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Ancient Monuments Laboratory
Report 177/87

THE IRONWORKING RESIDUES FROM BEESTON CASTLE, CHESHIRE.

J G McDonnell BTech PhD MIFA

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Summary

Examination of the residues show that iron smithing was practiced on the site from prehistoric period onwards. There was no evidence of iron smelting. The large deposits of smithing debris probably derive from the constructional phases of the Medieval Castle. Analysis of two slag samples showed a range of compositions etc. typical of smithing slags.

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The Ironworking Residues from Beeston Castle, Cheshire.

1 Introduction

The majority of the slags and residues sent for identification were of types commonly found on many archaeological sites. There were also 'residues' that were less common or were thought to be of special significance.

The manufacture of iron artefacts was a two stage process. Firstly the metallic iron was extracted from the ore by the smelting process. Secondly the iron was refined and worked into artefacts by means of the smithing process. Both processes generated residues as by-products. Full discussion of the processes and their associated residues can be found in the literature[1,2].

The residues can be divided into the diagnostic slags, those that derived soley from the iron working process, and the non-diagnostic slags, those which may have derived from any pyrotechnological process (including the working of the domestic hearth). The latter include hearth or furnace lining, fuel ash slag and cinder, although some cinders can be classed as diagnostic residues by their morpholgy and their association with diagnostic residues. The diagnostic residues are the iron silicate slags, and these have been classified according to their genesis[1], and divide into the smelting slags from the smelting process and the smithing slags from the smithing process.

The residues recovered from excavations can normally be classified into specific types on the basis of their morphology, although some smelting and smithing slags cannot be distinguished by this method. Detailed chemical and mineral anslyses can be applied to elucidate differences between these slag types.

2 The Beeston Castle Residues

A total of 128.9 kg of residues were examined, and classified into seven types. A full listing by site and context number and by site and archaeological group is given in Appendices 1-3. A listing by A.M. Lab. Number is given in Appendix 5. The seven types were:

Diagnostic Slags

2.1 Hearth Bottoms

Hearth Bottoms are plano-convex slag lumps that formed in the base of the hearth during the smithing process. They are often characterised by having a depression in the upper surface formed by the air blast from the bellows. Their morphological texture varies from fayalitic slag to cindery (high silica content) and from agglomerated to flowed surfaces. The hearth bottoms may contain large non-slag inclusions e.g pebbles and have fragments of hearth lining attached where they were fixed to the hearth structure by reaction between the slag and the clay lining. The dimensions of 54 Beeston hearth bottoms were recorded and the mean and standard deviations were:

		MEAN	S.D.
Major Diameter	(mm)	125	25
Minor Diameter	(mm)	105	20
Depth	(mm)	60	25
Weight	(gm)	960	640

The Beeston hearth bottoms were very large in comparison to those from earlier dated sites but as yet no directly comparable material has been reported giving hearth bottom dimensions. The Standard Deviations show that there was considerable variation in the size of the hearth bottoms (a full listing of the dimension is given in Appendix 4).

2.2 Smithing Slag

Smithing slag are randomly shaped pieces of slag generated by the smithing process. They range in size from 10gm upto several 100gm, and do not normally exceed 100mm in length/diameter. They are lumps of smithing slag that were removed from the hearth before they became fully developed hearth bottoms. Texturally they are similar to the hearth bottoms.

2.3 Smelting Slag

Three small fragments of possible tap smelting slag were recovered from the site (total weight 115gm). This quantity is not significant and can therefore be ignored in later discussions. It is possible that they were fragments of smithing slag that had been subjected to high temperatures causing them to flow.

Non-Diagnostic Slags

2.4 Cinder

Cinder is a high (>40%) silica slag, and therefore of lower density than iron silicate slag. It was also vesicular and has vitrified surfaces. A small quantity of cinder was identified (1.6 kg). In all cases except one it occurred in contexts that also contained smithing slag and hearth bottoms, and since some of these had a cindery texture, it can be assumed that the cinder derived from the smithing process.

2.5 Hearth/Furnace Lining

Hearth or furnace lining was the clay lining of the hearth (or furnace) that had been subjected to high temperatures so that the clay was very well fired and/or that the internal hot-face surface became vitrified. Ironworking hearth/furnace linings may also have suffered attack by slag. The region of hottest temperature was in the tuyere zone and therefore the tuyere mouths were often preserved in the lining. Hearth/furnace linings may have derived from any pyrotechnological process, and can only be ascribed to a process by e.g. adhering slag or associated residues.

2.6 Fuel Ash Slag

Fuel ash slag is a very high (90%) silica slag and occurred as small very vesicular nodules, usually white/grey in colour and sometimes with vitrified surfaces. It can derive from any pyrotechnological activity. Only a very small quantity (0.1 kg) of fuel ash slag was recovered.

2.7 Other Residues

Included amongst the residues were other materials that could not be ascribed to any of the above types or were thought might derive from non-ferrous technology, therefore they were grouped as 'other residues'. They included the following materials.

2.7.1 Iron Ores

Small ore nodules (total weight 0.4kg) had been recovered from prehistoric contexts in which copper alloy working debris had been found. Identification of the ore type was requested. Morpholgically the ores were identified as examples of goethite and hematite iron ores rather than copper ores. Energy dispersive X-ray analysis confirmed the absence of copper (see Section 4.1).

2.7.2 Lead Working Debris.

A small lump of dense yellow granular material (weight 50 gms) was recovered from Context 408 (AML. No.852666). Energy dispersive X-ray analysis showed the presence of aluminium, silica, lead, (see Section 4.2)

2.7.3 Fired Clay/Hearth lining/Crucible/Rampart debris?

This material comprised large pieces of well fired clay/sandstone sometimes with areas of vitrification. It was therefore, similar to hearth lining but was much larger in size, in particular thicker, than conventional hearth lining. It was widely dispersed across the Castle, and could not have derived from a single hearth. It is therefore probable that it was material from the vitrified rampart.

2.7.4 Other

There were also fragments of fired clay, coal and slate, and burnt bone.

3 The Phase and Spatial Distribution

3.1 Outer Gateway (Site Code O) (Slag listing Appendix 1).

The largest deposits of smithing slag were recovered from this excavation. In the pre-medieval phase two Groups contained a small amount of smithing debris. Group 116 (Context 858) contained a single hearth bottom (weight 0.17kg), and Group 78 (Context 363) contained 0.18kg of smithing slag. These quantities do not represent the location of the smithing activity, they can be considered back-ground levels, but indicate that iron smithing had been practiced on the site prior to the building of the Medieval castle. Other material recovered from this phase included very small amounts of fuel ash slag, 0.02kg of goethite, and 0.775kg of the probable vitrified rampart material (Group 127, Context 634 (0.725kg), and Group 57, Context

589 (0.05kg)). Group 127 has a C-14 date of 380 +/- 40 b.c., and is the earliest date for this material. This would support the hypothesis that the material did derive from the vitrified rampart.

The Groups firmly dated to the Medieval Period produced 1.05kg of smithing slag (Group 10, Context 804). This was the only stratified evidence for smithing during the construction of the Medieval Castle. Small quantities of the probable 'vitrified rampart' were also present (Groups 48 and 109).

Smithing slag was present in 17th Century Groups (26 and 56), but whether this was residual or represented activity at this time cannot be determined.

In the 18th Century Group 20 contained a small quantity of smithing slag and 'vitrified rampart' material.

The largest deposit of smithing debris derived from the unstratified topsoil, (Group 1, Contexts 801 (53.8kg) and 806 (45.3kg)). This slag was residual, and it could not be determined whether it derived from the constructional phases of the Castle. The quantity is definite evidence for either sustained smithing activity, ie. a permanent smithy operating over a long period of time, or an intense short period of activity, eg. building activity. It is very probable that the debris represents both activities.

3.2 Site Outer Ward (Site Code OW). (Slag listing in Appendix 2)

The prehistoric contexts produced no evidence of ironworking. A small fragment of non-ferrous metal working crucible and a fragment of hearth lining were recovered. Also, small fragments (21gms) of goethite (FeO.OH) were present.

These cannot be interpreted as 'iron ore' fragments, but may either occur naturally or were used for some other purpose. Goethite fragments were also recovered from the Iron Age site of Beckford, Worcestershire[3].

A small amount (0.565kg) of smithing slag occurred in the Lower Soils (Group 203, Context 181). This indicates that iron was being smithed at this period but not in the area of the excavation. Fragments of the 'vitrified rampart' were recovered as well as a quantity of goethite and hematite. These were considered to be residual from the Prehistoric Phase.

There was no slag recovered from the Civil War Levels or the 19th Century Features. The topsoil produced 1.545kg of smithing slag and 0.03kg of goethite.

There was no evidence for iron working having been practiced in the excavated area of the Outer Ward.

3.3 Inner Ward Site (Site Code 72, Slag Listing Appendix 3)

A total of 14kg of smithing debris was recovered from the Inner Ward Excavations. The slag recovered was morphologically similar to that from the Outer Ward and Outer Gateway. There were no residues or slags recovered from the prehistoric or constructional phases of the site. Two small fragments (total weight 0.085kg) of possible smelting slag were recovered from Trench D, but they are not significant. A total of 0.335kg of 'vitrified rampart' material was identified. All of it derived from post-medieval contexts except for a small amount (0.1kg) in Trench E. A total of 14kg of smithing debris was recovered from the site. It was concentrated on Trench D, 2.93kg occurred in Medieval and 4.3kg in Post-Medieval contexts. There was also a significant amount (1.67kg, all Post-Medieval) in Trench R which abutted Trench D (Figure 1). The absence of slag in Trenches A, L and B indicate that the levels had not been disturbed, although the presence of slag in Post-Medieval levels in Trench D suggests local disturbance. There was also a small concentration of slag in Trench J (2.98kg, all Post-Medieval) and Trench W (0.35kg, Post-Medieval). It cannot be determined with certainty whether these concentrations represent dumping of smithing residue or activity in the area of excavation. The limited distribution of the deposits suggest that smithing occurred on Site D, probably in the Medieval Period, but that the Trench J material was a secondary deposit. The presence of small quantities of cinder and hearth lining on the site, and in Trench D in particular, would support the presence of smithing activity on the Site.

4 Analyses of Samples

4.1 Analyses of Goethite and Hematite Samples

A total of 0.4kg of goethite and hematite fragments were recovered from the excavations. The distribution suggested that they derived from the prehistoric occupation of the site. Confirmation was required that they were iron rather than copper ores, because of the presence of (Post-Medieval) copper mines in the area, and the exceptional number of copper alloy artefacts recovered from the site (this aspect will be discussed in the full site report). Consideration also had to be given as to whether the fragments represented an iron ore source.

Samples of goethite and hematite were analysed qualitatively using an energy dispersive X-ray system attached to a scanning electron microscope. The results (Figures 2 and 3) show that in the goethite sample the major peaks were Fe_k^{α} and $Fe_k\beta$, with minor peaks for Si and Al present. A similar compostion was obtained for the hematite sample. These results confirm the morphological identification as iron rather than copper ores. It is unlikely that these fragments were collected for a smelting operation. They could either occur naturally on the site or have been collected for other purposes (cf Beckford[3]).

4.2 Analysis of Lead Residue

A piece of lead residue was recovered from the Outer Gateway Site (Group 58, Context 408, weight 0.05kg). Qualitative analysis showed (Figure 4) that it comprised Pb, Al, and Si probably in oxide form. The residue derived from lead melting.

4.3 Analyses of Iron Working Slag Samples

Two samples of slag were selected for analysis, one (Sample BC804) derived from the 13th Century Construction Phase (Group 10, Context 804). The second sample (BC808) was from the later 17th Century phase of the site (Group 26, Context 808).

Each sample is described morphologically. A thick section was cut through the diameter of the slag piece, mounted and prepared in the usual manner for microscopy. The mineral texture was examined using the metallurgical microscope. The bulk and phase analyses were obtained using an X-ray energy dispersive analytical sytstem attached to an electron microscope.

4.3.1 SAMPLE BC804 (GROUP 10, CONTEXT 804, AML 844279)

Morphology

A partially formed hearth bottom. It had a cindery texture and a low 'apparent' density, indicating that it was heavily vesicular. The upper surface was vitrified, and the basal surface was agglomerated.

Dimensions

Major Diameter	85mm
Minor Diameter	75mm
Depth	30mm
Weight	200gms

Mineral texture

The section was characterised by the presence of silica(?) inclusions, which confirms the morphological cindery appearance. The volumetric phase compostion showed considerable variation, the mean and standard deviations are given in Table 1. The silicate occurred as short laths, and the free iron oxide as either fine dendrites, some of which were cubic (typical of magnetite rather than wustite), or unusualy, as fine rods. There was a glassy matrix. The mineral texture indicates a rapidly cooled silica rich slag, the variation in the volumetric phase percentages are typical of smithing slags.

TABLE 1 SAMPLE BC804 MEAN VOLUMETRIC PHASE PERCENTAGES

	Mean	S.D
Silicate	50	15
Glass	40	15
FEOX*	10	5

* FEOX - Free Iron Oxide

Bulk and Phase Chemical Composition

Five areas of the sample were analysed (Table 2 Bulk Analyses B1 - B5). They confirm that the slag was silica rich, (normally silicate slags have a silica content of about 30%), and show considerable variation in the SiO_2/FeO ratios. The alkali oxide contents are lower than normal, indicating that the glass phase would also be silica rich. The slag contains a small MnO content, and high titania levels (in particular analysis B5). The very low phosphorus level is untypical. The phase analyses show that the silicate phase had a fayalitic composition but was silica rich (normal silica content is 30%). The glass phase was also silica rich, and had a high potassium content. The analysis of the iron oxide phase was also silica rich and had a high Co content. The low total (90.1%) indicates that it was magnetite rather than wustite. (The elemental iron percentages were converted to oxide assuming the composition FeO, if other iron oxides were present e.g. Fe_3O_4 then the total will not achieve 100%).

Interpretation

The mineral texture and the chemical analyses show the slag to be a heterogeneous, silica rich, fayalitic slag. The analysis is in accordance with the initial morphological interpretation as a 'cindery' smithing hearth bottom.

TABLE 2 SAMPLE BC804 BULK AND PHASE ANALYSES (WEIGHT %)

	B1	B2	B3	B4	B5	SIL	GLAS	FEOX
Na_2O	0.1	N.D	0.4	0.1	0.1	0.1	0.3	0.3
MgO	0.2	0.1	0.2	0.1	0.3	0.7	0.2	0.2
Al_2O_3	2.5	2.0	2.4	1.0	1.6	1.6	5.5	0.8
SiO_2	47.6	43.3	51.1	81.1	62.7	40.3	73.1	4.6
P_2O_5	N.D	N.D	N.D	0.2	N.D	N.D	N.D	N.D
S	0.2	0.1	0.1	0.2	0.2	0.1	0.2	N.D
K_2O	1.8	1.1	1.6	0.8	1.1	1.1	4.5	0.1
CaO	1.7	0.9	1.4	0.4	0.5	0.6	1.4	N.D
TiO_2	0.6	0.4	0.5	0.2	1.0	0.3	1.1	0.3
V_2O_5	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Cr_2O_6	0.1	N.D	0.1	N.D	N.D	N.D	N.D	N.D
MnO	0.3	0.3	0.1	0.1	0.2	0.3	N.D	0.1
FeO	45.6	48.7	38.6	18.3	31.3	54.1	12.8	82.5
CoO	0.2	0.4	0.3	0.2	0.4	0.6	0.1	1.0
NiO	0.2	0.2	N.D	0.1	0.2	0.2	N.D	0.2
CuO	0.1	N.D	N.D	N.D	0.1	N.D	N.D	N.D
Total	101.2	97.5	96.8	102.8	99.7	100.0	99.2	90.1

N.D = Not detected

4.3.2 SAMPLE BC808 (GROUP 26, CONTEXT 808, AML 844281)

Morphology

Sample BC808 was a large 'double' hearth bottom, i.e. two hearth bottoms fused together. It was therefore, difficult to determine the 'way-up'. One surface was cindery and the other agglomerated. Diametrical sectioning showed it to be hollow, the internal surface comprising platelets of slag, possibly hammer scale, which became fused together to form the massive slag.

The dimensions of the hearth bottom were:

Major Diameter	150mm
Minor Diameter	130mm
Depth	100mm
Weight	1200gms

Mineral Texture

The polished section showed the slag to have a heterogeneous composition, with areas of massive iron oxide present as well as a more usual slag structure of massive silicate, dendritic iron oxide in a glassy matrix. There were also metallic inclusions present. There were oxide rings around the vesicles indicative of post-depositional oxidation. The mean volumetric analysis is given in Table 3.

TABLE 3 SAMPLE BC808 MEAN VOLUMETRIC ANALYSIS

	Mean	S.D
Silicate	70	10
Glass	10	5
FEOX	20	10

The mineral texture indicates that the slag cooled slowly, and had a high silica content (low glass and free iron oxide contents), indicative of heavy fluxing of the metal, but not too excess to cause silica saturation.

Bulk and Phase Chemical Composition

The bulk analyses (Table 4) show considerable variation, and in general a low silica content. There is not a corresponding increase in the iron oxide content indicating that higher iron oxides were present (magnetite or hematite), hence totals of 100% were not achieved. The alkali oxide contents were low similar to

BC804, as was the phosphorus content. The silicate was fayalitic but was slightly deficient in iron, and the glass had a typical alkali oxide rich composition. The low total of the FEOX analysis confirmed that higher iron oxides were present.

TABLE 4 SAMPLE BC808 BULK AND PHASE ANALYSES

	B1	B2	B3	B4	B5	SIL	GLASS	FEOX
Na_2O	0.6	1.0	0.4	0.1	0.4	0.1	1.8	N.D
MgO	0.6	0.3	0.6	0.1	0.1	1.1	N.D	N.D
Al_2O_3	2.5	2.9	1.1	3.8	0.2	0.4	17.0	N.D
SiO_2	27.1	23.0	24.5	18.0	1.7	29.2	44.3	0.6
P_2O_5	N.D	N.D	N.D	0.1	N.D	N.D	1.3	N.D
S	0.1	0.1	0.2	0.2	0.1	N.D	0.3	0.1
K_2O	0.5	1.0	N.D	1.4	N.D	N.D	8.9	N.D
CaO	1.5	0.2	0.8	1.0	N.D	0.7	4.8	N.D
TiO_2	N.D	N.D	N.D	0.2	N.D	0.1	1.1	0.1
V_2O_5	0.1	N.D	N.D	0.1	N.D	N.D	N.D	N.D
Cr_2O_6	N.D	N.D	0.2	0.1	N.D	N.D	N.D	N.D
MnO	0.1	N.D	N.D	N.D	N.D	0.1	N.D	N.D
FeO	62.5	57.0	65.9	58.7	71.1	66.2	11.0	85.0
CoO	0.5	0.6	0.4	0.4	0.8	0.7	N.D	0.6
NiO	0.1	N.D	0.2	N.D	0.2	N.D	N.D	0.2
CuO	N.D	N.D	N.D	0.1	0.1	N.D	0.2	N.D
Total	96.2	86.1	94.3	84.3	74.7	98.6	90.7	86.6

Analyses Interpretation

The analyses indicate that the slag was a fayalitic slag deficient in iron oxide, but not silica rich. It was probably formed under relatively oxidising conditions, hence the presence of magnetite or hematite iron oxide dendrites, although the occurrence of metallic inclusions show that the such conditions did not prevail the whole time. The mineral texture shows that the slag cooled slowly (massive silicate).

Comparison of Analyses of Samples BC804 and BC808

The samples were selected because they showed the range of morphological textures observed in all the slags from the Castle, and because they were from stratified contexts. They were not chosen to show differences between Medieval and 17th Century slags. There was no evidence from the analysis to suggest that the slags derived from the smelting process. Their morphology and mineral texture and composition accords with the original interpretation that they were smithing hearth bottoms. They can be considered typical of many smithing slags because they show a range of morphological textures, agglomerated to cindery, and differ in their mineral texture, Sample BC804 having a typical fast cooled structure and BC808 a slow cooled one. The bulk and phase compositions differ most in their silica content, BC804 was silica rich, and BC808 iron oxide deficient. There were similarities, both were low in alkali oxides, and had very low phosphorus contents. Both glass phases were rich in titania.

The slags can therefore be considered to be typical smithing slags, the differences in texture and composition can not be ascribed to the slags having been formed during different processes, (eg. simple forming or fire welding). They were probably due to different working practices, e.g. amount of flux used.

6 Conclusion

The examination of the residues from Beeston Castle has shown that iron smithing was practiced on the site in the Prehistoric period and in the Medieval and later periods. There was no evidence for iron smelting. The largest deposits of smithing debris occurred in disturbed layers and therefore no firm date can be established for the activity. It is probable, however, that it was generated during the construction phases of the site, since there is little evidence for extensive Medieval occupation of the site. The analyses of two slag samples showed that they had a range of morphological texture, mineral texture and chemical composition typical of smithing slags.

References

1 McDonnell JG The classification of early ironworking slags PhD Thesis Aston University 1986 (Copy in AML)

2 Tylecote RF Metallurgy in Archaeology Institute of Metals 1986

3 McDonnell JG Report on slag recovered from excavations at Beckford, Worcestershire 1986 AML Report 64/86

APPENDIX 1 BEESTON CASTLE SITE OUTER GATEWAY (CODE 0) LISTING IN CONTEXT ORDER

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
0	30	U/S	50	380	0	0	0	0	0	15
0	40		1	730	0	0	0	0	0	20
0	41	19	19	0	0	0	0	0	0	5
0	81	W200	0	0	0	30	0	0	0	0
0	274		48	0	0	0	0	0	0	95
0	284		19	0	0	0	0	0	0	50
0	304		20	0	0	0	0	0	0	120
0	311		26	0	0	0	0	0	0	900
0	312	39	48	0	0	0	0	0	0	45
0	353		38	0	0	0	0	0	15	5
0	354	362	127	0	0	0	10	0	0	0
0	363	156	78	180	0	0	0	0	0	0
0	385		19	0	0	0	0	0	0	15
0	391		19	0	0	0	0	0	0	25
0	396		58	0	0	0	0	0	0	10
0	397		56	0	0	0	0	0	0	50
0	398		58	0	0	0	0	0	190	0
0	401		56	50	0	0	0	0	0	5
0	408		58	0	0	0	0	0	0	50
0	542	309	105	0	0	0	1	0	0	0
0	589	323	57	0	0	0	0	0	0	50
0	634	370	127	0	0	0	0	0	0	725
0	801		1	21755	32061	740	10	0	185	0
0	802		20	420	0	0	0	0	0	0
0	803		26	200	0	75	0	0	50	75
0	804		10	1050	0	0	0	0	200	0
0	805		10	1300	275	70	15	0	60	0
0	806		1	29195	16190	250	0	0	150	20
0	808		26	1675	1350	0	0	0	50	0
0	809		109	0	0	0	0	0	0	25
0	858	815	116	0	170	0	0	0	0	0
** Total **										
				56935	50046	1165	36	0	900	2305

HEADINGS

SITE	- SITE CODE	
CONT	- CONTEXT NUMBER	
LAYER	- LAYER NUMBER	
GRP	- GROUP NUMBER	
SMITH	- WEIGHT OF	SMITHING SLAG
HB	- " "	HEARTH BOTTOMS
CIN	- " "	CINDER
FAS	- " "	FUEL ASH SLAG
SMELT	- " "	SMELTING SLAG
HL	- " "	HEARTH LINING
OTHER	- " "	OTHER MATERIAL

APPENDIX 1 BEESTON CASTLE SITE OUTER GATEWAY (CODE 0) LISTING IN GROUP ORDER

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
0	81	W200	0	0	0	30	0	0	0	26
0	40		1	51680	48251	990	10	0	335	40
0	804		10	2350	275	70	15	0	260	0
0	41	19	19	0	0	0	0	0	0	95
0	304		20	420	0	0	0	0	0	120
0	311		26	1875	1350	75	0	0	100	975
0	353		38	0	0	0	0	0	15	5
0	274		48	0	0	0	0	0	0	140
0	30	U/S	50	380	0	0	0	0	0	15
0	397		56	50	0	0	0	0	0	55
0	589	323	57	0	0	0	0	0	0	50
0	396		58	0	0	0	0	0	190	60
0	363	156	78	180	0	0	0	0	0	0
0	542	309	105	0	0	0	1	0	0	0
0	809		109	0	0	0	0	0	0	25
0	858	815	116	0	170	0	0	0	0	0
0	354	362	127	0	0	0	10	0	0	725
** Total **										
				56935	50046	1165	36	0	900	2331

APPENDIX 2 BEESTON CASTLE SITE OUTER WARD (CODE OW) LISTING IN CONTEXT ORDER

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
OW	7		200	45	0	0	10	0	0	0
OW	19		200	0	0	0	0	0	0	10
OW	161		203	0	0	0	0	0	0	2
OW	166		203	30	0	0	0	0	0	10
OW	181	1908	203	0	0	0	0	0	0	1
OW	194	1872	203	0	0	0	0	0	0	15
OW	204		203	0	0	0	25	0	0	5
OW	216		0	0	0	0	0	0	0	25
OW	259	1894	0	0	0	0	0	0	0	1
OW	277	2115	205	0	0	0	0	0	0	15
OW	282		204	0	0	0	0	0	0	10
OW	323		205	0	0	0	0	0	0	2
OW	513	2757	203	0	0	0	0	0	0	350
OW	518		200	0	0	0	0	0	10	0
OW	519		200	525	0	0	0	0	0	0
OW	522		200	975	0	0	0	0	0	20
OW	523		203	475	0	0	0	0	0	0
OW	525		203	75	0	15	0	0	0	65
OW	529		201	0	0	0	0	0	10	0
OW	543		203	0	0	0	0	0	0	280
OW	557		203	15	0	1	0	0	0	146
OW	598		203	0	0	5	0	0	0	0
OW	606		203	0	0	0	0	0	0	20
OW	639		204	0	0	0	0	0	0	5
OW	683		204	0	0	0	0	0	0	1
OW	770		204	0	0	0	5	0	0	0
OW	776		204	0	0	0	5	0	0	0
OW	852	870	117	0	0	0	0	0	0	20
** Total **										
				2140	0	21	45	0	20	1003

APPENDIX 2 BEESTON CASTLE SITE OUTER WARD (CODE OW) LISTING IN GROUP ORDER

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
OW	852	870	117	0	0	0	0	0	0	20
OW	7		200	1545	0	0	10	0	10	30
OW	529		201	0	0	0	0	0	10	0
OW	161		203	595	0	21	25	0	0	894
OW	282		204	0	0	0	10	0	0	16
OW	277	2115	205	0	0	0	0	0	0	17
** Total **										
				2140	0	21	45	0	20	977

APPENDIX 3 BEESTON CASTLE SITE INNER WARD (CODE 72) LISTING IN CONTEXT ORDER

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
72	248	SL1	0	700	0	0	0	0	60	0
72	250	SL3	0	0	575	0	0	0	0	0
72	251	SL4	0	1500	480	100	0	0	0	0
72	252	SL4	0	0	610	25	0	15	50	0
72	253	SL6	0	300	0	0	0	70	0	0
72	254	SL7	0	300	0	0	0	0	0	0
72	255	SL8	0	140	0	0	0	0	0	0
72	256	SL9	0	4000	0	20	0	0	0	0
72	257	SL10	0	1150	0	100	0	0	0	0
72	258	SL11	0	0	0	0	0	0	20	0
72	1798	SL12	0	1575	0	0	0	30	40	0
72	1799	SL13	0	1100	0	0	0	0	0	0
72	1800	SL14	0	400	0	0	0	0	0	0
72	1801	SL15	0	0	0	0	0	0	0	30
72	1802	SL16	0	0	0	0	20	0	0	0
72	1803	SL17	0	0	0	0	0	0	0	190
72	1804	SL18	0	0	0	170	0	0	0	0
72	1805	SL18	0	140	0	0	0	0	0	0
72	1806	SL20	0	0	0	0	0	0	0	15
72	1807	SL21	0	0	0	0	0	0	0	100
72	1808	SL22	0	775	0	0	0	0	0	0
72	2124	SL23	0	350	0	0	0	0	0	0
** Total **										
				12430	1665	415	20	115	170	335

APPENDIX 3.1 BEESTON CASTLE SITE I LISTING

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
I	0	W002	0	50	0	0	0	0	0	0
** Total **										
				50	0	0	0	0	0	0

APPENDIX 3.2 BEESTON CASTLE SITE INNER GATEWAY (1975-77 EXCAVATIONS) LISTING

SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
OWO	500		0	25	0	0	0	0	0	0
OWO	501		0	375	0	0	0	0	0	0
OWO	502		0	150	0	0	0	0	0	0
OWO	503		0	3300	0	0	0	0	0	0
OWO	504		0	3800	0	0	0	0	0	0
OWO	505		0	1400	0	0	0	0	0	0
** Total **										
				9050	0	0	0	0	0	0

BEESTON HEARTH BOTTOM DIMENSIONS [HB1 ETC=WEIGHT(GMS)
D1,D2=DIAMETERS (MM)
DP=DEPTH(MM)]

AML.NO	CONT	HB1	D1	D2	DP	HB2	D1	D2	DP	HB3	D1	D2	DP	HB4	D1	D2	DP
844276	801	730	120	110	45	304	90	80	40	850	130	100	50	810	150	110	30
844276	801	725	130	100	45	630	130	90	70	450	110	100	50	0	0	0	0
844276	801	570	140	100	50	1272	125	130	70	660	130	100	50	0	0	0	0
844276	801	525	100	90	45	275	110	85	30	225	90	80	30	0	0	0	0
844276	801	650	130	110	30	500	120	90	35	0	0	0	0	0	0	0	0
844276	801	2800	180	140	80	0	0	0	0	0	0	0	0	0	0	0	0
844276	801	850	150	110	65	1560	140	120	75	1275	120	130	80	2900	160	110	120
844276	801	1825	160	130	70	0	0	0	0	0	0	0	0	0	0	0	0
844276	801	1035	140	120	80	1250	140	120	80	1830	160	120	85	1275	120	120	70
844276	801	1960	160	150	90	1275	160	140	60	870	140	120	60	2180	170	130	100
844280	805	275	85	80	25	0	0	0	0	0	0	0	0	0	0	0	0
844283	806	317	115	90	45	1067	130	115	95	525	110	95	40	510	105	90	50
844283	806	270	80	80	40	1215	130	130	60	1056	125	120	50	0	0	0	0
844283	806	1430	140	130	70	1080	110	100	80	1410	150	110	50	375	120	80	25
844283	806	1560	160	140	70	0	0	0	0	0	0	0	0	0	0	0	0
844283	806	590	110	105	50	1180	130	110	60	0	0	0	0	0	0	0	0
844283	806	1400	130	110	70	1675	110	120	95	0	0	0	0	0	0	0	0
865071	806	530	90	80	40	0	0	0	0	0	0	0	0	0	0	0	0
844281	808	1350	150	120	110	0	0	0	0	0	0	0	0	0	0	0	0
844284	858	170	80	70	20	0	0	0	0	0	0	0	0	0	0	0	0
724150	250	575	100	80	40	0	0	0	0	0	0	0	0	0	0	0	0
724151	251	300	95	85	45	180	100	80	30	0	0	0	0	0	0	0	0
724152	252	280	100	90	30	330	100	80	60	0	0	0	0	0	0	0	0

APPENDIX 5 BEESTON CASTLE SITE LISTING BY AML. NUMBER

AML.NO	SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
724148	72	248	SL1	0	700	0	0	0	0	0	0
724149	72	248	SL1	0	0	0	0	0	0	60	0
724150	72	250	SL3	0	0	575	0	0	0	0	0
724151	72	251	SL4	0	1500	480	100	0	0	0	0
724152	72	252	SL4	0	0	610	25	0	15	50	0
724153	72	253	SL6	0	300	0	0	0	70	0	0
724154	72	254	SL7	0	300	0	0	0	0	0	0
724155	72	255	SL8	0	140	0	0	0	0	0	0
724156	72	256	SL9	0	4000	0	20	0	0	0	0
724157	72	257	SL10	0	1150	0	100	0	0	0	0
724158	72	258	SL11	0	0	0	0	0	0	20	0
724159	72	1798	SL12	0	1575	0	0	0	30	40	0
724160	72	1799	SL13	0	1100	0	0	0	0	0	0
724161	72	1800	SL14	0	400	0	0	0	0	0	0
724162	72	1801	SL15	0	0	0	0	0	0	0	30
724163	72	1802	SL16	0	0	0	0	20	0	0	0
724164	72	1803	SL17	0	0	0	0	0	0	0	190
724165	72	1804	SL18	0	0	0	170	0	0	0	0
724166	72	1805	SL18	0	140	0	0	0	0	0	0
724167	72	1806	SL20	0	0	0	0	0	0	0	15
724168	72	1807	SL21	0	0	0	0	0	0	0	100
724169	72	1808	SL22	0	775	0	0	0	0	0	0
724170	72	2124	SL23	0	350	0	0	0	0	0	0
841649	0	805		0	400	0	70	0	0	0	0
844276	0	801		1	3480	2694	0	0	0	0	0
844276	0	801		1	0	1805	0	0	0	0	0
844276	0	801		1	4260	2502	0	0	0	0	0
844276	0	801		1	2625	1025	510	10	0	160	0
844276	0	801		1	2850	1150	130	0	0	25	0
844276	0	801		1	750	2800	0	0	0	0	0
844276	0	801		1	600	0	100	0	0	0	0
844276	0	801		1	3200	6585	0	0	0	0	0
844276	0	801		1	0	1825	0	0	0	0	0
844276	0	801		1	3800	5390	0	0	0	0	0
844276	0	801		1	0	6285	0	0	0	0	0
844276	0	801		1	190	0	0	0	0	0	0
844277	0	802		20	420	0	0	0	0	0	0
844278	0	803		26	200	0	75	0	0	50	75
844279	0	804		10	1050	0	0	0	0	200	0
844280	0	805		10	900	275	0	15	0	60	0
844281	0	808		26	1675	1350	0	0	0	50	0
844282	0	809		109	0	0	0	0	0	0	25
844283	0	806		1	0	2419	0	0	0	0	0
844283	0	806		1	0	0	0	0	0	0	0
844283	0	806		1	1220	2541	0	0	0	0	0
844283	0	806		1	2600	4295	0	0	0	0	0
844283	0	806		1	3915	1560	250	0	0	150	0
844283	0	806		1	2375	1770	0	0	0	0	0
844283	0	806		1	3460	3075	0	0	0	0	0
844283	0	806		1	3125	0	0	0	0	0	0
844283	0	806		1	3230	0	0	0	0	0	0

APPENDIX 5 BEESTON CASTLE SITE LISTING BY AML. NUMBER

AML.NO	SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
844283	O	806		1	0	0	0	0	0	0	20
844283	O	806		1	9270	0	0	0	0	0	0
844284	O	858	815	116	0	170	0	0	0	0	0
844285	1	0	W002	0	50	0	0	0	0	0	0
852666	O	408		58	0	0	0	0	0	0	50
865005	OW	204	1652	203	0	0	0	0	0	0	5
865006	OW	194	1872	203	0	0	0	0	0	0	15
865007	OW	259	1894	0	0	0	0	0	0	0	1
865008	OW	166	1896	203	0	0	0	0	0	0	10
865009	OW	181	1908	203	0	0	0	0	0	0	1
865010	OW	277	2115	205	0	0	0	0	0	0	5
865011	OW	277	2118	205	0	0	0	0	0	0	10
865012	OW	522	2253	200	0	0	0	0	0	0	20
865013	OW	557	2467	203	0	0	0	0	0	0	1
865014	OW	557	3061	203	0	0	0	0	0	0	20
865015	OW	525		203	0	0	0	0	0	0	15
865016	OW	543		203	0	0	0	0	0	0	150
865017	OW	557		203	0	0	0	0	0	0	125
865018	OW	606		203	0	0	0	0	0	0	20
865019	OW	639		204	0	0	0	0	0	0	5
865020	OW	683		204	0	0	0	0	0	0	1
865021	OW	852	870	117	0	0	0	0	0	0	20
865022	OW	518		200	0	0	0	0	0	10	0
865023	OW	557	3103	203	15	0	0	0	0	0	0
865024	OW	522		200	25	0	0	0	0	0	0
865025	OW	522		200	25	0	0	0	0	0	0
865026	OW	513	2757	203	0	0	0	0	0	0	350
865027	OW	522	2305	200	925	0	0	0	0	0	0
865028	OW	543	2881	203	0	0	0	0	0	0	125
865029	OW	519		200	525	0	0	0	0	0	0
865030	OW	523		203	475	0	0	0	0	0	0
865031	OW	525		203	75	0	15	0	0	0	0
865032	OW	525		203	0	0	0	0	0	0	50
865033	OW	598		203	0	0	5	0	0	0	0
865034	OW	543		203	0	0	0	0	0	0	5
865035	OW	161		0	0	0	0	0	0	0	2
865035	OW	557	2487	203	0	0	1	0	0	0	0
865036	OW	166		0	30	0	0	0	0	0	0
865037	OW	204		203	0	0	0	25	0	0	0
865039	OW	282		204	0	0	0	0	0	0	10
865040	OW	323		205	0	0	0	0	0	0	2
865041	OW	19		200	0	0	0	0	0	0	10
865042	OW	7		200	0	0	0	10	0	0	0
865043	OW	529		201	0	0	0	0	0	10	0
865044	O	354	362	127	0	0	0	10	0	0	0
865045	O	363	156	78	180	0	0	0	0	0	0
865046	OW	770		204	0	0	0	5	0	0	0
865047	OW	776		204	0	0	0	5	0	0	0
865048	O	274	30	48	0	0	0	0	0	0	20
865049	O	312	72	48	0	0	0	0	0	0	30
865050	O	274		48	0	0	0	0	0	0	75

APPENDIX 5 BEESTON CASTLE SITE LISTING BY AML. NUMBER

AML.NO	SITE	CONT	LAYER	GRP	SMITH	HB	CIN	FAS	SMELT	HL	OTHER
865051	0	312	39	48	0	0	0	0	0	0	15
865052	0	41	19	19	0	0	0	0	0	0	5
865053	0	542	309	105	0	0	0	1	0	0	0
865054	0	589	323	57	0	0	0	0	0	0	50
865055	0	634	370	127	0	0	0	0	0	0	725
865056		81	W200	0	0	0	30	0	0	0	0
865057	00	30	U/S	50	380	0	0	0	0	0	15
865058	00	40		1	725	0	0	0	0	0	0
865059	00	40	Y1273	1	5	0	0	0	0	0	20
865060	0	284		19	0	0	0	0	0	0	50
865061	0	304		20	0	0	0	0	0	0	120
865062	0	311		26	0	0	0	0	0	0	900
865063	0	353		38	0	0	0	0	0	15	5
865064	0	385		19	0	0	0	0	0	0	15
865066	0	396		58	0	0	0	0	0	0	10
865066	0	391		19	0	0	0	0	0	0	25
865067	0	397		56	0	0	0	0	0	0	50
865068	0	398		58	0	0	0	0	0	190	0
865069	0	401		56	50	0	0	0	0	0	0
865070	0	401		56	0	0	0	0	0	0	5
865071	0	806		1	0	530	0	0	0	0	0
865072	OW	7	161	0	25	0	0	0	0	0	0
865073	OW	7	290	0	20	0	0	0	0	0	0
865083	OW	216		0	0	0	0	0	0	0	25
** Total **											
					71555	51711	1601	101	115	1090	3643

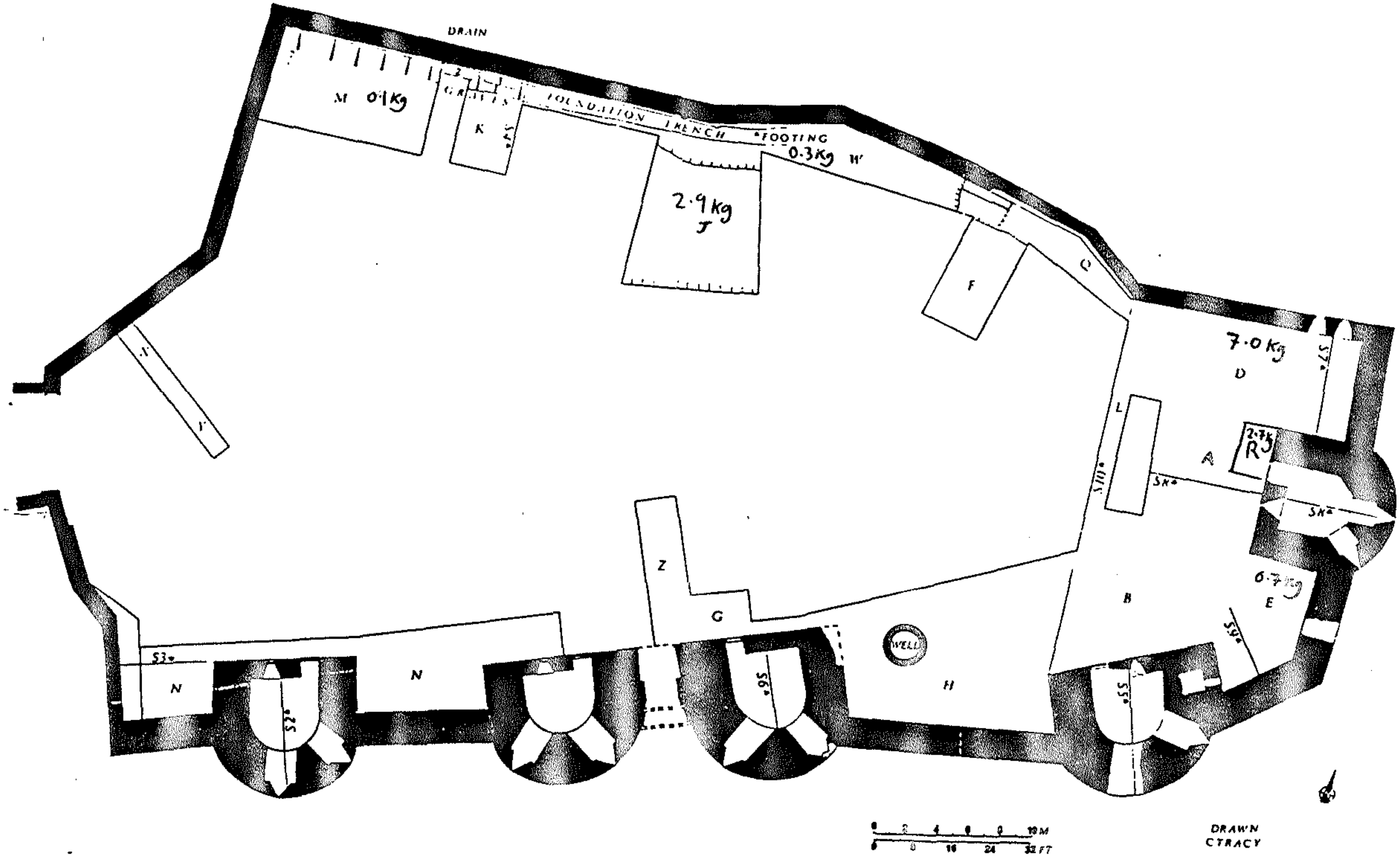

FIGURE 1 Beeston Castle, Inner Ward Location of 1972 Excavations
Trench Numbers are given by Letters
Numbers are the weight (in Kg) of smithing debris in that trench

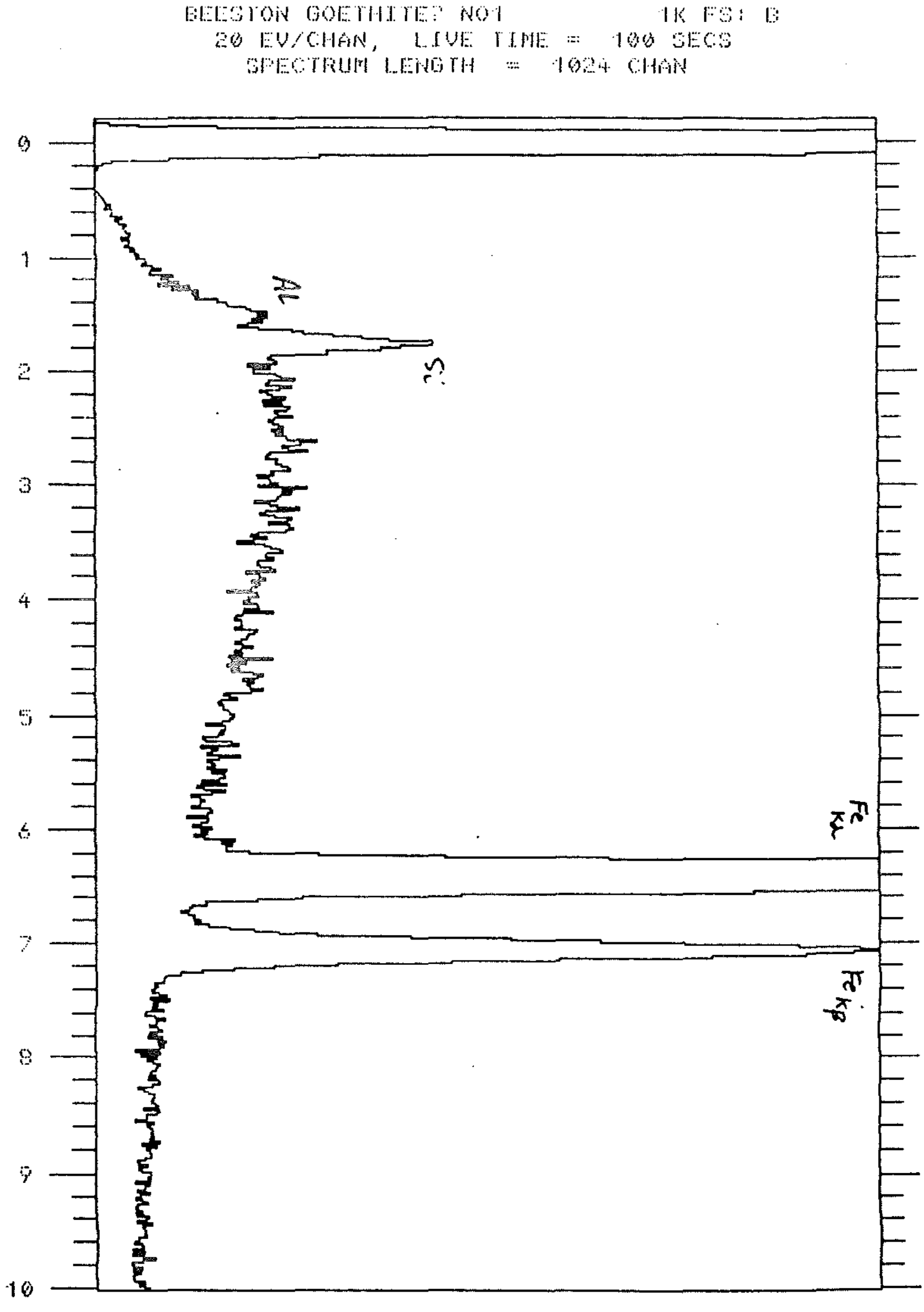

FIGURE 2 Qualitative EDS X-ray Analysis of goethite
(FSD=1K counts)

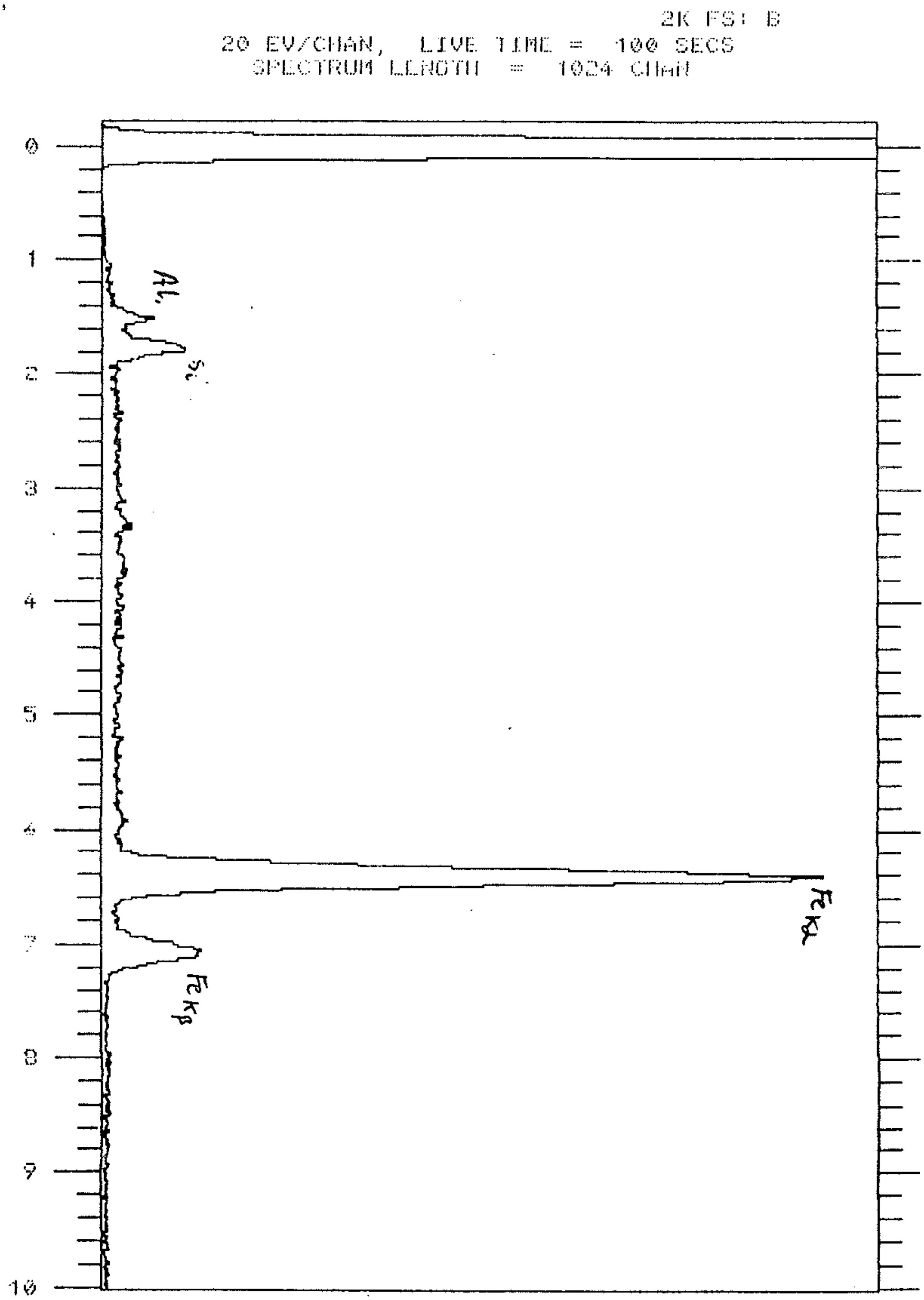

FIGURE 3 Qualitative EDS X-ray Analysis of hematite
(FSD=2k counts)

FIGURE 4 Qualitative EDS X-ray Analysis of lead residue
(FSD=511 counts)