Book reviews

Metals and mines: studies in archaeometallurgy edited by S La Niece, D Hook and P Craddock. *Archetype Publications in association with the British Museum, London, 2007, A4, xii+250pp, many colour and B&W figs and tables, index, ISBN 9781904982197, £45.00 p/b.*

This volume presents a selection of 25 papers from the meeting *Metallurgy: A touchstone for cross-cultural interaction*, which was held in April 2005 to celebrate the 40 years that Paul Craddock worked at the British Museum. Even in his retirement, Paul was a co-editor of the volume and provided its introduction.

The book is quite large and set in small type, so the amount of information presented between its covers vastly exceeds what you might expect from its mere 250 pages. The presentation of the volume is exceptional, with the page layout fresh, clear, clean and inviting. The work is profusely illustrated, with widespread use of colour throughout. My only minor quibbles would be with some of the colour illustrations of artefacts which can tend to be a little bit murky and low contrast, as is so often the case, and also that some of the illustrations would have been enhanced by being reproduced a little larger. Such minor niggles, however, do not detract from the generally very positive feeling one gets from handling and using the book.

The subject matter is diverse, in terms of materials, geographical location and age, but the contributions are united by their high quality and by the clarity of the exposition of the underlying science. There are 19 papers dealing with non-ferrous metallurgy and six with ferrous. Approximately half of the papers deal with Europe, three with the Middle East, five with areas of eastern Asia and three with Africa. The articles are structured into four sections.

The first section, *Mining and smelting*, contains papers by Bourgarit on chalcolithic copper smelting, reviewing evidence from Europe and Middle East, Müller *et al* on the origins of metallurgy in southern Portugal, Timberlake on the role of experimental archaeology in the investigation of Bronze Age mining and smelting, Craddock *et al* on the products of the Early Mines Research Group's copper smelting experiments, Bayley and Rehren on crucible classification, and Mighall *et al* on the investigation of palaeo-pollution in bogs.

The heavy emphasis in the first section on early copper smelting is also carried through into the second section, *Copper, tin and bronze*. Prehistoric copper production at Timna is discussed by Hauptmann and Wagner, the origins of metallurgy in SE Asia by Piggott and Ciarla, early metals in the Persian Gulf by Weeks, the first use of metals in Minoan Crete by Muhly, cross-cultural networks in Bronze Age Crete by Gale and Stos-Gale, and tin and bronze production in southern Africa by Chirikure *et al.*

The third section, *Brass and zinc*, includes contributions by Thornton on brass and bronze in SW Asia, by Montero-Ruiz and Perea on early brass in Iberia, by Istenič and Šmit on early European brass, particularly from the SE Alpine area, from Weisgerber on Roman ingots from the western Mediterranean, by Garenne-Marot and Mille on copper-based objects from Mali, from both Liu Haiwang *et al* and from Zhou Weirong on early zinc smelting in China.

The final section is *Iron and steel*, which has papers by Veldhuijzen and Rehren on early iron in the Middle East, Paynter on early iron smelting in Britain, Rehren *et al* on human decisions in early African iron-making, Crew and Charlton on the detailed structure of a bloomery furnace from Wales, Wayman and Michaelson on early Chinese ferrous swords in the Britsh Museum and finally Williams on the role of crucible steel in some medieval European swords.

These papers are all individually excellent and far too diverse to review individually; they convey a sense of the excitement of modern archaeometallurgy at its best. Only a few of the articles really touch on 'cross-cultural interaction', so the decision to drop that tag-line between the conference and the publication was a wise one. Indeed, these papers make me wish I had been at the conference to hear them – and the others not included in this volume. It was that tag-line that dissuaded me from going; I couldn't really see at the time how my own interests might mesh with that aim;

it would now appear that most of the contributors did not make that link either!

As always with conference volumes one must consider the market for the publication. This is not always easy; they are often cheaply produced short-lived products of their moment. This volume, in contrast, stands out both in the quality of its production and its content. It has drawn me into reading about subjects and places which are way outside my normal areas of interest. There is so much here to which readers can turn, not only to learn about aspects of ancient metallurgical practice, but to explore how archaeometallurgists are developing their science. This is a reference volume that will appeal to practitioners of archaeometallurgy from many different backgrounds and perhaps, given the diversity of the content, particular to educators. I would hope that once in university libraries around the world, it will serve to excite and inspire the next generation of students of the discipline.

Tim Young

Metallurgy in the Early Bronze Age Aegean edited by P M Day and R C P Doonan. *Oxbow Books, Oxford (Sheffield Studies in Aegean Archaeology 7), 2007, 240x170mm, xii+263pp, figs, tables, ISBN 978-1-84217-293-3, £28 p/b.*

The Early Bronze Age Aegean has been a core region of interest for archaeometallurgists and archaeologists alike, so this volume is bound to be of interest to both. Published in late 2007, it finally makes available the proceedings of a workshop held in January 1998 as the 3rd Aegean Round Table organised by the Sheffield Centre for Aegean Archaeology. It contains 14 chapters; some are single-authored contributions focusing on a particular site or topic, while six chapters are designed to work in pairs, looking at three sites from two different perspectives. Unsurprisingly, these twin presentations are mostly split in a traditional manner: the archaeological context first, followed by the technological analysis. A much bolder step, in the editors' own words, was taken by 'organizing a meeting [on Aegean early metallurgy] without its main emphasis on provenance, or the debate over lead isotope analysis' (p.xi).

So what have we been waiting for all these years? As in any serious edited volume, there is an introductory chapter by the editors setting the scene for what follows. This introduction, *Mixed origins and the origins of mixing: alloys and provenance in the Early Bronze Age Aegean* (p.1-18), makes for interesting and at times thought-provoking reading: even if not in the sense intended by the authors. I was particularly bemused by Day and Doonan's commentary on archaeometallurgy and its academic origin ('Founding a Specialism'). They boldly include classical and renaissance authors in the lineage of our profession, but only for their brief mentions of old ways or some curiosity about the origins of metals, often in a metaphorical context. This charitable view seems to stop in the more recent past, specifically when 'in the late 1960s a new banner, "Archaeometallurgy", was considered necessary' [to the best of my knowledge, this term did not appear before May 1973 with the establishment by Beno Rothenberg of the Institute for Archaeo-Metallurgical Studies]. Day and Doonan then continue: 'Understanding why researchers began to use this term … explains why Archaeometallurgy has failed to address recent theoretical concerns' (p.4). They contrast this with other fields, stating that labels such as 'archaeoceramics' are not used – though a search on Google showed their own Department houses an Archaeoceramics Group, with Day as a leading member!

After this gaffe Day and Doonan continue their vendetta against 'archaeometallurgy' and 'archaeometallurgists' with a thinly veiled attack on lead isotope studies and the whole provenance discussion, comparing Childe's early metallurgists and their perceived elitist standing in society (1942) to the newly emerging 'archaeometallurgists'. In a strangely negative tone they continue describing the early metallurgists as 'most likely male' and 'at least eager experimenters and keen observers' (p.4). Can it be that they are unaware of concepts such as specialisation and team work, typical of complex societies even today, where some specialists ('eager experimenters and keen observers') generate and present the data which others can then interpret, within whatever theoretical concerns they may have? But without data, lead isotope or otherwise, there is little to interpret, so one can only speculate.

Luckily, the rest of the book is significantly more substantial and presents a wealth of long-awaited new information, thought and discussion. The delay in publication even facilitated inclusion of papers not available during the workshop.

Bassiakos and Philaniotou's joint paper on the *Early copper production on Kythnos: archaeological evidence and analytical approaches to the reconstruction of metallurgical processes* (p.19-56) is a fine study combining a summary of known sites with several newly discovered places. The analyses indicate that an oxidic self-fluxing ore was smelted in furnaces

producing copper metal and a magnetite-rich silicate slag with only a few weight percent copper. The metal produced, judged by the analyses of small prills trapped in the slag, was rather rich in iron (several percent) but low in arsenic (under *c*0.5 wt%). The furnaces were reconstructed as short perforated shafts, in keeping with other sites elsewhere in the Aegean.

The next two chapters present the exciting finds from the *Final Neolithic to Early Minoan III metallurgical site at Chrysokamino, Crete*, first with the archaeology presented by Betancourt (p.57-67), followed by Catapotis and Bassiakos' technical assessment (p.68-83). Chrysokamino has recently been published in detail (Betancourt 2006 and papers therein; Pryce *et al* 2007) and it suffices to point at some still enigmatic observations: there seems to be no viable copper source nearby, no evidence for ore processing other than smelting, and no permanent settlement. The metal prills are significantly higher in arsenic and nickel than the few ore fragments excavated, and the social or economic network within which this technology flourished remains little understood.

The next set of papers looks at *Craft production and exchange at the harbour town of Knossos* (Dimopoulou-Rethemiotaki *et al*, p.84-97), before offering *Lame excuses for emerging complexity in EBA Crete* (Doonan *et al*, p.98-122). In contrast to the previous site which clearly represented primary production of copper, here we learn about the evidence for manufacturing by casting in an urban context. The crucible, mould and metal finds are relatively straightforward in their appearance and composition; non-refractory clay was used to produce crucibles which were heated from above. Exciting is the report of a partly-heated fragment of iron arsenide mineral, which according to the authors preserves in its core a geological structure, while near the surface it shows an anthropogenic structure indicating partial melting in the process (p.109). Could this be offering a glimpse of the elusive source of arsenic in the copper objects? The evidence is compelling and seems to offer for the first time direct evidence for this deliberate alloying of copper with iron arsenide. A closer look at the material makes it even more interesting. Doonan *et al* report the composition of this 'mineral' (they suggest it to be loellingite, $FeAs_2$) as 53% Fe and 39% As, which is clearly Fe_2As, not $FeAs_2$, and hence not a mineral but an artificial metallurgical phase akin to the one reported earlier from EBA Shar-i Sokhta (Hauptmann *et al* 2003). This material, speiss, is not a mere mineral, but an intentionally produced alloy, indicating advanced metallurgical understanding.

Georgakopoulou then reports on her recent work on the precious few finds demonstrating *Metallurgical activities within Early Cycladic settlements: the case of Daskaleio-Kavos* (p.123-34) on the western end of the island of Keros. Again, a comprehensive publication of this has recently appeared in Renfrew's (2007) full report of his work here. Remarkable is not just the context of these finds, but the range of metallurgical activity attested, including silver refining and apparently two types of copper smelting.

The next set of papers looks at *Aghia Photia-Kouphota: a centre for metallurgy in the Early Minoan Period* in Eastern Crete (Tsipopoulou, p.135-45 and Betancourt and Muhly, p.146-53). The assemblage stems partly from an Early Minoan settlement (mould fragments and a metal axe) and partly from a cemetery (metal and two crucibles). The latter in particular are very well preserved, and Betancourt and Muhly discuss their possible stylistic connection to Cycladic metallurgy, a link also indicated by other finds from the site.

The final five papers are all single-authored. Papadatos (p.154-167) reports on the *Beginning of metallurgy in Crete: new evidence from the final Neolithic to Early Minoan I settlement at Kephala Petras, Siteia* in Eastern Crete. The amount of metallurgical evidence here may not be overwhelming – two pieces of ore, some slag fragments, a bit of copper wire and some burnt clay – and scientific analysis is still ongoing. However, the very early date of it is remarkable, pushing metallurgy on Crete back in time towards the same period as elsewhere in the Aegean.

The last four papers look beyond individual sites, offering broader views and syntheses. Zachos (p.168-206) gives a well-documented and comprehensive *Reassessment of the Neolithic background*, listing and discussing in detail the earliest finds known from the wider region. Catapotis (p.207-23) follows this with a paper on the *Spatial organisation of copper smelting activities in the southern Aegean*, based on his PhD studies at Sheffield and combining archaeological evidence with insights gained from experimental reconstructions of copper smelting using perforated furnaces. He discusses both the size and the location of slag heaps and smelting sites, factors which are highly relevant for technical as well as social and economic considerations. Nakou (p.224-244) focuses on the interplay between ceramic and *Metal vessels in the Aegean at the end of the third millennium*. In this, she goes back to a century-old discussion of skeuomorphs in ceramic of rarer and more novel metal vessels, stressing less the

exact copy of a metal shape, but suggesting instead that the principle of smooth, thin and dark grey (=silver) was adopted for specific forms and purposes or social contexts.

The final chapter, by Susan Sherratt, offers a review of the *Archaeology of metal use in the Early Bronze Age Aegean* (p.245-63). Taking Renfrew's 1972 book on the Cyclades and the Aegean as a starting point, she concisely and convincingly outlines what changes have happened in the archaeological treatment and understanding of the subject matter. Both material and chronological ranges have expanded, with more, and more different, metals being used earlier than previously thought, across a wider geographical range. Even more revolutionary is the massive expansion of technological evidence for metallurgy in the shape of workshop remains of all possible sorts, and the subsequent recognition of 'the idea of metallurgy as a lifestyle activity', combining the highly theatrical with the potentially dangerous and the opportunity for travel. It is here that I felt the spiritual connection – raised by Doonan and Day in their introductory chapter – between our Early Bronze Age forbearers and current archaeometallurgists emerging, although probably accidentally. Besides picking up and explaining past and recent academic developments in archaeometallurgy in an impressively forward-looking manner I was most touched by her brief note that between the divergent archaeological and technological strands in our current endeavour we are in danger of leaving the economic roles of metals unaddressed. Over more than 200 pages this volume has made a great contribution in establishing technology as an equal partner with typology and provenance in Early Bronze Age metallurgy in the Aegean; it took Susan Sherratt less than two lines to point to the next big challenge in (not only Early Aegean) metallurgy, and the huge gap which the late Andrew Sherratt has left.

Thilo Rehren

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Prehistoric and medieval direct iron smelting in Scandinavia and Europe: aspects of technology and society edited by Lars Christian Nørbach. *Aarhus University Press, Aarhus (Acta Jutlandica LXXVI: 2 – Humanities Series 75), 2003, 270 x 210mm, 335pp, many figs, ISBN 87 7288 7745, £34.00 p/b.*

This volume has only recently been received for review, but warrants a summary, as the digest of the proceedings of a conference held at Sandbjerg in 1999, under the auspices of the Comité pour la Siderurgie Ancienne, l'UISPP, celebrating the 70th birthday of Radomir Pleiner. It contains texts from 35 papers, particularly but not exclusively dealing with aspects of the archaeometallurgy of the Scandinavian and Baltic region. The proceedings are divided into five sections. Under *Iron Production and Settlement*, Henriette Lyngstrøm, Lars Erik Narmo, Lena Grandin, with Eva Hjäthner-Holdar, and Ines Spazier examine medieval production and consumption of iron, in Denmark, southern Norway, south-central Sweden and southern Brandenburg respectively. Peter Hambro Mikkelson discusses evidence for farming practices derived from straw within the slags from Danish slag-pit furnaces. From outside the region, there are two Italian contributions, Constanza Cucini and Marco Tizzoni on a late-Roman ironworking site near Brescia, and Maria Elena Cortese on archive evidence for the introduction of water power to medieval ironworking near Siena. A further section of *regional studies*, six in all, comprise Frank Nikulka's study of slag-pit furnaces in north-west Germany, Lars Christian Nørbach's brief historiographic survey of research on iron working in Denmark and Irene Schrüfer-Kolb's overview of evidence for Roman iron smelting in eastern England; Lars F Stenvik investigates contrasts iron smelting methods within Scandinavia, Eva Hjärthner-Holdar and Christina Risberg seek parallels in the introduction of iron making in two contrasting eastward-looking regions, Sweden and Greece, while Jonas Navasaitis and collaborators outline evidence for Roman-period iron making in Lithuania.

Sixteen contributions make up two sections on *metallography*, which range more widely over Europe. The first group largely comprises examination of forged items: two papers by Mattias Dinnetz, on material from Toledo and on examination of a Swedish iron sword; Jüri Peetz on iron-age and medieval Estonian forging technology; Vasco La Salvia with L'ubomir Mihok discuss the products of an Italian medieval smithy. There are contributions by Philippe Fluzin on 5th-6th-century forge material, Alain Bouthier on early-medieval forging in central France, Vanessa Fell on Iron

Age hooked iron blocks from England and Elzbieta Nosek on Scythian weapons from the Ukraine. Alain Ploquin and collaborators discuss electron transfer and silicate melt polymerisation in ironmaking. The second section on metallography concentrates on the examination of blooms and bloomery slags: Ingo Keesman and Andreas Kronz, and Hans Ludwig Knau with Manfred Sonneken, provide two contributions on slags from the Sauerland, Germany, L'ubomír Mihok and Alena Pribulová a paper on Iron Age material from Slovakia. Vagn Fabritius Buchwald contrasts bloomery irons with the products of later methods of making wrought iron. More generally, Radomir Pleiner considers work on 100 bloom-fragments and 370 iron objects from across Europe, E G Godfrey, A Vizcaino and J G McDonnell examine the role of phosphorus in early ironworking, and Arne Espelund discusses the literature on the interaction of the four phases – carbon, gas, slag and metal – in the bloomery.

Finally there are three papers on *Geophysics* – on prospecting and on archaeomagnetic dating. Niels Abrahamsen and six collaborators consider archaeomagnetic mapping, modelling, analysis and dating of Iron Age slags in Denmark; Peter Crew, Tatyana Smekalova and Bruce Bevan review their high-resolution surveys of iron-smelting furnaces in north-west Wales; Tatyana Smekalova and Olfert Voss set out field procedures for magnetic investigation of slag-pit furnace sites.

This is a valuable review of current work, largely on the bloomery periods. Even though the contributions are brief, and appear to be summaries of the delivered papers, they are well referenced, providing gateways to wider work on their topics. Illustrations are grouped at the end of the volume, and are generally well reproduced. There is no index.

David Crossley

Spätmittelalteriche bis frühneuzeitliche Edelmetallgewinnung in den Hohen Tauern. Montanarchäologische Forschungen im Bockhartrevier, Gasteiner Tal (Bundesland Salzburg). [Precious metal production in the Middle Ages and early modern times in the Hohe Tauern. Archaeological research in the Bockhart mining field, Gastein Valley, Salzburg] by Brigette Cech. *Mainz, Römisch-Germanischen Zentralmuseums (Monograph 70), 2007, A4, xii & vii + 599pp, ISBN 978-3-88467-113-9, many plates and figs, 24pp colour illustrations, pocket map. 90.00€ h/b. German with English summary and captions.*

This major two-volume monograph records the survey and excavations of the late medieval-post medieval gold and silver mines high above the Angertal Valley, in the Bockhart mine area of the Hohe Tauern in the Gastein

16th-17th century gold mines on Kreuzkogel, Sportgastein. Note the roof slabs of the Schneekragen *covered way linking the mine buildings on the right with the adit entrance to the left* (photo P T Craddock 1987).

region of south-west Austria. The precious metal occurs as free gold in quartz, with gold also occurring in the associated pyrite and arsenopyrite, as well as in the silver in the galena ores (Mongiatti *et al* forthcoming). The mining seems to have commenced during the 14th century, and had effectively ceased by the 19th century, with production peaking in the 16th century, when in 1577 the Gastein and Rauris mines produced no less than 830kg of gold and 2723kg of silver.

The present project concentrates on the mines in the Bockhart mining area, especially those on the flanks of the Seekopf Mountain, hundreds of metres above the valley floor, and over 2,000m above sea-level, creating very exposed conditions, especially in winter. The excavated surface areas of the small settlement included the two miner's houses, the smithy together with the ore-crushing and dressing plant.

The mountainside is covered with many underground mine workings and just one was selected for detailed recording. It seems to have been mined by a combination of firesetting and pick work, the whole deposit having been worked out before the introduction of blasting in the 17th century. The ore was moved out of the mine by *Hundt*, the wooden trucks that were pushed along regular tracks. Parts of a hundt and the trackways were discovered. The later led out of the mines along covered pathways, known as *Schneekragen*, running for up to 70m into the miner's quarters. When viewed by your reviewer in high summer many years ago the *Schneekragen* were inexplicable. However in winter the vicinity is covered

deep in snow and if work was to continue there had to be such a protected passage between the mine entrance and the buildings where the ore was processed. The miner's houses and the smithy were of dry stone construction, and had gone through several phases of rebuilding through the approximate 200 years of occupation. The buildings were reasonably well preserved and the sizeable slag heap shows how busy the smithy must have been. That and the enormous number of iron finds on the sites brings home just how important the smithy was at early mines where the tools must have required almost daily repair and resharpening.

Careful geophysical and mineralogical study of the gangue material at the ore dressing site, showed that the ore must have been broken, probably by hand with hammers, before passing on to be crushed at the dressing area. Here there was a small stamp mill where it is believed the ore was further broken up before it was fed into the ore mill for rotary crushing between millstones, which were found in one of the leats. The mill was water-powered and the leats and the wheel pit survived together with the housing for the axles of the millstones. The beneficiated ore was sent down the valley on sledges for smelting (Mongiatti *et al* forthcoming), but evidence was found, in the form of cupellation debris and slags, that the ores were routinely assayed at the mines themselves.

Brigette Cech integrates the archaeological discoveries with the known history of the Gastein mines and the contemporary mining technology as expounded by Agricola and others. There are also some specialist geological and archaeometric reports on the wood etc. The text, not unreasonably, is in German, but there is a 30-page English synopsis that includes translations of the captions of all of the figures and colour plates. This goes way beyond the usual foreign language summaries, and must have involved considerable effort on the author's part, but makes it perfectly easy for a non-German reader to follow what is being discussed at any point in the main text.

This is a highly competent and detailed excavation report, produced to the very high standards associated with the Römisch-Germanisches Zentralmuseums Mainz (although the absence of an index is a serious detraction), and as such is a major addition to our knowledge of mining practices in late medieval to post-medieval Europe.

Paul Craddock

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The saga of Indian cannons by R Balasubramaniam. *Aryan Books International, New Delhi, 2008, 220 x 310mm, xvii + 332pp, many colour photographs, bibliography and index, ISBN -978-81-7305-339-9, Rs4500 in India, £150 in UK.*

This is a major technical and historical survey of the artillery of India. As the author rightly claims cannon are amongst that country's most neglected historic treasures. Many hundreds of massive iron and copper alloy guns literally lie abandoned on the walls of forts, in army camps or, more incongruously, in parks or on traffic islands, often half buried in the undergrowth. Your reviewer has previously gone in search of some of the more famous guns and after reading this book now realises there were others that he was unaware of, often lying in the same fort. Outside of South Asia the other prime location for Indian ordnance is, of course, Britain, many having been sent back as trophies of war and Empire.

This present work makes no pretensions to be a comprehensive inventory of the surviving ordnance, but one of its glories are the hundreds of recent, good quality photographs many taken by the author. The illustrations also include not just the actual guns but also many early Indian paintings depicting the guns in transit and in action.

Professor Balasubramaniam is a metallurgist at the Indian Institute of Technology at Kanpur but, as his excellent monographs on the Delhi Iron Pillar have already demonstrated, he is also knowledgeable on the historical and cultural background of his material and describes these aspects fully, integrating them skilfully with the more technical matters. As well as the cannon themselves and their manufacture there are also chapters on the gun carriages and limbers, the fortifications that either opposed or housed them, the production of gunpowder (India was after all the major source of saltpetre in the post-medieval world), and finally a fascinating chapter on military rocketry. The latter makes it clear that rockets had been a major component of battlefield weaponry in India several centuries before they were deployed against the East India Company's forces by Tipu Sultan in the Mysore Wars in the 1790s. Several rockets were sent back to England where William Congreve saw their potential (although there is no evidence that he actually participated in these Indian campaigns as stated in the

book). Very shortly afterwards rockets were regularly deployed by British forces in the Napoleonic Wars and throughout the 19th century (Winter 1990).

Cannon seem to have arrived in South Asia quite suddenly in the late 15th century, thus the Portuguese noted many cannon already in Gujarat and on the western Deccan seaboard when they arrived there. These guns seem to have been imported from the Middle East, but cannon can really be said to have arrived with the invading Afghan armies of Babur (who also describes the casting of a large mortar in his autobiography). Through his skilful use of artillery his much smaller force completely defeated the opposing indigenous forces of the Delhi Sultanate at Panipat in 1526, thereby establishing the Mughal Dynasty. Not surprisingly, thereafter artillery formed a major component of both the field armies and static fortifications (it is noticeable how often major pieces of artillery brought up against fortresses were left there at the completion of the siege).

To some degree the well-documented major weapons weighing up to fifty tons steal the limelight, but as Balasubramaniam makes clear, the armies of South Asia developed a wide range of artillery with a number of small pieces such as the *shaturnal*, which was designed to be fired by a two-man team mounted on a camel.

As befits Balasubramaniam's metallurgical interests there are good descriptions on the technology of the cannons. Basically they are of two types, either of cast copper alloy or built up from wrought iron bars held by red-hot iron rings shrunk-fitted around them. These are very similar to the late medieval European wrought iron artillery such as Mons Meg or Dulle Greit (Smith and Brown 1989). In South Asia there were also composite pieces where copper alloy was cast around the barrel formed of wrought iron staves. The production of wrought iron guns seems to have continued well into the 18th century in South Asia, long after they had been superceded by cast iron cannon in Europe. Indeed the first iron castings produced in South Asia were cannon, as was the case in Europe some centuries before. The first cannon were cast by Europeans, either at their own bases such as the East India Company's foundry at Cossipore near Calcutta, or the foundry established by the French for the Nizam of Hyderabad in what is now the aptly named Gunfoundry district of Hyderabad city. It does seem that by the late 18th century purely indigenous iron cannon were being cast by the Indians, as exemplified by the cast iron cannon of the Marathas who never had any serious alliance with any European powers, although as with the locally-cast European cannon, it is not clear from where the cast iron itself was coming, whether imported or locally produced.

Gun foundries are described in detail, especially the surviving foundry at the Jaigarh fort just above Jaipur (Gander 2000). This is probably the best preserved post-medieval gun foundry in existence, and has recently been splendidly restored. It comprises the furnace installation for melting the metal complete with casting pit and the bullock-powered boring unit. There are also unused moulds together with a complete set of boring bars and other tools. However there are problems, both with the dates and with some of the reconstructions. The foundry is described as dating from the 16th century, but the furnace is a sophisticated reverbatory unit, and if the date is correct, then this is by far the earliest example of such technology in South Asia, which was otherwise still using small simple shaft furnaces (Babur describes the metal as flowing from eight small furnaces in his 16th century account of cannon casting). It is also not certain whether the cannon were cast solid to be bored out completely, or cast around a wooden former that acted as a core and was then drilled out to create the bore, the drill bit also reaming the sides of the bore to create greater accuracy. Inspection of most indigenous Indian cannon shows this was the usual practice as it had once been in Europe. Unfortunately in the recent restoration the boring unit has been incorrectly reconstructed with a rotating boring bar held against a static barrel, whereas inspection of the surviving bars at the foundry shows that it was the barrel that rotated against a static boring bar, as was the usual European practice (de Beer 1991).

Thus, although this book introduces and comprehensively illustrates Indian ordnance, it does not fully answer all the questions. It is a wonderful exposition, and should encourage all those interested in the subject to set off and track down the hundreds of pieces in their various exotic locations – and also to pick up the book, it being approximately one third of the price in rupees in India as it is in pounds in the UK! Also, as Balasubramaniam himself stresses, it may raise public awareness and induce those responsible for these mighty weapons in South Asia take better care of them.

Paul Craddock

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