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Culduthel

An Iron Age Craftworking Centre in North-East Scotland

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Chapter 4

PERIOD 3 – THE IRON AGE CRAFTWORKING CENTRE

Introduction

After a hiatus in occupation of at least 100 years, a major period of settlement begins on site at some point after the mid-4th century BC. This settlement is dominated by 10 similar 'workshop' roundhouses, which are constructed across the terrace. Many of these buildings contained upstanding iron-smelting furnaces constructed in stone, most with their final firings in situ (Illus. 4.1). The quantity and uniform design of the workshops and furnaces suggests that the site was a craft-focused settlement, primarily engaged in the manufacture of iron objects.

A wealth of information has been revealed about the iron manufacturing practices taking place on site from the excavation of the smelting furnaces alone. This data has been further enhanced by the analysis of the ferrous metalworking waste (including over a third of a tonne of slag and other working vitrified debris), and one of the largest assemblages of iron objects ever identified from an Iron Age site in Scotland. More than 150 objects were recovered, including a range of tools and weaponry, both produced on site and imported. Brought together, this data set shows that all stages of ironworking were undertaken at Culduthel, from the reduction of iron ore to fine smithing.

Concurrent with the manufacture of iron was evidence of a thriving and sustained glass and copper alloy industry producing a wide range of goods – glass beads, enamels and decorative metalwork – on stone-lined hearths and within a turf-walled workshop. While the output of these highly specialised crafts appears to be at a much smaller scale than the iron, the assemblage of objects and waste indicates that Culduthel was a substantial producer of glass and bronze objects in the region.

In contrast with the wealth of craftworking evidence, indications of domestic occupation in this period is limited. Four post-ring roundhouses located on the north-west side of the site (Houses 7, 9, 10 and 17) may have been dwellings but could equally have functioned as 'clean' workshops for the final finishing of ferrous, non-ferrous and glass objects or for the production of organic crafts. More compelling evidence comes from a range of well-worn rotary querns reused in the fabric of the furnaces and hearths and in the construction of buildings as packing material for posts, an assemblage that suggests that the craftworking community wished to maintain a tangible link with a contemporary or abandoned domestic settlement close by.

Preservation

The extraordinary preservation of pockets of archaeology on the site resulted in some of the best surviving lowland archaeological features encountered in Scotland, and it is a salutary lesson in what can survive in ploughed landscapes given the right conditions. The highly unusual circumstances that allowed for the blanket protection of archaeological features in some areas of the site had three main contributing factors: the topographic situation of discreet areas of the site; the development of hillwash; and the sealing of parts of the site with waste debris from the industrial activity. The area to the east and south-east of House 10 was particularly well preserved. Here the house and three workshops were constructed within a slight hollow at the base of a slope, built directly over the hillwash that sealed the cairns and cobbles seen in Period 2. Paved and cobbled surfaces, post-holes, stone-built hearths and the stone bases of turf walls had all survived the plough in this area, sealed in turn by a series of hillwashes and capped by thick layers of waste debris.

During the excavation, this area was considered to be the manufacturing hub of the site and was labelled 'the industrial area'. This interpretation was given due to the intact nature of the surviving archaeology (especially the smelting furnaces) and the quantity of waste material and artefacts recovered here associated with ferrous and non-ferrous working. While this area can be recognised as the best preserved on site, it was not necessarily the core of production. Evidence from plough truncated areas of the site, such as the fragment of cobbled yard identified on the eastern edge of the site (detailed in Chapter 5), shows that iron production was certainly taking place in other parts of the site and considerable activity may have been lost by the plough.

Chronology

Twenty-nine radiocarbon dates have been placed in Period 3. These all fall between 360 BC and AD 340 (Table 2.1) and form a seemingly single continuous distribution spanning a potential 700-year period. While seven centuries are certainly not the duration of the Iron Age industry identified on site, without Bayesian analysis, a start and end date for this activity is currently not possible.

As 21 of these radiocarbon dates were obtained from charred material from secondary or tertiary deposits (these samples mainly coming from the backfills of post-holes and pits), they cannot be

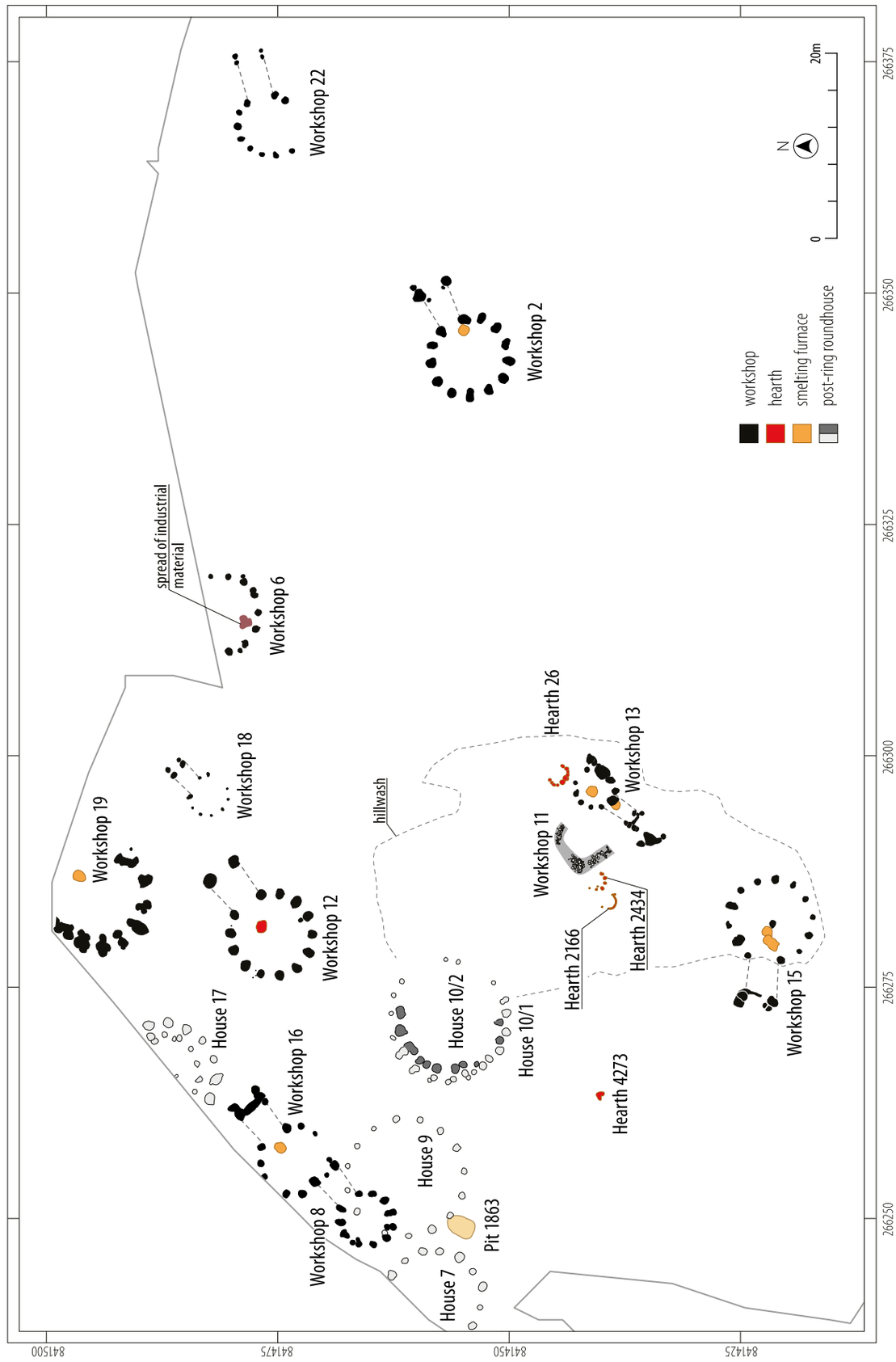


Illustration 4.1
Period 3a – The Iron Age craftworking centre

used with confidence to date these features. This group includes the dates obtained from the backfill of one of the glass/copper alloy hearths [2166] and associated workshop (Workshop 11).

Single radiocarbon dates (SUERC-30377, SUERC-30390 and SUERC-30406) were obtained from the basal charcoal deposits interpreted as the final firings of three iron-smelting furnaces (Furnaces 2246, 3050 and 4262). These radiocarbon dates from primary deposits indicate that the final use of these furnaces was between 200 BC and AD 120. Material retrieved from the ashy or charcoal rich fills immediately overlying the basal fills of four further iron-smelting furnaces (Furnaces 4147, 4355, 3790 and 681) are also considered to be by-products of their final firings. The radiocarbon dates made for these (SUERC-30400, SUERC-30401, SUERC-30391 and SUERC-30365) were also between the 2nd century BC and the early 2nd century AD. Radiocarbon dates obtained from charred material within the backfill of post-holes of three iron-smelting workshops (Workshops 13, 15 and 16) also appear to substantiate this date range for the iron-smelting activity on site (SUERC-30389, SUERC-30395 and SUERC-30378). As the origins of this material are less certain, these radiocarbon dates have not been used to date these buildings.

Illustration 4.2
House 7 and Workshop 8 (looking west)

A radiocarbon date retrieved from a compacted layer of charcoal-rich black sandy silt (SUERC-30386) overlying the flagstone base of the glass and copper alloy hearth [2434] has also been interpreted as a date for its final firing. This radiocarbon date indicates that this event took place between 170 cal BC and cal AD 20. This date is tentatively supported by the evidence that the bulk of the copper alloys from site were a pre-Roman Iron Age leaded bronze recipe and that a 2nd–1st century BC copper alloy sword hilt, presumably brought onto site for recycling, was found in the adjacent cobbled yard.

As a distinctive later phase of development can be identified during the lifetime of the settlement with the construction of two large ring-groove roundhouses, Period 3 has been separated into the primary phases of settlement (Period 3a – this chapter) and these later additions (Period 3b – Chapter 5). Although the Period 3b structures were obviously built into a well-established site, the lack of a chronological framework for the development or longevity of the other buildings in this period means that any or all of the structures placed into Period 3a could equally have been constructed or still been in use in Period 3b.

Period 3a

Post-ring roundhouses

Four post-ring roundhouses were located on the north-west side of the site (Houses 7, 9, 10 and 17). As the material culture recovered from each house was clearly residual it is not clear if these buildings were primarily dwellings or workshops. The proximity of Houses 7 and 9 and the truncation of House 9 by a later workshop (Workshop 8) indicates that multiple phases of construction had occurred in this part of the site (Illus. 4.2).

House 7

Only the southern half of the post-ring of House 7 was revealed within the excavation area. Nine post-holes (which varied from 0.30 to 1.1m in diameter and 0.25 to 0.60m in depth) would have formed a *c.*9.7m diameter structure (Illus. 4.3). No entrance was apparent within the excavation area. Most of the post-holes contained small quantities of iron slag identified as smithing waste. Post-hole [1834] contained a fragment of an iron strap with a nail in situ (SF0330) and a small, translucent mid-blue annular bead (SF1260) was found in post-hole 1778 (Illus. 6.61). A single AMS date from charcoal from a post-pipe of post-hole 1830 yielded a date of 360–50 cal BC (SUERC-30369).

Several shallow post-holes were present in the interior and four formed a clear linear pattern, potentially an internal wattle wall projecting from the southern side of the house. A short dagger (SF0363), which had been damaged on one side and had been resharpened, was recovered from one of these post-holes [1898] (Illus. 6.46). Extensive brown corrosion identified on one side of the blade is probably from leather, suggesting that the dagger was sheathed when it was deposited. It is not clear when the dagger was placed in the post-hole and it could theoretically have been deposited at any time between the construction of the hole to after the post went out of use.

House 9

House 9 was a single post ring of 15 post-holes placed at between 1.40 and 1.80m intervals, creating an internal diameter of *c.*11.80m

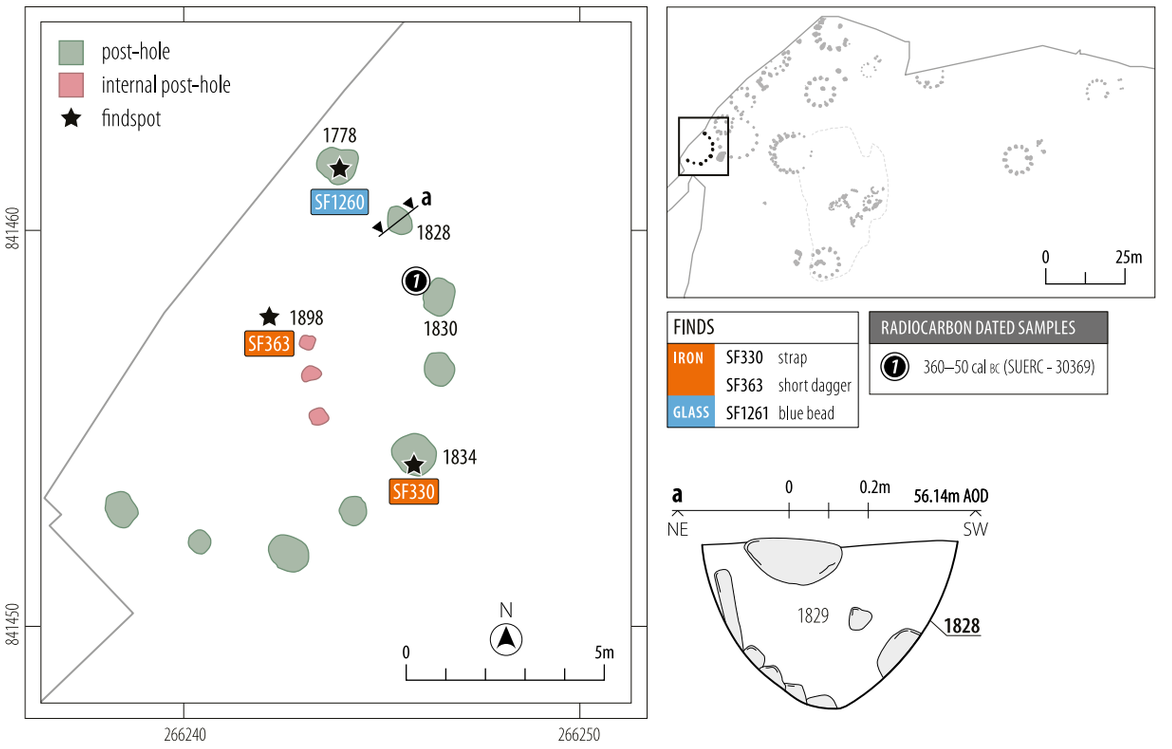


Illustration 4.3
Plan of House 7

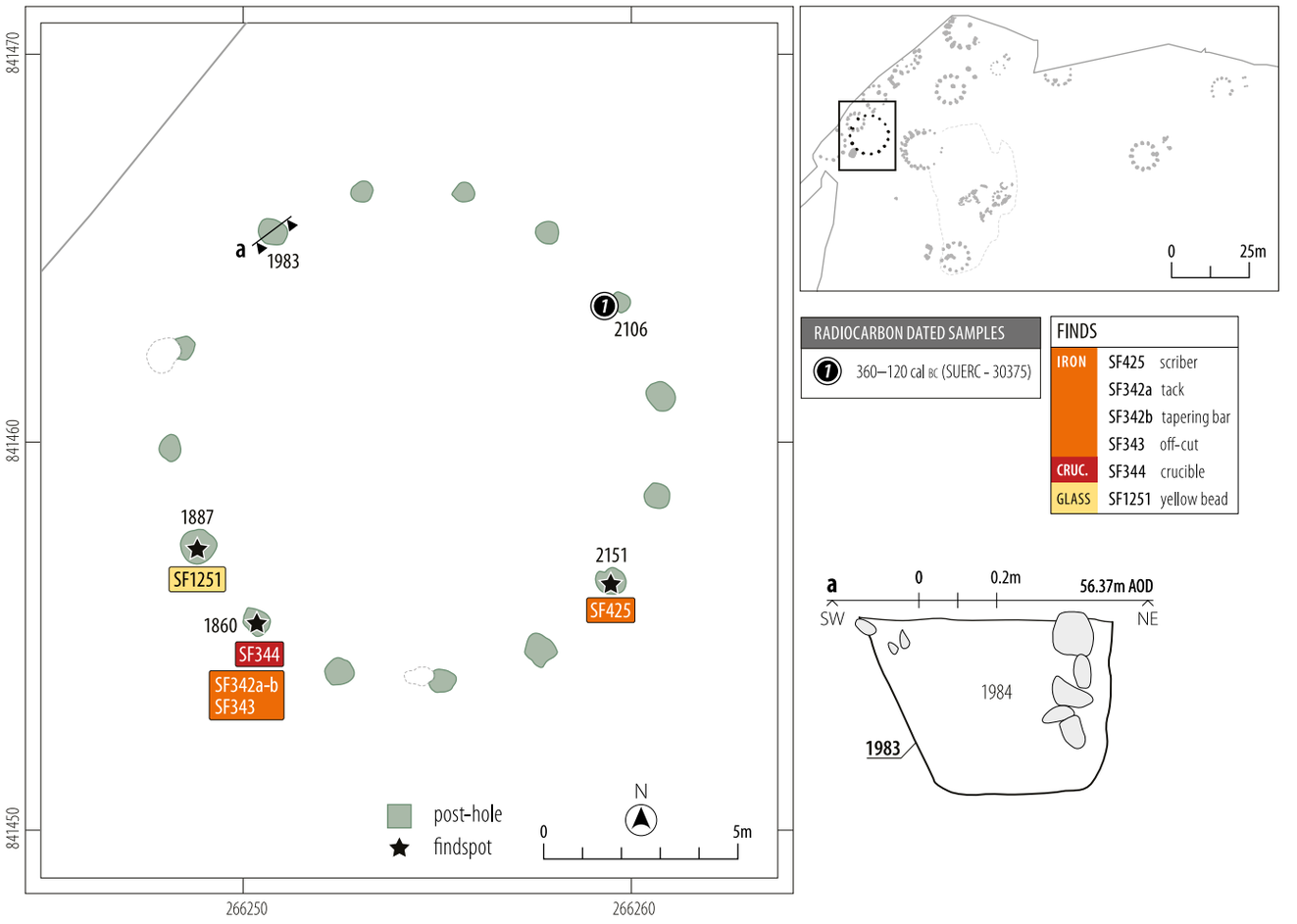


Illustration 4.4
Plan of House 9

(Illus. 4.4). The posts varied from *c.*0.40m to 0.80m in diameter and from 0.20 to 0.50m in depth. There was no obvious entrance into the house.

The majority of the backfill of the post-holes contained small amounts of iron slag and several contained artefacts. A small, fine iron tool, perhaps a point or scriber used for leatherwork or fine metalwork (SF0425), was recovered from post-hole [2151]; an iron offcut that had been thinned at both ends (SF0343), a small square-headed tack (SF0342a), the broken end of a tapering bar with rounded tip (SF0342b) and a possible crucible sherd (SF0344) were all recovered from post-hole [1860]; and a small yellow glass bead (SF1251) was recovered from post-hole [1887]. A single AMS date from charcoal from a post-pipe of post-hole [2106] yielded a date of 360–120 cal BC (SUERC-30375).

A large oval pit [1863] measuring 2.8 by 2.4m was situated on the south-east edge of the roundhouse, cutting the post-ring. The pit was clay-lined with a large amount of charcoal, lumps of burnt clay and a lesser amount of burnt bone. A hammer/rubbing stone (SF0323) was recovered.

House 10

Located on a flat terrace at the base of a slope was a house plot with a long and complex history (Illus. 4.5 and 4.6). The initial post-built roundhouse (House 10/1) was replaced on almost the same footprint by a new post-built house (House 10/2). Both of these houses are detailed here. House 10/2 was subsequently replaced by a very large ring-groove building (House 10/3) (Chapter 5).

Few artefacts were recovered from either house, and there was a notable absence of iron slag, which was recovered in high quantities across the rest of the site in this period. This absence of material culture may be due to ground clearance across their footprints for the construction of House 10/3 but it is possible that these buildings were separated from the dirty hot processes

Illustration 4.5
House 10 under excavation

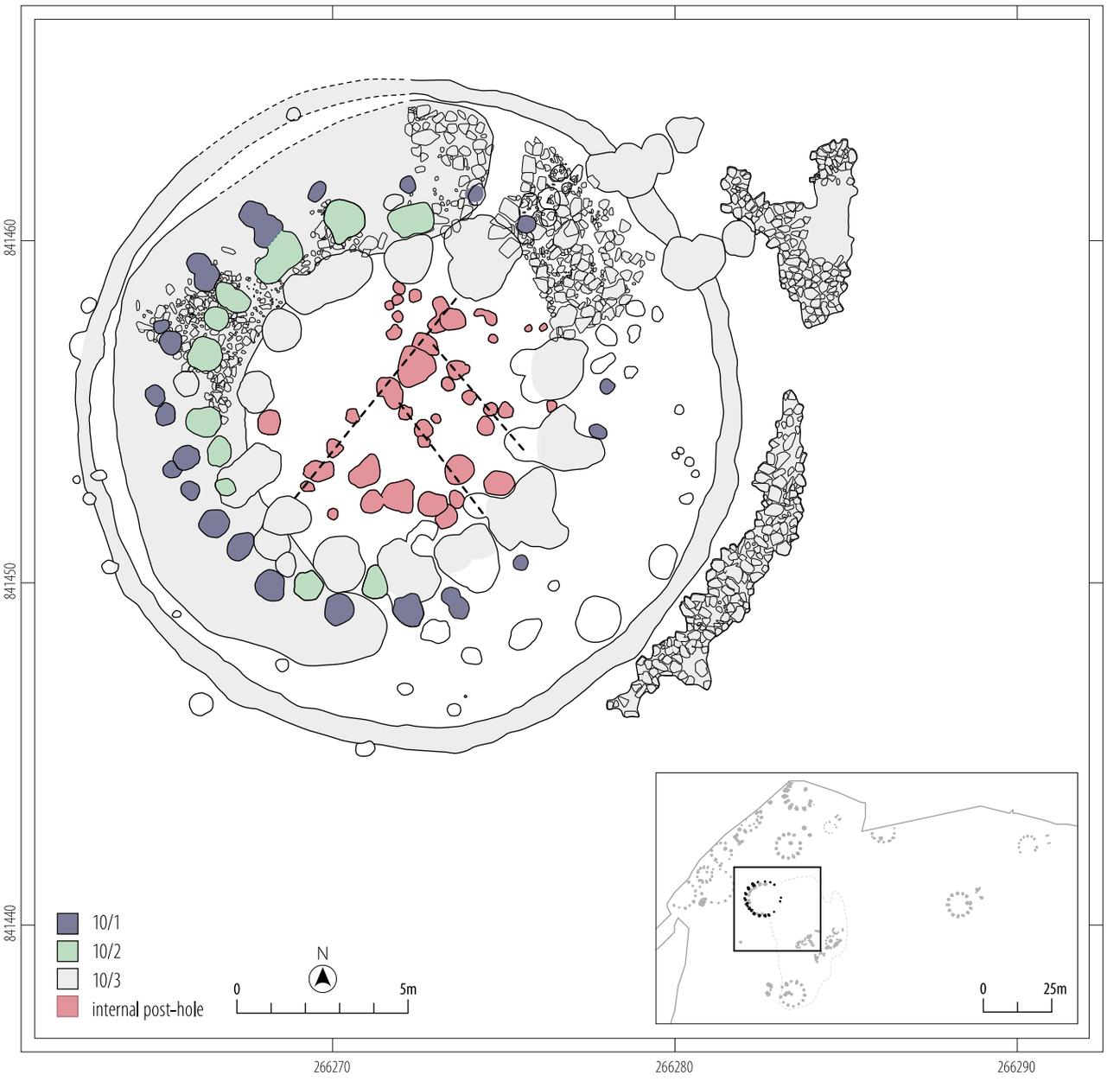


Illustration 4.6
House 10 all phases

that surrounded them and regularly cleaned (as observed in many domestic dwellings of this period, cf. Armit and McKenzie 2013, 184).

House 10/1

The earliest roundhouse survived as a 20 post-ring structure of *c*.12.50m internal diameter (Illus. 4.7). The south-east of the house had been truncated by later constructions and no entrance was identified. Aside from obvious truncated elements of the post-ring, many of the post-holes were placed at intervals of less than 1m and many were very closely set.

The post-holes were circular or slightly sub-circular in plan with diameters varying between 0.3m and 0.9m and depths between 0.08m and 0.6m; the larger diameter and deeper post-holes were in the south and west. Six post-holes in the south-west had been recut, indicating that posts had been replaced over time.

Artefactual evidence recovered from the post-hole fills consisted of small quantities of iron slag, burnt clay and flint flakes. A single AMS date of 2910–2680 cal BC (SUERC-30399) was obtained from charcoal within post-hole [3868].

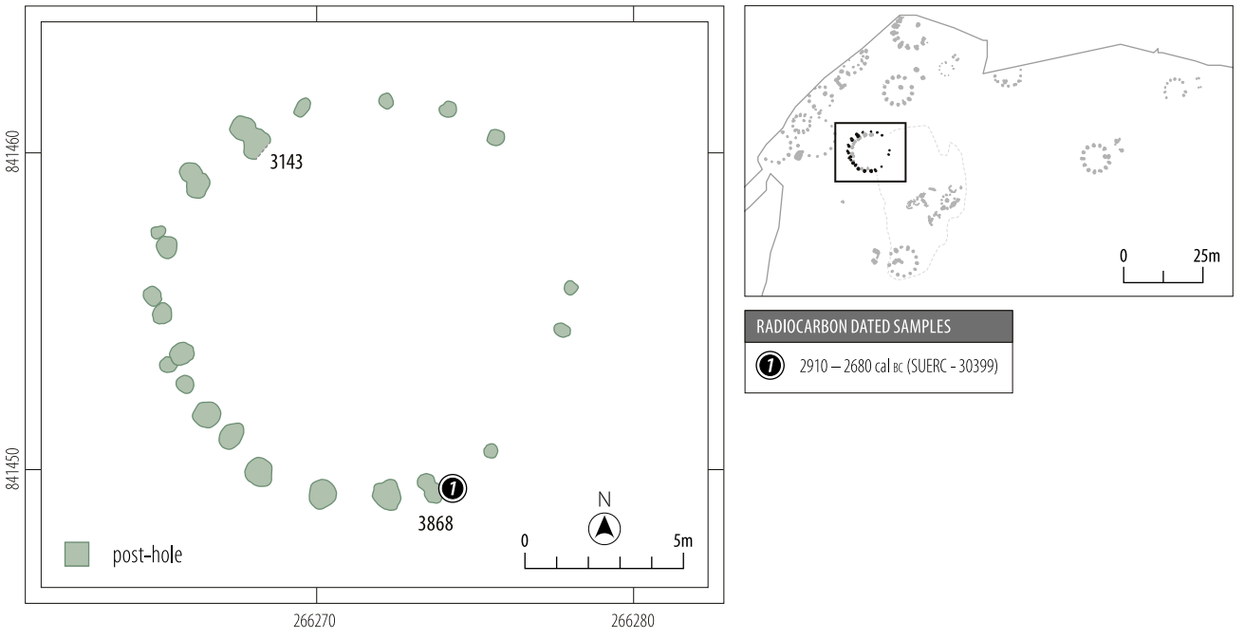


Illustration 4.7
House 10/1

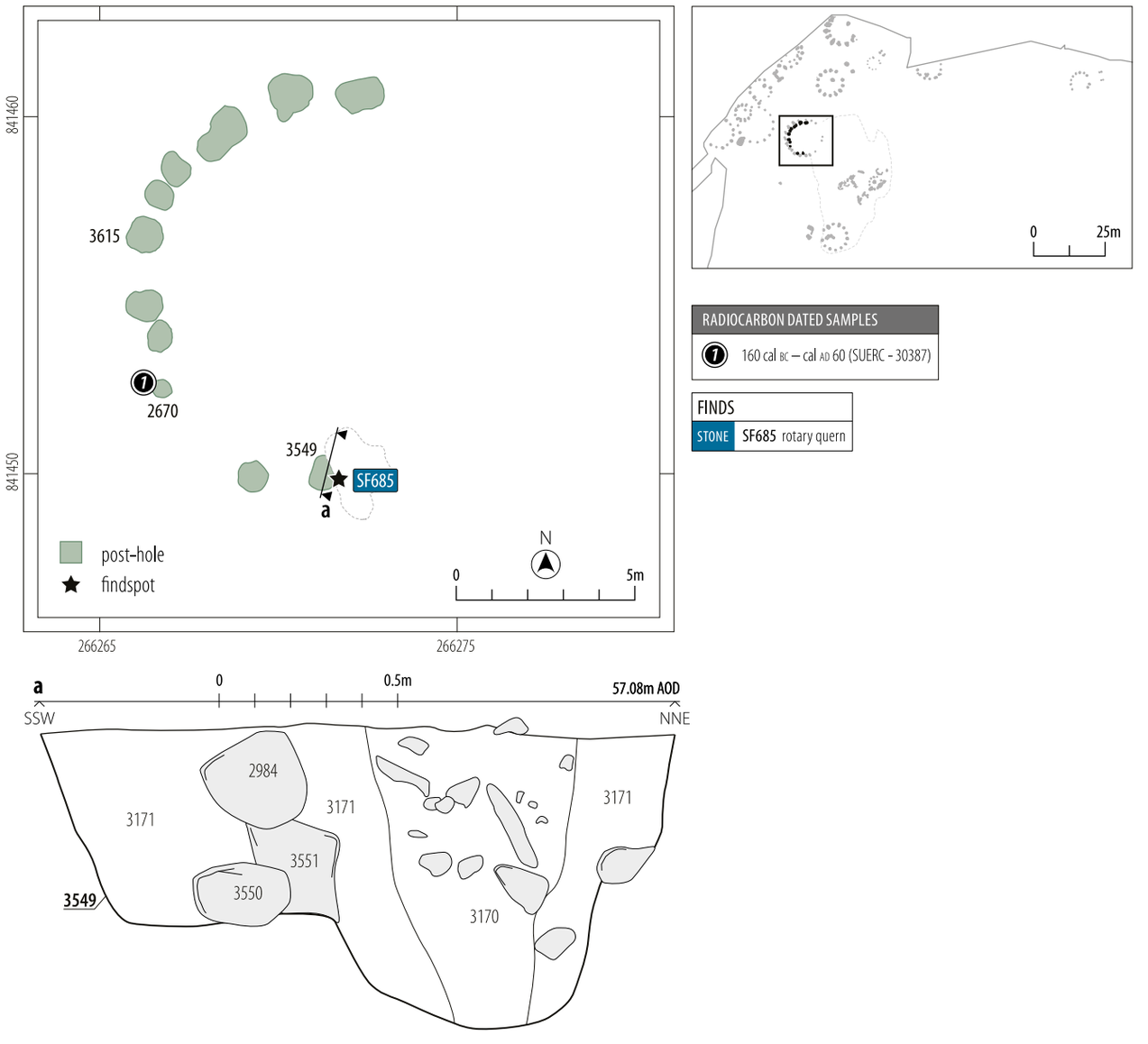


Illustration 4.8
House 10/2

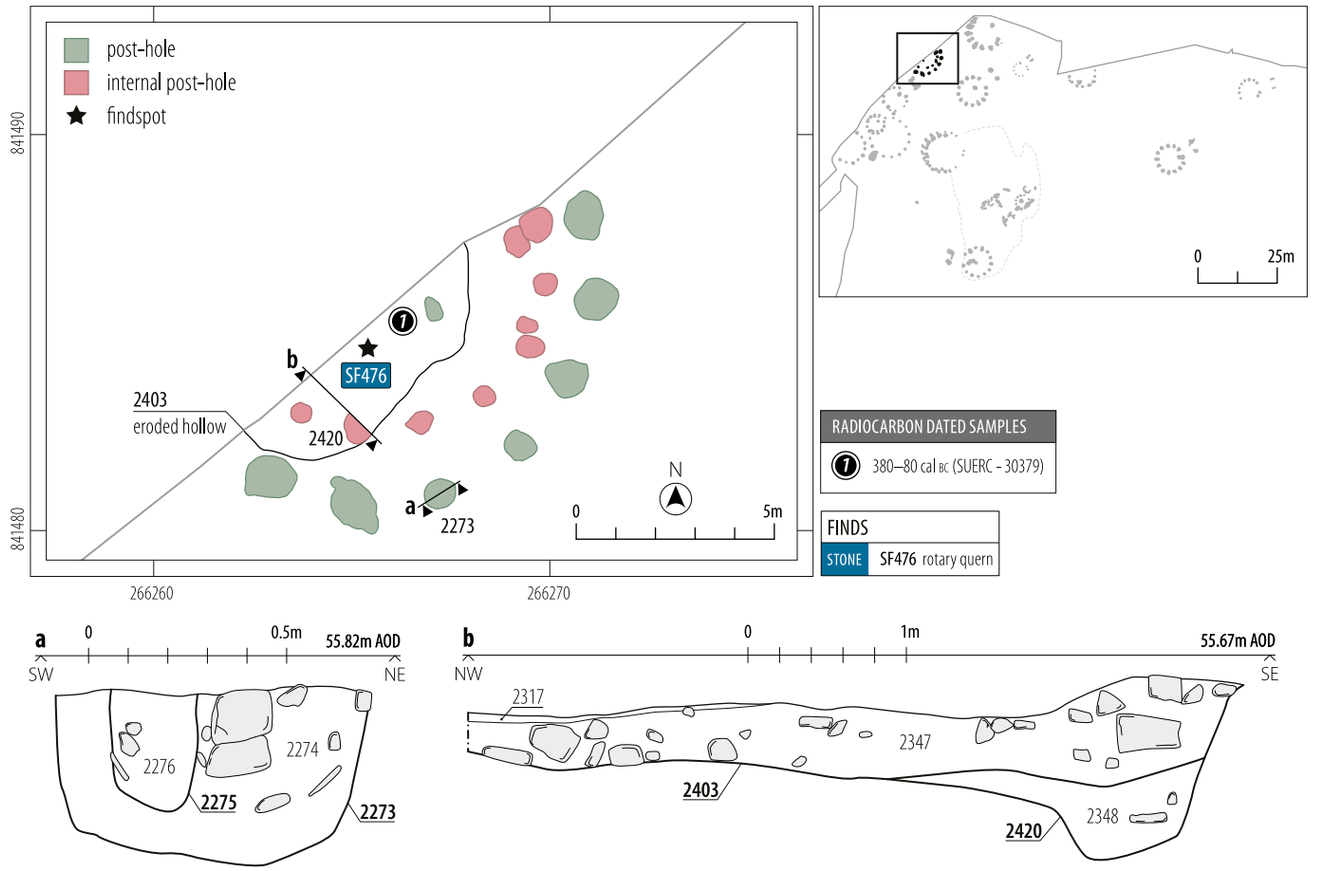


Illustration 4.9
Plan of House 17

House 10/2
In a second phase, House 10/1 was replaced by a slightly smaller post-ring roundhouse, House 10/2 (Illus. 4.8). A concentric post-ring was constructed along the inner edge of the original post-ring, creating a building with an internal diameter of *c.*10.5m. Only 11 post-holes survive, with the east side and entrance of the house truncated away. The post-holes diameters ranged from 0.35m to 1.2m and depths between 0.2 and 0.5m, and some had been recut.

Artefactual evidence from the post-holes, like the primary phase of the house, was almost exclusively confined to small pieces of iron slag and daub, as well as small quantities of magnetic residue. However, in one post-hole [3549] a fragment of bun-shaped rotary quern (SF0685) had been incorporated into the packing material close to the base of the cut. A single AMS date from post-hole 2670 gave a date of 160 cal BC–cal AD 60 (SUERC-30387).

House 17
Only the southern half of House 17 was located within the excavation. The roundhouse was formed by a post-ring of seven post-holes *c.*1m apart, which would have formed a *c.*14m internal diameter (Illus. 4.9). Some contained packing stones and one had clear evidence of a post-pipe.

Within the interior of the house was an arc of another post-ring. This post-ring contained seven circular post-holes placed at *c.*1m intervals. Three post-holes contained packing stones and two had been recut. A shallow undulating scooped feature [2403], a probable hollow eroded by wear, was *c.*0.2m deep and truncated two of the internal post-holes. A spread of stones and a bun-shaped upper rotary quern stone (SF0476) had been placed within the base of the hollow, presumably to level it and prevent further erosion. A single AMS date from charcoal recovered from the fill of the hollow gave a date of 350–50 cal BC (SUERC-30379).

Workshops, furnaces and industrial waste

Five remarkably similar roundhouses (Workshops 2, 13, 15, 16 and 19) were identified across the site in this period. Each was constructed with a single post-ring and four had a porch extending some way out from the main structure. Each contained the surviving stone bases of furnaces used to smelt iron ore, some of which had been repeatedly replaced over time. Most of these furnaces were located at the entrances of the buildings and appeared to be integral to the design and function of the workshop. Another two very similar buildings (Workshops 6 and 12) were also probably iron smelting workshops. Workshop 12 contained a hearth associated with metalworking (potentially a disturbed

Table 4.1
Summary of principal features of the workshops

Workshop	Diameter	Porch width	Porch length	Porch orientation	RC Date	Furnace	Furnace RC date
2	7.3	1.2	4	NE	50 cal BC–cal AD 120	681	40 cal BC–cal AD 120
6	7.8	n/a	n/a	—	200 cal BC–cal AD 1	—	n/a
8	4.7	1.8	3	NE	350–50 cal BC	—	n/a
12	7.8	1.10	4	NE	110 cal BC–cal AD 70	Hearth pit/disturbed furnace 2226	n/a
13 Stage 1	3.7	1	n/a	NE	40 cal BC–cal AD 130	3050	160 cal BC–cal AD 50
13 Stage 2	3.7	1	2	SW	—	3050	90 cal BC–cal AD 80
15	8	2	4	NW	40 cal BC–cal AD 120	4355 4262 4147	4355 110 cal BC–cal AD 70 4262 50 cal BC–cal AD 120 4147 170 cal BC–cal AD 20
16	6.90	1.3	4.10	NE	170 cal BC–cal AD 20	2246	200 cal BC–cal AD 1
18	4.3	0.5	3	NE	n/a	—	n/a
19	9	n/a	n/a	—	n/a	3127	n/a
22	6	2.5	5	NE	n/a	—	n/a

furnace) and Workshop 6 contained a thick spread of material identified as rake-out from an (unseen) nearby iron smelting furnace. A further three roundhouses had an identical 'porch and ring' design but contained no furnaces or ironworking material within their interiors (Workshops 8, 18 and 22). Given the similarities in design, these buildings are likely also to have functioned as some type of workshop space. Table 4.1 summarises the principal features of the workshops.

Strikingly different in design was a turf-and-stone structure (Workshop 11). This U-shaped arrangement of stones may have been the foundation for a turf/stone-walled structure. Within its boundaries were deposits containing glassworking and copper-alloy-working residues, and close by were two stone-lined glass/copper alloy hearths (Hearths 2166 and 2434). The workshop and hearths appear to have been primarily engaged in the manufacture of both glass and copper alloy objects.

Workshops containing iron-smelting furnaces

Workshop 2

Workshop 2 was a single post-ring of 13 post-holes with an internal diameter of 7.3m (Illus. 4.10). Two posts formed a north-east facing porch, which was *c.*1.2m in width. The porch was located at *c.*3.2m from the internal post-ring. Two small posts positioned just inside the main porch post-holes ([145] and [398]) may be the door jambs. The posts within the post-ring were placed at approximately 1m intervals with many containing packing stones.

Several artefacts were recovered from these post-hole fills. Most were likely related to metalworking activity including charcoal, heat-fractured stones, burnt clay and slag.

A pink glass bead (SF0156 – Illus. 6.61) was recovered from the upper fill of post-hole [597]. The bead is problematic, however, as, despite coming from a seemingly secure context, it does not have an ancient glass composition and is a colour otherwise unattested in the Iron Age. It also appears remarkably fresh and may well be a modern intrusion, a reminder that objects can significantly move between the top and subsoils. A small fragment of runned slag (SF1006) was recovered from the basal fill of post-hole [637]. A single AMS date from charcoal recovered from post-hole [597] gave a date of between 50 cal BC and cal AD 120 (SUERC-30361).

A well-preserved base of an iron-smelting furnace [681] was situated just inside the post-ring of the building (Illus. 4.11). It was constructed of four large edge-set stones in a 'horseshoe' shaped arrangement placed in a sub-rounded cut. Two stones had been used to form the back of the structure with one located either side. The stones were angled inwards at approximately 40°

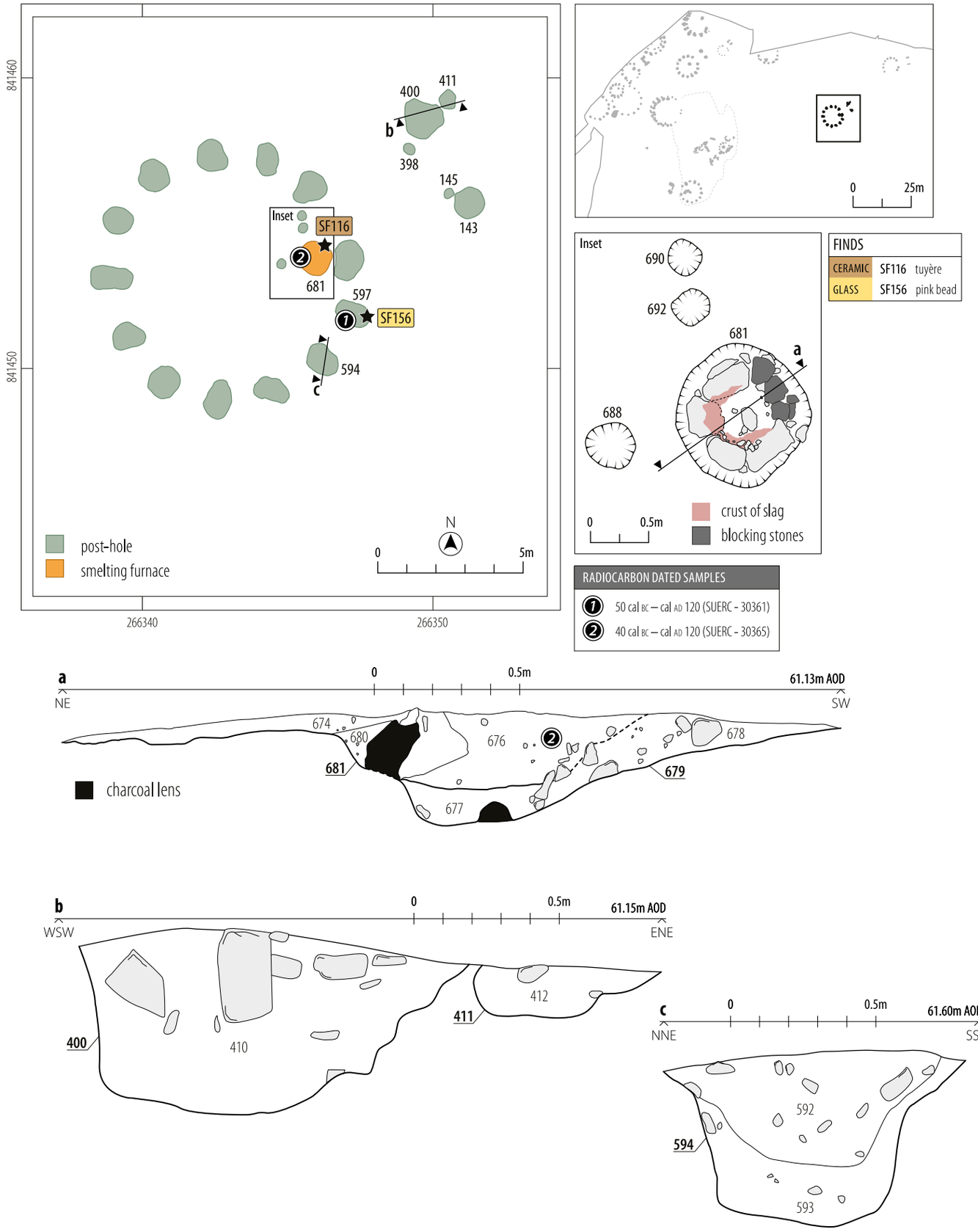


Illustration 4.10
Workshop 2 and smelting furnace; Section through smelting furnace

and rose to a height of 0.4m from the base of the cut. These heat-fractured stones were fused together at the upper internal edge by a crust of slag up to 0.10m thick. Smaller angular stones had been used to block the opening.

The furnace contained three fills, each of which related to its final firing or immediate post-use. The basal fill (677) was moderately compact black silty sand that covered the base. Small pieces of dripped slag and lumps of charcoal were abundant; the charcoal increased in size towards the base. Above this, a sandy clay (675) had been placed up against the inside of the stone structure as lining. This deposit contained few stone inclusions and had very fine flecks of charcoal and charcoal dust. A fragment of a conical tuyère (a clay nozzle through which air was forced into the furnace – SF0116) was identified in this deposit. Two large pieces of slag (SF0131 and SF0132) were slightly pressed into this clay lining towards the back of the furnace. This slag was an amalgam of smaller droplets and had a large amount of mineralised charcoal attached to it. Sealing this was another black deposit (676) that contained less charcoal and more slag than the basal deposit. Frequent fragments of burnt clay were recovered, which are likely to have originated from the clay superstructure of the furnace. A single AMS date from charcoal recovered from within this deposit gave a date of between 40 cal BC and cal AD 120 (SUERC-30365).

The space between the stone structure and the edge of the pit cut was filled with a moderately compact dark-brown sandy silt containing charcoal, slag and burnt clay. A fragment of a thick cylindrical tuyère (a bellows shield) with the partial remains of a circular bellows hole (SF0133) was recovered here. A sub-oval, shallow cut [679] present at the open end of the furnace was perhaps for the removal of waste or to control of air. An amorphous spread (674) surrounding the furnace was thought to be the remains of a contemporary ground surface. Three small post-holes ([690], [692] and [688]) were situated close to the furnace and may have been related to its use.

Illustration 4.11
Smelting Furnace 681 within Workshop 2

Workshop 13

Stage 1

Workshop 13 was originally built as a single post-ring roundhouse of nine post-holes with an internal diameter of *c.*3.7m (Illus. 4.12). The initial entrance was located on the north-east side of the building, defined by two post-holes ([2917] and [2919]) *c.*1m apart. A single AMS date from charcoal retrieved from [2919] returned a date of between 40 cal BC and cal AD 130 (SUERC-30389). The post-holes were mostly sub-circular with diameters ranging between 0.4 and 0.6m. Two had been cut by later pits [3792] and [4179]. Post-hole [2912] had a plano-convex ovoid rubbing stone (SF0598) incorporated into the packing and [2900] contained a sandstone worked surface (SF0599). The post-hole fills all contained varying amounts of iron slag, up to 1kg, and small quantities of burnt clay.

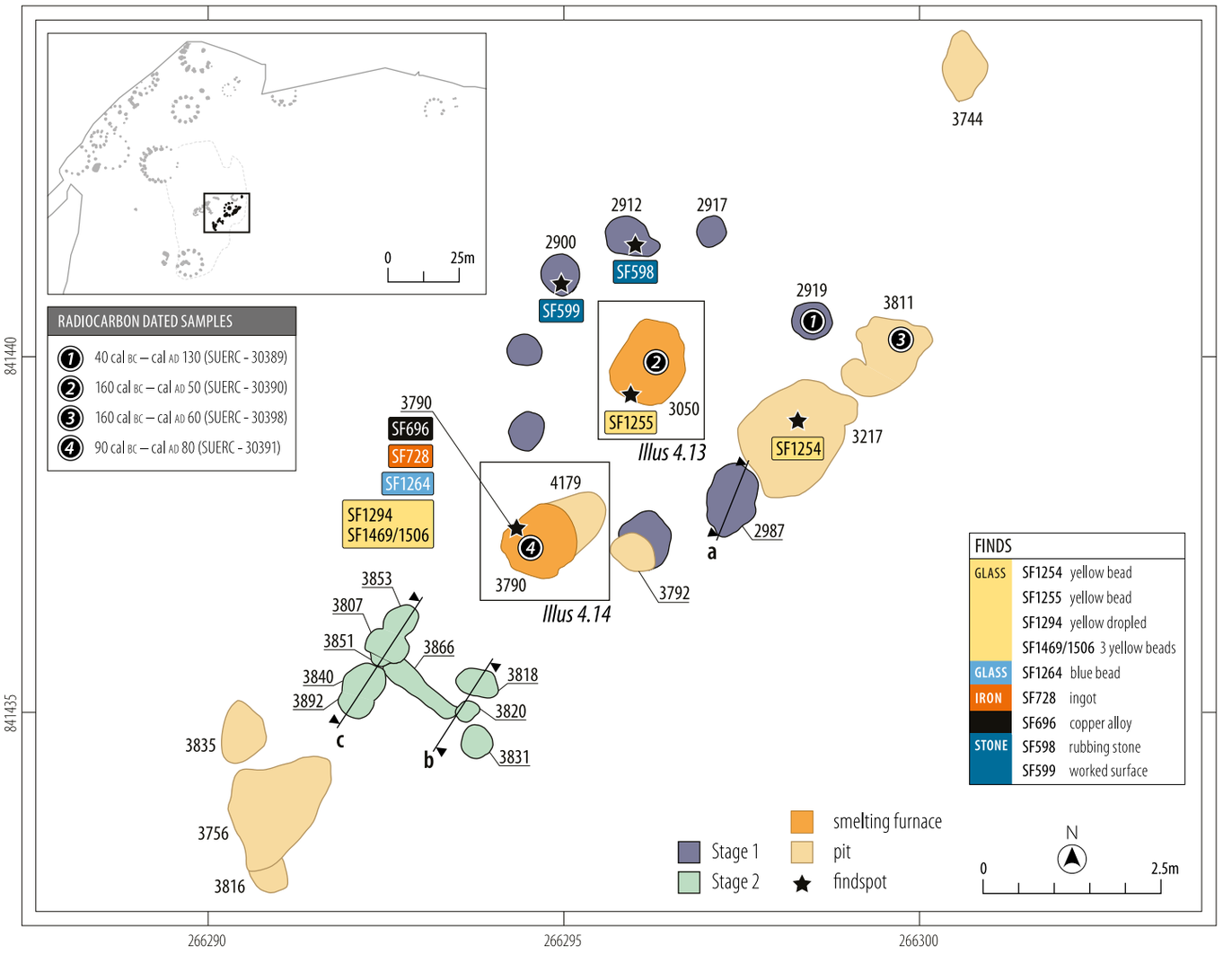
Located within the centre of this post-ring was the stone base of an iron-smelting furnace [3050] (Illus. 4.13). The rectangular stone setting was set into a steep sided sub-oval pit (*c.*1.2 × 0.97m), forming a box 0.30m in height. The two side slabs of sandstone were set on edge and angled inwards at *c.*60–70°. Both had been heavily heat-affected and had fractured into several pieces. The short sides of the furnace were formed by two or more stones, with the three stones on the north-east forming a removable blocking.

The furnace interior contained three fills, all relating to its final use or immediate post-use. The basal fill (3204) was fine black silt that was very rich in charcoal and iron slag (approximately 2.7kg). Small pieces of burnt clay and flecks of burnt bone were also present. A clear interface existed with the deposit overlying this layer (3147), a mottled brown sandy silt with large concentrations of charcoal and iron slag (approximately 5kg). A single AMS date retrieved from charcoal within (3204) returned a date of between 160 cal BC and cal AD 50 (SUERC-30390).

The upper fill (3064) was softly compacted, dark grey sandy silt with occasional fire-cracked stones (whereas the lower fills were largely stone-free) and 'ashy' patches that suggest a mixed deposit of furnace debris and backfill. A large quantity of iron slag (approximately 9kg) and burnt clay, most likely from the furnace superstructure, was recovered from this deposit. The space between the furnace stones and the edge of the cut was also filled with dark grey sandy silt (3458) that contained small quantities of iron slag, charcoal, prill and a small annular yellow glass bead (SF1255).

Stage 2

The second phase of Workshop 13 saw major alterations both to the building and to its interior. A south-west facing porch was constructed *c.*2m south-west of the post-ring, formed by two roughly parallel lines of post-holes, *c.*1m apart, joined by a narrow gully [3866]. The post-holes on the north side of the porch were more substantial than those to the south, with the largest [3807] measuring 0.6 × 0.46m and 0.42m deep with a recognisable



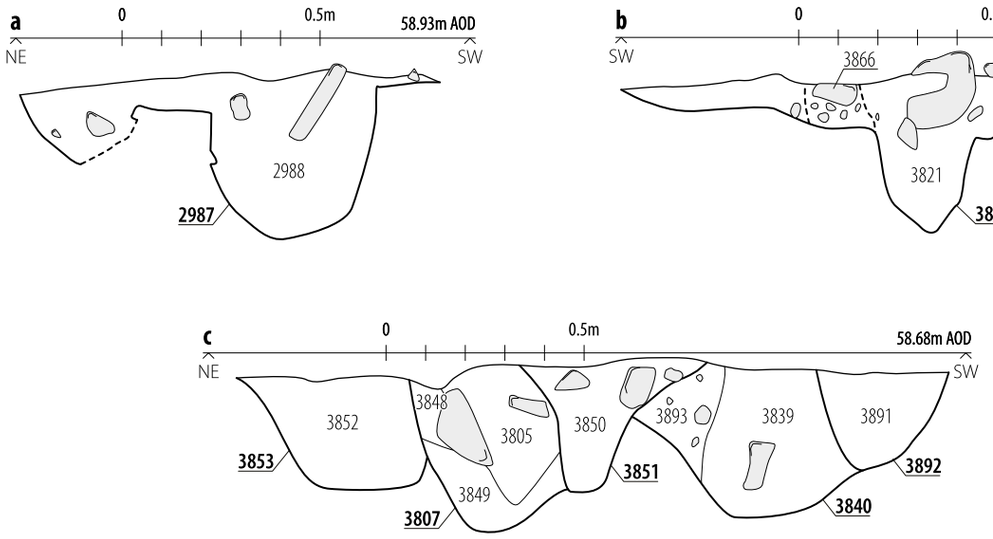


Illustration 4.12
Workshop 13 Stages 1 and 2; Sections through Workshop 13 post-holes

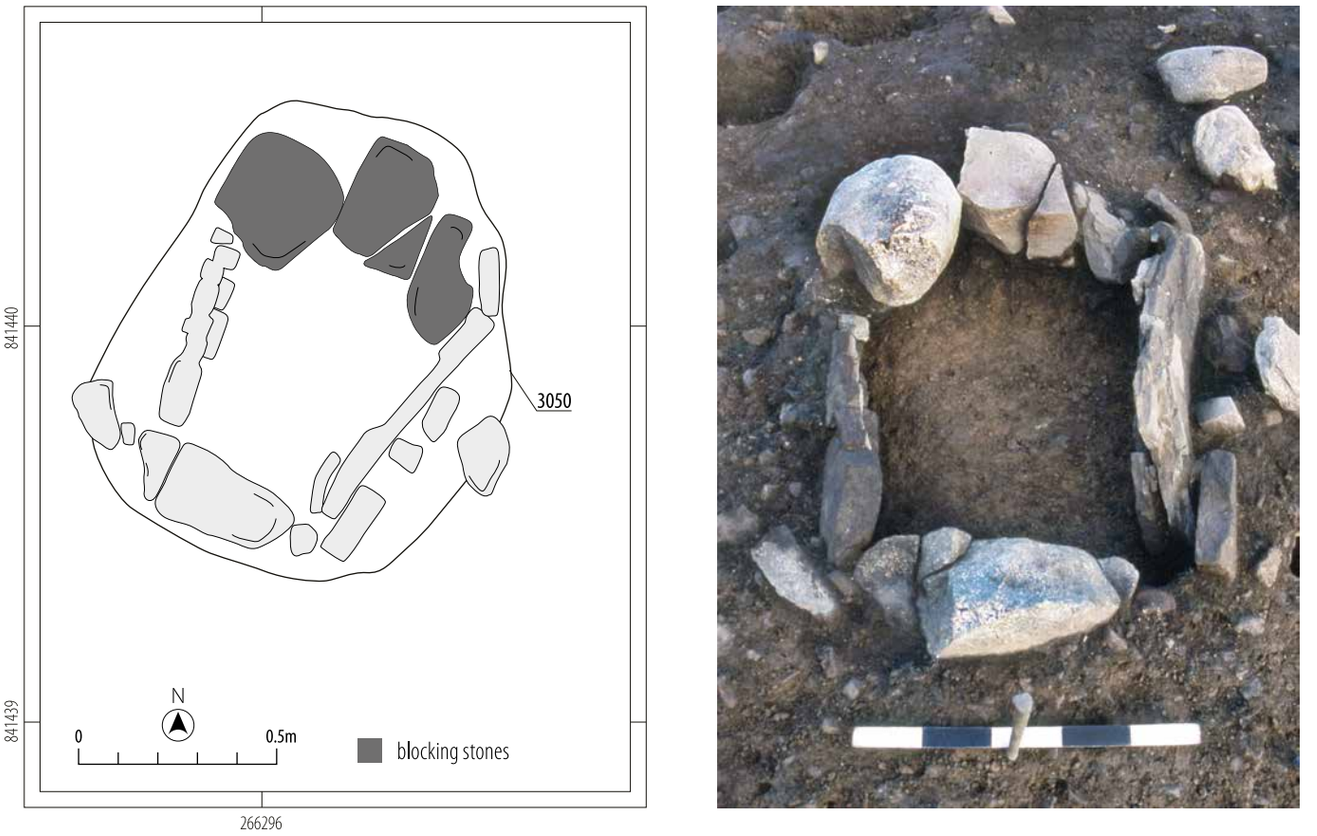


Illustration 4.13
Plan and photo of Furnace 3050

post-pipe and packing. The gully, which likely formed a wooden threshold to the building, contained a small amount of iron slag.

Located slightly on the outside the post-ring at the 'building end' of the porch was the stone base of an iron-smelting furnace [3790] (Illus. 4.14). This was a sub-rectangular stone setting, very similar to the furnace located within the building. Seven stones of varying size were set in a U-shaped structure into an oval pit (*c*.0.96 × 0.94 m). The stones were massively heat-affected and fused together by a crust of iron slag up to 0.18m thick. They had been set tilting inward at an angle of approximately 60°, 0.3m in height. The 'open' north-east end of the stone setting had been blocked by a line of removable stones and clay.

The concave base of the furnace had been lined with a thin layer of clay over which a deposit of unspent fuel (charcoal) and iron slag (6.46kg) had formed (4182). The deposit above (3467) differed from this basal fill as it contained larger pieces of iron slag and abundant lumps of burnt clay. These deposits appeared to represent the final firing of the furnace and its immediate post-use.

A total of 25.7kg of iron slag, 1.2kg magnetic residue, 0.031kg of prill, 6kg of burnt clay and a fragment of an iron ingot (SF0728) was recovered from (3467). Other artefacts recovered were not associated with ironworking. A small amorphous fragment of copper alloy (SF0696), three small yellow glass beads (Guido class 8: SF1469, SF1506 – Illus. 6.61), a very dark blue opaque annular glass bead (SF1264) and a small droplet of yellow glass (SF1294 – Illus. 6.76), possibly waste from bead manufacture, were also recovered. A single AMS date retrieved from charcoal within (3467) returned a date of 90 cal BC–cal AD 80 (SUERC-30391).

Furnace [3790] superseded an earlier furnace formed by an oval pit [4179]. This pit contained an arrangement of sub-angular stones and burnt clay towards its north-east end, similar to the blocked end of the later furnace, and high concentrations of iron slag, burnt clay and significant quantities of micro-debris diagnostic of smithing. This furnace appears to have been dismantled and backfilled to accommodate the construction of furnace [3790].

Metalworking pits

Clustered around the entrance to the porch of Workshop 13 were several pits and post-holes. Two pits were of note as they contained an abundance of metalworking debris that may have originated from the building's furnaces. Pits [3756] and [3835] both contained heat-fractured cobbles, charcoal and iron slag, burnt clay and magnetic residue. Pit [3756] cut an earlier, smaller pit [3816] which containing burnt clay and iron slag as well as small amounts of hammerscale.

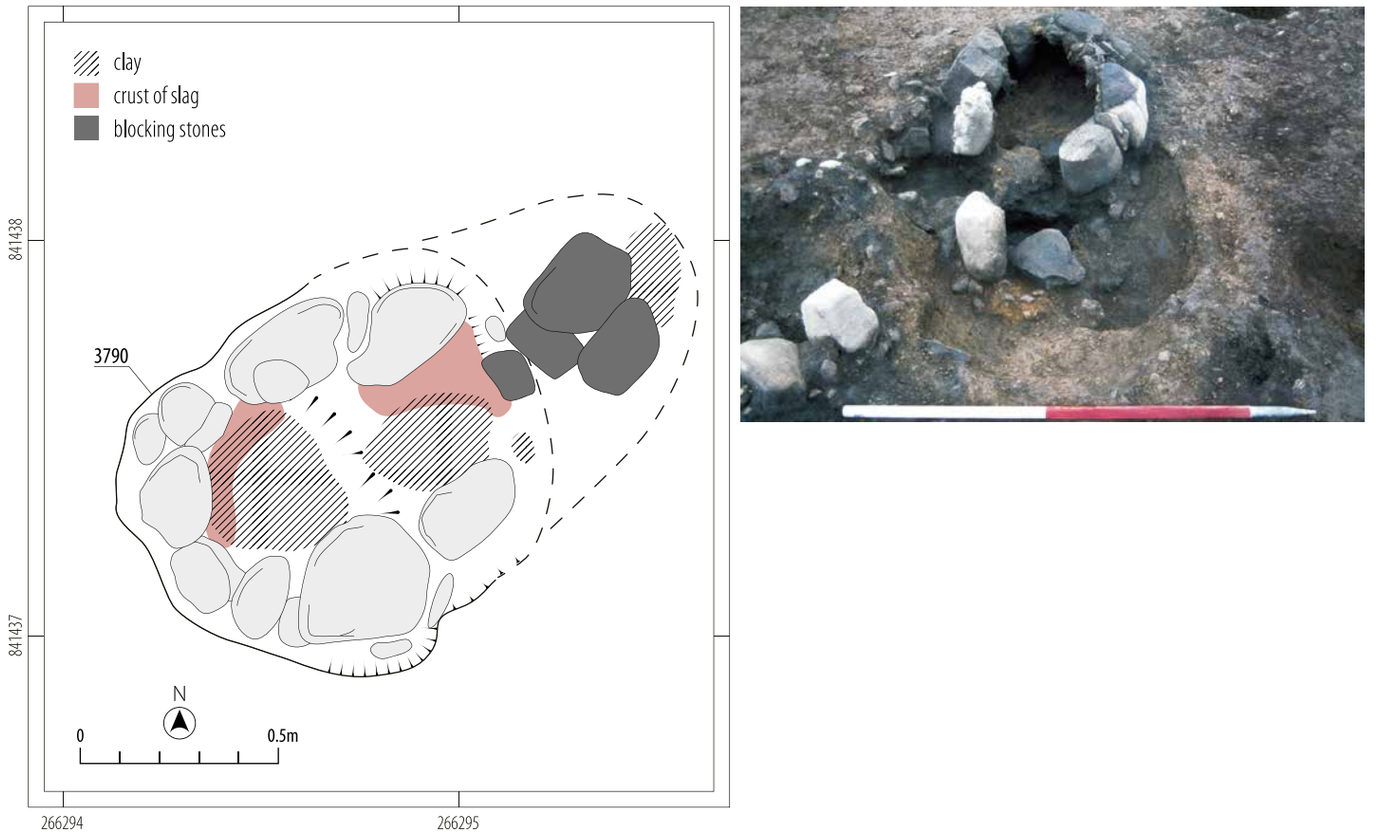
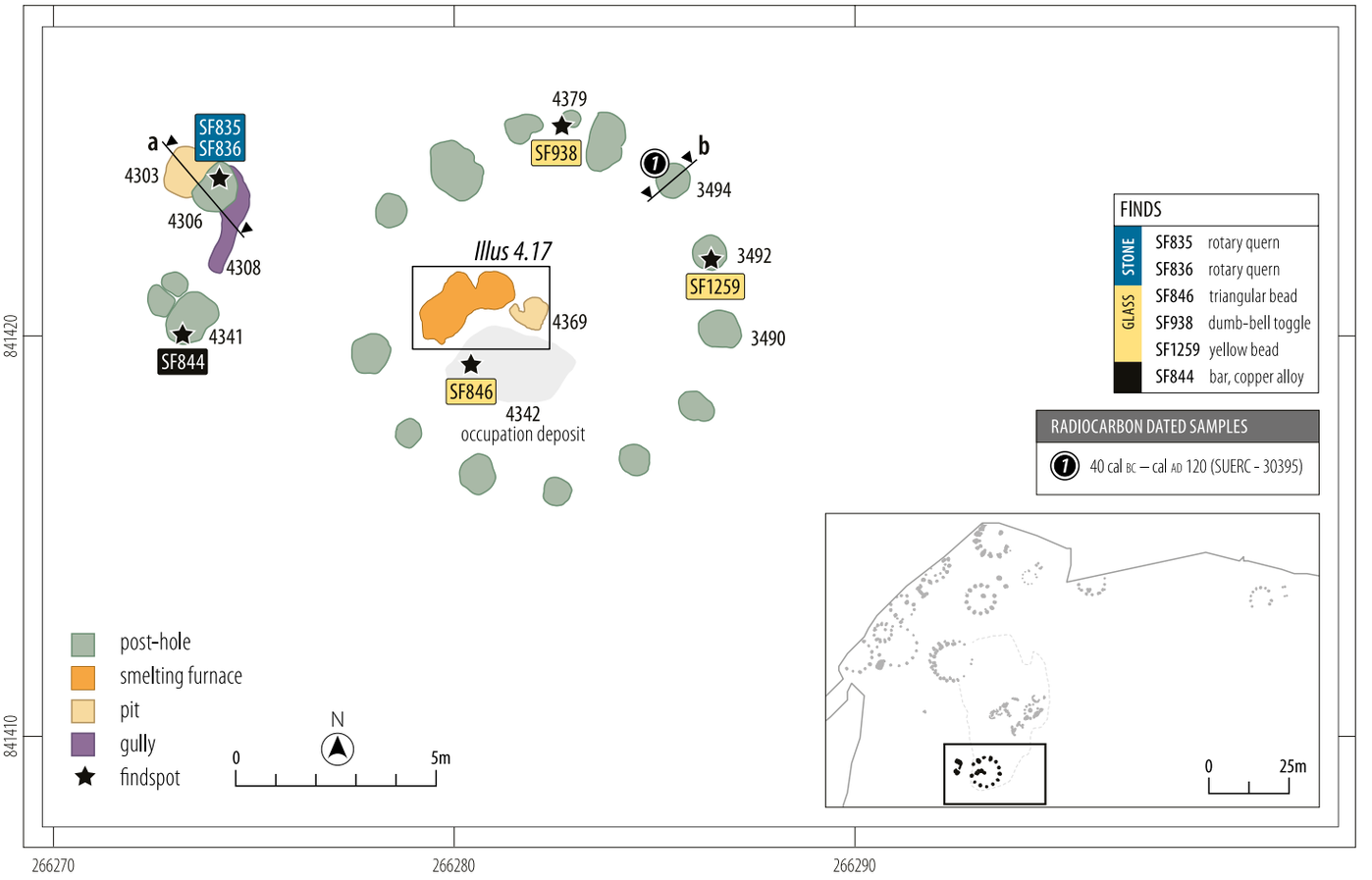


Illustration 4.14
Plan and photo of Furnace 3790

Illustration 4.15
Workshop 15 under excavation



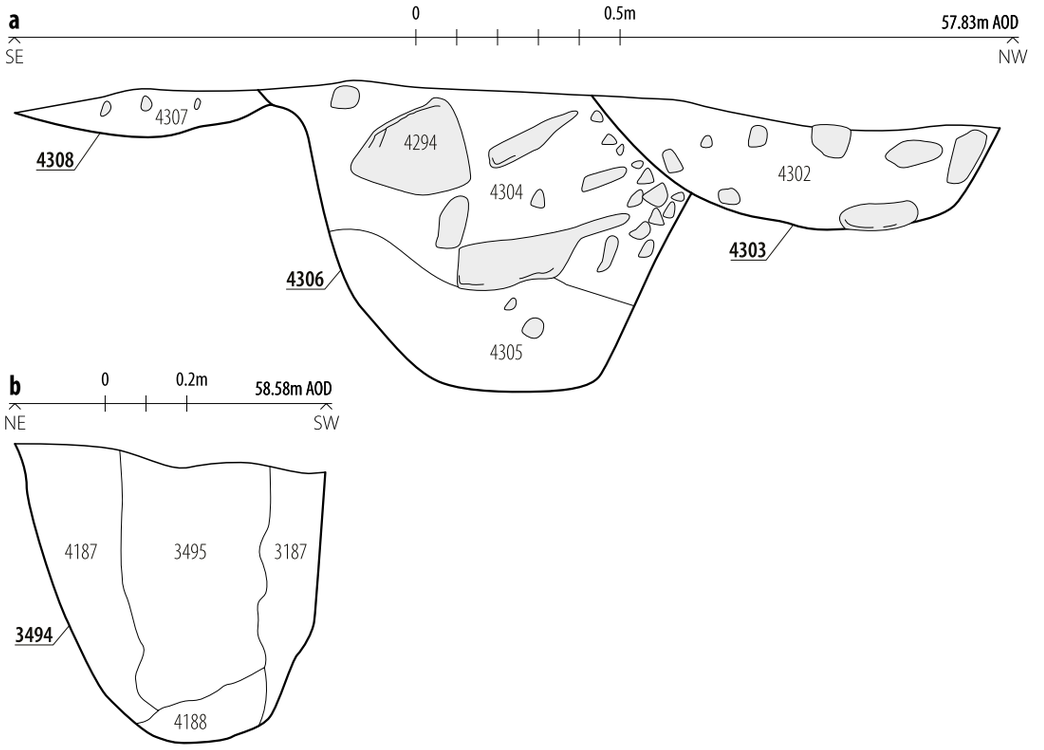


Illustration 4.16
Workshop 15 and smelting furnaces; Section through Workshop 15 post-holes

Adjacent to furnace [3790] was a small pit [3792] that truncated a post-hole of Workshop 13. This pit was oval in plan, measured 0.8 × 0.6m and was 0.25m deep, and its top edge of cut had been lined on one side by five large stones. These stones appear to have formed a setting for a large square boulder that was accidently removed from the pit during the topsoil strip (pers. comm. Ross Murray) and was not recorded in situ. The setting of this large square boulder next to an iron-smelting furnace may indicate that it was an anvil.

To the east and north-east of the workshop were further clusters of pits and post-holes, which contained metalworking debris in varying quantities. Of note were several pits to the north-east of the building. Pit [3217] contained 2kg of iron slag and a small opaque, amber-yellow glass bead (SF1254). Immediately to its north was Pit [3811]. This stone-lined pit was backfilled with material rich in industrial debris (3812) and sealed with two heat-affected flat stones, and may have been the remains of a decommissioned furnace. A single AMS date retrieved from charcoal within (3812) returned a date of 160 cal BC–cal AD 60 (SUERC-30398).

Pit [3744] situated to the north-east of the building contained abundant iron slag (1.9kg), fired clay (315.2g) and magnetic residue as well as a small quantity of prill. Much of the fired clay had wattle impressions indicating that wet clay had been applied to a wattle surface. Close by was post-hole ([2835] – not illustrated), which contained both ferrous and non-ferrous metalworking debris in the form of iron slag, prill and a small piece of copper alloy slag.

Workshop 15

Situated to the south-west of Workshop 13 was a single post-ring roundhouse with a north-west facing porch (Illus. 4.15 and 4.16). The post-ring consisted of 13 post-holes placed at *c.*1m intervals with an internal diameter of *c.*8m. Metalworking debris was present in many of these post-holes. Two glass beads were recovered: a yellow Guido class 8 glass bead (SF1259) from the upper fill of post-hole [3492]; and half a triangular bead (SF0846 – Illus. 6.61), of complex design and high quality, which was recovered from an occupation deposit (4342) located within the interior of the building. One post-hole located between two post-holes in the post-ring [4379] contained a dumb-bell toggle made from two conjoined spheres in very dark greenish blue glass with yellow stripes and patches (SF0938 – Illus. 6.61). Samples were analysed from two post-holes (3490 and 3494), both of which contained low levels of charred cereal grains. A single AMS date from charcoal retrieved from post-hole [3494] returned a date of 40 cal BC–cal AD 120 (SUERC-30395).

The *c.*2m-wide porch extended *c.*3.30m to the north-west of the post-ring and comprised two large post-holes ([4341] and [4306]) with a narrow gully [4308] between, representing a setting for a wooden threshold. A square sectioned copper alloy bar (SF0844) and a large quantity of dense iron slag (SF0845)

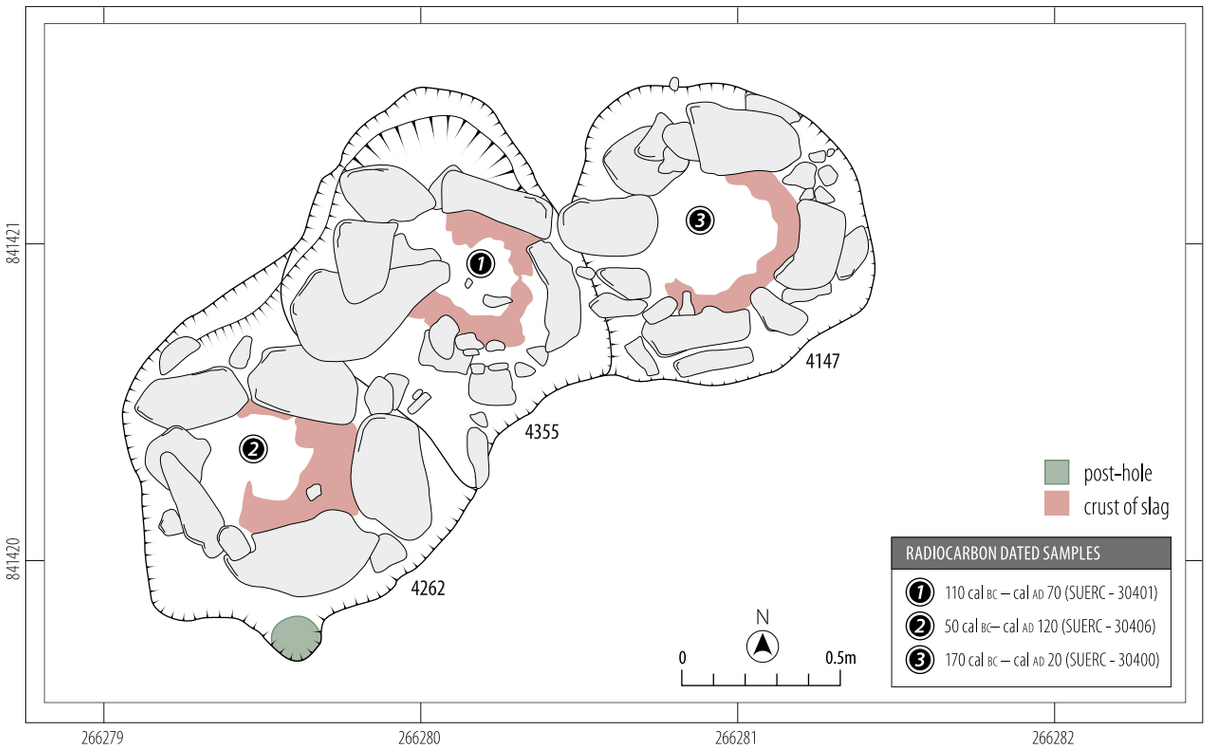


Illustration 4.17
Smelting furnaces 4355 (centre), 4262 (left) and 4147 (right)

were recovered from the southern post-hole [4341]. The northern post-hole [4306] contained large packing stones with two rotary quern fragments (SF0835 and SF0836) incorporated.

The bases of three identical iron-smelting furnaces were located just inside the entrance of the post-ring (Illus. 4.17 and 4.18). The earliest furnace [4355] was a horseshoe shaped stone setting within an oval pit (*c.*1m in diameter). It was cut to the east by furnace [4147] and to the west by furnace [4262]. To the south-east of the complex of furnaces was a 0.15m thick occupation deposit (4342), which contained heat-fractured stones, lumps of charcoal and fired clay, probable rake-out waste from the furnaces.

Furnace 4355

The stones that formed the main structure of furnace [4355] were fused together by a ring of iron slag, and two blocking stones had been placed at the open south-west end (Illus. 4.18 and 4.20). The stones on the south and east side were very fragile due to heat exposure and had been damaged by the construction of the two adjacent later furnaces. A thin deposit of pinkish brown sandy clay (4217) lined the interior of the stones. The basal fill (4218) was rich in charcoal and pieces of 'dripped' slag, and overlaid a thick deposit (4148) containing burnt clay and iron slag as well as large quantities of charcoal; this was found in higher concentrations towards the open end of the furnace. A single AMS date retrieved from charcoal within (4148) returned a date of 110 cal BC–cal AD 70 (SUERC-30401). The upper fill (4121) appeared to be a deliberate backfill of both this furnace and furnace [4147] and contained abundant burnt clay and iron slag.

Illustration 4.18
Smelting furnaces 4147 (top), 4355 (middle) and 4262 (bottom)

Furnace 4262

Furnace [4262] was also formed by horseshoe-shaped stones set on edge at an angle of approximately 60°. It was located to the west of furnace [4355] and cut through its back end. The stones were fused together by two tiers of iron slag with the remains of the furnace superstructure still adhering to the stones' upper surface as patches of burnt clay and small decayed stones (Illus. 4.19 and 4.20). A thick basal deposit of charcoal and slag (4257 – 0.26m deep) was present and likely represented the final firing of the furnace. A single AMS date retrieved from charcoal within (4257) returned a date of 50 cal BC–cal AD 120 (SUERC-30406). Deposits immediately overlying (4257) contained burnt clay fragments with finger and hand impressions, likely the remnants of the clay superstructure.

Furnace 4147

Furnace [4147] was located immediately to the east of furnace [4355] and cut its front end. Furnace [4147] was also horseshoe-shaped and formed by large stones set on edge at an angle of approximately 60° set into an oval pit (*c.*0.80 × 0.60 m). A thick crust of iron slag had fused most of the stones together. Loose stones had blocked the opening and were still in situ (Illus. 4.21). The remains of the furnace superstructure were present as a ring of burnt clay with fragments of quartz and stones located on the top of the stones, spreading down over their external faces. On the outer face of the stones the clay had noticeably fewer inclusions and in several places wattle and finger impressions were noted.

The basal fill of the furnace was a 0.04m thick layer of charcoal and 'dripped' slag. A deposit (4141) containing abundant iron slag, burnt clay and charcoal, sealed this basal fill. As with furnace [4355] the charcoal within this layer was more concentrated towards the open end of the structure. A single AMS date retrieved from charcoal within (4141) returned a date of 170 cal BC–cal AD 20 (SUERC-30400). The upper fill (4121) was a spread of material, likely deliberate backfill, across both furnace 4147 and 4355.

A pit [4369] was situated within the interior of the workshop and immediately to the east of the furnaces. It appeared to be related to the metalworking process. The top edge of the 1m diameter pit was lined by well-fired clay and it was backfilled with large quantities of burnt clay, clay fused to slag and iron slag.

Workshop 16

The roundhouse comprised a single post-ring of 10 posts with an internal diameter of 6.90m (Illus. 4.22). The post-holes were between 0.7 to 1m in diameter and 0.3 and 0.7m deep. The porch was defined by two (heavily recut) posts (1.30m apart) located 2.65m to the north-east of the post-ring. These post-holes were

Illustration 4.19
Smelting furnace 4262 with elements of the furnace superstructure intact

Illustration 4.20
Smelting furnaces 4355 (foreground) and 4262

joined by a linear gully which formed a threshold into the porch entrance.

Post-holes within the post-ring yielded a number of finds including a fragment of a bun-shaped rotary quern (SF465/471) reused as a packing stone (2253), a possible working surface (SF0464 in [2306]), a small yellow glass bead (SF1252 in [2284]) and a possible sharpening stone (SF0456), which had been reused as a packing stone of one of the porch post-holes. Iron slag and prill was present in a total of six post-holes. A single AMS date retrieved from charcoal within post-hole [2303] returned a date of 170 cal BC–cal AD 20 (SUERC-30378).

The truncated base of a smelting furnace [2246] was located within the interior, placed just inside the post-ring in line with the entrance. The sides of the rectangular cut (1.3m long, 1m wide and 0.23m deep) were partially lined with a mixture of rounded and flat stones. Two stones, one on the west edge (SF0457) and the other on the south (SF0458), were fragments of a rotary quern. These were set on edge with the central perforation located at the top of the cut and were heat damaged, heavily vitrified and fragile. These rotary quern fragments had been incorporated into the furnace structure with their central perforations potentially reused to support ceramic tuyères.

The basal fill (2288) was the in situ remains of its last firing. The deposit was a black, compact amalgam of gravel, burnt clay, iron slag and charcoal, approximately 0.15m deep. A single AMS date retrieved from charcoal recovered from (2288) gave a date of 200 cal BC–cal AD 1 (SUERC-30377). The upper fill of the furnace was lighter in colour with small fragments of burnt clay, iron slag and charcoal, and probably derived from post-use silting. Within the interior of the workshop was a shallow circular pit [2238] located 1m to the south-west of the furnace. Half a bun-shaped rotary quern (SF0465) had been placed with the central hole facing upwards against the cut of the pit, echoing the position of the quern fragments reused within the furnace.

Illustration 4.21
Smelting furnace 4147 showing blocking stones

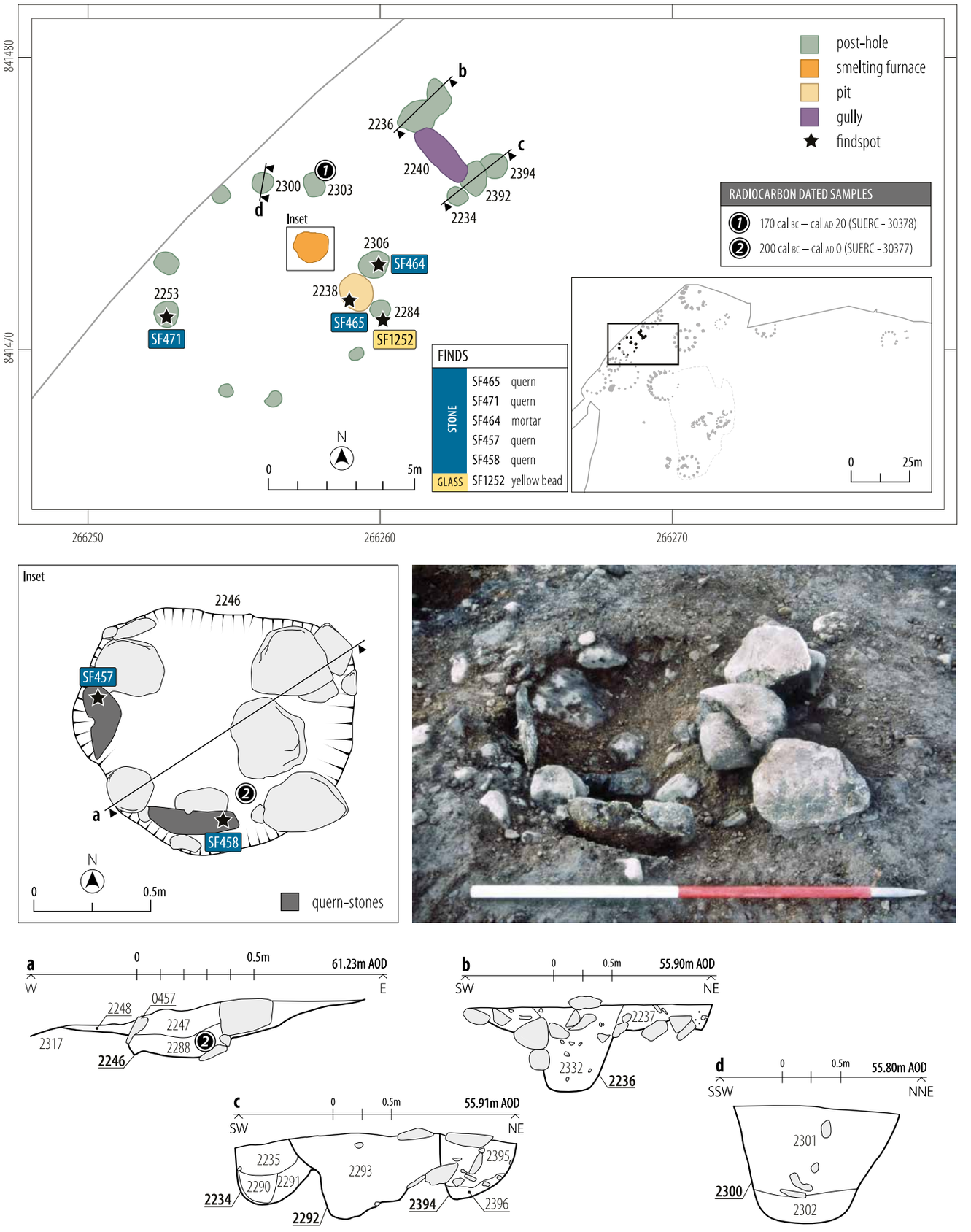
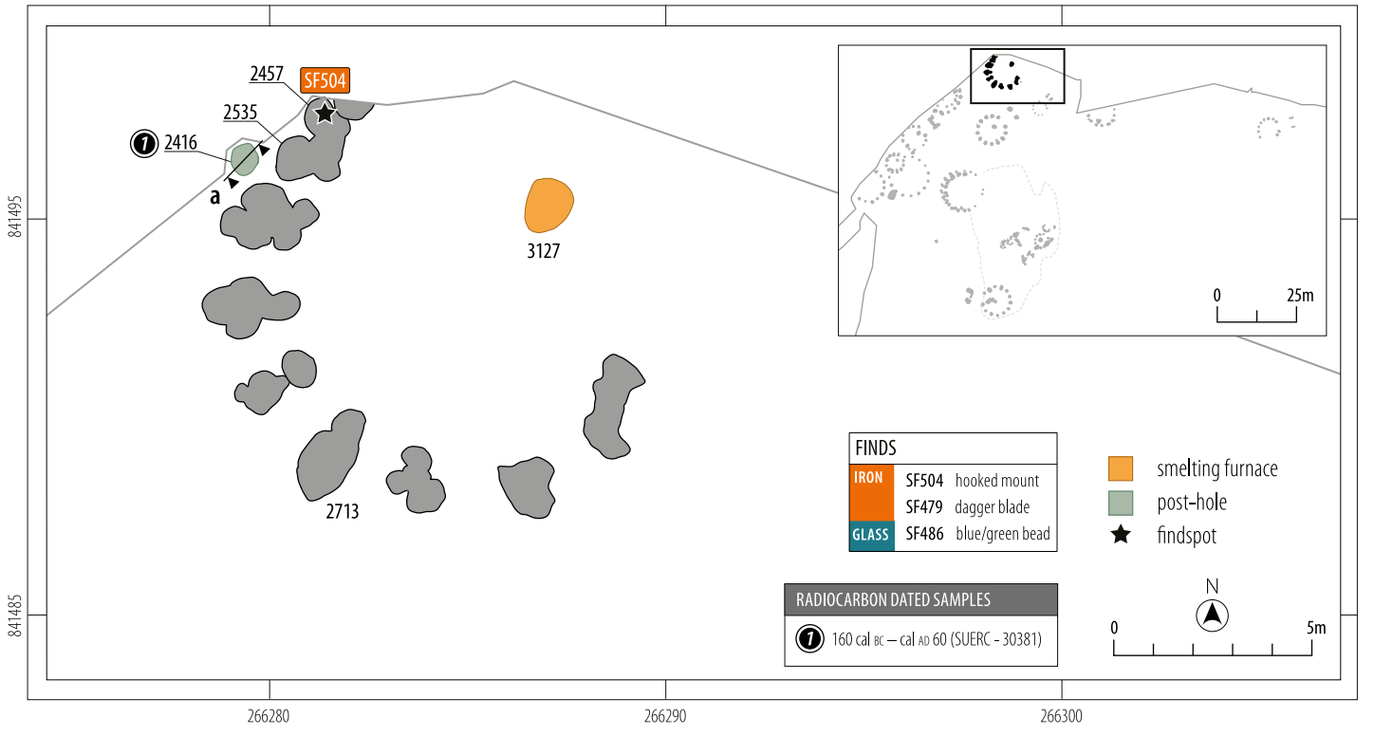


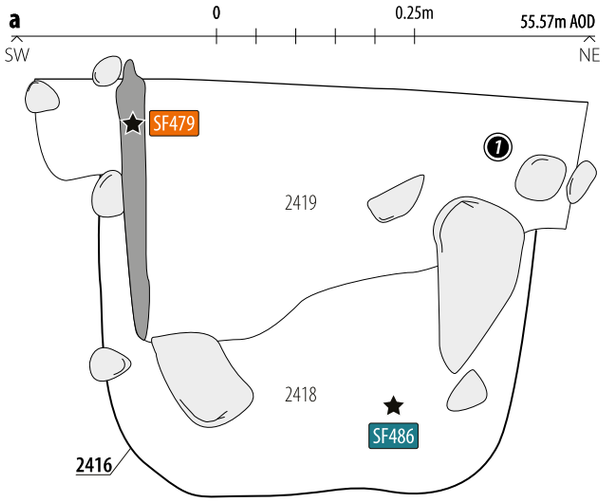
Illustration 4.22
Plan of Workshop 16 and smelting furnace 2246; Sections through Workshop 16 post-holes; Smelting furnace 2246 showing reused rotary quern in situ

Another part of this bun-shaped quern was identified within one of the workshop's post-holes [2253].

Workshop 19

The post-ring of a *c.*9m diameter roundhouse was only partially exposed within the excavation area and only two post-holes were excavated (Illus. 4.23). Nine post-holes were visible, all of which appeared to be heavily recut. Post-hole [2713] was sub-oval, measuring 1.2 × 1.1m, and was 0.94m deep. The section revealed a 0.7m wide deposit of redeposited natural packing material abutting a clear 0.4m post-pipe that tapered slightly towards the base. This post-hole truncated the ring-groove of Structure 20 (Illus. 1.10). The largest post-hole [2535] measured 1m in diameter and was 0.72m deep. Packing stones had been placed along its southern edge; these and the post-pipe suggested a post width of *c.*0.4m. This post-hole was truncated by a small pit [2457], which contained an iron hooked mount (SF0504–Illus. 6.46).





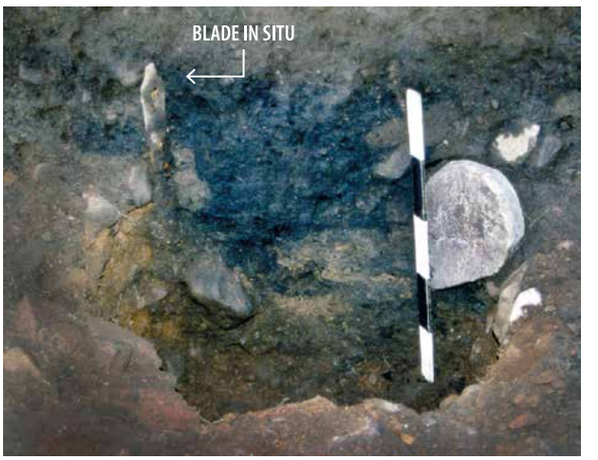


Illustration 4.23
Workshop 19; Section through post-hole 2416; Photo of dagger blade in situ

A stone-lined feature [3127], located in the interior of the workshop, was identified as an iron-smelting furnace in plan. It was not excavated and was preserved in situ.

Post-hole 2416

This circular post-hole was situated to the north-west of Workshop 19. It was 0.65m in diameter, 0.35m in depth and contained packing stones, some of which were heat-fractured, surrounding a post-pipe. Incorporated into the packing material up against the post-pipe was an iron dagger blade (SF0479 – Illus. 6.46). The dagger had been placed vertically with its point down alongside the post when it had been originally set. The dagger was 0.28m in length and had a maximum width of 0.037m. The lentoid-sectioned blade had a stump of a tang measuring 0.02m and, while it had been deposited whole, it had fractured into three fragments in antiquity. A small mid-blue-green glass bead (SF0486 – Illus. 6.61) and a fragment of crucible were also recovered from the fill. A single AMS date retrieved from charcoal from the upper backfill of the post-hole [2419] returned a date of 160 cal BC–cal AD 60 (SUERC-30381).

Numerous other pits and post-holes, a circular post-built building (Structure 21) and a ring-groove building (Structure 20) were also identified in this corner of the site. Aside from the two post-holes of Workshop 19 and post-hole [2416] these features were not excavated and were preserved in situ (Illus. 1.10)

Other workshops

Workshop 6

Only the southern half of a *c.*8m diameter roundhouse was identified within the excavation area, with eight post-holes of a single post-ring exposed (Illus. 4.24). These were spaced around 1.8m apart, and were between 0.08 to 0.44m in diameter and 0.16 to 0.61m in depth. No entrance was identified.

A large piece of burnt clay adhered to slag (SF0208) was found in post-hole [889], and the head of an iron spear (SF1026), probably a light throwing spear, was found within the packing material of post-hole [1607]. A single AMS date retrieved from charcoal from post-hole [1618] returned a date of 200 cal BC–cal AD 1 (SUERC-30368).

No hearth or furnace was identified within the interior of the building but a thick spread of material rich in metalworking debris (1632) was present. This deposit was a dump of material or rake-out from a firing of an iron-smelting furnace. As this material is unlikely to have travelled far from its source, Workshop 6 could have contained an iron-smelting furnace within its interior located beyond the excavation area.

Workshop 12

Workshop 12 was a circular building formed by a single post-ring of 13 post-holes with an internal diameter of *c.*7.8m. A porch extended 4m to the north-east (Illus. 4.25). Most of the posts were located *c.*1m apart, with the porch post-holes *c.*1.10m apart. The upper fills of the post-holes contained many heat-fractured stones, lumps of iron slag and burnt clay. Metalworking debris was common in their basal fills and slag had been reused as packing material. A single AMS date was retrieved from charcoal within post-hole [2459] and returned a date of 110 cal BC–cal AD 70 (SUERC-30385).

A shallow circular hearth pit [2226] was located adjacent to the entrance in line with the porch and contained charcoal, heat-fractured stones, quantities of iron slag and magnetic residue. Its backfill and similar location to many of the furnaces seen on site suggests that this pit was the remains of an iron-smelting

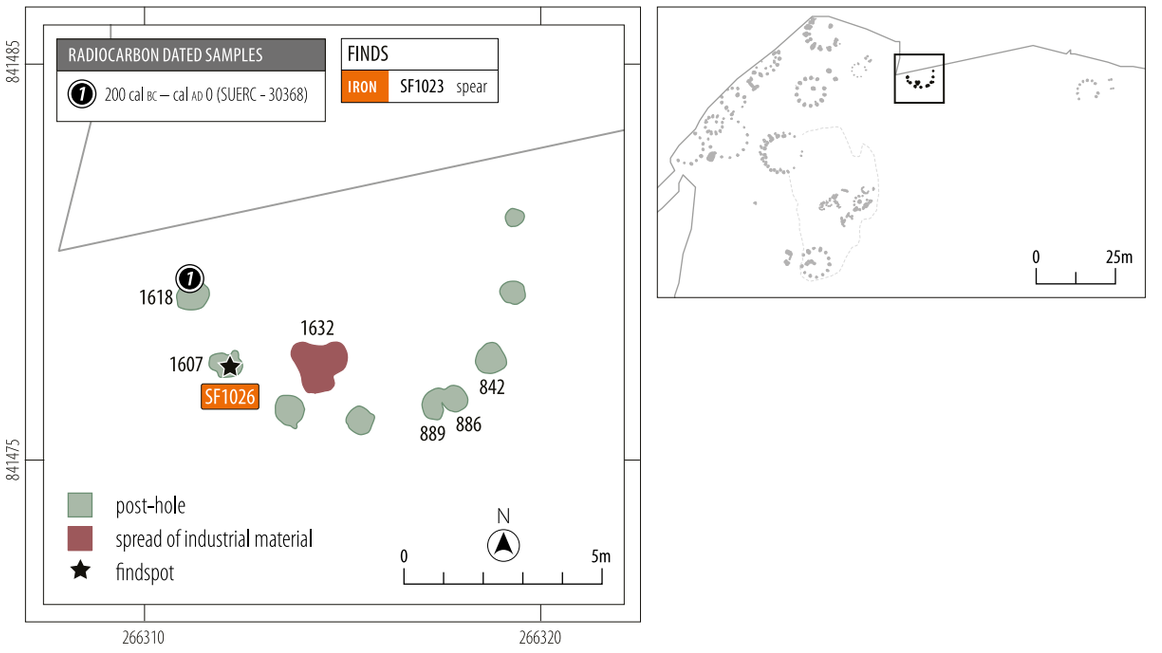
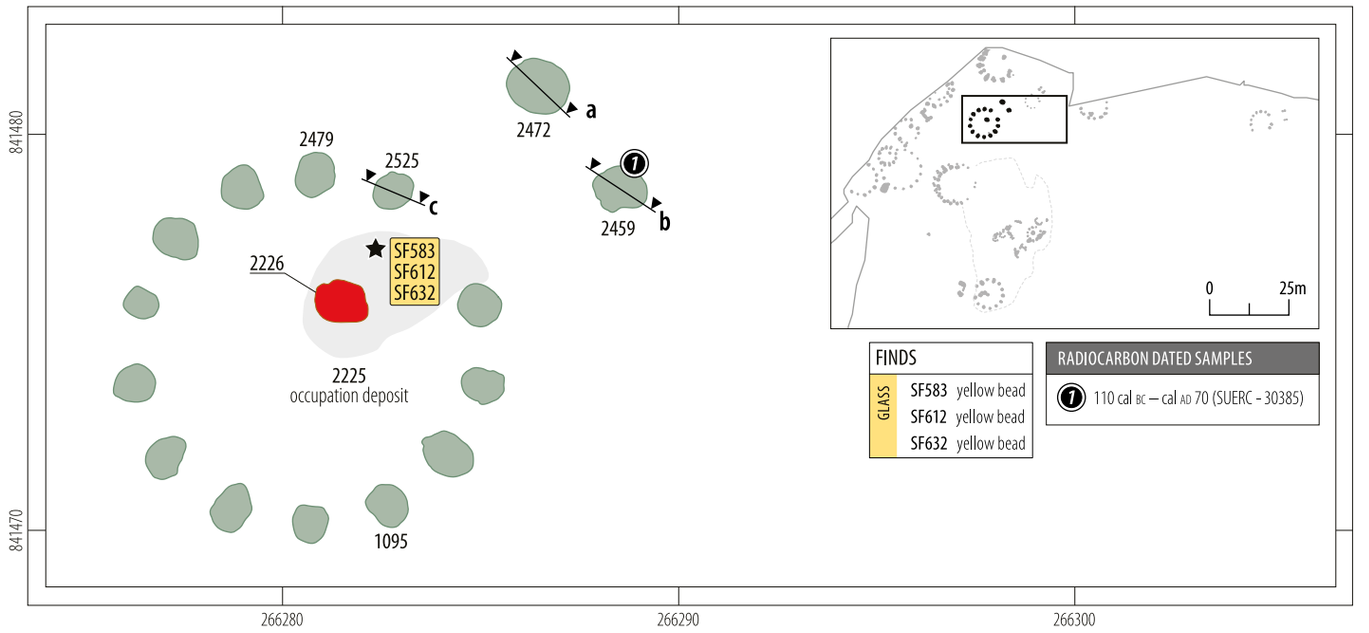
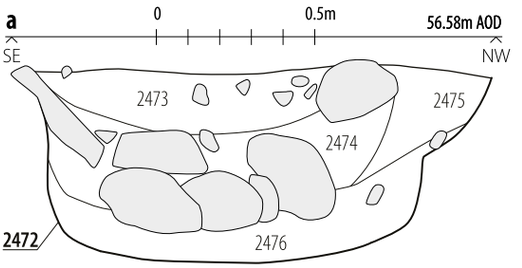
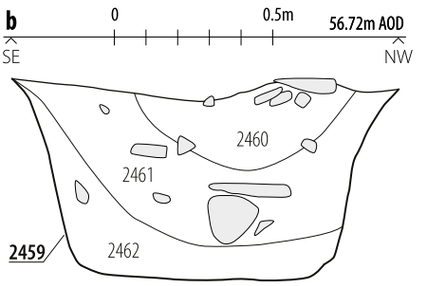


Illustration 4.24
Workshop 6







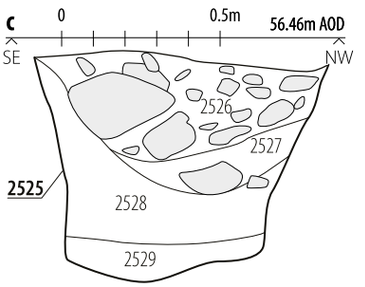


Illustration 4.25
Workshop 12; Sections through Workshop 12 post-holes; Workshop 12 (looking east)

furnace that had been removed. The pit cut an occupation deposit (2225), which contained three yellow beads (SF0583, SF0612 and SF0632 – Illus. 6.61).

Workshop 8

This roundhouse comprised a single post-ring of 11 posts with an internal diameter of 4.7m. It had truncated a post-ring roundhouse House 9 (Illus. 4.26). A porch was located 3m to the north-east of the post-ring of the building, with an entrance *c.*1.8m wide. No internal features were identified. A single AMS date retrieved from charcoal recovered from this feature gave a date of 350–50 cal BC (SUERC-30370). The similarity of the layout of Workshop 8 to the iron-smelting workshops suggests that this building also functioned as a type of workshop.

Workshop 18

Workshop 18 was a single post-ring of nine post-holes with an internal diameter of 4.3m (Illus. 4.27). The post-ring and the interior of the building were heavily truncated, with no internal features surviving and only slight traces of many of the post-holes. The porch area appeared to be least affected and four post-holes formed a north-east-facing porch *c.*1.2m in width. Most of the post-holes contained small quantities of iron slag.

Workshop 22

Workshop 22 was a single post-ring of 12 post-holes with an internal diameter of 6m (Illus. 4.1). It was excavated during the top-soil stripping of the site by Alba Archaeology and only minimal records survive. Four post-holes formed a north-east facing porch *c.*2.5m in width and were located *c.*5m from the main structure. No furnace or hearth pit was identified within the building's interior. A small fragment of fired clay spindle whorl (SF0584 – Illus. 6.18) was recovered from one of the post-holes of the structure. Pits to the north and east of the workshop (Pits [1076] and [1077]) contained glass working debris.

A SMITHING HEARTH

A shallow oval pit [4273] was located to the south of House 10. It was lined with clay on three sides of the cut, forming a 0.10m

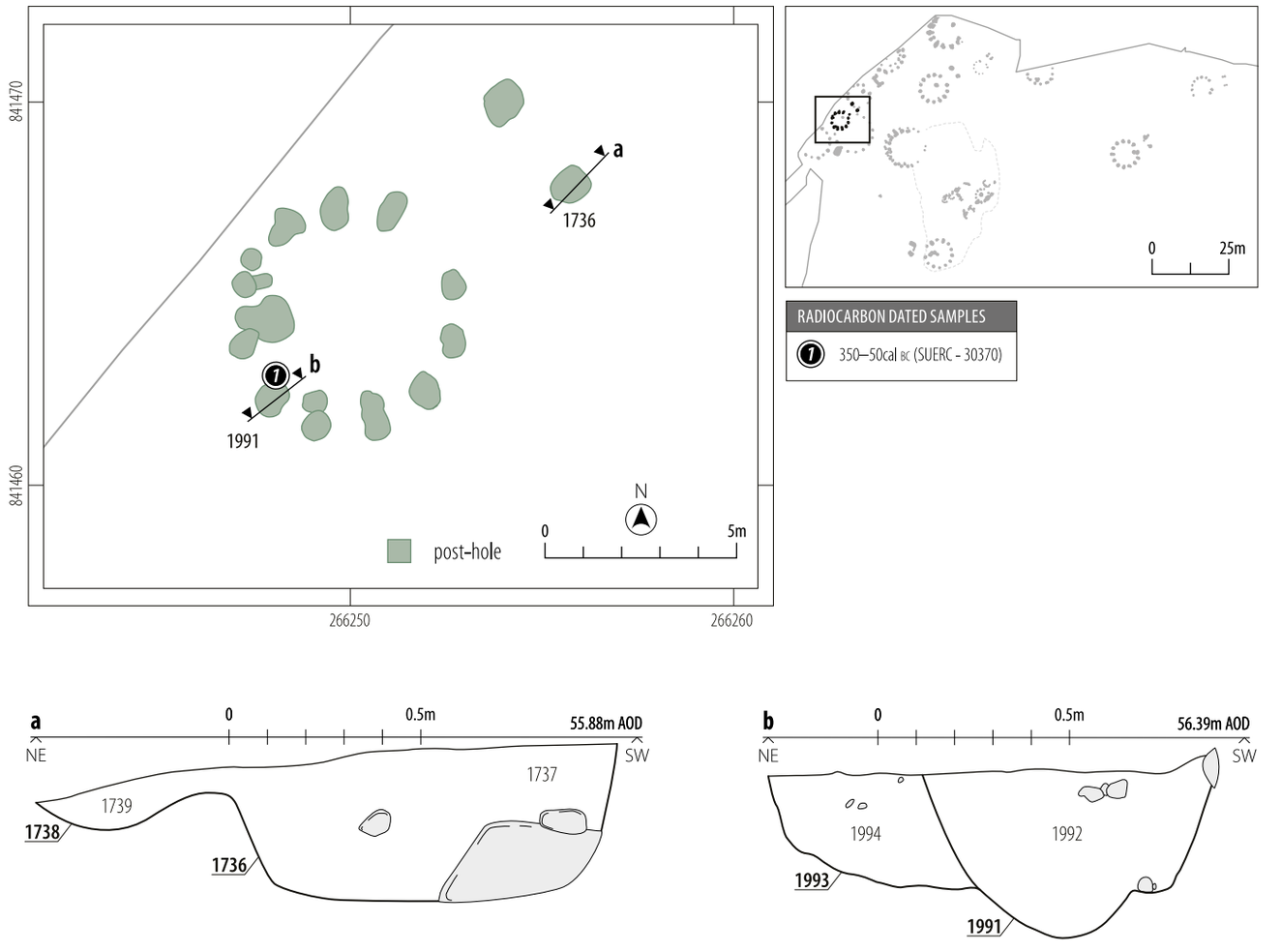


Illustration 4.26
Workshop 8; Sections through Workshop 8 post-holes

thick dark-grey horseshoe-shaped band. Beneath the clay was a deposit of light pink clay and charcoal-flecked dark-brown silty sand, which sealed the basal deposit of the hearth, a brown silty sand (4279). Over 1kg of vitrified ceramics and iron slag was recovered from the hearth alongside 0.2kg of magnetic residue, identified as smithing waste. A single AMS date retrieved from charcoal within (4279) returned a date of 350–40 cal BC (SUERC-30407).

Glass and copper alloy production

Two paved hearths (Hearths [2434] and [2166]) and a turf-and-stone workshop (Workshop 11) formed a tightly placed group of features located to the north-west of Workshop 13 associated with the manufacture of glass and copper alloy objects (Illus. 4.28 and 4.29). Deposits within and surrounding each of the hearths and the workshop contained abundant evidence of copper alloy casting alongside finished glass and copper alloy objects including glass beads and a bronze rivet. Hearth 26 located to the north-east of this group may also have been associated with copper alloy casting. Iron slag, hammerscale and other smithing waste around the workshop and the hearths indicated that ironworking and smithing was also taking place in this area.

Glassworking waste was limited to Hearth [2434] and its internal deposits, a distribution that suggests that Hearth [2434] was used as a glass furnace.

The distribution of copper alloy objects, crucibles and moulds in this area is shown in Illus. 4.34. The distribution of glass beads across the site is shown in Illus. 4.36.

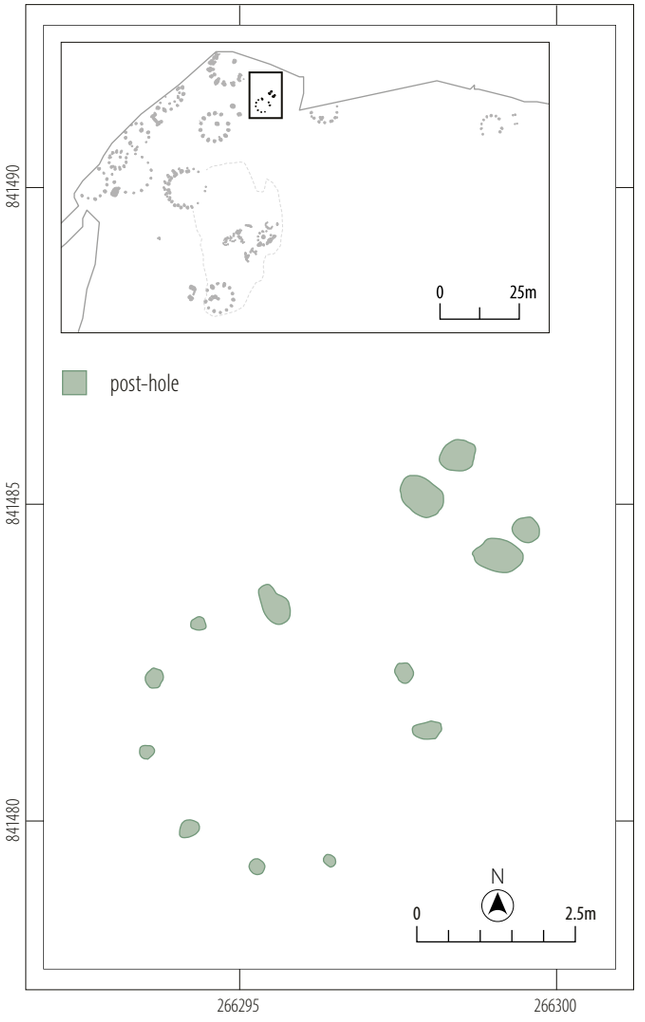


Illustration 4.27
Workshop 18

The hearths

Hearth 2434

This hearth survived as five closely spaced edge-set stones set in a C-shape with a flagstone base (Illus. 4.30 and 4.31). Overlying the flags was a compacted layer of charcoal-rich black sandy silt (3035)/(2677)/(3022), interpreted as the remains of the final firing of the hearth. A single AMS date from charcoal retrieved from (2677) returned a date of 170 cal BC–cal AD 20 (SUERC-30386).

Abundant iron, copper alloy and glass waste debris was recovered from these internal deposits, including 1.6kg of iron slag, two small pieces of copper alloy casting waste (SF0433 and SF0445), a fragment of stock metal (SF1246), crucible rim sherds (SF0447 and SF0481; the latter had an adhering copper alloy fragment – Illus. 6.5), body and base sherds, mould fragments including two fragments of a ring mould (SF1125 – Illus. 6.7) and three fragments of red glassworking waste (SF1281, SF1282 and SF1283). Nine iron objects were also recovered. These were: a small V-shaped object (an unsuccessful decorative terminal?) and a possible peg or bolt (SF0434a&b); a U-shaped shaft, possibly part of a chain link, staple or bent nail (SF0435); a small round ball (SF0438); a probable nail (SF0487); a tool blade with toothed tip-blunt teeth (SF1002 – Illus. 6.46); a strip of iron, possibly an offcut (SF1018); and part of a blade (SF1019). Burnt clay was abundant and included one finger-impressed piece (SF0558).

An arc of four post-holes ([2541/2549/2547/2543]) was located on the south side, curving around the flagstones. The post-holes were sub-circular, between 0.25m and 0.45m in diameter and 0.1 to 0.2m deep. Their backfills were remarkably rich in artefactual evidence. They contained crucible sherds (SF1111-5), fragments of a ceramic mould (SF1110), fragments of glass/enamel-working debris (red, blue/yellow, blue and clear), a lump of copper alloy casting waste (SF0535), an iron file (SF0534 – Illus. 6.45), a cast fine rivet (SF1240) and fragments of a flat cast object (SF1241), iron slag and magnetic residue (Illus. 4.34 and 4.36).

To the north and north-west of the hearth was a cobbled surface (1945), which respected the hearth and may have been contemporary with its use. A spread of dark-brown sandy silt (2435) covered the hearth and must have accumulated or been dumped after it went out of use. A pair of fine iron scissor-shears for delicate metalworking (SF0540 – Illus. 6.46), two sherds of a crucible (SF0539) and a piece of copper-alloy waste (SF0490) were recovered from this layer.

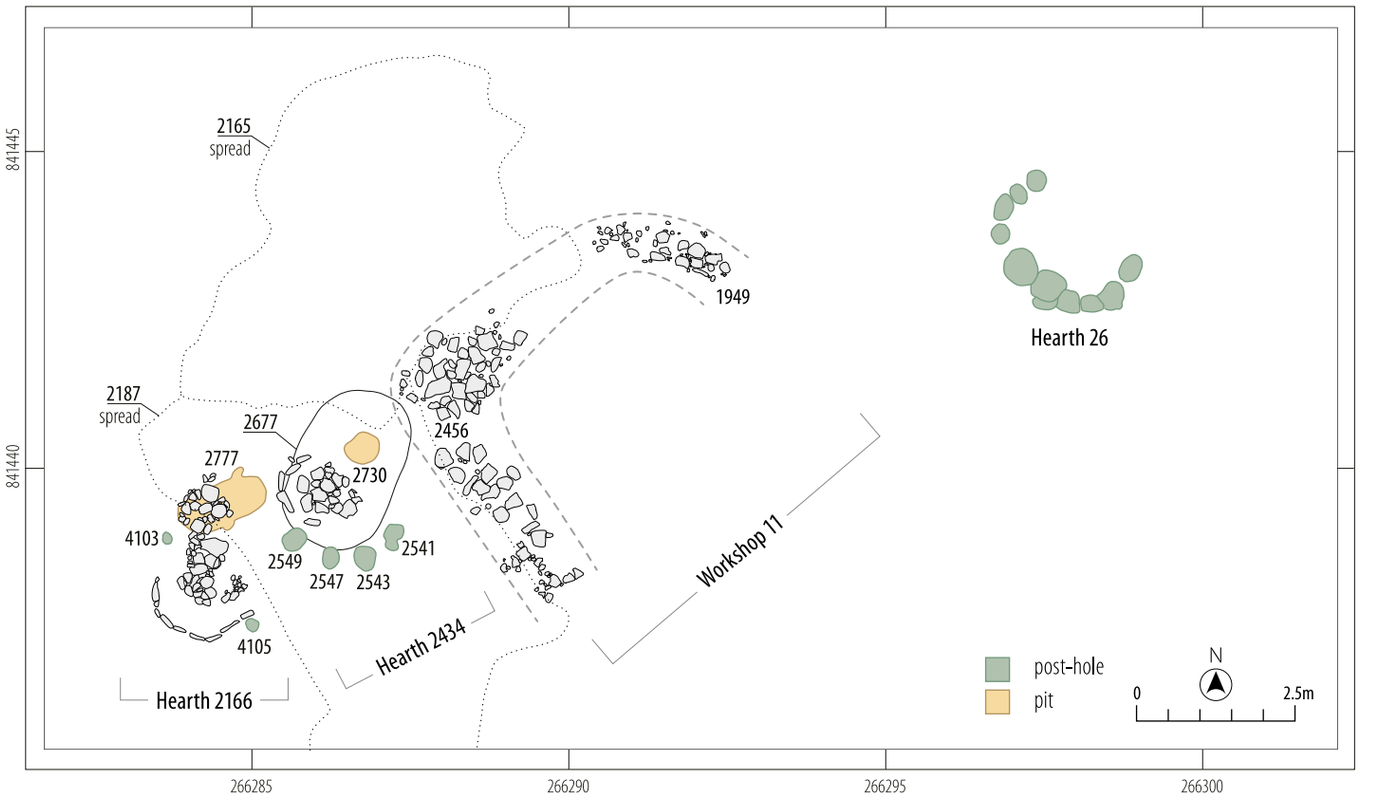


Illustration 4.28
Workshop 11 and Hearths 26, 2434 and 2166

Illustration 4.29
The glass and copper alloy hearths under excavation

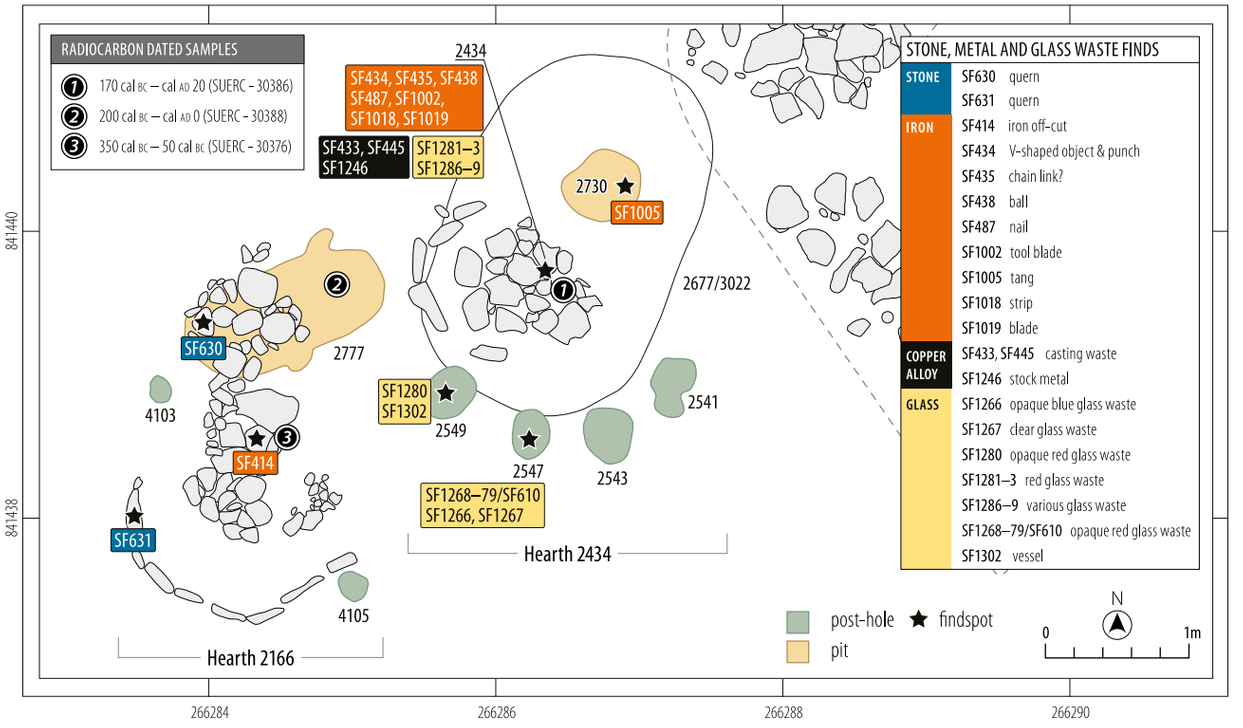


Illustration 4.30
Plan of Hearths 2434 and 2166

Illustration 4.31
Hearth 2434

An oval pit [2730] adjacent to the hearth contained a black charcoal rich sandy fill with frequent fire-cracked stones and an iron tang (SF1005). Small quantities of iron slag and magnetic residue were also present.

Hearth 2166

Situated immediately to the west of hearth [2434] was a similar hearth [2166] (Illus. 4.32). Its edge was defined by eight closely spaced edge-set stones in a C-shape. One of these stones was a fragment of a bun-shaped upper rotary quern stone with a decorated collar (SF0631). As the quern fragment was not heat damaged and had no adhered slag, it probably functioned as an edging stone rather than as a support for a tuyère or bellows as seen in several of the iron-smelting furnaces. The interior of the hearth was covered in heat-fractured flagstones surrounded by cobbling. Finds recovered from its interior include an iron offcut (SF0414), a crucible rim and body sherd (SF0415) and another fragment of a bun-shaped upper rotary quern (SF0630). Two adjacent post-holes (4103 and 4105) may have been associated with the superstructure of the hearth, and a cobbled surface (1945) located along its northern side respected the flagstone.

A single AMS date retrieved from charcoal overlying the flagstones returned a date of 350–50 cal BC (SUERC-30376). It is clear from the excavator's records that this material was not considered to be the final firing of the hearth. A single AMS date retrieved from charcoal within an oval pit [2777] partially underlying the hearth yielded a date of 200 cal BC–cal AD 1 (SUERC-30388), providing a *terminus post quem* for the construction of the hearth. The pit contained sherds from crucibles (SF1127–9).

Hearth 26

This structure consisted of 10 closely spaced post-holes forming a U-shaped structure *c.*2m wide (Illus. 4.28). Most of the post-hole fills contained metalworking debris in the form of iron slag and burnt clay. One contained a crucible sherd (SF0656) and a fine iron nail (SF0629); another contained a small piece of copper alloy slag. These post-holes may have been the settings for stones like C-shaped constructions seen in hearths [2166] and [2434].

A circular pit [3564] 1.5m to the north-west may be related to the hearth. The pit had a diameter of *c.*0.7m, was vertical sided and was 0.57m deep. Both the upper and lower fills of this feature contained approximately 1kg of iron slag. A spread of dark-brown charcoal-rich silt (2102) to the north of the pit contained multiple crucible fragments and iron objects, including the tip of a fine knife blade (SF0340), and may again represent a dump of material from the firing of the hearth or furnaces close by.

Workshop 11

Situated to the east of hearths [2166] and [2434] was the fragmented stone base of an irregular U-shaped structure (Illus. 4.28 and 4.33). Two curvilinear arrangements of flat stones formed the remaining foundations for a probable turf wall. A 2m long and 0.6m wide structure (1949) formed the north-east corner of the structure. This wall base had three large pieces (up to 4kg) of iron slag/furnace base incorporated into the stones. To the south-west a curving length of flat stones (2456) formed part of the north and

Illustration 4.32
Hearth 2166

west walls of the structure. The flat stones here formed a base up to 1.48m wide. Two joining pieces of a stone basin (SF0505 and SF0506 – Illus. 6.15) and two fragments of upper rotary querns (SF0507 and SF0508) had been incorporated into this surface and an iron tool (SF0509 – Illus. 6.45) was recovered from within the stones. A thick layer of compacted light-yellow sandy silt (2477) overlying the stones here was interpreted as collapsed turves. Several post-holes were identified within the interior of the structure, one [3829] containing a fragment of mould (SF0712).

The walls had been built onto a compacted sandy layer (2471) that contained charcoal, burnt clay and slag, a blue barrel shaped bead (SF1261 – Illus. 4.36 & 6.67) and moulds fragments (SF1108-9 – Illus. 6.7). Several layers contained within the interior space formed by the wall bases were interpreted as deposits associated with the use of the structure. These included a spread of compacted black silt (1952), which contained large quantities of burnt clay, iron slag (over 10kg), a crucible rim sherd (SF1101-2) and a rotary quern that had been reused as an ingot mould (SF0339) for copper alloy metalworking (Illus. 4.34, 4.35 and 6.17). The mould was two-sided, with a dish and bar mould on one side and a vase-shaped mould carved around the central feeder pipe on the smoother 'grinding' face. In the north corner of the interior, another very similar deposit (2191) also appeared to be waste debris and contained frequent fire-cracked stones and iron slag.

To the north-west of the building was a cobbled surface (1945), which respected the outer edge of the north wall of the structure. A deposit rich in charcoal and industrial debris (2100) overlaid this cobbling and Workshop 11. This spread measured 6.2m × 2.3m and varied in depth from 0.1m to 0.2m. The remains of three industrial processes were present here: 18 crucible fragments indicative of non-ferrous metalworking/glassworking; a small piece of red glassy material (SF0355), which was waste from enamelling or glass making; and large lumps of iron slag (totalling 6.5kg) from ferrous metalworking. Eight iron objects were also recovered from (2100) including a possible graver (SF0372 – Illus. 6.44), a toothed leather decorating tool (SF0371 – Illus. 6.44), a fragment of a fine bent bar (SF0379), a fragment of a U-shaped square-sectioned bar (SF0409) and an iron nail (SF0407). A single AMS date from charcoal

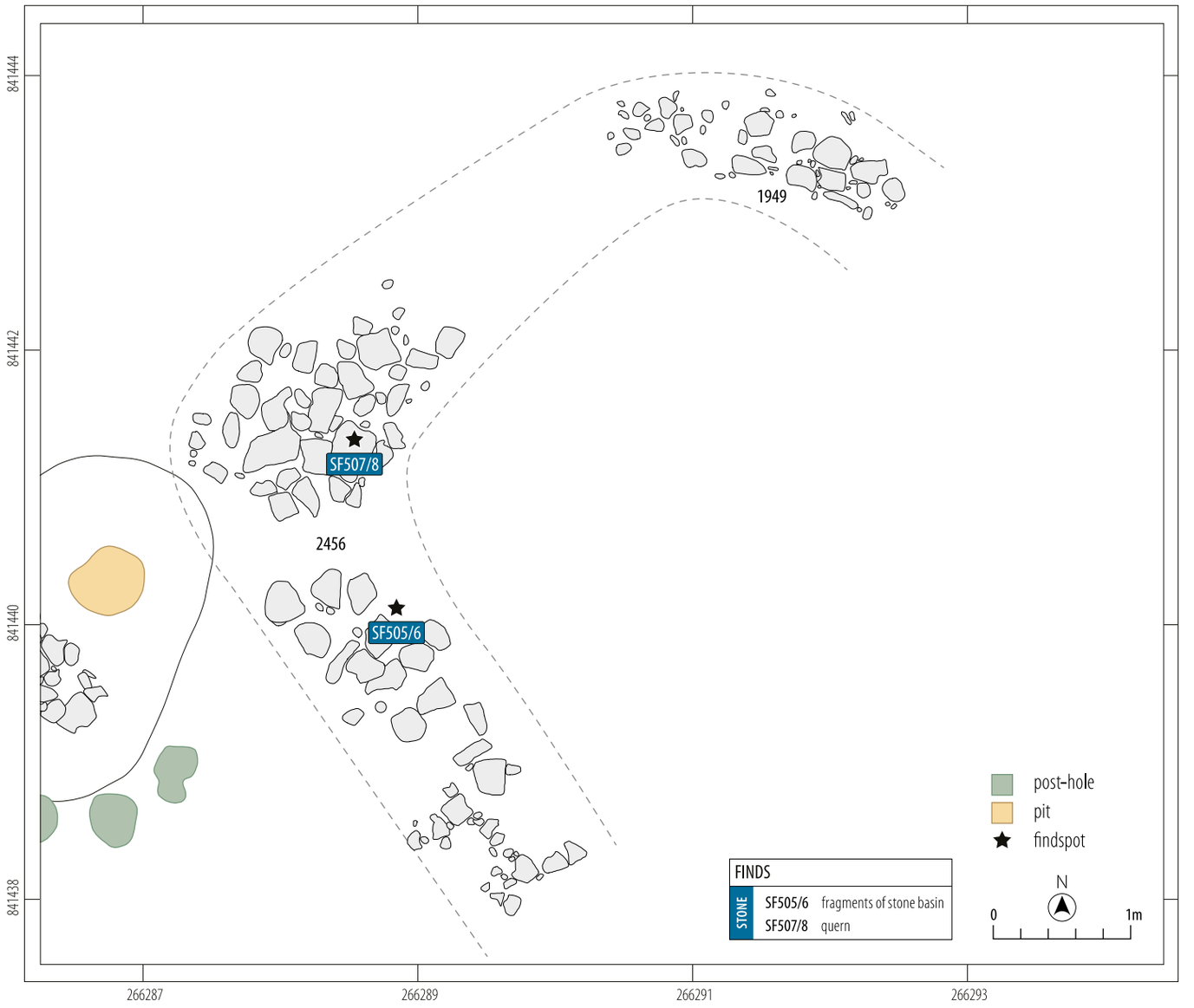


Illustration 4.33
Plan of Workshop 11 showing the location of stone basin and rotary quern

retrieved from (2100) returned a date of 90 cal BC–cal AD 90 (SUERC-30371).

Overlying Workshop 11, the three hearths [2166], [2434] and [26], the cobbled surface (1945) and layer (2100) was a series of spreads of dark-brown silts, which contained frequent slag, fire-cracked stones, burnt bone, teeth and burnt clay inclusions (1896, 2165, 2187 and 2186) (Illus. 4.34 and 4.36). Fragments of crucibles, moulds, fire-cracked stones, and smelting and smithing slag, including a smithing hearth bottom, were also recovered from these spreads, which may represent dumps of material from the firings of the hearths and furnaces in the vicinity.

A further dump of material that included iron slag (including a furnace bottom, smelting and smithing slag) was identified in an oval pit [2143] located to the south of the hearths. The pit was lined with heat-fractured pebbles and may have originally been a forge or furnace.

Environmental summary for Period 3a

Scott Timpany, Sarah-Jane Haston and Abby Mynett

Pit 1863

Four samples were analysed from pit [1863], located overlying the post-ring of House 9. Three samples (593, 594, 601) came from backfills of the pit (1862, 1864, 1865) and one sample (607)

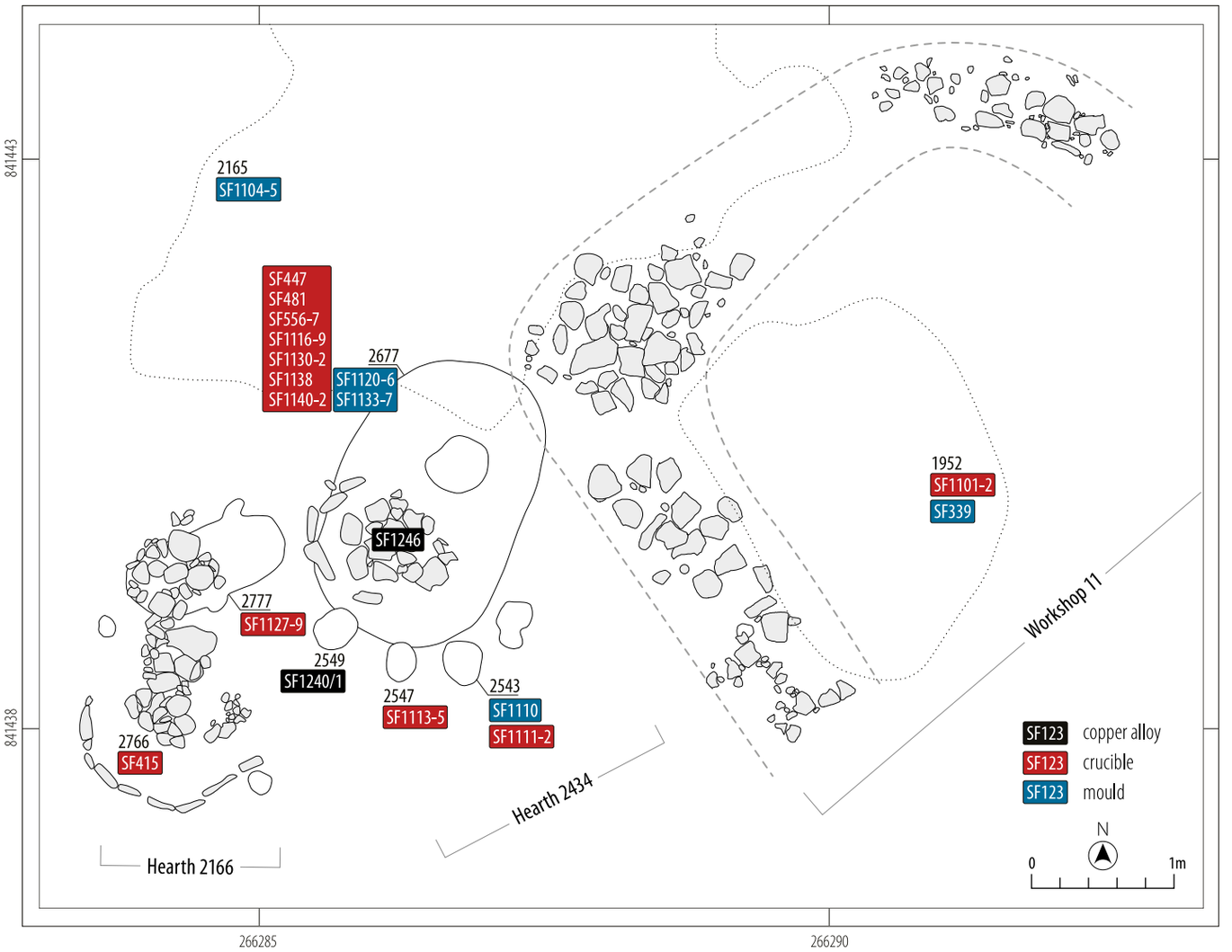


Illustration 4.34
Distribution of CU objects, crucibles and moulds

Illustration 4.35
Ingot mould SF0339 in situ

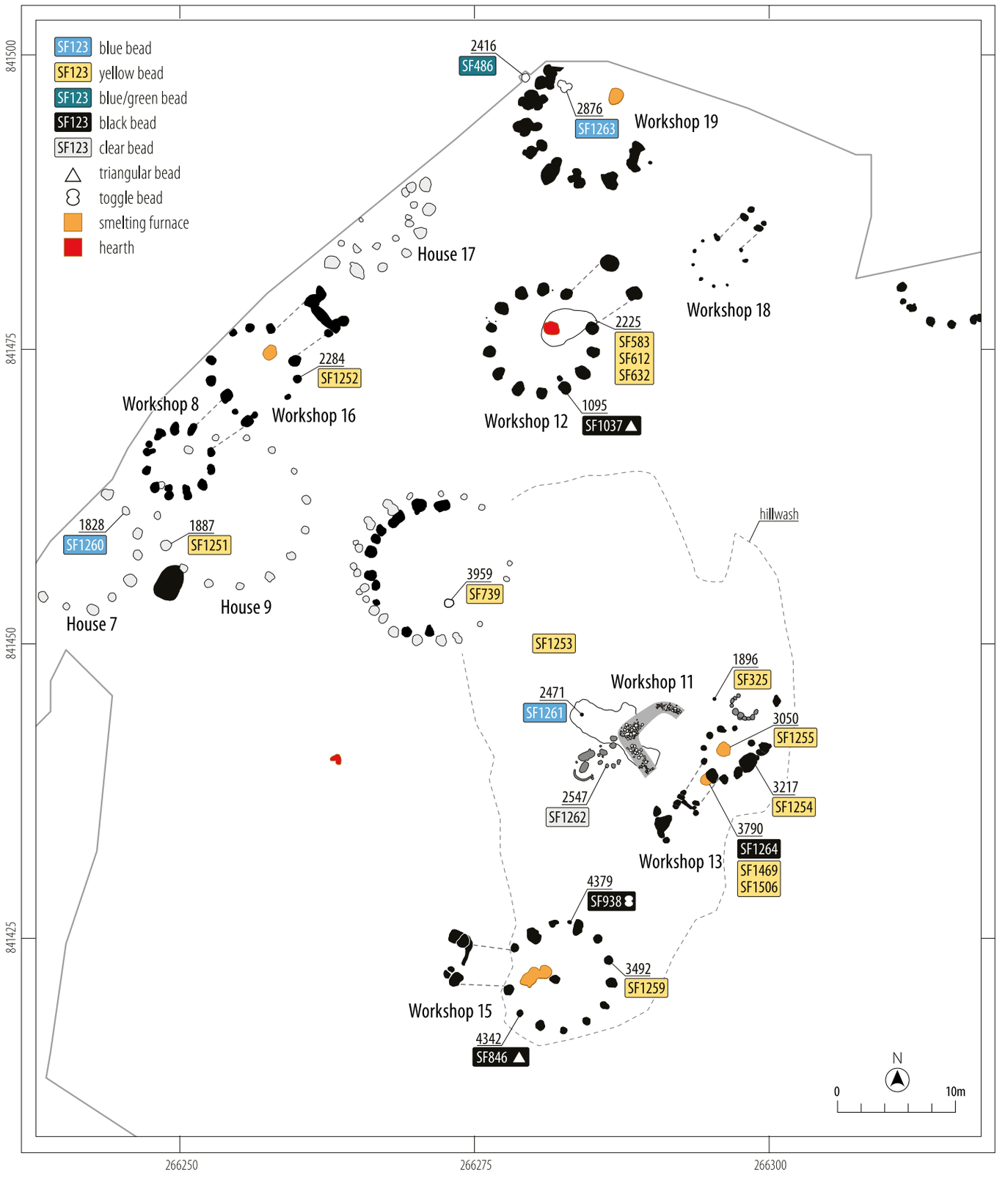


Illustration 4.36
Distribution of glass beads

from the burnt clay lining (1884). The clay lining of the pit contained a mixed charred grain assemblage, mostly consisting of hulled barley, thought to represent 6-row hulled barley, together with oat, with poor preservation meaning most of the oat grains can only be identified as probable oat (cf. *Avena* sp.). A small number of wheat grains with wheat sp. (*Triticum* sp.), probable spelt wheat (cf. *Triticum spelta*) and probable club/bread wheat were also represented. The wild taxa assemblage contained mainly arable and grassland plant such as grasses, goosefoots, corn spurry, sheep's sorrel (*Rumex acetosella*) and hemp nettles (*Galeopsis* sp.).

The backfills (1862 and 1864) of pit [1863] contained moderate quantities of cereal grain primarily consisting of hulled barley grains, and again it is suggested that this represents the cultivation of a hulled 6-row barley. Single grains of probable naked barley and emmer wheat were also present, which may represent a relict crop from the Neolithic now present as an arable weed, as too might the single grain of probable club/bread wheat in fill (1862). Small numbers of oat and probable oat were present, while there is a rare presence of probable rye (cf. *Secale Cereale*) within fill (1864). The wild taxa assemblage consisted mainly of arable and grassland taxa, including goosefoots, ribwort plantain (*Plantago lanceolata*), common hemp-nettle (*Galeopsis tetrahit*), grasses and buttercups (*Ranunculus* sp.).

Backfill (1865) contained an abundant and diverse grain assemblage, particularly in relation to the other pit fills, with 108 grains recovered per litre compared to 10–29 grains per litre in the other pit fills. Similar to the other contexts, the majority of grain present was hulled barley and it is again suggested that this represents the cultivation of a 6-row hulled barley variety. Within this sample were a number of broken barley embryo fragments, which suggests that a proportion of grain had sprouted. Growth of embryos is also associated with the malting of grain as part of the brewing process and may provide some tentative evidence for this activity at Culduthel.

A significant number of oat grains (175) were present in this assemblage, with palaea/lemma fragments recovered, together with a single glume base of common oat (*Avena sativa*), indicating this was the type of oat that was being cultivated. Significant numbers of wheat grains were also recovered from this fill, including grains of wheat sp., bread/club wheat, emmer wheat and spelt wheat (*Triticum spelta*). The numbers of wheat grain recovered are suggestive of some, perhaps limited, cultivation of different wheat types. Rye grain was also recovered from this fill and marks this as the only feature analysed at Culduthel to contain this cultivar. Large numbers of wild taxa were also present within this assemblage and, similar to the other fills, consisted largely of arable and grassland taxa, in particular grasses, goosefoots, docks (*Rumex* sp.), sheep sorrel, corn spurry and bristly oxtongue (*Helminthotheca echiodes*). A small number of damp/wet ground taxa were also recorded, such as sedges (*Carex* sp.), probable butterbur (cf. *Petasites hybridus*) and probable floating sweet-grass (cf. *Glyceria fluitans*). There is also some tentative evidence for the collection and consumption of wild foodstuffs, with the presence of a single probable crab apple pip (cf. *Malus sylvestris*) and a single probable wild strawberry fruit (cf. *Fragaria vesca*).

House 10/1

Charred grain from one of the post-holes (the postpipe (3144) in post-hole [3143]) produced a characteristic Iron Age grain assemblage of hulled barley grains. The number of 6-row hulled barley grains outnumbered the number of 2-row hulled barley grains at a ratio of approximately 3:1, indicating that it was the 6-row variety that was being cultivated. A significant number of indeterminate grains were present. The wild taxa assemblage was three goosefoot seeds, which, due to poor preservation, could not be identified to species level and are suggested to represent arable weeds.

House 10/2

Charred cereal grain from the fill (3616) of post-hole [3615] contained a small and varied grain assemblage. Hulled barley was the main cultivar present with both 2-row and 6-row grains identified, suggesting that 6-row barley was the main cultivated barley type. Along with the hulled barley there is evidence for the cultivation of oats, with both oat and possible oat recovered, and potentially spelt wheat, with spelt and probable spelt wheat both recovered. Together with the grain, a variety of wild taxa were identified, largely of arable weeds such as redshank, probable creeping buttercup (cf. *Ranunculus repens*), goosefoots, corn spurry and sheep's sorrel, together with grasses. Damp ground indicators such as sedges and pale persicaria suggest drainage may have been an issue in fields with areas prone to pooling of water. The presence of a small quantity of charred hazel nutshell fragments also suggests the continued collection of wild foodstuffs to supplement the diet.

Workshop 13

Samples were analysed from two pits ([3217] and [3811]) and a possible furnace [4179]. A small number of hulled barley grains were recovered from pit [3811], representing the cultivation of a 6-row variety. A limited assemblage of arable weeds of buttercup sp., grasses and fat hen were also recovered. Hazel charcoal from the fill of pit (3811) produced a radiocarbon date of 170 cal BC–cal AD 60 (SUERC-30398).

Pit [3217] contained a greater variety of grain. The majority was hulled barley, and probably reflects the cultivation of a 6-row variety. A small number of naked barley grains were also recovered, identifiable as 2-row naked barley, which may represent a relict crop now present as an arable weed. The recovery of grains of oat and probable oat suggest oats were being cultivated as a possible second crop to barley. Wheat was also represented by a small amount of emmer wheat grains, which again may also be part of a relict crop, together with a small amount of spelt wheat grain. The wild taxa assemblage was similar to pit [3811] and consisted mainly of arable and grassland taxa including goosefoot sp., hedge bedstraw (*Galium album*), black bindweed (*Fallopia Convolvulus*), redshank, docks and common chickweed (*Stellaria media*). There is also evidence for foraging and consumption of wild foodstuffs with the recovery of a significant amount (>100) of charred hazel nutshell fragments.

Five samples (1469, 1539, 1544, 1661 and 1666) from the fill (3467) of a possible former furnace [4179] were analysed. As this furnace was heavily cut into by the overlying furnace [3790] these samples may have been contaminated by this feature The samples

contained hazel nutshell fragments (in particular from samples (1469) and (1539), which both contained >100 nutshell fragments), a blackthorn fruit stone and a small assemblage of charred cereals consisting of hulled barley, likely 6-row hulled barley and oats, together with a single emmer wheat grain. Small numbers of arable weeds and wayside plants were also present such as fat hen, grasses, nipplewort (*Lapsana communis*) and common chickweed.

Workshop 15

Sparse amounts of charred cereal grain consisting of hulled barley, including one grain of 6-row hulled barley and grains of oat and probable oat, were recovered. Both samples contained a higher percentage of wild taxa to cultivated grain at 82–84% wild taxa. Goosefoot sp. seeds were present in the largest numbers, together with corn spurry and common chickweed. Other wild taxa present included possible woodland margin plant, nipplewort and damp ground plants in possible club-rush (cf. *Eleocharis* sp.). Hulled barley from the fill of [3494] returned a date of 50 cal BC–cal AD 130 (SUERC-30395)

Material was also analysed from the fill (4121) of Furnace [4147]. Sample (1609) contained slightly more cultivated plant remains (56%) to wild taxa (44%). Barley was again the main cultivar with hulled barley recovered in the largest volume (although small number), with a single 2-row hulled barley grain and two 6-row hulled barley grains also retrieved. Naked barley was also represented in the assemblage from the furnaces, with probable naked barley and 2-row naked barley grains recorded. A single barley type grain (*Hordeum* sp.) was also present. The only other cultivar recorded in this assemblage was a single oat grain. A small number of wild taxa were present in the assemblage, which largely consisted of arable weeds such as mustards, redshank, goosefoot sp. & common chickweed. Possible wild foodstuff remnants of hazel nutshell fragments and crab apple pips were also present, similar to that seen in Workshop 13.

Discussion

Candy Hatherley with David Dungworth, Fraser Hunter, Dawn McLaren and Gillian Paget

A craftworking centre

The Period 3a settlement comprised a group of 10 'workshop' roundhouses, many with distinctive porched entrances, and four post-ring roundhouses. The majority of the workshops were for the smelting of iron and other processes associated with the manufacture of iron objects. Five contained stone smelting furnaces (Workshops 2, 13, 15, 16 and 19), each of which was in use at some point between the 2nd century BC and the early 2nd century AD. A further two workshops (Workshops 6 and 12) had evidence that smelting or other iron manufacturing processes were taking place within their interiors. Three workshops had no direct evidence of ironworking (Workshops 8, 18 and 22). Two (Workshops 8 and 18) were small buildings in the corpus of workshops identified on site and may have functioned as storerooms or shelter for other processes associated with the ironworking. Alternatively, these buildings may have been dedicated to the production of other 'clean' crafts, such as leather, wood or textiles. The four post-ring roundhouses (Houses 7, 9, 10 and 17) identified on site could equally have been workshops for organic crafts or non-combustible elements of ironworking. It is also possible that at least a few of these were domestic dwellings that predated the establishment of the craftworking settlement.

To the south of the main cluster of buildings, two stone-lined hearths and a turf-walled workshop were engaged in the production of glass and copper alloy objects. Only one of the hearths appears to have been used as a glass furnace and the date of the final firing of the hearth indicates it was undertaken at some point between the 2nd century BC and the early 1st century AD. Both hearths and the workshop were also engaged in ferrous and non-ferrous metalworking, and glass, bronze and iron objects may well have been made in tandem in this area.

The layout of the settlement suggests a closely packed but well organised group of workshops evenly spaced out across the terrace in a broad north-east/south-west orientation. Clear routeways between the workshops and open areas around each entrance can be recognised, presumably to assist the movement and stockpile of raw materials for iron-smelting (the charcoal and iron ore) to the workshop doors.

It is not clear if the workshops were constructed contemporaneously or if the craftworking site developed over time. Only on the north-west side of site, crowded with roundhouses and workshops, can the progressive development of the buildings be recognised. The archaeological record does indicate, however, that both the buildings and furnaces had complex histories. The multiple rebuilds of several of the furnaces show that these structures required a high level of maintenance and could have undergone periods of intense iron production. Similarly, the workshops were maintained over time and one was extensively remodelled. The rebuilding of House 10 may signify something distinct, perhaps that this was an important building or location in the settlement for the community and its continued presence was required.

Iron production at Culduthel

The exceptional preservation of seven iron smelting furnaces along with the large assemblages of iron objects and waste materials recovered from site demonstrate that the craftworking settlement at Culduthel was a highly organised enterprise that specialised in producing iron and high-quality natural steel. This evidence has illuminated many aspects of the cycle of iron manufacture undertaken on site, from the initial smelting of the ore to the finishing of objects. The iron objects show the activities the community was undertaking, the tools indicate that a wide range of crafts was practised, building materials were being manufactured and weapons were being made and repaired. Some finds, such as the chariot linchpin, daggers and spearhead, are rare finds for Iron Age Scotland and suggest that the community was of some status.

Resources

Iron ore and charcoal are the main resources required for the manufacture of iron. Although the evidence for the smelting of ore to extract metallic iron dominates the archaeological record at Culduthel, no ore was recovered from the tens of kilos of waste

material collected across the site. Analysis of the waste and the objects recovered from the site has shown that the majority of the ore came from local sources and only a small percentage was imported.

Bog ore was widely available throughout the wetlands of Europe in the Iron Age (Tylecote 1986, 125; Pleiner 2000, 88) and was almost certainly used at Culduthel. Peat moorland is a familiar feature throughout the highlands of Scotland, and Drummossie Muir (an area of now drained blanket bog previously located a few miles to the south-east of Culduthel) is a good candidate for the main source of ore for the settlement (Ordnance Survey 1874, Sheet XII). As early medieval iron manufacture has also been identified close by (at Headland Phases 7 and 8) this may have been a continued source of good quality accessible ore.

A considerable amount of charcoal would have been required to fuel the furnaces and hearths. Pleiner (2000, 118) calculates that 8–10 units by weight of charcoal would be the minimum required to produce 1 unit by weight of iron, and this may have increased to 15 units for natural steel. The charcoal was most likely produced in managed or semi-managed woodland surrounding the site (Wheeler 2007). The initial identification of the wood species from the final firings of the furnaces indicated a mixed resource, with alder, hazel, oak and wild cherry were all used.

Production

The primary process to prepare iron ore for smelting is to roast it in a fire to remove unwanted material and break it into manageable lumps (Historic England 2011). This process was absent from the archaeological record at Culduthel but, practically, must have taken place reasonably close to the site. The lack of ore across the site and the lack of any evidence of its primary processing suggests that this work was separate, and production was highly organised on site with dedicated areas for specific tasks and a clear flow of processes through the site.

The main iron production processes identified at Culduthel were smelting and smithing. Each of the iron-smelting furnaces was remarkably consistent in form and appears to have been built following an established design. Each was built into a sub-circular or sub-rectangular pit with the edges of the pit lined with a horseshoe arrangement of water-worn boulders or slabs bonded with clay. Built onto this stone base would have been a thick clay-walled superstructure. This clay chimney would have been constructed by moulding wet clay around a roundwood withy frame and the stone base. Evidence for the clay superstructure, in the form of furnace walls and rims, were identified as fired clay fragments found within the interior of the furnace and adhering to the upper side of the stones with preserved wattle impressions. The rim fragments are a significant find, unparalleled within a Scottish Iron Age context, and confirm 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. Due to the fragmentary nature of the fired clay it was not possible to determine the diameter of the shaft top or its height, but it is not unreasonable to suggest that may have been up to 1m in height (Pleiner 2000, 175). A possible reconstruction of one of the shaft-furnaces is shown in Illus. 4.37.

The smelting furnaces were all free-standing non-tapped furnaces that produced bloomery iron, an identification made through the types and quantities of slag recovered. To produce iron within a non-tapped smelting furnace, a fire is first started in the base of the furnace (the slag pit) with the ore and charcoal placed into the shaft above. The ore and charcoal would be heated together, and slag would gradually form in the pit. To reach the temperature required for smelting (*c.*1200°C), bellows would be used to blow air into the furnace, with the colour of the flame indicating when conditions suitable for reduction were reached, a process that would have taken hours (Historic England 2011, 3–4 and fig. 4; Pleiner 2000).

The ceramic tubes (tuyères) used to protect the bellows or to direct air into the interior of the furnaces were found in abundance on site. Three types of tuyère were identified, each presumably designed to be used in slightly differently structures. Some were very thick and heavily vitrified, suggesting that they were built into the clay shaft of the furnace. One furnace within Workshop 16 had a fragment of rotary quern where the central perforation had been reused as a support for a tuyère. The iron, leather and wood tools needed to construct a set of bellows are all present within the artefact assemblage.

Once cooled, the spongy metallic iron slag (the bloom) could be removed from the base of the furnace. The temporary wall seen in the stone lining of many of the furnaces at Culduthel was to allow access to remove the bloom. Within the furnaces was the last firing, which contained up to 10 kg of slag. The analysis of these bloom fragments show that the smelting process produced carbon steel in a single process, as opposed to producing plain iron, which would have been subject to further processing to produce steel or steeled edges; this direct steel is often known as natural steel. One significant discovery of the analysis of the waste

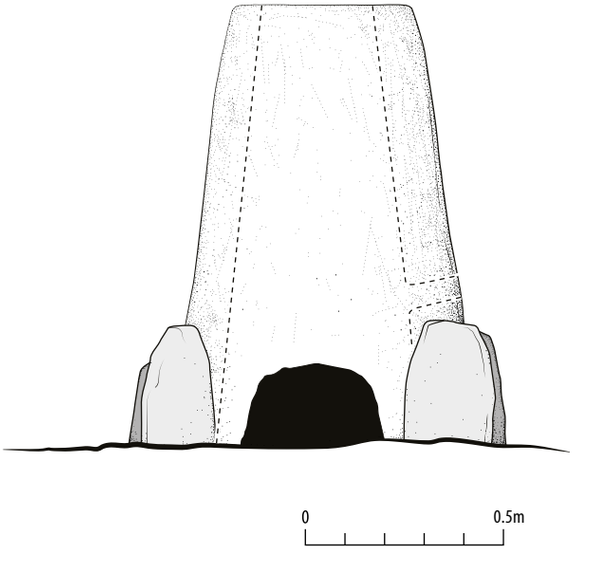


Illustration 4.37
Reconstruction of iron smelting furnace

material was that flakes and globules, first thought to be a type of hammerscale, had formed during smelting by flakes of metal forming between layers of fuel and ore, and by the globules of iron burning in the furnace.

Once completed, the iron bloom would first require further consolidation through primary smithing to remove impurities prior to the final process of shaping the iron to form bars, billets or objects. Evidence for smithing on pre-industrial sites is often found alongside the smelting furnaces due to this need to forge the bloom prior to any further working. From the waste material and iron objects recovered on site, both the initial forging of the bloom and the shaping of the iron were taking place. This waste material included pieces of 'smithing pan', processed bloom and plano-convex cakes of slag that form in the bottom of the hearth. Compacted fragments of floor surface, presumably close by the smithing hearths, contained hammerscale, charcoal and tiny slag fragments.

The iron objects produced on site demonstrate some of the processes used in the hot working of iron. The iron tools included sets that would have been used to cut up pieces of bloom and worked billets of iron. Bloom would be worked into a series of bars or billets of iron, which could then be further worked to make a product. The waste generated by these processes would include offcuts from the bloom and billets, hammerscale and hearth residues. Out of a total of over 470g of iron offcuts, the bulk came from the ends of various forms of bars.

Iron objects were also being recycled on site and several reused items are recognisable: fragments cut from a joiner's dog, a knife, and a bolt. Some pieces graphically illustrate the practicalities of recycling, with the ends heated up and twisted with the tongs to give them a good grip while the iron was cut. There was also ornamental ironworking being made, with a fine decorative branched terminal recovered that had been broken and abandoned during manufacture.

As well as recycling it appears that some objects were on site to be repaired or overhauled by the blacksmiths; Hunter (Chapter 6, Iron Artefacts) suggests that the copper alloy hilt guard was part of a sword that had been dismantled for repair, work that could be undertaken by a worker of metal. Other items showed signs of on-site repair, including a pair of iron snips and a bolt head.

Smithing hearths or forges are not easy to identify on archaeological sites as they do not require specifically built structures and can be simple pits which, during excavation, look like domestic hearths (Hodges 1989, 84). The evidence presented on site suggests that the main bank of smithies may have been located at some distance from the smelting of iron and outside of the excavation area. The only smithing hearth identified on site was a simple clay-lined bowl-shaped pit to the south of House 10. The hearth was a shallow oval pit that was bounded along its upper lip by a 'wall' of clay, presumably placed to support the bellows and protect the smith from the intense heat. This clay lip (or a series of lips) had fallen into the pit, sealing the final firing of the hearth. Concentrations of smithing waste was also identified around the area of the glass and copper alloy hearths and workshop (Workshop 11) and to the south in Workshops 13 and 15. Workshop 13 is a good candidate for the location of a smithy. Here a possible anvil stone set into a stone-lined pit was machined out during the topsoil strip and two blacksmith's sets (SF0352 and SF1001 – chisels with shafts or handles used to cut hot and cold metals) were recovered, one from the waste layer overlying the building and one close by. Alongside these tools were a collection of offcuts and unfinished items, which give a vivid picture of the blacksmithing processes potentially underway in this area.

The scale and duration of production

As the radiocarbon dating programme has only been able to identify a broad period of iron production between the 2nd century BC and the early 2nd century AD it is difficult to gain a better understanding of the potential scale of iron production at Culduthel without knowing whether this was a short-lived or long-term enterprise and when it started and finished. Iron artefacts do little to help to refine this chronology but the iron dagger (SF0479) of pre-Roman style and the lack of nails potentially hints that the majority of manufacture could predate Roman contact in Scotland from the later 1st century AD (Hunter, Chapter 6, Iron Artefacts).

Evidence for the scale of production is limited. The dumps of iron waste material are likely to represent only a small percentage of the later periods of production and cannot be used to accurately calculate the scale of production. Pleiner (2000, 172) states that, if maintained, a thick-walled free-standing shaft furnace could have been used intensely for years. The stone bases of the smelting furnaces do show repeated and intensive use and the thin skims of moulded clay recovered from their interiors would have been used to reline and repair the clay superstructures where necessary between smelts. Devitrified (heavily burnt) slag was also identified that could only have developed through multiple firings of the furnaces.

Workshop morphology

The workshops were each defined by a single post-ring that formed the load-bearing post-ring for the building. The roof of each workshop would have extended beyond the post-ring and an outer wall would have been located under the eaves, forming a circle round the house and adjoining the inner or outer ends of the porch. Giving the function of these buildings it is possible that an outer wall was extant or was in the form of moveable wattle screens to aid ventilation and control light when required.

The size of the workshops' post-rings varied considerably, from the smallest, which was only 3.7m in diameter (Workshop 13) up to the largest, at 9m in diameter (Workshop 19) (Table 4.1). This variation in size may have been the individual builder's choice but could reflect the multifunctional nature of the building. If the smelting of iron was a seasonal or periodic industry, these buildings may have been used at times for other craftworking or domestic habitation.

The eight workshops completely exposed in plan all contained porches. These entrances were predominantly located on the north-east side of each building, with only two on different orientations (Workshop 13 Stage 2 and Workshop 15). The porches were all narrow, with most a metre or under in width and one (Workshop 18) less than 0.5m wide. Their posts were consistently more substantial than those of the post-ring and many had multiple posts located at the outer ends, suggesting that doors were in place across the entrance or that posts for the outer wall were attached here. The length of the porches varied from *c.*2

to 5m from the inner post-ring, all considerably longer than the average prehistoric roundhouse porch of *c.*1.6m (Pope 2003, 196).

The north-east orientation of the entrances may have been linked to the time of year, and even the time of day, that iron smelting was underway. As the spring and summer sunrise is to the north-east (from April to September) this orientation would have harnessed the early morning sun, potentially to coincide with setting up for the day of work. Equally, this orientation would have ensured that the sun was not directly coming in during the winter months, being restricted to the SE–SW path during this season. The north-east opening would also have minimised the effects of the prevailing south-westerly wind (the predominant wind direction in northern Scotland). Only one entrance (Workshop 15) was orientated north-west, with one other (Workshop 13) shifting orientation from the north-east to the south-west. As both buildings were clearly engaged in the smelting of iron it is unclear why the entrance orientation was reversed for these buildings. Perhaps these workshops were designed to maximise the afternoon spring/summer sunlight or the winter light. It is also possible that certain other tasks (such as smithing) undertaken within these buildings required different ventilation conditions and the prevailing wind was of use.

Although it is not unequivocal that these buildings were constructed for the sole purpose of metalworking, their recurring design and similar internal layouts suggests they were. The repeated positioning of the furnaces just inside the entrance indicates that they were purposefully placed close to the doorway, presumably to maximise and control the light and ventilation into the interior of the building during smelting (McDonnell 1998b, 160). Being able to control the light is especially important here as the colour of the flames and the bloom were the sole indicators of temperature (a blue flame would show that carbon monoxide was present in excess and the conditions suitable for reduction – Hodges 1989, 88). As the furnaces in use would have been an astonishing sight for the community, especially glimpsed through the long narrow tunnel created by the porch, their placement would also have enhanced the spectacle and enigma of iron production.

Iron products and their distribution

The presence of well-stratified deposits at Culduthel had major implications for the recovery of finds during the excavation and has enhanced the understanding of their deposition. Hunter (Chapter 6 – Iron Artefacts) identifies that 77% of the ironwork came from occupation layers (i.e dumps of waste material or the backfill of ring-ditches), with the remaining 23% coming from features such as furnaces, pits or post-holes. So even on this rich site, barely half of the roundhouses produced iron objects, and only the well-preserved House 10/3 in Period 3b produced more than three finds. With this taphonomy in mind, if Culduthel had consisted only of negative features, less than a quarter of the iron objects would have been recovered. Even in deeper negative features that might have survived plough-truncation (such as the ring-ditch of House 10/3 in Period 3b), the more interesting patterns of deposition were usually identified in the upper fills. Without the protection of the hillwash or the spreads of waste material, these upper fills would have been lost or severely disturbed by the plough.

The working waste debris in Period 3a was mostly found within spreads of material identified across the site, either located within buildings or close by in adjacent open areas. These spreads probably represent the tramping of material during the occupation of the building or working area, or material accumulated immediately after. The spreads contained many artefacts that appeared to have been misplaced or discarded in the course of their use: fixings and fastenings, and small tools.

There are also examples of structured deposition in Period 3a, with several iron weapons deliberately incorporated into post-holes. A short dagger (SF0363 – Illus. 6.46) had been deposited in a post-hole located within the interior of House 7, a feature not definitively associated with the building. The dagger had clearly been well-used and maintained and had been resharpened prior to deposal. A second iron dagger (SF0479 – Illus. 6.46) was found in a post-hole immediately outside of the post-ring of Workshop 19. This dagger had been placed vertically point down into a matrix of stones and sandy silt that had been packed around the post. For the dagger to have survived intact it must have been carefully placed during the construction of the post-hole and the packing material built up, a difficult task to do without damaging the blade. The final weapon deliberately deposited was the head of a small throwing spear (SF1026) that had been placed within a post-hole of the post-ring of Workshop 6. The spearhead was also located within the stone packing, suggesting either deposition during the construction of the post-hole or very careful deposition when the post-hole was in use.

The deposition of high-status objects was also observed within the larger, and more elaborate buildings, in Period 3b (House 4 and House 10/3), which suggests that this was a relatively long-lived cultural tradition for the occupants of the site. These rites are discussed in greater detail in Chapter 7.

Glass and copper alloy production

Glass and copper alloy working debris (including droplets, rods and flakes of glass and crucibles, clay moulds, castings and casting debris) and finished or partially finished objects such as glass beads and decorative metalwork were recovered from a concentrated area to the south-east of House 10 (Illus. 4.34 and 4.36). Their distribution showed that the manufacturing hub for glass and copper alloy objects on site was three hearths ([2166], [2434] and [26]) and a turf-walled U-shaped structure (Workshop 11). The chronology of these industries is not well understood but a single radiocarbon date for the final firing of one of the hearths [2434] shows that this event took place at some point between the 2nd century BC and the early 1st century AD. This date is tentatively supported by the bulk of the copper alloys identified on site, which were a pre-Roman Iron Age leaded bronze recipe and a 2nd–1st century BC copper alloy sword hilt discarded in the nearby cobbled yard, presumably brought to the site for recycling.

Glassworking material (small flakes, droplets or fragments of rods or bars) was restricted to Hearth [2434] and its internal deposits, a distribution which suggest that only Hearth [2434] was used for glassworking. All three hearths contained non-ferrous casting debris including one large failed casting (SF0333 – Illus. 6.57), small fragments of casting waste (mostly droplets or nodules

spilled from moulds) and crucibles and moulds, an assemblage that suggests that they were each used for casting bronze. The distribution of glass beads and copper alloy waste and objects (Illus 4.12, 4.16, 4.34 and 4.36) also suggests that Workshops 13 and 15 (or the areas where they stood) may have been utilised during the manufacture of glass and bronze objects.

The concentrations of glass and copper alloy casting debris across this area proves that the production of glass beads, enamelling and bronze-casting were undertaken in tandem, over the same hearths and within one specialist workshop. As these simple hearths could have been easily adapted to work either material, and enamelling was used to decorate bronze objects, these shared spaces seem both practical and functional. It also seems logical that these specialist workers, their toolkits and the precious raw materials required were kept together in one area of the settlement.

Alongside the glassworking material and the copper alloy casting debris were impressive assemblages of bronze items and glass beads, including an unfinished harness strap mount seemingly awaiting enamel. This evidence for Iron Age working of glass is very rare in Scotland and is exceptional for the UK. The recovered material indicates that the craftspeople had two main products: opaque red glass for inlay for metalwork (enamel) and yellow, blue and clear glass for jewellery, mainly beads. This production appears to be the reworking of imported glass ingots and objects, some at least coming from the Roman world. Glass could have been made at Culduthel and some level of primary production is implied by the assemblage of red glass fragments recovered. Non-ferrous casting has been identified on other Iron Age sites in Scotland (cf. Heald 2005). The Culduthel assemblage is an extraordinary find, however, and one of the largest ever discovered. It represents production of some scale, carried out within a dedicated workshop.

These assemblages and the evidence for glass and bronze-working on site show that Culduthel was a major production centre in the region for high status prestige items including glass jewellery and inlayed bronze objects.

Manufacture and resources

The hearths and workshops

The two stone hearths ([2434] and [2166]) were of similar design, comprising a paved area of flat stones edged on the south and west by a C-shaped area defined by edge-set stones and post-holes. The edge-set stones would have provided support for bellows and the post-holes may have supported timber fencing to protect from the weather. A third hearth (Hearth [26]) also had a close-set group of post-holes creating the C-shaped 'wind-break' along the south-west edge but no paving or pit was extant. All three hearths appear to have been used for bronze casting while only Hearth [2434] was used as a glass furnace.

To fire enamel and glass the temperature of these open fires would have had to reach *c.*800°C, an achievable temperature in a sheltered location with the aid of bellows (Bateson 1981, 87). Although there is no evidence that these hearths were located within a formal structure, it is assumed that they were protected from the elements by windbreaks of some form during firings. It is unclear if the U-shaped turf-walled workshop was roofed but even as an open structure it could have provided a level of shelter from the elements for various tasks associated with manufacture, such as the shaping and working of the glass, the inlaying of the metalwork and pouring molten bronze into moulds.

Glass

Glass arrived on site as recycled objects or imported ingots or bars. The glassworkers melted these items and shaped the molten glass into various forms. The paved hearths would have been ideal for this task. Most of the beads recovered from the site (the Guido 8 and 13 and the blue beads) were made at Culduthel and presumably within Hearth [2434]. Some single beads (the blue, black and green beads and the blue and white spiral bead) are characteristically Roman in composition and style and were imported.

There is no evidence that glass was coloured on site but imported rods or canes of different colours could easily have been combined here and cables or trails added using fine strands created from the primary canes. One high-quality opaque blue and white cable or trail intended for inlay in beads was probably Roman, identifying that specialist pre-formed components from the Roman world were also imported.

To create a glass bead, the glass ingots or objects would first have been melted over a fire within a crucible and poured to create short rods or canes. The rods would then be heated to 'plastic' over a flame on an iron rod (a mandrel), which also formed the central perforation. Once the glass was plastic it was shaped into beads through various methods (i.e. cut to shape, wound around the iron rod, twisted with other canes). Evidence of this manufacturing technique was seen on the beads, several of which had the fragile iron scale still in place from being worked on a mandrel. An unidentified iron tool recovered from Workshop 11 (SF0509 – Illus. 6.45) could have been used to roll heated glass beads.

For enamelling, the ingots of ready-made imported opaque red glass would first have been ground into a powder or paste with a mortar or rubbing stones before being placed into individual cells, like those seen on the unfinished strap mount from the site (SF0318). This careful work would have been done with a spatula or knife before the object was placed into the fire with tongs to melt the glass into place (Bateson 1981, 87). The item would then have been finished off by lightly grinding the surface of the glass-filled cells before polishing.

Copper alloy

The early stages of copper alloy production (the preparation of the ore, smelting and refining) are not evident at Culduthel. Analysis showed that the copper alloys on site were not, as has often been assumed for this period, made of mainly reused Roman material. The bulk were an Iron Age leaded bronze recipe, which indicates that the main period of production was prior to major contact between the settlement and the Roman world. The copper source cannot be pinpointed but analysis of lead coils found on site (presumably imported to make the leaded bronze) indicates a source in the Wanlockhead/Leadhills area in south-west Scotland. Zinc-containing alloys are evident in small quantities, showing that an amount of recycled Roman material was available at times.

The melting of copper alloy to cast could have been undertaken in a crucible over a sheltered fire intensified with bellows. Once the metal is heated within a crucible, and any impurities skimmed off, it can be poured into a mould of stone, clay or metal. The pouring and subsequent cooling would be done within a roofed building to keep the mould dry and clean as it was often prepared with a dressing of soot, ash, flour or animal fat to ensure a good surface for casting (Hodges 1989, 70).

The crucibles were made from local clays and would have been made on site (Chapter 6 – Sahlén). Many have signs of sustained use and evidence for curation, relining and repair. These objects show that the copper alloy workers at Culduthel were highly competent, with considerable technological knowledge. They clearly understood which alloys worked best for casting and which were good for sheetwork. Several very large crucibles suggest that substantial objects were being cast, while unusual forms of crucible indicate a willingness to experiment and try unorthodox forms.

Evidence for what they were manufacturing on site is unfortunately slim as many of the moulds are too fragmentary to identify what objects were cast. Elements of the bronzesmiths' toolkit, used to finish both objects and sheetworking, suggest that fine decorative objects were being made. These include fine snips for trimming pieces (SF0540), files (SF0512 and SF0534 – Illus. 6.45) for removing irregularities, a graver (SF0372) for engraving, a tracer (SF0357) for chasing them, scribers (SF0425 – Illus. 6.45 and SF1013) and punches (SF0366a – Illus. 6.44) for laying out designs.

A fine bar ingot (SF0844), the reused quern mould (a mould for bar ingot SF0339 – Illus. 6.17) and the concentrations of sheetworking debris show that casting to create roughouts for sheetworking was undertaken. The unfinished harness strap junction, and several other items (a toggle and a projected ring-headed pin), along with a failed casting of a possible ring, suggest that the site was creating exceptionally decorative pieces. Their style indicates that they were made by craftsmen with extensive knowledge of different regional and national artistic styles that were influenced from both Britain and the Roman world.