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WHITBY CLIFF, WHITBY, NORTH YORKSHIRE AN ASSESSMENT OF METALWORKING DEBRIS FROM THE WHITBY CLIFF EXCAVATIONS

TECHNOLOGY REPORT

Victoria A L Lucas and Sarah Paynter

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An Assessment of Metalworking Debris from the Whitby Cliff Excavations

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SUMMARY

160kg of material from the Whitby Cliff excavations, thought to provide evidence for metalworking, were submitted for assessment. The material was examined for the purpose of identifying and quantifying the debris in order to ascertain what metalworking processes had taken place within the excavated area. The majority of the diagnostic evidence was found to be indicative of iron smithing.

ARCHIVE LOCATION

Fort Cumberland, Portsmouth

DATE OF RESEARCH

September 2009

CONTACT DETAILS

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INTRODUCTION

During 2001 and 2002 the rapidly eroding edge of East Cliff was subject to investigation by English Heritage Archaeological Projects, under the supervision of Peter Busby, Tony Wilmott and Sarah Jennings. The cliff is to the east of the town of Whitby, North Yorkshire and is the location of Whitby Abbey (also subject to archaeological investigation in 1998 – 2004). To the south and south-east the headland widens, gradually rising to the North York Moors. The excavation took place in three stages, referred to as WCI, WCII and WCIII, and the excavated area was subdivided; the majority of the material in this report was recovered from WC1 (trenches Q11-Q29), WCII (Q30-Q35) and WCIII (Q36 and U1) (Figures 1 and 2).

Traditionally the site of Whitby Abbey is recognised as the location of the monastery of Streaneahalch, founded in AD 656-7, which is unlikely to have survived into the later 9th century. A Benedictine monastery was founded on the site of this early monastery in 1076, and was followed by more building work later. The present ruins date approximately from the 13th to the 15th centuries. Following the Dissolution, the lands of the abbey and its estate came into the possession of the Cholmley family whose large house, known as the Banqueting House, was constructed *c* 1672 (Hunter *et al* 2005).

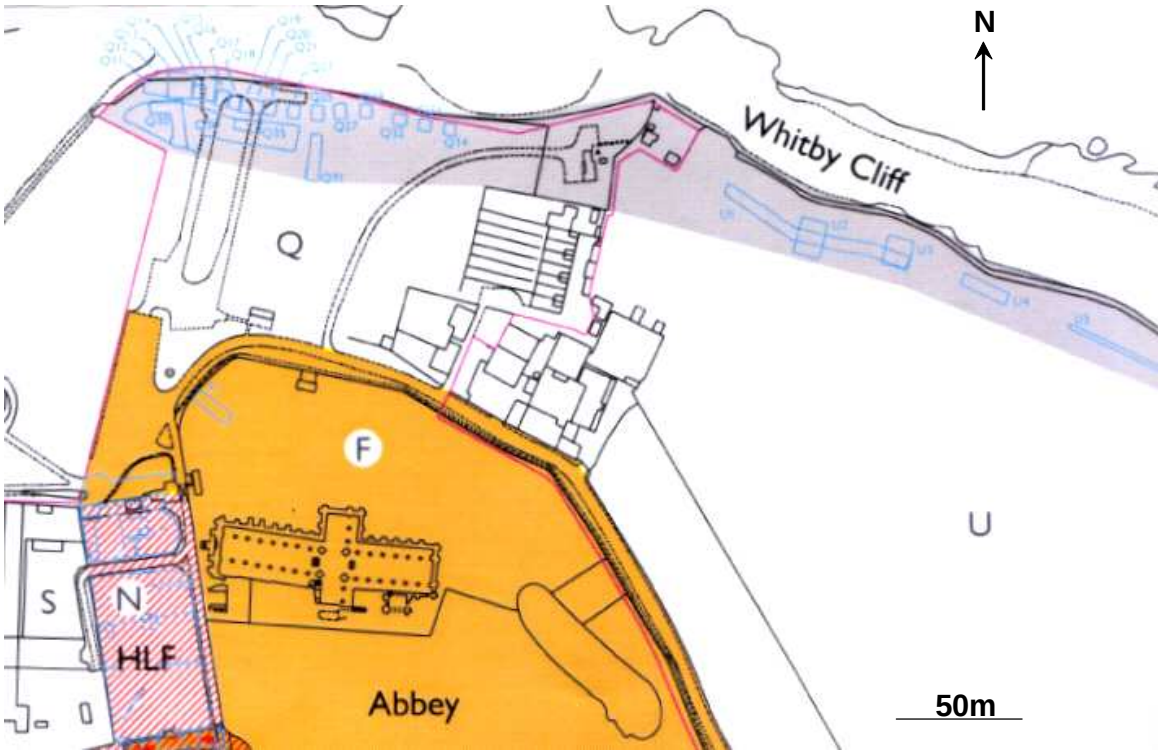

Figure 1: Whitby cliff, showing the location of the Abbey relative to the trenches from the Whitby Cliff excavations, top in pale blue. The cliff edge is shown by the black line bordering the section labelled Whitby Cliff (illustration by Eddie Lyons).

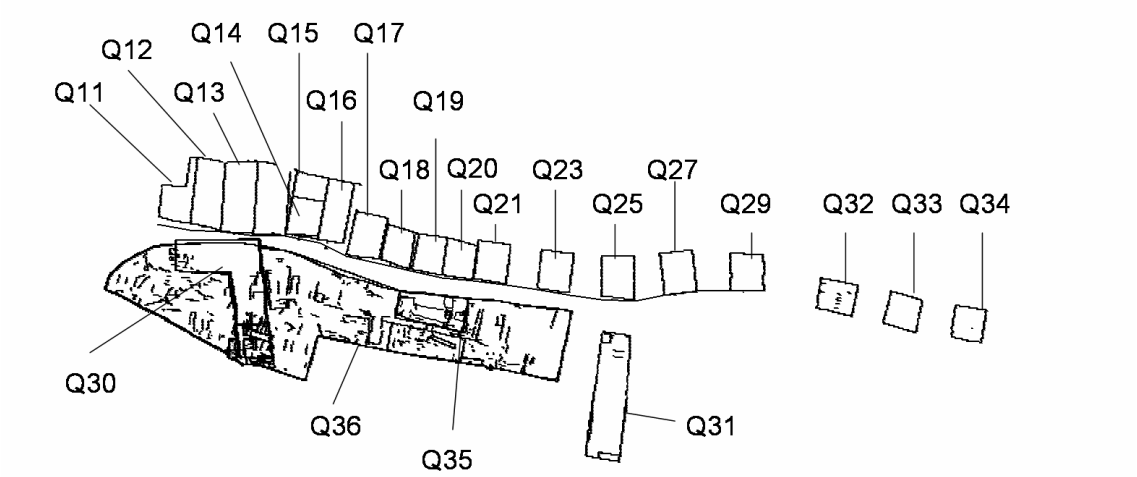

Figure 2: The Whitby Cliff trenches in more detail (from a plan by Eddie Lyons). Q36 is a large trench sited over the locations of earlier trenches Q30 and Q35.

A Jurassic sedimentary sequence capped with glacial boulder clay forms the underlying geology of the East Cliff headland (Hunter *et al* 2005).

13kg of smithing waste from the HLF area excavations at Whitby (see Figure 1) have previously been reported (Hunter *et al* 2005).

METHOD

There are two principal forms of ironworking: smelting and smithing. Smelting is the extraction of metallic iron from its ore. Smithing is the shaping of iron whereby the metal is heated in a hearth and hammered into the desired form. These processes produce characteristic debris that can be classified according to morphology, colour, porosity and density.

A total of c160kg of probable metalworking debris from Whitby were submitted for assessment. This material was visually assessed and classified according to the categories below (Bayley *et al* 2001, Paynter 2008):

Smithing Hearth Bottom (SHB) slag is diagnostic of iron smithing. SHB slag accumulates in the smithing hearth and tends to be porous with a convex-concave profile. There will often be lumps of adhered hearth lining and impressions of fuel evident on the sides or base.

Hammerscale (HS) is a by-product of smithing and is formed when hot iron is struck. There are two types of hammerscale; flake and spheroidal, both of which are generally only a few mm in size and highly magnetic. Flake hammerscale is made up of thin scales of iron oxide whereas spheroidal hammerscale comprises hollow, spheres of iron-rich slag. Sometimes hammerscale becomes fused together and form a hard mass, also known as smithing pan. When found *in situ*, distribution patterns of hammerscale can be used to

locate areas of activity within a smithy. Only small quantities of hammerscale were found amongst the Whitby finds.

Fuel Ash Waste (FAW) is a low density, porous, light grey / green slag formed by the reaction of plant ashes (e.g. from charcoal) with clay or other siliceous material. Although it can be a metalworking by-product, other non-metallurgical, high temperature processes can also produce these slags, and so alone it is not diagnostic of metalworking.

Undiagnostic Slags (UDS) comprise iron-rich waste slag from ironworking, but the waste is not morphologically distinctive and cannot be linked to a particular ironworking process.

Dense Slags (DS) are iron-rich slags with particularly low porosity, although sometimes impressions of large fuel fragments can be seen. This slag has often cooled slowly, resulting in large crystals, which are visible by eye in fresh fracture surfaces.

Iron (Fe) includes pieces of iron metal found in amongst the assemblage. These are dense, rusted and strongly magnetic. There may be complete objects, or forms of trade and stock iron, such as bars, and some iron incorporated into waste slag.

Vitrified Hearth Lining (VHL) is clay that has been exposed to high temperatures in contact with reactive plant ashes, such as those derived from fuel, and has consequently become glassy in nature. This type of waste is formed during metalworking but is also a by-product from most high temperature processes and therefore is not necessarily diagnostic of metalworking.

Fired Clay (FC) is clay which has been exposed to high temperatures and again is not necessarily diagnostic of metalworking.

Stone (S) comprises any geological material within the assemblage. Although most is not diagnostic of metalworking, particular note was made of iron-rich stone as this may be ore from iron smelting.

Coke (C) was found in small quantities amongst the assemblage. This material is light, black and porous. Coke was sometimes used as a fuel in iron smithing (Dearne and Branigan 1995) but no evidence of this was found at Whitby. The coke is not diagnostic of metalworking and only its presence was noted, rather than precise amounts.

X-radiography of pieces of iron metal found in association with the metalworking debris was carried out in order to identify objects, which were subsequently labelled as small finds.

RESULTS

Table 1: A comparison of the amounts (kg) of different categories of waste from WCI, WCII and WCIII (for full results see Appendix 1, Tables 1, 2 and 3)

	SHB	VHL	DS	FC	UD	Fe	HS	FAW	S	Total
WCI	8.6	1.2	0.4	0.1	6.5	0.8	0.0	2.3	0.0	20.0
WCII	4.0	1.0	5.4	0.1	13.2	0.7	0.0	0.4	0.6	25.1
WCIII	46.9	9.2	4.7	2.1	36.5	1.9	0.1	17.4	0.3	119.1

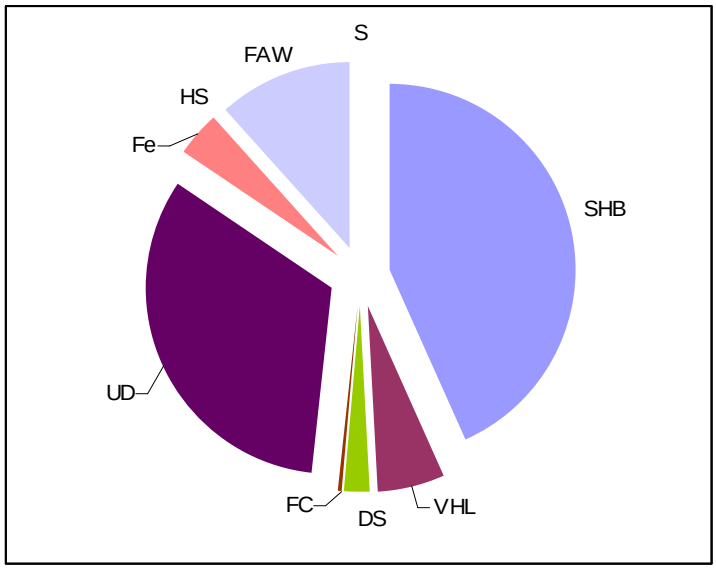

Figure 3: Pie chart showing the proportions of metalworking debris in WCI

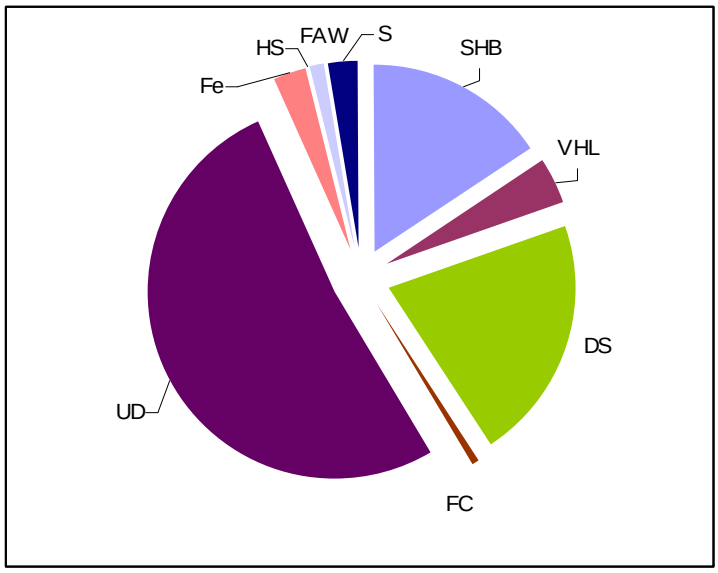

Figure 4: Pie chart showing the proportions of metalworking debris in WCII

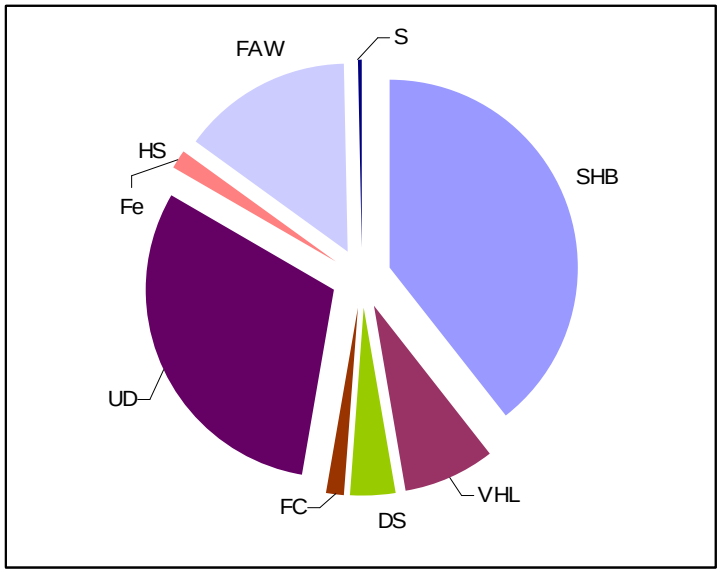

Figure 5: Pie chart showing the proportions of metalworking debris in WCIII

ANALYSIS

Ironworking

By far the largest quantity of waste was recovered from WC III (see Table 1). The material was largely recovered from pit fills with none *in situ*. The dominant debris types present are undiagnostic slags, fuel ash waste and smithing hearth bottoms, consistent with smithing activity (Figure 5). The vitrified hearth lining has a distinctive, quartz-rich fabric and the fuel used was charcoal in all cases. The smithing slags are of variable size but typical shape with a light grey / green colour.

Smaller amounts of waste were recovered from WCI and WCII (Table 1). WCI (Figure 3) contains similar proportions of industrial debris as WC III, again indicative of smithing activity.

The assemblage from WC II is small and incomplete; one box of material could not be located. Nevertheless the waste from this area contained different relative amounts of the various slag types (Figure 4), suggesting that another type of metalworking activity may have been taking place. Smithing slag was present, but made up a smaller proportion of the total, whereas the assemblage contained larger proportions of undiagnostic slag, dense slag and stone than WCI or III.

Figure 6: A 1kg lump of dense slag from WCII, context 30967, which also contained smithing slag, undiagnostic slag and burnt, iron-rich stone

The dense slag from WCII includes large fragments with flowed surfaces and impressions from reasonably large pieces of wood or charcoal (Figure 6). This resembles the slag produced by iron smelting using a non-tapping, or slag pit, type furnace. This type of furnace was in use in England during the Iron Age and Anglo-Saxon periods (Paynter 2007, Tylecote 1990). Such furnaces probably comprised some kind of superstructure above ground level, such as a shaft or dome, and a pit below ground level. The molten waste slag produced during smelting drained down into the pit and accumulated there, sometimes in large (10kg or more) masses referred to as furnace bottoms or slag cakes. The slag waste and furnace remains from non-tapping furnaces are less distinctive than the tapping furnaces and slags typical of other periods, and so more difficult to conclusively identify. The relatively small amounts recorded here would represent only one or two smelts, but similar waste may have been lost through processes such as cliff erosion or during agriculture use.

Fragments of stone are also found more frequently in the WCII assemblage. A large piece from context 30967 is very iron-rich and burnt, with a distinctive bright red colour. Such fragments maybe discarded or unused ore. Ore from smelting sites often shows evidence of heating in an oxidising atmosphere (Paynter 2008) suggesting that the ore was prepared by roasting prior to smelting.

Date and Location of Ironworking Activity

Table 2 summarises the contexts from which around 2kg of slag, or more, was recovered. Easily the largest dump of material was from trench Q36, pit [40144] (see Figure 7), dominated by smithing waste. Fill 40145 has a provisional date of the 1st or 8th/9th centuries. Since the majority of other contexts containing smithing debris have been provisionally dated as Anglian, or later, the 8th/9th century period for this activity seems most likely. Intrusion of 12th to 13th century pottery into earlier contexts was noted, and so it is unclear whether there was further smithing activity in the 12th/13th centuries (Table 2). Feature [40144] is at the edge of trench Q36 and so further evidence of the smithy may survive inland, outside the limits of the excavation. Alternatively the original location of the smithy may have been beyond the present day cliff edge with the archaeological remains destroyed by subsequent erosion of the cliff.

Table 2: Contexts containing approximately 2kg, or more, of waste

Trench	Context	Description	Provisional date	Amount (kg)
Q18	30184	-	-	3.4
Q25	30257	-	-	3.2
Q30	30967	Deposit	8th/10th and 13th C	4.2
	30973	Fill of pit [30972[	12th/13th C	1.9
Q31	30403	Layer	19th/20th C	1.9
Q32	30509 & 30504	Fill of pit [30534]	8th/9th and first half of 13th C	5.6
Q36	40149	Waste pit [40144]		9.1
	40145		1st or 8th/9th C	27.4
	40264	Fill of pit [40224]	-	6.5
	40263		Anglian	3.6
	40577	Layer	-	4.9
	40950	Fill of cut [40952]	Late 12th/13th C	8.3
	40011	Layer	-	9.7
	40253	Fill of gully [40252]	-	8.9
	40373	Fill of pit [30351]	11th/12th C?	4.3

The possible smelting evidence appears to be confined mainly to trench Q30 (Figure 7), in the same area as the largest concentrations of smithing waste, described above. Although less information is currently available on the finds and features from trench Q30, the form of this waste suggests a non-tapping furnace, which would be consistent with an Anglian date.

Figure 7: Plan of part of trench Q36 overlaying earlier L-shaped trench Q30. The heavy outline shows waste pit [40144], containing fills (40149) and (40145), of 1st or 8th/9th century date.

Hammerscale

The hammerscale described in this report came from multiple sources. Some hammerscale, particularly concretions, was noted amongst the bulk finds and is recorded in the appendix, Tables 1, 2 and 3. Hammerscale was also retrieved from sub-samples, some of which had already been processed (floated and graded) and some of which were processed as part of this study.

High concentrations of hammerscale (in excess of 30wt%) are typical of occupational deposits from iron smithing workshops. Amounts significantly less than this are unlikely to be archaeologically significant since hammerscale is easily dispersed and low, 'background' levels can be found across a wide area (Bayley *et al* 2001). The samples taken from WCI, II and III were between 32 and 34 litres each but no more than 2g of hammerscale was found in any sample (less than 0.1wt%).

A common feature across all three areas, however, was the large size of the hammerscale. The largest fragment of flake hammerscale recovered was approximately 15mm in length and 10 mm at the widest point, which is unusually large and the majority of the hammerscale was in excess of 2mm in length. Since hammerscale is brittle and breaks easily, for example by trampling, this suggests that much of the waste examined here was dumped soon after its formation, together with the associated hammerscale. The largest amount of hammerscale recovered from amongst the bulk finds was 14.5g from WC III, Q 36, 40264 (see the Appendix Table 3), which is a pit fill.

Evidence for Non-Ferrous Processes

There are two pieces of evidence for non-ferrous metalworking amongst the assemblages. A droplet of copper alloy embedded in a fragment of hearth lining was found in WC III, Q36, 40011, however, the rest of the debris is indicative of a typical smithing assemblage (see the Appendix, Table 3). There is no adhering ferrous slag suggesting that the copper was melted in a separate process, and not in a smithing hearth.

The other find is a fragment of crucible with a red vitrified inner surface (see cover) indicative of copper alloy working; this was recovered from the Whitby Abbey excavations.

There is insufficient evidence to suggest that copper working was taking place on the Cliff; context 40011 is the plough soil making the likelihood of contamination from migratory material high. It is probable however, that copper working was at some point taking place at the Abbey site.

Bone Inclusions

Several contexts yielded debris with animal bone inclusions; these were WCI, Q25 30275 and Q18 30184 and WCIII, Q36, contexts 40264, 40951, 40950 and 40030. Most of the bone fragments are not completely incorporated into the metalworking waste and it seems likely that the bone became attached post deposition in many cases; in the instance of 30184 a tooth was adhered with iron corrosion. Many contexts comprise a mixture of industrial debris and animal bone, suggesting a general dump of industrial and domestic waste. However, in some cases the bone may have been introduced into the smithing hearth, perhaps accidentally; possible examples include slag fragments from 40264, 30275 and from 40030.

Sampling

Different strategies were adopted during the WC excavations, depending on the type of evidence being sought, and this has influenced the proportions of different waste types recovered. There were fewer processed samples from WCIII and the most from WCII. When only processed samples are considered, a bias in the types of waste can be seen. For example, fuel ash waste, hammerscale and hearth lining, all light, friable materials, are strongly represented in floated, graded samples. The heavy fraction of processed samples contains small fragments of slag that, due to their small size, cannot be identified, and so undiagnostic slag is strongly represented. However the varying sampling strategies have not influenced the overall conclusions since bulk finds, rather than samples, make up the majority of each assemblage by weight.

CONCLUSIONS

The majority of the evidence from Whitby Cliff is indicative of iron smithing. This activity is likely to have taken place in the Anglian period in the cliff area, but the precise location

of the smithy cannot be determined. There is also some evidence to suggest small scale iron smelting, using a non-tapping furnace. This would be consistent with an Anglo-Saxon date also. There is also sparse evidence for copper alloy casting in the vicinity, although the location and date of this activity are unknown.

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APPENDIX

Table 1: Catalogue of the quantities of waste (g) for each context from WC1; for descriptions of the waste types see the text

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q11	**30113**	**n/a**	133							16			149
	30114	**n/a**	500				176			50			726
	30114	**<32000>**	298				75			8			381
	30117	**<32025>**							0.67	1			2
	30117	**n/a**					68			53			121
	30117	**<32025>**					32			32			64
Q12	**30124**	**n/a**		37			178			60	34		309
	30125	**<32081>**								2			2
	30125	**n/a**	421	173			435			83			1112
	30126	**<32022>**					21		5.21				26
	30126	**<32022>**							1.9				2
	30126	**n/a**	47				660	30		15			752
	30173	**n/a**	206	124			85			17	12		444
	32128	**<32028>**							0.07				0
Q13	**30133**	**n/a**				35	26			6	5		72
	30134	**n/a**			422								422
	30136	**n/a**	208				81	20		18			327
	30136	**<32021>**							0.48	18			18
	30139	**n/a**	261	424			122			13			820
Q14	**30147**	**n/a**		41									41
	30147	**<32020>**								1			1
	30147	**<32020>**								5			5
Q15	**30154**	**n/a**					159			77			236

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q16	**30165**	**n/a**	94				27			10			131
	30165	**<32024>**							0.61	34			35
Q17	**30175**	**n/a**		58			39			7			104
	30176	**n/a**	509				232	55		24			820
	30176	**<32016>**								18			18
Q18	**30184**	**n/a**	489	43			182			146			860
	30184	**<32014>**	1286				324		7.67	932			2550
Q19	**30193**	**n/a**					104						104
	30196	**n/a**					176	9					185
	30196	**<32015>**					34		2.34	18			54
Q21	**30213**	**n/a**					111	105					216
	30215	**<32001>**					4			14			18
	30216	**n/a**					19						19
	30216	**<32002>**		18			50			2			70
	30294	**<32018>**							0.04	1			1
	30294	**n/a**	709				111	105					925
Q23	**30001**	**n/a**								46	20		66
	30002	**<32007>**					2						2
	30002	**<32006>**							0.11				0
	30235	**n/a**	87				16			7			110
	30235	**<32012>**					17		0.38	4			21
	30236	**n/a**					31						31
	30236	**<32004>**		7			40			8	2		57
	30237	**<32003>**	849	55			476	2		103			1485

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q24	**30295**	**n/a**					19						19
	30295	**<32019>**							0.2	3			3
Q25	**30256**	**n/a**						281					281
	30256	**<32017>**					4			14	12		30
	30257	**<32010>**					151		2.19	90	5		248
	30257	**n/a**	1221	128		92	916	225		273			2855
	30257	**<32011>**				5	63			30			98
	30257	**<32008>**							0.86	23	5		29
Q27	**30275**	**n/a**	653				1055						1708
	30275	**<32009>**	625	61			153		0.1	39			878
Q29	**30293**	**n/a**					18						18
Total			**8596**	**1169**	**422**	**132**	**6474**	**832**	**23**	**2321**	**95**	**0**	**20082**

Table 2: Catalogue of the quantities of waste (g) for each context from WCII; for descriptions of the waste types see the text

SSD	Context	Sample Number	SHB	VHL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q30	**30333**	**<32204>**								1			1
	30393	**<32223>**					1			2			3
	30398						22						22
	30402												0
	30539	**<32268>**					14			2			16
	30706												0
	30709	**<32331>**								1			1
	30776												0
	30780												0
	30817	**<32232>**				4							4
	30821	**<32235>**								1			1
	30825	**<32237>**					1						1
	30829			17									17
	30830			6									6
	30831						194						194
	30833	**<32239>**								0.4			0
	30838	**<32241>**								5			5
	30838	**<32241>**				32							32
	30839	**<32244>**					1		0.02	1			2
	30840						50			8			58
	30840	**<32236>**					55						55
	30844	**<32234>**					8			4			12
	30844						22						22
	30858	**<32243>**					11						11
	30858						124						124
	30861	**<32293>**								3			3
	30861						28						28
	30862	**<32242>**							0.08	1			1
	30863	**<32250>**								4			4

SSD	Context	Sample Number	SHB	VHL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q30 cont.	30863	<32250>			439		8						447
	30863			40									40
	30869	<32246>								1			1
	30892		620										620
	30900	<32259>					1						1
	30902	<32257>								1			1
	30908			64			953	542					1559
	30909					6	24						30
	30919	<32262>								2			2
	30938	<32265>								7			7
	30938									31			31
	30938						12						12
	30943	<32267>								0.3			0
	30948						37						37
	30955						68						68
	30957			2									2
	30959	<32270>					22		1.21	4			27
	30959						27						27
	30961				318		118						436
	30961				318								318
	30967	<32272>	61				42						103
	30967	<32287>							0.1				0
	30967	<32281>					42		0.21	18			60
	30967		750	71	1246		471						2538
	30967	<32287>					34						34
	30967		560	31			706						1297
	30967											126	126
	30968	<32274>					1						1
	30970									15			15
	30973	<32290>								14			14
	30973				200		1717						1917

SSD	Context	Sample Number	SHB	VHL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q30	30975						82						82
cont.	30976	<32276>								22			22
	30981						24						24
	30983	<32282>				2				30			32
	30984						1						1
	30985		851										851
	30986	<32286>								15			15
	30997	<32289>					4		2.39	1			7
	39214	<32292>							0.04	1			1
Q31	30400						134				1	20	155
	30402					31	283						314
	30403				1514		408			8	16		1946
	30406						19						19
	30408						12						12
	30447						45						45
	30450				42		23						65
	30463	<32329>					2			1			3
	30465	<32328>					2			1			3
	30465						66						66
	30466	<32330>					1			1			2
	30466						12						12
	30477	<32323>					8			2			10
	30706	<32306>								1			1
	30706	<32306>					58						58
	30706			11	172		62						245
	30708				121		6			6			133
	30709	<32343>	31				19	2	0.43	2			54
	30709	<32331>								4			4
	30709						57						57
	30709	<32342>		16			17					6	39
	30709		47	168			541					307	1063

SSD	Context	Sample Number	SHB	VHL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q31 cont.	**30727**	**<32304>**					11						11
	30738						7						7
	30743						7						7
	30749						4						4
	30755						3						3
	30757	**<32309>**					8						8
	30764						16						16
	30771				35		20						55
	30776	**<32312>**					19		0.71	7			27
	30776	**<32314>**					3			2			5
	30776											43	43
	30776			6	337		23	16					382
	30780			15	217		20						252
	30790	**<32318>**								10			10
	30790						49						49
	30790						15						15
	30799	**<32321>**								3			3
	30977	**<32323>**								0.1			0
	39002	**<32324>**				9							9
	39008	**<32326>**					9			2			11
	39012	**<32327>**								5			5
	39012						11						11
	39026						18						18
	39032	**<32344>**					1			2			3
	39032						15						15
Q32	**30509**	**<32422>**					66		1.12	54			121
	30512	**<32423>**								1			1
	30516	**<32424>**					13			20			33
	30540	**<32427>**								1			1
	30502		70	51			144						265
	30503						6						6

SSD	Context	Sample Number	SHB	VHL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q32	30504						43						43
cont.	30504	<32400>					38			8			46
	30504	<32401>					528			3			531
	30505						9						9
	30509		321	249			2060	129					2759
	30509	<32403>					721			11			732
	30509	<32422>	81	65	399		946						1491
	30511		53	42			277						372
	30512		203				49						252
	30514						10						10
Q33	30502												0
	30552						34						34
	30553	<32405>					45						45
	30554	<32402>					47						47
	30554	<32402>					69						69
Q34	30609	<32414>								4			4
	30613	<32410>					10			0.5			11
	30616	<32406>	41										41
	30617	<32407>					0.5						1
	30619	<32409>					4				1		5
	30655	<32420>					13						13
	30655	<32420>					7						7
Q35	39102						263						263
	39103	<32426>		10									10
	39103						217						217
	39106			106			227						333
	39107						82						82
	39122						4						4
	39125						8						8
	39127		266				283						549
Total			**3955**	**970**	**5358**	**84**	**13183**	**689**	**6**	**355**	**18**	**501**	**25119**

Table 3: Catalogue of the quantities of waste (g) for each context from WCIII; for descriptions of the waste types see the text

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36	**30384**	n/a	925	8		6	193			108			1240
	40005	n/a	1105	146		9	254			157			1671
	40007	n/a								19			19
	40008	n/a	116	136			240	86		36			614
	40011	n/a	2309	225	255		3383	344		3134	57		9707
	40012	n/a					34			5	3		42
	40016	n/a	84				40						124
	40017	n/a	75							36			111
	40018	n/a		22						23			45
	40019	n/a	125				33			17			175
	40021	n/a					45						45
	40022	n/a								102			102
	40027	n/a					5						5
	40028	n/a	540				52			101			693
	40030	n/a	450										450
	40033	n/a								66			66
	40035	n/a	631	177			837	10		333			1988
	40039	n/a	406				65						471
	40045	n/a	30				35						65
	40046	n/a	168				142			32			342
	40047	n/a	66				25			7			98
	40047	<43104>		17						11			28
	40052	n/a	356			5	279			35			675
	40054	n/a					24						24
	40055	n/a					64			36			100
	40059	n/a		72									72
	40061	n/a	97										97
	40069	n/a					69						69

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36 cont.	**40069**	<43106>	20	2			21						43
	40070	<43107>	1129	39			525	23					1716
	40070	n/a	129										129
	40077	n/a					12			61			73
	40079	n/a					31			11			42
	40081	n/a	594			9	202						805
	40084	<43242>	6							6			12
	40085	n/a					37						37
	40092	n/a				13	17						30
	40096	n/a					11						11
	40101	<43115>	3							4			7
	40102	<43231>	635	35			111			40			821
	40104	n/a					29			28			57
	40108	<43141>	45				14						59
	40113	n/a		5		6	19			6			36
	40121	n/a								3			3
	40124	n/a	32				266			2			300
	40125	n/a	85				43	612					740
	40137	n/a					24						24
	40139	<43109>								2			2
	40145	n/a	5592	1387	336	83	4493			2662			14553
	40145	<43110>	2431	335	1069	1332	7633	15					12815
	40146	n/a		113			63						176
	40149	n/a	2339	145	486	20	543			1550			5083
	40149	<43114>	1894	136	177	14	1398			389	11		4019
	40172	n/a		9			55						64
	40174	n/a	296				19						315
	40175	n/a	344				88			67			499
	40178	n/a	102										102
	40209	n/a					46						46
	40210	n/a				43	37						80

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36 cont.	**40219**	n/a								71			71
	40234	n/a								83			83
	40251	n/a								32			32
	40251	<43125>					171		0.32	6			177
	40253	<43131>	5722	85	18		1457	29	0.41	1564			8875
	40260	<43123>								78			78
	40262	n/a	62			233				30			325
	40262	<42135>				13							13
	40263	n/a	533	2308	81		391			93			3406
	40263	<43128>					197	12					209
	40264	n/a	2222	1056		136	2562	8	36.5	502			6523
	40269	n/a	114		56	3	96			49			318
	40279	<43130>					82						82
	40284	<43126>						14					14
	40286	n/a					95			10			105
	40289	n/a								7			7
	40295	n/a								14			14
	40311	n/a	215										215
	40321	n/a					113			17			130
	40322	n/a					247			248			495
	40323	n/a					17			221			238
	40324	n/a								30			30
	40332	n/a		13						6			19
	40333	<43138>	59	3			28			56			146
	40334	n/a					159						159
	40334	<43139>					85			108			193
	40335	n/a	137				62						199
	40338	<43136>	628			1	21			142			792
	40343	n/a					11						11
	40345	n/a	190				424			78			692
	40352	n/a					61						61

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36 cont.	**40370**	n/a		170			315			29			514
	40372	<43143>							0.04	23			23
	40373	n/a	4019				255			65			4339
	40376	n/a					14						14
	40376	<43193>					8						8
	40386	n/a					52			9			61
	40387	n/a					13						13
	40398	n/a				2	190			3			195
	40398	<43145>	99			31							130
	40414	n/a				22	19						41
	40416	n/a					70						70
	40417	n/a	75										75
	40419	<43146>					7						7
	40422	n/a	611				106						717
	40426	n/a								3			3
	40428	n/a		191			525						716
	40429	n/a					25			7			32
	40435	n/a								10			10
	40444	n/a					4						4
	40446	n/a	73				83			20			176
	40446	<43206>					77			13			90
	40452	n/a					93						93
	40457	n/a						103					103
	40462	n/a					35						35
	40464	n/a		103						7			110
	40465	n/a								7			7
	40470	n/a					14						14
	40471	n/a					135						135
	40472	n/a								66			66
	40472	<43172>					6						6
	40484	n/a					38			25			63

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36 cont.	**40488**	n/a		597									597
	40493	n/a					17						17
	40495	n/a					22			4			26
	40498	<43162>	372							17			389
	40504	n/a	693	33			149		0.72	34	7		917
	40505	n/a								1			1
	40506	n/a	734			3		7			18		762
	40510	n/a	168										168
	40515	n/a	595							27			622
	40523	<43177>				60	29			10			99
	40529	n/a					34		9	51			94
	40530	n/a								8			8
	40538	n/a								19			19
	40540	n/a								15			15
	40556	n/a					29			31			60
	40558	n/a		87									87
	40560	n/a								21			21
	40566	n/a								24			24
	40569	n/a		8									8
	40577	<43171>	712	147			2332	50	2.53	1310		299	4853
	40578	<43214>					30						30
	40600	n/a								3			3
	40601	n/a	227										227
	40606	n/a					23						23
	40619	n/a		31			12						43
	40620	n/a					37			12			49
	40622	n/a	148				80	8					236
	40634	n/a								6			6
	40660	n/a								7			7
	40661	n/a					100			26			126
	40664	n/a		34									34

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
Q36	**40670**	n/a				60							60
cont.	**40685**	n/a								50			50
	40687	n/a					97			114			211
	40691	n/a								38			38
	40697	n/a	80										80
	40706	n/a		45									45
	40721	n/a					19			23			42
	40722	n/a		50									50
	40752	<43194>					29		51	26			106
	40760	n/a	147				25						172
	40762	n/a	205							118			323
	40802	n/a						35					35
	40805	n/a					35						35
	40811	<43215>					18			5			23
	40815	n/a		136									136
	40815	<43207>					8						8
	40854	<43202>					9						9
	40874	n/a		31									31
	40879	<43205>								11			11
	40893	<43228>	632				57		4	25			718
	40894	<43241>								76			76
	40918	n/a					36						36
	40950	n/a	2392	548	109		2784	464		1663			7960
	40950	<43243>	102				31			192			325
	40951	n/a	1337	58						134			1529
	40951	<43232>	102				34			25			161
	40971	n/a						73		38			111
	40979	n/a								165			165
	40979	<43236>					15	25		10			50
	u/s	n/a	352	77		4	266	28		105	16		848

SSD	Context	Sample Number	SHB	VL	DS	FC	UD	Fe	HS	FAW	C	S	Total
U1	**35000**	n/a								88			88
	35002	n/a					27						27
	35004	n/a					10						10
	35008	n/a					59			7			66
	35022	n/a								11			11
	35026	<37100>					34						34
	35034	<37108>					4						4
	35036	<37101>			28				2			30	
	35036	<37122>					9						9
	35037	<37102>							1			1	
	35037	n/a								6			6
	35038	<37103>					51			3			54
	35038	n/a								33			33
	35207	n/a		336									336
	35207	<37120>		6		9				4			19
Cliff Edge					1973								1973
Total			**46916**	**9162**	**4560**	**2145**	**36470**	**1946**	**105**	**17420**	**112**	**299**	**119135**