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THE UNIVERSITY OF ASTON IN BIRMINGHAM

DEPARTMENT OF METALLURGY AND MATERIALS ENGINEERING

CHERRY WILLINGHAM (LINCOLNSHIRE)

INTERIM SLAG REPORT

The residues were found in association with a probable Anglo-Saxon smelting furnace. The furnace was not seen during excavation, but from examination of the plans, sections and photographs it appears to have been built in a pit with the pit extending in front of the furnace and sloping upwards, similar to some furnaces from Wakerley (Northants) (site 4, numbers 2, 3, 4A and 4B)[1]. There appears to have been little of the superstructure remaining of the Cherry Willingham furnace, and it is not clear whether there was a 'tap hole' (or 'front arch') or tuyere mouths at the front of the furnace.

The residues from the furnace consisted of furnace lining including burnt clay, smelting slag, and some run or tap slag and fuel ash slag (see table). There was no ore identified amongst the residues.

The Furnace Lining

A total weight of 6.05 kilograms was recovered, and it included a substantial amount of burnt clay. Furnace lining is the clay structure that has been fired to a high temperature, often resulting in vitrification of the internal face, the liningwas also attacked by the slag to a depth of several milimeters and often has concretions of slag adhereing to the internal face. The furnace lining, which survives well in the archaeological record, represents only that part of the structure subjected to intense heat, and is often less than one centimetre thick, being the depth of penetration of the heat. The larger part of the structure may survive as burnt clay though in many cases the bulk of the structure is lost from the archaeological record.

The furnace was built from a very sandy clay, no other material was added to act as a grog, and there was very little carbonaceous material in the fabric. Some of the material was typical of furnace lining in that it had vitrified surfaces (vitrification colour was green) and showed evidence of slag attack. None of the furnace lining showed evidence of tuyere mouths, (i.e. the hole in the furnace through which the air blast was introduced).

The Smelting Slag

Smelting slag is the slag derived from the smelting process which was not tapped from the furnace and therefore occurs in randomly shaped lumps. It was either retained within the furnace when the 'bloom' (the lump of reduced iron) was removed or may have been raked out in a viscous state and cooled outside the furnace.

The smelting slag from the site was typical, randomly shaped lumps, of varying size (e.g. from several cc's volume to hundreds of cc's volume), large charcoal impressions were present (several centimetres long), and many surfaces showed evidence of having flowed. Several random specimens were sectioned, polished and examined under the reflecting light microscope. The microstructure of the slags was of fayalite (iron silicate) laths and a very low percentage (five per-cent maximum) of iron oxide dendrites in a glassy matrix. In certain sections there was no iron oxide present, and throughout the specimens there were occasional inclusions of metallic iron. X-ray diffraction was used to confirm the presence of fayalite and showed the iron oxide present to be wustite (FeO).

The Tap (or run) Slag

A small quantity of run slag was present, mostly in the form of small randomly shaped pieces. There was one large 'pan', approximately 15 cms in diameter, but only 1.5 cm

thick. It appeared to be the result of several flows of slag.

Fuel Ash Slag

There was only a very small quantity (0.125 kg) of Fuel Ash slag present. It is believed to be formed by the reaction of the fuel with high silica bearing materials, e.g. sand and clay, and occurs as a very low density, heavily gassed pale coloured slag. It was present, as expected, adhering in small quantities to the furnace lining. The sandy texture of the furnace lining would encourage the formation of fuel ash slag, its lack of presence in quantity suggests that other conditons prevailed to prevent its formation.

Interpretation

The lack of a quantity of tap or 'run' slag shows that the furnace was not tapped, i.e. during the smelting process, the excess slag was not run off, (which enables more slag to be formed thus smelting a greater quantity of ore which produces a larger bloom). The microstructure of the smelting slag indicates that it cooled relatively quickly and the flowed nature of some of the surfaces, therefore suggest that the slag may have been raked from the furnace, while in a viscous state, this may have occurred at the end of the smelt, i.e. during removal of the bloom, or part way through the process to enable more slag to form. The run slag, and the larger slag 'pan' are the result of the outflow of liquid slag and may therefore be derived from an initial flow of slag when the furnace was opened.

Conclusion

The amount of residue is consistent with a single operation of the furnace, which was of the non slag-tapping variety.

CHERRY WILLINGHAM (CW 80) - SLAGS

Context	Slag types present	Amount (kg)
AA (upper fill of furnace)	Furnace lining	0.810
	Fuel Ash slag	0.125
	'Run' Slag	0.270
	Smelting slag	1.835
AB (lower fill of furnace)	Furnace lining	0.050
	Run slag (including 'pan')	1.300
	Smelting slag	2.540
AC (furnace lining)	Burnt clay	1.850
AD (furnace lining)	Furnace lining	2.600
B (cleaning level)	Smelting slag	1.400
D ('stoke hole fill')	Furnace lining	0.740
	Run slag	0.250
	Smelting slag	2.550
TOTALS:	Furnace lining (incl. burnt clay)	6.050
	Fuel Ash slag	0.125
	Run slag	1.820
	Smelting slag	8.325

NOTE:
This is an interim report which will be supplemented by a bulk analysis of the slag at a later date (within the next few months). The analysis, and any further interpretation resulting from it will be forwarded at a later date.

Signed: _____

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References

1. D.A. Jackson and T. Ambrose, Britannia, 1978, 9, p. 153-160