

HMS NEWS

Historical Metallurgy Society
69 Summer 2008

Letter from the Chairman

Tim Young

Since writing a note for the Newsletter this time last year, there has been a great deal of activity in HMS. The last year has seen some exceptionally exciting meetings, with the Annual Conference in Dublin in September and two excellent meetings organised by the Archaeology Committee, that on “Changing Technology in Medieval and Post-Medieval Metalworking” in Bradford in November and “19th-century Ferrous Metallurgy” in Sheffield in April. The Archaeology Committee has now also completed its important research framework for archaeometallurgy, which should be published any day now.

In my note in the newsletter last year I commented on some of the challenges which face the Society in terms of membership, outreach and engagement with all those of vastly different backgrounds and interests who make up the broader community involved with historical metallurgy. To address these concerns, various structural changes are taking place within HMS to ensure it is best placed to respond to demands and possibilities, both old and new. Members will have seen notice of the changes to Council put before, and approved by, the recent Extraordinary and Annual general meetings. These changes allow more flexibility in the make-up of Council and for the immediate future the main implications are the creation of four new Officers of Council – the Membership Development Officer (Eddie Birch), the Conservation Officer (Paul Belford), the Newsletter Editor and the Website Manager (both positions held by David Dungworth). The posts are all significant because they relate, to a greater or lesser extent, to the outward face of the Society.

Alongside the changes to Council there are also revisions to the committee structure being implemented this year. The **Archaeology Committee** has functioned well over recent years and I hope that it will continue to flourish. It provides a good model for how well committees can function once they reach a critical size and forward momentum.

The Journal Editors apologise for the late appearance of the first part of this year’s *Historical Metallurgy*. It is now being set, and we hope to have it sent out to all members by the end of August. Before then you will receive a free copy of our Occasional Publication, *Metals and metalworking: a research framework for archaeometallurgy*, which has been produced by the Society’s Archaeology Committee.

The first of the significant changes is the recent creation of a new committee, the **Archives and Collections Committee**. Their remit is to manage, curate and develop the Society’s holdings of books, papers and specimens, so that not only are they cared for to the highest professional standards, but also will be more easily accessed by researchers. Current challenges for them include not only the previously existing holdings of books and papers, but also the rapidly developing National Slag Collection and the recently acquired collection of specimens which had belonged to Ronnie Tylecote. This committee is already “up and running” and making great progress.

The second big change is the **Membership and Promotions Committee**. This unites coordination and planning of all our activities in membership development, in promotion and in our programme of events and meetings. Their purpose is to develop a coherent programme to appeal to the needs and wishes of all the existing membership, but also to make the Society and its activities as attractive for as many as possible of those involved with historical metallurgy in the broadest sense and ultimately to transform their interest into becoming paid-up members. Although some of the members of this committee will be ex officio meeting convenors or as other relevant Council Officers, it is important that the committee is also representative of the broader Society membership.

A new **History and Recent Metals Committee** is also beginning to take shape. The Society has always had a strong interest in the development of metallurgy and the metallurgical industries over the century or so, particularly through the background of many of our members within those industries. There has not, until now, been a specific place within our committee structure where activities in this area can be developed and fostered. By uniting this with the existing role of the History Committee, with which there is much common ground, it is hoped that these interests can once again provide a vibrant part of the Societies activities. The Society recently removed the long-moribund formal link between Council and the IOM3, but I hope that the new committee will form the focus

of a new and more dynamic relationship between the two organisations. The importance of this committee to the future of the society is reflected by the importance Council placed on nominating historians for council vacancies this year.

The key to the success of the Archaeology Committee over recent years has been an active membership drawn broadly from the society's membership and representing various outside bodies and institutions as well as comprising individuals with great personal commitment to the development of archaeometallurgy. We now need to tap into similar expertise to develop the new committees. I am certain that there will be many members of the society who have just those skills and interests that we need to develop our new activities. Committee membership typically lasts 2–4 years, with rotation to ensure freshness and energy, so there are always openings for new contributors. I would urge all those who may feel they have something to offer and who are prepared to involve themselves in 2–3 committee meetings per year, to make themselves known to me.

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Comité pour la Sidérurgie Ancienne (CPSA)

Union Internationale des Sciences Préhistoriques et Protohistoriques (UISPP)

Janet Lang: Honorary Secretary, CPSA

With the support of Professor Thilo Rehren, Institute of Archaeology, University College, London, a refurbished CPSA website is being designed by Dr Xander Veldhuijzen. It is hoped that the new website will be up and running within the next few months. The website will carry on the work of the Communications produced with such success by Professor Radomir Pleiner to act as an information source for those interested in ferrous archaeometallurgy. The site will contain a brief outline of the CPSA's aims and activities, abstracts and news of conferences, excavations, exhibitions, courses and publications, with a running bibliography and perhaps a glossary. It is hoped to have a list of members with their e-mail addresses. It would also be excellent to recruit new corresponding members from around the world who might periodically send news in about activities and publications in their area. The effectiveness of the site will depend upon the co-operation and participation of ferrous archaeometallurgists world-wide.

If you would like your name to be added to the list contact cpsa.uispp@gmail.com for further details.

Council News

The AGM and EGM between them have approved new structure for Council and the committees. After the various votes at the AGM the new Council comprises the following:

President

David Crossley (President and Hon. Joint Editor)

Chairman

Tim Young

Hon General Secretary

David Cranstone

Hon Treasurer

Mike Cowell

Hon Joint Editors

Justine Bayley, David Crossley and Sam Murphy

Conservation Officer

Paul Belford

Membership Development Officer

Eddie Birch

Archaeology Committee Chairman

David Cranstone

History & Recent Metals Committee Chairman

Eddie Birch

Archives and Collections Committee Chairman

David Dungworth

Membership and Promotions Committee Chairman

Robert Smith

Publications Committee Chairman

Justine Bayley

Finance Committee Chairman

Michael Cowell

Newsletter Editor

David Dungworth

Website Manager

David Dungworth

Other Members of Council

Brian Read, Jonathan Ayles, Louise Bacon, Eleanor Blakelock, Roger Doonan, Lynne Keys, Paul Cort, Chris Evans, Colin Phillips, Duncan Hook.

An Early Zinc-smelting Retort from China

Paul Craddock

The British Museum has recently acquired a zinc-smelting retort (Figure 1) from the excavations at Yangliusi, a small settlement on the banks of the Yangtze River in Fendu County, Chongqing (Liu Haiwang *et al* 2007). Several other early zinc smelting sites have recently been located and surveyed in that region by Prof. Chen Jianli and his colleagues from the Dept. of Archaeology and Museology, Peking University and at the University of Science and Technology, Beijing.



Figure 1. Zinc-smelting retort from Yangliusi, British Museum Reg. 2008, 3006.1. (BM / T. Springett)

The retort was exchanged for an early Indian zinc-smelting retort from Zawar in Rajasthan at the 6th BUMA conference held in Beijing in Sept. 2006 (Figure 2).

The retorts are both about 500 years old, but the two distillation technologies could not be more different. The Indian process, which probably began as an industrial process about 1,000 years ago, is by downward distillation with the zinc vapour passing into

a cool chamber and receiving vessel (Craddock *et al* 1998) (Figure 3), but the Chinese process, which probably began as an industrial process around 500 years ago, has an internal receiver (Figure 4). This is based on the principle of the much earlier Mongolian still, used for the distillation of alcohol and aqueous solutions (Needham 1980, 62–74). The retort would have been filled with the smithsonite, zinc hydroxycarbonate ore and cakes of sintered mineral coal. The latter has a very low sulphur content and can be used directly in contact with the ore. On this sat the collecting dish, known as the birds' nest, (Figure 5) with a gap to allow the zinc vapour to rise into the condensing chamber above. This was formed of the clay collar with a loose lid. The retorts stood upright in the furnace with their upper parts exposed and thus these were much cooler. During the smelting operation the zinc vapour rose into the upper chamber, condensed against the relatively cool lid and dripped down into the bird's nest receiver below.



Figure 2. Zinc-smelting retorts from India and China, almost certainly the first time that such retorts have ever been together. Although contemporary the processes are totally different; in the Indian process the zinc vapour descends, in the Chinese process it rises. (BM / T. Springett)

The fate of the two traditional zinc-smelting industries and their interaction with Western economies and technology were also very different. The Indian traditional industry, based solely at Zawar, boomed during the 16th and 17th centuries, very probably with a substantial proportion of the production going to Europe in the vessels of the Portuguese, Dutch and British East India Companies, but production was disrupted by the chaotic conditions that prevailed in western India during

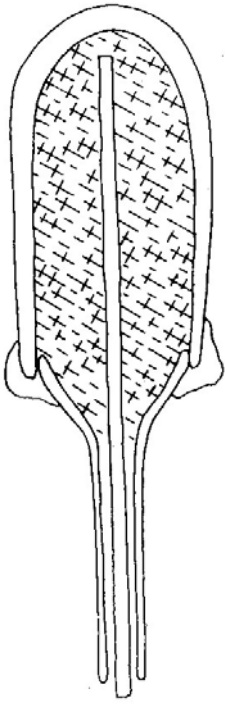


Figure 3. Principal of the Indian process. (B R Craddock)

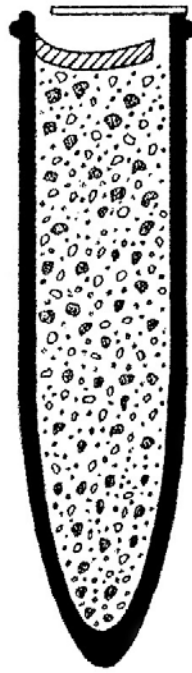


Figure 4. Principle of the Chinese process (from Xu Li 1998, redrawn B R Craddock)

encouragement of home production by any means enabled the industry to survive. During the second half of the 20th century the process evolved, a rare example of a traditional technology developing instead of just terminating in the face of modern processes (Xu Li 1998; Craddock and Zhou Weirong 2003). Production still continued in the provinces of Guizhou, Yunnan and Sichuan, sometimes operating rather incongruously alongside huge state-run plants producing zinc electrolytically. However, the fate of the traditional process, which seemed precarious in the 1990s, is now reported to have ceased due to belated environmental pollution and health concerns.

Brass, the alloy of copper and zinc, only became popular in China from the 16th century, when it was adopted for the *cash* coinage, and it is assumed that the production of zinc on an industrial scale dates from that period. The radio carbon dates from the Yangliusi site range from the late 15th to early 17th century, and thus support this dating. However, as Haiwang Liu and his colleagues have pointed out, the furnaces excavated belonged to a developed stage of an industry that could be considerably older in origin. Their continuing investigation of these sites promise to be exciting!

References

- Craddock, P T 2007 'Perceptions and reality: The fall and rise of the Indian mining and metal industry', in SK Sarangi (Ed) *Proceedings of the 7th International Mining History Congress*. Bhubaneswar: Society of Geoscientists and Allied Technologies, 47–62
- Craddock, P T and Zhou Weirong 1998 'The survival of traditional zinc production in China', in Y. Imai (Ed) *Proceedings of the Fourth International Conference on the Beginnings of Metals and Alloys (BUMA IV)*. Sendai: Japan Institute of Metals, 85–96
- Craddock, P T, Freestone, I C, Gurjar, L K, Middleton, A P and Willies L 1998 'Zinc in India', in PT Craddock (Ed) *2,000 Years of Zinc and Brass*, 2nd ed. London: British Museum, 27–72
- Craddock, P T and Zhou Weirong 2003 'Traditional zinc production in modern China; survival and evolution', in PT Craddock and J Lang (Eds) *Mining and Metal Production Through the Ages*. London: BMP, 267–92
- Liu Haiwang, Chen Jianli, Li Yanxiang, Bao Wenbo, Wu Xiaohong, Han Rubin, Sun Shuyan and Yuan Dongshan 2007 'Preliminary multidisciplinary study of the Miaobeihou zinc-smelting ruins at Yangliusi village, Fengdu county, Chongqing', in S La Niece, D Hook and P Craddock (Eds) *Metals and Mines*. Archetype, London, 170–78
- Needham, J 1980 *Science and Civilisation in China V pt. 4*, CUP, Cambridge
- Xu Li, 1998 'Traditional zinc-smelting technology at Magu, Hezang county of Guizhou province', in PT Craddock (Ed) *2,000 Years of Zinc and Brass*, 2nd ed. London: British Museum, 115–32

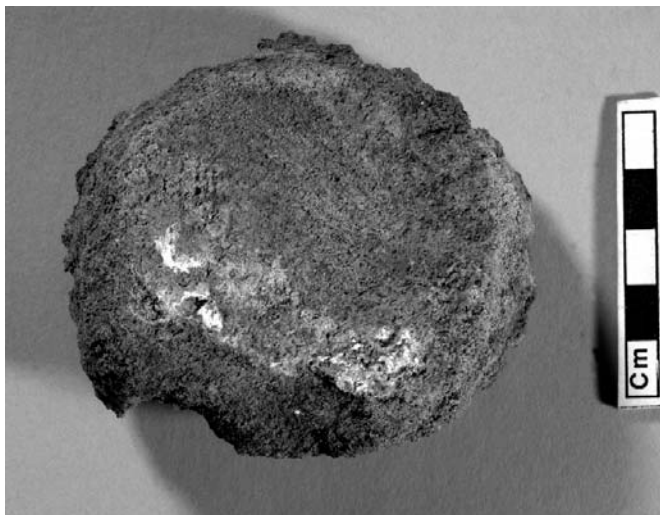


Figure 5. Tiny ceramic 'bird's nest' collecting tray from the neck of the retort. (BM / T. Springett)

much of the 18th century, finally ceasing in 1812 (Craddock 2007). The Chinese industry must also have benefited enormously from the European trade, such that by the early 17th century Chinese zinc dominated world markets, albeit traded and transported by the Dutch. Thereafter the international trade declined but the industry continued to supply zinc to the nearby main Chinese mint producing brass coins until the early 20th century. Through the 20th century the vagaries of geopolitics meant that much of western China was cut off from the rest of the world by the Sino-Japanese war and then following the communist take over the

Iron and cast iron in China: report of a mission

Philippe Dillmann and Ivan Guillot



Figure 1. Cast iron oxen in Pujin bridge

Last April the Chinese Academy of Cultural Heritage (CACH) invited Professor Ivan Guillot (University of Paris XII) and Dr Philippe Dillmann (French CNRS) to visit several sites with monumental cast iron sculptures and guns from Han to Qing periods (2nd century BC to 19th century AD). The aim of this visit was to prepare a future collaboration between CACH, CNRS and University of Paris XII with particular focus on corrosion studies and conservation of these beautiful ferrous artefacts and monuments. In addition to these visits and meetings, contact was also made with the Institute of Historical Metallurgy and Materials Research Centre for Science-Technology and Civilisation in the Science and Technology University of Beijing.

During the Chinese trip, Professor Qinglin Ma of the CACH team of was our friendly and welcoming host who guided us to the various sites with enthusiasm and competence. Dr Shen Dawa, Dr Yong Xin Qun, Dr Li Naisheng and Dr Zhiguo Zhang must be kindly acknowledged for their assistance.

The first site to be visited was the Jinci temple located 25km southwest to Taiyuan (Shanxi province) and known for its beautiful Zhou dynasty monuments and painted terracotta statues. In the middle of the site are four cast iron warrior statues. According to the inscriptions on their chests, two of these are dated from the Song dynasty (and cast around 1097), one from the Ming and one from the Qing dynasty. All these statues have remarkable “patinas” that will be studied in the future. Also exhibited on this site are very nice cast iron bells and lions statues from different periods (e.g. Ming and Qing).

Another marvellous site was the Tang dynasty (AD724) iron oxen at Pujin bridge excavated in 1994 (Figure 1). Examinations were made and ideas discussed between Chinese and French scientists about the conservation states of the oxen that are now exposed to the air on a platform that can be visited by the public. These wonderful statues, that held the cables of a bridge through a former arm of the Yellow River, are about 1.5m high and 2m long and are truly masterpieces of iron casting of this period.

The Cangzhou lion (Hebei province), which dates from AD930, is said to be the largest iron casting in the world (Figure 2) and has been documented by D. Wagner in his recent book. This Lion has some serious conservation problems, which are apparently more linked with mechanical stresses than corrosion. Scientists of CACH are now trying to design an adapted stand to support the Lion in a proper way.



Figure 2. The Cangzhou lion

Guns dating from the Opium War period at Daguko near Tianjin were also examined. Three Chinese pieces are most interesting because of the “dual” structure of their barrels which are made of an inner cylinder probably in wrought iron (to be verified in further studies) and an external cylinder of cast iron. Because their burial environment was not far from the sea, the corrosion product could contain high quantities of chloride and adapted desalinisation treatments has to be set up.

These 10 days spent in China were also dedicated to fruitful discussions that will probably lead to Chinese student visits in the French laboratories. We hope that this first contact between CACH team and our Laboratories will lead to significant and regular collaborations in the next future.

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Iron-smelting in Kamalia, West Africa

Robin Fox

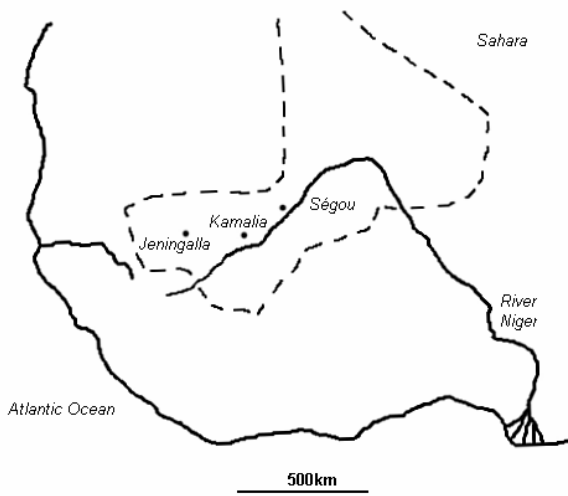


Figure 1. Map of Mali and the river Niger



Figure 2. 1 A view of Kamalia in Mandingo country (detail) from Park (1816)

In 1796, Mungo Park, a young Scottish surgeon/botanist, returning from his first West African journey to determine the course of the River Niger, wrote:

‘... the owner and his workmen made no secret about the manner of conducting the operation, and readily allowed me to examine the furnace, and assist them in breaking the ironstone. The furnace was a circular tower of clay, about ten feet high and three in diameter, surrounded in two places with withes, to prevent the clay from cracking and falling to pieces by the violence of the heat. Round the lower part, on a level with the ground (but not so low as the bottom of the furnace, which was somewhat concave), were made seven openings into every one of which were placed three tubes of clay, and the openings again plastered up in such a manner that no air could enter the furnace but through the tubes, by the opening and shutting of which they regulated the fire. These tubes were formed by plastering a mixture of clay and grass round a smooth roller of wood, which, as soon the clay began to harden, was withdrawn, and the tube left to dry in the sun. The ironstone which I saw was very heavy, and of a dull red colour, with greyish specks; it was broken into pieces about the size of a hen’s egg. A bundle of dry wood was first put into the furnace and covered with a considerable quantity of charcoal, which was brought ready burnt from the woods. Over this was laid a stratum of ironstone, and then another of charcoal, and so on, until the furnace was quite full. The fire was applied through one of the tubes, and blown for some time with bellows made of goats’ skins. The operation went on very slowly at first, and it was some hours before the flame appeared above the furnace; but after this it burned with great violence all the first night, and the people who attended put in at times more charcoal. On the day following the fire was not so fierce, and on the second night some of the tubes were withdrawn, and the air allowed to have freer access to the furnace; but the heat was still very great, and a bluish flame rose some feet above the top of the furnace. On the third day from the commencement of the operation all the tubes were taken out, the ends of many of them being vitrified with the heat; but the metal was not removed until some days afterwards, when the whole was perfectly cool. Part of the furnace was then taken down, and the iron appeared in the form of a large irregular mass, with pieces of charcoal adhering to it. It was sonorous; and when any portion was broken off, the fracture exhibited a granulated appearance, like broken steel. The owner informed me that many parts of this cake were useless, but there was good iron enough to repay him for his trouble. This iron, or rather steel, is formed into various instruments, by being repeatedly heated in a forge...’.

It was in Kamalia (close to Bamako, the modern capital of Mali, see Figure 1) that Mungo Park observed the iron-smelting operation, and this passage is probably the first such description by a European. The published account (Park 1816) includes an etching of the scene, based on his drawing (Figure 2). Ten years later he made another expedition to Ségou, with the intention of mapping the Niger to its mouth, but perished by drowning. His diary of the journey to Ségou records a halt at Jeningalla, where he examined and sketched another smelting furnace, similar to that at Kamalia but smaller at the top (Figure 3). In 1796 iron-smelting had long since disappeared from the coastal region of West Africa, where the industry had succumbed to cheap imports of bar iron from Europe. In Kamalia, however, Park tells us that

‘...the natives smelt this useful metal in such quantities, as not only to supply themselves from it with all necessary weapons and instruments, but even to make it an article of commerce with some of the neighbouring states.’

Iron smelting by various methods – high-shaft and low-shaft furnaces, bowl furnaces – survived in Africa well into the last century.

When did the Iron Age begin in sub-Saharan Africa? There is little doubt that smelting was under way from early in the first millennium BC, and some commentators make a case for its independent discovery in Africa. Alternatively, the technologies may have arrived by diffusion from the north - across the Sahara and down the Nile Valley (Alpern 2005; Kense 1985). A more answerable question is whether, once established in sub-Saharan Africa, bloomeries evolved in specifically African ways. Here attention has focused on three features identified in archaeological and other work – the employment of long tuyères that might have increased furnace efficiency by pre-heating air before it reached the heart of the furnace (thus anticipating a British patent of 1828); the production of steel; and the use of high-shaft furnaces that functioned with natural draught rather than bellows (Pole 1985) Two of these features are illustrated by Park’s Kamalia furnace, which required bellows only at the start of the smelt and yielded a bloom containing steel. He does not tell us whether the tuyères projected into the chamber. Sceptics point out that the incidental production of high-carbon iron in a bloomery is not remarkable, and that the efficacy of pre-heating by the tuyère method remains hypothetical. The tall natural-draught furnace is a much stronger candidate for an ‘African’ technology, since this method does not seem to have been used in Mediterranean countries (Kense 1985)

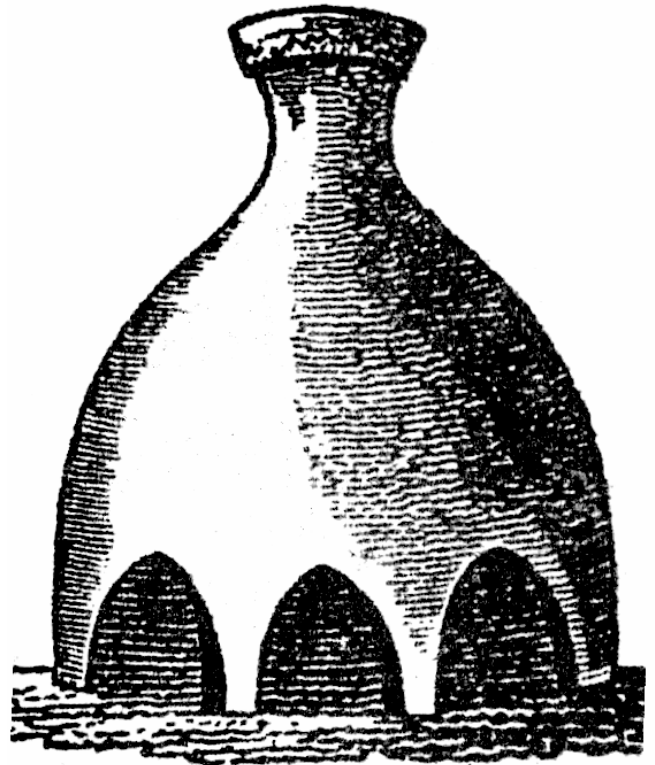


Figure 2. Furnace sketched by Park at Jeningalla in 1805 from Park (1816)

References

- Alpern, S B 2005 ‘Did they or didn’t they invent it? Iron in sub-Saharan Africa’, *History in Africa*, 41–94.
- Kense, F J 1985 ‘The initial diffusion of iron to Africa’, In: Shinnie P, Haaland R (Eds). *African Iron working, Ancient and Traditional*. Bergen, 11–27.
- Park, M 1816 *Travels in the Interior Districts of Africa: performed in the years 1795, 1796, and 1797: with an account of a subsequent mission to that country in 1805*. London.
- Pole, L M 1985 ‘Furnace design and the smelting operation: a survey of written reports of iron smelting in West Africa’, In: Shinnie P, Haaland R (Eds) *African Iron working, Ancient and Traditional*. Bergen. Bergen, 142–63.

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Report on actualistic casting pre-experiments – The copper hammer and adze-axes from the Carpathian Basin

Historical Metallurgy Society Coghlan Bequest
Julia Wiecken

The transition from the Neolithic to the Bronze Age in Europe represents one of the most profound technological changes in later prehistory. Significant social transformations can be observed, with individual status increasingly conspicuous during the Bronze Age. As an entirely novel material, metal must have had a major impact on society. How can we determine and qualify this impact? In my own research I am trying to investigate these issues through the experimental exploration of early copper technology. In order to apply the experimental results to the archaeological record I think it important to carry them out as actualistically as possible, meaning in this case using materials and technologies which would have been available in the Copper Age of South-Eastern Europe.

Source	Production technique
Coghlan 1943, 52	Bi-valve, two part closed mould. He dismisses the idea of the axes being forged from solid metal.
Childe 1944, 9–10	Cold hammering of copper led to creation of shaft-hole axes
Berciu 1939–1942	Lost wax, although he thinks some might have been completely forged
Garasin 1954, 71	Notes hammer marks on most as well as a casting seam on one of the Serbian shaft-hole axes, but does not commit.
Pittioni 1957	Cast in open moulds, shaft hole might have been cored later, finished by hammering. Native and smelted copper was used. Notes diversity in production techniques
Coghlan 1961	After metallographic analysis and reading Pittioni's article, Coghlan thinks some axes were cast in open moulds, with the shaft having been cored later
Charles in Renfrew 1969, 40–42	Simple shape cast with core in place, forged into final stage
Vulpe 1975, 18	Cast in one piece open mould, and hammered into final shape while still warm. Shaft-hole was made using clay or stone peg.
Patay 1984, 13	Cast in one piece open mould due to asymmetry of objects. Shaft-hole was made by piercing the still liquid metal with a pole or with core in place while casting.
Mareş 2002	Lost wax, or two-part mould

The most suitable artefacts to study for this purpose are copper axes, as they are emblematic of this period and region and provide a good sample size. Little consensus exists regarding their function due to a lack of experimentation and systematic analysis. They have been subjected to a wide range of interpretations, as tools, weapons, status symbols or ritual objects.

Unfortunately not a single mould fragment exists in the archaeological record which makes it extremely difficult to ascertain the production technique used for these objects. Metallography can be used to try and answer questions of production technique, but so far not nearly enough axes have been analysed in a strategic way. Although a number of the publications in table 1 include the analysis of microstructures, notably Pittioni (1957), Coghlan (1961) and Mares (2002), the literature does not provide conclusive evidence for the mould material used. The same can be said about the actual shape of the moulds, as moulds can potentially be one-part open moulds, or closed bi-valve moulds. The debate on these issues is still ongoing. This diversity in opinion regarding the production technique of these axes seen in table 1, is of course partly due to the lack of any mould finds in the archaeological record. However a very careful experimental and more detailed metallography should be able to narrow the possible techniques considerably.

The complete lack of moulds for the copper axe-adzes and indeed hammer-axes in the archaeological record could be due to two reasons. The moulds have either not yet been found, or they were cast into a material which does not survive archaeologically. Having excavated in Eastern Europe myself, I know that late Neolithic and Copper Age pottery sherds are often simply thrown out due to their sheer quantity. This is especially true for undecorated sherds, the most likely pieces to have been part of moulds. Archaeologically invisible moulds could be made from sand, as various scholars have pointed out recently. (Goldmann 1981; Ottaway and Seibel 1998) Moulds made from sand would simply disintegrate, leaving nothing for the excavator to find.

Due to the considerations mentioned above I decided to cast in clay and sand moulds. Both open and closed moulds would be used as there is no consensus, which shape was used to cast these axes. Casting both in open and closed moulds makes it possible to compare the microstructure of the experimentally produced axes to the archaeological ones, and start a reference collection for future use. The next problem concerned the actual technique employed for melting the metal. Again not a single casting site is known from the archaeological record, although judging through my own experiments; they could easily have been misinterpreted as hearths. A trial run during my MA with a bowl furnace supplying the air from below the crucible was not successful. In

September 2006, I worked with a Swiss group 'Experiment A'. We cast bronze for 5 days using different furnace designs and air supplies. The most efficient model was based on a tuyère found at Sanskimost, in Bosnia and Herzegovina (Fiala 1899, 90–91). Although the tuyère dates to the Bronze Age and the copper axes are much earlier, I decided to use this technique, as they must have melted the metal somehow, and it would not influence my end result of producing actualistic copper axes. It was for this project that I applied successfully to the Coghlan bequest.

Bellows

As can be expected, there are no surviving bellows from the archaeological record. I therefore made similar leather bag bellows to the ones used by 'Experiment A' as they were easy to use and made from entirely organic materials. I used old leather coats from charity shops, which is by far the cheapest way to buy leather. In order to connect the two bellows to the one tuyère a pair of leather 'trousers' were made (Figure 1).

Pipes, tuyères, crucibles and moulds

The pipes connecting the bellows to the tuyère via the leather 'trousers' as well as the tuyères, crucibles and moulds were made using Devon earthenware clay mixed with sand at a proportion of about 2:1. The objects were then fired at 750° C in an electric kiln.



Figure 1. The finished furnace, tuyère, pipes and bellows

Furnace construction

A whole was dug into the ground and lined with the same clay mixture as was used for the pipes, tuyères, crucibles and moulds (Figure 1). The platform or flat area by the side of the hole was made to scrape the charcoal onto when placing the crucible inside the furnace. This helps keep the charcoal soil free inside the furnace. If too much soil gets into the furnace, the silica content vitrifies, which lowers the temperature as it is mixed with the charcoal, creating pockets where no combustion takes place. A small fire was lit inside the furnace to dry the clay slightly before adding the charcoal.

Casting session 1

Remembering the problems during the last casting session, I only added a small amount of copper to the crucible. This would not fill the mould but the first session should simply test if the set up was working properly. Once the furnace was full with glowing charcoal, the charcoal was scraped onto the side platform, and the crucible was placed directly underneath the tuyère opening, with about 5–7cm between the rims of the crucible and the tuyère. The charcoal was then piled over the crucible and up to the 'eyes' of the tuyère. In order to test if the copper was molten it was possible to insert a green willow shoot into the crucible. Running the shoot along the bottom of the crucible one could feel if there were any lumps left. Once the copper had melted; it was also possible to feel a slight 'bubbling' when inserting the shoot into the crucible. It took two hours and 30 minutes to melt the metal. This was mainly due to the bellows, as they were not as efficient as anticipated. The leather of the finger loops stretched which made it difficult to grip when operating the bellows. The two students helping me with the bellowing had never bellowed before, so that the first hour or so was spent practicing and the air flow was not always constant. This was a recurring problem, as I had different students helping me each time. The wooden tongs I used were simply made by splitting a branch some way up and tying a little wedge between the two sides. The mould was tied together using a leather strap, and situated in a small trench. For the first cast, the mould had not been pre-heated. The charcoal was scraped aside, the tongs were used to grab the crucible with one arm, and with my other arm I was holding a stick onto the rim of the crucible in order to stop the charcoal from blocking the pouring cup. The process of pouring the copper worked surprisingly well for the first trial. As anticipated it was only enough copper to fill the bottom half of the mould (Figure 2). The surface of the copper was fairly smooth but very porous or spongy (Figure 3), quite unlike the archaeological axes. It was interesting to observe the complete vitrification of the 'mouth' of the tuyère (Figure 4).



Figure 2. The partly filled mould after casting session 1

Casting session 2

This time the process was repeated as above, but the crucible was filled to its full capacity, and some amendments to the bellows meant that they were working more efficiently. The same two part clay mould was used, as I had not yet managed to fill it, although this time it was preheated next to the furnace. Despite these alterations, it took two hours to melt the metal. After pouring the metal, I noticed that I had not managed to fill the mould again, although I had weighed the amount of copper which could fit into the crucible, and it was equal to the weight of the axe, the mould had been made after. Again the surface was porous although slightly more solid feeling (Figure 5).

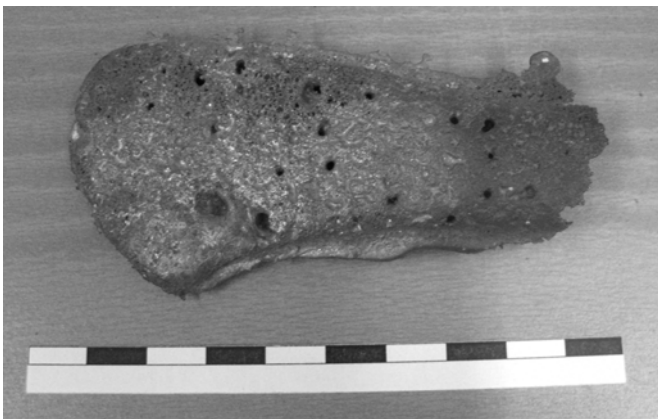


Figure 3. The cast from session 1



Figure 4. The partly vitrified tuyère



Fig. 5: Showing cast from session 2

Casting session 3

In order to finally fill the mould, I made a larger crucible for the third casting session. This time it took three and a half hours to melt the copper. When I attempted to take out the crucible with one arm I realised that it was too heavy and had to use both arms to pour. This meant that I could not hold the charcoal off, which blocked the pouring cup after having poured only a little copper. I poured the rest of the copper onto the clay surface next to the furnace and realised that there was a ring around the crucible wall of un-melted copper. As the crucible had been in the furnace for three hours it could only mean that the diameter of the crucible was too large for the tuyère opening. The axe piece from the last cast was the most solid casting without any obvious porosity (Figure 6).

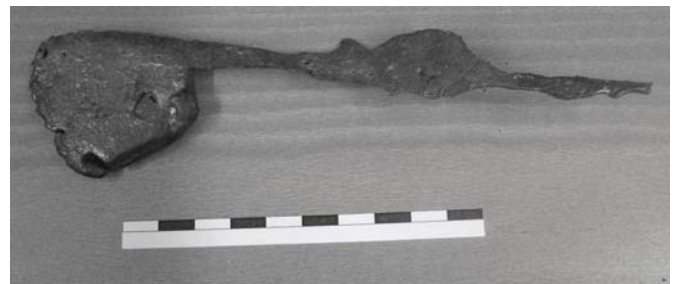


Figure 6. The cast from session 3

After the third casting session my material had run out and I realised that if I wanted to carry out statistically meaningful experiments with a large enough sample size, I would have to find an alternative way to melt and cast copper. The three casts will be sampled and I fully intend to carry out metallography, to compare the microstructure to other experimentally cast axes as well as archaeological ones. It is important to know for example if the microstructure of actualistically cast axes varies from axes cast in a modern furnace. I am now about to start a series of experiments using a gas furnace and the remaining copper. However the actualistic experiments were very valuable indeed. It made me realise and understand the processes which are

necessary to melt and cast these enigmatic and large objects. It also illustrated how ephemeral these activities can be, which might explain why not a single casting site is known from archaeological contexts. These early furnaces can easily be misinterpreted as hearths. A further observation was the importance of seeing metallurgy as a composite technology, with many other technologies involved. We should study metallurgy in a more organic way, taking into account the invisible processes as well as the visible metallic remains.

I would like to thank the Historical Metallurgy Society for helping me carry out my pre-experiments through the Coghlan bequest, without which I would not have been able to buy all the materials necessary. I would also like to thank the group 'Experiment A' and A. Young for helping me on the way to become a practical metallurgist, and last but not least all my 'bellowers', Tine Schenck, Via Baker, Genevieve Hill and Sophie Thorogood.

References

- Berciu, I 1939–42 'Topoare de cupru cu doua brațe opuse. Tipologie și origina'. *Apulum* I, 39–71
- Childe, V G 1944 'Archaeological ages as technological stages'. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 74, 7–24
- Coghlan, H H 1943 'The evolution of the axe from prehistoric to Roman times'. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland* 73, 27–56
- Coghlan, H H 1961 'Some problems concerning the manufacture of copper shaft-hole axes'. *Archaeologia Austriaca* 29, 57–75
- Fiala, F 1899 'Das Flachgräberfeld und die prähistorische Ansiedlung un Sanskimost'. *Wissenschaftliche Mitteilungen aus Bosnien und der Hercegovina* 6, 62–94
- Garasin, M V 1954 'Schafthlochäxte aus Kupfer in den Sammlungen serbischer Museen'. *Bericht der Römisch-Germanischen Kommission* 34, 61–76
- Goldmann, K (1981) 'Guss in verlorener Sandform — Das Hauptverfahren Alteuropäischer Bronze-giesser?' *Archäologisches Korrespondenzblatt* 11, 109–116
- Mareș, I 2002 *Metalurgia aramei în neo-eneoliticul din România*. Suceava.
- Ottaway, B S and Seibel, S 1998 'Dust in the wind: experimental casting of bronze in sand moulds', in Frere-Sautot, M C (Ed) *Paleometallurgie de cuivres - Actes du colloque de Bourg-en-Bresse et Beaune 1997*. Montagnac, Editions Monique Mergoil.
- Patay, P 1984 *Kupferzeitliche Meissel, Beile und Äxte in Ungarn*. Munich, C.H. Beck'sche Verlagsbuchhandlung.
- Pittioni, R 1957 'Urzeitlicher Bergbau auf Kupfererz und Spurenanalyse — Beiträge zum Problem der Relation Lagerstätte-Fertigobjekt'. *Archaeologia Austriaca* 1, 1–88
- Renfrew, C 1969 'The autonomy of the south-east European copper age'. *Proceedings of the Prehistoric Society* 35, 12–45
- Vulpe, A 1975 *Die Aexle und Beile in Rumaenien II*. Munich, C.H. Beck'sche Verlagsbuchhandlung.

HMS Spring Meeting 2008 19th-century Ferrous Metallurgy Sheffield, 18th April 2008

The spring workshop provided a forum to discuss recent and ongoing investigations into 19th-century ironmaking. The meeting was organised by Anna Badcock in Sheffield and was well attended by field archaeologists, historians and metallurgists.

The recent redevelopment of brownfield sites (that is ones which had previously had industrial uses) in many of our city centres has provided archaeologists with many opportunities to investigate iron and steelmaking sites of the 19th century. At the spring meeting we heard about recent excavations on the sites known to have had blast furnaces, puddling furnaces, cementation furnaces and foundries. Curatorial staff, archaeological contractors and metallurgical specialists provided informative and candid assessments of their experiences.

Some people still question the need for any archaeological research into such a recent period but many speakers illustrated the ways in which archaeology can enrich historical accounts. Christine Ball's excellent presentation went even further and illustrated how the historical record could contain errors; it was created by individuals who could be biased, lazy or even malicious.

The archaeological investigation of many of these brownfield sites is certainly a challenge for many of the people involved. Helen Gomersall recalled how until recently everyone thought the archaeology of 19th-century ironworks was a lost cause and that most archaeologists were not keen to excavate such sites because of their nature and scale. These sites often cover several hectares, may be covered in several metres of rubble and could even be contaminated with hazardous chemicals. Ben Reeves described how some of his colleagues thought that his site "wasn't real archaeology" and his excavation team had virtually no experience of 19th-century industrial sites. Nevertheless, many speakers illustrated how far the archaeological excavation of such sites has progressed in such a short period of time.

Due to a technical problem it was not possible to see David Cranstone's slides on the day, however, the images and text are available to download from the HMS website: <http://www.hist-met.org/cranstone.pdf>

37th International Symposium on Archaeometry

Sienna, Italy, 12–16th May 2008

David Dungworth

The 37th International Symposium on Archaeometry was held this year in Sienna. As usual the symposium included sessions on a wide variety of archaeological science subjects, but there were at least 18 oral presentations (and over 70 posters) which focussed on metallurgy. The metals covered included gold, silver, tin, copper alloys and ferrous alloys. The periods included the earliest use of metals through to the post-medieval period and the areas of interest ranged across the globe. Limitations of space and personal prejudice preclude reviewing every paper and poster given at the conference and what follows are the highlights for me.

For me one of the most interesting papers was that presented by Peter Bray on the British Bronze Age. Peter is carrying out his research in Oxford where intensive research into the metallurgy of the British Bronze Age can be traced back to the 1950s. Peter revealed that approximately 4,500 metal artefacts of this period are known from the British Isles and over half of these have been sampled for scientific examination or analysis by earlier researchers. Existing research has focussed on trace elements (such as arsenic and nickel) as ways of determining the sources of the copper ores smelted. The focus for Peter's research has been the behaviour of such trace elements during the fabrication and recycling of copper, e.g. the loss of volatile elements such as arsenic. It is hoped to re-examine some of the samples taken by earlier researchers (e.g. Coghlan) and apply more recent analytical techniques (such as ICPMS).

Oliver Pryce gave a fascinating talk about his research (as part of the Thailand Archaeometallurgical Project) into early copper production in the Khao Wong Prachan Valley. Excavations between 1986 and 1992 had identified slag heaps covering many hectares at two sites: Non Pa Wai (1500–700BC) and Nil Kham Haeng (1100–300BC). Oliver's scientific examination of samples of slag was complemented by experimental reconstructions of the possible smelting techniques. The use of satellite images as a way of locating smelting sites was impressive and formed a satisfying partner for the microscopic investigation of slag.

Vincent Serneels reported on his investigation of iron smelting in the Dogon Country of Mali (15th to 19th centuries). Although only a single ore source has been identified, the iron smelting slags from different areas in

the Dogon tend to have different chemical compositions. These differences are likely to be due to different technological approaches to iron smelting.

The adoption of blast furnace technology and the employment of different types of malleable iron in France was reported by Maxime L'Héritier (see also his paper in the *Journal of Archaeological Science* for 2006). The analysis of slag inclusions in structural iron showed that the adoption of wrought iron (as in decarburised cast iron from a blast furnace) in place of bloomery iron lagged 50–150 years behind the appearance of the blast furnace.

Marcos Martín-Torres gave a fascinating paper on the examination of the remains of a 17th- to 18th-century laboratory at Kapfenberg, Austria. The assemblage of crucibles, cupels and other metallurgical vessels and apparatus was discovered within a wall of the castle and has been interpreted as the remains of an illicit laboratory where ores stolen from nearby precious metal mines were tested.

Eleanor Blakelock gave an award-winning poster which summarised her masters research into slag inclusions in iron. Using several of Tim Young's experimental iron smelts (see HMS NEWS 59), Ellie compared the composition of the smelting slags with the slag inclusions in the blooms and worked iron. This showed that compared with the tap slag, some elements in the slag inclusions are depleted and some enriched during the forging of the iron. The results of this research will make a major contribution to attempts to provenance iron artefacts through the examination of slag inclusions (see also Sarah Paynter's paper in *Archaeometry* 2006).

Bastian Asmus displayed an interesting poster on medieval copper smelting in Germany. He reported on the scientific examination of medieval copper smelting slags recovered during recent archaeological excavations near Goslar and the Rammelsberg mountain. The results show interesting correlations with the account of copper smelting given by Theophilus in *On Divers Arts*. The translation of Theophilus by Hawthorne and Smith includes comments that his description of copper smelting is 'confusing' and 'garbled'. Bastian's research indicates that Theophilus's account may be far more accurate than we have previously imagined.

The venue, close to the medieval heart of Sienna, was delightful (an experience which was further heightened by the filming of the next James Bond film while we were there), and the conference as a whole was well organised and very successful.

The 73rd Meeting of the Society for American Archaeology

Christopher P. Thornton (University of Pennsylvania)
Aaron N. Shugar (Buffalo State University)

The 73rd annual meeting of the Society for American Archaeology (SAA) was held in Vancouver (Canada) over five days at the end of March 2008. Archaeometallurgical research was very well represented at this meeting, including three entire sessions devoted to the subject and numerous individual papers and poster presentations focusing on metals in other thematically-based sessions. In total, we counted roughly 35 paper or poster titles dealing with the application of archaeometallurgical techniques, the discussion of metal artifacts in their archaeological contexts, or the importance of metallurgical research to larger theoretical paradigms. Unfortunately, given the high number of presentations at this conference, it was impossible for the reviewers to attend them all. However, we have attempted here to give a brief overview of some of the highlights and readers are encouraged to see the SAA website (www.saa.org) to search through the final program for a more detailed list of participants and their presentations.

The first of the three main sessions dealing with archaeometallurgy utilized a new format called an ‘electronic symposium’, in which scholars are invited by the organizers to submit a publication-ready paper to be circulated among the other participants (and the audience) before the actual conference, at which time there are simply two hours of discussion. The symposium on Thursday evening was organized by Ben Roberts and Chris Thornton and entitled: “Modelling Early Metallurgy: Old and New World Perspectives.” In this symposium, fourteen scholars were invited to provide papers synthesizing the development of metallurgy in their specialist regions, paying close attention to the various theoretical and archaeological paradigms at play that affect the collection and interpretation of metallurgical data in their region. The authors were also asked to note particular lacunae in our understanding of early metallurgy in their region, and suggest ways to improve the dataset in the future.

The papers for this session proved to be well-written and stimulating fodder for the ensuing discussion. After insightful comments from both Dorothy Hosler (in absentia) and Vincent Pigott about the papers, the well-attended public discussion centred around two key points. First, questions of independent invention vs. migration/diffusion of early metallurgy need to be qualified by more nuanced theories about the mechanisms of cultural transfer. For example, can a

technology be transferred incompletely due to local conservatism or partially-ignorant informants, leading to an archaeological picture that seems to suggest indigenous development but is really local adoption and innovation of foreign ideas? Can radiocarbon dating or other absolute dating methods provide the necessary evidence to support claims of indigenous development of iron and/or copper metallurgy in Africa, India, and central China? These and other questions are currently unanswerable, but various ways were suggested to find empirical evidence to support different positions, most especially the use of thermoluminescence (TL) dating to date slags and technical ceramics directly, and greater emphasis on studying refractory ceramics (e.g., crucibles, moulds, furnaces).

The second point of some discussion at the Thursday evening symposium was about the role of elites in the development of metallurgy; or, put another way, about the role of metals in the development of elites. For example, in far distant areas such as North America, Western Europe, and the Indus Valley, metallurgical production seems to have played only a minimal role in rising social complexity, while in areas such as Southeast Asia, South America, and the Middle East, metallurgy was intimately intertwined with the development of complex societies and elites. By placing the metals back into social contexts, these sorts of archaeological questions can be answered through archaeometallurgical investigation.

This theoretical discussion continued in Friday morning’s workshop entitled “Current Archaeometallurgical Research in Mesoamerica: New Approaches, Discoveries and Perspectives,” which was organized by Aaron Shugar and Scott Simmons. The workshop dealt with broader issues related to the varied roles that metal objects played in the development and maintenance of social and economic complexity in Mesoamerican societies. For example, a consistent theme in the workshop discussion was about how elites gained and maintained control over the production of metal artifacts, whether by primary smelting or secondary re-melting and working. Furthermore, the social significance that metal objects held for the people who made and used them was also discussed.

In particular, new evidence was presented for the smelting of copper in Honduras during the contact period, while regions east of the known production centres in western Mexico provided good indications for the re-melting and casting of new objects. In West Mexico, strong evidence was presented that supports the idea of long distance acquisition of raw materials. The role of investigating ethnographic materials was discussed in detail with key examples shown for the metallurgy of West Mexico. In addition, the use of non-

destructive analytical techniques (such as portable XRF) was discussed in regard to its ability to acquire compositional data that reflect social and economic aspects of ancient Mesoamerican cultures as a whole. The application of non-destructive analytical methods has shown its efficacy in Old World metallurgy, but seems to have a more limited role in the New World.

The third and final session devoted solely to archaeometallurgical research was held on Saturday afternoon and was comprised of nine papers focused on presenting new laboratory and field data dealing with ancient and historical metal technologies. The session, entitled “The Minds behind the Metals: Accessing Past Metallurgical Experience”, was organized by Claire Cohen, Louise Iles, and Jane Humphris (all of the UCL Institute of Archaeology) with Thilo Rehren as Chair and Robert Tykot as discussant. The papers spanned an incredibly broad range of areas (from the Andes to the Caucasus and from England to Rwanda), an incredibly broad range of topics (from ethnographic examples of iron smelting in East Africa to visual analysis of Anglo-Saxon pewter brooches), and an even broader range of time periods, including one of the earliest copper smelting sites in Europe (ca. 5200BCE) up to Late Medieval iron production. Needless to say, the discussant had his work cut out for him.

Although the papers were highly variable and, some might say, unrelated, they demonstrated superbly the vast range of techniques used by archaeometallurgists to target early metallurgical practices. This included highly technical approaches such as slag analysis and metallographic analysis, as well as less direct methods such as analyzing the strength of local wind patterns to consider the possibility of draft-blown furnaces. There was a strong representation of archaeological fieldwork, ethnographic studies and oral histories, and even a theoretical paper on the importance of ‘quality over quantity’ in early European iron working – all of which suggests that modern archaeometallurgical research is committed to melding rigorous scientific practice with nuanced archaeological (and anthropological) interpretation.

Given the content of these three sessions (and the numerous other papers and posters) it is wonderful to see the development of new ideas infiltrating the field of archaeometallurgy. The application of theory, at one point seen as incompatible with the finite analysis of metals, has now allowed a new generation of archaeometallurgists the chance to expand and explore new horizons. It is a testament to the growth and future of the field of archaeometallurgy that so many superb presentations and posters were present at the meeting in Vancouver, and we hope to see an even greater number at the next SAA meeting in Atlanta in 2009.

HMS Spring Meeting 2009 **Urban Archaeometallurgy: historical metallurgy in towns and cities**

21st February 2009

David Dungworth

Information

A great number of archaeometallurgical remains are found in urban contexts. These include, among others, foundry remains, forges, goldsmith workshops, mints, assay offices or just stray finds of crucibles, slag or metal objects. Although these assemblages are increasingly studied by specialists, many remain unidentified or neglected in archaeological archives.

Urban metallurgists used skills and techniques quite different from those used by miners and smelters, and played an important technological and economic role in urban life. Their endeavours were closely related to those of other crafts, and their products were directly relevant to those living in the immediate vicinity. Thus, the documentation and study of urban metallurgical workshops and artefacts provides an interesting path to the functioning of historical towns and cities, as well as insights into relatively unexplored areas of historical metallurgy.

This workshop aims to provide a forum for the presentation of studies on metallurgical remains excavated in urban contexts. To provide a balance for the focus on ferrous metallurgy of previous HMS workshops, we particularly encourage presentations of research on non-ferrous and noble metals, and we welcome studies of both metalworking debris and finished artefacts. The chronological and geographical remit is purposefully broad, but we hope to showcase studies of materials recovered during rescue excavations in historical cities. The underlying intention is to provide examples of the use of such assemblages for research purposes, maximising their informative potential and saving them from neglect. By inviting urban archaeologists and finds specialists as well as archaeometallurgists, we also intend to create a network for the development of future projects.

Venue

The spring day meeting of the Historical Metallurgy Society will be held at the Institute of Archaeology at University College London.

Organiser

The Day Meeting is being organised by Marcos Martín-Torres. Email: Marcos Martín-Torres.

Please send abstracts (up to 250 words) for proposed papers to Marcos Martín-Torres.

Fe09: Coalbrookdale 300 Footprints of Industry

3rd to 7th June 2009

Announcement and Call for Papers

The 300th anniversary of the first successful commercial use of coke to smelt iron is an appropriate moment to consider the impact of the industrial revolution on the modern world.

It will be 50 years since the iconic blast furnace at the centre of the 'Birthplace of Industry' was rediscovered. That last half century has seen a dramatic expansion of research into historical industrialisation, coupled with overwhelming public support for the conservation of its material remains. The wide range of disciplines involved – archaeology, history, metallurgy and conservation – have themselves developed in response to the challenges of understanding this often fragile heritage. Big themes and issues arise which have tremendous relevance to the world today: environmental change, social transformation, technological progress, leisure as industry and industry as leisure. This conference provides an exciting opportunity for inter-disciplinary debate, discussion and analysis, through which we can find ways to take forward the study of these important processes and bring our findings to bear on the reality of life today.

Venue

The conference will be hosted by the Ironbridge Gorge Museum Trust in Coalbrookdale, Shropshire with the support of the Historical Metallurgy Society, the Society for Post-Medieval Archaeology, the Association for Industrial Archaeology and the Newcomen Society.

The Conference is being organised by Paul Belford.
Email: paul.belford@ironbridge.org.uk.

Further details on the HMS website
www.hist-met.org/conf2009.html

WORLD OF IRON CONFERENCE 2009 (WIC)

London, 16–20 February 2009.

First circular – CALL FOR PAPERS

Scope of the conference

The 'World of Iron' conference sets out to explore and celebrate the anthropological significance of the inception, adoption, expansion, and impact of prehistoric iron production outside Europe. Interlacing regional and themed sessions, it will relate

archaeological and archaeometallurgical studies to wider anthropological issues such as technological style; technological variation, change and development; technical and social adaptation; and the evolving influences of iron on society and the physical environment.

This five day event is the first attempt to synthesise the latest research being conducted on iron and steel around the world, and to stimulate future research of the highest level. It creates a globally comparative perspective, integrating insights gained from established and emerging analytical techniques, Anthropology of Technology, and environmental history, highlighting nuances often obscured by Eurocentric perspectives. By bringing together established scholars and young researchers from four key regions, namely Africa, East Asia, the Indian Subcontinent, and Western and Central Asia, it stimulates an international exchange of ideas and experiences.

Sessions

The Regional Sessions bring together scholars and research from four key regions around the world and discuss the latest anthropological, archaeological and metallurgical research in the context of region-specific and wider anthropological themes and considerations:

- Africa
- East Asia
- Indian Subcontinent
- Western and Central Asia

The Themed Sessions incorporate the latest research being carried out in all regions, including Europe, on both theoretical, technological, and environmental topics, to ensure maximum coverage of all major anthropological considerations concerning the study of iron production:

- Invention, Innovation and Inspiration
- Theoretical Approaches to Technology
- Scientific Approaches to Technology
- Analytical and Environmental Considerations

Abstracts

Abstracts should have a length of maximum 500 words. They should contain a brief description of the paper's topic, how it relates to the core subjects of the conference, a description of the research goals, the techniques used and the results obtained so far, and its core interpretations.

Forms to submit your abstract and personal details will be available from
<http://www.ironsmelting.net/WIC2009/>

Registration Fees

Before December 1st 2008:

£200 (Students £150, proof of student status is required)

On December 1st 2008 or later:

£250 (Students: £200)

Key Dates

Deadline for submission of abstracts: October 1st, 2008

Notification of acceptance or rejection: November 1st, 2008

Deadline for registration and payment of reduced registration fee: December 1st, 2008

Organisers

Jane Humphris, Thilo Rehren, Xander Veldhuijzen,
WIC2009@ironsmelting.net

While submissions to the Newsletter are welcome at any time, if you want to have something in a specific issue of the newsletter then it needs to be with me by the following deadlines.

1st March, 1st July 1st November
Contributions can be sent in any format (hand-written, typed, email, floppy disk, CD-ROM, etc).

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