THE CRUCIBLE

Historical Metallurgy Society News
Issue 103 Spring 2020

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Inside The Crucible

The HISTORICAL METALLURGY Society

FROM THE EDITORS

There's no doubt we are living in strange times and we're all having to adjust to a new normal, but some things in this world endure – your HMS Newsletter! We are very pleased that we have been able once again to deliver a printed copy of ***The Crucible*** to you, albeit a little later than usual. In truth, several weeks ago when we started to discuss this issue the situation looked bleak. We were distracted by the onset of the virus and the editorial team had all just been sent to work from home. This meant none of us had access to the software we use to compile the newsletter and our first reaction was to cancel the issue, in the way that everything else was being cancelled. Then, with some calm reflection and ingenuity on the part of members of the team, we found ways to gain access to the software. The next hurdle was physical printing and we suggested that for the first time ***The Crucible*** would be an online only newsletter. That idea produced a predictable and justified groundswell of disappointed mutterings which spurred us into discussions with our printers who agreed that they would be able to handle, and in fact would welcome, a print run after the end of April. So, proudly, here we are again. You can turn off your screens and settle down with a cup or glass of your favourite medicine and be transported away from the news of today to the news from our glorious metalliferous past!

We welcome to the editorial team Uche Onwukwe and Mahfuz Karim who, with Danny Aryani, will form the new Brunel editorial group, working together with the Exeter team (Carlotta Farci and Jack Cranfield). We thank very much Susanna Venditti and Amy Flynn for their support in the previous issues and we wish them the best of luck for finishing their PhD and starting their new careers.

In this issue we have especially looked closely at forthcoming events to try to bring members as much up-to-date information as we can on conferences, meetings and events that have been cancelled or rescheduled. We have also included a new section under events, listing interesting material available online to help fill the time we are all spending at home. As none of us should be 'out and about' these days we have also reimagined this section as a 'virtual out and about', using material from our own photographic archives. We hope you like the concept and submit your own virtual out and about experiences for the next issue. Which leads us to remind members that ***The Crucible*** is only as good as the content submitted – please keep sending things to us!

The Editors

Front cover image top left: *Rockley Lower Furnace built sometime between 1698 & 1704, rebuilt 1726. Picture taken during excavations 1978 - 1982 showing casting pit (WIRG archive)*

Apology: readers may have noticed a lack of quality in our last issue (No. 102) and the reprinting of an article that had appeared in a previous newsletter. This was the result of an editorial team confusion which lead to an incorrect early version of the issue being sent to the printers rather than the final edit. We apologise to our readers for this. The correct version of No. 102 is now available to download from the HMS website. For this reason we have included in this issue the review of the 2019 HMS RIP meeting in Cambridge which should have appeared in the last printed issue.

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.

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*

Launched: Our New Website

Over the last three months I have been working on a new and improved website. This involved changing software but also a change of domain (which we hope will be easier to remember). The new website can be found at **www.historicalmetallurgy.org**

HMS have taken this opportunity to modifying the design of the site, everything has been transferred over from the old site, but some pages may have moved slightly. The new, improved website has more capabilities than the old site and will now work on a variety of devices including mobile phones. There are a bunch of new features, including links to our online databases, including the Tylecote and National Slag Collections, among others.

The newsletters have been given a facelift, and each newsletter or ***Crucible*** has a list of contents before you download them, making it easier to find the one you want. A timeline of past events has been compiled, and many of the events from the last 20 years have their own pages with photos, reviews, abstract books and/or programmes (where available). There is also the facility to have items on a map, a glossary, and we have created a space for members to contribute either portfolios or items of research they would like to share. Hopefully, with contributions from HMS members, these will provide more reasons to visit the site. Finally, the shop has been improved with list of titles, authors and searchable abstracts. I hope that in the near future we will have even more improved content. The new system means that downloadable volumes (which are out of print) can be purchased and immediately downloaded. I hope you enjoy the new website! Please let me know if you encounter any problems at **webmaster@historicalmetallurgy.org**

Ellie Blakelock (HMS Web-manager)

Covid-19 and HMS

Frankly, we have been taken by surprise.
A month ago we had made no preparations; three weeks ago we began to write an operational plan for keeping HMS going during the emergent pandemic and 19 days ago we held an on-line meeting of HMS Council to put in place the basic arrangements. We are not alone in being caught out. Despite glib daily televised briefings from ministers, the (slender) literature of Covid-19 (see BMJ, Lancet, Nature) shows that the basic parameters of the problem are still subject to huge uncertainties and the final outcome estimates are, therefore, no better than order-of-magnitude estimates.
Fortunately for HMS, some of the basic precautions have been taken. Cancellation of the AGM and the associated conference (known as "Accidental and Experimental 2.0") could have been very expensive indeed. Fortunately, the organiser, Vanessa Castagnino, negotiated timely deals that mean postponement will cost the Society nothing. Similarly, Ellie Blakelock fixed meetings without incurring cancellation charges.

So, to extract a positive, please put June 4th- 6th June 2021 in your diary for the Conference and activities that should have happened in Cranbourne this June.

It is also fortunate that HMS changed its rules recently to allow its Council to make decisions via electronic media. We tried this out last year and again a few days ago when we needed to cancel the AGM and Conference. As I write (Saturday 4 April) Council should have been meeting in Leeds. Instead I can see that members of Council are actively using a rather cumbersome online discussion board to consider the business of the Society. It will fall to Chairman Paul Rondelez to summarise the discussion of each issue and to rule on the results. Advice from Company's House and the Charity Commissioner is being kept under review as it is being updated.

The society *will* continue to do its business and members *will* remain in contact. Please look for the new (and excellent) website **https://historicalmetallurgy.org/** This should improve communications during this time of isolation.

Jonathan Prus (Hon. Sec.)

ERRATA CORRIGE - HMS SUPPORTED PROJECTS

Dear members, we would like to apologise for an error in our Issue 99 Winter 2018 p.4.

The Burghmote horn pictured is in the care of New Romney Town Council and not of the Folkestone Town Council as erroneously stated.

The traditional craft of leather bellows-making: techno-ethnoarchaeological perspectives from Sholapur, India

Bellows are devices constructed to furnish strong blasts of air into the hearth or furnace, resulting in the fuel burning more intensely and with a brighter flame. Although the use of bellows is a crucial aspect of metallurgical processes, this is one area that does not lend itself to easy study in the archaeological record since bellows are made of perishable materials. Although fragments of furnaces and other forms of archaeo-metallurgical debris such as tuyeres, crucibles and moulds are known, bellows are rarely reported from archaeological contexts, particularly from India.

It is therefore timely to trace the making of leather bellows in India through evidence for current practices. This study brings out the methods of manufacture of leather bellows with the help of a survey of workshops in the Sholapur and Nagpur areas. This research will document and understand the technology of leather bellows-making from the initial to the final stage. It is important to document the indigenous craft of bellows-making so that the craft can be passed on to future generations. This research will discuss the methods of traditional leather bellows-making with reference to Sholapur district, Maharashtra, through an ethnographic survey. The research has been supported by an award from the R.F. Tylecote Fund.

Study Area

Sholapur district is located in Maharashtra state, India (Fig. 1). The city of Sholapur is the district headquarters and is located on the south-east edge of the state and lies in the river basins of the Bhīma and Sina rivers. The Sholapur district is rich in archaeology and history. The leather bellow-making artisans are located in Kontam Chauk, Basaveshwar circle, in Sholapur city.

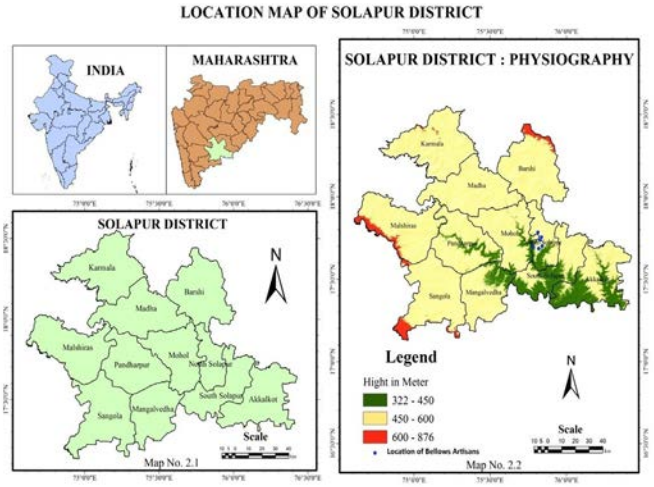


Fig. 1. Location of Sholapur District, Maharashtra

Observations on bellows-making in Sholapur

Bellows-making in Sholapur involves a variety of techniques and processes including preparing the goatskin, shaping the wooden components, making the desired outline for the bellows length and size, and creating the designs to decorate the wooden frame. Indian smelters and smiths regarded the bellows as the most important element of their work. In many parts of India, the iron-smelting process was simply known as 'blowing the bellows' and competent smiths were referred to as 'men skilled in bellows'. Iron smelting and forging technology has a long history and is practiced even today. Despite this, we have no evidence for bellows in the archaeological assemblage. However, in ethnoarchaeology we have important information on the making of bellows for smithies (Fig. 2 and 3).

Fig. 2. The author with the leather bellows artisans from Sholapur

Fig. 3. Bellows made in the Sholapur workshop

The decline in leather bellows-making techniques

The current situation is that leather bellows-making is fast disappearing, the numbersof artisans is dwindling as many are changing their occupation as the demand for leather bellows declines. The main reason for the decline in demand is the use steel mechanical bellows now available in the market. These new bellows are compact and therefore easier to use for the ironsmith. Very few ironsmiths are now buying the traditional leather bellows. Further reasons for the decline in bellows-making is the lack of goat or cow skin, and the lack of skilled labour to work in the workshops alongside the skilled traditional chief artisan.

S. Udayakumar

LESLEY-ANN COWELL - MEMBERSHIP SECRETARY

I joined HMS with Mike in the 1980s. Although I have a limited knowledge of metallurgy, archaeology or history, I have always enjoyed the meetings and conferences – and learnt a little along the way. I became Membership Secretary in 1999 whilst still working as a Registered Paediatric nurse.

My main function is to keep the database up-to-date so that members receive their copy of ***The Crucible***. I also ensure that lapsed members are removed so that postage costs are not wasted. I keep files of new and removed members so that the statistical trend of membership is available for Council. And I work closely with our Treasurer to ensure that he is notified of all the PayPal payments and we correlate information. I also bank the cheque payments. I am co-opted onto Council so feel I am able to have a positive input into some aspects of running the Society. I am responsible for mailing ***The Crucible*** to members three times a year, together with any other papers they require for information. Latterly I have also taken over mailing the journal, *Historical Metallurgy*, to our overseas members. This has helped in cutting down the amount of time it has taken them to receive their copy.

I very much enjoy engaging with members through emails, letters and phone conversations. The job has changed quite a lot since 1999 but nevertheless keeps me quite busy. Over the years, I received lovely letters, cards and words of kindness from members, all very much appreciated.

Outside of HMS I am an active member of our church, including being secretary of the Parochial Church Council, a Sunday school teacher and, once a week, taking the worship session at our village school. I also currently edit our Parish magazine, and I am a volunteer with our local Brownie unit. I take bookings for both our village halls, as well as being a Trustee of one of them. In between everything else, I also enjoy amateur dramatics and if that were not enough, there is the community choir and my small allotment plot!

AUDE MONGIATTI

I have been working as a research scientist in the Department of Scientific Research at the British Museum since 2007. I have an interest in both archaeological and ethnographic material and technologies, such as ancient crucible remains and museum artefacts as well as current indigenous manufacturing processes.

I hold an MSc in chemistry with a specialisation in materials science from the French Grande Ecole *Ecole Nationale Supérieure de Chimie de Paris* and I then completed a PhD in Archaeological Sciences/Archaeometallurgy at the Institute of Archaeology of University College London in 2009.

Several current research projects, which I am involved in or have worked on recently, include the ethnographic and scientific study of modern silversmithing in Oman, with a special focus on a community of female silversmiths from southwestern Oman; study of Scythian gold artefacts from the State Hermitage Museum and the British Museum; and Sasanian and early Islamic copper-alloys from the Persian Gulf.

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

I have spent all my professional life in the British Museum, having been very fortunate to get my current job before finishing my PhD. The extraordinary BM collection has given me the opportunity to contribute to studies on artefacts from a variety of different cultures and periods, from Achaemenid gold from the Oxus Treasure, Anglo-Saxon gold from Sutton Hoo and Taplow, Iron Age gold from Snettisham and Scythian gold, to EBA copper technologies from the Iberian Peninsula and archaeological crucible remains from early Islamic Iran and first-century AD Sudan. The human dimension behind all these past and present material cultures never stops fascinating and amazing me!

THE CRUCIBLE: What is your most memorable professional moment?

Tricky one! There are many! One memorable event was during my PhD, about 15 years ago, when I was involved in the digging of the substructure of a Roman iron smelting furnace on Dr Brigitte Cech's major *Ferrum Noricum* excavation site in Hüttenberg, Austria. It was my first experience on a dig and surreal to be sitting cross-legged inside a 2000-year-old structure, whose diameter was as large as my arms fully stretched sideways and whose height was almost mine! I felt small and in awe of ancient technology: it comforted me in my choice of studying archaeometallurgy! A totally different but fantastic experience took place last year, on my first ethnographic field trip, when I met incredible ladies, female silversmiths and potters in Dhofar, southwestern Oman, who were the embodiment of women's empowerment, adaptation, resilience, entrepreneurism and a real inspiration.

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

Very difficult to single out one individual, as many colleagues and mentors have inspired me over the years. I would not be the researcher I am today (for good or bad!) without the teaching and advice received from my two PhD supervisors Thilo Rehren and Marcos Martinón-Torres; without knowing it, they are probably still influencing the way I carry out research today. It has also been a real pleasure and great learning and stimulating experience – and still is – to work alongside my BM colleagues, such as Nigel Meeks, Sue La Niece, Janet Lang, and Duncan Hook to name but a few. However, one researcher who has probably been most influential – and still is – is Paul Craddock, whom I have had the real privilege to have as a colleague and who has always been eager to share his extensive knowledge and invaluable experience.

THE CRUCIBLE: What is your main current project?

I am currently involved in an exciting international collaboration with three exceptional researchers: Dr Fahmida Suleman (Curator of Islamic Art and Culture at the Royal Ontario Museum, Canada), Moza al-Wardi (Director of Collections at the National Museum of Oman) and Marcia Dorr (independent scholar and consultant for the Oman Across the Ages Museum project). Our project researches modern silversmithing practices in Oman, with a special focus on a community of female silversmiths from the southwestern part of the country.

This project started 10 years ago, when Fahmida, at the time curator of Modern Middle East at the BM, acquired a large collection of 20th-century Omani silver jewellery from northern and central Oman, for which I studied the manufacturing and decorative techniques, and interviewed

a silversmith from Nizwa, northern Oman, to document present-day processes used by a traditional silversmith. This was followed by the acquisition of a second contemporary collection from the south of Oman, which is undergoing a similar scientific study. The silversmithing techniques and materials will be compared between regions and with those used by currently practising silversmiths or recently retired smiths to understand whether any changes have occurred to reflect adaptation to modern demand and variations. This study comes at a crucial changing time for silversmithing in Oman: this craft has been a long and reknown tradition, a national pride, and it is currently disappearing in the present socio-economic context. We would like to document the traditional processes before they totally disappear by interviewing silversmiths from different regions of Oman.

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

Not having specialised in a particular culture, time or region, I find it difficult at this point in my career to pinpoint one project. My research interests and projects have developed through discussions and collaborations with curators and archaeologists and are centred on the BM collections; it is such a vast collection that I feel I have only caught a glimpse of individual cultural points in time and space and cannot connect the dots yet (if ever…). However, documenting and contextualising modern endangered silversmithing traditions in Oman, which are changing and potentially disappearing at a fast pace, inspires me to widen this type of research to any vanishing indigenous metal-related crafts.

Otherwise, the dream of any researcher I guess: creating an infrastructure dedicated to teaching/learning/studying archaeological sciences and especially archaeometallurgy, in a similar way to the Francis Crick Institute (on a smaller scale though…).

THE CRUCIBLE: Which publication should every HMS member read?

Having enjoyed working on many different subjects and developed widespread interests related to archaeometallurgy over the years, I am not sure I would recommend one specific publication. There are many good books and articles out there, in addition to new media, such as blogs and videos. I would rather suggest reading broadly and, as colleagues have advised before me, not only in the field of archaeometallurgy but in other fields as well, as great ideas can come from texts and studies not necessarily or apparently relevant to our field. I also find that discussing their published research with the authors of a book or article, if feasible, is most stimulating and useful as a learning process.

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

Nothing new here and true for any discipline I would say: keep an open mind; go beyond the mere technological questions and keep learning and asking questions about human beings and their choices. Discuss your research with peers from a variety of disciplines from sciences and the humanities, as they will be able to give you their own perspectives and this is key to getting as close to an understanding of past and present cultures as can be. Most of all: love what you do!

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

I learn something new pretty much every day and hope to be doing so for many years to come. I feel very fortunate to be able to work in an interdisciplinary field of research, which both stimulates and moves me. What I find most rewarding though are the many knowledgeable and inspiring colleagues from this community, thank you all!

LADLES FOR THE GREENSIDE MINE LEAD SMELTER

Cowans Sheldon was founded in 1846 when John Cowans and Edward Pattinson Sheldon, who had both been apprentices for George Stephenson, took over the foundry that had been set up at Woodbank, near Carlisle, by the Bouch brothers on a water-powered site that had previously been a printworks. William Bouch was given the job of locomotive engineer for the Stockton and Darlington Railway and both he and his brother, Thomas, became sleeping partners in Cowans Sheldon. They originally intended to make locomotives but the majority of the early work involved making wheels and axles for wagons, tenders and locomotives. A large amount of the work was for either the Sheldon Engine Works and Gilkes, Wilson & Co of Middlesbrough. However, examination of the order books show that they were happy to undertake any work to keep the company going.

Whilst searching through the order book of Cowans Sheldon in the Carlisle Archive Centre (DB/40/ORD/1) for evidence of them making parts for various waterwheels, I came across the two entries below.

10th July 1861 Greenside Mines

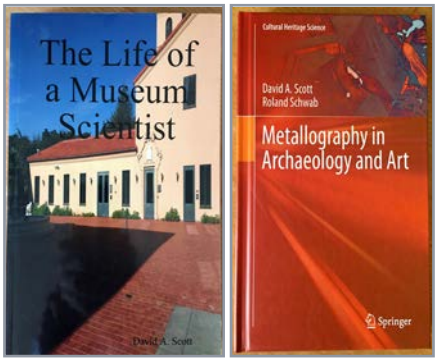
Number ordered	Size	Description
6	13 inch	drossing ladle
6	12 inch	drossing ladle
6	10 inch	drossing ladle
6	9 inch	drossing ladle
2	17 inch	separating ladle

1st July 1862 Greenside Mines (all interior sizes)

Number ordered	Size	Holed/not holed
3 ladles	13” diameter; 4.5” deep	½” holes
12 ladles	11½” diameter; 3” deep	5/16” holes
12 ladles	12” diameter; 4” deep	½” holes
	all of the above 8½d each	
24 ladles	9” diameter; 4” deep	no holes
12 ladles	5½” diameter; 2½” deep	no holes
12 ladles	6” diameter; 2½” deep	no holes
	all of the above 7½d each	

Greenside Mine is situated at the junction of Swart Beck and Glenridding Beck (NY 365 174) in the Lake District. Mining probably started in the mid-18th century, but closed in 1819, and was reopened in 1825 by the Greenside Mining Company. A smelter was built in 1827-29. Further additions were made in 1830, with a slag hearth and silver refinery. Increased ore production lead to reverbatory furnaces being added between 1844 and 1851. These however proved expensive to operate and were removed, and in 1855 simple ore hearths were installed. It will have been in this smelter that these ladles were used. Not knowing a lot about lead smelting or separation of silver I was intrigued by the wide range of ladle sizes ordered but of no great actual difference in size.

Graham Brooks



TWO BOOKS FROM DAVID SCOTT

The Life of a Museum Scientist. This volume charts the journey of an academic from a working class tower block in inner London to the Museum Research Laboratory of the J. Paul Getty Museum. The book is available on Amazon for about $16. Dr. Scott eventually left the Getty to found the UCLA Conservation Training Programme in Archaeological and Ethnographic Conservation, and became a distinguished professor in the Department of Art History at UCLA in 2003. The new programme was a great success, and Professor Scott “retired” to Hastings in 2017. He still runs his Summer School, On Ancient Metals and Metallography each year in Hastings. This course has been running since 1983.

Professor Scott and Dr. Roland Schwab have co-written a volume on Metallography in Archaeology and Art, published by Springer in 2019. The book provides a comprehensive introduction to the metallographic study of ancient metals. Metallography is important both conceptually as a microstructural science and in terms of its application to the study of ancient and historic metals. This volume is 260 pages in length and provides a useful synopsis of the subject from two different experts in the field.

THE EARLY DAYS OF WIRG'S SMELTING EXPERIMENTS

In July 1969, the late Prof Henry Cleere conducted four experimental bloomery smelts. The last two, on 26 and 27 July, being demonstrated to the public for the princely sum of one shilling (5p post decimalisation!). The wider event, *'Horam Week'*, was organised jointly by the Wealden Iron Research Group (WIRG) and the Sussex Industrial Archaeology Study Group.

WIRG recently came into possession of Henry's records of these smelts, and have passed them to the Historical Metallurgical Society for archiving. At that time in 1969, Henry was General Assistant Secretary of the Iron & Steel Institute, which enabled him to coax funds, equipment and analytical facilities from the then British Steel Corporation (BSC) and the British Iron & Steel Research Association, (BISRA), and advice from various Universities. HMS also contributed with advice and some analyses via interested members. Indeed, as evidenced by the many letters Henry wrote to gain support, he even persuaded Monty Finniston - later to become Chairman of BSC - to authorise assistance. Items included the loan of an expensive Pt/PtRh thermocouple, enabling temperatures in excess of 1000°C to be recorded, an Orsat gas analyser to calculate CO/CO_2 ratios and an electric blower. Laboratory facilities provided analysis and metallographic examination of the products, including using transmission electron microscopy – a far more challenging technique than today's more commonplace scanning electron microscopy.

Henry's bloomery furnace was based on his excavation of furnaces at Holbeanwood, an outlier of a Roman settlement at Bardon, East Sussex, dating from the first half of the second century. He used local clay, after tests by BSC showed it was sufficiently refractory. BSC also recommended adding 20% pre-fired clay grog to reduce shrinkage, something Henry did not do as there was no archaeological evidence for this. Ore was collected from a local brick quarry at Sharpthorne. Wealden ores are largely the iron carbonate, siderite, typically containing 40% or so iron, and are readily reducible after roasting.

The furnace (Fig.1) had a slightly tapering internal shaft, with a hearth diameter of 30cm and a top diameter of 20cm, built around a central former created using 'sausages' of puddled clay. The wall thickness was 9-12" (23-30cm) and height initially 2'6" (75cm) but extended to 3' (91cm) after the first smelt. The interior and exterior walls were finished with a clay slurry and left to dry for six days followed by gentle firing with green wood.

The tuyere was inserted through the clayed-filled slagging arch, using a different height or inclination for each smelt. An aluminium tube of 19mm diameter was used for one trial as well as trumpet-ended clay tuyeres and double tuyeres moulded within a single block of clay, based on rare finds at Bardown. Flagon necks had also been found at Bardown and also thought to have served as tuyeres,

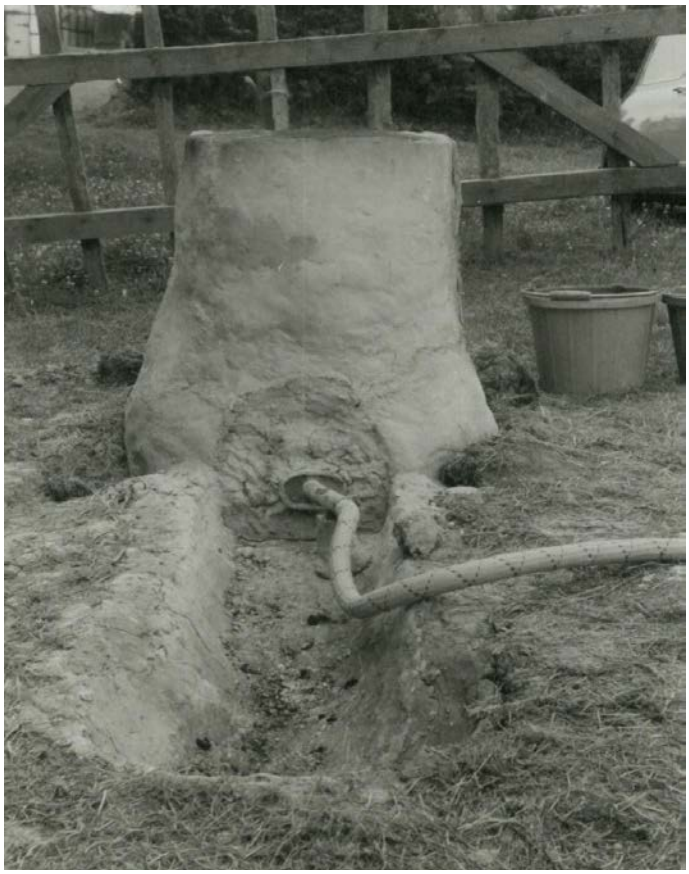


Fig. 1. The bloomery furnace with double tuyere inserted through slagging arch

possibly for a roasting trench. The maximum tuyere-position height above the furnace floor was 6" (15cm), dictated by the height of the slagging arch. A trench lined with clay was dug in front of the furnace to collect slag. Ore was roasted in pits, one square with a base of puddled clay, the other a trench 8'x1'x1' (243 x 30 x30cm), also lined with puddled clay and open at one end, based on evidence from the Bardown excavation. Layers of charcoal and ore broken to 2-3" (5-7.6cm) were spread in this and ignited. To accelerate roasting, air was blown in via a tuyere. Roasting was stopped when the ore turned red but subsequent analysis indicated that only the surface had been calcined – at least in the samples examined. The magnetic response of this ore erroneously led Henry to the conclusion that magnetite (Fe_3O_4) had resulted; subsequent XRD analysis of current smelts by WIRG have shown the product to be the magnetic form of Fe2O3, maghemite. The roasted ore broke easily and was screened to select material of 3/8 – 1" (0.94-2.5cm), and charcoal of a similar size was screened for the smelt.

Four thermocouples were inserted through the back wall of the furnace at vertical intervals of 9" (23cm), the lowest (T1) being 2" (5cm) above the internal furnace base and the top one (T4) 5.5" (14cm) below the rim of the furnace. Each was inserted 2" (5cm) into the charge. The lowest thermocouple was Pt/PtRh in order to measure

temperatures in excess of 1000°C and the remainder were chromel/alumel (Fig. 2). An isothermal plot on a diameter of the furnace normal to the tuyere axis showed a symmetrical heat pattern ranging from 1300°C closest to the tuyere to 600°C near the top of the furnace and 500°C at the hearth circumference (Fig. 3).

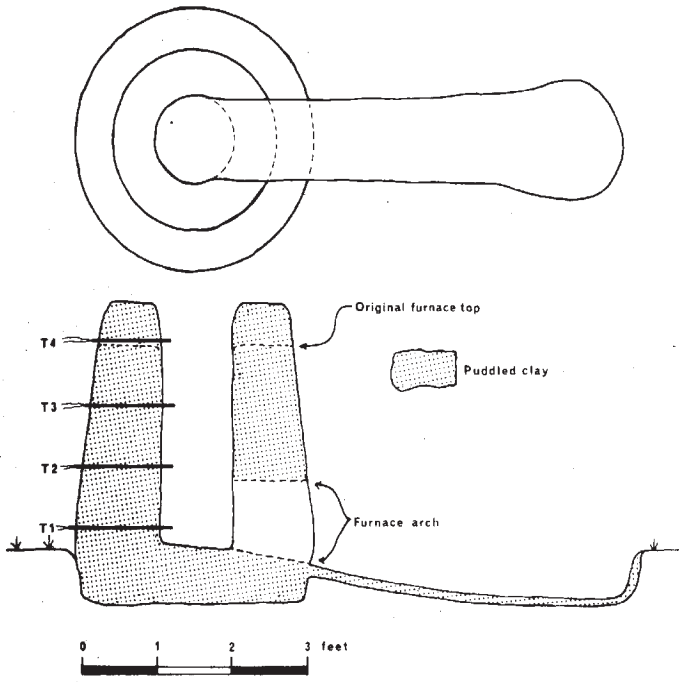


Fig. 2. Plan and cross-section of furnace with thermocouple locations

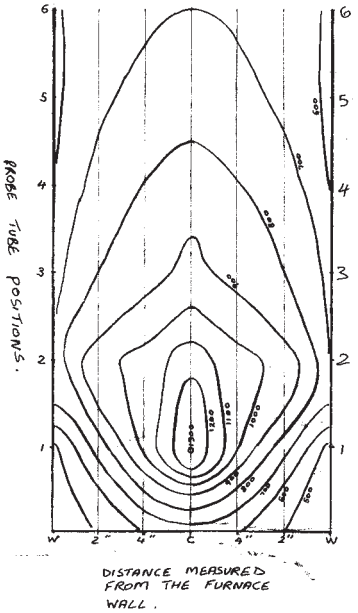


Fig. 3. Isothermal plot on a furnace diameter normal to the tuyere axis

The results of gas analysis taken every 30 minutes during smelt 2 – the longest and most successful – and smelt 3, showed that the level of CO_2 rises and reaches a fairly steady value after ore charging has stopped. Completion of reduction was marked by a drop in CO_2. A sudden drop in CO_2 during charging indicates that reduction has stopped and something is wrong. A rough guide to the progress of the smelt is indicated by the flame at the top of the furnace. This burns strongly before reduction commences and dies down as reduction proceeds, sometimes to the extent of being extinguished.

Of the four smelts conducted, the second, which took place over the longest period of 10.5 hours, was the most successful producing a bloom weighing 19.5 lb (8.8kg) from 201 lb (91kg) of ore and 217.5 lb (98.6kg) of charcoal, excluding that used to preheat the furnace. The charcoal to ore ratio was initially 1.5:1 for the first 2.5 hours, resulting in an initial $CO_2/CO+CO_2$ ratio of 22, which then fluctuated between 14.3 and 20.3, dropping steeply to a steady 12 when the charcoal-ore ratio was reduced to 1:1. This level was maintained over the next 8 hours to the end of ore charging. The slag totalled 139 lb (63kg). A single tuyere was used for this smelt, located 6" (15cm) above the internal furnace base and elevated upwards at 15°. The blower used provided a fixed air flow of 450 lit/min somewhat above the 300 lit/min recommended in the literature for this size of furnace (Cleere 1971). Consequently, blowing was reduced by an unmeasured amount by moving the air hose away from direct contact with the tuyere. In an attempt to simulate the action of bellows, an intermittent blow was introduced after an hour and 10 min by blocking the air blow for two seconds in every five. This was carried out for an hour and resulted in a fall in temperature of 50-60°C for the lower three thermocouples, and just 15°C for the top thermocouple. An acceleration in the downwards passage of the charge was noted due to the fluctuating pressure.

The other smelts produced little or no bloom, attributed in smelts 1 and 4 to heat lost during slag tapping by opening the arch too much and thereby re-oxidising the bloom. In the case of smelt 3, the poor result was attributed to the inability to tap slag as a sandstone block had been used to seal the arch, which became welded into place and could not be removed. For smelt 4, a block of turf proved the most appropriate method for blocking the base of the slagging arch, this burning through when slag accumulated behind it producing a continuous run of slag from an aperture 6x2" (15 x 5cm) for the remainder of the smelt. No attempt was made to empty the furnace on the same day as a smelt. Following a final charge of 2lb of charcoal, the furnace was left to burn down over night drawing natural draft through the tuyere and part opened slagging arch. A steel lid was placed on top of the furnace.

Sectioning of and metallographic examination of these and material forged to an arrowhead, as well as slag analysis

were conducted. The bloom from trial 2 blooms (Fig. 4) showed multiple voids and slag entrapment. Analysis revealed the iron to be almost completely ferrite of hardness 152HV_5 this suggesting an appreciable quantity of phosphorous present. The shaft of the forged arrowhead showed a carbon gradient from 0.1-0.2% at the centre to 0.7% at the surface, attributed to carburisation during forging (Fig. 5).

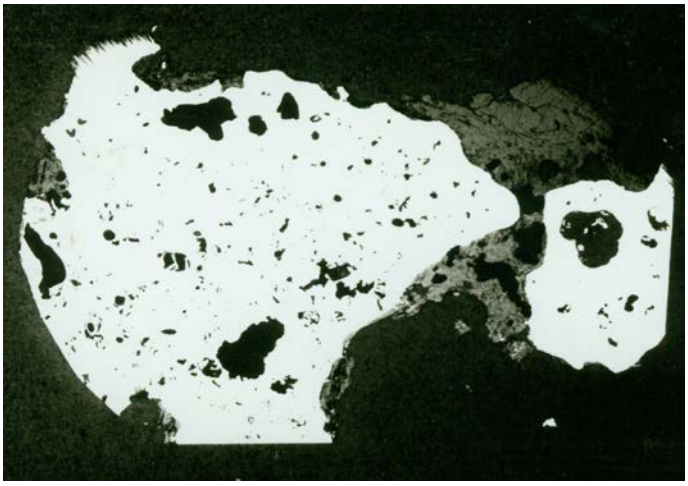


Fig. 4. Section of bloom (x5). White = iron, dark = voids, grey = slag

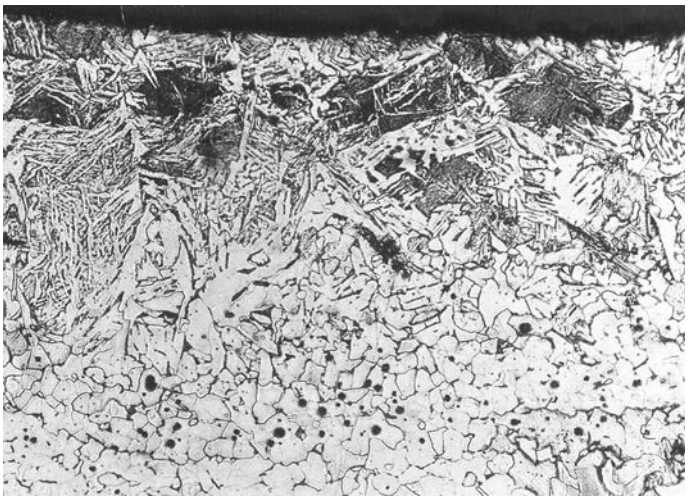


Fig. 5. Forged arrowhead shaft showing carbon gradient from interior to edge (x100)

Slags were chemically and metallographically analysed by BSC. The furnace slag (Fig. 6) was coarse crystalline enclosing charcoal fragments and contained pores encrusted with hercynite ($FeOAl_2O_3$) and fayalite ($2FeO.SiO_2$). Some wustite (FeO), and iron monticellite ($CaO.FeO.SiO_2$), were also present. The fayalite crystals were up to 3mm long. The presence of an abundance of hercynite was considered unusual and a result of a high proportion of alumina in the ore (5-7% in three of four samples). The tap slag (Fig. 7) consisted of phases of fayalite, hercynite, wustite, magnetite and iron monticellite with some locally occurring metallic iron, oxidised haematite and lime-rich pockets with dicalcium silicate and various calcium ferrite compounds (e.g. $2CaO.Fe_2O_3$) or with anorthite crystals in a glassy matrix.

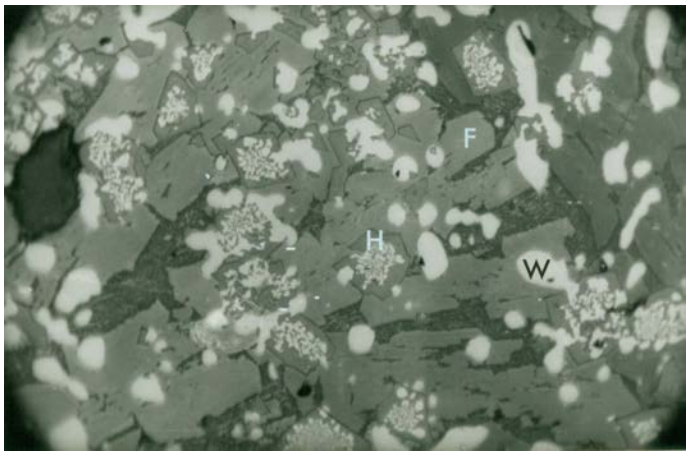


Fig. 6. Furnace slag: F=fayalite; W=wustite; H=hercynite (x165)

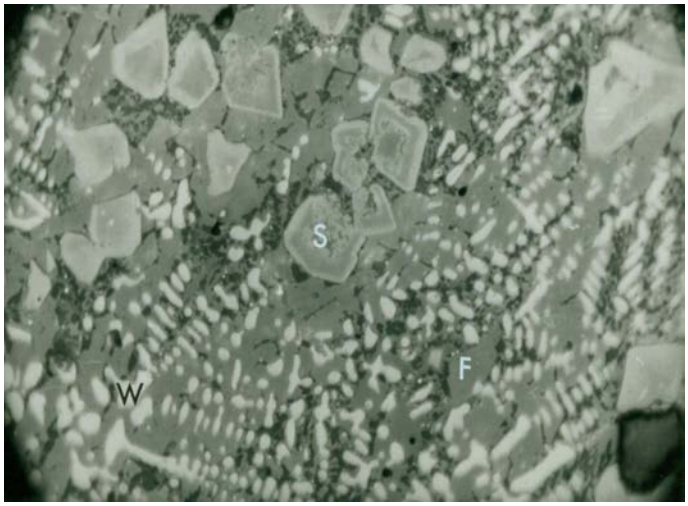


Fig. 7. Tap slag: F=fayalite; W=wustite; S=spinel Fe.Al (x165)

Today, WIRG continues the work of experimental smelting using a larger furnace of 60cm hearth diameter based on one excavated at Little Furnace Wood. The lower third is constructed as a dome with a shaft of nominally 30cm internal diameter rising to a height of about 150cm.

Dr Tim Smith

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AN EARLY COALBROOKDALE CAST IRON POT

This small Coalbrookdale three-legged cast iron bellied pot was found many years ago and has been in deep storage awaiting repair and cleaning. Inspired by the recent talk given by Richard Williams to the Newcomen Society, the pot has been unearthed and examined properly for the first time. This talk, amongst other things, gave the historical, technical and metallurgical background to the casting of these pots and can be seen here:

https://www.youtube.com/watch?v=NWANrIPzwB0&feature=youtu.be&app=desktop

The pot rim diameter is 20cm (8”) and its overall height is 15cm (6”), with the parting lines characteristic of a sand casting in a four-part mould. The main interest is in the unusual ‘trade mark’ which has been partially cleaned and reads **C • B • D A L E** and **1 G A L L** in two lines within joining frames, the name in a rectangle and the capacity in a trapezoid with curving sides. The mark is 6.5cm by 2.5cm overall and is slightly eccentric to the ridges, partly overlapping the upper ridge. Both the E and the right-hand side of the upper frame are rather faint, which suggests that the pattern was not fully impressed. The capacity is rather less than an imperial gallon (wine measures were used for Coalbrookdale pots until at least 1875). The ears are round in section and taper from 10mm to 5mm. Their distinctive shape is rather different to those on the earliest pots, which have ears made from two straight components. The feet are 4cm (1½”) long, D-shaped in section and taper from 15mm to 5mm. In the centre of the base is a slightly raised rough area of about 15mm diameter from the sprue. The pot is 4 to 4.5 mm thick at the rim, increasing to 5mm around the sprue. Unfortunately the pot is broken into two pieces but after cleaning and the removal of samples, for metallographic examination by Brian Gilmour, it will be repaired.

Some preliminary research has been carried out and such marks rarely seem to have been recorded on Coalbrookdale pots. There are two in the Ironbridge Gorge Museum, one with DALE CO in a rectangular frame on a large (?8 gallon) pot and one with COALBROOKDALE on a larger whaling pot, both probably of 19th century date. The former was used by John Challen for his 2010 BBC Shropshire programme titled *“The Darby Cooking Pot which changed the World”* and for a subsequent exhibition at the Ironbridge Gorge Museum. Other marks on furniture items, fire surrounds etc. seem to be more frequent, including COALBROOKDALE, DALE CO and C.B.DALE CO, the latter usually with the triangular Design Registration mark (dating from 1842 to 1876). It has been suggested by David de Haan that the earlier marks CBD or C.B. DALE were used before the company was restructured in the 1790s, and that the full COALBROOKDALE marks are mid-19th century. This indicates that this pot was probably made between the mid-18th century and 1794.

If anyone has any information about other similar pots, named or not, either in museums or private collections, or about the possible dates of the different marks and company names used, we should be most grateful for details.

Peter Crew and Richard Williams

THE FERRO VIVO PROJECT: THE ARCHAEOMETALLURGY OF IRON IN TARAMUNDI (ASTURIAS, SPAIN)

Taramundi is a county in western Asturias included in the Biosphere Reserve of *Ria del Eo, Oscos and Tierras de Burón*, which is known mainly for being the cradle of rural tourism in Spain but also because here past and present are strongly linked through the living heritage of iron working. Taramundi is part of the northwest peninsular area of Spain, where a significant iron industry, organized as a network of water-powdered smithing centres, equipped with mallets and forges, was set up between the 16th-19th centuries (Fig. 1). The industry survives as a cultural legacy still visible nowadays through the artisan production of renowned quality pocket-knives and knives, unique to Asturias.

Fig.1. The landscape of Taramundi is made up of narrow valleys, with dense vegetation and small settlements that preserve traditional stone and wood architecture. Traditionally, rivers and streams were used to drive hydraulic mills, including mallets for the forging of iron billets and larger pieces. One of them, Os Teixóis, is still in operation today and can be visited as part of an important ethnographic centre (see front cover). The metallurgical tradition is currently maintained in the artisan production of knives (knives picture courtesy of J. Arrojo).

The casual discovery of slags during the execution of a forest track, in an area distant from the main concentration of artisan workshops, stimulated us to investigate further and generate information to support the a growing interest in iron making and working within this territory. Specifically, our focus was to search for the roots of the industry, the non-hydraulic technology prior to the 16th century, of which there is scant knowledge. This was the origin of the *Ferro Vivo Project: iron archeometallurgy in Taramundi*. In 2018, a multidisciplinary team of archaeologists, geologists, botanists, specialists in geophysical prospecting and archeometallurgy, focused on filling the knowledge gap concerning the beginnings of iron metallurgy in the area, and its history prior to the introduction of hydraulic technology, which characterises the well-known prime of the industry.

The existing data is vague and merely points to habitation settlements during the Iron Age II and the High Roman periods in the vicinity of Os Castros, a major fortified archaeological site.

The Ferro Vivo Project is a private initiative that arose out of institutional disinterest in this idiosyncratic material and the intangible heritage of this community. With limited economic resources we have so far been able to carry out interventions at two archaeological sites:

As Mestas - this is the location where slags were collected after the clearing of a road (Fig. 2). The fieldwork include documentation of the deposits exposed in the cut section of the road, geophysical prospecting, AMS dating and archaeometric study of the slags (Fig. 3). The results confirm the existence of an iron workshop (a smithy) of which the extent was delineated. Within the workshop there was a series of structures, separated by walls, and soils altered by high temperatures, clearly devoted to iron working activities, were detected. The site is chronologically -dated to the second half of the 17th to 19th century.

*Fig. 2. Section of **As Mestas** discovered after the clearing of the road*

*Fig. 3. Cut section of a lump of slag recovered from **As Mestas**, showing large inclusions and corrosion by-products*

A Veiga de Escouredo lies on a small fertile plain close to the Cabreira river. Here, toponymic indications and bibliographic references suggested the existence of a hydraulic mallet, now disappeared. The fieldwork carried out at this site involved preliminary archaeological and geophysical prospecting, test-pitting, radiocarbon dating, and analytical study of the recovered technical materials (Figs 4 and 5). The research confirmed the existence of an iron workshop, but in this case the facility was not based on water-powered technology, and the chronology dated back to 1st-3rd centuries AD. The site appears to be related to Os Castros through dating and spatial proximity (it lies barely 200 m from the fortified town). Notably, this is the first ironwork of this kind researched archaeologically in Asturias. The site also presents a direct spatial relationship between the habitation area and the working space, a relationship hitherto unknown or unpublished within Taramundi`s archaeological register.

*Fig. 4. Excavation at **A Veiga de Escouredo** Roman period ironworking site close to the major settlement of Os Castros*

The slag analysed from both sites are the typical fayalitic slag with glassy matrix and abundant free iron oxides (wüstite), with a few particles of metallic iron. Significantly, in ***A Veiga***, the oldest site, both smelting and smithing slags were recovered, whereas in ***as Mestas***, the water-powdered facility, only smithing slag was recorded. These are only preliminary results, however, they seem to suggest that the older workshop was a complex smithy were more than one activity was taking place, while the more recent workshop was part of a more diversified industry where the smelting took place elsewhere.

Hence, ***A Veiga de Escouredo*** has been a pleasant surprise, dating back to the Roman-period and currently marking the oldest archaeological evidence of iron production, not only in the Taramundi area, but also in the overall Western area of Asturias. The research allows us to speculate that the iron metallurgy that had its peak here between 16th-19th centuries maybe the result of a technological tradition rooted to some 1400 years earlier. In addition to its obvious archaeological interest, this pioneer research also has an important impact within the local community, that discovers its traditional ironmaking heritage is deeply rooted within the land and through time.

*Fig. 5. Typical tap slag cake from **A Veiga de Escouredo** showing ropey flows on the upper surface*

These promising first steps encourage us to continue researching this much neglected area, with the aim of contributing to our knowledge of iron-making, preserving past technologies as well as the cultural landscape, in an attempt to make a significant contribution to the management of the cultural heritage of this area.

Estefanía Sánchez Hidalgo
Alfonso Menéndez Granda
David Larreina-García

Identifying metallurgical processes at the national site of Blihun Hanben – research in progress

The origins and development of iron smelting and smithing has received little attention in Taiwanese archaeology. Despite the discovery of several ancient iron working sites, most notably in the northern and eastern parts of Taiwan, none of the remains have been subjected to rigorous analysis and interpretation. This has led to an almost total absence of research on the ancient metallurgical traditions of Taiwan and a poor understanding of the development, diversity and origin of its iron working technologies (Chen 2000).

Recent excavations at the national site of Blihun Hanben, eastern Taiwan, provide an overdue opportunity to investigate iron working technologies in Taiwan. The excavations, conducted by teams from Academia Sinica and Archaeo Cultures Co. Ltd, unearthed the remains of a large settlement, c.400m N-S and 150m E-W, with two major occupation phases dated to c.1100 – 1400 BP and c.1400 – 1700 BP (Chu 2017). The site is situated on a narrow strip of land sandwiched between the Central Mountain Range to the West and the Pacific Ocean to the East, approximately 1km North of the mouth of Heping River (Figs 1 and 2). The site's later phase of occupation revealed a large quantity of archaeometallurgical waste (c.2.4 tonnes uncovered by Academia Sinica and another c.3 tonnes excavated by Archaeo Cultures). At the time of excavation the remains were characterised as smelting waste but the assemblages have now been made available for specialist analysis.

Fig. 1. Location of Blihun Hanben archaeological site in Taiwan (google maps 2020)

Fig. 2. The site sandwiched between the Central Mountain Range to the West and the Pacific Ocean to the East (google maps 2020)

A preliminary analysis of the archaeometallurgical remains from the Academia Sinica excavations has been published by Jiun-Yu Liu (Liu 2019) as part of his doctoral research at the Department of Anthropology, University of Washington, USA. The c.3 tonnes of material collected by Archaeo Cultures is being investigated by the author as part of a project funded by the Ministry of Science and Technology (Taiwan). The aim of this project is to provide a full assessment of the iron working remains from Blihun Hanben by combining morphological, microscopic and compositional analyses of the material. Along with Liu's (2019) findings, this would provide the first study of its kind for a Taiwanese site and hopes to inspire future studies and further research into past iron smelting and smithing in Taiwan. Here, the author presents some of the preliminary findings from the morphological analysis of the material (Fig. 3).

Fig. 3. Author recording the metallurgical assemblage from Blihun Hanben

Material

A total of 1768kg (57% of the assemblage) has been visually analysed. Six material types were identified – slags dominate (95.18%), followed by geological material (2.82%), possible working floor (1.39%), hammerscale (0.39%), iron (0.15%) and possible furnace material (0.07%). These types where further refined morphologically into 21 material sub-types. It is also important to note here that although Liu (2019) did not offer a quantification of material types, his classification of the remains shows that the same types of material were present in the areas excavated by Academia Sinica.

The most striking trend was the unequivocal dominance (c.85% of the assemblage) of small circular or sub-circular slag cakes with convex bases and concave top surfaces -- undoubtedly smithing hearth bottoms (Figs 4 to 6). Some of these cakes had sand covering their convex bases (Fig. 5), while others had geological material adhering to one edge (Fig. 6). This was consistently a slate-like material with vertically-oriented cleavage planes. The remaining slag consisted of small, complete or near-complete rounded slag lumps and amorphous charcoal-bearing slags also common in smithing assemblages. Small, solid fragments of slag were also found which probably derived from the smithing hearth cakes. Approximately 1.2% of the assemblage consisted of slag more reminiscent of smelting waste. This included large, amorphous and porous, charcoal-bearing slag fragments dominated by large charcoal impressions and voids as well as very few smaller, very porous, light fragments with an almost honeycomb-like texture.

Fig. 4. Example of a smithing hearth slag cake from Blihun Hanben

Fig. 5. Example of smithing hearth slag cake with sand on the underside

Fig. 6. Example of smithing hearth slag cake with adhering slate fragment

Possible working floor fragments (Fig. 7) were identified. These fragments varied in size and shape but larger pieces had a plate-like profile, thin (<4cm) with flat surfaces. They appear to be an agglomeration of compacted materials including sand, soil, charcoal, slag, stone and hammerscale. In addition, a few small fragments of possible vitrified hearth lining were also identified. However, preliminary microstructural analyses suggest that these fragments are vitrified geological material with unidirectional layers or bands of quartz and vitrified matrix, consistent with the plate-like morphology of slate or schist which are prevalent on site.

Fig. 7. Example of possible working floor fragment

Although the majority of iron artefacts recovered from the excavations were separated from the assemblage and are subject to specialist analysis by other researchers, small iron artefacts were still identified along with possible bloom fragments (Fig. 8). To the author's knowledge, the soils were not probed for hammerscale, a challenging task since slatey sand, similar in appearance to hammerscale, was abundant on the site. Nevertheless, larger hammerscale flats (Fig. 8) were identified, along with spheroidal hammerscale (Fig. 8).

Technology

The visual analysis of the assemblage has revealed an overwhelming dominance of characteristic smithing waste, particularly small concavo-convex smithing hearth bottoms and hammerscale. The majority of the other slag types are also common in smithing assemblages and represent small, amorphous slag lumps that form in the hearth away from the main slag accumulation. Only the larger, more porous charcoal-bearing slags resemble iron smelting waste. However, they constitute a very minor proportion of the assemblage. Considering that smelting, which produces substantial quantities of waste and typically dominates assemblages when both technologies are present on a site, indicates that blacksmithing was the dominant technology here and that iron smelting did not occur in the parts of the site excavated.

The presence of hammerscale is also informative. Although hammerscale flakes were not specifically probed for at the site, they were however present in the waste assemblage. While the large quantity of iron artefacts recovered indicates that secondary smithing and object manufacture was taking place at Blihun Hanben, the occurrence of hammerscale flats and spheroidal hammerscale are significant in that they are strongly indicative of primary smithing. The varying size and shape of the smithing hearth bottoms and small amorphous slag lumps also indicate the presence of both primary and secondary smithing. In addition, iron fragments resembling unconsolidated bloom iron support the presence of primary smithing and that the source of the iron is probably from bloomery iron smelting. Future microstructural and compositional analyses of the iron fragments and slags, planned for the next phase of this project, will shed more light on the technology used to produce the iron being refined.

Fig. 8. Small iron bloom fragment (left), hammerscale flats (centre) and spheroidal hammerscale (right)

The evidence for primary smithing is important. Given very little diagnostic smelting slag was present in the assemblage, indicating that iron was not produced within the settlement, where was the iron itself manufactured? Raw blooms of iron are rarely traded and exported over long distances since they contain substantial quantities of unwanted and heavy waste slag. It is therefore probable that the iron being refined in the smithing workshops of Blihun Hanben was produced near the site, outside the settlement and closer to the resources used in smelting (ore, clay and charcoal). The more diagnostic but sparse charcoal-bearing smelting slags identified in the assemblage could therefore be evidence of the presence of iron smelting nearby. In any case, it is certain at this stage that smithing was dominant at Blihun Hanben and that the iron being refined was produced elsewhere, beyond the excavated area. Determining where and how the iron was produced will require further survey and excavation in the areas surrounding the site.

Reconstruction

Two circular stone structures made of stacked schist and slate were unearthed during the excavation and identified as smelting furnaces by the excavators (Chu 2017; Liu 2019). However, neither structure was lined with clay and neither showed signs of having been subjected to high temperatures; i.e. no vitrification or adhering slag (Liu 2019). Based on this evidence, Liu (2019) correctly refutes their iron smelting associations and suggests instead that they could be smithing hearths. However, once again, with the lack of clay lining or convincing evidence for high temperature activities, it is hard to justify a correlation with the metallurgical activities on site. Their size is also problematic, with inner diameters up to 60cm they seem too large for smithing, particularly since the smithing hearth bottoms identified rarely exceed 15cm in diameter.

Several of the waste material types in the assemblage reveal clues of the type of structure that may have been employed in the smithing process. The presence of sand on the undersides of some of the smithing hearth cake similar to the sand found across the site, suggests that the hearths were dug into the ground (floor-level hearths) or at least that beach sand was intentionally used to line the base of some hearths.

Another diagnostic feature of these slag cakes is the adhering slate material on one edge. The slate is fused to the slag, often with partial melting of the slate surface and considerable erosion from the slag suggesting that they came into contact at high temperatures, most likely during the smithing process. An important feature is the orientation of these adhering fragments of slate. They are consistently set vertically, that is with the cleavage planes of the stone orientated vertically and the slag cake adhering on the flat side of the slate, perpendicular to the cleavage. This is in contrast to the large circular stone structures mentioned above, where the orientation of the stacked stones is horizontal. The slate fragments also often protrude from the slag in all directions, including the underside, suggesting that slate slabs may have been embedded in the ground. Melted sections of slate are also sometimes present above the cake suggesting that the air supply came into the hearth above where the slag cake formed. Taken as a whole, the evidence points to the utilisation of ground-level hearths with a slate charcoal-retaining wall similar to those reported by the Pioneering Metallurgy Project in South India (Fig. 9) (Girbal 2017, 182-184; Juleff et al 2011).

Fig. 9. Smithing workshop in the village of Nagaram, Telangana, South India (Pioneering Metallurgy Project 2010). Note the stone built charcoal-retaining wall of the hearth.

Preliminary conclusions and future work

Despite prior assumptions linking the waste at Blihun Hanben with iron smelting (Chu 2017), this study reveals the dominance of a large-scale bloom forging and blacksmithing industry during the later phase of the site's occupation c.1100 – 1400 BP. Nevertheless, the presence of primary smithing suggests that the iron being refined was probably produced locally and future surveys would be required to determine its location. The next stage of the project is to scientifically analyse selected samples using SEM-EDS with an aim of testing the observations made during the morphological analysis stage of the study. The data will then be compared with other analyses of iron working slags from Taiwan to generate a broader discussion on iron working technologies in the region.

Brice Girbal

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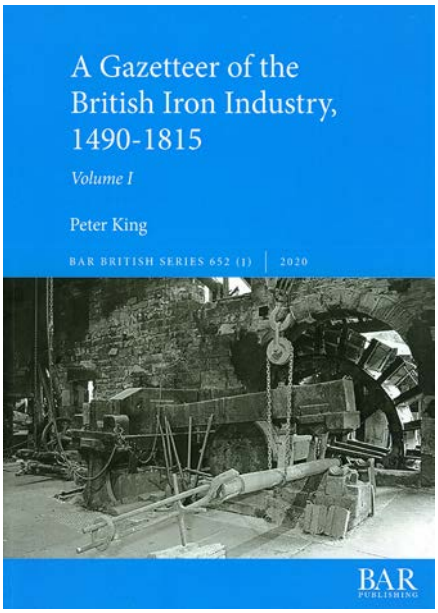
A Gazetteer of the British Iron Industry 1490-1815



Gazetteer cover showing Belly Helve Hammer at Wortley Top Forge

A two volume, 738 page book: *'A Gazetteer of the British Iron Industry, 1490 – 1815'*, published in January 2020, arises from extensive research by the author, Dr Peter King, dating back to the 1990s.

As the size of the volumes suggest, this is far more than a listing of sites. It includes a 13-page general introduction as well as regional introductions to each area described. The book encompasses ironworking sites, and the ironmasters who ran them and the trade. Descriptions of close to 450 blast furnaces, 400 refining forges, 78 bloomery forges and 163 other sites using iron, such as plating forges, screw mills, wire mills etc, are included, many in great detail.

All the sites were mechanically powered, mainly by water, but from the 1740s increasingly by steam, at first by pumping water that had driven a water-wheel back to a higher pond for re-use, but, by the 1780s, following the invention by James Watt to capture rotary motion, by directly driving bellows or air cylinders. The start date of 1490 coincides with the arrival of the first blast furnace in Britain. Using Walloon technology transferred from Europe, this furnace was at Buxted on the Weald of Southern England, an area rich in carbonate ore, timber for charcoal and streams that could be dammed to create ponds. The 1815 cut-off date is chosen as the point where the output of coke-fired furnaces exceed charcoal-fired furnaces, although this date is extended in some cases when the final days of a particular site are within a few decades of this date. Also, early coke-fired furnaces are included.

Regions are sub-divided into 44 geographic areas each with an outline map giving the location of sites by type and numbered for identification by name. Thus, for example, the Northeast Region is divided into six areas. Each area starts with a comprehensive introduction running to several pages. For example, the opening description of the Pennine Dales of West Yorkshire runs to seven pages and includes a family tree of the Spencers who, from 1658, were in partnerships owning several furnaces and forges in the area. The gazetteer of sites for this area is divided into charcoal ironworks, forges, smithies and water-powered bloomeries. Each site includes the national grid reference if known, a comment on the site as of now, the history of the site including ownerships and lessees, production and trading, and key dimensions and output if known. The sources of the information conclude the entry.

Dr King argues the case for correcting some past misinterpretation of sites, often where sites have been confused, either through common ownership or because they are in close physical proximity. Wherever possible, he has drawn on primary sources including estate records, account books, diaries of ironmasters and visitors, letterbooks, merchants' records and the Boards of Naval Ordnance and Victualling, the latter reflecting the high demand for iron barrel hoops essential for the provisions for crew.

Other useful information of a general nature includes a note on weights and measures. While our older generation may recall that an imperial ton consists of 20 hundredweight (cwt) or 2400 pounds (lb) (1.088 metric tonnes) they may not recall this was named a ton *longweight* to distinguish it from the oddly named Yorkshire *shortweight* ton of 22cwt (2640 lb or 1.117 metric tonnes), which differs again from the short ton of 2000lb (0.907 tonne) used only in the USA. Imports from Sweden were weighed in *skeppound* (shippound), equating to 299.8 lb (English) or 136kg, while Russian imports were based on the *pood*, equating to 36lb or 16.3kg. Tinplate, a key export, was sold by the box of 225 'single' sheets, each 20x14 inches (508 x 355mm), while 'doubles' were twice this length with 112 in a box. A box weighed 108 lb (49 kg). Other measures addressed are the 'load'(12 bags of charcoal = 3814 litres, weighing about a ton or 477 litres of ore).

Volume 2 closes with a two-page conclusion, a 41-page Bibliography, a four-page table of patents and a 59-page Index. The book has seven family trees but is light on tables, with only two, and lacks any illustrations of sites apart from the cover picture. However, given the great volume of information the book contains, the author can be forgiven for not including illustrations other than the 44 maps.

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Tim Smith

HMS Research in Progress Meeting 2019: McDonald Institute, Cambridge

This year's HMS Research in Progress Meeting was held at the McDonald Institute at the University of Cambridge. It had a great atmosphere and a very interesting and diverse programme of talks, covering many fields of metallurgical research. Everything from archaeology, history, scientific analysis, to experimental research was represented throughout the day, illustrating the breadth of the field of historical metallurgy.

Following a welcome from the organisers Yi-Ting Hsu, Jasmine Vieri and Julia Montes-Landa, the day began with a keynote presentation by Dr Jane Humphris, a Senior Research Associate at the Department of Archaeology in Cambridge. She discussed her project at the site of Meroe in Sudan, where a series of large slag mounds have been examined along with workshops and an associated mining site. The preservation of the workshops was particularly significant, with many of the clay pot bellows still remaining intact around the furnace structure, thus allowing the layout of these workshops to be reconstructed.

After the break, Session One commenced with Nicolas Nikis, discussing the copper trade in Central Africa. It was fascinating how extensive these trade networks were during the 2nd millennium AD and how Nicholas has been able to trace these by looking at the distribution of copper ingots, which are distinctive in their cross shaped appearance. His talk was followed by a presentation by Matteo Cataldo on non-invasive characterisation of Nuragic bronzes. Using neutron diffraction, Matteo has been able to understand the composition of the bronze and the metalworking techniques that were applied in manufacture, which has enhanced understanding of the development of metalworking within the region.

Jiun-Yu Liu presented his research at Blihun Hanben, a settlement site in Taiwan that has revealed evidence of ironworking. His investigation into the nature of ferrous pyrotechnology within the settlement has included possible evidence of furnace sites, from which he collected samples for analysis at the University of Washington. It was great that Jiun-Yu had made a special trip all the way from Seattle to attend the conference.

Before lunch we heard from Kay Smith about the continued work in casting a medieval canon. Last year Kay and Peter Vemming built a reverbatory furnace which was put into action this year to cast a bronze cannon. While several issues arose that prevented a full casting from being achieved, the project really demonstrates the benefits of experimental archaeology in understanding techniques and learning from mistakes. They hope next year to achieve a complete casting.

Lunch was held in the McDonald Institute and it provided a great opportunity to catch up and network, while eating delicious locally made pizza. The recently refurbished Museum of Archaeology and Anthropology is near to the institute, and lunch provided the chance for some members to visit its amazing collections.

Session Two began with a talk by A Bujl on neutron diffraction, which has been used to examine oriental swords. This was followed by Saltanat Amirova, who discussed her research into copper and tin bronze metallurgy on the Late Bronze Age site of Semiyarka in Kazakhstan. The site is large scale and could be identified through aerial reconnaissance along with metalworking debris. Crucibles attest to the production of tin-bronze at the site, a technique not usually identified in the region.

Tim Young presented on his analysis of hammerscale and the process of its creation. His experiments have significant implications for archaeology, in that it would appear much hammerscale residue is discarded during archaeological recovery. Louise Bacon gave a fascinating paper on Burghmote horns which she has been examining from Cinque Ports across Southern England. She explained how these horns were used in civic ceremonies to summon bailiffs of the city to the Burghmote court and are still used in special occasions to this day. Examples, such as one from Canterbury date back to the 12th Century. Her use of radiography has shed light on the metallic composition of these horns.

Stephanie Aulsebrook and Christina Clarke outlined past approaches to identifying Minoan and Mycenaean metalwork and the need to reassess the ways in which metal styles are classified. Using the Vaphio Cups as a case study, they explained that current stylistic classification is still largely based on the work of Ellen Davis, who, in interpreting the two gold cups, viewed the more 'peaceful' cup depicting a tethered bull as Minoan, while the second cup displaying a 'violent' capture of a bull was viewed as Mycenaean. Stephanie and Christina argued for the need to move away from an association of 'peaceful' Minoans vs 'warlike' Mycenaeans and be more critical of the way metalwork from the Bronze Age is interpreted. Jack Cranfield discussed his recent work investigating the Tudeley Ironworks in Kent, where he is applying a landscape approach to investigate the medieval ironworks and identify how it is connected to the wider economic landscape and associated industries. He hopes that the cross disciplinary use of historical sources and archaeological evidence, will shed new light on the nature of iron production in the Weald.

The final presentation of the day was given by Marc Gener-Moret, who, through the project IBERIRON, is examining metal technology of Iron Age weapons from the Iberian Peninsula. Scientific analysis using techniques such as SEM-EDS and LA-ICP-MS have been applied to look at the manufacturing techniques of weaponry as well as their significance in cultural and practical use.

Marcos Martinón-Torres concluded the conference by praising the diversity of research that is taking place within the field of historical metallurgy. From excavation, archaeological field surveys to experimental metalworking, all of these lines of inquiry were illustrated through the day's papers and how their findings are enhancing our understanding. Finally, the student prize was awarded to Saltanat Amirova for her pioneering work on copper and tin bronze metallurgy on the Late Bronze Age site of Semiyarka.

Everyone agreed that it was a brilliant conference, with an interesting range of papers. Particular thanks goes to Yi-Ting Hsu, Jasmine Vieri and Julia Montes-Landa from the University of Cambridge, for their time and hard work in organising such a great day.

Jack Cranfield

Virtual Out and About

As we are all staying at home across the world there is not a lot of out and about activity to report. So in its place the editorial team has indulged in our own 'virtual out and about'. Many of us are using some of the spare time we have been gifted by the situation to do that long overdue sort of the accumulated images on our computers. Hidden amongst all those thousands of photographs are some fascinating sites and objects and here a few from the editorial team. As none of us will be getting out and about again anytime soon we would love to run a readers virtual out and about in the next issue as well, so please start sharing your own favourite photographs.

Painting on mica of a smith, 19th century, Bangalore, India. These near-miniature paintings of the crafts and castes of India were popular during the East India Company period. The mica gives them a delicate, ethereal quality. I like the theatricality and self-importance of this smith, with his lustrous moustache, jewellery and draped curtain. He reminds me of Robert Knox's 1681 description of a master blacksmith in Sri Lanka, 'the Smith sits very grave upon his stool … they themselves who come with their work must blow the bellows … and they must hammer it themselves, he only with his little hammer knocking it sometimes into fashion'. Not the customary image of the dirty, muscled smith. *GJ*

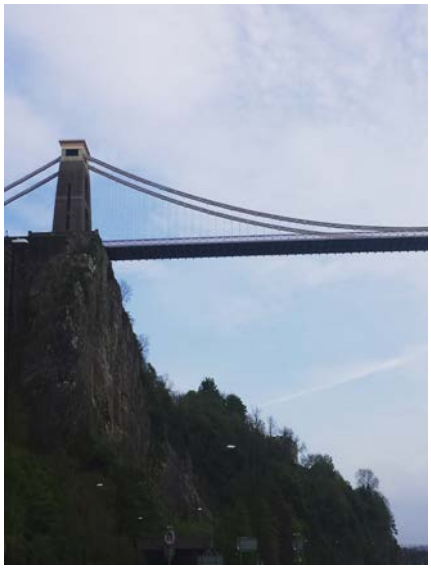
Detail from The Last Judgement (see front cover) triptych by Hieronymus Bosch, 1486, Groeningemuseum, Bruges. I was entertained to spot this detail in the typically bizarre and grotesque painting by Bosch. While, academically it tells us something about the structure and layout of a slightly run down smithy, its immediate impact is the cruelty of the torture, the central message of the painting. *GJ*

Last May, the **Sussex Weald Young Archaeologists' Club** had a session learning about the processes behind the production of early iron. The Weald has long been associated with the iron industry, which existed here from the Iron Age. In our many visits to archaeological excavations and fieldwalking across Sussex, the Young Archaeologists (YACs) have frequently uncovered evidence of the county's ironmaking heritage. One YAC even brought in a cannon ball that had been discovered under the stairs of his house during building work, a reminder of the cannon industry that was prevalent in the Weald during the sixteenth century. We recreated our own replica furnace using air-drying clay and an old wicker washing basket – complete with tissue paper fire, to demonstrate how a furnace would have operated to produce a bloom of iron. The use of bellows meant the YACs could appreciate the importance in keeping the furnace supplied with oxygen. *JC*

Few years ago I had the fortune of visit the **village of Argentiera**, in the county of Sassari, in Sardinia (Italy). The mining landscape and buildings still present in the village are striking and I found the place extremely interesting and beautiful. Argentiera was a lead mine, where also zinc and iron were extracted and it was functioning until pretty recently (1960s). Many structures were made of wood and archival photography shows a very intense system of buildings linked to the mines. Some of the buildings still in existence are now used for exhibitions linked with the mining heritage, organised by the Department of Architecture (University of Sassari), and the company Landmarks. In my last visit Landmarks had also set up a "remediation" garden with a large variety of autochtonous hyperaccumulator plants that thrive in contaminated soils. *LA*

Yantra Raj astrolabe, 18th century, Jantar Mantar observatory, Jaipur, India. One of the world's largest astrolabes, these two huge discs, one of iron and the other bronze, are now presented separately but would originally, I understand, have been joined to form a single instrument on a central spindle. There are precise azimuth lines scribed onto the bronze disc and the plates of the iron disc are beautifully riveted. *GJ*

Every time I pass through Bristol I always look with amazement at the Clifton Suspension Bridge and I feel some sense of pride since I work at Brunel University, London, and the bridge was built based on Isambard Kingdom Brunel's design (even though the revisions made later do move away from his initial plans). It just occurred to me though how the bridge also enters in the heritage of iron production of the UK in the 19th century. Completed in 1864, it comprises three independent wrought iron chains mounted on roller saddles at the top of each tower in order to move independently and counteract the passes of loads on the bridge, and 162 vertical wrought-iron rods in 81 matching pairs that suspend the bridge. Contracts with the Dowlais ironworks for iron supplies to build the bridge were made ensuring the strong link with iron production in close-by South Wales industrial area. The reality is that the iron used was in fact coming from the demolition of another of Brunel's bridges in central London, however in the story, the strong link between mining and civil engineering remains alive in this iconic bridge. *LA*



Conference, date and locations	Description	Websites and emails
Public Lecture: Great Metallurgical Myths of 18th Century Iron Making by Richard Williams 27/04/2020 Kelham Island Museum	CANCELLED	http://www.simt.co.uk/whats-on; email: ask@simt.co.uk
Trial by Fire 2020 02/05/2020 - 03/05/2020 University of Liverpool	CANCELLED	https://www.trialbyfireteam.com email: trialbyfireteam@gmail.com
43rd International Symposium on Archaeometry ISAS2020 18/05/2020-22/05/2020 Lisbon, Portugal	Postponed – further details to be confirmed	https://www.isa2020-lisboa.pt/ email: isa2020@isa2020-lisboa.pt
DigNation Festival 2020 13/06/2020-14/06/2020 Sudeley Castle	Tentative – further details to be confirmed.	https://digventures.com/projects/dignation email: hello@digventures.com
EAA Annual Meeting 2020 26/08/2020-30/08/2020 (Tentative). Virtual meeting	Tentative - Virtual meeting, with further details to be confirmed.	https://www.e-a-a.org/EAA2020 email: helpdesk@e-a-a.org
The Tenth International Conference On The Beginnings On The Use of Metals And Alloys 7/09/2020 -10/09/2020 Bangkok, Thailand	Further information to be released at the beginning of June.	https://www.sac.or.th/interconference/bumaxbangkok2020/index.html email: reg.bumax@gmail.com
7th Balkan Symposium on Archaeometry 22/09/2020-25/09/2020 University of West Attica, Athens	The main theme of the Symposium is: "Science and Heritage" and it will focus on interdisciplinary research projects on cultural heritage of the Balkan countries.	https://bsa7.uniwa.gr email: bsa7th@gmail.com
Reconstructive and Experimental Archaeology Conference (REARC) 16/10/2020- 17/10/2020 Virginia , USA	The Centre for Historic Preservation at the University of Mary Washington will host Friday presentations. And on Saturday, REARC craftspeople will hold a variety of demonstrations/workshops at George Washington's Ferry Farm. 150-word abstract submissions are due by 15th September.	https://exarc.net/meetings/rearc email: Neil Peterson neil@treheima.ca
ICANMR 2021: 15. International Conference on Archaeometallurgy and Non-Metallurgical Residues 15/02/2021-16/02/2021 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 and Non-Metallurgical Residues. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Archaeometallurgy and Non-Metallurgical Residues	https://waset.org/archaeometallurgy-and-non-metallurgical-residues-conference-in-february-2021-in-dubai
EMBERS 2020: Eurasian Metallurgy from Beginning to End Postponed from 02-04/09/2020 to 03/2021 Wolfson College, Oxford	Postponed until March 2021. Further details to be confirmed soon.	http://flame.arch.ox.ac.uk/embers/index.html email: embers2020@gmail.com
12th Experimental Archaeology Conference 29/03/2021-31/03/2021 Exeter, UK	Now is a good moment to look at where we are and set an agenda for the future. We at EXARC and the Dept. of Archaeology at Exeter University invite you to come to Exeter and celebrate where we are now and map out the future developments. We plan to make this a memorable bringing together of all of the diverse interest groups that contribute to the field.	https://exarc.net/meetings/eac12 email: info@exarc.net

Conference, date and locations	Description	Websites and emails
Iron in Archaeology 29/06/2021-2/07/2021 Fribourg, Switzerland	For all things iron in archaeometallurgy, hosted by the CPSA Comité pour la Sidérurgie Ancienne – the Committee for Ancient Ironworking.	
World Archaeology Congress WAC-9 postponed from 5-10/07/2020 to 04/07/2021- 09/07/2021 Prague, Czech Republic	Conference now postponed from 5-10/07/2020 to 04/07/2021- 09/07/2021	https://www.wac-9.org email: wac-9@guarant.cz
Interdisciplinary Intersections - ACANS-ANSTO 2020 Archaeology, Archaeometry and Cultural Heritage Conference Postponed from 14-15/09/2020 to 09/2021, Macquarie University, Australia	Postponed, further details to be confirmed. The overarching theme of the conference is the expanding and integral collaboration between the humanities and science in the fields of archaeology and cultural heritage. The aim is to explore the design of collaborative research projects which negotiate humanities/science boundaries and which propose interdisciplinary interfaces.	http://events.mq.edu.au/events/interdisciplinary-intersections-acans-ansto-2020-archaeology-archaeometry-and-cultural-heritage-confx email: Blanche Menadier blanche.menadier@gmail.com
EAA Annual Meeting 2020 Postponed from 26-30/08/2020 to 2022 Budapest, Hungary	Postponed until 2022, further details to be confirmed.	https://www.e-a-a.org/EAA2020/Home/EAA2020/Home.aspx?hkey=2913d798-bf0e-4a04-af62-1c28ba7bc0a1: email: helpdesk@e-a-a.org

VIRTUAL CONTENT

Programs/ Content	Description	Websites
"Our most metal episode of all time" from the podcast "The Dirt"	An episode covering the genesis of human-metal interaction, in the most metal way possible!	https://dcs.megaphone.fm/FULLCAST1809538609.mp3?key=834acddce6e96678e2312832d44a0e02
"Staffordshire Hoard: Interpretation with Cathy Shingler" from the "British History Podcast"	We are presented with an episode examining the Staffordshire Hoard with an insight into the past.	https://www.thebritishhistorypodcast.com/87-staffordshire-hoard-interpretation-with-cathy-shingler/
"Fossil Feathers in Colour" from the "Naked Scientist"	Dive into the past as scientist investigate the colouration of birds based on trace metals found in their pigments	https://www.thenakedscientists.com/articles/interviews/fossil-feathers-colour-planet-earth-online
"A history of Jewellery" from the "V & A" museum	The V&A museums tells us something we already know in a fancy way that our ancestors really loved shinny trinkets.	https://www.vam.ac.uk/articles/a-history-of-jewellery
"Open learn" from the "Open University"	Gaps in your knowledge or just curious? Take advantage of free courses covering important aspects of history.	https://www.open.edu/openlearn/history-the-arts/free-courses/?filter=date/grid/577/all/all/all/
"How to explore the British museum from home"	Traipse through the labyrinth that is the British Museum by using this amazing resource page.	https://blog.britishmuseum.org/how-to-explore-the-british-museum-from-home/