HMSNEWS

Historical Metallurgy Society

40 Winter 1998/9

Forthcoming Events

10th to 12th September 1999 HMS Annual Conference. The Iron Industry of Furness.

Preliminary notice is given that the 1999 Annual Conference will be held at Ambleside, Cumbria. The meeting will be the occasion of the launch of the volume setting out the results of the survey of the iron industry of the Furness district by the Royal Commission on the historical Monuments of England. Members of the Commission's staff have promised to lecture and to guide the Saturday tour. Details and booking forms will be sent to members with the notice of the 1999 A.G.M. Early application will be necessary, as numbers will be limited by the logistics of the site visits.

HMS AGM will be at the Institute of Materials on May 15th. There will be an introductory lecture. Particulars enclosed on separate leaflet.

March 17th The Finds Research Group will hold a seminar at the Society of Antiquaries, Burlington House, London, on Recording our Past. It will concentrate on conservation issues arising from the recovery and recording of Portable Antiquities. Contact Quita Mould, Christmas Cottage, Choseley, Docking, Kings Lynn, Norfolk PE31 8PQ.

September 20th to 24th Founders, Smiths and Platers. An International Conference on Metal forming and Finishing from the earliest times at St. Catherine's College, Oxford.. Lectures will include "A Modem Sculpture foundry" and "Making and firing a replica of a wrought iron gun from the *Mary Rose*" R. Smith, The Royal Armouries. Papers invited. Contact Dr Peter Northover, Dept. of Materials, University of Oxford, Parks Road, Oxford 0X1 3PH Tel +44 (0) 1865 273728/273779

September in Budapest "Economic Structure in Change, Industrial Heritage in Danger — International Conference on the Conservation of Industrial Heritage of Mining and Iron Metallurgy" If you are interested contact David Starley.

October 21st to 23rd. The Centre for Archaeological Research of the CNRS. **Arts du feu et productions artisanales**. Metallurgy, glass and pottery. Particulars from Centre de Recherches Archéologiques, 250 rue Albert Einstein, Sophia Antipolis, 06560 Valbonne, France.

Obituary — Professor Emeritus Jack Nutting.

Jack was born in Yorkshire in 1924 and was educated at Mirfield Grammar School and Leeds University. His academic career has been properly described in Materials World (August). It is sufficient here to say that he was a distinguished scientist who became Professor of Metallurgy in the Houldsworth School of Applied Science in Leeds. After his retirement he became Visiting Professor at the University of Barcelona.

He joined the Historical Metallurgy Group of the Iron and Steel Institute before it became the Historical Metallurgy Society. From the beginning his interest was in the later history of metals and he lost no opportunity to remind us that this was a neglected area. Much of the plant he was concerned about has now gone, perhaps without adequate recording. He organised the 1995 Spring Meeting at Leeds.

He was President of the Society in 1984. He was elected an Honorary Member of the Society in March of this year in recognition of his many years of service to the Society.

Jack's main contribution to the Society will be little known to those who have not been Council Members. For a long period he has been the Institute of Materials (as it is now) representative on Council. He was admirably suited to this post, having many contacts within the IoM because of his involvement with the management of their finances. He advised the Society on its investment policy for many years. He resigned from Council last year and we have missed his cheerful presence at Council meetings. We can only hope that his successor will uphold our interests as well.

He leaves his second wife Diana, daughters Alison and Jeannie and son Peter.

Report on the Joint Day School with the East Midlands CBA

Held at the Papplewick Village Hall, Nottinghamshire on 7th November 1998 The delegates were welcomed by the CBA chairman.

Robert White (Senior Conservator, Lincolnshire Museums Laboratory) told us of the important role of modern technology

in the conservation of artefacts recovered from excavations. Many, when first recovered, consist of an almost unrecognisable mass of mineral deposit and, for metal objects corrosion products. Removal of the accretions by an unsuitable technique could lose valuable detail from the object. A most important tool was the X-ray machine. With its help it is possible to "see" what is inside. Sometimes it is possible to tell from the X-ray shadow left in the mass what was there before it corroded away. It is possible to detect non-ferrous decoration on iron objects by this method. Careful visual examination is also needed. Often very small clues will suggest that there could be some enamelling or other decoration below the corrosion. The accretions are very often removed by a technique similar to microscopic sand blasting. He showed slides of some very impressive con- served and partly finished items.

Brian Read (HMS and the Derbyshire Archaeological Society) gave us an account of the Britannia Foundry, “the firm up the road”. Many people thought of this company as a local foundry. Brian showed us examples of very impressive bridges and similar structural ironwork from all over the world. One feature of their work that was perhaps unusual was that everything was erected in Derby before it was despatched. Some of the structures, such as the largest bridges, must have been of great interest to the locals if they were in view.

From the fairly recent industry of Derby we were taken back to Elizabethan times in the Lake District by **Richard Smith** (HMS). The conversion of the Royal arsenal from wrought iron to bronze had been a splendid bonus to the Swedish copper industry and the Tudors decided that it was time to exploit the English mines. They employed a number of German miners over the years to prospect for ore and set up smelters in South Wales and Cumbria. The production of copper from sulphide ore requires more skill than the reduction of any of the oxidised ores. The process is a series of alternate roasting and smeltings. After each smelting the “metal” (as the smelters called it though it was really a sulphide mixture) was richer in copper and contained less iron and other metals. The final smelting gave "black copper". This was refined to remove the last of the sulphur and cast into ingots for sale. While technically the was successful there was initially no market for the copper. This had to wait for the development of battery works where pots and pans and similar wares were made.

An excellent buffet lunch was provided. During the break for lunch the opportunity was offered to purchase a wide variety of books or to view the nearby earthworks.

The afternoon began with **Peter Crew** (Snowdonia National Park) taking us even further into the past, to the iron age. Early archaeometallurgists (about 30 years ago) were looking for iron age smelting sites in areas where they thought exploitable iron ore resources (by modem standards) existed. In the early 1980s, in the course of excavating a supposed dark age site, the archaeologists working from the study centre at Plas Tan y Bwlch discovered an iron age smelting site in and around a camp at Bryn y Castell. This was described to us in some detail. Looking for something different a site near Trawsfynydd was investigated, only to find more smelting furnaces. Finds have since been made in many areas of the country where we would say there is no iron ore. Where there are no known sites there are often no investigators either. It was pointed out in response to a question that a cubic metre of iron ore was more than sufficient to support an iron age smelting site for many years, and that such deposits, especially of bog ore, were widespread. It was thought necessary to reproduce the slags by smelting in a replica furnace to discover the type of slag associated with each stage of the process. This has been very successful and has progressed to cover other aspects of iron age smelting technology. A number of blooms have been produced and forged to “currency bars”.

Prehistoric iron is usually found as “currency bars”, a name coined some time ago based on a Roman assumption. It is now thought that a more apt description is “trade iron”. This was demonstrated by “finds” of currency bar ends at smithing sites, the remainder having been used to make utensils of some kind. The wide range of shapes was thought to be perhaps some kind of trade mark. The forged points and sockets would demonstrate the quality of the iron.

Keith Challis (Trent and Peak Archaeological Trust) took us forward in time to the Middle Ages. A “rescue” excavation at Stanley Grange started with a magnetic survey that initially revealed some very clear magnetic anomalies. When the survey was refined some very clear dipoles showed where there were likely to be furnace remains. We were taken through the excavation process, which revealed furnaces, slag and charcoal with some excellent slides.

Kevin Leahy (North Lincolnshire Museums) pointed out that when you have smelted your copper or iron you have to turn it into something useful. There are two basic methods of doing so. The simplest, at least for copper alloys, is to melt it and cast it into a mould, a method familiar to all cooks. For simple shapes this is easy. You make a mould in, for example, a suitable stone. For the simplest object this could be cut into the top of the stone and just filled up. This would produce a flat topped shape, but the top would be oxidised and might have to be ground off with a coarse stone. Putting a top on the mould would avoid this problem. If this was done it is unlikely that even if a stone was used an excavator would be able to recognise it. Wood would do the job required and this would be unlikely to survive. We shall probably never know whether our forbears did this. For more complex shapes you need a double sided mould. These are known from very early periods. As casting techniques developed it was found that bronze moulds could be used to cast bronze objects. A number of these are known for casting axe heads of various designs.

Bronze (and early iron) axes and other sharp tools have to be work hardened (by hammering) before they will take a sharp edge. Some of the axe heads that have been found have had flanges raised on the body of the axe by hammering. This technique developed into the beating of shields cauldrons and other “sheet metal” objects from cast pieces with intermediate annealing.

Early iron tools were made by blacksmithing. It was not until the Middle Ages that cast iron became available. They were often embellished by casting bronze hilts onto the iron blade. We were shown slides of a cast “trumpet” from Ireland and a modem abortive attempt, with all the necessary controls, to cast a replica. The metal from the only English cast trumpet that has

been found was analysed in Victorian times. Unfortunately the sample size used was the whole trumpet.

Peter Hutchison

Report on the HMS Annual Conference at Plas Tan y Bwlch.

Sixty -five members gathered at Has Tan y Bwlch, Maentwrog, for a most successful conference. Our Chairman David Cranstone welcomed delegates and introduced the proceedings.

Peter Crew then spoke on **Medieval ironworking in Coed y Brenin**. In the northern part of this district there is a group of some eleven iron working sites with fifteen large slag mounds. These had for some time been speculated to be of Roman date (the road from Tomen y Mur to Brithdir passes through this part of Coed y Brenin) or to be linked with the later Cistercian Cymmer Abbey. It is now known that all the sites, except that at Bedd y Coedwr, are on what was Crown Land and archaeological research has produced a number of records relating to 14th century ironworking. These interesting documents give details of rents due and payments made to the Crown. The slag mounds consist primarily of tap slag and it has been suggested that these bloomeries were each worked for about ten years, using the charcoal from the vicinity before it became more economic to move the bloomery rather than to bring the charcoal from an ever increasing distance. (Crew and Crew 1995 "Medieval Bloomeries in North Wales)

Two of the sites in this area were visited on the Saturday Field Trip. At **Gelli Goch** we saw the base of a furnace that had survived in good condition. The clay superstructure seems to have been supported by a square setting of stakes. To the north of the furnace there were traces of an arrangement for the bellows and to the west an 0.5m deep pit in which the last tap slags are still in situ.

Our second visit was to **Llwyn Du** where work on the charcoal storage area had given a radio carbon date in the late 14th century, tying in well with documentary evidence. The furnace had been excavated for a conference held at Plas Tan y Bwlch in 1997, and proved to be a substantial structure some 2m by 1.50m overall, built of clay with a stone casing.

The field trip on Saturday; which was a day of heavy showers and rainbows; of steep bending roads through oak woods beside rivers and waterfalls, also took us to visit the remains of **Glasdir** copper works and the **Elmore Flotation Plant**.

Dol y Clochydd provided good remains of a 16th century blast furnace which is historically documented from Star Chamber Proceedings. In 1588 it was a water powered bloomery, which was converted to a blast furnace in 1596. In the mid 1980s it was excavated by teams from Plas Tan y Bwlch.

The last visit of the day was **Cefn Coch Gold Mine** remains with excavated smithy and assaying plant.

The second lecture on Friday evening was **Early Ironworking in the Bristol Channel Orefield** by **Tim Young**. Geoarchaeological research at Cardiff had been examining ore from a number of archaeological sites in the Bristol Channel Orefield, which covers a very large area, from Worcester through South Wales and the Forest of Dean to Bristol. The aim being to explore the possibility of determining the original location of the ores and residues, many of which were smelted at a distance from where they were mined. The involvement of the furnace lining and questions about fuel ash are also being examined. Geochemical techniques for provenancing are also being investigated.; the use of trace elements, including rare earths and ceramics, is said to be proving promising. These techniques have been used to provenance the cargo of the medieval boat from Magor, and are being employed to investigate the iron ores from the Palaeolithic burial in Paviland Cave.

Other sites on which recent laboratory work has been taking place are Ariconium, Froster Court, Caerleon, Cardiff, Miskin, Iron Acton, Trelech and Llanelen. The Lydney Park site has been the subject of a detailed geophysical survey this year.

There were some interesting lectures on Sunday. **Edric Roberts** and **Dave Chapman** brought us up to date with work at the **Bronze Age Copper Mine** and other sites on the **Great Orme** headland near Llandudno.

Examination of well defined wear patterns on stone artifacts is elucidating their function in the crushing and sorting of copper ore; while the production of copper and bronze tools and the techniques and practice of using them is also being studied. Computerised records and the plotting of calibrated radio-carbon dates aim to build up a long term database to give a clear picture of the periods when the underground areas were in use.

Barry Burnham spoke of **Roman Ore Processing at Dolaucothi** in the light of 1991–3 excavations. Survey work in 1982 revealed a complex of archaeological features which were tentatively identified as a possible water driven trip-hammer mill. This was near the well known ‘motte’ feature but subsequent excavations between 1991–3 to test for the presence of processing wastes demonstrated, however, that the ‘motte’ was little more than a conical spoil tip. C14 dates from beneath these wastes now indicate a Roman date with important implications both for the remains of the mill and for the nature of Roman ore processing at Dolaucothi.

Jake Almond gave a clear account of **Elmore and the Flotation Process**. A century ago the Elmore brothers Francis (Frank) and Stanley originated the *bulk-oil flotation* method of extracting copper economically from the mineral deposit at **Glasdir**. The process was improved, using smaller proportions of oils and introducing a vacuum to generate bubbles. This was installed at Glasdir around 1909 and it led to the era of *froth flotation*.

Peter Crew told us about the extraction and restoration at the 19th-century copper and gold mines at Cefn Goch gold mine (which was visited on Saturday) and a long term project to consolidate the mills has been partly funded by the National Trust, Cadw and the National Park. Excavations have been

carried out on a small assaying plant and combined smithy, and various fire-assaying tools have been recovered. At **Cwn Ciprwth** copper mine the waterwheel, pumping system and the linking of the flat rod system have been restored, in a project jointly funded by the National Park and the Welsh Development Agency.

Members contributions were as usual interesting and varied. **David Bick** made a plea to examine the possibility of prehistoric lead mining in Wales. It had always been considered that copper had been mined but that lead had not. Whereas he agreed there was no proof there was definitely evidence for it, and (he whole position ought to be reconsidered.

Harold Morris talked about a lead bole furnace near Llanfrothan, local tradition had led him, and **Trevor Davis**, to 19thc records — a book called *Penryn As It Was And As It Is* published in 1880 said that on the top of a hill there was an old Roman furnace for smelting lead. Inspired field walking, later incorporating the use of metal detectors that discovered prills of lead, and three pieces of party smithed galena, had led them to ascertain the location of the furnace. There are no slags visible at the site but it has interesting implications for the recognition and discovery if sites elsewhere rich ores may have been smelted.

Ian Hedley had been studying Bastle houses in Otterburn on land owned by the military. It was discovered that an area known as Iron House Field dated back to 1398 and this had led to the location of 14 bloomery sites.

Tim Smith spoke of Rockley blast furnace near Junction 36 on the Ml in S. Yorkshire. Whereas Philip Riden had dated it to 1632 he believed this had been a case of mistaken identity and the real date should be 1700. He questioned a suggestion that the round pit before the furnace had been for supplying armaments, in the form of cannon, as he thought it far more likely that it had been for casting cylinders for sugar refining. The firm of Staveley, who were using the furnace, were known to have been supplying cylinders for the Caribean, so it followed that this was a far more likely use.

Martha Goodway had examined 24 sherds of crucibles for use in the making of Wootz Steel, and after prolonged experiments had decided that the processing temperature was lower than had been thought hitherto. 1000 to 1050°C seemed the most likely temperature.

Mike Davies-Shiel propounded his theory for bloomery spacing based upon fuel consumption. Some 220 Medieval and older bloomeries have been discovered in Cumbria and about fifty water-powered sites dating from the 1520s. To these can be added about a dozen copper and lead-smelting sites of the 17th and 18th centuries, most of them miners' works around Keswick. When mapped against a basis of Medieval 'forests' and 'chases' the majority of the bloomery sites lie within their boundaries — the only dating evidence available at most sites. Latterly his formula for bloomery spacing, based upon fuel consumption or charcoal or coked coal, considerably speeded up discoveries. This spacing, dependent upon either standard or coppiced trees being charcoaled, has also been applied to areas where no bloomeries had previously been found, leading to the identification of another 15 new sites between Windermere and Kendal and another 10 south of Kendal, towards the North Lancashire border. He believes many yet remain to be found using this technique.

David Starley spoke of a Middle Saxon ironworking assemblage from Flixborough. The site provided evidence of a wide range of crafts, including ironworking. Slag deposits showed that smithing has been carried out at various times from the 8th century onwards, but that smelting only took place in the 10th century. Amongst the bulk slags a rare bun-shaped bloom was identified, contemporary with the smelting activity. The site lies close to the Frodingham ironstone deposits and physico-chemical analysis was undertaken to determine whether examples of this ore found on the site could have been viable, given the efficiency of the smelting process. Knife blades, examined by metallography, were generally of high quality, with composite construction with steel edges, butt welded to either pure iron, phosphoric iron or heterogeneous backs.

Amina Chatwin

Archaeometallurgy

Early copper smelting site on the Great Orme. This site near Llandudno in north Wales, reported in an earlier Newsletter (No.38), has now been excavated by **David Chapman** in conjunction with the Gwynedd Archaeological Trust. Abundant evidence of habitation on the site suggests long term occupation. However, only a small portion of the original habitation site survived, most having been removed during road construction which left only a small area for excavation. The location of the site is of interest. As it is of considerable distance from the mine and perched on a cliff, it would not immediately appear to be the best choice for a camp site. The inclement weather during excavation in January 1998 gave a possible insight as to why it was chosen — cliff provided excellent shelter as well as a good harbour for sea access to the Great Orme.

Evidence for the smelting of copper was found in abundance; slags from copper smelting, prills of copper and copper ore were present throughout the stratification of the site. The ore found is consistent with that from the Great Orme mines and has been identified by A. Lewis as copper carbonate in dolomitic limestone. Slags were in the form of a spongy black matrix, containing small prills of copper metal, the largest of which was only about 7mm long. The average size of the slag was approximately 3mm, so they appear to have been crushed, probably for the collection of copper prills. A midden pit was excavated along with several

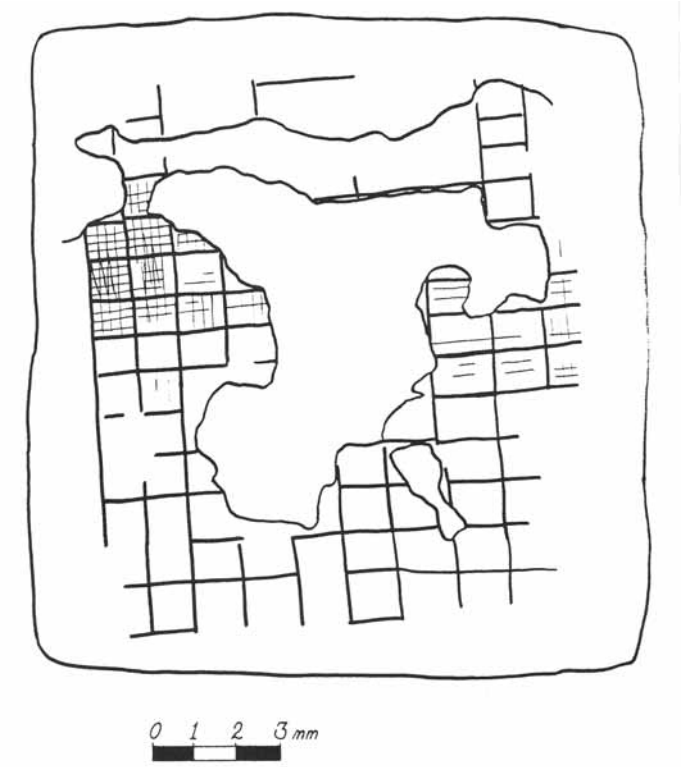
burnt layers, all of them containing smelting debris as well as bone, shells, burnt beach stones and charcoal. Other finds from the pit included a small section of a shale bracelet and a whetstone. This stone had been used as both a hammer stone and as a pestle. Clear wear marks are consistent with the stone having been used to pound and crush the copper prills from their slag matrix. Further work is now being carried out at the site, and post-excavation analysis is being undertaken. Radiocarbon dates will provide a time frame into which the site can be placed.

Evidence of coin production in Saxon Thetford

Unexpected and exciting evidence for the minting of coins has emerged during the recent post excavation analysis of artefacts and samples from the site of Thetford Mill Lane, Norfolk, originally excavated by the Norfolk Archaeological Unit in 1995. The site had already produced evidence of copper alloy melting ironsmithing and, perhaps surprisingly in an urban context, iron smelting. More exotic activities first became apparent when quantities of "litharge cake" were identified amongst the assemblage of iron slag being examined at the Ancient Monuments Lab. of English Heritage. Litharge cake derives from the purification of silver. In the process, lead combines with the impurities within the silver. The lead is then oxidised and separated out by allowing it to be absorbed into the bone ash lining of a hearth. This leaves pure, metallic silver on top of the lead-rich "litharge cake". One of the most probable reasons for refining silver is to use it to manufacture coinage. With this in mind Quita Mould, the finds specialist involved in the project undertook further X-radiography of some of the possible tools including a broad punch which revealed a faint shadow across its striking face. The artefact has subsequently been examined by John Davies at the Norwich Castle Museum who believes it is an extremely unusual upper die for striking coins. The artefact is currently undergoing careful cleaning with the aim of revealing the incised surface.

Migration period die for cross-hatching gold foil

During the excavation of a small burial mound at Tjitsma, Wijnaldum in the province of Friesland, Netherlands a small die was found. The purpose of the die was to impress a cross-hatched pattern on gold foil. Such foil was placed behind thin slices of garnet in jewellery to give a bright reflection. The object is dated to between 650 and 750 AD. The die is almost square (17.4 x 16.1mm) and the surviving surface area shows an irregular boxed pattern (see figure). Each of the main squares had been further divided into either 16 or 20 irregular divisions. This contrasts with the only two other dies known, both from Denmark (Gudme and Neble), which have only a standard, single, pattern of squares. The die has been studied by **Caroline Tulp** of the **Rijksuniversiteit Groningen** and the pattern compared with a wide range of garnet jewellery, including that of the Sutton Hoo treasure. Unfortunately no exact matches between the die and surviving foil in jewellery have yet been found. It is suggested that the reason that so few dies have been found is their small size and the difficulty of recognising the artefact when corroded.



The face of the foil die

Roman iron metallurgy using coal

Recent work in Xanten, Germany, produced significant amounts of iron slag from a safe 2nd/3rd century context within the Roman settlement of Colonia Ulpia Traiana. The context is currently under investigation by Bernd Liesen from Xanten. The slag was not found *in situ*, but had been used as hardcore for subsequent building. The slag is typical mineralogically, with fayalite, wüstite, metallic iron and a glassy matrix. However, its morphology is very distinctive, with a high proportion of fuel

fragments including coal, charcoal and wood. Physically the slag resembles smithing hearth bottoms but shows some characteristics of tap slags. Scientific work, currently being undertaken by **Thilo Rehren** at the **Deutsches Bergbau-Museum Bochum, Institute für Archaeometallurgie**. This will focus on the relationship of mineral and biomass fuel in the slag and on determining whether the slag is from either smelting or smithing. In cooperation with Wemer Pfisterer from Bochum, more information concerning the type and origin of the coal will be sought.

For the time being this appears to be the earliest evidence for the exploitation of coal in Germany, and for its use in a metallurgical process. In view of the widespread use of mineral coal in Roman Britain (Dearne & Branigan 1995 in Antiquaries Journal vol. 75), including for metallurgical operations, Thilo would be highly interested to learn whether any scientific study is currently being conducted on this. A juxtaposition of material, data and interpretations would be highly welcome.

Experimental iron smelting

A programme of experimental iron-making was begun at the Museum of Welsh Life/Amgueddfa Werin Cymru (a branch of the National Museums and Galleries of Wales) during the summer of 1998. The project is. being organised by Tim Young of GeoArch, with support from Ken Brassil and Aaron Petersen (NMGW) and Gary Thomas (Cardiff University). There have been regular smelts between June and October in a low-shaft bloomery furnace with an internal diameter of 40cm, 25–30cm thick walls, and a bed depth of 50cm (subsequently increased to 70cm), built of clay dug on site. Forced draught was provided by two pairs of 19th century smith's bellows, and much of this season's effort has concentrated on blowing technique. Blowing has largely been undertaken by volunteers, mainly archaeology undergraduates from Cardiff University.

A reasonably high degree of success has been achieved in generating blooms of up to 9kg raw uncleaned weight from charges of 30kg ore. Most smelts in 1998 utilised goethite ores from the Forest of Dean, or siliceous goethite/haematite ores from Llanharry. The final smelt of the season was a trial run with Carboniferous siderite ores from Blaenafon. Despite the apparently good-quality blooms (only one has so far been refined down to final product), the success of producing slags similar to ancient examples has been mixed. Most smelts have produced an appropriate amount of slag, and some of this appears compositionally correct. However, we have had only limited success in tapping slags, most being too viscous, even at temperatures approaching 1300°C.

The analysis of the products and by-products of this season's smelting is only just beginning. Next season is now being planned, and it hoped that smelting will start again in early March (with a major programme planned for SET week 99; March 12th-21st) and continue at intervals throughout the summer.

Many thanks to the contributors for the above items. Any archaeometallurgy contributions for the Spring 1999 issue, by 22 January to:
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Further Evidence for the Use of Cast Iron in Medieval England

Over the past few years the evidence for the use of the blast furnace process of iron making on the Continent from the 11th and 12th centuries has been growing steadily, and recently the author of this note pointed out evidence, albeit very indirect, for the existence of the blast furnace process in England from the 13th century (Craddock 1997). Very recently further evidence has been published, equally intangible, for the recognition and use of cast iron in the 14th century.

The accounts of the Tudeley ironworks form the only detailed accounts of production and itemised expenses to survive from the Medieval Wealden iron industry, and are now in the Public Record Office (Lists and Indexes XXXV). They have been published previously by Giuseppi in 1913, and have now been republished by Hodgkinson and Whittick (1998) who have translated the rather charming Medieval 'latinaise' of the originals. In these we learn that the principal items sold were the blooms, many dozen in an average year, weighing about 30lb each, for a price varying between about three shillings and three shillings and sixpence. In the years 1350–1351 and again in 1352 another item appears with the blooms sold: '*Et de vjd receptis de groynes venditis*', 'and sixpence for the graynes sold'; followed in the next year's accounts by 'De greyn' ferri venditis iijd', 'greyns' of iron sold for threepence'. What were these grains of iron? Clearly with annual sales of sixpence and threepence when a single bloom fetched over

three shillings, they constituted a very minor product — very likely a by-product. It is well known that the bloomery process produces iron of varying carbon content and that in some small pieces the content is so high that small droplets of molten iron are produced. These are often to be found entrapped in the slag from bloomery sites and were present in the blooms themselves (David *et al* 1989).

Usually these drops were discarded, and it is significant here that they were not only collected but sold. There was a market for cast iron in 14th century England.

This raises the next question — for what were they used? The records of the bloomery industry in India and elsewhere suggest some possibilities. Blandford (recorded in Percy 1864, p.262) noted that in Orissa they were used as a substitute for lead shot, and the Persian author, al Biruni writing in the 12th century, describes how the sword smiths of the Sind sprinkled cast iron powder onto the wrought iron blades that they were forging to create a harder and more attractive surface (Allan 1979, p.79).

There are, however, much more interesting possibilities. Holland (1892, p. 148, and reprinted in Craddock 1998) describes a process carried on at Salem, the traditional steel-making centre of Tamil Nadu in the south of India, whereby the grains, or shot as he calls them, of cast iron were ground up and carefully resmelted to partially decarburize them, the smiths knowing that too vigorous a working would result in ordinary wrought iron. The product was a small ingot of steel. This is the only record from India of such a process, which suggests that it was not common, although Holland does state that the smiths knew of no other process for making steel, and had practised it for generations.

The Mafa peoples of North Cameroon in central Africa, used a similar technology until the recent past (David et al 1989). Their distinctive iron smelting process produced an extremely heterogeneous product containing pellets of what, depending on the carbon content, could be variously described as cast iron, steel or low carbon iron. These were collected, placed in an open crucible, loosely covered with clay and heated to partially decarburize the metal to steel. The still-solid pieces were then hammer-welded to form a bar of steel.

Returning to Medieval England it is difficult to imagine what use the grains could be put to in their unmodified form. The fining of iron was certainly being carried on at many centres in North West Europe by the time of the Tudeley accounts. Given that, is it possible that the grains were sold to the smiths for transformation into wrought iron, or even to steel, in a process similar to that recorded as having been practised in India and Africa, where the direct production process persisted until the late 19th century and early 20th centuries?

P.T. Craddock, Depfc of Scientific Research, The British Museum, London WC1B 3DG.

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WEALDEN IRON RESEARCH GROUP

Volume 18 (1998) of the Group's Bulletin, Wealden Iron, was published this summer. The main article comprises a translation into English of the 14th century accounts of the ironworks at Tudeley in Kent. Original published as a Latin transcription in 1913, they set out the income and expenditure of the works during two periods, from 1329–31 and from 1350–54, when they were operated in hand for Lady Elizabeth de Burgh. Preceding the translation there is a discussion of the operation of the works. Two other articles relate the Sands family of forgemen who ran Hawksden forge near Mayfield, Sussex, and an unprovenanced letter which describes the casting of bronze ordnance at a Kent furnace near Tonbridge in 1758.

In the usual collection of field notes there are reports of newly discovered bloomery sites at Heathfield, Maresfield, and Peasmarsh near Rye, in Sussex, at Burstow in Surrey, and at Newenden and Sutton Valence, in Kent. Two bloomeries at Hadlow Down, Sussex, have been dated to the Roman period, and one at Waldron possibly to the late-Iron Age. Evidence of ironworking in the medieval period has been found at Loxwood, Sussex, and most notably at Crawley where two hearths were found, and dated archaeo-magnetically to the late-14th/early-15th century. The steady accumulation of evidence of production in Crawley in this period is building up a picture of the town as a major centre for iron. Finally, fieldwalking over the area postulated as the site, south of East Grinstead, of the ferraria mentioned in the Domesday Book, has begun to reveal evidence of ironworking.

Jeremy Hodgkinson

Correspondence

The Titanic debate rumbles on - further to correspondence in HMSNews 38 and 39 we now have the following two comments Also calling D.L. Simms on heat experiments.

1. A letter on p7 (HMSNews No 39) from Professor Leighly comments on your earlier report (no 38) about the sinking of the Titanic and the possibility that this was caused directly by

failure of rivets. Your original report was extracted from The Sunday Times but refers to the US Institute of Standards and Technology; it seems very probable that the original source of the disputed statement was a report recently forwarded to me: ‘Metallurgy of the RMS Titanic’ NIST - TR 6118 by Tim Foecke.

The comment about rivets is one of eight conclusions in the report, the last one of which is 'Given the knowledge base available to engineers at the time of the ship's construction, it is the authors opinion that no apparent metallurgical mistakes were made in the construction of the RMS Titanic'. A copy of the report is enclosed for your information; copies are available, I believe, on the Internet.

On p 2 D.L. Sims requests information on the liquidus and solidus temperatures of Bi-Pb-Sn alloys. Mention is made of a phase diagram compilation by Villars, Prince and Okamoto; I am not familiar with this but it is possibly an updated version of the phase diagram bibliography issued by Prince in the 1950's or 1960’s. If so it will not give the diagrams, only references to the original papers. The only diagram I can find is that published by Charpy in 1898(?) which itself has some historical significance as the first comprehensive determination of the liquidus for a complete ternary system. A copy is enclosed in case no other, more recent, information is found.

Although the ASM ‘Metals Handbook’ includes a considerable number of ternary phase diagrams for alloys of practical significance the Pb-Bi-Sn system is not among them. Diagrams of the solidus surface for ternary systems are often more difficult to find. I enclose a sketch of possible features of the ternary solidus surface based on known features of the limiting binary systems; I make no claims for this but it may be of some use if nothing else turns up and D.L. Simms is sufficiently desperate.

Brian Bastow, Hillside, Woodend, Egremont, Cumbria CA22 2TD

Please contact the Editor (see below) if anyone requires copies that Mr Bastow encloses.

Embrittlement of Archaeological Silver

Dr. R.J.H. Wanhill, Senior Research, Engineer Structures and Materials, National Aerospace Laboratory NLR. Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands, has forwarded a Preprint of his paper given at the XVth Conference of Classical Archaeology, Amsterdam, July 1998 on the identification, restoration and conservation of Brittle Archaeological Silver.

‘Archaeological silver can be brittle and may be found cracked or fragmented. The brittleness is a long tern consequence of corrosion and microstructural changes, acting separately or together. This paper presents current knowledge of the embrittling mechanisms, factors contributing to the types and severity of embrittlement, and possibilities for restoration and conservation.’

The article runs to 13 pages. If any members are particularly interested in the subject, please contact the Editor (see below)

Sedbury Iron Works — Information Wanted

An undated penny token, struck ca 1813, exists for Sedbury Iron Works. However, whilst the piece illustrates the works, it does not give a location and all attemps to find further details have so far failed. W.J.Davis, in The Nineteenth Century Token Coinage of Great Britain (Birmingham 1904) credits the piece to Sedbury in Gloucestershire. There were a number of works higher up the Severn Estuary than Sedbury, at Newnham and Framilode. These were worked by the Pumells, ironmasters of Dursley; iron from the Forest of Dean was processed there. However, although Sedbury, best known for its cliffs, which are the southern termination of Offa’s Dyke, may have had bloomeries in its neighbourhood, they would have been small and somewhat earlier than this token. There are no traces of a works of this type at this time. Although there is another Sedbury, in the North Riding of Yorkshire, this is an equally unlikely location. It is possible that the token is bogus and that iron works with that name never existed at all, but that is the least likely of the options. Does anyone have knowledge of this works and its whereabouts?

Paul Withers. The Old White Lion, Market Street, Llanfyllin, Powys SY22 5BX.

Perhaps the less metallurgical amongst us might welcome the table below, especially when reading the Journal.

Aluminium	Al	Nickel	Ni
Antimony	Sb	Nitrogen	N
Argon	A	Osmium	Os
Arsenic	As	Oxygen	O
Barium	Ba	Phosphorus	P
Bismuth	Bi	Platinum	Pt
Boron	B	Radium	Ra
Cadmium	Cd	Silicon	Si
Carbon	C	Silver	Ag
Chromium	Cr	Strontium	Sr
Copper	Cu	Tin	Ti
Gold	Au	Tungsten	Sn
Hydrogen	H	Uranium	U
Iron	Fe	Zinc	Zn
Lead	Pb	Zirconium	Zr
Lithium	Li		

Watch your television screens in the new year. We understand the Wealden Iron Research Group and their experimental smelting team became involved with Channel 4’s Time Team. The result was a successful smelt

The Hon Editor Amina Chatwin, The Coach House, Parabola Close, Cheltenham GL50 SAN. Tel (01242) 525086 welcomes contributions for the HMSNews, by the end of February, June 11th, and November 5th. If possible on Apple Mac, or Ascii.

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