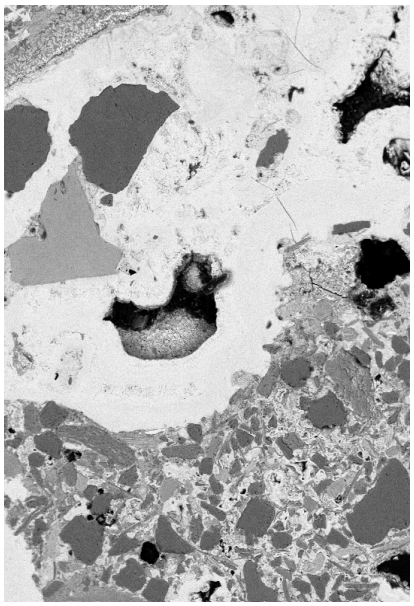
THE CRUCIBLE

Historical Metallurgy Society News
Issue 102 Winter 2019



Inside The Crucible

The HISTORICAL METALLURGY Society

Dear members, it is once again my honour to address our diverse membership across the globe. This time, I would like to give you some insights into what your Council has been up to recently.

There are dramatic changes happening in the international publishing world: information is moving from behind pay-walls to become freely accessible to both people and machines. Much is still being discussed but this Open Access movement will have a serious impact on how the Historical Metallurgy Society publishes its Journal. A Task Force has been set up to document the recent history of our Society (members, Journal, events, etc.) as well as looking at how other countries, institutions and learned societies are reacting to these changes. Next year, based on the findings of the Task Force, decisions will be made about the future of our Society.

I sincerely hope you are all enjoying your Journal. By the time you read this, Part 1 of Issue 52 could already be in your possession and we expect to have two further Journals ready by early next year. A major change is that from now on, Lesley-Ann Cowell will be sending out the Journals as opposed to the distribution firm we used previously. Especially non-British members should get their volumes much faster than before.

Thanks to Eleanor Blakelock's efforts, the HMS website probably looks rather different from the last time you visited. Still the go-to place for practical information on Journal articles and the HMS Datasheets as well as upcoming events it now has detailed information on the various HMS committees. An extended glossary of archaeometallurgy and access to the digital catalogue of the Tylecote and other collections are coming soon.

Especially exciting was an event recently organized by the Archives and Collections Committee as part of Ironbridge Gorge Museum's Festival of the Imagination. A guided walk took people through aspects of the local iron heritage ranging from slag mineralogy to working conditions of the period. Hopefully, Vannessa Cheel and her team, and others, can expand on this idea and bring the Society's knowledge to a broader audience.

But all the work done by your Council is ultimately destined to be of service to you, the membership, so if any of you have suggestions how we can do things better, do not hesitate to contact me or anybody else on Council.

Finally, I would like to thank all the other members of Council for their continued hard and creative efforts and to wish all members a Merry Christmas and a Happy New Year!

Paul Rondelez, Chair of the Historical Metallurgy Society prondelez@yahoo.com

DR SOPHIA ADAMS

Dr Sophia Adams is a Research Associate at the Scottish Universities Environmental Research Centre (SUERC), University of Glasgow, on the Leverhulme Trust funded project 'Setting Artefacts Free: an independent chronology for British Iron Age brooches'. Her archaeological career began in 1993 as a volunteer excavating sites in Kent; followed by degrees at University College London (BA and MA) and the University of Leicester (PhD), interspersed with developer-funded fieldwork, community archaeology projects and teaching roles. Her research focuses on later prehistoric artefacts: their production, use and deposition.

Front cover images:

Top Right: View of Dawley. The conical building is the Round House, a converted pottery kiln, since demolished. (Page 15)

Top Left: Amorphous silicatic matrix containing quartz grains, iron metal, iron oxide and calcium carbonate, of a sample from Roman age in San Tommaso, Pavia, Italy.

Bottom: Cooper bell (Page 9)

Historical Metallurgy Conference

Accidental and Experimental Archaeometallurgy 2.0

To celebrate the 10th anniversary of the hugely successful experimental conference at West Dean in 2010, and the subsequent volume of the same name, the Historical Metallurgy Society would like to invite submissions for both practical metallurgical experiments and oral presentations to be held over a two-and-a-half-day event at the Ancient Technology Centre, Dorset (https://ancienttechnologycentre.com/) in June 2020. We would welcome submissions from smelters, casters, smiths and related craftspeople.

Accommodation will be provided on site with the rare opportunity to sleep in a Viking Age longhouse. There will also be an area to camp close to the activities. There are additional accommodation/pubs and eateries available in the local village. Transport from the train station can be arranged. A 'conference dinner' will be available on-site and from 12pm on the Sunday, our activities will be open to visitors.

The call for oral presentation papers is now open, we would welcome offers on all aspects of experimental metallurgy. There are also still a few places available for experiments. Please send your proposals for oral papers or experimentation (with clear details of your experiment and its requirements) to Vanessa Castagnino (vrc505@york.ac.uk). The deadline for submissions is December 20th 2019.

For more details email vrc505@york.ac.uk or go to

http://hist-met.org/meetings/experimental-archaeometallurgy-agm.html

Slag standards for XRF

The ACC-HMS (Archives & Collections Committee) has become aware that a few people need standards for analysing ancient slags, especially those from iron smelting.

Do any HMS members

a) know of suitable standards,

b) also have a need for similar material or

c) would like to collaborate in the production of suitable standards?

Comments and wish-lists will be received gratefully at ACCchair@hist-met.org.

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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HMS Workshop

HMS is looking into the possibility of running seminars/workshops on aspects of archaeometallurgy.

The first of these would be on X-Ray Fluorescence (XRF) aimed at all users from the curious, to novice to expert.

This will be a hands on practical approach to the technique.

To gauge demand for this first seminar would anyone who may be interested in attending please contact

mike@mikedobby.com for further information.

FUTURE COVER IMAGES

Do you have any intresting pictures that you like to share with the community on the front of The Crucible?

Please send them to us at thecrucible@hist-met.org

DR JOAN TAYLOR

Dr Joan Taylor, who will be well known to members of the Historical Metallurgy Society as the author of Bronze Age Goldwork of the British Isles, died on October 30th 2019, after a long period of hospitalisation which followed a tragic fall at her home in the autumn of 2017.

She was born in Washington DC in 1940 and was the daughter of Frank Taylor, founding-director of the Smithsonian Institution's Museum of Technology and History (now the National Museum of American History). Joan was devoted to her father and his example and influence stayed with her all her life. Undoubtedly she inherited his interest in science and technology, and his devotion to education.

After taking a first degree at the University of Pennsylvania she planned post-graduate study there as well, but transferred instead to the University of Cambridge. Despite numerous visits to see her father, she never lived in America again. Her post-graduate studies at Cambridge, supervised by John Coles, set her on a path for life. This research focussed on Bronze Age gold-working in Britain and Western Europe, prompted by the opportunities and new data which were then becoming available through the application of scientific techniques to the study of gold artefacts. But she always saw this technology as part of society and influenced by historical events. She was one of the few archaeologists who did not buy the 'Beaker Package' and must have been very pleased to learn that the Amesbury Archer had come from Central Europe.

After her post-graduate research Joan worked in Birmingham Museum and later, Bristol, where she forged links with the South-West and its archaeologists which remained with her for life. But she preferred teaching to museum administration, and in 1976 she was appointed Rankin Lecturer in Prehistoric Archaeology at the University of Liverpool, where she remained until her retirement in 2008.

During this time she developed a fieldwork programme which involved work in Cumbria, Cheshire and on the Mendips. She was also involved with the Great Orme mines in North Wales, work which combined her expertise in the technology of bronze-working with an on-going excavation and exploration of the galleries. The work of her students has been important to the understanding of the significance of this surprisingly large mine, and to the success of its commercial display.

Working on this scale, Joan needed a network of friends and collaborators – and these she readily found. She was a member of the Bronze Age Studies Group, an informal, but very fruitful travelling circus of Bronze Age scholars (where I first met her) and of L'Association pour la Promotion des Récherches sur l'Âge du Bronze and remained devoted to the SW Museums Petrology Committee to the very end. She also maintained her close relationship with museums and worked especially effectively with Liverpool where she edited a useful series of 'Worknotes'. These friends and colleagues will be particularly saddened by her untimely death. At her funeral at Caldy in the Wirral on November 15th the wide range of people present, friends, colleagues and former students, all spoke of her great personal kindness to them.

Frances Lynch

Dr Michael Bode

I am an archaeometallogist currently working as the deputy manager of section material science/research laboratory at the Deutsches Bergbau-Museum Bochum (DBM). My main interests are trace element and isotopic analytics, provenance studies and ICP-mass spectrometry. I am currently working on projects on early Iron Age copper and Roman metallurgy in Europe and south east Asian archaeometallurgy.

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

With my diploma thesis in geology/palaeontology, my research focus was first rather on metamorphic petrology. However, through a colleague at the Institute of Mineralogy in Münster, I became aware of the Deutsches Bergbau-Museum Bochum (DBM) and its research on mining archaeology and archaeometallurgy, which I found very exciting. With the support of both institutions, I could work as a doctoral student on Roman-Germanic lead-silver production in Germania. In the right place at the right time, in 2009, I started as a Postdoc fellow at the DBM, being in charge of the new clean lab and trace element and isotopically analytics (HR-ICP-MS plus laser ablation). From then, which my analytical work, I was involved in many archaeometallurgical and mining archaeological projects at the museum and of external institutions.

THE CRUCIBLE: What is your most memorable professional moment?

Perhaps the stay in the museum of Olympia with my colleagues from the tripod cauldron-project in 2015 for sampling LBA/EIA-tripod fragments. Not only seeing the hundreds of classical helmets stored in the depot was very impressive, but also entering the Olympic stadium and (hopefully) feeling the spirit of the ancient athletes (just alone without any tourists that day!).

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

This is definitely my former supervisor, great colleague and friend Andreas Hauptmann, who is a 24-hour-scientist and has the precious talent to repeatedly fascinate people with archaeometallurgy.

THE CRUCIBLE: Which publication should every HMS member read?

One of many interesting publications: A. Hauptmann, E. Pernicka, Th. Rehren & Ü. Yaçin (eds.): The Beginnings of Metallurgy. Proceedings of the International Conference “The Beginnings of Metallurgy”, Der Anschnitt, Beiheft 9, Bochum 1999.

One Minute Interview

THE CRUCIBLE: What is your main current project?

With Moritz Kiderlen (Humboldt-Universität zu Berlin), Yannis Bassiakos, Eleni Filippaki and Giorgios Mastrotheodoros (National Centre for Scientific Research (NCSR) "Demokritos", Athens, I am currently working on the production and provenance of EIA copper-based tripod cauldrons from Greek sanctuaries. Copper ingots from that period are missing in Greece, for which reason tripod cauldrons (altogether 900 fragments) are the best alternative. As holy votive objects of highest category, they have not been recycled but after usage broken into pieces and buried close to the altar. Analytical data from more than 250 fragments are the basis on which we try to reconstruct the trade connections for the copper supply through the centuries from c. 1200 to 700 BC.

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

Chemically characterizing all ancient mining sites worldwide before (many) of them are lost by modern mining.

THE CRUCIBLE: Do you have any advice for young students interested in archaeological and historical

Be part of workshops doing experimental smelting and casting, visit old mining sites and be precise with analytical data presentation and aware of the data's true value (e.g. invasive *vs.* non-invasive measurements).

I would like to tell every reader of The Crucible that the best part of my job is to meet colleagues from other fields of research, to learn from them and to discuss with them open research questions.

FUTURE INTERVIEWS

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

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

ALEXANDER RABY – ENTREPRENEUR, PHILANTHROPIST AND BANKRUPT

Fig.1. Alexander Raby's furnace today at Llanelli, South Wales

In 1970 HMS held its conference in Swansea and visited a number of sites in the area including Alexander Raby's furnace at Llanelli, which they considered to be the best preserved furnace in South Wales. Forty-eight years later members of the Wealden Iron Research Group visited several of the same sites including Raby's furnace. Raby's furnace is presently badly overgrown with vegetation including tree growth which is damaging the structure. I have informed Cadw (Ref site CM219) who tell me they have now placed it at a 'Monument at Risk' level and will send the Field Monument Warden to assess the site and approach the owner to see if vegetation can be cleared. The site is on private land and the Warden will also see if he can obtain agreement for official public access. The following summarises the activities of Alexander Raby, a most remarkable man who first learnt his trade in the Weald of Sussex and embraced technologies bridging the 18th and 19th centuries.

The eldest son of a London ironmonger, Alexander Raby was born in 1747 and lived to the ripe old age of 88 - a significant achievement for those times.

In 1764, he was assisting his father, Edward, at Warren furnace in Sussex which, among other products, cast guns and shot for the Board of Ordnance. This market was precarious, highly profitable in times of war, but vanished in times of peace, often leaving gun-founders with cancelled orders and unsold stock on their hands. Smaller guns could be sold for merchant ships, but 'great' guns were only required by the government in times of war. Indeed, Edward Raby was declared bankrupt in 1764 but two years later was back in business offering guns to the Board of Ordnance.

Edward Raby died in 1771 when Alexander, now 23, was manager of Warren furnace. Even before his father's death he was establishing his own businesses, taking leases on water-powered sites in the adjacent county of Surrey and converting them to forges, rolling mills and foundries.

Local furnaces and forges were charcoal-fired but at his Downside Mill he brought in coal, since no coal measures occurred in the region, and built coke ovens to provide coke to fire air furnaces to melt metal for castings in iron and brass.

In his rolling mill he produce sheet for tin plating and employed women in preparing the iron plates for tinning. Despite having coke, charcoal-refined iron was considered better quality for tinplate with coke-refined iron considered inferior and simply referred to as 'coke plate'.

At Coxes Mill, the major output was hoops for barrels, which were in great demand by the government Victualling Board during the American war of Independence, from 1776 to 1783. This forge had a hammer working at 2700 blows an hour (45/min) which attracted complaints due to the noise. Likewise, complaints came from the owners of the canal which supplied the water to turn the waterwheels following unauthorised breaches to take more water. In 1798, he proposed building a new mill with the aim of adopting Cort's puddling and rolling method of refining pig iron patented in 1783 & 84, but there is no evidence this new mill was built.

In 1792, he took a lease on the Dale Abbey ironworks at Stanton in Derbyshire which had two coke-fired blast furnaces. No doubt the local coal measures attracted his attention since the first coke-fired furnaces were introduced by Abraham Darby I by 1709 at Coalbrookdale in Shropshire. His two Derbyshire furnaces produced 474 tons of iron in 1796.

In 1796 he sold Cobham Park, his house in Surrey for £175,000 and moved to South Wales. His first venture was to construct a blast furnace at Penrhiwtyn, Neath, probably using coke as fuel. Shortly after he moved to Llanelli, then a small fishing village and port, exporting coal, 12 miles west of Swansea. Here, he established himself as an iron and coal baron with interests in railways, ports and shipping.

He is credited with the growth of Llanelli into an industrial centre which, by 1886, boasted seven tinplate works, a copper smelting works, four large foundries, a lead and silver works, a ship-building yard, three sawmills and six collieries, the latter exporting 87500 tons a year. Today, only tinplate production remains in the town as Tata Steel's Trostre works.

In 1793, Raby foreclosed on a furnace built by two associates he had financed which first used charcoal but later coke. In 1800 he built a second furnace at present day Furnace on the NW edge of the town. Here, he also built himself a house. Output from the first furnaces was 1664 tons in 1796 rising to 2267 tons in 1805 from the two furnaces.

At first, demand was stimulated by the Napoleonic war (1803-15) and Raby supplied the Board of Ordnance with carronades (short barrelled cannon) and round shot.

Site	Location	Dates Occupied	Partner	Facilities	Main Products
Warren Furnace	Felbridge W Sussex	1771-1772	Edward Raby	Charcoal blast furnace & boring mill	Ordnance incl 'Great guns' Pig iron, castings in iron and bronze
Downside Mill	Cobham, Surrey	1770-1806	Mereton	Two refining forges, rolling mill, coke ovens, coke melting furnaces	Anchors, Castings Tinplate
Coxes Mill	Addleston e, Surrey	1776-1807	Obadiah Rogers	Refining forge Large hammer	Barrel hoops Bar iron Gun carriages Calcined lime
Abinger Hammer	Gomshall, Surrey	1783-1787	Unknown	Refining forge and wire mill	Bar iron Wire?
Dale Abbey furnaces	Stanton, Derbyshire	1792-1805	None	Two coke blast furnaces & Forge	Pig iron Castings Railway products
Ember Mill	East Molsey, NE Surrey	1795-1802	None	Forge	ironware
Llanelli Camarans hire	Furnace, NW Llanelli	1796-1820	None	Two coke blast furnaces, forges, bar mill, Collieries, Tramlines, docks	Iron, coal & coke Ordnance Railway products

Fig.2. Summary of sites held by Alexander Raby

Following the Peace of Amiens in 1802, Raby bought large quantities of cannon which were treated by a method which he devised for separating an amalgam of iron and copper. In 1804 he built a new forge with a mill to roll bar. However, orders for ordnance ceased in 1805 following Nelson's victory at Trafalgar. He constructed a dock and installed Trevithick high-pressure steam engines in one of his collieries and at his furnaces and forges. He owned four ships and a network of horse-drawn tramways including the Carmarthenshire Rail Road Company which brought iron ore and limestone some 12 miles to his furnaces. Good to his workers, he paid high wages and built over 100 cottages to house them.

But, by 1806, Railroad shareholders were complaining they were not receiving the expected dividends and Raby experienced a financial crisis. Tramway tolls were owed as well as £1000 rent on the sites of his furnaces. To raise funds, he sold his interests in Derbyshire and Surrey. By 1809 he was in financial difficulty again and all his assets in Llanelli were put up for sale. With his son, and help from friends, he set up a new company supplying iron and coal, but both furnaces were out of blast by 1815, the year of the end of the Napoleonic wars. By 1820, Raby & Son were in debt by £10,000 and work at the forge stopped. At the age of 76, Alexander Raby retired and in 1825 was forced to leave Llanelli moving to Bath in Somerset where he died in 1835 at the age of 88.

Tim Smith

Visiting the site

The site is at NGR SN 50381 01574 off the E side of the B4309 at Furnace on the NW edge of Llanelli. Turn first right after 250m N of the junction with Rhodfa Llwyneithin road. This is the dam of the lower furnace pond under which culverts can be seen. The upper pond, still in water, is 500m N. To access the furnace turn right immediately crossing the dam and descend a flight of concrete steps. Turn left at the bottom for ~ 100m to the furnace.

Acknowledgements:

This article draws heavily on the proceedings of a conference held by the Surrey Industrial History Group in 1998 'Alexander Raby, Ironmaster', a brief review of the Llanelli site in JHMS 5.1 (1971 p3) and production data from Phillip Riden's 'British Blast Furnace Statistics 1790-1980'.

Copper Bell Casting in Mexico

Pure copper bells, or crotals, were cast using the lost wax process during Phase 1 (AD 600 to AD 1200 or 1300) and Phase 2 (AD 1200 or 1300 to AD 1521) in West Mexico up until the Spanish Conquest (Hosler). Possible techniques for casting bells "in the style of" pre-contact West Mexico such as those found at various sites throughout northern Mexico and the southwestern United States – Snaketown, Pacquime, Gila etc. – are being explored because, although there have been a few previous efforts at recreating these delightful tinkley little creatures, the reported results, for instance using steam to force the molten metal into the mould, while certainly inventive, is not overwhelmingly convincing (Hawley 1953; Long 1964).

In some writings the question of process is bypassed and briefly summarized ... "Fabrication methods were identified through interpretation of artifact microstructure using metallographic techniques ... By examining the microstructure of an artifact it is possible to describe, step by step, the fabrication history of that object." (Hosler 1988, 1995) ... in favor of a more lengthy discussion centered on the question of what the bells were used for, the answer to which you would expect to focus on ceremony, dance, and spirituality.

However, in the case of the bells, a surprising analysis takes place around the idea of gold and silver representing the excrement of the sun and moon respectively, so that "casting" a gold or silver bell is aligned (synonymous) with creating this divine manure (Hosler). Interestingly, in the French language, the idea persists in that to "couler un bronze" - literally: to cast a bronze - is slang for defecating. Is it possible to imagine copper as the excrement of the earth and thereby extend the analogy to a copper bell as a sacred terrestrial object?

Through a series of experiments (trials by fire) it has been possible to recreate a lost wax casting process that produces a reliable and consistent ideophone. The results are of pure copper, contain a pebble as a clapper, are thin walled, have one sprue and no visible evidence of vents having been added to the mould, have a tinkly sound, are cast using only natural materials, and are created in a furnace that could easily be modified to resemble something pre-industrial by replacing the fire bricks and electric blowers with an earth structure and bellows.

Further experiments will be conducted to replace the few inconsistencies - manufactured stoneware clay, fire brick, electric blowers - with materials more consistent to the age in which the originals were produced.

Piers Watson

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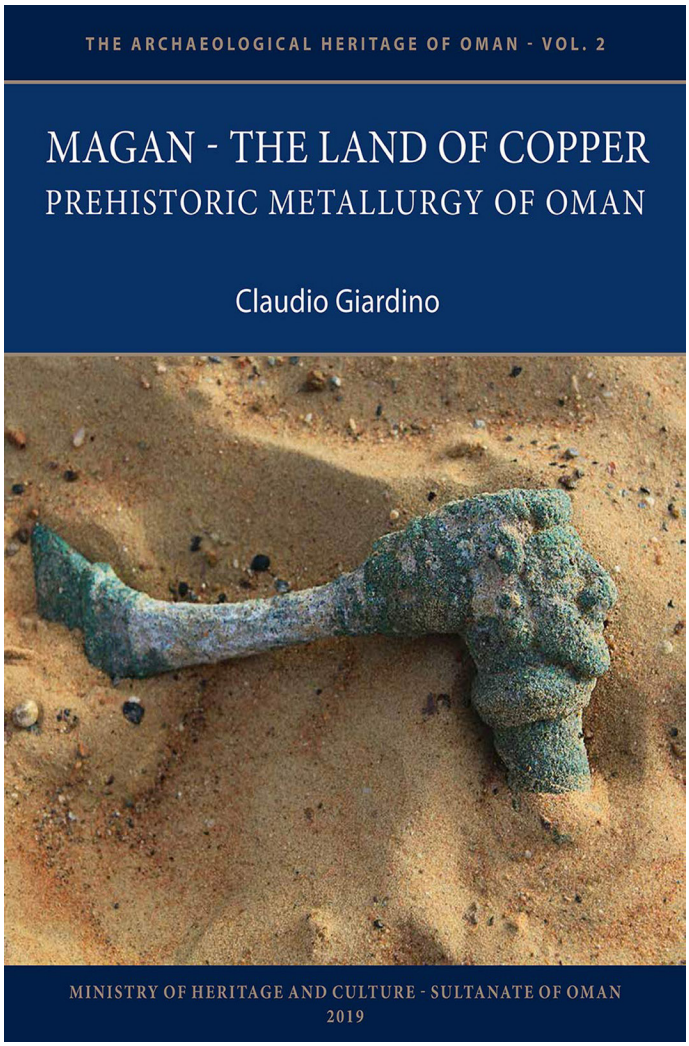
Magan – The land of Copper. Prehistoric Metallurgy of Oman



Claudio Giardino. The Archaeological Heritage of Oman – Vol. 2, Archaeopress Archaeology.

In the last Issue of the Crucible (Issue 101), we presented the abstract of this book to the community. In this issue, we would like to give you a review to provide a bit more of the flavour of this interesting book.

The book focuses on the prehistory of Oman from a metallurgical perspective. In his foreword, Prof Giardino states "metallurgy is in fact a science that cannot be really understood without considering the cultural structure of the societies that produced that technology. Metal artefacts and metallurgical residues are in fact an excellent tool for understanding the complex interaction between technology and society". He indeed follows his predicament linking thoroughly societal changes and metallurgical innovations.

The book is divided in 12 chapters setting the scene of the country (chapter 1), its geology (chapter 2), and the basis of metallurgy (chapter 3).

After this, the author gives a chronologic exploration of metallurgy in Oman, from its earliest appearance (middle of the 5th millennium BC) until 300BC (chapters 4 to 11). The last chapter is dedicated to the analyses of artefacts, copper fragments and metallurgical residues (such as crucible), obtained by Energy Dispersive X-ray Fluorescence and some data interpretation.

Oman holds a strategic geographic position, which was important for the development of the Omani civilisation and the proliferation of metallurgy in the area. Its climate allowed sufficient wood to be available as fuel, fostering the development of early metallurgical activities. Coastal areas where fishing activities flourished are the places where evidence of metallurgy is also found, both as objects (not only luxurious but also for everyday use such as hooks for fishing), and as melting and casting workshops.

Hundreds of copper deposits occur in the Al-Hajar Mountains, in the North of the country, however metal formations are also found on the island of Masirah in the South. Most of the copper is contained in the Semail Ophiolite. Massive sulphide copper deposits are present within the pillow lavas and diabase. Their exposed top sections are colourful because of the presence of limonite, goethite and jarosites, representing a perfect guide for mining prospectors in antiquity. The main ore includes pyrite and chalcopyrite with rich secondary copper mineralisation. Copper carbonates were easier to smelt than chalcopyrite, making them more accessible for early metallurgists. The Semail Ophiolite deposit presents a characteristic elemental fingerprint for its high Ni and Co content. This makes the backbone of the argument of the author in the following chapters.

Chapter 3 clearly describes the basis of metallurgy from a structural and consequently metallurgical perspective and it is a very useful chaper for educational purposes.

Evidences of metal objects in Oman date to 8000-7500BC. However, real signs of metallurgy are clearly visible during the 5th/4th millennium BC when a strong metal industry starts being developed with a large use of copper alloys.

Copper was traded as plano-convex ingots as common at the time and it is interesting to see how the main metallurgical sites of Dilmun and Magan are associated by the author using ceramic evidence, and the consequent metal trading routes are drawn. However, where Magan is located is a fascinating question that the author tackles with much evidence from different disciplines and sources.

Most of the earliest copper artefacts recovered were tools or objects related to fishing activities and they were mostly made of pure copper and by hammering, showing that at the beginning the metal was worked as a “stone”.

Fig.1. Statue of Gudea of Lagash (Louvre Museum)

Around 3200BC the emergence of new architectural features (the Hafit type graves) are visible. This corresponded with the creation of the Oasis system. At this stage, objects made of pure copper are accompanied by objects made of arsenical copper alloys. Prof Giardino details the types of objects in this period, and does the same in the previous and the following periods in the next chapters, allowing the readers to evaluate the changes in metal composition and aesthetics. In the Hafit graves periods, evidence of metallurgy is found, characterised by rather poor reducing conditions. The author presents micrographs to show the grain structure of the metal, linked with the metallurgical process.

The following millennium starts showing the appearance of tower settlements where also metallurgical activities were performed, in particular refining copper oxide. In this phase, tin bronzes started appearing, as well as workshops that used the casting process, which so far was not observed. At this stage more finish that is elegant and a variety of colours determined by the different alloys used, also appear.

Chapters 4 to 7, with their chronological assessment, linking the various changes in society and its development and refinement with the changes in metallurgy reads very well and presents a wider perspective in the material archaeology of Oman. Chapters 8 and 9 deal with copper mining and smelting including experimental archaeology data to corroborate further the evidence given by the objects evaluated in the previous chapters. A wealth of new results are presented in the following chapters, showing a sophisticated and complex metallurgical environment.

This book is very pleasant to read and very informative. New data and evidence are presented and accompanied by more fundamental explanation, which form the base for a thorough understanding. The book is a very good value for money and would interest many of us in the historical metallurgy community.

Lorna Anguilano

HMS Research In Progress 2019: McDonald Institute, Cambridge

Fig. 1 Research in Progress Attendees outside the McDonald Institute

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.

Fig. 2 2019 Student Prize winner Saltanat Amirova for her presentation on Copper and tin bronze metallurgy on the Late Bronze Age site of Semiyarka .

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 change 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 an 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

IL Maglio Museum

Fig.1. The hammer and grindstone

Visitors to the Pre-Alps of northern Italy who are looking for old technology should visit the village of Ponte Nossa in the Commune region of Bergamo and about 27km from the city. The name derives from the river Nossa that is one the shortest in Italy; it is only 500 metres long. The Nossa rises from underground springs in great volume and pours down the valley until it merges with the river Serio. A good museum has a surviving forge with tilt hammer. This region had supplies of ironstone, silver and lead; this with the abundance of wood and a good water supply made it an ideal place for iron production and working. In 1446, a sale of a forge was recorded in Ponte Nossa.

Walking up the Nossa a visitor quickly comes to the Museo del Maglio, a museum that is open to the public and is run by volunteers. The building is a late survivor of a working forge that was operating up to 1985. At this time, it was making a wide variety of agricultural implements and this is what it had been doing, with little change, for several hundred years.

The first thing that a visitor sees on reaching the forge are two waterwheels, walking a little further they see a torrent of water coming down the leat. This is just a dribble compared with what is flowing in the river below and that is a shadow of what it once was before the Nossa was used as a water supply. The undershot waterwheels are quite small and must be grossly inefficient, but since water is available in great profusion, efficiency is not important (Fig. 3). Being small and having low inertia, they can be stopped and started very quickly.

Also seen from outside are two pillars that have a separate water feed. These are trompettes that provide air to the forge.

Once inside, the machinery that the two wheels operate can be seen (Fig. 1). The smaller wheel runs a grindstone; there is a contrate gear that reduces the speed of the stone. It is not large, but there is on display a stone of around two metres diameter that was once used. The larger wheel drives the tilt hammer that is pivoted in its centre, the tail operating on wooden cams on the axle of the mill wheel. An iron hammerhead at the working end can have different heads and the anvil is on a massive rock that is let into the floor and cannot be seen. In operation, the hammer could deliver four blows per second. All lubrication is by continuously running water, two channels with small tubes take the water to the cams, bearings, and beam bearings and to a bosh. Instead of a penstock, the chutes that direct the water onto the wheels can be moved sideways to deflect the water flow away from the buckets.

In the corner of the forge is the hearth, a gentle draft comes up from the bottom tuyere supplied by the trompettes. These are latter two wooden tubes about 300mm in diameter, 5 metres high and at the top have vertical aspiration tubes a metre long. The upper ends of these tubes are open and the lower ends are in the water flow, thus the air is introduced by a venturi action.

Fig.2. Tools made

Fig.3. The two waterwheels in the foreground and the trompettes are visible slightly further upstream

Next to the hearth is the air receiver, water falls on a round stone inside the enclosure to reduce splashing and of course, there is no issue with erosion.

On display are many tools of the sort made at the forge (Fig. 2). Most of these are varieties of spades, adzes and hoes, but there are some interesting other examples. One of these is a circular disk about 200mm in diameter, when mounted on a long handle it was used to remove lime from a kiln. Another is an adze with a long sharp spike on its end; this was used for breaking up chalky ground. An oddity is a long wrought-iron nail that had been bent into a corkscrew shape. It seems that the nail hit a tough knot in the wood and instead of penetrating just bent into a spiral. The stages of making a spade are shown, the final stage was to mark the shape of the blade with a template and trim it with the hammer.

From the early 20th century, feedstock was scrap railway lines. These were cut into lengths in the winter months when the weather was very cold. An old hammerhead from the tilt hammer was hoisted up on a rope and pulley system and dropped onto a rail, fracturing the metal. Once in usable lengths, the rail was divided into three parts using a chisel shaped head on the hammer. Top, middle and the foot all provided basic stock.

The blacksmith's domestic accommodation was an upstairs room that now contains some good models of the hammer, trompettes and the grindstone. Today it is accessed by a staircase, when in use as a forge access was by a vertical ladder. The blacksmith's children slept in a gallery above the grindstone area.

Once the spring where the Nossa rose was a tourist attraction, it must have been a spectacular sight since the river can have a flow rate of 20 cubic metres per second. Now the source has been covered with a concrete roof since the Nossa is now piped to supply Bergamo with water.

Our guide was both knowledgeable and enthusiastic. He spoke no English but my friends who took me there translated. The museum is open by appointment, best to see the web site for details or to email in advance.A leaflet that has an English commentary is available, also a booklet in Italian about the museum. A DVD in Italian tells about the forge and the region; it runs for 1 hour 20 minutes and can be purchased for €10.

www.maglionossa.it or **info@maglionossa.it**

Chris McKay

TELFORD SLAGS

The Seven Gorge

"The most extroardinary district in the world: the two banks on each side are elevated to the height of from 300 to 400 feet, studded with Iron Works, Brick Works, Boat Building Stablishments, Retail Stores, Inns and Houses, perhaps 150 vessels on the river, actively employed or waiting for cargoes, while hundreds and hundreds of busy mortals are assiduously engaged, melting with the heat of the roaring furnace; and though enveloped in thickest smoke and incessant dust, are cheerful and happy"

Charles Hulbrt, 1836

What is now Telford was, in the eighteenth, nineteenth and for over half of the twentieth centuries, a collection of small, linked industrial towns. All of them were involved in at least one, or in most cases more activities connected with the ironworking industry; extracting the raw materials essential for the production of metalic iron - limestone, coal, clay and iron ore, which are plentiful and conveniently grouped in the area's geology, then smelting, processing and working the iron. It's not surprising then that the huge quantities of slag that were produced, much of which remains, has had a defining and unique role in the history and topography of the town.

Much of our woodland has grown up over slag heaps and post industrial sites and many of our paths through them follow the routes of old tramways used for transporting materials between sites (Fig. 1).

Fig.1. Old tramway footpath metalled with slag

A Letter from Telford

There's a strange contradiction to living among woodlands growing on old industrial wasteland, on the one hand the trees and greenery hide the gritty historical reality, but on the other, would I like to live in a slag heap? At least it's comforting to think that whilst the area lays claim to being the birthplace of industry, it must also accept that it is the birthplace of the climate crisis, so the trees are doing something to counter that. But for the derogatory connotations, a contender for the town's motto might be, 'Telford - city of slags'.

By the middle of the twentieth century those busy little centres had slid into decline as the larger and better-placed industrial towns and cities took over and the area was chosen as the basis for the 'New Town' of Telford. From 'Slag tip to forest city' is the strap line coined by the Development Corporation in the 1960s and it drove the town planning design, not a 'garden city' - a city in a garden but a city in a forest. It summarises the transformation that the town has undergone over the past 200 years and highlights the particular association Telford has with slags. The town is literally built on slag (Fig. 6) and not infrequently built with slag. Our footpaths are not paved with gold but many are metalled with the glassy, distinctive blue, green and black slag (Fig. 1). You can see it in old walls and although you can't see it, it's the aggregate in many of our tarmac roads (Fig. 4).

Although the little towns that now make up Telford all had their part to play in the industrial revolution, attention is focussed on Ironbridge and Coalbrookdale and they have become a UNESCO World Heritage Site, the only one in the West Midlands. This has been celebrated every year since, but in summer 2019 the celebration was transformed into the 'Festival of Imagination' which ran from September 14th to 29th and included film, poetry, arts, heritage crafts, live music, exhibitions, food and drink, with a large yurt for performances and screenings, an outside area with a bus bar and relaxation space.

The HMS had a part to play in the celebrations through Mike Dobby's contribution to an evening stroll through the Blist's Hill Museum. For the few who may not know Blist's Hill, it is an open air museum built around the Blist's Hill furnaces and now includes a pretty 'Victorian' town of commercial buildings salvaged from around the West Midlands, reconstructed on the site of a former brickworks and, surprise, surprise, slag (Fig. 5). The village is bright and quaint, has a fairground on what would have been a casting floor, and all with the picturesque ruins of the furnaces as a backdrop amongst the greenery and woodlands.

Fig.2. Colliery slag heap, Dawley

Fig.3. Slag heaps

The stroll came from a vague idea to look at things on the site that don't really get much attention but deserve to. Contributors were, John Box, an ecologist who has investigated post industrial sites throughout the West Midlands; Mike Dobby of HMS, whose career covers analysing all aspects of metal production from ores, metal, slags, crucibles, furnace linings, the gases that were emitted and ancient iron samples; Paul Ashmore, a skilled blacksmith who teaches historic ironwork conservation at Hereford College; Pete Jackson, who is currently heavily involved with 'Cinderloo 1821'; myself, a conservator of large metal objects, and; Andrew Howe, artist, who is also part of the Cinderloo 1821, recorded the evening. The event was a bit last minute, improvised and, because it was pulled together at short notice, not well publicised, so we would have been happy if 10 people had turned up. In the event, there were 40!

Paul and I talked about an insignificant looking rectangular iron container, a tub boat, the only survivor of several built around 1830-40, a very early example of a floating iron vessel and of containerisation, but first we headed for the slags.

The site has tons of it in great craggy banks of clinker, broken down furnace linings, slags and iron residues, now hidden amongst brambles and trees.

John described the special ecology of the nutrient light material, how plants first start to colonise it, how that develops and creates progressively more viable conditions for subsequent growth. Given that the furnaces were in production and still turning out toxic fumes, slags and clinker until 1912, it's a fairly rapid process.

We then moved onto the remains of the furnaces where Mike spoke about the processes and chemistry involved in producing usable metal iron, the conditions that needed to be created in the furnace to separate out the metal, and the slags and gases that were the byproduct.

Over the concluding fish and chip supper from the village's chippy Pete talked about the actuality of the lives in the industrial townships; the bone damage to young children caused by heavy work and poor diet; accidents and ill health that were due to sheer exhaustion; the damage that the fume and dust from the local industries caused to the health of the workers and general populace. Blist's Hill Village is a fiction and a fanciful historical construct, but the little towns were not, they were places of poverty, bad housing, poor health and deprivation (Fig. 2).

Fig.4. The slag tips ... much reduced by use as aggregate, now a retail park

Fig.5. Blist's Hill 'village'

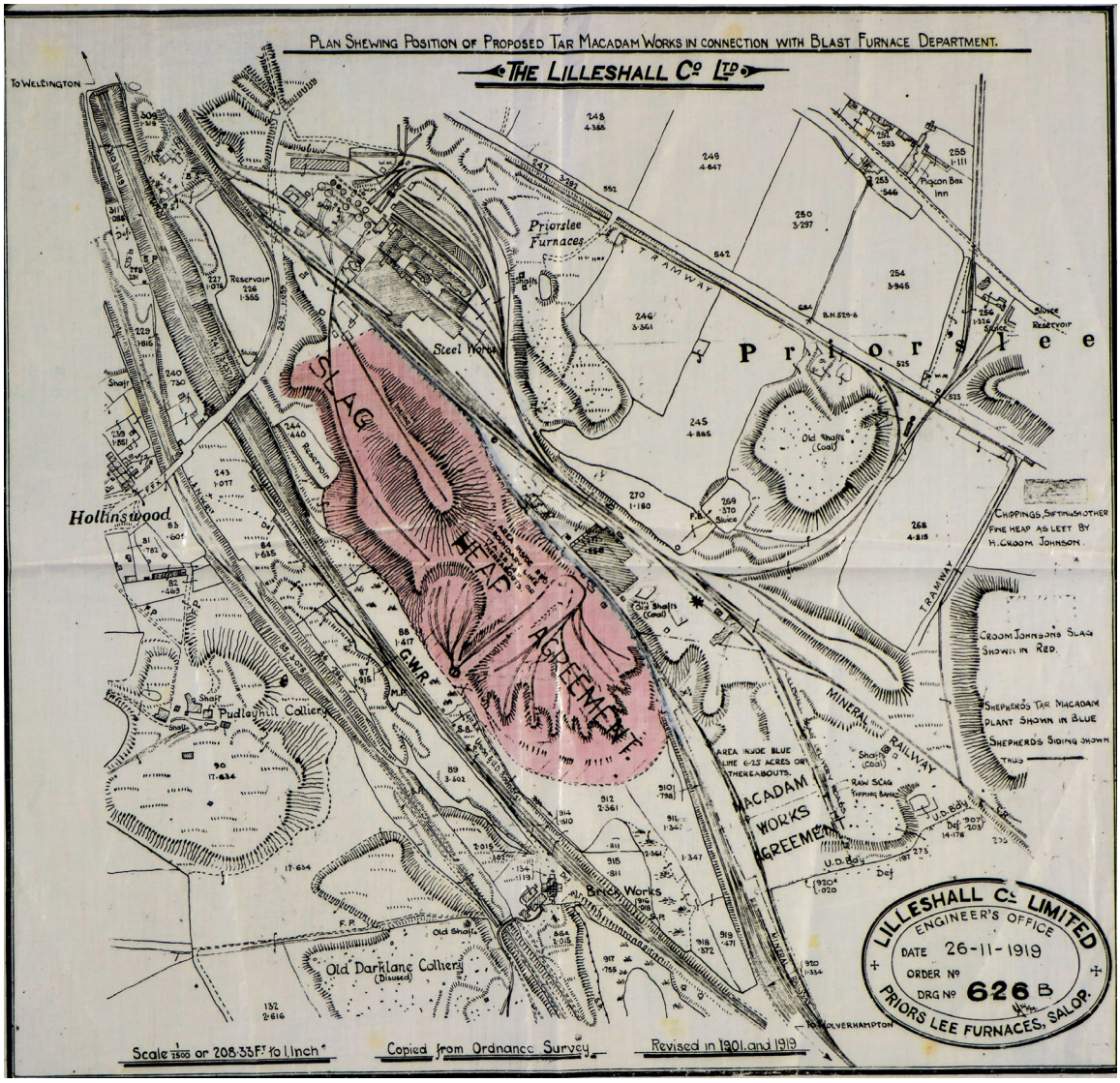


Fig.6. Map of the area that is now Telford's town centre

Deprivation and slag came together dramatically in 1821 at the 'Battle of Cinderloo'. At the end of the Napoleonic War there was a reduction in demand for iron from the area and two years after the Peterloo Massacre, local ironmasters (who also owned the mines) formed an illegal combination to reduce the wages of the miners across the coalfield from subsistence level to poverty level. Three thousand men, women and children marched and gathered in protest on the 'Cinder Hills', the slag heaps of Old Park foundries. A one sided battle ensued between the Shropshire Yeomanry using bullets and sabres on the crowd and the protesters who replied by hurling lumps of slag. Many protesters were injured, including Tom Palin who was later hung for his involvement and two died from injuries received on the day.

Ultimately the protesters gained a small increase in pay but lost overall. The site of the battle and its closeness to Peterloo gave the event its title, Cinderloo, but although it is an event of significant historical importance to the area, it is one that is largely overlooked and completely unrepresented. The Cinderloo Project aims to change this by marking the centenary in 2021, but in the meantime there is the 2020 Festival of Imagination to think of.

In 2019, 15,000 people attended the Festival, 40 of them to our informal stroll around Blist's Hill. The eyes of those 40 were opened to the significance of slag in this UNESCO World Heritage Site and its topography and there were many requests for a repeat, but in greater detail at the next Festival. HMS is committed to working with Cinderloo 1821 at the next Festival to focus on the historical, archeological, topographical, ecological and cultural contribution of slag to the development of this small part of Shropshire that had such a large impact on the world.

Andrew Naylor

METALLURGICAL MYTHS OF 18TH CENTURY IRON MAKING

8TH JANUARY 2020 @ 5:45 PM

A presentation by Richard Williams –

A ferrous metallurgist with a doctorate in metallurgical thermodynamics and 10 years' experience of the foundry industry, Richard Williams has for the last seven years been studying both the science and the history of the change from charcoal to coke in all the iron making processes of the 18th Century, the essential pre-requisites for the industrial revolution. During that period our knowledge of the subject has improved significantly. His updating of 'myths' will include (inter alia) the extent of the foundry industry that existed before Darby, the manner in which a small cold blast coke furnace really worked, the role of the Newcomen engine in allowing coke iron to be used in the forges for the first time and the real reason why Cort's puddling process, as detailed in his patent, did not work.

All welcome.

www.sciencemuseum.org.uk/researchers/dana-research-centre-and-library

conference, date and locations	Desciption	websites, emails and prices
18/05/2020 - 22/05/2020 Lisbon, Portugal	The 43rd International Symposium on Archaeometry (ISA 2020)	https://www.isa2020-lisboa.pt/
05/06/2020 - 07/06/2020 Ancient Technology Centre, Cranborne	Accidental and Experimental Archaeometallurgy 2.0 HMS AGM Summer Meeting	http://hist-met.org/meetings/experimental-archaeometallurgy-agm.html
29/06/2021-2/07/2021 Fribourg, Switzerland	Iron in Archaeology Conference	
02/02/2020 - 07/02/2020 Israel	Early Iron Production: Experimental Archaeology The Southern Levant and Africa Research Workshop of the Israel Science Foundation	https://www.ariel.ac.il/wp/lp/early-iron-production-experimental-archaeology/