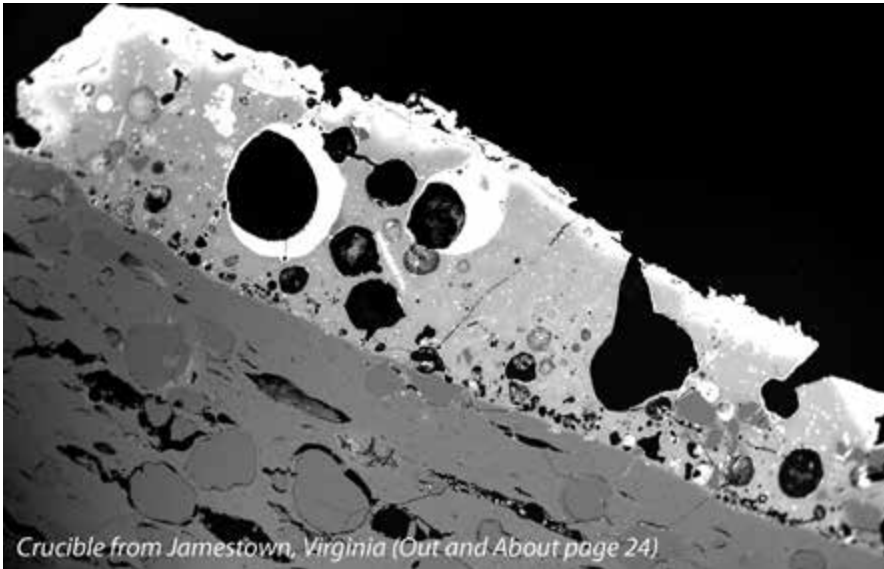


# THE CRUCIBLE

**Historical Metallurgy Society News**  
**Issue 96**

**Winter 2017**



*Crucible from Jamestown, Virginia (Out and About page 24)*



*Tigray, Ethiopia (Page 6)*



*Vincent Serneels, Burkina Faso (page 12)*

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The **HISTORICAL METALLURGY** Society

# FROM THE EDITOR

It is both exciting and daunting to be taking over the Editorship of *The Crucible*. Over the last few years Marcos and his team have transformed *The Crucible* into the attractive, readable and informative newsletter that we all look forward to landing on our doorsteps and desks three times a year. Marcos has left big shoes for us to step into, which is why it is reassuring to be sharing the role of editor with Lorna. Between us, we and our new editorial team at Brunel and Exeter, will endeavour to maintain and build on the high standard that has been set.

What's special about *The Crucible* is that it is a traditional print newsletter. It is there at your elbow to pick up and browse over tea or coffee, when the screens have been turned off or the internet is down. It may not have the immediacy of facebook, the web or social media but it is where you will meet fellow HMS members and share experiences and information at a pace that suits you.

Initially, we will be learning the ropes – getting to grips with gathering content, editing and compiling, type-setting and printing – but in time we hope to develop a number of new features and encourage new contributors. In this issue you will see that ‘what are you up to ...’ has become ‘out and about’. The idea is to go beyond new work that is being done to include interesting or little known sites around the world that members have visited, some of which may have conservation issues that deserve reporting. In another change, ‘Meet your council ...’ has become ‘Meet your community’. As many long-serving members of the Council have now been introduced through this excellent feature, we would like to extend the concept to include others in the field alongside new council members.

A new occasional feature we plan to introduce in the next issue will be ‘from the back of the filing cabinet’. This will be an opportunity to air a piece of work that may have been done some time ago but for various reasons did not reach publication or dissemination. The sort of short report that contains information that fellow HMS members would find interesting and useful but has languished at the back of the filing cabinet. We would love to hear from anyone who thinks they might have just such a report, I know I have!

Please keep all your contributions coming, we look forward to hearing from you.

*Gill Juleff*



*Early thoughtful editor's meeting in Forbidden City, Beijing, 2009*

## **Editors**

Gill Juleff

Lorna Anguilano

## **Assistant Editors**

Danny Aryani

Carlotta Farci

Amy Flynn

Ole Nordland

Susanna Venditti

## **Submissions**

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

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.

## ***The Crucible***

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## SOCIETY GRANTS

The Society awards grants each year for projects or activities that fall within our aims and objectives, broadly those with a metals or metallurgical theme. There are three funds available.

**Coghlan Bequest:** The aim of this fund is to facilitate research, for example fieldwork, experiments, and analysis. Awards are made once a year, usually in March, and applications must be in by the end of the preceding January. As a guide up to about £700 may be awarded.

**R F Tylecote Fund:** This commemorates the renowned archaeometallurgist who was a founder member of the HMS. Awards focus on travel and subsistence for conferences, research visits, excavations, fieldwork and are made twice a year in March and October. Deadlines for submission are the end of the preceding January and August. As a guide up to about £200 may be awarded in each round.

**Anniversary Fund:** This was set up in 2013 to commemorate the 50th anniversary of the founding of the Society and provides support for activities outside the remit of the other funds. This could include the provision of exhibition materials, an educational event or conservation work. Awards may be considered in March or October. Deadlines are the end of the preceding January or August.

As we often have multiple applications, individual awards may be less than requested or the guidance above. When we have all the applications in a sub-committee examines them in detail, often contacting applicants for more information, and submits recommendations to Council. The final decisions are then made by the full Council. More details of the grants, and an application form, can be found on the website at <http://hist-met.org/about-hms/hms-grants.html>. Following an award, once the activity or project is complete, we require a short report of the results (c. 500-1000 words) suitable for inclusion in *The Crucible*.

### Recent Awards

We recently awarded a Coghlan grant to Maria Teresa Plaza, a PhD student at the Institute of Archaeology UCL, for a research visit to San Pedro de Atacama in Chile to examine and analyse (by pXRF) gold and silver artefacts from Middle Period contexts (AD400-900). The background to this research was reported in *The Crucible* (92). We have also awarded an Anniversary Fund grant to the Khalikov Institute of Archaeology (Kazan, Russia) to help fund the purchase of basic microscopes for a Jewellery studies workshop at Bolgar International Field School. A report on the workshop appeared in *The Crucible* (94). The Tylecote Fund has also recently provided useful funding for students presenting papers and posters at conferences.

## MEMBERSHIP MATTERS – changes in email postal addresses

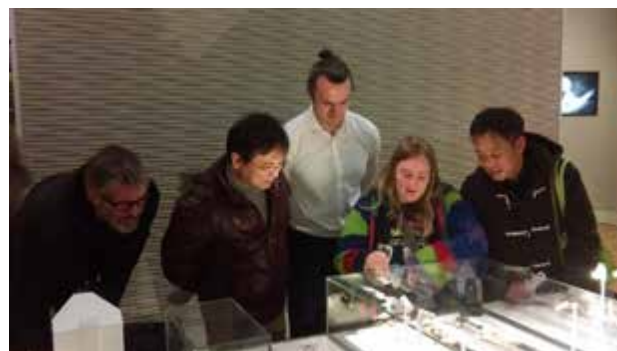
If you make changes to your email contact address and/or the address to which you wish your mail to arrive at please inform Lesley-Ann Cowell (Membership Secretary). If members retire from their place of employment, or change jobs, or just move house Lesley-Ann spends a lot of time trying to trace members when their copy of *The Crucible* is returned to her. The process is easy – just email Lesley-Ann with your changes, or write to her at Little Gables, 17A Thorncote Road, Northill, Bedfordshire SG18 9AQ UK, or telephone +441767627776.

## FORTHCOMING EVENTS

The Historical Metallurgy Society maintains a list of events that may be of interest to our members, which we share on our website. If you know of any relevant events in related fields that might be of interest to our members, be they in the UK or further afield, please email the details to the HMS Events Officer at [events@hist-met.org](mailto:events@hist-met.org).

## HMS JAPAN COLLABORATION - VIDEO

Thanks to a grant from the Sasakawa Foundation, HMS were able to host three visitors from Japan in November 2016. The Japanese group, led by Prof Yasuyuki Murakami from Ehime University with Yasufumi Sasazawa and Seiji Manabe, joined a two-day experimental iron-smelting event with Jake Keen in Wiltshire and then travelled to Birmingham to attend and contribute to the Research in Progress meeting. Ellie Blakelock recorded the event, including interviews with the visitors, and has now edited this into a valuable video which will soon be available through our facebook page and the website. The visit and the grant was an exciting step forward in our internationalisation campaign.



## CELTIC-ROMAN AGE IRONMAKING IN NORWAY

In 2014, together with the archaeologist Larse Stenvik, I published in *The Crucible* (87) a paper titled 'No bellows needed'. The key object was a shaft furnace with a slag pit, named by us the 'Trøndelag furnace' (Fig. 1), representing a type of bloomery furnace designed for re-use, very standardized and in use for some 800 years, beginning in the Celtic period at about 300 BC. Instead of bellows, a chimney fire was created by the deliberate direct use of pine containing tar and resin.

Since the year 2014 some new observations have been added to our first discussions. The furnaces are located on the edge of a flat plateau, facilitating removal of the slag by simply rolling the large blocks of slag downslope. More important, however, is facilitating the drainage of water from the slag pits, dug in silt or clay to a depth of some 80cm. Other new observations deal with the origin of the technology.

In the 2014 paper an origin for the method in the Middle East was indicated, based upon general knowledge. However, excavations led by the archaeologist Brigitte Cech at Semlach in Carinthia, the Roman province of Noricum, led to the identification of a slag pit of a size identical to our very standardized pits (Cech 2008, Fig.2).



Fig. 1 The slag pit of the Trøndelag furnace after being emptied (Photo AE)

Both have a side opening, enabling removal of solid slag without any damage to the shaft. The only difference was the use of different building materials, stones in Norway and clay/silt in Austria, both materials easily found locally.

There is, however, a discrepancy in the dating. Our furnaces can be traced back to 300BC, while those in Semlach seem to be younger. In response, the German archaeologist Guntram Gassmann tells us about finds of the same character from the Hallstatt-period, i.e. 500BC (Gassmann pers.comm.). This author published a book in 2013 which included not only a description of the finds,



Fig. 2 The slag pit of the Semlach furnace, excavated by Brigitte Cech (Cech 2008)

It is proposed that they represent a complex, cyclic process resulting in high quality slag-free metal with a controlled amount of carbon and with a high output of large blooms (Espelund 2013).

As there is no indication of experiments leading to the documented construction and proposed operation, nor any development during the centuries, it is suggested that the method was 'imported', brought by individuals from Celtic Europe to Norway. They must have appreciated supplies of abundant bog iron ore, low in phosphorus.

Large-scale production took place, reaching a maximum, including export, around AD 200. The finds and our research should lead to new insight into European history and contact between the Roman Empire, with its script and developed material culture, and 'Barbaricum'.

Arne Espelund

### References

- Cech, B., 2008: *Die Production von Ferrum Noricum am Hüttenberger Erzberg*. Wien  
Espelund, A., 2013: *The evidence and the secrets of ancient bloomery ironmaking in Norway*. Trondheim

## SHEDDING LIGHT ON THE DARK AGES

Their popularity in the media leaves no doubt that Vikings are a hot topic. What began as a student project at SUNY-NCC, (State University of New York – Nassau Community College) has bloomed into an international project.

In 2016, the Anthropology Club of Nassau Community College (TACONCC), started the Shedding Light on the Dark Ages project. This has turned into a college wide consortium of students, faculty and staff interested in helping the club with research into various aspects of this time period. In spring 2017, the club held a showing of Secrets of the Viking Sword with a phone Q&A with master blacksmith Ric Furrer, and we plan to follow up with a conference and workshop during fall 2017.

Collaborative student-faculty research led to evidence suggesting that the so-called Ulfberht Viking swords should be associated with the reign of Hakon the Good of Norway. This was presented at the 2nd International Conference on Weaponry, Kyiv, in May 2017 (Feuerbach & Hanley).

We returned to the Ukraine for a week in June this year to work with colleagues on projects related to the study and preservation of cultural heritage. Our activities included a seminar on the metallography of ferrous artifacts at the National Museum History of Ukraine & Institute of History of Ukraine, a two-day workshop on microscopy for conservation and research at the Institute of Archeology of B. Grinchenko, Kyiv University, and a seminar presenting our latest research on Ulfberht Swords, at the Golden Gate



Fig. 1 Workshop on microscopy

We used this opportunity to distribute a questionnaire to cultural heritage professionals inquiring about their most pressing conservation needs. They were very appreciative of the list of conservation, microscopy, and research related resources available online.

While they are common sources for most of us, these are difficult to find when English is not your native language and you do not know where to start looking or what keywords to use.

One of the most intriguing aspects of this summer's research was the increasing evidence for the connections between the British Isles, Scandinavia and the Ukraine during the 10th-11th centuries. While the Viking connection is well known, the details of influences and impacts are still unclear but they seem to be greater than most scholars have hitherto suggested.

As part of the metallography seminar, we had the unparalleled opportunity to examine the spectacular Ljudota sword (Fig. 2). The Ljudota sword was found in Viking period context in Ukraine and shows evidence of various cultural connections. It has local Slavic characters inlaid on the blade, the hilt decoration is comparable to those found on Swedish runestones, and the pommel decoration is similar to that found on a grave slab from St. Paul's Cathedral in England (Androshchuk, 2003).

To explore this topic in more depth we are planning a conference in Kyiv on Swords and Saints, for summer 2018.

*Ann Feuerbach*



Fig. 2 Examining the Ljudota sword

### References

- Androshchuk, F. (2003). The 'Ljudota Sword?' (An episode of Contacts between Britain and Scandinavia in the Late Viking Age) Fedir Androshchuk.
- Feuerbach, A, and T. Hanley (Summer 2017). Ulfberht swords: New Answers to Old Questions. *In History of Antique Arms Researches 2016* (ed: Denys Toichkin), National Academy of Sciences, Ukraine.

## ARCHAOMETALLURGY IN TIGRAI: A PILOT INVESTIGATION OF ANCIENT IRON PRODUCTION IN ETHIOPIA

The ancient Kingdom of Aksum, dating from the 1st to 10th century AD, ruled much of what is today Eritrea and northern Ethiopia. Iron objects are often found during excavations of Aksumite archaeological sites. However, little is currently known of the ancient technologies or craftspeople responsible for their production. With partial support from the Institute of Archaeometallurgical Studies, a short archaeometallurgical field season was conducted in June 2017 to reveal insights into the region's metallurgical history. The aim was to document two ancient iron production locations, Mariam Takot and Mariam Kadih (Figs 1 and 2) and collect samples of iron slag, possible iron ore, technical ceramics and associated archaeological material for laboratory analysis, and charcoal for radiocarbon dating.



*Fig. 1 The archaeometallurgical sites of Mariam Kadih and Mariam Takot, shown in relation to key pre-Aksumite (Yeha) and Aksumite (Aksum) sites*



*Fig. 2 The church of Mariam Kadih*

## Fieldwork

Recent road construction activities created a section near the church of Mariam Takot which led to the site being recognised as a large iron production location. The team documented the section in detail, including areas of particularly intense iron production debris and architectural features (Fig. 3). The wider landscape was surveyed, revealing a slag scatter extending at least 0.6 km in a north south direction. The pottery found during the survey and excavation at Mariam Takot indicates a high possibility of Aksumite and even Pre-Aksumite occupation.

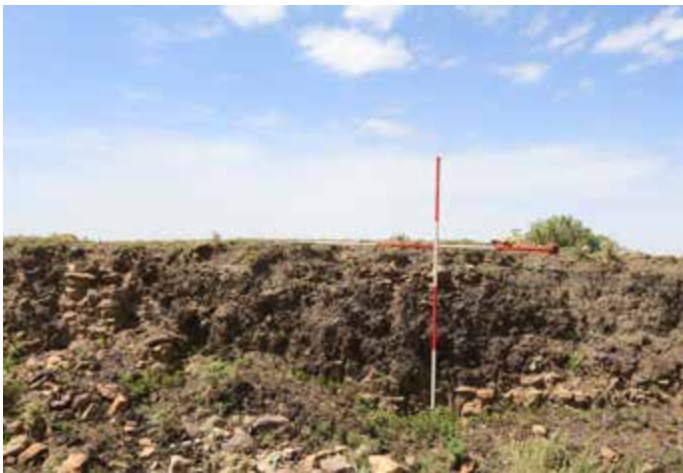


Fig. 3. A wall and possible pavement visible in the modern section

An area of the modern section was excavated to natural at a depth of 4.35 m (front cover and Fig. 4). The samples collected from throughout 31 documented contexts include 38 slag samples, 16 possible ore samples, 9 samples of furnace material, 1 tuyère fragment and 33 charcoal samples. In addition, 31 diagnostic pottery vessel units (Fig. 5) were documented and deposited alongside 41 non-diagnostic, photographed pottery sherds, in the Wuqro museum where they await further investigation by the UCL Qatar team.

Mariam Kadih, c. 35 km south of Mariam Takot, was recognised as an iron production location due to the identification of scatters of iron slag fragments within and around the church complex. The team documented the site and surveyed the immediate landscape to understand its scale and nature. Surface finds of pottery and a terraced hill-slope to the west of the church indicate a possible Aksumite date for ancient activity in the area. Due to the complexities of excavating within a church complex and the time pressures of this initial field season, only ten samples of slag were collected from the surface at Mariam Kadih, to provide comparative data for the more comprehensively investigated site of Mariam Takot.

## Next steps

The field research above was made possible following the provision of a licence by the Authority for Research and Conservation of Cultural Heritage in Ethiopia (ARCCH), who also granted permission for samples to be exported to UCL Qatar for destructive analysis. All charcoal samples have undergone wood species analysis and 17 of these samples are undergoing radiocarbon dating at the NSF University of Arizona Dating Laboratory. The samples of slag, possible ore and technical ceramics have been documented and are currently undergoing microscopic and chemical analysis at UCL Qatar.

Jane Humphris, UCL Qatar



Fig. 4 Sampling strategy in progress



Fig. 5 Pottery found during the excavation

## A FURTHER VISIT TO IRISH BLAST FURNACE

During a visit to Blackstones furnace, County Kerry, SW Ireland, two unidentified cast iron objects were found beside the furnace. The first, a 'beam' 150mm x 150mm in section and 1240mm long and estimated to weigh 190kg, and second, a 'saddle' consisting of three 60mm thick cast plates at right angles with external dimensions 360mm x 280mm, estimated to weigh 107kg (Figs 1 and 2).

The site, dating from 1701, consisted of two furnaces (only one now remaining) and a finery forge. Unlike most Irish furnaces, it made a good profit (£27k in 1731) but had closed by 1755. The 'beam' was evidently not a furnace lintel as, with only one exception found to date, the blowing and casting arches of Irish furnaces are of a vaulted construction (Fig 3). The exception is Woodford furnace, where a lintel dated 1681, square in section at its ends but triangular in the middle, was found and is now exhibited at the local Heritage Centre (Fig 4).

In UK, vaulted arches are the exception with only three furnaces exhibiting at least one vaulted arch - in Cumbria (NW England), Nibthwaite (built 1735) and Duddon (1736) and, in Scotland, Glen Kinglass (~1722-5). The last of these is known to have been built by Irish workers, while in Cumbria, Duddon was built by the Backbarrow Company which had Irish connections and charcoal and skilled manpower travelled between Barrow-in-Furness and Ireland in the 18th century.

Since no early British furnaces remain extant, this leaves the possibility that early furnaces used vaulted arches rather than the more angular structures supported by lintels, the latter being a later, simpler construction. At Wealden furnaces, which date from 1490 and follow the Walloon design, only one lintel has ever been found. This was later used in a farmhouse fireplace and has the date 1696 cast on it along with the letters 'WBD' indicating its origin as Lamberhurst furnace. In addition, Irish furnaces were built of unfaced stone-rubble whereas English furnaces were mostly faced with ashlar masonry.

HMS visited the sites of furnaces around Lough Derg in 2014 in a trip organised by Paul Rondelez, who recently completed his PhD on 13th to 16th century ironworking in Ireland. In September this year, Paul invited a small group of WIRG members to visit four other furnace sites within a day's journey of Cork - Kilmackoe, Araglin, Derrycunihy and Blackstones - as well as Ballyregan mine, which was drained by rag-mop powered waterwheels. Only Araglin and Blackstones have extant remains.

The first documented evidence of a blast furnace in Ireland is at Mallow in County Cork, built in 1590, 100 years after the first blast furnaces arrived in England at Buxted, East Sussex, southern England. In Ireland, over 150 water-powered ironworks, including furnaces, finery forges and bloomeries, built during the following two centuries, have been identified, with ruins of a number of the furnaces still remaining.



*Figs 1 & 2 What are these for? Any ideas please send to [secretary@wealdeniron.org.uk](mailto:secretary@wealdeniron.org.uk)*





*Fig. 3 Vaulted blowing arch of Derryoover Furnace County Galway.*

Irish ores were largely of poor quality, thus three-quarters of the charge to some furnaces relied on imported bloomery slag (cinder) from the Forest of Dean, a trade later stopped at the demand of Dean Ironmasters. Trade with Wealden ironworks occurred with anvils and hammer heads supplied to Irish ironworks in the 1650s. Timber for charcoal was initially abundant and attracted English ironmasters, including two from the Weald, but lack of management of the woodlands resulted in rapid depletion of the forests. Around half an acre (2000m<sup>2</sup>) of woodland is required to make the three tons of charcoal necessary for each ton of iron. Annual output per furnace ranged from 120 to 400 tons, thus depleting surrounding forests by 60 to 200 acres (24-81h) each year.

Many of the furnaces were built and operated by foreigners; English and, in one case, Walloons. The settlement for workers included accommodation and 200-400 acres (81-162h) of land to farm.

By 1778, only three charcoal blast furnaces remained. Scarcity of coal delayed the use of coke-fired furnaces until 1781, 79 years after Abraham Derby first used coke at Coalbrookdale. Peat charcoal was tried but generally was too costly. The last blast furnace was coke and later peat fired, starting in 1852 and closing in 1896 with several periods of inactivity between these dates.

For more information <http://www.furnaceproject.org/publications.html>

*Tim Smith*



*Fig. 4 Woodford Lintel showing changes in section*

## ANCIENT IRON SMELTING IN ISWAL, SOUTH-EAST RAJASTHAN

With this contribution to *the Crucible* we present the evidence for metallurgical activities related to iron production in south-east Rajasthan, focusing on the material evidence found at the site of Iswal.

The ancient iron smelting site at Iswal is located in the Udaipur district of Southeast Rajasthan, Western India (Figs 1 and 2). Geographically, the village is situated in the core of the Aravalli Hills, i.e. in the southern part of these ranges. This area is rich in iron ore and its exploitation goes back to around the 1st millennium BCE as evidenced by sites such as Noh (IAR (Indian Archaeological Review), 1963-64 to 1964-65), Ahar, Sunari (IAR, 1980-81), Barirat (IAR, 1962-63), Gilund (IAR, 1959-60).



*Fig. 1 and 2 Views of the site and village of Iswal*

### Iron Smelting Furnaces, Tuyeres and Metal Objects

The major finds at the site of Iswal include iron smelting furnaces, tuyeres, iron ores, iron, brass and bimetallic artefacts.

One furnace was encountered in close proximity to a structural complex found at a depth of 10.82m. Semi-circular in shape, it is made of stone and bricks. The surrounding floor is made of fine clay and slag material. A great amount of fine ash was also recovered from within the furnace. It is estimated that its original depth was approximately 52cm, and its inner proportion measured 34cm (NS) x 49cm (EW). Two more furnaces were recovered at a distance of 70cm. One of them has a triangular shape and measures 80cm in height and 60cm in width. The walls of both furnaces are about 2.4cm thick and are covered with ash.

Another furnace made of compact mud was exposed at a depth of 12.50m. It measures 60cm (EW) x 75cm (NS) and all corners of the square furnace are strengthened with bricks and pebbles. The central part of the structure measuring 16 x 30cm was full of loose soil. A thick layer of red soil covering the upper layer of the furnace is indicative of the high temperatures of the metallurgical operations. A stone, 25 x 21cm in size was found in close proximity to this structure (Fig 3).



*Fig. 3 Square furnace at Iswal*

The tuyeres found at Iswal are of different sizes; the reason being that tuyeres are made according to the size of the furnace and the quantity of ore smelted. They are all handmade, manufactured using red clay tempered with quartzite grains. Their shape is cylindrical, slightly tapering towards the exterior. Moreover, they appear flattened on one side, which suggests they were placed flat at ground level and connected to the furnace through holes on the furnace's walls (Fig 4). Tuyeres are usually found with one end eroded due to contact with the fire inside the furnace, suggesting they were discarded when the length of the nozzle had shortened due to repeated heating. Along with iron ores, tuyeres and furnace remains, iron objects were also found. This suggests that Iswal was not only an iron smelting site but also a forging site. The iron objects recovered include arrowheads, chisels and musical instruments. There are also brass and bimetallic artefacts.



Iswal

Fig. 4 Tuyeres from Iswal

The findings at Iswal suggests that the smelters and blacksmiths had a good knowledge of iron and brass

alloy technology. Their expertise in iron technology is indicated by the presence of furnaces of different types and functions, and well-crafted artefacts manufactured with different alloys. The evidence also suggests that the ancient metalworkers exploited local iron ores and locally available clays for the manufacture of the tuyeres and furnaces.

This site brings even more evidence to the broader picture, corroborating the view that iron working played an important role during the Iron Age and Early Historic period of the region. The hope is to carry out archaeometallurgical studies on this assemblage and shed more light on the study of ancient iron technology in South Asia.

## Acknowledgments

Thanks to all staff members of Rajasthan Studies, JNR Rajasthan Vidyapeeth, Udaipur and special thanks to Deccan College Library. Special thanks to Sharma Centre for Heritage Education, Chennai. Special thanks to Ms. Diya Mukherjee.

*S. Udayakumar, V.S. Shinde, L. Pandey*

**WEST DEAN COLLEGE**  
**ARTS & CONSERVATION**



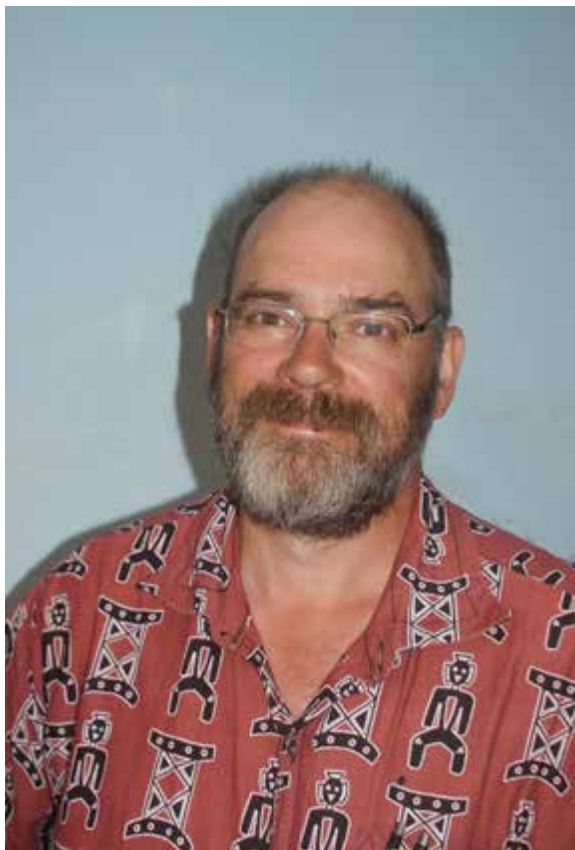
**Open Day, 3 February 2018**

Find out about our Metalwork programmes from Foundation through to MA and funding opportunities.

The practical emphasis of the Metalwork programme (73%) is based on assessment and treatment of clients' objects. All work is grounded by research into the historical context of each object, supported by visiting lecturers and postgraduate science lecturers. Network in the sector, visit museums and collections, attend seminars and work placements to develop your professional practice.

You will also be able to tour the college facilities, which includes the purpose-designed Metalwork workshop, with areas for photography, analysis (microscopes, metallurgy), chemicals, hot work (including casting, soldering, welding) and machining.

## VINCENT SERNEELS



Vincent Serneels is an Associate Professor at the Department of Geosciences in Fribourg, with vast experience archaeometry. His geology background and personal interests lead him into archaeology, applying mineralogy and geochemistry to archaeological materials. Vincent's main research and many publications, focuses both in the technological aspects and the organisation of production of iron metallurgy considering evidence from the mine, to metallurgical remains and the finished objects; from the origins, to the 19th century; and from Switzerland, to Europe and Africa. Yet, his expertise and interests go beyond iron archaeometallurgy, including non-ferrous metals, ceramics, crucibles, soapstones, millstones and pigments. During his career, Vincent has worked in different laboratories in Europe, such as Belfort (France), Bochum (Germany) and Oxford (UK), and now is responsible of the geochemical laboratory (XRF) and the archaeometry programme in University of Fribourg.

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

**VINCENT SERNEELS:** As a child, I was fascinated by the ancient Humans. As a young volunteer, I felt deep emotions during archaeological excavations in Southern France. At Lausanne, Switzerland, I completed a degree in Geology with the solid hope to carry on research combining natural and human sciences. By chance, an archaeologist brought some iron slag fragments to the lab. This was the beginning of my PhD and some years of post-doc research on metallurgical remains and teaching of mineralogy.

In 2000, Prof. Marino Maggetti hired me in Fribourg as an assistant for his teaching in archaeometry. In 2005, he retired and I was appointed as professor. My main interest is for ancient iron: on the field and in the laboratory, from the beginnings up to the 19th century, in Switzerland, Europe, Africa and elsewhere. But I am also interested in all kinds of mineral materials used in the Past (metals, ceramics, stones, pigments). I am working on technological aspects but also on the organization of the production and on the impact of raw materials on human societies. Teaching, mineralogy and archaeometry, and field archaeology is also an important aspect of my activity.

**THE CRUCIBLE:** What is your most memorable professional moment?

**VINCENT SERNEELS:** After several days of hard work to get something interesting out of the analytical data from the smelting site of Boécourt in the Swiss Jura, I woke up in the middle of the night with a very simple idea: everything that enters a bloomery furnace must go out of it. This was the first step for the development of mass balance calculations between ore, slag and iron and a quantitative approach to iron smelting slags. I am still working on this

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

**VINCENT SERNEELS:** My first contact with archaeology was under the guidance of Fanette Laubenheimer on the excavation of a potter's workshop at Sallèles d'Aude, France and this experience, lasting more than ten years, has been highly formative to me. Later on, at the time of my PhD in Lausanne, I met Prof. Paul-Louis Pelet, an historian who led pioneering field work on the iron smelting sites in Switzerland. He passed to me his invaluable research experience. His advice was to focus on important questions and... to be lazy. For him, this means to concentrate on underexploited research topics where new data can provide a significant increase of knowledge. Finally, in the specific field of archaeometallurgy, Peter Crew's experimental work is a very important source of inspiration, even if I remain a very poor experimentalist.

**THE CRUCIBLE:** What is your main current project?

**VINCENT SERNEELS:** I just start a new project on raw materials exploitation and technologies on Madagascar during the Medieval period. The main goal is to study the conditions of technological transfer between very different societies. At the time of the contacts with the large Indian Ocean network, the islamized settlers started to make iron, to quarry soapstone and rock crystal but do not improve the ceramic production.

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

**VINCENT SERNEELS:** For 15 years, I am involved in archaeometallurgical research in Mali, Burkina Faso and Ivory Coast. There are so many remarkable metallurgical remains in Western Africa and so few means, financial and human, to study them! Those remains can provide not only very valuable knowledge about the African history, but also fantastic data to understand broader questions related to the development of technologies by human societies. The historical frame of Africa south of the Sahara is different from that of Eurasia. Iron tools replaced stone tools and not copper ones. Things did not happen in the same way. I really would like to understand why.

**THE CRUCIBLE:** Which publication should every HMS member read?

**VINCENT SERNEELS:** There are many books on archaeometallurgy and I cannot pinpoint one single publication. Moreover, my advice will be to read also other books. Many times, I experienced that readings apparently not linked to my topic opened my mind to very useful new ideas. For example: *The Savage Mind (La Pensée Sauvage)* by Claude Lévi-Strauss. To keep the sense of science and humor, I always recommend to my students to read a short text by George Perec: "Experimental demonstration of the tomatotopic organization in the Soprano (Cantatrix sopránica L.)". [Http://pauillac.Inria.Fr/~xleroy/stuff/tomato/tomato.Html](http://pauillac.Inria.Fr/~xleroy/stuff/tomato/tomato.Html)

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

**VINCENT SERNEELS:** Keep your mind open, broaden your knowledge, take any opportunity to learn something new and do not hesitate to make things that look not

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

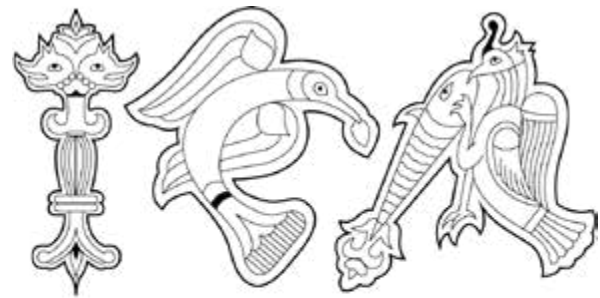
**VINCENT SERNEELS:** There are many ways to make good archaeometallurgical research and every input is welcome.

## FUTURE INTERVIEWS

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

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

*Please let us know at [thecrucible@hist-met.org](mailto:thecrucible@hist-met.org).*



56° CONGRESO  
INTERNACIONAL DE AMERICANISTAS  
SALAMANCA 2018

## ICA 2018, CALL FOR PAPERS

**Symposium: "Archaeology and History of Mining in the Old and New World: potential contributions in the analysis of American and urban colonial contexts"**

Mining has been pointed out as the engine of Andean economy during colonial time. It has also defined social relationships between diverse historical agents, directly related to the social configuration of the future American national states and the development of industrial capitalism in Europe. This session aims to promote the debate about the context of colonial mining in colonial and urban sites, and also gather researchers who study American and European historical and archaeological contexts related to colonial mining. Therefore, we invite to submit proposals that contribute to theoretical and methodological debates around the specificity of mining in colonial and urban contexts; history of mining in the Old and New World; changes and continuities in mining, arts and crafts; techniques and technologies; tensions between agents and agencies involved; environmental impact, daily life, power relationships, and the identification of the diversity of sites, archaeological and historical evidences.

*56th International Congress of Americanists (ICA), 15-20 July 2018. Salamanca, Spain. Deadline for abstracts, the 20th October 2017. Organisers: M. Florencia Becerra ([florenciabecerra@gmail.com](mailto:florenciabecerra@gmail.com)) and Luana Campos ([luanacampos@insod.org](mailto:luanacampos@insod.org))*

## LORNA ANGUILANO



**M**y name is Lorna Anguilano, I was born in Milan in 1977 and ever since I was a child I had a fascination for metallurgy as my father was a welder and a blacksmith and in his free time he loved making things out of iron for the house. Now retired he has betrayed metal and gone into wood working!

I studied Geology at the University of Milan and I fell in love with Mineralogy, in particular applied mineralogy, taught by Prof Gilberto Artioli. At the time (around 2000) Gilberto started a project on Neolithic copper smelting in the Trentino Alto Adige region and I had the pleasure of being one of his first students to work in Archaeometallurgy.

The discipline really captivated me and I decided to continue to investigate the potential of science applied to Cultural Heritage by attending a multi-disciplinary Masters at the University of Milan.

For my dissertation I had the pleasure of being accepted by Prof Thilo Rehren for an internship at the Institute of Archaeology, UCL. With Thilo I worked on lead smelting from Copa Hill, Cwmystwyth, Wales and Laurion and I had the pleasure of having some short excavation experience with Simon Timberlake at Cwmystwyth. The place was so unbelievable that a couple of years ago I decided to buy a house in that neck of the woods.

During the internship with Thilo we developed an idea for a PhD to work on the Roman silver production at Rio Tinto, Spain, which a year later was funded through a Marie Curie Early Career Researcher Fund and allowed me to spend 3 years of intense learning at UCL.

In 2008, I moved to work at Brunel University as a materials scientist to work with industry for failure analysis and material characterisation and development, but also to continue my research which has now diversified both to modern composites, manufacturing techniques and archaeometallurgy.

I work with my colleagues, Elisa Grassi, Vasco La Salvia and Peter Claughton who are a continuous source of interesting material and ideas. I also work in close relationship with Cadw and the Cambrian Mines Trust to bring together modern developments, respect and preservation of our historic landscape.

Last year I started teaching modern-day manufacturing at Brunel University and Archaeometallurgy at Sassari University. My experience at Brunel is offering me the opportunity to bring together ancient and modern manufacturing innovation and technologies, whilst my experience at Sassari is offering me the opportunity to create multidisciplinary groups of students to work and learn together in an extremely vibrant environment.

Last year I was delightedly selected to be a part of the Council of the Historical Metallurgy Society and a few months ago I became co-editor of *The Crucible* with Dr Gill Juleff.

Historical metallurgy, mining and industrial archaeology continue to fascinate me like the first day Gilberto introduced me to the discipline and I am happy to be part of such a varied and interesting community such as the Historical Metallurgy Society.

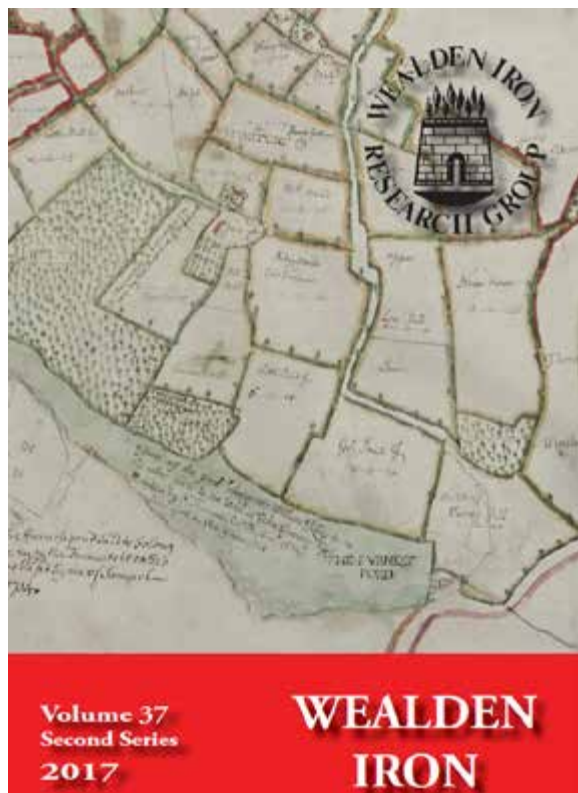
*Lorna Anguilano*



*At work in front of our Jeol 2100 TEM with Vulcan Cathodoluminescence detector and EELS spectroscopy*

## WEALDEN IRON

A summary of Volume 37, 2nd series, 2017



After 43 years David Crossley has retired as Editor of Wealden Iron, and the writer has taken over. David's tenure of the office has seen the publication develop in format and content. It has encompassed a wide range of articles, reflecting the diversity of disciplines that study of the Wealden iron industry embraces. The volumes published under his editorship form an unrivalled collection of focussed regional industrial resources.

After last year's two-part Bulletin, this year's is more modest in size. Two articles relate to fieldwork: a description of iron ore pits in the parish of Brede in East Sussex; and finds of metal objects at the site of Horsmonden Furnace in Kent. The latter includes a heavy, pierced casting which is suggested was part of the mechanism of a cannon 'boring' mill.

Three theoretical articles address different aspects of bloomery smelting. The first examines the Activation Energy value - the minimum threshold heat energy for starting a chemical reaction - in relation to the time taken for the reduction of ore and the formation of a bloom of iron. The second article explains why a seal is not required between a tuyere and a furnace wall in a bloomery furnace. The third explores the interaction between different materials - wüstite, fayalite, silica, carbon, lime and furnace gasses - in bloomery furnaces and how varying conditions in the furnace affect potential outcomes.

In volume 36 (2016) an article proposed how finery forge might have been operated within the surviving water management layout at Mayfield Furnace in East Sussex. An article in this latest

volume challenges that interpretation of the evidence and casts doubt on the assumptions made by the authors. In so doing, a possible alternative is suggested. Finally a short article describes two previously unrecorded leases for the forges in St Leonard Forest, near Horsham in West Sussex, towards the end of the seventeenth century.

For further information about the Wealden Iron Research Group, and downloadable pdfs of past volumes of Wealden Iron, see [www.wealdeniron.org.uk](http://www.wealdeniron.org.uk).

*Jeremy Hodgkinson*

### **Metallography and Microstructure. A Summer School Course in Ancient and Historic Metals.**

University of Brighton, Hastings Campus, Havelock Street, Hastings, East Sussex.

**Monday July 2nd-Friday 6th July 2018**

This week-long course introduces or further develops knowledge of the microstructure of ancient metals and the practical application of metallography. Using prepared samples from the most extensive collection of mounted ancient metals in the world, course participants will learn how to sample, mount, polish, etch and interpret microstructural features. The geographical spread of metals studied encompasses: ancient Greece, Rome, European Bronze Age, Bronze Age China (Warring States to Tang), Africa, Colombia, Peru, Ecuador, England and Ireland. Lectures on a variety of case studies are included. A lecture on the Wealden Iron Industry will be given by Jeremy Hodgkinson. The course will be held in the centrally located Hastings campus of the University of Brighton. Hastings is a popular seaside destination with many attractions including the Jerwood Gallery and various Museums.

Fee for course is £400. Early booking is advisable due to the holiday trade in the summer months. There are many Airbnb and hotels in the area. Booking: for 2018 bookings please send an e-mail to: [dascott@ucla.edu](mailto:dascott@ucla.edu).

Professor Emeritus, David A. Scott, is the former head of the Museum Research Laboratory, J. Paul Getty Museum, Professor in the Department of Art History, UCLA, and Founding Director of the UCLA/Getty Conservation Programme.

## THE METALLURGY OF OUR PORTABLE HERITAGE

17th June 2017, London, England

This one-day meeting was organised jointly with the Portable Antiquities Scheme ([www.finds.org.uk](http://www.finds.org.uk)) and was held at the Institute of Archaeology, UCL on a glorious sunny June day. It included the HMS AGM where new Council members were elected (see elsewhere in this newsletter for details).

As we've come to expect from HMS meetings, there was a packed programme with eleven papers on a wide variety of topics ranging in date from the Bronze Age to post-medieval times. The involvement of the PAS meant that the majority of the papers dealt with metals and metalworking in Britain, but two of the speakers had travelled especially from abroad to present their papers. Takahiko Kutsuna spoke about the change of gold production from gold dust to gold ore in Japan. It is thought gold mining started in Yamanashi prefecture, central Japan, in the 16th century and two mine sites there were excavated in the 1990s. More recently scientific examination of ceramic finds has identified gold on them, demonstrating their use in smelting gold ores. Cupellation has not been identified from physical remains but its use is clearly shown on the Sado gold and silver mine picture scrolls that survive from the Edo period (1603-1868). Diya Mukherjee's approach was rather different as she spoke about understanding lost wax casting through an ethnographic study of present-day craftsmen, showing a film of them at work. This technique has been used in the Indian sub-continent since at least the 3rd millennium BCE and is still in use today.

The Bronze Age was well represented with three papers. Miriam Andrews explained her work measuring the use-intensity of Bronze Age palstave axes. Replicas were subjected to systematic wear by repetitive wood-cutting and were re-sharpened at optimum intervals. The incremental increase in hardness of the axe blades was due to both use and sharpening, and the results of the project can be used to estimate the degree of use of prehistoric axes and the number of times they have been sharpened. Harriet White described a Middle Bronze Age four-flange twisted gold bar torc, discovered by a metal detectorist near Reach, East Cambridgeshire in 2015. It was 1.265m long, weighed 732g and is one of the largest found in Britain, Ireland and the near Continent. Its composition was determined for the Treasure process and a technical examination investigated manufacturing methods and wear, comparing it with other bar torcs. Tim Young described his attempts to determine the composition of Late Bronze Age ingots from St Michael's Mount, Cornwall. pXRF was used on external surfaces while some pieces were sliced to expose a fresh cross section. The coarse dendritic microstructure and

the strong weathering of the external surface meant the analytical data proved extremely problematic; the most useful were those obtained with the pXRF on a cut surface, with multiple analysed areas, each of approximately 8 x 10mm. Representative elemental analyses were not obtainable from drilled samples. Although the analyses tentatively suggested a Welsh Borders source for the copper, the most important outcome was that unless previous analyses of ingots were made on large areas of fresh cross sections, they should be considered of dubious utility. These problems affect essentially the whole corpus of British Bronze Age copper ingots.

Matt Phelps described the scientific examination of precious metal jewellery from a mid-1st-century AD hoard from Colchester. The results demonstrate the application of a wide range of production methods including diffusion bonding, hard soldering, wire production by hammering and rolling, details on the setting of emeralds within the gold rings and information on the fabrication of the silver medallion. The jewellery was of a high-grade gold alloy typical of Roman compositions and much purer than Iron Age gold coinage. Eleanor Blakelock's talk also focussed on gold: her analysis of objects from the Middle Saxon Staffordshire Hoard. They had found quite varied compositions with up to 30% silver and a few % copper in the gold. More surprising was the repeated observation that the surface 10-15µm of many objects was depleted in these elements, systematically giving the gold the appearance of a purer alloy than that actually used to make them.

Justine Bayley noted there was little technical innovation in the processes used to manufacture base metal objects during the 1st millennium AD. Evidence for the processes comes from part-made and finished objects as well as from the tools and debris that can be found in abandoned workshops; things such as scrap and waste metal, moulds and crucibles. She provided insights into the ways craftsmen worked in the past and how they made the metal objects archaeometallurgists study today. Kevin Leahy also dealt with metalworking processes, but by reviewing some of the finds of various dates reported to the Portable Antiquities Scheme. The earliest examples were a mould for a Bronze Age palstave and a Celtic coin die. Other, early medieval, dies showed how pressblech work and backing sheets for interlace were produced. Mis-cast objects and lead patterns for making clay moulds were also illustrated.

Alex Bliss described a class of finds that is virtually unknown from archaeological excavations. These are medieval jettons (accounting tokens), mainly of English origin, which were converted for use as brooches. The necessary fittings were riveted onto the obverse and the reverse was gilded; they are found mainly in East Anglia. Their manufacture, use and possible social significance to the people who wore them were all discussed.

The final two papers concerned post-medieval objects. Ann-Marie Carey showed how she and her colleagues had



reconstructed two objects from the 17th-century Cheapside Hoard by producing detailed laser scans of them. The scent bottle made of gold and precious stones was recreated from its many component pieces to understand the manufacturing processes involved, while for the Ferlite watch just the casing and the internal bell were recreated. This meant the bell could be struck; its peal was clear and beautifully pitched, an unusual association of sound with a museum artefact.

John Davis talked about the metallurgy of portable sundials, part of an ongoing study of medieval scientific instruments. The alloy compositions are being measured by XRF but copper-alloys suffer from the well-known problem of ‘dezincification’ which can seriously distort XRF results as it is a surface-sensitive technique. Experiments are being carried out to quantify and profile this loss of zinc. Eventually, it is hoped that some light may be shone on the locations of the workshops producing these early ‘mathematical instruments’ and on their sources of materials and the techniques employed.

*Justine Bayley*

## ADVENTURE IN IRON

BY BRIAN G. AWTY

Brian Awty (1925-2013) was a long-standing member of HMS and his interest in iron went back to before 1957 when he published his first article on the subject, on the ironmasters of Cheshire and Lancashire. He was working as an archivist at the Lancashire Record Office in Preston at the time. But his output on the subject was sparse over the ensuing 20 years. A change of employment, however, as a librarian at the London School of Economics brought him to London, and its proximity to the ironworking district of the Weald, reignited his interest. From the late 1970s he began researching the immigration of ironworkers from northern France culminating in his groundbreaking 1981 paper in *Economic History Review*, ‘The Continental Origins of Wealden Ironworkers’. Taking early retirement, Brian took on the task of seeking out the roots of those continental origins by going to the local archives in France and reconstructing the family relationships of the ironworkers who were to migrate to Sussex in the early 16th century. Such in-depth research into continental records had probably not been undertaken before on such a scale. Brian’s facility with languages was crucial; his university degree had been in German and Spanish. His research, however, could not be confined to foreign sources. The families, whose history he had traced, remained in the iron industry in their adopted land and many moved away from south-east England to work in the Midlands and the north, and in some cases across the Atlantic. Their lives, too, whether on the continent or in Britain were

inextricably involved with the spread of technology and many of the eight articles Brian would write for *Historical Metallurgy* would trace the development of iron-making processes, and often through the movement of ironworkers and their families. This study of the integration of new technology in early modern Europe was as important a thread in Brian’s research as the exploration of the personnel by whom that technology was operated.

*Adventure in Iron* is the culmination of this research over more than 30 years. Its sweep is broad yet detailed and the evidence of research impressive. Inevitably it is a work of considerable length, and it is that which proved an impediment to commercial publication in Brian’s lifetime. The Wealden Iron Research Group, which celebrates its 50th anniversary next year, has benefited from a substantial legacy that is currently enabling it to co-sponsor a doctoral studentship at the University of Exeter. In furtherance of its aim to foster research into the iron industry, the Group, which is a registered charity, is covering the cost of publishing a limited edition of Brian’s book. Details are to be found in the flyer that has been circulated with this edition of *The Crucible*, and at [www.wealdeniron.org.uk/publications/adventure-in-iron/](http://www.wealdeniron.org.uk/publications/adventure-in-iron/). To enable the Group to judge an appropriate print run, expressions of interest are being sought from individuals and institutions who might consider purchasing the two parts of *Adventure in Iron* when it is published next year. Please email [books@hodgers.com](mailto:books@hodgers.com) to be kept informed of the final publication details.

*Jeremy Hodgkinson,*

*co-editor with Christopher Whittick*



## BEGINNINGS OF THE USE OF METALS AND ALLOYS (BUMA IX)

Busan, South Korea (16th-19th October 2017)

BUMA was co-founded by Professor Ko Tsun and Professor Robert Maddin in 1981 and is an international gathering for archaeologists, archaeological scientists, material scientists, and engineers working on the production and use of ancient metals. It has travelled to Beijing, Zhengzhou, Sanmenxia (China), Matsue, Nara (Japan), Gyeongju (South Korea) and Bangalore (India) over the last 36 years. The chair of BUMA IX was Professor Chang Oek Choi from Dong-A University, South Korea. The conference was made up of one plenary talk, four keynote speeches, sixteen academic sessions and 59 poster presentations, and regions covered spanned from Eastern Asia to North Africa.

Professor Hyung Yong Ra from Seoul National University opened the conference with a plenary talk on the manufacturing history of Korean Bells and their intricate designs. The first academic session focused on precious metals and coinage with Jonathan Wood (UCL) presenting innovative research on the provenance and mixing history of silver artefacts using trace elements and lead isotope ratios, and James Lewis and Lyce Jankowski (Oxford) presenting their chemical and numismatic analysis of Korean coins in the Ashmolean Museum. Marcos Martín-Torres (UCL) presented his work on gold and silver ornaments in the Qin First Emperor's tomb and identified how casting technology, rooted in the bronze manufacturing tradition of the Central Plains of China, was used in producing gold and silver artefacts.

The second session looked at casting techniques for bronze and iron. Yoshiyuki Iizuka (Taiwan) presented bronze alloying experiments with cassiterite and the implications for ancient Chinese bronze technology and Mathilde Mechling (Leiden and Paris) presented a technical investigation of three Indonesian bronze statues in the Guimet Museum. Weng Cheong Lam (Hong Kong) presented research on small-scale Western Han Dynasty iron production at Taicheng, and the technological choices in selecting the materials to make casting moulds.

After coffee, Professor Srinivasa Ranganathan (Bangalore, India) in his keynote encouraged scholars to cross disciplinary borders for educational purposes in the study of metals, material heritage, and materials science. A session on the history of alloys followed with Chao Huang (Sun-Yat-Sen, China) giving a talk on his recent research on Paktong production in Yunnan in late imperial China and Hisao Fukuoka (Matsue, Japan) presenting quantitative analysis of mine mills using 3D laser scanning.

Eiji Izawa (Kyushu, Japan) presented a study of the production and use of 'shiomé', a copper arsenic-lead alloy and iron-copper speiss, in pre-modern Japan.

The afternoon session covered experimental metallurgy, survey methods, and conservation. Lee Nam Kyu (Hanshin, Korea) presented his study of ancient iron making technology in Korea and Kentaro Minami (Okayama, Japan) presented research on surface and use wear analysis of a bronze bell, the dotaku, from Japan. Cho Daeyoun (Chonbuk, Korea) talked about his investigation of iron production in Korea during the Three-Kingdoms period and the function of the tuyère.

The second keynote speech was by Professor Jianjun Mei (Cambridge) on the development of forging techniques in pre-Qin China. This was followed by two sessions on swords and iron artefacts.

Constantin Canavas (Hamburg, Germany) presented research on sharp penknives in Arabic, Ottoman, and Persian calligraphy and Manako Tanaka (Showa, Japan) gave a talk on a non-destructive study of Japanese iron nails from Saga castle using X-ray and neutron imaging techniques. Filomena Floriana Salvemini (ANSTO, Australia) described her research on non-invasive investigation by neutron techniques of a Samurai's sword and James Scott Lyons (Berkeley, USA) spoke on technological choices and manufacturing techniques of a Medieval Japanese sword. Stephanie Leroy (CNRS, France) gave a presentation on an integrated archaeometallurgical investigation of architectural crampons for documenting the iron economy of Angkor.

The last two sessions of the day were on copper and bronze technology. Tze Huey Chiou-Peng (Illinois, USA) presented research on metals at Early Bronze Age sites in Yunnan. Thomas Fenn (Pomona, USA) spoke on the flow of copper metals in Late Bronze and Early Iron Age Mongolia. Brice Vincent (EFEO, France) presented the archaeological investigations of the Royal Palace bronze foundry at Angkor Thom and Martin Polkinghorne (Flinders, Australia) presented the results of excavations at a 16th century royal bronze foundry in Cambodia. Two papers from Korea were on 4th – 5th centuries AD wire-making technology, studied through texture analysis (Dong-Ik Kim from Gangwon) and manufacturing techniques of ancient bronze Buddha statues from Bagan, Myanmar (Jae Sung Lee from the National Research Inst). Papers from China included Kunlong Chen (USTB) on the early use and production of copper in the Ili Valley, Xinjiang and Ji Zhang (PKU) on the chemical composition and lead isotope ratios of bronze vessels from the Eastern Zhou period. The session concluded with Kathryn Linduff (Pennsylvania) talking on the production and use of metal dragon plaques in the Buryatia and the Ordos. A rich evening banquet in the International Building brought a fascinating day to a close.



The keynote that opened day two was given by Tayfun Yildirim (Ankara, Turkey) on recent research concerning Hatti and Hittite metalwork in North Central Anatolia. The first academic session was on the theme of copper and bronze technology. Papers included Early Bronze Age copper alloy artefacts from Egypt (Martin Odler from Prague); the technological and experimental study of patination methods on black bronzes, Shakudo and Wu Tong (Agnese Benzonelli from UCL), and the scientific examination of Eastern Zhou bronze weapons with tin enriched surface decoration (Quanyu Wang from the British Museum). A special session was then dedicated to the archaeology of the copper mining and smelting site at Tonglushan, China, with Shuxiang Chen (Hubei) presenting findings from recent excavations. In addition to the copper mining galleries and smelting slag heaps, ore processing sections, administrative quarters, and a workers' cemetery have been identified.

The next session was also on copper and bronze technology with papers from Siran Liu and Brett Kaufman (USTB) on a bronze manufacturing foundry at the site of Taijiasi in the Huai River Valley and palatial metal production at the Davidic Iron Age Large Stone Structure in Jerusalem respectively. Chunxu Pan (Wuhan, China) shared his study of manufacturing techniques of Chinese bronze artefacts using various analytical methods and. Oliver Pryce (CNRS) presented an outline of early Southeast Asian non-ferrous base metal exchange networks and reflections on the début of regional metal technologies. Two papers from Italy covered surface treatments on later period Chinese vessels (Alessandra Giunlia-Mair of Archeoanalisi) and an investigation of ancient steel swords using neutron imaging (Francesco Grazzi of the Consiglio Nazionale Ricerche). S. Jaikishan (Hyderabad, India) spoke on developments in cannon production and operation in Medieval Deccan and Kazuo Miyamoto (Kyushu, Japan) presented research on decarburizing techniques for cast iron during the Yayoi period.

The last two academic sessions of the conference were on ores and metal production. Papers included Eunwoo Lee (NRICH, Korea) on the characterization of the early iron-production technologies in Chungju, Korea;

Concluding the morning's session with iron and steel technology, Jang Sik Park (Hongik, South Korea) gave the keynote on a comparative study on iron-making traditions in Korea, Mongolia and India, followed by Niwa Takafumi (Nara, Japan) on ancient East Asian curved tuyères used in bronze casting and Tomotaka Sasada (Ehime, Japan) on two types of iron smelting furnaces in ancient Mongolia. Jianli Chen (PKU) then presented criteria for identifying puddling steel based on slag inclusion analysis and Paul Craddock (British Museum) spoke on the many and varied roles of manganese in the production of iron and steel. David Larreina-Garcia presented his study of bloomery iron in Qing China and Kazuhiro Nagata (Tokyo) spoke on 'Wakibana' sparks in flame as a sign of iron melting in Tatar processes.

Reynaldo Ramos Avellana on new data on metallurgical production in first millennium AD Philippines; Wenli Zhou (CAS, China) on zinc distilling with sulphidic lead-zinc ores in Guiyang, China; and Miljana Radivojević (Cambridge) on mining and metal exchange in the Bronze Age Semirechye, Kazakhstan. The depth and breadth of the papers presented at BUMA IX is testament to the wealth of archaeometallurgical research now being conducted both in East Asia and connecting East and West, and especially the international community of researchers coming together under the BUMA umbrella.

At end of the conference, a special session was held for the two co-founders of BUMA. A memorial was given for Professor Ko Tsun who recently passed away at the age of 101 years old and a celebration was held for Professor Robert Maddin's 100th birthday. In the closing ceremony, Oliver Pryce summarized the conference, while Marcos Martín-Torres announced new members of the advisory and standing committees. The venue of the next BUMA (X) will be at Silpakorn University in Bangkok and a general plan was presented by Pira Vennunan, on behalf of the next local organizing committee. Professor Jianjun Mei made final remarks and announced the end of this very successful BUMA. The post-conference excursion was a tour to Kimhae Nation Museum and Daegaya Museum, a visit to Kyungju National Museum, and to an iron-making experiment in Ulsan.

*Siran Liu, Brett Kaufman and Kunlong Chen*

## THE TINWORKING LANDSCAPE OF DARTMOOR AND EUROPE

While Cornwall, the most south-westerly county of England, may be better known for extracting tin, the granite outcrop of Dartmoor in the adjacent county of Devon, played an important role in tin production from the bronze age until the closure of the last tin mine, Golden Dagger, in 1939. Recently, this has been eclipsed by the re-opening in 2014 of the former Hemerdon Mine – now called Drakelands, on the SW corner of the moor which aims to produce 5000t of tungsten concentrate and 1000t tin concentrate a year.

Dartmoor is rich in evidence of mining from small-scale prehistoric alluvial streamworks alongside streams, through medieval period larger scale alluvial works and eluvial works, the latter elevated on valley sides using water brought by leats. Later came gulleys working back along lodes into the hillsides, open cast-pits and finally shaft mining. As well as this topographic evidence, there are remains of blowing (smelting) houses, mortar stones on which ore was crushed by water driven stamps, wheel pits and mould stones into which molten tin was ladled.

Recently published, the 153 page A4 soft cover Proceedings of a conference held in May 2016 to celebrate the 25th anniversary of the founding of the Dartmoor Tin Research Group (DTRG) contains 11 papers, six examining sites on Dartmoor, one Cornish site and four in Europe.

Former Chairman DTRG and co-organiser of the conference, Dr Tom Greeves, opened proceedings putting Dartmoor tinnery in a historical context from the 12th to the 20th century. His paper, well-illustrated with photographs from the 20th C, finds, and early and current maps, traces the development of mining on the Moor. A graph of tin metal production presented for coinage between 1450 to 1750 shows heightened output between 1515 to 1538 with an average annual output around 525000 pounds (238 tonnes) in this period. Output declined significantly after this to zero by 1645 but appeared again from 1675 to 1720 but seldom exceeding 50000 pounds (22 tonnes).

A map of distribution of tinnery in 1373 shows that activity was concentrated in the southern half of the Moor in two bands, one to the west, the other more central. In a second paper, Tom addresses the archaeological evidence of miners accommodation, stamping sites and smelting, again well illustrated with photographs, maps and plans. An extensive table with map lists the location and characteristics of 177 sites.

Geologist, Richard Scrivener mapped the veins of tin across the Moor which generally lie in a SW – NE orientation. The tin lode occurs as brown coloured cassiterite (SnO<sub>2</sub>) associated with quartz.

Henrietta Quinnell addressed tin production prior to the medieval period the earliest evidence being a bead of tin found during the excavation of an early Bronze Age cist at Whitehorse Hill, but more definitive activity is found at a Bronze Age settlement on Dean Moor. The potential of geochemical work is expressed.



*Miners at Vitifer Mine c1919*

Phil Newman looked at tin mining in the 18th to 20th centuries from the landscape evidence. Included is a summary of some 80 sites where significant field remains survive as well as detailed descriptions, including plans, of seven.

Simon Hughes of AC Archaeology described the archaeological investigation of Crownhill Down prior to the reopening of a tungsten – tin mine in 2014. Tinworking remains were dated to medieval and 19 C activity on eluvial and lode tin deposits. Measures were found to prevent tailings from entering water courses.

Moving away from Dartmoor into Cornwall, Peter Herring of Historic England described how the study of the historic landscape enables the impact of mining on the community to be understood.



*Tin moulds (foreground) and furnace remains at Teignhead Farm dated 1457 (courtesy Tom Greeves)*

Further afield, a jointly authored paper from the Curt-Engelhorn-Zentrum Archaometrie of Mannheim and the Institut für Geowissenschaften, universitat Heidelberg discussed how tin isotope fingerprinting of ores and ancient bronze could be used to find the origin of tin used in artefacts. Heavier isotopes are associated with tin from Devon and Cornwall compared with the Erzgebirge region of Germany and the Czech Republic.

Petr Rojik of the Czech Republic described the evidence of surface workings in the Erzgebirge region of the Bohemian Massif. A network of leats was used in the 16C to facilitate extraction of tin.

Also from the Czech Republic, Michael Rund of Sokolov Museum described the Jeronym (Hieronymus) mine which was active from the mid 16C to early 17C. The underground mine boasts chambers surviving from its early times and is now open to the public.

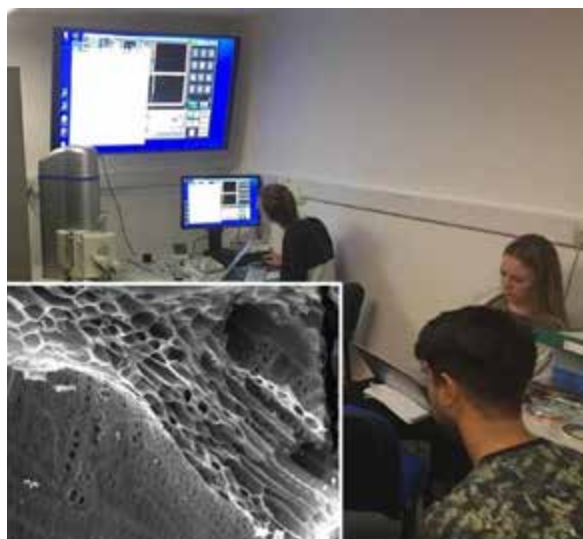
The final paper moves to the northwest Iberian peninsula which contains the largest tin belt in western Europe, three times the length of the Devon – Cornwall deposit. There is evidence of mining from the Bronze Age to modern times. A map shows the locations of known mine sites. Trials of experimental tin smelting are also described.

‘The Tinworking Landscape of Dartmoor in a European Context’ Papers presented at a conference in Tavistock, Devon 6-11 May 2016. Edited by Dr Phil Newman. Publication No 5 of the Dartmoor Tin Research Group ISBN 978-0-9529442-4-9 Price £18 +£2 p&p from [www.dtrg.org.uk](http://www.dtrg.org.uk)

*Tim Smith*



*Waterwheel at Hexworthy Mine c 1905 (courtesy Tom Greeves)*



**D**APHNE YOUSSEF, LUCY KING, ANGUS MALMGREN, TARA SKOK, KENEN D'SOUZA and PATRICK DAYKIN are 3rd year Natural Sciences student group at the University of Exeter using a Scanning Electron Microscope (SEM) to research structural and elemental composition differences between used and unused charcoal samples taken from experimental and archaeological smelting sites. Most metal-working sites yield charcoal but it is rarely clear whether it is charcoal awaiting use or charcoal that has passed through a furnace or hearth. The question the team is addressing is whether there are detectable differences between unused and used charcoal, and if the differences are indicative of process. Machine learning techniques, including neural networks, have been trained on quantitative data and images from samples produced by experimental archaeology and will

be used to predict whether the archaeological charcoal samples have been used or not. The project is still ongoing but preliminary results are encouraging as to the validity of this approach. **YOU CAN HELP** – the project is seeking used and unused charcoal sample pairs from experiments to help build the database - any metal, any process. If you have suitable material contact [g.juleff@exeter.ac.uk](mailto:g.juleff@exeter.ac.uk)

**F**REDERIK RADEMAKERS writes: The EACOM project ([ecom.be](http://ecom.be)) investigates early copper production through excavation, laboratory analysis and experimental archaeology. One major focal point is the Middle Kingdom Egyptian smelting site at Ayn Soukhna (IFAO – Université Paris-Sorbonne – Université du Canal), where dozens of near-identical smelting workshops, typically containing four furnaces, were identified. Two such smelting furnaces are replicated in Aubéchies, Belgium, within which different fuel types (charcoal, green wood, donkey dung) are tested to best reproduce the furnace lining colorimetry, slag types and other metallurgical remains encountered during excavation. This iterative approach (forty-nine experimental smelts and counting!) allows us to close in on the ancient process, while greatly improving excavation techniques too, as minute deposits are more easily detected when identified through experimentation. Ongoing chemical and lead isotope analysis of the experimental production remains provide an important reference for broader technology and provenance studies of ancient Egyptian copper, which are equally conducted within this project.





**PAUL RONDELEZ** writes: Recently, a pit containing metalworking waste was excavated at Stradbally, Co. Waterford in Ireland. Most of the material consisted of lumps of iron-rich slag, the most dense of which had copper-staining. Next to this, over 200 sherds of coarse ceramic material was recovered. These were fragments of rather shallow vessels with an average diameter of 190mm and an average height of 60mm. Some sherds had embedded droplets of metallic copper. Finally, the assemblage contained the front part of a bottle-shaped tuyere was found. The assemblage was tentatively interpreted as

the remains of matte-refining. A radiocarbon date placed the activity in the fifth to early sixth century AD. The full report can be downloaded from [www.slag.ie](http://www.slag.ie).



**GILL JULEFF** writes about Time and Tide, a new project with colleagues at Exeter University's Penryn Campus (History and Camborne School of Mines) and a local museum that is looking at mining evidence exposed in cliffs being eroded by increasing winter storms as a result of climate change. The cliff-scape at Perranporth in Cornwall is iconic, appearing on countless postcards and drawing tens of thousands of visitors every year. But few recognise that the huge rock arches and caves are the remnants of mining, perhaps dating to Medieval or earlier periods. In September the group held a one-day event called 'Heritage on the Beach'. Exeter students conducted a public survey, gathering data from 450 visitors, while members of Perranzabuloe Museum and the university gave 'pop-up' walks and talks on geology, mining, surveying, St Piran and Poldark (which was written at Perranporth). The survey shows that the majority of visitors on that day thought that the cliff features were natural.



**UMBERTO VERONESI** writes: As part of my PhD project I am currently investigating early chemistry and mineral prospection at colonial Jamestown, Virginia. The scientific analysis of crucible fragments and their inner residue are revealing an impressive number of different activities going on in the workshop and, most importantly, their highly experimental nature. Various ores were tested in search for metals, zinc minerals used to attempt brass cementation and experimental glass was produced too. When these results are considered in light of contemporary documentary evidence they become a powerful tool to tell the story of English colonisation in the New World. Indeed, Virginia was described as a promised land where England could finally find the resources that would make it independent from other countries and great profits could be made. The experiments at Jamestown tell us about attempts at making sense of a new world, at adapting technological knowledge to the local environment and at establishing manufactures for the industry (see front cover).



## FORTHCOMING EVENTS

Conference, Date and Location	Description	Website, Email and Prices
<b>West Dean College Arts and Conservation</b> Open day 3rd February 2018	Find out about our Metalwork programmes from Foundation through to MA and funding opportunities.	<a href="https://www.westdean.org.uk/">https://www.westdean.org.uk/</a>
<b>XX International Congress on Ancient Bronzes</b> 17 <sup>th</sup> -21 <sup>st</sup> April 2018 Tübingen, Germany	The conference -to be held in University of Tübingen- will bring together experts from different backgrounds in order to develop further the study on ancient bronzes.	<a href="https://klassarch.uni-tuebingen.de">2018AncientBronzes@klassarch.uni-tuebingen.de</a> <a href="http://uni-tuebingen.de/ancient-bronze-congress-2018">uni-tuebingen.de/ancient-bronze-congress-2018</a>
<b>REHABEND</b> 15th-18th May 2018 Cáceres, Spain	This major international conference is oriented to construction and cultural heritage management. Some interesting topics are “Conservation of industrial heritage” and “Restoration of artworks and archaeological materials”.	<a href="http://www.rehabend.unican.es/index.html">http://www.rehabend.unican.es/index.html</a>
<b>BushFire Forge “Forge – In” demonstrations and lectures</b> 18 th -20 th May 2018 East Wickham Farm, Kent, UK	Bush is hosting three days of lectures, practical demonstrations and forging. Forge-In is a friendly international event, a great opportunity to meet some of the worlds best Bladesmiths and tap into a wealth of information that you would be hard pushed to find elsewhere on the planet.	<a href="http://owenbush.co.uk/forge-in-may-6th-7th-8th-2016/">http://owenbush.co.uk/forge-in-may-6th-7th-8th-2016/</a> <a href="mailto:forge-in-2018@owenbush.co.uk">forge-in-2018@owenbush.co.uk</a>
<b>Metollography and Micostructure</b> University of Brighton 2nd-6th July 2018	A Summer School Course in Ancient and Historic Metals	<a href="mailto:dascott@ucla.edu">dascott@ucla.edu</a>
<b>56th International Congress of Americanists (ICA)</b> 15 <sup>th</sup> -20 <sup>th</sup> July 2018 Salamanca, Spain	The 56th ICA, to be held in the University of Salamanca, includes “Metallurgy as an axis for the understanding of the political, social and economic changes of pre-Columbian and Colonial societies in America” and “ Archaeology and History of Mining in the Old and New World”. The topics include: “Metals across time”, “Processes and technologies”, “Pre-Hispanic and colonial mining” and “Aesthetic and symbolic dimensions”. The deadline for proposals is the 20th of October 2017.	<a href="http://ica2018.es/home/">http://ica2018.es/home/</a> <a href="mailto:luchivetter@hotmail.com">luchivetter@hotmail.com</a>