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Culduthel

An Iron Age Craftworking Centre in North-East Scotland

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Chapter 6

THE FINDS

Introduction

The excavation at Culduthel produced an extensive assemblage with a rich range of material that is highly significant for the study of the Scottish Iron Age. It is rare to find such a productive site in the cropmark zone of Scotland; the range of material has painted a detailed picture of a wide range of activities at the site, including the craft processes at play, the contacts and networks for the procurement of raw materials and the exchange of both utilitarian and exotic objects. The assemblage has also informed wider research topics for the Iron Age in the north-east and other areas of Scotland, illuminating the contact between Scotland and Rome in the early 1st millennium AD and adding to our knowledge of how status was defined and displayed in this period. These wider topics are expanded on here and in greater depth within the concluding Chapter 7.

The excellent preservation of areas of the site sealed by hill-wash, and the excavation strategies adopted to deal with this phenomenon (including dry sieving many deposits during the excavation and wet sieving in the lab), meant that the recovery of artefacts was maximised. As many of the artefacts were presumed to be found in the location they were lost or discarded, the record of their exact locations (which were three-dimensionally recorded) meant the spatial distribution of artefacts are considered to be detailed and accurate. This data has allowed for the location of certain activities, such as the glassworking areas of the site, to be pinpointed and has aided the recognition of structured deposition of objects.

Of particular importance from the assemblage is the evidence for glass- and enamel-working, which is unique in Iron Age Scotland and very rare in Britain generally. The working debris recovered, alongside the information gained from the in situ hearths and workshop identified on site, has shed much light on the technology of glass and enamel in the Iron Age. The working debris indicates that the site was reworking imported glass ingots to produce beads and for enamelling, some of this material coming into the site from the Roman world as pre-formed dual colour cables or trails. As the majority of working debris, and a high percentage of the beads, were recovered during the post-excavation processes through wet-sieving and sorting, the identification of such large quantities of glass can be directly linked to the extensive sampling strategy adopted across the site. This wealth of information obtained for Iron Age glassworking in Scotland will assist future researchers of Iron Age material

culture, especially personal adornment, and later prehistoric technology.

The quantity of ferrous metalworking waste (over a third of a tonne of slag and associated vitrified debris) and its recovery in situ within furnaces and from spreads of material formed from multiple heaps of debris has allowed an understanding of the technology of iron, from ore to artefact; this is exceptionally rare, especially in an Iron Age context. The assemblage of iron objects is one of the largest and most important from Iron Age Scotland, with a number of unusual items such as daggers, a spearhead and a file. The iron tools give some incredible insights into life on an Iron Age settlement and the craft activities underway: the knives, awls and decorating tools for the working of wood, leather, horn, antler and bone; a possible iron mandrel for making glass beads; and a needle for stitching fabric or leather.

The non-ferrous metalworking debris is also some of the largest and most important from Iron Age Scotland and has illuminated the technology of copper alloy manufacture utilised at Culduthel. The objects, the working debris and the analysis of the alloys has allowed for a better understanding of the technology used for copper alloy manufacture and the sources of the raw materials. Sheet copper and the casting of objects was taking place. Remarkable objects such as the harness strap mount were being made, and objects such as the hilt guard were being brought onto site for repair by a specialist team of copper alloy workers.

Other elements of the assemblage also help to illustrate the activities of the artisan community. A wide range of stone tools, including smoothers, polishers and grinders for preparing leather and finishing metal items and potentially crushing down pigments for painting and dyeing, were identified within the workshops, roundhouses and spreads.

There are a number of notable absences from the assemblage that are significant and informative. Not a single piece of bog ore was identified across the site, suggesting that its storage and initial processing was undertaken at another location. The absence of ore and the clearly defined areas of ferrous, non-ferrous and glass-working identified on site shows that different processes were segregated in a highly organised enterprise. Domestic pottery is also minimally represented. While this lack of later prehistoric pottery is unsurprising in this period in north-east Scotland, it is

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more intriguing when viewed alongside the large assemblage of ceramic material clearly made on site, including crucibles and complex moulds. Finally, the lack of whetstones defies explanation on a site where sharp knives and tools must have been indispensable.

Together the finds assemblage indicates that Culduthel was a major production site and a specialist craft-working centre,

producing a diverse range of objects ready for use or exchange, with accessories in leather, wood and textile to compliment them. These craftworkers were clearly a creative, experimental, ambitious and well-travelled group.

For ease of reference, Chapter 6 has been divided into four parts by material. Part A covers the pottery and fired clay; Part B the stone; Part C the metal and Part D the glass.

Part A

Pottery and fired clay

Prehistoric pottery

ANN MACSWEEN

The pottery assemblage comprises 236 sherds (mostly small body sherds), fragments and crumbs, from which 21 vessels could be distinguished. The majority of the pottery could be identified as early prehistoric with both the Early and Late Neolithic represented. The meagre assemblage of later prehistoric pottery is unsurprising for Iron Age north-east Scotland. Ceramics were certainly widely used in this period on site in the manufacture of copper alloy and glass, and clay and the technology to produce pots was clearly widely available to the occupants. The absence of pottery within this period may show a society using other materials (wood, iron, leather) for cooking and storing food or it may simply be a reflection of the main purpose of this site (a non-domestic craft centre) with the domestic occupation perhaps located beyond the excavation to the north.

Pottery was recovered across the site, much of it from the backfill of pits. No radiocarbon dates were obtained from contexts containing prehistoric pottery. The full assemblage is described and discussed by period of activity below.

Early prehistoric pottery

CARINATED BOWLS

Sherds of carinated bowls dating to the early Neolithic were recovered from a number of contexts:

Context 98: fill of shallow pit 97

A rim sherd with a lip slightly rolled to the exterior, possibly from a round-based bowl, was recovered from context 98, the fill of pit 97. From the rim profile, burnished exterior and fabric (fine clay with c.10% of larger quartz), it could be from a Neolithic bowl.

Context 156: upper fill of pit 153

Eleven sherds and two crumbs of pottery, including a rim and a carinated sherd from the same vessel (V1 – Illus. 6.1), were recovered from the upper fill of pit 153. Three body sherds, also from V1, were found in the middle fill of pit 153 (context 155), and two small sherds and two fragments, probably from two different vessels, were recovered from the sampling of that context. A sherd and two fragments from a different vessel (V14, undiagnostic) were also recovered from the middle fill (context

155). The lower fill, context 154, produced a tiny rim fragment (V15) from a sample.

Context 815: fill of pit 2172

A rim and four body sherds (one carinated) from the same vessel (V3 – Illus. 6.1) were recovered from 815. The rim is perforated.

Unstratified

A further carinated vessel (V2 – Illus. 6.1) was represented by a rim sherd and three body sherds (two carinated), which were unstratified. A further three rim sherds, five body sherds (two carinated), three fragments and two basal fragments (flat bases) were recovered during the topsoil strip.

Discussion

The vessel that gives the best indication of vessel profile is V3 (context 815), which has a long flaring neck. V1, V2 and V3 are burnished on the exterior and all are of fine sandy clay with a low percentage of rock fragments. Where vessel form could be identified, most were, either from the presence of carinated sherds or from the rim form, thought to be from round-based, carinated vessels (V1; V2; V3; V8; V20).

Dates from Scottish sites indicate that simple carinated bowls were in use from around 4000 BC (Sheridan 1997, 219–20), with ‘modified assemblages’ (characterised by the use of fluting, the addition of lugs, and a preference for shallow forms) following a couple of centuries later, but the simple carinated bowls continuing to be made. Carinated bowls continued to be made in some areas into the later Neolithic (e.g. at Kintore in Aberdeenshire some of the carinated bowls dated to c.3000 BC (MacSween 2008, 179)).

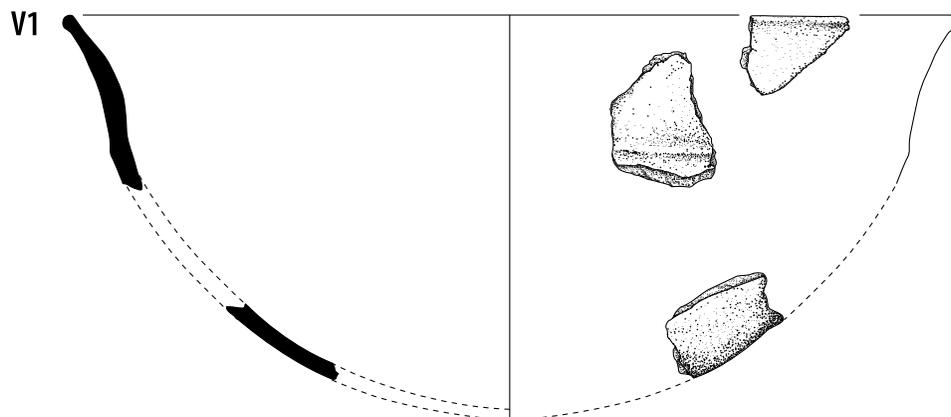
BEAKER

Sherds from four decorated vessels are probably from Beakers, although the sherds are very small. The sherds are generally thin-walled with fine fabrics. Sherds from two vessels were recovered from pit fills, one sherd was recovered overlying the external cobbled yard adjacent to House 10/3, and the sherds from the fourth possible Beaker are uncontexted.

Context 402: the fill of stone-lined pit 401

Sherds from a decorated vessel, possibly a Beaker, were recovered from context 402 (V18 – Illus. 6.2). The exterior surface was smoothed and decorated with evenly spaced lines of impressed twisted cord. The fabric is fine sandy clay with some coarse quartz. A body sherd and two fragments from a different vessel

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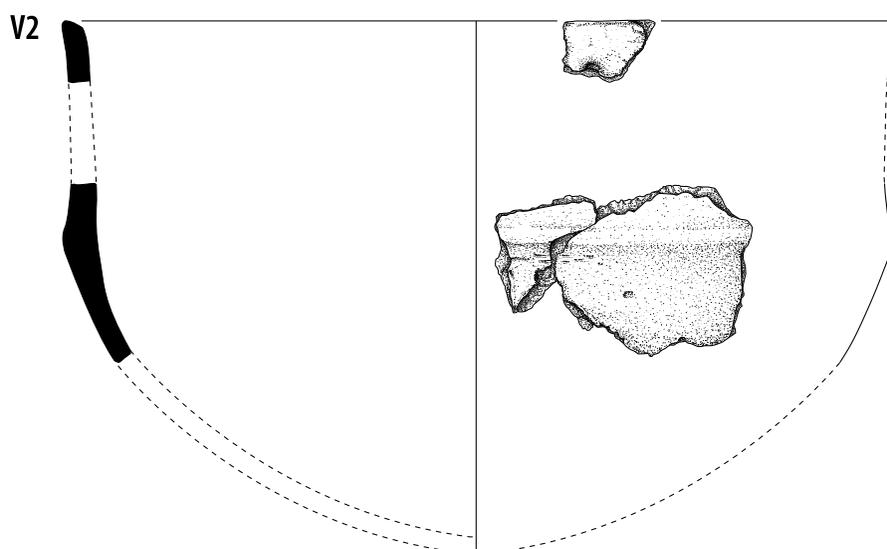
(V21) were recovered from the same context.

Context 429: basal fill of pit 428

Two small sherds of possible Beaker pottery (V10) were recovered from the sampling of context 429. The larger fragment has three closely spaced rows of comb impressions.

Context 2982: external cobbled yard to the east of House 10/3

A small, thin-walled sherd decorated with two incised lines (V13) from sampling of 2982 may also be from a Beaker. The fabric is fine sandy clay.



Unstratified

Two small sherds, one with a line of impressed cord, were recovered during surface cleaning.

Discussion

Beakers are a frequent find from excavations in the north-east of Scotland, many from burial contexts (see for example Shepherd 1986). The sherds from Culduthel are too small for detailed discussion of their decoration etc. but they are important as a marker for activity on or near this part of the site at around 2600 to 1800 BC (Kinnes et al 1991).

Later prehistoric pottery

A total of 31 probable later prehistoric pottery sherds were recovered from two separate contexts. This very small assemblage represents the total Iron Age pottery recovered from Culduthel. The two contexts are associated with two separate phases of the site. An undated cobbled surface, likely to be associated with the Early Iron Age settlement (Period 2), contained sherds of flat rimmed pottery, while a single rim of decorated pottery was recovered from an occupation deposit within the interior of the final phase of House 10/3, occupied between the 1st and 3rd centuries AD.

The paucity of ceramics in the northern Scottish Iron Age is a well-known phenomenon. The lack of domestic later prehistoric pottery at Culduthel could suggest that the settlement fits within this tradition but could equally indicate that the later prehistoric settlement identified was purely the industrial zone of a much larger (unseen) settlement.

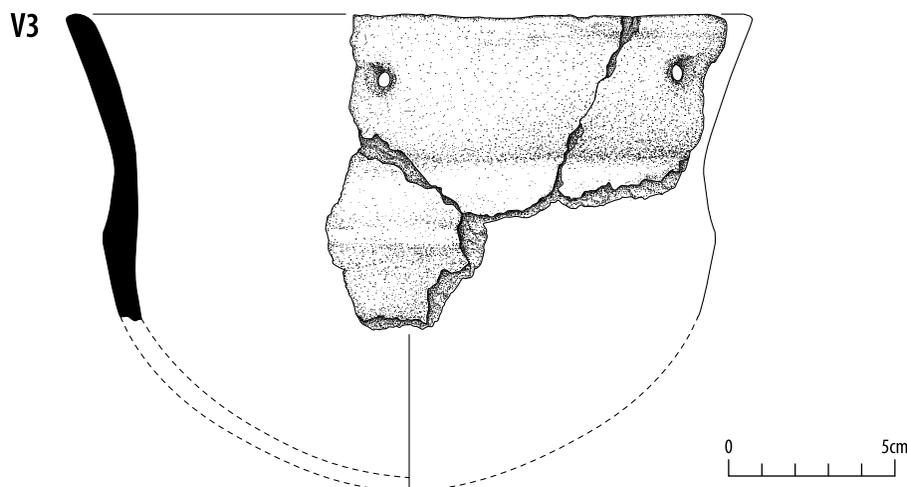


Illustration 6.1
Prehistoric pottery (Vessels 1–3)

POTTERY AND FIRED CLAY

PERIOD 2

Flat-rimmed

Sherds of flat-rimmed pottery, probably later prehistoric domestic pottery, were recovered from an area of cobbling.

Context 3651: Cobbled surface

Eight flat rim sherds, 22 body sherds and 8 fragments (V4 – Illus. 6.2) were recovered from context 3651. The exterior surface is smoothed and the fabric is fine sandy clay with c.60% of crushed rock fragments.

PERIOD 3

Possible decorated Iron Age pottery

One rim sherd with a rounded lip and a long neck, decorated with incised motifs may, from its decoration, be Iron Age in date (V19 – Illus. 6.2).

Context 2470: occupation deposit, House 10/3

Rim with a rounded lip and a long neck, decorated with incised infilled triangles. The fabric is fine clay with organics (grass).

POTTERY UNATTRIBUTED TO PERIOD

Much of the pottery is undiagnostic, and many of the sherds are too small to enable attribution to fabric type with any confidence. These are listed here by context, and under the catalogue by vessel:

Context 83: fill of post-hole 85

Body sherd with traces of incised decoration on the exterior surface, and a smaller fragment from a different vessel.

Context 142: fill of pit 140

Five sherds and two crumbs.

Context 346: secondary fill of pit 344

Abraded body sherd with c.20% of igneous rock (from samples).

Context 432: fill of pit 431

Thirteen fragments and crumbs of pottery (from samples). The fabric (fine clay with a low percentage of rock fragments) is similar to the carinated bowl pottery. Three body sherds and three fragments from another vessel were also recovered. The fabric is similar to the Neolithic bowls but the vessel walls are much thicker.

Context 521: pit within the interior of the palisade enclosure

Seven body sherds, one decorated with criss-crossed incised lines (V17). The fabric is fine sandy clay with c.20% of coarse quartz.

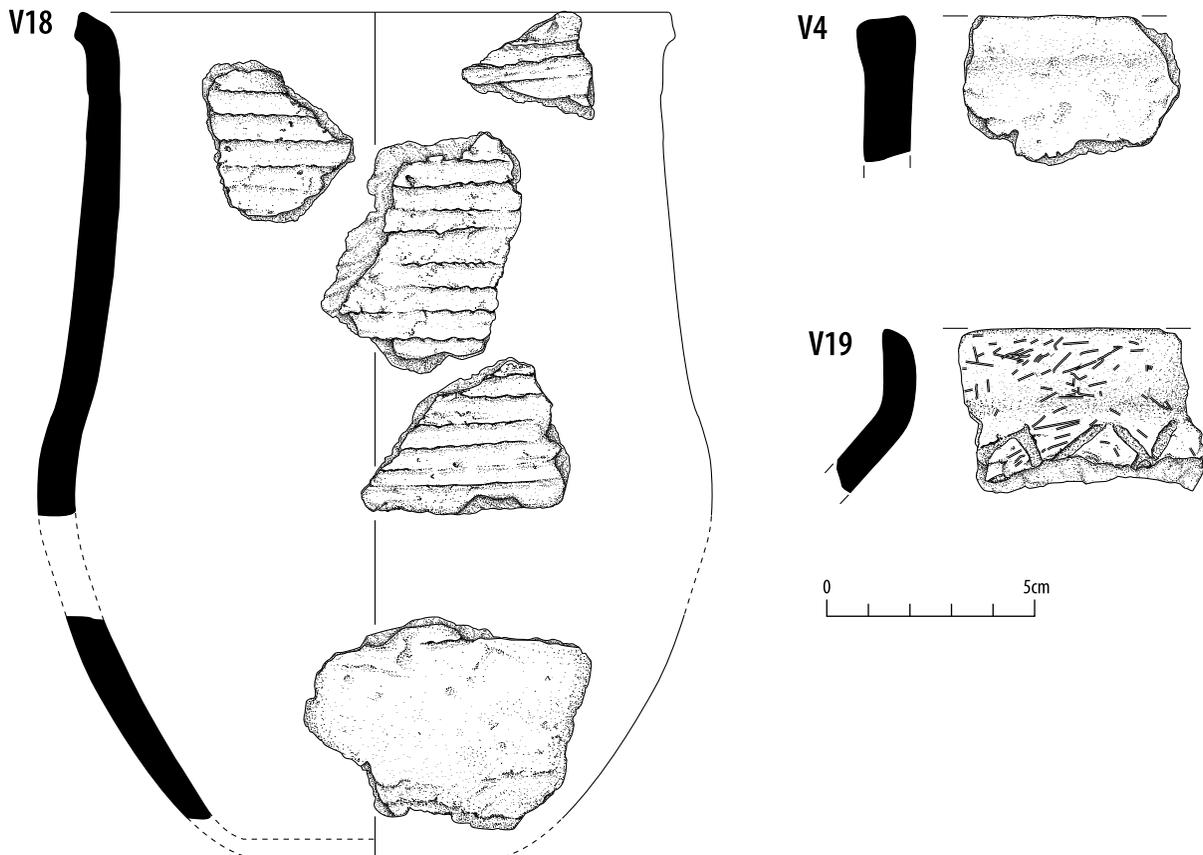


Illustration 6.2
Prehistoric pottery (Vessels 4, 18 and 19)

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Context 741: primary fill of post-hole 740
Body fragment (from sampling). The fabric is fine sandy clay.

Context 798: spread of industrial waste
Body sherd (V16) of fine sandy clay.

Context 1725: fill of post-hole 1726
Abraded body sherd (from sampling)

Context 2169: fill of post-hole 2167
Body sherd (from sampling). The fabric is fine clay with *c.*10% of larger quartz.
Upper fill of pit 2172
Rim sherd (tapered) and a body sherd were recovered from the upper fill of pit 2172.

Context 2816: fill of post-hole 2815
Body sherd (from sampling). The fabric is fine clay with *c.*10% of rock fragments, again similar to the fabric of the carinated bowl pottery.

Context 2930: fill of post-hole 3635
Body sherd (from sampling). The fabric is sandy clay.

Catalogue

Vessel 1

Context 156; Find 2; 10 small body sherds (one carinated) and 2 crumbs; Wt 14g; Th 6mm

Context 156; Find 8; Vessel 8; Rim sherd with a slightly flattened lip; Wt 4g; Th 7mm

Context 155; Find 7; 2 body sherds; Wt 21g; Th 4–7mm

Context 155; Find 5; 1 body sherd; Wt 2g; Th 6mm
From a coil-constructed vessel with diagonal junctions. The exterior surface is burnished. The fabric is fine sandy clay with occasional large quartz and angular rock fragments, which has fired hard and is grey with brown surfaces. There is light sooting on both surfaces.

Probably from a Neolithic carinated bowl.

Vessel 2

u/s; Rim sherd and 3 body sherds (two carinated); Wt 49g; Th 9mm

Rim sherd has a slight interior bevel. The exterior surface is burnished. The fabric is fine sandy clay with occasional large quartz/mica which has fired hard and is grey with brown surfaces. The interior surface is sooted. Carinated bowl.

Vessel 3

Context 815; Find 191; Rim, 2 body (one carinated), 2 fragments, 1 crumb; Th 9mm; Dia 220mm; Wt 97g

Below the lip of the vessel are two perforations (14mm and 17mm below the lip), 94mm apart. The body sherds are more abraded than the rim sherd. The exterior surface is burnished. The fabric is fine sandy clay that has fired hard and is grey with brown margins. The interior surface is sooted and there are patches of light sooting on the exterior surface. Carinated bowl.

Vessel 4

Context 3651; Find 937; 13 fragments, 6 crumbs; Th 11mm; Wt 35g (residue)

Context 3651; Find 930; 1 rim, 5 fragments, 2 crumbs; Th 11mm; Wt 28g

Context 3651; Find 930; 1 rim (broken in 2); Th 11mm; Wt 45g

Context 3651; Find 913; 1 rim; Th 11mm; Wt 34g

Context 3651; Find 917; 1 rim; Th 11mm; Wt 30g

Context 3651; Find 932; 1 rim; Th 13mm; Wt 26g

Context 3651; Find 930; 1 rim (broken in 2); Th 11mm; Wt 45g

Context 3651; Find 918; 1 rim; Th 10mm; Wt 20g

Context 3651; Find 934b; 1 rim; Th 12mm; Wt 25g

Context 3651; Find 935b; 1 body sherd; Th – abraded; Wt 12g

Context 3651; Find 936; 1 body sherd; Th 8mm; Wt 8g

Context 3651; Find 916; 2 rims, 7 body sherds, 2 fragments; Th 10mm; Wt 51g

Sample 1754; 2 rim fragments, 2 body sherds, 29 crumbs; Wt 26g

Flat-rimmed later prehistoric vessel. The exterior surface is smoothed. The fabric is fine sandy clay with *c.*60% of crushed rock fragments, which has fired hard and is grey with brown surfaces. The interior surface is sooted.

Vessel 5

Context 2170; Find 421b; Rim sherd; Th 10mm; Wt 7g

Context 2170; S 739; 1 body sherd; Th 9mm; Wt 26g
Rim sherd and body sherd from a vessel with a tapered rim (probably slightly inverted). The exterior surface is smoothed. The fabric is fine sandy clay with *c.*20% of angular quartz and large mica that has fired hard and is grey with a red exterior margin. There is light sooting on both surfaces.

Vessel 6

Context 1725; S 753; 1 abraded body sherd; Th 8mm; Wt 6g
The fabric is coarse clay that has fired hard and is grey with a brown exterior surface. The interior surface is sooted.

Vessel 7

Context 142; S 51; 5 body sherds, 2 crumbs; Th 7mm; Wt 9g
The exterior surface is burnished. The fabric is sandy clay, which has fired hard and is grey with a brown exterior surface.

Vessel 8

Context 98; S 41; rim sherd; Th 7mm; Wt 6g
Rim sherd, the lip slightly rolled to the exterior. The exterior surface is burnished. The fabric is fine clay with *c.*10% of larger quartz, which has fired hard and is grey with brown surfaces. Neolithic carinated bowl.

Vessel 9

Context 432; Find 92; 3 body sherds; 3 fragments; Th 15mm; Wt 28g

POTTERY AND FIRED CLAY

The exterior surface is smoothed. The fabric is fine sandy clay with c.10% of large quartz, which has fired hard and is grey with a red exterior surface.

Vessel 10

Context 429; S 181; 2 small fragments; Th 5mm; Wt 1g
The larger fragment has three closely spaced rows of comb impressions. The fabric is fine sandy clay with c.10% of coarse quartz that has fired hard and is grey with red margins.

Vessel 11

Context 2816; S 1106; Body sherd; Th 12mm; Wt 6g
From a coil-constructed vessel with N-shaped junctions. The fabric is fine clay with c.10% of rock fragments, which has fired hard and is grey with red margins.

Vessel 12

Context 741; S 330; 1 fragment; Wt 4g
The fabric is fine sandy clay that has fired hard and is grey with a buff exterior surface.

Vessel 13

Context 2982; S 1218; body; Th 8mm; Wt 2g
Small body sherd decorated with incised lines. The exterior surface is smoothed. The fabric is fine sandy clay that has fired grey. Possibly Beaker.

Vessel 14

Context 155; Find 4; 1 body sherd; 2 fragments; Th 6mm; Wt 3g
Body sherd. The fabric is fine clay with c.20% of large quartz inclusions, which has fired soft and is orange. From same feature as V1.

Vessel 15

Context 154; S 69; Tiny rim fragment; Th 5mm; Wt <1g
The exterior surface is burnished. The fabric is fine clay with c.10% of large quartz, which has fired hard and is grey. The exterior surface is sooted. From same feature as V1.

Vessel 16

Context 798; Find 196; 1 body sherd; Th 8mm; Wt 4g
The fabric is fine sandy clay that has fired hard and is grey with a red exterior margin.

Vessel 17

Context 521; Find 96; 7 body sherds; Th 7mm; Wt 28g
The fabric is sandy clay with c.20% of coarse quartz, which has fired hard and is grey with a brown exterior surface. One sherd is decorated with criss-crossing incised lines.

Vessel 18

Context 402; Find 87; 9 body sherds and 2 crumbs; Th 8mm; Wt 96g
The exterior surface is smoothed and decorated with evenly spaced lines of impressed twisted cord c.1mm thick and c.5mm apart. The fabric is fine sandy clay with coarse quartz, which has fired hard and is red with a grey interior margin. The interior surface is sooted. Beaker.

Surface cleaning u/s

Two small sherds, one with a line of impressed cord; Th 7mm; Wt 3g. Grey with red margins. Fired hard.

Vessel 19

Context 2470; Find 666; 1 rim; Th 8mm; Dia 180mm; Wt 45g
Rim with a rounded lip and a long neck (broken in four). Below the neck is incised decoration, possibly infilled lozenges or triangles. The fabric is fine clay with organics (grass), which has fired hard and is red. Possible decorated Iron Age pot.

Vessel 20

Topsoil strip

Three rims (one broken in two), five body sherds (two carinated), two basal sherds and three fragments; Th 11mm; Wt 114g

Rounded rim with a carination 20mm below the lip. The exterior surface is slipped. The fabric is fine clay with c.40% of large angular rock fragments, which has fired hard and is grey with brown surfaces. The exterior surface is sooted. Neolithic carinated bowl.

Vessel 21

Context 402; S 162; 1 body, 2 fragments; Th 8mm; Wt 7g
Exterior surface smoothed. The fabric is coarse sandy clay that has fired hard and is grey with brown surfaces. From same feature as V18 (Beaker).

Roman pottery

COLIN WALLACE

A small body sherd of a Roman oxidised ware vessel came from the western part of the excavated site. The dark sandy silt, full of metalworking debris (context 225 – a radiocarbon date of cal AD 130–340 was made on the charcoal within (225) (SUERC-30359)) above the cobbles in the long hollow (Cobbled surface 227), produced a body sherd (SF046: now broken in two: weight 3.0g) that has lost both its surfaces. The fabric, from the fresh break, is a fine oxidised one, orange with a darker core and very sparse fine quartz inclusions. This might originally have been from a fine oxidised ware beaker or bowl, or even a colour-coated vessel, of 1st or 2nd century AD date. While the suggested date-range is a broad one, it compares well enough with the other Roman-period material from the rest of the site, and the Culduthel Roman pottery looks to belong to the same horizon as the material from northern sites such as Birnie, Brackla, Deskford and Tillydrone, but not as late as the pottery from Kintore, Keiss or Crosskirk (Hunter 2005a, 93; Hunter 2001a, table 1; Wallace 2008; Robertson 1970, table 1; Fairhurst 1984, 115). Locally, and unfortunately only vaguely identified, there is the 'grey Romano-British coarse ware' sherd from the earlier cairn at Stoneyfield, Raigmore, a short distance away to the north-east (where there was also an early Roman headstud brooch: Simpson 1997, 56, 65, 74 and 77).

Ceramic whorl

DAWN McLAREN

One small fragment of a biconical, fired clay spindle whorl was recovered from a post-hole within Workshop 22. This is the only finished spindle whorl fragment from the site, although one stone roughout (SF0584) came from a post-pipe within the latest phase of the substantial roundhouse House 10/3. The rounded biconical form of the ceramic example is comparable to that found at the Iron Age wheelhouse at Cnip, Western Isles (Hunter and MacSween 2006, 131–3, SF 284, Illus. 3.18e).

SF0158 Spindle whorl fragment. Small, rounded-edge fragment from a biconical ceramic whorl. Buff-coloured fine-grained fabric. No central perforation remaining. D 43.5 T 20mm. Context 525, Upper fill of post-hole (context 597), Workshop 22.

Fired clay

GIL PAGET AND DAWN McLAREN

A large assemblage of fired clay fragments was recovered throughout the excavated area at Culduthel. The total of 29.7kg of fired clay was examined macroscopically, allowing classification based on form, colour, fabric type and condition. Petrological analysis of a small sample has been undertaken and is reported on separately. The majority of pieces have probably been burnt unintentionally. The assemblage is dominated by small, fractured and abraded fired clay fragments, most lacking any original surfaces. In most cases, insufficient material survives to allow reconstruction of their original form. A small quantity of more significant pieces, with evidence of shaping, wattle impressions and finger impressions, are the main focus of this report. A small proportion of the assemblage comprises tiny abraded crumbs of fired clay; it is possible that included within this material are abraded undiagnostic pottery fragments. A full catalogue of the material is contained in the archive. Although often described as burnt daub, such undiagnostic fired clay fragments do not necessarily derive from burnt clay walls of houses. As such, the term fired clay is preferred to describe this material unless it is more diagnostic.

Fabric and material analysis

FABRIC

Due to the fractured and often abraded condition of the fired clay, identification of specific fabric types was problematic. However, three main fabric types can be identified among the assemblage: fabric A with organic inclusions as temper; fabric B with fine-grained quartzite/sand inclusions; and fabric C, a combination of both organic and quartzite/sand inclusions (Table 6.1). Many fragments have no definable inclusions and are categorised as untempered clay.

Fabric A used organic fibres, possibly grass, disaggregated straw or animal manure. These organic inclusions are present on the surfaces of the fired clay as fine linear, often tapering, voids. Due to the abraded condition, it is not always possible to determine

Table 6.1
Summary of fabric types present

Type	Description	Weight	Percentage
Fabric A	Fine to very fine-grained matrix with organic inclusions	9.5 kg	32%
Fabric B	Fine to very fine-grained matrix with poorly sorted quartzite/sand inclusions	3.9 kg	13%
Fabric C	Fine to very fine-grained matrix with organic impressions and poorly sorted quartzite/sand inclusions	15.1 kg	51%
Untempered	No distinct inclusions	1.2kg	4%

whether these voids represent inclusions within the clay matrix or impressions on the surface made during production. No attempt to distinguish these has been made. The inclusion of fine-grained quartzite and sand grains was noted within fabric B. Petrographic analysis indicates that these inclusions comprise poorly sorted fine quartz and feldspar grains as well as some larger gabbro inclusions. It is not certain whether these inclusions are a feature of the natural clay or were deliberately added as temper. A small proportion of the raw clay used (4%) appears to be natural, lacking distinctive evidence of deliberate tempering such as the addition of larger crushed rock fragments, grog, shell or bone. This is confirmed by petrological analysis which indicates the use of fine or very fine, poorly mixed clay with unsorted fine quartz and feldspar inclusions.

Condition

The fired clay present displays varying degrees of oxidation (Table 6.2). The vast bulk has been lightly fired (67%), in most cases probably accidentally, and is red-brown or orange-brown in colour. A small proportion has sooting on the surface from direct exposure to intense heat and flame (1%). Only 3% (0.9 kg) is unfired clay with little evidence of any deliberate modification or use.

Table 6.2
Summary of condition of the fired clay

Condition	Weight	Percentage
Unburnt	0.9 kg	3%
Burnt	20.1 kg	67%
Burnt & abraded	6.4 kg	22%
Vitrified	8.7 kg	30%

POTTERY AND FIRED CLAY

SF0139



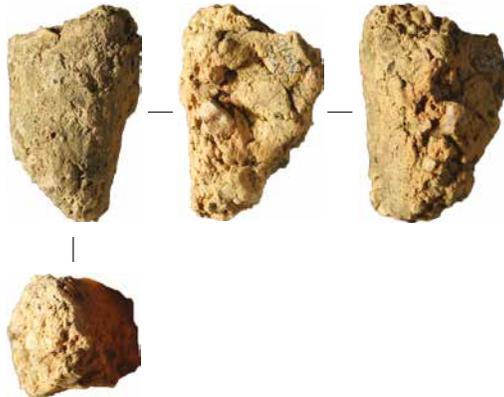
SF0852



SF0891



SF0895



SF1149



SF1150



Illustration 6.3
Fired clay

Approximately 30% of the fired clay assemblage has been exposed to prolonged, intense heat, causing the vitrification of at least one face, and is likely to have derived from a hearth or furnace associated with a high-temperature pyrotechnic process such as metalworking. This material forms as a result of a high temperature reaction between the clay lining of the hearth/furnace and the alkaline fuel ashes or 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). There will be a certain amount of overlap between the vitrified ceramics discussed here and the more diagnostic furnace lining fragments analysed alongside the ferrous metalworking waste. A large proportion of the fired clay fragments are highly abraded (22%). The external surfaces have been worn smooth through weathering, many with few discernible edges or original surfaces remaining. The abraded condition of such a large proportion of the assemblage suggests it may have been left lying around on site for an extended period of time after collapse, dismantling or destruction of the features. These amorphous rounded fired clay nodules are light sandy brown through to orange-brown in colour and are often friable and powdery in texture.

Significant pieces

SHAPED FRAGMENTS

A significant proportion of the assemblage (23%) comprises fragments with evidence of deliberate shaping in the form of smoothed rounded (56%) or flattened surfaces (35%). In the majority of instances, the fragments are so small and fractured that one cannot determine what form the original object or structure took. Some original surfaces preserve finger smears from smoothing by hand when wet. Others have distinct finger impressions produced when pressing, pinching or moulding the clay to shape. A small quantity (1.5kg) of the fired clay bears impressions that indicate it had been pressed against flat stones, or into corners formed by flat stones, suggesting use in a structural feature. Wattle impressions were found on 5% of the shaped fragments. These will be discussed further below.

In addition to these undiagnostic shaped pieces are a small quantity of more unusual or identifiable forms. These include six fragments of possible furnace or hearth rims. Recognisable fragments of the upper structure of a clay-built furnace or hearth are very rare. These have been identified due to the robust, heavy-duty form of the rim itself, the coarse fabric of the clay and the light patches of vitrification present. The lack of adhering slag makes it impossible to relate them directly to a particular high-temperature pyrotechnic process. However, their recovery from a series of furnace features associated with ferrous metalworking debris suggests that they are likely to be pieces of the upper structure of ceramic shaft furnaces.

Also present is a small quantity of thin curving clay plates that appear to be a relining of a furnace structure. This confirms the evidence from the vitrified ceramic associated with the ferrous metalworking debris of the repair and reuse of at least one of the furnaces.

FURNACE/HEARTH RIM FRAGMENTS

SF0139 Two joining fragments of fired clay forming a fairly straight, rounded thick rim. Both ends are broken and the base is

fractured; thus original depth is unknown. Fabric A. L 54, W 21 remaining D 22mm. Mass 19.8g. Context 675. Clay lining of furnace [681], Workshop 2. (Illus. 6.3)

SF0852 Shaped sub-cylindrical amorphous lump of fired clay with distinct finger impressions produced when pinching the clay to form an irregular sloping corner or rim; possibly a furnace rim but lacks any evidence of vitrification. Both ends are broken and it has been detached from a larger object or structure. An angular flat impression on the fractured edge (41 × 8mm) indicates the clay had been pressed into and against a stone. The irregular finger impressions are particularly clear on one face; some attempt has been made to smooth the surface of the opposite face after shaping. Fabric A. L 68 W 29 remaining T 35mm. Mass 55.3g. Context 4257, Basal fill of furnace 4262, Workshop 15. (Illus. 6.3)

SF0891b Shaped, elongated triangular-sectioned nodule of fine fired clay, pinched and smoothed to form a conical rim or edge. The clay has been shaped around horizontal stone fragments. The piece has been constructed by building two elongated cylindrical lumps on top of one another, with little attempt to conceal the join. One face has been smoothed after shaping, with finger impressions present. The other face is lightly vitrified. Fabric B. L 61 W 38.5 remaining T 50mm. Mass 69.5g. Context 4258, Primary fill of furnace 4262, Workshop 15. (Illus. 6.3)

SF0895 Thick rounded clay rim produced from light buff-coloured clay with frequent small to medium sized angular quartz inclusions. The piece is fairly straight along its length, broken at both ends. Both faces are lightly vitrified towards the broken edge. Fabric c.L 48.5 W 29 remaining T 26mm. Mass 36.6g. Context 4258, Primary fill of furnace 4262, Workshop 15. (Illus. 6.3)

SF0898 Thick vitrified rounded clay rim fragment. The clay is light buff in colour, with frequent small to medium angular quartz inclusions. The fragment curves slightly along the length but insufficient quantity survives to determine the original diameter. The rim runs parallel to a slightly uneven rounded linear wattle or stone impression (D 16.5mm) on the fractured edge. Both faces are lightly vitrified from exposure to intense heat. Fabric A. L 65 W 30 remaining T 44mm. Mass 53.25g. Context 4258, Primary fill of furnace 4262, Workshop 15.

SF1149 Large robust sub-cylindrical fragment of coarse clay with large angular quartz inclusions. Much of the surface has been lost on one face but the other has been flattened and smoothed. The piece curves slightly in length, indicating it formed part of a circular or sub-circular structure. Smooth, curving impression on the fractured edge indicate the clay had been formed around rounded pebbles. Fabric c.L 86 W 62 remaining T 72mm. Mass 307.7g. Context 4127, Fill of post-hole 4126, House 10/3. (Illus. 6.3)

FURNACE RELINING

SF1148 Furnace relining. Fourteen thin irregular curving plates of fired clay. Possibly a thin skim of material applied to a pre-existing curved surface, perhaps also of clay. The convex rounded surfaces, which would have been in contact with the

POTTERY AND FIRED CLAY

existing material, are pitted and uneven, preserving an impression of the underlying surface. The opposite, concave faces are smooth with finger smears remaining from shaping. The pieces range in thickness from 5.5 to 12mm. Untempered fabric. Mass 71.5g. Context 677, Primary fill of furnace (681), Workshop 2.

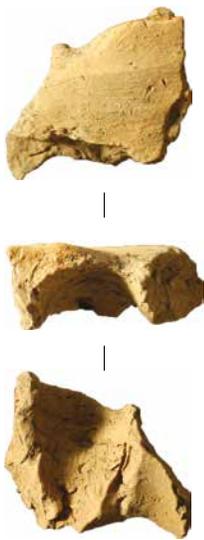
WATTLE IMPRESSIONS

A small percentage (9%) of the fired clay fragments preserve wattle impressions in the form of linear notches of varying diameters that indicate the former presence of a framework of wooden withies around which the clay was applied (Table 6.3). Wattle (the timber framework) and daub (the clay) have been used since early prehistory to construct walls, partitions and other structures. The use of wattle and daub structures at Culduthel is consistent with similar material recovered from other later prehistoric settlements such as Seafeld West, Inverness (Hunter 2011b) and Fairy Knowe, Stirlingshire (Willis 1998, 332–5).

Table 6.3
Summary of range of wattle impressions present

Impression description	Weight	Quantity
Single narrow withy	1.19kg	multiple fragments
Single wide withy	0.29kg	5
Two angled withies	0.03kg	1
Two parallel withies	0.14kg	multiple fragments
Three parallel withies	0.01kg	1
Angular timber	0.03kg	3
Frame	0.39kg	multiple fragments

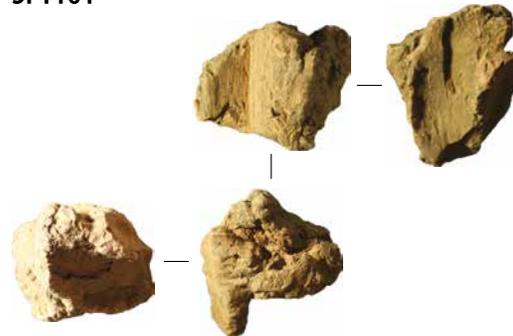
SF1153



SF1156



SF1161



SF1172



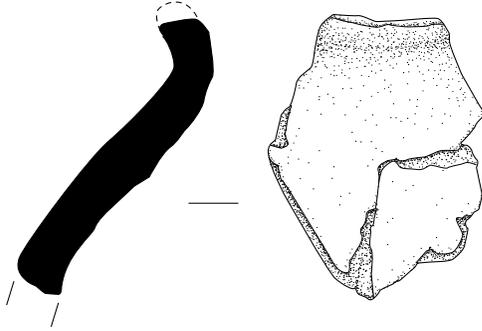
SF1173



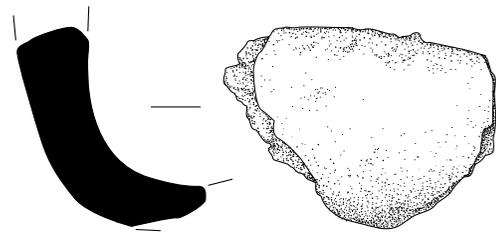
Illustration 6.4
Fired clay

CULDUTHEL

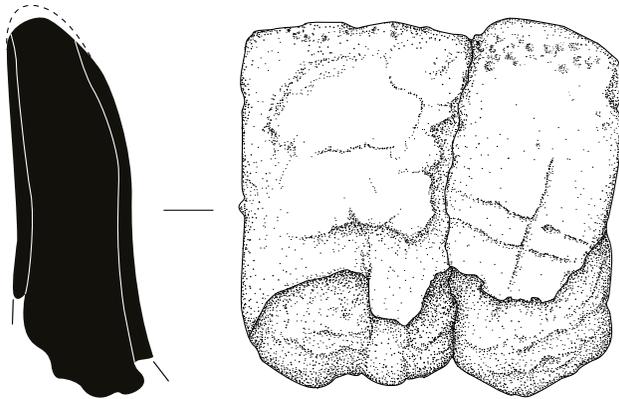
SF1153



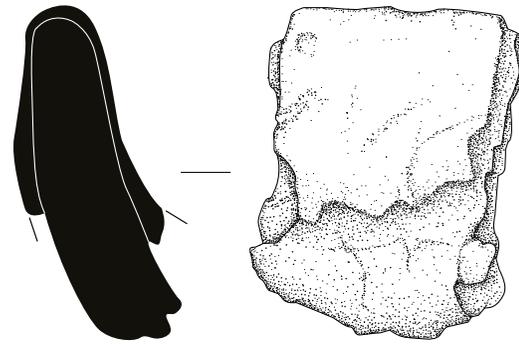
SF0412



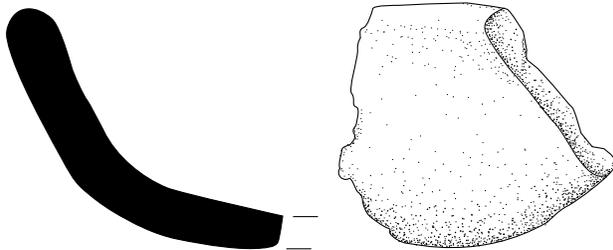
SF0375



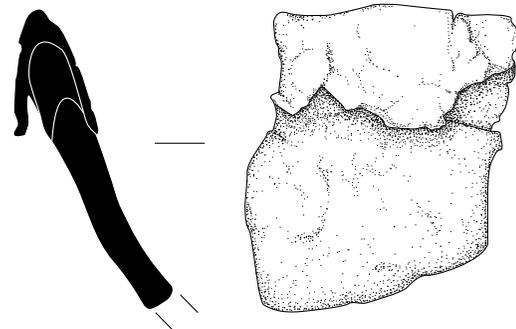
SF0481



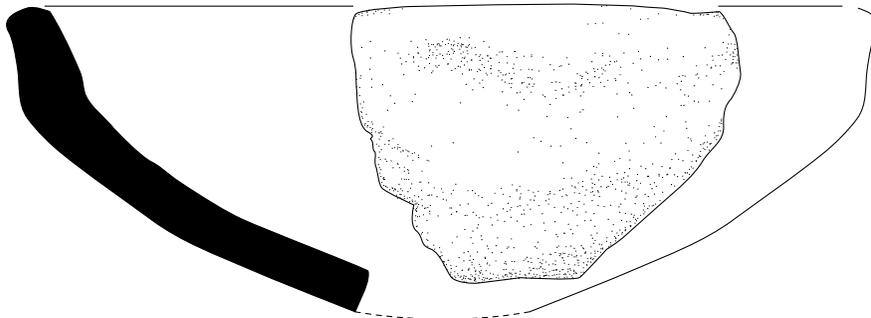
SF0377



SF0556



SF0447



0 2.5cm

Illustration 6.5
Crucibles

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The majority of the fragments (54%) are highly abraded, making identification of the form and orientation of the withies difficult to determine.

The majority of the recognisable fragments have the impression of a single narrow circular-sectioned withy ranging in diameter from 7 to 17mm. Wider withies were also used, sometimes in conjunction with the narrower pieces (e.g. SF1153 – Illus. 6.4 and 6.5), and range in diameter from 19 to 33mm. The average diameter used was 13mm. Examination of the interior of these impressions provides further detail of the materials used. Most of the wattle impressions are smooth, suggesting that the bark had been removed from the withies prior to their use. A small number of impressions have ribbed, textured impressions, implying that the bark had been left on.

Three fired clay fragments (SF1145, SF1161, SF1162) have angular impressions, indicating the use of cut timber rather than circular-sectioned withies. Due to their fragmentary condition it has not been possible to estimate the original size of the timbers used, but they must be from squared timbers or planks. The grain of the wood is clearly visible. In most cases, insufficient clay surface survives to allow reconstruction of the orientation or configuration of the withies. However, a small number of pieces provide more detailed information. SF1150 preserves the impressions of three separate withies; two parallel impressions and a third, perpendicular impression with a much wider diameter. This suggests the use of a simple framework of thick vertical struts, cross-cut by a series of narrow horizontal withies (Illus. 6.3). Others, such as SF1165 and SF1173, are slightly more haphazard, indicating the use of near-parallel, but differently aligned, narrow withies. Both circular-sectioned withies and prepared squared or rectangular-sectioned timbers (as in SF1161 – Illus. 6.4) were used to create a frame around which the wet clay was applied.

CATALOGUE OF ILLUSTRATED FRAGMENTS

SF1156 Wide, single withy impression. Abraded amorphous fragment of orange-brown fine clay. No original surfaces remaining. Along one elongated face is a wide tapering wattle impression (D 16.5–25.5mm); slight ridges in the interior suggest that the bark was not removed. Fabric *c*.L 75 W 51.5 T 41.5mm. Mass 71.8g. Context 1864, fill of pit 1863. (Illus. 6.4)

SF1153 Parallel withy impressions. Fine-grained burnt clay; the original slightly rounded surface has clear finger smears from smoothing while the surface was wet. An impression from a wide, thick, circular-sectioned vertical withy (D 20.5mm) runs perpendicular to the original surface. The ribbed interior surface suggests that the bark was not removed from the withy. 3mm from the edge of this impression is a further ribbed wattle impression from a narrow withy (D 12.5mm) set at a sharp diagonal angle. Fabric A. L 44.5 W 33.5 T 16mm. Mass 15.2g. Context 3218, fill of post-holes 3531 and 3532. (Illus. 6.4 and 6.5)

SF1172 Parallel withy impression. Small, lightly abraded fragment of orange-brown fired clay with impressions of two parallel circular-sectioned narrow withies (D 12–15mm) running perpendicular to a smoothed original face. Fabric *c*.L 24 W 22 T 15mm. Mass 4.8g. Context 2685 (=798 spread of waste debris). (Illus. 6.4)

SF1173 Three withy impressions. Rounded fragment of fired clay, one rounded smoothed face remaining. The opposite face has three parallel circular-sectioned narrow wattle impressions (D 11.5mm, 12mm, 13mm), the middle withy orientated at a slight angle. Fabric *c*.L 37.5 W 32 T 17.5mm. Mass 13.6g. Context 2685 (=798 spread of waste debris). (Illus. 6.4)

SF1161 Angular timber impression. Small angular fractured fragment of fine-grained fired clay with three wattle impressions. A right-angled corner impression comes from a modified square or rectangular-sectioned timber baton (17.5 × 11mm). Linear ridges on the interior indicate that this was core timber rather than a branch or twig. Running diagonal to this angled impression are two parallel circular-sectioned withy impressions (D 6.5–14mm). No original surfaces remain to confirm the orientation of the withies. Fabric A. L 38 W 33 T 27mm. Mass 16.4g. Context 2685 (=798 spread of waste debris). (Illus. 6.4)

SF1150 Framework impression. Sub-rectangular fragment of fine-grained fired clay. While wet, the clay has been pressed firmly around one large vertical circular-sectioned withy (D 27.5mm), leaving three distinct, regularly spaced finger impressions on the opposite face. At right angles to the wide-sectioned lateral withy are two evenly spaced, parallel horizontal narrow withy impressions (D 11–12mm), indicating the clay had been applied around a built framework of withies. The ridged interior of the narrow impressions suggests that the bark was left on the withies. In contrast, the interior of the wider impression is smooth, suggesting that the bark had been removed. Fabric A. L 55.5 W 19 T 19mm. Mass 15.2g. Context 3218, fill of post-holes 3531 and 3532.

DISTRIBUTION

Fired clay was recovered from across the main occupation areas within the excavation area. The vast bulk (89% 26.3kg) was recovered from within House 10/3, and Workshops 13 and 15. A detailed consideration of the distribution by area follows.

Workshop 2

Within Workshop 2 is an iron smelting furnace (F681). A total of 8.8kg of fired clay was recovered from this structure, 83% from deposits relating to the furnace (contexts 674, 675, 677, 678, 680). Only 0.6kg displayed any evidence of vitrification or exposure to intense heat. Five samples directly related to the furnace had been deliberately shaped, including thin fragments of possible relining (SF1148), and these are interpreted as fragments of the upper structure of the furnace. Unfortunately, despite their fairly fresh condition, insufficient details remain to allow any reconstruction of the form of the upper structure.

The remaining 147g of fired clay was recovered from post-holes (contexts 411, 464, 594, 613, 634, 639, 646, 649, 670, 671, 698, 704).

House 3

This structure has been preserved as a partial ring-groove and a series of internal post-holes and pits. Only 5.9g of fired clay was recovered from this structure (ditch fill 724 and fill of post-hole 852), the majority highly abraded.

CULDUTHEL

House 4

Only 63g of fired clay was recovered from this roundhouse, 69% from the ring-ditch and ring-groove (contexts 775, 776, 871, 1627, 1629, 1784) and the remaining 31% from post-holes within the interior of the structure (contexts 1706, 1708, 1708, 1710, 1795, 1918, 2356, 2360). The final structure was destroyed by fire, which may account for the formation of some of the material. 32% of the fired clay was abraded, suggesting it had been exposed to weathering prior to deposition. Two fragments from the ring-ditch (contexts 871 and 1784) had narrow wattle impressions, perhaps indicating the former presence of internal wattle and daub screens or other structural elements. One fragment of vitrified ceramic (sample 242) came from the upper floor deposit in ring-ditch 1810 (context 775).

Workshop 6

One fragment of vitrified ceramic was recovered from post-hole 889 (context 890) within this partially excavated post-ring structure. A total of 190.4g of abraded amorphous fired clay was recovered from context 1632 associated with Structure 22. This context has been described as a dump of material from a furnace. None of the fired clay fragments bore evidence of vitrification or adhering slag.

Cobbled surface 227

A total of 514g of fired clay was recovered from this large, cobbled surface (context 221, 225, 226). 75% was vitrified from exposure to intense heat. It was found in association with significant quantities of ironworking slag and is likely to have derived from the upper structure or lining of a ferrous metalworking feature such as a hearth or furnace.

Other

A further 59.8g of amorphous, undiagnostic fired clay was recovered from isolated pits, post-holes and deposits surrounding cobbled surface 227 (contexts 393, 430, 447, 510, 529, 532, 642).

Workshop 12

Only 6g of fired clay was recovered, all of it vitrified, from the secondary fill of post-hole 2444 (context 2447).

Workshop 16

A total of 1.4kg of fired clay was recovered from Structure 16, a roundhouse. 99% of it came from an iron smelting furnace (2246) and is interpreted here as fragments of the upper structure of the furnace itself. 0.72kg of the clay from the basal fill of the furnace (2288) is interpreted as the in situ remains of the last firing. 0.71 kg came from the post-abandonment fill of the furnace (context 2247, 2248), approximately 88% of which is highly abraded, suggesting that it had been left to weather and erode for some time prior to deposition.

House 17

Only 11.7g of fired clay was recovered from this structure, deriving from post-holes 2263, 2240 and pit 2410. The pieces are amorphous in shape, with few original surfaces remaining, and were insufficient to allow reconstruction.

Workshop 18

8.8g of abraded, amorphous fired clay was recovered from post-hole 3540 of this small roundhouse.

Workshop 19

Only 9.1g of fired clay was recovered, from post-holes 2535 and 2522 of this large roundhouse. One piece showed signs of being deliberately shaped and smoothed, the other was highly abraded.

North-west edge of site

A further 5.9g of highly abraded fired clay came from post-hole and pit features within this area (contexts 2314, 2319, 2418, 2593, 2649).

House 9

Only 3.1g of amorphous fired clay was recovered from this structure, all coming from post-hole fills (context 1762, 1861, 2108, 2112).

Workshop 13

A total of 5.68kg of fired clay was recovered from this small two-phase roundhouse.

0.4kg derived from iron smelting furnace 3050 (Phase 1) and is likely to represent fragments of the upper structure or lining of the furnace. Very little of this material (126.3g) preserved any evidence of deliberate shaping, making reconstruction of its form impossible. 91% of this fired clay was vitrified, indicating exposure to intense heat. The majority of material associated with this structure came from iron smelting furnace 3790 (Phase 2). A total of 5kg of fired clay came from this furnace; 50% of it was vitrified, confirming its interpretation as lining or fragments of the furnace structure. Cross-cutting wattle impressions on a small quantity of the material (216g) indicate the use of a wattle framework around which the raw clay was applied. In addition, a small quantity (56g) displays evidence of deliberate shaping, with smooth, rounded surfaces remaining. Only 0.4kg of the fired clay was highly abraded, suggesting that the clay upper structure was deposited fairly soon after destruction. A further 0.28kg of material was recovered from post-holes (contexts 2819, 2898, 2912, 2919, 2936, 2987, 3793, 4194, 4272), including one fragment of unburnt clay from post-hole 2936 and a fragment with wattle impressions from post-hole 2819.

Pit 3744 (close to Workshop 13)

A total of 0.74kg of fired clay was recovered. Just under half of this clay (315.2g) had wattle impression. These indicate that both circular-sectioned withies with the bark remaining and prepared squared or rectangular-sectioned timber battens were used to create a frame around which the wet clay was applied. Only one fragment (SF1167) had enough original surfaces remaining to indicate that the surfaces had been deliberately smoothed and rounded. Two pieces (from samples 292 and 1039) were vitrified.

Hearth 2434

76.1g of fired clay came from the charcoal-rich spread surrounding this hearth. Over 50% of the clay was highly abraded (40.7g) with many of the original surface features being removed by weathering

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and erosion. Only one fragment displayed evidence of deliberate shaping, and none was vitrified.

Hearth 2166

Just under 1.2kg of fired clay was recovered from the vicinity of this hearth (contexts 2165 and 3180). 67% bears traces of deliberate shaping to create smooth, round external surfaces, including SF1145 with a single, angular wattle impression. Only 4% of this material was vitrified.

Workshop 15

A total of 10.1kg of fired clay was recovered from this roundhouse, with significant quantities coming from each of the three furnaces

Furnace 4355

A total of 2.15kg of fired clay was recovered from this middle furnace (contexts 4354, 4217, 4148). Large quantities of smelting slag confirmed its use for iron bloomery smelting (Dungworth & McLaren, Chapter 6, Iron). The majority of the clay pieces were small and fractured but lacking evidence of prolonged weathering. The fabric is fairly coarse with distinct angular quartzite inclusions. Four samples (samples 781, 785, 1682, 1683 and context 4345) displayed evidence of deliberate shaping with flattened, smoothed surfaces, some with finger impressions. In addition, samples 1682 and 1683 have partial wattle impressions, indicating the clay was built up around a framework of narrow withies. Only 12% of the fired clay was vitrified, but it is likely that all of this material represents the dismantled upper structure of the furnace.

Furnace 4147

3.1kg of fired clay came from furnace 4147 (contexts 4141, 4176, 4122, 4146). 69% of the clay was abraded, suggesting it had been left to weather for some time prior to deposition. Only 741.6g of the clay was severely vitrified (24%). Three fragments had evidence of deliberate shaping; two pieces with smoothed, rounded external surfaces and one piece with a flattened, vitrified, slag-attacked surface from the interior of the furnace.

In addition, just over 1kg of fired clay was recovered from context 4121, an upper fill within both furnaces 4355 and 4147, which represents deliberate backfilling after use. Over a third of this material (39%) is vitrified, suggesting that it represents further fragments of one or both dismantled furnaces. No differences in the fabric of the clay used in each furnace could be detected and only 9% of the material from this context was abraded. Three samples (SF0761, 7692 and 774) contained fragments that had deliberately smoothed and rounded surfaces, presumably deriving from the exterior surface of the furnace.

Furnace 4262

A total of 1.35kg of fired clay was recovered from this furnace feature. Two distinct fills were noted during excavation. 36% derived from the primary fill (context 4258) and 39% from the upper fill (context 4257). Little difference in clay morphology was noted between the two deposits. Only 21% of the material was vitrified. Less than 1% of the clay was distinctly abraded, suggesting deposition soon after destruction and limited weathering. A significant amount of the clay from this furnace was shaped,

including four fragments of rounded or slightly flattened thick robust clay furnace rims (SF0852, SF0891, SF0895 – Illus. 6.3 and SF0898). Three fragments were recovered from the primary fill (SF0891b, SF0895 and SF0898), one from the upper deposits (SF0852). Differences in fabric type suggest that these derive either from two separate phases of furnace use or from at least two separate furnace structures. Fragments 895 and 898 are very similar in thickness, form and, more crucially, fabric type, comprising a coarse, light-buff-coloured fabric with frequent small to medium sized angular quartz inclusions. Both are likely to have derived from the same furnace structure. SF0852 and SF0891 are very different. They comprise crudely shaped pinched rims with distinct finger impressions and finger smears. They have been produced from fine-grained clay with some possible organic impressions. Angular impressions on the basal fracture surface indicate that the clay had been constructed around small flat, regularly spaced angular stones. None of the furnace rim fragments show heavy vitrification. Unfortunately, all four fragments are so small that the original diameter cannot be determined.

Pit 4369

This circular pit, immediately east of the above furnaces, was associated with significant quantities of iron smelting slag and may represent either a dismantled furnace or a dump of waste material. The pit was clay-lined, with 2kg of fired clay recovered from the interior, the majority amorphous lumps lacking any distinctive features. 15% had smoothed and rounded surfaces and 10% was abraded. None of the material was vitrified.

Workshop 15 post-holes and occupation deposits

A further 0.5kg of fired clay was recovered from Structure 15, 26g from occupation deposits (context 4342) and 472g from the fill of the inner post-holes (context 4132, 4268, 4289, 4295, 4297, 4311, 4312, 4322). 85% of the pieces recovered from the post-holes preserved wattle impressions. Only 8% of the material is abraded and 1% of pieces are vitrified. This fired clay could indicate the presence of an internal partition within the roundhouse or suggest the distribution of the spread of debris from the nearby furnaces.

House 10

A total of 2.3kg of fired clay was recovered from Structure 10. Only 39% has been assigned to the three identified structural phases, 99% of which comes from the final phase in the sequence.

10/1 3g of fired clay was recovered from post-hole 3601.

10/2 Minute crumbs of abraded fired clay weighing a total of 0.3g were recovered from post-holes 2488, 2771, 3338, 3613 and 3615. No external surfaces were preserved.

10/3 0.9kg of fired clay was recovered from postpipes, stake-holes and post-holes (contexts 2587, 2842, 2873, 2842, 3460, 3605, 3623, 3746 and 3750). The greatest concentration came from post-hole 3750, which contained 0.8kg of fired clay, the majority of which was vitrified and is probably furnace lining. 7.7g came from the ring ditch and outer ring-groove (contexts 1764, 2203, 2215).

Small quantities of undiagnostic material also came from surface deposits (34.6g from contexts 2450, 2452, 2470, 3113, 3567), from

the stone wall base outside the ring-groove (9.5g, context 1853), from abandonment deposits (1.05kg, contexts 1671, 2199), and hillwash overlying the structure (17g).

Phase unassigned 1.4kg of fired and vitrified clay from Structure 10 derived from features and contexts that cannot readily be assigned to a particular phase. Over 85% (1.2kg) was recovered from post-holes (contexts 2211, 2539, 2606, 2701, 3680, 2680, 2860, 2887, 2889, 2891, 3019, 3045, 3286, 3449, 3468, 3603, 3680, 3868, 4061, 4126, 4185). A further possible furnace rim fragment (SF1149) was recovered from post-hole 4126.

Features to the east and south-east of House 10

In addition to the fired clay from distinct features described in detail above, a large quantity of fired clay pieces derived from pits, post-holes and other deposits within this area. 2kg comes from various pits (pits 1863, 1936, 2143, 2454, 2777, 3517, 3051, 3564, 3756, 3808, 3811, 4134, 4375, 3795), 0.9 kg from post-holes (post-holes 1972, 1981, 1997, 2541, 2547, 2796, 2811, 2815, 2905, 2925, 2929, 2934, 3150, 3161, 3278, 3455, 3531, 3532, 3626, 3653, 3703, 3772, 3758, 3814, 3816, 3829, 3886, 3933, 3953, 4030, 4094, 4101, 4283, 4292, 4298), 0.3g from hillwash (contexts 3435 and 2102), 175g from occupation deposits (context 1896), 4.6g from turf wall (context 2477), and 0.78 kg from various deposits (contexts 798, 2102, 2187, 2191, 2682, 3883, 4279) and cobbled surfaces (SF1945 and SF2130).

Discussion

Although much of the fired clay is small, fractured and abraded, limiting the information it can provide, a small quantity of more significant pieces are present, including pieces with wattle impressions and evidence of deliberate shaping. 70% of the fired clay assemblage (20.9kg) was recovered in association with metalworking structures including iron smelting furnaces and possible smithing hearths. It is likely that this material derived from the clay-built upper structures of these features. The examination of the fired clay has provided a complementary picture to the furnace lining fragments analysed alongside the ferrous metalworking waste assemblage. Significantly, this assemblage provides a wealth of information about the above-ground structural element of the iron smelting furnaces in use at Culduthel. Very little information is available on the upper structure of Iron Age furnaces due to the rarity of their preservation, so this evidence is of importance. Identifying the form of the furnace, particularly distinguishing between bowl or shaft furnaces, is near-impossible when only the base of the furnace remains (Tylecote 1986, 133), and identifying the furnace form is normally not possible. Although vitrified ceramic fragments, interpreted as pieces of furnace or hearth lining, are commonly encountered within later prehistoric slag assemblages, they generally provide only limited information about the construction and form of the structure. This is due to four main reasons. Firstly, the fragments are often slag-attacked or highly vitrified, indicating that they derived from near the base of the furnace and can tell us very little about the overall construction. Secondly, such vitrified ceramics often consist of small fractured

pieces with only the internal, slag-attacked face intact. The unvitrified external surface will be very friable and liable to degrade rapidly, if left exposed. Thirdly, if fragments of the upper structure survive, they will not necessarily be vitrified, sooted or severely heat-affected, and are more fragile and vulnerable to erosion. Lastly, any unvitrified fired clay is commonly separated out from the vitrified material, often resulting in the material being examined by two separate specialists. Our impression of Iron Age furnaces is often constructed with reference to later, Roman shaft-furnaces rather than from contemporary evidence, which is sadly lacking in Scotland. This has always left the interpretation of the form of later prehistoric iron-smelting furnaces on shaky ground. The recovery of a small number of thick, robust furnace rim fragments are a significant find, unparalleled within a Scottish context of this date. Their identification confirms the use of cylindrical shaft-furnaces at Culduthel; an element of Iron Age ironworking technology that has always been assumed in Scotland but never demonstrated. Unfortunately, due to the small, fractured condition of these pieces, it is possible to determine neither the diameter of the shaft top nor its height. The wattle impressions present on many fragments indicate the use of a framework of withies around which the clay structure was moulded. These were predominantly roundwood, both with and without bark, but also included some squared timbers.

The fired clay also provides plausible evidence for the relining and repair of the upper structures. This is present in the form of thin skims of clay that appear to have been deliberately moulded against an existing curved wall, and confirms the evidence of relining noted within the vitrified ceramics from the ferrous metalworking debris.

In addition to the material recovered in association with the metalworking structures, 3.9kg of material, representing 13% of the total assemblage, came from post-holes across the site. These pieces concentrate within the interiors of Houses 10 and 4, perhaps indicating the former presence of internal wattle and daub screens.

Metalworking ceramics

Crucibles and moulds

FRASER HUNTER

WITH SCIENTIFIC ANALYSIS BY SUSANNA KIRK AND JIM TATE

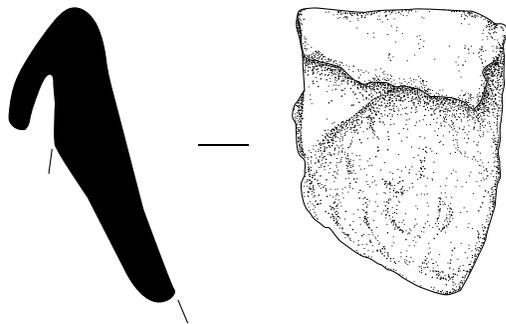
The Culduthel excavations produced 72 sherds and fragments (318g) of crucibles (Illus. 6.5 and 6.6) and 60 fragments (215g) from at least 10 moulds (Illus. 6.7 and 6.8), the vast majority from the craftworking area to the east and south-east of House 10.

CRUCIBLES

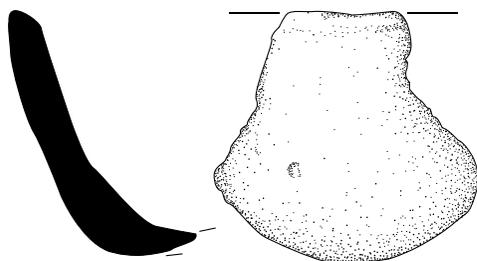
The fragmentary nature of crucibles often inhibits reconstruction of their form. Here, diagnostic fragments indicate that the typical deep triangular crucible was predominant, the sides either straight or convex in plan. A few sherds represent other, more unusual forms. There is at least one large thick-walled shallow triangular crucible with rounded sides, a type more typical of southern

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SF1103



SF1116



SF1132

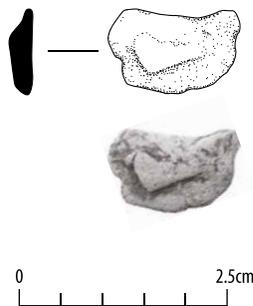


Illustration 6.6
Crucibles

England (Spratling 1979, 130) but known occasionally in Scotland (for instance at Midhowe (Orkney; NMS GVM 160), Birnie (Moray; unpublished) and perhaps Traprain Law (East Lothian; NMS GVM 583 (C14) and 585 (C24)). More unusual are sherds of a globular crucible, the neck everted into a lost rim. This form is extremely unusual for Scotland, not represented in Heald's (2005) Scottish crucible typology of the period *c.*700 BC–AD 800. Bayley's (1990) type-series indicates such forms are found in both the Roman period and the 9th–12th centuries, and there are very rare Scottish parallels: a carinated sherd from Dunadd (Lane and Campbell 2000, illus. 4.42 no. 666), and a poorly dated globular vessel with everted rim from Bretta Ness, Rousay (Hunter [forthcoming a]). The profile can also be affected by sagging or deformation during use; a near-intact triangular crucible from Traprain Law (NMS GVM 579a) has a sinuous profile in one area

caused by distortion. However, that does not seem to be the case here.

There are no complete profiles to allow a better assessment of size, but SF1116 has an internal height of *c.*35mm, quite typical for Iron Age crucibles (Illus. 6.6); SF0412, again a near-complete profile, is rather smaller, its internal height *c.*20mm (Illus. 6.5). The shallow triangular crucible SF0377/SF0447, with a height of *c.*30mm and a diameter of at least 100mm (Illus. 6.5), was rather larger, giving it a bigger capacity, while the substantial bases SF0332 and SF0384 point to notably larger crucibles, which are unusual in surviving assemblages. Wall thickness may act as a crude proxy for crucible size, although it is complicated by variation along the profile (being thicker near the base) and by relining (see below). Thickness varies from 3.5 to 12.5mm with a cluster from 3.5–8mm, suggesting a range of vessel sizes. Some fragments provide clues to the technology of forming the crucibles. The unusual globular crucible SF0374/SF0656 has split along a construction line (not a relining; the indistinct boundaries indicate it had formed while the clay was still plastic); the clay used for the upper part, closing the mouth, was notably more quartz-rich. SF0384 also shows a composite construction using several pieces of clay: it is the base of a large crucible which has failed along a construction line, leaving a stepped edge where the wall attached and a raised lip around the interior. There were different methods of forming a spout. In some cases the corner was everted; in others the inner side of the lip was thinned. These minor variations in habitual procedures suggest the hand of different individual craftworkers. See Sahlén (the section on petrographic and technological analysis of ceramic materials below) for discussion of fabrics. The location of vitrification indicates crucibles were heated from both above and below. The rims are consistently the most heavily vitrified areas, while most of the five preserved bases show evidence of heating (one base was unused, and one unheated). On two fragments (SF0332.5; SF0332.6), the distorted vitrified surface preserves rectangular indents, probably from tongs; in one case these are on a base, but the other is less clear. The degree of vitrification and other signs of heating (such as the reduction of the fabric from the freshly manufactured light brown to various stages of grey) shows that crucibles in all stages of use are present, from barely used to heavily used, reused and failed.

RELINING AND REPAIR

A most intriguing feature is the evidence for relining of crucibles to extend their lives. Eighteen of the 72 fragments had been relined with a layer of clay 1.5–4mm thick. Where the rim was preserved, the lining was normally either stacked on the rim or wrapped round it, in the process raising the vessel's height; this would provide compensation for the corresponding loss of capacity in the interior. In a number of cases, the original surface was grooved to increase adhesion of the new lining. Twelve fragments had been relined once, and two fragments twice. There were also four instances with an unfired clay patch, presumably an unfired lining. In one case, the relining clearly covered only part of the interior, suggesting it was a response to damage in one area. Relining was not just a response to heat damage, but was used to extend the life of a crucible. In the eight instances where evidence was visible, six showed signs of use damage (only lightly

in two cases) and two showed none. This suggests relining was actively used as a deliberate strategy to curate the crucibles and extend their lives, sometimes long before substantial damage occurred. The assemblage produced other evidence of repair. On SF1103 the relining was an unusual one, as it hooked over the back but did not lie flush on the rear face (Illus. 6.6). This was probably to accommodate and restrain a partly spalled area, in an attempt to extend the crucible's life. There were also two small sub-oval patches (SF1132 – Illus. 6.6 and SF1138) with marks of keying; these seem to have been pushed into a crack that had been keyed to hold it. They show no signs of significant heating.

Relining has been noted in other assemblages, though not so frequently and with a variety of interpretations. Bayley and Rehren (2007, 50) note that thin-walled crucibles often had an outer layer of less refractory clay. This was a sacrificial layer that would quickly vitrify; it was intended to insulate the crucible, distribute heat more evenly and reduce thermal shock (see also Bayley 1992, 755). Other interpretations are possible. At Dunadd, Lane and Campbell suggested that relining was connected with fixing lids to crucibles (2000, 205). At Mote of Mark, occasional relining was noted both externally and internally (Laing and Longley 2006, 31–2), the latter clearly indicating reuse of damaged crucibles. Relining could also be confused with construction lines. Since the phenomenon has only been systematically reported in modern studies of larger assemblages, none of Iron Age date, published data provide a poor basis for establishing how common relining was. To set the Culduthel evidence in context, a sample of crucibles in the national collections was examined in two ways. Material from 20 small Iron Age/Early Historic assemblages from across Scotland was examined, to give a presence/absence indication of relining, while from three larger assemblages (Traprain, Dunadd and Brough of Birsay), a substantial sample of sherds was examined to give an idea of the frequency and nature of relining. It is clear that relining, in various forms, was a common phenomenon. It was noted in nine of 20 small assemblages (representing 12 of 33 crucibles), and is present in all the large assemblages studied. Samples from these gave the following, notably consistent figures: 9/73 sherds (12%) from Dunadd, 13/138 (9%) at Birsay and 4/51 (8%) from Traprain. There are obvious problems in using a simple sherd count for such calculations, with issues such as differential fragmentation on different sites, multiple sherds from one vessel, and so forth, but even so, the figures from Culduthel are notably higher, with c.25% of sherds relined. Study of the Traprain, Dunadd and Birsay material shows some diversity to the relining process. There are very occasional examples of layering from construction lines, while Dunadd in particular shows layers from the attachment of lids. However, the bulk of the evidence most plausibly relates to repair: there are internal and external linings, both partial and total, fired and unfired, sometimes with a clear focus on the rim area. There are also examples from all three sites of layering over both unvitriified and vitrified surfaces. This is closely comparable to the evidence from Culduthel, and seems to represent both repair of damaged but favoured crucibles, and preventative maintenance of effective specimens. In contrast to Bayley and Rehren's (2007, 50) observations, the clay from the relining seems as good in quality as that of the original, suggesting this is not some sacrificial layer, while the evidence of relining over

heat-affected surfaces indicates it represents repair rather than extra insulation.

In the vast majority of cases the crucibles show little or no sign of wear after use, and this clearly represents a primary or near-primary deposit. One item (SF1103) does provide rare evidence of reuse after breakage, with one end oxidised and worn, and traces of a clay skin over it (Illus. 6.6). This suggests the fragment was built into another structure, presumably to take advantage of its refractory properties.

THE MOULDS

The clay mould fragments are frustratingly incomplete, as is so often the case, and it is uncertain what was being cast. The 60 fragments represent at least 10 different moulds (based on the minimum possible numbers from each context). They come from piece-moulds, predominantly two-piece, but one shows clear signs of being more complex (SF1108 – Illus. 6.7); it appears to be the head portion of a composite (three-piece?) mould, perhaps for pins, although this seems a little unnecessary for what are normally simple items. The moulds often show evidence of luting or cladding to seal them (or in one case to strengthen a thin area); there are also grooves from binding the halves of the mould together. Two of the small fragments preserve keying marks, in one case a protruding lug, in the other a rectangular hollow. The larger fragments, by contrast, do not show keys; they use either concave and convex valve surfaces or longer channels/ridges along the valve edges.

None of the products can be securely identified. Most distinctive is SF1125, for a linked pair of rings, slightly asymmetrical in detail. SF1110 is from another, larger ring, but there are hints of a more complex, decorative lobed form in places; too little survives to identify the product. The surviving face of SF1104 (Illus. 6.7) and SF1109 (Illus. 6.7) would produce a parallel pair of bars, slightly sinuous in profile. SF1108 might be a pin mould although, as discussed, it seems to be from a complex three-part mould, unusual for a pin (Illus. 6.7). Too little of SF1105 survives to hazard a guess, while SF0433b revealed the protruding circular edge of something reasonably tall (Illus. 6.8).

The stone mould SF0339 (Illus. 6.17) is discussed elsewhere. It most likely represents a blank for sheetworking; the product is uncertain, though it may have been a vessel.

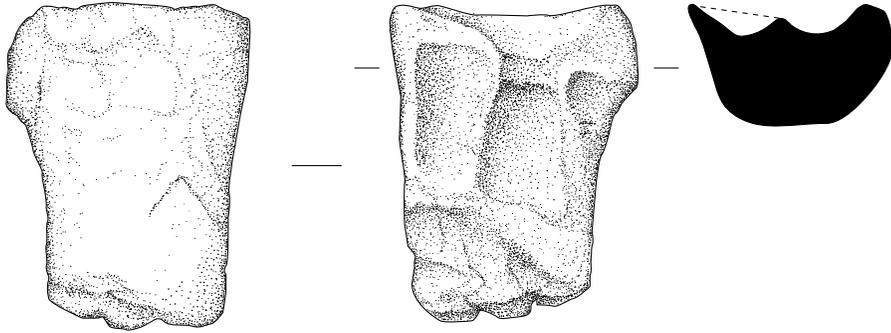
THE CASTING ALLOYS

SUSANNAH KIRK, JIM TATE AND FRASER HUNTER

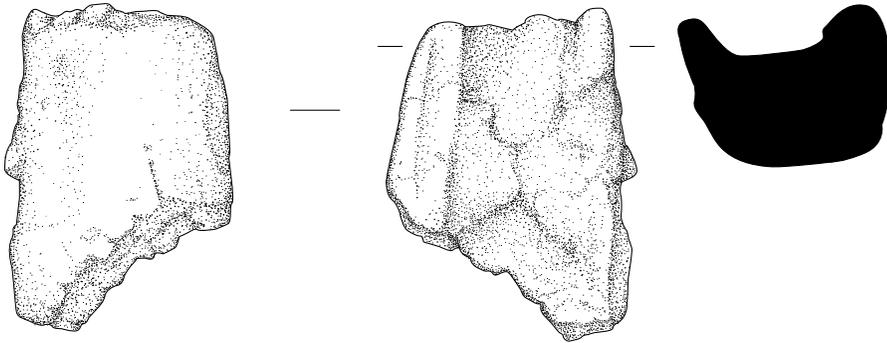
Sixty-eight crucible fragments and 20 mould fragments were investigated by X-ray fluorescence analysis (XRF) to assess the alloys being cast; see archive report for methodology. Areas with apparent residues were analysed in the first instance, with generally two more analyses being taken from each fragment. In the smallest fragments (less than 10mm across) usually only a single area could be analysed. All the moulds produced very low X-ray counts, with the metal peaks being just above the background. Both crucibles and moulds showed a similar range of elements from the ceramic component: iron, manganese, calcium, potassium, titanium, strontium, rubidium and occasionally zirconium. Full results are available in the archive report; this section provides a synthesis.

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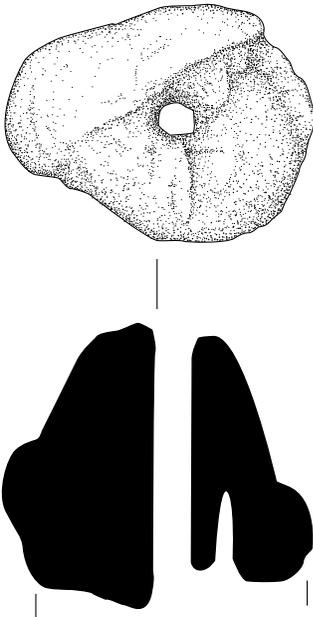
SF1104



SF1109



SF1108



SF1125

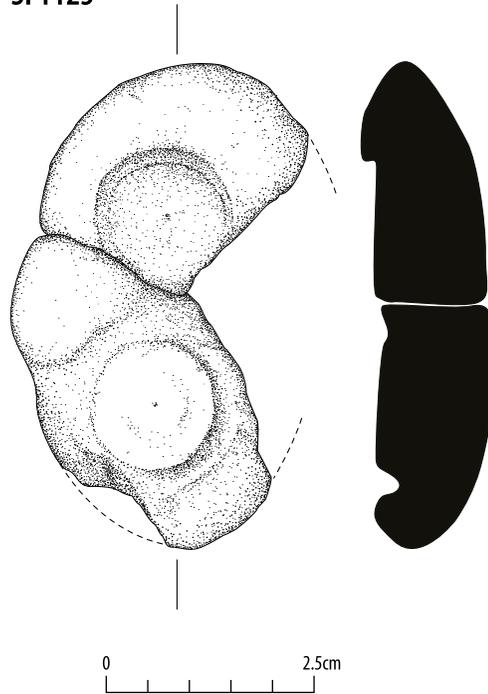


Illustration 6.7
Moulds

SF0433b



Illustration 6.8
Mould

CULDUTHEL

There are difficulties in assessing alloy type from such evidence. It is well known that certain elements can be present in crucible residues even when they were present at only very low levels in the original metals. Zinc, lead and tin can all be enriched compared to their level in the original metal due to the volatility of these elements during melting (Barnes 1985; Dungworth 2000). Zinc has the highest volatility, and Dungworth (2000) suggests that very low levels of zinc in the original metal can give rise to significant levels within the crucible residues. This means that definitive extrapolation of the original metals from refractory ceramics is unlikely to be possible. Other factors, such as the reuse of crucibles and corrosion of metallic residues, may also complicate results, although metal residues will give more reliable results than ceramic surfaces.

Illus. 6.9 summarises the data as a bar chart for each of the key elements, showing how many sherds had a peak, a trace or a blank for that element. It is immediately clear that the vast majority of sherds provide evidence of the casting of copper alloys. Only one mould fragment lacked such traces, and of the two blank crucible fragments, one had lost its surface, and the other was so heavily vitrified it may well have failed before being used. There are clear differences between the results for moulds and crucibles; the moulds show no tin and a markedly greater presence of zinc, due to a systematic bias in the absorption of metal traces in moulds compared to crucibles (Barnes 1985; Dungworth 2000). They thus give less reliable results than the crucibles and will not be considered in detail here; their results essentially support the crucible analysis.

A key question in such analysis is the presence of zinc, as this is not present in typical Iron Age alloys and is thought to derive from recycled Roman metal (Dungworth 1996). Given the well attested dominance of zinc in XRF spectra where even minor amounts were present in the alloy (Barnes 1985; Dungworth 2000), it is notable that only 10 crucible sherds showed a significant zinc peak, compared to 58 which did not (sherds with only traces of zinc are treated as insignificant, since this probably represents enhancement of the very low levels of zinc (0.1–0.3%) found in quantitative analysis of the leaded bronze casting waste; given the dominance of Roman alloys in the casting pool in and after the Roman Iron Age (Dungworth 1996; Heald 2005), this strongly suggests that the bulk of the casting evidence is pre-Roman. The presence of lead in most of the crucible and mould analyses confirms that leaded bronze was the main alloy type.

Of the 10 crucible sherds with significant zinc peaks, three are from upper levels (1681, 2100, 2102) that are likely to run into the Roman Iron Age. Seven sherds from five different contexts do seem to be securely pre-Roman; Hearth 2166 (with a radiocarbon date of 350–50 BC), Hearth 2434 (with a radiocarbon date of 150 BC–AD 30), 2778 (underlies Hearth 2166, date to 200 BC–AD 0), 3035 (underlies fill of Hearth 2434, 2677 dated to 170 BC–AD 20), and 3153 (Hearth 26, under 1896). There are a number of possible explanations. It may be that pre-Flavian Roman material did reach the area, and was melted down; this seems unlikely, however, as there is very little material of this date from Scotland (Hunter 2007a, 22). It may be that the supposed ‘zinc horizon’ is illusory, although it has found general support in large analytical programmes (Dungworth 1996, 407–10; Heald 2005). Apart from extremely rare imports (Craddock et al 2004), pre-Roman

alloys containing zinc have only been found in areas using naturally zinc-rich ore, and there is no hint of that in the quantitative analysis of the casting debris. The other possibility is that mixing of the deposits has caused some stratigraphic intrusion. This is plausible in an active craft zone such as this, and evidence of joining sherds across contexts is noted below. Of the seven sherds in early contexts, three are small (maximum dimension 8–16mm), and thus potentially easily displaced; two are larger (33–39mm) but, significantly, show a moderate degree of wear. This is unusual for the assemblage, almost 80% of which shows no or only limited wear (Illus. 6.10). It suggests these sherds have moved around and become worn; they are likely to be intrusive. A further sherd (SF0656, 3153) joins SF0374 in 2100 (abandonment of Workshop 11 dated to 60 BC–AD 90), and thus could be Roman Iron Age. Only SF1138 (3035), a patch 23mm long, lacks clear signs of being intrusive, but a single sherd is a weak basis. The possibility of pre-Roman zinc-containing alloys is tantalising, but this detailed examination of context and taphonomy suggests Culduthel does not provide sufficiently robust evidence for this. It seems that zinc-containing alloys became a small part of the metalworkers’ resources as they became available from recycled Roman metal during the Roman Iron Age, but leaded bronzes were the dominant alloy. This is consistent with the results of the metal analysis.

Eleven crucible sherds show trace levels of other elements: arsenic, antimony, nickel and silver, which were all found as minor elements in analysis of the copper alloys from the site. In nine of the 11 sherds, visible metal residues or globules were present, and these are the likely origin of these elements. There is, however, one intriguing exception. Of the eight sherds with a silver trace, five are readily explicable as minor elements in copper

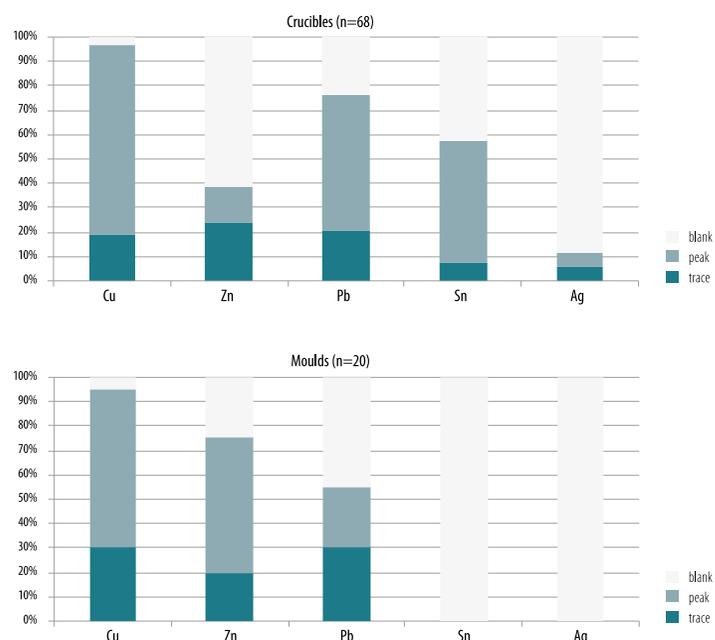


Illustration 6.9

Proportion of analysed sherds showing a peak, a trace or no evidence for key elements (Cu, copper; Zn, zinc; Pb, lead; Sn, tin; Ag, silver). (a) crucibles (68 sherds analysed); (b) moulds (20 sherds analysed)

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alloy globules surviving in residues, but three are not: sherds SF0396.3–5, from the abandonment deposit 2101. These had a significant silver peak; indeed, SF0396.4 had only traces of elements apart from silver. This is rare and potentially significant, since there is no secure evidence of casting silver in Scotland before the 4th century AD (Heald 2005; Hunter 2007c, 218–19). These three sherds thus merit more attention. It is likely they come from a single crucible; they were found together, along with two other crucible sherds, but are substantially more worn than them. As noted above, this is unusual in the assemblage, and strongly suggests they are not in situ, in contrast to most of the assemblage. These three sherds from this high level are likely to be later, intrusive material. Unfortunately they are too small to determine their form; but given the Pictish activity at the neighbouring Headland Phase 7 and 8 site, it is possible they are

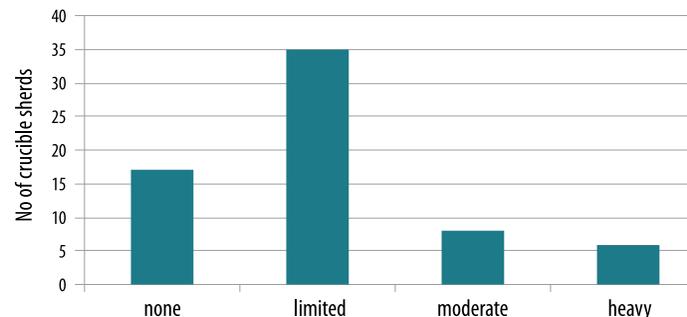


Illustration 6.10

Degree of wear on crucible sherds (excluding items recovered from sieving, since this process caused wear)

Table 6.4

Distribution of crucibles and moulds by context (by fragment count and weight). Joining fragments in a context are counted as one. 'p/h' = post-hole; 'craft area' = area of deposits to south-east of structure 10

Context	Feature	Crucible		Mould	
		Sherds	Mass/g	Sherds	Mass/g
220	Pit, near cobbled surface 227	1	3.93	—	—
1681	Area to the east and south-east of House 10	3	15.46	—	—
1861	House 9 posthole 1860	1	6.35	—	—
1952	Area to the east and south-east of House 10	2	6.57	—	—
1978	Area to the east and south-east of House 10	6	23.26	—	—
2100	Area to the east and south-east of House 10	14	97.89	—	—
2101	Area to the east and south-east of House 10	7	20.41	—	—
2102	Area to the east and south-east of House 10	7	24.75	—	—
2165	Area to the east and south-east of House 10	1	9.67	2	35.29
2166	Area to the east and south-east of House 10	1	4.42	—	—
2187	Area to the east and south-east of House 10	2	41.34	1	9.91
2264	House 17 posthole 2263	—	—	1 (v worn)	6.00
2419	Posthole 2416, nr Workshop 19	1 (tiny)	0.04	—	—
2435	Area to the east and south-east of House 10	2	8.92	—	—
2471	Compacted sand layer underlying Workshop 11	—	—	2	33.21
2544	Posthole 2543 ass w Hearth 2434	2	1.94	23	33.07
2548	Posthole 2547 ass w Hearth 2434	3	2.65	—	—
2677 = 3022	Hearth 2434	9	42.26	23	85.35
2778	Pit 2777 associated with Hearth 2166	4	2.10	—	—
3035	Hearth 2434	2	2.30	7	9.46
3038	Heat-affected under Hearth 2434	3	0.38	—	—
3153	Heath 26 posthole 3152	1	2.71	—	—
3830	Posthole 3829 within Workshop 11	—	—	1	2.39
	Totals	72	318.47	60	214.68

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Table 6.5
Catalogue of illustrated crucibles

SF no.	Context	Description	H/mm	W/mm	Wall T/ mm	Max T/ mm	Mass/g	Residues	Relined/ repaired
332.5	1978	Thick base sherd, cracking and glazing on the exterior indicating heating from below. Two fragmentary sub-rectangular impressions (W 10.5mm, L 10+mm) are probably from tongs. Size indicates a substantial crucible. Slightly worn	40.0	36.0	12.0	—	11.26	Grey glassy exterior	—
341	2102	Triangular crucible fragment with rounded sides; tapers slightly in to rounded rim, which is vitrified. Interior uneven from use-damage. Unworn	18.0	31.5	5.0	—	3.34	Red glaze at rim; clear glaze externally	—
351.1	1681	Rounded crucible rim, relined on the interior (T 2.5) and hooked over the rim, raising its height by 7.5mm. Moderate wear	25.0	23.0	7.5	10.5	4.97	Red glassy residue on rim and interior; dark area on lower interior	Relined
364.1	2102	Curved sherd tapering to rounded rim. Slight wear	27.0	32.0	8.0	—	6.21	Opaque yellow-brown glaze on interior; overlying patches of darker slag	—
374 / 656	2100	Unusual globular crucible form, with evidence of a construction line at the shoulder, the upper part more quartz-rich. (Interpreted as construction line rather than relining as the indistinct boundaries show it formed when the clay was plastic). Sinuous profile with globular body and everted (lost) rim. Unworn	39.5	24.0	5.0–6.5	—	9.65	Dark to pale brown residue on exterior at neck and all over interior	—
375 / 481	2100, 2187	Two fragments from an upright, near-straight-sided crucible tapering to a rounded rim; upper wall curves slightly, lower more tightly, suggesting a thick-walled, shallow form. Remains of two relinings on the interior and wrapped round rim (interior up to 4mm T, exterior 2.5). Each inner face has vitrified residue, indicating very heavy use. Grooves on the exterior surface were probably for adhesion. Top very vitrified. Slightly worn	46.0	48.0	10.0	15.0	49.11	Red-brown glassy residue and vitrification on the rim and interior; petrographic section revealed drops of trapped copper alloy	Relined twice
377 / 447	2100, 2187	Non-joining fragments of a shallow triangular crucible with rounded edges; estimated height 30mm. Profile slightly irregular; SF377 is less curved in plan and has a regular curve in section. Section shows a clear colour gradient, vitrified at the top, grey in the middle of the vessel and brown at the base, indicating heating from above. Very slight wear	59.0	49.0	6.5–8.5	—	35.31	Red glaze at rim; dark residue in base	—
384	2101	Rounded base from large crucible; cracking and heating indicating it was heated from below. Fracture follows construction lines; it seems the base failed along a stepped edge in places, with a raised collar defining the rather irregular interior. Edge probably stepped to maximise adhesion. Probably a large vessel. Some wear	37.5	34.0	12.5	—	11.06	Small area of dark staining	—
412	2165	Near-complete profile with tapered, rounded rim; probably a small, shallow, rounded triangular crucible. Unworn	29.0	33.0	7.0	—	9.67	Thick attached slag with charcoal and small copper alloy droplets	—

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Table 6.5
(continued)

SF no.	Context	Description	H/mm	W/mm	Wall T/ mm	Max T/ mm	Mass/g	Residues	Relined/ repaired
417	2101	Rim sherd with tapered, flattened rim, the edges rounded. Some vitrification. Remains of a layer of light brown clay (with similar temper) in a patch on the exterior suggest repair or relining in progress; it overlies an area of slight rim damage. Very slight wear	37.0	21.5	8.0	—	7.10	Red glaze on top of interior; uneven deposits in base	Unfired relining
556	2677	Upright rim, slightly curved into a rounded tip; slightly curving sides indicate rounded triangular form. Two relinings, stacked on top of the original rim, leading to the crucible gaining in height as it loses in depth. Both are hooked over the existing rim, although damage means their full extent on the faces is unclear. On the exterior, an uneven area for c.11mm below the rim has been deliberately roughened for adherence. Layers c.1.5mm T, increased the height by 11mm and 5mm respectively. Slight red glassy residue on inner rim of primary face; second one obscured; third lining has red glass on interior and rim. Moderate wear	39.0	32.0	4.5	11.5	9.01	Red and brown glaze on rim and interior	Relined twice
1101	1952	Heavily vitrified crucible fragment; inner surface lost integrity. Wall very thin as it survives. Relining covers earlier use-residues. Slight wear	22.0	14.0	3.5	6.0	1.59	Copper-staining on interior and original exterior	Relined (1.5mm thick)
1103	2100	Upright rim sherd from triangular crucible, tapering to rounded rim. Outer side spalled; a relining has sought to repair this, standing proud of the outer surface, presumably to fit round the part-spalled wall. Lower end of sherd is oxidised to red and more worn, and there are traces of orange clay over various parts, suggesting the sherd was reused or built into something. Slight wear	38.5	25.0	8.0	12.5	7.37	Vitrified at rim	Exterior relined to repair; also reused
1116	2677	Near-complete profile from corner of triangular crucible, with slightly curved upright sides tapering to a narrow rounded rim; outside of base lost, inside near-complete, giving an internal height of c.35mm. Inner surface narrowed to form pouring spout at corner. Slight wear.	39.0	32.0	6.0	—	7.14	Scattered dark grey residue internally	—
1127	2778	Relined crucible rim sherd. The original vessel tapered to a slightly angled rim with an internal bevel; the relining (T 1.5mm) raised the height by 5 mm, forming a rounded rim.	28.5	12.0	5.5	—	1.67	Patches of light brown deposit on interior	Relined
1132	3022	Patch from a crucible? Irregular but complete sub-oval object, flat on one side, the other with a raised sub-triangular area with a few lower diagonal lines extending from it; these are probably keys cut into a damaged surface to take the patch. No sign of any heating effects. Slight wear	16.0	10.5	3.5	—	0.41	—	—
1138	3035	Crucible patch? Sub-oval object, broken at one edge; one surface flat, the other bossed with short linear indents on each side. A further fragment, no longer joining, probably comes from the broken edge. Light grey fabric. Unworn	23.0	15.0	9.0	—	2.30	—	—

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Table 6.6
Catalogue of illustrated moulds

SF no.	Context	Description	L/mm	W/mm	T/mm	m/g
433b	2187	Mould fragment preserving part of a near-flat circular base and a barrel-shaped form, with remains of clay luting up to 4mm thick. This has been smeared in certain places rather than being continuous, and was perhaps intended as a support where the object to be cast was too close to the edge, as seems to be the case. No valve surface survives, but remains of a casting face preserve a circumferential hollow, rounded in section against the mould's wall. If circular, it would be c.20–25mm in diameter. Unidentified. Slight wear	32.0	33.5	15.0	9.91
1104	2165	Head of the female valve of a D-sectioned two-part mould with expanded dished ingate. Broken at end and one side. Partial remains of thin luting. Remains of a deep channel on the edges of the valve to engage the other half. The casting surface is a flared rectangle in section, expanding from 7 to 9mm, 4mm deep, with two parallel channels separated by a ridge; this has mostly broken off in removing the object, but part of the upstand survives, giving channels 3–3.5mm W and a ridge of 3mm. The form is closely similar to that of SF1109; they do not join, but could be from the same mould, although SF1109 is rather thicker. They are certainly for casting the same type of object, although its identification remains elusive	38.5	31.0	22.5	15.13
1105	2165	Fragment of male half of a two-piece mould, lacking ends and one edge. Thin clay luting (T 1mm) in places. Oval section, the valve face slightly convex to engage with the other half. All that remains of the casting face are two indents (the centres 16 mm apart); the better-preserved one is D-shaped with a rounded tip (W 8, H 5, D 4mm) and traces of a channel leading from this to a lost feature. Unidentified	39.0	32.0	20.0	20.16
1108	2471	Large fragment of mould with remains of luting up to 5mm thick; this has a horizontal notch in one area for binding the mould. Conical fragment, oval in section, from the end of a mould with a longitudinal cylindrical hollow (D 4mm). This suggests a pin mould, but in the fracture surface is a parallel D-sectioned hollow tapering to a rounded tip pointing to the top of the mould. This is unlikely to be part of the casting, as it would not be gravity fed, and thus is probably keying. If so, it suggests a multi-part mould, with a conical head separate from two lower pieces. The top of the cone lacks a gate (though about two-thirds of the rim is damaged), but notches cut into the surviving part may have been intended as seating for a separate gate component	34.0	37.5	25.0	19.35
1109	2471	Two joining fragments from the female half of a two-piece mould, broken at both ends (though its form suggests it is part of SF1104. Sub-square in section, rounded at the back and expanding to one end. Remains of clay luting with a slightly angled notch (W 6mm) to bind the two halves together. Remains of two shallow channels on the edges of the valve faces acted to engage the other half. These flank a deeper channel (12mm W), rectangular in section with rounded corners, which is deeper at one end, rises up to a damaged area and then deepens again at a slight curve. The middle of the casting surface is lost on both this and the similar SF1104; this consistency suggests there was a central ridge which came away with the casting, and there is the vestigial stub of such a feature towards one end. The object being cast is unclear, but it consisted of two parallel struts (2.5–3.5mm W and 6.5mm apart), sub-square in section and rising towards the middle	39.5	29.5	20.0	13.86
1110	2544	Multiple fragments from a bivalve mould; three preserve significant parts of the casting surface, indicating this was a ring-like object, U-sectioned in the surviving portion (external D 45mm, W 7mm). One fragment, perhaps from the other valve, has what appears to be a slight lip on the edge of the ring and two conjoined lobes protruding from it, perpendicular to its plane. This suggests something more decorative than a simple ring, although too little survives to identify it. Orange-brown fabric, reduced to pale grey on one valve only. Remains of an irregular clay cladding with fingerprints on the exterior. Fragment sizes 32 × 28 × T 14, 18 × 11 × T 10, 29 × 17 × T 15 (other valve)	32.0	28.0	14.0	33.07
1120	2677	Rounded, slightly everted fragment, perhaps the lip of the cup at the head of a mould. Worn	14.0	9.0	10.0	1.01
1125	2677	Two joining fragments of the male / back half of a mould, the valve slightly convex for engagement; around a third is missing, but it was probably oval in form and D-sectioned; there is no trace of luting. The ingate is broken but the channel for the metal indicates its position. The object being cast was a pair of conjoined rings, the upper with a U-section, the lower with a stepped profile comprising two concave steps (in the surviving portion). A shallow channel at least 6 mm wide joins the two, its width suggesting it was structural rather than a casting strut. There is a boss in the centre of each ring, broken in the lower one. This might suggest a bossed centre, but the surface of the intact one is a different colour from the ring casting surface (very dark rather than pale), suggesting the metal did not flow over it and thus the rings were open. Upper ring: external D 20, internal 13.5mm; lower, external 17mm, internal 12.5mm	58.0	33.0	16.0	23.18

linked to this. It is regrettable that they cannot be more closely dated, or indeed linked to the main phase of metalworking in the craft area, as this would be highly significant, but evidence for the casting of silver is still a valuable addition to the developing picture of its use. The analysis suggests either casting of a fairly debased alloy, or use of the crucible for both copper and silver alloys.

THE CONTEXT

The vast majority of moulds and crucibles cluster in the sequence of spreads to the south-east of Structure 10; Table 6.4 summarises the data. Key concentrations (>5 fragments) are associated with Hearth 2434, restricted spreads 1978/2102/2677/3022, and more general spreads 2100/2101 overlying the stone hearths and Workshop 11. This area also produced most of the copper alloy casting debris (>80%), the stone mould SF0339 (Illus. 6.17) and a cluster of glassworking debris. The lack of significant wear on most of the fragments (Illus. 6.10) indicates deposition soon after breakage; the spatial concentration indicates this was the locus of manufacture. This is supported by evidence of sherds from the same vessel in different layers (linking 3153 and 2100; 2187 and 2100; probably 2165 and 2471), suggesting the deposits represent a connected series of events. The few finds not in this area are generally small and worn, suggesting they are secondary, residual material; there is no sign of any other concentration of casting activity.

THE WIDER SIGNIFICANCE

The Culduthel assemblage is a significant one for the study of Iron Age metalworking, and is among the largest known. Heald's (2005) appraisal of Scottish non-ferrous metalworking evidence from the long Iron Age (700 BC–AD 800) identified over 100 sites, but most produced only a handful of mould or crucible fragments. Even with due caution over the material's fragility and the resulting bias against its survival, this suggests most are the residue of small-scale casting events. Evidence of larger-scale or longer-term manufacturing episodes is rarer. If we consider sites of Roman Iron Age date or earlier that have produced 10 or more crucible/mould fragments (an arbitrary but useful limit), only eight other examples are known: from the north-east, Birnie (Moray); from the lowlands, Traprain Law (East Lothian) and Fairy Knowe (Stirlingshire); from Argyll and the Western Isles, Dun Mor Vaul (Tiree), Dunagoil (Bute) and Loch na Beirgh (Lewis); and from the northern Atlantic zone, Gurness and Mine Howe (both Orkney). This evidence reflects rather different activities on these sites. Some represent the fortunate survival of a single event. The 27 sherds from Fairy Knowe represent only two crucibles and four moulds, dispersed in the dark layer that covered the interior (Willis 1998); they are clearly not in situ, but suggest debris from a single short-lived casting episode. This is likely to be the case also at Beirgh, where material was concentrated in a small area (Heald 2001, 689–90; Harding and Gilmour 2000, 39–40, 63–4). Other sites suggest a series of such short-lived events: at Dun Mor Vaul, small numbers of finds came from several different locations in different phases (MacKie 1974, 150–2). The same is true of Birnie, while at Gurness the middle Iron Age finds show two different concentrations (Close-Brooks 1987). The evidence from Traprain Law is also spatially dispersed

(Burley 1956, 219–21), again suggesting a series of events rather than a sustained workshop. By contrast, Mine Howe provides a clear picture of a long-lived workshop, used so intensively that the floor was stained green from copper droplets (Harrison 2005, 10–15). Dunagoil may also have produced a dump of material from a sustained workshop; the records are poor, but suggest the material was found at one location within the fort (Mann 1925, 58). The Culduthel evidence fits best into this latter category. The evidence points to sustained use, with the remarkable evidence for curation, relining and repair suggesting intensive activity; this is supported by its spatial concentration and the associated hearths.

It is regrettably unclear what was being made: the mould evidence, as so often, is too fragmentary to be diagnostic. However, size variation in the crucibles suggests they included large specimens capable of substantial castings. The part-finished items provide further clues, notably the unfinished harness strap junction, SF0278; there is also a failed casting SF0333, perhaps of a ring, while the fine bar ingot SF0844 is a reminder that much casting was directed towards creating roughouts for sheetworking. This is true also of the reused quern SF0339 (Illus. 6.17) with its moulds for a bar ingot and a remarkable fish-shaped form, most likely a roughout for something like a vessel.

The typological variation within the crucible assemblage is another unusual feature; while triangular crucibles dominate, the evidence of other forms in the same suite of contexts is rare. In the Early Historic period diversity in crucible form is typical, due in part to the range of different alloys being cast, but it is much less common in the Iron Age, although to some extent this is because the amount of fragmentation makes reconstruction of the form difficult. However, there are local parallels for unusual crucible forms, perhaps suggesting a degree of experimentation in the area: the shallow triangular form, unusual in Scotland, is paralleled along the coast at Birnie, while Cullykhan has a unique lipped and lugged form alongside more conventional triangular crucibles (Greig 1972, 230).

Birnie and Cullykhan are the only other Iron Age sites along the Moray Firth littoral with evidence of Iron Age non-ferrous metalworking so far; that from other sites, such as Lesmurdie Rd, Elgin (I Suddaby, pers comm) or Green Castle, Portknockie (Ralston 1987) is a few centuries later. This strongly suggests that non-ferrous metalworking was a restricted skill in the area, highlighting the importance of Culduthel as a sustained craft centre.

Tuyères

DAWN MCLAREN

In order to achieve high temperatures within non-domestic hearths and furnaces such as those used for metalworking, a consistent flow of air would be directed into the interior by the use of hand-operated bellows. Although no later prehistoric bellows have been preserved, it is assumed that they were produced from leather with a non-heat-conducting nozzle produced from an organic material, such as bone, to direct the flow of air (Cleere 1971, 210). In order to shield the nozzle from the intense heat of the hearth or furnace interior, a heat-resistant tuyère or bellows

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shield was used for protection. Tuyères are known in a range of forms, from simple conical, block or cylindrical examples with single central bellows holes, to more complex examples that could accommodate multiple bellows (Tylecote 1986, 142). The British and Irish forms are usefully summarised by Tylecote (1986, 141–3, fig. 86–7) and Scott (1994, 162–3, 167, fig. 6.5.7). In Scotland, they are typically produced from fired clay, but steatite examples are known from later prehistoric/Norse levels at sites such as Burland, Sandwick and Scatness, Shetland (Heald 2010; Ballin Smith et al 2019; Bond 1998, 90, fig. 17) and Skaill, Deerness, Orkney (Porter 1997, 105, fig. 8.13, no. 3000). Tuyères are not chronologically distinctive and are not diagnostic of a particular high-temperature pyrotechnic process (Tylecote 1986, 141).

At Culduthel, a minimum of 18 fragmentary ceramic tuyères were recovered (Table 6.7). These comprise small fractured pieces of fired clay with one heavily vitrified, often slag-attacked face,

Table 6.7
Distribution of tuyère fragments by form

Structure	Feature	Conical	Narrow cylindrical	Thick, flat-faced, cylindrical
2	Furnace 686	SF116		SF133
Cobbled surface 227	Possible furnace 185			SF70
10	Outer ring groove 1763	SF524		
	Fill of posthole 3635			SF1179
11	Concentration of burnt material 1952			SF431, SF1182
	Abandonment phase deposits 2100			SF1180
Area to the east and south-east of House 10	Waste associated with industrial hearth 2166	SF1175		
	Posthole 4001		SF1176	
	Spread of industrial waste 798			SF1181
	Spread of dark brown burnt clay 2102			SF1183, SF1184, SF1185
	Post-abandonment deposit 1681			SF1177, SF1178 a & b
Unstratified				SF1186

with partial remains of circular bellows holes and curving, convex edges. Due to their similarity to vitrified hearth and furnace lining, most were identified during post-excavation work within the slag and fired clay assemblages. Recovery of a complete ceramic tuyère is rare; an unused example from Arnbathie, Perth and Kinross, is a notable exception (NMS: x.CM 40; Tylecote 1986, 142, fig. 86). Typically, only the vitrified layers of the ceramic tuyères, those in direct contact with the heat of the fire or furnace, are preserved. The external ends, which are not in direct contact with the fire, do not become vitrified and rarely survive. No complete examples were identified among the Culduthel assemblage. Three distinct forms of ceramic tuyère have been identified within this assemblage, comprising conical (approximately 90–92mm diameter), narrow cylindrical (approximately 67mm diameter) and flat-faced thick cylindrical examples (ranging from 90–150mm diameter), all with single, central perforations. The bellows holes range from 14–26mm in diameter, averaging 20mm. Subtle differences in the use of these different forms can be identified. The conical and narrow cylindrical tuyères are less heavily vitrified in comparison to the flat-faced cylindrical examples, but show a greater area of vitrification, extending further up the length of the tube. This suggests that a far greater length of the tuyère was exposed to the fire, indicating use in the more focused heat of a hearth rather than a built-up furnace. It is likely that the robust flat-faced examples were built into iron-smelting furnaces, based on the form and extent of vitrification. In contrast, only fragments of a thin vitrified, slag-attacked disc have been preserved from the thick cylindrical examples, indicating that only the internal face of the tuyère was directly exposed to high temperatures. It seems likely that this represents a distinction between those used in conjunction with hearths or furnaces and non-ferrous metalworking in contrast to ironworking, although this is not proven. This interpretation is reinforced by the analysis of the glassy residues on the exterior surface of one conical example (SF0524 – Illus. 6.11), indicating the presence of high levels of copper. The bulk of the fragments were recovered from the main focal area for craft activities on the site to the east and south-east of House 10. None of these fragments came directly from a furnace or hearth, but they were associated with a series of spreads and deposits deriving from the metalworking features in the area. Apart from one conical fragment (SF1175), which came from waste deposits associated with hearth 2166, it is not possible to identify which exact feature these tuyère fragments derived from. Concentrated around and associated with hearth 2166 are quantities of glassworking waste and a suite of debris from non-ferrous metalworking, and it is likely that this particular example was associated with one or both of these craft processes.

In addition to the examples associated with the foci of craft activities, a further fragment (SF0524) was recovered from the outer ring-groove of adjacent roundhouse House 10/3, relating to its final phase of construction.

Two, one conical example and one thick, flat-faced cylindrical example (SF0116 and SF0133), came from the fill of iron-smelting furnace 681, located within Workshop 2. It is unclear whether the presence of two examples from this furnace indicates the contemporary use of multiple bellows during a single smelt, or whether the tuyères represent separate phases of use. A further

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fragment came from the fill of a possible ironworking feature (context 185) associated with the cobbled surface 227.

This large quantity of tuyère fragments is difficult to parallel, but is not unexpected given the scale of high-temperature craft processes that were undertaken at the site. The identification of various forms of tuyère from the same site is also unusual. The evidence suggests that these distinct shapes saw different uses, and it is suggested that this relates to a difference between non-ferrous/glass and ferrous processes. There may also be chronological differences, although only three fragments derive from dated features, making chronological comparisons difficult. Fragments of two conical tuyères were associated with Heath 2166, dated to 350–40 cal BC (SUERC-30376). A much later date of AD 130–340 is suggested for cobbled surface 227, which produced one thick, flat-faced cylindrical tuyère (SF070). Although this could suggest that the conical examples are an earlier type, a third dated feature puts this chronological distinction in doubt. Fragments of both a conical and a thick, flat-faced tuyère (SF0116 and SF0133) were associated with a furnace in Workshop 2 (context 681). Charcoal from this furnace has produced a date of 40 cal BC–cal AD 120 (SUERC-30365). The recovery of two distinctive tuyère types from a single metalworking feature suggests that the different forms were used contemporaneously, or at least that their currencies overlapped.

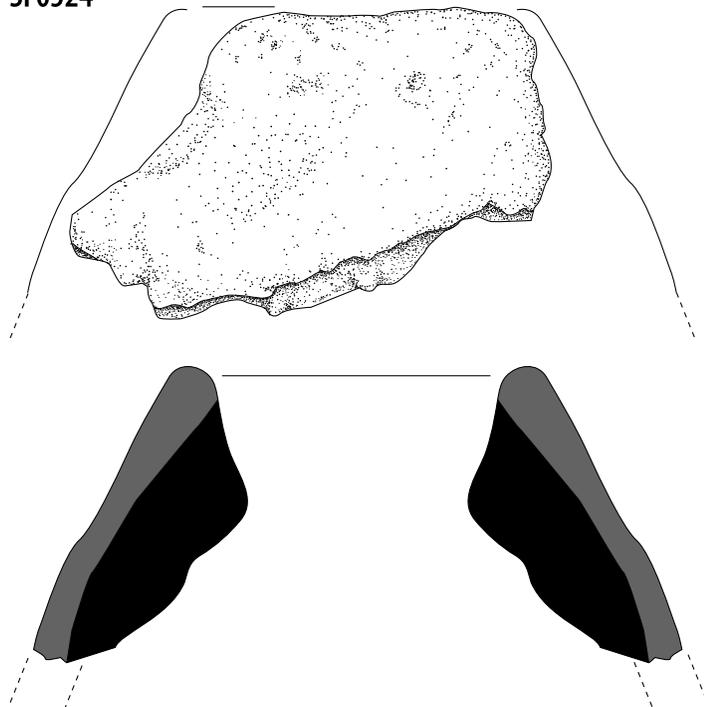
CATALOGUE

Conical tuyères

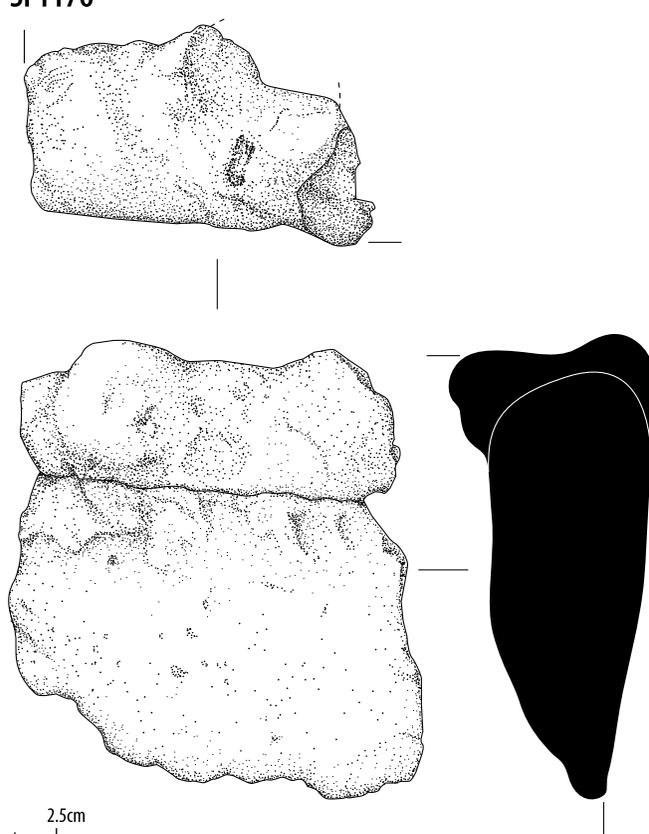
SF0116 Thick, triangular-sectioned, wedge-shaped fragment of coarse, quartz-rich vitrified clay, with remains of a longitudinal circular-sectioned smooth bellows hole (D 23mm) at one edge; other three edges broken. This fragment represents approximately 15% of the circumference of an expanding, conical fired clay tube, the surface of which is heavily vitrified. Diameter of heat-affected face approximately 92mm; remaining thickness 48mm. Mass 51g. Context 675, clay lining associated with furnace 681, Workshop 2.

SF0524 Wedge-shaped, triangular-sectioned fragment of conical tube of fired clay, heavily vitrified on the remaining curving face with distinctive glassy, bright red residue from copper-alloy-working. Only one original edge remains, preserving the curving edge of a slightly counter-sunk circular bellows hole (D 22.5mm) that perforates the clay cylinder longitudinally; the other three edges are broken. The glassy vitrified face indicates that the tuyère projected at least 42.5mm into the hearth or furnace; the unvitrified portion has not survived. Diameter approximately 90mm; remaining thickness 42.5mm. Mass 36g. Context 1764, fill of outer ring-groove context 1763, House 10/3. (Illus. 6.11)

SF0524



SF1176



0 2.5cm

Illustration 6.11
Tuyères (SF0524)

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SF1175 Seven fragments representing possibly two tuyères, both of conical form. Two non-joining fragments preserve steeply sloping, curved edges from expanding, narrow, conical fired-clay tuyères. The external surface of each piece is heavily vitrified, glassy and similar in form, but the clear differences in colour and morphology indicate the presence of two separate objects. Partial, smooth edge fragments from a circular bellows hole indicate original diameters of approximately 20mm and 26mm respectively. The full thickness and height of the tuyères are unknown as only the vitrified surfaces were preserved, giving a minimum height of 44mm and approximately 90mm diameter. Mass 109.7g. Sample 904. Context 2165, waste deposit to the north of Hearth 2166.

Narrow cylindrical tuyère

SF1176 Twelve vitrified ceramic fragments including two rejoining pieces from a narrow cylindrical clay tuyère, longitudinally perforated with circular bellows hole (D 20mm), representing approximately one-quarter of the circumference. The rounded edge surrounding the bellows hole and the upper 32mm of the convex, curving side is heavily vitrified, indicating the extent to which the tuyère projected into the hearth or furnace. Original diameter approximately 67mm; remaining H 55mm. Mass 102.8g. Context 4002, fill of post-hole 4001, area to east and south-east of House 10/3. (Illus. 6.11)

Thick cylindrical tuyères

SF070 Thirteen flat, non-joining fragments of heavily vitrified fired clay, preserving approximately 15% of the vitrified face of a thick cylindrical, flat-faced tuyère. One fragment preserves a partial smoothed curved edge of the central bellows hole (14–22mm). Only the thin glassy vitrified face of the tuyère remains; the unvitrified section, not in direct contact with the heat of the furnace or hearth, has not survived. Diameter approximately 120mm; remaining thickness 42mm. Mass 351.5g. Context 182, fill of furnace base context 185.

SF0133 Single flat rectangular fragment of heavily vitrified ceramic circular clay disc with partial remains of a circular bellows hole (D 26mm) preserved on one edge; the other three sides are broken. The ceramic displays a gradient in colour and texture from the fractured buff-orange fired sandy clay interior through to a dark-brown, glassy, heavily vitrified face. Only the slag-attacked face of this circular-sectioned, thick-walled fired clay cylinder has been preserved, giving it the appearance of a flat perforated plate; the original thickness is unknown. Diameter at least 100mm; remaining thickness 34mm. 62.6g. Context 680, fill of furnace cut 681.

SF0431 Four joining fragments of a flat, circular, centrally perforated fired clay tuyère, heavily vitrified on one face; the other

SF0431

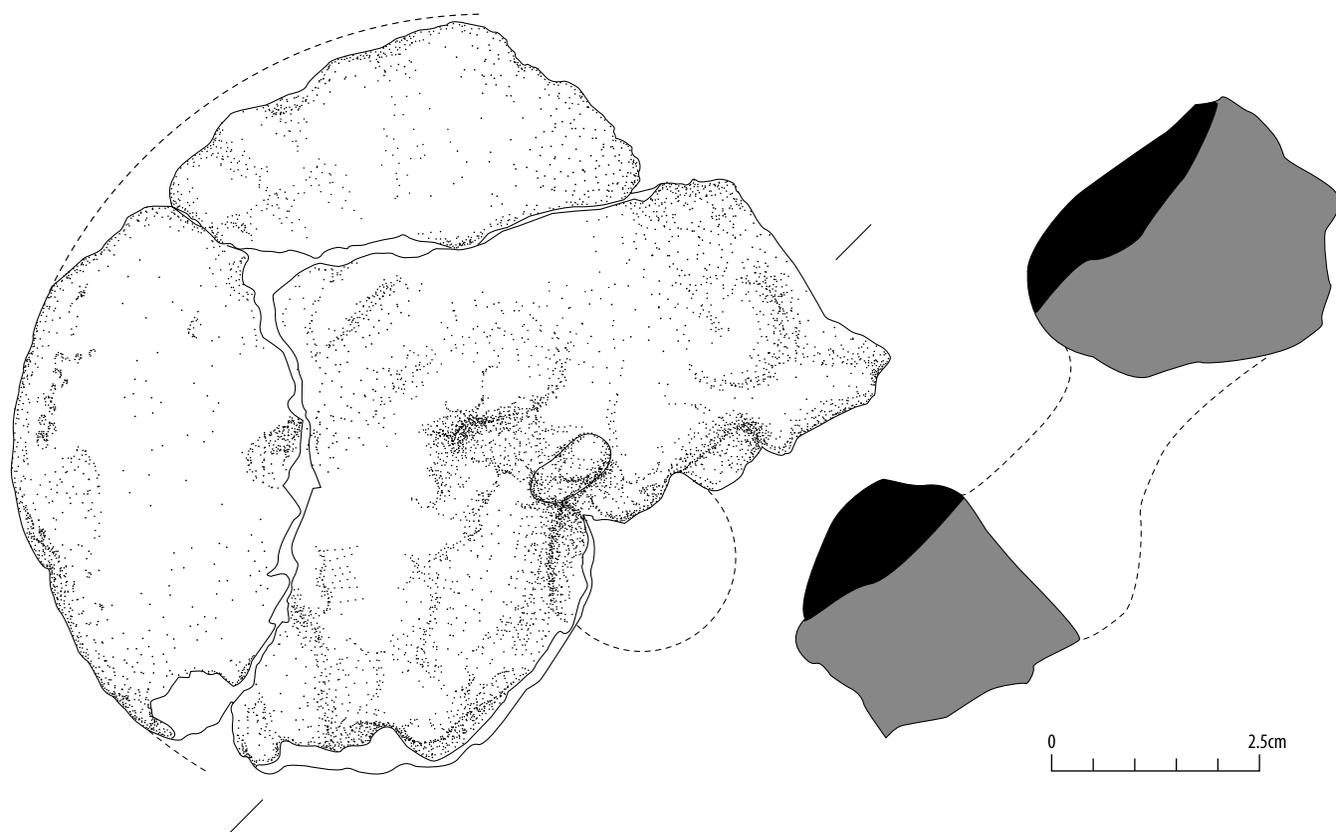


Illustration 6.12
Tuyères (SF0431)

face is fractured, indicating the full thickness has been lost. The central circular bellows hole (D 22mm) is almost complete. Approximately one-third of the circumference is present, indicating a slightly irregular, thick-walled smoothed cylinder with longitudinal perforation. The original height cannot be reconstructed. Twenty-four small undiagnostic vitrified fragments may be further pieces of the tuyère. Original diameter approximately 124mm; remaining H 59mm. 315.9g. Context 1952, concentration of burnt material, Workshop 11. (Illus. 6.12)

SF1177 Twenty-two flat, non-joining fragments of heavily vitrified fired clay, representing part of at least one flat-faced, thick cylindrical tuyère. The majority of fractured pieces preserve one slag-attacked, glassy vitrified surface, indicating contact with the interior of the furnace. One fragment preserves a partial curved edge of the central bellows hole; the diameter is difficult to estimate but was at least 12mm. Little of the unvitrified, fired clay portion of the tuyère survives beyond the slag-attacked face, but where present, smooth curving surfaces suggest a short, thick, cylindrical form. Diameter at least 90mm; remaining T 38mm. Mass 287.6g. Context 1681, post-abandonment deposit to the east and south-east of House 10/3.

SF1178 Four fragments, possibly representing two thick, flat-faced cylindrical tuyères. Three flat, non-joining, abraded fragments represent 15–20% of the flat, circular surface of a tuyère. Each piece preserves a partial circular edge of the central bellows hole (D 24mm). Two fragments preserve the smooth rounded edge of the face and indicate the body of the tuyère had curving smoothed sides. One surface is heavily vitrified and glassy; the opposite surface is fractured and abraded where the unvitrified portion of the cylinder has not survived. Diameter approximately 110mm; remaining thickness 25.4mm. Mass 126.3g.

The fourth fragment is very similar in shape but the colour and texture of the vitrified surface is distinctly different, suggesting the presence of a second tuyère. This fragment is sub-rectangular in shape, heavily vitrified on one face, with three sides broken. One original edge preserves a partial edge from a circular bellows hole but not enough survives to allow an estimation of diameter. It is not possible, from the small fragment remaining, to estimate the original diameter of the tuyère with any accuracy but the slag-attacked face must have been at least 120mm in diameter. Remaining T 17.5mm. Mass 28.5g. Context 1681, post-abandonment deposit to the east and south-east of House 10/3.

SF1179 Three joining, smoothed curving edge fragments from a thick flat-faced cylindrical fired-clay tuyère, representing approximately one-third of the circumference. The circular vitrified face has not survived and no trace of the bellows hole remains. The fired clay shows a gradient in colour and morphology from light-buff sandy clay through to dark-brown vesicular vitrified material. A small leaf impression is preserved near one broken edge. Original diameter approximately 140–150mm; remaining H 39mm. Mass 116.4g. Context 3636, fill of post-hole context 3635, House 10/3.

SF1180 Twelve flat, non-joining fragments of a flat-faced thick cylindrical fired clay tuyère, heavily vitrified on one face. Two flat vitrified fragments have curving edges from the circular, central bellows hole (approx. D 18mm) and preserve portions of

the rounded edge of the tuyère, suggesting a smooth, cylindrical form with longitudinal perforation. Only the vitrified surface remains. Original diameter 128mm; remaining H 48mm. Mass 310.7g. Context 2100, abandonment phase associated with the industrial use of Workshop 11.

SF1181 Eighteen fragments of fired clay, each with one heavily vitrified face. Five fragments are consistent with tuyère fragments due to their flat, glassy faces and curving edges but only one preserves a small curving edge of a possible bellows hole. The remaining 15 fragments are undiagnostic. It has not been possible to estimate the original dimensions, but it appears to be consistent in form and size with the flat-faced cylindrical examples. Mass 210.8g. Context 798, spread of industrial waste to the east and south-east of House 10/3. Abandonment.

SF1182 Four non-joining flat heavily vitrified fragments of a flat-faced, cylindrical tuyère. The vitrified face is porous, vesicular and light yellow-green in colour, distinguishing it from SF0431 from the same context. Only one diagnostic piece is present with a small crescentic edge from a circular bellows hole estimated at c.15mm in diameter. No edge fragments remain to confirm the original diameter but it appears consistent in form and size with the other examples. Only the vitrified face, in direct contact with the heat of the furnace, has been preserved. Remaining H 15.5mm. Mass 83.7g. Context 1952, concentration of burnt material, Workshop 11.

SF1183 Single flat sub-rectangular fragment of fired clay, heavily vitrified on one face; broken on two sides. One original edge preserves the curving edge of a central circular bellows hole (D. 20mm), the opposite edge is the curving convex edge of the flat face of the thick cylindrical tuyère. Only the vitrified face has survived. Original D approximately 124mm; remaining H 20mm. Mass 30.5g. Context 2102, spread of dark-brown silt with burnt clay, Hearth 26.

SF1184 Eight, non-joining, flat angular fragments of a heavily vitrified fired clay disc, representing approximately 15% of the surface of a thick cylindrical tuyère with slightly bevelled, curving edges. Only the vitrified surface has survived. Original diameter approximately 125mm; remaining H 31.5mm. Mass 388.5g. Context 2102, spread of dark-brown silt with burnt clay, Hearth 26.

SF1185 Single flat, sub-rectangular fragment of fired clay, heavily vitrified on one face, representing approximately 10% of the surface of a thick cylindrical tuyère. The curving edge of the central bellows hole (D 19mm) is present on one edge; the other three sides are broken. Only the vitrified face of the tuyère has been preserved. Original diameter approximately 136mm; remaining H 33.5mm. Mass 91.6g. Context 2102, spread of dark-brown silt with burnt clay Hearth 26.

SF1186 Three non-joining fragments of a flat-faced cylindrical tuyère with partial bellows hole notches preserved on two edges (D 19mm). A fourth fragment may also be a tuyère fragment but no diagnostic features are present to confirm this. Original diameter approximately 100–110mm; remaining H 19mm. Mass 61.75g. Unstratified.

Petrographic and technological analysis of ceramic materials

DANIEL SAHLÉN

The discovery of a wide range of domestic pottery and technical ceramics at Culduthel, particularly crucibles for the melting of non-ferrous metals, provides a valuable opportunity to study variation in ceramic production. It was anticipated that a thorough investigation of ceramic technology and the use of raw materials would provide important evidence for production and industrial activities at the site and the broader Moray Firth region in the prehistoric period. This investigation focuses on petrographic and technological characterisation of the ceramics through a combination of macroscopic observations and microscopic examinations frequently applied in ceramic studies (Tite 1999; Sahlén 2011).

The intention of the present study was to examine the main groups of ceramics recovered from Culduthel (crucibles, clay moulds, pottery, furnace lining and daub) with the goal of comparing material and technological approaches in the production of ceramics at the site. The pottery from the site is predominantly Neolithic and early Bronze Age, while the technical ceramics are all of Iron Age date. This made it impossible to compare pottery and other ceramic materials from the same period, but it was still possible to contrast technology and materiality between two separate periods and between different materials. It was decided to use two complementary techniques for analysis: ceramic thin section petrography and scanning electron microscopy (SEM).

Ceramic thin section petrography has long been central to the investigation of ceramic technology and material composition (Williams 1983); it has occasionally been employed on Scottish materials (MacSween 1990). SEM, in combination with energy-dispersive X-ray fluorescence analysis (EDAX), is a powerful tool for the study of material composition and technology due to its possibility to analyse the microstructure and micro-topography of the material as well as provide quantitative data on element composition (Tite 1992). It was judged that these two techniques combined would give reliable evidence of ceramic manufacture and the diversity of clay material used at the site during the Iron Age and earlier periods.

Sampling strategy and analytical methodology

The whole assemblage was first examined with a stereomicroscope and a hand lens to characterise the different groups and select samples for detailed material examination, building on existing reports. The metalworking ceramics show little variation in fabrics, generally being made from sandy clays or possibly sand-tempered clay. The crucibles are made of a sandy fabric with fine quartz sand, feldspars and some mica. Some fragments contain a proportion of coarse sand and larger sandstone inclusions (e.g. SF0447), but it is not possible from macroscopic investigation to assess if this material forms a separate fabric/sub-fabric or is a variation within the same fabric. The moulds are made from a sandy fabric, similar to that of the crucibles, but appear to contain larger amounts of coarse quartz sand and sandstone inclusions, albeit with some variation. The furnace lining and tuyere are tempered with considerable amounts of coarse sand and sandstone

grits. The fired clay that was found in high quantity at the site in association with the furnaces seems to be unprepared raw clay, which has been heated during the use of the furnace. There is some evidence of the use of straw and/or fibre as temper, seen from the presence of fine linear voids, particular in the mould material. The thickness of some of the voids suggests that the tempering material used was a fibrous material, possibly hair or disaggregated straw; the surface of one fragment shows a couple of voids and their fibrous structure. Fabrics and characteristics of the prehistoric pottery are discussed in detail by MacSween (Chapter 6, Prehistoric pottery).

Fourteen samples were selected: six crucible sherds; one each of furnace lining, mould, daub and fired clay; and four pottery sherds (Table 6.8). Six samples were selected from the crucibles because these were one of the largest ceramic groups from the site and the material showed considerable variation. Three samples of thick-walled crucibles (average thickness 6.8mm) and two samples of thin-walled crucibles (average thickness 4.7mm) were selected, along with one sample of heavily vitrified crucible. Only one sample each was selected from the moulds, furnace lining, daub and fired clay since this material showed considerable macroscopic homogeneity. Three samples of Neolithic pottery and one of Early Bronze Age pottery were sampled. This was only a selection of the different pottery wares discussed by MacSween, but the focus of this study was to compare different ceramic materials rather than give full details of the pottery from the site. The samples were prepared as thin sections, by mounting a polished fragment of the ceramic with epoxy resin to a glass slide and grinding the ceramic material down to an average thickness of 30µm (Humphries 1992). The thin sections were used for petrographic thin section examination, investigation of the microstructure and analysis of the composition of selected major and minor elements. The petrographic analysis was carried out at the Department of Geology, NMS, using a Leica polarising microscope, and aimed to characterise the mineral contents and technological modifications of the material. The study of SEM images and element calculations was carried out at the Analytical Research Section, NMS, as a supplement to the petrographic analysis.

Results and discussion

The petrographic analysis had two goals: to characterise the ceramic material and the technology used for its manufacture; and to evaluate whether the material was produced locally. Full details of the petrographic analysis are within the archived petrographic report (Appendix 1 within the petrographic report held within the CDF05 archive at the NRHE) and a summary is presented in Table 6.9. The material background of the different ceramic materials and the possible provenance is discussed, and the ceramic technology compared between the different Iron Age materials, and between the Iron Age ceramics and the Neolithic/Early Bronze Age pottery. The evaluation of provenance is based on examination of the thin sections and comparison with the local geology (Auton et al 1990; Fletcher et al 1996), supported by chemical analysis of the material (Appendix 2 within the petrographic report held within the CDF05 archive at the NRHE). It is not possible to give a precise origin for raw materials, only to assess the relation between the ceramic

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Table 6.8
List of ceramic samples selected for petrographic and technological analysis

Sample no.	Find no.	Context	Material category	Date	Description
Culd1	0344	1861	Crucible	Iron Age	Pale grey fine silty fabric, thick sherd
Culd2	0356	2100	Crucible	Iron Age	Pale brown fine silty fabric, thick sherd
Culd3	0362	2102	Crucible	Iron Age	Pale brown fine silty fabric, thick sherd
Culd4	0375	2100	Crucible	Iron Age	Heavily vitrified rim sherd, dark grey to black
Culd5	0396	2101	Crucible	Iron Age	Pale grey to pale brown silty fabric, thin sherd
Culd6	1211	2544	Crucible	Iron Age	Pale grey fabric, thin sherd
Culd7	None	3456	Tuyère	Iron Age	Reddish brown to pale grey clay fabric
Culd8	1469	3467	Furnace lining	Iron Age	Pale reddish brown silty clay, partly grey from heating, occasional grits and larger gravels
Culd9	1037	2677	Mould	Iron Age	Dark grey core and one pale yellow-brown outer surface
Culd10	0833	4311	Daub	Iron Age	Dark reddish brown, sandy clay
Culd11	0087	402	Pottery	Early Bronze Age	Gritty fabric with quartz and mica inclusions
Culd12	0092	432	Pottery	Neolithic	Coarse sandy fabric with large amount of quartz inclusions; the material is unevenly fired
Culd13	0330	741	Pottery	Neolithic	Fine clay with large dark mica inclusions; one surface possibly covered with slip
Culd14	0916	3651	Pottery	Neolithic	Gritty dark fabric with large angular rock inclusions

material and the local geology. A close parallel between the ceramics and a defined geological locality can be used to argue for the provenance of the material, but it is often only possible to assess whether the material is likely to be local or not. For the purposes of this paper the definition of what is local is based on Arnold's (1985) study of clay collection in traditional societies, in which he concludes that potters would rarely go beyond 7km to collect clay. The comparison between ceramics and the local geology in ceramic thin section petrography is often based on the identification of mineral and lithic inclusions in the ceramic material, since clay minerals are generally too small to be identified in the microscope.

The Iron Age material contains predominantly sedimentary minerals and rock inclusions most likely originating from the nearby surroundings of Culduthel, which is dominated by sedimentary glacial deposits (Illus. 6.13). But it seems that two different clays or clay pastes were used during the Iron Age: one for the manufacture of crucibles, and one for the manufacture of other ceramic materials. The composition of the clay used for the crucibles in particular is generally high in alumina and low in alkali and earth alkali oxides, giving it high refractory properties (cf. Martinión-Torres and Rehren 2009, 54). The daub (Culd10), mould (Culd9), furnace lining (Culd8) and fired clay (Culd7) are instead made from clay lower in alumina and/or higher in alkalis, which would be less suited for high temperatures. But there is some variation and the material does not form uniform groups (Illus. 6.14). Interestingly the heavily vitrified crucible sample (Culd4) is chemically more closely

related to the sampled mould with low refractory properties, which could explain why this crucible is so badly vitrified. It should be noted that the sample population in the current chemical analysis was limited; this assessment is indicative rather than conclusive.

The Neolithic pottery (Culd12–14) has mineral and rock inclusions associated with metamorphic and igneous rocks, while the Bronze Age pottery (Culd11) has inclusions more related to sedimentary deposits, but of a different nature than the Iron Age material. Although both metamorphic (towards the south-west) and igneous rocks (on the east side of the River Nairn) would have been on the limit of Arnold's (1985) threshold, this material could possibly have been accessible at a much shorter distance, transported by glacial movement from the last ice sheet that covered the region (Merritt 1990). It was not possible to carry out any clay sampling around the site to check this, but it seems to imply that Neolithic potters went further to obtain their clays than the Iron Age craftsmen. It has not been possible to identify the location of the sedimentary inclusions in the Bronze Age pottery, but it is interesting to note the apparent difference between this material and the sedimentary inclusions in the Iron Age material, suggesting that they used different but related sources.

The production of Iron Age material shows the use of two distinct methods of preparing the ceramic material. The sample size is small, but there are trends that are comparable with materials from other sites in Scotland (Sahlén 2011). The crucibles can be divided into two groups: thick crucibles (Culd1–3)

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Table 6.9
Summary of petrographic analysis

Sample no.	Material category	Colour	Description of thin section
Culd1	Crucible	2.5Y5/3; light olive brown	Fine porous matrix with occasional medium-sized quartz and angular sandstone inclusions, and possible grog inclusions
Culd2	Crucible	2.5Y 5/3; light olive brown	Fine matrix with occasional medium-sized quartz and lithic inclusions, and some possible grog inclusions
Culd3	Crucible	2.5Y5.3; light olive brown	Fine porous matrix with occasional medium-sized quartz inclusions, and some possible grog inclusions
Culd4	Crucible	2.5Y3/1; very dark grey	Heavily vitrified fragment; the matrix is isotropic, but some fine to very fine and medium-sized quartz inclusions are identified
Culd5	Crucible	2.5Y4/1; dark grey	Severely vitrified fragment, with fine to very fine quartz inclusions
Culd6	Crucible	2.5Y4/1; dark grey	Severely vitrified fragment, with fine to very fine quartz and medium sized quartz. One edge has severe staining
Culd7	Tuyère	2.5YR4/6; red	Very fine fabric with frequent fine quartz grains and occasional subangular sandstone fragments
Culd8	Furnace lining	10R4/4; weak red	Fine matrix with plenty of fine quartz and feldspar grains, some larger mineral grains and some larger lithic inclusions. The material is poorly mixed
Culd9	Mould	7.5YR4.3; brown	Silty matrix with predominantly fine to very fine quartz and feldspar grains and a few medium-sized mineral grains and sandstone inclusions
Culd10	Daub	10R4/6; red	Fine matrix with plenty of fine quartz and feldspar grains, some larger mineral grains and some larger gabbro inclusions. The material is poorly mixed
Culd11	Pottery	10R4/6; red	Sandy micaceous with medium to large feldspars and augite inclusions
Culd12	Pottery	5Y2.5/2; black	Coarse porous fabric with large metamorphic rock fragments and feldspar inclusions
Culd13	Pottery	2.5Y3/2; very dark greyish brown	Sandy matrix with predominantly fine- to medium-sized quartz grains, a few metamorphic and igneous rock fragments and feldspar inclusions
Culd14	Pottery	2.5Y3/2; very dark greyish brown	Coarse porous fabric with large probable gabbro rock fragments, feldspar inclusions

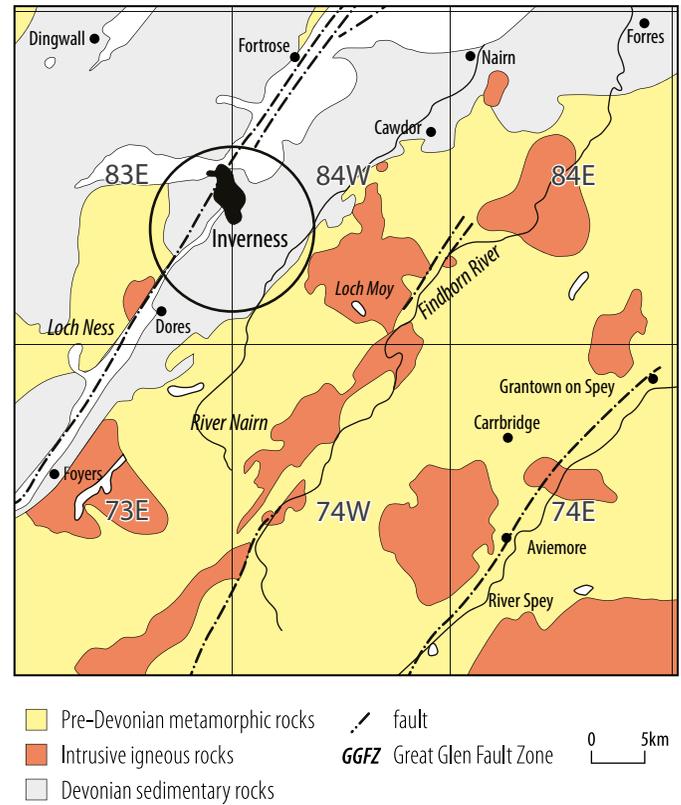
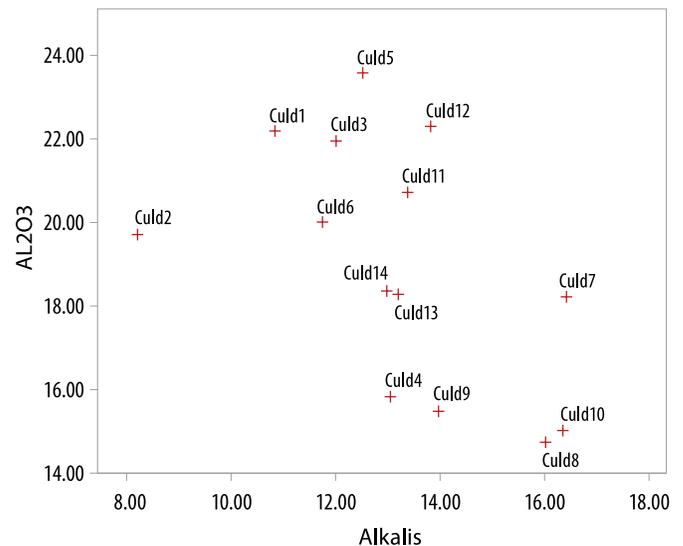


Illustration 6.13
Geological setting of the district around Culduthel, Inverness, after Fletcher et al (1996)



Comparison of amount of alumina versus alkali elements for the different samples; values are percentages

Illustration 6.14
Comparison of amount of alumina versus alkali elements for the different samples; values are percentages

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tempered with angular sandstone fragments and small rounded grog inclusions; and thin crucibles (Culd5–6) with fine quartz inclusions (but note that both Culd5 and Culd6 are severely vitrified and the analysis of these samples was limited). It has not been possible to assess the technology of Culd4 since this sherd was largely destroyed by vitrification. The difference in size and technology can possibly be related to the thickness of the vessel, something that is seen at other contemporary sites in Scotland (Sahlén 2011). The furnace lining and the daub show little evidence of preparation; inclusions present could either have been added or be natural to the clay. It is likely that the mould has been made from the same clay with a large amount of fine quartz grains added. This is supported by examination of the fired clay (Culd7), which in appearance is similar to the mould, furnace lining and the daub, but lacks the quantity of quartz and auxiliary minerals, suggesting that sand has been added to the clay to make different ceramic materials. It is not impossible that the crucible has been made from the same clay, with the addition of a different sand material.

The rock fragments present in the Neolithic pottery seem to have been added as temper, and it is possible that at least some of them come from crushed rocks. The size and amount of inclusions indicate a consistent practice, and there was also a consistent use of certain types of rock temper. The material present in the Bronze Age sherd does not seem to have been added deliberately since this is very uneven in size and type of inclusion; it is likely that the Bronze Age sherd was untempered.

In conclusion, it seems that prehistoric craftworkers at Culduthel used a series of resources for the production of different ceramics, and the material shows both chronological and technological differences. In the Neolithic period the potters seem to have been more systematic in their selection of tempering materials and possibly travelled further to obtain this material. In later periods sedimentary deposits close to Culduthel seem to have been exploited, although the uses of different sources are possible. It is quite clear that Iron Age craftworkers used different ways to prepare their clay and in this way were able to produce materials fit for purpose.