Society of Antiquaries of Scotland

Culduthel

An Iron Age Craftworking Centre in North-East Scotland

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ISBN: 978-1-908332-19-6 (hardback) • 978-1-908332-20-2 (PDF)

Part C

Metal

The manufacture of iron at Culduthel: ferrous metalworking debris and iron metallurgy

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Overview

The excavations at Culduthel have produced a nationally significant assemblage of ferrous metalworking waste, comprising over a third of a tonne of slag and associated vitrified debris. The significance of the material lies not only in its quantity, which represents the largest volume of iron slag to be recovered from a well dated, recently excavated Iron Age site in Scotland, but also because of the direct association of much of the material with in situ furnace and hearth features. The range of debris identified is comprehensive and indicative of all stages of ironworking, from the reduction of ore to bloom within smelting furnaces, and the processing of bloom to object by smithing. Scientific and morphological analysis have allowed us to query the traditional interpretation of certain aspects of the process, notably in identifying variant forms of hammerscale, typically associated with smithing, which in fact came from smelting. One very intriguing and significant missing component within this assemblage is ore. It is assumed that bog ore would have been exploited in this area, yet not a single piece of either bog ore or ferruginous rock was identified. Material thought to be ore was collected on site, but it turned out not to be – one stone, believed to be ore on collection, has no viable iron-rich minerals. The quality of the resulting metal was very high, with natural steel being produced.

The majority of the slag was recovered from a single area within the settlement, the area to the east and south-east of House 10/3, which appeared to form the main focus for craft activities on the site. Manufacture was not restricted solely to ferrous metalworking but included glassworking and non-ferrous metalworking. The siting of smelting furnaces within roundhouse structures is repeatedly observed and suggests that these buildings were workshops.

An additional assemblage of ferrous metalworking debris was recovered from subsequent excavations at Culduthel Mains Farm (Headland Phases 7 and 8). Unlike the vitrified material that is the subject of this contribution, the Phases 7 and 8 slag was all from secondary contexts and has been dated to the Early Historic period. However, the technology represented was essentially the same.

This report surveys the technological background of the iron bloomery process and outlines the typical products, before discussing the methodology of this study. The morphological classification of the material is then presented, followed by the results of scientific analysis of slags, microslags, bloom and iron artefacts. The distribution and taphonomy of the material are then interrogated to assess the activities taking place in different areas, whether primary smelting and smithing, secondary dumps and spreads, or reuse. Finally, comparative material is drawn into the discussion, and the significance of the assemblage is synthesised.

Technological background

There are several aspects of the Culduthel slag, in particular their morphology and their chemistry, which require careful consideration. It may be helpful to rehearse some of the previous research into comparable assemblages. Before the introduction of the blast furnace into Britain at the end of the 15th century, all iron appears to have been manufactured using a single-stage, direct process in which iron was smelted but not melted (Bayley et al 2001). This process is usually known as the bloomery process (the raw product resembled a bloom or sponge) although there were undoubtedly several different bloomery processes (Paynter 2007a). Understanding the exact nature of the bloomery process employed on a particular site is hampered by the fact that iron smelting furnaces almost never survive to their full height and may not contain in situ residues. In addition, most metalworking debris (in particular the slag) is usually found in secondary contexts such as pits and ditches. Nevertheless, slags are often the most useful evidence for ironworking due to their durability. The size and shape of lumps of smelting slag preserve traces of the ways in which they formed, flowed and solidified. The formation of a fluid slag was essential in order to separate the impurities in the ore from the solid bloom. Some types of slag (and the associated processes) are well known while others are poorly understood.

Iron smelting furnaces (and the slags produced by them) are usually divided into those in which the slag was tapped from the furnace (and solidified as ropey sheets of tap slag) and those in which the slag remained at the base of the furnace (Paynter 2007a). In Britain, tap slags are common from Roman and later medieval iron smelting sites but are rare on prehistoric and early medieval sites. If slag was not tapped, then it would have to collect at the base of a furnace and remain there until the end of the smelting process. The most distinctive slags from these furnaces are large (>50kg) furnace bottoms (Halkon and Millett 1999; Paynter 2007a); however, not all non-tapping iron smelting sites yield large furnace bottoms (e.g. Crew 1987; Dungworth 2011). The most distinctive slag from these iron smelting sites tends to be a form of flowed slag that displays signs of vertical flow (unlike tap slag, which shows signs of horizontal flow). Such iron smelting sites also produce some plano-convex cakes of slag but these are often porous and can resemble the plano-convex cakes of slag produced in a smith's hearth. The reasons why some non-tapping furnaces produced large furnace bottoms while others produced small cakes and flow slag are uncertain. It is possible that the differences in slag morphology relate to the size of the furnace employed; a small furnace would produce small volumes of slag while a large furnace would produce more slag, which could then form a large furnace bottom. Alternatively, the differences in the slag morphology might be due to differences in the ore used: a relatively poor ore would yield more slag while a very rich ore would produce much less slag.

While many bloomery sites have been identified in the Highlands of Scotland (e.g. MacAdam 1887; Aitken 1970; Photos-Jones et al 1998), few have been excavated and even fewer of these dated. MacAdam (1887, 90–1) identified three types of slag found at the sites he surveyed: 'cinder which is poorly fused'; 'dense and compact' slag; and 'fused and glassy' slag. The description of the first type of slag bears many similarities to the various types of slag from non-tapping furnaces, in particular slag cakes. MacAdam's second type of slag may be tap slag and the third type probably represents blast furnace slag. Aitken's excavations recovered examples of tap slag (Aitken 1970, pl. 18) as well as non-tapped slags. The latter included what are likely to be slag cakes: 'Close search discovered the hearth. Although it had been badly damaged it still retained a half sphere of slag within the bowl' (Aitken 1970, 194, see also pl. 18). In addition, much of the slag comprised 'small to fairly large rough cindery masses, sometimes containing small particles of charcoal' (Aitken 1970, 196). The slag collected by Photos-Jones et al from several excavations is described as tap slag; however, it is noted that most lumps were rather small – 'equivalent to a "trickle"' (1998, 23). It is possible that these 'trickles' are the flow slag noted above. Unfortunately, most of these sites remain undated, making the tracing of chronological variations in Scottish bloomery processes (and the slags produced) difficult. In his examination of the middle Iron Age slag from Howe, Orkney, McDonnell identified two types of iron smelting slag (McDonnell 1994). The first comprised randomly shaped lumps, often with a vesicular texture, charcoal impressions and a flowed surface which was described as 'raked' slag, while the second consisted of plano-convex cakes. The assemblage of slag from Culduthel lacks any tap slag but includes some slag cakes, some runned slag and a great many randomly shaped lumps of vesicular slag with abundant charcoal impressions, referred to throughout as unclassified iron slag. The types of slag and the total quantities recovered at Culduthel point to the smelting of iron using a non-tapping process that did not produce large furnace bottoms.

The chemistry of bloomery iron smelting is fairly well understood: only ores containing a fairly high proportion of iron could be smelted, and a great deal of the iron in the ore was effectively lost due to the formation of slag. Most impurities in the ore (such as silica) have such high melting temperatures that they could not be melted without the presence of another material that would lower their melting temperature. In the bloomery process the additional material that fluxes the impurities is iron oxide. Thus, an ore for use in a bloomery needs to provide enough iron oxide to form a slag before any bloom can be formed, explaining why only rich ores were suitable. While the nature of the ore plays an important role in slag formation, smaller contributions are made by the ceramic material used to construct or line the furnace and the ash from the charcoal fuel used to heat the furnace. The chemistry of early iron smelting slags shows regional characteristics that offer considerable potential for the provenancing of iron artefacts through the chemical analysis of the small inclusions of smelting slag that remain trapped in many artefacts (Paynter 2006). A thorough study of a range of smelting and smithing slag was undertaken by Gerry McDonnell, which aimed, in part, to identify criteria that would allow the identification of smelting and smithing slags (McDonnell 1986). McDonnell found that many smelting slags contained significant concentrations of manganese but that element was largely undetected (<0.3wt% MnO) in smithing slags. The presence of manganese in smelting slags reflects the fact that most iron ores contain manganese. Unfortunately, there are some ores that contain negligible amounts of manganese, and the slags associated with these ores also contain little or no manganese. Nevertheless, it is almost unknown for smithing slags to have significant manganese content. However, McDonnell (1994) applied the manganese criterion to slags from Howe, Orkney but found that all slags (including examples that had been identified on the basis of their morphology as smithing slags) contained significant levels of manganese (0.6–3.0wt% MnO).

The nature of the iron produced by the bloomery smelting process varied depending on the type of ore used as well as aspects of the smelting technology and the skill of the smelters. When smelted, ores rich in phosphorus will tend to produce iron, which contains a small but significant proportion of phosphorus. Iron-phosphorus alloys tend be stronger than pure iron and such alloys are common from the Iron Age until the early post-medieval period. Ores with little or no phosphorus could be smelted to produce pure iron or a steel, depending on the skill of the smelter and the demand for the two alloys. The smelting furnace would be operated under reducing conditions and, by manipulating the ratio of ore and charcoal (as well as the rate at which air was introduced into the furnace), the bloom could be made to absorb carbon from the charcoal to form steel. Most bloomery iron also contains a proportion of slag. While this can derive from several sources, one must be the remains of slag that formed during the smelting process and that could not be completely separated from the bloom. This phenomenon is the basis for the idea of provenancing iron through the chemical analysis of slag inclusions (Blakelock et al 2009; Hedges and Salter 1979).

Methodology

During iron production, a range of vitrified materials is produced, as outlined above. These include materials that are diagnostic of particular ironworking processes (e.g. smelting or smithing), those indicative of ironworking but not identifiable to a specific process, and those that could have been produced by a range of pyrotechnic processes and are not diagnostic of ironworking. Only a few categories of slag are traditionally considered to be truly diagnostic of ironworking (for example, tapped slag for smelting and hammerscale for smithing). Significant amounts of material within most slag assemblages are unclassifiable, making the classification of individual pieces, particularly fractured or small samples, to specific types and processes by visual examination alone difficult (Crew and Rehren 2002, 84). Certain classifications of iron slag have been more comprehensively studied and are better understood than others (e.g. plano-convex hearth bottoms and hammerscale), but it would be unwise to claim that all aspects of Iron Age ferrous metalworking technology are equally understood. It was apparent from the initial assessment stage that the slag assemblage from Culduthel had the potential to clarify (and perhaps redefine) some aspects of slag identification and enable a better understanding of aspects of early ironworking. This was due not only to the large quantities of material recovered, but also to the complete range of debris (from smelt to final product) available for study. Apart from one missing component, the ore, the assemblage included samples of all forms of vitrified waste material that one would expect from a later prehistoric ironworking site, from fragments of the furnace superstructure through to part-worked pieces of iron bloom.

Classification of the Culduthel material was based on two stages of examination. The first involved macroscopic visual examination of the slag by Dawn McLaren, categorising the material based on density, colour, morphology, vesicularity and magnetic properties. This examination formed the basis for initial classification of the material and the construction of a detailed archive catalogue to record the details of the assemblage in full. A representative sample of the assemblage was then selected for chemical analysis by David Dungworth to allow the composition of the slags to be identified and compared to the metallurgy of the iron objects from the site. The aim of this analysis was, in part, to test the accuracy of visual categorisation and also to determine whether differences in the composition of the slags could be identified across the site that could indicate use of different ores, technologies, techniques and chronological change. Samples of all the major diagnostic and undiagnostic categories were selected, including waste from both smelting and smithing. In addition, some more unusual pieces were included that were difficult to identify by visual analysis alone. These include possible smithing pan (an accumulation of smithing micro-debris built up on a floor surface within an area of bloom- or blacksmithing), bloom and a possible fragment of tapped slag. The samples selected were chosen from the main areas of the site where slag was present (around cobbled surface 227; the main industrial zone to the east and south-east of House 10/1–3) focusing, where possible, on probable in situ furnace or hearth features. A detailed description of the sampling strategy, preparation and methods of examination and analysis, as well as a full list of results, are included in the archive.

Classifications

A total of 337.5 kg of vitrified material was recovered throughout the excavated area. This quantity includes both bulk slags recovered by hand and residues from soil samples. It should be noted that, due to the exceptional volume of vitrified material encountered in some areas (e.g. context 798), only a bulk sample was collected in the field and retained for study. The total excludes the large quantities of vitrified material (vitrified ceramic furnace lining and unclassified iron slag) that remain fused to the heat-affected stones used to construct the furnaces. The total mass of vitrified material referred to in this report necessarily reflects a minimum quantity only.

The slag has been described throughout using common terminology (e.g. McDonnell 1994; Starley 2000; Bayley et al 2001) and these are outlined below. The majority of pieces were small and fragmentary. However, where discernible they appear to fall into two types: significant quantities of bulk- and micro-slags suggestive of ironworking (both smelting and smithing); and those created during a range of pyrotechnic processes, and not necessarily the result of metalworking (Table 6.13). A full

Table 6.13
Range of diagnostic and undiagnostic debris present at Culduthel

Process	Material type	Mass/g
Smelting	Plano-convex cake: furnace bottom (PCC:FB)	28,011
	Tapped slag (TS)	2,858
	Unprocessed bloom	7,250
Suggestive of smelting	Runned slag (RS)	71,095
	Charcoal-rich slag (CR)	14,971
Smithing	Plano-convex cake: hearth bottom (PCC: PCHB)	17,829
	Hammerscale flakes (HS)	1,954
	Slag spheres (SS)	59
	Smithing pan	459
	Processed bloom	2,219
Undiagnostic of particular process	Plano-convex cake: unclassified	23,346
	Unclassified iron slag (UIS)	81,144
	Slag amalgam (SA)	20,073
	Atypical hammerscale flakes (HS(a))	2,169
	Atypical slag spheres (SS(a))	50
Undiagnostic	Vitrified ceramic (VC)	56,730
	Fuel ash slag (FAS)	989
	Heat-affected stone	1,289
	Magnetic vitrified residue (MVR)	4,779
	Non-magnetic vitrified residue (NMVR)	216

catalogue of the material is given in the archive report (archived as CDF05 at the NRHE).

Smelting

Furnace bottoms

These are large accumulations of slag that form at the base of a non-tapping iron smelting furnace. Like smithing hearth bottoms, these furnace bases are generally plano-convex in shape, having accumulated at the base of a rounded pit within the furnace, and are more generally referred to as plano-convex cakes (PCC). Furnace bottoms (FB) are typically dense accumulations of grey non-magnetic slag with large charcoal inclusions and/or impressions, and can be molten or runned in appearance. Unless the furnace bottom is complete and/or preserves enough of the structure of the cake to identify conclusively, it is difficult to differentiate a fragmentary furnace bottom from smaller fragments of smelting slag. Some of the fragments of furnace bottoms from Culduthel are substantial in size (up to 200mm across, the largest typically 1.5–2.0kg in weight, with one outlier of 5kg); these have large charcoal inclusions and are undoubtedly the result of smelting. Others are much smaller and, as such, can be easily mistaken for smithing hearth bottoms, although as noted above, chemical analysis has some success in differentiating smelting from smithing slags based on high levels of manganese in the former.

Tapped slags

These are formed when the slag is deliberately released from the base of the furnace by a small, pre-formed aperture. When the plug is removed, the slag pours out, sometimes into a deliberately made channel or pit, forming a substantial linear run of dense grey slag or a compact, dense plano-convex cake. Only one possible fragment of tapped slag (TS) was identified from the site (Cat no: C237, SF015; lab no: 1148, context 182). This is a linear asymmetric horizontal run of molten-looking slag, 343mm in length and 160mm in maximum width, weighing 2.8kg. The dimensions and shape of the piece make it unlikely to have formed inside a smelting furnace but its form appears unconstrained or uncontrolled. It is not possible to confirm whether this slag was deliberately 'tapped' from the furnace; it may have been produced accidentally during the opening of the furnace to remove the bloom or due to a rupture of the furnace wall during use.

Unprocessed bloom

This is spongy, highly magnetic red-brown lightly vitrified material. Early furnaces were not routinely able to reach the temperatures required to allow iron to become molten (*c.*1200 degrees). The iron particles that were extracted from the ore formed in a spongy, lightly vitrified mass known as the bloom, typically around the tuyère or bellows hole, which was the hottest part of the furnace. Visually these may look like spongy amorphous masses of lightly vitrified red-brown slag or like a corroded mass of iron, but they can be distinguished from unclassified slag or plano-convex cakes fragments by their high magnetic response.

Smithing

Plano-convex hearth bottoms

These are plano-convex accumulations of hammerscale flakes and slag spheres that form at the base of the smithing hearth. Traditionally, these tend to be smaller in diameter, denser and far more magnetic than cakes formed during smelting (see furnace bottoms above) and have much lower levels of manganese. Charcoal inclusions are less frequent in such slags and where present, they tend to be much smaller in size. Charcoal impressions, particularly on the rounded base of the cakes, are typical. An interesting and significant aspect to the smithing hearth bottom fragments from Culduthel was revealed by detailed chemical analysis. Several of the plano-convex hearth bottoms (PCHB) fragments selected for analysis had unusually high manganese levels, which would suggest that they were the product of smelting rather than smithing. Two scenarios are suggested here: either these small, thin, dense cake pieces are edge fragments from furnace bottoms rather than smithing hearth bottoms; or these are indeed hearth bottoms from smithing but were formed during primary bloom smithing rather than from forging or welding.

Hammerscale

These are small flakes of iron produced by the impact of hammers on hot iron during either the refining of iron blooms or the working of wrought iron. When found in quantities this is indicative of in situ iron smithing. Hammerscale flakes (HS) and spheres (discussed below under 'slag spheres') are traditionally thought of as one of the few diagnostic categories of waste from ironworking, and smithing in particular. At Culduthel, two distinct types of hammerscale were identified: traditional hammerscale (small flakes of iron-rich vitrified material, highly magnetic, varying in size but typically between 2–5mm in length) and atypical hammerscale (large flakes between 5mm and 15mm in length, atypical in size and morphology). This atypical hammerscale was frequently found in association with smelting furnaces and deposits of smelting waste. Chemical analysis of this material confirms high manganese levels consistent with smelting slag, suggesting that this residue either formed in the smelting furnace, or was the product of primary bloom smithing. Much of this material appears to be thin films of slag that have formed between lumps of charcoal in the smelting furnace, rather than being associated with smithing. The compositional characteristics of the traditional hammerscale are similar to other analysed hammerscale (Dungworth and Wilkes 2009).

Slag spheres

These are small spheres ejected as spherical globules of molten slag during iron smithing. When found in quantities this is indicative of in situ metalworking. As with the hammerscale flakes, the slag spheres (SS) from Culduthel were found in two distinct forms: traditional hammerscale spheres (small, magnetic spheres, ranging from 1.5–2.5mm in diameter) that are the residue from iron smithing, and atypical slag spheres, distinguished by their larger size and misshapen form, which are generally unmagnetic or have only very low magnetic qualities. These are often found in association with smelting furnaces and deposits of smelting waste at Culduthel. Chemical analysis of a sample of these atypical residues revealed that the spheres contain elevated concentrations of a range of elements. There are several possible sources of these minor elements, including slag inclusions, furnace lining, flux and fuel ash. The increase in the minor elements in the spherical hammerscale shows closest similarities with the smelting slag.

Smithing pan

Smithing pan (SP) is where hammerscale, slag spheres and other debris (such as charcoal, soil and slag fragments) accumulate on the ground around the smithing hearth and anvil, and can become trampled into a hard layer and fused together with corrosion over time (Bayley et al 2001, 14; Paynter 2007b, 17).

Processed bloom

The iron bloom extracted from the prehistoric furnace cannot be immediately smithed into an object as there are likely to be significant slag and charcoal inclusions retained within it. As the impurities become molten at a much lower temperature than the iron, the bloom requires further heating to try and run off as many of these impurities as possible, and smithing to remove any slag trapped within the interior. The lower the impurities, the better the iron, yet a danger lies in over-working, as repeated heating and hammering can make the iron brittle. Dense lumps of bloom, often indistinguishable from corroded iron without an X-ray, suggest such initial processing, as iron of this density is unlikely to have been produced in the furnace. Many of the bloom fragments from Culduthel have been processed and some bloom offcuts are also present. The bloom fragments analysed were all carbon steels. Where slag inclusions were present they generally had compositions that provided a moderate to good match with the Culduthel smelting slag. The presence of bloom fragments of hyper-eutectoid steel confirms that the smelting process produced carbon steel in a single process (as opposed to the production of plain iron, which would subsequently be carburised). Such direct steel is often referred to as natural steel.

Undiagnostic of particular process

'Runned' slags

These are runs of dense grey slag, typically non-magnetic, liquid or flowed in appearance. Runned slag (RS) can be formed in the lower portion of the furnace where the heat is more intense, allowing the gangue to solidify and flow between and around the charcoal used as fuel. Such runs of slag can take the form of short 'drips' or larger accumulations of molten-looking grey slag. Such 'runned' slags, where found in quantity and comprising sizeable pieces, are typically seen as the debris from smelting, but this is dependent on several factors: the quantity and size of the pieces present; the presence of high or moderate levels of manganese; and its association with other residues indicative of smelting. This ambiguity is caused by the fact that small runs of slag (often referred to as prills) can also be formed in a smithing hearth. The recovery of a limited quantity of small pieces of liquid-looking slag cannot be interpreted as the residues from smelting, unless associated with other evidence diagnostic of the same process.

Charcoal-rich slags

Charcoal-rich, often non-magnetic, red-brown slags cannot be exclusively identified as smelting residues, but their association at Culduthel with significant quantities of 'runned' pieces implies that the majority of the charcoal-rich slags (CS) from the site were produced during iron smelting. These amorphous, often angular fragments, appear to have formed near the top of the furnace, where the heat was less intense. Here the gangue was starting to separate from the ore and had become amalgamated with the dense charcoal.

Unclassified iron slag

Unclassified iron slag (UIS) are randomly shaped pieces of iron silicate slag, probably rake-out material, generated either by smelting or smithing.

Slag amalgams

Slag amalgams (SA) are randomly shaped pieces of slag, including plano-convex slag cakes and hearth lining, which have fused together to form larger masses (McLaren and Heald 2008, 203).

Undiagnostic

Vitrified ceramic (hearth or furnace lining)

Vitrified ceramic (VC) is the clay lining of an industrial hearth, furnace or kiln that has a vitrified or slag-attacked face. The surviving lining is typically heavily burnt and vitrified, often with adhering slag. Often the material shows a compositional gradient from unmodified fired clay on one surface to an irregular cindery material on the other (Starley 2000, 339). Recovery of vitrified ceramic is not indicative of ironworking, but could have been produced within any clay-built high temperature hearth. In addition to the vitrified ceramic discussed here, further quantities of furnace/hearth lining, including possible rim fragments from furnace shafts, have been identified among the fired clay. Also present and discussed separately are several tuyère fragments. A small quantity of the vitrified ceramic from the furnaces appears to be double-walled, suggesting that the furnace was either repaired or relined at some stage, as there are two superimposed layers of vitrified ceramic with slag-attacked faces.

Fuel ash slag

Fuel ash slag (FAS) is formed when material such as sand, earth, clay, stones or ceramics are subjected to high temperatures, for example in a hearth. During heating these materials react, melt or fuse with alkali in ash, producing glassy (vitreous) and porous materials. These slags can be formed during any high temperature pyrotechnic process and are not necessarily indicative of deliberate industrial activity (McDonnell 1994, 230).

Magnetic vitrified residues and non-magnetic vitrified residues

These are mixtures of various types of material, fused together through heat. Two different types were recovered: those that comprised mainly sand, clay, stone and other material and were magnetic (MVR); and those that shared similar constituents but were non-magnetic (NMVR). Although it is impossible to relate these small pieces to any specific process, it is likely that much of the magnetic material was related to ferrous metalworking.

Fuel
Like most other metalworking sites, wood charcoal was used as fuel (McDonnell 1998b, 151). At Howe, Orkney, the predominant fuel used for metalworking was willow charcoal (Ballin Smith 1994, 133). At Wiltrow, Shetland, Curle suggested that peat had been used for smelting (Curle 1936, 153, 155) but as McDonnell points out, there is some question over whether the debris that Curle was referring to was actually residue from smithing instead (1998b, 151).

Micromorphology

Sampling
A total of 45 samples of slag and possible bloom were analysed. Of these, three slag samples and two possible bloom samples were too corroded to allow full investigation. The remaining 40 samples comprised two bloom fragments and 38 slag samples (one of which was tentatively identified as bloom prior to scientific examination but which is actually a slag). Thirty-six samples from bulk slags were successfully analysed. Full detailed results of this analysis are presented in the archive. Twelve samples were also taken from stones or ceramic material used to construct or line furnaces or hearths. A total of 89 fragments of hammerscale were analysed (19 sphere and 70 flake). In two cases multiple hammerscale analyses were carried out on a single sample. In the first case the sample comprised a fragment of smithing pan (a concreted mass of hammerscale and other material that formed on the floor of a smithy). In the second case the hammerscale was found trapped in the corroded surface of a slag sample. The exact formation process for this slag sample is not immediately apparent. Further samples of hammerscale were submitted for analysis but were either too corroded to allow investigation or turned out to be films of smelting slag (referred to henceforth as atypical hammerscale). In addition, 16 ferrous artefacts were selected for scientific examination, including finished artefacts as well as offcuts of iron/steel. Unfortunately, several of these artefacts proved to be too severely corroded and no original metal survived. Thirteen artefacts and five bloom samples proved fit for analysis.

Bulk slags
Most of the bulk slag samples (i.e. all samples except the hammerscale and furnace fragments) show many similarities with other bloomery iron smelting slags (Morton and Wingrove 1969; McDonnell 1986). They all contain varying proportions of the olivine iron silicate fayalite (Fe_2SiO_4). The form of the fayalite varies from large (up to 1mm in diameter) equiaxed crystals, through long, thin plates to tiny (~1 micron in diameter) crystals within the glassy matrix (Illus. 6.19 and 6.20). The chemical composition of the fayalite varied due to the substitution of a proportion of the iron by other elements (magnesium, calcium and manganese).

Most samples contain at least some wüstite (FeO); and in a few samples this is the most abundant phase. The wüstite occasionally has a morphology that suggests it is magnetite (Fe_3O_4). In addition, the iron oxide (wüstite or magnetite) in these samples often shows more than negligible proportions of elements such as aluminium, titanium and manganese.

The mineral hercynite ($FeAl_2O_4$) was present in many samples (Illus. 6.21). The hercynite was present as euhedral crystals up to 100

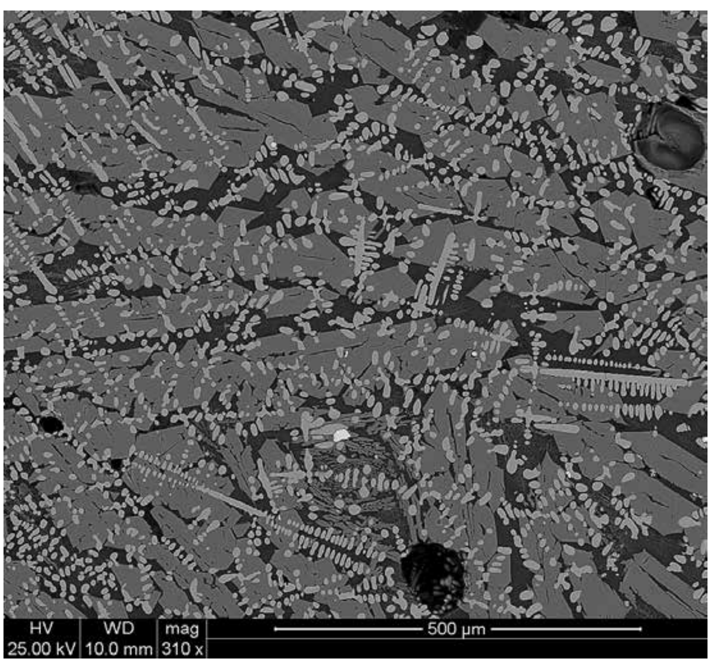


Illustration 6.19
SEM image (back-scattered electron detector) of sample 1139 (slag cake from context 411). The bright globular dendrites are the iron oxide wüstite, the light grey laths are the iron silicate fayalite

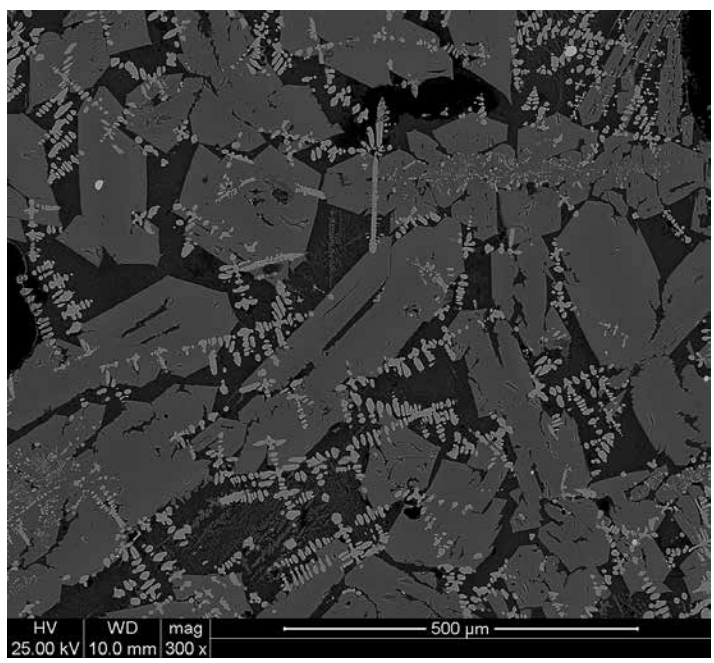


Illustration 6.20
SEM image (back-scattered electron detector) of sample 1148 (large fragment of flowed slag from context 185). The bright globular dendrites are the iron oxide wüstite, the light grey laths are the iron silicate fayalite

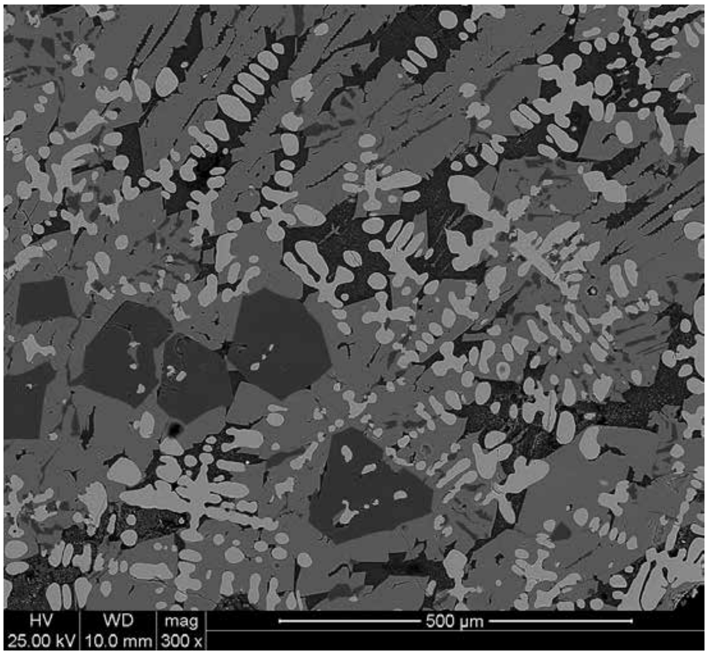


Illustration 6.21
SEM image (back-scattered electron detector) of sample 1157 (slag cake from context 4145) showing wüstite and fayalite as well as several large hercynite ($FeAl_2O_4$) crystals (mid-grey, centre and left)

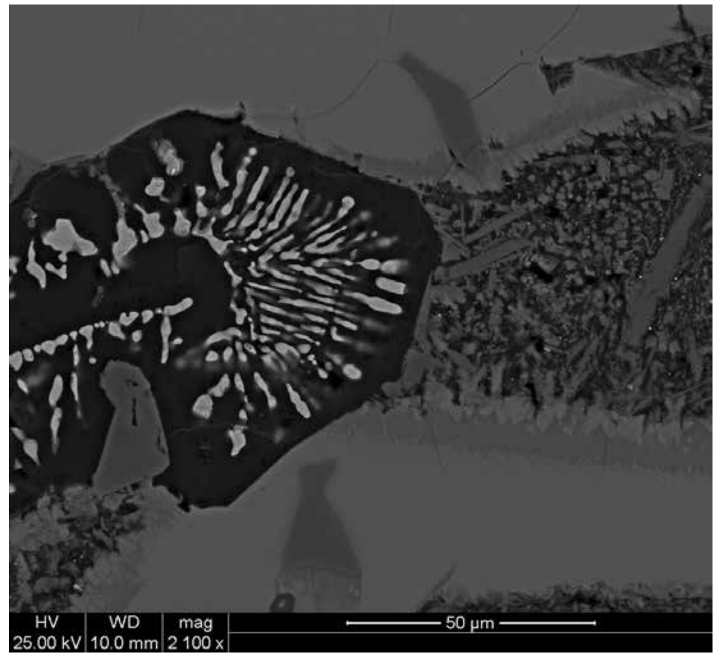


Illustration 6.22
SEM image (back-scattered electron detector) of Sample 1130 (unclassified slag with charcoal impressions and some signs of flow from context 4260) showing a crystal of leucite and leucite-wüstite (centre left)

microns across but could also be seen as much smaller crystals at the margins of fayalite crystals. The hercynite crystals often contained small proportions of magnesium, titanium, vanadium and manganese. In all of these cases the additional elements appear to have substituted a proportion of the iron oxide in the hercynite. Despite there being a solid solution between magnetite, Fe_3O_4, and hercynite, $FeAl_2O_4$, none of the hercynite contained an excess of iron that might suggest the presence of Fe_2O_3 substituting the Al_2O_3.

Leucite ($AlKSi_2O_6$) was present in about a quarter of all samples but tended to be most abundant in the slag cakes. The leucite often contained small amounts of sodium, iron and barium: the former would substitute for the potassium in the leucite but the role of the other two elements is uncertain. A negative correlation between the barium and silicon content, however, suggests that the barium may have substituted for silicon in leucite. Much of the leucite was present as a leucite-wüstite eutectic (Illus. 6.22). Leucite is only usually observed in slags that are rich in aluminium and potassium (Dungworth 2007). Even in slags with moderate aluminium and potassium content, the formation of leucite is often suppressed due to the rapid solidification of the slag. Leucite is largely absent from rapidly cooled slags (such as tap slags), which instead often contain a substantial proportion of a glassy matrix.

Sample 1152/8 (dense slag from a smelting furnace; context 4145) contained additional mineral phases including a calcium-iron pyroxene and several unidentified alkali-aluminium-silicates. The latter included both sodium-rich and a potassium-rich aluminium-silicate but their compositions could not be matched with common alkali-aluminium-silicates.

A small number of unusual microstructures were noted. Several samples contained a very high proportion of iron oxide, such that other phases were almost completely absent (Illus. 6.23). The iron oxides showed varying degrees of substitution by magnesium, aluminium, titanium and manganese. These samples were recovered from several different features and included slags with varying overall morphology.

The areas in between the main crystalline phases in most bloomery smelting slag are glassy, although this glass may contain some small crystals. In many of the Culduthel slag samples, however, what initially appeared to be a glassy matrix was actually composed of an intimate mixture of several different crystalline phases (Illus. 6.24). The small size of these crystals precluded their direct chemical analysis but it is likely that most of them were wüstite, fayalite, hercynite and leucite. The presence of crystalline phases in place of the usual glassy matrix suggests that these slags cooled extremely slowly. Alternatively, the slags may have cooled under typical conditions, leading to the formation of a glassy matrix, but then have been subject to sufficient heat for this to devitrify (crystallise). Whatever the exact mechanism responsible for the absence of the glassy matrix, it is likely that these samples remained inside the furnace for a long period.

Even those samples that contained a glassy matrix often displayed unusual texture (Illus. 6.25). Such micron- and submicron-sized droplets are characteristic of microphase-separated glass (e.g. Vogel 2006). Many complex silicates when melted will form two immiscible liquids, and prolonged heating of solid silica-based glass below its melting temperature will encourage the separation of these two phases. Both phases remain as glasses and the separated phase usually forms spherical droplets rather than distinct crystals. Microphase separation is deliberately employed in the modern glass industry but is rarely seen in archaeological materials. Some waste materials from post-medieval glass

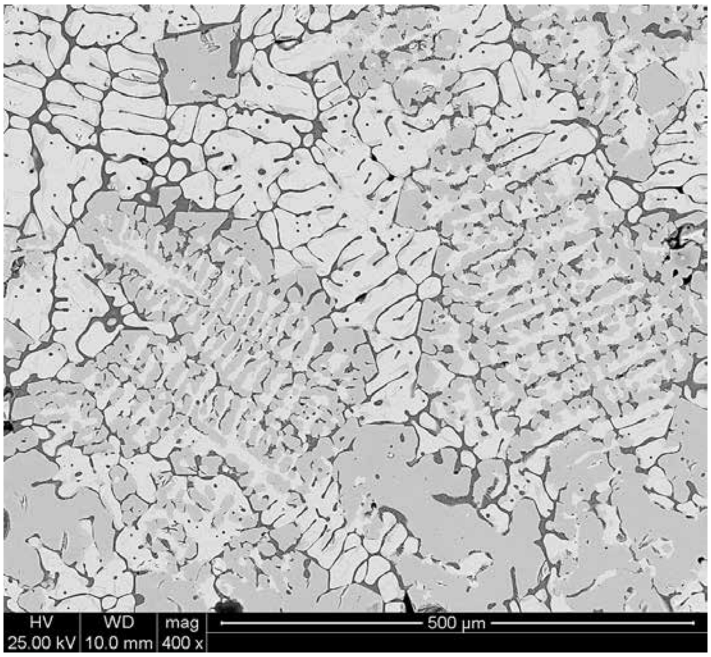


Illustration 6.23
SEM image (back-scattered electron detector) of Sample 1153 (small lump of dense slag from context 3756) showing a microstructure dominated by iron oxides. There are clearly two different types of iron oxide present: the darker phase contains a small proportion of aluminium

production sites display microphase separation and this has been interpreted as the result of prolonged exposure to high temperatures (e.g. glass waste that has fallen into a furnace; see Dungworth and Paynter 2011). Microphase separation is also evident in the vitreous surface of many of the samples of furnace lining from Culduthel (see below).

The Culduthel slags have microstructures that can in most respects be paralleled with previously published investigations of bloomery smelting slags. The range of phases present in most of the Culduthel slags and their size, shape and distribution all point to the rather slow cooling of the slag. This is likely to have taken place within the furnace, a point that is echoed by the overall morphology of the slag (i.e. the absence of tap slag which cooled rapidly when it was removed from the furnace). There were no correlations between overall slag morphology and microstructure.

Furnace/hearth lining

The vitrified ceramic examined consisted of silica-rich clay or rock with vitrified interior surfaces (Illus. 6.26). Clay seems to have been used sparingly to help bond together the stones used to build the furnace walls. Some slightly larger fragments of clay may have been used to build up a superstructure above the stone wall or for specific areas such as the tuyère hole (for discussion of superstructures, see Paget and McLaren Chapter 6, Fired Clay Both the rock and clay samples were strongly affected by exposure to high temperatures that had led to the melting of most of the clay minerals. Most samples contained angular grains of silica (from <100 microns across to several millimetres across), often with severe cracking due to heat, in a vitreous matrix. The silica-rich rock used is likely to have been Old Red Sandstone.

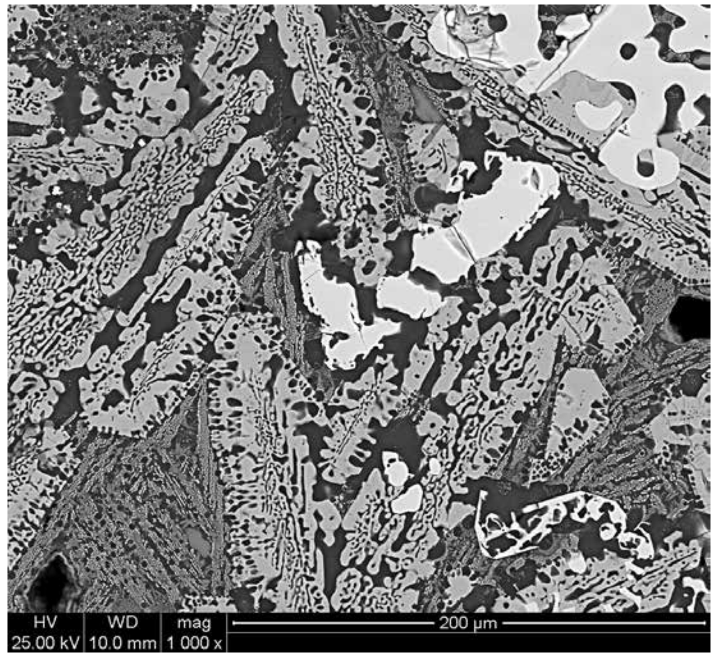


Illustration 6.24
SEM image (back-scattered electron detector) of Sample 1152 (plano-convex slag cake from context 4145) showing the complete crystallisation/devitrification of the glassy matrix

Many of the vitrified surfaces of the clay and stone furnace wall material contained small crystals and/or microphase-separated glass (Illus. 6.27).

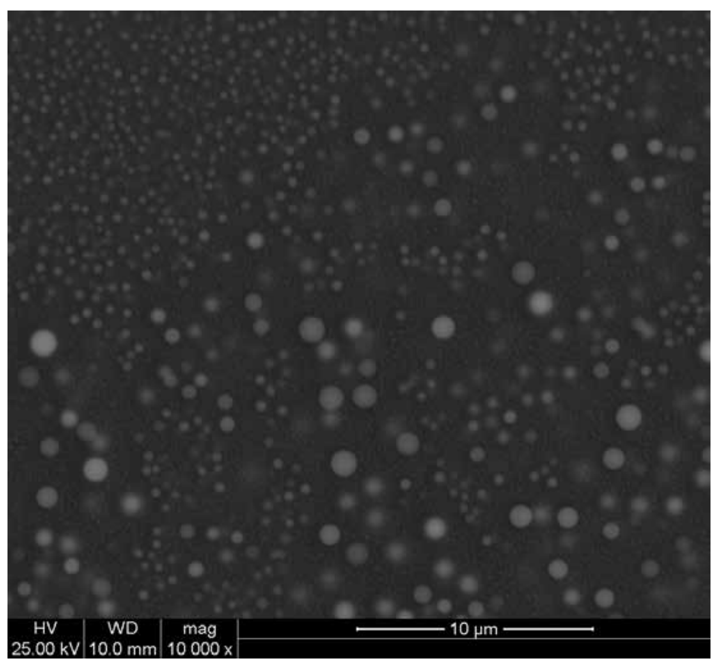


Illustration 6.25
SEM image (back-scattered electron detector) of the microphase separation in the glassy matrix of Sample 1152 (plano-convex slag cake from context 4145)

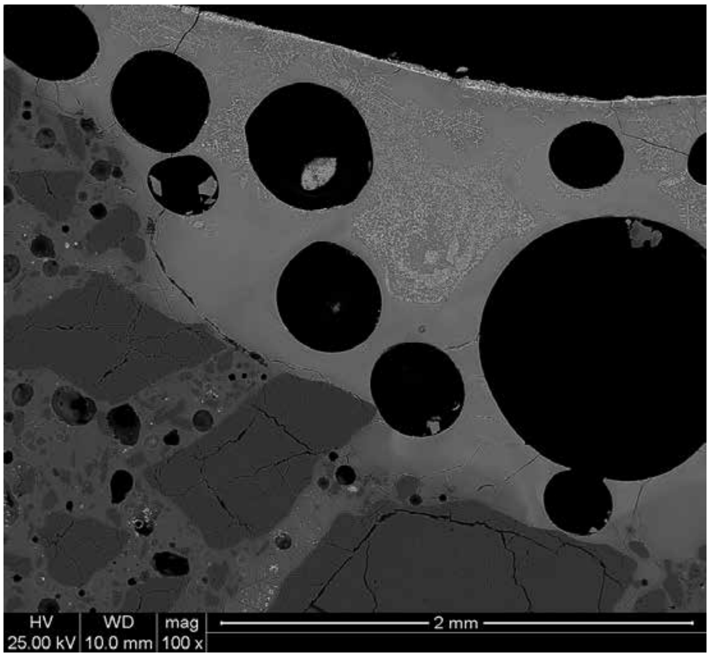


Illustration 6.26
SEM image (back-scattered electron detector) of Sample 1123 (clay furnace wall material from context 4175) showing the vitrified outer surface at the top (containing large areas of porosity (black)) and the underlying ceramic material (containing large angular grains of quartz (dark grey))

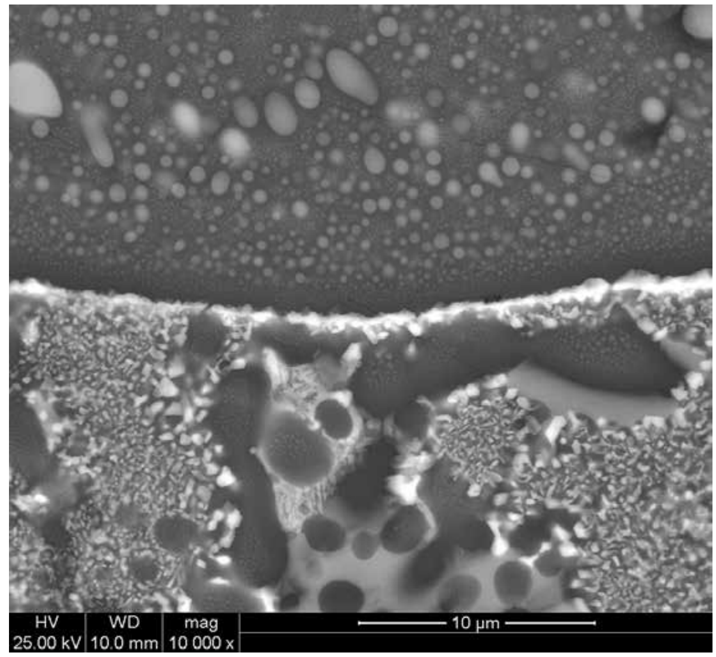


Illustration 6.27
SEM image (back-scattered electron detector) of Sample 1123 (clay furnace wall material from context 4175) showing the microphase separation in the vitrified outer surface

Hammerscale flakes and spheres

The hammerscale samples mainly comprised flake and spheres recovered from soil samples but included a fragment of smithing pan (i.e. a concreted mass of hammerscale from a workshop floor surface). Most of the flakes (Illus. 6.28) and spheres (Illus. 6.29) exhibited classic microstructures comparable with similar material from other sites (cf. Dungworth and Wilkes 2009). The flake hammerscale is composed almost entirely of iron oxides and these often occur in layers (wüstite on the surface closest to the metal on which the flake originally formed with varying proportions of

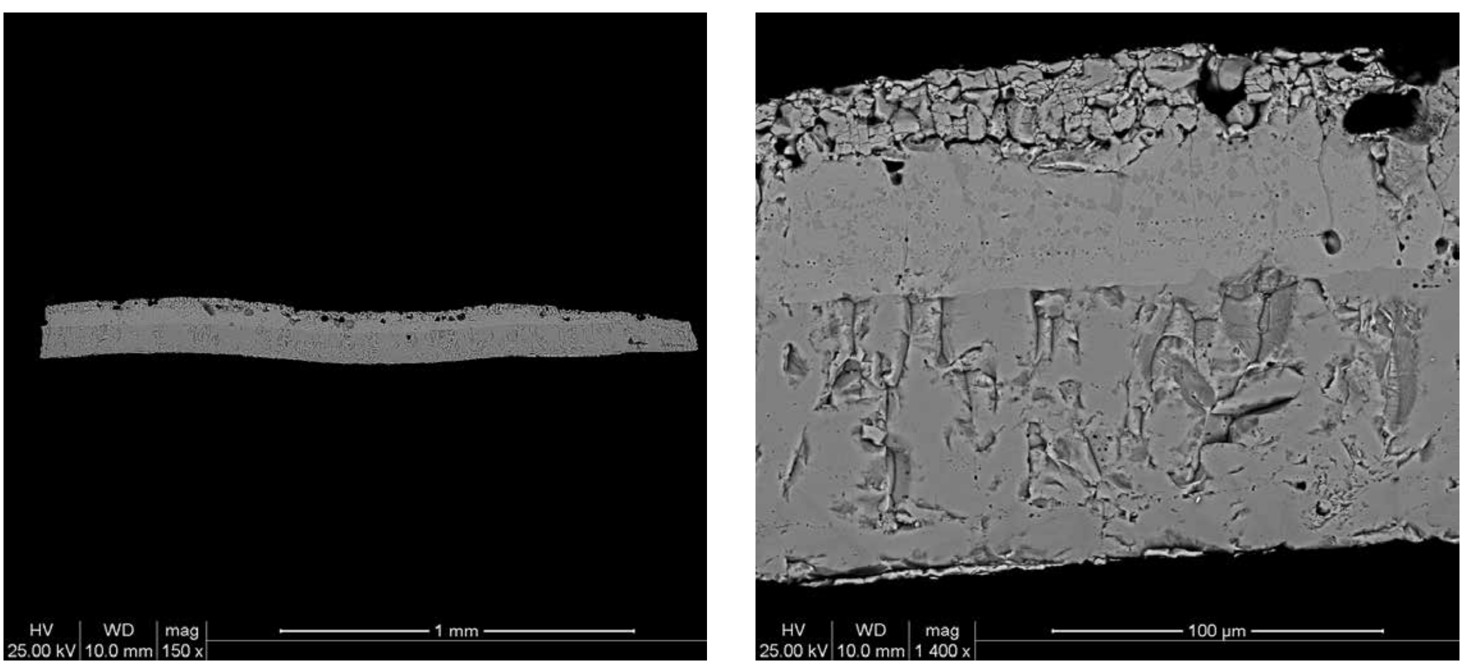


Illustration 6.28 (a and b)
SEM images (back-scattered electron detector) of Sample 1065 (flake hammerscale from context 3022) showing the layers of wüstite/magnetite

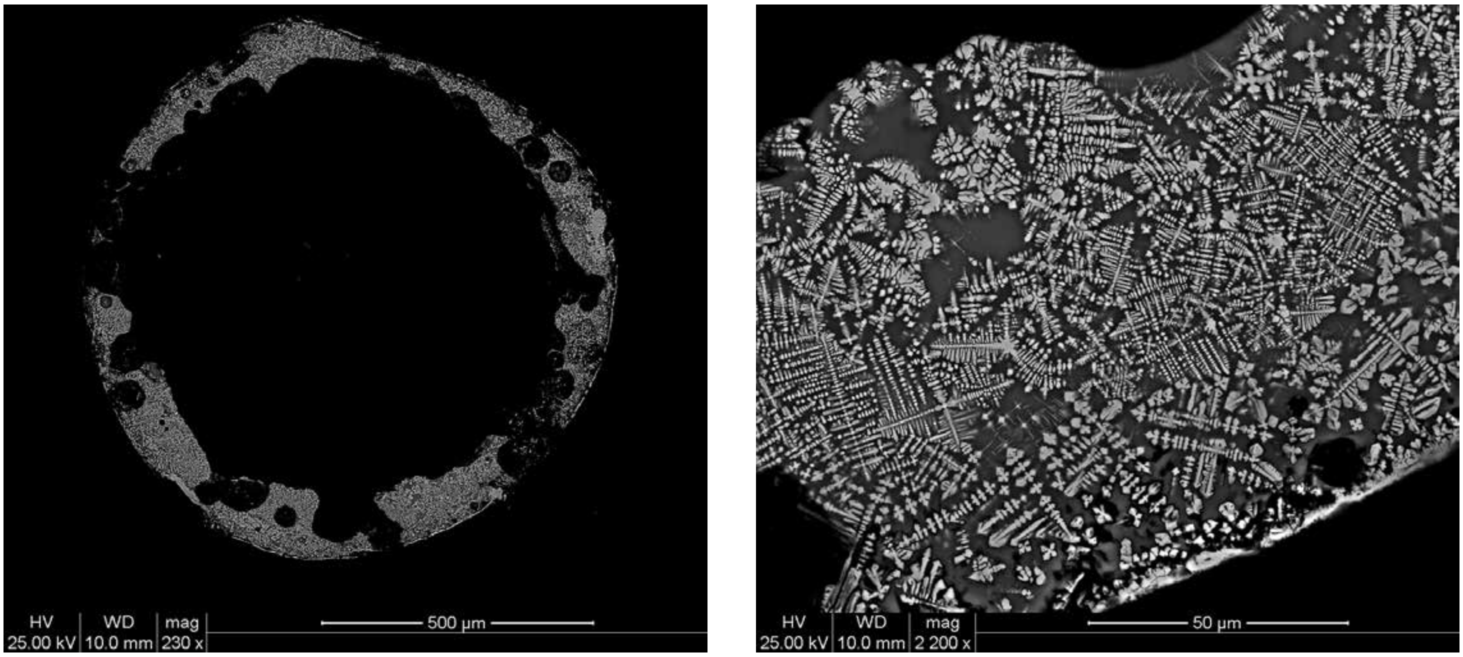


Illustration 6.29 (a and b)
SEM images (back-scattered electron detector) of Sample 1052 (spherical hammerscale from context 3022) showing the typical hollow spherical structure and dendritic microstructure

magnetite in outer layers). The spherical hammerscale samples included examples with widely varying degrees of porosity and are composed of very fine iron oxide dendrites (wüstite-magnetite) in a glassy matrix. A small number of samples initially identified as flake or sphere were recategorised as miscellaneous after SEM examination. The manganese content of many of the spheres (and some flakes) suggests that a proportion of the hammerscale was produced during iron smelting and/or bloom refining (as discussed above).

The smithing pan comprises abundant hammerscale flakes and occasional hammerscale spheres along with silica-rich rock (Illus. 6.30).

A series of samples from context 3204 (the basal fill of Furnace 3050 located within Workshop 13) submitted for analysis

Illustration 6.30
SEM image (back-scattered electron detector) of Sample 1126 (smithing pan context 412) showing the flake hammerscale and rock fragments

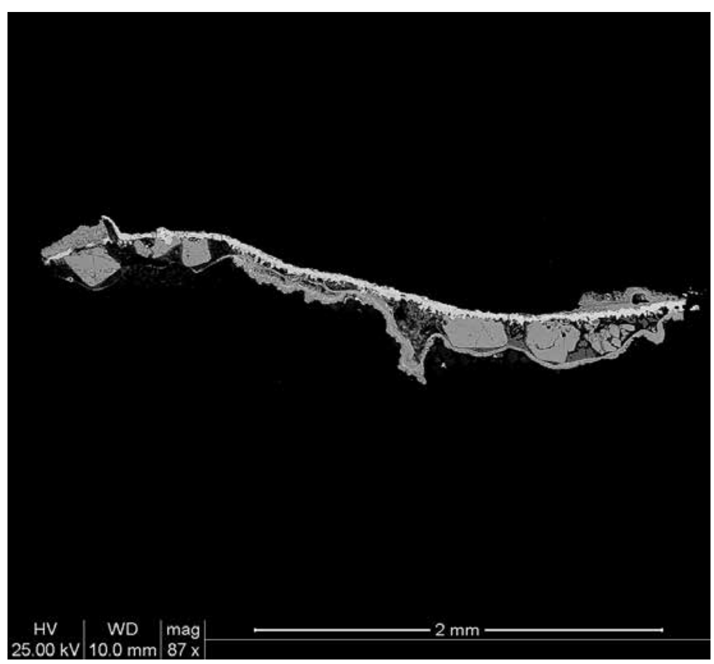


Illustration 6.31
SEM image (back-scattered electron detector) of Sample 1103 (magnetic flake from context 3050) showing the grains of fayalite (grey) and film of hydrated iron oxides (corrosion)

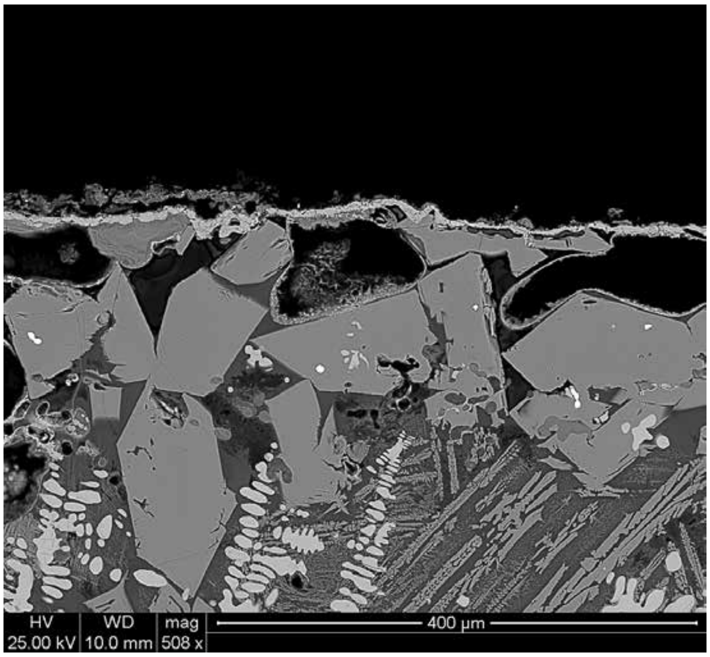


Illustration 6.32
SEM image (back-scattered electron detector) of Sample 1149 (unclassified slag lump from context 185) showing the grains of fayalite (grey) and film of hydrated iron oxides (corrosion) at the surface

consisted of small magnetic flakes that were initially identified as possible flake hammerscale. The microstructure of these samples, however, differed completely from all of the other hammerscale (Illus. 6.31). They comprise a series of fayalite grains cemented together by a film of hydrated iron oxides. This microstructure is almost identical to some of the outer surfaces of the bulk slags (Illus. 6.32). It is concluded that these magnetic flakes are not hammerscale but fragments of the outer surface of bulk slags which have become detached.

Chemical composition

Bulk slags

The bulk slags have chemical compositions that are broadly comparable with most bloomery slags from Europe: they are rich in iron and silicon (Illus. 6.33) with a range of other minor elements (aluminium, potassium, calcium, manganese, phosphorus, magnesium, sodium, barium and titanium) (Illus. 6.34 and 6.35). The vast majority of the bulk slags contain significant proportions of manganese (Illus. 6.35) and as such are likely to have been produced as a result of iron smelting rather than iron smithing. The considerable variation in the chemical composition of the smelting slag samples is typical of smelting slags produced in non-tapping furnaces. There were no correlations between overall slag morphology and chemical composition.

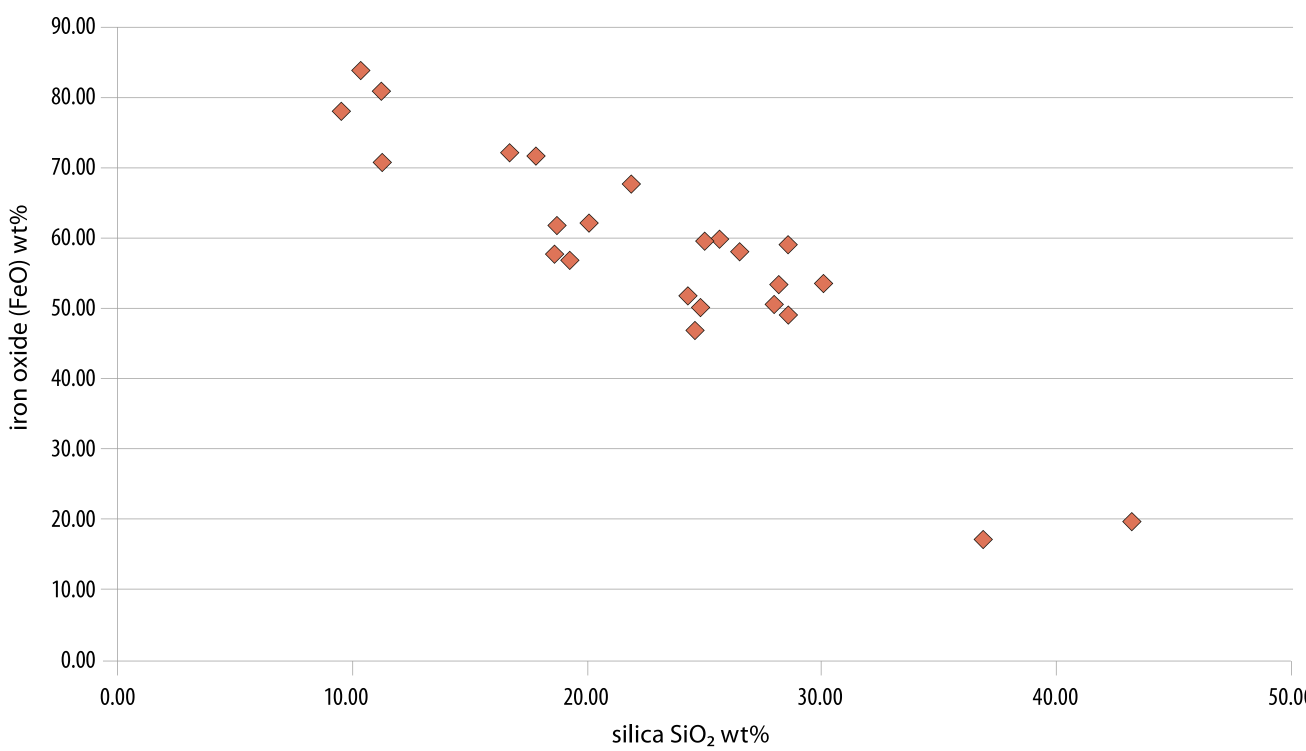


Illustration 6.33
Silica and iron oxide content of all bulk slags

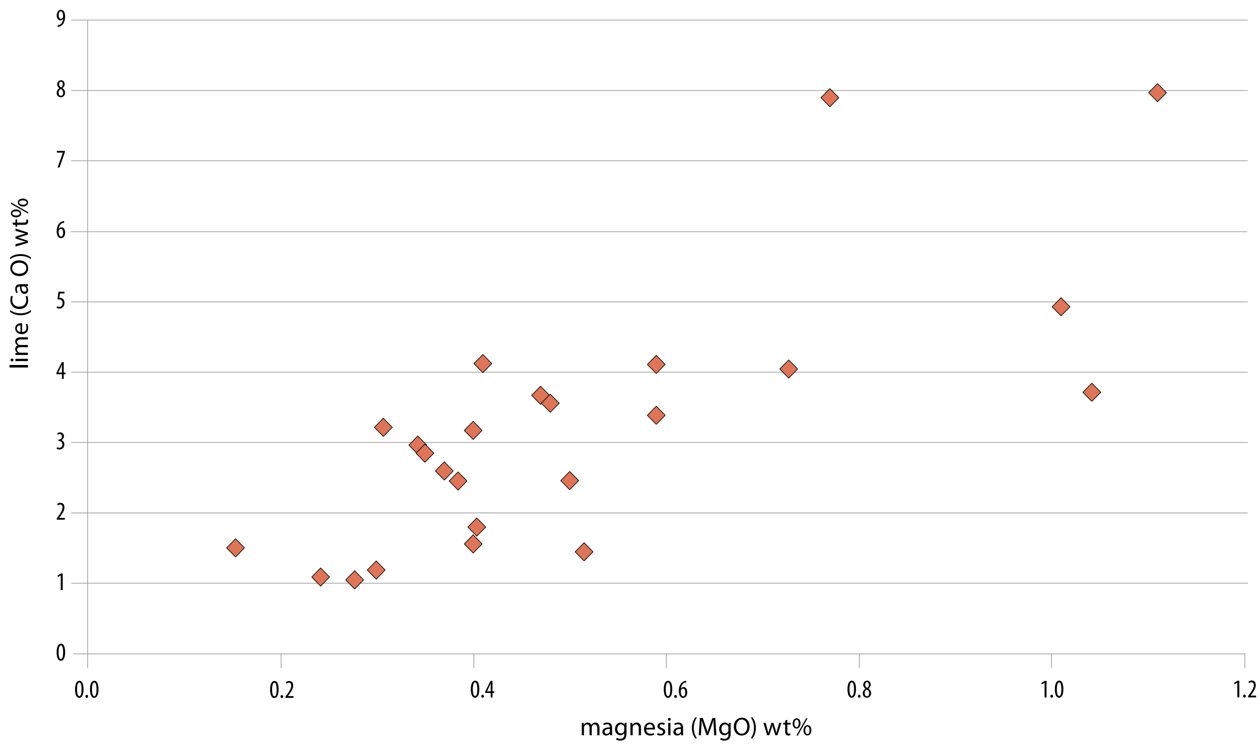


Illustration 6.34
Magnesia and lime content of all bulk slags

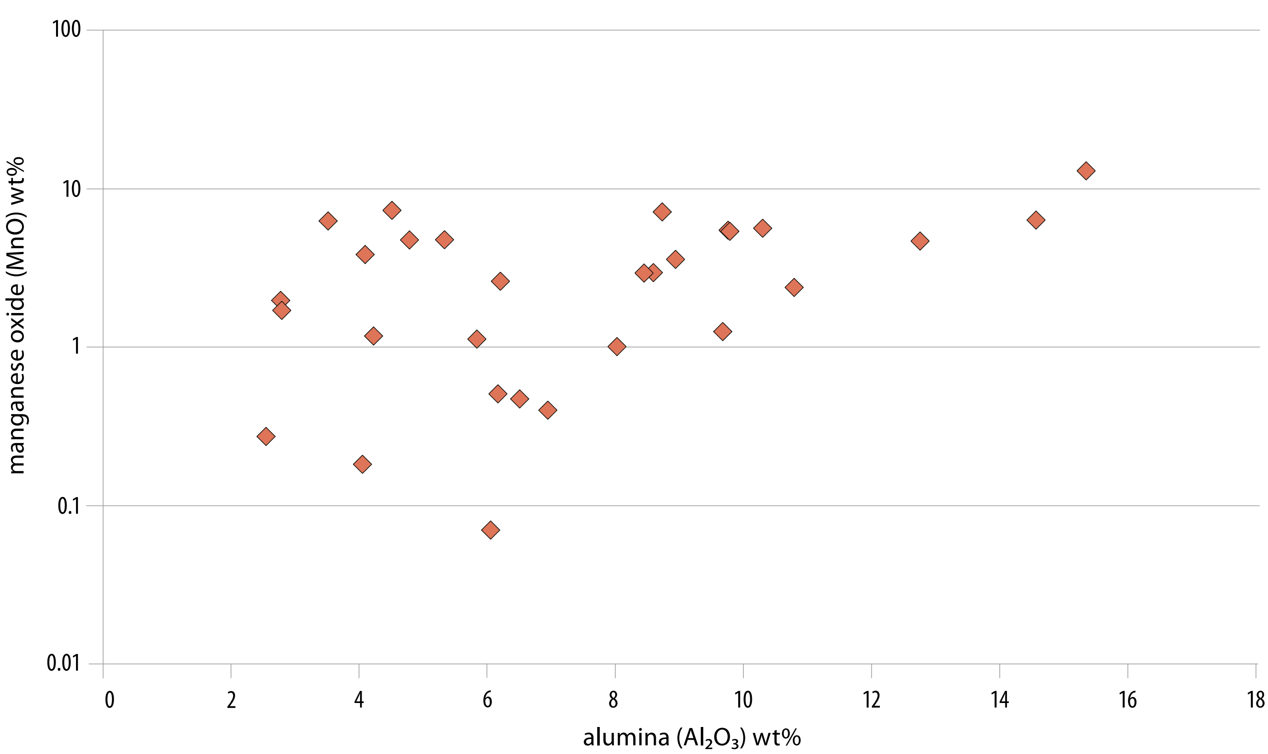


Illustration 6.35
Alumina and manganese oxide content of all bulk slags

Furnace/hearth lining

Both the clay and stone furnace wall fragments are rich in silica and alumina – these two oxides usually account for 90wt%. This composition would indicate that the materials were sufficiently refractory to withstand the temperatures required for bloomery iron smelting. The vitrified interior surfaces, however, show considerable enrichment in elements that are abundant in the slag (especially iron, manganese and calcium, see Illus. 6.36). The vitrification of the interior surface of the furnace wall is likely to have occurred in two ways. The exposure to high temperatures will have encouraged the clay or stone to vitrify and even melt. In addition, in some parts of the furnace, the furnace wall will have reacted due to direct contact with molten slag. The vitrified surfaces that have undergone little reaction with the slag in the furnace tend to be those that display microphase separation. The vitrified surfaces that have reacted with slag usually contain a similar range of phases to those seen in the slag (especially fayalite).

Hammerscale flakes and spheres

The compositional characteristics of the Culduthel hammerscale are similar to other analysed hammerscale (Dungworth and Wilkes 2009). The hammerscale samples fall into two major

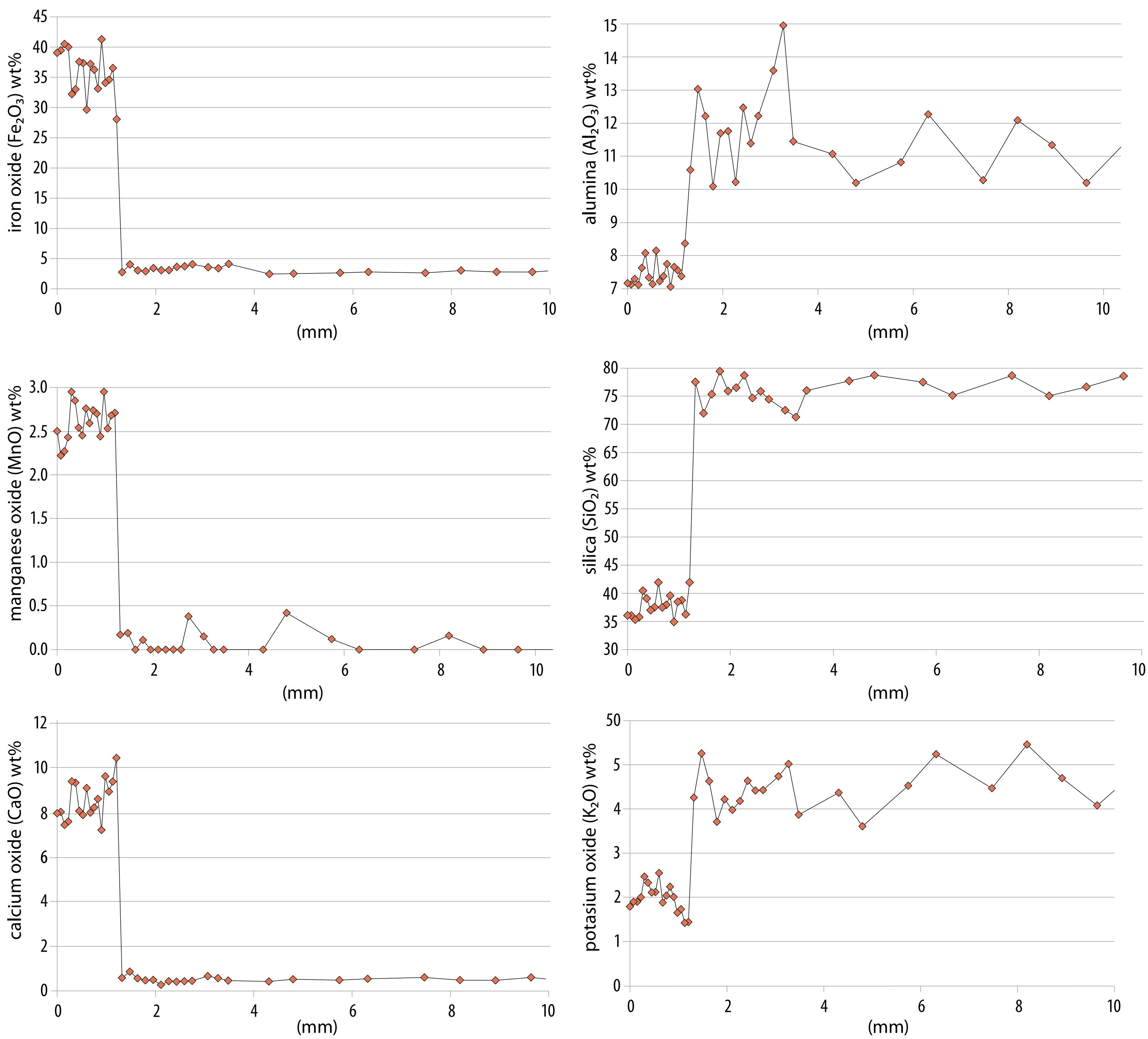


Illustration 6.36

Linescans through the thickness of a fragment of furnace wall (sample 1120, context 185)

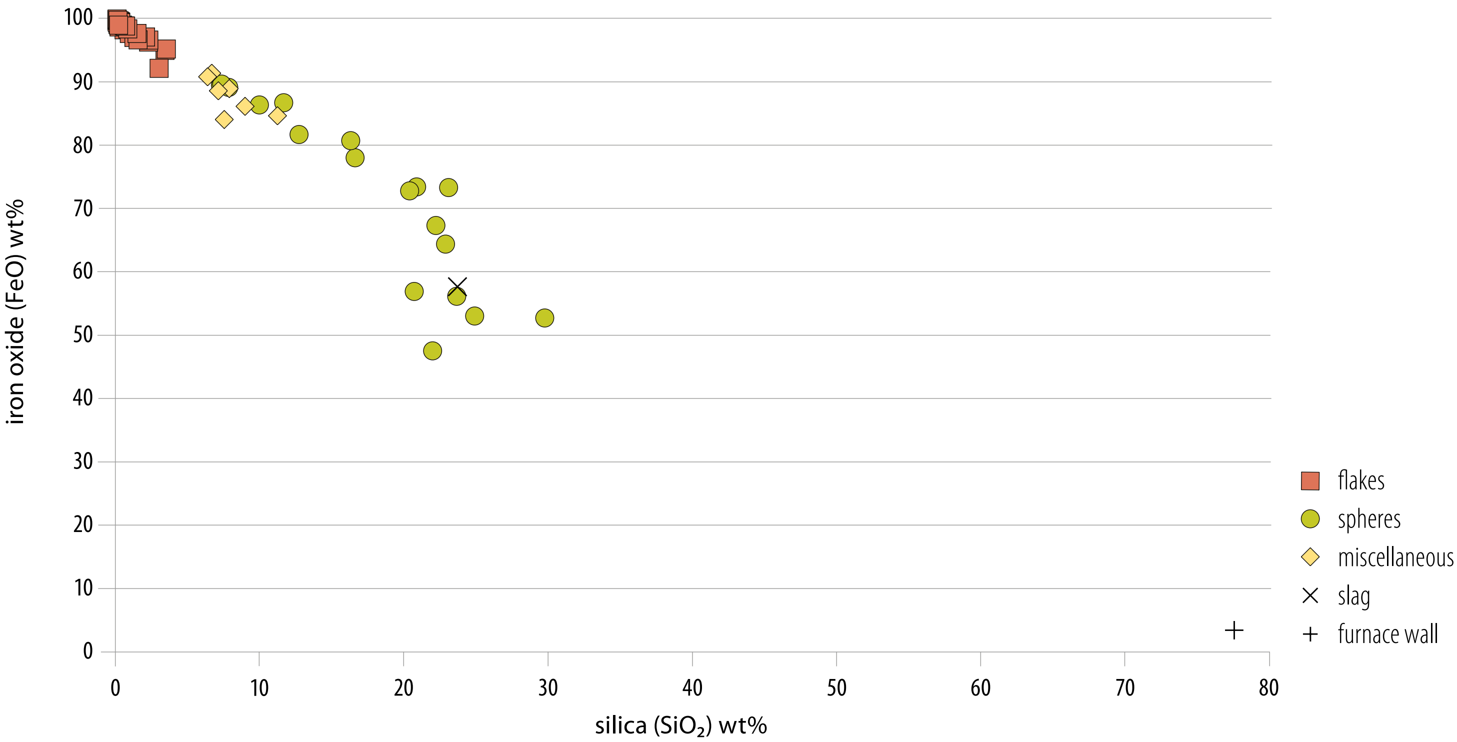


Illustration 6.37
Iron oxide and silica content of the hammerscale samples

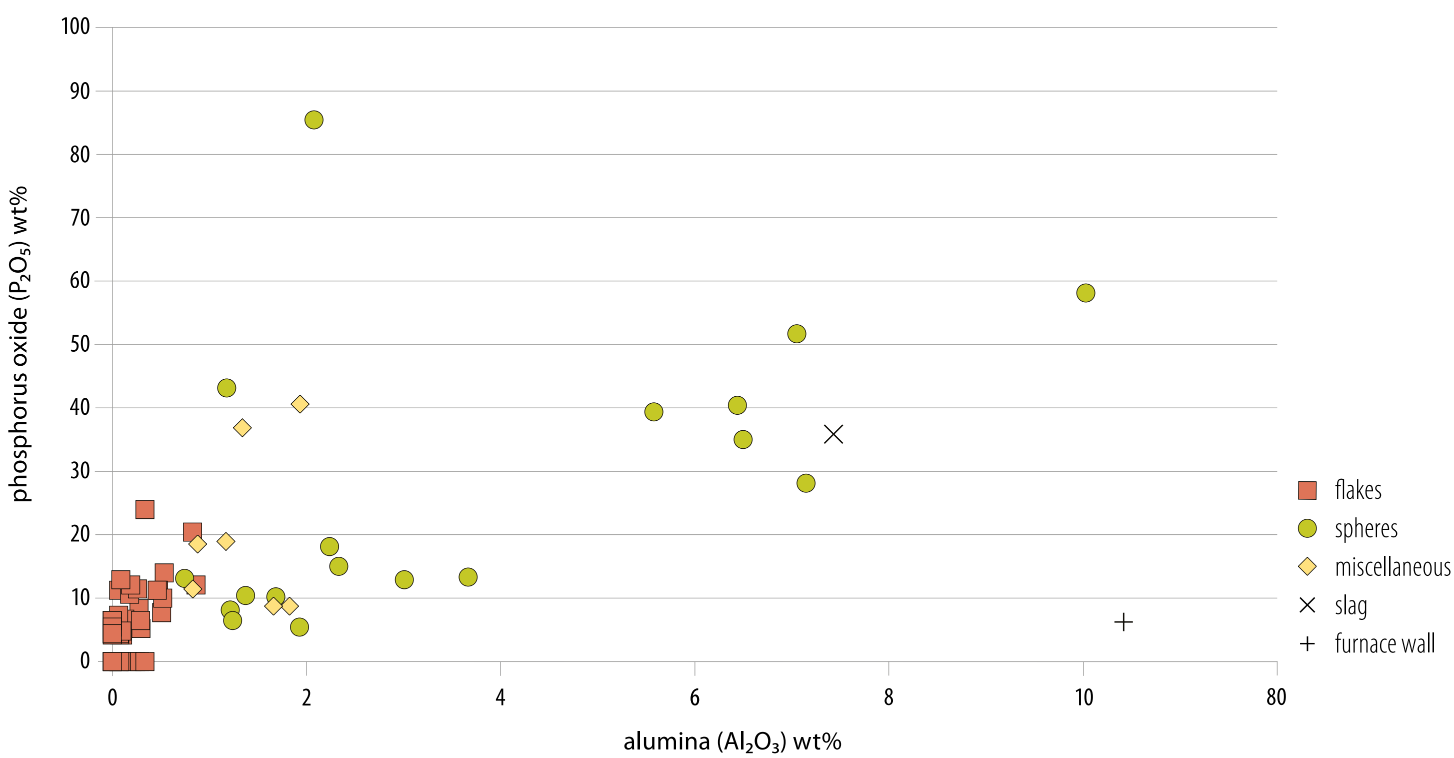


Illustration 6.38
Alumina and phosphorus oxide content of the hammerscale samples

compositional groups: the flake hammerscale is very iron-rich while the spheres contain elevated concentrations of a range of elements (Illus. 6.37 and 6.38). There are several possible sources of these minor elements, including slag inclusions, furnace lining, flux and fuel ash. The increase in the minor elements in the spherical hammerscale shows closest similarities with the smelting slag (which should correlate with the composition of the slag inclusions, see below).

Metal microstructure and slag inclusions

The metallic samples from Culduthel examined included five possible fragments of bloom, seven fragments of bars/offcuts/ unfinished objects, a nail, two knife tips, a spearhead, a reaping hook and a strapping fragment. The bloom fragments were all carbon steels (Illus. 6.39). The most abundant phase present was pearlite (the iron-carbon eutectoid comprising parallel and concentric bands of alternating ferrite (pure iron) and cementite (iron carbide) (Illus. 6.40 – 6.41). A eutectoid carbon steel is one in which the only phase present is pearlite; reference to the iron-carbon phase diagram indicates that a eutectoid steel contains 0.8wt% carbon. Carbon steels are often described as hypo-eutectoid when they contain less than 0.8% carbon, the microstructure containing both pearlite and ferrite, and the carbon content can be easily estimated from the relative abundance of these two phases. Hyper-eutectoid steels are those that have more than 0.8wt% carbon – the microstructure consisting of pearlite and cementite. All of the Culduthel bloom samples are hyper-eutectoid steels. SEM-EDS analysis failed to detect any elements other than iron (ie <0.1wt% phosphorus). The carbon content of the Culduthel blooms appears to have varied from 1 to 3wt%. Where slag inclusions were present, they generally had compositions that provided a moderate to good match with the Culduthel smelting slag (Illus. 6.42 - 6.43). The presence of bloom fragments of hyper-eutectoid steel confirms that the smelting process produced carbon steel in a single process (as opposed to the production of plain iron which would be subsequently carburised). Such direct steel is often referred to as natural steel.

The bars, offcuts and unfinished artefacts were all composed of hyper-eutectoid or medium steel (0.5–1.5wt% carbon, Illus. 6.39). The slag inclusions showed varying degrees of agreement with the composition of the Culduthel smelting slags (Illus. 6.42). While some provide a good match, and so are likely to have been made using locally manufactured iron, some provide a rather poor match and probably represent iron manufactured elsewhere. The remaining artefacts were all made of plain iron (no carbon) or low- to medium-carbon steel. Their slag inclusions generally showed a poor to moderate agreement with the Culduthel smelting slag.

Distribution and taphonomy

Contextual and distributional analysis, outlined in detail in the archive, demonstrates that ferrous metalworking waste was found throughout much of the excavated area (Table 6.14). Debris from around House 10 and Workshops 11, 13 and 15 dominates the assemblage. To enable further patterns in the material it is pertinent to analyse the contextual distribution more closely.

Illustration 6.39
Optical microscope image of a bloom fragment (Sample 2006, SF0361). The sample is dominated by pearlite with laths of cementite

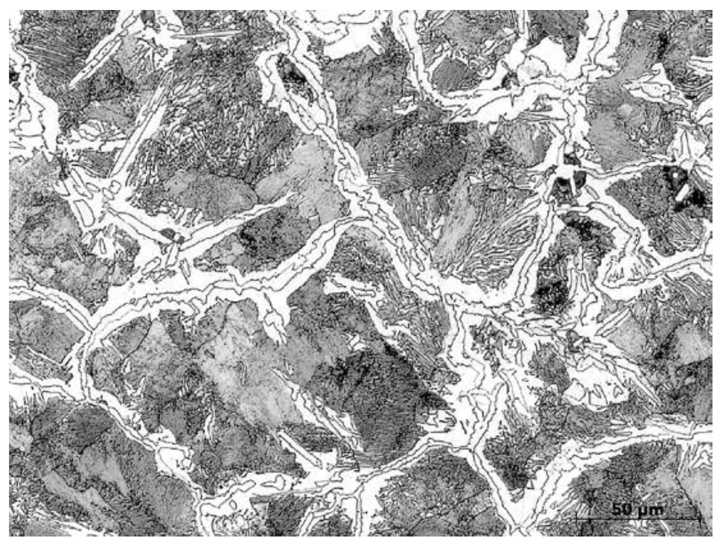


Illustration 6.40
Optical microscope image of a bar fragment (Sample 2016). The sample is dominated by pearlite with cementite at prior austenite grain boundaries

Due to the sheer quantity of material recovered and the number of contexts associated with metalworking debris, an integrated approach combining analysis of the distribution, the character of associated features and aspects of taphonomy has been applied to extract as much information as possible. This will allow a broader narrative to be developed, which aims to describe the assemblage by the significance of the associated context, with the aim of illustrating elements of the craftworking areas, the metalworking structures, and the strategies employed in reusing and disposing of metalworking debris. This approach has demonstrated that ferrous metalworking waste is present at Culduthel as five main categories of deposits (Table 6.15): in situ material associated directly with hearths and furnaces; discrete

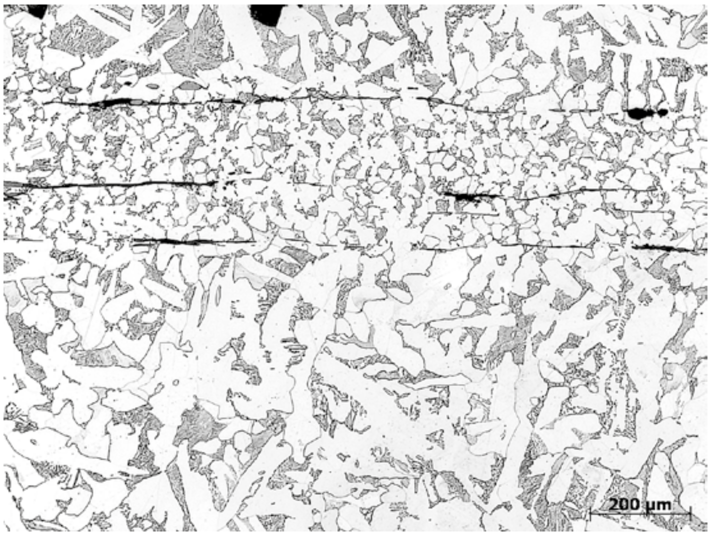


Illustration 6.41
Optical microscope image of a spearhead ferrule (Sample 2014, SF1026). The sample contains both pearlite and ferrite. Note also the dark thin bands of entrapped slag (slag inclusions)

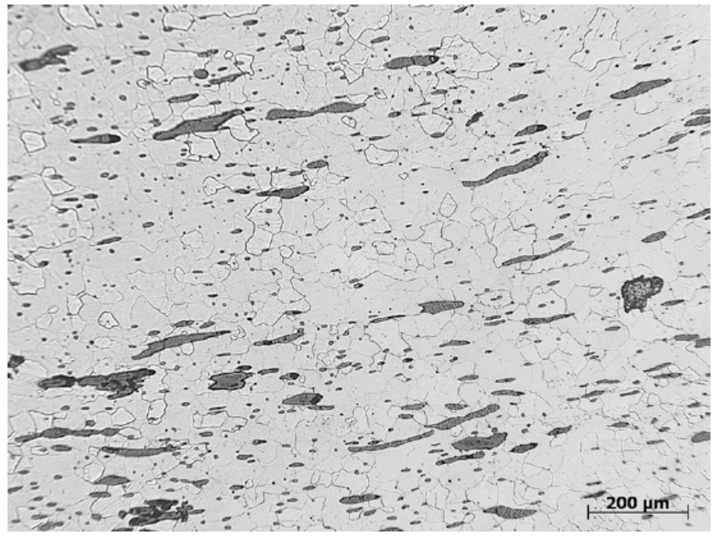


Illustration 6.42
Optical microscope image of a knife tip (Sample 2013, SF1209). The sample contains only ferrite. Note also the dark thin bands of entrapped slag (slag inclusions)

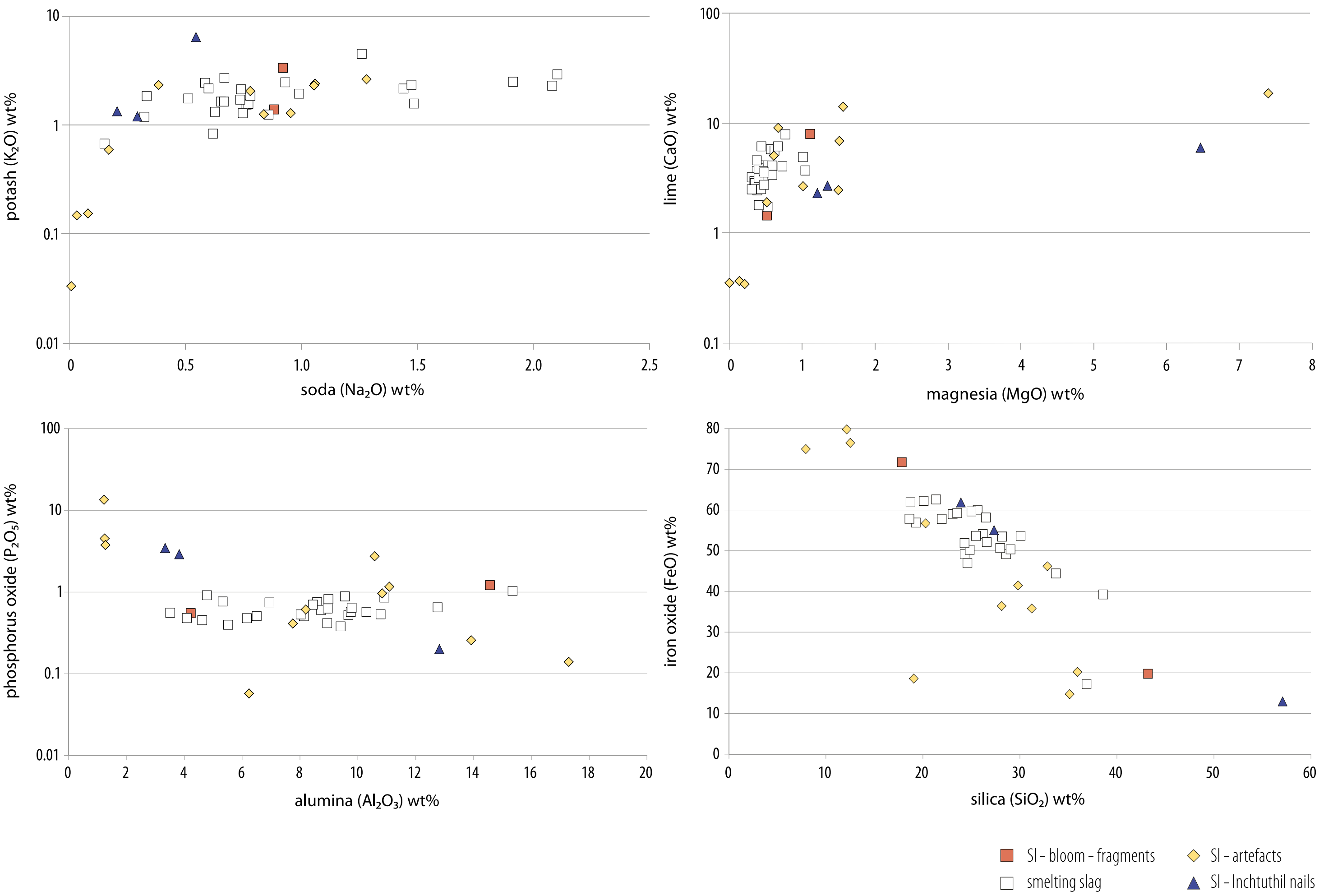


Illustration 6.43
Average chemical composition of slag inclusions compared with Culduthel slag

Table 6.14
Distribution of slag by area

Area	Mass/g
South-west corner of excavation area	2
Around cobbled surface 227	52,128
North-east corner of excavation area	1
East and south-east of House 10	251,110
Northern and north-west edge of excavation area (north of House 10)	20,859
U/S	13,390

Table 6.15
Distribution of ferrous metalworking waste by context type

Context type	Mass/g
In situ features (furnaces and hearths)	123,612
Discrete dumps	21,585
Spreads	94,473
Purposeful reuse	33,238
Residual	51,192
Unstratified	13,390
Total	**337,490**

dumps within pits; spreads or accumulations; residual scatters of waste; and purposeful reuse as metalling or built into walls (Table 6.16). The significance of each group of material will be discussed in detail below.

In situ features: furnaces and hearths

One exceptional aspect of the metalworking evidence from Culduthel is the quantity of in situ structural features, including the basal portions of smelting furnaces and stone-lined hearths. The structural components of these features, their preservation and design are discussed in further detail elsewhere. Eight smelting furnaces containing substantial quantities of smelting waste were noted, plus a possible cleared-out furnace (Table 6.17). These were associated with Workshop 2 (furnace 681), 13 (furnaces 3050 and 3790), 15 (furnaces 4147, 4262, 4355), 16 (furnace 4226) and 19 (furnace 3127). In addition to these in situ features, an earlier furnace (4790) was noted in the field directly under furnace 3790, and it was not possible to distinguish the debris from the earlier and later features. The furnace structures were sub-circular or sub-rectangular heat-affected pits, the edges lined with a horseshoe arrangement of water-worn boulders or slabs superimposed with medium- to fine-grained fired and vitrified clay. Many pieces of this furnace lining preserved wattle impressions, suggesting that a withy frame was used to build up the clay superstructure of the furnace shaft. There is a consistency in form and construction between the furnaces; all appear to be non-tapped shaft furnaces with cylindrical thick clay-walled superstructures. The soil immediately surrounding these features is frequently scorched or heat-affected. Substantial quantities (over 5kg) of smelting slag were associated with these structures, indicating that the waste from the final smelt remained in the furnace on abandonment or that debris was infilled into the base of the furnace after its final use. The presence of vitrified ceramic and slag within a pit is not sufficient to indicate an in situ metalworking feature, and could easily be a dump of secondary waste: for an in situ feature to be identified, structural evidence of the hearth or furnace is necessary.

Having said this, one feature, pit [185], may represent a cleared-out furnace. This pit lacks any structural evidence to confirm the former presence of a furnace but the morphology of the pit and the quantity of slag suggest a metalworking feature may have been present. This interpretation is bolstered by the recovery of a large horizontal run of slag which is an accidental or deliberate flow of molten waste, aligned with the main axis of the pit floor.

In contrast, pit 4273 was described in the field as the base of a collapsed clay-built metalworking feature. Although small quantities of unclassified iron slags, residues and vitrified ceramic were recovered from the pit, they were more typical of smithing waste. It is difficult, based on the quantity and range of slags present, to confirm that this was a furnace; it is more likely to be a smithing hearth.

Unlike smelting furnaces, smithing hearths do not require specifically built structures and tend to be more difficult to identify, as they are more ephemeral. Only one smithing hearth (4273) was tentatively identified, but smithing residue was recovered throughout the excavated area.

Discrete dumps

These consist of concentrations of significant quantities of waste slag (over 0.5kg) and associated vitrified material within discrete features (i.e. pits/post-holes) that lack any structural evidence to suggest the former presence of an in situ metalworking feature. Dumps differ from spreads in that they are contained within distinct and well-defined features and are not considered to be residual due to the volume of material present. These dumps generally consist of a mixture of bulk slags, fragments of vitrified ceramic and small quantities of magnetic residues, typically dominated by unclassified rake-out material (e.g. UIS), which could have derived from either a smelting furnace or smithing hearth. These dumps are usually but not exclusively located in the vicinity of an in situ metalworking feature. One, in pit 1632 within Workshop 6, is quite far removed from any recognised metalworking structures and may indicate that smelting activities continued to the north of the excavated area.

Nine discrete dumps have been identified, including seven from the area to the east and south-east of House 10 and two from around the cobbled surface 227 (Table 6.18). The contents of the pits, described here as dumps, are variable in terms of quantity and range of material present. Some, such as the possible furnace 4179 within Workshop 13, contain fairly small amounts of debris, in this case only 186g, but encompass significant quantities of

Table 6.16
Range and quantity of slag by feature category

	In situ features	Discrete dumps	Spreads	Purposeful reuse	Residual	Unstratified	Total/g
Smelting							
Plano-convex cake: furnace bottom (PCC:FB)	9,519	1,225	6,590	7,787	1,643	1,247	**28,011**
Tapped slag (TS)	2,858	—	—	—	—	—	**2,858**
Unprocessed bloom	791	310	3,714	697	1,167	571	**7,250**
Suggestive of smelting							
Runned slag (RS)	33,929	3,355	23,938	2,426	5,948	1,499	**71,095**
Charcoal-rich slag (CR)	11,358	249	1,804	—	1,374	186	**14,971**
Smithing							
Plano-convex cake: hearth bottom (PCC: PCHB)	85	1,027	4,926	3,428	7,996	367	**17,829**
Hammerscale flakes (HS)	487	314	65	97	955	36	**1,954**
Slag spheres (SS)	4	20	3	2	29	1	**59**
Smithing pan	43	—	—	—	416	—	**459**
Processed bloom	164	9	1,157	245	541	103	**2,219**
Undiagnostic of particular process							
Plano-convex cake: unclassified	825	1,222	11,378	5,337	2,926	1,658	**23,346**
Unclassified iron slag (UIS)	22,141	9,531	20,345	7,687	17,549	3,891	**81,144**
Slag amalgam (SA)	15,053	—	3,666	—	671	683	**20,073**
Atypical hammerscale flakes (HS(a))	1,894	188	84	—	—	3	**2,169**
Atypical slag spheres (SS(a))	50	—	—	—	—	—	**50**
Undiagnostic							
Vitrified ceramic (VC)	22,171	2,804	16,576	5,222	6,847	3,110	**56,730**
Fuel ash slag (FAS)	128	45	167	98	538	13	**989**
Heat-affected stone	702	—	—	41	546	—	**1,289**
Magnetic vitrified residue (MVR)	1,400	1,285	47	131	1,895	21	**4,779**
Non-magnetic vitrified residue (NMVR)	10	1	13	40	151	1	**216**
Total/g							**337,490**

Table 6.17

Range and quantity of slag present within in situ metalworking features. A = in situ smithing; B = in situ smelting; C = cleared out furnace or dump

	Workshop 2 posthole 411	**Workshop 2 Furnace 681**	**Pit 185**	**Workshop 13 Furnace 3050**	**Workshop 13 Furnaces 3790 & 4790**	**Workshop 15 Furnace 4147**	**Workshop 15 Furnace 4355**	**Workshop 15 Furnace 4262**	**Hearth 2343 & related features**	**Workshop 16 Furnace 2246**	**Workshop 19 Furnace 3127**
Smelting											
Plano-convex cake: furnace bottom (PCC:FB)	—	1,863	840	—	2,288	520	1,736	2,272	—	12,371	—
Tapped slag (TS)	—	—	2,858	—	—	—	—	—	—	—	—
Unprocessed bloom	—	85	—	26	633	24	—	—	23	—	—
Suggestive of smelting											
Runned slag (RS)	13	7,858	1,076	2,198	10,252	4,656	396	1,702	—	5,765	13
Charcoal-rich slag (CR)	—	3,445	—	4,049	3,431	34	—	399	—	—	—
Smithing											
Plano-convex cake: hearth bottom (PCC: PCHB)	85	—	—	—	—	—	—	—	157	—	—
Hammerscale flakes (HS)	19	91	97	—	—	—	13	110	2	—	—
Slag spheres (SS)	—	—	—	—	—	—	2	—	—	—	—
Smithing pan	43	—	—	—	164	—	—	—	—	—	—
Processed bloom	—	—	—	—	—	—	—	—	—	—	—
Undiagnostic of particular process											
Plano-convex cake: unclassified	—	219	216	—	152	—	238	—	—	—	—
Unclassified iron slag (UIS)	1,791	—	961	2,691	10,515	2,405	672	1,310	156	1,633	7
Slag amalgam (SA)	97	3,184	—	2,566	4,199	955	3,622	430	—	—	—
Atypical hammerscale flakes (HS(a))	—	—	—	155	1,379	167	—	—	—	193	—
Atypical slag spheres (SS(a))	—	23	2	—	15	—	—	—	—	10	—
Undiagnostic											
Vitrified ceramic (VC)	66	291	545	3,337	5,064	4,677	2,106	918	37	5,130	—
Fuel ash slag (FAS)	—	—	114	—	12	—	—	2	—	—	—
Heat-affected stone	—	171		—	531	—	—	—	—	—	—
Magnetic vitrified residue (MVR)	219	538	146	—	157	—	32	102	206	—	—
Non-magnetic vitrified residue (NMVR)	—	—	—	1	—	—	—	9	—	—	—
Interpretation	A	B	C	B	B	B	B	B	A	B	B
Total/g	**2,332**	**17,768**	**6,855**	**15,023**	**38,793**	**13,438**	**8,817**	**7,254**	**581**	**12,731**	**20**

Table 6.18
Range and quantity of slag present within discrete dumps. D = Dump; D? = Dump?; D:smi = Dump: smithing; D:sme = Dump: smelting

	Workshop 6, pit 1632	Cobbled surface 227, pit 222	House 10, pit 3750	Workshop 13, pit 4190	Workshop 15, pit 4369	Pit 2143	Context 2186	Context 2130	Smithing Hearth 4273
Smelting									
Plano-convex cake: furnace bottom (PCC:FB)	553	–	–	–	–	672	–	–	–
Tapped slag (TS)	–	–	–	–	–	–	–	–	–
Unprocessed bloom	–	–	–	–	–	–	172	102	36
Suggestive of smelting									
Runned slag (RS)	456	–	540	–	431	988	–	925	15
Charcoal-rich slag (CR)	–	–	–	–	249	–	–	–	–
Smithing									
Plano-convex cake: hearth bottom (PCC: PCHB)	–	–	–	–	–	–	156	871	–
Hammerscale flakes (HS)	15	95	120	23	–	31	–	1	29
Slag spheres (SS)	2	10	1	4	3	–	–	–	–
Smithing pan	–	–	–	–	–	–	–	–	–
Processed bloom	–	–	–	–	–	–	9	–	–
Undiagnostic of particular process									
Plano-convex cake: unclassified	–	–	–	–	–	–	–	1,222	–
Unclassified iron slag (UIS)	–	–	4,497	–	1,603	1,292	257	1,439	443
Slag amalgam (SA)	–	–	–	–	–	–	–	–	–
Atypical hammerscale flakes (HS(a))	181	7	–	–	–	–	–	–	–
Atypical slag spheres (SS(a))									
Undiagnostic									
Vitrified ceramic (VC)	86	–	528	–	630	62	517	914	67
Fuel ash slag (FAS)	–	–	–	–	–	45	–	–	–
Heat-affected stone	–	–	–	–	–	–	–	–	–
Magnetic vitrified residue (MVR)	2	866	12	159	–	–	–	–	246
Non-magnetic vitrified residue (NMVR)	–	–	–	–	1	–	–	–	–
Interpretation	D?	D:smi	D:smi	D:smi	D:sme	D?	D	D	D:smi
Total/g	**1,295**	**978**	**5,698**	**186**	**2,917**	**3,090**	**1,111**	**5,474**	**836**

Table 6.19
Range and quantity of slag present within spreads. s/s = smelting/smithing; sme = smelting; smi = smithing; u = undiagnostic
* contexts 2164, 2180, 2198, 2470, 3567

	Hearth 2166 & spreads overlying 2165, 3180	Spread 2187	Spread 1896	Spread 798	Spread 1681	Spread 1680	Spread 2102	Overdburden	Hillwash (2435, 2586, 2588, 3720, 3727)	Occupation deposits within House 10/3	Abandonment & post-abandonment	Concentration of burnt material within Workshop 11 1952	Spreads overlying Furnaces 4355/4262/4147 Workshop 15
Smelting													
Plano-convex cake: furnace bottom (PCC:FB)	2,946	—	—	2,694	950	—	—	—	—	—	—	—	—
Tapped slag (TS)	—	—	—	—	—	—	—	—	—	—	—	—	—
Unprocessed bloom	11	—	632	1,990	374	118	—	—	123	—	352	114	—
Suggestive of smelting													
Runned slag (RS)	2,694	979	1,911	5,850	2,112	1,590	—	—	3,881	184	305	4,419	13
Charcoal-rich slag (CR)	—	140	831	833	—	—	—	—	—	—	—	—	—
Smithing													
Plano-convex cake: hearth bottom (PCC: PCHB)	963	37	205	307	2,326	—	91	—	—	—	—	997	—
Hammerscale flakes (HS)	36	5	3	—	1	—	3	—	2	5	3	7	—
Slag spheres (SS)	1	—	—	—	—	—	—	—	1	1	—	—	—
Smithing pan	—	—	—	—	—	—	—	—	—	—	—	—	—
Processed bloom	53	5	152	352	113	—	4	—	89	—	193	196	—
Undiagnostic of particular process													
Plano-convex cake: unclassified	1,905	207	980	2,394	1,593	719	174	486	1,445	323	1,152	—	—
Unclassified iron slag (UIS)	3,492	65	1,098	5,110	2,524	1,506	27	330	1,574	1,090	1,386	1,489	654
Slag amalgam (SA)	651	—	532	588	549	478	193	—	—	—	675	—	—
Atypical hammerscale flakes (HS(a))	—	—	—	—	—	—	—	—	—	—	—	—	84
Atypical slag spheres (SS(a))	—	—	—	—	—	—	—	—	—	—	—	—	—
Undiagnostic													
Vitrified ceramic (VC)	3,228	164	1,391	2,557	1,925	1,219	308	654	1,488	15	31	1,988	1,334
Fuel ash slag (FAS)	—	1	—	—	—	—	—	—	69	66	—	—	—
Heat-affected stone													
Magnetic vitrified residue (MVR)	1	—	—	—	1	—	1	—	25	5	1	—	13
Non-magnetic vitrified residue (NMVR)	—	—	—	—	—	—	5	—	5	2	1	—	—
Interpretation	s/s	s/s	sme	sme	s/s	sme	u	sme	smi	u	u	s/s	u
Total/g	**15,981**	**1,603**	**7,735**	**22,675**	**12,468**	**5,630**	**806**	**1,470**	**8,702**	**1,691**	**4,404**	**9,210**	**2,098**

Table 6.20
Range and quantity of slag reused as cobbling and wall core material

Structure	Context	Mass /g	Smelting			Suggestive of smelting		Smithing					Undiagnostic of particular process					Undiagnostic					Interpretation
			PCC: FB	Tapped slag	Unprocessed bloom	RS	CR	PCC: PCHB	HS	SS	Smithing pan	Processed bloom	PCC: unclassified	UIS	SA	HS(a)	SS(a)	VC	FAS	Heat affected stone	MVR	NMVR	
House 4 Ring ditch	contexts 766, 767, 775, 776, 777, 805, 871, 965, 1629, 1657, 1715, 1731, 1791, 2148, 2370	2,739			342	89		944	7	1			847	183				281			44	1	Cobbling?
Cobbled surface - 227	contexts 221, 225, 227	10,765			74			1,922				20	2,127	4,842				1,612	70	41	57		Cobbling?
House 10/3	contexts 1764, 1880, 2210, 2214, 2155, 2179, 2203, 2232, 2421, 2429, 2491, 2492, 2533, 2588, 2590, 2686, 2697, 2728, 2837, 2843, 2859, 2874, 2875, 2948, 2949, 3147, 3170, 3171, 3222, 3439, 3440, 3459, 3607, 3622, 3633, 3634, 3645, 3646, 3647, 3749, 3798, 3799, 3800, 3847, 3883, 3973, 4035, 4076, 4112, 4113, 4116, 4117, 4128	2,529			179	115			55	1		4	1,029	629				437	15		26	39	Secondary as cobbling or residual
Cobbled yard 1945	context 1945	2,271	701			23		562	32			74		46				816	13		4		Secondary reuse: cobbling
Wall base Workshop 11	context 1949	7,783	6,840															943					Secondary reuse: wall
Turf wall 2477 Workshop 11	context 2477	983	246		62	252						34						389					Secondary reuse: wall
House 10/3 Collapsed wall 1682	context 1682	1,431				488								943									Secondary reuse: wall

Table 6.21

Range and quantity of slag in residual contexts. r:u = residual: undiagnostic; r:s = residual: smithing; r:s/s = residual smelting/smithing; p/h = posthole; p/hs = postholes

					Smelt-ing		Suggestive of smelting			Smithing					Undiagnostic of particular process					Undiagnostic					
Area	Structure	Feature	Context	Mass /g	PCC: FB	Tapped slag	Unprocessed bloom	RS	CR	PCC: PCHB	HS	SS	Smithing pan	Processed bloom	PCC: unclassified	UIS	SA	HS(a)	SS(a)	VC	FAS	Heat affected stone	MVR	NMVR	Interpretation
A	n/a	Pit 77	78	2																			2		r:u
B	2	Various p/hs	144, 146, 394, 410, 412, 436, 437, 592, 593, 595, 596, 601, 602, 606, 607, 610, 612, 614, 632, 633, 634, 635, 636, 637, 638, 644, 645, 647, 669, 670, 671, 689, 691, 692, 697, 699, 700, 702, 788	7,561			46	1,087	706	303	###	2		17	181	3,348				761	31	478	480	1	r:s/s
B	3	Residual	832, 855, 934, 957, 959, 969, 1641, 1642, 832, 834, 853, 938, 999	56												52								4	r:u
B	4	Ring-groove	705, 707, 1628, 1656, 1659, 1721, 1784, 1787, 1789, 1798, 1800	169							13					156									r:s
B	4	p/hs	764, 765, 845, 1621, 1622, 1636, 1648, 1662, 1664, 1665, 1701, 1706, 1708, 1710, 1723, 1725, 1727, 1795, 1815, 1827, 1901, 1908, 1912, 1914, 1916, 1918, 2168, 2169, 2173, 2182, 2217, 2229, 2351, 2356, 2360, 2430)	230							45	1		37		40				77	5		21	4	r:s
B	5	p/hs	652, 656, 662, 714, 739, 820, 1699, 781, 820, 1699, 658, 660, 739, 741	27							2					23							2		r:s
B	6	p/hs	384, 385, 393, 397, 400, 456, 458, 631, 810, 1608, 1612	223							1	4				177					15		25	1	r:s
B	22	p/hs	context 868, 1611, 1640	66																65				1	r:u
B	24	p/h	context 340	1																				1	r:u
B	30	Palisade ditch	468, 533, 549	29								1				28									r:u
B	n/a	Pit 200	context 204	4												4									r:u
B	n/a	Isolated features (postholes & pits etc.)	165, 177, 193, 203, 318, 333, 350, 393, 394, 535, 557, 587, 716, 720, 748, 763, 895, 897, 1675), pits (167, 171, 189, 220, 243, 258, 321, 425, 427, 429, 622, 642, 665, 666, 826, 1616, 1637, 1652, 1684, 1687) and other deposits (296, 297, 447, 725, 1920)	1,030							12	1		74		582				336		7	17	1	r:s
C	n/a	Pit 451	Context 452	1												1									r:u
D		Cairn 4234	2671, 4288, 4289, 4301	23																20			2	1	r:u
D	10	Phase 1 features	context 2147, 2695, 2845, 2852, 3339, 3551, 3614, 3616, 4056, 4125	479	295		55				1	1				75				49			2	1	r:s/s
D	10	Phase 2 features	2691, 2849, 2995, 3135, 3605, 3716, 3781, 3782, 3784, 3789, 3844, 3876	46							1					38							2	5	r:s
D	10	p/hs and stakeholes	1883, 2507, 2513, 2540, 2555, 2563, 2567, 2581, 2598, 2599, 2605, 2611, 2613, 2635, 2639, 2641, 2643, 2647, 2649, 2655, 2661, 2702, 2703, 2704, 2705, 2721, 2723, 2740, 2744, 2752, 2760, 2765, 2769, 2861, 2862, 2866, 2884, 2888, 2890, 3012, 3016, 3018, 3020, 3028, 3042, 3044, 3132, 3144, 3145, 3223, 3287, 3288, 3462, 3471, 3627, 3630, 3636, 3743, 3804, 3902, 3904, 3961, 3964, 3986, 3992, 3994, 4060, 4062, 4098, 4110, 4127, 4130, 4185, 4186, 4193, 4198, 4199, 4213	2,187			58	494	66		62	1		8		557				563	115		245	18	r:s/s
D	10	Cobbled spread	2725, 2982	259				105								153								1	r:s
D	10	Other features	2553, 2878, 3566, 3875, 3895, 4033	402											356								4	42	r:u
D	11	Abandonment spreads	1978, 2100	6,674			251	1,460		1,751				61		1,746				1,285	120				r:s/s
D	13	p/hs	2787, 2791, 2793, 2797, 2802, 2808, 2810, 2814, 2820, 2822, 2824, 2828, 2834, 2836, 2896, 2899, 2901, 2910, 2913, 2916, 2918, 2920, 2922, 2928, 2940, 2943, 2945, 2988, 3794, 4189, 4278	2,936			18	109		661	80	1	161			1,126				406			374		r:s

Table 6.21
(continued)

					Smelt-ing		Suggestive of smelting			Smithing					Undiagnostic of particular process					Undiagnostic					
Area	**Structure**	**Feature**	**Context**	**Mass /g**	**PCC: FB**	**Tapped slag**	**Unprocessed bloom**	**RS**	**CR**	**PCC: PCHB**	**HS**	**SS**	**Smithing pan**	**Processed bloom**	**PCC: unclassified**	**UIS**	**SA**	**HS(a)**	**SS(a)**	**VC**	**FAS**	**Heat affected stone**	**MVR**	**NMVR**	**Interpretation**
D	14	p/hs & ring ditch	3248, 3250, 3315, 3448, 3251, 3269, 3271, 3273, 3319, 3323, 3454, 3516, 3444	44							1	1				29							11	2	r:s
D	15	Pits	4220, 4324, 4336, 4380	1,333				137		1,126	1					45				21				3	r:s
D	15	p/hs	3491, 3493, 3495, 3513, 3559, 3944, 3968, 3972, 3983, 3996, 4132, 4187, 4188, 4268, 4295, 4297, 4299, 4300, 4304, 4311, 4312, 4349, 4351, 4354, 4364, 4372	2,106			124	116		245	68	1		35		1,466				7			40	4	r:s
D	15	Other features	4342, 4308, 4357	161							18					142								1	r:s
D	26	p/hs	3149, 3151, 3153, 3155, 3157, 3158, 3162, 3279, 3283, 3285	128												105					4		18	1	r:u
D	n/a	Pit/p/h 2777	2778	36							1					35									r:s
D	n/a	Isolated features (postholes & pits etc.)	1745, 1753, 1756, 1845, 1873, 1877, 1892, 1898, 1900, 1925, 1926, 1933, 1935, 1973, 1975, 1982, 1986, 1989, 1995, 1998, 2137, 2144, 2153, 2548, 2681, 2783, 2785, 2799, 2804, 2806, 2816, 2830, 2832, 2894, 2904, 2906, 2908, 2924, 2926, 2935, 3218, 3336, 3456, 3535, 3539, 3561, 3583, 3654, 3655, 3662, 3664, 3666, 3670, 3672, 3676, 3679, 3689, 3698, 3704, 3708, 3715, 3718, 3731, 3739, 3741, 3744, 3745, 3759, 3767, 3771, 3772, 3775, 3796, 3805, 3815, 3817, 3819, 3825, 3830, 3832, 3834, 3839, 3842, 3850, 3852, 3873, 3885, 3887, 3933, 3934, 3954, 3966, 3980, 4000, 4002, 4005, 4031, 4073, 4075, 4079, 4090, 4093, 4102, 4104, 4135, 4150, 4222, 4224, 4245, 4263, 4275, 4277, 4286, 4293, 4315, 4322, 4333, 4384, 2126, 2933, 3398, 3457, 3518, 3520, 3565, 3756, 3757, 3812, 3810, 3836, 4033, 4253, 4346, 4376, 4380	1,6871	1,348		505	2,293	602	2,002	###	9	44	249	1,210	4,472	671			2,049	200	61	631	41	r:s/s
E	7	p/hs	1779, 1829, 1831, 1833, 1835, 1837, 1839, 1841	196				10		148	10					5					22		1		r:s
E	8	p/hs	1775, 1856, 1958, 1959, 1980, 2346	374			73				4	1				296									r:s
E	9	p/hs	1746, 1747, 1762, 1861, 1967, 2106, 2116, 2126, 2129, 2152	755			36	103		329	1					84				179	20		2	1	r:s
E	12	p/hs & pits	2428, 2445, 2446, 2447, 2460, 2461, 2473, 2474, 2475, 2528, 2546, 2961, 3010, 3140, 3417 2227, 2410, 3594, 4153	3,223							3				550	2,111				551			2	6	r:s
E	12	Iron Age ground surface	2225	42							15	1				26									r:s
E	16	p/hs	2241, 2286, 2302, 2304, 2324, 2368, 2395.1751, 2237, 2286, 2324, 2326	7							1	1				3							1	1	r:s
E	17	p/hs & pits	2264, 2384, 2408, 2466, 2276, 2342, 2344, 2382, 2389, 2441, 2448, 2347	15							2					11							1	1	r:s
E	18	p/hs	3525, 3529, 3543, 3553, 2736, 3547, 3581, 3591, 3600, 3642, 3644	73							1	1				69								2	r:s
E	19	p/hs & other features	2458, 2520, 2521, 2716, 2458, 2478, 2497, 2517, 2592, 2714, 2857, 2882, 2517, 2523, 3225	3,293				34		1,431	4	1	211	40	629	449				478	6		9	1	r:s
E	28	p/hs	2337	1												1									r:u
E	n/a	Other features	2293, 2312, 2323, 2329, 2334, 2367, 2417, 2418, 2712, 2877, 3137, 3593, 3596, 3597 and other deposits (2239, 2310, 3585, 3586)	129			1				4	1		20		94							3	6	r:s
U/S				13,390	1247		571	1,499	186	367	36	1		103	1,658	3,891	683	3		3,110	13		21	1	r:s/s

micro-debris diagnostic of smithing. The number of dumps is unexpectedly small considering both the scale of metalworking taking place and the wide area over which this activity was conducted. This would imply that the metalworkers at Culduthel did not typically clear out the metalworking areas and dispose of the debris away from the main area of activity (unless outwith the excavated area) but rather let the material accumulate in the vicinity of where the work was undertaken.

Spreads

The vast bulk of the ferrous metalworking debris from the site came from a series of spreads and deposits within the main craft-working zone beside House 10 (94.4kg; Table 6.19). Thirteen spreads of debris have been identified here and each comprises significant quantities of waste material distributed among charcoal-rich material, including waste diagnostic of both smelting and smithing. The spreads appear to represent accumulations of waste material from furnaces and hearths, and tend to be dominated by fractured pieces of bulk slags. As discussed above in relation to distinct dumps, it appears as though the common practice at Culduthel was to allow the slags to build up in the vicinity of the metalworking structures rather than clearing up after each successive firing and disposing of the slag outwith the immediate area. The taphonomy of these spreads is of interest: the most significant spreads in terms of the scale of the area covered and the quantity of material present come from contexts 798 and 1681. (It should be noted that context 798 comprised a particularly extensive slag-rich spread which was sampled in the field. The mass of ferrous metalworking waste thus represents only an unquantified sample of the total.) These spreads have accumulated in a natural hollow, leading to their preservation. This leaves open the possibility that the same density may have been present across more of the site but has over time been truncated by erosion and dispersed by successive hillwash episodes.

Secondary reuse

The deliberate reuse of slags as metalling and building material has been noted in nine locations across the site (Table 6.20). This typically involves bulk slags only, with a preference towards large, fractured pieces of plano-convex cakes from smelting or smithing, and rake-out material. Bulk slags of these types are fairly robust and would have been hard-wearing underfoot. Such slags appear to have been deliberately reused alongside stones and other material to form cobbled surfaces within roundhouse structures (e.g. within House 4 and House 10/3) and outside them (cobbled surface 1945 and 1679), or as building material within walls (such as contexts 1682, 1949, 2191 and 2477). This reuse appears entirely functional. There is no evidence or patterning to suggest that this material was incorporated for any symbolic or ritual purposes.

Residual

Small background quantities of waste material, usually micro-slags and small fractured pieces of bulk slags, were observed as low-density scatters over wide areas of the site (Table 6.21). This material, deriving from nearby in situ metalworking features, dumps and spreads, infiltrates most negative features on the site through a combination of soil creep, hillwash, human action and post-depositional slumping. The presence of a background scattering of smithing waste within the post-hole features of Houses 7 and 9, and Workshops 8 and 12, is of interest as no in situ smithing hearth or dump of material has been located in this area. It suggests that the focus for smithing in this area of the site is likely to have occurred outwith the excavated area.

Comparison to Culduthel Mains (CSE) assemblage

During excavation of an adjacent field at Culduthel (Phases 7 and 8) a further small assemblage of ferrous metalworking waste was recovered (24.5kg), comprising slags diagnostic of both smelting and smithing. No evidence for in situ ironworking in this area was present. This has been discussed in a separate publication (Cruickshanks and McLaren 2011) but is worth summarising here as it forms an interesting comparison to the current assemblage. The majority of the assemblage (18.4kg) represented a dump of smelting and smithing waste which came from a single pit (pit 036) situated on the edge of the south-west corner of the site. The pit had two distinct fills, suggesting deposition in two separate events. The upper fill has been dated to AD 770–990, indicating that metalworking at Culduthel continued into the Early Historic period.

Chemical analysis of a sample of the Phases 7 and 8 slags confirmed that the plano-convex slag cakes or bottoms identified during initial classification were the product of smelting within a non-tapped furnace. Like the assemblage at CDF, significant quantities of hammerscale (both flake and sphere) were found in association with diagnostic smelting waste. Many of these flakes and spheres were noted during initial visual inspection as atypical in size and shape for smithing debris, the slag spheres being large (over 3mm diam) misshapen globules and the flakes also being larger than expected. Analysis of these large slag spheres confirmed unusually high levels of manganese and iron oxide, suggesting that, rather than being the product of blacksmithing, these spheres may have been formed either due to overheating of the bloom in the primary furnace or during bloom-refining.

The average slag compositions of the slag from each site are indistinguishable (Table 6.13) and evidence for the manufacture of natural carbon steel blooms can be found in the examination of material from both areas. It is reasonable to conclude therefore that the iron manufacture at both sites took place within a single technological tradition and employed similar techniques and raw materials despite the chronological differences.

Beyond Culduthel: local parallels

Recent excavations have revealed a range of ironworking evidence from the Moray littoral. Furnaces at Tarras and Grantown Road, Forres,[1] are not yet published in detail (B Will, pers comm; M Cook, pers comm), but work at Seafield West, Inverness, uncovered a good range of smithing debris from a blacksmithing hearth dated to 180 BC–AD 70 (Heald et al 2011). In terms of the quantity of the slag, the most comparable assemblage comes from the Iron Age settlement at Birnie, near Elgin in Moray.

1 Editor's note: The excavation report of Granton Road, Forres has since been published in Scottish Archaeological Internet Reports as volume 61.

Post-excavation work is at an early stage but an interim study of the slag assemblage has been conducted (Cruickshanks 2010). At the time of writing, a minimum of 210kg of ferrous metalworking waste and associated vitrified material has been identified representing the residues from both smelting and smithing activities (ibid). Like Culduthel, much of the slag from Birnie appears to be residual or unstratified but four smelting furnaces and at least two smithing areas (represented by distinct spreads of hammerscale) are present. Their dating is not yet clear. Two of the Birnie smelting furnaces are stone-built and display a remarkable similarity to the Culduthel examples. In contrast are two clay-built smelting furnaces, which share no parallel with the furnace forms noted at Culduthel. Radiocarbon assays for these features and chemical analysis of the associated slag will aim to clarify whether these differences in form reflect a chronological and/or technological distinction.

Discussion

Several aspects of the Culduthel slag assemblage are unique within a Scottish Iron Age context, not least the volume of ferrous metalworking waste (over 337kg) and the quantity of identified smelting furnaces and smithing hearths, summarised in Table 6.18. The scale of iron production at Culduthel overshadows other known contemporary Scottish sites; the significance of this and its place in the broader context is discussed more fully in consideration of the artefact assemblage as a whole.

Slag morphology

The slag morphologies and micromorphologies show some similarities with prehistoric iron smelting from England (e.g. Dungworth 2007; 2011). In all of these cases the limited degree of flow to the slag and the microstructural evidence for slow cooling indicate that the slag formed inside the furnace and remained there until the smelt was completed. The slag was probably only removed from the furnace once it had completely cooled. The small size of most of the slag lumps and the limited evidence for flow all suggest that relatively small quantities of slag formed. This can be explained either by suggesting that the furnaces were charged with small quantities of ore, which would yield a small bloom and little slag, or that the ore used was so rich that it would form very little slag. It is most unfortunate, therefore, that no fragments of ore were recovered from the areas excavated.

Chemical analysis of the furnace bottoms and the vast majority of the bulk slags revealed that they contain significant proportions of manganese and as such are likely to have been produced as a result of iron smelting rather than iron smithing. Considerable variation in the chemical composition of the smelting slag samples was noted. This is typical of smelting slags produced in non-tapping furnaces. There were no correlations between overall slag morphology and chemical composition, and no meaningful differences between furnaces.

The product

Analysis of bloom fragments showed that natural steel was being produced consistently in the furnaces. This is a high-quality iron, and it is unfortunate that no evidence was recovered of the ore used. The slag inclusions on some of the iron objects that were analysed match the Culduthel slags, but others do not, indicating the use of sources beyond the site.

Aspects of methodology

This assemblage has afforded the opportunity to rethink aspects of classification of ferrous metalworking debris, highlighting that our traditional interpretations of some categories of slag are no longer suitable, or at the very least require reconsideration. This is particularly true of hammerscale, which has always been seen as diagnostic of smithing. At Culduthel (CDF and CSE), small flakes and spheres were identified among slags diagnostic of smelting, sometimes in furnaces, other times in pits associated with dumps of smelting debris. Initially these were identified as hammerscale from smithing. Further examination in comparison with conventional hammerscale elsewhere on the site indicated that some of the flakes and spheres associated with smelting were identical to the other hammerscale samples, but others were atypical, consisting of large flakes and large oval globules. Clearly, these were different but the process of their formation and their relationship to smelting was not well understood. Detailed chemical analysis revealed high manganese levels indicative of smelting rather than smithing. Secondary electron SEM images also helped to demonstrate that the flakes were actually films of slag that had formed between the fuel, and that the atypical spheres were hollow spheroids produced as the result of iron burning in the furnace, similar in form to those produced during fire-welding (Dungworth and Wilkes 2009, 44–5).

Within such a large assemblage of microresidues it was possible to compare these atypical flakes and spheres with normative hammerscale samples and to conduct limited chemical analysis. But in a smaller assemblage, would it be possible to distinguish by visual examination alone the difference between hammerscale and the flakes and spheres produced in a furnace? This question cannot be answered here, but the conclusion to be drawn from this methodological problem is that the presence of flake and spherical residues cannot, on their own, be taken as indicative of smithing. Where found in quantity, and in association with other debris from smithing, the classification of flakes and spheres as hammerscale is valid. But without associated diagnostic smithing slag and/or association with a hearth, flakes and spheres in small quantities are unreliable evidence for smithing.

Context

Ironworking at Culduthel cannot be considered in isolation as this was only one process in a suite of crafts being undertaken on site. Wider aspects of craftworking, including non-ferrous metalworking and glassworking, the significance of such activities within a settlement and aspects of status and importance of ironworkers will be discussed in the overview of the finds assemblage.

Iron artefacts

Fraser Hunter with metallographic analysis by David Dungworth

The ironwork from Culduthel is one of the largest Iron Age iron assemblages from Scotland, with over 150 finds weighing *c.*2.4kg.

In conjunction with the slag and furnace evidence, it gives us an all-too-rare picture of the entire ironworking cycle, from ore to artefact. The wide range of finds casts light on a spectrum of activities at the site, and includes many that are rare or unique: the range of tools (especially for metalworking – Illus. 6.44–6.46), the weaponry (a rare find on Scottish sites – Illus. 6.46) and an unusual linchpin (Illus. 6.47) all merit special mention, while the offcuts and unfinished items give a vivid picture of the blacksmithing process. After some general remarks, this discussion will consider the key functional categories in turn (summarised in Table 6.22) before looking at issues of metal quality, distribution, deposition and broader comparisons. Dating evidence is only mentioned specifically for significant objects; Table 6.27 summarises the dates for structures, which are discussed in detail elsewhere.

A key aspect of this assemblage has been its careful treatment, from field to laboratory. Too often, ironwork is not well treated on site, with fragmentation and corrosion due to careless excavation and poor storage; this is often compounded by a lack of conservation. In the case of Culduthel, the significance of the material was realised early in the process, with metal-detecting helping to maximise recovery. The entire assemblage was X-rayed (which was critical in assessing its significance), and a large proportion was conserved. This not only ensures the long-term survival of this important assemblage but also allowed (for instance) fine tools to be spotted at an early stage, rather than being ignored as probable nails; it also allowed the identification of substantial amounts of bloom, which would have been impossible without X-rays.

Table 6.22
Summary of functional categories in Culduthel ironwork, with numbers and total mass of iron

Functional category	No. items	Mass/g	Function/identification
Tools	27	636	Blacksmithing Bronze metalworking Leather-working Textile-working Wood-working Agriculture General (range of knives, including specialist ones)
Weapons	3	233	2 daggers, spear
Transport	1	77	Linch pin
Ornaments	4	9	Projecting ring-headed pins, hooked mounts
Fixtures & fittings	9	153	—
Nails	13	57	Range of small nails and tacks
Working evidence (63; 791g)	63	791	Offcuts (471g), working debris (41g), unfinished objects (169g), stock iron (110g) (bloom fragments catalogued separately)
Unidentified	32	422	Fragmentary material
Total (152; 2,379g)	**152**	**2,378**	

Key groups

The tools are a key assemblage, providing evidence for a wide range of on-site craft activities: iron- and bronzesmithing, wood-, leather- and textile-working, and agriculture (Illus. 6.44–6.46). Tools, in particular fine tools, can be hard to identify due to the effects of corrosion and damage: once the working tip is gone, identification is impossible. Some forms were shared between different materials; small punches, for instance, are used both in leather- and bronzeworking. Study is further complicated because tools would be made for the job in hand, and need not stick to rigid typologies. Table 6.23 provides a summary of the tool assemblage; detailed discussions of attributions are in the catalogue. Both iron- and bronzeworking are represented, as other evidence from the site confirms. Some tools could be used for both, notably the files SF0512 and SF0534 (Illus. 6.45), but the two sets (SF0352 – Illus. 6.44, SF1001 – Illus. 6.46) are typical items for hot-cutting iron (as the evidence of offcuts confirms – Illus. 6.49), while fine metalworking is represented by a range of tools. Most are concerned with decoration: two plausible scribers (SF0425 – Illus. 6.45, SF1013) for laying out designs; a graver SF0372 (Illus. 6.44) for engraving them; and a possible tracer (SF0357) for chasing them. The punch SF0366a (Illus. 6.44) could have been used for decorating either leather or bronze; the snips SF0540 (Illus. 6.46), a highly unusual find, might have been used for trimming sheet copper alloy, although their fineness suggests a more delicate role, perhaps for textiles or leather. The enigmatic tool SF0509 (Illus. 6.45) might be for shaping glass beads, though its broken condition makes this uncertain.

Woodworking is suggested by an unusually small axe SF0338 (Illus. 6.44); it may be a votive model, but these are typically in bronze rather than iron (Robinson 1995), and a role in delicate woodworking is more plausible. Textile-working is only securely attested by a single needle SF0334 (Illus. 6.44), but a range of finds stem from leatherworking. Awl SF0326 (Illus. 6.44) would be used to pierce holes for stitching, and modern analogies suggest the two triple-toothed handled tools (SF0371 – Illus. 6.44, SF1002 – Illus. 6.46) could have served to make perforations for decorative stitching (with thanks to Ann Wakeling for information on modern equivalents). They are especially interesting since they foreshadow a similar socketed form typical of the early medieval period. Embossing tool SF0429 (Illus. 6.45), with its bone handle, would have been used for decorating leather, emphasising its rarely considered artistic potential.

Agriculture, that vital element of daily life, is often poorly reflected in finds assemblages, but Culduthel produced two reaping hooks or sickles (SF082 and SF0510 – Illus. 6.45). Among the other material is a range of knives, all notably fine. The unusual form of one (SF1019), with its small, curved blade and angled shank, is reminiscent of items identified as surgical knives in Denmark (Frölich 2003). Curved knives were also used for leatherworking, to avoid ripping the hide, although these tend to

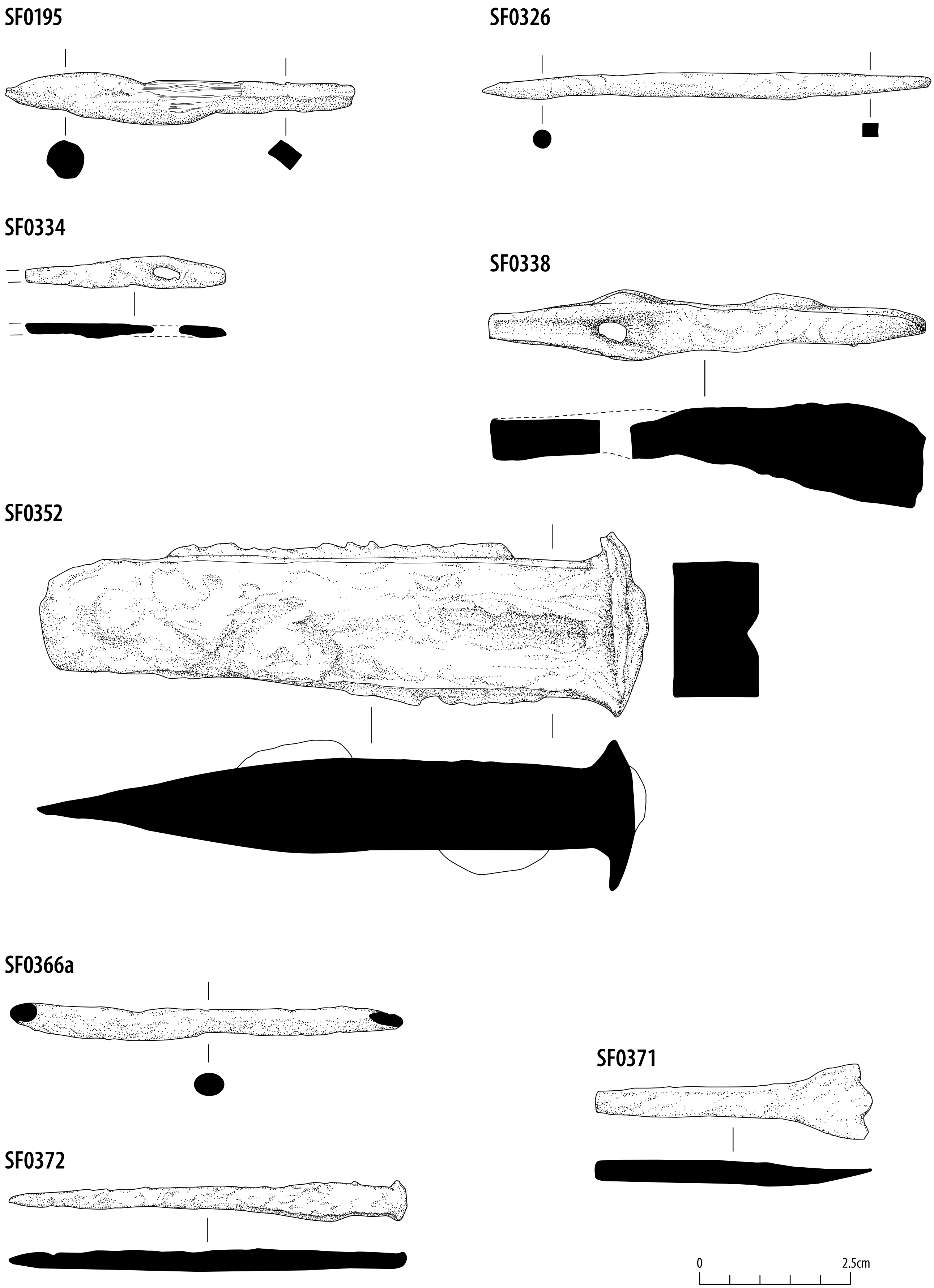
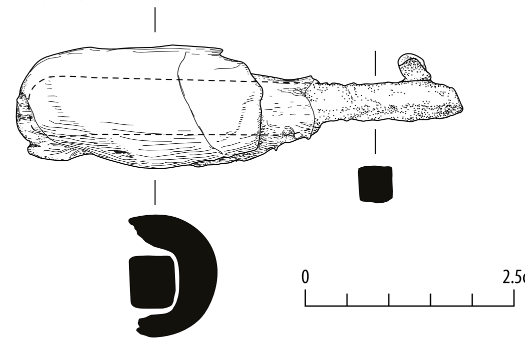


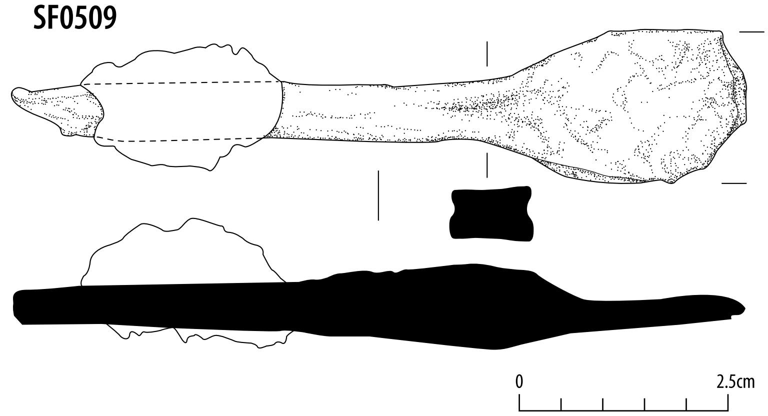
Illustration 6.44
Iron craft tools

SF0425

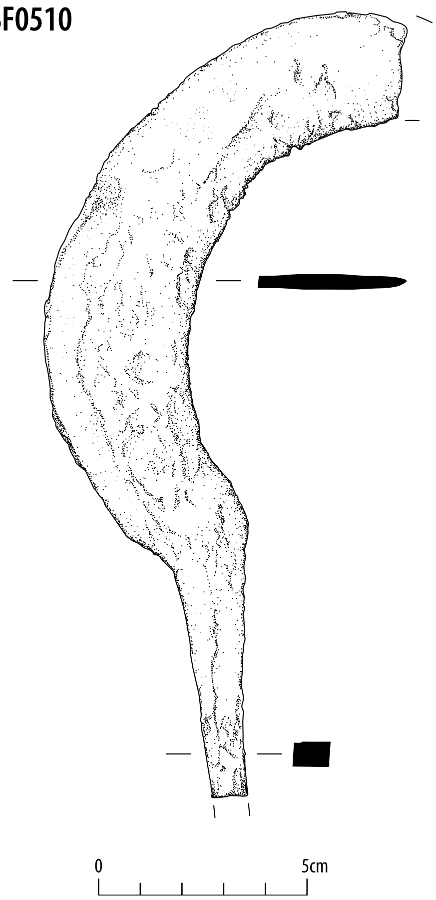
SF0429



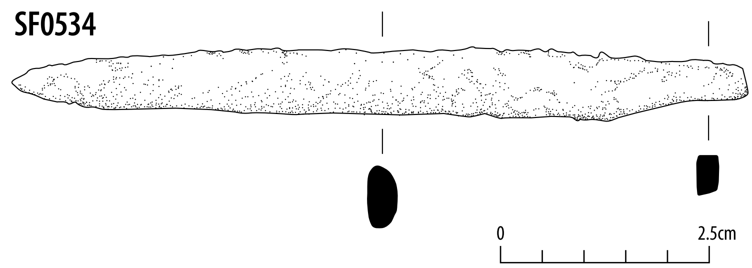
SF0509



SF0510



SF0534



SF0512

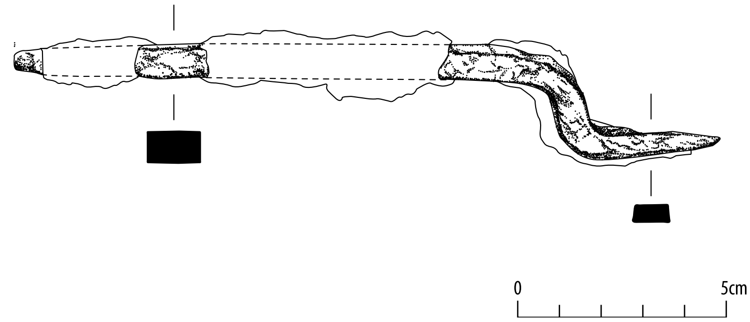


Illustration 6.45
Iron craft tools and sickle (SF0510)

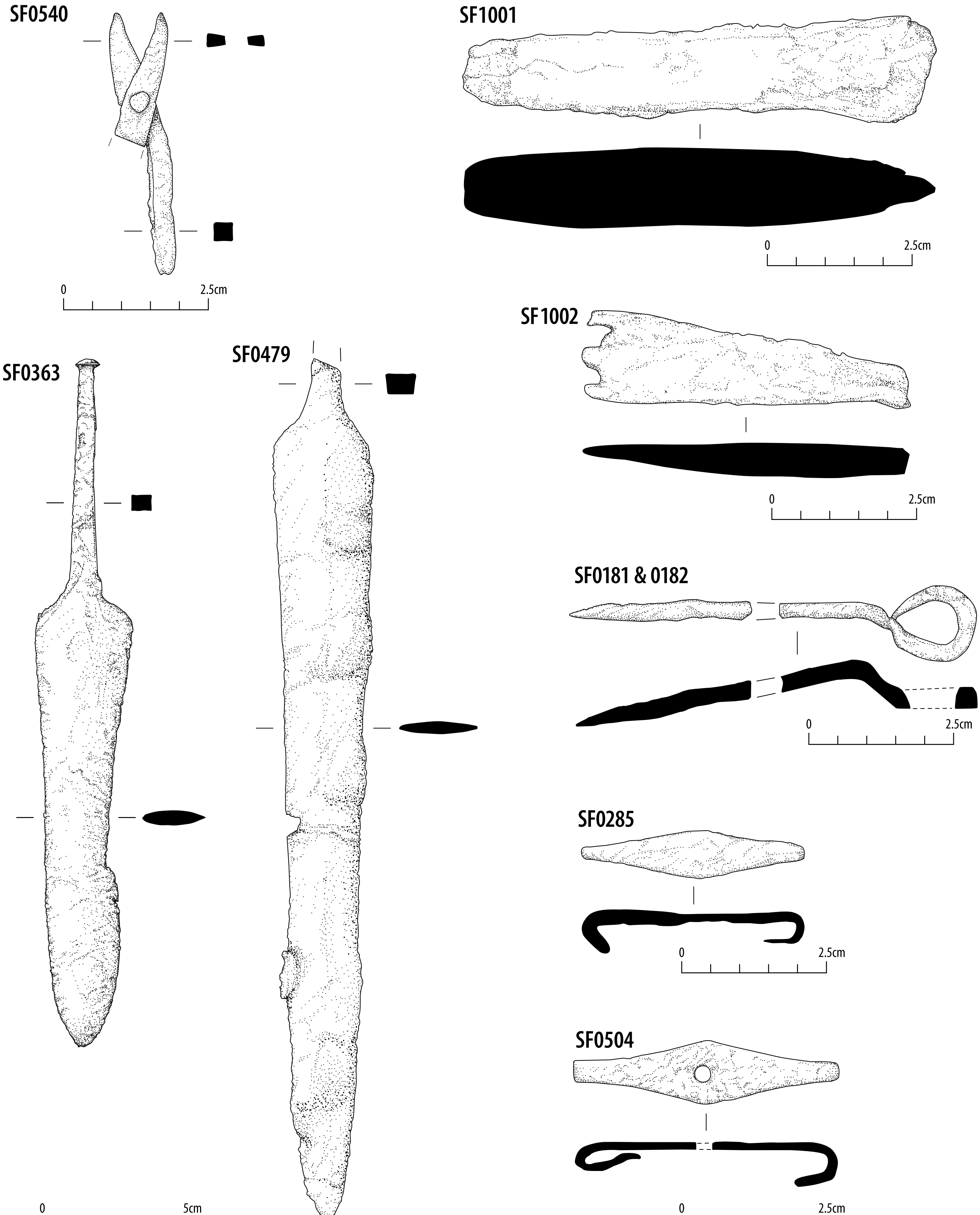


Illustration 6.46
Iron tools, daggers, pins and belt hooks

be larger (Manning 1985, 39); in technical terms, leatherworking and surgery are related, since both involve cutting skin, so similarities in tools are unsurprising. The size of this example points to a specialist task, either very fine leatherworking or medical treatment. The latter need not be far-fetched; Danish evidence points to some surgical knowledge there by the early centuries AD, and a small, curved bronze knife from Traprain could be interpreted as a lancet (Curle 1915, 188–9, fig. 37.1). Equally, ritual rather than medical practices could have a need for blood-letting.

Weaponry is represented by two daggers and a small spearhead. These are notably rare finds in a Scottish context, since there was no tradition of weapon deposition in much of Britain; thus, weaponry is generally only found as small, broken and discarded fragments (Hunter 2005b). The intact nature of these daggers strongly suggests they were deliberate, votive deposits (see below); other recent finds point to a tradition of dagger use and deposition in northern Scotland (Cruickshanks 2017). The two daggers differ markedly in size: the larger (SF0479 – Illus. 6.45), with a blade length of 277mm, falls within the size range for daggers rather than short swords (Stead 2006, 5); the smaller (SF0363; blade L 154mm – Illus. 6.45) was clearly a valued item, as considerable effort went into resharpening it after it sustained edge-damage. Their form is essentially similar, with sloping (campanulate) shoulders and straight sides tapering to a point. Such shoulders are typical of the pre-Roman Iron Age (Stead 2006, 13), and are reflected also in the copper alloy hilt guard from the site. This is confirmed by radiocarbon dates: SF0479 comes from a context dated to 160 cal BC–cal AD 60 (2σ % age probability) (GU-21923 2025 ± 35 BP), while SF0363, if associated with House 7, dates to 360–50 cal BC (2σ % age probability) (GU-21914 2140 ± 35 BP).

Daggers are most common in Britain in the late Hallstatt and early La Tène periods, overwhelmingly in south-east England (Jope 1961), yet there are later, more widely distributed but less well studied examples (e.g. Jope 1961, 339–41; Stead 1991, 71). Scottish examples come from Redcastle (Angus), Balloch Hill (Argyll), and a group from Lochlee (Ayrshire; Hunter 2005c, 85–6; Peltenburg 1982, 192, fig. 18.115; Munro 1882, 125–6); recent excavations have produced a number of other examples from Skye and Orkney (Cruickshanks 2017). Balloch Hill and Lochlee are poorly dated, but Redcastle dates from the 1st–2nd century AD. The Balloch Hill dagger has rather more angular shoulders, and the Redcastle one is broader, with a rounded tip, but one of the Lochlee ones is similar to thoses found at Culduthel, and the form finds parallels elsewhere (e.g. Rudston, East Yorks; Stead 1991, fig. 55 R 153).

The size of the small spearhead (SF1026) suggests it was a throwing weapon. There has been no systematic treatment of British Iron Age spearheads but similarly small, simple examples with rounded blades and a maximum width high on the blade are known from Iron Age contexts (e.g. East Yorkshire cemeteries, where they fall within Stead's type B2; fig. 124 no. 2, 7). SF1026 comes from Workshop 6, dated to 180 cal BC–cal AD 20 (2σ % age probability) (GU-21913 2060 ± 35 BP).

Transport is represented by a very unusual linchpin with a decorative fan-shaped head (SF0683 – Illus. 6.47), from House 10/3 (cal AD 50–240 (2σ % age probability) (GU-21933 1890 ± 35 BP)); this is paralleled only along the coast at Birnie (unpublished), and in Angus at Hurly Hawkin (Henshall 1982, fig. 7 no. 38, though not identified as such), suggesting it was a regional north-eastern type. As discussed in the catalogue, this serves as a reminder of how sparse our knowledge is of such finds outside the south of Britain. It also acts as a marker of the site's importance, as wheeled vehicles were prestige items at the time. This is reflected also in the copper alloy horse harness strap junction.

Ornamental material is sparse, comprising two pins and two mounts. Three pin fragments come from two pins, the recognisable one (SF0181 and SF0182 – Illus. 6.46) being a projecting ring-headed pin, the standard Scottish Iron Age type (there is also a copper alloy example from the site. They come from upper contexts in the dense industrial spreads to the east of House 10/3, not closely dated but probably 1st century BC–2nd century AD.

The assemblage also offers valuable insights into a previously unconsidered type of belt hook. These diamond-shaped fittings have two tangs on the reverse, one flattened to fasten the leather belt, the other forming an open hook (SF0285 and SF0504). Examples have been found elsewhere, in both iron and copper alloy (see Iron catalogue below). The hole in the centre of SF0504 probably held a decorative element. Their contexts (one from the industrial spreads, one perhaps linked to Workshop 19) would support a date of *c.*100 BC–AD 150.

Table 6.23
Iron tools from Culduthel

Craft	Tools
Metalworking (iron or bronze)	Files 512, 534
Ironworking	Sets 352, 1001
Bronze-working	?Tracer 357 Graver 372 Scriber 425, ?1013
Leather-working	Awl 326 Toothed implements 371, 1002 Embossing tool 429
Textile-working	Needle 334
Wood-working	Miniature axe 338 (unusual form)
Agriculture	Reaping hook 82 Sickle 510
Knives	340a, 1019 (unusual form), 1196, 1209
Uncertain	Snips 540 (bronze, textiles or leather) Fine tool 195 (leather, bronze?) Punch 366a (leather, bronze?) Tang 1005 ?Glass-working tool 509 Unidentified fine blade fragments 1197, 1206

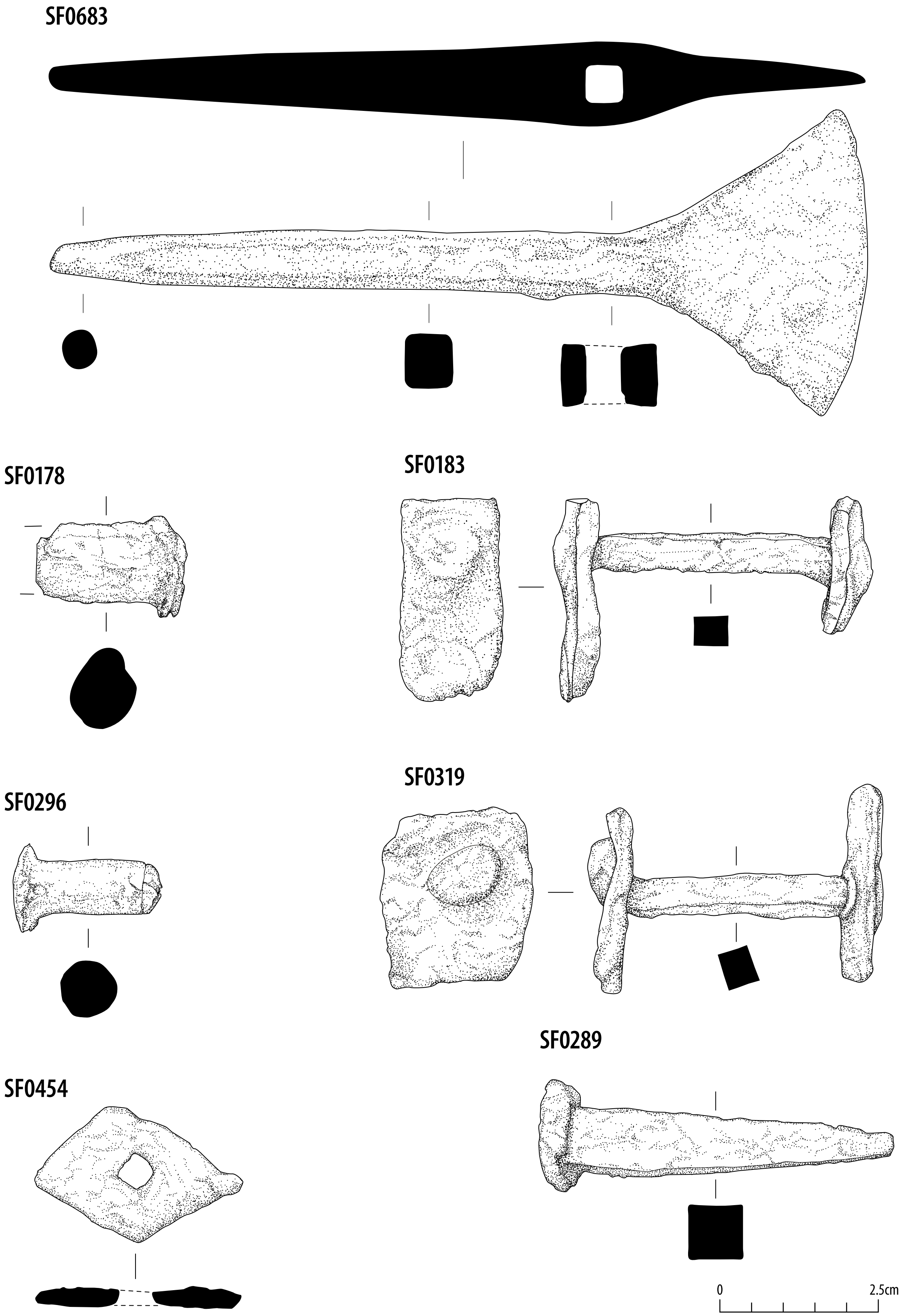


Illustration 6.47
Iron linchpin, holdfasts, bolts and a rove

Among the limited range of fixtures and fittings are a couple of holdfasts to secure timber joints 37–41mm thick (SF0183 and SF0319 – Illus. 6.47). The sparsity of nails is notable, with only 13 examples. This is a general Iron Age trend, with valuable iron being kept for more important roles, but other iron-rich sites such as Traprain Law and Fairy Knowe have larger amounts of nails (Table 6.28; Hunter 1998b, 366–7). Culduthel differs markedly from this, which suggests that the widespread use of nails depended not just on the availability of iron but also exposure to the concept of nail-based carpentry. Given that the bulk of activity at Culduthel predates Roman contact, it is tempting to see this as reflecting a lack of Roman influence in carpentry styles. The few nails and tacks present are notably fine (length varies from 20–60mm), and show considerable diversity of form: tapering, headless, narrow-headed, and tacks. This suggests an occasional and custom-made role rather than a habitual standardised use. Many are likely to come from fine furniture or other household items; the fine tacks SF1210–12 all have wood traces, indicating deposition while still within a wooden item.

Illustration 6.48
Unfinished iron. Top left: SF0287, top centre: SF0358a, top right: SF0294, bottom left: SF0435, bottom right: SF0522

The bulk of the remainder of material is concerned with ironworking (Illus. 6.48 and 6.49). Bloom fragments and offcuts are dealt with elsewhere, but the sheer quantity of offcuts is noticeable (>470g), while the bloom offcuts confirm on-site processing. The bulk of identifiable offcuts come from the ends of various forms of bars; this is unsurprising, as making a bar was a key stage in most products. Iron was also being recycled, and a number of reused items are recognisable: fragments cut from a joiner's dog, a knife, and perhaps a bolt (SF0178 – Illus. 6.47, SF0450 and SF0748). One of these, SF0450, shows the practicalities of recycling, with the end heated up and twisted with the tongs to give them a good grip while the iron was cut (cf. also SF0409 and SF1200). Another fragment, SF0434a, indicates more ambitious ornamental ironworking; it is a fine decorative branched terminal, broken and abandoned during manufacture.

The nature of the raw material

Fraser Hunter and David Dungworth

The metallographic examination, reported in detail elsewhere, has provided valuable information on the nature of the iron being produced. It is of notably high quality; analysis of bloom fragments showed these were consistently medium or hyper-eutectoid steels. Table 6.24 summarises the metallographic information on the artefacts, and the information from analysis of slag inclusions. This has interesting implications, not least that this locally made iron was not the only source being used; a number of the finished artefacts do not correlate with the local product in microstructure or slag inclusions. Indeed, one of the offcuts is a poor correlation, indicating the working of imported material or the reworking of broken items of non-site origin. It indicates we should be cautious in assuming that Culduthel was the predominant regional iron production centre; instead, it seems to have been one of several. Metallographic study was restricted to more fragmentary material, and thus covers few of the tools and weapons, although the knives that were examined showed no complex features. Unfortunately, the spearhead blade was too corroded to produce useful information. Work on other Iron Age material has shown these more specialist items did sometimes make preferential use of more carbon-rich alloys, or received more complex treatments such as tempering and/or quenching to alter their properties (Fell 1997 and1998; Lang 2006). There were no signs in the Culduthel radiographs of any complex structures or welds, but given the

Illustration 6.49
Offcuts

Table 6.24
Summary of metallographic and slag inclusion data

SF no.	Object	Metallography	Slag inclusion match to local slags
166	Offcut	Hyper-eutectoid steel	Moderate
188	Offcut	Low-carbon steel	Moderate
435	Unfinished/offcut	Low-carbon steel	Moderate
562	Offcut	Medium-carbon steel	Good
1012	Offcut	Medium-carbon steel	Poor
290	Bar	Medium-carbon steel	Moderate
1187	Bar	Hyper-eutectoid steel	No inclusions
86	Strapping	Plain iron	No match
340a	Knife	Low-carbon steel	No match
1209	Knife	Plain iron	No match
1026	Spearhead (socket)	Medium-carbon steel	Moderate
82	Reaping hook	(too corroded)	Moderate
282	Nail	(too corroded)	–

quality of the basic metal, these would be much less necessary than in regions where steel for cutting edges was scarce.

There has been little metallographic work on Scottish Iron Age iron, but the picture so far is one of diversity. Hutcheson's (1997) work comparing indigenous and Roman ironwork from southern Scotland suggested a distinction could be made between the two, with indigenous material characterised by greater numbers of slag inclusions, which tended to be more clearly aligned and more mixed; the finds also showed less indications of complex or composite construction. The results were intriguing but the data-set was relatively small, with only nine of the 15 items sampled being Iron Age. Subsequent work on the iron from Fairy Knowe, Stirlingshire, suggested a more complex picture, with the results contrasting with some of Hutcheson's findings (McDonnell 1998a). Here, the seven iron objects sampled were of good quality iron, with remarkably few slag inclusions, and included a tool of composite construction, with iron and steel welded together. The only other substantial programme of analysis comes from Pool, Sanday, Orkney; the sequence covered a large span of the Iron Age, but was predominantly of the later 1st millennium AD (McDonnell and Berg 2007). This analysis showed, among other things, the use of rather heterogeneous iron, although both steel and composite constructions were in use for blade tools. Otherwise, work has been restricted to specific items, such as the shaft-hole axe from Dun Ardtreck, which was a good-quality near-eutectoid steel (Photos-Jones 2000; contra this report, there is no reason to see the axe as Roman, since it is a well-attested Iron Age type (e.g. Vouga 1923, pl. XLIII no. 7–8)). The limited work so far thus suggests considerable regional (and probably chronological) variety, as might be expected. It also shows individual instances of complex blacksmithing procedures (the welding of different qualities of iron, and the heat-treatment of edges). The Culduthel work did not cover the kind of material that would be expected to use such techniques, but it did show the strikingly high quality of the raw material available to the smiths. It also shows the potential of extending such analyses to other sites.

Distribution

Most of the finds (around two-thirds) come from industrial spreads (mainly those located to the east and south-east of House 10/3). The remainder come from features (predominantly pits and post-holes, with only a few from ring-ditches; Table 6.25). This emphasises the importance of sites with surviving stratification as reservoirs of material culture: the buildings represented only by negative features have very few iron objects, and a high proportion of these are likely to be structured deposits rather than losses in use (below and Table 6.27). There are indications of both functional patterning and deliberate deposition in the material. Working debris is disproportionately represented in occupation layers, probably representing distance from use; it comes overwhelmingly from the area to the east and south of House 10/3 and adjacent or associated structures. The deposits seem to contain predominantly material lost or discarded in the

Table 6.25
Overall character of iron finds by context type

	Deposits	Features	Ring-ditches	Unstratified
Fragmentary/distorted	39	20	1	–
Intact	16	9	3	1
Working debris	54	5	4	–
Total	**109**	**34**	**8**	**1**

course of its use; thus there are more fixings and fastenings, while the tools are predominantly small items that could have been misplaced. There is an element of use-loss in features too, with assorted fragmentary material, but there are also other patterns. Intact objects are more common in features (including ring-ditches), tools from features are almost all larger, and they also produce more unusual items – all three items of weaponry, and a linchpin (Table 6.26). This points strongly to structured deposition, with the deliberate burial of material as foundation offerings (in post-holes) and when a building was abandoned or its use changed (for instance in ring-ditches). In some cases, these objects were in or adjacent to boundary locations such as entrances: sickle 510 at the rear end of the ring ditch in House 10/3; linchpin 683 in a post-ring post-hole near the entrance of the same house; and spearhead 1608 in an analogous situation in Workshop 6. Interestingly, the two daggers do not come from post-ring post-holes but from internal or external features (assuming they can be linked to the buildings around them); their connection to the building's life cycle is less clear. The vast majority of iron finds come from the spreads in the area to the east and south-east of House 10/3 or features under it, and must represent discards from activities in this zone. Much of it is connected with ironworking, but other crafts are also represented in this area, notably the decoration of fine metalwork (bronzework), glass and leather, confirming this was a multi-craft zone, not one solely connected with iron.

Broader comparisons

Table 6.28 provides a broad comparison with other large Iron Age assemblages from Scotland. This should be considered with caveats: it is clear, for instance, that not all the Traprain iron was retained (many nails were discarded), while in all cases, a significant amount (12–50%) could not be closely identified. There are also chronological differences: the bulk of the Traprain and all the Fairy Knowe material is Roman Iron Age (RIA), as apparently is Mine Howe, while Howe has a much broader span, with much of the assemblage being 1st millennium AD in date. There are, nonetheless, interesting similarities and differences. A key observation has been noted already; the rarity of nails from Culduthel, in contrast to those sites of Roman Iron Age or later date, suggesting markedly different practices of woodworking. It was suggested above that the use of nails is linked both to an increasing abundance of iron and to an awareness of their use from contact with Roman woodworking practice. In the case of Howe, only one nail predates the RIA, with a third being broadly RIA in date and the remainder later (Ballin Smith 1994, 216, table 6.26–6.28). The dominant feature of Culduthel, in contrast to the other sites, is the preponderance of working evidence; iron-smelting is attested at Mine Howe and Howe, and smithing at Fairy Knowe, but excavations did not locate the same scale of production as at Culduthel. Ornamental material is always rare (copper alloy was the main decorative metal), as are items of transport equipment and weaponry; only Traprain has a notable percentage of weaponry. Tools and items of domestic ironwork (fixtures, fittings and vessel parts) are the other frequent categories, although the range of tools differs. Traprain has a notably broad range, while the others, with smaller numbers, tend to be more restricted (and less representative?). In part this represents the activities in the excavated areas. Mine Howe shows a focus on fine tools for decorating metal, consistent with the discovery of many in the workshop area, while Fairy Knowe produced a range of specialist tools indicating a range of craft processes. Howe, by contrast, produced primarily knives, with few specialist tools, suggesting essentially domestic activities. It is harder as yet to present detailed regional comparanda, although the publication of the finds from Birnie, and the publication of doctoral research on the topic by Gemma Cruickshanks (2017), will assist with this in the longer term. The only other sizeable assemblage from the Moray Firth is Birnie, with over 150 objects, at the time of writing not yet studied in detail. Other published or recently excavated sites are notable for their lack of iron. There are no iron finds from Grantown Road,

Table 6.26
Material categories by context type; intact objects (left), fragmentary objects (right)

	Intact			Fragmentary		
Material category	**Deposits**	**Features**	**Ring-ditches**	**Deposits**	**Features**	**Ring-ditches**
Fixture/fitting	4	–	–	4	1	–
Nail/tack	2	3	–	5	3	–
Tool	8	1	3	8	5	1
Ornament	2	1	–	1	–	–
Weapon	–	3	–	–	–	–
Transport	–	1	–	–	–	–
Unidentified	–	–	–	21	11	–
Totals	**16**	**9**	**3**	**39**	**20**	**1**

Table 6.27

Find categories by structure. This includes, in the case of House 10/3 and Workshop 15, material from overlying deposits. Finds from features within the extent of the structures are counted with that structure, though it is not always clear that they are connected. Asterisked structures are those underneath or immediately adjacent to the industrial spreads. Spread F = features under industrial spreads. Other F = other features.

	House 4	**Workshop 6**	**House 7**	**House 9**	**House 10/3***	**Workshop 11***	**Workshop 12**	**Workshop 13***	**Workshop 15***	**Workshop 19 and Post-hole [2416]**	**Hearth 26***	**Cobbled surface 227**	**Other F**	**Spread F**	**Spreads**
Fixture/fitting	—	—	1	—	1	1	—	—	—	—	—	1	—	—	5
Nail/tack	—	—	—	1	1	1	—	—	1	—	1	—	1	—	7
Tool	2	—	—	1	3	5	—	—	—	—	1	1	2	2	9
Ornament	—	—	—	—	—	—	—	—	—	1	—	—	—	—	3
Weapon	—	1	1	—	—	—	—	—	—	1	—	—	—	—	—
Transport	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Ironworking - offcut	1	—	—	—	7	3	—	—	1	—	—	—	2	2	30
Ironworking - debris	—	—	—	—	1	—	—	—	—	—	—	—	—	—	5
Ironworking - stock iron	—	—	—	—	1	—	—	1	—	—	—	—	—	—	4
Ironworking - unfinished	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Unidentified	—	—	—	1	3	1	1	2	—	—	—	—	4	3	17
Total	3	1	2	3	18	11	1	3	2	2	2	2	9	7	85
Date bracket															
(95%)	AD 80–240	200 BC–AD 1	360–50 BC	360–120 BC	AD 30–230	90 BC–AD 90	110 BC–AD 70	40 BC–AD 130	40 BC–AD 120	160 BC–AD 60?	—	AD 130–340	—	—	350 BC–AD 90+

Table 6.28

Comparison of major Scottish Iron Age ironwork assemblages

	Culduthel	**Fairy Knowe**	**Mine Howe**	**Traprain**	**Howe**
Tool	27	13	11	76	2
Weapon	3	3	—	40	—
Transport	1	1	—	6	—
Ornament	4	2	1	2	5
Fixture & fitting, domestic	9	6	7	49	6
Nails	13	192+	9	'a great many'	30
Working evidence	63	—	4	—	12
Unidentified	32	30	25	68	63
Other	—	—	—	19	6
Total	**152**	***c*.250**	**57**	**260+**	**124**

Forres (despite smelting evidence from the site), Seafield West or Balloan Park, and only three fragments from Seafield West (M Cook, pers comm; Hunter 2011b; Wordsworth 1999). Similar sites further afield in the north-east are likewise sparse, with no iron from Romancamp Gate (Fochabers) or Wardend of Durris (Barclay 1993; Russell-White 1995). Even the large-scale excavations at Kintore produced no prehistoric iron finds (Hunter and Heald 2008).

This leads on to two key aspects in considering iron. One is the issue of survival. Most of the sites quoted as comparanda are plough-truncated cropmark sites. It is clear that the presence of surviving deposits is key to recovering good assemblages. Of the Culduthel ironwork, 77% came from deposits or ring-ditches and only 23% from features; even on this rich site, barely half of the roundhouses produced iron objects, and only well preserved House 10/3 produced more than three finds. As noted above, a significant number of finds from features are best seen as deliberate deposits, not accidental inclusions. They thus represent a highly partial sample of the iron in use. Coupled with the generally poor survival of iron in Scotland's acidic soils, this makes for a very limited picture of iron in the Iron Age. The rich assemblage from Culduthel is thus a highly significant assemblage. While survival is a key issue, chronology might also be important. It is notable, for instance, that the bulk of the Kintore sequence predates Culduthel (Cook and Dunbar 2008, 317–21). It seems that iron was genuinely rare (or at least restricted) for most of the Iron Age, with production only increasing in the last century or so BC. Thus, the large and sustained scale of production and use at Culduthel would represent the beginning of an iron-rich Iron Age. This is perhaps seen in the Moray Firth region by other production evidence, such as the furnaces and slag piles at Birnie, Clarkly Hill, and at two Forres sites, Grantown Road and Tarra (Will 1998b, 66; Cook 2003, 109; Cook 2008, 123; Cook 2010a, 124).

Conclusion

The Culduthel iron assemblage is of value not only for the light it casts on activities at the site, but as a fundamental reference point for future studies. This arises from the scale of the assemblage, with a variety of unusual and unique finds, and the fact that the material is well dated, with much of it late pre-Roman Iron Age in date. Clearly a wide range of crafts was practised, but the discovery of the tools themselves is all too rare. The extent of iron manufacturing evidence, from ore to artefact, is another rare opportunity, and metallographic work has shown the quality of the raw material being produced – medium-carbon or hyper-eutectoid steels. Other finds stress the status of the inhabitants, such as the daggers and linchpin; these are rare, and indicate a site of above-average importance.

Iron catalogue

Tools

SF082 Blade of a reaping hook; where it is broken the section is more rectangular, indicating it had a flat fitting (probably an open socket, the edges turned round to grip a handle) with the blade angled at *c*.45°. Slightly curved blade and edge, the latter angled a little up at the tip. A slight bend to the blade indicates it was damaged when deposited. This is a well-known Iron Age type that continued into the Roman period (Rees 1979, 450–5); something of the diversity of forms is illustrated in Rees (1979), figs. 189–171. L 99, W 23, T 5mm; 30.0g. See Table 6.24 for results of metallographic analysis. (225), deposit overlying cobbles [context 227]; context dated cal AD 130–340 (95%).

SF0195 Unidentified fine tool. Rectangular-sectioned bar, the tip broken. The tang tapers to a point with traces of a wooden handle surviving for 39mm. This suggests it was a fine handled tool such as a metal-decorating tool or an awl. L 58, section 4 × 3mm; 4.4g. (871), fill of ring ditch [context 1715], House 4. (Illus. 6.44)

SF0326 Awl. Circular-sectioned shank tapering to a fine point, the extreme tip lost; swells to retain a handle at about two-thirds of its length, above which is a rectangular-sectioned tang tapering to a rounded end. 74.5 × 4 × 4mm; 3.5g. (1681), post-abandonment deposit in area to east/south-east of House 10/3. (Illus. 6.44)

SF0334 Needle with flattened, diamond-shaped head and oval perforation (4.5 × 2.5mm); very end of tip lost, whole object slightly curved longitudinally. Its width suggests a role for textiles rather than leather. L 33, W 5.5, T 2mm; 0.6g. (1681), post-abandonment deposit in area to east/south-east of House 10/3. (Illus. 6.44)

SF0338 Miniature axe with long narrow blade expanding from the squared butt to the slightly down-turned tip. Swollen around the square perforation for the handle, slightly off-centre and countersunk on one side. Its size might suggest a toy or votive miniature, although known examples of these are in bronze. More plausibly it is a specialist tool for very fine work; its handle socket is very small, although the end of the handle may have been whittled to a peg to fit. L 73, W 16, T 10mm; 23.7g. (1671), post-abandonment/decay deposit overlying House 10/3 (thus post-AD 50–240). (Illus. 6.44)

SF0340a Tip of fine knife blade. Parallel-sided blade, the back angled to the slightly rounded tip. L 32.5, W 9.5, T 1.5mm; 1.6g. See Table 6.24 for results of metallographic analysis. (2102), spread of dark-brown silt with burnt clay, deposit in area to east/south-east of House 10/3.

SF0352 Blacksmith's set. Square-sectioned heavy shank tapering to a fine, slightly rounded chisel edge. The head is expanded and burred from striking; a channel on one side below the head is probably from manufacture. Its length indicates it was held with tongs rather than by hand, thus making it a set rather than a chisel (Manning 1985, 8–9). L 105, head 30 × 24, shank 22.5 × 14mm; 176.5g. (1896), occupation deposit in area to east/south-east of House 10/3. (Illus. 6.44)

SF0357 Fine tool – metalworking tracer? Rectangular-sectioned shank, one end (tang?) rounded, the other forming a symmetrical cutting edge affected by damage; thus its original form (and function) are unclear, although it is plausibly a tracer for chasing designs in non-ferrous metalwork (cf. Maryon 1938; 1971, 118–22; Lowery et al 1971, 173–4). 73 × 5 × 3.5mm; 3.5g.

(2100), abandonment phase associated with the industrial use of Workshop 11.

SF0366a Tool – punch? Rod with a blunt tip at one end and slight taper to the other, which is apparently rounded, although a corrosion bubble has destroyed it. Probably originally handled. L 66, D 5mm; 5.03g. (2155), main fill of ring-ditch [context 2215], House 10/3.

SF0371 Triple-toothed tanged tool, probably for creating slits in leather for stitching, based on analogy with modern tools. The rectangular-sectioned tang with a squared end expands into a broader, thinner head with three rounded teeth cut into the edge, the central one being largest; one is broken. This and SF1002 appear to be early versions of an enigmatic socketed type known in the early medieval period from Scotland, Ireland and Wales, whose function has been much discussed (Craw 1930, 117, fig. 5.7; Nicholson 1997, 425; Laing 1975, 296; Hencken 1938, 52–3; Redknap 2000, 83). Roles in textile production (in tensioning the cloth) or leather production have been suggested, inter alia. The latter seems most likely; a similar tool from the Iron Age site at Sorte Muld, Bornholm, Denmark was interpreted as a leather-decorating tool (Lund Hansen 2009, 87), and similar tools are used today for piercing leather to make regular rows of holes. The Culduthel examples suggest Scottish origins for the subsequent early medieval development of the type. L 46; shank L 34, section 5 × 4.5; head W 12.5mm; 4.6g. (2100), abandonment phase associated with the industrial use of Workshop 11 (*c*.60 BC–AD 90).

SF0372 Graver. The parallel-sided shank (a tapered rectangle in section) tapers asymmetrically in a concave curve to a strong tip, triangular in section as it survives. Below the head the shank swells, probably for a finger grip; there is then a short rectangular-sectioned length leading to a narrow mushroom-shaped head, the long axis of this upper section being perpendicular to the lower shank. The form is suited for gripping between the fingers; the form and fineness of the head indicates it is designed for striking gently, suggesting use as a graver for fine metalworking (for such tools, see Maryon 1971, 152–3; Lowery et al 1971, 172). L 66, shank 6 × 2.5 / 4.5 × 3.5, head 7 × 2.5mm; 3.5g. (2100), abandonment phase associated with the industrial use of Workshop 11.

SF0425 Fine tool, perhaps a point or scriber. Thin bent bar, one end tapering to a fine point, the other expanding to a rounded tip. The point could be seen as a tang, but the rounded tip is an unlikely working end, and it is more likely that this is a point or scriber for use on leather or fine metalwork, with the end blunted and expanded for comfort in the hand. The bends indicate it was no longer in use when deposited. L 83 (straight L 86.5), bar W 3–4, head W 5.5, T 3mm; 3.4g. (2152), fill of post-hole [context 2151], House 9. (Illus. 6.45)

SF0429 Blunt-tipped point with bone handle, probably an embossing tool. Square-sectioned bar with blunt, rounded tip, tapering to a rounded tang. Remains of a cylindrical bone handle leaves 18mm of the tip exposed. The handle implies a hand-held tool, perhaps an embossing tool for leather as it seems too short to apply the necessary pressure for use on metal. A small, curved iron bar fragment (7.5 × 2.5 × 2.5mm) is attached by corrosion, not part of the object. L 54, tool W 4.5, handle L 36.5, D 15mm; 8.7g. (2101), hillwash in area to east/south-east of House 10/3. (Illus. 6.45)

SF0509 Unidentified tool. Tang with remains of burred end to retain a handle; expands and thickens along its length, then flattens into a blade with sloping shoulders and rectangular section. The end is lost (and thus identity uncertain); it could be a fine tanged chisel, although the blade is rather thin; hints of a bevel at the broken end might indicate an asymmetrical edge, but could simply arise from damage. Another possibility is that it is a glassworking tool, used to roll heated glass beads to shape (cf. Lane and Campbell 2000, 164, illus. 4.76); again, too little survives to be certain. L 89; tang L 63, W 6, T 10; blade W 18.5, T 4mm; 25.1g. (2471), sandy deposit south west of stones [context 2456], in area to east/south-east of House 10/3. (Illus. 6.45)

SF0510 Balanced sickle, the tips of both the blade and the rectangular-sectioned tapering tang lost (the former was present upon excavation, but subsequently lost). Scattered organic traces (grass) are present across the blade. L 195; tang 57 × W 8–16 × T 5; blade W 35, T 3.5mm; 111.0g. (2232), fill of ring-ditch [2215] (2155), House 10/3 (AD 50–240). (Illus. 6.45)

SF0512 File with offset handle. The rectangular-sectioned parallel-sided blade tapers at the very end to a squared tip; no teeth survive, making it impossible to say whether it was for wood or metal, but the latter is more likely as the teeth are finer and more readily lost to corrosion. The handle (offset by 20mm) thins to a rounded tip, with vestigial traces of a bone handle; there are intermittent traces of other organics at various points. Such cranked handles are rare but not unknown in the Iron Age (Fell 1997, 90). L 176, blade L 128, W 14, T 7.5mm; 105.0g. (1715), fill of ring-ditch [context 1716], House 4 (AD 70–240). (Illus. 6.45)

SF0534 File. Short rectangular-sectioned tang with squared end, expanding gradually into a slender parallel-sided blade tapering to a pointed tip. Sub-rectangular section, sides angled, broader face rounded, narrow face flat, tip plano-convex in section. Only hints of teeth survive on the broad face (the narrow one is obscured by corrosion); teeth are also visible on the sides, slanting forward on one side and back on the other, spaced at around 12 per centimetre, which indicates use in metalworking. L 89, W 8, T 4, tang L *c*.15mm; 7.3g. (2542) fill of post-hole 2541 associated with Hearth 2434. (Illus. 6.45)

SF0540 Pair of fine snips. The two sinuous arms are held by an iron rivet; one arm lacks the handle end and is markedly thinner, with a flat section; the other is thicker with a rectangular section and rounded end. X-rays indicate a second rivet hole on this arm nearer the tip, suggesting a repair, perhaps with the thinner arm being a replacement. Such snips could be used in various crafts, from textiles or leatherworking to fine metalworking. L 46, W 10, T 6; intact arm W 5.5, T 3mm; 3.3g. (2435), sandy spread, possibly hillwash after abandonment, in area to east/south-east of House 10/3. (Illus. 6.46)

SF1001 Blacksmith's set. Square-sectioned bar, tapered slightly to a squared striking end; the expanded blade edge is slightly angled, perhaps from wear. Its shortness suggests it was held with tongs, and thus is best seen as a set rather than a chisel (Manning 1985, 8–9). L 83, shank W 13, blade W 18.5mm; 63.0g. Unstratified.

SF1002 Three-toothed tanged tool, probably for leatherworking. Rectangular-sectioned bar tapering to the broken tang tip; poorly preserved organics in the corrosion imply the former presence of a handle, the material unclear, which finished *c*.12mm short of the working edge. This is expanded, thinned and slightly convex, with two U-shaped slots defining three teeth, the outer two slightly sloping, the central one slightly rounded. See discussion under SF0371. L 58, W 16, T 5.5mm; 13.1g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), in area to east/south-east of House 10/3 (context 50 BC–AD 50). (Illus. 6.46)

SF1005 Tang. Fine rectangular-sectioned bar tapering gently to a rounded tip, the other end broken. Poorly preserved organics in the corrosion stem from a bone or antler handle. 54.5 × 5.5 × 4mm; 7.0g. (2731), fill of post-hole [2730] Hearth 2434.

SF1013 Tool, square-sectioned (and thus probably not an awl), tapering to fine point. Head lost. Perhaps a scriber, for fine metalworking? 41 × 3.5 × 3.5mm; 1.7g. (798), spread of industrial waste, in area to east/south-east of House 10/3.

SF1019 Fine triangular blade with a curved cutting edge and angled, broken tang or shank. The blade is plano-convex in section. Its form suggests a specialised use. Curved blades were used for leatherworking, but this is rather small. It is reminiscent of surgical implements, known in an Iron Age context from Denmark (Frölich 2003). L 23, W 13.5, T 4; tang 4 × 4mm; 2.7g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), in area to east/south-east of House 10/3 (*c*.50 BC–AD 50).

SF1196 Small knife blade, lacking tang; convex back and blade edge, rounded tip. L 52, W 16.5, T 4mm; 9.7g. (2191), possible waste deposit, Workshop 11.

SF1197 Possible blade tip with straight edge and curved back. L 25, W 17, T 3mm; 9.4g. (3741), fill of post-hole [3740], in area to east/south-east of House 10/3.

SF1206 Fine ?blade tip; near-flat lenticular section, rounded tip. 18.5 × 7 × 1mm; 0.2g. (3151), fill of post-hole [3150], Hearth 26.

SF1209 Knife tip, ?snapped/cut square. L 49, W 14, T 4.5mm; 9.2g. See Table 6.24 for results of metallographic analysis. (4286), fill of post-hole [4287].

(See also SF0450, an offcut of a knife blade.)

Weapons

SF0363 Short dagger. The square-sectioned tang with burred tip appears to hold a small square washer to retain an organic handle. It leads into a sloping-shouldered blade, originally with converging straight sides that taper more rapidly at the tip. Damage to one side has led to resharpening, creating a broad notch. Extensive brown corrosion on one side is probably from leather, suggesting it was deposited in a sheath. Any hilt guard must have been organic; no trace survives. L 236; tang L 82, W 9, T 6; washer 8 × 8 × 0.5; blade L 154, W 34.5, T 6mm; 72.0g. (1929), fill of post-hole [1898] within House 7 (360–50 BC; though not necessarily connected to this post-hole). (Illus. 6.46)

SF0479 Long dagger, much of tang lost in recent break, otherwise intact. The rectangular-sectioned tang expands gradually into the sloping shoulders of the lentoid-sectioned blade, its straight sides tapering gradually to the point. The blade has no midrib or other features. Occasional organic traces survive, rather amorphous and without any obvious regular pattern; there is no trace of any scabbard or handle. L 296; tang L 19, T 10, T 7; blade L 277, W 34, T 6.5mm; 122.1g. See Table 6.24 for results of metallographic analysis. (2416), fill of post-hole [2419] within (but not necessarily connected to) Workshop 19; placed vertically, point down, against post pipe (context dated 120 BC–AD 60). (Illus. 6.46)

SF1026 Spearhead, probably a light throwing spear. Split socket leads into a short, rounded ovoid blade with the tip and much of one side damaged; however, the curve of the intact side indicates that no more than 5mm was lost, and this would always have been a rather small stumpy spearhead. L 87; socket L 44, W 19, internal D 15; blade L 43, W 34, maximum width at *c*.44% of blade length; 39.5g. (1608), upper fill of post-hole [1607], Workshop 6 (structure dated 180 BC–AD 20).

Ornaments

Pins

SF0181 and **SF0182** Projecting ring-headed pin, in two non-joining fragments. The slightly oval head is formed from square-sectioned wire, leaving a teardrop opening; it is angled forward from the plane of the shank. Overall L 66; head H 14.5, W 13.5, T 3.5; shank D 3mm; 3.6g. (798), spread of industrial waste, in area to east/south-east of House 10/3. (Illus. 6.46)

SF0286 Pin shank fragment, circular-sectioned, broken at both ends. The narrower end preserves the beginning of a slight bend, perhaps at the tip. L 31.5, D 3mm; 1.2g. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3.

Hooked mounts

The two lentoid or diamond-shaped mounts from Culduthel can now be recognised as an established type, with a broad east/north-east Scottish distribution, and a related outlier from Roman Carlisle with a rounder profile and decorative notched edge. Their form indicates they are belt-hooks, with the leather clenched in the closed hook and the open hook acting as fastener. Parallels are known from Fairy Knowe (Stirlingshire), Shanzie (Perthshire), Clarkly Hill (Moray) and Carlisle in copper alloy, Traprain Law (E Lothian) in both copper alloy and iron, and Birnie (Moray) in iron (Hunter 1998a, 339, fig. 18 no. 48a; Coleman and Hunter 2002, 90, illus. 19.5; unpublished; McCarthy 1990, fig. 112 no. 64; Curle and Cree 1916, 120, fig. 34 no. 10; Cree 1923, 194, fig. 9; unpublished). They consistently show differences between the two arms, with one being flatter than the other, or shorter. Typically one is turned against or parallel to the plate to retain the leather belt, while the other forms a hook. Finds so far indicate a broadly Roman Iron Age date; the Culduthel examples support this, but with earlier origins; SF0285 comes from a late layer in the industrial area in area to east/south-east of House 10/3. (?1st–2nd century AD), but 504 came from a pit probably connected to Workshop 19 (120 BC–AD 60?).

SF0285 Belt hook. Narrow lentoid mount, the ends narrowed to points and turned under; one is broken at a 45° angle, suggesting use as a hook. The one that clasped round an organic object such as a strap gives a thickness of 3mm for this substrate. L 39, W 8.5, H 6mm; 1.8g. (1681), post-abandonment deposit, in area to east/south-east of House 10/3. (2nd century AD?). (Illus. 6.46)

SF0504 Belt hook. Narrow lentoid-shaped object with a central cylindrical perforation (D 3mm), presumably either for a more secure fastening or a more decorative fitting. The ends taper to blunt points and are turned back on themselves, one flattened against the rear, the other forming a hook. L 46.5m W 11, T 8mm; 2.5g. (2458), fill of pit [2457], Workshop 19. (Illus. 6.46)

Transport

SF0683 Linchpin. Rectangular-sectioned shank, the edges facetted to avoid damaging the wood, tapering to a blunt tip and expanding into a fan-shaped head; a square transverse perforation (W 5mm) immediately below the head is a recurring feature of linchpins, designed to retain a securing cord (Stead 1991, 46–7). Although the identification is secure, the form of the head is unusual; it may be related to crescentic-headed linchpins, a well-known Iron Age type (Manning 1985, fig. 72), but the only parallels known to the writer are a recently excavated example from Birnie, Moray (unpublished) and a previously unrecognised example from Hurly Hawkin, Angus (Henshall 1982, fig. 7 no. 38). This reflects our poor knowledge of northern vehicle gear, in the absence of a tradition of burials and hoards; another recent linchpin find, from Phantassie in East Lothian, was also a unique specimen (Hunter 2007f). L 132; head W 48, H 33; shank section 9 × 13.5mm; 76.5g. The hole is 86mm from the tip, allowing an axle diameter of some 70mm. (3633), postpipe of post-hole [3632], House 10/3 (AD 50–240). (Illus. 6.47)

Fixtures and fittings

SF086 Strapping fragment; rectangular-section bar, end squared and slightly rounded off, with a square perforation (W 5mm) near one end, the other broken. 64 × 24 × 5mm; 25.3g. See Table 6.24 for results of metallographic analysis. (255), fill of post-hole [254].

SF0178 Bolt head; circular section with slightly expanded, flattened sub-circular head. A deliberate cut through the shank implies reuse or repair. L 25; head D 14; shank D 10–11mm; 10.0g. (798), spread of industrial waste, in area to east/south-east of House 10/3. (Illus. 6.47)

SF0183 Holdfast. The tip of the square-headed nail is burred to hold a rectangular rove. This is notably and deliberately off-centre, suggesting it was intended to project, perhaps to retain something that was slotted in. Nail L 52, head 20.5 × 17.5, shank 5.5; rove 32 × 17 × 4; timber thickness 41mm; 22.3g. (798), spread of industrial waste, in area to east/south-east of House 10/3. (Illus. 6.47)

SF0290 Broken bar terminal with rounded tip and rectangular section. L 32, W 15, T 5mm; 9.4g. See Table 6.24 for results of metallographic analysis. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3.

SF0296 Short circular-sectioned bolt with a rounded tip and slightly domed, expanded sub-square head. L 24, head 14 × 12.5, shank D 8.5mm; 8.3g. (1679), cobble surface, in area to east/south-east of House 10/3. (Illus. 6.47)

SF0319 Holdfast. Sub-square-headed nail with rectangular rove held by head and the tip clenched to hold another, giving a wood thickness of 37mm. It is unusual to have a rove at the head as well as the tip. L 48.5; nail head 11.5, shank 6; roves 31.5 × 23 × 2 / 27.5 × 22 × 2.5mm; 22.3g. (1733), post-abandonment deposit, House 10/3. (Illus. 6.47)

SF0330 Strapping fragment. Flat lentoid-sectioned bar fragment, the ends broken, with a nail in situ (hexagonal head, most of shank lost). L 31, W 26, T 3.5mm; nail head W 8, shank W 4, L 6.5mm; 6.8g. (1835), fill of post-hole [1834], House 7.

SF0410 Broken ring, sub-square in section, notably flatter on one face. D 19.5, section D 4mm; 2.7g. (2100), abandonment phase associated with industrial use of Workshop 11.

SF0454 Slightly irregular diamond-shaped rove with central square hole for nail. L 33, W 22, T 3mm; 4.8g. (2130), cobbles 1945, in area to east/south-east of House 10/3. (Illus. 6.47)

SF1187 Strengthening bar? Flat rectangular-sectioned bar, ends broken, with a narrow perpendicular bar off one side and a square nail hole (W 7) at one fractured end. L 33, W 38, T 9mm; 50.2 g. (798), spread of industrial waste, in area to east/south-east of House 10/3.

(See also SF0748, offcut from a joiner's dog.)

Nails and tacks

SF0262 Headless nail, bent through 90° at a third of its length. Rectangular in section, tapering to the top and expanding gradually to the squared head end. L 43, W 4–5, T 2.5–3mm; 1.6g. (1616), upper fill of large pit [context 1615] W of House 4.

SF0282 Nail with slightly expanded thin square head, tip lost. L 26, head 8.5 × 7.5 × 1, shank 6 × 6.5mm; 3.5g. (1671), post-abandonment/decay deposit overlying House 10/3.

SF0289 Intact nail with a slightly domed sub-square head. Its excellent condition shows clear traces of the manufacturing method: the shank is parallel-sided immediately under the head from the action of the heading tool, and then tapers to a point. L 57, head 17 × 14 × 5, shank W 10mm; 23.9g. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3. (Illus. 6.47)

SF0320 Nail, lacking tip; small flat square head. L 36, head W 11, shank W 8mm; 5.4g. (1777), overburden, in area to east/south-east of House 10/3.

SF0342a Small square-headed tack with circular-sectioned shank, the tip broken. L 20, head 4.5 × 5, shank D 2.5mm; 0.8g. (1861), fill of post-hole [1860], House 9.

SF0383 Rectangular-sectioned tack with slightly expanded head, the sides near-parallel with an angled tip. L 27, W 7, T 4mm; 1.9g. (2101), hillwash, in area to east/south-east of House 10/3.

SF0407 Nail, much of head spalled off, tip broken at bend. L 50, head 9, shank 5.5mm; 4.7g. (2100), abandonment deposits associated with industrial use of Workshop 11.

SF0487 Bent headless nail. 51.5 × 5 × 5mm; 4.4g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), Area D.

SF0629 Fine nail, rectangular section, off-centre slightly expanded irregular rectangular head. L 31, head 4.5 × 7.5, shank 4 × 3mm; 1.3g. (3153), fill of post-hole [3152], Hearth 26.

SF0719 Bent nail fragment (shank and tip). L 34.5, W 7mm, 7.7g. (1945), cobbled surface outside House 10/3.

SF1210 Small tack with sub-square head and tapering shank; wood remains imply it was deposited still within a wooden item. L 21, head 6 × 5, shank W 3mm; 0.7g. (4108), fill of post-hole [4107].

SF1211 Small tack, lacking head; wood remains imply deposition within a wooden object. 16.5 × 4 × 3mm; 0.6g. (4108), fill of post-hole [4107].

SF1212 Broken fine bar or tack, the head lost and the tip bent, with vestigial wood remains implying deposition within a wooden item. 19 × 4.5 × 2mm; 0.3g. (4108), fill of post-hole [4107].

Ironworking debris

Unfinished items

SF0287 Irregular flat object in a sinuous W-form with a pronounced central bulge and lentoid section. Apparently complete (one end rounded, other pointed), but function unclear – probably unfinished. L 50, W 17.5, T 2mm; 3.4g. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3. (Illus. 6.48)

SF0294 Unfinished object? Complete item with short square-sectioned shank (the end burred) expanding and thinning into a broad semi-circular head with a slight central stub, perhaps where it was cut from a bar. L 37.5, W 21, T 4mm; 5.4g. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3.

SF0358a Bar with slightly rounded end, expanded and rounded at the other. Apparently complete, but not an obvious object type, suggesting it is an unfinished roughout. 61 × 33 × 17mm; 8.6g. (2101), hillwash, in area to east/south-east of House 10/3. (Illus. 6.48)

SF0435 Unfinished object or offcut. Part-formed ?nail with bent irregular square-sectioned shank and flat expanded head in the same plane; surface poorly consolidated. 32 × 18 × 7mm; 6.8g. See Table 6.24 for results of metallographic analysis. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), context 2187, in area to east/south-east of House 10/3. (Illus. 6.48)

SF0522 Unfinished fitting. Two joining fragments of an irregular lentoid-sectioned slightly tapering bar. One rounded end has an oval perforation (15 × 11mm); the other is irregularly squared. Its spongy texture implies it was bloom-smithed. One edge is quite straight but the other is irregular; this and the porosity suggest it is unfinished. Porous glassy slag is attached to one face. L 123, W 46, T 7mm; 144.8g. (2477), remains of turf wall, House 10/3. (Illus. 6.48)

Stock iron (bars etc.)

SF0340c Fine square-sectioned bar, one end squared, other slightly rounded. Stock iron? L 110, W 4.5, T 4mm; 8.7g. (2102), spread of dark-brown silt with burnt clay, in area to east/south-east of House 10/3.

SF0366b Fine bar, slightly facetted circular section, ends slightly rounded. Stock iron? L 55, D 3mm; 2.5g. (2155), main fill of ring-ditch [2215], Structure 10, Area D.

SF0385 Small bar, the section a slightly tapered rectangle; ends cut square. Probably stock iron. 45 × 10.5 × 5mm; 8.62g. (2101), hillwash, in area to east/south-east of House 10/3.

SF0531 Short rod, apparently intact, with rounded ends. Stock iron? L 22.5, D 4.5mm; 1.2g. (2495), occupation deposits, in area to east/south-east of House 10/3.

SF0728 Ingot fragment. Corner broken from a slightly spongy mass, flat on one face, edge and base irregularly curved. 44 × 41.5 × 30mm; 87.5g. (3467), ash fill of furnace [3790].

Offcuts

The catalogue covers selected pieces only; for summary details of the distribution of all offcuts, see Table 6.27. Note also SF0178 in fixtures and fittings, a bolt head that may have been cut off to reuse the body of the bolt. Bloom offcuts are considered in the section on slag.

SF0177 Offcut? Slightly irregular tapered strip, one end thinned and cut in two angled facets; a small protruding tongue is probably an artifact of the cutting. The other end is cut near-square, again in two slightly angled cuts. L 29, W 16, T 3.5mm; 3.9g. (798) spread of industrial waste, in area to east/south-east of House 10/3.

SF0188 Offcut. End of flat bar, the corners cut at an angle; cut square, with flashing in one area. 20 × 19 × 3.5mm; 3.9g. See Table 6.24 for results of metallographic analysis. (775), upper fill of ring-ditch, House 4.

SF0291 Offcut. Flat bar terminal; squared end with rounded corners and lentoid section. Slightly curving cut across its width. L 25, W 27, T 3.5mm; 6.2g. (1681), post-abandonment deposit in area to east/south-east of House 10/3.

SF0340b Offcut from end of fine rectangular-sectioned bar, slightly tapered and rounded tip. L 16.5m W 4.5, T 3mm; 1.1g.

(2102), spread of dark-brown silt with burnt clay, in area to east/south-east of House 10/3.

SF0393 Offcut. Rounded bar tip, sub-rectangular in section, cut at one end with the side irregular and flared from striking. Bar L 20, W 13, T 6; max W 29mm; 6.6g. (2101), hillwash, in area to east/south-east of House 10/3.

SF0395 Offcut? Very irregular thick, flat sub-triangular fragment; protrusion from one corner, one side with stepped cuts from a narrow chisel. Perhaps the end of a bar, the corner drawn out to hold it before cutting it off. L 53, W 42, T 9mm; 40.8g. (2101), hillwash, in area to east/south-east of House 10/3.

SF0408 Offcut from a fine square-sectioned bar, the tip drawn out and curved, perhaps from gripping it. 26 × 4 × 4mm; 1.4g. (2100), abandonment deposits associated with industrial use of Workshop 11.

SF0414 Offcut. Slightly irregular, rounded end of a fine, rectangular-sectioned strip. 21 × 4 × 2.5mm; 0.7g. Hearth 2166.

SF0430 Offcut? Short square-sectioned rod, flared and flattened at broken end, with a longitudinal slit created by cutting from each side; no sign of finishing. L 20, W 9, T 2mm; 7.3g. (2101), hillwash, in area to east/south-east of House 10/3.

SF0434a Offcut – perhaps an unsuccessful decorative terminal. Square-sectioned bar, cut at one end, the other branched with the surviving branch thinned and turned into a twist. The other branch is lost in an old break, suggesting this was a decorative terminal that was cut off and discarded after one branch broke. 16 × 13.5 × 10; bar 4 × 4.5, branch 2.5 × 1.5 (4.5 × 1.2mm at tip); 1.6g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), in area to east/south-east of House 10/3.

SF0434b Cylindrical rod tapering to a lost point, other end cut square; a slight lip shows it was not struck and thus is not a punch. Perhaps a peg or bolt, or alternatively an offcut. L 25, D 6mm; 3.2g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), in area to east/south-east of House 10/3.

SF0450 Offcut, probably from a bent knife blade. Asymmetrical U-shaped fragment, triangular in section; one end curves steeply to the tip, the other is cut square. The symmetry implies this is an offcut rather than a clamp or mount. The section indicates it is the end of a narrow parallel-sided knife blade; this form could arise from gripping the end in tongs and bending it for a secure grip while the remainder of the blade was cut off. L 14.5 (unbent L 31.5), H 11, T 2mm; 3.6g. (2130), deposit of stones, in area to east/south-east of House 10/3.

SF0748 Offcut, probably from a joiner's dog. L-shaped object as it survives, the longer arm tapering gradually along its length, the short stubby one tapering in section. The form suggests the long arm was inserted into ?wood (to a depth of 20mm), with the short arm part of the body of the clamp. Probably cut off to reuse the rest of the clamp. 31 × 10 × 14mm; 7.6g. (3113), occupation deposit, House 10/3.

SF1018 Offcut, cut square across the terminal of a tapering square-ended bar; flat section with tapered edges and shallow, broad hollow on one face. L 16, W 15, T 3.5mm; 2.6g. (2187), silty deposit underlying hillwash (2101) and dump of fire-cracked stones (2186), in area to east/south-east of House 10/3.

SF1200 Offcut, circular-sectioned rod bent into a triangle (probably to get a grip with the tongs) and then cut off. 19 × 11 × D 3.5mm; 1.1g. The gap in the triangle shows the tong tip was no more than 6mm wide. (2191), possible waste deposit, Workshop 11.

Working waste

SF0199 Working debris. Irregular cylinder, part-forged and consolidated, with possible tong marks on one side, the ends irregular, perhaps burnt in the forge from over-heating. 36 × 14.5 × 11mm; 14.0g. (798), spread of industrial waste, in area to east/south-east of House 10/3.

SF0203 Irregular triangular fragment, slightly curved, with sub-rectangular section. Two ?original tapered edges, the third broken. May be working waste. 18 × 16.5 × 4.5mm; 3.0g. (798), spread of industrial waste, in area to east/south-east of House 10/3.

SF0345 Irregular sub-square object, one side flat, the other slightly raised, with a protruding off-centre fine square-sectioned stub. Its form implies it was hammered against something, and it may be the debris from making fine rods. 24.5 × 19 × 6.5mm; 4.2g. (1681), post-abandonment deposit in industrial area, in area to east/south-east of House 10/3.

SF0453 Irregular pentagonal fragment, surface uneven; working debris? 24 × 19.5 × 11mm; 8.3g. (2130), deposit of stones, in area to east/south-east of House 10/3.

SF0497 Very irregular amorphous fragment, probably working debris (cf. SF0488 and SF0724). 34 × 14.5 × 13.5; 12.0g. (2232), fill of ring-ditch [2719], Structure 10, Area D

SF1191 Working debris? Rectangular-sectioned rectangular irregular fragment with a deep irregular tear on one side; probably split during working, leading to it being cut off and discarded. L 72, W 32, T 10mm. (1680), dumped deposit, in area to east/south-east of House 10/3.

Copper alloys and coins

The copper alloy finds

Fraser Hunter with Roman coins by Nick Holmes and scientific analysis by Susanna Kirk and Jim Tate

The copper alloy assemblage comprises 21 objects and 20 fragments (36.2g) of casting debris. Post-medieval material was also recovered (in archive report): three items (one of pewter) from 798 (upper spread overlying industrial area by House 10/3), and two from 225 (dark deposit over cobbles 227). Table 6.29 summarises the objects by function and findspot. The assemblage includes some highly significant items: an unfinished and unusual decorated harness strap mount, a decorated sword hilt guard (the first from the area), and a Romano-British brooch (Illus. 6.50).

Table 6.29
Summary of copper alloy assemblage by functional category and context

Functional category	Area to east and south-east of House 10/3	House 10/3 use	House 10/3 abandonment	House 4	Workshop 15	Workshop 16	House 17
Ornament (4)	–	–	278 brooch 318 strap mount 368 pin	–	–	1027 toggle	–
Weapon (1)	483 hilt	–	–	–	–	–	–
Vessel/fitting (3)	–	–	313 ring	173b vessel frag 232 ?mount	–	–	–
Sheetwork (2)	1240 rivet	–	–	241 offcut	–	–	–
Casting (21)	333 failed casting 34.1g debris	–	–	–	–	0.1g	2.0g
Roughouts etc. (3)	1246 rod offcut	–	–	173a stock metal	844 bar	–	–
Other (7)	1241	405, 503 Roman coins	311 (?intrusive)	231a strip 231b sheet	–	1236	–

The bulk of the finds consists of casting debris from the industrial area by House 10; the remainder is fragments of various fittings and fastenings, including a patch from a sheet vessel, and fragments of sheetworking debris, with two further decorated items, a toggle and a projecting ring-headed pin. Further detail is provided in the catalogue at the end of this section.

Harness strap mount

The cruciform harness strap mount SF0318 (Illus. 6.50 and 6.51) is a rare and remarkable find. It is decorated with small geometric cells intended for enamel: trumpet-related shapes and bosses, typical of British Celtic art of the first two centuries AD. Such objects, although decorated in indigenous styles, continued into the Roman period, and this is emphatically confirmed by the 2nd century AD date for this piece (it overlies a layer containing a Trajanic coin of AD 112–14). The general type is familiar, but no precise parallels are known to the writer; this is quite typical for the better-quality pieces of Celtic art, as each would be made individually, the craftworker creating the piece from their knowledge of styles and parallels. It falls into MacGregor's (1976, 33–4) category of petal- or cruciform-shaped strap junctions and mounts (mounts have only a single bar on the rear, while junctions have two). Her analysis and later work by Taylor and Brailsford (1985) remain the main published studies, although there have been many subsequent finds. The type can be split into two on decorative grounds, one with relief boss-and-trumpet ornament, the other with enamelled cells and relief trumpet-based patterns; Culduthel falls into the latter. This division reflects a more general split in the Celtic art of central Britain into two main casting traditions (MacGregor 1976, 184; Hunter 2007a, 289–93). The four-armed form shows a range from four (or even six) petals through alternating petals and rectangular arms to the cruciform style of Culduthel. Cruciforms are notably rare; only two others are known to this author, both from Traprain Law (MacGregor 1976, nos 28 and 29, the latter probably unfinished). When MacGregor was writing, the distribution lay between Tyne and Forth, with one or two outliers in East Anglia and two unprovenanced examples. Table 6.30 lists examples known to the writer, showing the expansion of the distribution in the last 25 years. The boss-and-trumpet style remains a central British phenomenon, from Humber to Forth. The enamelled examples are more widespread, from the Moray Firth to the Severn, although two of the nine known examples are unprovenanced.

What is most striking with Culduthel is that the piece is clearly unfinished; the slot for the strap on the rear has not been cleaned out after casting, and the enamelled cells are crisp but with no traces of enamel. There can be no real doubt that it was made on site. This requires a major rethink of views of Celtic art in this area. The art of the first two centuries AD in Scotland is characterised by different regional traditions: massive metalwork in the north-east, and central British metalwork (itself in different styles) from the Forth to the Humber (MacGregor 1976; Hunter 2007a, 290–2, fig. 2). Recent metal-detecting and excavation finds have revealed a thin scatter of this central British material and other apparently exotic finds in the north-east, which have been interpreted as evidence of contacts to the south (Hunter 2006a, 151–7). It now seems that some of the enamelled styles were being produced locally, alongside the more typical 'massive' tradition; there is an emerging distinction between more personal items such as jewellery, made in local styles, and other material such as horse harnesses, which marked affiliations to wider traditions (Hunter 2014a, 333).

The hilt guard

The hilt guard SF0483 (Illus. 6.50 and 6.52) is another find that shakes our preconceptions. The standard work on Iron Age swords shows nothing north of the Forth (Stead 2006, fig. 1), although Iron Age-style finds from Roman sites extend this into

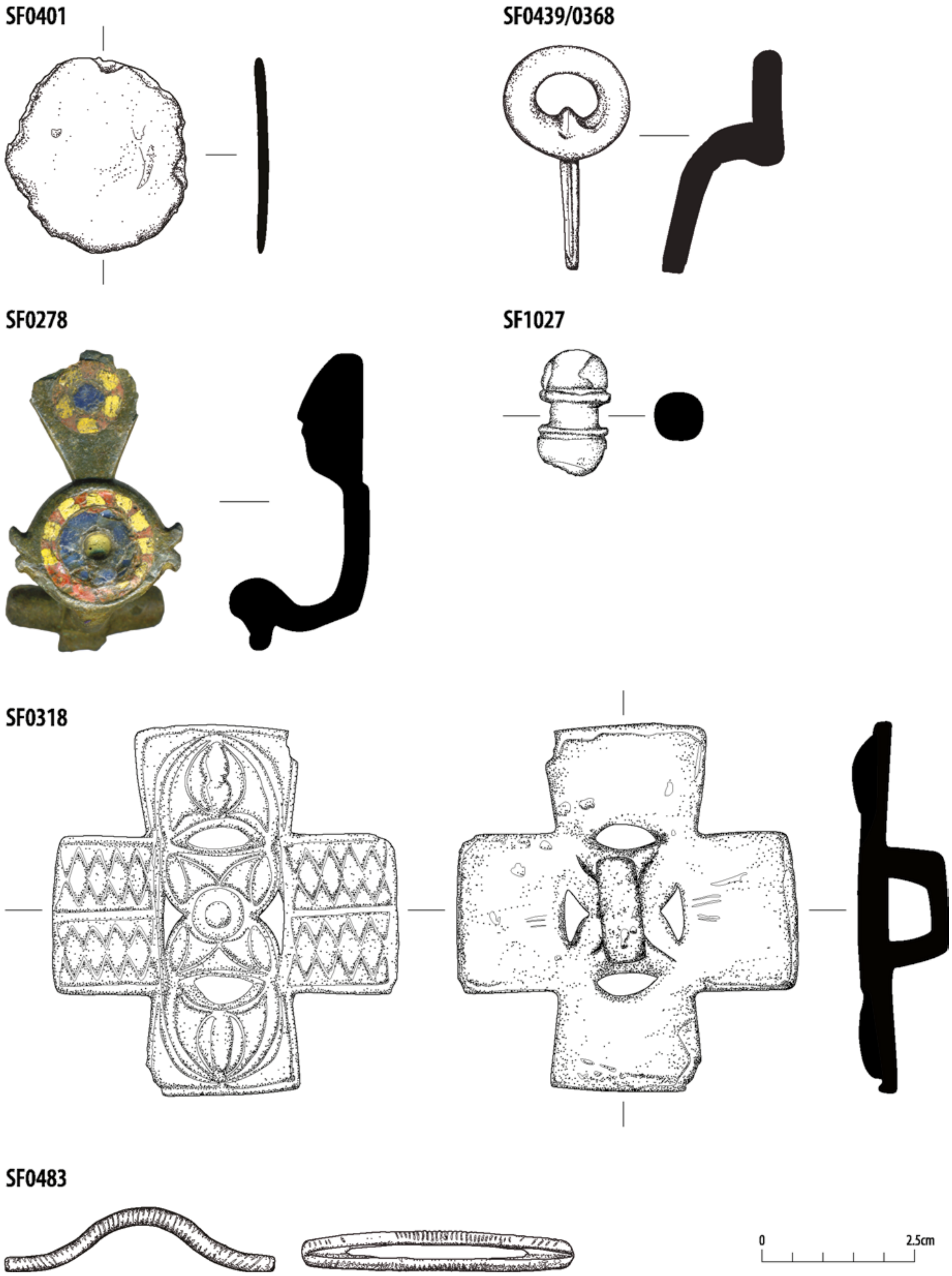


Illustration 6.50
Copper-alloy artefacts

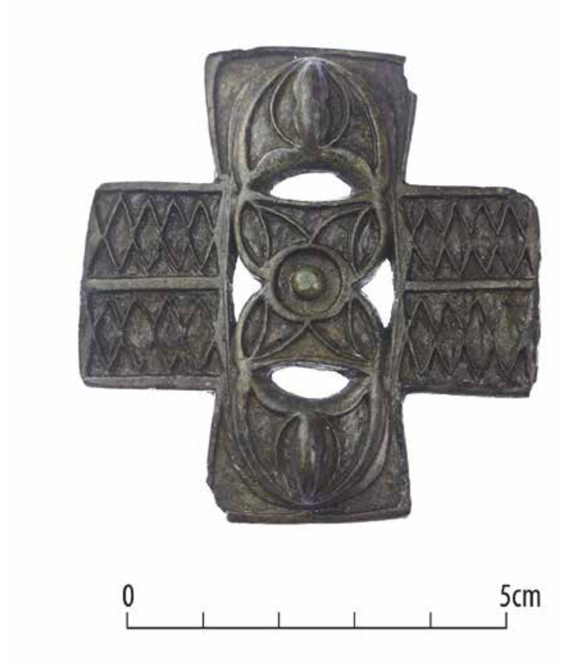


Illustration 6.51
Harness strap mount

Illustration 6.52
Sword hilt guard

Perthshire (Piggott 1950, fig. 12; Hunter 2006b, 82–3). Existing distributions are radically shifted by the two iron daggers from Culduthel, a fragmentary sword from Birnie (unpublished), a long-overlooked sword fragment from Laws of Monifieth, Angus (with campanulate shoulders; Anon 1892, 241; NMS GN 41), and this hilt guard. Its blade width (43mm) suggests it was for a sword rather than a dagger. The campanulate style is typical of the pre-Roman Iron Age (Stead's type vi; 2006, 13, 15, 17, 58–9, 68–9), and this is confirmed by the contextual date, which predates 90 cal BC–cal AD 90; given that the hilt guard was worn when deposited, it is most likely of 2nd–1st century BC date in origin. Similar campanulate hilt guards and matching scabbards are known in southern Scotland, from Bargany, Ayrshire (scabbard), Stevenston Sands, Ayrshire (iron), Ashkirkshiel, Selkirkshire (bronze), and Marshill, Alloa, Clackmannanshire (bronze; Stead 2006, nos 182, 192–3, A283; MacGregor 1976, nos 139–40; *Proc Soc Antiq Scot* 103 (1970–1), 19, fig. 1). Of these, only Ashkirkshiel is decorated (with a sinuous groove), but ornamented hilt guards are found in southern Britain (e.g. Stead 2006, figs. 64–6, 69, 92, 96 no. 191), often echoing decoration at the scabbard mouth. Hilt guards from Orton Meadows (Cambridgeshire) and Battersea (London) show notching similar to Culduthel, albeit on iron guards and on one side only (Stead 2006, fig. 57).

Although this is the first hilt guard from northern Scotland, the overall rarity of such finds makes it foolhardy to suggest this must be a southern import, especially with the cautionary tale of the unfinished strap mount in our mind; our evidence base is exceedingly sparse. It is a valuable reminder that this area was drawing on styles common across Iron Age Britain. Wear on the decoration shows it had seen extensive use; its location, as a single find in the industrial area by House 10, might suggest a weapon that had been dismantled in order to be re-hilted.

Other decorative metalwork

The other two indigenous decorative finds are both more common types. Projecting ring-headed pins were a long-lived 'type-fossil' of the Scottish Iron Age (Clarke 1971, 28–32). Cast examples are thought to start later than wire-made ones, though their currency overlaps (Stevenson 1955, 288; Campbell 1998, 168–9); the Roman-influenced alloy type of this example (SF0368/0439 – Illus. 6.50 and Illus. 6.53) and the 2nd century AD date for its context confirm this. This is reflected in its decorative qualities, unknown in the wire examples – a keel on the ring where the pin articulates evokes a trumpet design typical of Celtic art. Similar mouldings (often less clearly defined swellings) are found on other examples (e.g. Ness (Caithness); Fast Castle (Berwickshire); Smith 1925, fig. 110; Hunter 2001a). The

Illustration 6.53
Projected ring-headed pin

Table 6.30
Petal and cruciform strap mounts and junctions known to the writer

Findspot	Type	Context / date	Reference
ENAMELLED			
Culduthel, Inverness-shire	Cruciform mount; unfinished	Iron Age settlement (C2)	This chapter
Culbokie, Ross-shire	Enamelled ?cruciform mount or junction	Stray	DES 2010 (forthcoming)
Traprain Law, East Lothian	Cruciform mount (unfinished?)	Iron Age settlement	MacGregor 1976, no. 29
Glenlochar, Kirkcudbrightshire	Petal mount	Roman fort (late C1–mid C2)	Dumfries Museum 83.46.1
Middlebie, Dumfriesshire	Petal junction	Hoard of horse harness	MacGregor 1976, no. 22
Saham Toney, Norfolk	Petal junction	Hoard of horse harness	MacGregor 1976, fig. 1 Taylor & Brailsford 1985, 267, fig. 15 no. 53
South Cerney, Gloucestershire	Petal junction	Stray	*Chris Rudd List* 32, 1998, no. 30
Unprovenanced (British Museum)	Petal junction, curvilinear decoration	?	Taylor & Brailsford 1985, no. 44
Unprovenanced (Uffizi)	Petal junction	?	Kemble 1863, 194–5, pl XIX, 5
BOSS AND TRUMPET STYLE			
Traprain Law, East Lothian	Six-arm petal junction	Iron Age settlement	MacGregor 1976, no. 26
Traprain Law, East Lothian	Petal mount	Iron Age settlement	MacGregor 1976, no. 27
Traprain Law, East Lothian	Cruciform mount with openwork centre	Iron Age settlement	MacGregor 1976, no. 28
Kinneil, West Lothian	Openwork petal and rectangle junction	Roman fortlet (mid C2)	Webster 1996
Newstead, Roxburghshire	Petal and rectangle junction	Roman fort (late C1–C2)	MacGregor 1976, no. 24
Newstead, Roxburghshire	Petal junction	Roman fort (late C1–C2)	MacGregor 1976, no. 25
Ward Law, Dumfriesshire	Openwork petal junction, enamelled rings	?Roman camp	DES 2007, 60
Middlebie, Dumfriesshire	Petal and paired circle junction	Hoard of horse harness	MacGregor 1976, no. 23
Burnswark, Dumfriesshire	Petal mount	Iron Age settlement	Jobey 1978, fig. 14, 3,
Burnside, Gribton, Dumfriesshire	Quadrilobate mount with rounded arms	Stray	DES 2010 (forthcoming)
Corbridge, Northumberland	Openwork petal junction	Roman fort	MacGregor 1976, no. 21
Malton, Yorkshire	Petal and rectangle mount	Roman fort *vicus* (C2)	Lloyd-Morgan 1997, 133–4, fig. 50 no. 6
South Keveston, Lincolnshire	Petal mount	Stray	Portable Antiquities Scheme NLM4198; Bonhams *Antiquities*, 26.10.07, Lot 260

Illustration 6.54
Dumb-bell toggle

type went on to more decorative development in the following centuries, and later examples from along the Moray coast at Covesea, Birnie and Urquhart suggest this was an innovative area (Benton 1931, fig. 16; unpublished; Treasure Trove TT 51/10).

The well modelled dumb-bell toggle (SF1027 – Illus. 6.50 and Illus. 6.54) is a type found widely in copper alloy, bone and glass, in both Iron Age and Roman contexts (MacGregor 1976, 134, fig. 18 nos 13–19); indeed, there is a glass example from the site. MacGregor suggests a Tyne-Forth distribution, but the type is more far-flung; for instance, there are local parallels in metal-detecting finds from Garguston (Muir of Ord) about 10km to the WNW, and Urquhart, some 60km E (Hunter 2009a, 126; 2014b, 109–10).

Roman finds

Three copper alloy finds show contact with the Roman world – two (perhaps three) coins (Holmes, below) and a brooch – while the evidence of alloys used in manufacturing other objects shows some further Roman influence, in the recycling of Roman objects for raw material, as discussed below. The brooch (SF0278 – Illus. 6.50) is a disc and fantail type (Hull's type 163; Bayley and Butcher 2004, 169, fig. 143). It is a substantial and striking example, decorated with three different colours of enamel. There was a preference among indigenous societies for brooches that either mirrored local tastes in metalwork (often enamelled, and with locally favoured motifs such as trumpets) or were clearly unusual and highly decorative (Hunter 2001b, 300–1). This brooch fits into the former category, its enamelled decoration and form (such as the decorative lips) fitting local tastes, and yet at the same time being a clear symbol of contacts with Rome. The type is rare in indigenous contexts; the only other examples are from a wheelhouse at Kilphedir, S Uist (Lethbridge 1952, 182–3, fig. 4 no. 1), the hillfort of Traprain Law, East Lothian (Cree 1924, 251, fig. 9.1; Burley 1956, 161, no. 49), and stray finds from Kinneswood and Kinnaird, Perth and Kinross (Hunter 2009b, 157; Hunter 2014c, 169). Roman finds from the Moray Firth area have increased greatly in recent years from excavation and metal-detecting, and it is clear there was considerable contact with the Roman world; brooches were one of the most favoured items (Hunter 2007a, Appendix 3). In the immediate environs of Culduthel, there are stray finds of an early Aucissa type (pre-Flavian) from Dores and an enamelled trumpet brooch from Torbreck, a headstud brooch from an earlier ritual site at Stoneyfield, Raigmore, and two brooches (headstud and Polden Hill) from the Iron Age site of Seafield West (Robertson 1970, 222, fig. 10, 1; Hunter 2008a, 108; Mackreth 1996; Hunter 2011b).

The Roman coins

Nick Holmes and Fraser Hunter

Two certain and one possible Roman coin all come from House 10/3 (SF0401, SF0405 and SF0503). SF0401(Illus. 6.50 and 6.55) a possible sestertius, SF0405 a Trajan sestertius (AD 112–14); SF0503 (Illus. 6.56) a As, uncertain emperor, possibly Domitian (AD 81–96). SF0401 and SF0503 are from the same deposit in different areas of the ring ditch, and SF0405 is from a later layer but spatially close (2164 is later stratigraphically but spatially close enough to be considered relatively contemporary with 2155).

The coin of Trajan, in this condition, conforms precisely to what would be expected in primary contexts on an early Antonine Roman military site, such as an Antonine Wall fort. If the *As* is indeed Domitian, this could of course indicate pre-Antonine contact between the inhabitants of the Culduthel settlement and the Roman army, but Flavian copper alloy coins have occasionally been recovered from Antonine Wall forts, so this is really entirely inconclusive. A 2nd century date of deposition is suggested by their context: both come from the final phase in House 10 (and thus constrain the range of the single C14 date of cal AD 30–230 (SUREC-30397).

Illustration 6.55
Roman coin (SF0401)

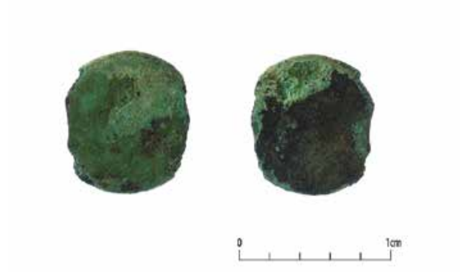


Illustration 6.56
Roman coin (SF0503)

These copper alloy Roman coins (two certain, one too worn for certain identification) are an unusual find. These were always uncommon on indigenous sites, silver ones being proportionally more common compared to Roman sites (Robertson 1975, 418). This difference from Roman practice reflects the role of the coins – these were not part of a circulating coin economy that needed small change. The higher-value metal was more sought after, as shown by the silver coin hoards from the area, best seen as a form of prestige good or special-purpose/socially useful money (Hunter 2007c). Yet the bronze coins deserve explanation. Using data from the regular roundups in the *Proceedings of the Society of Antiquaries of Scotland* (Bateson and Holmes 2006, with earlier references; Robertson 1983 summarises finds to that date), and considering only finds pre-dating the devaluation of the *denarius* in AD 238, some 36 indigenous sites in Scotland have Roman coins as single finds rather than hoards: 11 have silver only, 19 bronze only, and seven have both. With the exception only of Traprain Law (Sekulla 1982), these coins occur in very small numbers. Turning to the area north of the Forth, it is notable how many of the sites with bronze coins are those otherwise defined as higher status, notably several of the Angus and Stirling brochs (Leckie, Hurly Hawkin, Fairy Knowe), and on the north-east littoral, sites like Birnie as well as Culduthel. This supports the view that richer sites had access to a wider range of Roman material culture, only some of which was passed on to other sites (Hunter 2001b, 297).

It is unclear what use was made of these bronze coins. They may simply have been valued as a source of raw material (as was probably the case with the hoard from Longhorsley, Northumberland, found with a casting sprue; Abdy 2003), but they might have had rather more social significance. It is noteworthy that the three coins from Culduthel were found close together, at the rear

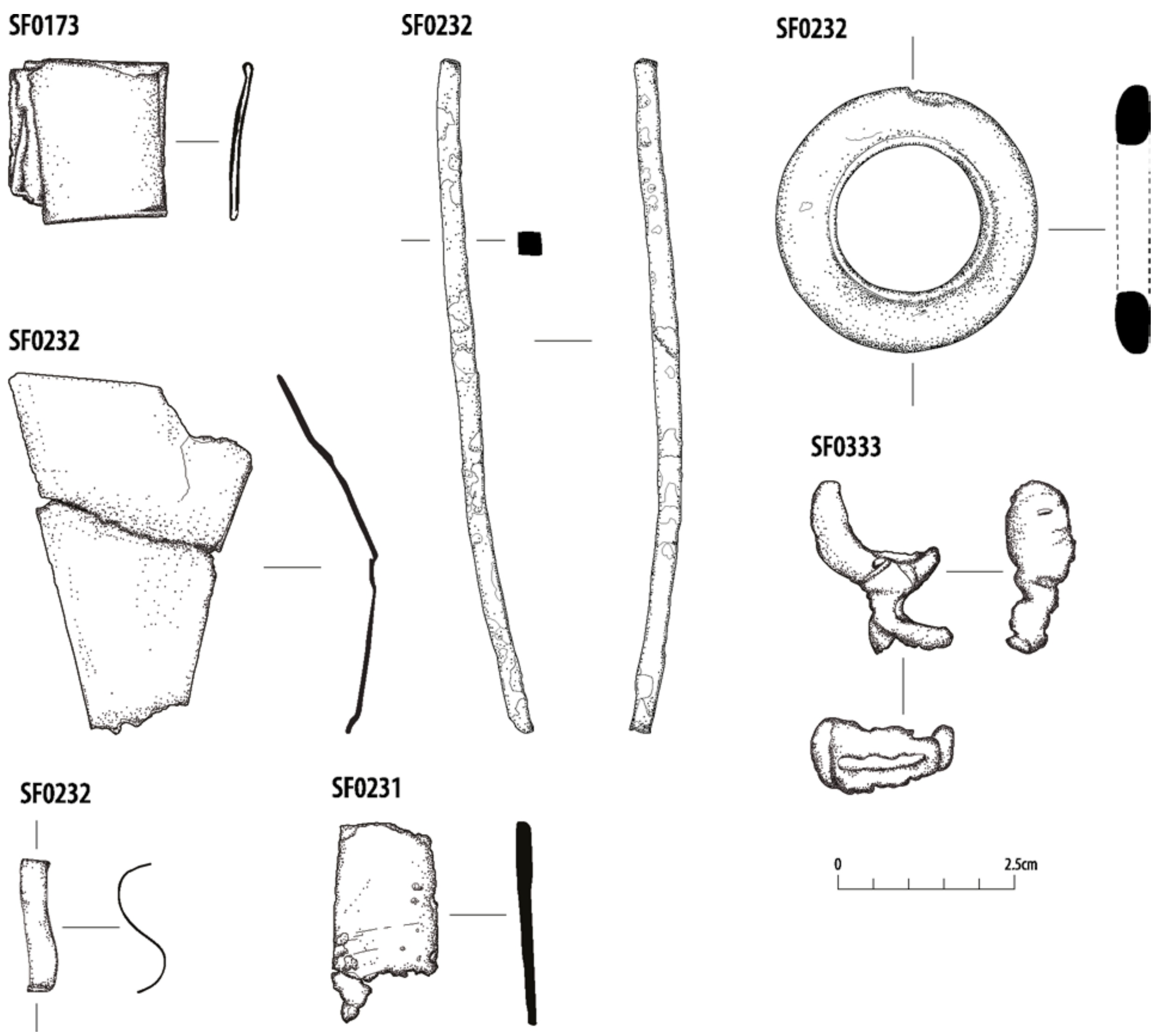


Illustration 6.57
Copper-alloy artefacts

entry of the ring-ditch in House 10/3 in its last phase; they could be seen as deliberate deposits in the building upon abandonment, perhaps even a small scattered hoard. This indicates they were perceived as having a social value. Likewise, the settlement site at Clarkly Hill, near Burghead, produced a hoard of bronze coins of Antonine date as well as a late 2nd century *denarius* hoard (Chapman et al 2009, 225); there was clearly a perceived value to Roman bronze coins, at least among some people. Future work might usefully compare and contrast the evidence of denominations and dates, but for the moment, the Culduthel coins remain locally unusual.

Other finds and manufacturing evidence

The other finds are mostly rather fragmentary, and thus hard to identify, but include pieces of a sheet copper alloy vessel (SF0173b – Illus. 6.57) and an enigmatic ring fitting (SF0313), its role unclear. There is also a notable quantity of casting debris, with one larger failed casting (SF0333 – Illus. 6.57) and 20 small fragments (36g) of casting waste, mostly droplets or nodules spilled from moulds. This is all from the industrial area by House 10, apart from two single fragments that are best seen as secondary dispersals from the core production area (analogous to the single crucible fragments found elsewhere). A bar (SF0844) from adjacent Workshop 15 may point to some non-ferrous metalworking in this structure too. The industrial area by House 10 has no certain evidence of sheetworking; there is only a single, used rivet. The certain sheetworking evidence all comes from the ring-ditch of House 4; indeed, all the items from this building could be interpreted as the residue of sheetworking, but it is a tight concentration rather than a spread, suggesting a scientific analysis rather than the dispersal of working debris.

The alloys

Susanna Kirk, Jim Tate and Fraser Hunter

Virtually all of the copper alloy objects were analysed non-destructively using X-ray fluorescence (XRF) in order to ascertain the alloy types used (full details are available in the archive). The objects were analysed on the flattest possible area of their surface, with at least two spots analysed except where size (<10mm) or fragility precluded this. Any existing breaks were analysed to try and see beneath the corrosion layer, and for the larger objects multiple analyses were taken to check for consistency; very little variation was found. Alloy types can be defined by looking at the ratios of different alloying elements to one another or the absolute quantities of alloying elements within the metal (Bayley and Butcher 2004, 14). For example, Bayley and Butcher (2004, 14) define brass as being either a metal with the level of zinc being more than four times that of tin or a metal with more than 8% zinc. Within their study bronze is defined as having more than 3% tin and gunmetal as a bronze with significant zinc; leaded alloys are defined strictly as being those with more than 8% lead. However, definitions do vary. For example, Dungworth (1997) defines bronze as containing at least 5% tin, brass as containing at least 15% zinc, and gunmetal as containing more than 5% tin and 5–15% zinc; leaded alloys are those containing more than 1% lead, it being argued that at this level the presence of lead affects the properties of the metal. For this study, alloy type was based on the presence of a distinct peak for the major elements of interest, copper, zinc, lead and tin. A 'trace' of an element was defined as being a peak just visible above the background. The attribution of alloy types from surface analyses is always somewhat speculative since, due to the presence of surface corrosion, the analyses may not be representative of the bulk metal. However, in the present study some of the casting debris was subsequently sampled, abraded and analysed quantitatively to act as a control on the surface results (Table 6.33); the agreement in alloy attributions between the two methods was good. Catalogue entries include the alloy type for each object.

Table 6.31 summarises the correlation between alloy type and manufacturing technology. Looking first at the objects, the dominant alloy was bronze or leaded bronze, consistent with the predominantly pre-Roman dating of the site. Zinc-containing alloys (brass and leaded gunmetal) are found only in imported Roman items or in finds from late (Roman Iron Age) phases in House 10 (the harness mount and ring-headed pin). The relatively few sheet fragments used only bronze or leaded bronze, predominantly the former, while cast objects were more often leaded, the lead making the casting process easier. It is unwise to place too much weight on indications of minor elements, as they are often near the instrument's detection limits, but there are hints of patterns (Table 6.32). Traces of silver and/or antimony were found in just over half of the cast objects and casting waste, but in none of the wrought items. This suggests a clear and careful separation in metal source for casting and sheetworking alloys. The sample size is too small to see any clear correlations between minor elements and alloy types. The casting debris is overwhelmingly of leaded bronze; this was clearly the main casting alloy used on the site. It

Table 6.31
Alloy types (from surface X-ray fluorescence) correlated with manufacturing technology

Technology	Leaded copper	Bronze	Leaded bronze	Leaded gunmetal	Brass	Totals
Sheet	–	3	2	–	–	5
Cast	–	2	5	4	2	13
Casting waste	2	2	15	2	–	21
Totals	**2**	**7**	**22**	**6**	**2**	**39**

Table 6.32
Occurrence of minor elements by technology and alloy type

Minor elements	As	Sb	Ag	n
Technology				
Sheet	–	–	–	5
Cast	2	4	8	13
Casting waste	2	14	13	21
Alloy type				
Leaded bronze/copper	3	14	14	24
Leaded gunmetal	–	1	4	6
Bronze	1	3	3	7
Brass	–	–	–	2

was not, however, the only one. The unfinished strap mount was of gunmetal, and a number of crucibles and moulds showed significant zinc traces, suggesting that gunmetals did come into use on the site in the Roman Iron Age. However, only two fragments of casting debris contained zinc. One, from 2677, is likely to be intrusive in this context (which is pre-Roman), presumably from higher deposits in the industrial area. The other, from a post-hole near Workshop 16, is one of the stray fragments distant from the main area.

Deposition

The fragments of casting debris are best seen as use-losses, and this is likely to be true generally for much of the material in the craft area. Fragmentary material from elsewhere may fall into the same category, but there are signs of other depositional processes at work too. As noted, the fragments from House 4 concentrate in one area and may be a deliberate cache. A number of the other items could be seen as deliberate deposits, linked perhaps with rituals connected to the abandonment of particular buildings. This is most convincing with House 10/3, with its striking finds: the two Roman coins in the entrance to the ring ditch, the Roman brooch in an abandonment layer directly in the entrance way, and the perfect but unfinished strap mount in the same layer, just inside the doorway. Such suggestions of patterned deposition are a warning against any simple correlation of finds to building function or status.

Catalogue

Alloy types were determined by surface X-ray fluorescence by Susanna Kirk and Jim Tate; see archive report for method.

Table 6.33
Results of quantitative analysis of six fragments of casting debris, compared with the results from (semi-quantitative) surface analysis and (italicised in the final column) the alloy type from surface analysis

Find	Analysis	Fe	Ni	Cu	Zn	As	Pb	Ag	Sn	Sb	Alloy
288	abraded	0.1	0.1	89.1	0.1	0	2	0	8.6	0.1	leaded bronze
	surface	*1.9*	*0.1*	*54.0*	*0.7*	*0*	*6.5*	*0.2*	*36.5*	*0.2*	*leaded bronze*
321	abraded	2.3	0	85.4	6.8	0.1	0.4	0.1	4.6	0.3	gunmetal
	surface	*9.1*	*0*	*72.5*	*2.9*	*0.4*	*1.1*	*0.9*	*12.3*	*0.8*	*bronze/ gunmetal*
424	abraded	0.1	0	94.3	0	0	2.7	0.9	0.2	1.7	leaded copper
	surface	*7.7*	*0*	*62.7*	*0.1*	*0.2*	*17.5*	*2.1*	*0.4*	*9.3*	*leaded copper*
490	abraded	0.9	0.1	74.6	0	0	8.8	0.4	13.7	1.2	leaded bronze
	surface	*4.6*	*0*	*45.1*	*0.2*	*0*	*15.6*	*0.8*	*30.6*	*3*	*leaded bronze*
696	abraded	0.4	0.1	68.3	0	0.3	0.2	0.2	30.3	0.3	bronze
	surface	*1.3*	*0.1*	*52.6*	*0.5*	*0.1*	*0.6*	*0.6*	*43.3*	*0.7*	*bronze*
1242	abraded	0.2	0	63.9	0.3	0	6.3	0.2	29	0.2	leaded bronze
	surface	*2*	*0*	*37.5*	*0.9*	*0*	*9.8*	*0.3*	*49.2*	*0.3*	*leaded bronze*

The Roman coins

Nick Holmes

SF0401 Coin, worn almost to the point of being unrecognisable; original edges lost; traces of a bust right. Could be a sestertius or a very worn George III penny. Alloy: brass (trace lead). 32 × 30 × 2.7mm; 8.32g. 2155 (House 10/3, main fill of ring-ditch 2215). (Illus. 6.55)

SF0405 Trajan (AD 98–117): *sestertius* (AD 112–14)

Obv.: [IMP CAES NERVAE] TRAIANO AVG GER DAC P M TR P COS VI P P; bust laureate right, with drapery on left shoulder.

Rev.: [FELICITAS AVGVST]; S C to left and right in field; Felicitas standing left, holding caduceus and cornucopiae.

30.0mm, 19.92g, die axis 165°; damaged and encrusted green patina; moderate wear.

RIC 625; BMC 964–5 variant (bust type). Alloy: leaded gunmetal.

Context 2164 (House 10/3, fill of ring ditch 2215).

SF0503 Uncertain emperor, possibly Domitian (AD 81–96): *As.*

Legends illegible and reverse design unidentifiable; bust on obverse may be of Domitian.

29.0mm, 9.23 g; highly corroded, and degree of wear therefore uncertain. Alloy: brass.

Context 2155 (House 10/3, main fill of ring-ditch 2215). (Illus. 6.56)

Ornaments

SF0278 Romano-British enamelled plate and fantail brooch (Hull's type 163; Bayley and Butcher 2004, 169, fig. 143); the hinged pin, integral headloop and parts of the fantail are lost (the latter being recent damage). The cylindrical head has a solid copper alloy axis (D 2mm) to hold the pin. The central circular plate on the bow has diametrically opposed projecting pairs of lips on the edges and three concentric enamelled fields (maximum D 18mm) defined by solid walls. These comprise a central opaque yellow dot (mostly lost); a mid-blue translucent ring; and an outer ring of alternating opaque yellow and red blocks, with no cell divisions. The regular shape of the yellow blocks indicates they were inserted as blocks; where they are lost, it can be seen that red underlay them, implying the red was applied first and slices of yellow blocks pushed into it while it was still malleable. Lethbridge (1952, 182) notes the same phenomenon on the Kilphedir brooch. Overlapping of the red into the blue ring indicates the red was applied before the blue. The fantail bears a ring and dot motif (D 11mm); the central blue dot is surrounded by a ring of yellow and red blocks, the form again indicating that the yellow was applied as blocks. On the underside of the disc is a central dot, its role unclear; perhaps for centring the brooch while the enamel was applied? Alloy: leaded gunmetal (minor silver). The blue enamel is probably coloured with cobalt and opacified with calcium antominate; the yellow is coloured by lead (unusually, there is no trace of tin or antimony, lead stannate and lead antimonite being common colorants in yellow plain enamels); the red is probably coloured by copper. L 51.5, H 19.5; head L 28, D 8; disc D 29mm; 21.8 g. Context 1671 (House 10/3, post-abandonment deposit, directly over entrance). (Illus. 6.50)

SF0318 Unfinished enamelled cruciform harness strap mount with a single loop on the rear (the description takes this to be vertical). The central panel is a saltire formed of four trumpets (each with two cells, body and 'mouth', to take enamel), springing from a central three-dimensional boss with a surrounding recessed ring. Concave-sided enamelled triangular panels lie vertically between the trumpet pairs; there are openwork gaps between the central panel and the wings (lentoid at top and bottom, concave-triangles to the sides). The side wings, in lower relief, each have pairs of horizontal enamelled panels (16 × 11mm), with a central row of four conjoined lozenges flanked by triangles above and below. The edge adjacent to the central panel has a slightly raised lip. The slightly flared top and bottom wings are dominated by a pair of vertically set conjoined high-relief ovals flanked to either side by a lower pelta and trumpet. Overall this forms a crescentic motif with a marginal lower-relief flange; two curved enamelled cells fill the gap between this and the corners of the wing. There is no evidence of enamel ever having been applied, although the bases of the cells are grooved for keying. The front surface is very well finished; the rear is less carefully finished, with fine file-marks in places. The single rectangular loop on the rear (L 19, H 10.5, T 7mm) is unfinished; it has a recess (11 × 7.5mm) to take a strap that has been perforated by a drilled hole (probably present in the model; D 7.5mm), but this has not been expanded to remove the rest of the metal, and the item was thus unusable. One or two horizontal nicks on one side of the arms probably come from post-casting working. There are hints of a casting seam on the loop edges; this must have been a lost-wax or multi-piece casting. Alloy: leaded gunmetal (trace silver). L 61, W 58, T 17.5mm; 56.4g. Context 1671 (House 10/3, post-abandonment deposit). (Illus. 6.50 and 6.51)

SF0368 and **SF0439** Two joining fragments of a cast projecting ring-headed pin, lacking the tip. The tapering lentoid-sectioned shank bends into a slightly oval circular-sectioned head with a low transverse decorative keel continuing the line of the shank's edges across the ring; this evokes a conjoined trumpet design. Alloy: leaded gunmetal (trace silver). L 38; shank L 26 × 5 × 3.5; head externally 20.5 × 19, internally 10 × 8, T 5mm; 7.6g. Context 1671 (House 10/3, post-abandonment deposit) and unstratified. (Illus. 6.50 and 6.53)

SF1027 Dumb-bell toggle; domed ends, with collars at their bases flanking a relatively deep rectangular-sectioned channel. Alloy: leaded bronze. L 20.5, D 11.5mm; shank D 7.5, L 4mm; 8.3g. Context 2252 (post-hole 2251, beside Workshop 16 post-ring). (Illus. 6.50 and 6.54)

Weaponry

SF0483 Decorated sword hilt guard of low campanulate form; parallel-sided with a slight taper to the rounded ends. The upper and lower faces are flat; the rounded edges bear an incised design of transverse V-sectioned grooves. This decoration is rubbed off the middle of the edge on both sides, the point of highest relief, indicating extensive use. It is more marked on one side, suggesting a preference to how it was worn. A lentoid V-sectioned slot is cut into the underside for the blade (L 43, T 2.5mm) and shoulders (W 30.5 as they emerge). The very clean edges indicate it was cut rather than cast; on the upper side, three central diagonal incisions on one side of the slot may be marking out lines for the perforation. The rounded edges suggest the piece was cast and then perforated, hammered to its final shape if required, and decorated. Alloy: bronze (minor silver, trace antimony). L 44.5, W 6.5, T 2.5, H 10.5mm; 2.5g. Context 2130, stone deposit (yard surface in industrial spread by House 10/3; predates 90 cal BC–cal AD 90). (Illus. 6.50 and 6.54)

Vessels and fittings

SF0173b Two fragmentary sheets, riveted together with three (surviving) rivets set in a triangle. No original edges survive, but it is likely this was a patch for a copper alloy vessel. Solid rivets (head D 3, burred shank D 2mm). The larger sheet has file-marks on the surface; little survives of the smaller sheet. Alloy of one sheet: bronze. 25 × 21 × 1.2mm; sheet T *c*.0.3mm; 0.7g. Context 775 (House 4, upper floor deposit in ring-ditch 1810). (Illus. 6.57)

SF0232 Mount? Sheet cut into an isosceles triangle, with two tips broken and a diagonal bend; edges cut square, with slight lip from cutting on one side. No trace of attachment system but likely to be a decorative mount. Alloy: leaded bronze. L 43, W 31, T 0.5mm; 3.8g. Context 775 (House 4, upper floor deposit in ring-ditch 1810). (Illus. 6.57)

SF0313 Ring, one face flat, the other gently rounded; broad perforation (D 21mm) with slightly rounded edge and raised lip on the upper face. Probably a decorative collar; no trace of fastening, such as solder. The lip is slightly uneven, probably from manufacture rather than wear. Alloy: leaded bronze. D 37.5, T 4mm; 14.0g. Context 1671 (House 10/3, post-abandonment deposit)

Sheetworking debris

SF0241 Sheetworking offcut. S-shaped strip, ends squared, one edge slightly tapered (with file-marks from shaping), the other cut; bending probably post-dates cutting. Alloy: leaded bronze. 18.5 × 4.3 × 0.6–1.0mm; 0.4 g. Context 775 (House 4, upper floor deposit in ring-ditch 1810)

SF1240 Cast fine rivet (in two joining fragments), tip lost; low-domed head and circular shank, filed to shape; bent (and thus probably used). Alloy: leaded bronze (minor silver, antimony and arsenic). L 7, head D 3, shank D 1mm; 0.1g. Context 2550 (pit 2549, associated with Hearth 2434)

Roughouts, stock metal etc.

SF0173a Folded and flattened strip, producing six layers of metal; probably a package intended for reuse. Broken at one end. Alloy: bronze. L 23.5, W 18, T 2.5mm (sheet T *c*.0.3–0.4mm); 4.9g. Context 775 (House 4, upper floor deposit in ring-ditch 1810). (Illus. 6.57)

SF0844 Slightly bent square-sectioned bar, one end square, the other slightly irregular from casting. Probably stock metal for

Table 6.34
Summary of casting debris by context

Context	Context description	No. items	Mass/g	Alloys	Type
1681	Post-abandon-ment deposit, by House 10/3	1	4.2	Leaded bronze	Nodular casting waste
1682	Collapsed wall/ bank material – adjacent to House 10.3	1	2.9	Leaded gunmetal	Nodular casting waste
2101	Hillwash	2	4.4	Leaded copper; leaded bronze	One linear droplet
2165	Spread of waste over Hearth 2166 & 2434	2	7.1	Leaded bronze	One flat spill
2187	Spread of waste over Hearth 2166 & 2434	2	3.5	Leaded bronze	Nodular casting waste
2252	Posthole 2251, beside Workshop 16 post-ring	1	0.1	Leaded gunmetal	Nodular casting waste
2433	House 17, posthole 2420	1	2.0	Leaded bronze	Nodular casting waste
2435	Spread of waste over Hearth 2434	1	6.0	Leaded bronze	Nodular casting waste
2677	Charcoal spread associated with hearth 2434	4	0.6	Leaded bronze, leaded gunmetal, leaded copper	One droplet
2836	Posthole 2835 adjacent to Workshop 13	1	0.1	Bronze	Nodule
3022	Charcoal spread associated with hearth 2434	1	3.1	Leaded bronze	Nodular casting waste
3038	Heat-affected natural – hearth 2434	1	0.7	Leaded bronze	Nodular casting waste
3159	Hearth.26, posthole 3158	1	1.1	Leaded bronze	Flattened, amorphous
3467	Ash fill of furnace 3401	1	0.4	Bronze	ID not certain; amorphous, corroded
Total		**20**	**36.2**		

working up. Alloy: bronze (minor silver and antimony). 96 × 3.5 × 4mm; 6.8g. Area D context 4340 (Workshop 15, fill of pit 4341).

SF01246 ?Offcut from tip of circular-sectioned rod; cut square; end slightly angled. L 4, D 3.5mm. Context 2677.

Casting debris

SF0333 Failed casting. Tapered curved object, lentoid in section with rounded terminals and a ridge on the concave side, indicating a two-piece mould. Sprue and irregular header attached to convex surface. It looks like the casting only partly filled the mould (perhaps for a ring?). Alloy: leaded bronze. L 28 (object L 19.5), W 10, object T 3.5mm; 4.3 g. Context 1681 (post-abandonment deposit by House 10/3). (Illus. 6.57)

(See Table 6.34 for a summary of the less diagnostic material.)

Unidentified

SF0231a Slightly tapered sheet strip fragment, one end broken, the other cut square with one part folded under; transverse file-marks. Does not join SF0173. Alloy: bronze (trace lead). L 22.5, W 14.5, T 0.6mm; 1.0 g. Context 775 (House 4, upper floor deposit in ring-ditch 1810). (Illus. 6.57)

SF0231b Two non-joining sheet fragments, lacking original edges. 10 × 7 × 0.2mm and 7 × 5 × 0.2mm; 0.1 g. Context 775 (House 4, upper floor deposit in ring-ditch 1810). (Illus. 6.57)

SF0311 Unidentified flat cast fragment, one side slightly convex; part of one straight, slightly lipped edge survives, but the others are lost. Alloy: brass (minor silver and arsenic; trace lead and tin). 22.5 × 20.5 × 3mm; 3.1 g. Context 1671 (House 10/3, post-abandonment deposit) Possibly a more recent intrusive piece.

SF1236 Rounded corner fragment from an object with flat faces. Alloy: leaded bronze. 4 × 2 × 2mm; 0.1 g. Context 2252 (post-hole 2251, beside Workshop 16 post-ring).

SF1241 Six non-joining fragments of a flat cast object, the surviving edge straight and square. Alloy: leaded bronze (minor silver and antimony). 0.1g; largest fragment 8.5 × 5 × 1mm. Context 2548 (post-hole 2547, associated with Hearth 2434).

Lead

Fraser Hunter

Nine lead items were recovered from Culduthel, predominantly small strips coiled into cylinders, triangles or cuboids, all of similar weight. There was also a solid ovoid item, perhaps a weight, and a part-worked bar with extensive tool traces, along with an unidentified fragment. All the coiled strips (SF0280, SF0281 – Illus. 6.58, SF0354a/b – Illus. 6.58, SF0386 and SF0403), the ovoid possible weight (SF0511) and the part-worked sheet (SF1000) are from artefact rich layer sealing House 10/3 and post-date its abandonment (*c*.1671). Only one of the finds is securely Iron Age, a sub-cylindrical fragment (SF1624) from a post-hole of House 10/3, but a Roman Iron Age is feasible for the remainder as *c*.1671 included a wide range of Roman and Roman Iron Age finds.

The six strips, slightly plano-convex in section, were coiled into various hollow forms, the ends overlapped to differing degrees. There is a broad consistency in dimensions, but not so close as to suggest a weight standard, suggesting use as a weight for holding or retaining something rather than measuring (Table 6.35).

Illustration 6.58
Lead artefacts

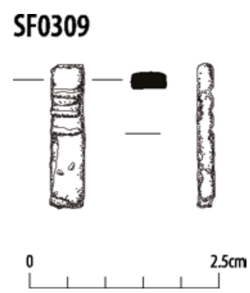


Illustration 6.59
Pewter artefact

Table 6.35
Catalogue of coiled strips. *c*.1671 is a post-abandonment context which represented the interface between the feature fills in House 10/3 and the base of the ploughsoil; it is not securely Iron Age

Find no.	Form	L (mm)	W (mm)	m (g)	Context
280	Cylinder	15	13-15	10.66	1671
281	Cylinder	13	14-15.5	11.22	1671
354a	Triangular	15	15-17	18.26	1671
354b	Cylinder	17	14-16	15.02	1671
386	Cuboid	15	13-14	12.52	1671
403	Triangle	14.5	16	14.60	1671

Both the presence and working of lead are a rarity in the Iron Age. Fragment SF1624 is securely contexted and shows some access to lead on the site. The bulk of the finds from post-abandonment layer *c*.1671 are Roman Iron Age in date, and there is little evidence of later intrusion. This would fit with wider pictures of lead use in Iron Age Scotland (for a review, see Hunter 2007e). Lead is extremely rare (though not unknown) until the Roman period, when it is found especially on sites showing evidence of Roman contact. This makes it likely that the ultimate source was recycled Roman lead. It is likely this was valued primarily as a raw material for recycling; there is no typologically distinctive Roman material, but a wide range of expedient use as found at Culduthel. The sheet with hammer-marks provides confirmatory evidence for on-site working.

The lead isotope analysis (below) is consistent with a southern Scottish source, but there is overlap between Scottish and English ore sources (e.g. the North Pennines) in isotope ratios (Rohl 1996), and a more southerly source cannot be ruled out. Our knowledge of the Roman exploitation of Scottish sources is too incomplete to support further speculation on this topic at present.

Lead isotope analysis

Rob Ellam

Isotope analysis of nine lead objects recovered during excavation at Culduthel was undertaken. The lead isotope ratios measured (Table 6.36) provide a fairly consistent suite of values. Comparison of the Culduthel isotope ratios to other published British and Irish lead sources suggest that the lead derived from a south-eastern Scottish source rather than exploiting more local sources. In Rohl's (1996) compilation of British and Irish lead ores, she recognised the following Scottish localities: Midland Valley (West Linton and East Calder), Southern Grampians (Tyndrum), Southern Uplands (Carphairn, Wanlockhead and Leadhills) and Southern Highlands (Strontian). Unfortunately, lead isotopes do not distinguish the Southern Uplands from the single East Calder sample analysed. The Culduthel lead samples fall comfortably within the Southern Uplands – East Calder field (Illus. 6.60). This is potentially highly significant as it indicates that the two closest sources to the site, Strontian and Tyndrum, were not exploited and that the lead used here was from a far more distant south-eastern source such as Wanlockhead or Leadhills.

Table 6.36
Lead isotope ratios

SF no.	206Pb/204Pb	%SE	2 SE	207Pb/204Pb	%SE	2 SE	208Pb/204Pb	%SE	2 SE	208Pb/206Pb	%SE	2 SE	207Pb/206Pb	%SE	2 SE	208Pb/206Pb
280	18.224	0.0054	0.002	15.566	0.0075	0.002	38.153	0.0076	0.006	2.09383	0.0035	0.00015	0.85423	0.0027	0.00005	2.09383
281	18.216	0.0063	0.002	15.560	0.0085	0.003	38.139	0.0081	0.006	2.09378	0.0033	0.00014	0.85423	0.0034	0.00006	2.09378
354a	18.236	0.0105	0.004	15.562	0.0138	0.004	38.158	0.0114	0.009	2.09230	0.0046	0.00019	0.85342	0.0045	0.00008	2.09230
354b	18.274	0.0057	0.002	15.574	0.0072	0.002	38.210	0.0074	0.006	2.09098	0.0025	0.00010	0.85229	0.0023	0.00004	2.09098
386	18.270	0.0059	0.002	15.571	0.0080	0.002	38.197	0.0079	0.006	2.09077	0.0041	0.00017	0.85226	0.0028	0.00005	2.09077
403	18.241	0.0079	0.003	15.568	0.0101	0.003	38.171	0.0091	0.007	2.09253	0.0047	0.00020	0.85347	0.0031	0.00005	2.09253
511	18.208	0.0060	0.002	15.551	0.0084	0.003	38.116	0.0092	0.007	2.09350	0.0039	0.00016	0.85415	0.0030	0.00005	2.09350
1624	18.197	0.0167	0.006	15.539	0.0240	0.007	38.083	0.0139	0.011	2.09269	0.0055	0.00023	0.85403	0.0091	0.00016	2.09269
1000	18.243	0.0054	0.002	15.567	0.0070	0.002	38.169	0.0070	0.005	2.09211	0.0031	0.00013	0.85324	0.0022	0.00004	2.09211
Standards																
NIST981	16.923	0.0087	0.003	15.480	0.0092	0.003	36.666	0.0096	0.007	2.16683	0.0062	0.00027	0.91483	0.0042	0.00008	
NIST981	16.919	0.0127	0.004	15.482	0.0136	0.004	36.675	0.0143	0.010	2.16755	0.0056	0.00024	0.91500	0.0043	0.00008	
NIST981	16.926	0.0064	0.002	15.486	0.0081	0.003	36.684	0.0083	0.006	2.16715	0.0037	0.00016	0.91492	0.0029	0.00005	
Mean	16.923			15.483			36.675			2.16718			0.91491			
2 SD	0.007			0.006			0.018			0.00072			0.00017			
"True"	16.9405			15.4963			36.7219			2.16771			0.91475			

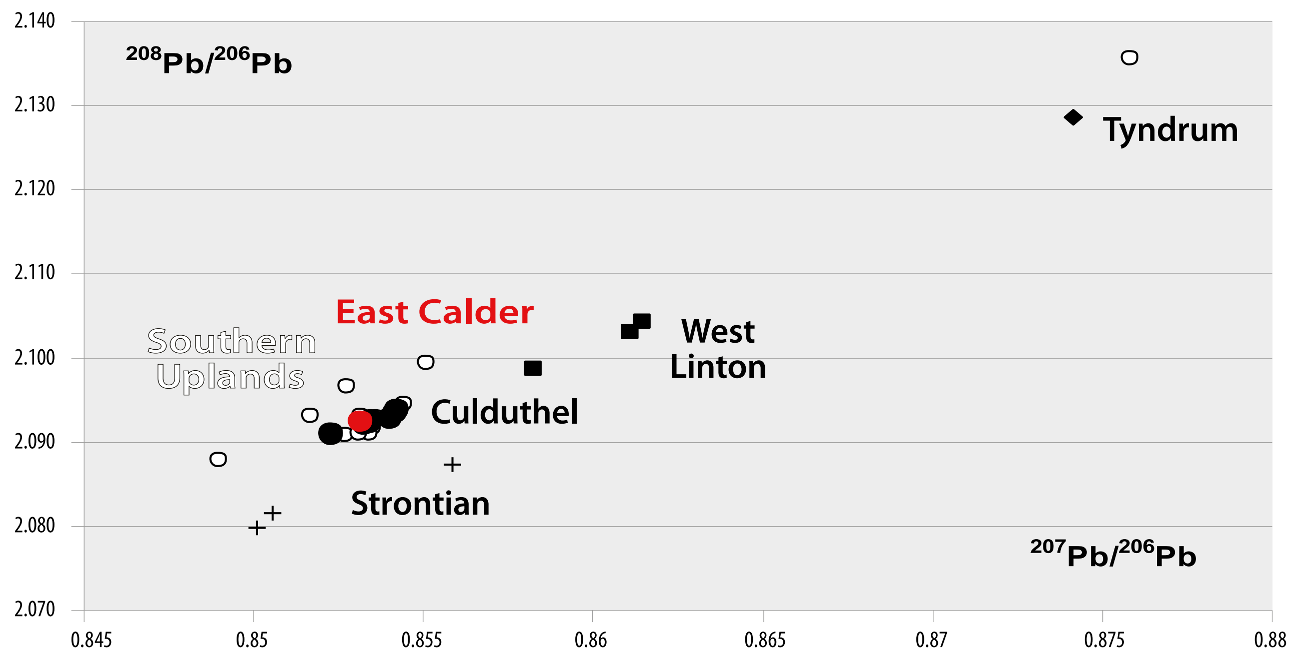


Illustration 6.60
Culduthel lead isotope values plotted against those from other published Scottish lead sources

Catalogue

SF0511 Well-rounded solid ovoid ?weight, formed from folding a strip in half and hammering to shape. End slightly damaged, overall form slightly irregular. L 18.5, D 14–15mm, mass 13.10 g. *c*.1671.

SF1000 Extended D-shaped sheet folded in half to form a tapered rectangle rounded at one end, the ends hammered closed and the surfaces with extensive toolmarks from flattening. On one side there are small oval facets, the best-preserved *c*.13mm × 4mm; at the broad end the hammer has caught it at an angle, giving sharp linear marks from the tool's edge. The other side has two deep, broad facets, one nearly triangular, the other slightly crescentic; it is likely these come from different areas of the anvil used while hammering. Probably prepared as raw material. L 92, W 36, T 14mm; mass 229.25g. *c*.1671.

SF1624 Sub-cylindrical fragment; unidentified. L 11, D 7mm, mass 2.00g. Context 2492.