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Evaluation of archaeometallurgical
residues from Four Crosses, Powys

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Abstract

Metallurgical residues from the site include a very small amount microresidues suggestive of iron working and a larger amount of residues from copper (or copper alloy) working.

The evidence for iron working is very sparse and includes only micro-residues in very low concentrations, recovered from a wide range of contexts from Bronze Age to Roman. At such low densities such material may well be intrusive into the earlier contexts and the small amount recovered (together with the complete lack of associated macro-residues) suggests that iron working was not a significant activity within the excavated area.

The evidence for copper working is entirely from contexts interpreted as Roman, though direct ¹⁴C dating of these features might be desirable given their great potential importance. Much of the material was recovered from features interpreted as postholes, though the unsuitability of the larger friable residues for packing, and the abundance of metallurgical fines, suggests rather that these may have been hearths or furnaces. The assemblages are rather similar in the different features, and include small droplets of copper or copper alloy, a small proportion of slags, vitrified lining suggestive of high-temperature firing of hearths or furnaces cut into, or formed of, a gravelly clay and partially lined with a higher quality clay. Air blast to the hearths/furnaces seems to have been through tuyères, of which one example is represented by three fragments. This tuyère seems to have been formed in a rectangular or D-shaped block, against which the clay of the furnace wall was tightly squeezed. Use of a pre-formed tuyère may have been necessitated by the poor quality of the gravelly-fired clay of the rest of the hearth/furnace material that was extremely friable and porous.

The site has not produced any evidence for crucibles or moulds, but one hearth did produce a single fragment of probable azurite-bearing ore. The analyses of archaeometallurgical ceramics previously undertaken for CA by David Dungworth indicated working of a copper alloy bearing lead, arsenic and zinc, but not tin. This suite of elements has been associated with copper produced from the Llanymynech deposits just to the north of the site. A group of Iron Age artefacts from central and north Wales formed of copper alloy with a high zinc content has been assigned an origin in this area. It is therefore tentatively suggested that the features bearing copper residues and slags are the bases of copper smelting furnaces. This suggestion requires further investigation through detailed analysis, Copper smelting locations and techniques are very poorly understood; no Roman copper smelting furnaces are yet known in Britain. This assemblage would add significantly to understanding if the suggested identification were to be confirmed and would provide a discovery of national significance.

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Methods

All the material submitted has been examined by eye, or under a low-powered binocular microscope. This allows attribution of residues to particular classes, but the interpretation in this evaluation is necessarily limited by the scope of the observations.

Results

Microresidues from ironworking

Microresidues from ironworking include the two classes of hammerscale: spheroidal and flake. Both classes are represented by very small amounts of material.

Spheroidal hammerscale was recorded from Phase 2 (Bronze Age) contexts 2263, 2336 and 1919. Possible flake hammerscale occurred in Phase 2 context 2336. In each case the hammerscale was represented by only a single particle. Indeterminate microscopic slag fragments occurred in contexts 1420, 1484 and 1975.

Phase 3 (Iron Age) context 1404 yielded two pieces of flake hammerscale. A possible microscopic slag fragment was recovered from context 1723.

Phase 4 (Romano-British) contexts yielding hammerscale were rather more abundant and provide slightly more evidence for ironworking at this period. Flake hammerscale was recorded from contexts 2123, 2153 and 2510. Spheroidal hammerscale occurred in context 2437. Both classes of hammerscale occurred together in contexts 2345/2346, 2371, 2431 and 2489

In addition, spheroidal hammerscale was recovered from contexts 1798, 2212, 2213, 2283 and 2374 (which also contained flake hammerscale), all of which yielded assemblages otherwise indicative of copper working. It is uncertain whether these spheroids are a residue from the copper working process, or whether they are indicative of iron working.

Possible copper smelting residues

Residues from probable Phase 4 copper working are extremely significant. Each assemblage from the site may contain some or all of various classes of residue: slag, metal droplets, fired gravelly clay, fired prepared clay (including tuyères and probable daub superstructure) and an iron- and charcoal-rich sintery material. Such assemblages derive from fifteen features, in some cases described as possible "kilns", but also as "pits" and "postholes":

Pit 1767
Pit 1796
Pit 2034
Pit 2071
Posthole 2210
?Pit 2219
Posthole 2242
Posthole 2252
Pit 2257
?Posthole/kiln 2272
?Posthole/kiln 2281
?Pit/kiln 2290
?Posthole/kiln 2297
?Pit/kiln 2313

?Kiln 2373

The rich assemblages of fine-grained residues in these contexts, together with the slabs of friable hearth or furnace lining, suggest that these contexts represent either *in-situ* metalworking, or primary dumps from hearth clearance.

One context (c2220; primary fill of pit 2219) yielded a very small fragment of what appears to be an azurite-bearing copper ore.

The fired clay from these contexts contained four broad categories of material, all with variable degrees of vitrification:

1. fired porous gravelly clay. This material is almost entirely reduced-fired. It bears pieces of gravel grade stone clasts in a friable porous clay matrix. It is not clear whether this is a construction material, or simply the natural substrate. The surface may be deeply vitrified, often with a slightly lilac coloured zone at and below the base of the vesicular vitrified zone. The surface may show adhering weathered metal droplets.

2. prepared lining. This material is of a fine-grained reduced-fired clay, sometimes containing some organic temper and having a smooth surface, which appears to have been applied to the surface of material of type 1. The material does not appear to have been applied uniformly to the bowl of the hearth and some fragments appear to show its upper limit.

3. prepared clay superstructure? This material is of a fine-grained clay and contains holes of 20-25mm diameter at low angle to its face. The hole size is similar to the bore of the tuyère material (see below), but the low angle of the holes to the surface suggests that instead these may be the impressions of wattles supporting a furnace superstructure.

4. tuyère. Three conjoining fragments (c 2243 and 2245) indicate a flat-sided tuyère block. The shape cannot be completely reconstructed, but the best-preserved side of the tuyère is almost planar but just very slightly convex. The axis of the bore reaches the front face 43mm above this surface. The bore is approximately 24mm. The front face is approximately perpendicular to the bore and at 98° to the planar side (the bore being inclined at 8° to the planar surface). The margin of the planar surface is indicated by a rounded angle offset approximately 60mm from the axis of the bore. It is uncertain whether the block would have originally been rectangular (compare the iron-working tuyère from Carpow; Tylecote 1986), or whether the flat side is a planar base and the whole tuyère had a "D"-shaped section (compare the Saxon tuyères from Rook Hall, Essex).

The slags from these contexts are relatively sparse and occur in small blebby pieces. A few pieces of dense black glassy slags also occurred. Many of the slags may be the result of interaction between copper and the debris in the hearth/furnace. Some small fragments of iron- and charcoal-rich material may have been

Small droplets of heavily corroded copper (or copper alloy) metal occur widely in these contexts.

Other materials

Small indeterminate slag fragments occurred in a number of the sieved residues.

Most of the sieved samples did not contain slag, but were dominated by magnetic grains of natural rock (79 samples; probably mainly heated rather than originally magnetic) and by large quantities of burnt organic material with a coked texture (32 samples). This material contains particles originally both of wood/charcoal and bone, but for most particles the original material was not determinable from visual inspection. A few samples contained iron-rich magnetic material with a rough flake-like morphology; whether these were derived from oxidation crusts on rocks or from rusted iron is not known.

Phase 2 context 1369 yielded a tiny strand of copper alloy, probably either a small waste scarf fragment from metalworking, or possibly from damage to an artefact.

Interpretation

The locations providing evidence for copper processing are scattered across the south-western part of the site. Features 1766 and 1796 lie close to [7107 8719]. Features 2034 and 2071 lie at [6990 8780]. The main group of 11 features lies around [7040 8740], but is divided into three: c2373 approximately 5m to the west of a cluster of features (c2219, 2242, 2252, 2257) which themselves lie 10m northwest of an approximately linear array of features (from north to south c2272, 2210, 2281, 2297, 2290, 2313).

The complete lack of evidence for crucibles or moulds from the site, coupled with the lack of evidence for tin contamination of the metallurgical ceramics previously examined by David Dungworth for CA, and with the possible example of copper ore, all suggest that the processing carried out on the site may have been primary smelting. Llanymynech hill, 3km NNW of the site, was a significant source of copper ore in early times. The ore appears to be characterised by a high natural zinc content, and use of copper from this source has been implicated in a group of prehistoric artefacts from central and northern Wales (Musson & Northover 1989; Northover 1991; Musson et al. 1992). The extensive use of intentional copper-zinc alloys (brass, gunmetal) in the Roman period means that the use of zinc-rich copper is not readily identifiable.

It has been suggested, on the basis of the high iron content of some of the high-zinc copper materials from the area, that the ore smelted at Llanymynech would have been a chalcopyrite ore (Northover in Musson et al. 1992 p. 275). The smelting of chalcopyrite would be expected to produce significant quantities of iron-rich slag, which have not been observed. The possible azurite ore fragment, suggests that carbonate ores might also have been available, and these could have been smelted with very little slag production.

Evaluation of potential

The possibility of copper smelting being undertaken on the site requires detailed investigation. If confirmed this would be of national significance. Extremely few early copper smelting sites have been identified in Britain and no Iron Age or Roman smelting furnaces are known in Britain at all.

The site may therefore have potential to enhance understanding of one of Britain's copper sources and also to contribute to understanding of furnace technology.

On a much smaller scale, the occurrence of slag spheroids in the copper processing residues is unexpected. Although the best-known form of slag spheroid is spheroidal hammerscale produced during iron working (Allen 1986; Starley 1995; Unglik 1991; Crew 1996), other origins for such bodies are known (e.g., production from iron-rich fuel ash, Young 2005), and the origin of these spheroids should be further investigated.

It is recommended that further detailed analyses be undertaken of a suite of the copper processing residues to provide additional information on their origin. Analysis (chemical and microstructural) should embrace slags, metal droplets, possible ore and slag spheroids, as well as further microscopy and ED-XRF on the ceramics to continue the investigations started by David Dungworth.

The archaeometallurgical investigations should be accompanied by re-appraisal of the field records of the contexts that produced the residues, with a view to re-evaluating whether any or all of those features might be furnaces. Ideally, independent dating of these features would also be highly desirable.

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