THE CRUCIBLE

Historical Metallurgy Society News

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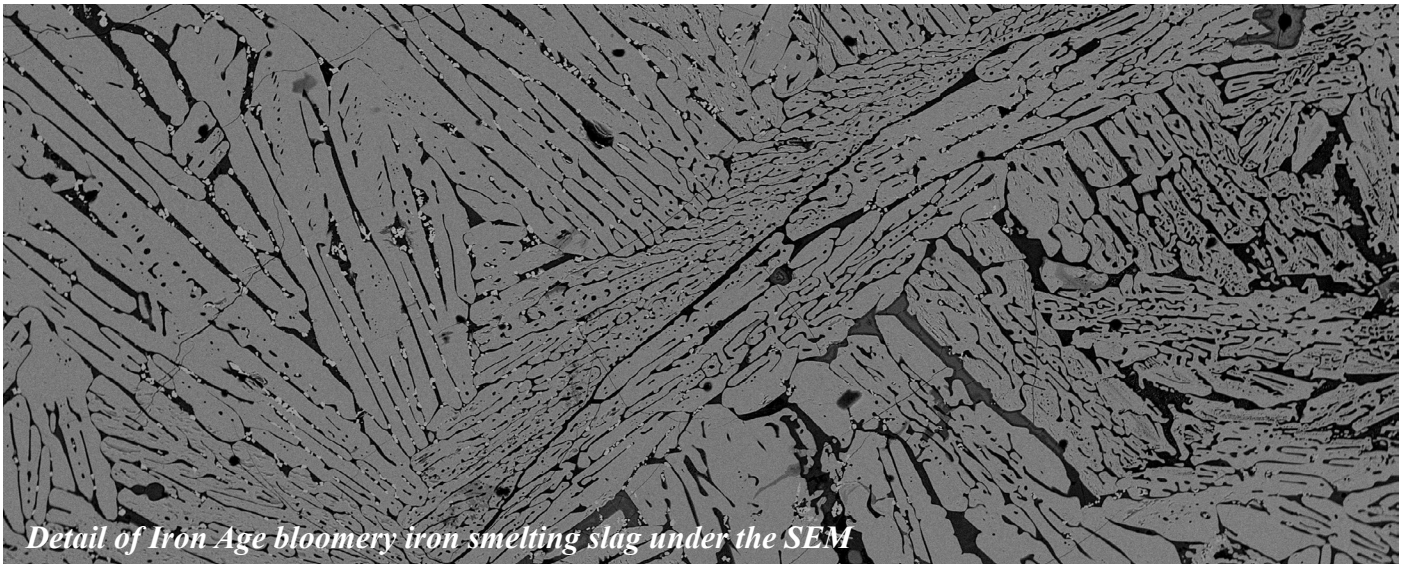

Detail of Iron Age bloomery iron smelting slag under the SEM

INSIDE THE CRUCIBLE

Submissions
Submissions to The Crucible are welcome at any time, but deadlines for each issue are 1st March, 1st July and 1st November every year. Contributions can be sent in any format, but we prefer digital if possible.

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The HISTORICAL METALLURGY Society

A Rare Cast Pig

An unusual discovery was made in 2016 during building recording on a listed farmhouse of probable late 17th–early 18th-century date near Buck's Cross in north Devon, UK. The lintel above an oven in the inglenook comprises a re-used cast iron pig, with the lettering (upside down in its current location) reading 'Principio * [or +] 1727'. The pig measures approximately 0.55m long by 0.1m wide (the depth could not be ascertained).

Cast iron pig in situ forming lintel to oven.

Detail showing lettering (image inverted).

This represents a rare survival of an early product of the Principio Iron Works in Maryland, USA, established 1719. The blast furnace in Perryville operated from 1723, being the earliest in the county and one of the first in the American colonies. It has been estimated that approximately 50,000 tons of pig and bar iron were exported from Maryland to Britain between 1718 and 1755, perhaps half from the furnaces of the Principio Company (Maryland Historical Trust website). Most of this went to London, but some consignments were sent to other ports, amongst which may have been Bideford 10km to the east of Buck's Cross. Perhaps the cast iron pig found there represents the opportunistic use of a suitable object to form a strong, fireproof lintel above the oven in the farmhouse (it has been retained in the current renovation).

Bob Davis and Mick Rawlings

Zinc in India

I have been completing the report on the excavations conducted by the British Museum, the M.S. University of Baroda, Hindustan Zinc, and the Peak District Mines Historical Society, at the major lead, silver and zinc mines at Zawar, Dariba and Agucha in the Aravalli Hills of Rajasthan. Although the fieldwork was largely completed in the 1990s scientific and historical work has continued for many years leading to recent publication by Archetype Publications. Over the years our perception of early Indian technology and particularly the role of Zawar in the history of zinc production has markedly continued to change, and now is extending to the interactions of technologies across the world.

We originally thought that Zawar was the first and only producer in India and that Zawar zinc played an important part in European maritime trade. We now know that there was at least one other producer in North India, almost as old as Zawar, and that far from dominating world markets production rapidly shrank in the face of competition first from China and then from Europe, such that from the 17th century India itself was a net exporter.

The overall importance of Zawar was that here for the first time scientific ideas, found in the medieval Indian iatrochemical treatises, had been translated into viable industrial processes. In truth, the birth of chemical industry, centuries before similar developments were made in Europe. Indeed it still seems likely that Champion's process developed in the 18th century in Bristol was based on the Zawar process.

By the 19th century such large scale technically sophisticated processes had largely ceased in India, to such an extent that most European observers were completely ignorant that they had ever existed. We have taken the opportunity to examine the causes of the demise of industry in India, using Zawar as a test case, together with the iron and steel industry. The attempts to revive them, their early failure but eventual success are also being investigated, for their story is the story of sophisticated technical industries in traditional societies everywhere when faced with the disruption brought about by the imposition of European technologies and commerce around the world.

Paul Craddock

The Gold Rings of the Colchester Hoard

In 2014 excavations conducted by the Colchester Archaeological Trust in Colchester (area of Insula 19, Williams and Griffin site) uncovered a small hoard of well-made and high quality gold and silver objects. The types of object, which included silver military awards and gold jewellery of various types, suggested ownership by a Roman veteran and family. The objects were found in a small depression dug into the floor of a room in a burnt-out building (Figure 1). The dating of the coinage associated with the hoard as well as the burnt horizon provided a dating for around the Boudican revolt in 60/61 AD. The jewellery was likely buried in haste before the sacking of Colchester and never recovered.

Fig. 1 Image of the hoard in situ (Image © Colchester Archaeological Trust Ltd.)

The jewellery consisted of 12 gold objects – five rings, four earrings (a pair of ball shaped earrings and a pair of crotalium), two gold armlets and a bracelet; and three groups of silver objects – a bulla, a medallion with associated armilla and a small penannular ring (see Crummy 2016). A range of these objects underwent scientific investigation at the Wolfson Archaeological Laboratories at the UCL Institute of Archaeology. Techniques included x-radiography, SEM-EDS, pXRF and digital microscopy, with the aim of identifying details of the manufacturing processes and the types of alloys utilised in the construction of these artefacts. The full results are published as Phelps (forthcoming) and only a brief description of the findings from the gold rings is provided here.

The gold rings (Figure 2) are all of a similar style, with a rounded hoop and flattened bezel. Three had emerald fittings, one was missing its fitting and the final had an image of a dolphin engraved onto the bezel. They were made of solid gold and are of various sizes, the largest having an 16mm internal diameter. pXRF analysis of the surface of all five rings identified a high-quality gold – ranging 92.7-95.2% gold, 3.2-5.4% silver and 1.0-2.1% copper. This produced yellow gold that was malleable but without being too soft. The gold composition is very similar to other Roman gold objects (La Niece and Meeks 2000, 225) and to later analysed hoards (Cowell et al 1983), and represents the standard Roman gold alloy for the period. Native golds typically contain high amounts of silver, and, depending on location, ranges from 1 to 80% silver (Ogden 1982, 18). In addition, base metal impurities can also be present. Therefore, the composition of Roman gold, and in the gold used for these rings, was controlled by refining processes. The base metals (e.g. copper, lead, tin) could be removed by cupellation; this involved heating of the metal in air, so the oxidised metals would then be absorbed into the hearth surface, leaving the precious metals unreacted on the surface. The second stage was to chemically remove the excess silver; this could be accomplished using the gold parting technique of salt cementation (Craddock 2000). Thin sheets of gold alloy were heated in a sealed container with sodium chloride (common salt). Reactions with the salt dissolved the silver away leaving the gold (the silver could be recovered later). As a final stage, the refined gold could have measured quantities of silver or copper added to improve the hardness or to control the colour. The refined compositions of the rings are markedly different to British Iron Age coinage (see Cowell 1992) which are unrefined and contain much lower gold (30-75%) and higher silver and copper.

Fig. 2 Photographs of the five gold rings. (Photos by P. Crummy. Image © Colchester Archaeological Trust Ltd)

The body of the rings exhibit no tool marks, nor is there a join visible between the hoop and bezel. Is it most likely that the rings were cast, as was typical for rings of the period (Lang 1997, 61). This could have been in a two-part mould, possibly of clay (Bayley 1989, 298), in which the clay was enclosed around a former, before being cut away, and the two halves baked. No flash marks or spurs are visible on the rings, but these could have been easily removed by burnishing and polishing. Evidence of reshaping on the shoulders can also be seen on some of the rings.

Emeralds decorated three of the rings. These were of bezel fit meaning that the emeralds were inserted into a well sunk into the bezel of the ring. The emeralds varied in size, with the largest (Figure 3) measuring 9 by 6 mm and 4 mm in height above the ring. Emeralds are a type of beryl, a beryllium aluminium silicate. The well was likely cut or gouged out of the bezel, and evidence for this is identified by the scratch mark observed in the ring missing its fitting. The ring well contained nothing to indicate drilling, nor is it likely that the depression was made as part of the mould during casting. The emeralds appear to be held in mechanically by enclosing the well tightly around the emerald and by pushing the metal of the ring up around the emerald, this can be seen in Figure 3 as a thin band of gold adhering to the lower edge of the emerald. This type of fit was stronger than glue and was typical of the Roman period.

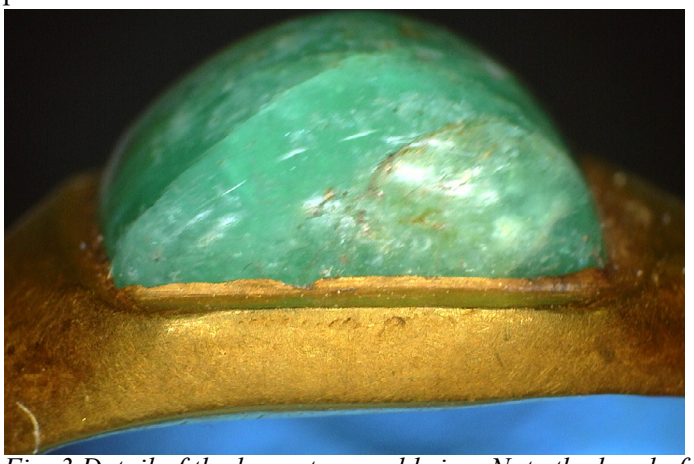

Fig. 3 Detail of the largest emerald ring. Note the band of gold around the emerald lower rim helping to hold it in place. (Image Matt Phelps)

The final ring had a flattened bezel onto which the image of a dolphin was engraved. The SEM image in Figure 4 provides some detail as to the formation of the image, as indicated by the scraping marks within the body of the dolphin where engraving has removed metal. The beak and fins of the dolphin were produced by a different tool, using a possible mixture of engraving and/or chasing (where the tool is pushed/hammered into the metal), forming a herringbone formation.

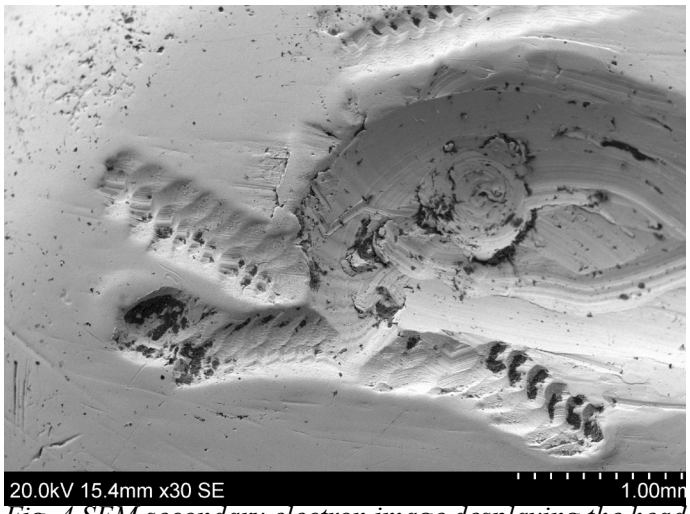

Fig. 4 SEM secondary electron image desplaying the head of the engraved dolphin. Note thte tool marks. (Image Matt Phelps)

The scientific analysis of these rings have shown them to be of typical Roman manufacture, using Roman period alloys distinct from native British production. They are beautiful and well-crafted objects, built with ingenuity and skill. Details of the site and the investigation of the other objects are to be published in Crummy (forthcoming).

Matt Phelps

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THE FUTURE OF HISTORICAL METALLURGY

There is something deeply satisfying about helping to ensure that the things that you feel are important continue into the future. For historical metallurgists, this probably includes wanting to ensure that their discipline and interests continue to be well supported. You can find details of the funds, largely provided from bequests, managed by HMS from the website at http://hist-met.org/about-hms/hms-grants.html.

Every year HMS makes grants from these funds for purposes such as:

- Helping students to attend relevant conferences
- The curation of archive material
- Meeting the travel costs for young researchers working in the field
- Providing outreach to schools
- Ad hoc publications in historical metallurgy
- Filling a gap in a PhD project funding, like obtaining ^{14}C dates

The money available, alas, is too little to support as much of these valuable activities as would be desirable. The external funding environment worsens and worthwhile projects may be stalled or weakened for want of a little financial support.

If you can, you might like to supplement one of the existing funds, or perhaps to earmark some money for specific purposes. You may be attracted to the idea of projecting your help and assistance into the future and have a pretty clear idea of how you would like the money spent (for example, you might want to support a PhD student working in a particular area of study). You can contact appeals@hist-met.org and have an informed dialogue about the available options. If you are one of those who are able to make bequests, or similar donations, you will certainly have been through the emotional issues that surround wills and letters of intent at least once (it's not too bad after the first one!).

Apart from the obvious and simple expedient of adding a codicil to an existing will, there are other choices that may be available, depending on your personal circumstances. For example, recent changes to the rules mean that it is now possible, for some pension-holders, to make a disposal of some (or all) of their un-drawn pension funds without making or changing a will. The details vary between different professional pensioner-trustees and between pension fund types, but they should all provide a form with a title such as "Death Benefit Nomination Form" which allows the pension holder to say who should receive the money from the residual fund in due course. In principle, this can be as many persons or charities as you want in any combination of percentages. This applies to pensions such as Small Self-Administered Schemes and Self Invested Pension Plans schemes where no annuity has been purchased (it doesn't apply to public sector pensions or to annuitised final salary schemes). It is very tax efficient, since the value of the fund does not form part of the donor's estate for Inheritance Tax purposes, and charitable recipients pay no tax on the incoming money. You, rather than the taxman, decide what happens to an important slice of money.

HMS does not pretend to be able to offer you financial advice, but the Society can point out what your options are and tell you what types of professional advice are available. If you wish you can email appeals@hist-met.org with the assurance that your contact will be strictly confidential.

If you are in a position to make a donation now, your money would attract Gift Aid. Gift Aid means that the taxman will add to the donation an amount equal to the basic rate tax that you have already paid him; a small but useful win.

BRIAN READ: MANY THANKS!

After many years, and many changes of technology, Brian Read has "retired" from running the HMS "bookshop".

This was no trivial task requiring, among many other things, having his loft strengthened to withstand the weight of journals stored awaiting orders.

The HMS Council has expressed its gratitude for Brian's dedicated service, and thanks will be echoed by all members who know how much Brian put into this outstanding contribution to the success of the society.

HMS council in 2008 with Brian Read at the far right.

Curious Mould Matrices from Gussage All Saints

A small collection of clay moulds with matrices for casting what appear to be parallel twisted bars has been identified in the collection of slag from Gussage All Saints (Figs. 1-4). Although 7174 mould fragments from the site have been studied in detail by Mansel Spratling and Jennifer Foster, resources were never made available to investigate the slag and associated debris to the same extent. Recent brief macroscopic investigation of the assemblage has brought to light these curious mould fragments and raises important questions about the type of artefacts being cast at Gussage during the second century BC.

For our Leverhulme funded research project The Social Context of Technology at the University of Bristol we, Jo Brück, Leo Webley and Sophia Adams, have been exploring the excavated evidence for later prehistoric non-ferrous metalworking in Britain and Ireland. This has included some investigation into the physical archive of the material excavated from pit 209 at Gussage All Saints, Dorset in 1972 (Wainwright 1979; Spratling 1979; Spratling et al. 1980; Foster 1980). Dorset museum kindly granted permission for a small-scale investigation of the moulds and crucibles including analysis by portable XRF. This work was carried out by the author in collaboration with Prof. Marcos Martinón-Torres and student Owen Kearn (UCL), Dr Julia Farley (British Museum) and Jennifer Foster (University of Reading). The metallurgical results will form part of the dataset for Owen Kearn's undergraduate dissertation and will be commented upon in due course.

These previously unpublished moulds were noticed in the boxes of slag while assessing the material held at the British Museum on behalf of Dorset Museum. The majority are vitirifed on at least one side but some pieces are vitrified on both the exterior and interior of the mould. It is possible these pieces were known of before but not published: Mansel Spratling had mentioned that the presence of over-fired moulds in the assemblage could take the overall quantity of mould fragments into five figures (Spratling 1979, 127). Jennifer Foster had been given some of the over-fired pieces to study but none that matched those currently stored in the boxes of slag. These boxes contain a range of material that warrants further study, including iron related debris which was not analysed in the original post-excavation programme (see e.g. Clough 1985).

The mould fragments in question have a distinctive matrix. It consists of parallel diagonal rounded ridges and grooves curving around one side of a rounded rod-like object c. 9−12 mm wide and over 60 mm long. Most of the fragments appear to represent two such forms laid

Fig. 1 Interior matrices of mould fragments showing chevron layout of ridges. Image courtesy of Dorset County Museum.

Fig. 2 Exterior of moulds fragments from Fig.1. Image courtesy of Dorset County Museum.

side by side with the ridges at a diametrically opposing angle creating an overall chevron-like pattern (Figs. 1 and 3). A few examples have the ridges on the two 'rods' on the same alignment, sometimes offset (Fig. 4). Our brief examination was not able to establish whether any of the pieces joined but the overall form suggests the 'rods' were decorated in the same fashion all round, rather than being flat or plain on one side. The series of rounded ridges and grooves in the matrix would form positive objects decorated with a series of parallel pointed ridges that wrap around the circumference, interspersed by rounded grooves. This is very similar to the relief effect of Bronze Age twisted torcs. As aforementioned the remains date to the second century BC so would have produced Iron Age objects not Bronze Age torcs. The question is what objects? Perhaps they cast straight ridged items or objects that were bent after casting. The outer surface of the moulds has a similar character to the previously studied lost-wax mould fragments from the pit (albeit over-heated) but some pieces appear to have been more rapidly finished. Small areas where the clay has been squashed around the

Fig. 3 Four views of one single mould fragment. Left to right: interior matrix, end-on view (below), side view, exterior. Image courtesy of Dorset County Museum.

Fig. 4 Interior matrices showing aligned ridges. Image courtesy of Dorset County Museum.

pattern are visible, whereas the other moulds are more carefully finished on the outside (J.Foster pers. comm.) (Fig. 2). Where the mould matrix could be identified on 4677 of the mould fragments from this pit they are all for casting equine equipment: parts of horse bridle-bits, strap fittings, terrets and the ends of lynch pins (Foster 1980, 25). Is there a part of the horse and vehicle fittings that would have necessitated this form of cast object? Or do we have evidence for the casting of non-equine related objects? If the latter is the case this opens up the question of what was being manufactured in this intense episode (of unspecific duration) at Gussage, who for and by whom.

If any readers know of similar moulds or objects that could have been cast in these moulds please do contact Sophia Adams: sophia.adams@bristol.ac.uk .

The Social Context of Technology research project:

http://www.bristol.ac.uk/arts/research/projects/the-social-context-of-technology-non-ferrous-metalworking-in-later-prehistoric-northwest-europe/

Sophia Adams

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In addition to the odd mould fragments, metallurgical remains from Gussage All Saints also includes these crucibles as well as other forms of moulds.

Barbara Armbruster

Communication is one of the major challenges of interdisciplinary research, as the jargon and interests of different specialists may appear difficult to reconcile. As such, collaborations become much easier when a single individual has knowledge and experience of all the possible strands of information and may serve as the connection for everyone else in the team. This is the case of Barbara Armbruster. Experienced in archaeology, ethnography, history, experimental replications, iconographic studies and archaeometallurgical analyses, her work is often exemplar of the integration of knowledge from all the above perspectives.

Her contributions to the history of metalworking technology are manifold, and she is particularly renowned for her work on precious metal jewellery from Prehistory to the Middle Ages. Today she tells The Crucible readers about ongoing work on Celtic Gold, current colleagues and future plans.

THE CRUCIBLE: Can you summarise your career in a couple of sentences?

BARBARA ARMBRUSTER: After 5 years of professional training the fine metal working in a German school of applied arts and the work in a jewelry workshop I studied archaeology and ethnology at Frankfort University. During my academic studies I developed a manifold methodology. Experimental work in my own goldsmith's workshop and ethno-archaeological field work in Mali, Burkina Faso, Egypt, Sri Lanka and India contributed significantly to this approach. While my PhD research concentrated on bronze and gold technology from Bronze Age Iberia, my Habilitation à diriger des Recherches (HDR) dealt with Late Prehistoric gold from the entire Atlantic Europe. Before integrating the French Centre National pour la Recherche Scientifique at Toulouse in 2000, I worked at the Archaeological Museum Schleswig on bronze, silver and gold work from Northern Germany and Scandinavia, from the Late Neolithic up to the Viking period. Since then I had the chance to coordinate and collaborate in major projects, such as the Chalcolithic gold from Bulgaria, Bronze Age gold and bronze from Scandinavia, Mesopotamia, Caucasus, Iron Age gold and bronze in Eurasia, up to migration period gold from Sweden. These studies include the technological features of the original metal artefacts as well as tools, workshops, craftspeople and all materials implied in the making.

THE CRUCIBLE: What is your most memorable professional moment?

BARBARA ARMBRUSTER: My one year field work and apprenticeship in West Africa working with gold miners, goldsmiths, blacksmiths and bronze casters in a ethnoarchaeological and experimental perspective.

THE CRUCIBLE: Who has been your most influential colleague, and why?

BARBARA ARMBRUSTER: I must note at least two colleagues. One is the archaeologist an archaeometallurgist Alicia Perea form the Consejo Superior de Investigaciones Científicas at Madrid who influenced my archaeometallurgical approach. The other one is Max Fröhlich, gold and silversmith master from Zurich, who studied traditional metal working in Ghana and Cameroun, and encouraged my ethnoarchaeological and experimental approach.

THE CRUCIBLE: What is your main current project?

BARBARA ARMBRUSTER: "Celtic Gold - Fine metal work in the Western Latène culture" is an international and interdisciplinary French-German project (2017-2020 granted by DFG and ANR) in collaboration with Roland Schwab from the Curt-Engelhorn-Centre Archaemetry, and our experienced team of specialists coming from universities, museums and material science laboratories. This research project stands for the continuity of the former French-German assignment "West Hallstatt Gold" (2012-2015). Both are scrutinizing economic, social and technological perspectives of Iron Age gold in Europe crossing archaeology, archaeometry and technology.

THE CRUCIBLE: What multi-million project would you like to develop?

Gold work from the male burial at Gönnebek, Schleswig Holstein, Germany, dated in the Early Nordic Bronze Age. This assembledge belongs to the collections of the Archäologisches Landesmuseum Schleswig. These objects were part of Barbara's study on Nordic Bronze Age gold vessels published in the "Prähistorische Zeitschrift" in 2012.(photo: Barbara Armbruster)

BARBARA ARMBRUSTER: A history of art and technology of metals from the inception of metallurgy to the Early Medieval period in Eurasia. Function, economy, technology, archaeometry.

THE CRUCIBLE: Which publication should every HMS member read?

BARBARA ARMBRUSTER: Untracht, Oppi 1982, Jewelry concepts and technology, London.

THE CRUCIBLE: Have you got any advice for young students interested in archaeological and historical metallurgy?

BARBARA ARMBRUSTER: Try to work with a cross discipline approach to metalwork combining archaeometry with humanities (archaeology, art history), technology, experimental archaeology and ethnoarchaeology.

THE CRUCIBLE: I would like to tell every reader of The Crucible that…

BARBARA ARMBRUSTER: The "regard croisé" and the collaboration of different actors in material culture studies should be facilitated in teaching, research and archaeological practice.

RECENT PUBLICATIONS:

Armbruster, B.R. 2016. Manufacturing processes of Atlantic Bronze Age annular gold ornaments - a case study of the Guînes Gold Hoard (Pas-de-Calais, France). *Materials and Manufacturing processes*, 31, 1-12

Armbruster, B.R. 2016. Technological aspects of the gold objects from Ur - preliminary results and perspectives. *Metalla*, 22, 2, 113-135.

Armbruster, B.R., Eilbracht, H., Hahn, O., and Heinrich-Tamáska, O. (eds.) 2016. *Verborgenes Wissen. Innovation und Transformation Feinschmiedetechnischer Entwicklungen im Diachronen Vergleich*. Berlin studies of the ancient world (Berlin).

FUTURE INTERVIEWS

Who would you like us to interview for the next issue of **The Crucible***?*

Would you like any additional question added to our standard list?

Please let us know at thecrucible@hist-met.org.

Gill Juleff

Being a member of HMS and serving on the Council I regard as being one of the more rewarding and enjoyable aspects of my working life. Whatever else has been happening, HMS has been one of my constants over the last three decades. Looking back over previous contributions to this page and contemplating writing this feels a bit like having a shot at our own 'Desert Island Discs' – a moment to reflect.

I suppose metals and minerals are embedded in my DNA. Brought up on a farm in Cornwall in a family with as many miners as farmers, I was always more interested in the names of ruined engine houses dotted across the landscape than learning how to keep chickens. I was captivated by stories of mines in Brazil, South Africa, Australia and California where relatives went to seek their fortunes. Like my Great Grandfather, who rose through the ranks to become Captain of City Deep, Johannesburg, and did return with sufficient money to buy a local country house (sadly no longer in the family!). Later I discovered a branch of my family had been crucible-makers and received mention in Percy's Metallurgy. But turning that fascination into any form of career never occurred to a teenager in the late 1970s and I first left home to pursue a course in artefact conservation at Lincoln Art College. In Lincoln I discovered archaeology and spent a year in the lab at the Archaeological Trust from where, with the help of Kate Foley, who mentored a generation of young hopefuls, I gained a place at the Institute of Archaeology in London.

The Institute, as it was affectionately called, was a wonderful place to study and it still feels like a privilege to have gone there. While artefact conservation was my reason for being there, archaeometallurgy soon captured my curiosity, fuelled by lectures from Ronnie Tylecote, Nigel Seeley, Bachmann and Rothenberg. With its international outlook, the Institute also ignited a desire to see the world. However, the first place archaeology took me to was Bristol City Museum, on a three year contract to work in the lab for the then DoE (Department of the Environment). Fortunately, Nigel Seeley did not forget me and when a chance of work in Sri Lanka came up he only needed to mention it once. What was originally intended as a year working with the UNESCO-Cultural Triangle Project turned into 13 glorious years of adventure!

While Sri Lanka may be best known for its beaches and cricket team, it does also have hugely important World Heritage sites and a long cultural history. Even so it did not feature on the radar of archaeometallurgy so when I was looking for a PhD topic the options were either the magnificent cast bronze statues of the medieval period or Coomaraswamy's eye-witness account of iron smelting and crucible-steel making in the early 20th century. I decided on the latter when I discovered that the same area was being developed as a major hydro-electric scheme and there was potential for funding support for survey work. After three months camped in the jungle in 1988, I packed over 30 kilos of slag into my (hand) luggage and headed for the Institute, thinking that I would follow a well-established pattern of sample prep/analysis/interpretation. An atrocious 72-hour journey of delayed flights with nothing but a passport and 30 kilos of slag took the glamour off the idea, and realizing that the questions raised by the evidence we encountered in the hills of Sri Lanka could not be answered through slag analysis, I switched focus to the archaeology of the 80+ sites we had recorded on remote and wind-swept hilltops across a small area of the south of the island. Six-months of excavation with the Archaeological Department of Sri Lanka in 1990/91 and years of post-excavation work took the project far beyond the scope of a PhD and culminated in 1994 with a series of experimental smelts using reconstructed furnaces driven by powerful monsoon winds. Within a few months the results were published on the front cover of Nature and I belatedly submitted my thesis. Along the way, the project had also found the site where Coomaraswamy had seen crucible steel being made and had discovered in another part of the island, and dated (6th-9th century AD), the earliest field

evidence for crucible steel. Of all the academic and media coverage that followed the project, I will forever be most proud of the adventure comic book about my research that had been written in Sri Lanka, unbeknownst to me, and published in three languages!

Returning to UK started a more subdued phase of life combining parenthood with lecturing at Exeter University. My teaching covers archaeometallurgy and archaeological materials as well as the archaeology of the Indian sub-continent. Research projects include further work in Sri Lanka, smelting sites on Exmoor and collaborative work in India looking at the iron and crucible steel production landscape of Telangana (that was northern Andhra Pradesh). Work on the transmission of iron technology in Asia has led to new contacts with China and Japan. Increasingly in recent years my interests are gravitating towards Cornwall and the mining landscapes of my childhood. Of all that I cover, I most enjoy supervising PhD students. It is hugely rewarding supporting them in designing and developing research. In the last few months three major theses associated with our work in India have been submitted and other projects in China, Sri Lanka and the Weald are in progress.

As I said at the outset, through all the twists and turns over the years HMS has been a constant thread. Its strength lies in staying true to its core ideals of bringing together and providing a platform for people with shared interest in historical metallurgy, regardless of their background. It was borne out of the skills and knowledge of those working within our metallurgical and engineering industries of the past and now, in the face of the disappearance of these industries and the increasing ascendency of academia, we should endeavour to maintain our links with industry and practice, whether it is in UK or indeed overseas. Even though we are currently rightly striving to bring our Journal into line with modern academic publishing norms, we would be a poorer society if we became purely academic. The fun of spending a couple of days scrambling over slag heaps in the Weald or discussing the fine detail of cast iron drain covers makes HMS special.

Looking to the future, the big issue that HMS wants to engage with that I also feel passionate about is internationalisation. There are individuals and groups across the world in industry and academia who share our interests and connecting with them will always be rewarding. HMS is an excellent and enduring model of a specialist society that caters for a wide range of characters and interests and we would do well to promote our model on an international stage.

Medieval Jewelry Studies Programme at Bolgar International Archaeological Field School

14th - 28th August 2016, Bolgar Historical and Archaeological Complex, Republic of Tatarstan, Russian Federation

This year, an annual multi-disciplinary Bolgar International Archaeological Field School (BIAFS), jointly organized by Kazan Federal University and Khalikov Institute of Archaeology (Kazan, Russia), offered four training programmes on Archaeobiology, Archaeological Glass, Stone Tools and Medieval Jewelry Studies.

The report presented below is about the outcomes of the latter programme, generously supported by the Anniversary Fund of the Historic Metallurgy Society.

The Medieval Jewelry Studies programme was designed for undergraduate and postgraduate students with their research interests set on archaeometallurgy and jewelry studies and welcomed 15 participants from Russia, China, Romania, Turkey, Australia and Slovenia. The participation of students from a wide range of archaeological backgrounds from all over the world in this programme established a unique international and inter-disciplinary atmosphere at BIAFS, significantly broadening the perspectives of the programme.

The programme developed by Dr Natalia Eniosova (Moscow State University) and delivered by Artyem Belyavskiy (a research fellow, Moscow State University) included the following:

- Three theoretical modules on medieval jewelry studies methods; medieval jewelry raw materials and medieval jewelry technologies and social issues.
- One experimental module, involving experimental studies within the framework of research projects suggested by the participants of the programme on the experimental grounds of BIAFS under the supervision of Artyem Belyavskiy.
- One practical module on trace analysis for medieval jewelry studies, the implementation of which was possible with the help of the HMS funding the purchase of two optical microscopes for the programme.

In fact, the experimental part of the programme became the most overwhelming one in terms of both the complexity of the research objectives and technologies to be analysed and the time devoted to experimental projects that exceeded its limits of the BIAFS schedule due to the enthusiasm of the participants and the staff of the programme continuing their experimental works even at nights. Among the experimental works conducted by the participants, it is necessary to highlight a joint project on the reconstruction of the production of silver jewelry in the medieval city of Bolgar. This promising research project initiated at BIAFS is based on medieval stone moulds recently found in Bolgar Historical and Archaeological Complex as well as on Medieval silver jewelry artefacts from the collections of the Museum of Bolgar Civilisation. During the Medieval Jewelry Studies programme, the participants of the projects made the replicas of some stone moulds and conducted a series of 5 experimental melts in a modelled Medieval furnace at the experimental grounds of BIAFS.

In spite of the fact that the above mentioned experimental project has not yet been completed, its initiation is probably one of the most important outcomes of the programme that aimed to provide the participants with necessary skills and experimental grounds for conducting research projects on Medieval Jewelry studies, as well as becoming a networking event for young researchers working in this field.

The programme on Medieval Jewelry Studies will be continued at BIAFS-2017, to be held from the 21st August to the 3rd September and will be enhanced with a new programme on Experimental Archaeometallurgy. Both programmes will include the analysis modules with the use of two optical microscopes, acquired with the financial help of the HMS.

Further information on BIAFS is available through the website: http://archtat.ru/en/arch-school/ and via e-mail: arch.school.bolgar@gmail.com.

Aryat Sitdkov
Leonid Vyakov
Ekaterina Makarova
Nargiz Aituganova

HMS Research in Progress Meeting

29th November 2016, University of Birmingham

The annual HMS Research in Progress meeting, which took place in November, 2016 was graciously hosted in the Department of Materials and Metallurgy at Birmingham University. In attendance were collaborators from a range of backgrounds, including academic researchers, professionals and interested non-specialists. The one day event proved to be a wonderful forum for individuals to communicate preliminary metallurgical data, discuss aspects of ongoing experimental investigations and disseminate their findings. The presentations which covered a variety of topics related to historical metallurgy, archaeology and other closely connected disciplines offered a valuable insight into current research within each of these fields.

Following a welcome and introduction from the organiser Dr Eleanor Blakelock, the meeting commenced with a paper given by Umberto Veronesi on Bronze Age metal production at Taldysaj, central Kazakhstan. Previous excavations at the site had uncovered substantial quantities of material connected to copper smelting, from two key periods of occupation, the Andronovo culture (c. 1700 -1500 BC) and Alekseevka-Sargary culture (c. 1300 – 1000 BC). Copper smelting slags, situated in four different furnace types were analysed to better understand the chaîne opératoire of the smelting process. The microstructural and elemental characterisation of the copper smelting slags, emphasised some significant technological differences between the furnace structures and their operation. Through further investigation of the site finds, the project aims to build a picture of both the nature and organisation of Bronze Age copper smelting in central Kazaksthan.

Raphael Herman, from Newcastle University was up next with a presentation on the experimental reconstruction of use-wear patterns on Late Bronze Age swords from the British Isles and Sicily. The ongoing research tackles this question by first analysing patterns of wear on these swords, to distinguish marks made by different actions such as slashing or stabbing. The second approach is to complete controlled combat tests on replica swords, which will provide much needed comparative data in the hope to better understand the pattern of characteristic marks left on the archaeological examples. This inclusive two-phased approach, could reveal previously unattainable information about the function of LBA weaponry and potentially identify the existence of regional fighting styles.

The succeeding presentations both focussed on the archaeology of Iron Age Britain, with the first speaker Steffan Golby discussing the regional variations evident

Question and answer session following the keynote presention on Archaeometallurgy in Japan.

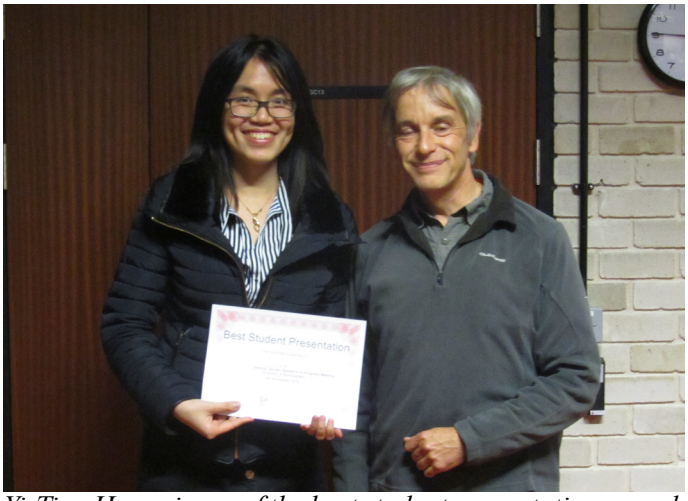
in iron production practices in England. Dr Tim Young, founder of GeoArch shed new light on the Iron Age in southern Britain with a chemical characterisation of smelting residues and fragmentary iron ores recovered from local sites. Trace element analysis revealed much of iron in the region was smelted from gossan ore during the middle late Iron Age. Characterisation of Iron Age furnace structures from the region demonstrated the existence of a complex system of smelting at southern Iron Age sites.

In the second session of the day, three papers were presented by current PhD researchers from the UCL Institute of Archaeology. The first from María Teresa Plaza, focussed on the manufacture of both gold and gold-silver alloy objects in the south central Andes during The Middle Horizon (AD 400-900). The objects under investigation were all uncovered alongside a number of individuals buried in the cemeteries of San Pedro, a practice often reserved for specific graves. Analysis of these objects, offered an exciting opportunity to glean more information about the manufacture of these items. Due to the cultural significance of these precious items, non-destructive analysis was carried out using pXRF, SEM-EDS and PIXE. Preliminary results from the cemetery Casa Parroquial found that the items were imported from different regions and later reshaped and refashioned to reflect popular local traditions. A second presentation by Jasmine Vieri focussed on characterising gold-working from pre-Columbian societies spanning north of Peru to central Mexico. The archaeological investigation brought together existing compositional data for gold bearing objects in the region, in an attempt to highlight spatial and temporal patterns. To complete the second session of the day Yi-Ting Hsu, presented ‘Analysis of cupels and minting materials from the late medieval Mint of Porto (Portugal)’. The aim of this research was to discern the manufacturing process of medieval coin minting in Portugal from the analysis excavated material connected to the mint.

During a break for lunch we were offered a tour of the

Metallurgy and Materials department, providing the opportunity to view the state of the art equipment available for archaeometallurgical research. The newly refurbished Electron Microscopy suite was extremely impressive and it was great to see students, making full use of the facilities.

The third sitting of the day continued after lunch with Dr Peter King, who presented an historical account of greensand iron founding traditions at Coalbrookdale furnace. Kay Smith from the South-east Asian cannon project offered some thought-provoking insights into the collection of Bronze cannons held by the Museum Bronbeek in Arnhem. A detailed inspection of the cannons, suggest an intricate arrangement of chaplets were used to produce them.



Yi-Ting Hsu, winner of the best student presentation award, with HMS Chairman Tim Young.

The final presentation of the day came from the Keynote Speaker Professor Yasuyuki Murakami from Ehime University, Tokyo discussing the details of his fascinating fieldwork project. The project focussed on a specific type of ancient iron smelting technology which uses a furnace known as a Tatara, to smelt pig iron from iron sand. The transmission of this iron technology has been traced through a number of archaeological excavations spanning across Asia and Kazakhstan to Japan, via Siberia, Mongolia, and China. The experimental investigations recreated this process with the knowledge and support of Akira Kahira, a traditional Japanese iron smelting specialist. This was a particular honour for individuals involved in the project, as this knowledge is reserved for apprentices of murage (furnace master). It was wonderful to get a glimpse into the exciting projects being carried out both in the UK and globally.

Overall the conference was a fantastic success, providing a friendly atmosphere for individuals to share their ongoing projects. On a social basis it was wonderful to discover more about those currently undertaking archaeometallurgical research and provided a great opportunity for me to inquire more about particular topics which peaked my interest.

Nicola George

David Scott on Instagram!

David Scott is now on Instagram (@DavidScottMetals)! David has been adding a number of his photomicrographs with detailed information about them to his Instagram account. It's an excellent account to follow.

Is anybody else on Instagram? use #historicalmetallurgy to let us know and we may feature you and your metal related images in the next issue of The Crucible.

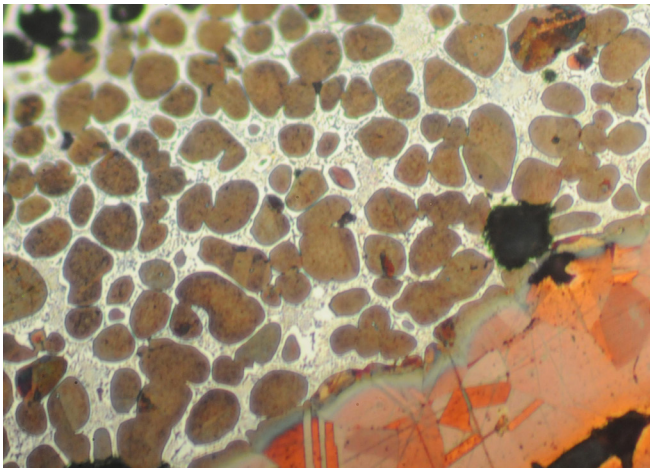


Figure 1. A 10th century AD silver-surfaced copper alloy penannular nose ornament. It has been made by fusion silvering of a silver-copper alloy over a copper-arsenic alloy with about 1% of arsenic, finished by working and annealing to final shape and then the silver-copper alloy has been flowed or fused over the surface to create an excellent intermetallic join.

Historical Metallurgy Big Sale! Hurry Up!

The price of Historical Metallurgy will be going up in the near future. However, we are giving our readers a last chance to buy any issue of the journal for £10, on orders made before the end of June. This is a great opportunity to fill that annoying gap in your run of the series, to get a copy of that special issue that you would like to take with you on holidays, or perhaps to treat yourself to a whole set! Do visit the online shop before it is too late. There you will find a list of all the papers ever published in the journal, and whom to contact for discounts if you are buying a lot of issues.

For details, visit our website **www.hist-met.org**.

ANDREA DOLFINI: How did people fight in the Bronze Age? Can prehistoric weapons shed light on long-forgotten fighting styles? These questions are being explored by the 'Bronze Age Combat' project, conducted by a Newcastle-Leicester-Durham team. First, we put a sample of Late Bronze Age swords and spears-heads under the microscope to identify combat marks on their cutting edges. Second, we carried out rigorous field tests using replicas of the same weapons to understand how these marks were generated. We are excited to report that the preliminary results of the project are already changing our understanding of prehistoric fighting practices!

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https://sites.google.com/site/bronzeagecombat/

XOSÉ-LOIS ARMADA: We are starting a new project on Atlantic European metallurgy at the Institute of Heritage Sciences (Incipit, CSIC) in Santiago de Compostela, Spain, with the participation of several scholars from other institutions from Spain, Portugal and the UK. The project (2016-2020) will focus on two key topics: Atlantic Late Bronze Age metal hoards and Iron Age gold. It also aims to create an online information system to make the data available in open access. Our next step for the following months will be the analytical study of Iron Age goldwork from Northwestern Iberia (mainly earrings) using micro-XRF.

LOUISE BACON: Marshall & Sons Traction engine. This engine stands in the courtyard of the Museum of National History in Santiago, Chile. According to the label it is dated to the 1850's. Marshall & Sons production centre was the Britannia Iron Works in Gainsborough, Lincolnshire and they exported world-wide.

KUNLONG CHEN: The production of ritual bronze vessels is an idiographic feature of Bronze Age China. However, while the production of ritual bronze vessels predominated in the Central Plains, recent research is showing how surrounding regions exhibited local characteristics in bronze production, reflecting idiosyncratic ideological, cultural and technological choices. Founded by the Newton International Fellowship, I am working on a project with Professor Marcos Martinón-Torres at the UCL Institute of Archaeology to explore the characteristics of regional metallurgies and their relationships under the recognition of trans-cultural interaction networks. We hope this research will bring a more comprehensive understanding of the relationships between metallurgy and the development of early civilizations in Bronze Age China.

Forthcoming events

Conference, Date and Location	Description	Website, Email and Prices
International Early Engines Conference 11th - 13th May 2017 Elsecar , South Yorkshire, UK	Including visits and presentations, the inaugural International Early Engines Conference will provide a forum for presentation and discussion of new research into heat engines prior to 1812.	https://www.earlyengines.org/
8th International Conference on Science and Technology in Archaeology and Conservation 21st - 25th May 2017 Amman, Jordan	With a significant portion of this conference dedicated to ancient technologies and techniques and its close proximity to the Feynan mining district, this conference is sure to cover some topics of interest to many of our members.	http://watch-events.eyeonculture.net/
Iron in Archaeology: Bloomery Smelters in Europe and Beyond 30th May - 2nd June 2017 Prague, Czech Republic	International conference in honour of the late Radomír Pleiner and to commemorate the 50th anniversary of the founding of the Comité Pour la Sidérurgie Ancienne (CPSA).	http://www.arup.cas.cz/iia2017/index.html
The Historical Metallurgy Society's 2017 AGM 17th June 2017 UCL, London, UK	This year's AGM conference has for a theme 'The Metallurgy of our Portable Heritage'. Held in participation with the Portable Antiquities Scheme, and as always, the meeting is aimed at bringing together as wide a range of contributors as possible, from archaeological metallurgists, excavators, post-excavation specialists and PAS officers.	http://hist-met.org/meetings/agm-meeting.html events@hist-met.org
National Association of Mining History Organisations (NAMHO) Conference 2017 23rd - 26th June 2017 Godstone, Surrey, UK	Mining enthusiasts will not want to miss this conference covering historical British mines and including several day trips, lectures, and other activities around Surrey.	http://namho2017.info/
23rd European Association of Archaeologists (EAA) Annual Meeting 30th August - 3rd September 2017 Maastricht, Netherlands	This year's EAA meeting has several themes that will cover various aspects of archaeology relevant to archaeometallurgists, including "*The 'Third Science Revolution' in Archaeology*". One regional session in particular should be of interest to our readership: "*Early Mediterranean metallurgy: technological innovation and cross-craftsmanship*".	https://www.klinkhamergroup.com/eaa2017/
9th International Conference on the Beginnings of the Use of Metals and Alloys (BUMA IX) 16th - 19th Ocbtober 2017 Busan, Korea	The main theme at the Busan Conference is "*Cultural Interaction and the Use of Metals*". The Conference will provide a forum for discussion on the effects of metals on the culture and history with a special focus on Asian materials. Comparative studies and case studies on ancient and traditional metallurgy from other regions can illuminate the interactions between the Far East and the West through South Asia as well as Eurasia.	http://eng.kim.or.kr/Board/board.asp?b_code=3231&Action=content&GotoPage=1&B_CATE=BBS11
Science of Ancient Egyptian Materials and Technologies Conference (SAEMT) 4th - 6th November 2017 Cairo, Egypt	This conference is an opportunity for specialists working within Egypt and employing archaeological sciences to get together and present their research and exchange ideas. Topics of interest to our readers are "Mining and quarrying " and "Pyro-technology".	http://www.saemt.com/calling-paper.html submit@saemt.com