Not so much Gold, Silver, Bronze - more Copper, Zinc and Brass

SS Great Britain, Bristol, BS1 6TY, England

6th-7th October 2012

Abstract Book

Historical Metallurgy Bristol Conference Programme

6th October 2012

9.00-10.00	***Registration & Coffee***	
10.00-10.15	Welcome & Anniversary Year	
10.15-10.40	Jocelyn Baker	"Copper, Brass and Gold? Quantifying Anglo-Saxon Metallic Colour Space"
10.40-11.05	Gerald Eisenblätter, Alexandra Franz and Gert Kloess	"Analysis of X-ray computed tomography images: a look inside Roman copper coins."
11.05-11.20	***Break***	
11.20-11.45	Simon Timberlake	"Brief observations on Chalcolithic and Roman hard-rock gold mining and Middle Bronze Age Alpine copper mining and ore processing"
11.45-12.10	Wenli Zhou	"Distilling zinc in China: the technology of large-scale zinc production in Chongqing during the Ming and Qing Dynasties (AD 1368-1911)"
12.10-12.40	Joan Day and Tony Coverdale	"The Avon Valley Copper and Brass Industry 1700 to 1740"
12.40-13.40	***Lunch***	
13.40-14.10	Keith Morgan	"When Welsh Copper Ruled the Waves"
14.10-14.50	David Etheridge	"William Champion's Warmley Brass and Zinc works: Archaeological investigation and recording 1994-2011"
14.50-15.10	***Tea break***	
15.10-15.50	Chris Evans	'"Guinea Rods" and "Neptunes": the role of copper and brass articles in the transatlantic slave trade'
15.50-16.10	Discussion & Closing Speech	
16.10-17.30	***Time to explore the SS Great Britain***	

Fieldtrip Sunday 7th October

Meet 10am (SS Great Britain car park (unless told otherwise))

10.30 - 12.30 Tour of Warmley Brass and Zinc Works

Lunch Break 12.30 – 14.00

14.00 – 16.00 Tour of Saltford Brass Works

List of Attendees

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Copper, Brass and Gold? Quantifying Anglo-Saxon Metallic Colour Space

Jocelyn Baker
Durham University

Gold has dominated elite material culture for thousands of years. The popularity of gold in early Anglo-Saxon culture is undeniable, but the supply of all metals in this period was limited, leading to the almost exclusive use of gold as gilding. Brass also has a similar golden appearance, but cementation and thus brass-making was lost to Britain at this time, further limiting the ability of metalworkers to create the desired 'golden' metal colour for costume jewellery. Was the obsession with gold found in contemporary literature simply a reflection of its increased value due to scarcity, or was 'gold' more visually evident than the material culture indicates? Using an interdisciplinary approach, this paper will explore how similar or different the elite metalwork of 5th-7th century England truly was in appearance of colour, and how the perception of colour, human differentiation ability and assumptions of appearance may have contributed to a culturally skewed conceptualisation of 'gold'.

Spectrophotometry and ED-XRF were used to characterise the relationship between copper alloy and precious metal alloy colour space. A selection of Anglo-Saxon gold artefacts and copper alloy grave-goods were analysed to provide a contemporary framework for metal artefact colour. Quantitative colour differentiation tests were also conducted on a variety of individuals to determine the ability of the human eye to distinguish differences between metals, giving a biological variable of comparison with which metallic colour space can be understood. Using these variables as well as patterns of colour use in other forms of material culture and Old English literature, the communication of colour and, specifically, of 'gold' within Anglo-Saxon culture will be explored.

Analysis of X-ray computed tomography images: a look inside Roman copper coins

Gerald Eisenblätter, Alexandra Franz, Gert Kloess
Leipzig University, Faculty of Chemistry and Mineralogy, Institute of Mineralogy, Crystallography and Materials Science (Scharnhorststr. 20, 04275 Leipzig)

Today non-invasive methods are of special interest in historic and archaeological sciences to understand and preserve the cultural heritage. An ideal technique for analysis of ancient artefacts should be non-destructive, non-invasive, fast, universal, versatile, sensitive and able to examine multiple phases.

Many archaeometallurgic analyzes were done on silver or gold coins due to their value and well preserved state. Copper objects in contrast are highly corrosive. The corrosion takes not only place at the surface but also in the inside of the copper coins showing different paths of corrosion and depletion. With surface analysis only a small amount of the real existing corrosion could be described. First results using X-Ray 3D-computed microtomography (3D µ-CT) have shown the corrosion inside the copper coins.

Trying to combine surface sensitive analysis techniques like XRF or EPMA and XRD with X-ray computed tomography the state of preservation can be described into more detail. With imaging methods like X-ray tomography or radiography predictions to the reliability of the surface analysis data can be made. Especially the spread of grey values gained by 3D µ-CT allows conclusions to the material composition, defects and depletion. A correlation is done between measured mass density data and calculated density data by defect volume analysis. As our work has shown (see figure 1) there is a dezincification in the bulk material. The depletion of zinc or tin is assumed by radiography studies (see figure 2) and part of future studies.

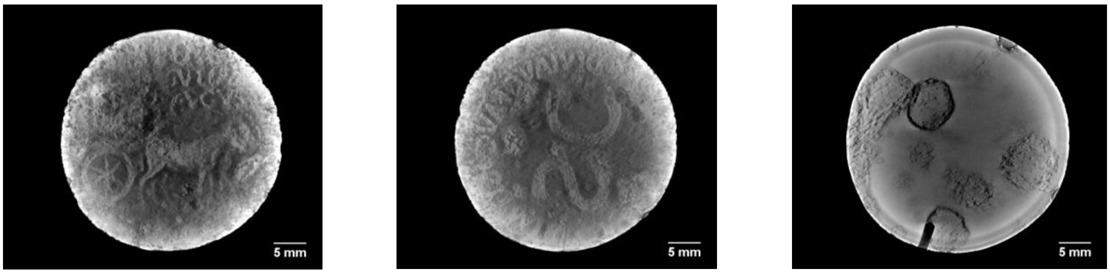

Figure 1 a-c: 3D-µCT imaging a sestertius of Tiberius obverse (a), reverse (b) and inner part of the coin (c) with drill hole and showing depletion of zinc

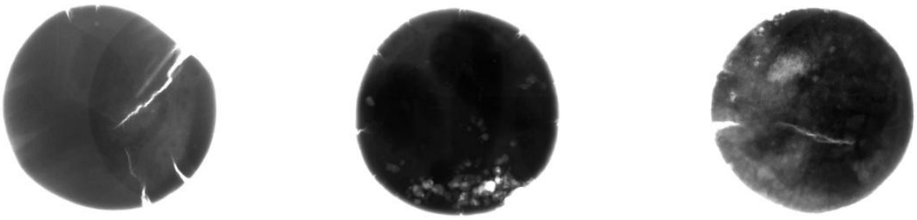

Figure 2 a-c: Typical radiographs of dupondia showing cracks, pores and/ or depletion

The archaeometric studies are carried out on ancient Roman copper coins that are dated to the Julio-Claudian dynasty. The coins are stored at the Leipzig University Library “Bibliotheca Albertina” and the Herzog Anton Ulrich Museum Brunswick in Germany.

Brief observations on Chalcolithic and Roman hard-rock gold mining and Middle Bronze Age Alpine copper mining and ore processing

Simon Timberlake

'A summary account of a programme of experimental mining and archaeometallurgy carried out in 2011 and 2012 with a team from the DeutchesBergbau Museum (Bochum); at Sakdrissi in Georgia and in the Mitterberg region of the Austrian Alps. On-going experiments at the recently excavated 3rd millennium BC mine of Sakdrissi have demonstrated how highly resistant dacitic rocks were worked by firesetting and hafted stone tools to extract the gold-bearing hematite-quartz veins, and how the exceedingly fine-grained and sub-visible gold could have been recovered from this by continuous assay panning in order to sample wide variations in the richness of this orebody. The extraction method found at this earliest known hard-rock gold mine will be compared briefly with the early industrial-scale operation seen at the Roman (2nd-3rd century AD) mines at Rosia Montana in the Apuseni Mountains of Roumania, a site worked at by the author in 2012 as part of the team assembled by Beatrice Cauuet (CNRS Tracers Lab.Toulouse).

The final study is a brief report on the very first experiments carried out this summer on the Mitterberg using a reconstructed Middle Bronze Age wooden sluice box which was excavated at the Troiborden ore processing site close to the Main Vein on the Mitterberg in July 2011. The initial results suggest this box was used with a controlled flow of water to seperate various grain-size grades of rock, ankerite and quartz gangue from sulphides hand-crushed on stone anvils and querns, primarily as a means to concentrate the poorer chalcopyrite ore prior to its roasting and matte-smelting. Perhaps the very first buddle ever to have been recognized'

Distilling zinc in China: the technology of large-scale zinc production in Chongqing during the Ming and Qing Dynasties (AD 1368-1911).

Dr Wenli Zhou

Zinc made a relative late appearance in the metallurgical history of China. As a volatile metal, its production required sophisticated distillation installations. The production of this metal played a special role in both the technological and economic history of Ming and Qing China: as a key constituent of the copper-alloy brass, zinc was employed for coinage and also exported via long-distance maritime trade. Our understanding of Chinese zinc distillation technology has traditionally been limited by a lack of studies of production remains. Recent excavation of zinc smelting sites in Fengdu and Shizhu, Chongqing, provides an excellent opportunity to address this issue.

This paper presents the analyses, technical interpretation and socio-economic contextualisation of the production remains from three sites in Fengdu and one site in Shizhu. Zinc ore, zinc metal, retorts and slag were analysed by optical microscopy, scanning electron microscopy with energy dispersive spectrometry (SEM-EDS), electron probe micro-analyser with wavelength dispersive spectrometry (EPMA-WDS) and X-ray diffractometry (XRD). Following on a detailed technological reconstruction, some differences were found between the zinc distillation technologies in Fengdu and Shizhu, not only in technical efficiency but also in the organisation of production. These differences can be explained as adaptation of the zinc production for coinage to the different social, political and economic constraints affecting each group of sites.

This paper offers a first contribution towards a detailed comparative reconstruction of Chinese zinc distillation technology that considers both variations in time and space as well as common elements that characterise the Chinese technological style. The significance of Chinese zinc production is contextualised and discussed with reference to coinage in Ming and Qing China, but also by comparing it to other brass and zinc making technologies in China, India and Europe, and by assessing the influence of Chinese zinc in the international maritime trade.

The Avon Valley Copper and Brass Industry 1700 to 1740

Joan Day and Tony Coverdale
Saltford Brass Mill Project

The first four decades of the eighteenth century saw the evolution of a major copper, zinc and brass industry in the Avon valley, starting from early experiments with the use of coal to smelt copper, and culminating in an integrated complex of manufacturing processes supplying an international trading market. The story starts with the experimental coal-fired smelting of Cornish copper ores on the banks of the Avon using Bristol coal, and culminates with a sophisticated multi-site complex of mills variously: smelting copper; alloying copper and calamine to produce high quality brass; manufacturing brass hollow-ware by water-powered battery hammers; using water-powered rolling, slitting and drawing apparatus to manufacture brass wire; and applying water-powered rolls to produce sheet copper and brass. Finally the output from those mills was distributed through a sophisticated trading system able to deliver the products of the industry to the British market and export those products to developing markets in Africa and North America.

Three important people in this story were John Coater, Abraham Darby and Nehemiah Champion. John Coster pioneered the smelting of copper and established the copper industry in the Avon valley. Abraham Darby, before turning his attention to iron, was the driving force behind the early brass industry, attracting workers from the Low Countries to operate the brass furnaces and battery hammers located on the rivers Frome, Chew and Avon. Nehemiah Champion advanced the brass making and manufacturing process, taking out important patents relating to the alloying and annealing of brass.

'When Welsh Copper Ruled the Waves'

Keith E. Morgan
Curator, Trostre Works Cottage & Industrial Museum

In the 19th. Century, 90% of the world's copper was smelted in South Wales. Initially, copper ore was imported from mines in Cornwall and Devon. When these mines petered out, the copper ore barques from the ports of Swansea, Neath and Llanelli, brought the copper ore back from around the world; in particular from Chile and Peru. The sailing vessels carried Welsh coal out and became known and famous as the *'Cape Horners'*. They had to traverse one of the world's most challenging and dangerous sea passages around the tip of South America to reach the copper rich ore fields of Chile and Peru.

By the 1650s, South Wales served an ever increasing industrial demand for products made out of the copper ore that was smelted there. The boat building industry in particular, had a growing appetite for copper where nails, rivets and bolts were needed in great quantities. In the mid 1700s, the Admiralty was experimenting with copper sheathing for the keels of its ships in order to combat the teredo worm and barnacles. By the end of the 18th. Century, copper sheathing was in universal use on navy ships and on the copper ore barques themselves.

This paper examines the development and use of copper sheathing, nails and rivets, in particular on HMS Victory, Nelson's famous flagship at the Battle of Trafalgar. HMS Victory, even though in dry dock at Portsmouth, is still a commissioned navy vessel and has gone through a number of restorations to preserve it. The paper is supported by physical examples of copper plates, nails and rivets recovered from HMS Victory during the latest preservation project.

William Champion’s Warmley Brass and Zinc works:Archaeological investigation and recording 1994-2011

David Etheridge

William Champion’s Warmley brass and zinc works, founded c. 1746, was the first integrated brass manufacturing site, where all parts of the operation, from raw material processing to the finished product, were undertaken at one location. William lived on-site in a modest mansion built by himself, surrounded on one side by the works and on the other by the pleasure grounds he had created. Uniquely these pleasure grounds incorporated parts of the works, utilizing copper slag in the construction of the principal features. Although William’s business failed in 1768, the site continued to be involved in the manufacture of brass goods and zinc until 1851.

A review of archaeological intervention and recording between 1986 and 2011, together with a new scientific analysis of the technological residues by David Dungworth, has revealed that despite development of the site over the last 160 years, substantial structural remains and industrial waste deposits related to the 18th century works are preserved below ground. In particular, the remains of Britain’s oldest surviving industrial zinc smelter have now been identified.

‘”Guinea Rods” and “Neptunes”: the role of copper and brass articles in the transatlantic slave trade’

Chris Evans
University of Glamorgan

Copper and brass were important elements in Europe’s commerce with sub-Saharan Africa from its inception in the 1440s. Although never as central as textiles to the transatlantic slave trade, non-ferrous metals were routinely carried on slaving expeditions. On some parts of the African coast they were indispensable items of trade.

This paper focuses on the eighteenth century, when the slave trade was at its zenith and when British ships dominated the trade. It addresses three questions:

- How did the expansion and shifting geography of the slave trade affect the demand for European copper?
- What effect did African demand for copper and copper-based products have on the British copper industry, which grew very rapidly during the period under review?
- To what extent did African traders influence the design of European-made copper articles?

The answers will draw upon recent archival research.

BIBLIOGRAPHY

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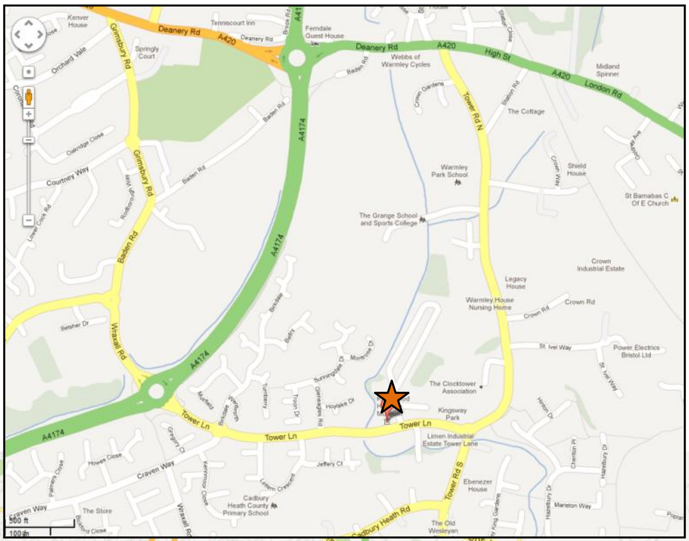
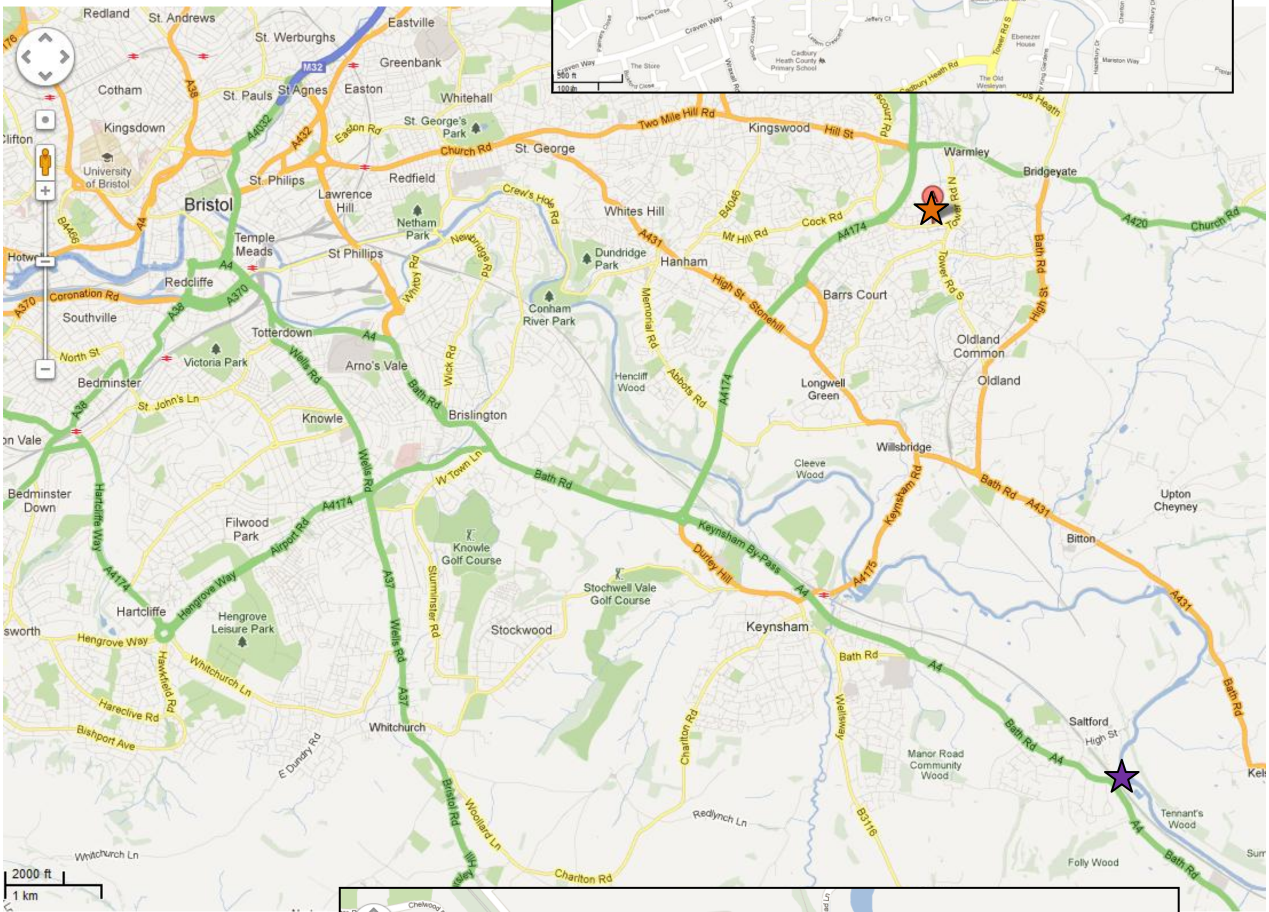
Eugenia W. Herbert, *Red Gold of Africa: Copper in Pre-colonial History and Culture* (Madison WI, 2003)

David Richardson, ‘West African consumption patterns and their influence on the eighteenth-century English slave trade’, in Henry A. Gemery and Jan S. Henderson (eds), *The Uncommon Market: Essays in the Economic History of the Atlantic Slave Trade* (New York, 1979), pp.303-30

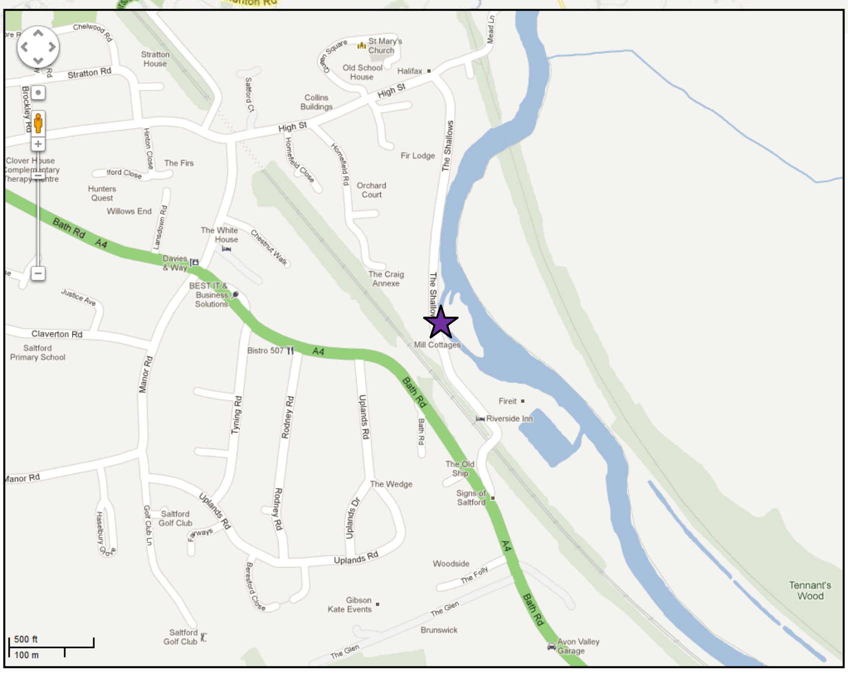
Sunday Visits Maps

Warmley Brass and Zinc Works
BS30 8XT





Salford Brassmill
BS31 3EY



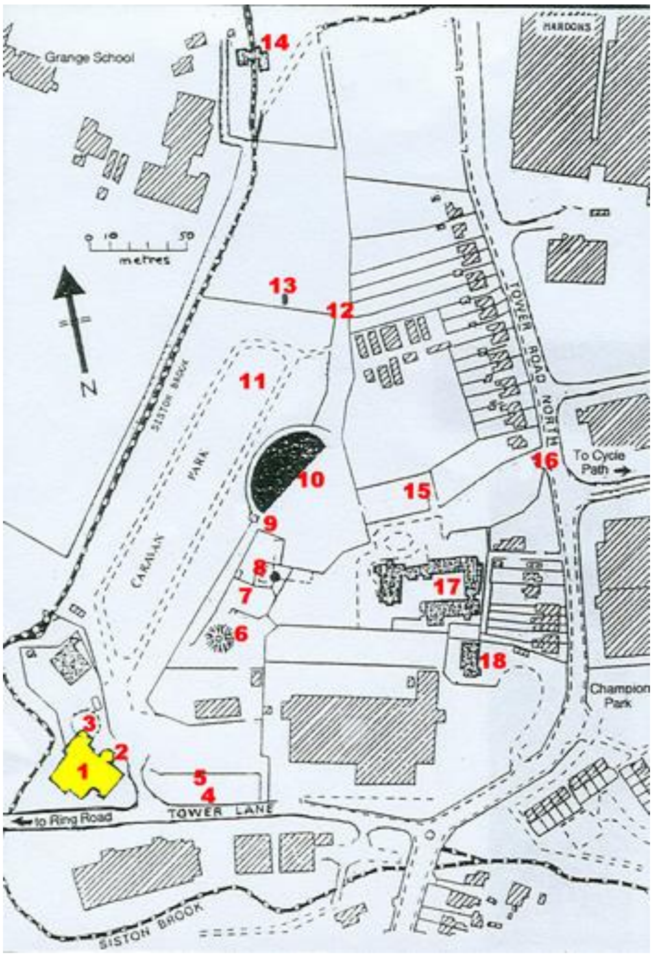
Warmley Brass and Zinc Works

William Champion was a Quaker industrialist who, in the 1740's, moved his copper, brass and zinc spelter works from Old Market in Bristol, to a green field site at Warmley. The site is thought to have been owned by his father Nehemiah Champion. Here William built his Paladian house, his works and a pin factory, as well as housing for his workers.

Brass is an alloy of copper and zinc. William brought raw materials such as local coal, calamine (zinc bearing ore) from the Mendips and copper ore from Cornwall into the site.

Before William's time, in Europe, only poor quality brass was made. It was produced by grinding calamine and copper ore, then mixing the two together and heating it in a furnace to produce brass. As zinc comes off the heated ore as a gas a way had to be found to capture the zinc. William was the first to produce zinc in commercial quantities. To extract the zinc metal from calamine, William invented an enclosed condenser into which he put the crushed calamine, this was heated and the resulting gas was made to go down a tube at the base of the condenser into a bath of water thus creating zinc flakes. Now he was able to mix the copper and zinc in just the right quantities to make brass of varying qualities.

For his pleasure in the fashion of the time William laid out fine gardens. He had a mound, an elm walk, semi-circular pond, a series of grottoes and a lake, in which was placed an enormous concrete statue of Neptune, decorated with slag from the works. It is thought that these elements were taken from Greek Mythology. The mound represents the mountain on which Zeus lived in a grove of twelve oaks, the lake represents the River Styx over which the dead were rowed after death by the ferryman. Until recent times a penny was placed on the tongue of the dead before burial with which to pay the ferryman. The grottoes represent the underworld; the face of a large dog can be made out in the grottoes perhaps being Cerberus the dog who guards the underworld. Neptune, or perhaps more correctly Poseidon, the god of the sea was built of concrete and decorated with slag from the works, he can be seen in what was the lake. William dammed Warmley Brook to provide water for his works that formed a thirteen and a half-acre lake.

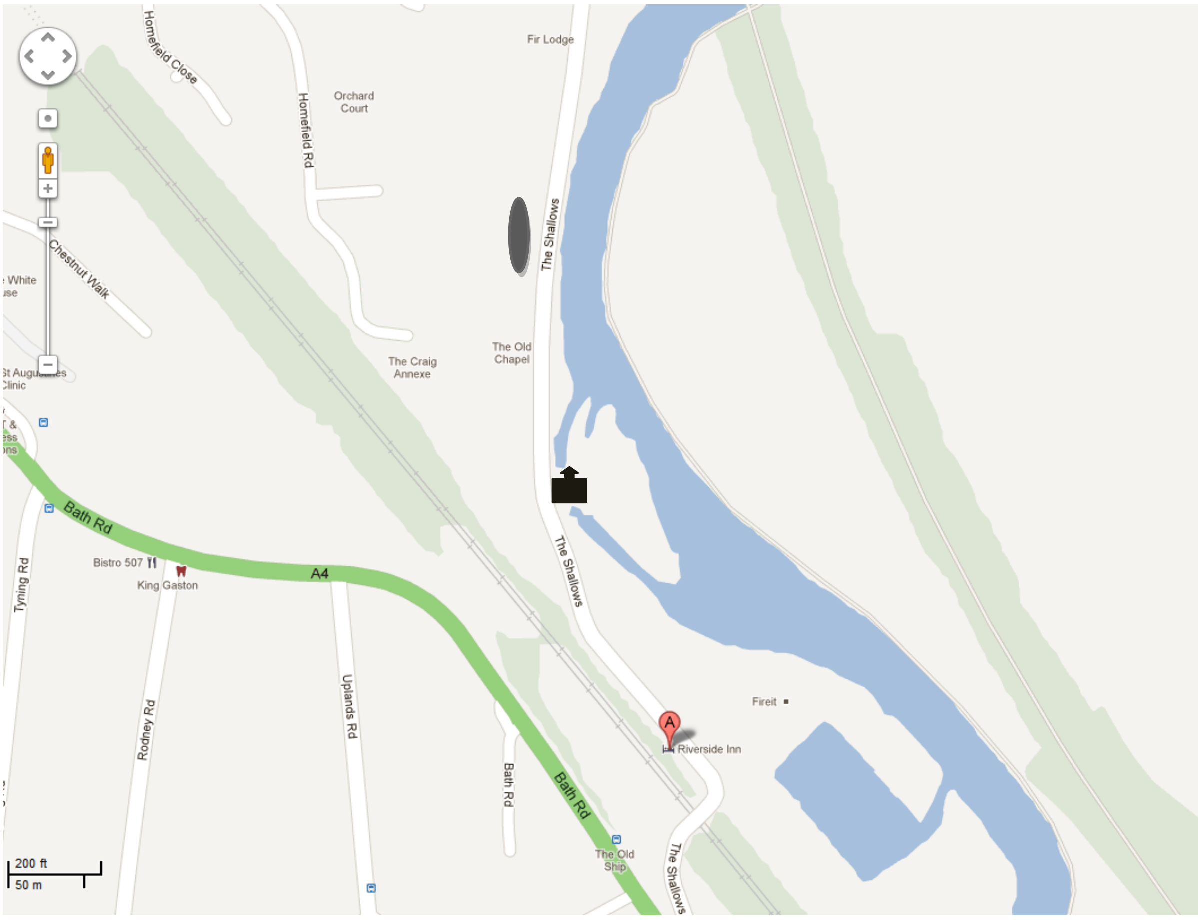


1 The Museum
2 The Windmill Tower
3 The Ice House
4 Museum Car Park
5 Former Site Of The Rank or Row
6 The Mound
7 Chequered Walled Garden
8 Grottoes
9 Boat House
10 Echo Pond
11 The Lake
12 Elm Walk
13 Neptune Statue
14 The Summer House
17 Warmley House
18 The Clock Tower

The Riverside Inn (for Lunch)

We have booked in for lunch here. Their website is http://www.theriverside-saltford.com/ and details were sent in an email before the event. It is only 10 minutes walk from the second site.

The address is The Riverside Inn, Saltford Marina, The Shallows, Saltford, Bristol, **BS31 3EZ**. It is marked by the A in the red circle.



There is parking both in the Marina but also on the shallows, marked by the grey oval. Saltford Brassmill is shown by the black square with chimney. Some people may prefer to try and park at the shallows, which is nearer to Saltford Brass Mill, and walk to the pub rather than move their cars multiple times.

History of Saltford Brass Mill

Saltford Brass Mill was one of a series of mills working in brass in the Avon Valley during the eighteenth century. Many of these mills, as at Saltford, employed waterwheels to power processes used by the company. Abraham Darby started making brass at Baptist Mills on the Frome in Bristol (near the start of the M32) in 1702. Brass-making was much later transferred to Keynsham's Avon Mill, because of its better water supply. River transport was used to deliver brass ingots and coal up to Saltford; Weston Mill, Bath and other mills of the company.

The earliest main process involved the shaping of brass sheet into hollow-ware vessels, such as pans, bowls, and vats. Large water-powered hammers were used originally, to beat the brass ingots into sheet, and then faster hammers shaped the sheet into hollow-ware. This beating process was known as 'battery', so Saltford Mill was known as a brass battery mill.

Rolling mills (pairs of heavy rolls working like an old fashioned mangle) were soon introduced by the company, which produced brass sheets more evenly than hammers. Saltford Mill also became a rolling mill but hammers continued to be used for the production of hollow-ware.

The brass was malleable enough to be worked cold, but rolling and hammering could continue only for a limited period as the brass would 'work-harden', causing cracking. To prevent this, partially worked brass was periodically softened by heating, or 'annealing' it.

When this work originally started, individual pieces were heated over charcoal. Soon the Bristol industry devised bulk annealing in large furnaces heated with local coal. The brass goods were protected from damaging coal fumes by an inner sealed arch, introducing a new type of large-scale `muffle' furnace. The remaining Saltford annealing furnace, one of four once working at the mill, is the best surviving example of this important local innovation. The only other examples are at Kelston Mills, where only the outer walls remain.

Skilled immigrant craftsmen came from traditional brass making areas of the Continent bringing their valuable expertise. The skills of these men partly account for the growing success of the industry throughout the eighteenth century. Many of their descendants stayed at the local mills and several of their families continue to live in the Avon Valley today, with names such as Buck, Crinks, Craymer, Fray, Frankham, Ollis, Racker and Steger.

Joan Day
Author: Bristol Brass: The History of the Industry
Website: http://www.brassmill.com

Brass Mill

1. Annealing Furnace
2. Annealing Furnaces (site of)
3. Annealing Furnace *(site of)*
4. Sluice (operational) and Waterwheel (ruined)
5. Sluice and Waterwheel *(operational)*
6. Sluice (operational) and Waterwheel (site of)
7. Sluice and Waterwheel *(site of)*
8. Battery Hammers *(site of)*
9. Battery Hammers *(site of)*
10. 'Breaking In' rolls: 1.7 m wide (*site of - 1859)*
11. 'Finishing' rolls: 1.0 m wide (*site of - 1859)*
12. Shears (site of – 1859, conjecture)
13. 'One Holer'

20th Century Changes

A. Squash Court *(1928)*

B. Dynamo, to illuminate the Squash Court *(1928)*

C. Circular Saw, belt driven *(1956)*

D. Battery Cam Wheel embedded in road

E. Bridge *(2000)*