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Editorial note

We are living through rather trying times. One unexpected result is that a number of people have sat down and written longer and, perhaps, more reflective pieces than you would usually expect to find in this newsletter. I hope that everyone is pleased by at least some of this selection.

In this issue

Changing attitudes to iron

By Judie English

We treat iron as an everyday material with no intrinsic symbolic or spiritual power but that has not always been the case. Although it is always difficult for us to understand past beliefs, especially when we have to rely on reports by others on the cosmology of preliterate societies, there are hints that iron had a place in prehistoric and later belief systems. The earlier period has already been discussed (English 2018) and the intention here is to look at changing attitudes through the Anglo-Saxon period.

Some classical comments suggest that iron was taboo during religious rituals of the Germanic tribes on the Continent. In the first century Tacitus (c.56 – c.120AD), discussing the Reudigni, the Aviones, the Anglii, the Varini, the Eudoses, the Suardones, and the Nuithones, described one such ritual in his Germania (Church & Brodribb 1876, XL) – it is not clear where he obtained the information but it is almost certainly not first hand:

"They are distinguished by a common worship of Nerthus, or Mother Earth. They believe that she interests herself in human affairs and rides through their peoples. In an island in Ocean stands a sacred grove, and in the grove stands a chariot draped with a cloth which none but the priest may touch. The priest can feel the presence of the goddess in this holy of holies, and attends her, in deepest reverence, as her chariot is drawn by kine. No one goes to war, no one takes up arms; every object of iron is locked

Figure 1 Anglo-Saxon iron workers

away; then and then only are peace and quiet known and prized, until the goddess is again restored to her temple by the priest, when she has had her fill of the society of men. Then the chariot, the cloth and the goddess herself, are washed clean in a secluded lake. This service is performed by slaves who are immediately afterwards drowned in the lake".

Weapons were probably banned in an attempt to curb the notoriously drunken and squabbling warriors but the quotation seems to imply a specific ban on iron, and this convention may well have followed the migration of the tribes into Britain. Iron itself, of course, was not regarded as problematic – late 5th or 6th century iron smelting and smithing took place at Lyminge in close proximity to the complex of 'royal' halls (Thomas & Knox 2014). Here the smith may have had a permanent base although most were probably itinerant. The 'value' of a smith can be gauged from the early 7th century regnal law code of Æthelberht of Kent which says 'if anyone kills the king's own smith, or his messenger, he is to pay the ordinary leohgild (in other words the blood price of a freeman, although the smith was unfree) (Whitelock 1979, 391). More generally however, the location of ironworks has been associated with the utmark, in a separation within the landscape, much used in Scandinavian archaeology, of the innmark, the area of settlement and fields, and the utmark, everywhere else (Holm et al 2005). This identification of iron workers and their working areas as 'other' echoes the finding of bloomeries in the ditches of hillforts like Dry Hill Camp (Winbolt & Margary 1933) and Hascombe (Winbolt 1932). These locations could have been chosen for practical reasons, in the case of the utmark for proximity to sources of ore and woodland for fuel, and at the hillforts for fire safety and shelter between the ramparts; but both are in different senses, liminal zones, neither in nor out of the hillfort, or on the margins of settlement and society. If the iron production of Anglo-Saxon England was in or around woodland this would explain why so few sites are known – archaeology has for many decades concentrated on settlements and cemeteries. It has been suggested that the inclusion of bells in the Tattersall Thorpe grave (see below) might indicate the need for strangers from the periphery to advertise their presence (Hinton & White 1993). The status as an 'outsider' should not be considered pejorative; the skill required to make a pattern-welded sword or to use steel to improve the cutting edge of a knife (Tylecote & Gilmour 1986) would have been admired and its possessor valued and, possibly, feared (figure 1).

There has been much debate over the source of iron in the early Anglo-Saxon period, with re-use of Romano-British objects, or import of finished items, particularly pattern-welded swords. The thesis that the iron from the earlier period was extensively re-used (for example Fleming 2012) has been refuted by examination or ores and slag from a 6th-7th century site at Quarrington and one from the 10th century at Flixborough (both Lincs). At both sites bedded ironstone ores were utilised (Hall 2018). The distribution of high status pattern-welded blades shows a concentration of 5th to 7th century examples in eastern Kent and the Thames valley (Birch 2011, figure 2) – import of either the blades or their producers from the Continent is certainly possible, but should we be finding more bloomeries dated to this period in the Weald? In 689 Oswine of Kent granted 'land on which iron has been mined' to St Peter's Minster, Canterbury in a charter pertaining to Lyminge (Sawyer 1968, no. 12).

Although all settlements must have had access to iron tools it is not clear whether all smiths could produce both implements and weapons. At Tattersall Thorpe (Lincs) tools, many of which were imported, had been buried in a 7th or early 8th century grave included items suitable for working precious metals or copper alloy but also heavy tools more useful in iron smithing (Hinton & White 1993). However, the Laws of Alfred refer to 'a sword-furbisher [who] received a weapon or a smith [who] received a tool for repair' (Whitelock 1979, 412). Weland (Wayland) most often appears as the god of weapon smiths but this may be due to a bias in the interests of storytellers and he was probably the god of all metal workers.

The conversion of the Anglo-Saxon kingdoms to Christianity after the late 6th century involved a long struggle to suppress practitioners of the existing religion, and over many centuries they came to be condemned as witches and wizards. One conversion story links Anglo-Saxon paganism with an avoidance of iron weapons by its priests. When King Edwin of Northumbria agreed to convert, the move was enthusiastically supported by his chief priest, and when the question was raised about who should profane the old temples and their enclosures, Coifi insisted that he was the right person to destroy the idols he had worshipped in ignorance. Bede (731) describes the theatre (figure 2):

"Then immediately, in contempt of his former superstitions, the king desired to furnish him with arms and a stallion, and mounting the latter, he set out to destroy the idols; for it was not lawful before for the high priest either to carry arms or to ride on any beast but a mare. Having, therefore, girt on a sword and carrying a spear in his hand, he mounted the king's stallion and proceeded to the idols. The multitude, beholding him, concluded that he was distracted; but he lost no time, for as soon as he drew near the temple he profaned it, casting into it the spear which he held. And rejoicing in the knowledge of the worship of the true God, he commanded his companions to destroy the temple, with all its enclosures, by fire".

Figure 2 "The High Priest Coifi Profanes the Temple of the Idols", Doyle, JWE 1864 A Chronicle of England.

Building D3 at Yeavering, the probable temple in question, was a post-built, wattle and daub walled and thatched roof structure

Whether this proscription on the priest simply related to weaponry or was made because the weapons mentioned would have been made of iron is unknown. However, the same interdiction can be seen in Tacitus' first century AD comments (see above).

Whilst the thesis that pre-Christian religion in southern Britain involved an avoidance of iron by its practitioners rests on somewhat circumstantial evidence, it is clear that for many centuries after conversion iron was considered to confer protection from witches. 'Witches' at this period and later were often people, particularly women, who practised the old religion. Early Christianity considered that ill health was a punishment visited by God on those who had sinned – seeking healing other than through prayer was to go against God's will. However, some medicine was practised and those who could not afford to visit the leech (doctor) would resort to women with knowledge of herbal medicine, and who were suspected of using spells. Laws condemning these people can be seen throughout the Late Anglo-Saxon period including:

"If wizards or sorcerers, perjurers or they who secretly compass death, or vile, polluted, notorious prostitutes be met with anywhere in the country, they shall be driven from the land and the nation shall be purified; otherwise they shall be utterly destroyed in the land - unless they cease from their wickedness and make amends to the utmost of their ability". Laws of Edward and Guthrum

During the medieval period and later, iron continued to be seen as protective against the power of ghosts and witches, and an iron knife buried in from of the door would ensure that such malevolent beings could not enter.

Before it became a symbol of good luck an iron horse-shoe was also believed to repel witches; this usage was remembered as late as 1824 when in Redgauntlet Sir Walter Scott wrote, "Your wife's a witch, man; you should nail a horse-shoe on your chamber-door." To be effective the horse-shoe must be used, not bought, and protection will only be given to its owner. This tradition may originate in a legend about St Dunstan (909-988), Archbishop of Canterbury. Apparently before entering the church Dunstan had trained as a metal worker, and when one day the Devil came to tempt Dunstan, he asked him to shoe his horse. Instead Dunstan shod the cloven-hoofed Devil with an iron horse-shoe and iron nails, causing him great pain – he never again returned to trouble Dunstan (figure 3) (Flight 1871). While this story may be 19th century in origin what does seem to be factual is that a plot was hatched against Dunstan by courtiers jealous of his friendship with Athelstan in which he was accused of involvement with witchcraft and black magic (Toke 1909).

Some possible remnant of these beliefs can be seen in the practice of galleting, pushing small stones into the wet mortar of a masonry building. The distribution is largely limited to the south-east of England, particularly in the Weald, and in Norfolk (Trotter 1989). It is not certain when galleting originated – some authorities consider that it has its genesis in the late medieval period whilst others place it later, in the 17th century (Trotter 1989; Sharpe 2011). The purpose has also been the subject of some debate – its presence on some high

Figure 3 Dunstan and the Devil as depicted on manuscript British Library, Royal 10 E IV

status buildings including parts of Windsor Castle, Eton College (c1441) and the Tower of London (1514), perhaps suggests a decorative function. However, it is also found on relatively humble cottages where the labour incurred seems less likely and one possible reason is that it deters birds pecking at the soft lime mortar. However, it has also been suggested that when the galleting involves carstone (a hard iron-bearing strata found within sandstone formations) the purpose is to protect the building from witches.

Acknowledgement

Thanks to David Lea for commenting on the first draft of this note and adding enough punctuation to make it readable.

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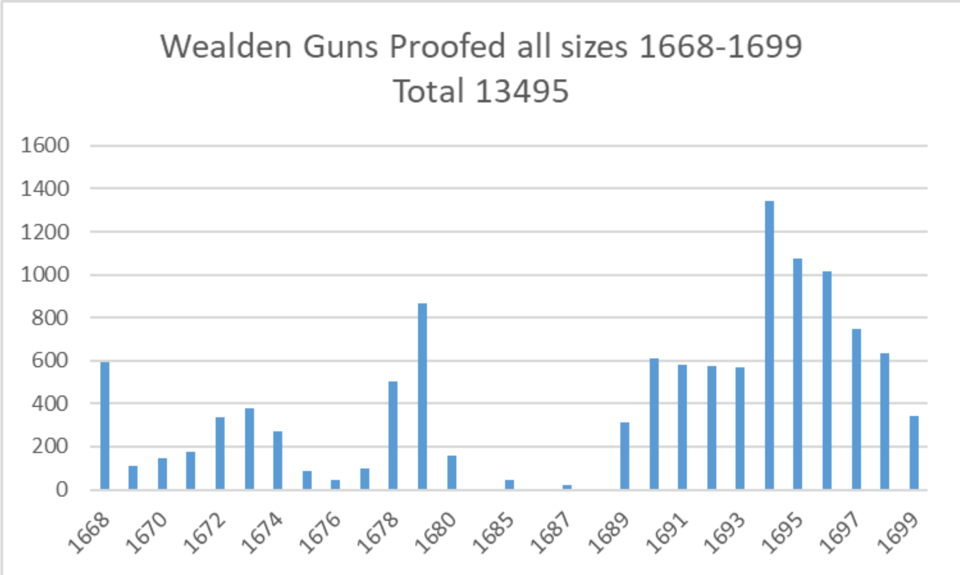
The King's Gunfounder – A correction and more

By Tim Smith

In the 2020 Spring issue of Newsletter No 71, I stated: *"……… by the 18C 'cannon' referred to guns firing 42 lb shot – a gun not made on the Weald where the 32 lb demi-cannon was the largest gun cast."* This was based on a statement by John Fuller and a Table in Straker (p160), indicating that the largest gun cast on the Weald was the 32 pounder demi-cannon.

Charles Trollope kindly supplied a copy of his inventory of proofed guns cast on the Weald which shows that at least 408 "Cannon of 7" (ie 7" bore) firing a 42lb shot were cast on the Weald during the period 1670 to 1760. The first cannon was cast by Thomas Westerne in 1670 who was lessee of



Robertsbridge Furnace at this date, soon followed by a cannon proofed the same year and cast by George Browne who operated Horsmonden (Brenchly) furnace.

Charles reports that the first successful iron guns were cast in 1543. Prior to that date cast iron guns had failed due to their measurements being copies of lighter sectioned brass guns. Brass gun measurements increased in 1538 and the casting of cast iron guns became possible. The first gun to be made was at Buxted, cast by Ralf Hogge (Huggett), and is immortalised in the Sussex ditty:

"Master Huggett and his man John,
They did cast the first can-non".

Casting of guns petered-out after 1760 when guns from other locations began to be accepted by the Board of Ordnance, diminishing further in 1770, when the Carron Company of Scotland started supplying the Board of Ordnance with guns, although their early guns proved inferior to those cast in Sussex. However, from 1775 the Board of Ordnance insisted that only guns cast solid and bored out would be accepted – a technology patented by 'Iron Mad' Wilkinson of Cumbria. This ended the Wealden gun trade, although reaming of surplus hollow cast guns continued into the 1780s to supply merchant ships and other markets.

What is amazing is that considerably in excess of 35,442 guns ranging in sizes from 42 lb shot to 0.5 lb were cast on the Weald during the period 1588 to 1770 – a time for which official records survive. This number does not include guns that failed on initial inspection or test firing at the furnace site, or were sold clandestinely without licence. Also, there are no numbers for the first 50 years from the casting of the first gun at Buxted in 1538 to 1588. During this period, some guns were cast for the Dutch – who sold some for a profit to the Spanish to recoup cost.

As casting guns was a specialist task, only 38 furnaces of the 119 operating in the Weald were capable of undertaking this work. Guns were cast vertically in a pit in front of the furnace, a bulbous gun head included on the muzzle fed molten metal into the gun to feed shrinkage cavities formed during solidification and also to act as a reservoir for slag and impurities to rise out of the gun into this head. The head was sawn off prior to boring the gun and sold to the forges at a reduced price as, being grey iron and containing slag, they were more difficult to refine than the iron sows cast for forging which normally would be white iron. Evidently they were not recycled through the blast furnace probably because of the effort needed to cut them into smaller pieces to safely do so.

The amount of iron needed for the largest guns would be around three tonnes. Cannon weighed up to 5500lb (2.5 tonnes) (Straker p159) and the amount of metal to be cast would be an additional 20% for the gun-head (Straker p156) i.e. 6600lb (3 metric tonnes). The smallest guns cast on the Weald weighed around 400lb requiring around 480lb

The Mount Aetna 'cannon' of 1776 with gun head still attached, Maryland USA https://www.hmdb.org/m.asp?

(220kg) of metal. Diderot (1751) illustrates the moulding of a gun in which the gun head can be seen and does, indeed, account for a fifth of the final gun's length. (See '*The Wealden Iron Industry*' J Hodgkinson p127). Further evidence is the picture of a rare find in the USA of a gun still with its head in place; a smaller example is in the Anne of Cleves House in Lewes. These heads seem unusually large since, when casting grey iron as required for a gun, the graphite formed counteracts much of the shrinkage porosity, but no doubt trial and error determined this as the correct size. Since Wealden furnaces typically produced little more than 1.0 to 1.5 tonnes of iron a day, it would be necessary to allow an accumulation of metal in the hearth over a period of three or four days to cast the larger guns, with the inherent dangers of a break-out of the metal or cooling causing a 'freeze-up' in the furnace. Indeed, the Fuller letters between 1738 and 1751 include such statements as: "*will not make 42 pounders* (cannon) *at £20 a ton – a gamble at £80 a throw, also when making 4 tons of metal 1 ton is burned away……"* George Browne (son of John), in 1664, makes a similar comment regarding the time needed to accumulate sufficient metal "…..*being so long as four nights if not more in the hearth, which will be in great danger of cooling in the hearth when it should run which when it happens (as in casting great pieces…is frequently to be expected) is the loss of the piece"* (See WIRG Newsletter Nov 1985 p8). Indeed, there are references to air furnaces being used in which metal could be melted and kept molten, certainly when casting brass guns, which several gun founders, such as the Brownes, undertook.

The demand for guns varied greatly from year to year as illustrated in a plot for the 31 year period 1668 to 1699 during which time 13495 Wealden guns of all types were proofed in London.

During this period England was involved in no less than four wars and a rebellion, peaks corresponding to the third Anglo-Dutch war (1672-74), the Franco-Dutch war (1672-1678) and the largest resulting from the Nine Years war (1688-1697).

This trend of variable gun production is also reflected for later periods.

Regarding the life of guns, Charles also points out that Straker misinterpreted the 40 and 55 numbers as the life of various guns. In fact, these numbers refer to the number of shot for each gun carried on board ship, the life of a gun far exceeding these values but no record has been found.

Acknowledgements: To Charles Trollope for letting me have copies of his compilation of the Board of Ordnance gun proof and earlier Debenture book and to Jeremy Hodgkinson for drawing my attention to the Mount Aetna gun.

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BERNARD CHARLES WORSSAM

BSc, DSc, FGS

1926-2020

Throughout his professional life Bernard Worssam worked for the Institute of Geological Sciences, now the British Geological Survey. Over more than 20 years he was to be the author or co-author of seven memoirs describing the geology covered by the Survey's One-inch, and later 1:50,000, maps. Moving to Horsham in 1960, he had already begun the fieldwork for the memoir on the Haslemere area and his 1964 paper for the Geologists' Association on 'Iron ore workings in the Weald Clay of the Western Weald' not only revealed the extensive digging of iron ore from pits in south-west Surrey and north-west Sussex but also examined the historiography of ore extraction for the iron industry. Fieldwork for the Horsham memoir resulted in a similar paper in 1971, by which time he had joined WIRG. Excavations were taking place then of the Iron Age and Roman iron-working site at Broadfield, in Crawley, and Bernard collaborated with the director of the dig, John Gibson-Hill, in a study of the ores associated with the many bloomeries there.

The Institute moved from South Kensington to Nottinghamshire and Bernard and family left Sussex in 1979. Notwithstanding that move, Bernard's work and his association with WIRG made him the obvious choice to write the chapter on geology in Cleere and Crossley's *The Iron Industry of the Weald* which was published in 1985. He retired in 1986 and moved back to the South East, to Otford, near Sevenoaks. Once again he was able to participate actively in WIRG. In 1996 he received the degree of Doctor of Science from University College London, on the strength of his body of geological research. Already a Vice-president, he was President of WIRG from 1997 to 2003, and he became a regular member of the Field Group, his insights and lucid explanations of the geology of wherever the forays took place being an invaluable addition to the discussions on the day. He contributed several articles to the Bulletin over the years, notably on the exposure of minepits at Sharpthorne brick pit and on the geology of the Pays de Bray, following WIRG's first continental foray there in 1989. In his retirement he became an expert on the types of stone used in early sculpture and in the construction of churches and other buildings.

Bernard Worssam, more than anyone else before or since, understood the geology of Wealden iron and his kindly expertise will be greatly missed.

BRIAN KENNETH HERBERT

1936 - 2020

Brian Herbert died suddenly on 26th August. It is fair to say that no-one had a longer or more active involvement in WIRG than Brian. He joined the Group in its early days, when it operated through locally-based teams - he and his wife Valerie were named as leaders of the East Grinstead team in the list of members in 1971 - and from the start his was a very practical approach to the study of the iron industry. He led forays and small excavations, and recorded sites: 11 of the manuscript field records, upon which were based the gazetteer entries in Cleere and Crossley's *Iron Industry of the Weald*, bear his name.

In his working life Brian was at the Philips Research Laboratories at Salfords, near Redhill, and his training in electronics equipped him to build himself a beat-frequency metal and slag detector long before commercial versions became popular. With it his attendance on a foray was essential, enabling the presence and extent of iron slag to be easily traced and allowing the detection of ironworking sites to be made considerably more efficient. He also used his scientific knowledge to pioneer in the Group the conservation of iron objects discovered on forays, most notably the cannon boring bar found at Stream Furnace, near Chiddingly, and now displayed at Anne of Cleves House in Lewes.

When experimental iron smelting was first undertaken by the group in the 1970s, in the grounds of The Pheasantry, Fred and Margaret Tebbutt's house on Ashdown Forest, Brian was a member of the team. And when, later, a new site had to be found it was Brian who took the lead in setting it up, building the furnace, the shelter for the tools and the cover to protect the bloomery from the weather when it was not in use. He devised measuring instruments to monitor air intake and constructed bellows and, of course, conducted and recorded the programme of smelts that has continued for more than 30 years. Filming for television sequences about the Wealden iron industry were drawn to the experimental bloomery and Brian was to be seen and heard in many of them.

His practical experience in WIRG led him to produce at his own expense *The Fieldwalker's Guide and an Introduction to the Iron Industries of the Weald*, combining hints about what to look for and where to look with technical information about the smelting and forging of iron, the geology of the Weald and important sites. When it came to Brian leading a series of forays to record in detail the course of the leat that had been constructed, probably in the early -18th century, to supplement the water supply for Ashburnham Furnace he compiled the findings in three detailed booklets with photographs and maps. Brian contributed 24 articles to the Bulletin, the first in 1972 and the most recent in 2016. He also wrote for the Newsletter on many occasions.

Brian gave talks to local groups about the iron industry and, in the 1970s, organised a permanent exhibition at Haxted Mill, near Edenbridge. He was the longest-serving member of the committee by many years and took charge of the Group's stock of publications, managing their sale at AGMs and winter meetings or by post.

Brian Herbert epitomised the Wealden Iron Research Group from its earliest days and he will be sorely missed.

BOOK REVIEW

P. King, *A Gazetteer of the British Iron Industry 1490 -1815*, BAR Publishing, 2020; 2 vols, 738pp., 44 maps, index; paperback; ISBN 978-1-4073-1512-6; £150 (also available separately and online).

Lists of ironworks began appearing in the early 18th century, inspired by political pressure to restrict imports from overseas. H. R. Schubert was the first to attempt a list of water-powered furnaces and forges in his *History of the British Iron and Steel Industry* of 1957. Since then, in 1987 Philip Riden published a gazetteer of sites active since 1660, which he revised in 1993. Peter King's survey is in a wholly different league, drawing, as it does, not only on published sources but on the author's own extensive research back to the primary sources from which they were derived and also a wide range of additional ones. In this he has been at pains to correct earlier errors and misconceptions

A comprehensive introduction explains the technology used at the sites listed in the text, defining the different processes, products, raw materials, and the terms used to describe them in the course of the book. The economics of the iron industry which dictated its location and viability are described briefly. Also useful is a section on weights and measures.

The main gazetteer is organised by regions: SE England; N Midlands; S Midlands; the SW and Wales; NW England; and Scotland. Each region is then sub-divided by a variety of criteria depending on the scale and geographical distribution of the sites therein. In the South East, the data for the Weald has very largely been derived, with WIRG's permission, from the Group's online database, and is sub-divided by river catchment areas. The other areas in the south east, the Thames Valley and Hampshire, where there was a smaller number of ironworks and, in the case of the former, a preponderance of secondary processing mills, are treated separately. In other regions where there was a heavy concentration of ironworks, such as the Stour Valley and Black Country, river catchments are also used, while in less densely exploited areas sites are grouped by geographical criteria.

The ironworks in each region and principal sub-regions are shown on maps by numbered symbols, though for the maps with a large number of sites the keys would have been clearer if the names had been arranged in columns. Cross-referencing the numbers on the maps with the entries in the gazetteer would have made it easier to find individual sites. Also the inclusion of the names of principal towns or villages appropriate to the scale of each map would have helped orientation. As it is, the maps seem to have used a national base map with only the largest population centres included and the names of these have not been appropriately scaled down on some of the maps of smaller areas.

Each region covered commences with a historical survey of the development of the iron industry there. Where appropriate this may include particular details of major consortia operating in the region, such as the Crowleys in the North East, the Darbys in Shropshire or the Foleys in the Stour valley of the west Midlands. This is particularly useful as it sets the ironworks in the region in their economic and historical context. The operational history of each ironworks listed is then as fully described as the available source material allows. Only for the Weald are site descriptions included, but each entry concludes with a list of its principal sources.

The full range of iron production sites is included in each region and sub-region, not only blast furnaces and forges but slitting mills, wire mills, plate mills and urban foundries, so it is somewhat of a disappointment to find that no detail is provided of the wire mill that later used the site of Woodcock Hammer, north of East Grinstead. The dearth of information on some sites highlights the need for further research.

As would be expected there is an extensive bibliography, and an index largely limited to the names of people and places.

This is an extremely important source of reference, and to anyone interested in the iron industry in one region the availability it provides for comparative study of the details of works in other regions is tremendously useful. Its price will deter many, I fear, but the promise of an online edition should compensate for that.

Jeremy Hodgkinson

Furnace wall from Roughter Wood, Udimore.

A piece of furnace wall, weighing by estimation 50 kg, has been found in Roughter Wood, Udimore., The bloomery site in Roughter Wood was noted by Straker but there are no records of it having been surveyed or excavated. It is undated. The slag and other debris was originally deposited at the top of a large natural pit and has over the years slipped down into the pit. Trees growing on the steep slope are unstable and are easily blown over in storms. Digging by badgers and rabbits also make the slopes unstable. The wall was revealed by a recent tree fall.

The section of the furnace wall recovered is 46cm in height and shows two distinct layers in the wall. On cleaning it shows burnt red clay on the outside. The

inside is yellow/grey clay with some slag adhering to the lower part of the wall. The attached photos show these features.

Measurement of the length of the arc of the inner wall and the maximum height of the arc enables the radius of the circle of which the arc is part to be calculated.

The result obtained is a radius of 54cm, indicating a furnace internal diameter of 1.08m. There is some uncertainty about these measurements and the furnace may not have perfectly circular but it seems that the Roughter Wood furnace may be larger than many of the other bloomery furnaces for which dimensions have been obtained.

My thanks to Stephen Hall who did most of the heavy lifting involved in the removal of the wall.

Bob Turgoose

Iron production sites on Felbridge Water, Worth and Felbridge, West Sussex

By Judie English

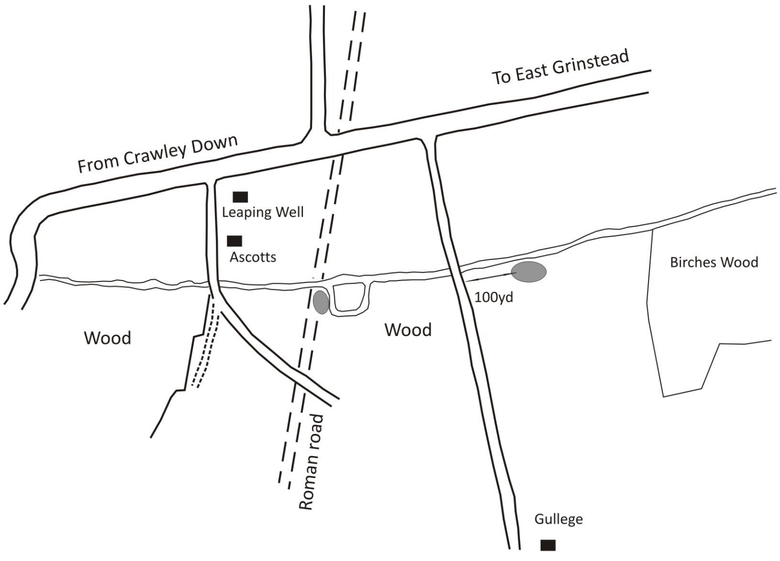
Whilst hunting through the Straker Collection at Barbican House, Lewes, looking for something entirely different, a letter came to light with a sketch map indicating a find of bloomery slag. The text, from R Mason of East Grinstead to Ernest Straker is undated, but in full reads:

> "I have looked at the pond bays at Pembury and could find no suggestion of iron. It seems to me possible that some sort of mill may have existed at the lowest of them which is quite close to 'The Alders Inn', Capel Village. I have, however, made a find much nearer home, that is if no-one has forestalled me. I have found cinder of the type enclosed beside the Felbridge Water at a point about 100 yards east of the old sunken road to Gullege on Imberhorne estate. There does not appear to be very much of it but a seam some 6" deep is exposed in the bank of the stream. I have not ascertained the true extent of it as I wait to hear whether it happens to be a specially interesting type. I also found a good solid bed of the other specimen near Ascotts, but I now find that by measurement I was probably uncovering a section of Mr Margary's Roman road. You will know whether this cinder is Roman, and, if so, Mr Margary would perhaps be interested to know that his road is intact at that point as it lies between two proven sections. It has occurred to me that there is almost certainly a fair-sized bloomery site near this point, as Mr Margary found cinder metalling from here to the borders of Lingfield, but one difficulty in locating it seems to be – if, as one would suppose, they were continually taking away the cinder for road repairs, are not the remaining deposits bound to be somewhat scanty? I should be glad of your opinion on that point as it will help me to know what to look for.
> Hoping I am not being a nuisance,
> Yours truly,"

The letter is accompanied by the sketch map reproduced here. The R Mason who wrote this letter is mentioned in Margary's *Roman Ways in the Weald* as RT Mason, and is presumably the architectural historian and author of *Framed Buildings of the Weald*. Margary (1949) credits Mason with excavating the Brighton / London road 'in the fields north of the Eden Brook just beside the Lingfield – Tandridge parish boundary, finding 'the metalling here was entirely of iron slag and where best preserved was found to be 12ft (3.66m) wide and up to 8ins (0.20m) thick'. However, this point is at TQ 3746 4254 (Margary 1965, 109, section 39B) rather than at the point indicated on the sketch map, TQ 3608 3902; at this latter point Margary notes 'Stone and cinder' (*ibid*).

What is clear is the extensive use of slag as metalling for this stretch of the Roman road – the material was noted at multiple points between Rivers Farm, just north of Haywards Heath to the Newchapel – Lingfield road, a distance of some 14km.

Three iron production sites are known along this stretch of Felbridge Water:



Derived from sketch map drawn by R Mason. Areas of 'cinder' shown in gray

Ascotts – NGR TQ 3600 3900. This is Site C (Hodgkinson 1985) where it is recorded as part of a fieldwork exercise with no further information, but presumably bloomery slag was found.
Felbridge Water – NGR TQ 3666 3926. A scatter of heavily weathered smelting and forging slag and charcoal found in an arable field (Hodgkinson 2001).
Smythford – NGR TQ 3581 3898. Excavated to reveal a probable smelting furnace and a consolidation hearth dated to the 1st century AD (Hodgkinson 1985).
The map drawn by Mason indicates two areas where he had found 'cinder' – almost certainly slag. The eastern one is located at TQ 3660 3918 and is probably that known as Felbridge Water and a seam exposed by the stream does suggest a working site. The western is at TQ 3608 3903, immediately to the west of a medieval moated site, probably the *caput* of Wardley Manor. Although described as 'near Ascotts' this is not the Ascotts site mentioned above. The Roman Road passes immediately to the west of the moat and any *agger* appears to have been used as a retaining bank. Clearly digging the moat would have caused disturbance in the area, and clearance of the moat itself in the 1930s by Sir Thomas Seagrave so that he could go boating on it was a further intrusion. Slag found in this area is more likely to have come from the Roman road that a production site in the immediate vicinity.
An extensive account of the Wardley site (JIC 2017) mentions two other points of potential interest. LiDAR images of the area show a possible retained pond athwart Felbridge Water, to the east of the moated site and stretching as far as the road to Gullege. No documentary evidence appears to have come to light and the use to which this pond was put is unknown. Sited astride the Roman road south of the moated site is a square field called Bottle and it has been suggested that this might have been a *mansio* similar in position relative to Felbridge Water to those of Hardham and Alfoldean to the Arun. This seems unlikely given the apparent lack of pottery finds from the field but the presence of the road would certainly have provided an convenient trade route for a heavy product like iron.

Hodgkinson, JS 1985 A Romano-British ironworking site at Crawley Down, Worth, Sussex, *Bulletin of the Wealden Iron Research Group*, 2nd series, **5**, 9-20
Hodgkinson, JS 2001 Field Notes, *Bulletin of the Wealden Iron Research Group*, 2nd series, **21**, 2-8
JIC 2017 *Tithing of Wardley* available at: https://www.felbridge.org.uk/index.php/publications/tithing-Wardley/
Margary, 1949 ID *Roman ways in the Weald*, Phoenix House, 2nd impression

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Early days of WIRG's Experimental Smelting

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

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

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

Continued on next page

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

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

The tuyere was inserted through the clayed up slagging arch each smelt using a different height or inclination. An alumina tube 19mm diameter was used for one trial as well as trumpet ended clay tuyeres and double tuyeres moulded within a single block of clay, based on rare finds at Bardown. Here, flagon necks had also been found, thought to have served as tuyeres, possibly for a roasting trench. The maximum height above the furnace floor was 6” (15cm), dictated by the height of the slagging arch. A trench lined with clay was dug in front of the furnace to collect slag. Ore was roasted in pits, one square with a base of puddled clay, the other a trench 8’x1’x1’, (243 x 30 x30cm) also puddled with clay, and open at one end, based on evidence from the Bardown excavation. Layers of charcoal and ore broken to 2-3” (5-7.6cm) were spread in this and ignited. To accelerate roasting, air was blown in via a tuyere. Roasting was stopped when the ore turned red but subsequent analysis indicated that only the surface had been calcined – at least in the samples examined.

The magnetic response of this ore erroneously led Henry to the conclusion that magnetite (Fe_3O_4) had resulted; subsequent XRD analysis of current smelts by WIRG have shown the product to be the magnetic form of Fe_2O_3, maghemite. The roasted ore broke easily and was screened to select material of $^3/_8$ – 1” (0.94-2.5cm), and charcoal of a similar size was screened for the smelt

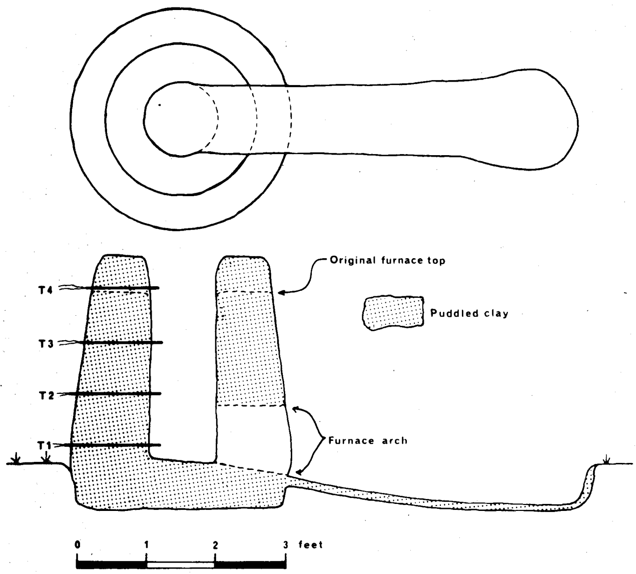


Fig 2 Thermocouple locations

Four thermocouples were inserted through the back wall of the furnace at vertical intervals of 9” (23cm) the lowest (T1) being 2” (5cm) above the furnace base and the top one (T4) 5.5” (14cm) below the rim of the furnace. Each was inserted 2” (5cm) into the charge. The lowest thermocouple was Pt/PtRh in order to measure tempratures in excess of 1000°C and the remainder chromel/alumel (Fig 2).

An isothermal plot on a diameter of the furnace normal to the tuyere axis showed a symmetrical heat pattern ranging from 1300°C closest to the tuyere to 600°C near the top of the furnace and 500°C at the hearth circumference (Fig 3).

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

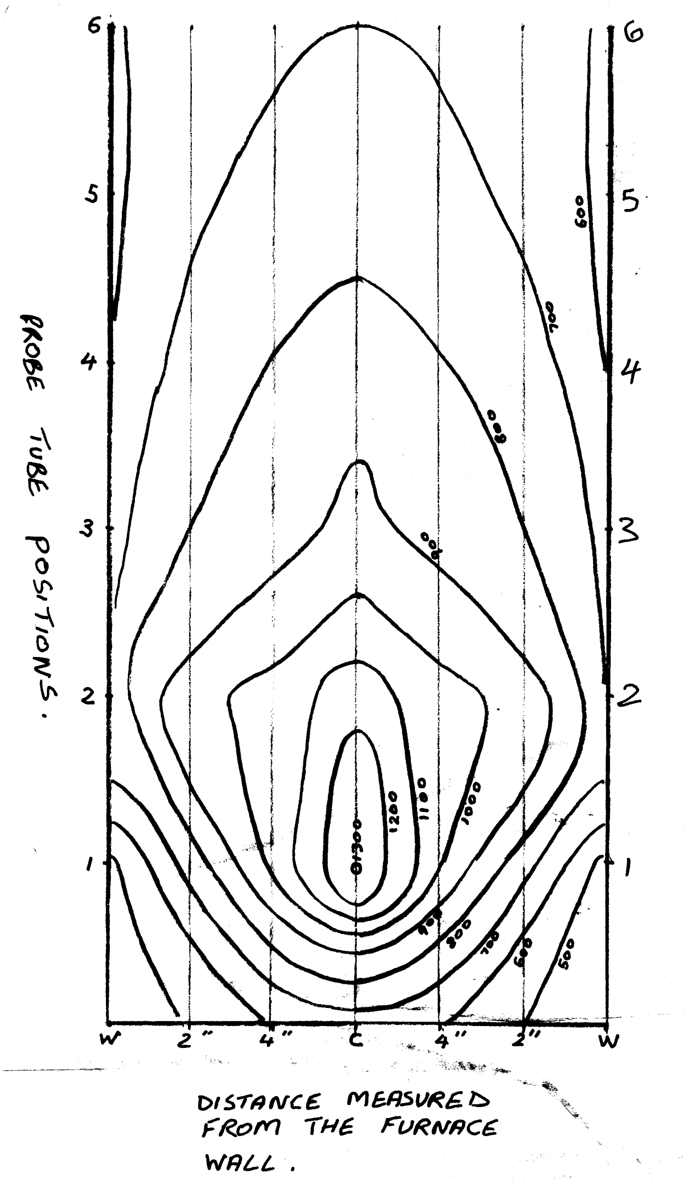


Figure 3. Henry's isothermal plot of furnace interior

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

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

Sectioning of blooms (Fig 4) and metallographic examination of these and material forged to an arrow head as well as slag analysis were conducted. The bloom from trial 2 showed multiple voids and slag entrapment. Analysis revealed the iron to be almost completely ferrite of hardness $152HV_5$ this suggesting an appreciable quantity of phosphorous present.

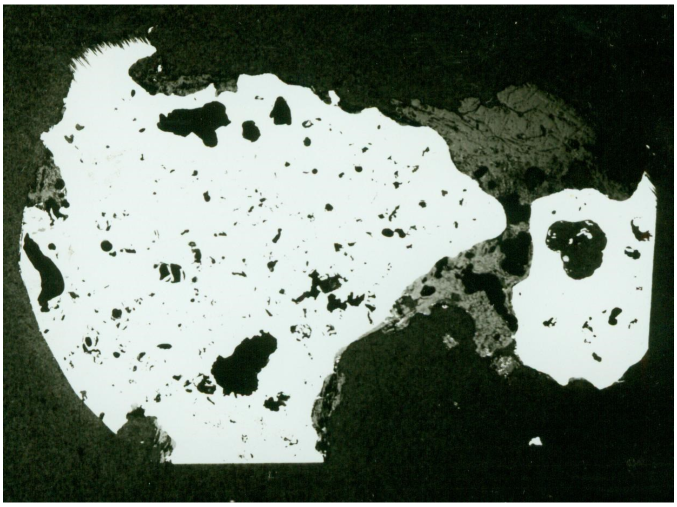


Fig 4 Section of bloom x5
White area is iron, dark are voids grey area in same plane is slag

The shaft of the forged arrow head showed a carbon gradient from 0.1-0.2% at the centre to 0.7% at the surface, attributed to carburisation during forging (Fig 5).

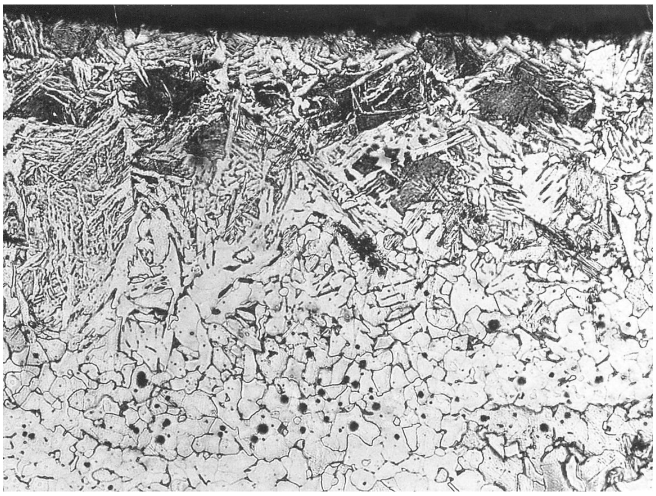
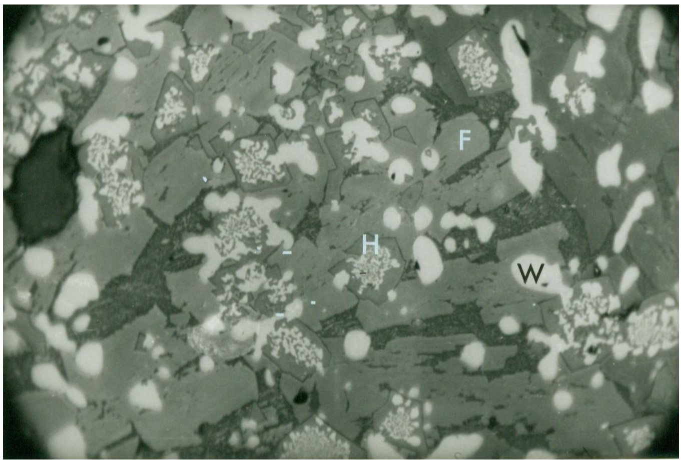


Fig 5 Forged arrow shaft showing carbon gradient centre to edge x100

Slags were chemically and metallographically analysed by BSC. Furnace slag (Fig 6) was coarse crystalline enclosing charcoal fragments and contained pores encrusted with hercynite ($FeOAl_2O_3$) and fayalite ($2FeO.SiO_2$). Some wustite (FeO), and iron monticellite ($CaO.FeO.SiO_2$), were also present.

Fig 6 Furnace slag: F Fayalite; W Wustite; H Hercynite x165



The fayalite crystals were up to 3mm long. The presence of a higher quantity of hercynite was considered unusual and a result of a high proportion of alumina in the ore (5-7% in three of four samples).

The tap slag (Fig 7) consisted of components of fayalite, hercynite, wustite, magnetite and iron monticellite with some locally occurring metallic iron, oxidised haematite and lime-rich pockets with dicalcium silicate and various calcium ferrite compounds (eg $2CaO.Fe_2O_3$) or with anorthite crystals in a glassy matrix.

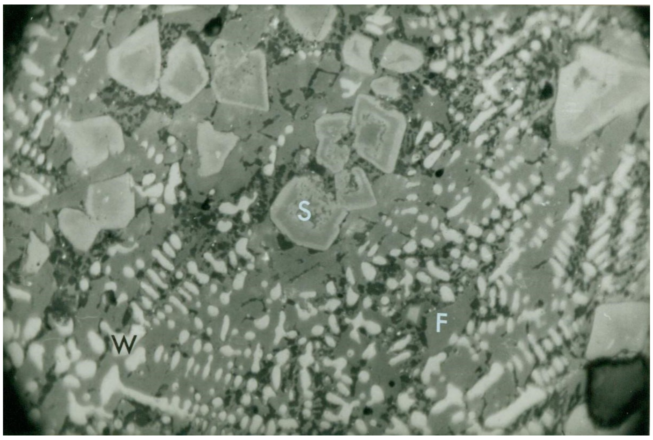


Fig 7 Tap slag: F Fayalite; W Wustite; S Spinel Fe.Al x 165

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

Tim Smith

WIRG Winter Meeting

Due to Covid-19 the winter meeting will be held on-line using *Zoom.* It will take place on Saturday 30th. January at 2.15 for a 2.30 start.

A presentation by Paul Rondelez

followed by a question-and-answer session:

Mediaeval forging and early modern smelting in Ireland.

There are some striking similarities with the Weald, and some stark differences.

Dr. Rondelez is an independent researcher who runs a consultancy providing specialist reports on metalworking residues.

If there is still anyone who has not met on *Zoom,* its easy and you don't need to have any special software to run it. Joining details will be sent out shortly.

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