Abstracts

GENERAL

P T Craddock. Scientific investigation of copies, fakes and forgeries. Butterworth-Heinemann (Elsevier), 2009.

This wide-ranging book contains four chapters devoted specifically to metals, including composition, patination and gold and silver, although metal objects are discussed in other chapters as well. JL

BRITAIN AND IRELAND

J Auer and A Firth. The 'Gresham Ship': an interim report on a 16th-century wreck from Princes Channel, Thames Estuary. *Post-Medieval Archaeology* 41(2), 2007, 222–241.

This was a small to medium-sized armed merchant ship built soon after 1574, probably in East Anglia or Essex. The cargo included folded iron bars, lead ingots and tin ingots, and amongst the four recovered guns is a rare English early cast-iron saker, marked with the grasshopper motif and initials of Sir Thomas Gresham.

P Craddock, N Meeks and S Timberlake. On the edge of success: the scientific examination of the products of the Early Mines Group smelting experiments. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 37–45.

The paper discusses the examination of the products of various experimental smelts carried out by the Early Mines Group and the implications of the results. It is suggested that very different extraction strategies may have been used in the British Isles, at least in the Bronze Age.

P Crew and M Charlton. The anatomy of a furnace … and some of its ramifications. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 219–225.

Historical, archaeological and analytical data suggest the medieval bloomery at Llwyn Du operated with a large volume of air. A model is proposed for the fast smelting of low-phosphorus bog ore which fits the data.

R Finlayson. *Hungate: Evidence from an excavation at the former Henly's garage, Stonebow*. Archaeology of York web series 5, 2006. http://www.yorkarchaeology.co.uk/ayw.htm

Evidence for medieval copper-alloy wire working, including chain mail, was recovered from the site.

T M Mighall, I D L Foster, P Crew, A S Chapman and A Finn. Using mineral magnetism to characterize ironworking and to detect its evidence in peat bogs. *Journal of Archaeological Science* 36(1), 2009, 130–139.

Magnetic susceptibility and remanence properties were obtained for charcoal, aerial dust, roasted bog ore and furnace dust from an experimental iron smelt and from material collected during the excavation of the medieval bloomery at Llwyn Du in Snowdonia. Magnetic measurements were made on a peat core collected close to the bloomery and on a constructed 'peat core' sprinkled with small quantities of furnace dust. The results confirm that roasted bog ore, aerial dust released from and accumulating in the furnace, are magnetically detectable. The aerial dust and roasted bog ore produced enhanced susceptibility and remanence signatures in the constructed 'peat core' experiments. Measured peaks in the Llwyn Du peat monolith appear to correlate with a time when the medieval bloomery was operational suggesting that the magnetic signatures remain in the peat record for several hundred years.

T M Mighall, STimberlake, S Singh and M Bateman. Records of palaeo-pollution from mining and metallurgy as recorded by three ombrotrophic peat bogs in Wales, UK. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the BM, 56–64.

Geochemical data from the ombrotrophic peat bogs demonstrate the usefulness of paleo-pollution records from peat bogs to reconstruct the origins and history of metal mining in Britain.

S Paynter. Innovations in bloomery smelting in Iron Age and Romano-British England. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 202–210.

Slag composition and morphology, which are not related, allow comparisons of the capability and operation of tapping and non-tapping furnaces. One innovation is the exploitation of siderite ores from the 1st century AD in the Weald. Tapping offered advantages when demand for iron was great.

S Timberlake. The use of experimental archaeology/archaeo-

metallurgy for the understanding and reconstruction of Early Bronze Age Mining and smelting technologies. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 27–36.

Discusses experiments and the use of reconstruction in understanding the development of early copper working, especially the simplest types of furnace and the extraction of copper from sulphide ores at the beginning of the Early Bronze Age.

EUROPE

J Bayley and T Rehren, Towards a functional and typological classification of crucibles. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 46–55.

Crucibles can be classified by their form, material and thermal properties, or by their function. Despite variations within the groups due to technological or cultural choices, both typologies end up with similar groupings, reflecting a strong relationship between functional requirements and technical attributes of crucibles.

C Bendall, D Wigg-Wolf, Y Lahaye, H-M von Kaenel and G P Brey. Detecting changes of Celtic gold sources through the application of trace element and Pb isotope laser ablation analysis of Celtic gold coins. *Archaeometry* 51(4), 2009, 598–625.

The alloy (Au–Ag–Cu) and trace element compositions in over 100 regional Celtic gold coins from the Römisch-Germanisches Zentralmuseum, Mainz were determined by EPMA and LA–ICP–MS, respectively, and their Pb isotope signatures were measured. Of the 28 trace elements measured, only Ni, Sb and Pt showed meaningful variations. Differences in the Pt/Au ratios indicate a significant difference in the gold sources exploited. The Pb isotope data confirm previous conclusions that the contribution of gold to the total lead in the Au–Ag–Cu coin alloys can be detected, especially for coins with >70% gold, and show that possible gold sources include both eastern Mediterranean and Alpine sources.

M Berrenger and P Fluzon. Organisation de la chaîne opératoire en métallurgie du fer aux IIe-Ier siècle av J-C, sur l'oppidum d'Entremont (Aix-en-Provence, Bouches-du-Rhone): la circulation du métal [Organization of iron smithing activities in the 2nd-1st centuries BC at the oppidum of Entremont: the circulation of metal]. *ArcheoScience* 31, 2007, 7–22.

A study of bloomsmithing and the fabrication of iron semi-products and objects provides information on the location of these activities within the settlement, and also on the distribution of products, and especially semi-products, on a regional scale. JB

G Bonnamour, N Florsch and F Téreygeol. Les prospections des ferriers de Castel-Minier: approche interdisciplinaire [The surveys of the Castel-Minier slag heaps]. *ArcheoScience* 31, 2007, 37–44.

Important silver mines were located here in the later 14th century but the slags were from bloomery iron smelting, an associated activity. Magnetic, electric and geochemical surveys allowed the organization of the site to be determined, showing there were two distinct iron working areas. JB

D Bourgarit. Chalcolithic copper smelting. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 4–14.

The paper reports and discusses the results from some 20 archaeological sites in the Old World, including the author's work in France. His conclusions, in agreement with other reports, are that there was s a lack of technical consistency in the processes used at the beginning of copper extractive metallurgy, some of which were quite technically advanced.

C Chiavari, M Degli Esposti, G L Garagnani, C Martini, D Prandstraller and T Trocchi. Bronze archaeological finds from the Villanovan necropolis of Orto Granara (Bo): study of manufacturing technologies and evaluation of the conservation state. *La Metallurgia Italiana* 5, May 2007, 43–52.

The composition and microstructure of 15 bronze objects and four copper ingots from tombs dating to 8th–7th centuries BC, are reported. JB

N H Gale and Z A Stos-Gale. Cross-cultural Minoan networks and the development of metallurgy in Bronze Age Crete. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 103–111.

Lead-isotope analyses of ores and artefacts show changing sources of metal were used; little came from Crete. Lavrion was an important source of copper as well as silver for the Aegean Bronze Age, including Minoan Crete.

A Hauptmann and H Stege (eds). Archäometrie und Denkmalpflege 2009 [Archaeometry and the conservation of monuments 2009]. *Metalla (Bochum)*, special publication 2, 2009.

This publication presents extended summaries of lectures and posters presented at a four-day conference. The section on metals is 40 pages long; three of the 17 papers are in English, the rest in German. Topics run from the Bronze Age to the post-medieval period, and from metal smelting to manufacturing techniques and analytical studies. All concern non-ferrous metals and most relate to Germany and surrounding areas. JB

J Istenič and Ž Šmit. The beginning of the use of brass in Europe with particular reference to the southeastern Alpine region. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 140–147.

Brooches found in Slovenia were analysed by PIXE. Results show brass was initially used for military equipment, including brooches, from *c* 60 BC. The earliest brass coins were issued later, in 46/45 BC.

C LeCarlier, M Leroy and P Merluzzo. L'apport de l'analyse morphologique, microscopique et chimique des scories en forme de culot à la restitution des activitiés de forge [The contribution of morphological, microscopic and chemical analyses of hearth bottom slags to the reconstruction of smithing activities]. *ArcheoScience* 31, 2007, 23–35.

Study of the slags (mainly SHBs) from the final La Tène site of Puy-de-Grâce, were used to reconstruct the operation of the smithy there. JB

M Martinón-Torres, I C Freestone, A Hunt and T Rehren. Mass-produced mullite crucibles in medieval Europe: Manufacture and material properties. *Journal of the American Ceramic Society* 91(6), 2008, 2071–2074.

Crucibles from Hesse have been famous since the Middle Ages due to their exceptional quality. 50 Hessian and non-Hessian crucibles were analysed using SEM-EDS, FESEM, and XRD to investigate their technology and properties. Hessian crucibles were made of kaolinitic clay with a low flux content mixed with quartz sand and fired at over 1300°C. Primary mullite developed in most of the glass matrix, with secondary mullite in some regions of clay-feldspar relict mixtures. Consequently, the vessels showed superior creep and thermal shock resistance, high-temperature strength, and thermal and chemical refractoriness.

M Martinón-Torres and T Rehren. Post-medieval crucible production and distribution: A study of materials and materialities. *Archaeometry* 51(1), 2009, 49–74.

14th–19th century crucibles from contexts in Europe and America were studied by optical microscopy and SEM–EDS, coupled with archaeological and historical data. Two major producers were identified, both in Central Europe, whose crucibles appear widely distributed. The analytical data explain the technical reasons for their superior reputation, though the two crucible types were radically different in manufacture and appearance. We argue that, besides technical considerations, sensorial aspects such as texture and colour may have played an important role in the perception and choice of materials.

D Mathiot, S Toron, E Wyremblewski, A Masse, S Durin and D Lemire. La métallurgie du fer au cours de la protohistoire récente dans la région Nord–Pas-de-Calais [Iron metallurgy in recent protohistoryin the Nord–Pas-de-Calais region]. *Revue du Nord* 88, 2006, 151–161.

A review of the increasing number of publications relating to iron artefacts and iron working in the region, and the information they provide on craftsmanship and the types of objects in use. JB

I Montero-Ruiz and A Perea. Brasses in the early metallurgy of the Iberian Peninsula. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 136–139.

The earliest brass (6th century BC) may be imported but the alloy is found in the Iberic culture from the 4th and 3rd centuries BC. Over 2% Zn in other metals could show remelting of brasses, suggesting they were commoner than yet detected analytically.

J D Muhly. The first use of metal on Minoan Crete. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the BM, 97–102.

A review of new evidence based on excavated remains at Hagia Photia and Chrysokamino, the latter the only Early Minoan copper-smelting site. Also considers growing evidence for Aegean copper and silver metallurgy during the final Neolithic.

R Müller, G Goldenberg, M Bartelheim, M Kunst and E Pernicka. Zambal and the beginnings of metallurgy in southern Portugal. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the BM, 15–26.

Results of a project investigating the innovation of copper metallurgy at the Chalcolithic fortified settlement of Zambujal and two nearby settlements in southern Portugal are given. Traces of extraction are possible at Zambujal but casting and working took place at all three sites. Lead isotope analysis suggests the ore source was at least 100km distant. The correlation between the artefact types and the arsenic content indicates a conscious selection of the metal produced.

A Perea, I Montero, P C Gutiérrez and A Climent-Font. Origen y trayectoria de una técnica esquiva: el dorado sobre metal [Rise and course of an elusive technology: metal gilding]. *Trabajos de Prehistoria* 65(2), 2008, 117–130.

The identification of fire (mercury) gilding is dependant on analyses of archaeological objects; if no analyses are carried out, fire gilding will not be found. EDXRF results for a group of 4th-3rd century BC Iberian silver brooches found fire gilding on over half of them and PIXE detected mecury on items from the Torredonjimeno treasure (7th–8th century AD). A local origin (*c* 4th century BC) is suggested for fire gilding in Iberia.

T Rehren and E Pernicka. Coins, artefacts and isotopes – archaeometallurgy and *Archaeometry*. *Archaeometry* 50(2), 2008, 232–248.

Archaeometallurgy is one of the earliest manifestations of archaeometric research, using science-based approaches to address cultural-historical questions. This review first outlines the extent of archaeometallurgy, defining the main branches and their specific methodological approaches. It then looks at some pioneering publications and the role that *Archaeometry* played in archaeometallurgical research. The type of archaeometallurgy published in *Archaeometry* initially had a strong focus on coin and object analysis, often combined with method developments. Later developments in isotope-based studies found only a limited representation in the journal, despite the leading role that the Isotrace Laboratory played in this discipline. More recently, this *Archaeometry*-specific 'flavour' of archaeometallurgy seems to weaken, with an increase in papers on iron and primary production in general.

P Tisseyre, S Tusa, W R L Cairns, F Selvaggio Bottacin, C Barbante, R Ciriminna and M Pagliaro. The lead ingots of

Capo Passero: Roman global Mediterranean trade. *Oxford Journal of Archaeology* 27(3), 2008, 315–323.

Epigraphic and isotopic analysis of lead ingots recovered from a shipwreck dated *c*38BC off Capo Passero (Sicily) suggests that the ingots were produced in the Cartagena region of Spain. This provides further evidence the Romans were trading lead throughout the Mediterranean.

G Weisgerber, with P T Craddock, N D Meeks, U Baumer and J Koller. Roman brass and lead ingots from the western Mediterranean. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 148–158.

A group of 10 plano-convex oval brass ingots and two rectangular lead ingots of trapezoid section, now in the Bochum Bergbau-Museum, came from a wreck; the cargo is thought to have originated in Spain in the late 1st century AD.

J-M Welter. La couverture en cuivre en France: une promenade à travers les siècles [Copper roofs in France: a journey across the centuries]. *Monumental: Le metal dans l'architecture*, 2007, 104–112.

Copper has been used for roofing from the 17th century but it became common in France from the 19th century. This paper sets modern production and use in a historical context. Trace element data for copper sheet of various dates are given. JB

A Williams. Crucible steel in medieval swords. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 233–241.

Some Viking-age swords, including some inscribed VLFBERHT, were made of crucible steel. There is written and metallographic evidence for the trade in such steel to western Europe at this time, and liquid steel was familiar to medieval chemists.

A Williams. The Armours of Cosimo I de'Medici and his contemporaries. In C Dobson (ed), *Art and Arms, Florence, City of the Medici*. International Arms and Armour Conference, 2003, 32–42.

Changes which took place in the making of Italian armour around the turn of the 16th century are discussed. Hardened steel does not seem to have been used after this point in Italy, maybe as a result of the increased use of fire gilding. At the same time ungilded armour, presumably for field use, was not hard either. Cosimo de'Medici (1519–74) tried to establish a modern iron industry in Tuscany, and even collected of recipes for quenching liquids, several of which promised to temper steel so it would resist firearms. Practical evidence for this has yet been found. JL

A Williams, D Edge and T Atkins. Bullet dents — 'proof marks' or battle damage. *Gladius 26* 2006, 175–209.

Breastplates from the 16th and 17th centuries bear hemispherical dents generally known as proof marks. It has been taken as axiomatic that these marks were made in order to demonstrate the armour's effectiveness against firearms. If, however, some of these dents are compared with dents which are the result of battle damage, it appears that they were made by energy levels of a different order of magnitude, and offer little guarantee as to the 'proof' of the armour.

NEAR AND MIDDLE EAST

E Ben-Yosef, L Tauxe, H Ron, A Agnon, U Avner, M Najjar and T E Levy. A new approach for geomagnetic archaeointensity research: insights on ancient metallurgy in the Southern Levant. *Journal of Archaeological Science* 35(11), 2008, 2863–79.

Ancient geomagnetic field intensity of copper-slag deposits, as well as other archaeometallurgical artefacts, from archaeometallurgical sites in the Southern Levant was determined. The results shed new light on the dating of these sites, including the copper-smelting installation of Timna 39b, a site that is important for the beginning of metallurgy during the 5th millennium BCE.

A Courcier, A Gasanova and A Hauptmann. Ancient metallurgy in the Caucasus during the Chalcolithic and Early Bronze Age: recent results from excavations in western Azerbaijan. *Metalla (Bochum)* 15(1), 2008, 21–34.

Analytical and metallurgical study of beads, rings, a dagger and an awl show the use of arsenical copper, gold, and auriferous silver. JB

A Courcier, D Kuparadze and D Pataridze. Archaeometallurgical researches on the early beginnings of metallurgy (6th–3rd millennia BC) in the Caucasus: an example of interdisciplinary studies. *Metalla (Bochum)* 15(1), 2008, 35–50.

A study based mainly on metal artefacts from the north Caucasus region. JB

S M Emami and B Yaghmaei. Remote sensing methods for investigation and recognition of ancient mining activities (case study on Cu-Fe-Mn mineralization in western part of central Iranian zone). *Metalla (Bochum)* 15(1), 2008, 3–20.

GIS techniques were used to study the Jian copper mining and Faryadan iron mining areas. The metals produced can be linked to Persepolis and other sites of the mid first millennium BC. JB

A Hauptmann and I Wagner. Prehistoric copper production at Timna: thermoluminescence (TL) dating and evidence from the East. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 67–75.

Early copper production at Timna and the Wadi Arabah is reviewed. Evidence of the social organization pattern of metal production was found to be similar to the patterns found in the Eastern Mediterranean, the Balkans and Europe. It is also concluded that there is evidence for metallurgical activities at Timna in the Late Bronze Age, but not earlier. JL

C P Thornton. Of brass and bronze in prehistoric southwest Asia. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 123–135.

Zinc-containing copper alloys occur widely from the 3rd to 1st millennium BC, their chronological and geographical distribution correlating with that of tin-containing alloys. This may be due to confusion of brass with tin-bronze; their linguistic separation in the 1st millennium BC may reflect larger changes in sociocultural categorisation of materials.

C Thornton, T Rehren and V Pigott. The production of speiss (iron arsenide) during the Early Bronze Age in Iran. *Journal of Archaeological Science* 36, 2009, 308–316.

Analyses of some unusual slag samples from the prehistoric site of Tepe Hissar in NE Iran are presented. These slags are the remains of a pyrotechnological process that produced speiss, a quasi-metallic material usually formed as an accidental by-product of copper or lead smelting. It is argued that they suggest the intentional production of iron–arsenic alloy (speiss) in pre-history. Preliminary assessment suggests that the speiss provided arsenic as a component of arsenical copper, the preferred copper alloy during much of the Early Bronze Age in Iran.

H A Veldhhuijzen and T Rehren. Slags and the city: early iron production at Tell Hammeh, Jordan and Tel Beth-Shemesh, Israel. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 189–201.

Science-based analyses of early iron smelting from Tell Hammeh and iron smithing from Beth-Shemesh identifies the technical ceramics and other finds associated with each process, allowing reassessment of earlier claims for iron production in the area.

L Weeks. Coals to Newcastle, copper to Magan? Isotopic analyses and the Persian Gulf metals trade. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 89–96.

Reviews evidence for metal production and exchange systems in the Bronze Age. Evidence for the use of non-Omani tin and tin bronze are addressed, and the possible import of copper ingots to Oman is considered but thought unlikely.

L Weeks, E Keall, V Pashley, J Evans and S Stock. Lead isotope analyses of Bronze Age copper-base artefacts from Al-Midamman, Yemen: towards the identification of an indigenous metal production and exchange system in the southern Red Sea region. *Archaeometry* 51(4), 2009, 576–97.

The results of the lead isotope analysis (LIA) of 15 copper-base artefacts suggest the existence of an indigenous Bronze Age metal production and exchange system centred on the southern Red Sea region, distinct from those in Arabia and the Levant. This suggests that local prehistoric copper extraction sites have so far gone unrecorded, and highlights the need for systematic archaeometallurgical fieldwork.

AFRICA

S Chirikure, S Hall and D Miller. One hundred years on: what do we know about tin and bronze production in southern Africa? In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 112–119.

The paper gives a synopsis of information available about the archaeology and technology of tin and bronze production from the early 2nd millennium onwards; profitable avenues for future reseach are suggested.

L Garenne-Marot and B Mille. Copper-based metal in the inland Niger delta: meal and technology at the time of the Empire of Mali. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the BM, 159–169.

Analyses of objects dated to the 11th–13th centuries AD reveal ties with metal from the Islamic World. The working techniques were local and the alloy choice, with colour an important factor, was culturally determined.

J Humphris, M Martinón-Torres, T Rehren and A Reid. Variability in single smelting episodes—a pilot study using iron slag from Uganda. *Journal of Archaeological Science* 36, 2009, 359–369.

The material studied comes from two iron-smelting sites in the Buganda Kingdom, Uganda, dated to the 18th and 19th centuries AD and represents evidence of industrial-scale iron production that supported the growth and power of the kingdom. The slag survives in large clusters of complete blocks, in some cases weighing over 100kg, each resulting from a single smelting episode in a pit furnace. A multi-sample approach allowed insight into the compositional diversity within the slag from single smelting events, reflecting changing parameters in the smelting systems. The internal variation of the slag blocks is compared within and between sites, to address issues of standardisation and to differentiate two technological traditions that appear very similar at the macroscopic level.

T Rehren, M Charlton, S Chirikure, J Humphris, A Ige and H A Veldhuijzen. Decisions set in slag: the human factor in African iron smelting. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 211–218.

Technical engineering, ethnographic and socio-political studies of iron smelting provide a a technically-defined envelope within which humans operated. Some decisions leave traces in the slag, so technical studies may offer insights into social and cultural practices.

ASIA

Lui Haiwang, Chen Jianli, Li Yanxiang, Bao Wenbo, Wu Xiaohong, Han Rubin, Sun Shuyun and Yuan Dongshan. Preliminary multidisciplinary study of the Miaobeihou zinc-

smelting ruins at Yangluisi village, Fengdu county, Chongqing. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 170–178.

Scientific studies show smithsonite and coal were used to produce zinc during the Ming dynasty. The process used closely matches the account given in the 17th-century *Tian Gong Kai Wu*.

J-S Park, A Chunag and E Gelegdorj. A technological transition in Mongolia evident in microstructure, chemical composition and radiocarbon age of cast-iron artifacts. *Journal of Archaeological Science* 35(9), 2008, 2465–70.

Metallurgical examination of cast-iron objects from the Khitan period (10th–12th century AD) shows that they include both Fe–C alloys of near-eutectic composition and Fe–C–Si alloys with reduced carbon content and numerous sulphide inclusions. By contrast, all the objects from the succeeding Mongolian empire period (12th–15th century AD) are Fe–C–Si alloys, indicating a technological transition had occurred during the Khitan period. Accelerator mass spectrometry on carbon samples extracted from artefacts in both groups and alloy compositions suggest the use of mineral coal in smelting was a major factor in this transition.

J-S Park and D Voyakin. The key role of zinc, tin and lead in copper-base objects from medieval Talgar in Kazakhstan. *Journal of Archaeological Science* 36(3), 2009, 622–628.

Metallurgical examination of copper-alloy objects from this medieval (9th–13th century AD) site shows that they were mostly cast from quaternary copper-zinc-tin-lead alloys with some that were forged from binary copper-zinc alloys. Brass was produced by the cementation process. The addition of tin and lead to the brass was considered beneficial in casting but was strictly avoided in forging. A major factor in establishing this unique brass tradition was probably limited access to tin.

V Pigott and R Ciarla. On the origins of metallurgy in prehistoric southeast Asia: the view from Thailand. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 76–88.

Current evidence suggests that tin-bronze metallurgy appeared in Thailand rather abruptly as a full-blown technology by the mid 2nd millennium BC and that it may have links to China. The links between the Eurasian steppe and the north and west of China are also explored; the paper discusses this research in relation to Thai metallurgy.

D D N Singh, S J Yadav, A Pandya and K S Panwar. Unfolding the mystery of the non-rusting behaviour of Damascus steel. In J Bridgland (ed), *ICOM Committee for Conservation 15th triennial conference, New Delhi*, 2008, Allied Publishers, New Delhi, India, Vol 1, 447–456.

Raman spectroscopy, electrochemical impedance spectroscopy, polarisation studies, image analysis and hardness testing, together with ferri-ferrocyanide tests were carried out to investigate resistance to the onset of corrosion by Damascus and other steels. The studies show that the resistance to rusting is due to the presence of a rich cementite phase formed on their surface by special heating, cooling and etching treatments of the surface.

M L Wayman and C Michaelson. Early Chinese ferrous swords from the British Museum collections. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 226–232.

Four Han-dynasty swords were made by piling carburized steel, and another by solid-state decarburization of a cast-iron sword. A medieval sword was pattern-welded using two different low carbon steels.

Zhou Weirong. The origin and invention of zinc-smelting technology in China. In S La Niece, D Hook and P Craddock (eds), *Metals and Mines: studies in archaeometallurgy, 2007,* London, Archetype Publications in association with the British Museum, 179–186.

The technology of metallic zinc production by distillation originated in the 16th or early 17th century, developing from Chinese cementation brass-smelting processes.

A Williams and D Edge. The metallurgy of some Indian swords from the arsenal of Hyderbad and elsewhere. *Gladius* 27, 2007, 149–176.

Six of ten broken blades from the Armoury of the Nizams of Hyderbad examined microscopically appeared to have been from crucible steel and were of notably high quality. By contrast, only one of the six blades from various private collections in England was made from crucible steel and three of the others were of very mediocre quality.

AMERICA

J D Light. A dictionary of blacksmithing terms. *Historical Archaeology* 41(2), 2007, 84–157.

This dictionary attempts to provide many of the orally-preserved terms once in use among blacksmiths in North America. The introduction of the Bessemer process began the eventual decline of blacksmithing which was an essential trade only as long as wrought iron was the basic ferrous metal.

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