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Pyrotechnological residues from Bornais, Mounds 2 and 2a

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Pyrotechnological residues from Bornais, Mounds 2 and 2a

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Abstract

The pyrotechnological residues from both Mounds 2 and 2A were dominated by fuel ash slag (FAS). Sampling was not undertaken at 100% for all contexts, so total amounts of slag retrieved are only indicative of abundance, but Mound 2 yielded 2.5 kg of FAS, whereas Mound 2A produced a total 100kg.

The fuel ash slag was mostly very fine grained, with an average particle weight of less than 0.4g. Such fine-grained residue assemblages parallel those previously described from both domestic hearths and cereal kilns at Bornais. Larger FAS masses were also recovered; these typically had a sheet-like form, mostly up to 30mm in thickness, but the Middle Norse ash layers and Late Norse middens on Mound 2A both produced examples ranging up to 80mm in marginal thickness. The FAS sheets showed glassy tops, often with small spheroidal particles of FAS apparently frozen in the process of merging into the sheet. The body of the slag sheets was highly vesicular, with some examples showing large cavities bearing discontinuous linings of foliated buff/orange 'ash', probably representing the moulds of wood fuel pieces. The bases of the sheets were typically formed by a slightly lobate, glassy, non-wetting surface, to which was locally attached rough sintered sand extending down from the otherwise planar surface.

On Mound 2, moderate quantities of FAS were retrieved from the occupation deposits of House 1, and a slightly lesser quantity from the occupation of House 2. Moderate quantities were also present in the infill of the House 2 hollow, but House 3 produced very little slag. Rather larger quantities (although still modest) were retrieved from Late Norse contexts in Areas H and I.

Large quantities of slag (14.5kg recovered) were present in the Early Norse (pre-mound) deposits of Mound 2A. Hearths with associated ash deposits were observed in this succession, but these yielded only modest assemblages of mainly small particles. The bulk of this early material may have been derived from elsewhere. Middle Norse contexts on Mound 2A produced large quantities of FAS (total weight 60.9kg; 61% of the assemblage from the mound), with small amounts directly associated with the two kilns, but very large quantities from the peripheral ash layers (50kg). The late Norse peripheral middens on Mound 2A also produced large amounts of slag (15kg), but the modest amounts of slag from the Late Norse houses largely came from construction and infilling deposits, rather than occupation. The Late Norse ancillary structures produced modest assemblages by weight, but persistently high numbers of small particles.

Both mounds also produced very small quantities of iron-working (smithing) slag. On Mound 2 this comprised five small fragments (total weight 30g) from Late Norse features in Block IB. Mound 2A produced five fragments of (or containing) iron slag, with a total weight of 601g, all from the Early Norse deposits of Block GA. Although these quantities are small, they are significant because evidence for iron working has not been recorded from the other excavated mounds.

Contents

Abstract 1

Methods 2

Results
Description of Residues 2
Fuel ash slags (FAS) 2
Smithing residues 3
Distribution of Residues 3
Fuel ash slags (FAS) 3
Smithing residues 3

Interpretation
Fuel ash slags (FAS) 3
Smithing residues 4

References 5

Table 1: summary catalogue Mound 2 6
Table 2: Mound 2 catalogue by block..... 10
Table 3: summary catalogue Mound 2A..... 12
Table 4: Mound 2A catalogue by block 23
Table 5: summary of detailed examinations 25

Methods

The material described here derives from excavations at Bornais, South Uist, conducted by Niall Sharples. Full details of sampling methods and policies are provided in the site reports.

The entire slag collection was counted, weighed and logged to a database (Tables 1 and 3; stratigraphy summarised in Tables 2 and 4), with unusual or particularly potentially informative specimens examined further in more detail (Table 5).

Results

Description of residues

A total of approximately 2.5kg of residues (approximately 12,000 particles) from 119 contexts was recovered from Mound 2, and a total of 100kg of material (approximately 276,000 particles) was recorded from 383 contexts on Mound 2A.

This large collection almost entirely comprised of very small particles (the overall average weight for the recovered particles was 0.20g on Mound 2 and 0.36g on Mound 2A) of fuel ash slag (FAS), together with a component of large pieces of FAS, ranging rarely up to 600g in weight.

The FAS assemblage from Mounds 2 and 2a was very similar in appearance, structure and overall morphology to materials described previously from Mounds 1 (Young 2012a) and 3 (Young 2005). No new laboratory analysis was applied, therefore, to the additional material.

There was also a very small component of ironworking slag, mostly fragments of smithing hearth cakes, with a total weight of just 631g.

Fuel Ash Slags (FAS)

The fuel ash slag varied greatly in fragment size. The original form of the FAS ranged from tiny individual particles of sand-grade partially molten material to large coalesced sheets. The sheets were broken into fragments of all sizes, with fragments of up to 600g, but with the majority reduced to pieces of less than 5g. There was only one large fragment that was probably an entire FAS cake.

The very fine-grained FAS represents a mixture of comminuted debris from larger slag cakes and tiny original particles, including extremely low-density spheroids.

The single possibly complete, large FAS cake (from context (1196), Block GAA, Mound 2) was of a slightly concavo-convex form, with the central upper concavity bearing a pad several mm thick of soft ashy residue. The cake was 140 x 170mm in diameter, with a sintery, irregular margin, and a central zone (below the ashy residue) that was approximately 35mm thick. The cake weighed 470g. The size of this FAS accumulation indicates a very localised area of slag formation, despite the 35mm thickness, and must indicate formation in a hearth with a very focused heat. The survival of the ashy residue adhering to its upper surface is unusual and presumably indicates a low degree of reworking, despite the location of the find in an agricultural soil.

The more typical FAS sheet fragments varied between 15mm and 35mm in thickness, but larger examples ranged up to 80mm in thickness, with the thickest areas apparently forming the margins of the sheets. These edges suggest that the sheets both thicken and have rising bases towards the earth margin.

The bases of sheets usually have a thin, discontinuous, layer of sand attached to the base of the sheet by a glassy cement. This sintered layer was commonly extremely intermittent, with the well-defined base to the slag layer proper visible in the gaps. In most cases the base of the slag was of a mostly non-wetted appearance, with an overall planar base, but formed by very slightly convex lobes of grey glassy slag separated from each other by narrow crevices.

The FAS showed little variety in its internal features: it was pale (in the range of mid-grey to almost white), highly vesicular (locally frothy), with both small, almost spheroidal vesicles and large roundedly tabular cavities up to several tens of millimetres across.

The upper surface of a typical sheet was of a slightly greenish glass, somewhat lobate, with upwardly convex lobe surfaces, but with little or no indication of flow. The slag appears, in general, to have been highly viscous (hence the high degree of bloating, because any gas generated with the slag tended to be trapped within the partially melted slag). The surface commonly showed small protuberances (typically 1mm or less wide) which graded into barely-attached FAS spheroids – suggesting that at least part of the slag was provided by descending tiny droplets.

Within many of the fragments of thicker sheets, there were cavities of an unusual form. These were large (often 20-30mm across) and elongate, with either circular or semi-circular cross sections. They showed a rough (albeit vitrified) surface to the surrounding slag, although that was usually well-vitrified. These cavities contained small quantities of small yellow or red-brown clusters of platy particles and dusty material around their margins. The platy particles we often apparently

aligned giving an overall foliated appearance to these cavity-lining deposits. These voids are probably fuel moulds, with small quantities of remnant ash. Their shape suggests they formed around small branch-wood.

Some of the large sheet fragments deviated from the usual planar base. A piece from context (874) (Block GBG; Mound 2A) showed a basal contact that appeared to be suggestive of a more bowl-shaped, rather than planar base. A sheet fragment from context GDA (context 864; Mound 2A) showed a well-developed, sharp, planar non-wetted basal surface, but this surface locally had some foliated reddish material attached, possibly suggesting the slag had formed over a large flat piece of wood, rather than a stone, that might otherwise be suggested by the sharp non-wetted surface.

Amongst the residues in the Middle Norse phase ash dumps (presumably from the kilns) on Mound2a (context (750), Block GBG), was a single example of an elongate green glassy prill. This 7g slag fragment was the largest piece recovered showing clear evidence for flow.

Smithing residues

A single almost complete example of a smithing hearth cake (SHC) was recovered from context (1193) of Block GAD on Mound 2A. The piece was 100mm x 75mm, although not complete in either dimension, and was 40mm thick. This SHC showed a well-layered structure, with a fine, pale, vesicular top, 5mm thick, overlying a 10mm thick layer with elongate olivine (and bearing a rounded lining slag clast laterally), an 8mm thick dense layer of finely granular olivine layer, and a basal 5mm thick vesicular layer, with elongate olivine. The piece weighed 393g and comprises probably approximately 80% of the original SHC. The SHC base is smooth with small prilly extensions and lumps. The top is smooth but irregular and formed of a pale sandy glass. The base also has rusted inclusions

A somewhat similar, but smaller, SHC fragment weighing 97g was recovered from context (2381) from the same stratigraphic block. The upper part has a large upstanding embedded mass of sandy black glass with an abrupt contact with underlying eutectic olivine/glass. This cake was 40mm thick, with a microprilly base and a top (away from the lining slag inclusion) shows fuel dimples approximately 10mm across.

A slightly different texture was exhibited by an SHC fragment of just 40mm x 45mm and 15mm thickness from context (1791) of Block GAA. This showed a base of sintered appearance and a top with raised lobes suggestive of formation from a descending slag. These features raise a degree of comparison with the FAS, but the composition is that of an ironworking slag.

Block GAA also produced (from context (2416)) a small fractured concretion bearing both some corroded iron (of uncertain form) and a small slag fragment that appears to be from ironworking.

Mound 2 also yielded a few ironworking slag fragments with five small fragments (total weight 30g) from context (1521) of Block IB. The slag fragments included a rather irregular slag lobe and two small fragments from SHCs.

Distribution of residues

Fuel Ash Slags (FAS)

The stratigraphic distribution of the recovered residues is given in Tables 2 and 4.

Mound 2 produced a relatively small assemblage of FAS with a total weight of just 2.5kg. Moderate quantities of FAS were retrieved from the occupation deposits of House 1, and a slightly lesser quantity from the occupation of House 2. Moderate quantities were also present in the infill of the House 2 hollow, but House 3 produced very little slag. Rather larger quantities (although still modest) were retrieved from Late Norse contexts in Areas H and I.

Mound 2A produced a much larger assemblage with a total weight of approximately 100kg. Large quantities of slag (14.5kg recovered) were present in the Early Norse (pre-mound) deposits of Mound 2A. Hearths with associated ash deposits were observed in this succession, but these yielded only modest assemblages of mainly small particles. The bulk of this early material may have been derived from elsewhere. Middle Norse contexts on Mound 2A produced large quantities of FAS (total weight 60.9kg; 61% of the assemblage from the mound), with small amounts directly associated with the two kilns, but very large quantities from the peripheral ash layers (50kg). The late Norse peripheral middens on Mound 2A also produced large amounts of slag (15kg), but the modest amounts of slag from the Late Norse houses largely came from construction and infilling deposits, rather than occupation (and may, therefore, potentially be reworked). The Late Norse ancillary structures produced modest assemblages by weight, but persistently high numbers of small particles.

Smithing residues

Both mounds also produced very small quantities of iron-working (smithing) slag. On Mound 2 this comprised five small fragments (total weight 30g) from Late Norse features in Block IB. Mound 2A produced five fragments of (or containing) iron slag (probably representing just 4 pieces), with a total weight of 601g, all from the Early Norse deposits of Block GA. Although these quantities are small, they are significant because evidence for iron working has not been recorded from the other excavated mounds.

Interpretation

Fuel Ash Slags (FAS)

Fuel ash slags are the product of the partial melting of silica- and alumina-rich hearth materials under the fluxing influence of alkali and alkali earth elements present in fuel ash. Wood ash is rich in both calcium and potassium for instance. FAS may be described as a ‘buchite’ – and they typically comprise a glassy melt, binding together relict quartz (and sometimes other mineral) grains. In the Mound 1 examples, the principle new-formed mineral was a salite pyroxene (Young 2013). In the In the case of sites like Bornais, a calcareous substrate will be an additional influence and aid to formation. As a further complication at Bornish, it is possible that peat was employed as an additional fuel, and that this has added much iron into the chemical mix of the partial melts, resulting in a high

proportion of magnetic particles in some of the Bornais assemblages.

FAS is thus a characteristic residue from processes in which the ashy floor of a hearth or kiln is heated sufficiently that the substrate may partially melt, under the influence of the fuel ash. This has been documented for cereal kilns (e.g. South Hook, Young 2010a, 2010b; Ysgol Bro Dynefor, Young 2015), possibly in lime-burning (Young 2012b) and in the conflagration of buildings constructed with daub (Young 2012b). The process is probably responsible for the 'Iron Age Grey' slags that occur particularly in Middle Iron Age contexts in central and eastern England (Cowgill 2000, 2008; Cowgill *et al.* 2001; Swiss & McDonnell 2001; Young 2009, 2011; Young & Bowstead Stallybrass 2003), and which share many structural and morphological features with the coarse FAS materials from Bornais. The generation of FAS in these settings is also similar in many ways to the formation of 'cramp' (Photos-Jones *et al.* 2007).

FAS has been described previously from Mounds 1 (Young 2012a) and 3 (Young 2005) at Bornais. On Mound 1 FAS occurred as very small particles associated with a large hearth inside the Late Iron Age house (CB. Slag also occurred on Mound 1 in much larger fragments from sheet-like cakes, in Late Norse contexts, associated with large, stone-sided hearths. On Mound 3 FAS occurred in small pieces, again in association with the internal hearth in a Late Norse house, but particularly from a contemporary cereal kiln.

The FAS from Mounds 2 and 2A was very similar to that present on both Mound 1 and Mound 3 (though just possibly just slightly darker in colour than some of the Mound 3 material). The presence of a full range of slag morphologies (from very fine-grained particles up to substantial slag sheets) also paralleled the FAS of the other described assemblages. One key difference of the coarse-grained FAS fragments from the Norse contexts on Mound 1 is that they contained partially melted rock fragments, probably spalled pieces of the large slabs employed to line the hearths there.

Mound 2A yielded large FAS fragments from the pre-mound deposits (Block GA), including an almost complete example with a slightly concavo-convex form. It would appear likely that as the cake forms it will develop downwards into the substrate most below its hottest area. Repeated removal of slag cakes from the base of hearths would tend also to cause them to develop a bowl-like profile, as evidenced by the form of the wedge-like margins to some of the thicker slag sheets. These early FAS cakes on Mound 3 are of uncertain origin. Block GA does include some evidence for in-situ hearths, but it I not clear if these generated any of the larger slag sheets.

The stratigraphic evidence from Mound 2A strongly suggests that the Middle Norse phase kilns produced both fine-grained FAS residues and larger sheet-like bodies. The investigation of the FAS from the Iron Age kiln on Mound 3 suggested that it produced only small residues (only 3 pieces were recorded as having weights over 3g, out of a collection of 850g), although this was based on study of the kiln itself, rather than any substantial contemporaneous dump of waste. The substantially larger collection from Mound 2A, both from in and around the kilns as well from the peripheral ash deposits, includes 61kg of slag with many examples of large slag sheets.

Since publication of the Mound 3 assemblage, an in-situ FAS sheet has been described from an early medieval cereal kiln near Llandeilo, Carmarthenshire (Young 2015). This slag cake was approximately 300mm by 400mm and was up to 30mm thick. It had a total original weight of 1755g. The structure and appearance of the FAS was extremely similar to that from Bornais. Analysis of the FAS suggested that partial melting of the substrate had been fluxed by the fuel ash, rather than by the calcareous component of the substrate. In fact, the cake was rather calcium-poor but magnesium-rich, suggesting that perhaps straw had been the main fuel and that the slag formation may also have involved some combustion of the cereal grains themselves. Despite the possible chemical differences, the Llandeilo example provides a comparative instance of the generation of a substantial FAS sheet with a cereal kiln. The Llandeilo FAS closely resembles material of a similar age (7th-9th century AD) from south Hook, Pembrokeshire, which occurred only as redeposited material with no recognised kiln.

The large volume of slag that may have been produced in the Block GB kilns (assuming there were no other major unexcavated sources of FAS on Mound 2A in the Middle Norse phase) is remarkable.

The finer-grained slag residues from both Mounds 2 and 2a may also have been generated in hearths within the houses. As with the evidence from Mound 3, it appears that the occupation deposits of the various houses are commonly rich in fine-scale FAS, and this is presumably from their hearths. The large quantity of FAS debris present on the mounds, particularly on Mound 2A, means that residual material may be a component of many of these assemblages.

The recognition of probable fuel moulds in several examples of FAS sheets is significant. Previous discussions of the origin of the FAS at Bornais have emphasised the potential use of peat as fuel. This new evidence suggests the presence of branch-wood within the fuel.

Smithing residues

The smithing slags were largely from well-formed, moderately dense SHCs. Only one piece (a 393g fragment from Mound 2A) suggested an original SHC size; with approximately 80% of the cake present, this piece was originally approximately 500g. An SHC of 500g is most likely to originate in blacksmithing rather than in bloomsmithing (the smithing of raw bloom as part of the *chaîne operatoire* of iron production). SHCs of this size do contain a significant mass of iron (typically around 50% of the weight of the SHC), so indicate processes entailing a substantial loss of iron into the hearth. This might either be from a prolonged work period of light work, or more likely a work period involving forge welding.

The very limited nature of the ironworking residue assemblage does not provide any basis for comparison of the technology with assemblages elsewhere.

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Table 1: summary catalogue of pyrotechnological residues from Mound 2

Context	Description	Block	>2mm		>10mm		Handpicked		total		Block totals		
			No.	wt (g)	No.r	wt (g)	No.r	wt (g)	No.r	wt (g)	block	No.r	wt (g)
1991?	?	?					95	295.6	95	295.6			
56	Yellow sand	AD					1	5.3	1	5.3			
56	Grey brown sand	AD					1	4.7	1	4.7			
68	Grey sand	AD					1	11.5	1	11.5			
69	Grey brown sand	AD					3	39.4	3	39.4	AD	6	60.9
51	Red brown midden	AE					2	5.7	2	5.7	AE	2	5.7
55	Dark brown sand	AG			2		2	1.3	4	1.3			
58	Grey sand	AG					5	74.1	5	74.1	AG	9	75.4
1526/ 1326	light grey sand?	BAE?					1	4.9	1	4.9	BAE?	1	4.9
1075	brown sand	BAG					1	0.2	1	0.2	BAG	1	0.2
1297	light brown sand	BBA					1	8.5	1	8.5	BBA	1	8.5
1818	post hole fill	BBB					7	24.3	7	24.3	BBB	7	24.3
946	dark brown sand	BBC	14	0.2	1				15	0.2			
1514	floor layer	BBC					2	4.1	2	4.1			
1525	floor layer	BBC					5	12.2	5	12.2			
2775	house 1 floor dark brown	BBC	5782	153.5	77	44.3			5859	197.8	BBC	5881	214.3
587	dark brown sand	BBD			1				1	0			
1003	grey brown sand	BBD			3				3	0			
1051	dark brown sand	BBD					1	5.5	1	5.5			
1523	dark brown sand	BBD					1	0.9	1	0.9	BBD	6	6.4
916	pit fill	BCA	9	0.2	8				17	0.2			
922	pit cut	BCA	5200	144.7					5200	144.7			
923	pit fill	BCA	6	0.2					6	0.2			
938	pit cut	BCA	45	1.3					45	1.3			
1239	pit fill	BCA					1	1.2	1	1.2			
2157	fill of cut [2073]	BCA					1	5.5	1	5.5	BCA	5270	153.1
594	white sand	BCB			1	1.0			1	1			
595	dark grey sand	BCB			4				4	0			
917	grey sand	BCB	2	0.1					2	0.1			
944	white sand	BCB	1	0.1					1	0.1			
2634	stone wall	BCB					1	0.8	1	0.8	BCB	9	2
182	Dark brown compact layer	BCC					1	2	1	2			
550	Pale yellow sand	BCC	5	2.7					5	2.7			

581	dark brown sand	BCC			1					1	0					
586	black and orange lenses	BCC			2					2	0					
596	dark brown sand	BCC			3					3	0					
921	pit fill	BCC					1	13.8		1	13.8					
1007	dark brown sand	BCC	476	2.3						476	2.3					
1008	dark brown sand	BCC			20		2	13.5		22	13.5					
1010	dark brown sand	BCC			1					1	0					
1057	dark brown sand	BCC			2	2.1				2	2.1					
1091	red brown sand	BCC			2	4.5	1	0.7		3	5.2					
1234	dark brown sand	BCC					1	0.6		1	0.6					
2038	red hearth	BCC					2	2.4		2	2.4		BCC	520	44.6	
578	dark brown sand	BDA					1	18.3		1	18.3					
945	dark brown sand	BDA			2		3	14.2		5	14.2					
1261	orange brown sand	BDA					6	100.2		6	100.2		BDA	12	132.7	
924	charcoal layer	BDB	2	0.1						2	0.1					
1024	orange silty sand	BDB			1					1	0					
1028	gulley cut	BDB					8	137.3		8	137.3		BDB	11	137.4	
942	light brown sand	BDC					1	0.1		1	0.1		BDC	1	0.1	
576	mid brown sand	BDD					1	2.6		1	2.6		BDD	1	2.6	
593	orange silty sand	BDE			1	6.6				1	6.6					
123	Yellow sand	BDF					1	0.6		1	0.6					
500	Red brown sand	BDF					1	95.3		1	95.3					
507	Dark brownn sand	BDF					1	3.8		1	3.8					
518	Dark brown sand	BDF					1	5.5		1	5.5		BDF	5	111.8	
118	Grey sand	BDG					1	0.8		1	0.8					
120	Shell layer	BDG					1	1.4		1	1.4					
121	Dark brown sand	BDG					1	0.7		1	0.7					
122	Wall	BDG					87	132.1		87	132.1					
194	Dark brown layer	BDG			1	1.0	1	3.4		2	4.4		BDG	92	139.4	
98	Light brown sand	BDH			2	2.2				2	2.2					
112	Yellow sand	BDH					2	6.2		2	6.2					
114	Grey sand	BDH					3	1.5		3	1.5					
115	Yellow sand	BDH					1	3		1	3					
116	Brown sand	BDH					1	5.3		1	5.3					
117	Dark brown sand	BDH					1	1.1		1	1.1					
119	Yellow sand	BDH					1	1		1	1					

174	Light brown grey sand	BDH							1	36.6		1	36.6	BDH	12	56.9
580	grey sand	BDI				1						1	0			
1053	brown sand	BDI				1			2	16.3		3	16.3			
1474	Floor	BDI							4	47.3		4	47.3			
2025		BDI							8	18		8	18	BDI	16	81.6
1084	brown sand	BDJ							1	2.5		1	2.5	BDJ	1	2.5
573	dark brown sand	BEA				1	2.5		6	24.2		7	26.7			
1340	Ploughmarks	BEA							2	12.5		2	12.5	BEA	9	39.2
1072	white sand	BEA/BGA							17	92		17	92	BEA/BGA	17	92
1055	post hole fill	BEC				1						1	0			
1076	dark brown sand	BEC				3	11.7					3	11.7			
1485	Floor	BEC							1	0.7		1	0.7	BEC	5	12.4
948	orange sand	BEE		1	0.1	2						3	0.1			
1048	dark brown sand	BEE				2						2	0			
2002	Pit fill	BEE		9	1.2							9	1.2	BEE	14	1.3
579	white sand	BEF							4	0.1		4	0.1			
599	dark brown sand	BEF				1						1	0			
947	brown sand	BEF		12	0.3	2						14	0.3			
1336	Brown sand	BEF							2	6.4		2	6.4	BEF	21	6.8
96	Dark brown sand	BEI				1	2.0					1	2			
107	Dark brown sand	BEI							2	3.1		2	3.1			
113	Brown sand	BEI							1	10.4		1	10.4			
135	Pit fill	BEI							1	1.8		1	1.8			
162	Orange brown loose sand	BEI							1	2.5		1	2.5	BEI	6	19.8
577	mid brown sand	BFA/BFE							1	10.1		1	10.1	BFA/BFE	1	10.1
1015	light brown sand	BFB				2	4.0					2	4	BFB	2	4
568	dark brown sand	BFD							3	0.2		3	0.2			
908	light brown sand	BFD							1	0.1		1	0.1			
913	white sand	BFD				1	3.0					1	3			
1073	brown sand	BFD							1	1.2		1	1.2	BFD	6	4.5
569	white sand	BGA							2	0.1		2	0.1			
1504	mid brown sand	BGA							4	20		4	20	BGA	6	20.1
1529	pit cut	BHA							1	149.2		1	149.2	BHA	1	149.2
1451	Grey sand	HF							9	56.2		9	56.2			
1460	Grey brown sand	HF							2	16.1		2	16.1			
1497	Brown sand	HF							4	31.8		4	31.8	HF	15	104.1

1457	Hearth	HG							2	16.2		2	16.2	HG	18	269.5
1063	brown sand	HH							1	2		1	2			
1421	Grey sand	HH							3	8.8		3	8.8	HH	4	10.8
172	Stone wall	IA							1	1.3		1	1.3			
582	dark brown sand	IA				1	3.7					1	3.7	IA	2	5
1505	light brown sand	IB							1	14.2		1	14.2			
1508	pit fill	IB							1	2.4		1	2.4			
1509	dark brown sand	IB							9	25.1		9	25.1			
1510	mid brown sand	IB							1	1.7		1	1.7			
1511	dark brown sand	IB							3	15.4		3	15.4			
1515	dark brown sand	IB							9	381.1		9	381.1			
1521	mid grey sand	IB										5	30	IB	24	439.9
57	Backfill								1	2.8		1	2.8			
85	Geophysics trench								1	19.8		1	19.8			
	TOTAL			*11564*	*307*	*154*	*88.6*		*379*	*2140.7*		*12101*	*2548.9*		*12015*	*2454*

Table 2: summary catalogue of pyrotechnological residues from Mound 2 by stratigraphic block.

block	Block totals	Fuel Ash Slag			Ironworking slag		
		No.	wt (g)	wt%	No.	wt (g)	wt%
	Area A						
AD	The infilling of structure AB (Middle Norse?)	6	60.9	2.5%			
AE	The construction of a house (Middle Norse?)	2	5.7	0.2%			
AG	The infilling of house AE (Late Norse)	9	75.4	3.1%			
	The Late Iron Age occupation						
BAE?	Unexcavated layers exposed in section and plan	1	4.9	0.2%			
BAG	Cut and fill of Pictish or Viking structure	1	0.2	0.0%			
	The Early Norse phase						
BBA	House foundation pits	1	8.5	0.4%			
BBB	House 1 structure	7	24.3	1.0%			
BBC	House 1 occupation	5881	214.3	8.8%			
BBD	House 1 abandonment	6	6.4	0.3%			
	The Middle Norse phase						
BCA	House 2 foundation pits	5270	153.1	6.3%			
BCB	House 2 construction	9	2	0.1%			
BCC	House 2 occupation	520	44.6	1.8%			
	The Middle Norse transitional phase						
BDA	Initial structural modifications	12	132.7	5.5%			
BDB	Occupation associated with BDA	11	137.4	5.7%			
BDC	Modifications of the BDA structure	1	0.1	0.0%			
BDD	Abandonment of initial structure and building of new structure	1	2.6	0.1%			
BDF	Infilling the house 2 hollow	5	111.8	4.6%			
BDG	Ephemeral structures	92	139.4	5.8%			
BDH	Further infilling of the house 2 structures	12	56.9	2.3%			
BDI	Activity preceding house 3	16	81.6	3.4%			
BDJ	Activity around the edge of house 3	1	2.5	0.1%			
	The Late Norse Phase						
BEA	House 3 construction	9	39.2	1.6%	5	30	100%

BEA/BGA		17	92	3.8%		
BEC	House 3 early occupation	5	12.4	0.5%		
BEE	House 3 late occupation	14	1.3	0.1%		
BEF	House 3 abandonment	21	6.8	0.3%		
BEI	Deposits associated with house 3 to west (above house 2)	6	19.8	0.8%		
	The final occupation					
BFA/BFE	Construction of ancillary structure	1	10.1	0.4%		
BFB	Use of ancillary structure	2	4	0.2%		
BFD	Abandonment of ancillary structure	6	4.5	0.2%		
	Windblown sand and topsoil					
BGA	Windblown sand and topsoil	6	20.1	0.8%		
	The enclosure wall					
BHA	The enclosure wall	1	149.2	6.2%		
	Trench to E					
HF	Midden dumping (Middle Norse?)	15	104.1	4.3%		
HG	Feature scatter (Late Norse?)	18	269.5	11.1%		
HH	Midden (Late Norse?)	4	10.8	0.4%		
IA	Late Norse house	2	5	0.2%		
IB	Late Norse features	19	409.9	16.9%		
	TOTAL	*12010*	*2424*		*5*	*30*

Table 3: summary catalogue of pyrotechnological residues from Mound 2A

Context	Block	Description	>2mm		>10mm		hand picked		total		Block totals		
			No.	wt (g)	No.	wt (g)	No.	wt (g)	No.	wt (g)	Block	No.	wt (g)
		GA The Early Norse phase											
712	GAA	Brown yellow sand					36	89.3	36	89.3			
969	GAA	Brown sand	60	1.7			4	17.2	64	18.9			
977	GAA	Grey sand					18	38.1	18	38.1			
990	GAA	Yellow sand	30	0.6			10	66.3	40	66.9			
1102	GAA	Wall	13	0.4	1	0.1			14	0.5			
1107	GAA	Red grey sand					1	8.3	1	8.3			
1125	GAA	Brown sand	16	10.2	5	10.6	35	374.7	56	395.5			
1145	GAA	Pit cut					4	8	4	8			
1146	GAA	Grey sand	15	0.4					15	0.4			
1191	GAA	Dark grey sand			123	194.3	2	4.4	125	198.7			
1192	GAA	Grey sand	4500	140.3	49	90.3	46	90.6	4595	321.2			
1194	GAA	Green clayey sand	580	17.6	11	19.6			591	37.2			
1195	GAA	Grey sand	3172	120.6	71	131	29	41.8	3272	293.4			
1196	GAA	Red ash	4140	111.6	77	111.8	1	479.5	4218	702.9			
1199	GAA	Grey sand	163	5	3	4	2	3.4	168	12.4			
1605	GAA	Red brown sand	51	1.1					51	1.1			
1617	GAA	Dark brown sand	1700	56.5	5	4.2	4	55.9	1709	116.6			
1622	GAA	Black charcoal sand	108	2.1					108	2.1			
1626	GAA	Red orange sand	64	1.7	1	0.4			65	2.1			
1649	GAA	Red sand	3679	97.7	41	70.8	97	374.4	3817	542.9			
1776	GAA	Orange sand			177	506.5			177	506.5			
1787	GAA	Mottled white and black sand			1	19.5			1	19.5			
1789	GAA	Red sand	31	0.6			2	18.7	33	19.3			
1790	GAA	Light red sand	103	2.2	1	5.8			104	8			
1791	GAA	Dark brown sand	268	6.5	1	0.6	114	338.6	383	345.7			
1792	GAA	Charcoal rich sand			53	53.9	182	275.9	235	329.8			
1793	GAA	Charcoal layer							0	0			
1795	GAA	Pink sand			19	47.5	30	94.5	49	142			
2301	GAA	Orange/red compact sand with ploughmarks					7	20.1	7	20.1			
2337	GAA	brown sand			10	9.9	15	58.5	25	68.4			
2356	GAA	yellow sand fill of cut [2358]	1020	35	4	5	2	3	1026	43			
2357	GAA	Black charcoal sand	1500	50.5	7	10.5	10	27.8	1517	88.8			
2360	GAA	Brown sand	2200	64.8	21	27.1	158	379.3	2379	471.2			
2390	GAA	dark orange compact sand	13	0.2					13	0.2			
2391	GAA	Dark brown sand	1800	108.4	34	38.7	58	138.8	1892	285.9			
2393	GAA	Red brown sand					1	1	1	1			
2394	GAA	light yellow sand layer			1	3.1			1	3.1			
2400	GAA	cut feature			13	18.2			13	18.2			
2405	GAA	mid/dark brown quite compact sand	447	12.7	2	0.3	21	55.1	470	68.1			
2407	GAA	Red brown sand	82	2.3			53	133.4	135	135.7			
2413	GAA	Red brown sand					2	2.6	2	2.6			
2414	GAA	red clay/sand	18	0.4			25	110	43	110.4			
2416	GAA	mottled red/brown/grey sand	15	0.4	1	0.3	3	57.2	19	57.9			
2421	GAA	mottled orange sandy deposit			2	3.4	7	15.9	9	19.3			
2424	GAA	Red brown sand					2	5.8	2	5.8			
2430	GAA	red clay mottled with black and brown patches	7	0.2			7	47.8	14	48			

2431	GAA	yellow charcoal mottled ash spread	18	0.4					18	0.4					
2432	GAA	Charcoal rich sand	9	0.5					9	0.5					
2438	GAA	Orange brown sand	4	0.1			2	12.9	6	13					
2439	GAA	Dark brown sand	872	20.1	5	4.8	2	2.6	879	27.5					
2440	GAA	grey brown with charcoal sand	1950	50.3	16	14.1			1966	64.4					
2441	GAA	dark brown with charcoal			2	1.4	5	13.9	7	15.3					
2447	GAA	Charcoal rich sand	220	7.3					220	7.3					
2448	GAA	orange brown with charcoal flecks			2	5			2	5					
2449	GAA	mottled red brown grey sand					4	6.2	4	6.2					
2450	GAA	brown and orange mottled	620	16.1	3	1.8	7	15.5	630	33.4					
2452	GAA	Orange sand					47	97.2	47	97.2					
2301/ 2421	GAA						8	11	8	11					
2304/ 2421	GAA						2	3.9	2	3.9	GAA	31315	5960.1		
2345	GAB	Yellow ash			55	57.2	9	15.6	64	72.8					
2442	GAB	Black charcoal sand			3	1.5			3	1.5					
2443	GAB	yellow slag rich ash			7	148.3			7	148.3					
2444	GAB	reddish grey			3	3.3			3	3.3					
2445	GAB	yellow with charcoal			30	41.4			30	41.4	GAB	107	267.3		
1794	GAC	Dark brown sand	3000	221.7					3000	221.7	GAC	3000	221.7		
863	GAD	Orange sand			20	16.3	565	1176.9	585	1193.2					
871	GAD	Brown sand					69	158.2	69	158.2					
895	GAD	Brown sand	54	1.3					54	1.3					
896	GAD	Orange brown sand	77	1.6			11	33.7	88	35.3					
953	GAD	brown, orange, black sand	81	5.6					81	5.6					
954	GAD	Dark brown sand	316	8	6	5.1	57	482.7	379	495.8					
960	GAD	red dark brown sand	217	7.6	2	0.6			219	8.2					
979	GAD	Brown sand	4360	133.4	34	41.5	424	875.6	4818	1050.5					
996	GAD	Grey sand					266	320.2	266	320.2					
997	GAD	Red brown sand					18	19.6	18	19.6					
1100	GAD	Charcoal patch	3400	103.1	10	6.7	28	40	3438	149.8					
1106	GAD	Orange sand					342	590.7	342	590.7					
1108	GAD	Orange sand	560	12.9	1	0.4			561	13.3					
1109	GAD	Orange sand	422	11.7	4	2.9	1	5	427	19.6					
1186	GAD	Grey sand			43	63	7	9.9	50	72.9					
1193	GAD	Brown sand			47	458.9	351	811.4	398	1270.3					
1197	GAD	Grey sand					10	73.5	10	73.5					
1611	GAD	Grey brown sand	3150	90	16	23.6	174	445.1	3340	558.7					
1625	GAD	Grey sand	720	23.7	4	6.1			724	29.8					
1707	GAD	Grey brown sand	1444	44.1	10	12.4	92	238.1	1546	294.6					
1714	GAD	Light brown sand	700	21.4	9	11.9	35	59.4	744	92.7					
1715	GAD	Grey brown sand	343	9.6	19	37.5	3	5.6	365	52.7					
1729	GAD	Orange brown sand	721	21	4	3.5			725	24.5					
1733	GAD	Red brown sand			5	4.9			5	4.9					
1747	GAD	Dark brown sand	2510	68.4	9	13.3			2519	81.7					
1788	GAD	Grey sand					70	221.3	70	221.3					
2305	GAD	Grey sand	1100	39.4	6	9			1106	48.4					
2309	GAD	Grey sand					30	147	30	147					
2321	GAD	light brown sand with charcoal flecks			1	0.8			1	0.8					
2327	GAD	yellow white sandy ash			6	6.4			6	6.4					

2328	GAD	brown/green clayey deposit- compact	1200	38.9	8	11.2	1	1.9	1209	52				
2330	GAD	Red sand	146	4.4	2	5.7	1	2.5	149	12.6				
2353	GAD	Grey sand	800	24.4	5	10.7	54	203.2	859	238.3				
2370	GAD	Grey sand			10	19.5	4	69.4	14	88.9				
2372	GAD	light brown/grey sand layer					169	324	169	324				
2373	GAD	Grey sand	415	28	11	32.5			426	60.5				
2380	GAD	Grey sand					6	16.7	6	16.7				
2381	GAD	Grey sand					14	117.9	14	117.9				
2384	GAD	orange-green clayey deposit	600	16.4	3	5	9	12.8	612	34.2				
2434	GAD	Grey sand					34	66.7	34	66.7				
2435	GAD	Brown sand with charcoal flecks	2800	84.3	22	35.3	7	7.6	2829	127.2				
2437	GAD	light brown sand with charcoal flecks	420	11.3	7	10.6			427	21.9				
2381/ 2372	GAD?						7	9.8	7	9.8	GAD	29739	8212.2	
998	GBA	Grey sand	1859	44.6	8	4.2	9	14.9	1876	63.7				
1134	GBA	Red brown sand	1295	37.9	3	3.3	330	510.9	1628	552.1				
1141	GBA	Brown sand	3900	124.9	68	77.2	398	496.6	4366	698.7				
1158	GBA	Red sand			18	19.9	2	41.8	20	61.7				
1168	GBA	cream silty sand					2	11.9	2	11.9	GBA	7892	1388.1	
1630	GBC	Yellow ash			17	15.5	16	27.9	33	43.4				
1635	GBC	Dark brown sand			13	26.1	4	7.6	17	33.7				
1636	GBC	Red brown sand			54	68.3	417	855.9	471	924.2				
1639	GBC	Red brown sand			34	41.9	10	13.4	44	55.3				
1641	GBC	White ash			22	9.3	76	103	98	112.3				
1647	GBC	Black charcoal sand			34	24.3	38	152	72	176.3				
1650	GBC	Grey sand			4	4.5			4	4.5				
1651	GBC	Red ash			34	38.6	39	66.9	73	105.5				
1653	GBC	Yellow sand with charcoal			9	14.9	2	3.2	11	18.1				
1659	GBC	Brown sand			47	51	91	186.3	138	237.3				
1662	GBC	Dark brown sand			28	45.8	28	114.4	56	160.2				
1663	GBC	Mottled red sand			106	125.2	44	97.4	150	222.6				
1668	GBC	Grey sand with charcoal			120	142.5			120	142.5				
1669	GBC	Red brown sand			36	42.4	28	61.2	64	103.6				
1673	GBC	Grey sand with charcoal	3939	104.8	10	12.1			3949	116.9				
1674	GBC	Dark brown sand	9346	273.5	28	40.6	32	62	9406	376.1				
1675	GBC	Orange sand			44	57.9	21	51.2	65	109.1	GBC	14771	2941.6	
2303	GBD	fill of 2302 (kiln) Orange/yellow ash	2400	92.3	27	30.1	4	10.6	2431	133				
2310	GBD	reddish well compacted sand (fill of 2302)			15	16.1			15	16.1				
2319	GBD	fill of [2302] grey sand			8	10.5	31	46.2	39	56.7	GBD	2485	205.8	
972	GBE	Grey sand	5100	155.2	152	189.6	498	724.4	5750	1069.2				
974	GBE	Brown sand			36	33.3	31	65.7	67	99				
978	GBE	Orange brown sand	5730	164.2	118	137.6	80	175.6	5928	477.4				
981	GBE	Orange brown sand	3640	105.4	120	157.9	361	765.5	4121	1028.8				
987	GBE	Red sand			30	39.9			30	39.9				
988	GBE	Red brown sand	13700	359.8	127	121.1	6	9.7	13833	490.6				
991	GBE	Grey brown sand	1300	57.9	91	67.4			1391	125.3				
992	GBE	Grey brown sand			146	180.9	50	171.1	196	352				
993	GBE	Light brown sand					26	89	26	89				
994	GBE	Grey brown sand					150	320.4	150	320.4				
1118	GBE	cancelled			7	7.8	17	28.3	24	36.1				

1119	GBE	Orange sand				2	2.3				2	2.3		GBE	31518	4130
1700	GBF	Pink sand	380	8.6		1	1.4	9	13.5		390	23.5				
1708	GBF	Grey sand	916	22.6		6	5.4	91	157.3		1013	185.3				
1746	GBF	Orange sand				1	1				1	1				
1785	GBF	Light brown sand	2150	60.3		8	12.7	761	1837.3		2919	1910.3				
2304	GBF	Fill of pit [2306] Dark brown/black	1900	58		19	22.5	2	20.8		1921	101.3				
2313	GBF	Fill of pit [2312]				9	10.6				9	10.6				
2318	GBF	Lower fill of cut feature [2312]				15	20.6	21	25.3		36	45.9				
2324	GBF	orange-red friable sand				2	2.2				2	2.2				
2364	GBF	fill of pit [2363]				2	1.4				2	1.4				
2371	GBF	black/orange deposit				1	0.4				1	0.4				
2375	GBF	fill of posthole [2374]				1	2				1	2				
2377	GBF	fill of [2376] dark brown with shells	229	7.4		3	10.6				232	18				
2379	GBF	orange-yellow compact sand with charcoal flecks	243	6.5		1	1.2				244	7.7				
2383	GBF	fill of pit [2382] dark brown shelly deposit	432	11.1		1	0.3				433	11.4				
2419	GBF	yellow with charcoal	1700	52.4							1700	52.4				
2420	GBF	red/black mottled ash deposit				1	0.4				1	0.4		GBF	8905	2373.8
717	GBG	Dark brown sand						5041	12275.6		5041	12275.6				
735	GBG	Dark brown orange sand				1283	3004.3				1283	3004.3				
750	GBG	Brown sand	1194	138.6		65	115.2	1911	4865.6		3170	5119.4				
766	GBG	Dark brown sand	3395	105.1		84	97.2	51	266.1		3530	468.4				
794	GBG	Red brown sand	293	8.6		16	40.2				309	48.8				
799	GBG	dark brown sand	17093	519.5		215	144.8	885	1760.3		18193	2424.6				
866	GBG	Dark brown sand	210	6.1				22	44.9		232	51				
874	GBG	Light brown sand	3700	109.7		2681	4649.2	831	6293.8		7212	11052.7				
875	GBG	Orange sand	1552	48.4		17	23.6	20	33.3		1589	105.3				
876	GBG	Orange sand				1	0	3	8.3		4	8.3				
881	GBG	dark brown sand	1853	56.1		19	23.2	151	368.1		2023	447.4				
888	GBG	Grey sand	433	12.3		2	2.2				435	14.5				
893	GBG	Grey brown sand						281	537.6		281	537.6				
989	GBG	Orange sand	80	2.9		2	2.6				82	5.5				
1115	GBG	Grey brown sand						2	11.4		2	11.4				
1144	GBG	Red sand				4	3.2	9	16.5		13	19.7				
1156	GBG	Grey brown sand				2	2.2				2	2.2				
1157	GBG	Yellow sand	7500	241.8		278	339.1	376	742.1		8154	1323				
1160	GBG	Orange sand	200	7.1		3	14.4				203	21.5				
1161	GBG	Grey sand	800	22.1		19	11.1	12	24.7		831	57.9				
1184	GBG	Dark brown sand				8	10.7	16	54.4		24	65.1				
1185	GBG	Red brown sand				4	3.1				4	3.1				
1187	GBG	Shell	153	4.1		3	5.6				156	9.7				
1198	GBG	Red grey sand	691	17.8		349	429.8	65	214.1		1105	661.7				
1602	GBG	Red brown sand				22	17	1	1		23	18				
1603	GBG	Orange brown sand				286	345.6	130	468.5		416	814.1				
1604	GBG	Light grey sand						36	124.8		36	124.8				
1606	GBG	Red brown sand	4175	99		63	100.3	217	1126.9		4455	1326.2				
1620	GBG	Orange sand	6000	82.9		48	88.1	7	14.2		6055	185.2				
1695	GBG	Red sand						6	5.9		6	5.9				
1743	GBG	Charcoal rich sand	10945	343.2		280	277.3	120	255.3		11345	875.8				
1748	GBG	Red brown sand	712	47.1		23	50.8	254	754.3		989	852.2				
1760	GBG	Brown sand	1270	41.9		70	172.2	430	1409.2		1770	1623.3				

1764	GBG	Pit fill	672	22.4	11	16.4			683	38.8						
1770	GBG	Orange sand			8	10.8	1	0.9	9	11.7						
1777	GBG	Dark brown sand			25	56.5			25	56.5						
1778	GBG	Orange sand					1	0.9	1	0.9						
1779	GBG	Light brown sand	3700	180.3	99	168.9	284	663.9	4083	1013.1						
1784	GBG	Red brown sand			226	409.4	1621	4337.7	1847	4747.1						
2340	GBG	brown grey sand	760	22.3	6	18.3	29	124.2	795	164.8						
2341	GBG	red/green compact deposit	241	6.5			4	3.4	245	9.9						
2350	GBG	Pink sand	600	23.5	13	21.5	15	98.3	628	143.3						
2351	GBG	Charcoal rich sand	550	16.7	21	41.1			571	57.8						
2365	GBG	reddish/black ash deposit	1452	44	10	10.6			1462	54.6	GBG	89322	49862.7			
952	GCA	Grey sand	3470	98.3	123	70.8	28	43	3621	212.1						
1159	GCA	Grey brown sand			9	8.7			9	8.7						
1178	GCA	Wall					1	1.5	1	1.5						
1685	GCA	Brown sand					2	3.5	2	3.5						
1686	GCA	Dark brown sand	525	15			6	12.1	531	27.1						
1696	GCA	Dark brown sand	720	17.9	4	5.8			724	23.7						
1697	GCA	Yellow brown sand	498	14.2	1	1.9	2	4.8	501	20.9						
1728	GCA	Post hole cut			2	2.1			2	2.1						
2355	GCA	fill of cut [2354]	123	2.8					123	2.8						
2366	GCA	orange sand fill of [2368]	400	10.6	2	1.1			402	11.7						
2369	GCA	fill of [2368]	750	19.7	3	2.7			753	22.4	GCA	6669	336.5			
755	GCB	Black charcoal sand	34	0.8					34	0.8						
1618	GCB	Black charcoal sand	3891	112	58	152.9			3949	264.9						
1677	GCB	Pit fill			3	1.8			3	1.8						
1678	GCB	Pit fill					1	5.5	1	5.5						
2359	GCB	dark brown deposit fill of [1147]					3	6.2	3	6.2						
2429	GCB	fill of [1147] dark brown sand	651	15.6	1	0.9			652	16.5	GCB	4642	295.7			
748	GCD	Floor layer			23	25.8	28	148.1	51	173.9						
749	GCD	Dark brown sand					1	2.2	1	2.2						
884	GCD	Orange brown sand	84	2.3	2	0	3	7.5	89	9.8						
1101	GCD	Grey brown sand	263	7.1			1	3.6	264	10.7						
1113	GCD	Grey sand					1	0.3	1	0.3						
1117	GCD	Brown sand	420	25.9	6	4.5	3	4.1	429	34.5						
1133	GCD	Grey brown sand			1	0.5			1	0.5						
1171	GCD	Dark brown sand			1	0.3	3	4.8	4	5.1						
1174	GCD	Green clayey sand			4	3.5			4	3.5						
1616	GCD	Red orange sand	457	12	4	8.3			461	20.3						
1657	GCD	Pit fill			4	5.3			4	5.3						
1687	GCD	Green clayey sand	36	0.5			6	2.4	42	2.9						
1694	GCD	Red brown sand			1	0.8	8	27.6	9	28.4						
1713	GCD	Mixed sand					5	8	5	8						
2338	GCD	brown/black clayey floor	143	2.8	1	0.9			144	3.7	GCD	1509	309.1			
711	GCE	Stone allignment			85	115.8	187	429.1	272	544.9						
713	GCE	Light brown sand					5	9.6	5	9.6						
727	GCE	Stone structure	1200	32.6					1200	32.6						
745	GCE	Dark brown red loam					2	10.5	2	10.5						
879	GCE	Grey brown sand					14	26.9	14	26.9						
958	GCE	Grey brown sand			4	5.5	108	259.2	112	264.7						
971	GCE	Pit fill					3	9	3	9						
982	GCE	Red brown sand	18	0.3					18	0.3						

985	GCE	Grey sand		40	0.8		2	2.3				42	3.1			
1164	GCE	Orange sand		1	0.1							1	0.1			
1167	GCE	Grey brown sand					1	0.2				1	0.2	GCE	1670	901.9
709	GCF	dark brown sand					2	3.9				2	3.9			
710	GCF	Dark brown red soil		45	1.6							45	1.6			
722	GCF	Floor layer		123	2.9		70	75.2		18	38.1	211	116.2			
730	GCF	Yellow brown sand		218	5.1		5	4.3				223	9.4			
733	GCF	dark brown sand								11	9.6	11	9.6			
746	GCF	Ash		1	0.1							1	0.1			
747	GCF	Dark brown sand								2	2.8	2	2.8			
751	GCF	Ash		2	0.1							2	0.1			
752	GCF	Charcoal		600	21.3		4	4.1				604	25.4			
754	GCF	Orange sand		117	5.2							117	5.2			
756	GCF	Charcoal layer		45	1.4							45	1.4			
757	GCF	Orange sand					1	1.5		7	5.5	8	7			
759	GCF	Pale pink ash		1046	28.2		1	1.9		30	37.9	1077	68	GCF	2348	250.7
720	GDA	Dark brown sand		5555	50.3		19	36				5574	86.3			
724	GDA	Orange brown sand					12	28.6				12	28.6			
797	GDA	Pink sand					5	8.8		7	26.3	12	35.1			
798	GDA	Green clayey sand					44	41				44	41			
860	GDA	brown sand		1376	41.6		7	9.8		20	51	1403	102.4			
864	GDA	Brown sand		4380	198.9		63	70.3		521	1662.1	4964	1931.3			
867	GDA	Grey sand		15	0.5					4	3.9	19	4.4			
868	GDA	Grey sand		89	1.9		1	0.8		3	5.3	93	8			
955	GDA	brown, orange, black sand		3810	111.8		319	498.3		1	28.9	4130	639			
957	GDA	Grey sand								4689	3936.4	4689	3936.4			
959	GDA	Wall								660	405.4	660	405.4			
962	GDA	Grey sand					6	6		39	86.3	45	92.3			
963	GDA	Red orange sand		426	10.2		8	6.4		10	36.3	444	52.9			
964	GDA	Light brown grey sand					20	21		82	130.6	102	151.6			
968	GDA	Light brown sand		192	4.3		1	0.8				193	5.1			
973	GDA	Pit cut		292	8.7		5	4.1		2	5.3	299	18.1			
980	GDA	Orange sand					3	1.4		12	25	15	26.4			
983	GDA	brown sand					10	21.6		19	26.8	29	48.4			
1121	GDA	Light brown sand					11	10.6		119	258.5	130	269.1			
1127	GDA	cream silty sand		500	13.6		9	4.7				509	18.3			
2300	GDA	Dark brown sand		488	13.7		9	18.4		24	110.1	521	142.2			
2308	GDA	Orange sand		77	1.6							77	1.6			
2316	GDA	dark brown sand		950	21.5		8	10.2		11	43	969	74.7			
2329	GDA	black/orange deposit		170	5.5		1	1.2		1	16.2	172	22.9			
2335	GDA	white sand		67	1.5		2	3.1		5	5.9	74	10.5			
2349	GDA	fill of [2348]		203	7.7		1	1.4				204	9.1	GDA	25383	8161.1
788	GDB	dark brown sand		511	16.9		26	19.6		866	3105.5	1403	3142			
1143	GDB	Red sand								35	64.3	35	64.3			
1154	GDB	Orange sand					2	1.4		3	12.4	5	13.8	GDB	1443	3220.1
704	GDC	Dark brown sand					1	0.8				1	0.8			
728	GDC	Dark brown sand								106	393.1	106	393.1			
760	GDC	Dark brown sand		528	15.5					11	110.7	539	126.2			
779	GDC	White sand		3	0.1					1	0.2	4	0.3			
790	GDC	Brown sand		89	1.8		1	1.1		114	205.9	204	208.8			
796	GDC	Brown sand		84	2.7		2	0.9				86	3.6			

862	GDC	Red brown sand	3	0.2	14	0	324	786.3	341	786.5					
878	GDC	Orange sand					1	0.1	1	0.1					
880	GDC	brown and white sand					1	0.1	1	0.1					
894	GDC	Light grey sand	43	1.1	4	3			47	4.1					
899	GDC	Light grey sand	78	1.6	2	0.5	1	34.4	81	36.5					
950	GDC	Dark brown sand					3	14.9	3	14.9					
965	GDC	brown grey sand	97	0.7					97	0.7					
1114	GDC	Grey sand	16	0.1	1	0.8			17	0.9					
1124	GDC	Pit cut	11	0.5					11	0.5					
1128	GDC	Yellow brown sand	1	0.1					1	0.1					
1132	GDC	Grey sand	5	0.2					5	0.2					
1135	GDC	Brown sand	36	0.8					36	0.8					
1138	GDC	Orange sand	23	0.5			9	15.8	32	16.3					
1140	GDC	Orange sand	7	0.5			15	58.9	22	59.4					
1150	GDC	stone			1	1.8	2	7.9	3	9.7					
1153	GDC	Orange sand					33	183.4	33	183.4					
1175	GDC	Cut			18	20.2			18	20.2					
1608	GDC	Dark brown sand	173	5.1	3	3.5	1	9.2	177	17.8					
1615	GDC	Red orange sand	48	1.4	3	7.8			51	9.2					
1619	GDC	Red brown sand	145	4.7	1	0	4	9.4	150	14.1					
1623	GDC	Yellow orange sand	66	4.6	1	0.9			67	5.5					
1624	GDC	Red sand	235	6.8	3	2	1	3.1	239	11.9					
1632	GDC	Yellow ash			1	1.3	1	8.1	2	9.4					
1633	GDC	Yellow ash	130	3	1	0.9			131	3.9					
1637	GDC	Dark brown sand	390	10.1	2	4.9	244	658.4	636	673.4					
1664	GDC	Red ash	180	5.5			3	4.1	183	9.6					
1672	GDC	Charcoal layer	68	2.6					68	2.6					
1688	GDC	Red and yellow sand	733	18.3	6	4.5			739	22.8					
1691	GDC	Grey sand	600	18.2	4	6.2	54	142.7	658	167.1					
1692	GDC	Orange sand	356	9.9	2	1.5	3	7.6	361	19					
1699	GDC	Yellow sand with charcoal			1	1.2			1	1.2					
1735	GDC	Yellow sand with charcoal			1	1.1			1	1.1					
1736	GDC	Brown sand					32	54	32	54					
1740	GDC	Red orange sand			2	2			2	2					
1742	GDC	Light grey sand			32	43.8	28	91.8	60	135.6					
1749	GDC	Grey brown sand			94	177.3	177	436.7	271	614					
1761	GDC	Brown sand					67	271.8	67	271.8	GDC	5585	3913.2		
1671	GEA	Red orange sand	1350	34.4			4	29.5	1354	63.9					
1722	GEA	Red brown sand			48	86.4	111	245.3	159	331.7					
1744	GEA	Light grey sand			76	98.7	322	747.7	398	846.4					
2453	GEA	light brown with shell-fill of [1745] - house 2					50	124.7	50	124.7	GEA	1961	1366.7		
725	GEC	Pale brown grey clean sand	1900	52.4					1900	52.4					
1629	GEC	Dark brown sand			24	39	7	36.2	31	75.2					
1634	GEC	Grey brown sand			27	37.7	36	130	63	167.7					
1638	GEC	Light brown sand			14	14.1	21	55.9	35	70					
1640	GEC	Red charcoal rich sand			10	34.5	31	97.4	41	131.9					
1642	GEC	Light brown sand	668	17.8	4	7.3	45	171.1	717	196.2					
1643	GEC	Brown sand with charcoal flecks			19	14.8	34	42.7	53	57.5					
1644	GEC	Orange sand			1	0.5			1	0.5					
1645	GEC	Light grey sand			70	128.4	51	202.7	121	331.1					
1648	GEC	Dark brown sand			5	4.9	6	9	11	13.9					

1654	GEC	Light grey sand			3	4.9			3	4.9				
1658	GEC	Dark brown sand			14	13.9	17	70.2	31	84.1				
1689	GEC	Light grey sand			7	16			7	16				
1690	GEC	Red brown sand			9	11.7	3	12.3	12	24				
1732	GEC	Grey brown sand			2	2.3	61	133.2	63	135.5				
1737	GEC	Grey black sand					52	108.5	52	108.5	GEC	3141	1469.4	
1716	GED	Dark brown sand					1	1.9	1	1.9				
2406	GED	dark brown sand with limpets					124	296.1	124	296.1	GED	125	298	
1718	GEE	Dark brown sand					5	9.9	5	9.9				
1727	GEE	Brown sand			19	29.2	12	41.5	31	70.7				
2436	GEE	Black charcoal sand					8	14.8	8	14.8	GEE	44	95.4	
2425	GEF	brown mottled sand			4	5.9	62	160.5	66	166.4	GEF	66	166.4	
1111	GFA	Brown sand	33	1.1	3	0.1			36	1.2				
1123	GFA	Red orange sand					10	19.1	10	19.1				
1679	GFA	Dark brown orange sand			2	4.5			2	4.5				
1680	GFA	Pale brown sand with charcoal			2	1.2			2	1.2	GFA	50	26	
700	GFB	Topsoil					5	9.1	5	9.1				
701	GFB	Dark brown yellow loam					5	64.5	5	64.5				
707	GFB	Dark brown sand			9	17.8	1373	3044.3	1382	3062.1				
739	GFB	Dark brown yellow sand					7	35.8	7	35.8				
789	GFB	Charcoal patch					45	135.5	45	135.5				
1103	GFB	Red sand					5	7.4	5	7.4				
1712	GFB	Brown sand					4	9.5	4	9.5				
2397	GFB	light brown sand with charcoal flecks					54	147	54	147				
2402	GFB	light brown sand with charcoal flecks					7	18.3	7	18.3				
2403	GFB	Light brown sand					18	49	18	49	GFB	1532	3538.2	
1151	GGA	Grey brown sand					12	22.7	12	22.7	GGA	12	22.7	
1613	GGB	Fill	60	1.5	1	0.9			61	2.4	GGB	61	2.4	
1149	GGC	Red brown sand	216	5.7	2	5.9	21	65.6	239	77.2				
1607	GGC	Grey sand	36	0.8			2	20.3	38	21.1	GGC	277	98.3	
1730		Cleaning layer					517	1170	517	1170				
1768		Cleaning layer					74	124.5	74	124.5				
897		Red orange sand					3	19.7	3	19.7				
1120		Charcoal patch			10	9	16	28.9	26	37.9				
u/s			597	15.3			606	1225.5	1203	1240.8				
		TOTAL	*233457*	*7169.1*	*10743*	*17417.1*	*33195*	*78041.8*	*277395*	*102628*		*275572*	*100035.1*	

Table 4: summary catalogue of pyrotechnological residues from Mound 2A by block and phase

Block	Description	Fuel Ash Slags						Ironworking slags		
		By block			By phase			By block		
		No.	wt (g)	wt%	No.	No.	wt%	No.	wt (g)	wt%
	GA The Early Norse phase									
GAA	primary cultivation soils	31312	5949.1	5.9%				2	111	18.5%
GAB	hearth/ash layers in GAA	107	267.3	0.3%						
GAC	hearth/ash layers on top of GAA	3000	221.7	0.2%						
GAD	grey sand layers	29737	7722.2	7.8%				2	490	81.5%
					64156	14060.3	14%			
	GB The Middle Norse phase									
GBA	horseshoe shaped stone setting on top of the grey sand	7892	1388.1	1.4%						
GBC	use of the south kiln	14771	2941.6	3.0%						
GBD	construction of the north kiln	2485	205.8	0.2%						
GBE	use of the north kiln	31518	4130	4.2%						
GBF	deposition associated with kiln use	8905	2373.8	2.4%						
GBG	ash layers spread around the periphery of the mound	89322	49862.7	50.1%						
					154893	60902	61%			
	GC Late Norse ancillary structures									
GCA	construction of ancillary building 2	6669	336.5	0.3%						
GCB	use of ancillary building 2	4642	295.7	0.3%						
GCD	use of ancillary building 3	1509	309.1	0.3%						
GCE	construction of building 4	1670	901.9	0.9%						
GCF	use of building 4	2348	250.7	0.3%						
					16838	2093.9	2%			
	GD Late Norse peripheral middens									
GDA	middens deposited on the west side of the mound	25383	8161.1	8.2%						
GDB	middens deposited on the north side of the mound	1443	3220.1	3.2%						
GDC	middens deposited on the east side of the mound	5585	3913.2	3.9%						
					32411	15294.4	15%			
	GE Late Norse houses									
GEA	construction of south house 1	1961	1366.7	1.4%						
GEC	infilling of south house 1	3141	1469.4	1.5%						
GED	construction of south house 2	125	298	0.3%						
GEE	use of south house 2	44	95.4	0.1%						
GEF	infilling of south house 2	66	166.4	0.2%						

						5337	3395.9	3%			
	GG An isolated Late Norse building										
GGA	structure dug into the deposits in the north east corner of the	12	22.7	0.0%							
GGB	occupation of the structure in the north east corner	61	2.4	0.0%							
GGC	abandonment of the structure in the north east corner	277	98.3	0.1%							
						350	123.4	0%			
	GF The final occupation on mound 2A										
GFA	isolated features representing the final occupation of the mound	50	26	0.0%							
GFB	layers representing post occupation erosion and sand accumulation	1532	3538.2	3.6%							
						1582	3564.2	4%			
	TOTAL	275567	99434.1							4	601

Table 5: summary catalogue of larger pyrotechnological residues from Mounds 2 and 2A showing interesting morphological or compositional features.

context	fraction	block	wt (g)	no	type	notes
Mound 2						
1028		BDB			?	[not seen]
1521	>10mm	IB	30	5	SHC	small fragments of dense slag; one is a dimpled blebby lobe; two are fragments of (probably) the same SHC, fine dense top and lower vesicular section
Mound 2A						
1196		GAA	470	1	FAS	possible almost complete FAS cake; 140x170x35mm, some missing edges; slightly concavo-convex; margins grade into spikey sintered sand with no solid slag; central top has a depressed area with a pad of ash; base irregular, sintery, with large fired shell fragment.
1747		GAD	183	2	FAS	one piece is slag sheet 20mm thick, with ashy top and sandy base and lots of adhering pale green glassy spheroids on upper face; the other sheet fragment is 35mm thick, well-formed but has a complexly vesicular/blebby/indented green sandy glassy top; grey indurated sand and non-wetted lobes on base; internal cavity (fuel mould?) with dark dull glassy surfaces; on fracture the glass is khaki - black with much sand and a low melt volume
1636		GBC	22	2	FAS	two fragments of FAS, with ash coated cavities, one broad and open, the other suggestive of 15mm radius semi-circular section wood
1636		GBC	147	1	FAS	large piece of 20-25mm thick slag, slightly darker glassy top than typical, but pale on some pinnacles; base very irregular, no neat basal contact - shows narrow raised ridges of slag (between fuel or into floor cracks?); apparent inclusion void on one edge may actually be deformation on removal with upcurving of one edge.
717		GBG	577	1	FAS	large wedge-shaped piece; planar sand contact base, with pale grey glassy lobes with minor sintering; lifts off plane at one end of base where after 5-8mm of slag there are large rounded voids in the slag, which bear reddened or rusty foliated fills; the top is smooth in places, slightly greenish-grey; top may rise to 90mm off basal plane at one end, but slag 50mm thinning to 30mm.
717	11.2-100mm	GBG	338	8	FAS	medium sized fragments all showing concave areas, mostly with foliated buff-coloured ashy fills; one shows a void fill of almost white soft material, presumably ash
750	11.2-100mm	GBG	34	1	FAS	complicated slag mass with large internal voids up to 35mm wide and 15mm deep; slag sheet 35mm deep; basal sand contact slightly reddish; top locally glassy and greenish
750	11.2-100mm	GBG	7	1	FAS	elongate prill of green glassy slag, 50mm long, 15mm wide and 5mm thick, one edge shows lobate overhang is if falling off edge of substrate, remainder of the base is dull and slightly purple
750	11.2-100mm	GBG	47	1	FAS	well-indurated fragment from 40mm thick sheet; well indurated sandy layer on base, followed by vesicular grey slag with included grains to 3mm; almost black viscous lobe surfaces, with internally-pointed cavity - just possibly a tool mark rather than a inclusion mould
750	11.2-100mm	GBG	36	1	FAS	smoothly lobate grey top; strong sintery dark grey base; one side shows a large void, the other a possible contact mould, neither very clear; hard slag in sheet 25mm thick
874		GBG	1170	4	FAS	four large blocks showing slag up to 80mm thick; mostly appears crudely layered with reddish cavities picking out the layering.
874		GBG	539	4	FAS	large blocks of rough dark slag; three show evidence for yellowish foliated fills in large voids; the largest shows wedge-section from 55-20mm over 120mm, with a sharp120 degree bend; the second largest also a wedge but thinner and more rounded.
1760		GBG	53	1	FAS	fragment of typical 20mm thick fuel ash sheet, pale glassy top variably sintered/non-wetted base; vesicular pale slag
1618	>10mm	GCB	49	1	FAS	typical dark slag fragment, but has almost semi-circular impression/unroofed void 25mm radius, 50mm long
751	11.2-100mm	GCF	144	2	FAS	one fragment with red sandy inclusion contact; larger piece shows one dark irregular surface and one of very pale green glassy material in long lobes - unclear if these were pendent.
864		GDA	260	1	FAS	base shows 55mm wide and 70mm long impression of a convex surface with a non-wetted contact- most likely a stone, but has foliated reddish material - so maybe a large wood contact; slag at least 60mm thick, but orientation not sure - particularly if non-wetted surface was inclined
955		GDA	9	1	FAS	bent elongate piece of typical FAS
957		GDA	44	2	FAS	1 piece conventional 15mm thick slag sheet; the other a piece of glassy slag with smooth upper greenish surface and irregular lower surface suggesting viscous flow down between fuel pieces?
728	11.2-100mm	GDC	51	1	FAS	shows basal sand contact, central part 25mm thick, but this separates two divergent rounded hollows suggestive of possible wood moulds - larger c. 20mm diameter, the other irregular and smaller; 8mm of slag between 'moulds' and base; slag vesicular, grey, rounded larger voids, lots of sand
1791		GAA	60	1	SHC	45x40x15mm fragment from margin of lenticular dense slag, probably an SHC; the base shows sintered slag, the top shows raised lobes and blebs suggestive of descending slag; internally dense typical iron slag appearance; vesicular along base, but much less so in interior.
2416		GAA	51	2	conc	concreted charcoal-bearing sand; one piece contains slag, the other piece contains metallic iron; probably two parts of same concretion, but a central section is missing
2381		GAD	97	1	SHC	part of small SHC, upper part has large part upstanding part embedded mass of sandy black glass with abrupt contact with eutectic olivine/glass; 40mm thick, base microprilly, top (where not upstanding glassy material) shows fuel dimples approximately 10mm across

1193	>10mm	GAD	393	1	SHC	Top fine pale vesicular to 5mm down, then 10mm with elongate olivine, (with rounded lining slag clast laterally), 8mm finely granular dense olive layer, basal 5mm vesicular, elongate olivine, probably around 80% of SHC; base smooth with small prilly extensions and lumps; top smooth but irregular in pale sandy glass; base has rusted inclusions; (100) x (75) x 40mm
959		GDA	<1	2	FAS?	coffee bean spheroids of dark vesicular slag; one shows glassy surface on one hemisphere, but is dull and rough on the other, with and has poorly developed symmetry; the other is well-dimpled and slightly more glassy
1640		GEC	166	1	natural/ modern?	grey slag with vesicular/frothy texture. Labelled pumice and may be – but texture similar to that of modern steel slag.

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