Ancient Monuments Laboratory
Report 64/86

# REPORT ON SLAG RECOVERED FROM EXCAVATIONS AT BECKFORD, WORCESTERSHIRE.

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Summary

Over 5kg of smithying slag and nearly 30kg of fuel ash slag were examined, the majority in both cases coming from middle iron age contexts. The slag from later contexts was probably residual.

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H.B.M.C.E. FUNDED ARCHAEOMETALLURGY CONTRACT

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# BECKFORD (WORCESTERSHIRE, N.G.R. SO984364)

# SLAG REPORT

## 1 SITE SUMMARY

Extensive excavations ahead of gravel extraction have recovered finds dating from the Mesolithic Period onwards. The most detailed results have come from the excavation of a large pre-Roman Iron Age settlement and associated field systems. A summary of the findings of the first series of excavations was published in 1975, (Britnell 1975).

## 2 THE IRONWORKING PROCESS

The ironworking process is an overall term applied to the manufacture of iron artefacts from the ore. The method used two separate operations; firstly the extraction of the metal from the ore by smelting and secondly the smithing process, the working of the iron into artefacts and their subsequent repair or re-working. Both processes generate slag as a by-product. The commonest form of smelting slag is tap slag, a flowed slag with a ropey texture. Different smelting technologies were used during differnt periods and in different regions and hence smelting slag occurs in a number of different forms. Some of these slags are difficult to distinguish from smithing slags. Smithing slag occurs as either randomly shaped pieces or, characteristically, as hearth-bottoms, plano-convex accumulations of slag Smelting and smithing slags are chemically and mineralogically similar being principally iron silicate ( Fayalite $2FeO.SiO_2$), free iron oxide ( normally Wustite, FeO), and a small proportion of alkali oxides (CaO etc.) which normally occur as a glassy phase.

The study of early ironworking, and in particular identifying which processes were carried out on a site in antiquity, is heavily reliant on the study of the slag. This survives burial unaltered, whereas the structures associated with both processes ( smelting furnaces and smithing hearths ) and the finished artefacts rarely survive in good condition. The durability of slag causes problems of residuality, and its suitability as hard-core or levelling material results in it being found in features that may have been contemporary with, but not directly associated with, the activity producing it.

The purpose of examining the slags is firstly to identify which processes were practiced in what periods on the site, and secondly to analyse the slags chemically and mineralogically.

## 3 THE CLASSIFICATION OF THE BECKFORD SLAGS.

The material grouped as 'slags' totalled 37.8 kg and included four main types of residue. Firstly cindery fuel ash slag, the product of a high temperature oxidising reaction between fuel ash and siliceous material. Secondly the furnace or hearth lining, which is the vitrified clay structure of a furnace or hearth (possibly deriving from any technology). Thirdly a general category of other materials, e.g iron ore, metal lumps Fourthly the iron silicate smelting or smithing slags. The material is discussed in four main phases, Middle Iron Age, Late Iron Age, Romano British, and Medieval. A small quantity of material was either unphased or derived from modern contexts.

3.1 The Fuel Ash Slag

The residues from the site were distinguished by the large quantity of fuel ash slag . This material is commonly found, but rarely exceeds a few percent of the total weight of residue recovered from the site. This is due in part to its low density, (it is highly vesicular), but primarily the quantity of the material is low. The total recovered from the site was 30 kg, the greatest amount (18.6 kg) occurred in ditches of the Middle Iron Age Period, ( Contexts 65987, 75536, and 65053 ). The remainder was equally divided between Late Iron Age and Romano-British contexts with a small quantity in Medieval and unstratified contexts. The slag was therefore probably formed during the Middle Iron Age, the later material being residual. Fuel ash slag normally occurs as small pieces (upto 5 cm in length) often with a vitrified surface. The Beckford fuel ash slag occurs in much larger pieces, e.g. fist-size, lacks a glassy lustre and contains large amounts of foreign material, (e.g. pebbles). It did not derive from reactions in a hearth, furnace or kiln, but may be a (high temperature) reaction between fuel ash and the soil or sub-soil. The site of Wasperton (Warwickshire) also produced a single large dump of similar material in a pit.

## 3.2 The Furnace/Hearth Lining

Furnace and/or hearth lining is the part of the clay structure that has been heated sufficiently to cause vitrification of the surface. This only occurs in the hottest part of the furnace or hearth, the tuyere zone. Tuyere mouths, holes one to two centimetres in diameter through which the air was blown, are commonly found in fragments of lining. Furnace and hearth lining is highly susceptible to attack by silicate slags, and therefore the lining from such structures may have adhering slag.

The furnace/hearth lining recovered from the site totalled over 2.8 kg, of which 0.38 kg derived from Romano-British Contexts, 0.17 kg from the Late Iron Age, and 1.71 kg from the Middle Iron Age Periods. There were no apparent spatial concentrations of lining, and it occurred in small fragments weighing less than 100 grammes (0.1 kg). One probable tuyere fragment was found in context 65229.

## 3.3 General Category

Several small pieces of goethite (FeO(OH)) ore were recovered from the site. It is not suggested that they were used as an ore source, but may have been collected for other purposes or occurred naturally, but rarely on the site. Several iron lumps were found, which were approximately cubic in shape, and a few centimeters in size.

## 2.4 The Iron Slags

Iron smelting and smithing slags are chemically and mineralogically similar, as mentioned above, and may also be morphologically similar. It can therefore be difficult to ascribe individual specimens with certainty to either process. This is particularily difficult on sites with mixed assemblages where both smelting snd smithing have been practiced.

The slag was identified morphologically, and there were no slag pieces that could only have been derived from the smelting process, although several specimens had very flowed surfaces, (similar to tap slags). Analysis of selected examples (see below) confirmed that they were all smithing slags.

# 3 THE PHASE DISTRIBUTION OF THE BECKFORD SLAGS

## 3.1 The Middle Iron Age Period

This period contained the greatest amount of smithing slag, and it was concentrated in the main Iron Age enclosure. The slag comprised small randomly shaped lumps and a few hearth bottoms. The slag occurred in the enclosure ditch (Contexts 4820, 4821, 4846, 4847 and 4848, [weight 1.26 kg]), in a wall trench (Contexts 4830 and 4831, [weight 0.96 kg]), and [1.26 kg] was in pit 4836 and small quantities [less than 25 gm] in six other pits. There was also a small dump of 'hearth fill', (ie. slag and charcoal), in the large east-west ditch, Context 5619. This section of the ditch also contained non-ferrous working debris. There was only one other small [50 gm] find of smithing slag from from Context 65370, a floor level.

## 3.2 Late Iron Age Period

No ironworking slag was recovered from features dated to this period.

## 3.3 Romano-British Period

A small quantity of slag [0.80 kg] was recovered from this period, but the finds came from secondary contexts, e.g. ditches. It is therefore probable that it is either residual from the Middle Iron Age Period or that they were intrusive from another (unexcavated) area of the site. It is unusual to recover such a low quantity of slag from a Romano-British site.

## 3.4 Medieval and Later Periods

Small quantities of all types of residues were found in Medieval and Later features. They are considered to be residual.

## 3.5 Summary of The Residue Distribution

The phase distribution of the four major slag types are shown in Table 1. The smithing slag includes hearth bottoms, and only the ore is given in the last group. There was small scale smithing practiced in a restricted area during the Middle Iron Age. At the same time there was some burning activity, probably also in a limited area, that caused a large quantity of fuel ash slag to be generated. The Romano-British material may be residual or represent smithing activity elsewhere in the vicinity.

TABLE 1 THE PHASE GROUPING OF THE BECKFORD SLAGS (Weight in kg)

| GROUPS | 1 (F.A.S.) | 2 (H.L.) | 3 (ORE) | 4 (SMITH SLAG) |
|---|---|---|---|---|
| MID IRON AGE | 18.61 | 1.71 | 0.07 | 4.13 |
| LATE IRON AGE | 4.47 | 0.17 | 0.00 | 0.00 |
| EARLY R-B | 2.16 | 0.07 | 0.01 | 0.11 |
| MID R-B | 1.46 | 0.18 | 0.00 | 0.08 |
| LATE R-B | 2.09 | 0 13 | 0.06 | 0.60 |
| MEDIEVAL | 0.22 | 0.03 | 0 00 | 0.43 |
| MODERN/ UNSTRATIFIED | 0.44 | 0.54 | 0.00 | 0.09 |
| TOTAL | 29.45 | 2.83 | 0.14 | 5.44 |

## 4 CHEMICAL AND MINERAL ANALYSIS

### 4.1 The Fuel Ash Slag

Fuel ash slag has not been studied in detail and no information is available concerning the details of its formation. Three specimens were selected for analysis from Early Iron Age contexts ( 55107, 65378, and 65495 ). X-ray Diffraction patterns were obatained from the powdered samples using cobalt radiation. The results showed a single major peak of silica ($SiO_2$) with other minor peaks that could not be ascribed satisfactorily to any other mineral. The background level of the traces indicated a glassy phase was also present. The powdered samples were also analysed using a scanning electron microscope with an attached energy dispersive analysis system. The analyses showed the major elements (in descending order of intensity) to be silicon, potassium, calcium, aluminium, and iron with phosphorus present as a minor element. The X-ray diffraction and chemical analysis indicates the major mineral to be present to be silica with perhaps a low percentage of other minerals present e.g fayalite ($2FeO.SiO_2$) and a glass phase containing aluminium potassium, calcium, and phosphorus oxides.

## 4.2 The Smithing Slag

The iron working slag was identified as deriving from the smithing process on morphological criteria. The slag occurred in small lumps and had an agglomerated appearance, although some surfaces of the slags had a flowed texture that could be associated with the smelting process. The slags deriving from the iron smelting and smithing process's can be morphologically, minerally and chemically alike This is particularily true for early ironworking technologies. Four samples of slag were sectioned in order to determine their mineral and chemical composition. Two derived from Middle Iron Age Contexts (4831 and 65370), and one from a Middle and one from a Late Romano-British Context (74119 and 65726). They were prepared in the usual manner (Addyman) and examined under the metallurgical microscope.

### Sample 4831

The sample contained a high proportion (50-60%) of large, rounded iron oxide dendrites (wustite (FeO) or magnetite ($Fe_3O_4$)) with randomly shaped silicate (30-40%) in a glassy matrix (10%).

Sample 65370

This sample had similar mineral percentages to 4831, but the mineral texture differed. The silicate occurred as fine laths which indicates rapid cooling. A second sample was prepared from another specimen from the same context. This had a similar mineral texture to 4831 but contained a second crystaline mineral probably hercynite ($FeO.Al_2O_3$), and rings of iron oxide around the vessicles.

Sample 74119

This sample had a similar micro-structure to 4831.

Sample 65726

The prepared section displayed two areas with different micro-structures. The first showed orientated fine oxide dendrites with 'broken' silicate laths in a glassy matrix. The second area showed massive silicate with a low percentage of finely distributed iron oxide dendrites with a very low percentage of glass.

The samples displayed a variation in micro-structure between the specimens, and in one case (65726) within one specimen. This heterogeneity is typical of smithing slags.

Chemical Analysis

The polished sections were analysed using a scanning electron microscope with a Link energy dispersive analysis system. 'Bulk' analyses were obtained using a raster scan at magnifications of approximately 200 times, and spot analyses were obtained for individual phases where applicable.

Sample 4831

The bulk analyses (Table 2) showed only minor levels of the glass forming oxides ($K_2O$, CaO etc.), phosphorus and sulphur were not detected. The analyses were rich in iron oxide. The silicate was identified as fayalite ($2FeO.SiO_2$) containing 68.4% Feo and 29.1% $SiO_2$.

Table 2 Sample 4831 Bulk Analyses (weight % oxide)

| Bulk Analyses | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Mg | 0.2 | 0.2 | 0.1 | 0.7 |
| Al | 2.8 | 2.5 | 1.9 | 1.8 |
| Si | 21.2 | 19.9 | 20.4 | 18.7 |
| P | N.D | N.D | N.D | N.D |
| S | N.D | N.D | N.D | N.D |
| K | 0.6 | 0.6 | 0.6 | 0.4 |
| Ca | 1.0 | 0.9 | 0.9 | 0.9 |
| Mn | N.D | N.D | 0.2 | 0.2 |
| Fe | 74.4 | 73.7 | 73.6 | 75.9 |
| Total | 100.2 | 97.8 | 97.7 | 98.6 |

Sample 65370

The bulk analyses, Table 3, show above average alumina contents and a high iron oxide content. The silicate phase contained potassium, magnesium and aluminium oxides, (Table 4), which is untypical. The iron oxide phase, (Table 4), gives the elemental iron concentration in brackets. [The percentage of elemental iron in the oxides is hematite-69.9%, magnetite-72.4%, wustite-77.7%]. The results of the analysis shows the iron oxide to be magnetite rather than wustite, which indicates slightly oxidising conditions rather than wholly reducing. Such conditions are common in smithing hearths. The glass analysis is typical, containing high levels of alkali oxides.

Table 3 Sample 65370 Bulk Analyses (weight % oxide)

| Bulks | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Mg | 0.2 | 0.2 | 1.2 | 0.3 |
| Al | 7.6 | 4.9 | 5.0 | 4.9 |
| Si | 19.0 | 13.9 | 13.1 | 13.8 |
| P | 0.5 | 0.4 | 0.2 | 0.5 |
| S | 0.3 | 0.1 | 0.3 | 0.2 |
| K | 1.7 | 1.0 | 1.3 | 1.5 |
| Ca | 3.1 | 2.2 | 2.4 | 2.4 |
| Mn | N.D | 0.1 | 0.1 | 0.1 |
| Fe | 64.5 | 73.6 | 73.0 | 71.4 |
| Total | 96.9 | 96.4 | 96.6 | 95.1 |

Table 4 Sample 65370 Phase Analyses

| Phase | Silicate | Iron Oxide | Glass |
|---|---|---|---|
| Mg | 1.5 | 0.5 | N.D |
| Al | 4.0 | 1.5 | 13.6 |
| Si | 29.7 | 0.7 | 36.2 |
| P | 0.6 | N.D | 1.5 |
| S | 0.2 | N.D | 0.8 |
| K | 1.6 | N.D | 6.8 |
| Ca | 3.3 | 0.1 | 14.0 |
| Mn | N.D | N.D | 0.1 |
| Fe | 58.7 | 93.1 (72.3)* | 25.0 |
| Total | 99.6 | 95.9 | 98.0 |

* % elemental iron

Sample 74119

The bulk results are given in Table 5 They are similar to those from 4831 with a high iron oxide content and low alkali oxides percentages The silicate was identified as fayalite [67.5% FeO, and 29.6% $SiO_2$]. The elemental iron percentage in the iron oxide indicated that it was magnetite rather than wustite. The low iron oxide content of Bulk 2 may result from the presence of hematite as the results are calculated as wustite in the bulk analyses. The glass composition was similar to that in Sample 65370.

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE MIDDLE IRON AGE | | | | | | |
| 65467 | 0 | 0 | 685 | 0 | 0 | 0 |
| 65495 | 0 | 0 | 35 | 0 | 0 | 0 |
| 65519 | 0 | 0 | 15 | 45 | 0 | 0 |
| 65525 | 0 | 0 | 0 | 10 | 0 | 0 |
| 65533 | 0 | 0 | 0 | 145 | 0 | 0 |
| 65547 | 0 | 0 | 5 | 50 | 0 | 0 |
| 65570 | 0 | 0 | 0 | 10 | 0 | 0 |
| 65580 | 0 | 0 | 65 | 20 | 0 | 0 |
| 65583 | 0 | 0 | 25 | 0 | 0 | 0 |
| 65585 | 0 | 0 | 0 | 25 | 0 | 0 |
| 65597 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65610 | 0 | 0 | 0 | 25 | 0 | 0 |
| 65686 | 0 | 0 | 0 | 45 | 0 | 0 |
| 65702 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65757 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65760 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65761 | 0 | 0 | 0 | 15 | 0 | 0 |
| 65769 | 0 | 0 | 30 | 30 | 0 | 0 |
| 65777 | 0 | 0 | 50 | 0 | 0 | 0 |
| 65778 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65780 | 0 | 0 | 80 | 0 | 0 | 0 |
| 65784 | 0 | 0 | 0 | 5 | 0 | 0 |
| 65785 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65795 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65809 | 0 | 0 | 45 | 0 | 0 | 0 |
| 65822 | 0 | 0 | 25 | 0 | 0 | 0 |
| 65825 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65877 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65939 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65963 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65987 | 0 | 0 | 3720 | 15 | 0 | 0 |
| 74176 | 0 | 0 | 15 | 0 | 0 | 0 |
| 74192 | 0 | 0 | 120 | 0 | 0 | 0 |
| 74309 | 10 | 0 | 40 | 0 | 0 | 0 |
| 74310 | 0 | 0 | 20 | 0 | 0 | 0 |
| 74312 | 0 | 0 | 30 | 0 | 0 | 0 |
| 74334 | 0 | 0 | 10 | 0 | 0 | 0 |
| 74358 | 0 | 0 | 15 | 0 | 0 | 0 |
| 74387 | 0 | 0 | 25 | 0 | 0 | 0 |
| 74404 | 0 | 0 | 5 | 0 | 0 | 0 |
| 74552 | 0 | 0 | 50 | 0 | 0 | 0 |
| 74583 | 0 | 0 | 15 | 0 | 0 | 0 |
| 74587 | 0 | 0 | 105 | 0 | 0 | 0 |
| 74596 | 0 | 0 | 70 | 0 | 0 | 0 |
| 75009 | 0 | 0 | 65 | 0 | 0 | 0 |
| 75015 | 0 | 0 | 35 | 0 | 0 | 0 |
| 75020 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75027 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75037 | 0 | 0 | 40 | 0 | 0 | 0 |
| 75041 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75091 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75468 | 0 | 0 | 50 | 0 | 0 | 0 |
| 75509 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75526 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75599 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75618 | 0 | 0 | 80 | 0 | 0 | 0 |

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE MIDDLE IRON AGE | | | | | | |
| 75639 | 0 | 0 | 140 | 0 | 0 | 0 |
| 75648 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75667 | 0 | 0 | 140 | 0 | 0 | 0 |
| 75674 | 0 | 0 | 0 | 0 | 0 | 10 |
| 75697 | 0 | 0 | 270 | 0 | 0 | 0 |
| 75833 | 0 | 0 | 50 | 0 | 0 | 0 |
| 75843 | 0 | 0 | 160 | 0 | 0 | 0 |
| 75936 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75977 | 0 | 0 | 15 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 3900 | 230 | 18615 | 1710 | 75 | 10 |
| * TOTAL FOR PHASE LATE IRON AGE | | | | | | |
| 5221 | 0 | 0 | 5 | 0 | 0 | 0 |
| 5420 | 0 | 0 | 20 | 0 | 0 | 0 |
| 5447 | 0 | 0 | 20 | 0 | 0 | 0 |
| 5596 | 0 | 0 | 180 | 0 | 0 | 0 |
| 7618 | 0 | 0 | 15 | 0 | 0 | 0 |
| 54145 | 0 | 0 | 5 | 0 | 0 | 0 |
| 55118 | 0 | 0 | 165 | 0 | 0 | 0 |
| 65033 | 0 | 0 | 0 | 30 | 0 | 0 |
| 65039 | 0 | 0 | 10 | 25 | 0 | 0 |
| 65055 | 0 | 0 | 115 | 0 | 0 | 0 |
| 65058 | 0 | 0 | 40 | 0 | 0 | 0 |
| 65072 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65097 | 0 | 0 | 130 | 60 | 0 | 0 |
| 65098 | 0 | 0 | 0 | 10 | 0 | 0 |
| 65100 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65107 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65114 | 0 | 0 | 45 | 0 | 0 | 0 |
| 65116 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65135 | 0 | 0 | 380 | 0 | 0 | 0 |
| 65153 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65162 | 0 | 0 | 180 | 0 | 0 | 0 |
| 65168 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65169 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65182 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65214 | 0 | 0 | 100 | 0 | 0 | 0 |
| 65216 | 0 | 0 | 50 | 0 | 0 | 0 |
| 65218 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65221 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65229 | 0 | 0 | 0 | 10 | 0 | 0 |
| 65252 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65267 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65311 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65505 | 0 | 0 | 75 | 0 | 0 | 0 |
| 65522 | 0 | 0 | 90 | 0 | 0 | 0 |
| 65628 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65667 | 0 | 0 | 0 | 40 | 0 | 0 |
| 65715 | 0 | 0 | 30 | 0 | 0 | 0 |
| 65798 | 0 | 0 | 10 | 0 | 0 | 0 |
| 74086 | 0 | 0 | 55 | 0 | 0 | 0 |
| 74087 | 0 | 0 | 205 | 0 | 0 | 0 |
| 74109 | 0 | 0 | 35 | 0 | 0 | 0 |
| 74531 | 0 | 0 | 255 | 0 | 0 | 0 |

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE LATE IRON AGE | | | | | | |
| 74590 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75080 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75155 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75391 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75448 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75579 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75741 | 0 | 0 | 25 | 0 | 0 | 0 |
| 75811 | 0 | 0 | 105 | 0 | 0 | 0 |
| 75816 | 0 | 0 | 170 | 0 | 0 | 0 |
| 75824 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75826 | 0 | 0 | 45 | 0 | 0 | 0 |
| 75827 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75828 | 0 | 0 | 35 | 0 | 0 | 0 |
| 75830 | 0 | 0 | 35 | 0 | 0 | 0 |
| 75831 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75835 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75838 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75847 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75852 | 0 | 0 | 90 | 0 | 0 | 0 |
| 75855 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75960 | 0 | 0 | 115 | 0 | 0 | 0 |
| 75962 | 0 | 0 | 525 | 0 | 0 | 0 |
| 75965 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75974 | 0 | 0 | 25 | 0 | 0 | 0 |
| 65019 | 0 | 0 | 735 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 0 | 0 | 4470 | 175 | 0 | 0 |
| * TOTAL FOR PHASE EARLY R-B | | | | | | |
| 5429 | 0 | 0 | 35 | 0 | 0 | 0 |
| 5598 | 0 | 0 | 35 | 0 | 0 | 0 |
| 5599 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65005 | 0 | 0 | 710 | 0 | 0 | 0 |
| 65016 | 0 | 0 | 165 | 0 | 0 | 0 |
| 65040 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65069 | 0 | 0 | 55 | 0 | 0 | 0 |
| 65089 | 0 | 0 | 30 | 0 | 0 | 0 |
| 65091 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65103 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65172 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65187 | 0 | 0 | 165 | 0 | 0 | 0 |
| 65631 | 0 | 115 | 0 | 50 | 0 | 0 |
| 65653 | 0 | 0 | 0 | 0 | 10 | 0 |
| 65831 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65832 | 0 | 0 | 15 | 5 | 0 | 0 |
| 65954 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65991 | 0 | 0 | 0 | 15 | 0 | 0 |
| 74006 | 0 | 0 | 250 | 0 | 0 | 0 |
| 74513 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75024 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75030 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75136 | 0 | 0 | 50 | 0 | 0 | 0 |
| 75162 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75211 | 0 | 0 | 100 | 0 | 0 | 0 |
| 75228 | 0 | 0 | 25 | 0 | 0 | 0 |

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE EARLY R-B | | | | | | |
| 75239 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75262 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75265 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75266 | 0 | 0 | 35 | 0 | 0 | 0 |
| 75344 | 0 | 0 | 40 | 0 | 0 | 0 |
| 75367 | 0 | 0 | 65 | 0 | 0 | 0 |
| 75569 | 0 | 0 | 155 | 0 | 0 | 0 |
| 75584 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75586 | 0 | 0 | 55 | 0 | 0 | 0 |
| 75865 | 0 | 0 | 10 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 0 | 115 | 2165 | 70 | 10 | 0 |
| * TOTAL FOR PHASE MID R-B | | | | | | |
| 5471 | 0 | 0 | 45 | 0 | 0 | 0 |
| 65004 | 0 | 0 | 140 | 0 | 0 | 0 |
| 65007 | 0 | 0 | 35 | 0 | 0 | 0 |
| 65011 | 0 | 0 | 355 | 0 | 0 | 0 |
| 65012 | 0 | 0 | 35 | 0 | 0 | 0 |
| 65017 | 0 | 0 | 80 | 0 | 0 | 0 |
| 65025 | 0 | 0 | 0 | 105 | 0 | 0 |
| 65026 | 0 | 0 | 25 | 0 | 0 | 0 |
| 65030 | 0 | 0 | 0 | 35 | 0 | 0 |
| 65078 | 0 | 0 | 0 | 40 | 0 | 0 |
| 65083 | 0 | 0 | 170 | 0 | 0 | 0 |
| 65085 | 0 | 0 | 230 | 0 | 0 | 0 |
| 65104 | 0 | 0 | 30 | 0 | 0 | 0 |
| 65112 | 0 | 0 | 50 | 0 | 0 | 0 |
| 65117 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65355 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65455 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65713 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65728 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65786 | 0 | 0 | 0 | 5 | 0 | 0 |
| 74016 | 0 | 0 | 10 | 0 | 0 | 0 |
| 74119 | 25 | 0 | 0 | 0 | 0 | 0 |
| 75124 | 0 | 0 | 45 | 0 | 0 | 0 |
| 75142 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75523 | 60 | 0 | 85 | 0 | 0 | 10 |
| 75901 | 0 | 0 | 60 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 85 | 0 | 1465 | 185 | 0 | 10 |
| * TOTAL FOR PHASE LATE R-B | | | | | | |
| 5485 | 35 | 0 | 110 | 0 | 0 | 0 |
| 5495 | 0 | 0 | 25 | 0 | 0 | 0 |
| 5499 | 0 | 0 | 660 | 0 | 0 | 0 |
| 5555 | 0 | 0 | 155 | 0 | 0 | 0 |
| 65048 | 0 | 0 | 75 | 0 | 0 | 0 |
| 65057 | 0 | 0 | 0 | 5 | 0 | 0 |
| 65067 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65079 | 0 | 0 | 380 | 0 | 0 | 0 |
| 65090 | 0 | 0 | 0 | 110 | 0 | 0 |
| 65092 | 0 | 0 | 10 | 0 | 0 | 0 |

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE LATE R-B | | | | | | |
| 65367 | 0 | 0 | 20 | 0 | 0 | 0 |
| 65502 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65507 | 60 | 0 | 0 | 0 | 0 | 0 |
| 65509 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65510 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65511 | 0 | 205 | 65 | 0 | 0 | 0 |
| 65512 | 0 | 0 | 40 | 0 | 0 | 0 |
| 65566 | 0 | 0 | 0 | 0 | 45 | 0 |
| 65623 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65644 | 0 | 0 | 5 | 0 | 0 | 0 |
| 65674 | 65 | 0 | 0 | 5 | 0 | 0 |
| 65726 | 0 | 75 | 0 | 0 | 0 | 0 |
| 65730 | 130 | 0 | 0 | 0 | 0 | 0 |
| 65768 | 0 | 30 | 0 | 0 | 15 | 0 |
| 65774 | 0 | 0 | 0 | 10 | 0 | 0 |
| 65776 | 0 | 0 | 15 | 0 | 0 | 0 |
| 65823 | 0 | 0 | 30 | 0 | 0 | 0 |
| 65935 | 0 | 0 | 25 | 0 | 0 | 0 |
| 66115 | 0 | 0 | 5 | 0 | 0 | 0 |
| 74201 | 0 | 0 | 270 | 0 | 0 | 0 |
| 75087 | 0 | 0 | 30 | 0 | 0 | 0 |
| 75508 | 0 | 0 | 25 | 0 | 0 | 0 |
| 75512 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75536 | 0 | 0 | 15 | 0 | 0 | 0 |
| 75564 | 0 | 0 | 20 | 0 | 0 | 0 |
| 75603 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75607 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75614 | 0 | 0 | 5 | 0 | 0 | 0 |
| 75941 | 0 | 0 | 30 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 290 | 310 | 2095 | 130 | 60 | 0 |
| * TOTAL FOR PHASE MEDIEVAL | | | | | | |
| 65001 | 50 | 0 | 100 | 0 | 0 | 0 |
| 65002 | 0 | 0 | 0 | 35 | 0 | 0 |
| 75001 | 0 | 0 | 50 | 0 | 0 | 0 |
| 75002 | 380 | 0 | 0 | 0 | 0 | 0 |
| 75004 | 0 | 0 | 60 | 0 | 0 | 0 |
| 75005 | 0 | 0 | 10 | 0 | 0 | 0 |
| 75022 | 0 | 0 | 5 | 0 | 0 | 0 |
| ** Subtotal ** | | | | | | |
| | 430 | 0 | 225 | 35 | 0 | 0 |
| * TOTAL FOR PHASE MODERN | | | | | | |
| 5000 | 0 | 0 | 50 | 0 | 0 | 0 |
| 5419 | 0 | 0 | 30 | 0 | 0 | 0 |
| 7000 | 15 | 0 | 0 | 0 | 0 | 0 |
| 65010 | 0 | 0 | 0 | 30 | 0 | 0 |
| 65013 | 0 | 0 | 0 | 160 | 0 | 0 |
| 65084 | 0 | 0 | 0 | 55 | 0 | 0 |
| 65500 | 50 | 0 | 20 | 0 | 0 | 0 |
| 65501 | 0 | 0 | 10 | 0 | 0 | 0 |
| 65936 | 0 | 0 | 25 | 0 | 0 | 0 |
| 75000 | 0 | 0 | 30 | 0 | 0 | 0 |

APPENDIX 1 BECKFORD SLAG LISTING BY PHASE (WEIGHT IN GRAMMES)

| CONTEXT | SMITH SLAG | H.B. | FAS/CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|
| * TOTAL FOR PHASE MODERN | | | | | | |
| 75501 | 0 | 0 | 20 | 0 | 0 | 185 |
| ** Subtotal ** | | | | | | |
| | 65 | 0 | 185 | 245 | 0 | 185 |
| ** Total ** | | | | | | |
| | 4770 | 685 | 29480 | 2845 | 145 | 205 |

APPENDIX 2 SUBSIDIARY LISTING OF FAS/CINDER FROM 1972-4 EXCAVATIONS
(WEIGHT IN GRAMMES)

| CONTEXT | PHASE | SMITH | HB | FAS+CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|---|
| 1219 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 1220 | | 0 | 0 | 70 | 0 | 0 | 0 |
| 1705 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 1706 | | 0 | 0 | 40 | 0 | 0 | 0 |
| 1729 | | 0 | 0 | 25 | 0 | 0 | 0 |
| 1731 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 1740 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 1750 | | 0 | 0 | 160 | 0 | 0 | 0 |
| 1757 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 1806 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 1809 | | 0 | 0 | 390 | 0 | 0 | 0 |
| 1825 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 1827 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 1828 | | 0 | 0 | 50 | 0 | 0 | 0 |
| 1829 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 1842 | | 0 | 0 | 1110 | 0 | 0 | 0 |
| 1855 | | 0 | 0 | 35 | 0 | 0 | 0 |
| 1856 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2001 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 2204 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 2532 | | 0 | 0 | 40 | 0 | 0 | 0 |
| 2713 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 2714 | | 0 | 0 | 60 | 0 | 0 | 0 |
| 2724 | | 0 | 0 | 165 | 0 | 0 | 0 |
| 2727 | | 0 | 0 | 35 | 0 | 0 | 0 |
| 2737 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2754 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 2754 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2759 | | 0 | 0 | 55 | 0 | 0 | 0 |
| 2780 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 2798 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 2799 | | 0 | 0 | 50 | 0 | 0 | 0 |
| 2801 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 2802 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 2813 | | 0 | 0 | 70 | 0 | 0 | 0 |
| 2820 | | 0 | 0 | 270 | 0 | 0 | 0 |
| 2831 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 2835 | | 0 | 0 | 55 | 0 | 0 | 0 |
| 2844 | | 0 | 0 | 60 | 0 | 0 | 0 |
| 2879 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 2880 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2907 | | 0 | 0 | 35 | 0 | 0 | 0 |
| 2952 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2961 | | 0 | 0 | 35 | 0 | 0 | 0 |
| 2968 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 2974 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 2978 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 2984 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 2993 | | 0 | 0 | 100 | 0 | 0 | 0 |
| 3501 | | 0 | 0 | 30 | 0 | 0 | 0 |
| 3802 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 3804 | | 0 | 0 | 50 | 0 | 0 | 0 |
| 3824 | | 0 | 0 | 15 | 0 | 0 | 0 |
| 3832 | | 0 | 0 | 180 | 0 | 0 | 0 |
| 3839 | | 0 | 0 | 140 | 0 | 0 | 0 |
| 3848 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 3850 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 3862 | | 0 | 0 | 72 | 0 | 0 | 0 |
| 3871 | | 0 | 0 | 40 | 0 | 0 | 0 |

APPENDIX 2 SUBSIDIARY LISTING OF FAS/CINDER FROM 1972-4 EXCAVATIONS
(WEIGHT IN GRAMMES)

| CONTEXT | PHASE | SMITH | HB | FAS+CIN | HL | ORE | OTHER |
|---|---|---|---|---|---|---|---|
| 3875 | | 0 | 0 | 5 | 0 | 0 | 0 |
| 3876 | | 0 | 0 | 10 | 0 | 0 | 0 |
| 3910 | | 0 | 0 | 70 | 0 | 0 | 0 |
| 3913 | | 0 | 0 | 25 | 0 | 0 | 0 |
| 3915 | | 0 | 0 | 20 | 0 | 0 | 0 |
| 3919 | | 0 | 0 | 45 | 0 | 0 | 0 |
| ** Total ** | | | | | | | |
| | | 0 | 0 | 3977 | 0 | 0 | 0 |