THE CRUCIBLE

Historical Metallurgy Society News
Issue 107 **Summer 2021**

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The HISTORICAL METALLURGY Society

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From the Editors

Dear readers,

After the upheaval of the pandemic we are begining to return to something more normal. As our travelling has been very limited in the past 18 months, the editorial team of ***the Crucible*** has tried to bring our Historical Metallurgy community closer by looking at research happening in different countries and continents. We hope to make this wider and wider with the help of our reader: please let us know which country's ancient metallurgy you would like to visit and if there are any specific researchers you would like to know more about and we will try our best to contact them and ask them to let us virtually enter their lab, their archives or their excavation. In parallel we would like to ensure that our community is engaged and in contact with each other, so please do email us to introduce your work, ask questions and show all of us images of interesting metallurgical places you have visited, and you want to introduce to all the other members. Finally, we already mentioned that we have started printing our Newsletter on recycled paper. We believe the last two issues printed on the new paper were good quality so we will continue on this route and hopefully soon moving towards sustainable inks while maintaining support for our local small printer.

Looking forward to hearing from you all,

We wish you a lovely summer,

Lorna and Gill

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. Images should be sent as high resolution jpeg or tiff files. We accept a maximum of 5 Harvard-style references per article only.

For consistency, we tend to use contributor's names without affiliations and email contacts. Anyone wishing to contact a contributor not known to them is welcome to forward a message in the first instance to the editors who will facilitate the contact.

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FUTURE INTERVIEWS

Who would you like us to interview for the next issue of ***The Crucible****?*
Please let us know at **thecrucible@hist-met.org**

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Lorna Anguilano
Assistant Editors
Danny Aryani
Jack Cranfield
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Uche Onwukwe

Dear HMS Members,

After two years, we finally had an Annual General Meeting (AGM) once again. Due to the circumstances, this was, as much of life still is for many of us, an online event. On the same day and before the AGM, the Historical Metallurgy Society held its first online Conference titled a Metallurgical Miscellany.

The Conference was a miscellany indeed, featuring presentations by Laura Perucchetti on forgeries of classical Greek coins, Justine Bayley on Roman mould technology and Peter Northover on the archive of William Forbes' copper rolling mill. Next were Peter King on the impact of the 1750 British Iron Act, Chamini Mendis on the history of magnesium and myself on the transition from floor-level to waist-level forging in Medieval Europe. The presentations will be available shortly for viewing on our newly-to-be-created HMS Youtube channel. Keep an eye on the website for updates.

I would like to heartily thank Justine Bayley and Lorna Anguilano for organising this excellent Conference and Sebastian Jenner (Brunel University) for his outstanding technical support. May the Metallurgical Miscellany be the beginning of more similar events to come.

The Conference was followed by the AGM where new members of Council were voted in and welcomed; Thomas Birch, Paul Cort and Jack Cranfield. We also thanked leaving members of Council Sophie Adams, Eleanor Blakelock, Rachel Cubitt and Peter Halkon for their past contributions to the Society.

Very important for the future of our Society was the unanimous approval of the changes to the Society proposed by Council, which includes the transition to Open Access Journal. This means that any author, academic or otherwise, can still submit papers for publication in our Journal but that, from now on, this paper also will be published digitally to Golden Open Access standards and available to all online. The papers will continue to be peer-reviewed to the usual high standards by Justine and her editorial team. And this at no cost whatsoever to the authors! If you have a paper ready you would like to submit, please forward it to submissions@historicalmetallurgy.org or if you want to discuss an idea for a future submission, please contact Justine at editor@historicalmetallurgy.org.

With kind regards,

Paul

Archive films search

At the HMS conference at Ambleside in 1999 the late Mike Davies-Shiel showed some archive film of Backbarrow Furnace when it was still in blast in the 1960s. There were elements of the operation of the furnace which were relevant to earlier blast furnaces, and it would be fascinating to see it again. If it has survived perhaps a way could be found of making it more widely accessible, on YouTube for example. If anybody has any information on this film could they please let us know at **thecrucible@hist-met.org**

MARK A. HUNT ORTIZ

Mark A. Hunt Ortiz was born in Rio Tinto mines, province of Huelva, Spain, one of the largest and most widely exploited massive sulphide deposits of the Iberian Pyrite Belt. His father John P. Hunt was general secretary of Rio Tinto Patiño mining company and his mother María Teresa Ortiz, graduated in Classical Languages, brought home Homer and the interest in Rome almost from the cradle. Since a teenager he was involved as a volunteer in the archaeological projects that were carried out in the Rio Tinto mines by various international teams, especially by the IAMS Huelva Archaeometallurgical Survey, which included excavations at sites such as Corta Lago, Chinflón mine and the Phoenician silver metallurgical workshop of Monte Romero. After graduating in Geography and History at the University of Seville, Mark completed an MSc in Archaeometallurgy at the Institute of Archaeology, University College London in the late 1980's, with a grant from the Institute of Archaeometallurgical Studies (IAMS). He was taught by professors such as R.F. Tylecote (who in one of the meetings in his house in Oxfordshire proposed him to become a member of the HMS), H-G Bachmann and D. A. Scott, in addition to doing his MSc thesis at the British Museum Research Laboratory, under the supervision of Dr. Paul T. Craddock, on pre-Roman silver production at Rio Tinto. With a grant from the Autonomous Government of Andalucía, Mark joined the Isotrace Laboratory, Nuclear Physics Department at Oxford University, as a research visitor. He was under the supervision of Prof. Noel H. Gale and Dr. Z. Stos-Gale, with collaborations with the Research Laboratory for Archaeology and the History of Art and the Earth Sciences and Material Sciences Depts., especially with Dr. Peter Northover. The formation in isotopic research was completed with a stay, invited by Jacqueline S. Olin, at the Smithsonian Institution Analytical Laboratory, and the NIST, in Washington DC. This analytical/lab work was complemented (within the University of Sevilla research group ATLAS HUM-694, then directed by prof. V. Hurtado and today by prof. L. García-Sanjuán) with intense field surveys and excavations in mining areas in the SW of the Iberian Peninsula. All of this effort culminated with the presentation of the European doctoral thesis entitled Prehistoric Mining and Metallurgy in South West Iberian Peninsula, which in 1999 received the Extraordinary Doctorate Award from the University of Seville.Since then, Mark has worked at the CSIC (Spanish National Research Council) with Ignacio Montero and Salvador Rovira in Madrid, with various Universities such as Lleida (prof. Nuria Rafel), Extremadura (prof. Alonso Rodríguez) and in the Department of Cultural Heritage in the Andalusian Government. He has also worked as a freelance archaeologist in his Arqueo-Pro studio, with relevant archaeo-metallurgical related projects from the Chalcolithic to the Modern era, such as La Pijotilla and San Blas (Badajoz), Cerro de San Cristóbal (Cáceres), El Trastejón (Huelva), Aznalcóllar mines and Las Cruces mine (Seville), Sa Mitja Lluna mine (Menorca) and La Turquesa mine and La Solana del Bepo mine (Tarragona) or his participation in Saruq el-Hadid (Dubai) project. In 2015 he joined the University of Seville, where he is currently Professor in the Department of Prehistory and Archaeology. He is also Dean of his professional College, elected member of the directory board of the Spanish Society for the Protection of the Geological and Mining Heritage (SEDPGYM), and a member of the Andalusian Archaeological Commission.

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

I am an archaeologist and I have been fortunate to have a formation that has allowed me to participate throughout my career in very diverse projects both chronologically, from the Chalcolithic to the 20th century AD, as well as of typologies of sites, from mines to tholoi (tombs), although my main line of

research has focused on historical/archaeological mining and metallurgy and the application of analytical techniques to that field of research, which I currently share with teaching at the University of Seville.

THE CRUCIBLE: What is your most memorable professional moment?

Archaeological work well done always brings great satisfaction and I have had the opportunity to direct large and complex archaeological projects, even in urban settings. In Spain there are great professional archaeologists, although not yet fully recognised as a profession, working with them has made each of the projects go ahead. Being elected Dean of my professional College by my colleague's archaeologist was a great moment. But there are many small important moments, such as the rescue operation that I organised in which the last underground mine cage of the Aznalcóllar mines was saved, which today can be seen in one of the squares of the town.

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

As I have mentioned, in my career as an archaeologist there are many professors and colleagues who have had a considerable influence on me. I have not yet mentioned Prof. Beno Rothenberg with his organisational skills and his understanding of archaeometallurgy as a multidisciplinary task; the working capacity of Profs. Claude Domergue and Javier Sanchez-Palencia, also the impetus and perseverance of Dr. Craig Merideth and the vocation and generosity of my Spanish colleagues working in this field Carme Rovira, Ignacio Soriano, Tomeu Llull, Laura Perelló.

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THE CRUCIBLE: What is your main current project?

I am involved in a few historical mining and metallurgical projects: the excavation of the Sa Mitja Lluna mine, on the islet of Colom, in Menorca, with the University of the Balearic Islands is one of them, but this year we have started the excavation of another prehistoric/Roman/modern mine in south Spain, Las Minillas mine, (Granja de Torrehermosa) with Prof. Johan Ling (University of Göteborg, Sweden) and Prof. Marta Diaz-Guardamino (Durham University). Also, we are working on projects of Chalcolithic and Bronze Age metal production with Prof. Martin Bartelheim (University of Tübingen) and the use of cinnabar pigment from the Almaden mercury mines with Prof. Mar Zarzalejos (UNED University) and pre and early Roman lead production in Badajoz with Prof. Alonso Rodríguez (Universidad de Extremadura), lead provenance from Roman Astigi with Prof. Salvador Ordoñez/Sergio García-Dils, and some more on archaeological sites/objects.

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

The creation of an Archaeological Mining and Metallurgical Research Center would be a project that I would love to develop. The Iberian Peninsula, and especially Andalusia, has a unique mining and metallurgical heritage, the product of thousands of years of ore mining and metal production. Investigation works, re-exploitation and environmental restoration of mining areas is provoking the loss of much of this heritage. So, a research centre should focus on the protection, archaeological and historical research and public knowledge of this heritage, with sufficient human and technical means and paying special attention to the relation with other areas of the world with strong historical relations, like the Mediterranean and America.

THE CRUCIBLE: Which publication should every HMS member read?

The works by Pliny, Isidore of Seville, Alonso Barba, Agricola, Percy, Tylecote, Domergue, Craddock, O´Brien...or the recently published by A. Hauptmann (*Archaeometallurgy - Materials Science Aspects*, Springer 2020) are of reference, but if I had to choose a single book, then I would invite you to read David Avery´s (1974) *Not on Queen Victoria's Birthday. The story of the Rio Tinto mines* (with a Spanish translation *Nunca en el cumpleaños de la Reina Victoria*, reviewed by my parents and daughter, Coral Ivy).

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

Archaeological mining and metallurgy is a fascinating world to which current research techniques allow a much more accurate approach ... and more complex ... you have to study the techniques and know how to interpret results, but you cannot know everything, it needs a multidisciplinary team. The field research in mining and metallurgy also allows spectacular landscapes to be visited, and the opportunity to work alongside specialists from other disciplines, which is always a great experience.

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

Spain, from the historical mining and metallurgy point of view, is exceptional. You can go from the Roman gold mines of Las Médulas (León) to the mercury mines of Almadén, both UNESCO World Heritage Sites, and really impressive sights. However, there are also many more mining areas, like the series of open-cast mines of the Iberian Pyrite Belt, of which Rio Tinto and its mining museum and the old mining train trip along the (red) Tinto River, are the main attractions. There are also many other unique mines that must be visited, like Tharsis, La Zarza, Herrerías, Aznalcóllar or in Portugal Aljustrel and São Domingos mines.

Thomas Birch

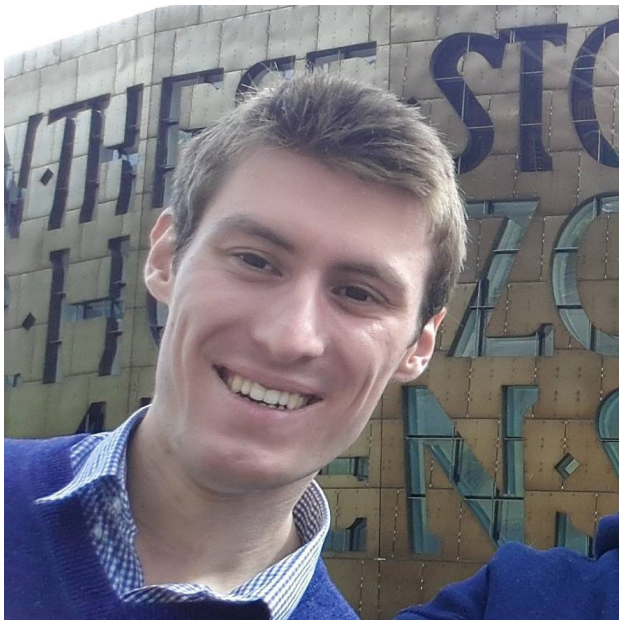
During his undergraduate studies, Tom first encountered several practical aspects of archaeometallurgy, undertaking mechanical testing of experimental Anglo-Saxon pattern-welded samples made by Hector Cole and learning basic metallography with Colin Shell. Tom became a member of HMS during his MSc. studies at UCL (Technology and Analysis of Archaeological Materials) under the supervision of Marcos Martinón-Torres and Thilo Rehren, where he presented his first poster presentation at the Bradford conference in 2009. His PhD thesis at the University of Aberdeen investigated the provenance of iron weapons from the famous Iron Age war booty sacrifices in Denmark, some of the best-preserved Roman war gear to be found in Europe. As part of the PhD, Tom investigated the iron provenancing method (slag inclusion analysis) with samples and great help provided by Peter Crew and Mike Charlton (still to be published!).

In 2013, Tom took his first post-doc in Frankfurt (Goethe University), working for the project "Coinage and the Dynamics of Power: the Western Mediterranean 500-100 BC", led by Fleur Kemmers. It was during these two years that Tom learnt lead isotope analysis of metals under the supervision of Sabine Klein. During 2014, Tom organised HMS's annual conference (Metallurgy in Warfare – a spur to innovation and development) along with his surname brother and fellow council member Eddie Birch. In 2015, Tom spent 6 months working at UCL Qatar under the leadership of Jane Humphris for the Kingdom of Kush project, researching iron production in ancient Sudan, after which, he returned to Frankfurt for another 6 month stint again with Fleur Kemmers and colleague Katrin Westner to research Roman silver coinage.

In 2016, Tom joined UrbNet (Centre for Urban Network Evolutions) at Aarhus University (Denmark) as Assistant Professor, where he had the opportunity to work on metallurgical remains from the first Scandinavian town (Ribe) as well as coins and metalwork from the Roman city Gerasa/Jerash (Jordan), working closely with his friend and MSc. colleague Vana Orfanou. Tom was recently (2020) welcomed into the Department of Conservation and Archaeological Science at Moesgaard Museum (Aarhus, Denmark), where he now provides archaeometallurgical services to other Museums and research institutions, as well as continuing with his own research interests – though these are many, his passion remains heartily with metalwork and weaponry from early medieval Northern Europe. His next steps are glass and gold…

Tom enjoys learning new skills, whether it's woodworking, coding, metalworking or a new language. Currently, it's operation market garden with raised beds, 20 plus tomato plants, supported by two young children and cherished wife. He very much looks forward to supporting HMS as council member, tackling new tasks and helping with the Grants committee. Hopefully he can pay forward some of the kindness and help from the archaeometallurgy community that has so greatly supported him on his journey.

Jack Cranfield



I became a member of HMS when I started my PhD at the University of Exeter in 2019. My PhD investigates the Medieval Iron Industry of the Weald, a project sponsored by the Wealden Iron Research Group and supervised by Dr Gill Juleff and Professor Levi Roach. The research seeks to understand the nature and scale of iron working throughout the Weald in Southeast England, using a range of archaeological methodologies including reconnaissance survey, geophysics, earthwork survey and fieldwalking. It focusses on two case study sites at Roffey in West Sussex and Tudeley in Kent, both of which have rare surviving documentary accounts.

Having grown up in Sussex, I always had a keen interest in archaeology, encouraged by programmes such as Time Team, membership of the local Young Archaeologists' Club (YAC) and frequent discoveries of Victorian pottery and clay tobacco pipes on my Dad's allotment! As a Young Archaeologist member, I was able to visit some of the local ironworking sites, and I remember on one occasion being allowed to take home a fragment of iron slag as a souvenir – treasure to an 8-year-old! Today I continue to run events for the Young Archaeologists' as a Co Leader of the Sussex Weald YAC branch. In a recent event the YAC's created their very own 'bloomery furnace' out of a wicker washing basket and air-drying clay - although I hasten to add that we did not attempt to light it!

I completed my Undergraduate degree in Archaeology and Anthropology at the University of Cambridge, and specialised in modules in Anglo Saxon and Medieval Britain. My Dissertation looked at the development of Medieval settlements in Sussex and through this it became apparent that the iron industry had a considerable impact on village economies. I went on to study an MA at the University of Reading, in the Archaeology of Medieval Europe. While at Reading, I looked at how the landscape determined the placement of Medieval Churches. In my research today, the influence of the wider landscape on iron production sites forms a significant focus of the project.

As well as archaeology, I love baking cakes, gardening, bellringing, and collecting anything old and interesting – you may have seen the 'Mouse Proof Pedal' in the last edition of ***the Crucible***? I am also is interested in the Arts and Crafts period and the importance the movement attached to traditional craft skills including metalworking that harked back to techniques used in the Medieval period.

On the HMS Council, I work as an Assistant Editor on *the Crucible*, and will shortly be helping coordinate the checking of the copyright status of images from past editions of the HMS Journal, so that they can become freely available online. I really look forward to being a member of the Council and making connections with others in the world of archaeometallurgy.

A Puzzling Indian Cannon

Travelling through central India back in 2009 I stayed in the historic city of Indore. Whilst there I visited the Central Museum and came across this centrally-displayed cannon, with its label stating that it dated from the 17th or 18th centuries (Figs 1 and 2). It was obviously unfinished, indeed the mould sections had misaligned during casting and there had been no attempt either to correct this by milling or turning, or to proceed to drill out the bore.

The main interest was that it had clearly been cast in a two-piece mould which is highly unusual, if not unique. I would have liked to have shown the photographs to Professor R. Balasubramaniam, the great expert on all aspects of Indian ordnance, but sadly he had recently passed away. And so, these pictures were put to one side to consult on a rainy day, or as it turned out during a pandemic.

The usual method of casting heavy ordnance in the Post-medieval period in India has been described in detail in Balasubramaniam's excellent book, *The Saga of Indian Cannons* (published by Aryan Books in 2008 and reviewed by Craddock in 2008, in *Historical Metallurgy* 42(1)). Very similar processes were used in Europe at the same time and there is a very good contemporary account of cannon casting as practiced at the Royal Brass Foundry at the Woolwich Arsenal, London, with superb detailed contemporary illustrations (*Eighteenth Century Gunfounding* Jackson and de Beer, published in 1973 by David and Charles). In addition, there is the surviving Post-medieval gun foundry, the *karkhana*, in the Jaigarh Fort, at Amber, near Jaipur (Figs 3 and 4). This is arguably the most complete such installation surviving anywhere in the world (fully described in *The Saga of Indian Cannons*, pp. 104-7). It has now been restored, and in happier times is a tourist attraction that should not be missed by any archaeometallurgist!

Fig. 2 Mouth of the cannon. Note the feeding head, or sprue which would have been sawn off before drilling commenced, and the prominent flash lines (P. Craddock).

Fig. 1 Small copper alloy cannon barrel now in the Indore museum. The casting was misaligned in the mould and abandoned. Note the flash lines running continuously all around, showing this was cast in a two piece mould (P. Craddock).

From this and from the written descriptions, it is possible to reconstruct the usual casting process. First, a template of the cannon barrel was created around a tapering wooden spindle of almost the same dimensions as the intended barrel. This was slightly longer than the barrel as the mould had to include a feeding head, or sprue, for the incoming molten metal (Fig 2). Next, rope was tightly wound around the spindle, greased and then clay was applied around it to build up the cylindrical positive template. At this stage projections such as the trunnions were applied, either in wax or wooden blocks held in place by iron pegs into the clay. The whole was then lightly waxed and the mould clay applied in a succession of layers until sufficient thickness had been built up. The whole assembly was now mounted in the casting pit and lightly fired, just enough to give the mould sufficient strength whilst the template was removed. This was done in stages. Firstly, the spindle was pulled out and rope unwound before the relatively thin clay template, which had probably begun the break up, was removed. The mould was then fired to bake it thoroughly (Fig 3) before the metal was run in from the furnace, such as that at the Jaigarh foundry (Fig 4). After several days cooling the mould was broken, and the solid barrel removed.

It was at this stage that the Indore casting was revealed as a failure and abandoned. If it had been successful, then first the feeder head would have been sawn off and the bore carefully drilled out using steel-tipped bits. This required great skill and precision, as well as strength. At the Jaigarh foundry there was an elaborate arrangement for securely holding both the barrel and the turning drill, operated by four pairs of oxen.

Fig. 3 Complete, unused mould for casting cannon, probably 18th -19th century, at the Jaigarh Fort cannon casting foundry. Note the iron binding bands (P. Craddock 2015).

Fig. 4 The Jaigarh foundry was established in the 16th century, but the present arrangement with a reverbatory furnace to melt the metal, linked to the casting pit, more likely dates from the 18th or even early 19th century (P. Craddock 2015).

The Indore gun, however, was cast in a two-piece mould. A template of the complete barrel, trunnions and all, would have been made, probably of wood. This would have been set into the mould clay, half in and half out, as indicated by the still visible mould flashes (Figs 1 and 2). The surface of the clay would then have been dusted with some powder so the when the other half of the clay was moulded over the template, the two halves did not stick together. The two halves were parted, the template removed, and rejoined, hopefully with better location than the Indore barrel! The joined mould was fired and the metal poured.

It is possible that it could have been a sand casting. However, there is very little evidence for the use of this technique in India, except for the small *bidri* castings. This is a very large two-piece casting, does anyone know of similar cast cannon, or can offer an alternative scenario for its production?

Paul Craddock

THE BELL TOLLS IN WHITECHAPEL

By the time this issue goes to press many readers in the UK will be aware of the sad and final demise of the Whitechapel Bell Foundry in London. Readers further afield may be less familiar with this cherished landmark of metallurgical heritage (Fig. 1). In early May this year, despite four years of fierce campaigning, the Secretary of State (for Housing, Communities and Local Government) made the definitive planning decision that the site of the foundry could be re-used to create a boutique hotel. What was officially the oldest manufacturing company in Britain closed as a commercial bell foundry in 2017. Immediately a campaign began to preserve the site and continue the tradition of bronze founding in the heart of the capital. A bitter battle was fought by local activists, historians of metallurgy and industry, heritage specialists and prominent national figures, against the might of capitalists and developers. The convoluted intrigue that ensued has been reported in the mainstream press and makes interesting reading (https://www.theguardian.com/news/2021/may/11/whitechapel-bell-foundry-battle-save-britains-oldest-factory).

Established in the 16th century, the Whitechapel Bell Foundry had been casting bronze bells since 1570. The Liberty Bell was cast there in 1752 and Big Ben in 1858. Whitechapel tower bells can be found across the world, with some 500 in Australia, 600 in the US and at least 900 in Canada. From a commercial point of view one of the problems with the success of the foundry over the centuries has been that the bells last too long. Two bells cast in Whitechapel in 1583 still hang in Westminster Abbey and function as new!

Fig. 1 The HMS 2006 visit to the Bell Foundry as part of its AGM day

Fig. 2 The traditional shop front of the foundry

There was of course bell casting in London much earlier than the 16th century. Derek Keene's paper (in *Historical Metallurgy* 30(2), 1996, 95-102) showed that the potters (who cast large vessels, including bells, and were later called brasiers) worked in the east section of the walled city in medieval times. They had expanded further east into Aldgate, immediately outside the city walls, by the 1290s, and on into Whitechapel in the following centuries. Thus, the casting of large vessels and bells in London has a history of nearly eight hundred years that only ended with the closure of the Whitechapel Foundry.

HMS has had its own close relationship with the Whitechapel Bell Foundry, with each generation finding an opportunity to make a site visit (Fig. 2). The very first page of our very first newsletter in 1976 records a day-long AGM meeting in London starting at 9.15am with a visit to the foundry (*Crucible* 100). The loss of this iconic establishment to yet another over-priced elite venue, and with no more than a nod towards the real history of the site in the form of a small handbell 'foundry' (no doubt with attached souvenir shop) is a bitter pill for those who have fought so passionately to save the factory that gave the world both Big Ben and the Liberty Bell.

Gill Juleff and Justine Bayley

TRADITIONS OF HISTORICAL METALLURGY IN NORTHEAST ASIA

Fig. 1 Map showing the four countries in Northeast Asia

Studies of cultural development in Northeast Asia (Fig. 1) have had a heavy focus on China, leading to an under-representation of technological achievements made in the peripheral regions, including Korea and Mongolia. Archaeological excavations revealing the near industrial scale iron production practiced in ancient Korea and Mongolia, however, points to the early achievement they made in one of the most advanced areas of material culture. Figure 2 illustrates a mid 5th century AD royal tomb constructed in Gyongju (arrow 1 in Fig. 1), Korea and iron objects representing the iron assemblage consisting of more than 3500 pieces of swords, spears, daggers, arrowheads, tools and product intermediaries. Metallographic examination provided evidence that the majority of them were forged out of bloomery iron, with only 300 items made of cast iron (Park 2012).

A similar bloomery-based technological tradition was also observed in the large metal assemblage recovered from a 1st century BC to 1st century AD royal Xiongnu tomb at Golmod 2 (arrow 2 in Fig. 1), Mongolia (Park et al. 2018). One of the groups in this assemblage consists of bushings (Fig. 3a) and caps (Fig. 3b) that were used in the crucial wheel-axle assembly of horse-drawn wagons. The number of recovered metal parts showed that they could represent at least a dozen two-wheeled carriages. The bushings were all made of bloomery iron and had a cut along their length (Fig. 3c), a sign of fabrication by forging rather than by casting, with only one exception indicated by the asterisk, which was made of cast iron. In contrast, the axle caps were all cast from either iron or bronze. Some of the iron caps were found to have bronze patches applied to fill empty spaces that came to exist due to pouring defects. No such defects, however, were identified in any of the bronze axle caps, demonstrating that the caps were manufactured in a technological environment with only limited experience in iron casting as opposed to its excellent com-

Fig. 3 Iron objects excavated from a 1st century BC to 1st century AD royal Xiongnu tomb at Golmod 2 (arrow 2 in Fig. 1), Mongolia. a) Iron bushings; b) axle caps cast from cast iron (top) and bronze (bottom); c) iron bushings with a cut along their length.

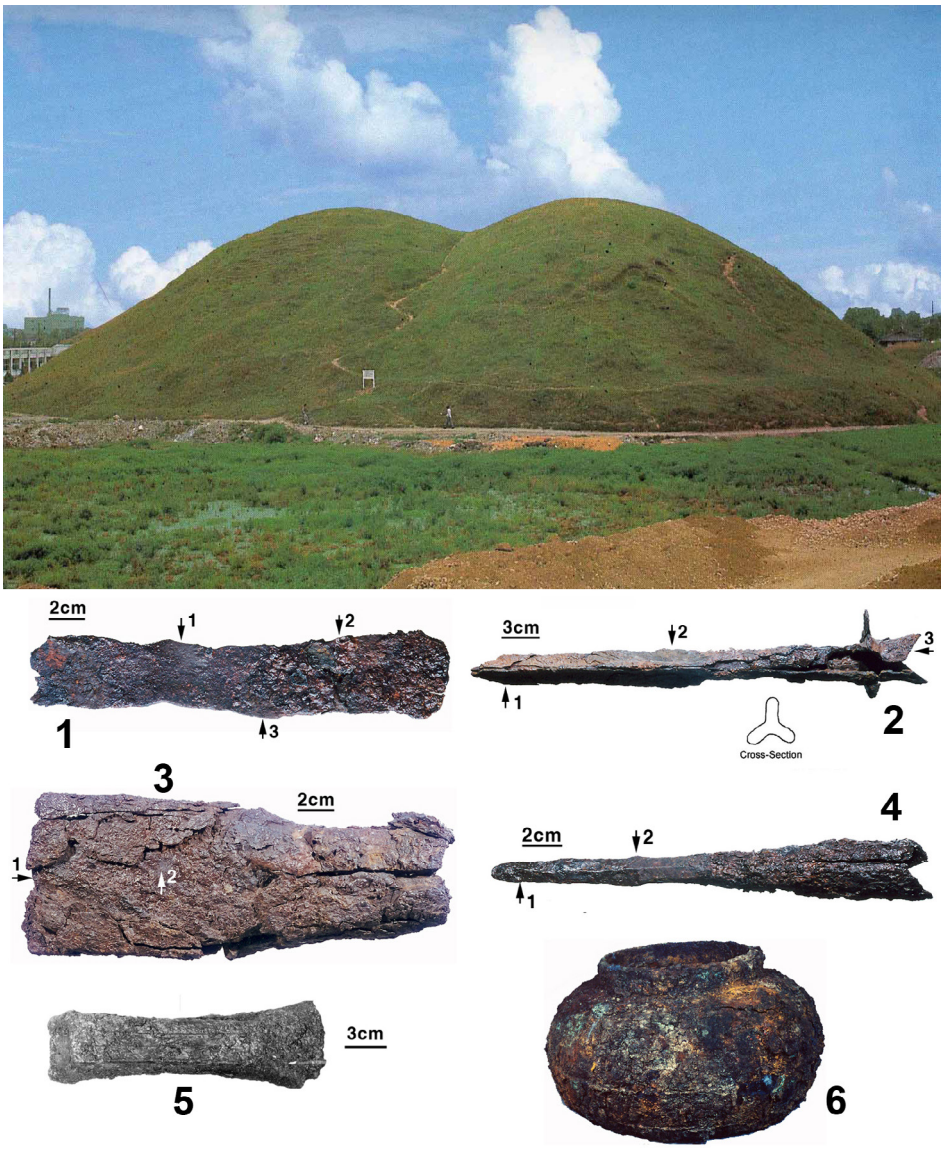


Fig. 2 A mid-5th century AD royal tomb named The Hwangnam Great Tomb in Gyongju (arrow 1 in Fig. 1), Korea and some iron objects representing the large iron assemblage from the tomb.

mand of bronze casting. Moreover, the alloy recipe for the bronze caps was arsenic- or low tin and limited lead-based, in strong contrast to the copper-tin-lead alloy system characteristic of the Han bronze industry (Park et al. 2011).

The cases presented above demonstrate technological traditions that are clearly distinguished from those practiced in contemporary China and are at odds with theories viewing China as the primary source of metal production in Northeast Asia. According to these theories, horse-drawn wagons excavated from royal Xiongnu burials are tribute items from China offered to Xiongnu elites, symbolising Xiongnu dependency on foreign states for technological and political development. Such vehicles then have no relation to indigenous Xiongnu craftsmanship. The evidence presented here does not support that idea and instead argues for a high degree of local manufacture using traditional Xiongnu metal technologies.

Jang Sik Park

References

Park J.S., 2012. A preliminary study on the role and implication of plate-type iron artifacts in the ancient iron technology of Korea. *Journal of Archaeological Science* 39:1925-1932.

Park J.S., Honeychurch W., and Chunag A., 2011. Ancient Bronze Technology and Nomadic Communities of the Middle Gobi Desert, Mongolia. *Journal of Archaeological Science* 38:805-817.

Park, J.S., Erdenebaatar, D., and Eregzen, G., 2018. The implication of the metallurgical traditions associated with Chinese style wagons from the royal Xiongnu tomb at Golmod 2 in Mongolia. *Archaeological and Anthropological Sciences* 10:1535-1546.

ANGLO-SAXON IRON WORKING AND THE SMITH

Re-creating a supposed idea of past practices is fraught with problems especially during the early Anglo-Saxon period (450-700AD) where facts are scarce and sources thin on the ground. However, through archaeological and written evidence we can glean a sense of the structure of both society and smith, and the relationship between the two. Iron production it seems, was mainly focused on the use of bog ore, rather than mined ore. This makes sense in that mined ores are much more difficult to find than their boggy counterpart, although the Romans did use mined cob stone from Suffolk as their ore and we can assume the reuse of some Roman iron workings took place during the Anglo-Saxon period. From a modern perspective, we view the past in neat groups; Romans, Saxons, Normans, but daily life drifted along the same, just the rulers changed. Smelting sites and villages rarely coincide as the materials may be some distance from a village and in limited quantities so a small local industry would develop at multiple sites.

The smith would not smelt his own iron, he was a specialist. Evidence from Northern Europe suggests that farmers in the winter months would mine the bog ore, roast and prepare it for smelting. The bog ore mining tools were simple, just re-purposed agricultural tools set to another task (Fig. 1).

Other farmers would prepare charcoal for the furnace and it is likely that one local farmer would specialise in smelting so perhaps four or five villages would have produced smelted billets for the smith to forge with all those involved in production due a share of the iron produced. No one village could support a smith, given the general size of a village at around four to ten houses the smith could produce substantially more than the village could use.

Fig 1. Tools of the Bog ore miner

Fig 2. The tattershall Thorpe smiths tools

So, we know that the smith was peripatetic; he would move from village to village plying his skills, this would not be random or haphazard process, he would not move from one village to the next but more likely between larger villages which themselves served two or three smaller villages, he would stay for a set time then move on to the next and overwinter at his home village. How the smith was paid we do not know; barter, accommodation, silver, all no doubt would play their part. Every smith would have had an apprentice who, on the basis of the Anglo-Saxon familial structure would most likely have been a nephew. His tools were simple and portable as the main smithing finds from the grave at Tattershall Thorpe show; a small anvil (no bigger than your fist) hammer and tongs (Fig. 2).

How was the smith regarded by his patrons? With fear and awe, no smiths' grave has ever been found in an Anglo-Saxon cemetery, he was a liminal figure with magic skills who hovered between worlds, between those of man and god, and we must presume that even in death he exuded some dark force that precluded burial with mortal men. In the United Kingdom there is only one known smiths' grave, from Tattershall Thorpe in Lincolnshire dated to 690AD, buried well away from any cemetery. Buried with care with his tools, no doubt by his apprentice.

Dennis Riley

Bronze and Iron Age silver reveal developments in long distance trade routes across the Mediterranean

Silver is a unique metal, much rarer than copper, and often shipped over long distances in antiquity. Silver differs from tin and gold as it contains lead, and therefore its origin can be traced using Lead Isotope Analysis (LIA). Importantly, it was used as a mean of currency in the Levant before the invention of coinage, and often hoarded below floors in the form of ingots, cut ingots, and broken jewelry. Forty of these hoards, which were not claimed by their rightful owners, have been unearthed on archaeological excavations in different locations in modern Israel. For my PhD dissertation, I analysed 250 items from these hoards, dating to the Bronze and Iron Ages. The chemical and isotopic analysis revealed a period of shortage in silver during the Iron Age I in the Levant (~1200–950 BCE), in which silver was systematically debased using local copper and arsenic which retained the silvery sheen of the alloy (Fig. 1). In the following period, during the Iron Age IIA (~950–800 BCE), large quantities of pure silver were brought to the Levant from Anatolia, Sardinia, and eventually also from Iberia (Figs 2 and 3). The results were interpreted as a period of shortage in silver during the Iron Age I in the Levant, caused by the collapse of Late Bronze Age societies in the Aegean, and the trade routes between the Aegean and the Levant (Eshel et al, 2021). The shortage in silver ended in the Iron Age IIA, when Phoenicians sailed to Anatolia and the western Mediterranean, bringing silver to the Levant in large quantities (Eshel et al, 2019). The silver hoards predate ceramic and architectural evidence of Phoenician colonization in Sardinia and Iberia and suggest that the quest for silver was an early motivator for Phoenician endeavors to the western Mediterranean. In the near future, additional data will be published, shedding light on two other periods of silver trade to the Levant: The Bronze Age (~2000–1200 BCE), and the Late Iron Age II (~800–586 BCE).

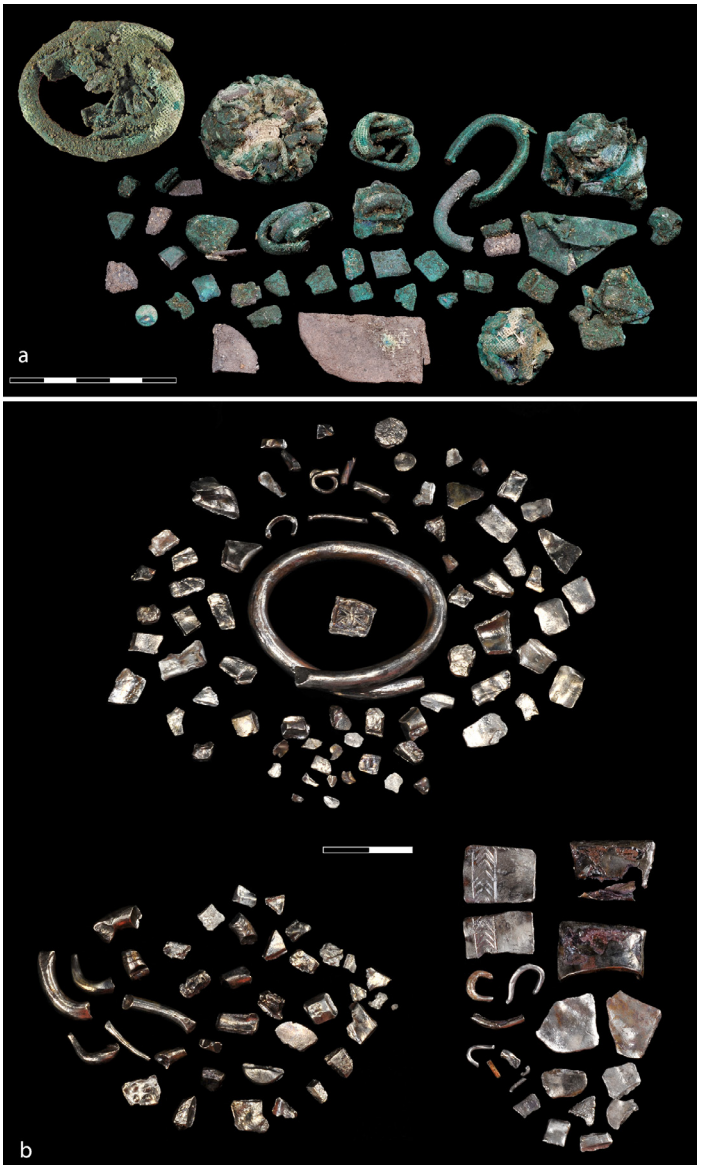


Fig. 1 Silver from the Tell Keisan hoard, before and after cleaning, photographed by Yael Yolovich, courtesy of the Israel Antiquities Authority. Copper debasement is evident only before cleaning of artefacts.

Fig. 2 ʿEin Hofez silver hoard, originating from Iberia. Image courtesy of the Collection of Israel Antiquities Authority. Photo by Warhaftig Venezian.

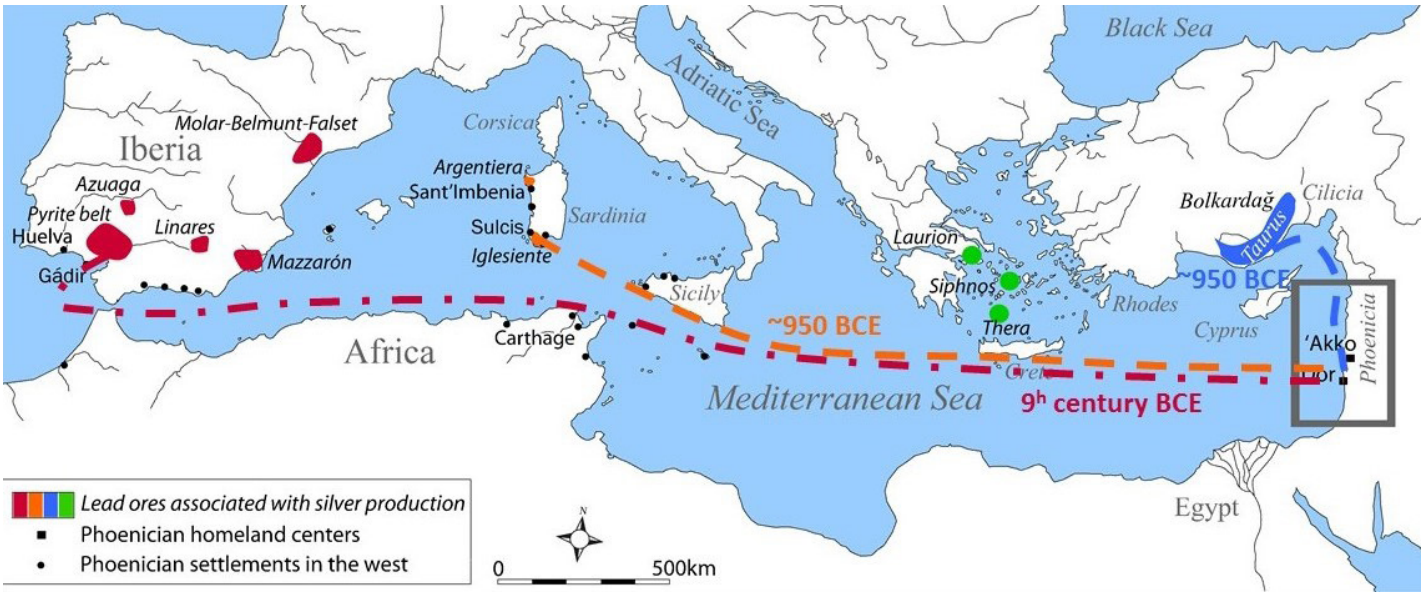


Fig. 3 The Mediterranean Sea, Phoenician sites, silver bearing lead ores and the origin of silver found in Phoenicia. Red, Iberia; orange, Sardinia; green, The Aegean; blue, Anatolia. Maps courtesy of Svetlana Matskevich (illustrator).

A few words on the methodology. This research was interdisciplinary, in the sense that it combined archaeological dating of the hoards, typology of the jewelry within the hoards, chemical and isotopic analysis, and geochemical methods. The research was supervised by Prof. Yigal Erel, the Institute of Earth Sciences, The Hebrew University of Jerusalem, Dr. Naama Yahalom-Mack, of the Institute of Archaeology, The Hebrew University of Jerusalem and Prof. Ayelet Gilboa, of the Zinman Institute of Archaeology and Department of Archaeology, University of Haifa. The research was supported by the Gerda-Henkel Foundation (Grant AZ 05/F/16; awarded to Prof. Ayelet Gilboa and Prof. Yigal Erel).

Tzilla Eshel

References

Eshel, T., Gilboa, A., Yahalom-Mack, N., Tirosh, O., & Erel, Y. (2021). Debasement of Silver throughout the Late Bronze – Iron Age Transition in the Southern Levant: Analytical and Cultural Implications. *Journal of Archaeological Science.* Vol. 125.

Eshel, T., Erel, Y., Yahalom-Mack, N., Tirosh, O., & Gilboa, A. (2019). Lead Isotopes in Silver Reveal Earliest Phoenician Endeavors in the West. *Proceedings of the National Academy of Sciences*, 116(13), 6007-6012.

A visit to Finch Foundry, Devon

Earlier this month I visited Finch Foundry on the edge of Dartmoor at Sticklepath in Devon, one of the last water-powered forges in the country. The forge was originally built as a woollen mill but later converted into a forge, wheelwrights, carpenters, and sawmill. Run by the Finch family in the 19th century, the foundry became a large producer of agricultural tools in Devon, which included everything from scythes to shovels. At peak production, the foundry produced 400 tools a day. Today you still get a sense of how it had been a family business, having been run by three generations of the Finch family. In the museum you learn how Suzanna Finch, wife of the first owner William, walked for nearly 20 miles to Tavistock whilst pregnant to sell tools. While there, she gave birth, sold the tools, and walked home a few days later with her new-born baby. It paints a vivid picture of how hard life was for a rural Devon industry at that time.

In the foundry, the volunteers demonstrated how the tilt hammer, drop hammer and sheer hammer are all still in perfect working order, powered by three over-shot waterwheels (see images). It was great to see the forge in operation too, and how many of the original tools and templates have been preserved. The tools and machinery represent a rare survival of an industry that disappeared over the 20th century due to increasing mechanisation and large-scale production. Finch Foundry was itself nearly lost when in 1960 its roof collapsed. Fortunately, it was saved by a Mr Barron who carefully restored it to working order. Today it is open to the public under the care of the National Trust.

For more information visit www.nationaltrust.org.uk/finch-foundry

Jack Cranfield

Research in Progress 2021
Saturday 13th November

This year's Research in Progress Meeting 2021 will take place on Saturday, 13th November, hosted by Moesgaard Museum (Aarhus, Denmark), though practically will take place as a virtual online event. We would like to invite all members, students, curators, researchers, metallurgists, commercial archaeologists, to attend the online event. We invite submissions for oral presentations, poster presentations, as well as the opportunity to create a pre-recorded multi-media visual mini-digest presentation – this might take the form of interlacing video footage with dialogue, results and illustrations/pictures (even with music!). The aim is to take advantage of the digital event and make it more stimulating for participants, presenters and viewers. For regular presentations, we recommend an average of 15 minutes (with time for questions added), though please feel free to request less/more time if you need when submitting an abstract. Abstracts (no longer than 250 words) and specification of presentation type (oral, poster, media digest) should be submitted to Thomas Birch (teb@moesgaardmuseum.dk) – if you do not receive a confirmation of receipt, please reach out using the HMS website contact. We look forward to seeing you in November! Further details will be circulated in advance of the meeting.

There will be an HMS prize for the best student presentation (oral/poster/media).

2019 Student Prize winner Saltanat Amirova for her presentation on copper and tin bronze metallurgy on the Late Bronze Age site of Semiyarka

Conference, date and locations	Description	Website and emails
EAA Annual Meeting 2021 08/09/2021 -11/09/2021 The University of Kiel, Germany	27th Annual Meeting of the European Association of Archaeologists	https://www.e-a-a.org/eaa2021 Email: helpdesk@e-a-a.org
3RD Perspective on Balkan Archaeology- PeBA 2021 International Conference Exact dates TBC (May 2022) Ohrid, Republic of North Macedonia	The theme of this conference is centred on "the mechanism of power in bronze and iron ages in south-eastern Europe"	https://pebasite.wordpress.com/peba-2020/ Email: pebaconference@gmail.com
43rd International Symposium on Archaeometry ISAS2020 16/05/2022 - 20/05/2022 Lisbon, Portugal	The symposium aims to promote the engagement in the use of scientific techniques to improve the extraction of archaeological and historical information from historical sites.	https://www.isa2020-lisboa.pt Email: isa2020@isa2020-lisboa.pt
World Archaeology Congress WAC-9 03/07/2022- 08/07/2022 Prague, Czech Republic	The World Archaeological Congress (WAC) seeks to promote interest in the past in all countries, to encourage the development of regionally-based histories and to foster international academic interaction. Its aims are based on the need to make archaeological studies relevant to the wider community.	https://www.wac-9.org Email: wac-9@guarant.cz
8th Balkan Symposium on Archaeometry Dates TBC (2022) Vinča Institute of Nuclear Sciences, Laboratory of Physics, Belgrade, Serbia.		https://bsa7.uniwa.gr

Virtual Program	Description	Website
8th International Conference on Mining, Material, and Metallurgical Engineering (MMME'21) 02/08/2021- 04/08/2021	The goal of this mining, material and metallurgical engineering conference 2021 is to gather scholars from all over the world to present advances in the relevant fields and to foster an environment conducive to exchanging ideas and information.	https://mmmeconference.com/ Email: info@mmmeconference.com.

ICAPSP007 2021: International Conference on Archaeometallurgy Processes, Standards and Practice 16/08-17/08/ 2021 in Dubai, United Arab Emirates	This conference aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Archaeometallurgy Processes, Standards and Practice	https://waset.org/archaeometallurgy-processes-standards-and-practice-conference-in-august-2021-in-dubai
ICAPNMR001 2021: 15. International Conference on Archaeometallurgy Processes and Non-Metallurgical Residues 23/08-24/08/2021 in Rome, Italy	A conference that presents the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Archaeometallurgy Processes and Non-Metallurgical Residues	https://waset.org/archaeometallurgy-processes-and-non-metallurgical-residues-conference-in-august-2021-in-rome

Other	**Description**	**Website**
Unveiling the secret of the archaeological site of Tel Abel Beth Maacah (webinar)	Webinar discussing the use of cutting edge technologies to determine the origin of archaeological metals and other materials.	https://www.youtube.com/
Tony Phillips on the History of the Benin Bronzes I-XII (Essay)	History behind the looted 600 year old Bronze statues of Benin currently residing in the British Museum.	https://www.vam.ac.uk/articles/tony-phillips-benin-
A British Museum Spotlight Loan :Gathering light: a Bronze Age golden sun (Exhibition) 10/09-12/12/2021	Solar symbolism and it depiction on metalwork from jewellery found in Shropshire Marches 2018.	https://www.britishmuseum.org/exhibitions/gathering-light-bronze-age-golden-sun

The HISTORICAL METALLURGY Society