HMS NEWS

Historical Metallurgy Society

68 **Spring 2008**

Annual General Meeting

Cambridge, June 2008

This year our AGM will be held in Cambridge on Saturday 14th June at the Scott Polar Research Institute. As usual the AGM will be held first to which all members of the Society are welcome to attend. Following the AGM we will have our usual Spring meeting of presentations and visits.
Presentations will include:

- Steve Walton, Penn State University, on Scientific Instruments
- Robert Smith on Frobisher's Gold.

We will also have the opportunity to see some of the wonderful museums in Cambridge – The Scott Polar Museum, The Fitzwilliam, the Sedgewick and the Archaeological Museum.

Grants

The society awards grants from the **Coghlan Bequest** and **R.F. Tylecote Memorial Fund** for research and travel. Members are encouraged to apply by completing forms available on the society's website (www.hist-met.org) and sending them to the Hon. Treasurer. The Coghlan Bequest was set up to facilitate any research into historical metallurgy, including fieldwork, experiments, analysis and travel. Money from the fund is **awarded once a year in March**; applications must be received by the end of the preceding January to be considered. The R.F. Tylecote Memorial Fund commemorates the renowned archaeometallurgist who was a founder member of the HMS and edited the Journal from its beginning until his death. It takes the form of Annual Travel Bursaries to help pay for travel, subsistence and conference fees, which will further the aims of the Society, including research, conferences, seminars, excavations, fieldwork and experimental workings. Money from the fund is **awarded in March and November**; applications must be received by the end of the preceding January and September. As a guide £100–£150 is usually awarded in each round. Following an award, the results of the research undertaken or a report on the study visit must be sent to the HMS for possible inclusion in the Journal the HMS newsletter. Any unused funds must be returned to the HMS.

Instrumenting an experimental Sri Lankan wind-driven furnace

Gill Juleff and Matthew Baker

In 2007 the Society's Coghlan Bequest generously supported Matthew Baker, an Engineering student from Exeter University, who joined a team from the Archaeology Department at Exeter University, under the direction of Gill Juleff, travelling to Sri Lanka to carry out a second series of iron smelting experiments. The funds awarded to Matthew were used to purchase thermocouples and scientific equipment to help record conditions within these highly efficient and unusual furnaces. The following report summarises the Monsoon Steel project and Matthew's role in it, and presents some preliminary results. A more comprehensive account of the new experiments will be published on completion of the full analysis of the data.

In the early 1990's research carried out in Sri Lanka uncovered evidence of a large-scale iron producing industry of the first millennium AD at Samanalawewa, in the southern foothills of the Central Highlands. Extensive survey and excavations revealed that iron was smelted in shallow, elongated furnaces which were located at the tops of steep hillsides and were driven by powerful dry monsoonal winds – a furnace design and technology far removed from the generally accepted bellows-driven, shaft furnace technology (Juleff, 1998). In 1994 a number of field experiments were conducted at Samanalawewa using furnaces reconstructed from the archaeological evidence. These first smelts set out to validate the theory that the wind-driven furnaces were viable and capable of smelting the locally available rich hematite ores. The results, reported in the journal Nature (Juleff 1996), demonstrated that the furnaces were able to reach and sustain temperatures that allowed directly smelting to high carbon steel. These experiments were then further validated in 2004, by modelling the operation of the furnace using computational fluid dynamics (CFD) (Tabor *et al*. 2005). This demonstrated that as the wind accelerates up the hillside it is diverted over the top of the furnace creating a high pressure region in front of the furnace wall and a low pressure region above the furnace bed. This pressure difference draws air into the furnace through multiple clay tuyères protruding through the front wall (Tabor 2004).

The purpose of this year's (2007) investigation was to return to Samanalawewa for a six week campaign to carry out a further series of smelts and collect temperature and wind speed data in order to achieve a more in-depth understanding of the parameters involved in the operation of the furnace. The site chosen for the new experimental smelts was the same as that used in 1994. It lies in the district of Balangoda and was designated the site code SM51 during the original archaeological survey (Juleff 1998). The site occupies the summit of an exposed ridge with an uninterrupted 180 degree aspect to the north, west and south and previous archaeological survey recorded a number of possible furnace locations indicated by single or pairs of upright stones used to terminate furnaces walls and by the extensive tumble of slag spreading down the western slope of the ridge. Two furnace locations were chosen for the smelting experiments. The first being the furnace built for the 1994 experiments, which had remained in reasonably well-preserved condition over the intervening 13 years. The second furnace was newly constructed in the position of an archaeological example marked by an upright stone. A total of four instrumented experimental smelts were carried out during the campaign, two in each furnace.

The 1994 trials indicated high temperature regions in the furnace ‘corners’ (the north and south ends of the furnace at the junction of the curving back wall and the straight front wall) and temperature variations across the furnace bed (Juleff 1998). One of the aims of the 2007 season was to investigate these observations further. To achieve this, temperatures were recorded both laterally across and vertically through the furnace by means of an array of thermocouples protruding through the front wall (Figure 1).

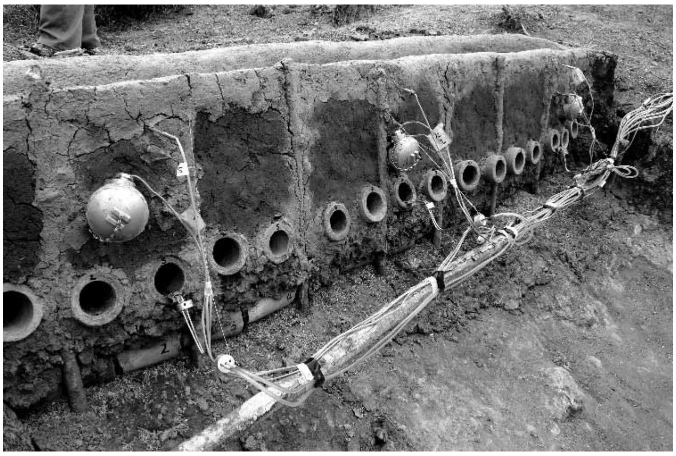

Figure 1. Experimental set up for smelt 3 (Photograph: Monsoon Steel)

During the original trials, optical pyrometer readings taken by sighting through the tuyères suggested combustion zone temperatures in excess of 1500ºC and the potential for higher temperatures with increasing wind velocities. For the new trials, ceramic R-type thermocouples were chosen for use in the combustion zone region due to their ability to record temperatures up to 1600ºC. Less expensive N-type Pyrosil C sheathed thermocouples capable of temperature measurements up to 1250ºC were used for other locations in the furnace. An optical pyrometer, sighted through tuyères was used to collect additional temperature readings from the black body emissivity of the charcoal. To leave airflow through the tuyère unimpeded, the R-type thermocouples were positioned penetrating the furnace front wall at a steep angle into the combustion zone a little above and in front of the tuyère mouth. The N-type thermocouples were set into the front wall horizontally and all connectors and cables were carefully labelled and then bundled and suspended above the slag tapping area in front of the furnace (Figure 1). Air temperatures were recorded throughout the smelts to calculate an accurate value for air density for further computational work.

Wind readings at the site were recorded by means of handheld anemometers throughout the six week period. The purpose of these readings was to examine diurnal wind patterns to determine optimum conditions and to correlate wind speeds with smelt progress and furnace temperatures. Wind data was collected from three locations across the site that corresponded with data collection points used in the 1990s, thus providing two datasets for the same site and time period (Juleff 1998). Readings were taken at heights of 0.5 and 2m to include the boundary layer caused by the ground effects. Wind direction was recorded by means of a stationary weather vane positioned on the leading west-facing edge of the ridge.

In brief, each smelt lasted approximately six hours, including an initial furnace preheat of approximately 45 minutes. Charging ratios of 1:1 charcoal to roasted ore by weight were used and each smelt consumed in the region of 90kg of ore. After charging the final ore further charcoal was added to maintain the fuel bed for a further 1–2 hours before the front wall of the furnace was broken down and the semi-solid products (slag and partially consolidated metal) removed. All of the smelts successfully produced free-flowing slag in significant quantities. However, while all of the smelts also produced reasonable quantities of metal (up to 15kg), very few well-consolidated lumps that could be termed ‘blooms’ were recovered. This is undoubtedly due to our lack of experience in operating the furnace rather than any shortcoming in its design.

Initial processing of the temperature data collected demonstrates steep vertical temperature gradients, with highest temperatures recorded, as would be expected, directly in front of the tuyères and lowest temperatures immediately below the surface of the charcoal bed at the top of the furnace. As the furnace is effectively driven by a pressure difference caused by the wind passing over the top of the furnace, the temperature immediately below the surface of the top of the charcoal bed behaves with less stability than that of the combustion and reaction zones (Figures 2a, b and c).

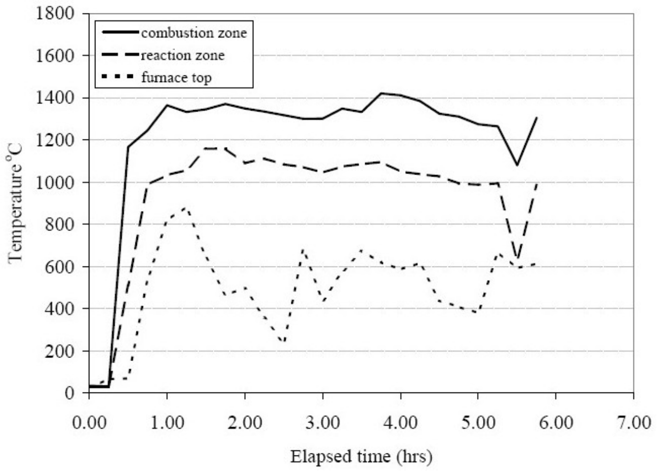

Figure 2a. Furnace 1; smelt 3. Temperature change with elapsed time for the North 'corner' of furnace

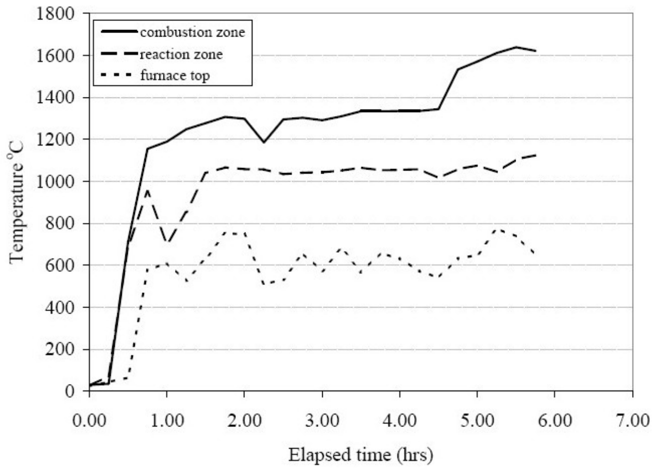

Figure 2b. Furnace 1; smelt 3. Temperature change with elapsed time for the Centre of furnace

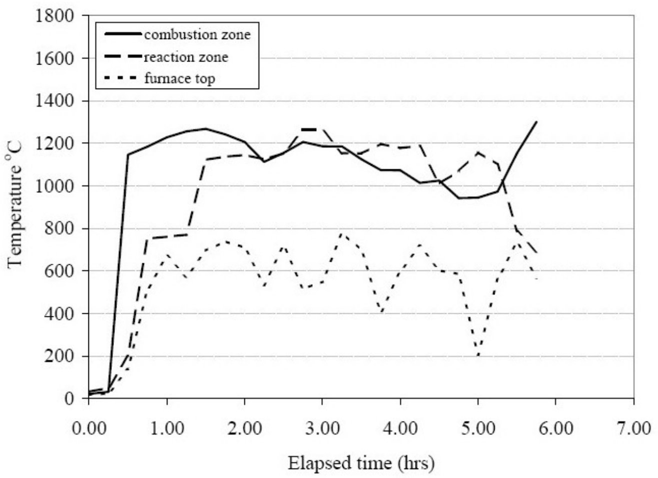

Figure 2c. Furnace 1; smelt 3. Temperature change with elapsed time for the South 'corner' of furnace

The combustion and reaction zones only deviate marginally with fluctuations of wind velocity once a steady state has been reached. Marked lateral variation was also observed, with the two ends of the furnace showing similar temperature ranges but far less stability than the central zone. Once temperatures are established in the central zone they show very little variation with changing wind velocity.

Wind speed and direction data recorded during the campaign indicate a predominantly westerly wind with horizontal angles of attack in the region of 18º around the perpendicular, and speeds reaching in excess of 50kmph.

The 2007 smelting trials demonstrate the value of experimental archaeology in archaeometallurgy. The project drew considerable local interest within Sri Lanka with both newspaper and television coverage and a public lecture at Peradeniya University, Kandy, was attended equally by archaeologists and engineers. Future work will include the application of computational fluid dynamics modelling using the data collected from the experimental trials to analyse combustion, air flow and temperature gradients through and around the furnace. A paper on the full outcome of the research carried out on this campaign is in preparation.

Acknowledgments

The Monsoon Steel project was supported by the Archaeology Department's Exploration Fund, University of Exeter. The authors would like to thank Ms Nirmala De Mel and Prof. Lakdas Fernando for their enormous help and support in Sri Lanka. The second author would also like to thank the Historical Metallurgy society for the generous support through the Coghlan Fund which made it possible to collect a wealth of important data.

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Anyone interested in more information on Exeter's Master's course in Experimental Archaeology can visit www.ex.ac.uk/archaeology/prospective/maexp.shtml

2007 Field Work in the Laurion, Greece Area

John Kepper

My work in the Laurion, Greece area in September and October of 2007 was focused on various types of water collection systems that supplied the domestic and industrial needs during the 5th–4th century BC silver-mining operations. Part of the field work was supported by the Coghlan Bequest for which I am very grateful. This is an interim report on the results of the study, and will be the basis for a more complete discussion of ancient water issues in the Laurion area for a future issue of *Historical Metallurgy*.

The normal ancient water collection systems described by Ardallion (1897) and Conophagos (1980), consist of cisterns and wells. Cisterns lined with a waterproofing compound, often accompanied by immediately adjacent settling basins, collected direct precipitation and surface runoff. Ardallion (1897) reported that the cisterns which directly supported the ore-washing workshops in Souresa and Botsaris Valleys were constructed along or very close to the thalweg of the main valleys where runoff concentrated (the thalweg is a line drawn along the lowest points along the entire length of a steam bed or valley in its downward slope). Rock-lined channels or low walls were sometimes used to guide these surface flows. Field study of the upper Souresa Valley, coupled with satellite images of both Souresa and Botsaris Valley to the north, show numerous cisterns excavated in bedrock on the slopes well above the valley floor. Although some can be tied to small ore-washing workshops, many cannot be so linked and these were probably used for domestic water supply. Groundwater seeping through fractured bedrock was also collected in wells excavated in marble or schist throughout the area. These were likely entirely for local, domestic water supply needs.

A common stratigraphy throughout much of Greece consists of interlayered marble (limestone) and schist (shale) formations. The fractured marbles are often karstic (cavernous) and function as aquifers, while the sub-adjacent schists serve as an impermeable barrier to water infiltrating through the marble-generating springs. In Athens the spring systems found at the Acropolis and the Pynx Spring in the Agora are good examples of this relationship. Certainly the marble/schist stratigraphy in the Laurion area (Kepper, 2005, fig.2) appears amenable to such water sources and the search for spring sites and collection systems was a major part of the 2007 field study.

The Upper Marble Formation is known to be cavernous (e.g. Kitzo Cave and the large cavern with enormous cave-formations found in the Plaka Mine in 1895). A recent hydrogeological report describes the Upper and Lower Marbles as aquifers of high permeability due to intense fracturing and ‘great karstification’ (cavern development). Evidence of past carbonate-bearing infiltrating groundwater commonly appears as deposits of travertine-like material lining fractures and open-bedding surfaces in the marbles. In the eastern Attic Peninsula the winter-early spring rainfall, coupled with long dry summers, means that not only must water be conserved, but dependable sources found. Springs can represent such a dependable water source. The water supply issue is compounded with years of drought such as during the 4th century BC (Camp 1982) when the mines were in full production.

I focused on three areas in the search for springs as water sources; Souresa Valley which is associated with a concentration of ore-washing workshops, the Camaresa Ravine area (particularly a major south tributary blocked by an ancient dam), and the industrial quarter at Thorikos. All of the potential springs sites described here are associated with the Upper Marble Formation. None of them appear to be functioning today.

Two spring collection systems can be identified on the north slope of the upper Souresa Valley. One system consists of a broad shallow channel, which heads not far below the crest of the ridge in sequence of interbedded schist and marble. There is no natural channel here so the source of water must have been seepage through the fractured marbles along the contacts with the adjacent schist. A short distance down-gradient from the crest this channel is bounded by rock walls (Figure 1) which guided the flow. Slabs of rock covered the channel just in front of a collection basin (e.g. similar to covered channels of the Great Drain at the Agora in Athens). The shallow, unlined collection basin contains sediment composed of red-colored, layered sandy fine-gravel and nearby are fragments of coarse red pottery (amphora or hydrai) that were probably used to carry drinking water. Overflow from this basin appears to have followed a crude, shallow channel into a lined square cistern. The second spring is on the lower portion of the north slope just northwest of Conophagos’ excavation of the ore-washing workshops on the valley floor. The ancient spring developed along two, small east-west normal faults that offset the contact between the Upper Marble and the underlying Lower Schist. Thick, bright red terra rossa deposits developed in the marble along the faults. An irregularly shaped depression (about 10 meters wide and 3 to 4 meters deep) was cut to capture spring flow from the faults on its north wall. There is no lining here so the pit was for collecting, not storing water. The south wall is undercut both inside and outside of the depression and there appears to be a covered pathway here that slopes down into the spring. Both undercuts are densely packed with brush and excavation will be necessary to work out the details of this site. Both of the spring sites on the north slope were in all probability for drinking water.

Figure1. Rock walls conducted spring flow through a shallow channel into a shallow basin located just on the other side of the slab-covered portion

An ancient dam and retention basin (Figure 2) of mortar and rock construction with a waterproof coating (see Conophagos, 1980, 254, 268–269) was constructed across a tributary on the south side of the Camaresa Ravine. According to Conophagos, the chemistry of the waterproof coating matches coatings found in ancient cisterns throughout the area and suggested to him that the dam/retention basin are of a similar age. The placing of such a well-built water collection structure here suggests that there was a dependable, up-gradient water source. This tributary heads in a steep ravine eroded into highly fractured marble located immediately east of the Chaos Kitzo structure. The tributary is densely choked with vegetation and only the uppermost part of the ravine was accessible, exposing travertine-filled fractures in marble that reflect past seepage. The Chaos Kitzo (or Trou de Kitzos) structure is about 150 meters wide and 50 meters deep. It is partially filled with large blocks of the Upper Schist and the underlying Upper Marble formations and appears to be a collapse structure (Figure 3).

Figure 2. Ancient dam extends across a tributary valley to Camaresa Ravine. The south wall of the retention basin in the background runs along the south side of the thalweg of the tributary

Figure 3. West and north walls of the Chaos Kitzos described here as a collapse structure. Blocks of tilted Upper Marble formation show in the foreground. On the north wall a north-striking, normal fault cuts across the marble. Such faults may have been involved in the development of the collapse structure

According to Huet (1885, 561) CFML excavated a gallery in the 1880s which intercepted the collapse structure at the 64 meter (altitude) level, (which means it extends at least 116 meters from the rim). Conophagos (1980 199) indicates the depth to the 3rd contact ore zone in the Camaresa area is on the order of 110 meters with depths decreasing in areas farther east and south in the direction of the collapse structure. At 64 meters the collapse structure would extend across the Lower Schist and into the top of the Lower Marble Formation including the 3rd contact ore zone. Huet (1885) says that the collapse is pre-19th century and post-ancient mining based on the absence of ancient galleries within the chaos area. However, the absence of ancient workings may largely be due to the presence of large volumes of calamine (obsolete term for smithsonite or zinc carbonate) here at the 3rd contact. ‘Calamine’ was waste rock to the ancient miners and rich ore to CFML. M. Simonet, one of the CFML engineers, is quoted in Huet to the effect that the chaos is a large chimney structure through which water infiltrated to produce the huge volumes of calamine at the 3rd contact zone in the vicinity of the chaos structure. If so, it is much older than the ancient mining. The most likely explanation for the chaos structure is that it resulted from collapse of the overlying rocks into a natural cavern in the Lower Marble before the time of the ancient mining. The dam and retention basin further suggest that the collapse structure was probably in existence prior to the 5th-4th century BC mining operations. At the surface it may have served as a catchment basin directing some of the infiltrating meteoric waters down through open fractures and into the lower parts of the ravine where spring flow was captured in the retention basin. There are no ore-washing workshops in the vicinity of the dam so the water use was likely for domestic or possibly agricultural purposes.

The final example of a water-collection system associated with seepage through fractured bedrock is in the Industrial Quarter at Thorikos. The buildings themselves are built into the bedrock which here is the Upper Marble Formation. A fracture in the marble making up the rear wall of a room extends south across the floors of several adjacent rooms. A narrow channel, with at least one small settling basin, was excavated along the fracture and conducted the seepage to a lined cistern cut in marble. Once again the spring was the source for a domestic water supply.

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CONFERENCE REPORT

Steel in Britain in the Age of Enlightenment

Chris Evans

Chris Evans (University of Glamorgan) opened the colloquium by pointing out the remarkable transformation of the steel sector in the British Isles between the 1680s and the 1720s. From being peripheral to European steel making, England suddenly became its most dynamic centre. The German lands, which had been the source of most of Europe's steel in the early modern period, were challenged in dramatic fashion. Moreover, English makers did so by employing the cementation method rather than the "direct" methods practised in central Europe. Although it did not originate in the British Isles, the cementation furnace was to be domesticated as a distinctively English technology. The blister steel produced by the cementation method was an imperfect material, however; hence the search for a supplementary refining technique that could render the steel more homogeneous in structure and predictable in its qualities. It was this imperative that led to crucible steel, whose development by Benjamin Huntsman provides one of the most celebrated episodes in the traditional telling of British industrialisation.

Paul Belford (Ironbridge Gorge Museum Trust) addressed the seventeenth-century beginnings of cementation steel-making in the British Isles. He noted that early steel makers often spoke of the 'art, trade, mystery and business' that they practised. Historians have tended to adopt a limiting focus on 'trade and business'; archaeologists, Belford suggested, were more attuned to issues of 'art and mystery', and were in a position to produce a richly contextualised picture of early steel manufacture. Reporting on the excavations he has recently directed at Coalbrookdale (see HMS NEWS 59 and *Historical Metallurgy* 41), he drew attention to the very specific intellectual and political setting for the programme of industrial investment undertaken by the Brookes, the Shropshire gentry family that built the first known cementation furnace in England *c*.1620. The mental framework was provided by the Reformation and the Renaissance, the political context by the sequestration of monastic lands and recusancy. This was a presentation that nimbly visited both European-wide currents of thought and (literally) parochial developments.

The Coalbrookdale furnaces ceased production in the 1680s. Their foundations were incorporated into later structures, and it is only now that basic data about their dimensions and alignment are being retrieved. Deducing their design and the work practices associated with them will be taxing. But even when researchers have abundant surface remains to study problems of interpretation can be acute. This was the message of David Cranstone (Cranstone Consultancy), who excavated and conserved the cementation furnace at Derwentcote in County Durham on behalf of English Heritage in the 1980s. Cranstone detailed Derwentcote's importance within the wider context of steel-making in the eighteenth-century North East. He also reviewed the theoretical changes that have swept archaeology in the twenty years since he completed his work on the site. In an exemplary piece of auto-critique, Cranstone repented of the assumption he once brought to the structures at Derwentcote: that function determined form. Archaeologists of industry should, he argued, be readier to acknowledge symbolism or formalism in the design of industrial plant. Reflecting on the shift from processual to post-processual archaeology, he also queried whether archaeologists should strive to reconcile the archaeological and written record, as he did in the 1980s; actively seeking discrepancies between the two, he suggested, might be more fruitful.

If Cranstone's paper stressed the need to understand the vernacular in eighteenth-century steel making, the contribution of Göran Rydén (University of Uppsala) dealt squarely with issues of enlightenment. Rydén examined the career of Sven Rinman (1720-1792), the Swedish metallurgist, intellectual and state official. Rinman grappled with the nature of knowledge: how was steel to be defined? In the absence of a secure chemical understanding, it was the consumers of steel – not producers, much less scientists – who were the arbiters. The sphere of circulation, for Rydén, was at least as important as that of production. Rydén also paid attention to Sven Rinman's changing conception of human agency. Early in his career, Rinman subscribed to the conventional wisdom of Swedish mercantilism, that divine providence had furnished humankind with all the resources necessary for a balanced social existence. The bounty of nature was paramount; the human art used to alter it was of far lesser importance. But Rinman's later writings – his *Järnets Historia* of 1772 and his *Bergswerks Lexicon* of 1788-89 – show him grappling with questions of agency and broaching, however hesitantly, the possibility of sustained human betterment.

Liliane Pérez (Conservatoire national des arts et metiers, Paris) also concentrated on human ingenuity. Her paper provided a startlingly fresh perspective on the business career of Benjamin Huntsman. Using the records of William Blakey, a prominent French 'toy' maker and merchant, she demonstrated that the making of crucible steel was not the only activity in which the Huntsman firm engaged. Indeed, the correspondence that passed between Sheffield and Paris in the 1760s suggests that the making of steel was a relatively minor element in a portfolio of business ventures. Huntsman traded in a variety of steels, not just the fabled cast steel to which he lent his name. Indeed, Huntsman emerges from Blakey's accounts more as a dealer than an industrialist: he shipped Blakey manufactured goods – some of them made from steel, others not – from suppliers across the north of England. Commercial agility and an attention to the demands of overseas customers for new types of tools or decorative wares were the distinguishing marks of Messrs Huntsman & Asline. Benjamin Huntsman should be seen in this light, Pérez argued, not as the 'heroic' inventor of legend. Her conclusion was striking: Huntsman steel was an achievement of Enlightened Europe, not a product of the British Industrial Revolution.

Simon Barley (University of Sheffield) also dwelt upon the importance of Benjamin Huntsman in the course of his presentation on saw manufacturing in the Sheffield region. Saw making was a well-established trade along the border between Derbyshire and Yorkshire, but the 1750s and 1760s witnessed major changes in technology and the organisation of production. The rolling of steel was substituted for the hand forging of sheets, and crucible steel became the material of choice for the leading makers. The new breed of manufacturer typically had a background in steel making and came equipped with significant capital; 'little mesters', the backbone of most Sheffield trades, were conspicuously absent. Barley exploited the archive of Joseph Wilson (1723–1796), who moved into the saw business in the late 1760s, to demonstrate the dynamics of the trade. Wilson operated a mill on the river Porter to the south of Sheffield, processing steel for a very large number of local users. But his business interests were diverse. The wheel on the Porter was also used to grind snuff on an extensive scale, and Wilson dealt in plated silver goods as well as steel tools. Indeed, Wilson was a merchant quite as much as he was an industrialist. As the exporter of locally made wares, he made crucible steel part of an expanding basket of Sheffield goods that circulated through the Atlantic world.

Hans Ludwig Knau (independent scholar, Kierpse) spoke on early modern iron and steel manufacture in the *Südergebirge*, the hilly region to the south of the Ruhr basin. This was a region of great political complexity, divided between competing jurisdictions and confessional authorities. It was also characterised by technical diversity, with iron and steel being processed by a variety of sub-regional specialist methods. Knau offered a guide to this landscape, ranging from the mining and smelting operations of the Siegerland to the wire-drawing townships of Altena, Lüdenscheid and Iserlohn. The *Südergebirge* was the source of much of the high-grade German steel that was imported into Britain before the rise of domestically produced cementation steel (and that continued to be imported for specialist uses long after). The *Südergebirge* was also the point of origin for the steel refining techniques that were transplanted to the North-East of England at the turn of the eighteenth century and used to process blister steel, yielding what was misleading called 'German' steel. Knau took as his point of departure a report prepared by the Prussian official Friedrich August Alexander Eversmann, published as *Übersicht der Eisen- und Stahl-Erzeugung auf Wasserwerken in den Ländern zwischen Lahn und Lippe* in 1804, and the writings of the businessman Ernst Alexander Jägerschmid. Both looked to England for inspiration. Indeed, Eversmann (1759–1837) was one of several Prussian functionaries who journeyed there in the 1780s. Both noted a short-lived cementation furnace at Altena, but differed as to why the English-style "artificial steel" it produced did not find a local market. Knau demonstrated how, in their respective careers, Eversmann and Jägerschmid raised important questions about the role of the state in stimulating or imposing 'enlightenment'. How were 'archaic' guild regulations to be distinguished from 'rational' guidelines? And what separated effective local mechanisms for the transmission of tacit knowledge from self-satisfied parochialism?

The role of guild regulation featured centrally in the presentation of Joan Unwin (Archivist to the Company of Cutlers in Hallamshire). The 1624 Act of Incorporation that established the Company of Cutlers in Hallamshire laid down that all bladed goods made within the Company's jurisdiction – the town of Sheffield and its immediate hinterland – should have an edge of steel. The Company was given powers to enforce this regulation. All cutlers were obliged to register an identifying mark that would be stamped on their goods, and the Company's six Searchers were authorised to enter workshops in pursuit of 'deceitful wares' that contained no steel. For much of the ensuing century and a half the detection of illicit goods was not a major concern for the Company, but by the 1770s there was increasing alarm at the number of cast iron wares that were being passed off as steel-edged. The reputation of Sheffield-made goods was now recognised internationally; so much so that local cutlers abandoned the practice, once common, of marking their products in a way that suggested London manufacture. Indeed, German cutlers were now counterfeiting Sheffield marks. If the town's cutlery was to maintain its hard-won reputation the suppression of cast iron wares was highly desirable. Outright suppression proved impossible, however. Instead, the Company focused on having cast iron cutlery firmly distinguished from the authentic steel-edged article.

The theme of quality control continued in the paper of David Starley (Royal Armouries Museum), who presented the findings of recent archaeometallurgical studies of armour and weapons in the Royal Armouries and other collections. Metallographic examination allows the method by which an artefact's constituent steel was made to be determined. Applying such techniques to arms and armour has several major advantages: most of the material can be closely dated and provenanced, it generally survives in sound condition, and contrasts between elite and munition quality can be made. Above all, developments in the age of Enlightenment can be viewed against long-term trends in ferrous metallurgy, which, in a wide-ranging review, were here taken back to the Dark Ages. Starley reported on X-ray investigations of eighteenth-century sword blades to demonstrate how artefactual evidence can extend archival knowledge. Using X-rays, the marks of artisanal makers in Birmingham can be detected under those of the official contractors who supplied the Board of Ordnance – the only names to appear in the written record. (Starley's presentation was also enlivened by video footage that demonstrated the extraordinary elasticity of eighteenth-century sabre blades.)

The historical potential of laboratory-based investigative techniques was taken up by Marion Unwin (University of Nottingham) and Joan Unwin (Archivist to the Company of Cutlers in Hallamshire). 'What's in a knife? Ultrasonic non-destructive evaluation of metal artefacts' was a lucid exposition of the benefits of adopting cutting-edge diagnostic technology from the world of electrical engineering. Ultrasonic non-destructive evaluation (NDE) techniques are widely used for the assessment of many safety-critical engineering structures. They can also be used for the evaluation of archaeological finds, providing information about the internal structure of metal objects. By being able to gauge the dimensions of metal layers, to assess the quality of welds, and to pinpoint the position of inclusions, NDE can yield information from which manufacturing techniques of which there is no written record can be deduced. The application of NDE to historic artefacts with their rough surfaces and irregular crystalline structures presents many practical difficulties, but the interpretative possibilities are considerable.

Jean-François Belhoste (École Pratiques des Hautes Études, Paris) spoke on Gabriel Jars and his *Voyages metallurgiques* (1765). He addressed a paradox of French industrial history. Although France was the largest single producer of bar iron in eighteenth-century Europe, she made virtually no steel – just a few hundred tons annually in the Dauphiné. In the early eighteenth century the French state sought to rectify this imbalance by promoting a domestic manufacture of steel. This was the context for Réaumur's *L'art de convertir le fer forgé en acier* (1722), a major attempt to theorise the properties of steel. Réaumur's practical exercises, although heavily subsidised, came to nothing, however. State sponsorship also underpinned attempts to master the cementation technique in the 1720s and 1730s. None succeeded, despite the best advice of the Academy of Sciences. The 1750s saw a new emphasis on the part of the authorities. When Gabriel Jars (1732-1769), a star pupil of the École des Mines, was commissioned to investigate foreign steel making he was warned against attempting a scientific understanding of the processes involved. His brief was to record the actual work procedures in minute detail. Observation of the concrete was to take precedence over abstract theorising. Jars was also to pay attention to questions of policy. Was the use of Swedish irons absolutely necessary for the success of the cementation method? (Réaumur had denied that it was.) And was the looseness of state regulation in England a help or hindrance to industrial development?

The attention of Gabriel Jars was fixed on cementation steel, not the crucible steel that was beginning to attract European-wide acclaim at the time of his visit to Britain. Chris Evans (University of Glamorgan) closed the colloquium by taking a fresh look at the origins of the crucible method. He took as his text the *Essays concerning iron and steel* (1773) of the London cutler Henry Horne. Horne's version of crucible steel's beginnings stands in stark contrast to subsequent historical accounts. Nineteenth and twentieth-century historians saw crucible steel as rooted in Sheffield, flourishing in an empirical metalworking tradition. This was Huntsman steel: *vernacular* and *provincial*. Henry Horne presented a very different genealogy. Benjamin Huntsman was not mentioned at all; nor was Sheffield. For Horne, crucible steel was developed in London; its progenitors were men of learning, intellectually and socially well-connected. The essential coordinates of crucible steel were *metropolitan* and *enlightened*. Whatever the factual basis for this argument, Horne's *Essays* do provide an alternative perspective on one of the key new materials of the eighteenth century. Horne discussed steel in the context of French *savants* and English encyclopaedists; he spoke of it in relation to contemporary scientific preoccupations such as electricity and magnetism. Evans suggested that Horne's account, however tendentious, offers a way of understanding crucible steel in ways that engage with current preoccupations in the history of enlightened Europe.

Steel in Britain in the age of Enlightenment brought together specialists from a variety of backgrounds. The papers they delivered suggested a variety of interpretative approaches. They also shared features in common, enough to suggest a new research agenda. Questions of knowledge were to the fore. How was steel understood in the age of Enlightenment? Both Liliane Pérez and Göran Rydén emphasised – in Kantian terms – the importance of synthetic knowledge (that grasped through use, through comparison with rival materials) for eighteenth-century consumers; it was knowledge generated in the marketplace. Analytical knowledge (that gained through a testing of steel's inherent qualities) was less widespread and less esteemed. The prestige of the laboratory was a matter for the future. Because the purchasers of steel did so much to define its essence – and the science of chemistry did so little – it is vital that steel is not studied in isolation. Steel circulated in company with many other materials and intersected with them in different ways. Jean-François Belhoste noted how Gabriel Jars was instructed to investigate the full range of coal-burning industries in Britain – vitriol manufacture and salt making as well as ferrous metallurgy – and Chris Evans drew attention to the ways in which crucible steel was employed as a decorative substance, to be used in conjunction with other high-value materials such as Josiah Wedgwood's jasperware. Indeed, it would be a mistake to demarcate the steel sector from other manufacturing activities. As Simon Barley pointed out, Sheffield's saw trade was driven forward by men who acknowledged no divide between steel casting and other industrial processes. Thomas Boulsover, to take one conspicuous example, was an innovator in both the rolling of steel and the making of *bijou* Sheffield-plate articles.

Both Paul Belford and Chris Evans sought to carry the discussion of steel beyond Sheffield. The adopted home of Benjamin Huntsman achieved global dominance in the early nineteenth century, but the origins of cementation steel making were to be found in Shropshire, and a significant role for London in the development of crucible steel cannot be ruled out. David Starley suggested a more far-reaching shift of horizon, pointing out the antiquity of liquid steel productions methods in south Asia.

The historiography of steel is very much skewed towards the study of production. There is still much that can be done here, not least through some of the diagnostic methods championed by Marion Unwin and David Starley, which can do much to aid interpretation in an area where archival documentation is not abundant. Nevertheless, for several participants it is the end uses of steel that now call for urgent attention. Despite the expansion of steel making in the British Isles in the first half of the eighteenth century the metal remained relatively expensive and was employed sparingly. Chris Evans stressed the ornamental or prestige uses of crucible steel, although evidence from the archive of Joseph Wilson revealed that – on the river Porter at least – it was more likely to be found in scythes than fine razors. Even so, there is clearly scope for research on steel as a material ingredient in the intellectual and cultural practices of the Enlightenment. A programme that interweaves research on artisanal technique, systems of enlightened knowledge, and new methods of marketing in the eighteenth century has much to offer, both to those working in historical metallurgy and to those working on the culture of enlightenment.

The full text of some of the papers presented at this meeting are available on the internet.
http://history.research.glam.ac.uk/steel/papers/

A Visit to the Almadén Mercury Mine, Spain

Paul Craddock

The mines are amongst the most famous in the world with a history of production of the pigments cinnabar and vermillion as well as metallic mercury going back at least to Roman times and continuing up to 2002 when the mines ceased production, at least for the foreseeable future. As with many old mines the world over they are now re-inventing themselves as heritage centres. At Almadén the mining and smelting operations have been restored by Fundación Almadén Francisco Javier de Villegas and an excellent Museum and Interpretation centre have just opened. Together these explain the story of the mining and production of mercury through the ages and as such have attracted considerable investment both from agencies within Spain as well as from the EU.

The mines are open every day except Mondays (as is common with Spanish museums and monuments) in May – September from 10.00 until 14.00 and then from 17.00 until 19.30 and October – April from 10.00 until 14.00 and then from 15.30 until 18.00. As the visit takes the form of a guided tour that lasts several hours, in practice this means being at the mine entrance at opening time either in the morning or the afternoon. The tours are normally conducted in Spanish, but some speak English, and the guide who led my party was very conscientious in providing an English summary at each stage in the tour.

The tour commences with a visit to the recently completed mine interpretation centre where various aspects of mining technology through the ages are explained. As elsewhere the texts are mainly in Spanish but the exhibits, photographs and visual aids are excellent, and for example, the problems of mine ventilation through the ages is explained as well as I have ever seen it done anywhere and are quite easy to follow. The display on pumping is centred on the installation of an atmospheric beam engine in 1787. The purchase of this engine from John Wilkinson's Bersham works is fully documented with the detailed costing dated December 29th 1786 at Broseley, Salop.

The underground tour is through the 17th- to 19th-century workings and takes about an hour. Throughout its history it seems that the mercury ores were smelted on site. The visitor emerges from the mine in the area where until very recently the mercury was extracted and condensed and the plant is standing. Even more interesting is the sole surviving Aludel or Bustamante distillation furnace (See Figure). This process was developed in Spain and in the Spanish Americas in the 17th century and remained in use until the early 20th century. The sulphidic ores were heated in the tall chamber on the left in the illustration causing them to break down into mercury vapour and sulphur dioxide. The vapours then entered the long rows of ceramic vessels, which still retain their Arabic name of aludels in which the bulk of the mercury condensed. The vessels were only loosely joined and any mercury that escaped would collect in the central gutter. The spent gases of carbon and sulphur dioxides entered the tall chamber on the right where any remaining mercury would collect in the bottom whilst the gases exited at the top. These rows of sloping condensers are reminiscent of the earlier Islamic retorts used in Spain for the distillation of rose water as well as the later horizontal retort process for the condensation of zinc, developed in the early 19th century by the Abbé Dony. One wonders if there is any connection.

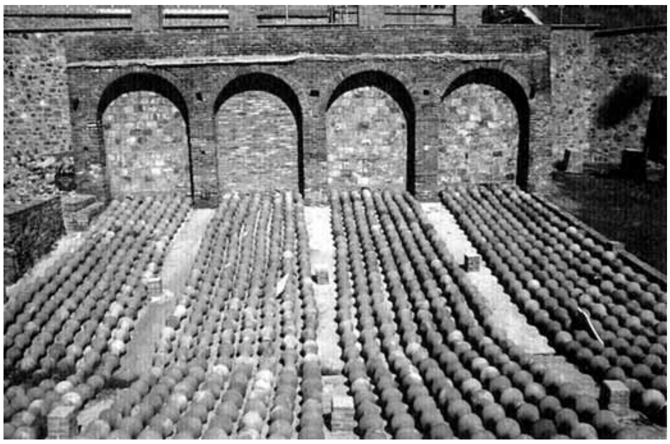

Figure 1. The sole-surviving Bustamante furnace at Almadén for the smelting and collection of mercury in the aludels as illustrated

Both the mining and the smelting exposed the workers to dangerous levels of mercury and poisoning was common such that a hospital, the Real Hospitale de Mineros de San Raefaele, was built in the mid 18th century for the victims and continued in operation almost until the mines closed and is now a museum concentrating on health and environmental issues.

Although there must be considerable potential no archaeology seems to have been done to try and recover evidence of the earliest phases of the mining or smelting. Some Iberian bronze brooches dating back to the 3rd century BC have been found to be mercury gilded and the Greek author Theophrastus mentions Spanish cinnabar also in the 3rd century BC. Presumably Almadén or a mine in the immediate vicinity must have been the source. In Roman time the settlement was known as Saesapo (Celtic for the cave of the metals) and must have been of some importance as it had its own mint. The mines came into increasing prominence first when under Islamic control in the early medieval period (Almaden being Arabic for 'the mine'). Authors such as al Hamdani describe the use of mercury to extract gold from the crushed ore and silver from its smelting slags. Although these accounts were written in the Middle East it is likely that Almadén was providing the bulk of the mercury used in the Islamic world. In the mid 16th century the process of extracting silver minerals from the ore with a mixture of metallic mercury salt, vinegar, corrosive sublimate (mercuric sulphate) and verdigris (copper acetate) and was discovered. This was of enormous importance as the newly discovered silver sources in the Spanish Americas were often devoid of lead and remote from good charcoal resources such that conventional smelting was not feasible. To no small degree the silver wealth of Spain depended on the Almadén mercury. For several centuries Almadén was arguably the most important mine in Iberia and the mercury was sent from the mines at Almadén in large and heavily guarded convoys over the mountains and down to Seville and then across the Atlantic to the Americas.

Almadén is in the beautiful but remote hills that form the borders between the central but now depopulated regions of Extramadura and the Mancha. The roads are good, but getting there by public transport can be a problem. The nearest town of any size is over 100 km distant, although a trip from Madrid south through Toledo and Cordoba could easily take in Almadén. In fact there are daily buses running between Madrid and Cordoba that stop in Almadén. One needs to spend a full day to do justice to the main mine complex and the miners hospital and realistically this means staying in Almadén. Fortunately there are several good pensiones and small hotels and a variety of places to eat or buy food. There are several massive volumes on the official history of the mines, and an excellent book on the arrival and installation of the steam engine, but little in the way of short guide books. However there is an excellent web site in English (Google Mayasa and you are there) which gives a potted history and everything about the visitor centre and museum except where they actually are. Also there are no signs at the mine to indicate the entrance for visitors. However this is not actually a problem. Almadén is a small place and is dominated by the modern headstock. Head for that and you have arrived.

HMS Annual Conference 2008

Metals in Musical Instruments

The 2008 HMS Conference (Metals in Musical Instruments) will be held in Oxford, 12–14 September. Accommodation has been arranged in Wadham College, with a bar extension. The conference will be based in the Holywell Music Rooms where there will be a harpsichord recital and talk by Steven Devine. Saturday will have a full morning of lectures. On Saturday afternoon we will visit the Bate Collection of Historical Musical Instruments, where some of the instruments will be available to us to 'play' if we wish. We shall also visit the gamelan at the Pitt Rivers Museum, the Museum of the History of Science and the Ashmolean Museum. Crispian Steele-Perkins will give a recital and talk on brass instruments on Saturday evening. He will be accompanied by Steven Devine. Sunday morning will start with member's contributions and continue with a further lecture session.

The full residential fee including the conference fee will be £235 and the conference fee for those organising their own accommodation will be £75. This includes admission to both recitals. A £10 discount is available to HMS members, and a further £10 discount to those booking before April 30th 2008. If you have any queries, or would like to know more about the conference, please contact Eddie Birch on 01226 370331 or email mejbirch@aol.com. Offers of papers should be made to Louise Bacon at lbacon@horniman.ac.uk.

19th-century Ferrous Metallurgy

HMS Archaeology committee Spring workshop
Sheffield, 18th April 2008.

The spring workshop provides a forum to discuss recent and ongoing investigations into all aspects of archaeometallurgy. This year, the theme is 19th-century ironmaking. The development of coke blast furnaces into the early 19th century is quite well understood, but what about the archaeology and archaeometallurgy of hot blast, and particularly the massive 19th century development of the forge and foundry sectors — how do we best approach excavation and analysis on these sites? And how do we understand the often 'difficult' evidence that we uncover? 20-minute papers will be presented, with plenty of time for general discussion about current approaches, new discoveries, scientific techniques, and archaeological fieldwork. The workshop is open to all, and we hope that most of those actively involved in the subject will take part.

The workshop will be held in the Humanities Research Institute at the University of Sheffield. Further details about the programme, venue etc will be available on the HMS website. The anticipated cost will be in the region of £15.

For further details please contact Anna Badcock on 0114 2222957 (a.badcock@sheffield.ac.uk) or write to her at ARCUS, Unit R6, Riverside Block, Sheaf Bank Business Park, Prospect Road, Sheffield S2 3EN (ARCUS have recently moved premisies — post to the old address will be forwarded to the new addresss).

Early Iron in Europe
Prehistoric and Roman Iron Production

Hüttenberg, 8–11 September 2008

The conference aims to cover all main aspects of prehistoric and Roman iron production in Europe, focusing on results of archaeological excavations of smelting and smithing sites and archaeometallurgical studies of furnaces, slags, blooms and iron objects. The conference is meant to offer a forum for established scholars, graduate students and younger colleagues to present and discuss the results of their research and the problems they encountered. The conference language is English.

The registration fee will be €120 and accommodation is available from about €25–30 (both the fee and accommodation costs may be subject to minor changes). Papers accepted for presentation (oral or poster) will be invited for submission to a fully refereed volume of Conference Proceedings.

Contact address
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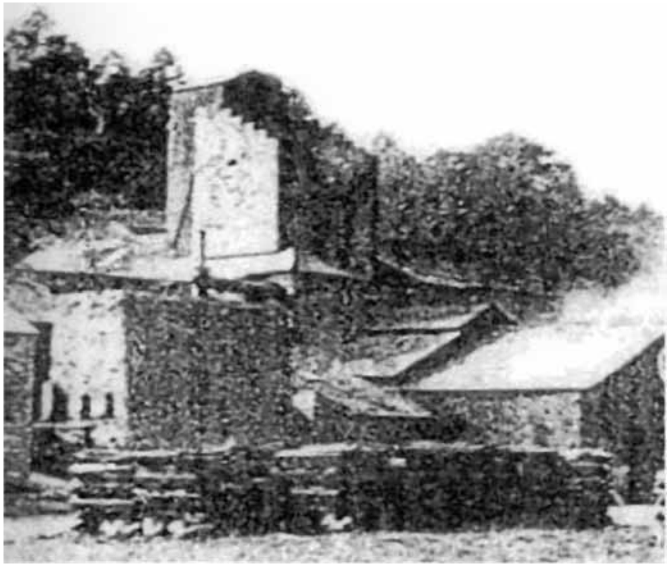
e-mail: cech.conference@gmx.at
Conference website: www.huettenberg.at

Master of Them All Iron Making in Cumbria



In October 2003 the Cumbria Industrial Archaeology Society and the Historical Metallurgical Society held a joint conference at Cockermouth on the subject of Iron and Steel making in Cumbria. At the time we stated that we intended to publish the papers and each delegate would receive a copy. A selection of the papers have now been published and are available for purchase for £7.50 (or £6.50 if purchasing 5 or more). Postage and packaging for a single copy is £1.00, for price of multiple copies please contact Graham Brooks, (Coomara, Carleton, Carlisle CA40BU) or via e-mail, gbrooksvet@tiscali.co.uk

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While submissions to the Newsletter are welcome at any time, if you want to have something in a specific issue of the newsletter then it needs to be with me by the following deadlines.

1st March, 1st July 1st November
Contributions can be sent in any format (hand-written, typed, email, floppy disk, CD-ROM, etc).

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