Book reviews

The Metallography of Early Ferrous Edge Tools and Edged Weapons, R F Tylecote and B J J Gilmour, *British Archaeological Reports, British Series 155, Oxford 1986. 263pp, price £18.00*

It should be said at the outset that this is a very important work in the field of ferrous archaeometallurgy. For the first time we have been presented with detailed metallographic studies of a significant body of English edged tools and weapons dating from perhaps the mid 1st millennium BC through to the 14th century AD. This general survey permits a much better impression to be gained of the development of ironworking in England, and in particular, the south and east.

The book falls into two parts, each representing the main contribution of one of the co-authors. Following a brief but useful introduction to the metallography of bloomery iron, the first main section contains Tylecote's examinations of knives and cleavers, shears and scissors, axes, scythes, sickles, billhooks, ploughshares, hammers, chisels, saws and augurs. The second section comprises Gilmour's study of arrowheads, spearheads, scramasaxes and swords. One must make two criticisms of the layout and information. First, there is a paucity of chemical data to augment the metallographic detail: thus, one would be most interested to know what roles were played by arsenic and phosphorus in forming some of the structures reported. Second, the ordering of the reports in the second section is somewhat esoteric: straight sequential ordering would have been much preferable.

A number of very interesting points emerge from the first section. Ronnie Tylecote has often referred to the "any old iron" produced in Roman Britain, but it is quite startling to see just how poor quality the average user was fobbed off with. The apparent lack of ability to apply heat treatments to steel is surprising, given the fact that steel was being produced, and that welding of iron to steel could be accomplished. The approach to the formation of working edges in the Roman period and after contrasts sharply, with that treatment becoming common from the Migration period onwards. The general impression to be gained is that Roman ironwork in England at least represents a lower level of quality production than that which went before, or came after. The quantity of information gathered here is impressive, and provides a very useful data base for comparative studies in other regions.

The section dealing with edged weapons is again of interest and value for the wealth of structural information it presents. It is somewhat surprising to find that such a high proportion of the Anglo-Saxon, scramasaxes and spearheads were pattern welded. The use of alternate laminae of high and low phosphorus iron was also observed as being common. Although Roman and pre-Roman Iron Age material is not so well represented in this section, nevertheless the contrast in quality is striking. The reconstruction drawings are a particularly useful feature of this part of the book, and they aid greatly interpretation of the sections as the authors followed them.

This book will be both an essential work of reference for archaeometallurgists, and will provide a good English language introduction for students to the detail of archaeometallurgical research. There is one defect, however, which must be noted, and that is the appalling quality of BAR's production. Well over half of what were obviously highly instructive microphotographs have been turned to muddy blurs. Some of the text layout is quite inept, and both of these detract significantly from the appearance of the book. In the days when BAR provided a genuinely cheap publishing alternative, some of this might have been acceptable: at £18 per copy, it is not ! Nevertheless, despite the indignities wrought on the authors by the publisher, the quality of information is evident, and one can commend this book to any serious student of the subject.

Brian Scott

Edgar Jones : A History of GKN, Volume One, Innovation & Enterprise 1759-1918. *Macmillan Press, Basingstoke, 1987, 442pp, 120 illustrations in black and white, 12 in colour. Price £19.50.*

GKN is a large group of companies, British based but operating internationally and with a very wide range of products. It is also long established; one of the founding companies in the group dates back to 1759, and for many years it was a major producer of pig and wrought iron and, later, steel.

There have been innumerable references to the various companies, their works and products and their personalities in books and articles but until now there has not been a complete group history.

A reader's first impression of the book is that it is a handsomely produced volume, with a wealth of illustrations and a good index. A more detailed examination reveals that the author must have had a formidable task just to work through the vast amount of information on record, let alone select the important items and assemble them into a coherent and readable story. The footnotes (nearly 1500 of them) and the bibliography give some idea of the size of the job. It becomes even more impressive if one examines some of the sources. The Dowlais collection in Glamorgan County Record Office, to mention just one example (Dowlais was one of the GKN founding companies), contains 563,000 letters and a large number of other documents !

So there was obviously a problem in deciding what to include and what to omit. In a book of this type, too, it is always difficult to strike a balance between the many facets of the company's history. Technology, economics, commercial considerations, labour relations, politics, personalities (the group has had some outstanding ones) and many factors all played a part in the making of GKN. All these have been given due consideration and due weight in the book.

A simple chronological arrangement would not have been practicable, since up to 1902 when the GKN group came into existence, there were three separate companies, each developing in its own way and for a variety of reasons. The author has divided the book into five main sections in such a way that while the history of each company can be seen in its own perspective, the three come together neatly as the history of the group.

The three companies were: The Dowlais Iron & Steel Company, The Patent Nut & Bolt Company and Nettlefolds.

Dowlais was the biggest and oldest. Starting with a single blast furnace at Merthyr Tydfil, South Wales, in 1759, it had developed to become, by 1845, the biggest ironworks in the world. It was guided successfully for many years by the Guest family (particularly Sir John Guest) and it had a number of innovations to its credit. Dowlais was closely identified with the railway boom, starting with the production of rails for the Stockton and Darlington Railway in 1821; it took out the first Bessemer licence in 1856 and in 1857 erected the world's most powerful rolling mill.

In due course the company took up open hearth steelmaking and abandoned both wrought iron and Bessemer steel, though it kept its blast furnaces. At the time of the amalgamation the original site had become inconvenient and blast furnaces and steelworks had been erected at Cardiff. It was here that the business was eventually concentrated, though Dowlais continued to operate for some years.

The Patent Nut & Bolt Co (PNB) developed out of a partnership between Francis Watkins and Arthur Keen in 1856. It took over premises at Smethwick, West Midlands, to make nuts and bolts with patented machinery (hence the 'Patent' in the title). The Smethwick works, incidentally, had become vacant because of the bankruptcy of Fox Henderson & Co, which was the main contractor for the Crystal Palace. PNB was formed in 1864 and took over other ironworks in the Midlands and Cwmbran, Monmouthshire. By 1878 PNB was producing about 30,000 tons of nuts, bolts and fasteners a year.

Nettlefolds originated in an ironmonger's shop, started in London in 1823 by J S Nettlefold. He soon branched out into the manufacture of wood screws. In 1834 he moved to Birmingham and started a wood screw mill. The business expanded under successive members of the Nettlefold family, taking in a number of other screw companies on the way. For a number of years the Chamberlains (later to become prominent in politics) took part in the management.

It was in 1901 that the first move to the formation of GKN took place. In that year Arthur Keen arranged an amalgamation of his Patent Nut & Bolt Co with the Dowlais Iron, Steel & Coal Co to form Guest Keen & Co. This was followed, at Keen's instigation, by amalgamation with Nettlefolds, the new company taking the name Guest, Keen & Nettlefolds Ltd in 1902.

The present Vol One takes the story down to the end of the 1914-18 war. Many changes have taken place since then and there will be much to record in the next Volume which, we are told, is in preparation.

As a record of the long and complex history of a major British industrial group, with interests in coal, iron, steel, fasteners and many branches of engineering, the book is outstanding. It is a pity that it is marred by a number of small, easily detected but nonetheless irritating, misprints. In the contents list, for example, what should be 'Output and Performance' (Part III, 9) actually appears as '302put'. 'Taft' in the caption to Fig 4 should be 'Taff'. The caption to colour plates 8 and 9 should be 'The Patent File Co', not 'Tile' Co. The Dowlais Ifor Works could hardly have had 149½ puddling furnaces (p255). These mistakes could — and should — have been seen and corrected in the proof stage.

There are a few technical errors, too, and these, unlike the misprints, are not immediately obvious. Thus, the caption to Fig. 9 says 'It is not known which iron foundry this depicts' — it is not, in fact, a foundry but a forge. The object in the foreground looks more like a helve axle than the cannon which the caption says it ' . . appears to be'. Then, on p273 it is clear that the Bessemer patents have not been clearly understood by the author. He says that ' . . . the patent required that a blast of hot air be passed through a brick lined furnace'. It is true that Bessemer did, in his earlier patents, call for 'highly heated air' but in practice he soon found out that this was totally unnecessary. In fact, as the Bessemer process was exothermic, it generated too much heat and it was necessary to add cold scrap towards the end of the blow. Bessemer acknowledged this fact in his patent No 356, 12 February 1856, when he specifies ' . . . air, preferably cold, for economy'.

Nor is it clear what is meant by the statement that in 1875 William Menelaus (Dowais manager) constructed ' '. . . a large, modern [blast] furnace, 60ft 6ins at the hearth'. British Steel Corporation's Redcar furnace (the largest in Europe) has a hearth diameter of 14m (45·9ft). There is something seriously wrong here.

But no book is perfect and it is unlikely that any book ever will be. When a company history has to deal with what are effectively a whole range of different subjects, it is inevitable that a specialist in any of those subjects will want (may need) to take issue with the author. The present book is no exception. But the author has woven a vast mass of material into a coherent whole and produced a volume which can be recommended to serious students of industrial history and also to anyone who has even a casual interest, for above all it is eminently readable. Publication of the next volume will be awaited with interest.

W K V Gale

A Gazetteer of Charcoal-fired Blast Furnaces in Great Britain in use since 1660 *by* **Philip Riden.** *A4, vi +* 48 pages, card covers ISBN 0 9503299 6 7. Price £3.00 per copy (including postage) from the author at 38 Park Place, Cardiff CF1 3BB.

This is a most useful compendium which complements the work which the Historical Metallurgy Society (then the Historical Metallurgy Group) has been doing since its inception.

The Group was founded in 1962 to produce a survey of historical furnace sites, with substantial buildings above ground, before they were lost or destroyed, intentionally or unintentionally. The founder, George Reginald Morton, drew up an initial list of 24 good examples of such furnaces and this work was taken over by Ronald Tylecote with the object of furthering the search for, and recording of, more similar furnace sites and, in the end, producing an illustrated booklet of early blast furnace remains, which had been both charcoal and coke fuelled.

Contemporaneously, Philip Riden, was endeavouring to measure the output of the British iron industry since the early eighteenth century — a matter of interest to historians and statisticians. He produced his first paper in 1977 entitled "The output of the British iron industry before 1870". This included a resumé of previous work, particularly that of Hammersly (1973) and Hyde (1971). He pointed out that the period between 1530 and 1710 was effectively covered by Hyde, and that the period 1790 to 1854 was covered by official Mineral Statistics.

It was the period between the beginning of the eighteenth century and 1790 — when the iron industry turned over from charcoal to coke fuel and from water to steam power for blowing — which presented the greatest problem. He used Hyde's data which was largely based on Schubert's work (1957) and produced a paper "Eighteenth Century Blast Furnaces : A New Checklist" which was published in Volume 12 Part 1 of the Journal of the Historical Metallurgy Society, 1978. Apart from two tables of estimates of pig iron production in Great Britain 1720-1789 and 1790-1870, there were 3 tables of blast furnaces in Great Britain (a) charcoal furnaces erected (22) (b) charcoal furnaces closed (72) and coke furnaces built before 1790 (91).

The author has now developed this work. He took up Hammersley's assertion that the charcoal iron industry was never threatened by extinction for want of fuel, nor was it in decline in the later seventeenth, and eighteenth centuries. In fact, in 1750, on the eve of adoption of coke smelting the output of charcoal smelted iron was probably greater than ever before.

He has made full use for the first time of the various eighteenth century lists of furnaces preserved among the Boulton and Watt papers in Birmingham Reference Library and has now produced this publication which provides a summary history (it is hoped) of all the charcoal fired blast furnaces in use in England, Wales and Scotland between 1660 and the end of charcoal smelting in Great Britain in 1921.

Coke fuelled blast furnaces are not included.

He set his starting date at 1660 — halfway through the charcoal iron period. Prior to this date production was mainly in the Weald and had been extensively explored and recorded. For the period after 1660 several massive collections of business records have yielded rich rewards. These have been added to results of extensive searches of local and national literature and archives.

The result is the Gazetteer of 170 sites, some not previously recorded. Bibliographical references are given for each furnace, together with an indication of any surviving remains and National grid references.

The sites are arranged in twelve geographical groups: South Wales (20 furnaces); Forest of Dean (20); Shropshire (10); Mid and North Wales (7); South Staffordshire, Worcestershire and Warwickshire (8); Cheshire and North Staffordshire (10); Derbyshire, Nottinghamshire and Leicestershire (14); Yorkshire (8); Lancashire and Cumberland (17); Northumberland and Durham (6); The Weald and Hampshire (40) and Scotland (10). There is an explanatory introduction and a very useful bibliography with 180 references, and an alphabetical list of furnaces.

By comparison, the Society's index contains, at present, 90 sites on which there are visible remains, of both charcoal and coke fuelled furnaces, from *c.* 1570, with a further six under consideration, and of these 40 furnace sites are common to both lists.

Philip Riden's new Gazetteer is highly recommended not only as a basis for future work on the British charcoal iron industry from 1660 but also for those historical metallurgists who, in their travels, might like to savour areas which had been in thrall to the tyranny of wood and water.

Charles R Blick

The Art of Converting Red, or Rosette Copper into Brass by means of Calamine Stone . . *by Messrs Galon & Duhamel du Monceau, 1749-1764 translated by A P Woolrich and A den Ouden, published by De Archaeologishe Pers, 1987,* Hardback £10.00, Paperback £7.50.

Galon's classic account of methods and equipment used in the making of brass at Namur in the 1740s, and published as part of Descriptions des Arts et Métiers in 1765, is undoubtedly of great value as a source of technical information. His text was accompanied by illustrations which are outstanding for their clarity and detail when compared with what previously had been available. It is widely accepted that they were also used as a basis for the similar but better-known illustrative material by Diderot and d'Alembert in l'Encyclopédie which was produced at about the same time. When published, the Galon account was accompanied by additional and later descriptions by Duhamel du Monceau, also illustrated, referring to techniques at Villedieu-les-Poêles and Essone. They fall short of the quality of Galon's work but nevertheless are well worthy of study.

These sources have been recognised for their value, and used briefly by previous writers in the field of brass and copper history, but consultations of their original texts and illustrations are far from easy in this country. The promise of an integral translation together with all the accompanying illustrative material was a prospect to be welcomed with eager anticipation for anyone interested in this aspect of the history of metals.

It has to be said, unfortunately, that the realisation of the promise proves to be disappointing. Initial impressions are gained from the presentation of those all-important illustrations which, here, sometimes take on the appearance of rather second-rate photocopies. Admittedly, one accepts that there may be difficulties in reproducing such finely-drawn engravings in a publication so modestly priced, but these particular portrayals are important enough to be well worth the cost of better treatment.

At first sight, the textual material seems very impressive indeed. This is especially so in descriptions of the mechanical handling of brass production, less so in interpretation of furnace operations where both Galon and du Monceau are often vague about details of the processes, perhaps not surprisingly for their time. But to any failed-linguist brass historian there is great value in being able to absorb such technical description in the English language, providing it is a reliable representation of the original. With a deeper appraisal, however, the doubts about details of translation begins to surface.

A comparison with the original text soon reveals words, phrases, or sections that are completely misplaced or missing entirely. While this might be admissable in the pursuit of clarity there is need, and indeed there are accepted conventions, for informing the reader of such manipulation which, here, are usually absent. Less forgivable are the omissions which have nothing to do with clarity and one wonders just why they are absent. Completely missing, for instance, is the reference on page 11 of the original text, to a waste deposit 'the colour of azure blue' produced from a furnace operation. This has an important relevance to the recent discovery of comtemporary brass furnace remains and the accompanying blue deposits found at Warmley, near Bristol.

Disappointing too, are descriptions which fail, quite unnecessarily, to correspond with the original text, such as those portraying the brass-making furnace. Where Galon quite specifically describes a domed or capped structure, (la callotte), which relates quite well to the illustrations, the translators refer to an upper wall and a top, in words which are inadequate for the purpose. There are other similar instances and also extraneous words and phrases which are inserted into the translated text.

The level of understanding of brass production by the translators is demonstrated in the descriptions of process used at Villedieu-les-Poêles. Here the reader is informed by du Monceau that 'brass becomes hard when the melting period is prolonged too much' The translators' bracketed explanation, '[due to the loss of zinc by sublimation]', can only at best be described as misleading.

Such technical misinformation is compounded by misquoting further sources of documentary material. In the chapter entitled 'Evaluation' it is stated that **coal-fired** reverberatory furnaces were used in the preparation of Mendip calamine. The furnaces were, in fact, **fired by wood,** as described in 1734 by Swedenborg, and quoted in French translation to accompany Galon's original work. On page 47 of the original, one reads, 'On fait un feu de flamme avec du petit bois & branches d'arbres;'.

It would be possible to continue to catalogue the maltreatment of sound material in this volume, but why go on? If the reader wishes to acquire accurate and reliable information on the accounts written by M Jean Galon and M Duhamel du Monceau it is, quite clearly, still necessary to consult the original versions, or the recently produced Swiss reprint. Given the obvious constraints, a dip into the volume under review can still raise considerable respect and enthusiasm for the wealth of technical description which is stored in the original sources.

Joan Day

Rieuwerts, J H 1988. A History of the Laws and Customs of the Derbyshire Lead Mines. *A5 paper, pp38. £1.60 plus 30p post and package. Available from Peak District Mining Museum, Matlock Bath, Derbyshire.*

1988 marks the 700th anniversary of Quo Warranto, an inquisition held at Ashbourne by order of Edward I to examine the privileges claimed by the lead miners. It is the first written record of their rights, which had been established probably in Anglo-Saxon times, and which in modified form survive today, complete with the Barmaster, the Barmoot Court and Jury.

The booklet is intended for the general reader — a full treatment to compare with Pennington's "Stannary Law" (1973) has yet to appear. However for this early period Dr Rieuwerts has researched for many years, and this is probably as good a summary as is currently possible.

Contents include an outline of the lead industry prior to 1288, and an examination of the events which led to the inquisition. After, a great corpus of detailed law and customs developed, which can only be summarised — this was the basis of two Acts of Parliament in 1851-52.

Also included is a reprint of Edward Manlove's "poem" of 1653, in which the liberties and customs were "composed in meeter" for the benefit of miners. If you have ever wondered where the verb 'to nick' came from, here is the answer. The dozen or so illustrations include the standard bronze (latten really) dish used for measuring lead ore, presented to the miners by Henry VIII, and of course a photograph of a nicking ceremony taken early this century.

Lynn Willies

C J Williams 1987 The Lead Mines of the Alyn Valley. *240 x 185mm Paper. 40pp. Flintshire Historical Society, £2.50 (£3 by post). Available from Clwyd Record Office, Hawarden, or Peak District Mining Museum, Matlock Bath, Derbyshire.*

This attractively bound booklet is a reprint from an article published by Flintshire Historical Society in 1980, but with minor additions. It should deservedly thus reach a much wider readership.

The Alyn Valley has been the scene of a great deal of mining activity, involving famous names such as John Wilkinson and John Taylor, and famous mines such as Llyn-y-pandy, and later the consolidated Mold Mines, and this century the Halkyn Deep Level and the Milwr sea level tunnel to the Halkyn Mines. Steam enthusiasts will find six pirated engines under Wilkinson, and a further seven engines under Taylor. Water power was also much used, the concentration necessary to cope with some of the wettest mines in the kingdom. Smelting only receives a brief mention, though a fine illustration on the cover shows both mining and smelting works.

This is a well researched and readable account as befits a professional archivist, and is illustrated with some well chosen photographs, and useful maps: one of the latter for Pen-y-fron Mine shows an astonishing use of water power. Mining has given many words to the language — the Alyn Valley donates "Loggerheads".

Worth reading about.

Lynn Willies

The Crafts of the Blacksmith edited by B G Scott and H Cleere
UISPP, 295 x 206mm, vi+180pp, £31.00 + postage. (Dept of Conservation, Ulster Museum, Belfast)

The book records the twenty two papers presented at the Symposium of the UISPP Comité pour la Sidérugie Ancienne held in Belfast in September 1984. It is dedicated to R F Tylecote who, more than any other, has brought the skills and knowledge of the archaeologist and metallurgist to the study of early metallurgy.

In the title, the term blacksmith is used in a very broad sense to include not only the fabrication of objects from iron, but also the production of iron from the ore, and the smithing of other metals. The papers cover a very broad range of topics, but three major groups dealing with the bloomery process, metallography of artefacts, and evidence of iron metallurgy in various places are discernible.

Cleere in the first paper entitled "Ironmaking in the Economy of the Ancient World: the Potential of Archaeometallurgy" considers the archaeological, historical and scientific approaches that have been made to the study of the remains of ancient iron industries and indicates a need for a methodology for discussions between archaeologists and metallurgists. Ancient iron making processes are well understood, but little is known about the iron-makers or the amounts of iron that they produced, yet iron was available in relatively large quantities and was relatively cheap in the first half of the first millenium BC The paper concludes with an analysis of the iron industry in Roman Britain, which demonstrates that trade in iron was a significant factor in the economy of the ancient world.

In "The Early Blacksmith" Maddin first considers the influence of prior knowledge of bronze smelting on the processing of iron, and concludes that the knowledge was of limited value to the iron smelter because the processes differed widely. The paper continues with a rather misleading account of the physical metallurgy of iron-carbon alloys and the structures formed in their heat treatment. The reader unacquainted with this would be well advised to consult one of the many excellent textbooks on physical metallurgy. He goes on to consider the microstructures of artefacts from several sites in the ancient world, making considerable use of the use of the traces of structures remaining in their corrosion products, so-called relict structures. In the writer's view such observations should be treated with extreme caution. The micrographs of the relict structures are unconvincing and the magnifications of many of the micrographs are omitted. A subsequent paper in the symposium by Nosek and Mazur deals with "The Oxidation of Iron Carbon Alloys at Low Temperature", and demonstrates that different iron oxides are formed when ferrite and cementite are oxidised at temperatures between 150 and 450°C, and may account for relict structures. However, the oxidation products formed at these temperatures are not necessarily those formed during the corrosion of artefacts under often damp conditions near room temperature. Markings on some of the micrographs suggest that labelling has been omitted in reproduction.

The first of the papers on the bloomery process by Clough entitled "The Bloomery Process — Observations on the Use of Rich Ores in the Production of Natural Steel" addresses the problem of smelting ores that produce very little slag, which is often the major indication of ancient smelting activities. He adduces ethnographic evidence from the third world of preference for rich ores. In conventional bloom formation the slag has three important functions: it takes up the gangue minerals, absorbs impurities, and protects the bloom from excessive oxidation or decarburization. Moreover, lack of slag makes particle agglomeration and growth difficult. However, use or rich ores yields a relatively large quantity of iron from a given quantity of ore. Ethnographic evidence shows that small bowl furnaces are commonly used for smelting rich ores, whereas larger, taller furnaces are used for poorer ores, because larger volumes of ore need to be employed to obtain the same quantity of iron. Production of natural steel is also considered and it is concluded that it could be produced by manipulation of the smelting variables in the bowl furnace. Finally the author warns of the indiscriminate use of furnace classification for cultural-historical reconstruction and dating. "The Ore-Slag-Technology Link" by Kresten employs the method used to represent composition in quaternary systems in a novel manner to relate the compositions of the slag to the composition of the ore from which it may have come. Thus, it is possible to deduce whether the slag found on a site could have come from the ore found on it, and if so whether fluxes had been used. The procedure was successfully applied to slags and ore found at four Swedish bloomery sites and two blast furnace sites. The procedure promises to be a useful addition to the techniques used in the study of bloomery and blast furnace technology. Bielenin's "Bloom Smithies in Early Historic Sites in the Holy Cross Mountains" gives an interesting account of the many organized bloomery sites in this part of Poland during the first three centuries of the first millenium. The sites studied each contained 100 to 200 furnaces, and produced several times as much iron as was required locally. Thus owing to the size of the operation, organized ore mining and export organizations would have been required.

Attention is drawn to the fact that evidence for smithing is much more sparse than that for smelting in McDonnell's paper "The Study of Early Iron Smithing Residues". He considers evidence concerning the remains of smithing hearths and smithing residues from two sites. A tradition of waist high hearths goes back to the Roman period, even though no examples have been found, but archaeological evidence points to hearths close to ground level. Smithing residues were divided into five groups: hearth lining material, fuel ash slag, hammer scale, smithing slag, and cinder. All were composed mainly of iron silicates and were very variable in composition. The paper gives an interesting insight into early smithing.

"The Technology of Celtic Iron Swords" by Janet Lang records the detailed investigtion of 17 Celtic swords, which span the period from Hallstatt C to La Tène III. She discusses the method of manufacture, the evolution of the technology of sword making, and the variations in technique in the various regions of England, and compares her findings with information gleaned from the classical writers. The swords were long, and from the La Tène period onwards were constructed by piling, using either edge to edge layering or surface to surface banding, and probably eventually pattern welding. In a few cases salt was used as a flux to facilitate welding. Hardening of the blades was achieved by the use of iron containing either phosphorus or carbon. Quench-hardening treatments were rarely used, thus swords were often rather soft. The value of this informative paper is enhanced by an appendix giving full details of each of the swords examined. "Examination of Some Early La Tène Period Knives from Bohemia" by Pleiner reports on the metallography of six knives attributed to the late Hallstatt, early, middle and late La Tène periods found in sunken huts and storage pits at the important settlement of that period at Radovesice. Four of the specimens had blades consisting of strips of wrought iron and carbon steel welded together, but there was no evidence of heat treatment. The early smiths seemed regularly to produce excellent work but, as amongst the knives examined, they also produced unsuccessful articles. The classification and metallurgy of Anglo-Scandinavian knives found at York are discussed in the papers "Anglo-Scandinavian Knives from 16-22 Coppergate, York" by Ottaway, and "The Metallurgy of Anglo-Scandinavian Knives" by McDonnell. Some 300 knives, more than two thirds dated to the Anglo-Scandinavian period (*c* 875-1066 AD) have been found on the site. They have been classified into five groups based on the shapes and slopes of their backs and their dimensions. The forms of the cutting edges were also studied. Many of these edges were slightly S-shaped, perhaps an indication that they had been well used and frequently resharpened, for the most used part of a knife blade used for cutting is towards the tang and would need most sharpening. The data amassed suggest that knives were made for a wide range of purposes, including specialist applications. Five knives were subjected to thorough metallurgical examination including metallography, electron-probe microanalysis, chemical analysis and X-radiography. The methods of manufacture were elucidated and they clearly demonstrated the smiths' knowledge of quench-hardening heat treatments.

In "Bryn y Castell Hillfort" Crew describes the excavation of a late prehistoric iron working settlement in north-west Wales. The site has yielded considerable evidence of iron smelting and bloom smithing in the periods 100 BC to 70 AD, and 150 AD to 250 AD. During the earlier period evidence suggests that there was a gradual improvement in technology. Several hundred kilograms of iron working residues have been found and await detailed metallurgical investigation.

Rozanova and Sedov assess the development of blacksmithing in Russia in "The Art of Metal Working in the Ancient City of Suzdal" by considering the manufacture of knives during the period from the eleventh to the thirteenth centuries. The 61 knives examined were divided into seven groups based on the materials and the methods of manufacture. More than two thirds of the knives had been welded, and the quality of the welding was good. Moreover, most of the blades had been effectively heat treated. They conclude that the smiths were very skilful. "A Study of Iron Technology in the Wessex Iron Age" by Ehrenreich gives the results of a preliminary study of the growth, acceptance, and distribution of the Wessex iron industry. A few hundred artefacts from sites in

Hampshire and Wiltshire were sampled, subjected to metallurgical analysis, and the data subjected to statistical analysis. The data suggest that phosphoric iron may have been deliberately selected for the manufacture of hooked blades, that carburizing and heat treatment processes were not used, and that expertise in iron technology was unevenly distributed throughout Wessex. The combination of metallurgical techniques, computer analysis, and archaeological experience is demonstrated to be a powerful way of increasing our understanding of the Iron Age. Photos et al give a preliminary report on "Iron Metallurgy in Eastern Macedonia'. It considers the geology of the island of Thasos and the mainland, the metallurgy practised in these places and the artefacts found, and gives the historical background of the region. Detailed analyses of magnetite sands, used as ores, iron slags and their individual phases are reported. The data is used to establish the provenance of the ores, and to draw preliminary conclusions about sources of iron ores, and the date of the introduction of the smelting of magnetite sands. "Who were the Blacksmiths in Jämtland and Härjedalen?" by Magnusson gives an interesting account of the character, prehistory, and history of two districts in the north of Sweden. The districts were sparsely populated and from Roman times in Jämtland and about 1000 AD in Härjedalen had settled farming populations. In the late Roman and migration periods there were great booms in iron production combined with farming, and again some three hundred years later. In the eighteenth century Sweden began to develop its industries, farming, and science and iron production became its major industry. Magnusson develops a social and economic model of an eighteenth century farm in these districts and concludes that the farmers were versatile, and produced by the bloomery process, iron that they turned into a variety of objects for home use and export. Gömöri in "Some Relics of the Early Hungarian Blacksmiths' Craft" examines the historical background of the iron industry in the tenth and eleventh centuries, considering linguistic evidence, place names, myths, archaeological evidence, and smithing slags. He then considers fourteen iron objects dating from the period. The paper is very confusing, and the figure numbers given in the text do not accord with those on the accompanying figures. Twenty four figures accompany the text, but reference is made to forty figures. Moreover, there seems to be confusion in the designation of some of the microstructural constituents shown in the micrographs.

A very lucid account of the statutes governing the mining and production of copper in the Municipality of Massa Marittima in Italy is given by di Caprio and Sorti in " . . . The Mining Statutes of Massa Marittima (Grosseto, Italia), an Early Fourteenth Century Act of the Miners' Corporation". The statutes cover prospecting, galleries, drainage, hauling, ventilation, ore dressing, copper smelting, copper refining, and quality control. They clearly demonstrate the high degree of regulation and controls that were operated in this city state.

In "The Status of the Blacksmith in Early Ireland" Scott draws on Irish legends and folk tales to establish the role and status of the pre-Christian blacksmith in early Ireland. He was clearly distinguished from other kinds of smith, and his skills were highly regarded. Moreover, he was accorded important social and religious status, and was considered to be endowed with mystical powers, associated with his role as provider of the gods with their weapons. The author presents his case and makes his point in an extremely interesting and entertaining manner: clearly the bards live on in Ireland !

The final three papers are concerned with the standardization of procedures used in the metallurgical examination of iron objects. Piaskowski in "Proposals for a Standardization of the Criteria for Determining Technological Processes in Early Iron and Steel Metallurgy" puts forward metallographic criteria for the identification of welding and carburizing, and illustrates their application to a number of objects found on Polish sites. He draws attention to the influence of phosphorus and arsenic on non-uniformity of carburization, thus causing banded structures. It is suggested that in earlier investigations errors may have occurred. In his second paper "A Standardization Procedure for the Presentation of the Results of Metallographic Examinations of Early Iron Implements" he draws attention to the need for a standardized procedure for presenting the results of metallographic examinations of early iron artefacts, so that they are understandable in whatever language they are presented, and puts forward a possible scheme. The final paper by Pleiner "Problems in the Standardization of Metallographic Investigations of Archaeological Iron Objects" draws attention to the fact that different laboratories have different capabilities. Moreover, there are three main objectives for archaeometallographic research, which influence the approach to be adopted. Rightly, he considers that at the present time it is impractical to lay down a detailed plan of investigation. Nonetheless, some reports fail to include all the essential and readily-determined data. Thus he sensibly suggests that data should be presented in a factual form, clearly identifiable from any interpretation put upon it, and that specimens should be retained as archival material, so that if necessary they can be re-examined as new techniques become available.

The reproduction of the book and especially the micrographs is good. However it suffers from a number of typographical errors, and in a few cases figures have been omitted. A surprisingly large proportion of the abstracts fail to indicate clearly the contents of the papers and the conclusions drawn. Nonetheless, the collection of papers, and especially the metallography, is impressive, and should be essential reading for those working on the archaeometallurgy of iron. The papers presented in this volume are indeed a worthy tribute to the first amongst archaeometallurgists.

Raymond Haynes

Vagn Fabritius Buchwald and Gert Mosdal 1985. Meteoritic iron, telluric iron and wrought iron in Greenland, Meddeleser om Gronland, *Man and Society 9:49pp Copenhagen 1985-12-31 (ISBN 87-17-05239-4).*

The scientific investigation of 74 iron objects from excavated settlements in Greenland, presently at the National Museum in Copenhagen, together with samples of local meteorites and telluric iron (iron bearing basalts) are presented in this very interesting and in-depth study on Greenland Eskimo iron metallurgy.

Professor Buchwald is a specialist in the study of meteorites a fact which makes him exceptionally suited to discuss, together with his collaborator Dr Mosdal a type of iron technology heavily based on meteoritic iron.

There are not many geographical regions where the path to iron metallurgy did not go through pyrometallurgy. It is a fact, we are told, that Greenland Eskimos did not smelt iron ores due to permanent shortages of fuel despite the presence of local resources. As a matter of fact pyrotechnological remains of any kind are absent and this includes ceramic artefacts. Thus, iron metallurgy consisted of cold working and reshaping of wrought iron brought in by Norseman as well as the working of two rarer sources of iron ie meteorites and iron bearing basalts.

An important attribute of this work is that meteoritic, telluric and wrought iron occur side by side within the same cultural context. One of the two aims of the investigation is the association of ore to artefacts particularly in what pertains to the first two sources. There exists a sufficient amount of literature on meteoritic iron from the E Mediterranean "the iron from heaven" of the Hittite texts. However, despite the abundant literary evidence and speculation about the meteoritic origin of a number of Europe's earliest iron artefacts very few have actually been conclusively identified as such on the basis of chemical analysis and metallography. Furthermore, no known sources of meteorites could be directly connected with these artefacts. This is where the present monograph's contribution is unique. Source (Cape York meteorite and Disko region iron bearing basalts) and artefacts are in close proximity and direct comparisons can easily be drawn.

The second point raised in this work is Eskimo iron working economy and trade contracts (16th c onwards) with Denmark and other European countries as can be deduced from the occurrence and distribution of wrought iron objects. Earlier (900-1200 AD). Norse settlements in the south were also responsible for the distribution of wrought iron among Eskimos in the period predating the opening of contacts with Europe. The authors reveal that the northwestern part of Greenland (north of Melville Bugt) resorted to the Cape York meteorite for its iron supply while the central and western part to the telluric iron of the Disko region. Finally, the south depended on the wrought iron of the Norse settlements imported from Europe.

A general background on the meteoritic iron in Greenland (Cape York meteorite) is juxtaposed with objects made from fragments of the above. A number of analyses of nickel content are given together with a comprehensive collection of photographs of metallographic structures. The presence of elongated taenite (high Ni) and kamacite (low nickel) bands, the result of distortion upon work-hardening during cold-hammering, combined with the absence of slag inclusions, are a criterion for meteoritic iron.

Some slightly misleading popular ideas presently propagated in the literature on meteoritic iron are lucidly clarified. First, a meteoritic shower produced from the breaking upon impact of a single meteorite far from being localised can spread over an area of more than 100 square km and can be traded to even longer distances of more than 2500 km. Second, not all meteorites can be worked due to a number of phosphide, sulphide or chromite inclusions and/or high nickel contents. One use for such "unworkable" meteorites, the authors suggest, may have been anvil stones but no such objects were found in Greenland. Thirdly, large, irregularly shaped pieces of meteorites would have been difficult to work without the application of heat, and thus local "smiths" would opt for easy-to-hammer small fragments.

Apart from the insight on meteoritic iron the present monograph is particularly instrumental in putting forward in the archaeometallurgical record analytical evidence for telluric iron both as source and artefact. W Greenland (Disko region) has one of the very few occurrences of that particular iron source in which pea-sized native iron inclusions are released from the basalt by hammering. The differences with meteoritic iron are clearly described and eloquently summarised (Table 14). Thus, the nickel content is lower than that of meteorites (1-4% Ni) while the carbon content ranges from malleable nickel iron (0.2% C) easily worked into tools, to white nickel cast iron, most probably never worked due to excessive hardness.

Data on increased hardness by cold working of both meteoritic and telluric iron is brought in to show that when a strong cutting edge can be acquired by cold hammering processes like quenching and annealing are made redundant. It is the first time, to the reviewer's knowledge, that data on hardness testing of archaeometallurgical nickel-rich objects is made available. The authors' experiments on work hardening of a fragment of Cape York meteorite and a modern mild steel are most illuminating.

The authors raise an important point namely that phase analysis of taenite and kamacite bands is more illuminating than bulk chemical composition in the analysis of meteoritic iron. Both terrestrial (smelted nickel-rich iron) as well as meteoritic iron can present laminations, the first arising from the forge welding of high and low nickel-iron, the second from kamacite/taenite bands (assuming the meteorite is an octahedrite). The reviewer would like to add that an additional incentive for phase analysis are irregular high and low nickel areas often detected in iron artefacts.

These are the result of uneven solid state diffusion of nickel in iron under bloomery smelting conditions (Photos, in press).

Some geological information on the Greenland iron ore sources may have not gone amiss. It is tacitly assumed but not explicitly mentioned that no nickel-rich ores are evident in Greenland. Some discussion on comparative material found in Scandinavia could have been useful. The ore source of Swedish nickel-rich currency bars (Thalin 1973; Hanson and Modin 1973) dating to the Migration period and almost contemporary with the first Norse settlements in Greenland still needs further investigation.

Another useful addition would have been the inclusion of one or two maps in which place names not included in the general map of Fig 1 could be easily found. Distinguishing between Eskimo and Norse settlements was not always self-evident.

Provenancing of the ore source for smelted wrought iron is one of the questions investigated in this monograph. Such work normally relies on a detailed analysis of slag inclusions in the artefacts and a good knowledge of the ore sources available. Given the random selection of the analysed wrought iron objects presented in this monograph it would be almost impossible to attribute ores to artefacts. Hematite and limonite ores are so widespread and so often found in association with oxidised copper minerals that one would hardly need to travel to N Spain to come across an iron ore containing copper (p26). Furthermore, one of the positive advantages, in provenancing the ore source is that contrary to bronze, slag inclusions originating from smelting cannot be lost even if two or more pieces of iron from differing sources are forge-welded to produce a new artefact. Thus, contrary to what the authors suggest it is still possible with detailed microprobe examination to identify the ore source of recycled scrap provided that characteristic minor or trace elements are associated with each ore type.

Overall I believe, this informative monograph should be consulted by all investigators working on archaeological nickel-rich iron. Its lucid photographs are most illuminating while its glossary serves as an archaeometallurgist's handy guide to meteoritic iron. It is, in some ways, unfortunate that Greenland Eskimos did not occasionally heat-treat their meteoritic iron. Had they done so, Drs Buchwald and Mosdal would have presented the reader with a unique handbook of structures to which investigators of meteoritic iron of any geographical region would always readily resort to.

References

1. **Hanson T and S Modin,** A metallographic examination of some iron findings with a high nickel and cobalt content. *Early Medieval Studies 1973,* **5,** *5-23.*

2. **Photos E,** The possibility of smelting Ni-rich iron ores in Greek antiquity: archaeological evidence and experimental results. *World Archaeology, February 1989.*

3. **Thålin L,** Notes on the ancient iron currency bars of N Sweden and the nickel alloys of some archaeological objects. *Early Archaeological Studies 1973,* **5,** *24-41.*

Effie Photos,Institute of Archaeology, London.

News and notes

An 18th Century Spanish wreck off the Portuguese coast

In February 1786 the Spanish vessel "San Pedro de Alcantara" bound for Cadiz from South America was wrecked in a storm on the headland of Peniche 75km north of Lisbon. It carried about 440 people and some of the bodies were buried in a small cemetery on top of the cliffs marked by a memorial cross. As the ship was wrecked in shallow waters salvage has been going on ever since. Recently, controlled underwater excavation on the wreck has been directed by Jean-Yves Blot of the Museum of Peniche and on the cemetery by his wife Maria Luisa de B H Pinheiro Blot of the Archaeological Museum in Lisbon.

We know from the finds and its manifest which was located in the Hague that the ship was on its way from the port of Callao in Peru which it left in 1784. When wrecked it was carrying 600 tonnes of copper "bars" and some pigs, as well as cartons of silver coins and some gold. The copper was probably loaded at Talcahuano, a port near Concepcion, and is therefore most probably Chilean. It is possible that this shipment was a once-only event designed to overcome the shortage which was developing in Spain due to the war with Britain cutting off their previous imports from Sweden. The copper "bars" measure about 65 x 25 x 10cm thick and weigh over 100kg. They have "ears" on either side on the top (casting side) surface and a large shrinkage cavity in the centre. The fact that Chile was capable of making such large ingots of copper in the 18th century seems incredible. It demonstrates the then scale of the metallurgical industry under Spanish and Portuguese control at that time and shows the enormous increase in size that had developed since that described by Alonso Barba in his book "Arte de los Metales" of 1640.

In the period 1761-1775 the king of Spain received 10,000 quintals (460 tonnes) of copper from Peru while other customers got 65,000 q. It is possible that tin also came from the same area (Bolivia still being one of the World's tin producers); this all went to make guns in the foundries of Spain.

The Dutch archives in the Hague have a drawing of the method of loading the ship. The copper consisted of 6930 bars and 13 "salmons" which was tightly packed together with the silver coins and probably some bars of tin.