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Points of reference: images of a bloom-forging in the ancient world.

Our mental image of the bloomery process in the Weald has been shaped by looking at much more recent bloomery practice, particularly that of nineteenth century India and the African processes. To a lesser extent the archaeology of Wealden bloomery furnaces has helped shape a shared view of what the process should look like. There are precious few images of British bloomeries, and, as far as your editor knows, nothing useful from the Weald. In this issue Paul Craddock and Dyfri Williams offer us what appear to be the earliest images of bloom-smithing.

(We are exposed to an extra intellectual risk: maybe we allow the experience of *experimental* bloomeries to form our view of *historical* bloomeries. The new pictures are useful.)

Points of reference: understanding how early modern ironmasters worked out what was (or wasn't) a good business opportunity.

I include a note on p4. of this issue that concerns our lack of understanding of the ideas, calculations and planning of Wealden ironmasters in the blast furnace era.

There are books of account still in existence. Some, indeed, have been well studied and even published. However, they provide little or no insight into how business decisions were made.

Your editor's intention is to provoke a debate.

A politically sensitive debate…

The sophistication of west African metallurgy has generally been ignored or understated. A recent paper has claimed that some technology hitherto attributed to Europeans originated with enslaved African metallurgists. This evidence for this is disputed.

The Wealden iron industry has intimate connections with this dismally sordid slave trade, so we include an article on the present controversy.

Ancient Greek furnace vases and the earliest depiction of bloom smithing

By **Paul Craddock**, emeritus researcher in Dept. of Scientific Research, paulcraddock74@btinternet.com and **Dyfri Williams** is a retired keeper of the Greek and Roman Dept. in the British Museum, dyfri@hotmail.com.

A small number of Athenian vases of the fifth century BC show a shaft furnace in operation surrounded by a variety of tools and metalworking activities. The shaft furnace is of the type usually associated with metal smelting, but the surrounding activities seem to be more associated with metalworking. These activities most clearly depict work on armour and statuary, especially finishing treatments. This dichotomy has led to many and varied explanations attempting to link all the activities (Oddy and Swaddling1985).

It has been pointed out that the activities directly associated with the furnace seem to indicate the working of solid metal rather than smelting or casting operations. Thus, on a column -*krater* (vessel for mixing wine and water, c. 470 BC) in Caltanisetta (inv.20371) next to the entrance to a shaft furnace, the smith-god Hephaistos is shown holding in his tongs a solid billet of metal over an anvil: he is smithing it with a small hammer held with one hand. On a jug (c. 500 BC) in the British Museum (GR1846,0629.45) (Fig. 1), however, the youth with his long-handled hammer head down on the ground, watching as the smith seems about to reinsert the billet into the furnace, prior to further working.

British Museum, GR 1846,0629.45: Showing the smith withdrawing a billet of metal from the furnace.

Fig. 2 St Louis, private coll.: Showing the flaming bloom and a small portion of the furnace to the right and the bellows operator.

These scenes are usually interpreted as depicting the ex

Continued on next page.

tended process of annealing iron, although one might have expected any annealing to have been done on an open hearth rather than in a shaft furnace.

On a fragmentary, but important *lekythos* (oil bottle, c. 500 BC) in a St Louis private collection, however, shaft furnace and activity are much more in harmony. Here, beside the mouth of the shaft furnace (upper part lost), a smith sits steadying with his tongs a large mass of flaming metal on a block (Fig. 2), as a row of three assistants, each equipped with a long-handled heavy hammer, prepares to strike it in turn (Fig. 3).

Fig. 3 St Louis private coll.: Showing the naked hammer men about to attack the bloom to the right.

The likely scenario is that the bloom of iron has just been removed from the smelting furnace and bloom smithing is about to commence. The intention of the three assistants is clearly to drive out the slag from the spongey bloom as rapidly as possible before it cools.

This would appear to be the only representation of bloom smithing from antiquity, with the bloom removed straight from the furnace and about to be worked. The scene on the British Museum jug and other similar scenes probably show the final stages of the bloom smithing when a, now much smaller, billet or ingot is being given its final treatment.

Such issues of comparison between what is shown on Athenian vases and what modern study of metallurgy and experimental experience, as gained by WIRG members, indicate a number of problems (not least the likelihood that the young men would have engaged in bloom smithing whilst naked!). We should be careful, however, not to treat the images on the vases as modern photographs. They are visual interpretations, sparked by observation but often tempered by other factors, including representational skill, cultural expectations, and the need to be interesting and understandable to their consumers. It is, indeed, possible that separate moments may be combined or alluded to in a single image. Thus, although we may consider the step-lidded *dinos* (basin) on top of the shaft furnace on the British Museum jug out of place, since the furnace should operate by drawing air in at the base and expelling air and waste gases from the top, it is possible that the vase-painter is alluding to the use of the furnace in a different manner, perhaps at later moment or for a different purpose. Such *dinoi* atop a shaft furnace are shown in images spread over some 120 years and cannot simply be a mistake.

References

Oddy, W.A. and Swaddling, J. (1985): Illustrations of Metalworking Furnaces on Greek Vases', in P.T. Craddock and M.J. Hughes (eds.), *Furnaces and Smelting Technology in Antiquity*, London, 43-58.

Experimental Furnace 2023

We smelt local ore in out experimental bloomery furnace located in Pippingford Park, about 3 miles south of East Grinstead, from April to October when the length of day is sufficiently long to complete the process.

2023 proved a difficult year. In April we processed ore we had collected in March going back to our original source in Beacon Wood a mile or so East of Benenden in Kent. We had tried to find a closer source just north of East Hoathly in East Sussex, with the help of member, Sam Bradford, who owns a farm there, but to no avail, despite several bloomeries and a 'Mine pit Wood' in the area. Reverting to Beacon Wood meant a steep muddy climb out of a valley to haul the ore out but fortunately, a gang of wood cutters kindly loaded some 125kg we collected onto their off-road vehicle and took it to the road for us.

The ore, collected from a small side stream, was heavily oxidized with a thick coating of limonite (hydrated Fe_2O_3) on an iron carbonate siderite core. The raw ore, analyzed by WIRG member, Alan Davies, ranged from 36 to 39% iron content and 8.6 to 5.5% silicon, the ratio of Fe to Si needing to be above 4 to produce a bloom, otherwise all the iron is lost to the slag.

Following roasting to drive off CO_2 and moisture and make the ore more friable for breaking to 20cm or less, the iron content increases to 44 to 48%, the size fraction of 10-5mm proving the richest with a bloom potential of 8 while the bulk fraction at 10-20mm has a bloom potential of 4.8. Hence, we selected a 750g 10-20mm plus 250g 10-5mm blend of these two sizes for each charge to the furnace. Hornbeam charcoal was sourced and broken and sieved to 25 to 10mm which served as the fuel and reducing agent for the ore. Each charge consisted of 1kg charcoal onto which 1kg of the mixed ore was sprinkled for each of 15 charges.

The first Saturday in May was earmarked for the first smelt of the season but the day turned out to be rainy for the whole day, conditions we cannot work in as we use an electric generator and electrically driven reciprocating blower to raise the temperature in the furnace.

We were all set to smelt in June – but this time, after a long period of dry hot weather later in May and throughout June, we decided the fire risk was too high to operate the furnace which is in woodland. Thus, July was the first smelt of the season.

For this smelt, we were filmed by a reporter from Meridian TV who also quizzed myself, Jeremy, and Jonathan on various aspects of the Wealden Iron Industry. His report can be seen at https://www.wealdeniron.org.uk/2022/12/17/wirg-on-itv-news-meridian/

Smelts continued in August and September using the recip

The Pippingford bloomery furnace

rocating blower – to simulate bellows - kindly donated by Peter Crew in North Wales which member, Stephen Hall, had refurbished over the winter. Watch this in action at https://wealdeniron.org.uk/bigfiles/Smelt%2010%20sequence%20merged.mp4

Smelts were also followed on Facebook from which a number of requests to attend a smelt have been received. In addition, we are helping Loughborough University with a project attempting to find the sources of wootz steel – famous for its use in the manufacture of Damascus steel patterned swords, by supplying them with samples of bloom iron.

If we are to continue this work in 2024, we do need more Members to help run the furnace. If you can help, please contact Tim by e-mail at secretary@wealdeniron.org.uk

Tim Smith

How did ironmasters make business decisions in the early modern period of the Wealden iron industry?

(An invitation to discuss the problem of imagining (and reconstructing) the cognitive processes of those who lived long ago. Also an invitation to identify the evidence, and the types of evidence, that will assist in solving this problem)

I write this note to initiate a discussion about an issue that has puzzled me for some time: how did early ironmasters manage their affairs in the absence of modern accounting methods? This rather general question leads to some more practical research questions set out below.

The documentary record seems biased towards failures and disputes. All businesses end in failure of some sort, so it is almost a truism to say that any class of businesses was run profitably the rest of the time. It is more useful to say that many Wealden ironworks ran well enough for decades and were transferred both within family networks and beyond them.

Accounts from Wealden forges and furnaces survive, and it is reasonably clear that they do not provide information that one would require from the accounts of every business today. Blind spots vary between extant records but include:

- Confusion of inventory with realised gain
- Inability to distinguish between salary and dividend owing to partners or shareholders, or
- Lack of a concept of depreciation, or
- Lack of a concept of a return accruing to capital
- No method for distinguishing capital expenditure from ongoing maintenance costs.

In addition to these blind spots, and partly because of them, the ability to make accounts-based forecasts of profitability *seems* to have been absent.

Although business transfers appear often to have been made within families, many seem to have been to unrelated persons or to connections where familial obligation may have been weak. This implies the introduction either of new working capital or what was, in effect, the loan of working capital from the old controlling party to the new. Until quite recently personal loans were backed by *bonds.* Such bonds had more in common with Antonio's bond with Shylock than a bond issued by a corporate entity today: default could result in imprisonment. But invoking the terms of a bond is a last resort; a lender wants reassurance upfront. My problem understanding how their system worked stems from my (relatively) modern experience. This experience prevents me imagining a lender (or a borrower) proceeding without the numbers to say when, why and how the loan will be repaid. And yet there seems no documentary evidence of any formal calculations. In short, no business plans.

Sidney Pollard tells us* that, for the most part, the marriage of double-entry book-keeping and forward cost accounting was not completed in the iron industry until the nineteenth century, but that some very large enterprises were able to use accounting data to evaluate new projects by the end of the eighteenth. Evidence of such methods is absent from the Weald. (I see that this does not prove that it didn't happen.) Wealden ironworks prospered until they were outcompeted by larger units with better inputs. Eventually no-one came forward to lease Wealden ironworks. Ironmasters must have had a method of predicting that they would not be wasting their time and losing their money.

- ***Research question:*** **is there any documentation of ironmasters soliciting working capital?**
- ***Research question:*** **do any extant bonds refer to income, expenditure or expected rates of return?**
- ***Research question:*** **did unrelated incoming lessees fail more quickly than relations who, we suppose, had accurate inside information?**
- ***Research question:*** **could the rate of profit in the iron business have been so high that forward planning was usually unnecessary?**

Jonathan Prus

*__Pollard, S.__ (1961) The Genesis of Modern Management. Edward Arnold. London.

A response to the article above

(your newsletter editor is grateful to Jeremy Hodgkinson for coming straight back with these responses)

As a response to Jonathan Prus's discussion article one perhaps should start with L. P. Hartley's line, "The past is a foreign country; they do things differently there". In the Weald ironmasters fell into two main groups: owners, who employed skilled and unskilled workers to operate the furnaces and forges on their land; and leaseholders, who did the same but took a greater risk by weighing the odds of making a profit against the costs of rent, and raw materials that they probably did not own. That said, in many leases landowners allowed generous terms to their lessees for the acquisition of ore and charcoal. Landowners were answerable to no-one but themselves, neither were lessees although it was not uncommon for silent partners or backers to be included as parties to leases indicating that financial support for an iron production venture might entail a sharing of the profits.

Although few have survived, I expect most ironworks will have kept accounts. The trouble with the evidence for accounting methods in the past is that most historical documents that have survived did so because they were legal records of transactions or of transgressions and accounts generally did not fall into either category if they were made by or compiled for private individuals. An exception in the Weald are the accounts of the ironworks held by the partnership of William Harrison and John Legas. Harrison died in 1745 and, until his elder son, Andrews, came of age, his trustees, Legas and Samuel Remnant, were legally obliged to compile accounts during the period of the trust.

David Crossley explored the accounts kept by the Sidney family who owned the ironworks at Robertsbridge and Panningridge in the mid-16th century and as well as publishing an edition of those accounts in 1975 he had previously written a paper in *The Economic History Review* in 1966 on the management of those works based on his study of the accounts. In it he wrote, "Accounting was regarded rather as a means of preventing or detecting fraud by the clerk of the works than of providing a source of information upon which decisions could be based". Those accounts did include references to "clear gain" or profit which cannot be said for the accounts of the Pelhams' works at Waldron Furnace and Brightling and Bivelham Forges between the 1690s and 1710s, although it is possible to work it out from the figures. Whichever Pelham was head of the family at the time owned the ironworks and employed a clerk to keep records of the expenditure during each campaign. Receipts were recorded but it is evident that money received for most of the products sold went straight to the Pelhams and were not recorded in the accounts. However, among the receipts recorded are payments from the Pelhams, though whether these could be directly linked to money they had received for the products sold is not possible to judge.

As to the financing of ironworking ventures the surviving accounts are vague. In the records of George Browne's and Alexander Courthope's dealings there are payments to individuals which could have been related to money loaned or invested but the details are lacking.

Regarding the question of whether 'unrelated incoming lessees fail more quickly than relations who, we suppose, had accurate inside information', I do not think there is evidence to support this notion either way. Owners who leased their ironworks may have done so for a variety of reasons, such as having other interests or occupations that required their fuller attention (as in the case with Sir Henry Sidney whose role at court and senior administrative positions in Ireland and Wales contrasted with the more local and hands-on involvement of his father), or they did not possess the experience or inclination to manage their own works, or they were content to receive the rent of what could be a useful source of unearned income, or (you name it). How successful lessees were depended on their individual skill and acumen, and the market they were able to exploit for their products. Their entrepreneurial act of leasing ironworks presumably meant that they were more likely to be attuned to the management and potential risk involved, but in both instances their reliance on skilled ironworkers should not be underestimated.

Generally the greatest profit in the iron trade in the Weald was in the ordnance business where, in wartime, the ironmasters could set their own price. But there was a high risk as well, for peace could be declared at short notice, sometimes as the result of a single engagement, and orders could cease unexpectedly leaving ironmasters out of pocket (and the Board of Ordnance was notoriously slow to settle debts). Several bankruptcies occurred following the end of the Seven Years' War in 1763, notably John Churchill, Richard Tapsell and the partners Alexander Master & Edward Raby, all Wealden gun producers and lessees. Owners of ironworks did not, on the whole, go bankrupt because they usually had other sources of income such as landed estates or, in the case of the Fullers,

sugar plantations in Jamaica. The Browne family, royal gun-founders since the end of the 16th century, who owned one ironworks but leased others, came to grief financially in the 1680s when they cast surplus 'neiled and turned' guns in the expectation of government orders and the orders were not forthcoming. Lack of business experience among the surviving junior family members probably contributed to this debacle. The experienced Thomas Western, who was casting the same type of ordnance, did not commit to the same extent and did not suffer from the government's decision to abandon their purchase of those expensive guns.

Forward planning must have occurred, if in a different form to the present day, but probably much more informally. Because it did not involve legal contracts there was no imperative to preserve any written records in the form of notes or correspondence. That said, the correspondence between John Churchill and Sir Whistler Webster in 1753-4 (WIRG Bulletin 2nd series 12, 1992, pp.56-62) is undoubtedly forward planning, with Churchill sounding out the prospects for his lease of the works at Robertsbridge, and information about the costs of raw materials and the accessibility of the site. Churchill was an experienced ironmaster from the west Midlands, so he knew what he needed to ask about.

Jeremy Hodgkinson

Minepits amd marlpits: a contrary view

In the Autumn 2021 Newsletter (p.10) Jonathan Prus speculated as to the motives determining the digging of shaft mine pits and of larger opencast workings, often described as marl pits. He suggested that large pits were the preferred method and that shaft pits were only resorted to when the slope of the ground and the resultant drainage forced their use as an alternative. As is so often the case, it is not always enough to merely consider the physical evidence but to take account of contemporary records when they are available, for what may seem logical to our 21st-century minds may have been regarded differently centuries ago.

In Bulletin 36, part 1 (2016), Tim Smith reported on some shaft minepits and larger pits that had been noted in Hawkhurst Common Wood, which is centred on TQ 5306 1909, SW of Cross in Hand. As the name implies, this wood had previously been a common. It currently extends to about 52ha (130 acres), but in 1789 when the Ordnance Survey draft drawing was made of the area the southern half of what is now wood was still common. And the fact that the evidence of pits, large and small, that can be seen on Fig. 1 extending in a N-S swathe, some 1,300m long, across the full extent of the wood (outlined in black) indicates that the entire area now wooded was once not so. The map also shows that the pits closely follow the boundary of the Wadhurst Clay (to the south and east of the red line) where it overlies the Ashdown Beds that extend to the north and east of the wood.

Recent study of the accounts of the ironworks that belonged to the Pelham family (British Library, Add Mss

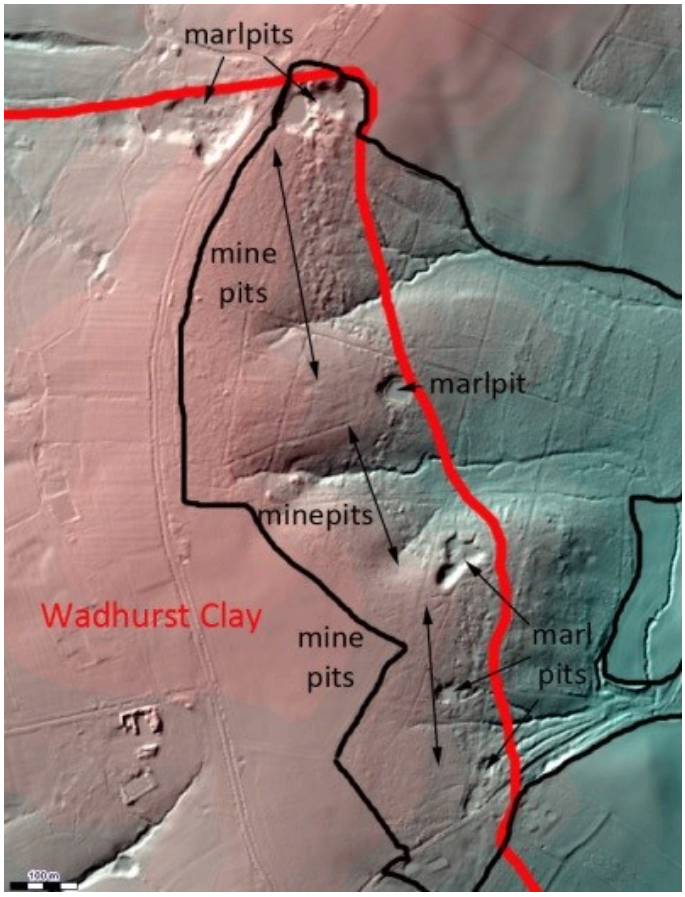

Figure 1: Lidar image of Hawkhurst Common Wood, Waldron, showing minepits and marl pits.

33154-6) has brought to notice four references to the extraction of iron ore on Hawkhurst Common that run contrary to Jonathan Prus's theory. The first dates from 1703-4 when Thomas Moore, the clerk to Waldron Furnace, paid Joseph Mittell for 10 loads of 'Marlepitte mine' that he had 'saved' and then delivered to the furnace. An almost identical entry appeared in the accounts in the next year, and

three other references to marlpit mine in other locations are also recorded, but there are only those five references in the 25 years covered by the accounts. Most of the references to the procuring of ore involve the payments to a landowner, to the people doing the digging, or 'drawing', of the ore and to the people who transported it to the furnace. Sometimes landowners employed their own miners and sold the ore ready dug. The quantities involved varied but often amounted to several hundreds of loads from a single source. The specific reference to 'marlpit mine' is deliberate because it attracted a different cost. It was a rarity and the use of the term 'saved' shows that the person engaged in digging a pit to extract 'marl' was putting the ore he came across aside to make a bit of extra money. Founders, I suspect, were grateful for any ore that come their way.

There are two further references in the accounts to ore being obtained at Hawkhurst Common. Both are much larger quantities - 120 loads in 1713-14 and 44 loads in 1715 - and in both cases the iron is being extracted by digging. Evidence of both types of pits in accounts only a few years apart shows that both marlpits and minepits were being dug on Hawkhurst Common contemporaneously with the lie of the land having no influence. The north end of the common is a mere 20m higher than the south end and the strip of minepits and marlpits is only about 100m wide. Between 1690 and 1716 there are 89 records of ore being obtained for Waldron Furnace that way, but only five from marlpits. Of course there is no way of knowing whether Hawkhurst Common had been exploited for its ore resources prior to 1690 or indeed was to continue to do so while Waldron Furnace remained active, probably until about 1765.

What these few records seem to point to, however, is that large pits were not the preferred method of ore extraction for the Wealden iron industry. Contemporary accounts refer to the requirement for the holes being dug to extract ore being backfilled, and at the expense of the ironmaster.

The fact that this quantity of ore was drawn rather than being 'saved' indicates that it resulted from the digging of pits. The implication of these two references is that the large pits on Hawkhurst Common and the smaller shaft minepits were roughly contemporary but dug for different purposes. And regarding the comment that use of the two types of pit depended on the lie of the land, the difference in the height of the ground at the north end of the wood compared with the south end is a mere 20m.

As to the preference for extraction of ore from large pits rather than from shaft minepits, two examples of contemporary quotes confirm normal practice:

> *"I confesse the Custome upon mee to pay for the throwing inn the clayes in the minepitts is a thing which I have very often excepted against, I think those who are admitted into my Land to break the ground and take out the Iron Stone ought to fill upp the pitts and restore me my land fitt for service afterwards and this I shall expect to be done whoever it is that shall draw any Iron mine for the future in my Estate…"*
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> 1695 (in R. Gunnis 'Letters of the First Lord Ashburnham', *Sussex Arch. Colls*, **88**,1949,10)

> *"In relation to Iron Oare … the Iron Master is at the whole charge of digging it, carrying it to his Furnace, and filling up the pits, only the Owner of the ground alloweth two pence for throwing in the Clayes, and also levelling the pits, if he will have it done, which may cost about a groate a pit more, and then the ground will look as well and be more profitable to the Tenant than it was before the oare was dug."*
>
> 1741 (in D. Crossley & R. Saville, *The Fuller Letters*, Sussex Record Society, 1991, 155)

Among the payments that were made at Waldron Furnace in the 1690s were the following, both in Warbleton:

> *"Pd to Rich: Day for levilling ye mine pittes against Mr Woodes land for fower days with two Cortes* [carts] *£1 0s 0d".*
>
> *"Allowed Rich: Sanderes a man one day to helpe him fille ye open mine pittes in ye wast against ye Iwood land, 1s 4d .*

Inevitably, owing to the survival of contemporary sources, each of these quotations dates from later rather than earlier in the industry's history but there is no reason to doubt that this was standard practice in the decades or centuries before.

Finally, Jonathan Prus avers that the shaft minepits in Beauport Park, near Battle, could not be reasonably associated with any blast furnace and must therefore be prospection pits. Brede Furnace was only four miles from Beauport, the same distance as Hawkhurst Common was from Waldron Furnace, so the Beauport minepits could very easily have been worked sources of ore. Indeed, iron for Waldron Furnace was sometimes brought from as far away as Mayfield, over eight miles distant. Unworked sources of ore became fewer in the 18th century so ironmasters had to look further afield for their supplies.

Jeremy Hodgkinson

Cort and the black metallurgists. Whose technology?

Several recent news articles have jumped on the assertation, without challenge, that Henry Cort, who history recognizes as the inventor of the Puddling process to produce wrought iron, 'stole' the process from enslaved Africans working at a foundry in Jamaica. The article *'Black metallurgists and the making of the industrial revolution'* by Dr Jenny Bulstrode of the Department of Science and Technology Studies, University College London, is available to download at https://doi.org/10.1080/07341512.2023.2220991

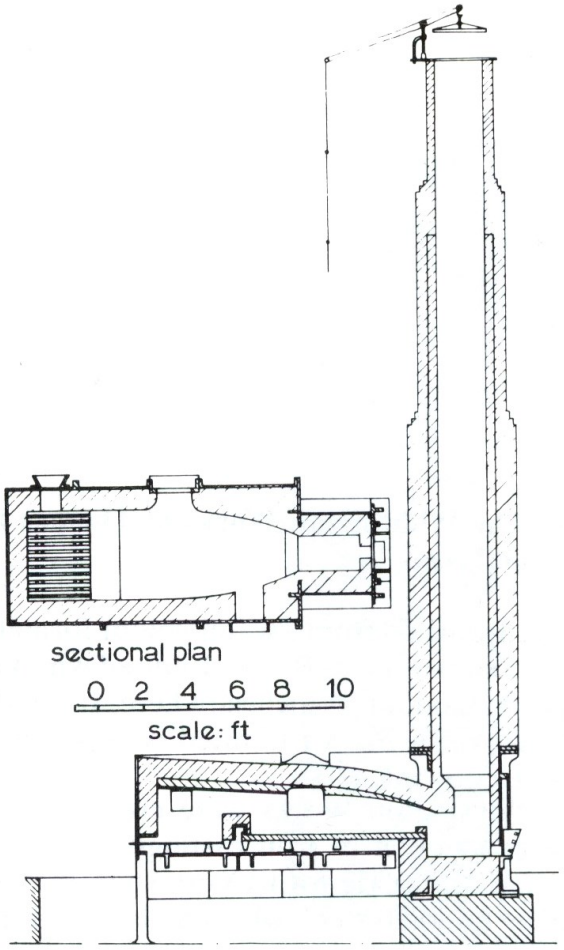
In 1770, a foundry was set up in Jamaica at Morant Bay by an English coppersmith, John Reeder, with the financial support of plantation and slave owner, William Baillie. It was established with the expressed aim of producing equipment for the sugar industry and to serve Port Royal which was a base for the British Royal Navy and merchant shipping. Such local manufacturing was, at that time, in contravention to Britain's colonial policy of supplying manufactured goods to the colonies from Britain. Reeder recruited 60 white artisans, presumably to build and equip the works, and for the instruction of a local enslaved workforce of 76. Dr Bulstrode states that all but one of these expatriates had left within 12 months.

The forge was dismantled in 1782 by order of the Lieutenant Governor of Jamaica under the threat of a French and Spanish invasion which could take advantage of the foundry at a time when Britain was at war with France who were supporting the American War of Independence (1775-1783). Dr Bulstrode attributes the closure to an alternative reason, the fear of the foundry being seized by insurgent Jamaican slaves, a group of 48 of whom had formed a settlement under the leadership of a man known as 'Three Finger Jack' in 1780.

Dr Bulstrode's asserts that puddling of iron was practiced there and that Henry Cort patented his process based on practices at the Jamaican foundry following its dismantling and the shipment of the equipment to Portsmouth where Henry had a contract with the Admiralty to recover scrap metal. This article tests those arguments.

Two key elements are the basis of Cort's puddling process, the use of an air draught reverberatory furnace and the application of grooved rolls to produce bar, rather than forging this by hammer.

Cort's patent No 1420 of 1784 states 'For the preparing, manufacturing, and working of iron from the ore, as well as from sow and pig metal, and also from every other sort of cast iron (together with or without scull and cinder iron and wrought-iron straps), I make use of a reverberatory furnace or air furnace ……..' A previous patent, (No 1351), granted a year earlier in 1783 to Cort was for rolling refined iron blooms in a mill with grooved rolls, later known as 'puddling rolls'. The patent describes how the bloom, resulting from the preliminary forging by hammer of the refined metal from the puddling furnace, could be rolled to bar rather than using the more laborious and skilled method of the time of drawing the metal out to bar under a power hammer.



Side and plan view of a natural draught puddling furnace. The fire is set to the left and the heat drawn across the charge in the right-hand chamber by the draught of the chimney

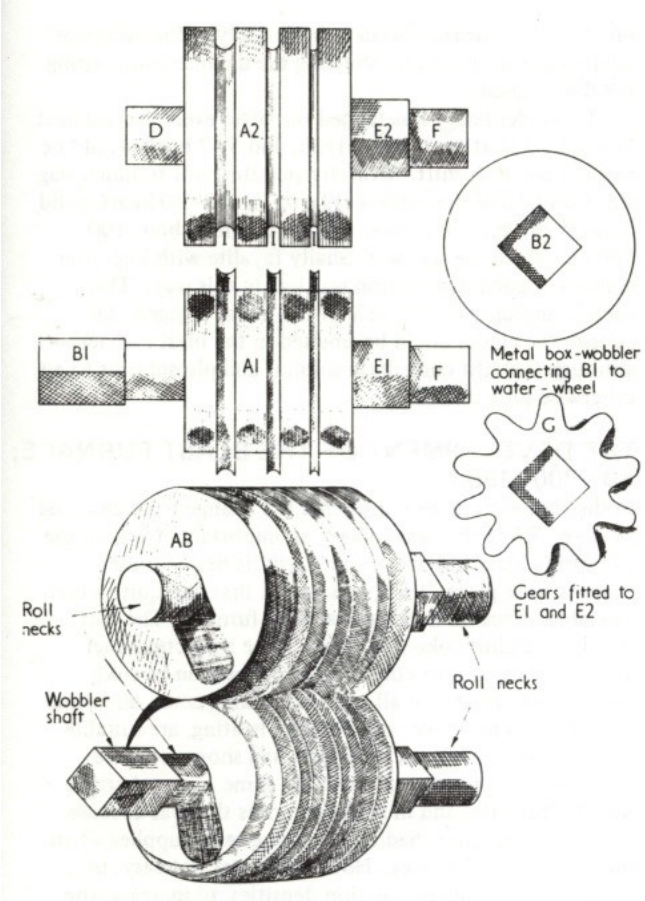
It is claimed that Reeder converted scrap metal to bar by bundling it together, heating to white heat and rolling in a mill with grooved rolls. This is not the process of puddling described by Cort, which was essentially to refine the high carbon pig iron coming from the blast furnace. Also, hammer welding by piling, was a practice well known to blacksmiths in the industrialised world.

Could Reeder be refining pig iron? A reference to smelting iron from ore suggests a blast furnace was possibly built, a technology familiar in Europe but unknown in sub Saharan Africa at that time. Reeder undertook casting guns, and a blast furnace could supply the required molten metal, but, if so, there would be no need to refine it to a more ductile wrought iron. Blast furnace iron can be diluted with low carbon scrap to lower the carbon content, something practiced by John Wilkinson in England at that time, and evidently scrap iron was readily available in Jamaica without the need to produce wrought iron for this purpose. Some cast iron may have reached the foundry from ship's ballast – known as 'Voyage' iron, which was a common practice to bring a saleable commodity on the out-bound journey and

replace this with a valuable cargo, such as sugar and spices, on the home-bound trip. Could such iron have been refined by Reeder? Possibly, but, if so, all the equipment necessary to do so was already known and available in Britain. In addition, Cort's method only worked well on pig iron from charcoal fired furnaces. Considerable later development by ironmasters was needed to apply the process to iron from coke fired furnaces because of the higher sulphur content of the iron. Ship's ballast would likely be iron from coke furnaces because of its lower cost.

The reverberatory furnace was known well before the time of Cort. In 1708, a reverberatory furnace was used to smelt lead in Flintshire, Wales[(1)]. Later, in 1761, John Wood used a reverberatory furnace in his 'potting' process for refining pig iron[(1)]. Hence, this was not a new technology established in Jamaica.

Grooved rolls for rod rolling designed by J Purnell in 1766 (Patent No 854)



Onions, also developed a 'puddling' process using a forced draught reverberatory furnace which he patented in 1783 [(1)], the year before Cort's second patent which specified the use of a natural draught reverberatory furnace to puddle iron.

The reverberatory action 'bounces' the heat from the burning fuel off the furnace roof causing it to be reflected to the charge located in an adjacent chamber so isolating the fuel from the charge. This enabled coal to be used as fuel, any sulphur present being oxidized and extracted up the flue preventing it from contaminating a charge of iron which would render it hot-short. This contrasted with the need to use more expensive charcoal in the long-established finery process in which the iron and fuel were in contact.

The second element of the process, the rolling mill with grooved rolls, was patented in 1766 by J Purnell[(1)] (patent No 854 1766) who used it to make ships' bolts and would likely be known to Cort who had contracts with the Navy. Mills for slitting bar were known even earlier than this dating from the early 17th century and normally incorporated smooth rolls to roll flat bar which was then slit into narrow pieces for such applications as nail production. Grooved rolls were also used to crush sugar cane, which may have prompted Reeder to modify these to roll bar, but equally, his background as a coppersmith in England, or the artisans he brought from there, were likely to be aware of their established use in rolling bar.

In 1782, Cort was seeking additional finance to expand his work and was advanced the sum of £27k by Adam Jellicoe, Deputy Pay Master of the Navy. Security for Jellicoe's loan was the rights to Cort's patents and the establishment of a partnership between Jellicoe's son, Samual, and Cort. Cort, it appears was unaware that the loan from Jellicoe senior had been acquired from Naval funds, not his private finances. When Jellicoe died in 1789, this was revealed and the Navy Board seized the property, works and trade effects of the firm Cort & Jellicoe at Fontley and Gosport. Physical assets were valued £17k, but the patents valued at just £100 and were confiscated, yet unpaid royalties from licensees of the patent would have paid the full debt of the money taken by Jellicoe senior, at least six times over.[(2)]

John Percy in his book 'Metallurgy' Vol 2 of 1864, devotes 62 pages to the Cort Puddling process, arguing that Cort – who died in poverty, had been tricked out of his patents by Jellicoe and his son, Samuel with the connivence of the British Government.

Academics at Oxford University reported in the Daily Telegraph of 16/9/23 have looked at the primary sources that Dr Bulstrode used and claim to have found misreadings, missing words, and evidence stating to the contrary of some of her assertions. There is no evidence that equipment from Jamaica was transported to Cort or that grooved rolls were being used in the foundry in Jamaica, or that they were forging bar iron from scrap.

Tim Smith

https://www.telegraph.co.uk/news/2023/09/16/oxford-scholars-debunk-industrial-revolution-hero-theft-claim/

1 'A history of Metallurgy' by R F Tylecote The Metals Society 1976 p111

2 'Metallurgy' Vol 2 by John Percy 1864 p631

Marlpits and minepits (2021) revisited.

Minepits

As ever I am grateful to Jeremy Hodgkinson for extracting detailed evidence from primary written records. This detail enhances our understanding of past processes. Revisiting my piece in the Autumn 2021 newsletter, I find that I seriously skimped on detailing the evidence of different mining techniques in different contexts at different sites. I will begin to try and put that right with four examples below.

First though, it is needful to state what is not in dispute. The received wisdom that Romano-British iron production is strongly associated with extensive excavations ("open-cast" perhaps) whilst small shaft pits are associated with the blast furnace era seems broadly correct. Back-filling small shaft pits seems to have been the normal practice (but it is yet to be explained why some backfills have left the characteristic bowl-shaped depressions and others are barely discernible). It is interesting that the article above documents landowners' (not unreasonable) insistence that the ground be levelled after digging.

It is not disputed that "marling" with clays from the Weald occurred and that ore was a by-product of digging for this "marl". In a much wider context, we can agree that marling in Norfolk transformed a large area of relatively unproductive land into rich farmland whilst "marling" in the Weald had no such effect. More on this below.

Example 1. Iwood.

Iwood appears on Speed's Map of 1610 (www.sussexrecordsociety.org/dbs/sussex-maps/). There is a handful of small bloomeries in its immediate vicinity but the lack of bloomery slag heaps suggests small scale production. Warbleton Priory Furnace is nearby (mid-sixteenth to mid-seventeenth centuries, intermittent operation, see www.wirgdata.com). It could well have been with in the original bounds of Iwood and is within a few hundred metres of it today. Iwood sits on a low ridge capped with Wadhurst clay but spills over on to the Ashdown sand. The latter does contain iron ore in tabular form, but there is no clear-cut evidence of mining activity in this sand. The clay has huge, irregular pits which have not been backfilled, see Fig. 1. These huge pits drain from one to the next and thence to small streams. There is also an area of small shaft pit depressions in a flat area at approximately TQ636173. Their shallowness suggests backfilling. The area of small shaft pit scars has a straight edge against the field boundary on its western side: I cannot say whether this shows that the field boundary pre-exited the mining or/and perhaps that the backfilling was more thorough (see JHS's article above). Their location suggests that they are coaeval with the large pits and that drainage was an issue.

Fig. 1 - Iwood: a verly large pit

Example 2. Beauport Park.

Beauport Park has been well documented for a long time (see www.wirgdata.com). The operation was so large that the required ore must have been sourced from well beyond the park as it stands today. Indeed, the park area has notably few pits of any sort. However, very large pits can be found to the east for several miles and for a shorter distance to the west. Of course, we cannot date any particular pit. We can infer that time and effort went into gathering ore and that the closest ore would have been sought out first. A series of large pits, one draining to the next, is located a few metres south of the slag heap, see Fig. 2. The highest of these is flanked by a few small shaft pit scars, maybe 1.5 metres in diameter. My interpretation of these is that they are prospection pits whose purpose was to establish whether a source of ore that had been lost in the nearby big pit could be rediscovered without excessive effort. I'm disinclined to believe that so few pits could be associated with (say) Breede Furnace. I must allow that they could have been prospection pits dug at a post-Roman date.

The first of a "cascade" of very large pits near the Beauport Park slag heap

Example 3. Fernhurst Furnace.

To the south of the Fernhurst Furnace pond there is a large area ("Minepit Copse") which is a perfect illustration of the consequences of failure to backfill. This is a more-or-less

level area of Weald Clay. The pits' scars are far deeper than most and provide a reference point that helps to distinguish between backfilled and unbackfilled small shaft pits.

Fig. 3 A small shaft minepit in Minepit Copse, Fernhurst. It hasn't been backfilled!

To the north (also Weald Clay, but a different member of it) there are intermittent pit-scars. About ten years ago Robin Barnes gave me the privilege of watching one of these pits being sectioned using a mechanical digger. Its original depth was less than 2 m. and contained lots of chert but no ore. It was much smaller in diameter than those in Minepit Copse. These provide a reference point for prospection pits: they are not very wide and form more intermittent patterns than minepits. Also, and incidentally, they show that prospection pits are associated with ore mining in the blast furnace era as well.

Example 4. Darwell Furnace.

Darwell Furnace (near Brightling, see www.wirgdata.org) was working between the mid-sixteenth century and the mid eighteenth century. There is evidence of one small bloomery working in the immediate area.

Fig. 4 Small shaft minepits adjacent to Darwell Furnace

There are very large pits on both sides of the valley in which the furnace site is located. The largest of these pits is about 500 m. from the pond bay and connected to it by a rutted track. There are also two areas of small shaft pitting, both of which have negligible gradients. One of these areas is immediately adjacent to the furnace site and the other connected to it by a track that may have been metalled in the past. There may have been mine pits in other areas around the site that have been completely levelled and ore my have been sourced from further away. Nonetheless it seems probable that both large open pit and small shaft mining were employed at this furnace. It also seems that small shaft pitting had to be employed if a shallow gradient precluded free drainage.

A visual theme connecting Figs. 1-4 above is wetness. There is no reason to suppose that the Weald was much less wet in the past, or that the soil drained more quickly. I share with Jeremy Hodgkinson the view that in the later part of the blast furnace era that ore was becoming more difficult to source. Adding the Romano-British propensity to dig large open ore pits, I conclude that , at least in part, the tendency to small shaft pits was driven by necessity: "the lie of the land".

Marlpits.

The agricultural science explaining marling is well established: raising soil pH reduces the uptake of toxic metals and improves the yields of crop plants. The marl that underpinned the agricultural revolution of the eighteenth century was rich in calcium carbonate. Such marl is extremely uncommon in the Weald, but clay is plentiful. This clay is "unctuous" but it is not the *white* unctuous material that Pliny described.

As far as I know there is no published study of marlpits as such, although there is a study of marling in Norfolk. However, there is no reason to suppose that the scar of a marlpit would look different to that of a minepit. What seems to have been true is that marlpits needed to be close to the land to which the marl was to be applied. So we might guess that Wealden "marlpits" would be physically distributed in a different manner to pits whose sole purpose was to get ore. The latter seem to cluster. The pattern shown up in the lidar above might, just, represent field-edge marlpits.

Maybe this is a topic waiting to be researched?

Jonathan Prus

Another picture of iron-making history

Tim Smith's article in the Spring edition of the WIRG Newsletter drew attention to the painting of a 16th century ironworks by Herri met de Bles in the Uffizi Gallery in Florence. A number of artists from northern Europe included ironworks in their paintings even if the declared subject of their work was sometimes nothing to do with ironmaking. Indeed the Uffizi painting is also entitled 'The Flight into Egypt' and has the figures of Joseph leading a horse, on which are Mary and the baby Jesus, past the forge. The artist, like his contemporaries, the van Valckenborch brothers, based the landscape for their compositions on the Meuse valley around Dinan and Namur, in modern Belgium, where there were many ironworks at that time.

Christopher Whittick has drawn my attention to another painting of the same period which he recently saw in another gallery in Italy, the Accademia Carrara in Bergamo. It is attributed to Tiziano Vecelli, more commonly known as Titian, and would have been an early work. It portrays Orpheus fatally looking back at Eurydice as he attempts to lead her from the underworld (Fig. 1). The land of Hades is symbolised by two iron furnaces, which can be seen in the top right of the painting (Fig. 2). Unlike the furnaces portrayed by Herri met de Bles and others from the north European tradition, which are square in plan, these furnaces appear to be circular. Beside them one can make out a number of water wheels.

Where did Titian draw his inspiration for the furnaces? In 1508, when it is thought Titian might have painted Orpheus and Eurydice, he was working with Giorgione in Padua. There were contemporary ironworks north of Venice, north-east of Genoa and in Tuscany but all the descriptions I have been able to find of them indicate that they were built on a square or rectangular plan. So was Titian unfamiliar with real furnaces and instead based his depiction on another structure, such as a lime kiln perhaps? Or was it just artistic licence?

Jeremy Hodgkinson