THE CRUCIBLE

Historical Metallurgy Society News
Issue 109 Summer 2022

A shepherds hut - the versatility of corrugated iron! See page 15

Inside The Crucible

The Historical Metallurgy Society

Iron Forge, Barmouth, Dolgelley'(British Museum 1904, 0819.21). See Archaeometallurgical News page 11

From the Editors

Dear HMS members and readers of the Crucible,

It has now been a few years since I started the beautiful adventure to be one of the editors of the Crucible.

The experience has been interesting and enjoyable, however as all good things should come to an end I have to regretfully leave this task. Unfortunately, my workload does not allow me to continue this editorial activity anymore and I will now go back to being one of the enthusiastic readers of the newsletter.

I would like to thank all the authors that have sent us pieces in these past years, as they showed us the variety of work that is going on in the field of Historical Metallurgy. I would like to also thank my co-editor Gill Juleff as she really taught me how important details are. My last but not least big thanks are for the Brunel University editorial team that helped with the Crucible in the various years: Danny Aryani, Amy Flynn, Susanna Venditti, Mahfuz Karim and Uche Onwukwe. They have been great at drafting the newsletter, battling with the software and hopefully enjoying and learning along the way. Thank you all very much, it has been a pleasure working with you.

Of course big thanks go also to the members of the Exeter team: Carlotta Farci and Jack Cranfield as their polishing work was always excellent and fundamental for the good quality of the newsletter.

I leave the Crucible in the good hands of the next editorial team.

Thank you all so much

Lorna

Submissions

Submissions to ***The Crucible*** are welcome at any time, but deadlines for each issue are 1st March, 1st July and 1st November every year. Contributions can be sent in any format, but we prefer digital if possible. Images should be sent as high resolution jpeg or tiff files. We accept a maximum of 5 Harvard-style references per article only.

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

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Dear all,

There is always a sense of satisfaction in seeing the final version of the newsletter before it goes to press, combined in no small measure with a sense of relief. The few weeks spent compiling ***the Crucible*** three times a year are always a rollercoaster – do we have enough material? what goes where? what have we forgotten? We're not the journal and don't need to work to their exacting conventions but over the years, and decades, the newsletter has established a standard that we try to emulate with each issue. Then, miraculously, the final version pops up. But it is not miraculous, a lot of hard work goes in by the team spread between Brunel and Exeter and we have learned together how best to overcome, and often circumvent, the idiosyncrasies of digital technology to get the result we are aiming for.

However, the success of the newsletter is down to the contributors who send us material and we urge the whole community to keep submitting to the newsletter. Very few pieces are 'commissioned' and the majority are sent in voluntarily and we have little idea from one issue to the next what will be in it. This makes each issue different and we know that our readership enjoys the variety and diversity.

We're sorry to lose Lorna and the Brunel team, it is their dynamic drive that has pushed each issue forward. It has been fun working with Lorna and her colleagues, and I thank her personally for her capacity to forgive and accommodate shortcomings! Thank you all!

Like Lorna, it has been quite a few years for me also and I too now need to stand back from editing ***the Crucible***. The Exeter half of the editing team will continue under the excellent stewardship of Jack Cranfield with Carlotta Farci. To help with the transition I will support the next issue. There is now scope for a new editorial team to take ***the Crucible*** forward with new ideas and I also look forward to becoming an enthusiastic reader and contributor.

Thank you all

Gill

We apologise for the absence of a Spring edition of ***the Crucible***. Due to unforeseen circumstances, printing was delayed, and the decision was made to incorporate articles from the Spring edition into the Summer ***Crucible***.

Community, Technology and Tradition: The Great Orme Mine in the Bronze Age

The Great Orme copper mine in north Wales will be familiar to ***The Crucible*** readers as one of the largest Bronze Age mines in Europe. Not only a site of international importance as a major source of copper during the Middle Bronze Age (Williams and Le Carlier de Veslud 2019), today the mine is also a major heritage attraction, with thousands of visitors every year. Imaginatively and informatively curated by Great Orme Mines, it is well worth a visit (Fig. 1).

Figure 1: Bronze Age mine-workings at the Great Orme mine.

I experienced this unique mining landscape first-hand only a few years after excavations began in 1987, on a field trip organised for students on the BSc in Archaeological Science in the Department of Archaeology at the University of Sheffield. I was lucky enough to then spend a stint there as a fieldwork volunteer, working and learning alongside Mr Geoff David, the mine archaeologist (Fig. 2). This included the opportunity for uncomfortable exploration of a tiny fraction of the more than 6,000 km of tortuously tight underground tunnels that the Bronze Age miners left behind (Fig. 3).

By the mid 1990s, although much research had already been undertaken into the geological structure of the ore deposit, the form and layout of the prehistoric workings, and the Bronze Age mining technologies used (e.g., Lewis 1996), the contemporary landscape surrounding the mine was less well understood. To help fill this gap, in 1996 I and a small student team from the University of Sheffield, under the supervision of Professor Barbara Ottaway, excavated the nearby wet ore processing ('ore washing') site of Ffynnon Rhufeinig (the 'Roman Well') (Fig. 4).

Animal bone from a distinct undisturbed layer of well-sorted washing waste was radiocarbon-dated to 1945 to 1545 cal BC in the Early Bronze Age (Beta-148793; 3450 +/- 70 BP; 95% probability; OxCal v.4.4.2 with IntCal20). This is so far the only example of ore-washing waste from Britain and Ireland of Bronze Age date. It indicates that the prehistoric miners did not restrict their activities to the immediate mine area, but also utilised the wider landscape and its resources. You can read more about this site and its significance in the full report published in Historical Metallurgy volume 51 (Wager and Ottaway 2019).

Figure 2: The mine archaeologist, Mr Geoff David, inspecting a prehistoric mine-working.

My appetite for the study of Bronze Age copper mines and mining well and truly whetted, I jumped at the chance to undertake an AHRB-funded PhD on the Great Orme mine (Wager 2002). Alongside the 'big' research questions about geology, mining history and technology, prehistoric mining commentators are also interested in the miners as a social group. This was the focus of my research. Over the past 20 years, what has continued to fascinate me about the Great Orme mine – and prehistoric mining in general – is the relationship between technology and society in the past. Social anthropologists have theorised that, at the same time as people do even the most mundane and utilitarian technological tasks, they also create and sustain beliefs about community, personal identity and one's place in the world (e.g., Pfaffenberger 1998; Lemonnier 1992). If we consider the copper production sequence, from making mining tools to crushing ore to smelting, from this perspective, what insights might be gained into the character and organisation of Bronze Age society?

Figure 4: Excavating the wet ore processing site at Ffynnon Rhufeinig, 1996.

When the physical record of mining appears to speak more directly to issues about technology and the mine environment, it is obviously challenging to interpret in terms of social life, roles and identity. By exploring how Bronze Age activity at the Great Orme mine was about both production and the making and reworking of ideas about the self and society, my research presents a methodology for a socially-informed investigation of prehistoric mine-working that could be used at any early mine. Shortly to be published in an open-access book format as *Community, Technology and Tradition: A Social Archaeology of Prehistoric Copper Mining at the Great Orme Mine, North Wales*, it draws on published and unpublished field data and research to place prehistoric ore extraction at this fascinating site firmly in its specific practical and social context.

This type of synthesis is only possible through the efforts of other Bronze Age researchers, too numerous to mention individually here, to all of whom I am indebted for their generosity with material and ideas. I would also like to thank the Historical Metallurgy Society for a grant contribution not only for the original research, but towards the publication costs of the current volume. Thanks to this financial support, the illustrations are now at an advanced stage of preparation, with submission of the full manuscript to the publisher on track for the end of May. While no publication date has yet been set, I will be pleased to update readers when more details become available.

Emma Wager

Figure 3: The author stuck in a Bronze Age working underground.

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Preliminary Results: Standardisation of Copper Alloy Artefacts cast in Soapstone and Clay Moulds

Casting experiments, which often focus on specific aspects such as the behaviour of metal compositions, mould materials or the types of objects cast in moulds, are increasingly used to study ancient production technologies (Wang & Ottoway 2004, 1). In this current study, experimental archaeology was used to study the uniformity of cast artefacts to determine the degree of standardisation copper alloy artefacts could exhibit when they are produced from the same moulds. A secondary objective was to determine the reusability of soapstone and clay moulds within the casting process. For this purpose, we cast a total of 20 bronze palstaves: ten cast in a bivalve soapstone mould and ten in eight bivalve clay moulds (Fig. 1).

Figure 1 (left): To the left: Ten palstaves cast in the soapstone mould. To the right: Ten palstaves cast in the clay moulds. Note that one is only partially cast and that the sprues are still attached, and that flashing has been removed

Our main hypothesis was that objects cast in clay moulds would be less uniform when compared to objects cast in soapstone moulds, as clay shrinks and warps during the drying and firing stages. We intend to explore this uniformity by creating a baseline coefficient of variation (CV) for the two mould materials. A CV is an effective tool for measuring the standardisation of artefact production, and can be used to assess craftsmanship, identify workshops and the typological fidelity towards the shape of an artefact. It is beneficial in being a dimensionless measure of standardisation which allows for comparison between datasets of different means (Birch & Martinón-Torres 2019, 34). To calculate the CV, the standard deviation is divided by the mean and converted to a percentage (Vanpool & Leonard 2011, 50-53). This percentage is interesting, since the smaller it is, the more standardised the artefact production process can be considered. CVs below 10% are often associated with specialised workshops (VanPool & Leonard 2011, 56; Crown 1995), whereas a CV value ranging between 4-5% should indicate the limit of human ability to manually produce similar artefacts (Eerkens 2000, 667). It is important to stress that CV-percentages are a relative measure which highly depend on the material and technology used to produce an artefact. Therefore, a CV percentage associated with standardised flint production cannot be compared to a CV for standardised ceramic technology. Thus, each technology requires an empirically derived standardised CV. Through this lens, an experimentally produced CV could determine the minimum attainable variation for copper-alloy artefacts produced in both soapstone and clay bivalve moulds.

The clay moulds were composed of 50% clay and 50% sand since our initial tests indicated that this ratio warped the least while still producing the best impressions. A temper, in the form of sand, increased the thermoshock resistance of the mould and reduced shrinkage, which otherwise could be up to 10% (Söderberg 2018, 3). A palstave from the soapstone mould functioned as a template to produce the clay moulds. For the experiment a modern toploader kiln was used to ensure an even firing of the moulds, which fired at 950 degrees Celsius. As an alloy we chose that of 9:1 copper and tin. An elaborate description of the mould making process will be described in a later paper.

Before the experiment took place, we expected the outcome to be that of two papers. The first would focus on object uniformity based on statistical analysis of standard measurements, to create a CV, further supported by shape analysis using 2D and 3D geometric morphometric approaches (Fig. 2). The second paper would elaborate on the phenomenological side of the experiment such as the production of the moulds. However, during the experiments, white residues were consistently detected on the moulds which will be described in its own forthcoming paper.

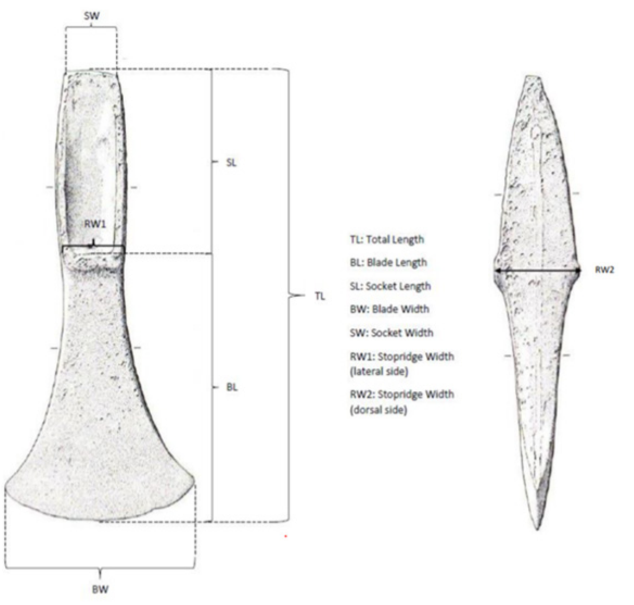

Figure 2: Palstave with measurement locations. B15 526; 4126 Hejnsvig.(Aner & Kersten 1986, 126)

CV's	TL	BLa	BLb	SLa	SLb	BW	SW	RW1	RW2
Soapstone	0.28	0.66	0.39	1.01	0.71	0.33	1.51	1.36	0.80
Clay	0.91	1.30	1.10	1.02	2.96	1.55	2.07	2.59	3.91

Table 1: Average CV percentages for the variables for the palstaves from the soapstone and clay moulds.

Preliminary results concerning artefact shape consistency and mould survivability: Table 1 provides the CV percentages which are to be expected when studying artefacts from the same mould or template. The results indicate that artefacts produced from soapstone moulds are highly standardised with very low CVs ranging between 0.22 and 1.51%. Clay moulds are not able to meet similar accuracy with a CV range of 0.91 - 3.91%. However, the CVs are low for both mould types and are not comparable to the 4 - 5% CV limit of manual artefact replication. Casting technology is more accurate and in the archaeological record low CVs should be expected. The difference in shape consistency for the two mould materials is further supported by the preliminary 2D morphometrics, which will be published in one of the forthcoming papers.

Mould survivability: Soapstone moulds survive multiple castings with minimum deterioration (Fig. 3). Clay moulds, however, performed poorly since six did not survive their first casting and the rest did not survive their second casting (Fig. 4). This result speaks in favour of Coghlan (1975), who argued that clay moulds should be considered single use objects, though this applies mostly to socketed objects. This does not necessarily dispel Kuijpers' (2008) argument that moulds without a core could produce multiple castings, since two of the clay moulds from our experiment did survive for a second casting. However, since we noted that the moulds consistently broke at the same location, we argue that the shape of the palstave in the negative space plays a significant role in mould survivability (Fig. 4). More obtuse angles may also help release the object post casting.

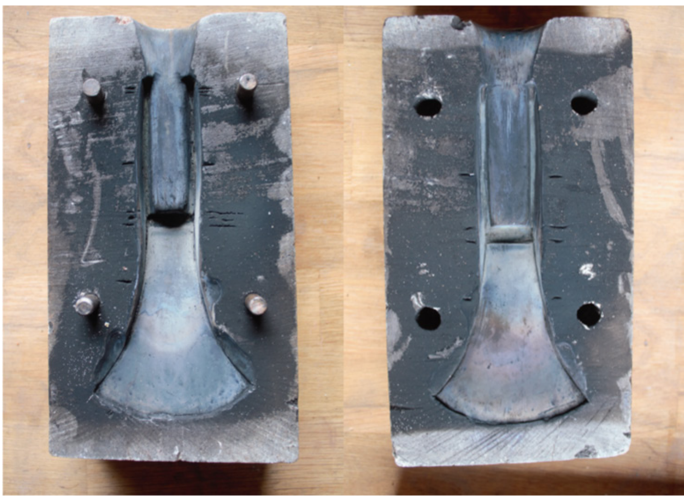

Figure 3: Stone mould after casting. The edges have broken off at the same places as the clay moulds. Note that they have been sanded down.

Figure 4: Typical damage to the clay moulds after (Left: One valve from CI. Right: One valve from CVII)

We are grateful to the Historical Metallurgy Society and the Coghlan Bequest and R.F. Tylecote Memorial Fund for their generous grant which enabled us to acquire the materials needed for the experiment.

Jakob T. Hviid, Bart J. T. Cornelis, Christian S. Hoggard & Thomas Birch

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Silver in Queensland

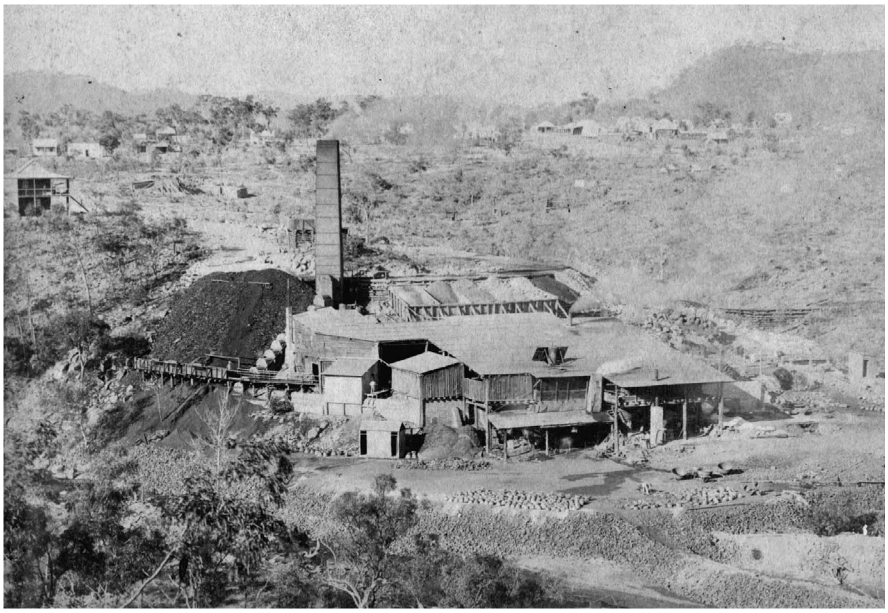

Figure 1. The smelter complex at Montalbion c.1886 (Royal Historical Society of Queensland, P9051J). Note the large heap of charcoal, fuel for the reverberatory furnaces, to the left of the smelter.

During the 1880s, Australia became a significant source of silver. By 1890, it accounted for 50 per cent of the £2,637,232 declared value for silver-bearing ores imported into the United Kingdom and by 1900 produced over 159 million ounces of silver refined in Australia. The vast majority of the latter came from mines in the Barrier Ranges of western New South Wales, around Broken Hill. Queensland accounted for less than 2 million ounces of refined silver prior to 1900 but by 1909, this number was around 10 per cent of total production in Australian. The sites in Queensland do however present evidence for a range of approaches to the treatment of silver bearing ores.

Over the last twelve years, the unfunded Queensland Silver Project has been examining the choices made in processing the ores prior to shipping to markets outside Australia. It has considered potential sources of further information on how and why particular methods of processing were chosen or rejected; what benefits, if any, were or might have been derived from those processes.

Several sites have been visited but thus far, on-site investigation and documentary research has focused on three groups of sites – Silver Spur, near Texas, in south-east Queensland; Totley, near Ravenswood and Argentine, both to the west of Townsville; and Montalbion, Muldiva, Mungana, and Silver Valley (Newellton), all in the area west of Herberton (Fig. 1). All bar one of these, Totley, chose to smelt on site using a number of different techniques. A small number of sites in New South Wales, particularly Sunny Corner (east of Bathurst) have also been investigated to provide useful comparisons with practices in Queensland and a preliminary report was prepared in 2013 drawing on those comparisons.

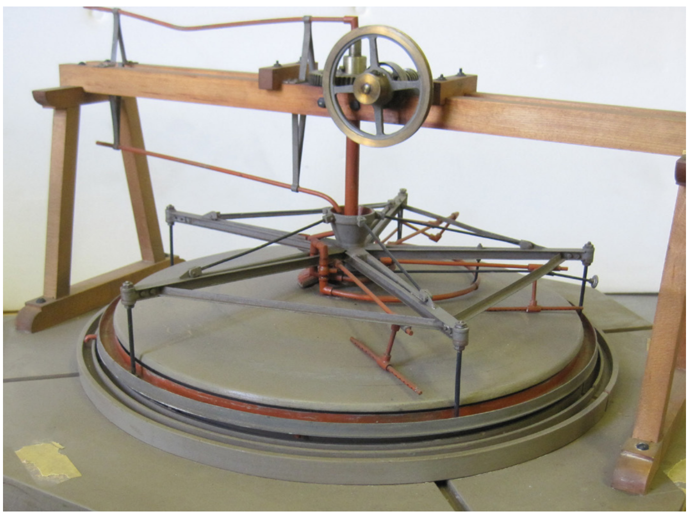

Figure 2. The Linkenbach table, as used for ore preparation at both Totley and Montalbion - a model held in the British Museum store, London.

It was evident that, where on-site smelting was the processing method chosen, a trend towards the use of North American type water jacket blast furnaces was very clear. Only at Silver Spur was the reverberatory furnace successful employed for a long period – producing a silver-rich copper/lead matte which was refined by Vivians in Swansea. The blast furnace technique could be effective, given informed operators and an ability to develop and modify the process, as was shown at both Sunny Corner and in north Queensland, at Montalbion. Both were curtailed by the dramatic fall in silver prices rather than resource depletion. Decisions to use ore concentration techniques, prior to either export or smelting on-site, were never given a fair trial. At Ravenswood (Totley), that was down to a failure to develop resources before expenditure on infrastructure, a feature of many share promotion ventures in the late 19th century, and at Montalbion it was defeated by the fall in prices.

Silver smelting in north Queensland relying on charcoal produced from local timber could not be sustained. A supply of coking coal and a rail link were essential to continued production, and those did not arrive in the Montalbion area until 1907. As to the effectiveness of the smelting processes themselves, some conclusions can be drawn from the results of the preliminary analyses carried out on the slags by Dr Lorna Anguilano at Brunel.

Although the first sample recovered from Silver Spur was only a random selection from the dump which might be associated with the earliest furnace used at that mine, it suggests that the recovery of silver was very effective. At the Sunny Corner group of blast furnaces, a small percentage of the silver was being lost to the slag despite the introduction of metallic lead as a collector, confirmed by the analyses. The analyses carried out for both the Silver Spur and the Sunny Corner group of smelters suggests that there were inefficiencies in the roasting process.

This has been investigated further, particularly in respect of Silver Spur where new documentary evidence was identified, and further samples collected from discrete dumps related to other furnaces and processes.

Figure 3. The smelter chimney at Argentine

In 2014 the opportunity was taken to investigate the reverberatory furnace at Argentine, within the Department of Defence's Townsville Field Training Area, which had failed during operation with remains of the charge still in the hearth (Figs. 3 & 4). Samples were collected and analysed at Brunel along with the discrete samples from Silver Spur (Fig. 5).

The results from analyses of the charge from within the hearth at Argentine, including the lack of evidence for silver, suggests that minerals from the weathered zone close to surface had been smelted as mined and that was poor in silver. On the other hand, it is evident that the deposit worked at Silver Spur was polymetallic, rich in the sulphides of lead, zinc, and iron, with a moderate copper component. This was reduced to a silver-rich copper/lead matte - 5.55% iron, 39.30% lead, 2.33% zinc, 19.136% sulphur, 31.50% copper, and 1.89% silver. The very low levels of silver found in the Silver Spur slags suggest that recovery was most efficient but further investigation is required to determine the efficiency of attempts, using a small blast furnace (c.1899-1901), to recover the lead lost to the slag from the reverberatory furnaces.

Work on the project, which has been on hold for the last few years (latterly due to Covid 19) is due to resume in April/May of this year.

Peter Claughton

Acknowledgements

I am indebted to Dr Lorna Anguilano for her help in analysing samples of smelting slag, and my thanks goes to the Australian Department of Defence, Townsville Field Training Area, and their archaeologist Dr Peter Bell, for access to the Argentine smelter site, and to Alcyone Resources Ltd for access to the smelter site at Silver Spur, Texas, QLD.

Figure 5. The remote slag dump with remains of tramway bridge, at Silver Spur.

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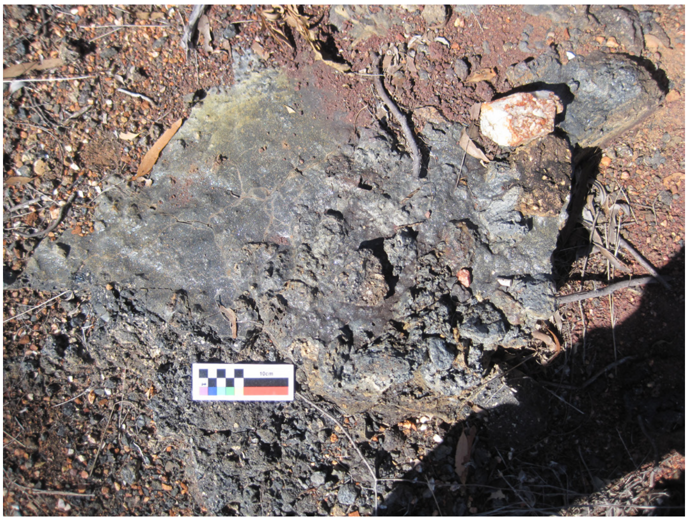

Figure 4. Frozen charge in the hearth

All that Glisters is not (Bronze Age) Gold: The Rathgall gilded phalera

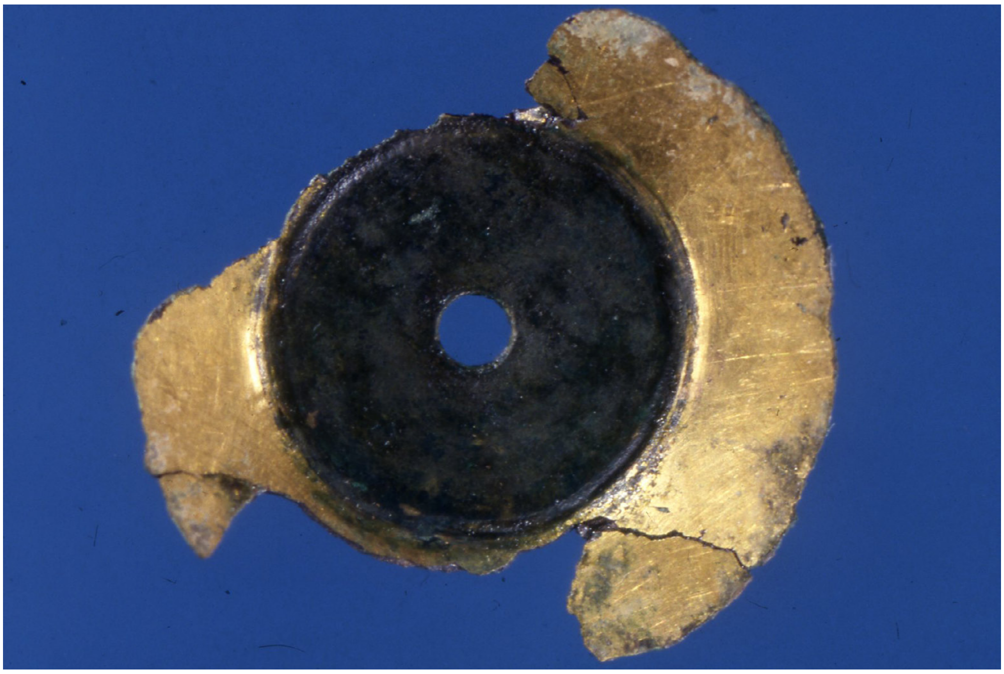

Figure 1 Small mercury gilt phalerae. Its diameter is 35mm.

Archaeological excavations at the great hillfort at Rathgall, near Tullow in County Wicklow, Ireland in the 1970s produced a huge number of artefacts, including metal artefacts and the remains of metalworking. These date from the Late Bronze Age through to the first millennium AD (Raftery 1971). Although there are numerous reports stressing the importance of the site, it remains substantially unpublished.

Some of the material was examined in the British Museum Research Laboratory back in the 1970s, including a foil-gilt bronze ring, E 84.6070, and a small gilt phalera, E 84. 6458, (Fig. 1). The latter roused considerable and continuing interest. This small bronze disc apparently from a secure Late Bronze Age context of the early first millennium BC had been mercury gilded. This would make it the earliest example of mercury or fire gilding anywhere in the world by several centuries. Elsewhere, mercury gilding is attested both in China and in Greece, both from the mid first millennium BC.

Our internal report was picked up by R.F. Tylecote, who recognising the importance of the phalera, included it in the revised edition of his The Prehistory of Metallurgy in the British Isles (1986), stating that ‘Mercury or firegilding was used in the 6th century BC at the Late Bronze Age site of Rathgall, Ireland.’ (p. 112), and also in his 1987 publication The Early History of Metallurgy in Europe, stated that ‘We know that mercury was used in the Late Bronze Age at Rathgall, Ireland.’ (p. 43), and again ‘mercury gilding was known as early as the 8th century BC in Ireland.’ (p. 240). These publications not only gave the mercury gilded phalera wide publicity but also credence, reported in such impeccable and authorative sources (the original unpublished Research Laboratory report was much more circumspect!). As such it was widely quoted thereafter and critically by Schwab et al (2010) who were investigating the Oedt sword. This is, or more correctly was, together with the Rothenmoor sword, the only other examples of Bronze Age mercury gilding known in Europe. The Late Bronze Age sword from Rothenmoor, Germany, was published as mercury gilded but with no supporting technical evidence to back up the claim. The Oedt sword, also supposedly of Late Bronze Age date from Germany, was thoroughly examined, and found that it was a composite assembly, the hilt was indeed mercury gilded, but unlike the rest of the sword, was made of gunmetal with about 4% of zinc. This was an alloy not known in Europe before the end of the first millennium BC.

On this evidence Schwab et al concluded that the gilded gunmetal hilt of the Oedt sword could not be of the Bronze Age and that ‘At present the disc from Rathgall in Ireland and the sword from Rothenmoor in Germany remain as the only supposedly fire-gilded Bronze Age objects. However they are of uncertain date in the case of Rathgall and of uncertain technique in the case of Rothenmoor. Both finds certainly need to be re-investigated.’

This is certainly true, as in the continued absence of an authorative report on the site of Rathgall itself or of its finds, the presence of the mercury gilding is frequently reported or misreported in popular accounts. For example, the Rathgall and Aghowle Brochure 2008-9 pdf published on line by the Rath Community Group, supported by the County Wicklow Heritage Plan, gives quite a detailed description of the excavations and the finds, and after stating that the ring was mercury gilt, concluded that ‘He (Barry Raftery) also found a disc with mercury gilding on it. Mercury was used to stick gold to bronze. He got the piece analysed by a British museum and the piece was dated back to 1000 BC. Before it was analysed Irish professionals did not believe that this came from Ireland as nowhere in the world had mercury

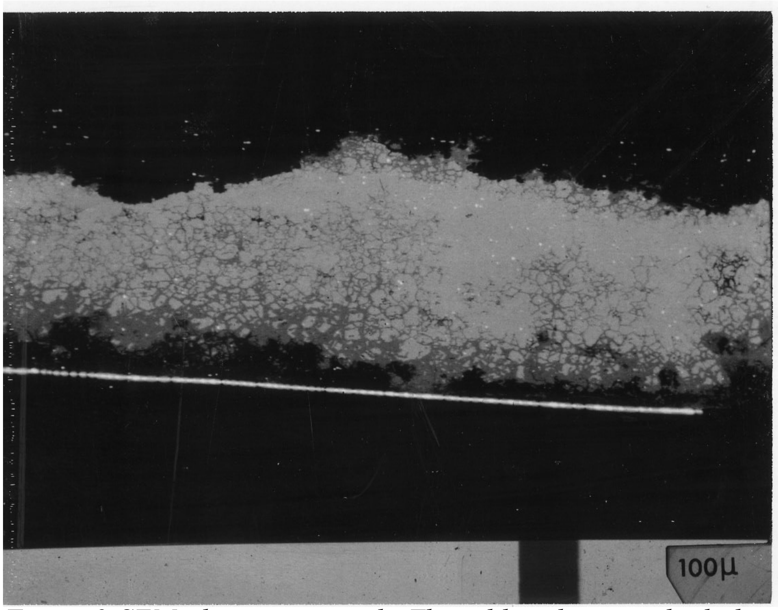

Figure 2 SEM photomicrograph. The gilding layer is the light line running across the lower part of the figure. It forms a uniform layer approximately 3 microns thick sitting directly on

gilding been found that was dated back further than 400 BC. Only the fact that that it was analysed by an English museum did they believe it!'

Thus it seems necessary to clear up the confusion by presenting the principal findings of the scientific examination of the phalera and then assessing the possibility that it could belong to the Bronze Age.

The bronze of the phalera is now totally corroded with the copper being preferentially leached out leaving a tin-rich corrosion product which was identified by X-ray diffraction as containing both cassiterite ($SnO2$) and romarchite (SnO). Qualitative X-ray fluorescence surface analysis showed it to be of tin bronze with a little lead and that the gilding was of gold with a little silver, but also contained mercury. A small sample was detached and examined by scanning electron microscopy. This showed the gilding to be in a uniform layer approximately 3 microns thick sitting directly on the now corroded bronze surface (Fig. 2), and micro analysis confirmed the presence of mercury. There can be no doubt that this is a mercury gilded artefact that has become corroded during prolonged burial.

The possibility that this piece could be of the Late Bonze Age must now be carefully considered, both the technical feasibility and in the context of contemporary metalworking. The technique is not intrinsically difficult. Finely divided gold is ground up with mercury to form an amalgam, and this is applied with a stiff brush. The piece is then heated to above the boiling point of mercury (3560C) and the vast majority of the mercury is driven off, leaving a gilded surface with a small but persistent trace of mercury.

In order to carry out mercury gilding the craftsmen must have had access to the necessary materials. The gold, of course, presents no problem, the Wicklow Mountains are believed to have been one of the main sources of gold in the Late Bronze Age, but the mercury could be considered as more problematic. However mercury does occur in Ireland and was actually produced commercially in the 1970s as a byproduct of copper production at the Gortdrum mine, which lies about 5 km north of Tipperary Town. There are even records of metallic mercury being found Ireland. When railway cuttings were being dug in the south west of the country in 19th century 'liquid silver', identified as mercury, was encountered running from the rocks on at least one occasion, as communicated to the authors by John Jackson, the first investigator of the Mt. Gabriel Bronze Age copper mines.

Thus, the raw materials were potentially available, but is there any other evidence for the use of mercury gilding in the Bronze Age of the British Isles? To this the answer has to be no. Gold plating was quite common in the Late Bronze Age, including the bronze ring, E 84.6070, which is covered with gold foil, coming from the same context at Rathgall, as the phalera, but mercury gilding has never been encountered. Similarly, the major study of penannular gold rings from the British Isles revealed a range of quite sophisticated and well executed gilding techniques but again with no trace of mercury (Meeks et al 2008). The earliest examples of the technique from the British Isles are currently some pieces from the Late Iron Age Snettisham gold torcs dated to the first century BC.

It might be thought that the composition of the underlying copper alloy might give an indication of date. Brass, the alloy of copper and zinc, began to replace bronze, the alloy of copper and tin over much of Europe and the Mediterranean from the beginning of our era. However, in Ireland bronze continued as the predominant alloy through the most of the first millennium AD, right up until the arrival of the Vikings, and thus the composition of the copper alloy would have been appropriate throughout the long period of Rathgall's occupation.

Much relies on the security of the Bronze Age context. More detailed study of the excavated material has identified a small ingot of silver apparently from the same layer as the phalera. Silver is almost totally unknown in the Bronze Age of the British Isles, but it became quite common in the first millennium AD, often in the form of small ingots. Immediately above the Bronze Age layers were others formed during the first millennium AD, and there is a strong possibility that some material from these later layers had sunk into the earlier deposits.

Thus, although the Bronze Age smiths certainly had the technical capability and could well have had access to the necessary materials, on balance it is likely that the foil-gilded ring is of the Bronze Age, but the mercury-gilded phalera is almost certainly to be intrusive from the Dark Age layers of the first millennium immediately above.

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Borthwnog forge – Paul Sandby illustrations 1771-1776

This note is a result of research relating to the Dolgun Blast Furnace and Forge. The Borthwnog forge is best known from Paul Sandby's aquatint published in 1776 in Vol II of his XII views in Aquatinta from Drawings Taken on the spot in North Wales. This illustration is well known and has been widely reproduced (Fig. 1). It is clear now, from earlier versions of the illustration, that the view has been reversed. This misled early attempts to identify the location of the forge, which was thought to have been at Bont Ddu, some 2km further west.

Figure 1 Paul Sandby "The Iron Forge between Dolgelli and Barmouth in Merioneth Shire", aquatint, 237 x 314mm

A version of this illustration, but reversed, is in the Metropolitan Museum of Art (MMA), which is incorrectly identified in Robinson's Museum catalogue as Abraham Darby's forge at Dolgun. No other significant detail is given on the MMA website except "Vendor: James Rimmel (British)". It was presumably produced as a print, though no other copies have been located (Fig. 2).

The correct orientation of this print is confirmed by the original pencil sketch by Paul Sandby. This was drawn 'on the spot' in 1771, during his tour of North Wales with Sir Watkyn Williams-Wynn. The most significant difference is that it shows two water-wheels.

In 1770 Williams-Wynn invited Sandby at his stately home Wynnstay near Ruabon, North Wales. They got on well and Sandby returned to Wales in 1771 to take part in a two week tour of picturesque sites of North Wales with an entourage comprising three gentlemen, nine servants and fifteen horses. It was an adventurous excursion for someone so young (Williams-Wynn was barely 20 years of age) into some of the most inhospitable parts of North Wales without any guide books or maps of any quality and little prospect of commodious accommodation. It was an expensive expedition, the fifteen day tour costing them £111.7.6d - the equivalent of some £10,000 in today's money. The tour included visits to several waterfalls, castles, an ascent of Snowdon and excursions by boat. It is widely acknowledged to have been the first extensive tour in Wales undertaken for the appreciation of landscape. The collaboration between Williams-Wynn and Sandby was clearly fruitful and mutually beneficial with Sandby being commissioned by Wynn 'to prepare a series of prints of the finest water-colours of the 1771 tour' and in 1776 the *XII Views of North Wales* was published.

The pencil sketch was published in Peter Lord, 1980, The Visual Culture of Wales – Industrial Society (University of Wales Press), Fig. 13, p. 2. Lord suggests that the seated figure is Williams-Wynn himself, also sketching, and being sheltered by an umbrella held by one of his servants (Fig. 3).

Figure 3 The original pencil sketch by Paul Sandby, 210 x293 mm. National Library of Wales, Aberystwyth. Note especially the two water-wheels.

Comparison with the later prints shows that they had numerous changes and romanticised additions, with a different layout of the building, with only one water wheel and with the tall chimney with the unlikely plume of smoke. The weir has also been made more dramatic, and the launder is shown clearly at a lower level. The added double doors have a stack of iron bars to their right, which are about 2m long.

Another version of the image survives as a rather fine water-colour, which was probably worked up by Sandby shortly after the tour. This must have been kept in the family collection until it was bequeathed in 1904 to the British Museum by William Arnold Sandby. It is a very close copy of the original pencil sketch, again with the two water-wheels, shown in full on the cover of ***The Crucible*** (Fig. 4). These illustrations make it clear that the forge was on the west bank of the river and its location can now be identified as being at Borthwnog, some 4km to the west of Dolgellau, as indicated in the 1802 sale particulars (*q.v.*), just across the estuary from Penmaenpool (SH 688 193). Nothing survives on the site.

There is no mention of the Borthwnog forge in the detailed diaries of John Kelsall, who was manager of the Dolgun furnace between 1719 and the 1730s, and during the later part of that period the Dolgun iron was shipped to the forge owned by the Payton family at Llanrhead, now Glanfraid (SN 634 877), south of the Dovey estuary, for further processing. The first documentary evidence for the Borthwnog forge is in 1760, when William Barrow of Welshpool is recorded in the Parish Register as iron refiner and forgeman. The forge had closed by 1802 when it was advertised for sale in the Salopian Journal along with Dolgun Forge, to the east of Dolgellau. The text is worth quoting in full:

'Two valuable Forges called Dolgyn Forge and Borthwnog Forge … are held under two leases for unexpired terms of 55 years from 12th November next, at annual reserved rents of £31 2s…Borthwnog Forge adjoins the Turnpike Road leading from Dolgelley to Barmouth, and is well adapted and may, at a moderate Expense, be converted into a Rolling Mill and Slitting Mill to roll Bars and Sheet iron, there being a fall of 32 feet and an Opportunity of making Reservoirs on the Mountain above it, so as to afford a sufficient Supply of Water in the driest Seasons. Boats of eight Tons Burthen can come up to the Yard of the forge to discharge their Cargoes. … The Port of Barmouth is only six Miles from Borthwnog Forge, from whence Vessels sail to all Parts of Europe.'

Figure 2 Metropolitan Museum of Art (36.8.32) c. 1776, graphite and brown wash, 220 x 290 mm, edges cropped.

The statement that the lease for Dolgun and Borthwnog had 55 years to run, suggests a construction date of the Borthwnog forge in 1757. The two wheels at Borthwnog were presumably one for the bellows and one for the hammer. This implies perhaps that either the forge had a single hearth for refining and

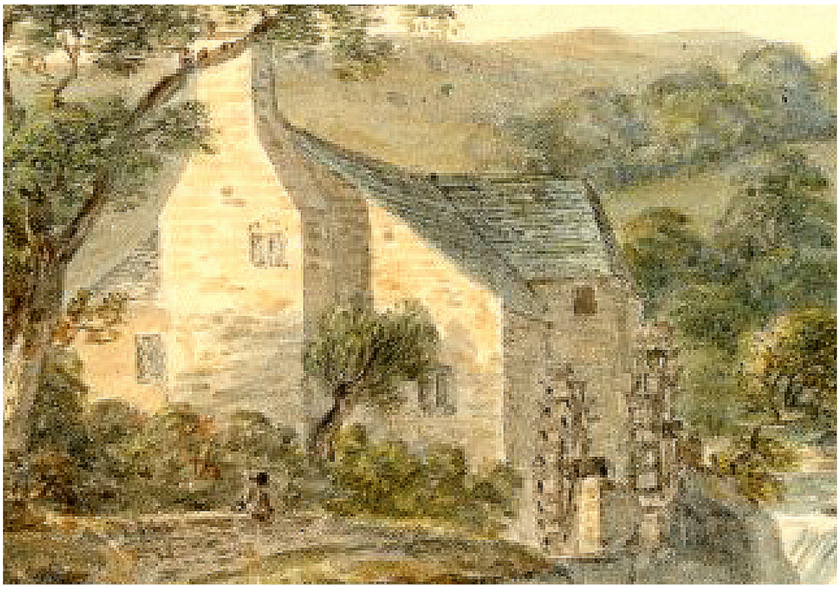


Figure 4 Iron Forge, Barmouth, Dolgelley enlarged extract from British Museum (1904, 0819.21).

forging, or perhaps more likely that it was used only for the re-heating and forging of partly refined blooms.

After the departure of John Kelsall there is no firm evidence for a furnace continuing at Dolgun. However, from the 1750's to the end of the century there is documentary evidence for a forge at Dolgun, with pig iron being sold to 'the Dolegun company' from the Horsehay Furnace, in 1759 to 1761, and also from Backbarrow in 1787. The record of two fineries and a chafery at Dolgun, in a sale notice of 1763 and in the 1794 list (King 2011, 'Iron in 1790: productions statistics 1787-96 and the arrival of puddling' HM 45.2, 102-133) shows that the pig iron was being refined and forged to bar iron there. The 1802 sale catalogue says that at the Dolgyn Forge 'from eight to ten tons of half blooms may be regularly made … or six tons of bar iron weekly', though it is not clear if this was based on historic production or an estimate of potential production. 'Half bloom' was the contemporary terminology for a thick square bar, which would be the result of the first refining. It is possible that some of the half blooms from Dolgyn were taken to Borthwnog for the final forging to bars, though this remains to be established.

Peter Crew

Acknowledgements

Thanks to Llew Williams of Bangor for the information about William Barrow and his family and for drawing my attention in 2004 to the discrepancy between the 1771 pencil sketch and the 1776 reproduction of the Sandby illustration; to Peter King for his references to the Borthwnog and Dolgyn forges; to Peter Lord for help with the Sandby 1771 sketch; and to Gareth Roberts for details of the Sandby tour.

CWMYSTWYTH MINE

To Wardell Armstrong (Crown mineral agents)

From Roy Fellows

21st May 2008

I am writing on the matter of the possible sale of the Cwmystwyth lead mines previously offered to the Welsh Mines Preservation Trust.

In furtherance of the objective of purchasing the mines I am willing to form a company limited by guarantee for the purpose of purchasing and managing the mines. I have given some thought to a suitable name and have provisionally settled on "Cambrian Mines Trust Ltd". In the event that a provisional agreement on the purchase of the mines is achieved, I intend to form this company without delay.

…………………………

The above historic letter was the initial step by Cambrian Mines Trust is acquiring the Cwmystwyth Mines. The mines always were a very important site for archaeologists, mining historians, and underground explorers; however, when the last mining company ceased to exist, the mines passed into the hands of The Crown Estate, who had grilled all of the entrances to the underground workings thus preventing access.

A group of stakeholders including representatives of Welsh Mines Preservation Trust attended a meeting with Wardell Armstrong, the Crown mineral agents, to attempt to find a mutually acceptable solution to the issue of access to the mines. It was suggested that a possible way forward would be the purchase of the mines by WMPT, however WMPT were unable to do this due to other commitments.

This matter was discussed at a NAMHO Council meeting and it was commented that it looked unlikely that a solution could be found. It was then that Roy Fellows suddenly announced to a stunned meeting "I will do it!"

The silence was deafening. Actually, the matter had been under consideration for some time, but no one else there knew this.

Figure 1 New gateway sign for Cwmystwyth Mine

Since the acquisition, the trust has become aware of the wider opportunities, far beyond underground access, presented by ownership. However, with access to the far reaches of Lefel Fawr threatened by imminent roof collapse, a program of underground remediation was given priority. Extensive underground support work was therefore undertaken to ensure continuity of access to this important level. Once completed the trust was able to turn its attention to other works, such as gateway signage. The trust has recently also installed interpretation boards on the historically important site of Copa Hill, and also at the Nant yr Onnen parking area.

One way or another the matter then dragged on until 2012 when things finally started moving again, the trust was formed with Roy Fellows and a Maureen Burns as subscribers and directors. Later Prof David James and Hugh Ratzer joined the board following the resignation of Maureen. Subsequently, Simon Lowe of aditnow, Simon Timberlake (Early Mines Research Group), and finally Ioan Lord (local mining historian, explorer, and author) would expand the board to six directors.

Cwmystwyth immediately presented a challenge. With the NAMHO 2013 conference only weeks ahead, major underground workings were blocked off with steel grills. Sunday May 28th 2013 saw a group of supports gather to help me in reopening the mines. The day was saved by Dave Tyson who turned up with a petrol driven angle grinder and reopened Lefel Fawr, Taylors, Aldersons, and Herberts levels.

Figure 3 reopening of Cwmystwyth Mine

Figure 2 reopening of Cwmystwyth Mine

Heavy metal discharge into the river Ystwyth from Cwmystwyth is currently a major issue. There is an imminent project by Natural Resources Wales in conjunction with the Coal Authority to remedy this. This project will also include a lot of site renovations to improve its status as a public amenity.

Archaeologically speaking, this site is not only one of the most important in the UK, but in the whole of Europe.

Roy Fellows

The Tin Tabernacle and the importance of Corrugated Iron

In a recent visit to the Weald and Downland Living Museum, at Chichester, West Sussex, I had the opportunity to look at a surviving example of a tin tabernacle or 'iron church' one of many that were built across Britain from the mid-19th century and into the early 20th century. Over the last 55 years, The Weald and Downland Museum has rescued many historic buildings from across Southern England that were due to be demolished, rebuilding them to their original configuration on the 40-acre site. Built at South Wonston, Hampshire, in 1908, St Margaret's is one of the more modern buildings on display, however, despite its juvenility, it represents a significant landmark in building history and the use of corrugated iron in building prefabrication (Fig.1).

Figure 1 St Margaret's Church from South Wonston

Corrugated iron had been invented by Henry Robinson Palmer in 1829 to construct the large warehouses in the expanding London dockyards. Lightweight, with high rigidity, and the ability to clad buildings with large surface areas, made corrugated iron the perfect material for creating mass produced prefabricated buildings that included anything from chapels, churches, village halls, warehouses, and sheds – even a shepherd's hut at the museum made use of this versatile material (see cover image). The latter half of the 19th century saw a population boom in Britain and with it came the rapid expansion of towns and villages. As church congregations reached capacity and as non-conformist communities grew, additional places of worship were required and tin tabernacles such as the example from South Wonston, sprang up across the country. Such churches could be purchased from mail order catalogues and came as kits of varying sizes and configurations to meet the needs of individual congregations. St Margaret's is typical in form, with an inner timber frame clad on the exterior in galvanised corrugated iron, painted green. The inside walls were typically covered with tongue and groove panels.

Figure 2 Interior of St Margaret's

For some, including William Morris and John Ruskin, corrugated iron was seen as lacking the aesthetic qualities and traditional craft skills championed by the Arts and Crafts movement. Morris claimed such corrugated iron buildings were 'spreading like a pestilence over the country'. Despite this, these products of an industrialised Victorian society did in their own way retain a sense of style and individuality, enhanced by embellishments such as gothic arched windows, imitating medieval architecture, cowls for bells and decoratively carved exterior woodwork, all of which are present at St Margaret's.

While many tin tabernacles were regarded as temporary until more permanent structures could be built, the many that survive are testament to the durability of corrugated iron. They are still much loved by the communities who use them both in Britain and abroad, in countries as far as America and Australia where many were exported. In some cases, such as the Tin Tabernacle, Kilburn, London, they have been awarded listed building status, while others lay neglected or have disappeared altogether. St Margaret's new home at the Weald and Downland Museum after 87 years as a parish church, serves as a reminder of the historical importance of these early prefabricated buildings, which like those that came before it, made use of the most modern innovations in building materials.

Jack Cranfield

HMS Research in Progress November 2022

After the success of last year's online Research in Progress meeting, it has been decided to repeat this year's RiP meeting again online in November to maximise inclusivity. We look forward to conducting these meetinings in person again in the future and aim to have an in-person RiP meeting in 2023.

For more information please see https://historicalmetallurgy.org/hms-events/

Rus – Vikings in the East (Special Exhibition, Moesgaard Museum, Denmark) – don't miss it!

Moesgaard Museum (Aarhus, Denmark) is hosting a rich exhibition on the Rus, Vikings in the East, until September 11th 2022. Overflowing in silver, sounds, interactive video displays and oral testimonies by the likes of Ibn Fadlan, this really is a unique and outstanding exhibition that cannot be missed. For those fascinated by the full extent of the world of the Vikings and the onset of the Middle Ages, the exhibition is accompanied by an accessible and well-rounded book written by leading experts, supported with exquisite photographs and illustrations (available in both English and Danish).

On your journey down the Dnieper river, escalating rapids, avoiding ambushes by Magyar horseman, sledding boats over land and forging alliances with the Khazars, your tour through the exhibition space takes you along waterways from the Nordic homelands in the North Atlantic down to Istanbul, from the Arctic Ocean through to the Caspian Sea and Mediterranean. Letters and seals document the fascinating lives of Danes (pretending to be Swedes) serving in the Emperor's elite bodyguard, the Varangian guard, skilled in combat and versed in maritime conflict. In a beautifully staged marble font placing you in Constantinople's Hagia Sophia, you can read the scratched runes left by Halfdan ('Half Dane'), whilst admiring the epitome of Viking craftmanship and weapon smithing, an Ulfberht blade.

The exhibition has consistently received 6 out of 6 stars by Denmark's leading critics (Politiken, Kristeligt Dagblad, Jyllands Posten). It is no wonder why, as the well-trodden trading routes by traders, slavers and slaves, merchants, and caravans, sailing between Christianity, Islam and animal cults, is brought to life by a maze of hack silver hoards, jewellery, weapons, tools, gaming pieces and animated amulets, taking you first-hand through the world of the Viking Rus.

The timing of this exhibition reminds us of the responsibility and importance of cultural heritage in an ever-changing world. Hosting over 2000+ silver artefacts on loan from the National Museum in Kiev, the Dynastic home of the Rus, it's painfully apparent how material culture plays an active role in identity-politics of the modern age.

This is not an exhibition you want to miss. In addition, the new Moesgaard Museum is an architectural masterpiece at the apex of a sloping valley to the Baltic sea surrounded by beautiful forest walks and neighbouring a very welcoming sandy beach. You can get wonderfully lost in the permanent exhibitions (Stone Age, Bronze Age, Iron Age, Viking Age, Middle Ages, Ethnography and Anthropology), which are not only deeply fascinating, but incorporate novel and world-leading museum display styles and methods that create an emotive experience that you will not forget. A great weekend opportunity only a direct flight hop away (Aarhus/Billund airports) from London and Manchester airports. If you decide to make the visit, don't hesitate to contact HMS council member and local resident Tom Birch – he might even offer you a personal tour of the infamous war booty sacrifices hosting the largest collection of Roman militaria in Europe.

Thomas Birch

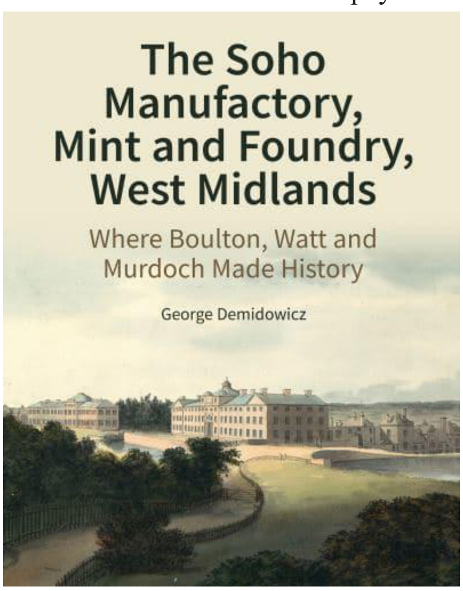
The Soho Manufactory, Mint and Foundry, West Midlands: where Boulton, Watt and Murdoch made history

The works of the title were those of Matthew Boulton, sometimes with James Watt. The manufactory and mint adjoined Handsworth Heath, just north of (and now within) Birmingham. The Foundry was a separate establishment beside the Birmingham Canal at Smethwick. Boulton inherited a 'toy' making business from his father and moved it from Birmingham to a purpose-built factory. There he was joined in 1774 by James Watt, the steam engine innovator with whom he formed a partnership to market Watt's patent engines. They were partners in that business and in making letter copying presses, but Boulton continued to operate other businesses alone or with other partners, including button making, toy making (buckles and other ornamental goods), and in establishing a mint to produce coins for Great Britain, the East India Company, and others. Boulton and Watt's sons built the Foundry in 1795, to manufacture complete steam engines. Previously, the fathers had supplied plans and skilled engine erectors, whilst only manufacturing certain specialised components. The businesses are documented in the vast Boulton and Watt archives, now all in the Library of Birmingham. The author has used this superb archive to reconstruct the development and use of the various buildings, both at Handsworth and Smethwick, lavishly illustrating in his text. This book is primarily a history of the buildings. Nothing except a few foundations survives of the Manufactory and Mint, but part of the Foundry remains as standing buildings.

The various Soho works were essentially manufacturing enterprises. Successive chapters cover the mill, which used water-powered, supplemented by Watt's original steam engine, to roll metal and polish metal goods, whose manufacture had taken place elsewhere in the works; the engine works, producing engine components; and the mint which used steam engines to power machinery to make coins. All these were at the Manufactory site, whose history, subsequent to its closure and demolition, is covered in a further chapter. Chapter 7 goes on to describe the development of engine production at the Soho Foundry at Smethwick, outlining its initial development mainly between 1795 and 1805, with further phases of building mainly in 1809-16 and 1823-4. The engine works at the Manufactory had continued in use throughout this period, but this was closed in the 1840s. Its work was transferred to the Foundry, where additional buildings were erected in this period, including a mint there initially using a press bought from the original mint. The business then traded as James Watt & Co (though with no Watt as a partner) until the Foundry was sold in 1896 to W&T Avery to produce weighing machines. A concluding chapter then assesses the significance of the three Soho works. Appendices report excavations carried out in 1994-6 by Time Team and others; a summary of identity and ownership of the various Soho businesses; and short biographies of the most important people involved.

This book is a major contribution to our understanding of this iconic group of businesses, but it will not be the last word in the subject. It is ultimately a history of the buildings with some details of the processes. Much writing on the subject has concentrated in the spectacular: the engines; precious metals, ormulu, etc. There remains a gap in our knowledge on the more mundane aspects of Boulton's businesses, particularly the more mundane aspects of the toy business. The author points out the lack of a thorough account of the button business, but this reviewer (whose exploration of the extensive archive has been limited) suspects that the gap is rather wider. The author states that Boulton retained his Birmingham premises until 1765. When he examined certain Boulton & Fothergill's account books from 1776, described as 'Soho Accounts' (Library of Birmingham, MS 3782/1/1-4), he was left wondering whether there were not also a separate Birmingham Accounts, dealing with a warehouse in the town and sales, but no such accounts survive. Certainly, there are aspects of Boulton's business that would repay further study.

Peter King



The Soho Manufactory, Mint and Foundry, West Midlands: Where Boulton, Watt and Murdoch Made History. George Demidowicz. Liverpool University Press for Historic England. £40

The Pioneering Life of Peter Kirk

Born in the village of Chapel-en-le-Frith in Derbyshire, England in 1840, Peter Kirk set up a successful business in Workington, Cumbria, manufacturing rail for the rapidly expanding global railway networks. Established in partnership with his brother in law, Charles Valentine, the company, established as the 'Workington Iron Co' was located at Mossbay on the southern edge of Workington, where they erected four blast furnaces in 1869. Bessemer converters were added in 1877 and the capacity of the works grew to 100,000 tons a year under the name, Moss Bay Hematite Iron & Steel Company Ltd.

Kirk had patented an innovative way of rolling rail, first by developing the three-high stand, which he paired with a following two high stand driven by friction as the bar, still passing through the 3-high stand, entered the following two-high stand. Thus, only one motor was needed and heavy reduction of the ingot achieved. In all, Kirk registered 16 patents in the UK, many related to rolling rail and one to improving the puddling furnace, a process Kirk had first-hand experience of.

A depression in demand lasting several years commenced in 1883, resulting from over production of iron in the area. Orders slumped and coal prices doubled forcing the works to lay idle, but Kirk invented new products such as a steel sleeper with integral chair to hold the rail, a product particularly suitable for India, Africa and Australia where timber sleepers were attacked by termites.

Having set-up an export office in New York some years earlier, Kirk travelled to USA in 1886 at the age of 46 with the attention of expanding his business there by establishing rail manufacture on that Continent. Demand for rail was booming as US railroad companies pushed further west, laying as much as 7000 miles of track a year.

Kirk's NY office had recently received an enquiry for the purchase of rail from the recently established Seattle, Lake Shore & Eastern Railroad company (SLS&E). The owner had also supplied an analysis of iron ore from a mine in the Snoqualmie Mountains, 50 miles east of Seattle. The quality intrigued Kirk who arranged to meet with the SLS&E owner in Seattle at a future date. Meanwhile, Kirk continued with his original plans to visit various US ore fields and steel mills, which, by this date, were largely using acid Bessemer Converters to make steel for rail track. Despite being offered inducements to set up a works in the East, Kirk travelled overland to Seattle, then a small town of some 15,000 people.

Kirk decided to build his US plant at Seattle, Washington State, rather than compete with established producers in the East. Others had failed to establish profitable iron works in the Pacific NW, but Kirk was determined. Reaching Seattle, he trekked the region looking for good sources of ore, coking coal and limestone. He found a vast deposit of ore in the Cle-Elum valley, coal at Franklin and limestone on the San Juan islands of Lake Washington. The coal was high in ash but low in sulphur, and the former could be largely removed by washing. He also secured further orders for rail track from more railway companies (Fig. 1).

With much trouble, Kirk secured a location for his new iron mill, eventually on the shores of Lake Washington. Named the Moss Bay Iron & Steel Co of America, shares were held both locally by US investors and by Kirk's Moss Bay company in England.

Kirk planned the 120-acre ironworks with an initial capacity of 312,000 tons per year, just half of the capacity to be built at first and the remainder later. The layout was to copy the English Workington works with four large blast furnaces each 75 feet high with a capacity of 1,500 tons of pig iron a week. The cost was estimated at $300,000 ($8.9M today). In 1888, the town of Kirkland was established to supply a workforce for the prospected mill and this was served by a branch line of the SLS&E railway.

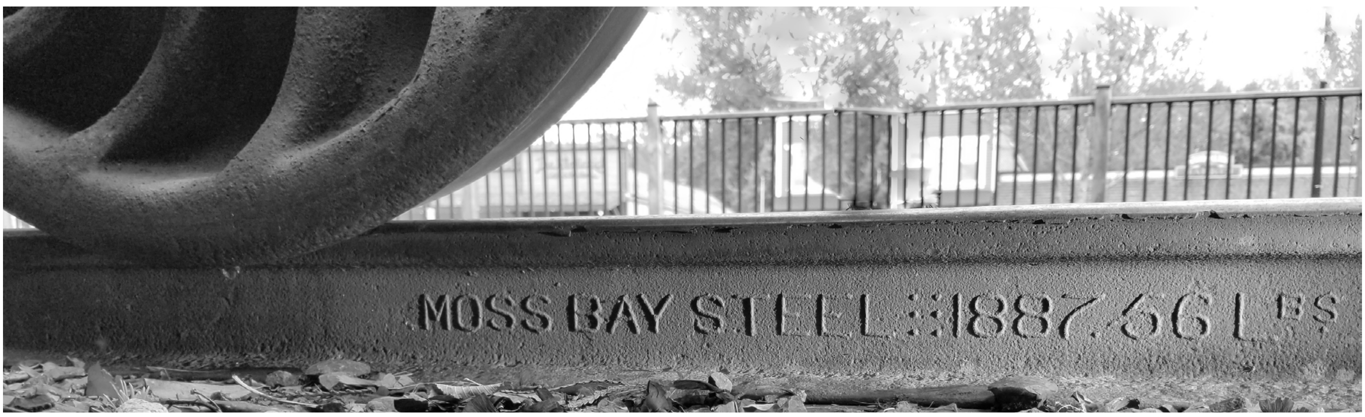


Figure 1 Rail track produced by the Moss Bay Iron and Steel Co.

But a fire destroyed Seattle's business district in 1889, and investment in the planned mill dried up. No financial help was available from Moss Bay Ltd in England as they were busy investing locally in coal mines and ports. In 1890, the directors dissolved the Moss Bay Iron & Steel Co of America and incorporated a new company called the Great Western Iron & Steel Co, backed by US interests. Kirk was appointed Manager of Operations with a salary of US$5,000 ($148,000 in 2021).

In 1891, equipment and refractory bricks for the blast furnaces and coke ovens were imported from England to the US east, by ship, including two steam powered blowing engines, Bessemer converters and cupolas. 5600 tons were stockpiled, ready for construction to begin.

When construction on building the mill ceased for the winter of 1892, it was never thought that it would not resume. This was the case though, as a depression hit the USA with banks failing, 20% of railroads going into receivership and unemployment rocketing. In May 1894, the Great Western Iron & Steel Company and its land assets were in default by $50,000 ($1.48M today). To pay this, much of the mill plant and equipment were sold off to the Philadelphia Engineering Works who shipped it to Hamilton, Canada. To make matters worse, the Directors of the Moss Bay Co in Cumbria, which itself was in financial trouble, sued Kirk for advances made by them towards setting up the US enterprise, and they sold off their holdings in the US mines. In 1893, creditors demanded the remaining mill assets forcing what remained of the Company into bankruptcy.

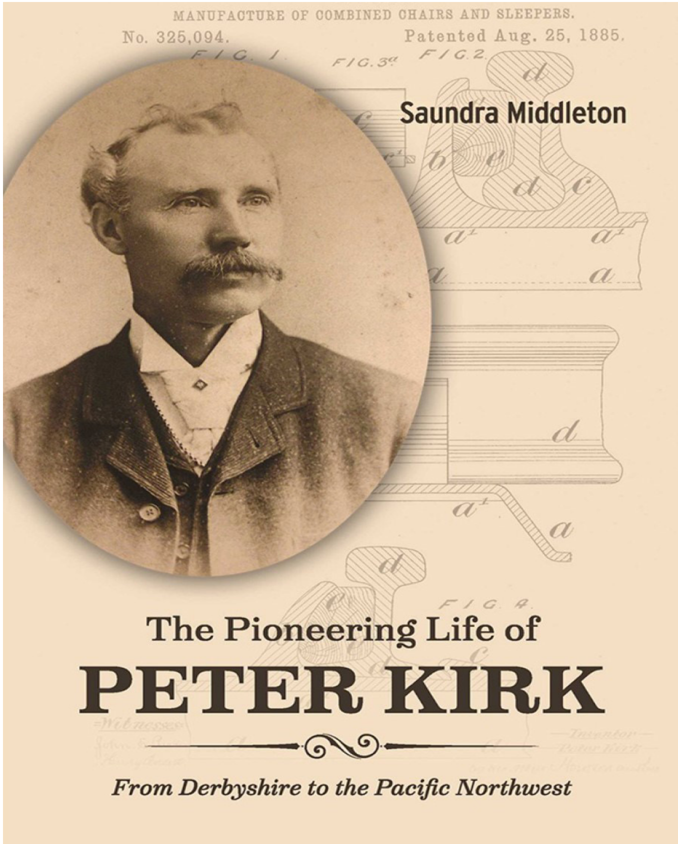
Kirk embarked on new adventures. A ferry service across Lake Washington and – well before his time – invented a machine for casting steel direct to bar or billet using centrifugal force – evidently a forerunner of continuous casting not achieved until the 1950s! However, a Patent was never registered.

With the Klondike Gold Rush of 1896 passing through Seattle, Kirk turned his inventive mind towards designing a machine to improve hydraulic dredging to recover gold, which he also hoped could dig a ship canal to link Lake Washington to the sea. He also Patented a combined ore roaster and smelter for the recovery of precious metals and entered into an agreement for its development with the Phoenix Reduction Company of Arizona, the latter being responsible for raising all funds for its construction, while Kirk accepted company stock and payment as a consultant. The smelter was built in Arizona and a railroad connection established, but after two-years the smelter had not started up and the company failed.

This proved to be the last technical enterprise Peter Kirk undertook. He returned to Kirkland where he profited selling timber from his estate and leasing out land for sheep farming. In 1901, his dream of a ship canal to link Lake Washington to the west coast at Puget Sound commenced and was completed 10 years later. Eight miles (13km) of canal link Lake Washington via Lake Union, Portage Bay and Union Bay to Puget Sound.

Today, Kirkland is a thriving community of some 92,000 inhabitants in King County, Washington State.

Tim Smith



The Book: This thoroughly researched book, with 202 source references and 806 Notes referring throughout its 24 Chapters, records Peter Kirk's achievements, and his ultimate failure to set up a steel works in the Pacific NW USA, away from the dominating eastern cartels set up by the likes of Alexander Carnegie. It records his inventions and successful businesses in Kirkland, the town, named after him, to be the location of the abortive steel works. It also examines his family connections from birth to his death in May 1916. *'The Pioneering Life of Peter Kirk – From Derbyshire to the Pacific Northwest'* By Saundra Middleton 382 pages, Index, Notes and illustrations Pub 'Genetically Inclined', Anchorage, Alaska 2021 ISBN 978-1-09837-091-6 (paperback US$19.95) ISBN 978-1-09837-092-3 (eBook US$ 4.99)

Conference, date & locations	Description	Website, emails and prices
9th International Conference on Mining, Material, and Metallurgical Engineering (MMME’22). 31/07/2022- 02/08/2022	The goal of this mining, material and metallurgical engineering conference 2021 is to gather scholars from all over the world to present advances in the relevant fields and to foster an environment conducive to exchanging ideas and information.	https://mmmeconference.com/ *Email:* info@mmmeconference.com
28th Annual Meeting of the European Association of Archaeologists Budapest, Hungary 31/08/2022 - 03/09/2022	A variety of themed sessions examining different aspects of European archaeology. The conference will take place in the ancient city of Budapest	https://www.e-a-a.org/EAA2022 *Email.* helpdesk@e-a-a.org
8th Balkan Symposium on Archaeometry Dates TBC (2022) Vinča Institute of Nuclear Sciences, Laboratory of Physics, Belgrade, Serbia.	The focus is on the Balkans and investigation of its cultural heritage. Topics on archaeometry: analytical methods, organic and inorganic materials, dating methods, experimental archaeometry, bio archaeometry, multidisciplinary investigations, new developments and management in cultural heritage, to name a few will be covered.	https://bsa.vin.bg.ac.rs/
HMS Research in Progress Date: TBC (November 2022)	After the success of last year’s online Research in Progress meeting, it has been decided to repeat this year’s RiP meeting again online in November to maximise inclusivity. We do look forward to conducting these still in person and aim to have an in-person RiP meeting in 2023. RiP November 2022, date to be confirmed.	https://historicalmetallurgy.org/hms-events/

Other Learning Resources

Program	Description	Website
Gold 20/05 – 2/10/2022 The British Library PACCAR 2	Take a journey around the globe to learn how gold elevated art in manuscripts and books. Discover the masterful techniques used to handle such a precious metal. Examine items that are hundreds of years old. Unveil the stories illuminated by gold	https://www.bl.uk/events/gold Advance Price: £8.00