

Ancient Monuments Laboratory  
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EXAMINATION OF SLAGS AND  
MOULDS FROM DYMOCK,  
GLOUCESTERSHIRE

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Summary

Just over 11 kilogrammes of ironworking slag and 5 fragments of ceramic mould were recovered from excavation of the Iron Age and Roman site at Dymock. The ironworking slag assemblage is dominated by tap slag and appears to be almost entirely derived from iron smelting. The mould fragments would have been used to produce small copper alloy artefacts which can be reconstructed as a trumpet brooch, a Colchester derivative brooch, a cone-headed pin and a lunate fitting.

Author's address :-

D Dungworth  
ENGLISH HERITAGE  
Centre For Archaeology Fort Cumberland  
Fort Cumberland Road Eastney  
Portsmouth  
HANTS  
UK  
PO4 9LD

# Examination of Slags and Moulds from Dymock, Gloucestershire

David Dungworth

## Introduction

In 1994 and 1995 Gloucestershire County Council's Archaeological Service carried out archaeological excavations for Severn Trent Water Ltd on the site of an extension to the sewage treatment works at Dymock (NGR SO 7027 3123). Excavations revealed a Roman period farmstead, although SMR records indicate the presence of a possible small town in the vicinity.

## Ironworking Slags

The total quantity of slag and other debris is 192 pieces totalling 11,485 grammes weight (see table 1). A large portion of the slag is tap slag that would have been produced during smelting iron from iron ores. Given the lack of any distinctive smithing slags, the large quantity of undiagnostic slags probably relate to iron smelting. The small size of this assemblage (in particular the small quantity of furnace lining) suggests that the smelting did not take place within the area excavated but somewhere nearby.

	Coal	Ore	Daub	Furnace lining	Fuel Ash Slag	Tap Slag	Undiagnostic	TOTAL
Roman		175	34	23	61	1979	507	2779
Post-Roman	1		86			1279	3791	5157
Unphased	2	406		130		1665	1346	3549
TOTAL	3	581	120	153	61	4923	5644	11485

Table 1. Weight of slag (grammes)

It is possible that the post-Roman slags are Roman in origin and are residual in the later contexts. The large quantity of undiagnostic slag in post-Roman contexts, however, may possibly relate to other iron working, e.g. iron smithing. The lack of diagnostic iron smithing slags (in particular smithing hearth bases) from Dymock make this no more than a possibility.

## Explanation of terms used

The fragments of dense, fayalitic (iron silicate) **tap slag** show a characteristic 'ropy', flowed, morphology on their upper surface and low vesicularity at their fracture surfaces. These are diagnostic of smelting (i.e. primary extraction from the ore) of iron and are typical waste products of the tapped bloomery furnace, in use during the Roman period, from which the molten slag was run out rather than collecting within its interior.

Fifteen iron-rich stones were examined and classed as **ores**. These were either reddish-orange and moderately friable or very hard and grey-black. Two fragments of ore (one of each type) were analysed using x-ray diffraction (XRD), which indicated that the reddish-orange ore is hematite and the grey-black ore is goethite. Both hematite and goethite can be found in the Forest of Dean (Fulford & Allen 1992: 188).

**Vitrified furnace lining** is produced by a high temperature reaction between the clay lining of a hearth or furnace, and the alkali fuel ashes or fayalitic slag. It can be formed by iron smelting, iron smithing, non-ferrous metalworking or other pyrotechnical processes. This material usually shows a compositional gradient from un-modified clay on one side to a glazed surface or irregular cindery material on the other.

**Fuel ash slag** is a very lightweight, light coloured (grey-brown), highly porous material which results from the reaction between alkaline fuel ash and silicates from soil, sand or clay at elevated temperatures. The reaction is shared by many pyrotechnological processes and the slag is not diagnostic. Energy dispersive x-ray fluorescence (EDXRF) analysis shows the presence of silicon and alkalis such as calcium, potassium and sodium with little or no iron.

Most assemblages of slag include **undiagnostic ironworking slag**, which is also of fayalitic composition and can be formed during iron smelting or iron smithing. However, in the absence of any clear evidence for the former it is probable that the undiagnostic slag also derives from iron smelting. It is possible that while some slag was removed in the molten state from the furnace, some may have remained inside the furnace.

## Moulds

Four mould fragments were submitted for examination (and a fifth was discovered during the assessment of the ironworking slag). The first four moulds are all in the same condition and were made from similar materials. They were all made from a grey-green clay tempered with mica, limestone, sandstone and an unidentified black mineral. The mica and the black temper are generally fine (up to 0.5 mm across) while the limestone and sandstone temper is coarser (up to 3 mm across). The softness of the clay fabric of the moulds suggests that they have not been fired to a high temperature. The last mould fragment is superficially similar to the others; the outer surface is a grey-green colour but the inner surface is black. The range of tempers used is similar but the particle size is smaller. The first four moulds would all have been used in pairs (front and back or left and right) as two-piece moulds; not enough survives of the last mould to be certain whether it was a piece mould or a >lost wax= mould. The shapes of the individual moulds (and of the artefacts which would have been cast from them) are discussed in turn below.

The EDXRF spectra collected from each mould showed the presence of zinc, lead and copper at levels far above what might be expected naturally in the clay or temper. While tin was not detected in any of the cases previous work has established that tin rarely penetrates mould fabrics to the same extent as lead and zinc. The differences in vapour pressure and other factors make the reconstruction of the actual alloy type used (bronze, brass, gunmetal, etc) impossible. Nevertheless the moulds clearly have been used, probably to produce copper alloy objects.

**sf 17 context 1037**

Dimensions: 41 mm by 25 mm by 13 mm

The impression is of a conical-headed pin. The conical head is 10 mm in diameter at its base and 13 mm high. The shaft is incomplete but approximately 3 mm in diameter and at least 23 mm in length.

**sf 21 context 1066**

Dimensions: 35 mm by 20 mm by 6 mm

The impression is of a fairly thin curvilinear artefact (surviving dimensions are roughly 25 mm by 20 mm by 2 mm). The depth of the impression and the flatness of the mould suggests that this portion of the mould was the >back= into which the pattern was first impressed. The surviving portion can be reconstructed as a lunate fitting such as those used to decorate horse harness (cf. Allason-Jones 1991: fig 112, No 57) or as a brooch (cf. Hawkes & Hull 1947: plate XCVIII, 170B3.)

**Sf 22 context 1067**

Dimensions: 22 mm by 20 mm by 10 mm (approximately)

The impression is of a rib or fin emerging from a larger curved object. One possible artefact which could have been produced from such a mould is a Colchester derivative brooch, the >fin= being the end of the rib running along the bow and terminating at the spring end of the brooch. This mould appears to have been subjected to some localised heating, which has turned the clay orangey-brown. This may be associated with the use of the mould or may have occurred accidentally after the mould was discarded. The shape of the mould, in particular its curvature, suggests that it was the >front= valve of the two mould halves.

**Sf 23 Context 1065**

Dimensions: 28 mm by 21 mm by 11 mm

This mould is one side of a left-right mould of a trumpet brooch (cf Hattatt 1982: 106) and is similar to one found at Prestatyn (Blockley *et al.* 1989: 184–7; Bayley 1988: figure 7). The mould is incomplete but shows the brooch from the head to approximately half way down the catch plate. The features, which can be made out, are described in turn starting at the head and working down to the catch plate. The flat lug protruding from the back of the head has a single opening for an axial pin. The head shows the usual >trumpet= expansion and the tight angle to the axis of the bow. The central moulding is fairly plain and conforms to Collingwood=s R(i).

**sf none context 1067**

Dimensions: 30 mm by 16 mm by 8 mm

This mould fragment appears to have been fired. The interior surface is reduced-fired black although the outer surface is still a grey-green colour. The fragmentary nature of the mould makes it difficult to be sure that this was a piece mould rather than a >lost wax= mould. Given the nature of the other moulds from this site and other Roman sites in Britain a piece mould is the more likely. The impression is of a curving bar with a single rib. One artefact type that could possibly have been made using this mould is a Colchester derivative brooch, however, not enough survives of the mould for this to be a certain interpretation.

## Conclusions

The types of ironworking slags from Dymock that can be clearly related to a particular process are all indicative of iron smelting. This is reinforced by the recovery of fragments of ores. The iron was smelted from hematite and goethite using the bloomery process. However, the small amount of furnace fragments and the small size of the slag assemblage as a whole suggest that iron smelting did not take place within the area excavated. It is unlikely that such material would be transported over large distances and the iron smelting would have taken place somewhere close to the area excavated. The five moulds recovered indicate that copper alloy casting took place nearby. None of the mould fragments are joining fragments and these may represent a small fraction of the total number of moulds which were originally produced.

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## Appendix

List of slag and other metallurgical debris (excluding moulds) from Dymock STW, Gloucestershire by context

Context	Type	Period	Weight
101	Tap slag	Modern	2
102	Undiagnostic	Medieval/Post-medieval	1
102	Undiagnostic	Medieval/Post-medieval	7
102	Undiagnostic	Medieval/Post-medieval	105
102	Tap slag	Medieval/Post-medieval	7
102	Tap slag	Medieval/Post-medieval	9
102	Tap slag	Medieval/Post-medieval	41
104	Tap slag	Roman	31
104	Tap slag	Roman	18
104	Tap slag	Roman	24
104	Tap slag	Roman	7
202	Tap slag	Medieval/Post-medieval	19
203	Ore	Geological	66
215	Fuel ash slag (17 fragments)	Roman	21
219	Ore	Roman	29
305	Undiagnostic	Medieval	33
305	Tap slag	Medieval	28
305	Tap slag	Medieval	24
406	Undiagnostic	?	21
406	Ore	?	44
406	Tap slag	?	28
1002	Undiagnostic	Modern/Post-medieval	521
1003	Coal	?	2
1003	Furnace lining slag	?	130
1003	Undiagnostic	?	268
1003	Undiagnostic	?	80
1003	Undiagnostic	?	92
1003	Undiagnostic	?	30
1003	Undiagnostic	?	93
1003	Undiagnostic	?	22
1003	Undiagnostic	?	27
1003	Undiagnostic	?	32
1003	Undiagnostic	?	1
1003	Undiagnostic	?	4
1003	Undiagnostic	?	10
1003	Ore (4 fragments)	?	190
1003	Tap slag	?	31

<b>Context</b>	<b>Type</b>	<b>Period</b>	<b>Weight</b>
1003	Tap slag	?	154
1003	Tap slag	?	142
1003	Tap slag	?	13
1003	Tap slag	?	6
1003	Tap slag	?	8
1003	Tap slag	?	16
1003	Tap slag	?	7
1003	Tap slag	?	22
1003	Tap slag	?	52
1003	Tap slag	?	67
1003	Tap slag	?	22
1003	Tap slag	?	34
1003	Tap slag	?	39
1003	Tap slag	?	39
1004	Undiagnostic	?	69
1004	Undiagnostic	?	46
1004	Undiagnostic	?	30
1004	Ore	?	143
1004	Tap slag	?	92
1004	Tap slag	?	74
1004	Tap slag	?	44
1004	Tap slag	?	26
1004	Tap slag	?	25
1004	Tap slag	?	24
1004	Tap slag	?	9
1004	Tap slag	?	5
1008	Undiagnostic	Post-medieval	43
1008	Tap slag	Post-medieval	32
1018	Undiagnostic	Post-medieval	7
1018	Undiagnostic	Post-medieval	20
1018	Undiagnostic	Post-medieval	28
1018	Undiagnostic	Post-medieval	36
1018	Undiagnostic	Post-medieval	40
1018	Undiagnostic	Post-medieval	31
1018	Tap slag	Post-medieval	53
1018	Tap slag	Post-medieval	72
1018	Tap slag	Post-medieval	12
1018	Tap slag	Post-medieval	14
1018	Tap slag	Post-medieval	27
1019	Undiagnostic	?	31
1019	Undiagnostic	?	71



<b>Context</b>	<b>Type</b>	<b>Period</b>	<b>Weight</b>
1019	Undiagnostic	?	103
1019	Undiagnostic	?	299
1019	Tap slag	?	17
1028	Ore	Roman	43
1030	Daub (reduce fired)	Post-medieval?	16
1030	Undiagnostic	Post-medieval?	599
1030	Undiagnostic	Post-medieval?	25
1030	Undiagnostic	Post-medieval?	15
1030	Tap slag	Post-medieval?	5
1030	Tap slag	Post-medieval?	6
1030	Tap slag	Post-medieval?	10
1035	Undiagnostic	Roman	4
1035	Undiagnostic	Roman	28
1035	Undiagnostic	Roman	28
1035	Undiagnostic	Roman	30
1035	Tap slag	Roman	23
1035	Tap slag	Roman	32
1035	Tap slag	Roman	9
1035	Tap slag	Roman	30
1035	Tap slag	Roman	100
1035	Tap slag	Roman	134
1035	Tap slag	Roman	80
1035	Tap slag	Roman	98
1035	Tap slag	Roman	60
1035	Tap slag	Roman	80
1035	Tap slag	Roman	51
1035	Tap slag	Roman	104
1035	Tap slag	Roman	26
1035	Tap slag	Roman	58
1035	Tap slag	Roman	162
1037	Tap slag	Roman	39
1039	Undiagnostic	?	17
1039	Tap slag	?	10
1039	Tap slag	?	14
1039	Tap slag	?	20
1039	Tap slag	?	10
1039	Tap slag	?	55
1039	Tap slag	?	70
1046	Daub	Post-medieval	70
1046	Undiagnostic	Post-medieval	54
1046	Undiagnostic	Post-medieval	315

<b>Context</b>	<b>Type</b>	<b>Period</b>	<b>Weight</b>
1046	Undiagnostic	Post-medieval	333
1046	Undiagnostic	Post-medieval	56
1046	Undiagnostic	Post-medieval	11
1046	Undiagnostic	Post-medieval	22
1046	Undiagnostic	Post-medieval	440
1046	Tap slag	Post-medieval	172
1046	Tap slag	Post-medieval	313
1047	Undiagnostic	Post-medieval	798
1047	Tap slag	Post-medieval	29
1050	Undiagnostic	Post-medieval	115
1051	Ore	Roman	61
1051	Tap slag	Roman	24
1064	Undiagnostic	Roman	30
1064	Undiagnostic	Roman	6
1064	Tap slag	Roman	5
1064	Tap slag	Roman	37
1064	Tap slag	Roman	57
1065	Daub	Roman	21
1067	Daub (coarse mineral temper)	Roman	13
1067	Furnace lining slag	Roman	23
1067	Undiagnostic	Roman	31
1067	Undiagnostic	Roman	19
1067	Undiagnostic	Roman	6
1067	Ore	Roman	13
1067	Tap slag	Roman	75
1067	Tap slag	Roman	6
1067	Tap slag	Roman	62
1067	Tap slag	Roman	65
1067	Tap slag	Roman	20
1067	Tap slag	Roman	34
1067	Tap slag	Roman	15
1067	Tap slag	Roman	8
1067	Tap slag	Roman	5
1071	Coal	Post-medieval	1
1071	Undiagnostic	Post-medieval	114
1071	Tap slag	Post-medieval	5
1071	Tap slag	Post-medieval	6
1071	Tap slag	Post-medieval	7
1071	Tap slag	Post-medieval	9
1076	Undiagnostic	Post-medieval	13
1076	Tap slag	Post-medieval	323

<b>Context</b>	<b>Type</b>	<b>Period</b>	<b>Weight</b>
1076	Tap slag	Post-medieval	39
1076	Tap slag	Post-medieval	15
1082	Undiagnostic	Roman	21
1084	Tap slag	?	335
1099	Ore	?	29
1111	Tap slag	?	10
1111	Tap slag	?	42
1118	Fuel ash slag	Roman	18
1118	Fuel ash slag	Roman	13
1118	Fuel ash slag	Roman	9
1118	Tap slag	Roman	113
1126	Tap slag	Roman?	36
1126	Tap slag	Roman?	37
1139	Tap slag	?	103
1166	Undiagnostic	Roman	33
1169	Tap slag	Roman	9
1170	Undiagnostic	Roman	31
1170	Undiagnostic	Roman	81
1170	Undiagnostic	Roman	16
1170	Undiagnostic	Roman	5
1170	Tap slag	Roman	53
1170	Tap slag	Roman	15
1170	Tap slag	Roman	137
1192	Undiagnostic	Roman	2
1192	Undiagnostic	Roman	3
1192	Undiagnostic	Roman	7
1192	Undiagnostic	Roman	13
1192	Undiagnostic	Roman	25
1192	Undiagnostic	Roman	30
1210	Undiagnostic	Medieval?	9
1230	Undiagnostic	Roman	35
1238	Undiagnostic	Roman	23
1238	Ore (2 fragments)	Roman	13
1240	Ore	Roman	16