

## Book reviews

**The Living Rock** by Arthur J Wilson. *Woodhead Publishing Ltd, Cambridge, 1994. xix+291pp. Many figures, index. ISBN 1 855573 154 1. £35-00, US\$65-00.*

This book, written by a layman in terms of scientific archaeometallurgy, though a professional writer with a sound record on metal matters, attempts to cover the subject indicated by its subtitle 'the story of metals since earliest times and their impact on developing civilisations'. To do so, it tackles the – essentially western – history in twenty individual chapters. The first group is devoted to the very beginnings of metallurgy in the neolithic and up to the fully blown economy of the Roman Empire, while the second half mainly treats developments since Agricola, focusing on modern times. Little is known about the Dark Ages in between, but enough to fill two chapters anyway. Asia east of Mesopotamia and sub-Saharan Africa are not dealt with at all, and the Americas appear only in their colonial context.

The book is good and easy to read, and at no stage is the reader bothered with scientific formula or specialized language. To the contrary, all information is neatly packed into tales and stories, often developed around individual men. The neolithic period, mainly used to give the pre-metal setting, features Leakey and Olduvai Gorge, while the prosperity of Egypt, owed to its vast gold deposits, comes along with the tremendous life work of Sir Flinders Petrie. Other periods star Sir Arthur Evans of Knossos, Georgius Agricola, to whom the whole book is devoted to commemorate his 500th birthday, and the Hoover family. What makes this book outstanding is the solid scientific background, remarkable especially for the early periods where other popular books often tend to oversimplify or, even worse, to give long out of date information. The source for this knowledge is easy to spot: A J Wilson is closely associated to the Institute for Archaeo-Metallurgical Studies, and its founder Beno Rothenberg wrote not only the introduction, but obviously also acted as scientific adviser. This close link also explains the prominent position given to his life and work, making Rothenberg outstanding among the aforementioned scholars. The reviewer cannot however help mentioning that there is more current archaeometallurgical research in the world, and in particular in the Arabah, than just Timna. Neglecting Feinan, situated only a stone's throw away across the valley, and at any rate outnumbering Timna in copper production through the millennia, certainly reflects a very personal view.

An interesting and important feature of the whole book is the connections that are frequently made between developments in mining and metallurgy and in overall history; certainly this is a connection not only the Hoovers would have liked. This gap-bridging, explicitly intended from the beginning, leads however to some sort of associatively structured chapters, whose content is sometimes not obviously linked to its heading. In this respect, the maps on pages 18 (Mines of the Middle East), 37 (Gold and copper mines of Ancient Egyptians) and 58 (Mining areas and sites in the central and eastern Mediterranean) especially do not really give what they promise; probably a minor niggle.

To sum up, *The Living Rock* is a devoted book for anybody interested in metals and history in general. Though it is not a scientific textbook, its content is up to date and presents fascinating new insight into the history of mankind. It should find many readers among the Historical Metallurgy Society!

Thilo Rehren

**A History of Metallurgy** edited by Fathi Habashi. *Métallurgie Extractive Québec, Québec, 1994. 330pp, 150x235mm, 123 figs, index. ISBN 2 9803247 1 X. Can\$35*

This book reproduces nine articles on extractive metallurgy from Singer, Holmyard and Hall's five volume *History of technology*, published in the 1950s by Oxford University Press. The editor has made occasional cosmetic alterations to the text and includes a brief preface and introduction. In the former he comments that '... this book will be an important tool to diffuse information of historical interest to metallurgists, to students and engineers. Although it is written by a number of authors, yet it looks like a textbook and can be used for teaching purposes.'

It is certainly convenient to have these papers reprinted in a single inexpensive volume, but there are drawbacks. The illustrations appear to have been scanned in from the original publications, which has in many cases resulted in loss of definition. What will doubtless be a source of frustration to many readers is that only the extractive metallurgy chapters have been reproduced, but not those dealing with mining or fabrication; thus both the beginning and end of the chain of metallurgical processes are omitted. However, these are only minor criticisms compared with the basic short-coming of the book: its

'period' feel. A brief paragraph in the introduction mentions more recent work but the latest reference in the main text is dated 1963, though Tylecote's (1976) *History of Metallurgy* does creep into the literature guide!

Nowhere is it suggested that knowledge about the history of metallurgy has increased or moved on in the forty years since these papers were written. In their day, they were masterful distillations of the current state of play, but since then the subject has developed by leaps and bounds. I can only hope that the new generation of students, at whom the book is aimed, will show more enterprise than its editor and will discover recent and current work, and with it the excitement of changing perspectives and new discoveries.

Justine Bayley

**In Quest of Mineral Wealth: Aboriginal and Colonial Mining and Metallurgy in Spanish America.** Edited by Alan C Craig and Robert C West. *Louisiana State University (Geoscience and Man No 33)*, Baton Rouge, 1994. 354pp. 86 illustrations including 23 maps, paperback. ISBN 0-938909-57-6. US\$25 plus US\$2 postage and packing within the US. Distributed by Geoscience Publications, PO Box 16010, Baton Rouge, Louisiana 70893-6010, USA.

This volume contains the proceedings of a symposium on Colonial Mining in Latin America presented at the 47th Congress of Americanists, held in New Orleans 7-11 July 1991. The editors, a geographer and a geologist, organised the symposium to include economists, historians and archaeologists; among them three are from Mexico, four from Spain and one each from Columbia and Chile.

The mineral wealth of the title applies mainly to ores and their exploitation. There are two contributions on other materials, one by Phil Weigand on the turquoise trade in Mexico and what is now the southeastern United States, the other on tar burning in coastal Ecuador. The area covered, Spanish America, represented most of the New World except for Portuguese America (Brazil), English North America (Canada and some of the United States) and French America (Quebec). The volume has been organized in two parts, aboriginal, and colonial. The emphasis in this volume is less on technology transfer from aborigine to colonist and more on the transfer of technology from Old World to New.

Robert West's overview of aboriginal metallurgy describes the south-to-north diffusion of metallurgical developments that accompanied evidence of trade from the Peruvian Andes coastwise to Mexico. This metallurgy was based on gold and copper and their alloys. Izumi Shimada's review of Andean metallurgy

describes the use of blowpipes in the absence of bellows, and the 'prill selection process' of smelting copper occasioned by the lower processing temperatures of lung-powered draught, but no one emphasizes the concomitant lack of smelted iron. Shimada's call (p.68) to use archaeological information to recognize the 'fusion' of pre-Hispanic technology, even its survival, is in order. One interesting survival was the *huayra*, a natural draught furnace used in the Andes to smelt high grade silver overnight when kadiabatic winds induced a draft by the venturi effect. These little furnaces were employed wherever suitably high grade ore could be found. On the evidence of a single photograph they survived at least until 1893 (p.282).

The Spanish Empire's need for gold to underwrite its army of mercenaries quickly depleted the aboriginal reserves. These are described by Otis Young (p.110) as 'the sum of centuries of patient, grain-by-grain accumulation'. Their exhaustion produced what Susan Ramirez calls 'the Spanish bullionist myopia' (p.97), in which the copper deposits important to the indigenous economy were ignored. In contrast, the great silver strikes of the 1530s were so swiftly exploited that by 1555 the Mexican patio process had been developed to beneficiate the remaining lower grades of silver ore by amalgamation with mercury. The abundant supplies of mercury available from Almaden in Spain were supplemented from 1566 on by local mercury from the great strike at Huancavelica in the Andes.

These developments coincided with the publication of the first great mining text, Agricola's *De Re Metallica*, in 1556. The transfer to Spanish America of the Saxon mining technology described by Agricola is discussed by several authors. Young points out (p.111) that this technology relied on the ready availability of wood, iron, and water power, all scarce in Mexico and the Andes, where they were replaced by stone, leather, and animal power. Leather was used for ladders as well as bags and buckets. Rawhide is still an expedient, being substituted for the proverbial iron baling wire used elsewhere. Efforts to mechanize the patio process by introducing the barrel system (p.335) were found inappropriate to American conditions. Though slow, inefficient and labour intensive, the patio process continued to be tolerated as late as 1880 because it required low capital and, most importantly, little fuel.

All this activity in Spanish America produced its own text, that of Padre Avaro Alonso Barba, whose *El Arte de los Metales* was written in 1637 and published in Madrid in 1640. His work is available in English translation by Ross E Douglas and E P Mathewson (New York, 1923). Barba wrote from his own experience. He is said to have been particularly skilled in the reprocessing of tailings.

Because the topics in this volume are treated from the viewpoints of several disciplines, it is in great need of cross referencing. There is no index. There are some errors, eg a description of electrochemical replacement plating is confounded with that of depletion gilding (p.16); units are not given in a table of elemental compositions (p.86). There is, despite the subtitle, very little metallurgy in this book. Its strength lies in other areas. Many of the 19 papers in this volume are based on current research in the Spanish and colonial archives that, since all the papers are in English, has been made conveniently accessible to those with little Spanish.

Martha Goodway

**La Métallurgie Comtoise: xv-xix siècles** by Jean-François Belhoste, Christiane Claerr-Roussel, François Lassus, Michel Philippe and François Vion-Delphin. *Inventaire Général, Région Franche-Comté, Besançon, 1994. 412pp, maps, figures, plates. 270x210mm. ISBN 2 9507436 1 7. 390FF.*

This well-produced volume is the fifth in the series of studies of the French iron and steel industry published by the *Inventaire* from the research of its regional teams. Jean-François Belhoste has had a central role in developing and maintaining consistent standards and format, as well as providing major contributions to the texts. The valley of the Saône is of particular importance for the introduction of the blast furnace and finery forge in the fifteenth century. The first chapter sets out the evidence for the early use of the indirect process, in the context of recent research into the medieval European pattern of innovation in iron smelting. Archive evidence shows that a blast furnace was in operation at the forge belonging to the Benedictine Abbey of Bèze in 1427, and another at Greucourt by 1469. It is suggested that a number of other forges which were constructed during the fifteenth century also used blast furnaces for smelting, probably bringing the total in the region to 15 by 1500.

The growth of the industry in the sixteenth century is shown by the construction of furnaces and forges in the southern tributary valley of the Saône, that of the Ognon, and by information about the developing trade in iron. Of particular value are an enquiry of 1562 into the iron trade of the area, which reports on the main works, and the accounts for the furnace at Cugney, 1620-22, which are discussed in a brief but illuminating chapter. This phase of the Saône industry was brought to an end in 1636 by the campaign of Henry IV, King of France, in which the majority of the ironworks were put out of action. The re-creation of the industry in the seventeenth century is seen from archive sources which illustrate the relationship between the forest economy of the uplands and the industry of the valleys, some of the works reconstructed,

others new, often taking advantage of more favourable sites for water power. The iron producers remained consumers of charcoal until the nineteenth century, attempts to use coke before 1800 being largely unsuccessful. Despite a change by several works from the 1820s, much of the industry of the region continued to be fuelled with charcoal over the nineteenth century. The final chapter discusses the reasons for this slow change, but shows that other contemporary innovations, cylinder-blowers, steam engines and hot blast, did not pass the region by.

The authors make excellent use of archive sources, and the text is illustrated by numerous extracts from contemporary maps, many finely reproduced in colour. The emphasis of the whole series has been on the written record, leaving the archaeological side of these studies somewhat muted. The gazetteer at the end of this book comprises notes on 52 sites (each of the entries is headed with the identifying number 70, which is assumed to be an error in setting). The information is, again, largely from archive sources, and the notes on the condition of remaining features are brief. It would have been useful to have been given more detailed topographical descriptions, of earthworks and evidence for the use of water power. The three-column format of the gazetteer has led to the over-reduction of photographs of buildings. Visitors seeking archaeological sites in France are inevitably hampered by the lack of numbered grid-lines on the commonly-available 1:100,000 IGN maps, and this is paralleled by the lack of precise locational information in gazetteers in this series. However, as the larger-scale maps, at 1:50,000 and 1:25,000, do at least bear marginal latitude and longitude scales, some attempt to make use of these would have been worth while and might be considered for the volumes now in preparation.

David Crossley

**Boles and smeltnills: report of a seminar on the history and archaeology of lead smelting held at Reeth, Yorkshire 15-17 May 1992.** Eds Lynn Willies and David Cranstone. *Historical Metallurgy Society, 1992. 66pp. ISBN 0 9506254 4 2. £10-00 (pb).*

This important publication resulted from a lively and successful weekend meeting of the Historical Metallurgy Society, held 'on location' within the former lead-producing area of Upper Swaledale, and actively supported by staff of the Yorkshire Dales National Park. Notwithstanding the long interval between the report's publication and the appearance of this notice, the production steps were completed rapidly and the product marketed at modest price in order to make it accessible.

The text is set in three columns on the A4 pages and at fairly small size to pack in a large quantity of



information, but the clear printing allows it to be readable and agreeable. Generally, the various illustrations convey their messages effectively, although the three pages devoted to micrographs of polished sections are of only moderate quality and, as they lack captions, necessitate searching of the text to obtain enlightenment. There are more than 20 articles by as many authors, three quarters relating directly to the lead industry of Swaledale and the northern Pennines. Several contributions draw on evidence in south-western England and concern relationships between the production of silver and lead. As the following details show, topics considered range from the chemistry, technology and archaeology of lead smelting, through the analysis of slags and soils, to the flora of the upper Nent valley and to protecting the remains of the industry in the Yorkshire Dales National Park.

Contents: *Lynn Willies*, Introduction. *David Cranstone*, Conclusion: the way forward. *Michael C Gill*, An outline of the chemistry of lead smelting, 3. *C J Salter and J P Northover*, The use of lead in extractive metal-working at Hengistbury Head, 4-5. Metallurgical examination of residues from the late Iron Age – Early Roman site showed lead was used either as metal or sulphide to extract silver from copper matte smelted at the site. *Justine Bayley*, Lead metallurgy in late Saxon and Viking England, 6-8. Lead was used in four main ways: (i) to make objects, (ii) to assist in the working of other base metals, (iii) as a necessary raw material for the refining (cupellation) of precious metals, and (iv) as a raw material for glass making. Archaeological evidence for these uses is presented. *Ian Blanchard*, Technical implications of the transition from silver to lead smelting in 12th-century England, 9-11. The paper examines the technology used during the great 12th-century British silver mining boom; it describes the emergence of a separate and discrete lead industry with its own technology which involved the use of a bole at the end of that century and the subsequent assimilation of these techniques to produce that new technological complex which underpinned the late 13th-century boom. *Peter Cloughton*, Medieval silver-lead mining in Devon, 12-15. Silver-lead smelting in the 13th and 14th centuries was fundamentally different from that of lead. With great reliance on the furnace, and high lead losses, it evolved to extract the maximum amount of silver from a restricted resource. *Lawrence Barker and Robert White*, Early smelting in Swaledale and Arkengarthdale: a further look, 15-18. A distribution of early smelting sites of varying form is outlined, together with some historical evidence for bole smelting and the removal of slag. *David Kiernan and Robert Van de Noort*, Bole smelting in Derbyshire, 19-21. The existing state of knowledge about the structure, operation and location of Derbyshire boles is outlined and followed by a description of a recent field survey of a bole site at Totley, near Sheffield. *J*

*Linda Drury*, Medieval smelting in County Durham: an archivist's point of view, 22-24. Most medieval documentary evidence of smelting is disappointingly vague as it was not compiled to record processes or technicalities; however, occasionally a more detailed document may be found. Various illustrations are given. *John Pickin*, Early lead smelting in Teesdale, 25-27. The occurrence and distribution of slag scatters relating to early, pre-16th century, lead smelting in Teesdale are discussed and a site gazetteer is included. It is suggested on the basis of site location that a distinction can be drawn between bole hearths and blackwork ovens. *David Cranstone*, Excavations at Old Gang smeltnill: an interim report, 28-31. Excavation and structural recording have revealed considerable information about a large Yorkshire ore-hearth smeltnill. In the 19th-century Lower Mill, the base of an ore hearth and associated structures was revealed. Nearby, a late building is interpreted as an assay house rather than a silver refinery. The (?18th-century) Upper Mill retains the arches of two ore hearths and an intensely-heated flue believed to have emanated from a reverberatory furnace. Flues from the Lower Mill were later inserted through the building; the eastern part was rebuilt at this time, and is argued to have contained at least one roasting furnace serving the Lower Mill. *Antony Francis*, Analysis of refractory material from Surrender smeltnill, 32-34. Samples of glazed firebrick from the hearth lining of the reverberatory furnace were analysed using a SEM. The possible uses of such a furnace are discussed. *Richard Lamb*, A smelting miscellany, 35-36. Both the history and visible remains of the numerous lead smelting mills of the Yorkshire Dales, have occupied much of the author's time over several years, and certain observations have led to conclusions often at variance with published accounts of these buildings. *Sallie Bassham*, Wharfedale lead smelt mills and fume condensation, 37-39. Wharfedale exemplifies well the development of smelting mills, from simple structures with a single hearth and no flue, to large compound structures with cupola furnaces and complex flue systems. *Lynn Willies*, Problems in the interpretation of cupola lead smelting sites, 40-42. Historical aspects of such smelting are outlined, and its usage is compared with contemporary alternatives. The implications are applied to the possible contribution of archaeology and related scientific studies to cupola sites. A problem case of interpretation at Stonedge Cupola is presented. *S Murphy*, Smelting residues from boles and simple smeltnills, 43-47. Residues from a number of sites in Yorkshire and Cumbria are described, and their implications for the technologies used are discussed. It is suggested that prior to the introduction of the slag hearth, boles and ore-hearths may have been operated in such a way that relatively small amounts of grey slags were produced, or alternatively that the grey slags may have been separately reduced by reworking under hot reducing conditions in the smelting hearths. The slag hearth may

have developed from the ore hearth as a result of this practice. *Gerry McDonnell, Steve Dockrill, Carl Heron, Dave Starley and Jan Tirpak*, Geophysics and slag analysis at Grinton Smeltings, 48-50. The application of a range of survey techniques to lead-smelting sites is proposed. Interim results from a brief survey are presented. The paper also discusses some issues relating to the methodology of undertaking surveys of early lead-smelting sites. *Michael Gill*, Analysis of lead slags, 51-53. This paper combines work on XRF analysis of slags and empirical data to discuss the factors affecting the amount of lead in slags. *Mike Wild and Ian Westwood*, Soil contamination and smelting sites, 54-57. A soil survey of North East Derbyshire is described, in which heavy metals were analysed and plotted on graphs. The results revealed sites associated with extraction and smelting, and follow-up studies based on fieldwork and historical material confirmed the value of the technique. Some comments are made on the health aspects of such historical contamination. *Peter T Buchanan*, Metalliferous plant communities: the flora of lead smelting in the Upper Nent Valley, 58-61. The Nent valley, once at the heart of the lead mining industry; today, an isolated area yet with relics of an industrial waste land. There is a legacy: that of the vegetation. This is the metalliferous flora. *Thomas Gledhill*, Smelting and woodland in Swaledale, 62-64. The history of lead mining in Swaledale up to the 18th century is outlined. The evidence for woodland management during the bale-smelting period is described. Finally the intimate nature of the relationship between woodland and early smeltmills is described, together with some possible reasons for the later disuse of wood as a fuel. *Robert White*, Protecting the remains of the lead-smelting industry in the Yorkshire Dales National Park, 64-66. The work of the Yorkshire Dales National Park Authority and other bodies in protecting the remains of lead-smelting sites in the National Park is discussed, together with an outline of future plans for consultation and interpretation.

Jake Almond

**A Nation of Steel, The Making of Modern America 1865-1925** by Thomas J Misa. *John Hopkins University Press, Baltimore and London, 1995. xxvi+367pp (inc 72pp of notes and references), 57 figs and 6 tables. ISBN 0-8018-4967-5. £37-50.*

This book is part of a series of studies in the history of technology. Its purpose is not really clear until the last chapter, when the author puts forward his ideas on how the dynamics of technical change should be assessed. The previous chapters then fall into place. That having been said the book is well written and easy to read. It is not a history of the steel industry of America but is a study of the interaction of some sectors of the industry with the consumers of the steel produced. There are some

misunderstandings of the facts, though on the whole these are not important to the studies. For example the author claims that the failure of Sir Arthur Kitson in 1890 to corner the market in Canadian nickel deprived the Europeans of a supply of this metal. The New Caledonia nickel deposit had been discovered 20 years before this and some of the Canadian mines were British owned.

The first chapter is a study of the interaction between the demand for rails, the wrought iron industry and the newly introduced Bessemer process. The wide range of demand caused by the railway booms of 1872, 1882 and 1897 meant that the Bessemer process, which could easily be closed down and restarted, seemed ideal for the steel industry of the time. The author claims that the emphasis on high volume low quality production was the cause of the problems with Bessemer steel. The railroads began the process of standardisation at this time by requiring chemical process control.

The following chapter is a study of the evolution of the American city. Railroads made it possible to feed the population of a large city from the other side of the continent if necessary. The demand for steel bridges and steel-framed buildings came at the end of the railway booms. Unfortunately for the steelmakers the Bessemer steel, of which there was a surplus, proved unsuitable for structural use and it was necessary to build open hearth steel plants for this new market. The study then considers the development of the rolled columns and beams now universally used for this purpose.

Armour and projectile development has always been a competitive business. Chapter three deals with the factors, largely political, involved in the development of armour for warships. The failings of the testing systems are revealed and the activities behind the scenes when the lucrative contracts were awarded. All came to naught with the international development of case hardened armour. The patents were pooled and the producers formed a consortium based in London which controlled the price of warship armour to all governments.

Chapter four deals largely with the mergers and takeovers that consolidated the railroads and created the United States Steel company – the largest in the world. Together these lead directly to an increased study of the factors affecting the performance of steel rails. This included an early application of the new technique of metallography to an industrial problem. Control of the rolling temperatures was introduced to eliminate unwanted metallurgical structures.

Chapter five deals with the interaction of the quality of the tools available and the ability to manage a production operation dependent on metal cutting. The development of high speed steel and the scientifically controlled

toolroom made it possible to predict machining times. The investigation of a complex problem such as machining, with its many variables led to the development of what the author describes as parameter variation. This is the technique, now well established, where only one parameter is varied at a time. The battle to control the high speed steel patents is described, and the rise of the professional Engineering Institutions.

The relationship between the car industry and its steel suppliers is the subject of the next chapter. The car was the first product to be made in quantity that could not be made wholly from mild steel. The need for better properties led to the development of steels that could not be easily made in the open hearth furnace, if they could be made at all. The crucible steel industry could not make enough and this accelerated the development of the electric furnaces that eventually closed the crucible steel shops. The need for vast quantities of sheet steel provided the impetus for the development of the continuous strip mill. This enabled steels of better and more consistent pressing properties to be produced and allowed the car designers more freedom.

The final chapter discusses the implications for the instigation of technological change. The author puts forward his views on the decline of the US steel industry. He then explains where the study fits into the wider field of understanding the process of technological change, and how it can be managed.

Peter Hutchison

**Steel city. Entrepreneurship, Strategy and Technology in Sheffield 1743-1993** by Geoffrey Tweedale. Clarendon Press, Oxford, 1995 440pp, 235x155mm, 16 figs, 40 tables, 3 maps, index. ISBN 0 19 828866 2. £45.

Britain's steelmaking towns, mostly born in the thirty years following Bessemer (1856), enjoyed but a century of fluctuating prosperity, before many ended their steelmaking life-cycle in the cataclysm of the 1970s and 1980s, some survivors albeit, managing to retain a foothold as finishers. Sheffield did not escape the ravages of this period. Uniquely however, it now looks back on 250 years of steelmaking ('not out' as in Boycott's Yorkshire), to still claim, however tenuously, the sobriquet of Steel City.

In his book, Geoffrey Tweedale examines the unique circumstances which account for Sheffield's remarkably long and successful industry, noting sadly perhaps, that 'For the young, Sheffield was now more famous for snooker and the World Student Games than for steel' and that whereas in 1920, steel employed 70,000 people, the figure in 1990 was well below 10,000 with the City Council easily the City's largest employer. Even so, the

steel industry and related trades continue to play a vital part in the local economy, and the drop in numbers employed is partly a tribute to rising productivity.

Getting a head start was Sheffield's secret. Crucial was the period in the mid-18th century when the city established worldwide competitive superiority with Huntsman's crucible steel – the key to development of tools and cutlery. Local availability of water power (to drive hammers and bellows), coal as fuel, sandstone for grinding wheels, refractory minerals for furnace linings, and a supply of Swedish iron, provided what were then uniquely favourable conditions for steel development. It was claimed 'that by the early 1840's the Sheffield area was producing about 90% of the country's steel output and about one half of world steel...' In due course success depended on a few large firms and a broad base of small owner-operated businesses, 'closely interlocked, competitive and yet co-operative'. Tweedale ascribes special importance to local skills and knowledge, to the structure of Sheffield industry in facilitating rivalry (and co-operation), and to establishment of a quality ethos.

The book traces the city's progress through the Bessemer phase, when advantage lay with others producing molten pig iron close to ore supplies (eg Barrow-in-Furness), into the cold-charge open hearth, and electric furnace eras when Sheffield was well sited to build on its reputation in special steels. This led to becoming a major centre for armaments with a key role in two world wars. Tweedale discusses the subsequent disadvantages resulting from over-concentration on armaments and on the other hand the benefit of reinforced supremacy as technology leader in special steels. By the post-war period, Sheffield with Rotherham had become home to the majority of Britain's leading research centres in ferrous metallurgy – an achievement worthy of the famous forbears Robert Hadfield and Harry Brearley.

Of the men managing the industry in the 19th century Tweedale says 'Most were natural autocrats, feared and respected rather than loved, with the small scale crucible works as their kingdom ... With this autocracy however went a high degree of paternalism. Labour relations at most firms were good, even enlightened'. He also draws attention to something that 'has rarely been commented upon', namely the significant contribution of German immigrants in the 19th century. So, success was not entirely due to Yorkshire grit, sturdy independence and genius, important though these were!

This is not a book to read just once. The general reader, historian and economist will each find stimulus for argument, and the chapter on Rationalisation and Nationalisation will no doubt reopen old controversies among contemporaries who faced the upheavals of the 1970s and 80s. The 'highly confused and disordered

situation' following a nationalisation plan which ignored output value and 'lacked industrial logic': the Dunford Elliott/Hadfield and Dunford Elliott/Brown Bailey battles: the raids of the predators 'the outsiders with no background in steel', Frank Welsh and wheeler dealer Oliver Jessel: and later the ill-fated take-over of Osborn and Edgar Allen by Aurora: the bitterness felt by the private sector toolsteel makers with a Government who would neither act on dumping nor apply to the private sector, the Davignon quotas negotiated for public sector products: all these attract comment.

The book contains a great deal of detail about the companies, the personalities, and the changes in technology and markets which have shaped Sheffield. Tweedale has drawn extensively on primary and secondary sources in his quest to explain the phenomenon which is Sheffield. He identifies for example, that historically the industry has been driven by

flexibility and opportunism rather than by too slavish pursuit of the economies of scale and speed, – an industry in which the quality ethos has held primacy and the metallurgist has enjoyed recognition – where to be an A.Met. has been to command high respect.

For those who remember the Sheffield of half a century ago, this book may stir memories of trams clanking through the dust and haze of the Wicker, Brightside Lane and Savile St, the whiff of the Grimesthorpe Foundry, the drama of Vickers' gunshop and of recreational escape to Nether Edge or Fulwood which even then were leafy and flushed with fresh Derbyshire air. The final Chapter, Survivors and New Agendas, and the Epilogue: Steel City and United Kingdom Industrial Decline provide much material for those wishing to join the debate about Britain's industrial decline and are brave enough to speculate about the future.

Robson Davies