 in UK, £9.60 overseas; only available from The Merchandising Manager, Royal Armouries, HM Tower of London, London EC3N 4AB; sterling cheques payable to Royal Armouries.*

The success of Wealden ironfounders, relative newcomers to the craft, in producing cast-iron cannon superior to those made by their continental counterparts is one of the most intriguing, but also one of the most perplexing events in the history of iron. The superiority of Wealden guns over continental rivals continued for some 70 years (1550-1620), and though gunfounding was able to maintain itself in the Weald for a further century and a half the rest of the story is a comparative anti-climax. The Royal Armouries are to be congratulated for publishing this detailed study of the industry's formative years.

Dr Teesdale has worked his way into the complexities

of 16th-century gunfounding in the Weald in a way scarcely possible for the authors of the broader surveys of Wealden iron. From the footnote citations it is apparent that the State Papers and other Public Record series, as well as collections in the British Library, have been examined for everything connected with gunfounding with the greatest thoroughness for the entire Tudor period. For the early period, little is added that is new, but the author has looked again at most of the evidence, and at the comments and accounts of the subject given by Lower, Dawson, Rhys Jenkins, Schubert and Cleere and Crossley. This enables him to present a clearer and more consistent account of the earliest, only partially successful developments in the Ashdown Forest area, whilst his research for his book on Ralph Hogge enables him to give a more complete account of events surrounding the triumphant production of the first successful cast-iron muzzle-loaders by Parson Levett and the Royal gunfounders at Buxted in the 1540s. However, inevitably given the survival of the main archival sources (the 1574 lists and the Henslowe MS, also dating from the late 1570s), it is for the Elizabethan period that this study is most illuminating. Readers of the *Bulletin of the Wealden Iron Research Group* will know that Dr Teesdale has carried a stage further (2nd Series, Bulletin 6) the analysis initiated by S A Cattell of the 1574 lists. This enables him to open the widest possible perspective on Wealden gunfounding at this period. He then goes on to use the Henslowe MS to focus on the operations of Ralph Hogge, the principal gunfounder of the first part of the reign, giving us a penetrating study of this very important gunfounding operation.

Of interest to a wider readership than just Wealden Iron enthusiasts will be the later chapters, which calculate the importance of Wealden gunfounding within the defence industry as a whole. Here the author is suitably conservative in his assessment. He is more specific than Michael Lewis, the author of *Armada Guns* (1961), in averring that not one of the 1,128 culverin-type cast-iron guns deployed in the action was installed in a Queen's ship. The long-range guns of the 34 Queen's ships that bore the brunt of the action were 683 bronze guns; all the cast-iron guns were carried by the 120 auxiliaries. He is able to point to the date 1590 for the first installation of cast-iron guns in a ship of the Navy. We are also shown that after the initial impetus given by the use of cast-iron guns in the coastal forts erected between 1539 and 1550, gunfounding in the Weald languished for a considerable time; that successive waves of renewal were encouraged by quite specific factors; firstly, exports to support the revolt of the Netherlands from 1570 onwards; secondly, the bounty paid on new merchant ships of over 100 tons during the years 1572-79, which caused a huge increase in Elizabethan maritime construction; thirdly, the war with Spain after 1585, which encouraged privateering; and finally and very importantly the renewal of the bounty in the years 1592-96, when more than one hundred new large merchant ships were built.

Dr Teesdale finds means of quantifying these aspects of demand (eight tons of guns to 100 tons of shipping) and concludes that in the last years of the century total production of cast-iron guns might have been around 1,250 tons annually (200 tons of this perhaps from Welsh furnaces) of which 900 tons would be authorized exports, 300 tons for English mercantile use and only some 50 tons for the Ordnance Office. The unquantifiable illicit exports are also discussed, with the conclusion that these were very probably much less than sometimes suggested by contemporary paranoia. All these conclusions are based on an impressive array of evidence, adduced in a scholarly and convincing manner, which may well stand the test of time.

In his concluding chapter 'Summary and Conclusions', Dr Teesdale returns to the problem of why cast-iron guns were produced so much more successfully in the Weald than in other European ironworking areas. He gives a judicious resume of the solutions that have been suggested. These are basically two: the 'superior materials school', which suggested that impurities specific to local ores may have accounted for the unique 'toughness and validitie' (Peake, 1601) of Wealden cast-iron; and the 'superior moulds' school, which suggested that the better drying qualities of loam moulds (as compared with sand moulds) and the English use of a considerably larger gun-head above the mould 'eliminated cavities being produced in the iron by the vapours'. Since Dr Teesdale wrote, some progress has been made in identifying cannon of the earliest period (eg the Padstow gun (possibly of 1544) on the English side, and a demi-culverin and falcon from the reign of Francis I (d. 1547) at Rouen) which for the first time make direct metallographic comparisons at this formative period a possibility. Apart from this aspect of the subject, the work under review is likely to remain the definitive account of the Wealden cannon industry in the Tudor period.

Brian G Awty

Lewis Morris and the Cardiganshire Mines by David Bick and Philip Wyn Davies. *National Library of Wales, Aberystwyth, 1994. 109pp. 44 illustrations and 1 pull out map. Price £15.*

This publication is an example of the National Library of Wales's commendable policy of providing a comprehensive view of one of its archive collections at extremely modest cost. The work is, in this case, not only derived from the scholarship of the Library's

curatorial staff; it also includes explanatory and descriptive material by David Bick who, single-handedly and over a long period has done so much to survey, interpret and develop awareness of the Cardiganshire ore-field. Many will know his privately published series of books, which first appeared in 1974-8 and some will be anticipating this work on Lewis Morris from the prefatory remarks in his editions.

Despite 'reclamation' efforts by local authorities lead mining remains proliferate in the Aberystwyth hinterland, in some cases set in an awesome, remote landscape. Lewis Morris's work, as a source to the understanding of these relict landscapes is a bonus not enjoyed by many other locations and the quality of his work, so admirably produced in the generous format of this book, provides a research tool which may save many the time and effort needed to work on the original. Beyond that, the story of Lewis Morris is worth the telling in its own right, illustrating yet again how, in this period, the mining entrepreneur was just as easily a public official or indeed a publisher and printer.

Some, however, may find the book a disappointment. The approach to the site descriptions is a trifle quaint; for example, the use of the 'industrial technology' when 'site description' is surely meant? There are no grid-references either and the general location map, having no grid co-ordinates and only a selection of minor roads, is difficult to use. Indeed, the key to the book's use in relation to sites is perhaps when David Bick says 'The series *The Old Metal Mines of Mid-Wales* ... will be useful as companion volumes'. To be blunt, they are essential, and even their references are incomplete. This approach contrasts with the policy in another recent National Library of Wales publication on documentary sources for chapels, where, in collaboration with its Aberystwyth neighbour, the Royal Commission, full accurate grid references were provided.

Some of Bick's own sources, too, are rather elusive. While the use of rather dated oblique aerial photography is most welcome, no indication is given of the scope or whereabouts of the archive where it is held. This is a pity. It is clear that the interpretation of the extensive ore-field landscapes is greatly assisted by the growing collection of aerial photographs, which give researchers a perspective and relationship of site components in a form almost impossible to appreciate on the ground.

For all that, however, this book is most informative and very good value.

Peter White

Secrets of Sheffield steelmakers by G B Callan. *Published by the author, 1993. iii+52pp, A4 paperbound. Figures, tables and plates. Price (incl P&P) £5.50, available from the author, 51 Chelsea Road, Sheffield S11 9BQ.*

In the late 1860s William Baker, a former pupil of John Percy, set up his shingle in Sheffield as a metallurgical analyst. The business prospered and, in 1872, he was appointed a public analyst. By 1876 his confidence had increased and he was taking in pupils — perhaps the most famous of whom was Robert Hadfield, later Sir Robert.

Although Baker was not widely known as an author of metallurgical papers, he did contribute to Percy's classic book, *Metallurgy*. However, he did leave an intellectual legacy in the form of a laboratory notebook, which was recently unearthed and which recorded confidential analyses of samples submitted to the baker laboratories by a variety of clients during the period April 1875 to December 1884. The results recorded are not all Baker's own work, for he died in 1878.

The period covered in the analytical records was one of change in the Sheffield steel industry. The acid Bessemer process was replacing the wrought iron cementation route for bulk steel production and the crucible process was being adapted to the production of tool steels. Chapters in the book deal with these changes and the metallurgical problems involved.

Baker's clients were chiefly from Sheffield and the surrounding regions and, from the records, he appears to have given turn round times of about one week from the receipt of the sample to the issue of an analytical certificate; hardly fast enough to meet the modern standards of process control, but helpful to companies carrying out development work, or wishing to check the quality of their bought-in materials.

Baker clearly served the analytical needs of the major Sheffield steelmakers and the author has given a series of thumb-nail sketches of these companies which greatly enhances the value of the book. There are also a number of drawings which help to give the 'flavour' of crucible steelmaking and the early acid Bessemer shops. It is, perhaps, salutary to examine the analyses in detail. In 1880, Sanderson Brothers & Co Ltd had a steel analysed which contained 0.002%S and 0.007%P. Some 110 years later with all the developments of arc melting and ladle refining, problems are still encountered in meeting such a specification.

The book, although short, is in the best traditions of historical writing, in that an excellent story has been told, based upon some clearly established facts.

Jack Nutting