# Metalworking residues from Glebe Ringfort, County Dublin (Site 43 00E0758)

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## Abstract

*The slag assemblage of forty four numbered finds includes nine pieces identifiable as smithing slags, ten pieces probably so, and four probably not slags. The total weight of the slag material was 5.2kg. Thus smithing slags (certain or probable) comprise 48% of the slag assemblage by number and 78% by weight. Of the remaining less certain material, there are no specimens which are certainly not smithing slags. The likelihood is therefore that the entire assemblage was produced by smithing. The smithing hearth slag cakes are very variable in morphology and size, including several in the 700-900g range, and one fragment suggestive of an original cake size of 3kg. This very large cake suggests bloomsmithing may have taken place here alongside the blacksmithing. There is no evidence for iron smelting.*

*The sediments bagged as possibly containing hammerscale included a large proportion of strongly magnetic grains, but these did not have the morphology of hammerscale. The subsample examined showed magnetic grains of stone and fired clay(?) with a dominant grain size of 1-4mm. It seems likely that they were produced by the heating of clay and sand, probably in a non-metallurgical context. It would appear that the magnetic material has been derived through intense heating of iron-rich materials. Those materials appear to include a quartzo-feldspathic coarse sand with iron rich grain coatings, and it is those natural grain coatings which have become magnetic on firing. The absence of true hammerscale from the sample makes it extremely unlikely that these deposits are associated with iron-working, and the location of the smithing activity, as evidenced by the macroscopic slags, should be sought elsewhere.*

*The assemblage therefore represents a low level of iron-working activity, with no evidence for the smithing to have been associated directly with the features yielding the magnetic sediment.*

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## Background

This report provides additional information on the slag assemblage from Glebe Ringfort (Site 43 00E0758) as described in the evaluation report 2002/16.

The evaluation report divided the macroscopic slags from the site into three classes:

1. Plano-convex smithing hearth cakes with relatively homogeneous fayalitic slag. Some examples may show protrusions from lower surface. There are few moderately intact cakes in the assemblage and the examples are also rather variable, so it is impossible to generalise on their morphology or size. The cakes vary from low convexity, elongate forms, to others of strong convexity.

2. Probable small smithing hearth cakes with abundant included rock granules. These are of low density, and is unclear at present whether the inclusions represent sloughing of the hearth wall or whether they indicate a deliberate flux.

3. Dense slags showing a more tabular- or sheet-like morphology. These slags were difficult to interpret, but it was suggested they represent flowage of slag to the base of the smithing hearth

All three classes of slag were interpreted as likely to be derived from a blacksmithing process. The macroscopic slag collection comprises 40 numbered finds which are probably slags, with a total weight of 5.2kg. The collection is therefore relatively small (although the site description does not indicate the proportion of the site dug).

Two aspects of the macroscopic slag assemblage were flagged as being interesting. The first was the apparently large size of many of the plano-convex smithing hearth cakes, with a single complete cake at 900g and several pieces of up to 500g, each comprising only a small fraction of an original cake. The second interesting feature identified was the presence of gravel-grade quartzose material included within type (2) above.

An examination of the already-separated possible hammerscale material was conducted. The particles proved to be highly magnetic. The picked samples were washed, and sieved at 200μm. The sieved material was then again magnetically separated and inspected optically. The magnetic material was found to be quite large (mainly in the 1 – 4mm range), moderately well rounded, and dominated by pale, fine-grained particles, interpreted as fragments of fired clay. Other granules were darker in colour and appeared to be lithic grains. None of the separated grains was hammerscale.

The recommended further study of the assemblage included production of a catalogue of the macroscopic slags and electron-microscope examination of examples of the microscopic material.

# Description of material

## Macroscopic material

Preparation of the catalogue (see Appendix) involved additional cleaning and examination of the specimens. This has resulted in some additional information.

Moderately complete smithing hearth cakes have a wide weight range. The smallest example weighs 95g (336/1), with specimen 394/1 being less certainly complete at 80g. Small cakes include 376/1 at 185g, 371/4 at 230g and 296/1 at 310g, Large cakes include 5/19 at 765g, 366/2 (820g) which effectively comprises two superimposed small cakes, and 288/2 (875g) a more conventional, if low convexity, plano-convex cake. Specimen 225/25 weighs 650g, but includes only an estimated 20% of the original cake, suggesting a total weight of around 3kg.

The material in type (3) of the evaluation report now seems likely to be related to the basal layer (crust) of dense slag seen in many of the smithing hearth cakes. These basal layers are 7-10mm thick, and comprise slag with few vesicles and inclusions, often in marked contrast to the inclusion and vesicle rich main body of the slag cake. Specimen 3/158, for instance, shows a marked basal layer, probably accentuated because of abrasion of the more porous parts of the cake. Some pieces (230/5 possibly and 296/1 more certainly) show evidence of formation during removal from the hearth. Such deformation may enhance the sheet like nature of the slag. In addition, several of the pieces show growth of the slag cake in an abnormally low-convexity form; in these the basal crust s sheet like and comprises most of the cake. Examples of this morphology include 336/2 , 288/2, 296/1). The existence of dense slags at the base of the slag cake is slightly unusual. In part the nature of this dense layer may be preservational, but it seems likely to indicate that these slag cakes involved a rather fluid slag, capable of descent through the fuel before solidifying.

Where fuel is seen to be included in the slags it is charcoal, mainly in rather small pieces. Specimen 225/20 shows 10mm diameter sticks of charcoal internally, with impressions of grass or straw on the base (probably remains of the kindling/tinder used in fire lighting).

The upper surface of many of the cakes is typically a dark glass. In many instances the upper layers of the cake are associated with gravelly quartzose debris. The evaluation report discussed the possible significance of the addition of such material, both within the context of the possible interpretation of slags with a coarse quartzose component from Hengistbury as possibly being from copper refining (Salter 1987), and from the viewpoint that quartz-rich materials might have been deliberately introduced by the blacksmith as a flux. Further consideration of the additional specimens revealed during the cleaning of the assemblage suggests that the coarse component is a granitic gravel – including quartz, feldspar and mica grains. Such an impure material is probably more likely to have entered the earth through wall collapse and melting rather than deliberate addition.

## Microscopic material

A proportion of the already-extracted magnetic fines were mounted and examined under an electron microscope. Optical inspection had already strongly suggested that these grains were not hammerscale, and the electron microscope study confirmed this. All of the grains examined and described below are from context 405 #735. The grains examined from both previously separated samples (#735 and #734) were similar in nature, and separation of additional material from context 370 #826 produced more identical material. Full magnetic separation from the bulk samples was therefore not undertaken.

The analytical approach involved mounting a selection of magnetic particles not SEM stubs and coating with carbon. The microanalysis was undertaken on the Cardiff University School of History and Archaeology's Camscan Maxim 2040 scanning electron microscope with Oxford Instruments energy-dispersive microanalysis system. The microanalyses were undertaken either as "spot" samples or as scans of limited areas of the surfaces of the grains. This approach gives only qualitative results.

***Details***

A small amount of material from sample 735 was examined under the SEM. The material was divided into three fractions for imaging and analysis; one stub with large dark particles, a second stub with large pale particles and a third stub with finer material. These samples appeared representative of the material present.

Four particles were examined in detail from the first stub. These grains comprised:

Grain 1. This was a rounded particle of 1.8 x 2.2mm approximately. The analyses show that some parts of the grain are iron oxide

Grain 2. This was an angular grain of about 1.2 x 2mm. The regularity of the shape suggests that the grain may be a fractured crystal termination. The microanalyses have fairly constant ratios of silicon, aluminium, calcium and potassium, suggesting that the mineral grain may be a feldspar. The iron and manganese contents are much more variable, suggesting these are present in the surface coating of the grain. The high manganese levels in some areas are interesting and may hint that this grain has received a ferromagnesian coating in the sedimentary environment (either in an iron-pan or in a fluvial environment).

Grain 3. This was an oblate subrounded grain, 1.7 x 1.4mm. The appearance of the grain is suggestive of an underlying mineral grain with a fine-grained coating. Microanalysis shows dominant silicon, with low aluminium and iron, with lesser amounts of potassium and calcium, and in one case traces of manganese.

Grain 4. This was an angular grain of 1.2 x 0.9mm. Microanalysis closely resembles that of grain 3. The morphology suggests a crystal termination; the analysis suggests most of this grain may be quartz.

Two particles were selected for microanalysis from the second stub:

Grain 5. This was an elongate angular grain, 4.3 x 2.1mm. Microanalysis shows similar results to grains 3 and 4, but with a markedly higher proportion of calcium and a slightly lower iron content. The analyses and shape suggest that this grain may be a feldspar crystal.

Grain 6. This was an angular grain, 3.2 x 2.7mm, with a markedly different appearance to grains 2-5, being clearly poly-mineralic. Much of the rain is dominated by material giving microanalyses high in silicon, aluminium and iron, with variable calcium and potassium. Some areas appeared to consist simply of an iron oxide.

The mounted fines material showed very variable microanalyses. The material included some grains of quartz of 200 - 300 μm diameter, but most of the material was aluminium-rich. Some analyses with just silicon and aluminium are suggestive of kaolinite, but most of the fine grained material contains calcium, potassium and iron in variable amounts and probably represents mixed clays and iron oxides.

# Discussion

## Macroscopic material

The macroscopic slag assemblage is rather varied, including a range of material that might be considered typical of the residues produced by blacksmithing. Several of the smithing cakes are quite large (3 in the range 700-900g) and one appears to be a fragment of cake which when complete would have weighed up to 3kg. The significance of the presence of large slag cakes is obscure. The size of the slag cake will relate to the amount of metal lost to the hearth by the smith in between cleanings. A large slag cake will therefore indicate a great deal of lost metal, which must in turn imply either a protracted period of work or a process involving a considerable rate of loss of material to the hearth.

One of the processes involving the greatest loss of metal to the hearth is that of the initial reworking of the raw bloom, to produce first a billet and then bar iron. In most cases, smithing hearth cakes of several kilograms are probably related to bloomsmithing, rather than to blacksmithing. This great loss of iron to the hearth can be demonstrated by experimental results (although it must be remembered that some of the experimental loss will be in the form of hammerscale and other anvil products). Crew (1991) showed an experimental loss of 48% in smithing a raw bloom to a billet, of 28% of the billet in smithing it to raw bar iron and of 18% of the raw bar in smithing it into a reproduction iron Age currency bar (i.e. a 41% loss from billet to currency bar). Sauder and Williams achieved similar results of 37% loss from bloom to billet and 42% from billet to currency bar. Overall Crew produced currency bars weighing 30% of the original bloom and Sauder and Williams (who probably had a denser original bloom) produced 37%. Of course, bloomsmithing is an extreme example of ferrous processing employing a large amount of high temperature welding. Other similar welding intensive, or other high temperature work, may also produce quite high losses.

The presence of a particularly dense layer of slag on the base of some the cakes (see above) may also be an indicator of high temperature or prolonged working, because it suggests that the slag was sufficiently mobile to sink towards the hearth floor before solidifying.

In summary, the slag cake estimated to have weighed 3kg is very likely to have been derived from bloomsmithing, the cakes in the 700-900 g range are marginal, perhaps resulting from intensive blacksmithing work, but also possibly being derived from the production of raw bar iron. The five slag cakes below 350g are likely to be the products of blacksmithing.

## Microscopic material

The magnetic residues do not appear to be either slag or hammerscale particles. Most of the larger grains examined were apparently mineral grains (probably including both quartz and feldspar) with a fine-grained surface coating of iron-rich material. Similar iron-rich material is to be found comprising smaller grains. Microanalysis suggests that the iron-rich material is rich in silicon and aluminium, with varying contents of iron, calcium, potassium and manganese. This suggests that the material is likely to be a mixture of clay minerals and iron oxides. Although the identification of this material as the magnetic component has not been proved, it would appear extremely likely. The origin of the iron-rich grain coatings is most likely to be within the soil or weathering bedrock. Such natural grain coatings would be non-magnetic, but could become magnetic through heating.

The role of heating in the genesis of these magnetic materials does not imply that they have an origin in metallurgical hearths. Appropriate temperatures could be reached in other sorts of hearths. Indeed, the lack of any true hammerscale in the examined samples makes it extremely unlikely that the deposit containing these magnetic particles was associated with iron-working.

## Conclusion

The total amount of slag recovered from the site is small. This may indicate that iron-working was not a particularly significant activity on the site, but might also indicate that the local focus of the activity was outside the excavated area. Given that the main activity was iron-working rather than smelting, the lack of evidence for a hearth does not necessarily indicate that the activity did not take place within the excavated area, since waist-level smithing hearths were probably more common than would appear from the archaeological record; they leave little archaeological trace. However, one might still expect to find a working floor with hammerscale around the anvil location, if preservation is suitable.

The small quantity of slags from the Glebe Ringfort makes comment on the nature of the iron-working process dangerous, but the relatively high proportion of large slag cakes suggests that some processing of raw blooms may have taken place here, alongside blacksmithing.

## References

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# Appendix 1: Macroscopic slag catalogue

| Context | Find no. | Labelled | Weight (g) | Descriptive notes |
|---|---|---|---|---|
| 3 | 158 | slag | 160 | 85 x 65 x 20mm thick. Dense iron slag. Both surfaces show impression of quite large charcoal fragments. Appears to be a worn smithing hearth cake with a 10mm thick dense lower crust; this is probably the distal end of the cake. |
| 3 | 438 | slag | 70 | Broken into three pieces. A small, poorly developed, smithing hearth cake with 7-8mm lower crust, which is still rather vesicular. The cake has a lower protuberance of unknown overall form; otherwise base smooth with small dimples. |
| 3 | 309 | slag | 95 | Small piece of weathered grey slag, with abundant rock particles (mainly quartz crystals). |
| 3 | 282 | iron slag | 5 | Dimpled piece of fairly dense iron slag. |
| 5 | 19 | | 765 | Deep, dense, plano-convex smithing hearth cake. 125mm long, 90mm wide, 60mm max depth (at 50mm from proximal end). Very knobbly under-surface; top with black glass bearing lots of silicate crystals. "Knobbles" on lower surface may also be clots of admixed material. Linguate in plan; widest 50mm from proximal end. |
| 79 | 41 | slag | 145 | Very irregular slag. Lower side with big charcoal dimples and incipient prills. Upper surface dark glass with crystals of qtz. Proximal end shows raised bump on upper surface with lots of corrosion. 65 x 80 x 25mm. Admixed material seems to be granitic. |
| 79 | 40 | ds63 | <5 | Disintegrated fragment of gravelly slag. |
| 81 | 29 | slag | 170 | Rather amorphous block of charcoal-rich but dense slag. 1 original surface - rusty, concave - but possibly not original shape |
| 127 | 22 | | 25 | Amorphous fragment of vesicular slag |
| 142 | 1 | ditch #4 | 55 | 11pieces of indurated wall and other altered slag material. |
| 143 | 2 | | <5 | Probably stone. |
| 213 | 3 | slag | 10 | Dense flowed slag lobe. |
| 213 | 4 | | 15 | 7 pieces (originally one?), rounded lump of vesicular slag. |
| 213 | 9 | | 10 | Rounded slag fragment. |
| 217 | 2 | | 50 | 2 pieces of amorphous vesicular slag. |
| 225 | 25 | slag | 650 | Dense smithing hearth cake with 2 protuberances (1 is rod 27mm diameter), a very dense block. Cake around 150mm diameter, 40mm thick originally? - around 20% of original cake? |

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|---|---|---|---|---|
| 225 | 17 | slag | 145 | Many pieces of badly weathered and fragmented slag pieces. Green (chloritic, after olivine?), platey, with pale weathering glass. Slag pale green/grey overall. Bears large slightly rounded quartzose grains up to 10mm - probably granitic gravel. |
| 225 | 26 | slag | 10 | Small piece of grey slag with quartz crystals, vesicular. Form unknown - may be folded? |
| 225 | 18 | | 10 | 2 pieces grey vesicular slag |
| 225 | 20 | | 65 | About half of a small smithing hearth cake with a 5-7mm lower crust and a highly vesicular interior. The lower surface with ?grass impressions. Interior has 10mm diameter charcoal sticks |
| 230 | 7(722) | wet sieved | 5 | Porous pale slag dark glass turning pale, some included large quartz grains. |
| 230 | sample 905 bank section 008? | wet sieved | 20 | 3 pieces of vesicular grey slag |
| 230 | 5 | | 55 | irregular (contorted?) slab cf. 79/41. Has a hole – possibly suggestive of a 12mm diameter poker? |
| 232 | 8 or 1 | slag | 5 | 3 small pieces of vesicular grey slag. |
| 249 | 2 | sample 710 | 80 | Rim of dense smithing hearth cake. |
| 278 | 6 | slag | 35 | Small piece of vesicular cake, some quartz on top. |
| 278 | 2 | | 40 | Charcoal- and iron-rich fragment of slag. |
| 288 | 2 | slag | 875 | Large low convexity smithing hearth cake. Lower face inverted-conical. 35mm thick at apex, approx. 140mm diameter. Protuberance on one side 60mm wide and extending 35mm out. Small lump about 40mm diameter and 20mm high on upper surface. Slag very porous and charcoal rich apart from lower crust. Chord 15mm deep missing from one side – probably the site of attachment to the hearth wall (the upper lump occurs on this side). Glassy top. |
| 289 | 8 | iron slag | 5 | Amorphous piece of dense slag |
| 296 | 1 | ditch section 25 | 310 | Probably originally a 130 x 80 x 25mm deep shallow smithing hearth cake, but with one end broken and folded back onto top of rest. Lower surface fairly smooth and very corroded. Upper surface with large dimples. Around one end, and where broken, shows dark glass bearing silicate crystals tending to bright blue and pale green. Overall the slag is dense so probably not like this throughout. |
| 298 | 2 | | 15 | 27 small slag pieces |
| 298 | 4 | | <5 | Corroded nail point? |
| 336 | 1 | | 95 | Thin linguate slab with flowed margins, 90x50x15mm. Probably a complete smithing hearth cake. |
| 347 | 2 | metal slag | 20 | Dense slag with partially melted granitic rock fragments. Green/blue glass in places |
| 347 | 1 | metal | 15 | Very corroded scrap of iron-rich slag. |
| 351 | 1 | | 35 | Amorphous fragment of vesicular slag. |
| 366 | 2 | slag | 820 | Double layer smithing hearth cake. Upper layer resembles beefburger, 85mm diameter, gently dished, broken proximally, probably sub-circular, 10-15mm thick. The lower layer is elongate, 30mm thick, 105mm preserved length, broken proximally and distally. 90mm wide. Has dense lower crust, and more vesicular interior. Lower surface dense and fairly smooth. Upper surface of upper cake smoothly lobate. |

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| 370 | 4 | | 100 | Small piece from large, dense smithing hearth cake. Basal crust abut 10mm, overlain by coarsely crystalline slag with cavities and several mm wide platey olivines. 45mm square and 25mm thick |
| 371 | 4 | slag | 230 | Small biconvex smithing hearth cake. Upper surface of conventional oval cake has upstanding mass, 50x60x10mm, which my be largely due to an attached metal piece? Cake 90 x 65 x 35mm deep, appears to have smooth/poorly lobate lower crust containing charcoal rich material. Piece starting to “explode” – so likely to contain significant metallic iron. |
| 376 | 1 | | 185 | Rather spoon shaped smithing hearth cake, 95 x 65 x 37mm. Very irregular base, upper surface with quite large charcoal impressions. |
| 391 | 1 | wet sieved | 5 | Scrap of vesicular grey slag. |
| 391 | 1 | slag | 50 | Distal piece of biconvex cake, lower moderately good crust, inside largely hollow, top dominated by glassy material with quartz grains. |
| 394 | 1 | | 80 | Attachment area of small smithing hearth cake. Local smooth glassy top close to Fe-rich gravelly ceramic, lower part charcoal-rich with descending blebs. Only extends about 30mm into hearth, not clear if broken or that was full size. 60mm wide x 30mm deep. |
| 485 | 2 | | 50 | Irregular, somewhat tubular slag piece. |
| 502 | 1 | | 15 | 1 piece of amorphous vesicular slag. |

## Appendix 2: SEM images and microanalytical results from magnetic grains