Excavation of a Romano-British ironworking site at Little Furnace Wood, Mayfield, East Sussex

Chris Butler

with contributions by
Jeremy Hodgkinson
Malcolm Lyne
Rowena Gale
Timothy Young
Brian Herbert

Between 2003 and 2007 the Wealden Iron Research Group excavated a Romano-British ironworking site at Little Furnace Wood, near Mayfield, East Sussex. Investigation of a slag heap revealed the remains of two bloomery furnaces, an ore-roasting pit, associated working areas and a slag deposit. The furnaces were terraced into a north-facing slope above a small stream and were partly sealed beneath a later slag dump. Radiocarbon and archaeomagnetic dating indicate that iron smelting took place from the mid- to later 1st century AD, possibly beginning soon after the Roman invasion, and may have continued intermittently into the 2nd or even 3rd century. The modest scale of the slag heap suggests intermittent or small-scale production. The site contributes important evidence for the chronology and organisation of Romano-British iron production in the central Weald.

INTRODUCTION

During a Wealden Iron Research Group (WIRG) foray to Little Furnace Wood, Mayfield, in 2003, a test trench was dug into a slagheap in search of dating evidence. After a little digging, it became apparent that the test trench had encountered the possible *in situ* remains of a furnace.

It was decided to excavate, and the author was asked to direct the work on behalf of WIRG. The excavations continued between 2003 and 2007, with members of WIRG, assisted by members of the Mid Sussex Field Archaeological Team (MSFAT), eventually uncovering the remains of two furnaces, an ore-roasting pit and other features.

Little Furnace Wood is 5.356ha in size and is situated on the north side of Newick Lane, between Heathfield and Mayfield, close to Old Mill Farm (Fig. 1a and b). The wood is currently associated with Old Mill Cottage. Great Furnace Wood lies to the south of Newick Lane.

The site is centred on TQ 59137 24372 (Fig. 2) and is situated on a terrace cut into a steep, north-facing slope above a small stream which runs from east to west through Little Furnace Wood. A further terrace to the south, slightly above the furnaces, carries an east–west trackway which also runs through the wood. The site continues across this terrace and trackway before the ground starts to rise again, with the whole site being situated between 70m and 90m above Ordnance Datum (AOD).

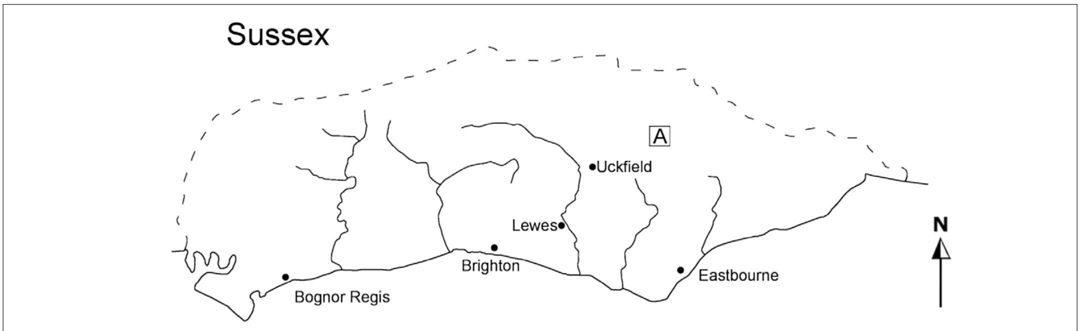

Fig. 1a. The location of Little Furnace Wood in Sussex.

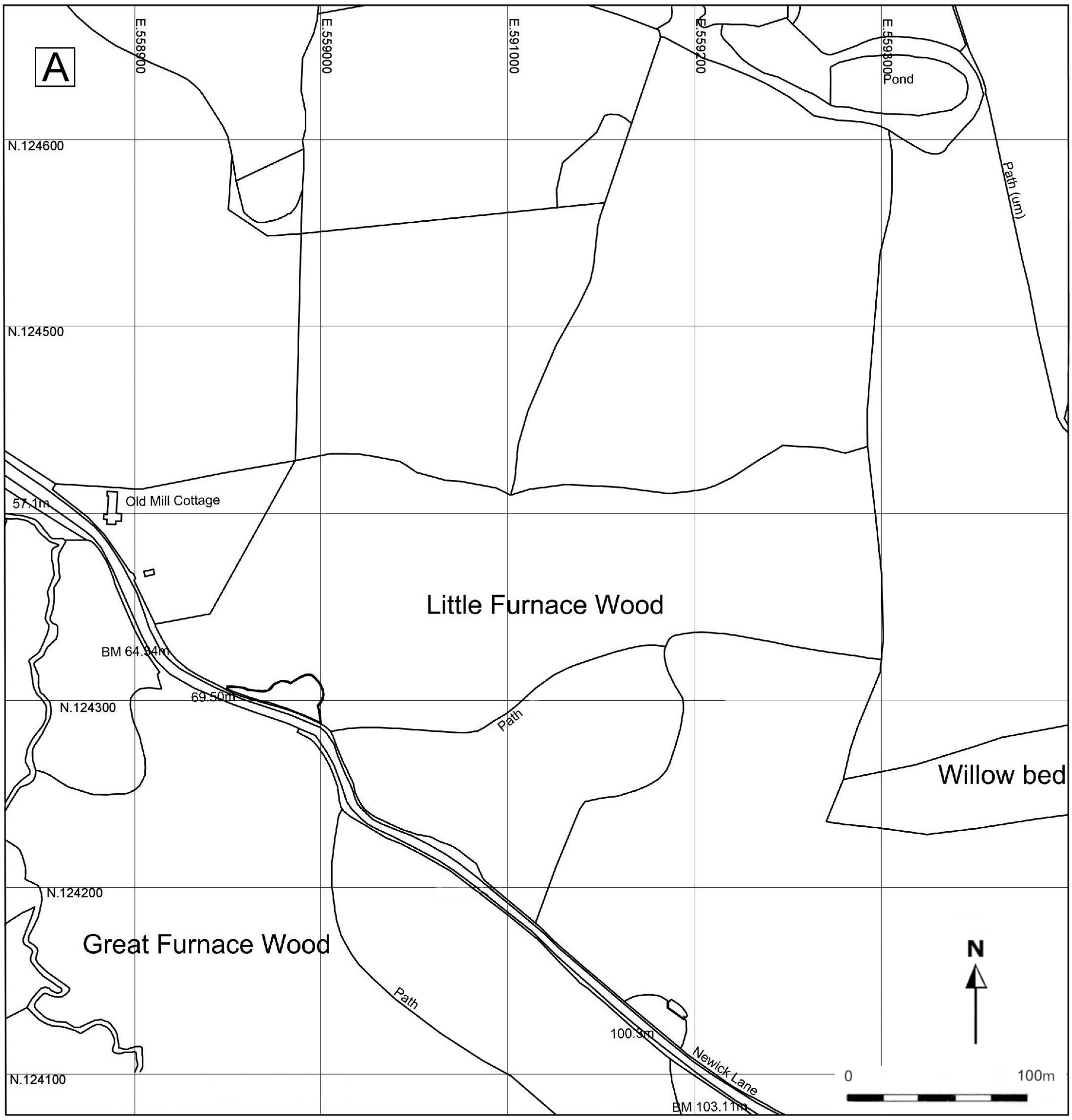

Fig. 1b. The location of Little Furnace Wood.

Due to the wooded nature of the site, a full, open-area excavation was not possible; the investigation, therefore, required excavating a series of test pits and extending any that yielded archaeological features. A magnetometer survey of the site, carried out by David Staveley, identified several potential targets for investigation and a Beat Frequency metal detector, designed by WIRG member Brian Herbert, was also used. The adjacent field was available for fieldwalking, but a transect survey failed to find any Roman artefacts. Other sampling included the excavation of transects of hand-dug test pits, two metres apart, east to west (B1 to B39) and north to south (A0 to A22) across the site, to sample the distribution of both the iron slag and other ironworking residue (Fig. 3).

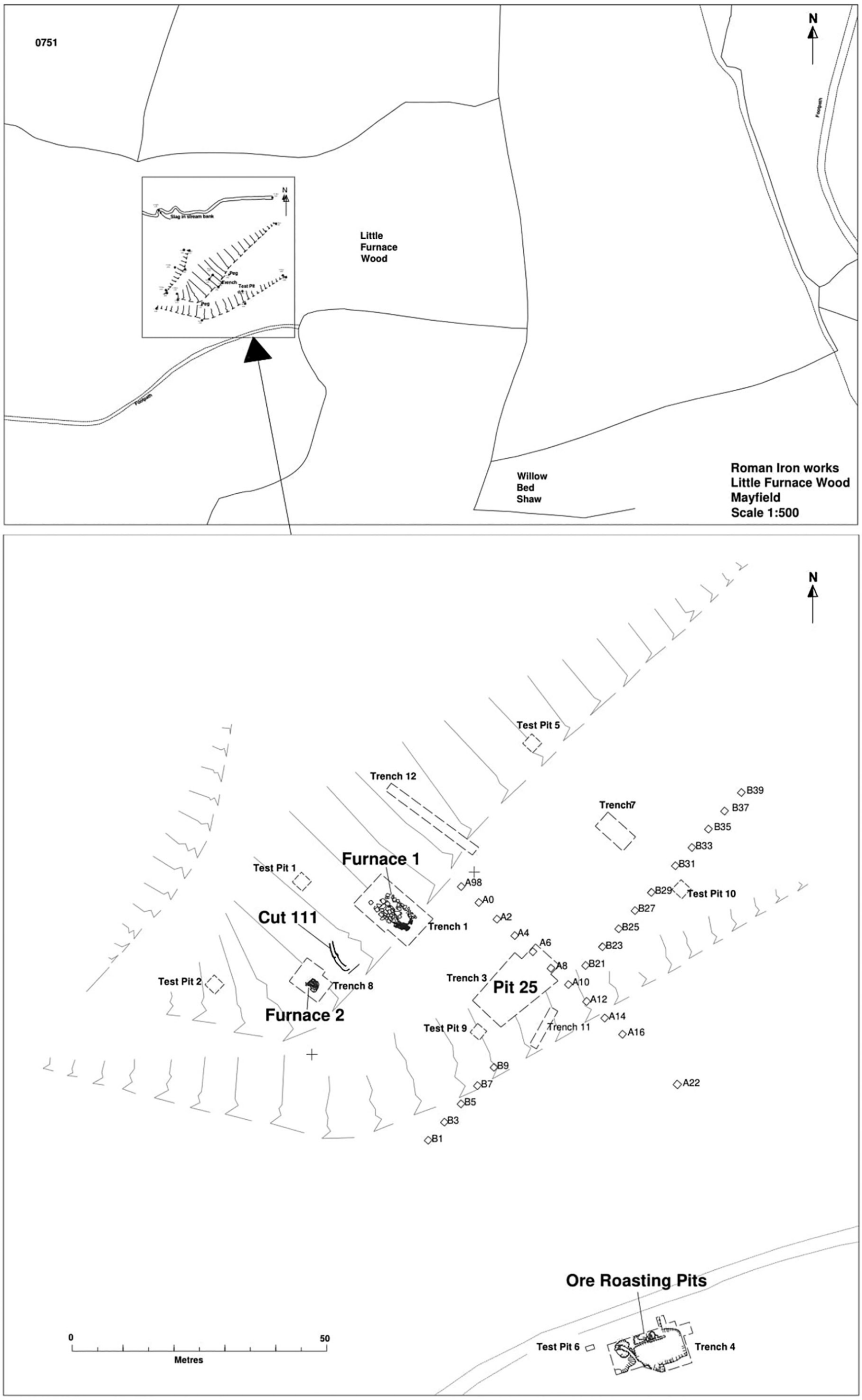

Fig. 2. The location and layout of the ironworking site in Little Furnace Wood.

The remainder of Little Furnace Wood was surveyed, revealing quarries and charcoal-burning platforms. A section was excavated across one platform, and a test pit was excavated in a second. Neither revealed any dating evidence, but both are thought to be later post-medieval.

FURNACE 1

Furnace 1 (Context 3) was located towards the top of the slope above the stream (Fig. 2). It had been cut into the upper slope so that the natural sandstone formed the rear and sides of the structure (Fig. 4). After abandonment it had been covered by the slag heap (Contexts 1 and 2), which had presumably been dumped from later ironworking further upslope.

Most of the furnace structure had been demolished or had collapsed, with the majority tumbling downslope to cover the furnace and the area in front of it. Some large structural pieces, with intact furnace linings of vitrified, slag-like material adhering to the clay wall, were found during the excavation, including fragments of a probable chimney that may have extended above the domed furnace structure.

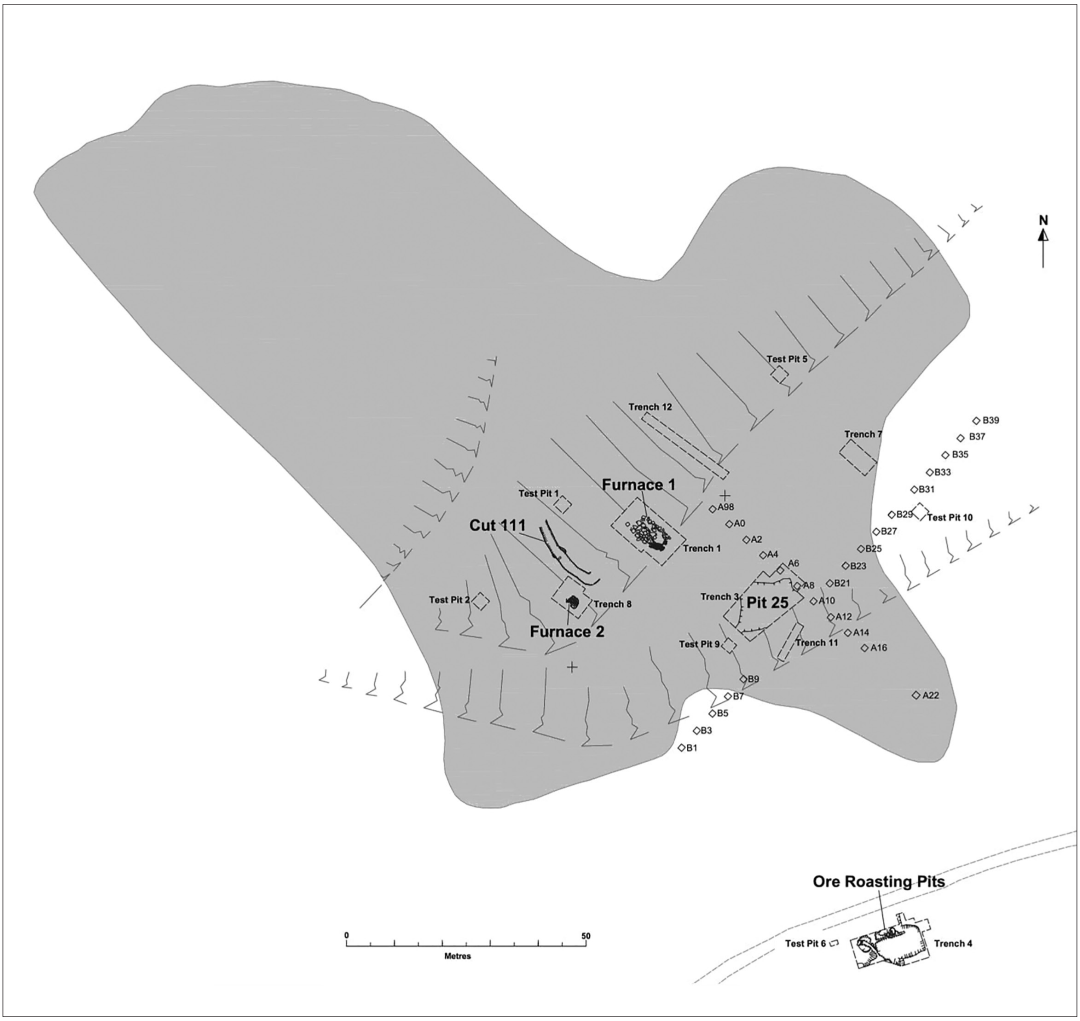

Fig. 3. The location and extent of the slag heap (shown in grey).

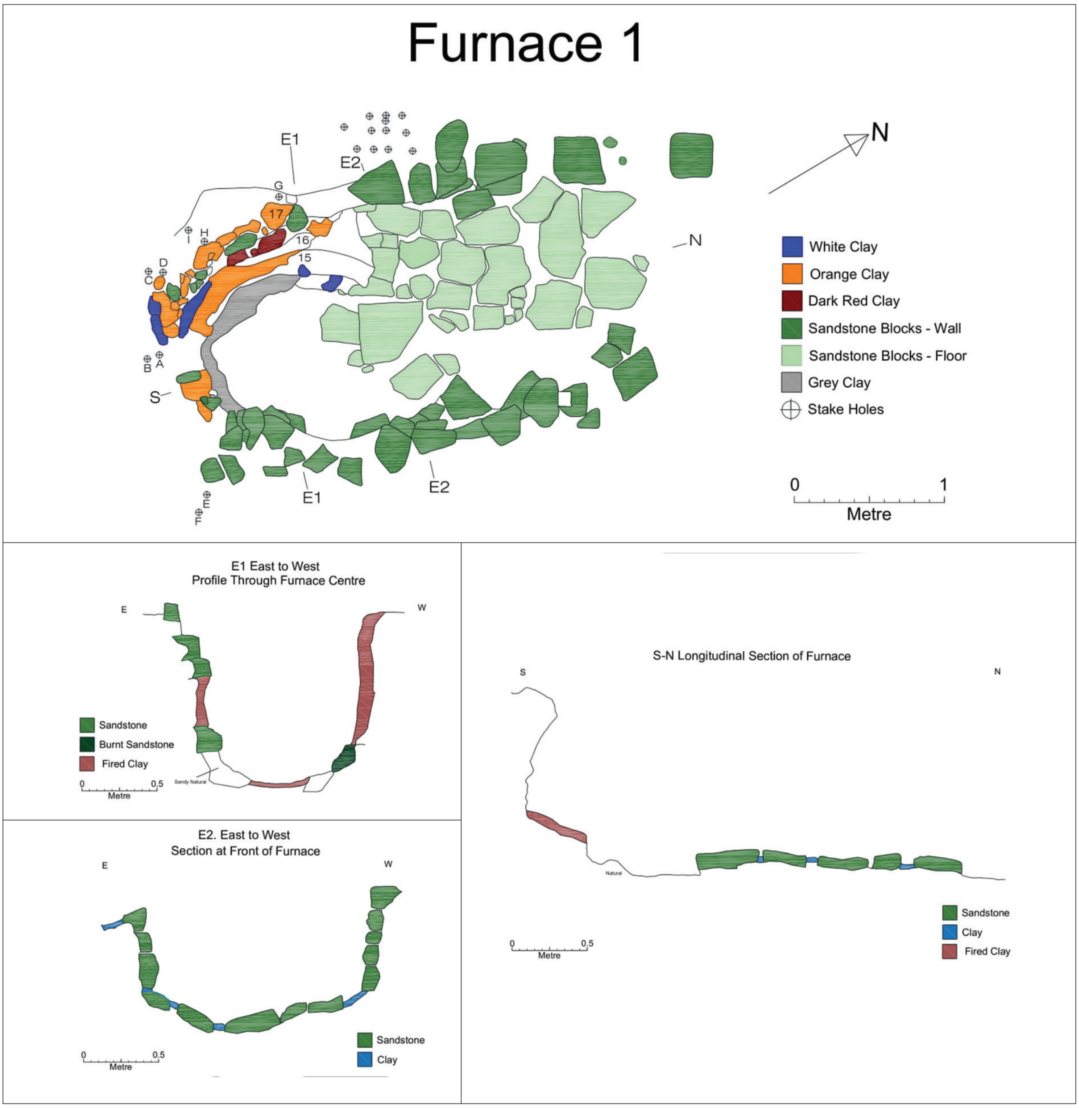

Fig. 4. The plan and profile of Furnace 1.

The furnace (Figs 4 and 5) was subcircular in plan, with the sandstone slope forming the rear third. Initially, it was thought that there was evidence for at least four construction phases, with surviving linings from the earlier phases (Contexts 15, 16, and 17) preserved at the rear of the furnace.

Context 15 is approximately 100mm thick and comprises white fired clay bonded to an orange fired clay backing. Context 16 comprises dark orange-red fired clay, about 130mm thick. Context 17 is also about 130mm thick and comprises a fired white clay bonded to a light orange-buff backing. However, on investigation, it appears that the differential colouring is probably the result of firing rather than rebuilding, and there were only two phases of use.

A number of stake-holes (Context 11) were excavated on the level surface above and to the rear of the furnace. These appear to be arranged in pairs, and it is possible they held a windbreak or a simple covering structure on the upslope side.

The clay-built furnace structure rests on sandstone blocks, with additional sandstone blocks incorporated into the wall, particularly on the east side. The sides of the furnace are made from clay 'bricks' built up to form the wall and then smeared on the inner face with more clay to form a lining. Gaps between the wall and the natural sandstone, and between the sandstone blocks, have been packed with clay. The clay bricks are broadly rectangular, with one rounded edge. They vary in size and frequently have finger impressions on one surface.

Similar bricks were used in the construction of furnaces at Hartfield (Tebbutt 1979, Plate 4) and Laxton (Jackson and Tylecote 1988, fig. 9). The furnace measured 1.7m wide, at least 1.3m deep (the front of the structure had been demolished) and survived to a height of 1.15m.

As the front of the furnace had gone, there was no evidence of a front arch or any *in situ* tuyère holes. However, a piece of furnace lining incorporating a tuyère hole was found in the tumble of material at the front of the furnace, and a double tuyère, complete with a clay plug, was found on the spoil heap associated with this furnace (Fig. 6).

Below the tumble of furnace structure in the centre of the furnace (Contexts 6, 10, 27, 28, 29) was a thick, charcoal-rich layer of dark grey to black, sandy clay loam (Context 12), with pieces of burnt clay, iron slag and furnace lining sitting directly on the floor of the furnace and may represent evidence for its last firing.

The furnace floor (Context 13) comprised an orange-red burnt clay layer, 70mm thick, resting on the natural sandstone. It was about 0.85m in diameter, although the front had been truncated. Here, a 20mm thick deposit of mid-grey, sandy loam (Context 18), with ash/charcoal flecks, small slag pieces, and sandstone pieces, appeared to run under the north end of the floor, perhaps suggesting the floor had been replaced at some stage.

Fig. 5. A photograph of Furnace 1 looking south.

Fig. 6. Double tuyère with plug.

The area immediately in front of the furnace comprised the slag heap (Contexts 1 and 2), overlying the tumble of fired clay and other material from the furnace structure (Contexts 4, 14, 19, 21, 22, 23, 24, 30, 34 and 46) and very badly disturbed by rabbit diggings.

The tumble of material at the front of the furnace proved complex, comprising a mixture of dark grey, brown, and black sandy loam soils containing slag and sandstone pieces, intermixed with orange-to-yellow fired clay, some of which appeared to have a solid structure but was simply a compressed tumble. Within this matrix were pieces of furnace lining and fragments of the bricks, which may suggest that the wall on the west side at the front of the furnace had collapsed into it.

The sides of the funnel-shaped working area in front of the furnace are lined with sandstone blocks two to three courses high, forming walls bonded into the furnace structure. The east wall (Context 31) projected 1.3m from the front of the furnace and was 0.2–0.25m wide and 0.6m high. Some sandstone blocks had been scorched by heat, especially at the bottom of the wall. The wall on the west side (Context 32) projected 1.4m from the front of the furnace and was 0.25–0.3m wide and 0.67m high. When the furnace rear wall was sectioned, it was evident that the sandstone wall continued around the entire circumference of the furnace, forming a base for the structure (Context 33).

Once the tumble of material in front of the furnace had been removed, it revealed a mid to dark grey, sandy clay loam (Context 35), containing charcoal pieces and flecks and numerous slag pieces (30%), which formed a layer overlying a sandstone block floor which filled the space (about 1.5m × 2m) between the two walls.

The floor (Context 36) comprised a single layer of large flat sandstone blocks, forming a dished area in its centre, which was filled by Context 35. The dished area was probably a primary forging hearth situated in front of the furnace, used to consolidate the raw bloom immediately after extraction, probably utilising some of the hot charcoal from within the furnace.

All the upper faces of the sandstone blocks forming its floor were burnt/scorched. Along the east side of the floor there was a gap between the sandstone floor pieces and the east wall. It was U-shaped, with a flat bottom and straight sides (Context 57), and had fired clay along its east edge, though it had been disturbed by rabbit diggings.

A thin deposit of charcoal-rich soil (Context 40) adjacent to the forging hearth may indicate a working area. In contrast, the area between the forging hearth and the front of the furnace, which contained a dark grey-brown, sandy clay loam with charcoal flecks and pieces, slag, and burnt clay pieces, could be a remnant of rake-out debris (Context 48). Another thin layer of dark grey-brown, sandy clay loam (Context 100), containing charcoal pieces, flecks, and burnt clay fragments, was also found on the sandstone floor below the tumble.

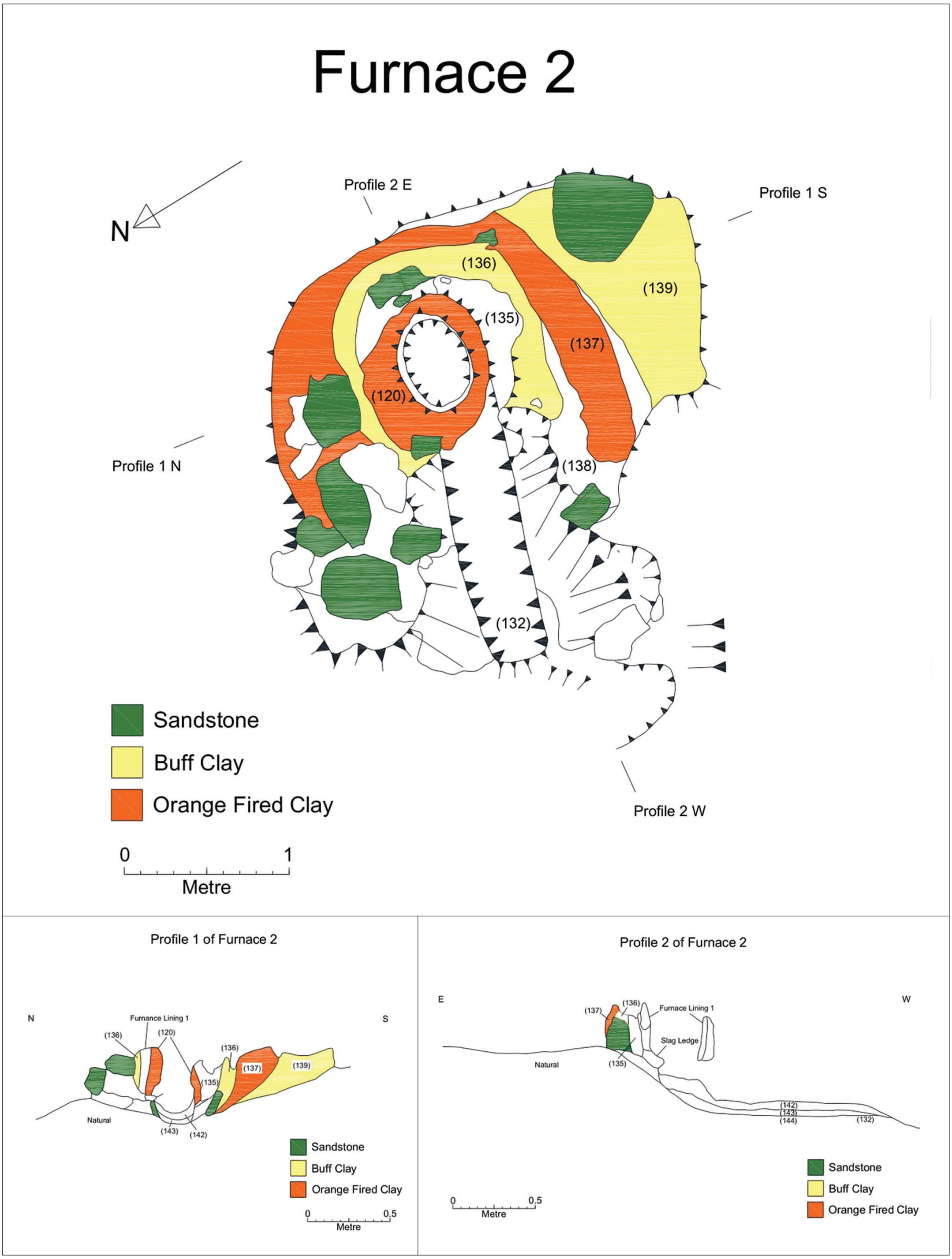

Fig. 7. The plan and profile of Furnace 2.

FURNACE 2

Furnace 2 (Context 120) was located to the west of Furnace 1 (Fig. 2) and was not as well preserved. This furnace had also been terraced into the slope, although not to the same extent as Furnace 1, and was found below a thin layer of the slag heap (Context 117) and topsoil. It comprised a subcircular chimney, about 0.2m in diameter, formed of fired clay, at the top of a small shaft, 0.28m in diameter, with an overall height of about 0.45m (Figs 7 and 8). The furnace had an orange, fired clay floor (Context 142) about 40–80mm thick at the base of the furnace. Below this was a thin layer, 30–50mm deep, of dark grey sandy loam (Context 143) containing charcoal flecks and pieces, above a base formed from sandstone pieces bonded with fired, orange clay (Context 144).

On the west side was an arch opening, 0.2m wide and 0.16m high, which led into a shallow channel formed of fired clay (Context 132), 70mm wide and about 0.3m in length, with the flat sandstone pieces continuing out from the furnace floor and forming its base. The channel was filled with a black, sandy clay loam, with 30% forging slag pieces and 10% charcoal pieces/flecks (Context 131), which also continued into the bottom of the furnace. Above this fill was a compact layer of light buff-coloured clay (Context 130), which also covered a layer of dark brown, sandy clay loam (Context 133) surrounding the channel.

Fig. 8. A photograph of Furnace 2.

Around the edge of the furnace were a series of earlier, fired clay linings (Contexts 135, 136, 137, 138 and 139). Although these may represent only two phases, the west side appears different and may have been rebuilt. These varied in colour from orange to buff to dark grey, with the outer layer (Context 139) being a yellow clay that had not been fully fired.

A 'ledge' formed of slag (Context 145) was found on the lower inside edge of the furnace on its north and east sides, being thicker on the east side at the back of the furnace. It is situated below the inner furnace lining of Context 120 and may relate to an earlier phase of the furnace.

Below the outer linings (Context 136 and 137) are sandstone blocks, about 0.2m in size, which form the outer edge of the furnace structure (Context 146). It appears that the small shaft furnace may have been built into the remains of an earlier, larger, and possibly domed furnace. There was no evidence of a tuyère associated with this furnace, although a tuyère fragment was recovered from the adjacent Cut 111.

ORE-ROASTING PITS

The first pit (Context 54) was located some 31m to the south of Furnace 1 (Fig. 2) using a Beat Frequency metal detector. It was below topsoil (Context 47) and light brown, compact, sandy clay loam subsoil (Context 49), neither of which contained any slag.

The pit measured 3.7m by 2.8m and was about 0.56m deep (Figs 9 and 10). It had an upper fill of mid-brown sandy clay (Context 55), which contained charcoal pieces and flecks (5%), fired clay pieces (2%), roasted ore (5%), sandstone pieces (3%) and rare slag pieces (<1%). This layer contained discrete horizons of charcoal and burnt clay. Below this, the primary fill of a dark reddish-brown, sandy clay loam (Context 59) contained burnt clay fragments (10%), charcoal pieces and fragments (10%) and roasted ore pieces (10%). The base and sides of the pit are formed of fired, orange clay (Context 56). The northern edge of Pit 54 appears to have been modified several times and may originally have extended beyond the excavated area, but a large tree stump prevented investigation.

A wall of fired clay (Context 98) extended east to west across the central northern part of the ore-roasting pit, perhaps to make a smaller pit for this final firing episode. It did not extend to either the east or west edges of the pit but was bonded to the pit floor.

Another fired clay wall (Context 97) was found just to the north of Context 98. This wall extended from the west edge of the pit but did not reach the east edge. It sat within the primary fill (Context 95) and was not bonded to the pit floor. A primary fill of dark reddish-brown filled the gap between walls 97 and 98, sandy clay loam (Context 95), containing roasted ore pieces (20%), fired clay pieces (5%) and charcoal pieces, and was below the secondary fill (Context 55).

Context 99 was a thin horizon of orange, fired clay, 25–30mm thick, extending some 0.40m into Pit 54 from its northern edge within the primary fill (Context 75). As this extends below wall 97, it may represent the base of another ore-roasting pit to the north of wall 97.

Within the primary fill, still *in situ*, were several carbonised birch and alder logs orientated along the longer east–west axis. Nine separate pieces were identified (Samples A to I). They were lying against the clay wall (Context 98). Other deposits of fired clay (e.g. Context 66) and roasted ore pieces (Context 75) within the secondary fill of the pit, all presumably dumped into the pit when it went out of use. A deposit of small, roasted ore pieces (to 10mm), mixed with charcoal 60–70mm thick (Context 77), was found above a layer of charcoal-rich, dark grey, sandy clay loam (Context 78) between the primary and secondary fills of the pit.

Around the outer edge of the ore-roasting pit, especially on the north side, was a compact layer of reddish-brown to mid-brown sandy clay, incorporating patches of fired clay, roasted ore fragments and charcoal pieces/flecks (Contexts 60 and 61), which was interpreted as a working surface.

Immediately to the west of pit 54 was another ore-roasting pit (Context 81), which was only partly excavated as it extended outside the trench. Its excavated extent was 2m × 1.7m, and it was about 0.35m deep. This pit was lined with fired clay with steeply sloping sides and had been cut by an oval pit (Context 116) on its north-eastern edge. The edge of Pit 81 was then reformed, bisecting Pit 116 with a wall of fired clay.

Pit 81 has a secondary fill of yellow-brown sandy clay (Context 83), with roasted ore pieces (5%) and charcoal pieces (5%), and a primary fill of mid grey-

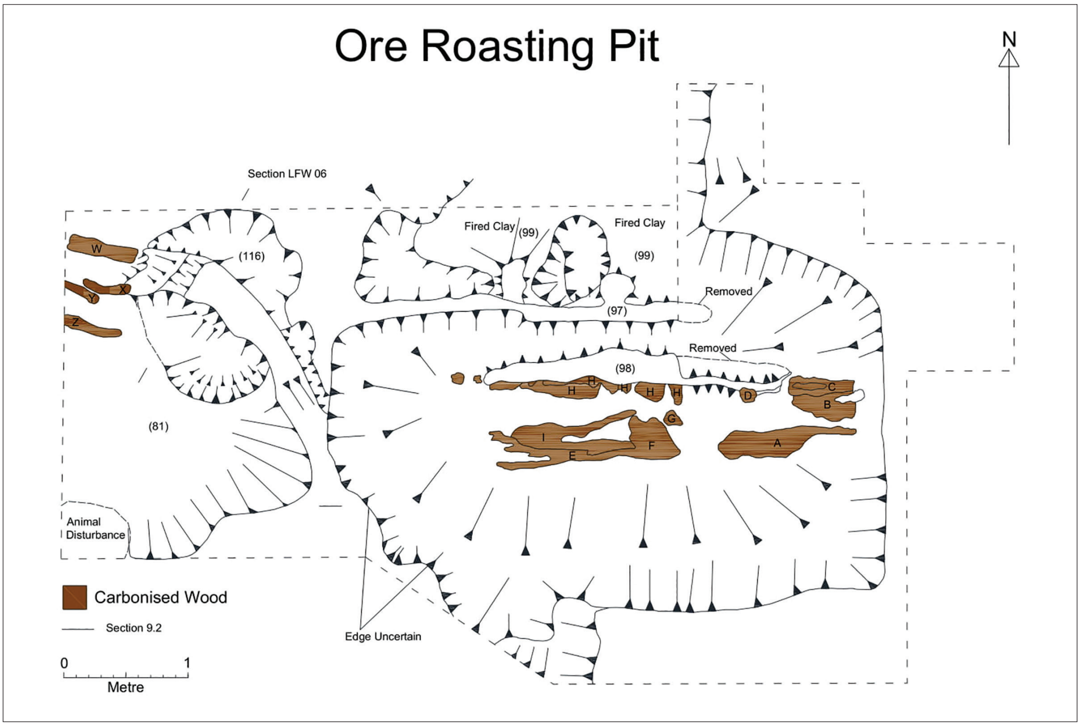

Fig. 9. Plan of the ore-roasting pit.

Fig. 10. A photograph of the ore-roasting pit looking north-east.

brown, sandy clay loam (Context 84), with roasted ore pieces (8%), sandstone pieces (3%), fired clay pieces (1%) and charcoal pieces (5%). Four pieces of carbonised logs (birch and oak) were found in this layer (Samples W to Z). There was no difference in the fills of Pits 81 and 116, and it is possible that they were, in effect, the same pit.

THE SLAG HEAP

The slag heap was surveyed using various methods, including a series of excavated test pits on a grid aligned with the site baseline, a Beat Frequency metal detector, and a magnetometer. The slag heap covered an area extending 65m east to west and 92m north to south (Fig. 3) and varied in depth between 0.3m and 0.6m. The slag density within the heap varies: some test pits have little slag, whilst others contain large quantities.

OTHER FEATURES

A test pit seven metres south of Furnace 1 (Fig. 2) located a large shallow pit (Context 25). This measured approximately 6m × 3.5m, with a maximum depth of 0.26m. The pit base was irregular and extended beyond the excavated area. It was noted that the pit base was frequently scorched, as if hot material had been placed in it. The main fill (Context 26) comprised a loose, dark grey to black, sandy clay loam, containing charcoal pieces and flecks, together with slag, sandstone and fired clay pieces, with a concentration of unheated sandstone pieces in the central part of the pit.

There were some variations in the pit fill, including a dump of redeposited natural material (Context 44), which included burnt sandstone and fired clay pieces; below this was a thin layer of dark grey, silty loam, with large quantities of charcoal pieces and flecks, as well as some slag and sandstone pieces. The pottery from this pit comprised nine sherds, predominantly from East Sussex Ware jars, spanning a broad date range from the Late Iron Age through to around AD 250.

To the east of Furnace 2 (Fig. 2) was a deep, enigmatic, linear cut into the natural sandstone (Cut 111), the purpose of which is unclear. It was over 6m long, between 0.95 and 1.5m wide, and up to 1.95m deep (Figs 11 and 12). Augering showed that this feature extends eastward upslope from Furnace 1, although there was not sufficient time to investigate it further. It contained a complex series of fills, many of which appeared to be material dumps, predominantly slumping down the east side of the cut.

Fig. 11. A photograph of Cut 111 looking south.

The earliest deposit was a dark brown, sandy clay loam (Fill 107), with a large quantity (>10%) of slag pieces, numerous charcoal pieces and flecks, and fired clay pieces. This contained a horizon of dark yellow-buff natural sand (Context 115). Above 107 was a dump of redeposited natural sand containing sandstone pieces, charcoal flecks (Fill 106) and a thin deposit of dark brown sandy clay (Fill 96) containing a large quantity of charcoal (>60%).

Above these are the main fill of the cut (Fill 86). This comprises a dark grey, sandy loam, with large numbers of slag pieces, fired clay fragments, sandstone pieces and charcoal pieces and flecks, within which are several lenses of sandy clay and sand which only contain a few pieces of slag and charcoal (e.g. Fill 108).

A further charcoal-rich deposit (Fill 114) of dark grey-brown, sandy clay, with fired clay fragments, was noted within Fill 86. Fill 105 occurred above and within Fill 86 and comprised a dark yellow-to-buff sandy clay with iron slag, fired clay, sandstone pieces, and charcoal flecks.

Fill 127 was a black, charcoal-rich layer of sandy loam with a few pieces of slag and sandstone, occurring between fills 105 and 106. Capping the cut was a compact layer of iron slag pieces (approximately 75%), with fired clay pieces and charcoal flecks in a dark grey to black, sandy clay loam (Context 76), below a thin deposit of charcoal mixed with a black, sandy clay loam (Context 68).

The 15 East Sussex Ware sherds from this feature include 12 fresh joining pieces from the lower parts of two jars. The lattice decoration on these jars was most common during the 2nd and 3rd centuries AD; however, some of the other sherds date back to the 1st century.

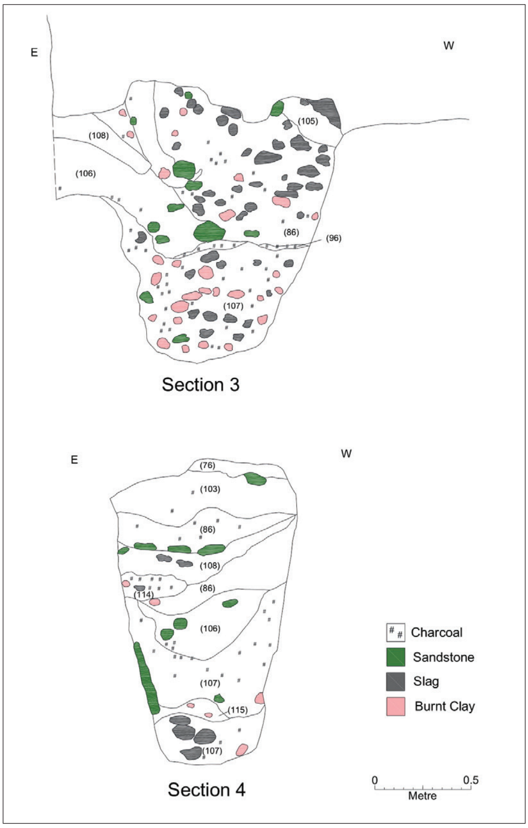

Fig. 12. Sections through Cut 111.

Two of the small test pits (B7 and B25) were expanded into larger ones (13 and 14), due to the quantity of slag found in them. In both cases, a compact layer of slag, roughly 75–80%, was found in a black to dark grey-brown, sandy clay loam. In Test Pit 13 (Contexts 101 and 110), six East Sussex Ware sherds dating to the Late Iron Age to early Roman period were found in the slag heap. The slag heap in Test Pit 14 (Context 102) produced 21 similarly dated sherds of East Sussex Ware, together with fragments of fired clay 'bricks', while below the slag heap a 100mm thick layer of black, charcoal-rich, silty clay loam was found (Context 103), containing a further sherd of East Sussex Ware, of Late Iron Age to early Roman date.

Below this layer, the ground surface had been heated and turned orange, and there were many possible stake holes, although no structural form could be determined. The thick layer of charcoal resembled that observed in post-medieval charcoal-burning platforms sampled elsewhere in the wood and, together with the burnt surface below, may suggest that this was the site of a Roman charcoal-burning area.

THE FINDS

THE POTTERY by Malcolm Lyne

The excavation yielded 87 sherds (1400g) of mainly Early Roman pottery, as well as a possible sherd from an Early Saxon silt-and-chaff-tempered vessel, five fragments from medieval cooking pots, and a possible jug, all from the upper levels in Test Pits 3, 4, and 8. Two fragments from 19th–20th-century vessels were in the topsoil.

All of the assemblages were quantified by the number of sherds and their weights per fabric. These fabrics were classified using an 8x magnification lens with an in-built metric graticule to determine the nature, size, form, and frequency of added inclusions, and three numbered fabric series were drawn up with the prefixes R, M, and PM for Roman, medieval, and post-medieval, respectively (*see* ADS supplement). None of the assemblages is large enough for more detailed quantification by Estimated Vessel Equivalents (EVEs) based on rim sherds (Orton 1975). The pottery is illustrated in Fig. 13.

Assemblage 1

From the soil layer (Context 123) adjacent to Furnace 2 in Test Pit 8a. Neither Furnaces 1 and 2 nor ore-roasting Pit 54 yielded any pottery, but this soil layer adjacent to Furnace 2 produced the following sherd:

No. 1. Slack-profiled rim sherd in soapy, very-fine East Sussex Ware fabric R1A fired yellow-beige. Ext. rim diameter 160mm. Paralleled at Pippingford Bloomery, Hartfield (Tebbutt and Cleere 1973, fig. 4–14), where it was dated c.AD 43–70. This piece suggests a mid-to-late 1st century date for the furnace.

Assemblage 2

From the slag heap (Context 101) in Test Pit 13. The five potsherds from this slag heap include large, fresh fragments from three vessels:

No. 2. Girth-carinated bowl in black East Sussex Ware, fabric R1C, with sparse surface vesicles and fine siltstone grog filler. External rim diameter of 160mm. This form in very-fine-sanded black Atrebatic 'Overlap' fabrics and their replacement Arun Valley Greywares dates from the last years of the Late Iron Age until around AD 120. This is the first example of grog-tempered East Sussex Ware observed by this author and probably dates to a similar period.

No. 3. Everted rim jar in a similar fabric. External rim diameter of 120mm.

No. 4. Small, slack-profiled jar or bowl in soapy, black East Sussex Ware, fabric R1A, with a burnished, acute-lattice band on its shoulder. External rim diameter of 120mm. A necked bowl from Beauport Park with similar decoration was dated to the 1st century AD (Green 1988, fig. 8–5).

The soil above the slag heap (Context 110) yielded one abraded fragment from the following vessel:

No. 5. Slack-profiled jar in soapy, black fabric R1A.

Assemblage 3

From the slag heap (Context 102) in Test Pit 14. The 21 fresh sherds from this context constitute the largest single assemblage from the site and include fragments from the following:

No. 6. Small, everted-rim jar in patchy black/buff East Sussex Ware, fabric R1B. External rim diameter of 120mm.

No. 7. Everted-rim jar in black East Sussex Ware, fabric R1C, with sparse siltstone grog filler. External rim diameter of 140mm.

This assemblage also suggests a mid-to-late 1st-century date for the slag heap.

Assemblage 4

From Pit 25, nine sherds of East Sussex Ware were recovered. Three sherds from this pit are from necked jars (Late Iron Age to AD 250). One is from an acute-lattice decorated jar (AD 70–250), and the other is a fragment of a Gallo-Belgic platter copy in East Sussex Ware, fabric R1C (around AD 43–120). A further fresh jar sherd dates to the Late Iron Age (AD 70). There was also a very abraded, underfired, black clay fragment, with silt and chaff filler. This latter fragment could be from an Early Saxon vessel of around AD 450–650, with its surfaces eroded away, but could equally well be from a furnace lining prepared using similar filler.

Assemblage 5

From the fills of the linear feature Cut 111 (Contexts 86, 105, 107 and 127). The 15 sherds from this feature lack rim fragments but include 12 fresh joining pieces from the lower parts of two jars in East Sussex Ware, fabric R1C, with siltstone grog filler from fills 105 and 107. Both jar bases feature the lower portions of the acute-lattice decoration on the sides of the vessels. This kind of decoration was used on East Sussex Ware jars throughout the Roman period, but was perhaps most common during the 2nd and 3rd centuries.

It may be, therefore, that Cut 111 is later than most other Roman features on the site, but this must remain uncertain in the absence of diagnostic rim sherds. The only other sherds from the feature are two abraded fragments of an East Sussex Ware jar from Context 86 and a fresh jar fragment from Context 127 in friable, black fabric R2, with sand and grog filler. This latter fabric is rather unusual but appears to be early, dating to before AD 70.

Assemblage 6

The two sherds from this context come from the rubble fill in the front bottom of Furnace 1 in Test Pit 1 (Context 23). They come from a jar in sandy off-white fabric R4, fired a rough, flecky grey. The fabric resembles Wickham Barn kiln fabric C1B (Lyne 2001, 35), dated to around AD 250–350.

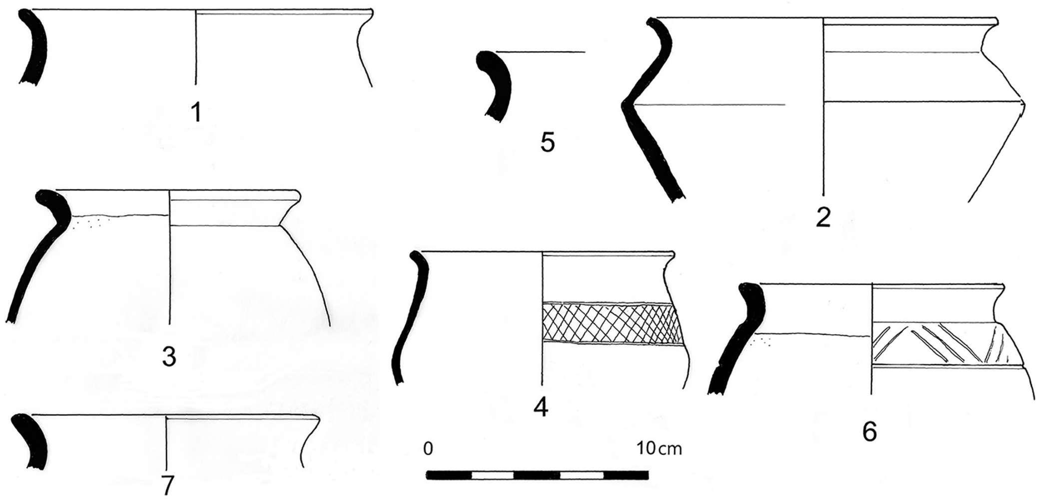

Fig. 13. The pottery from Little Furnace Wood.

THE FURNACE 'BRICK' by Dick Nesbitt-Dufort

Many specially made, fired clay 'bricks' were recovered from the structure and demolition deposits associated with Furnace 1. Other fragments were found within the slag heap and elsewhere on the site, but the vast majority were associated with Furnace 1.

These did not form the inner lining but were part of the furnace walls; some were found and recorded *in situ*, while the majority were mixed in with the collapsed tumble at the front of the furnace. A summary of the most complete 'bricks' is detailed in Appendix 2 (*see* ADS supplement).

The 'bricks' (Fig. 14) were very roughly made from a sandy clay and poorly fired, probably on site. Each brick had a convex top and a concave bottom, aligned lengthwise and roughly loaf shaped. A complete brick would have averaged about 0.22m in length, 0.14m in width and 0.14m in height and would have weighed about 3.3kg, although no fully complete bricks were recovered. The fabric was extremely friable and could not be easily cleaned or washed without disintegrating.

A few bricks exhibited traces of vitrified slag or charcoal on their surfaces. Several had finger marks on the sides, which appeared to have been caused by the bricks being picked up while soft before firing, although the consistency of the marks may suggest either a manufacturing mark or aid in the bonding of the bricks into the furnace structure. Similar bricks were found at Laxton, where they had been used to build up the above-ground shaft (Jackson and Tylecote 1988).

THE CHARCOAL by Rowena Gale

The charcoal assemblage included 34 samples from Furnaces 1 and 2 and associated ore-roasting pits and other features. Charcoal fragments were often large and abundant. Species identification was undertaken to indicate the type of fuel used and the character of the woodland environment from which the fuel was obtained. A report on the charcoal from the post-medieval charcoal burning platforms is contained in Appendix 3 (*see* ADS supplement).

Methods

Bulk soil samples collected from a range of features were processed by wet sieving. In addition, charcoal was collected by hand. Intact segments of roundwood were relatively frequent. Charcoal fragments measuring >2mm in radial cross-section were considered for species identification. Samples 12 and 19 were particularly large; 10% and 50% subsamples were examined. Sample 59 included several sub-samples from individual but fragmented logs.

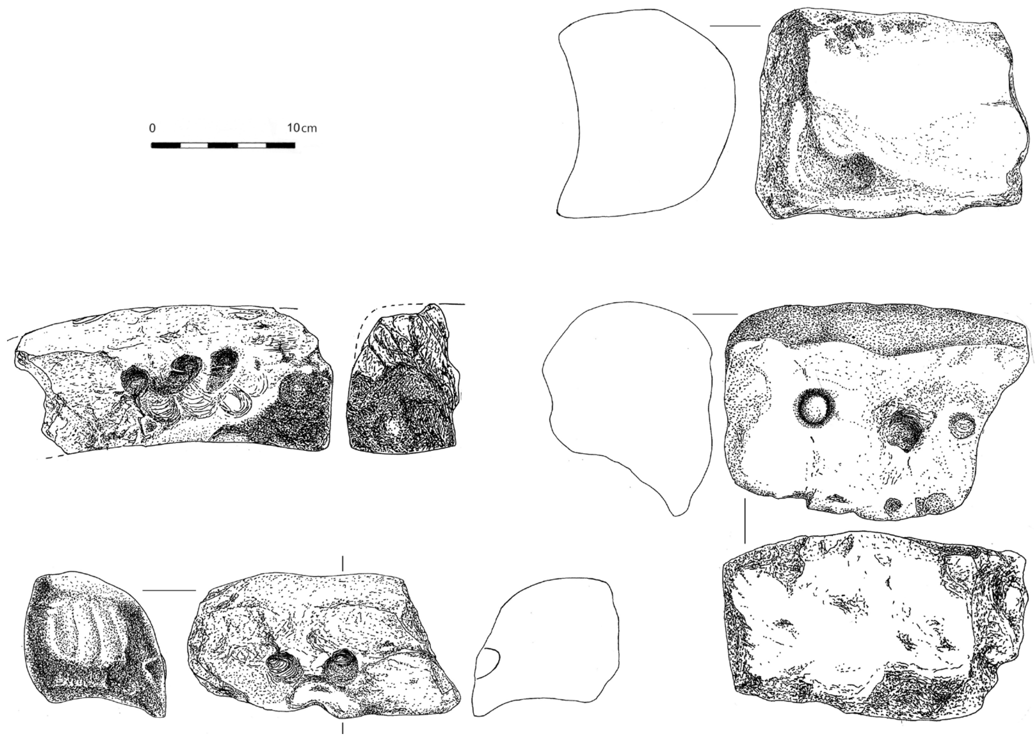

Fig. 14. Examples of 'bricks' from the Furnace 1 structure.

The charcoal was mostly firm and well preserved. Samples were prepared using standard methods (Gale and Cutler 2000). The anatomical structures were examined using incident light on a Nikon Labophot-2 compound microscope at magnifications up to 400x and matched to prepared reference slides of modern wood. When possible, the maturity of the wood (i.e., heartwood/sapwood) was assessed, and stem diameters and the number of growth rings were recorded. It should be noted that charred stems may be reduced in volume by up to 40%.

Results

The taxa identified are presented in Table 1. Classification follows that of *Flora Europaea* (Tutin 1964–80). Group names are assigned when anatomical differences between related genera are too slight to allow secure identification at the genus level. These include members of the Pomoideae (*Crataegus, Malus, Pyrus* and *Sorbus*) and Salicaceae (*Salix* and *Populus*).

When a genus is represented by a single species in the British flora, it is named as the most likely origin of the wood, given the provenance and period, but it should be noted that it is rarely possible to name individual species from wood features and exotic species of trees and shrubs introduced to Britain from an early period (Godwin 1956; Mitchell 1974). The anatomical structure of the charcoal was consistent with the following taxa or groups of taxa:

Aceraceae. Acer campestre L., field maple.
Aquifoliaceae. Ilex aquifolium L., holly.
Betulaceae. Alnus glutinosa (L.) Gaertner, European alder; *Betula* sp., birch; *Carpinus betulus* L., hornbeam.
Corylaceae. Corylus avellana L., hazel.
Fagaceae. Fagus sylvatica L., beech; *Quercus* sp., oak.
Oleaceae. Fraxinus excelsior L., ash.
Rosaceae. Subfamily: *Pomoideae*, which includes *Crataegus* sp., hawthorn; *Malus* sp., apple; *Pyrus* sp., pear; *Sorbus* sp., rowan, service tree and whitebeam.

These taxa are anatomically similar; one or more taxa may be represented in the charcoal.
Salicaceae. Salix sp., willow, and *Populus* sp., poplar. In most respects, these taxa are anatomically similar, especially in juvenile wood.

Furnace 1

The charcoal-rich Context 12, from the basal fill of the furnace, indicated the predominant use of oak (*Quercus*) heartwood, mostly from slow-grown largewood. A single fragment of hornbeam (*Carpinus*) roundwood (diameter approximately 40mm, 12 wide growth rings) was also identified.

Charcoal from other contexts associated with the furnace (10, 19, 22, 23, 27, 28 and 30) also demonstrated the consistent use of oak, although alder (*Alnus glutinosa*), hazel (*Corylus avellana*), birch (*Betula*) and the hawthorn/*Sorbus* group (*Pomoideae*) were also identified (Table 1).

The charred remains of several possible acorns were recorded in Context 27, from a tumble in the fill of the furnace. If these are, indeed, acorns, their presence in the furnace is puzzling, since it is unlikely that they would have been introduced with charcoal fuel (charcoal production is based on lengths of roundwood and cord wood, not the type of twiggy material that would produce acorns).

Samples from Contexts 35 and 48, from the fills of a forging hearth pit (36), included oak, alder, birch and possibly hazel, and were thus similar in character to fuel debris in the furnace.

Fragments of oak heartwood from Context 19 included both slow and fast-grown wood. The structure of hazel stems from Contexts 10 (the fill of the furnace) and 14 (fill of (7)) was consistent with that of coppice growth and included 12 and 10 growth rings, respectively.

Furnace 2

Furnace 2 produced little in the way of fuel debris. A single fragment of charcoal from the basal layer (context 143) was identified as hazel (*Corylus avellana*).

Ore-roasting pits

Unusually large pieces of charcoal were recovered from the ore-roasting pits (54) and (81). Context 59, from the lowest fill of pit 54, included the remains of several burnt logs, predominantly birch (*Betula* sp.), two of which measured up to 70mm in diameter (probably more than 100mm before burning), but also alder (*Alnus glutinosa*) and holly (*Ilex aquifolium*). (Individually labelled samples <A>, <E> and <F>: alder; <C>, <D>, <G>, <H> and <I>: birch; <B> too degraded to identify).

The evidence suggests that firewood, rather than charcoal, was used for roasting. Charred residues in Contexts 55 and 75, further fills of pit (54), also attest to the predominant use of wide birch roundwood or logs, although oak (*Quercus*) and alder (*Alnus glutinosa*) were (minimally) represented.

Wide roundwood from birch (*Betula*) was also recorded (Samples X, Y and Z), from Context 84 in the lower fill of ore-roasting pit 81, whereas Sample W included degraded oak (*Quercus*). Deposits from Context 26, the main fill of pit (25), included oak (*Quercus*), field maple (*Acer campestre*), alder (*Alnus glutinosa*), birch (*Betula* sp.), hazel (*Corylus avellana*) and a member of the hawthorn/*Sorbus* group (*Pomoideae*).

Contexts 38 and 58, also associated with pit (25), included oak (*Quercus*), hazel (*Corylus avellana*) and birch (*Betula*).

Linear Feature 111

Charcoal from the fills of the large linear (111) cut into the sandstone natural was examined from Contexts 86, 107, 122, 127, 128 and 134. Oak (*Quercus*) was common to each sample, mostly largewood, some of which was from slow-grown trees, whereas birch (*Betula*), alder (*Alnus glutinosa*) and hazel (*Corylus avellana*) occurred more sporadically (Table 1). Some of the larger pieces of birch appeared to be from wide roundwood or trunkwood, perhaps more than 100mm in diameter. Similar taxa were named from Context 68, charcoal-rich soil above a compact slag layer (Table 1). The origin of the charcoal is uncertain, although ironworking refuse seems likely.

Other deposits

A small amount of charcoal from a layer of compacted slag, Context 65, included alder (*Alnus glutinosa*) and oak (*Quercus*). Context 92, a soil layer, contained a single piece of birch (*Betula*) from wide roundwood. Context 103, charcoal-rich soil below the slag heap, included oak (*Quercus*), birch (*Betula*), hazel (Corylus avellana) and willow (*Salix*) or poplar (*Populus*).

Discussion

Fuel debris collected from residues within Furnace 1 produced a large volume of charcoal. The basal fill, Context 12, was especially abundant and demonstrated a preference for oak heartwood, supplied mainly from slow grown largewood. The dense oak heartwood produces particularly efficient charcoal fuel. The use of alder, birch, hazel and hornbeam was less frequent. Although hornbeam occurred in the post-medieval contexts, it was represented by only a single fragment at the site. Furnace 2 produced minimal charcoal compared to that from Furnace 1 but indicated the use of hazel.

Fuel debris from the two ore-roasting pits (54) and (81) differed from that of the furnaces in that unusually large lumps of charcoal remained; indeed, pit (54) contained the remains of several substantial birch logs, which may have measured more than 100mm in diameter prior to burning, and also alder and holly. Birch was the dominant taxon in both pits. Since prepared charcoal fuel tends to fracture easily with the consequent loss of wood morphology (i.e., cordwood/roundwood), especially with wider roundwood, the remains of entire logs suggest that firewood (as opposed to charcoal) was used for the roasting process.

Charcoal was relatively expensive to produce in terms of time required and wood consumption, and it is probable that firewood would have fuelled those processes for which charcoal was not essential (e.g. iron smelting, which requires high temperatures in an oxygen-reduced atmosphere). Although relatively lightweight, birch wood produces a very hot, although short-lived, heat source (Lines 1984).

Environmental evidence

The site was located within the Wealden forest and the taxa named from the charcoal residues are typically those of climax woodland in this area. Evidence from the charcoal suggests that the site was based on acidic soils, close to, or within, oak woodland. Associated woodland trees included birch, ash, hornbeam, field maple, holly and beech. Members of the hawthorn group may have grown in marginal woodland or as understorey, together with hazel. Areas of damp or wet soils are inferred by the frequency of alder and the occasional presence of willow/poplar.

Charcoal from the iron-smelting site indicated the abundant use of oak largewood, often from slow-grown trees but sometimes including fast-grown wood. This suggests that supplies were obtained from both managed and unmanaged woodland, although slow-growing trees may result from environmental stress in managed woodland (e.g., northerly aspect, competition for soil moisture, and shading).

It seems likely, however, that local woodland was managed, particularly if ironworking activities were large-scale or long-lived. Charcoal production clearly focused on oak but sometimes incorporated other species, perhaps reflecting either the distribution of species within the woodland supplying the coppice poles or the specific selection of oak for ironworking.

ARCHAEOMETALLURGICAL RESIDUES by Dr T. P. Young

The following summary has been extracted from a full report, which is contained in the site archive (Young 2011).

Methodology and analysis

Some 74kg of material, hand-picked from excavations, was submitted for investigation, including iron-smelting slags, structural elements from smelting furnaces, iron ores, and ironworking slags. A variety of analytical techniques (bulk chemical composition by XRF and ICP-MS; textural and microanalytical studies by SEM with EDS) were applied to samples taken from the collection.

The smelting slags formed the core of the investigation and ranged from dense examples with narrow flow lobes to lower density, vesicular examples with broad flow lobes, often showing surficial ridging or corrugation. The iron ores analysed were single samples of fresh and weathered varieties of a shelly ironstone.

The chemical composition of the weathered ore proved very similar to some of the samples of ore previously submitted by WIRG from elsewhere in the Weald. The weathering process apparently involved the loss of most of the calcium from the ore, as well as some iron and manganese.

Detailed consideration of the chemical composition of the new analyses was hindered by their relatively small number and their dispersion across various materials. Incorporation of the analyses published by Paynter (2006) increased the

Table 1. Little Furnace Wood: charcoal. Key. h = heartwood; r = roundwood (diameter <30mm); s = sapwood (diameter unknown). The number of fragments identified is indicated.

Context	Context description	Acer	Alnus	Betula	Carpinus	Corylus	Fagus	Fraxinus	Pomoideae	Quercus	Salicaceae
Area TP1											
4	Fill of (7)										1
10	Fill of Furnace 1					1r				3h	
12	Basal fill in Furnace 1				1r						
14	Fill of (7)					1r					
19	Layer – rubble fill in front bottom of Furnace 1								1	22h, 1r, 1s	
22	Layer of soil outside Furnace 1		2								
23	Rubble fill in front bottom of Furnace 1		3	3						3h	
27	Tumble in fill of Furnace 1			8						2h	
28	Fill in base of Furnace 1			1						8h	
30	Layer of soil outside Furnace 1		3							3h, 3s	
35	Upper fill of forging hearth pit (36)		1							3h, 3r	
48	Main fill of forging hearth pit (36)			1		?1				13h	
Area TP3											
26	Main fill in cut (25)	1	3	4		1r			1	5h, 1r, 2s	
38	Fill on south edge of pit 25			2						7h, 2r, 1s	
39	Upper fill of cut (42)		2r	1						4h, 1r, 1s	
58	Thin layer of charcoal rich soil in pit (25)			3		2				6h	
Area TP4											
55	Upper fill of ore-roasting pit (54)		1	44						1r	
59	Lower fill of ore-roasting pit (54), contained carbonised logs			13							
75	Compact fill of roasted ore in pit (54)			20							
84	Lower fill of ore-roasting pit (81)w									3	
84	Lower fill of ore-roasting pit (81)x			8							
84	Lower fill of pit ore-roasting (81)y			3							
84	Lower fill of pit ore-roasting (81)z			17							
Area TP7											
65	Layer of compact slag			1						10h, 3s	

Context	Context description	Acer	Alnus	Betula	Carpinus	Corylus	Fagus	Fraxinus	Pomoideae	Quercus	Salicaceae
Area TP8											
68	Charcoal rich soil above compact slag layer			19		3				1h, 3s	
86	Fill of linear cut (111)			8						24h, 8s	
107	Lower fill in linear cut (111)		1	4						16h, 1r	
122	Upper fill in linear cut (121), same as (111)			6		1r				3h	
127	Fill in linear cut (111)									1s	
128	Fill in linear cut (111)									4h, 3s	
134	Fill in linear cut (111)									1	
Area TP11											
92	Soil layer			1							
Area TP14											
103	Charcoal rich soil below slag layer		1	3		1				3h, 2r	1
Furnace 2											
143	Base of Furnace 2					1					

size of the dataset sufficiently to permit an improved level of interpretation.

Analyses of smelting slags formed three distinct compositional trends (Groups 1–3), interpreted as representing smelting of three different ores (particularly marked by varying calcium contents). The analyses also clustered into three regions of the CaO-SiO2-FeO diagram (Fields A–C).

Field A represented tapped slags from the dominant smelting process, with mass-balance calculations suggesting that 50%–60% of the iron in the ore was reduced to metal. Slags of compositions in Groups 1, 2 and 3 occurred in this field.

The indicated yields are similar to those calculated for Roman bloomeries in the Bristol Channel area. Some of the tapped slags from the rather calcic Group 3 also occurred in Field B.

This indicated a higher degree of iron extraction (70%–80% of the iron in the ore), permitted by the low liquidus temperatures of those iron-poor compositions with elevated calcium contents. Although this residue would have resulted from high-yield smelts, it is possible that the low iron content of the slag would have resulted in elevated carbon in the iron. It is also possible that these tapped slags are not representative of the overall bulk composition of residue from a smelt.

Field C included iron-rich examples of slags from Groups 1 and 3, together with an example of a slag 'rod' which did not fit within the identified compositional groups of tapped slags. These slags, if representative of a smelt, would be indicative of a low yield (20%–30% of the iron in the ore), but again are not necessarily representative of a bulk residue composition; averaging all Group 3 slag compositions gives a mean close to Field A.

These observations permit speculation about the utility of the dome form of furnace: the dome may have reduced the extent of involvement of the furnace structure in the reaction (aiding furnace efficiency), and its large floor area may have facilitated internal flow and accumulation of the possibly slightly viscous slags produced.

One example of a smithing hearth cake was analysed, as was one example of an unusual, extremely coarse-grained slag. Both slags had compositions similar to that of fayalite. Coarse fayalitic slags from elsewhere have been tentatively proposed as residues from bloom remelting processes, but there is insufficient evidence to confirm that possibility with the present material.

Discussion

The analyses of the smelting slags show that the site was involved in the smelting of several distinct iron ore types or mixes. The data also showed a series of fields indicating that the smelting slags were produced by processes with distinct yields.

The incorporation of all of Paynter's (2006) analyses as individual points, rather than presenting the average of points from the sample, may have accentuated the clustered distribution but did not generate it.

However, the nature of the rather small tapped slag pieces meant that it was not possible to determine whether the bulk residues from entire smelts corresponded to these different fields, or whether a single smelt might, during its course, produce slags spread over more than one of the fields.

The ore type with the highest calcium content could produce slags indicative of a very high yield (70%–80% of the iron present in the ore). However, the slags from this group (Group 3) were present in all three of the compositional fields. This suggests that either smelting was undertaken to produce a high yield only intermittently, even with a suitable ore feed, or, perhaps more likely, that a proportion of slags from a smelt with a more modest bulk yield were produced by higher degrees of local reduction.

If this is the case, then the bulk residue composition of each of the smelts from Groups 1–3 might have been close to that of Field A, which corresponds broadly to furnace extractive efficiencies of 50%–60%, similar to those seen in contemporary furnaces elsewhere (e.g. Thomas 2000). Although possible, it seems unlikely that this furnace deliberately exploited high-calcium ores to improve its extractive efficiency.

The presence of slag with a composition suggestive of a high degree of iron extraction does raise further questions. The creation of a slag with a low iron oxide content reduces the ability of the slag to limit the uptake of carbon by the metallic iron.

Although the creation of bloomery steel can be a desired outcome, if soft iron is required, as is the usual case, then steely blooms are problematic and can be difficult to forge. Any further progression towards the production of cast iron in the bloomery can be highly undesirable.

The limiting of iron extraction to a degree to preserve sufficient iron in the slag to keep the carbon levels of the iron within acceptable bounds would have had to be balanced against the increased yield of higher-carbon iron. Modelling of the viscosity of high-calcium slags yielded ambiguous results across different tools, but the textures of the glassier slags were distinct and suggestive of a higher viscosity melt. It is possible that the dome-shaped furnace would have allowed such slag to flow from the bloom while remaining at a high temperature within the furnace, keeping its viscosity low. It is possible that some, or even all, of the presumed tapped slags cooled within the furnace.

Some evidence for the cooling of at least some of the slag within the furnace may be indicated by the slags sampled from within and below the furnace floor. Similar furnace-floor flows were recorded from the larger domed furnace at Laxton (Crew 1998). If the furnace was not strictly slag-tapping, then the use of the arch for both blowing and furnace clearance might explain the lack of a blowhole/tuyère elsewhere in the structure.

The slag assemblage from the site is characterised by numerous small slag tubes or rods. It was hoped that analysis of the slag might help interpret these enigmatic residues. In fact, the slag from the analysed rod did not correspond to any of the compositional groups of smelting slags.

Although it remains likely that it is indeed a smelting residue, this was not proven in the present work. The low degree of iron extraction suggested by the analysis of this sample, if general, might suggest that these rods do not derive from the simple tapping of typical smelting slags, but might either arise early in the smelt (before a steady bloom-producing reaction has been developed) or through extraction of slag high in the furnace, perhaps above bloom level. Further work to determine slag rod composition on a broader basis would clearly be desirable.

The analysed smithing slag (LFW12) provided evidence of a strongly oxidising environment, with both magnetite and iscorite as significant phases. Although the relatively large size of the piece would suggest that it is a smithing hearth cake from a bloom smithing operation, the oxidising environment is unusual.

Further work on possible smithing residues from such sites would be desirable to determine which processes were undertaken close to the furnaces. Further evidence for the possible secondary processing techniques, albeit somewhat inconclusive, is provided by the very coarse-grained slag (LFW13).

The large size of the crystals of olivine in this slag (up to 15mm) indicates that it formed from the cooling of a substantial slag puddle. Such materials are rare in general, but somewhat similar materials do occur in the early medieval period in Ireland (e.g., Young 2012), where they have been tentatively attributed to bloom-refining processes involving remelting rather than simply bloom smithing.

One potential reason for a more complex bloom-refining process might be the need to compensate for elevated carbon content in the bloom. Percy (1864, 326) referred to the occasional need to refine blooms from the *stuckofen* which had gained too much carbon.

Secondary processing of blooms did occur on this site (with hammerscale and smithing slags as evidence), but the volume of secondary processing waste appears small, and most bloom refining may have taken place off-site, or at least outside the excavated area. Should significant bloom smithing/bloom refining deposits from such a furnace be discovered, their careful investigation may well assist in interpreting the product.

DATING RESULTS

Carbon 14 dates

A total of four radiocarbon determinations were conducted. Two samples were submitted to the Centrum voor Isotopen Onderzoek at Groningen. One (sample 1) from Context 12 (base of Furnace 1) was identified as oak (*Quercus sp.*) charcoal (February 2004), and the second sample (sample 2), from Context 39 (base of ore-roasting pit 54) was identified as birch (*Betula sp.*) charcoal (August 2005). Two samples (3 and 4) from Context 137 (Lining of Furnace 2) were submitted for parallel dating to the Oxford Radiocarbon Accelerator Unit and the Scottish Universities Environmental Research Centre (Table 2).

Archaeomagnetic dating

A total of 47 samples of fired material were removed from Furnace 1 (Context 3), Furnace 2 (Context 135) and the ore-roasting pit (Context 98) for the purposes of archaeomagnetic analysis and dating by Mark Burch and Cathy Drew of MOLAS. The samples were orientated *in situ* using the button method, combined with spirit levels and a north-seeking compass.

Some of the material was friable and, as a result, several samples disintegrated during transport and cutting. Demagnetisation tests showed that the magnetisation in the material is stable. The mean archaeomagnetic vectors in each context were compared with the UK Master Curve to suggest that the last firing occurred in the following date ranges (Noel 2008): Furnace 1 (Context 3), AD 40–60; Furnace 2 (Context 135), AD 60–220 or 270–480.

The dating ambiguity in Context 135 arises because the archaeomagnetic vector and its associated error span two distinct loops in the UK Master Curve. Archaeomagnetic vectors were too poorly grouped in Context 98 (ore-roasting pit) to form a basis for a reliable magnetic date.

Discussion

The combination of dating methods has provided potential dates for each of the three main

Table 2. Radiocarbon determinations from contexts 39 and 137.

Sample no.	**Laboratory reference**	**Uncalibrated radiocarbon age (BP)**	**2 Sigma calibrated date (95.4% confidence)**
Sample 1	GrN-28444	1850±30 BP	80–250 AD
Sample 2	GrN-29609	1800±20 BP	110–195 AD
Sample 3	OxA-18598	1883±24 BP	70–215 AD
Sample 4	SUERC-17259	1880±35 BP	70–215 AD
Weighted mean	—	1882±20 BP (at 88.9%)	70–215 AD

ironworking features on the site. Furnace 1 has a C14 date of AD 80–250, while the archaeomagnetic date is AD 40–60.

The C14 date was from charcoal in the furnace at the end of its life, perhaps even after it ceased operation, and this, together with the near overlap of the 1st-century dates, appears to suggest that this furnace was working in the middle to later first century AD, possibly very soon after the Roman invasion.

Furnace 2 has a single archaeomagnetic date, which suggests two potential date ranges. However, the C14 date of AD 70–215 confirms that the first is most likely, putting it as potentially contemporary with Furnace 1 in the late 1st century, but perhaps continuing in use into the second century. The ore-roasting pit has a single C14 date, which suggests a second-century date.

These diverse dates can be combined with the pottery analysis, which suggests two potential phases of activity at the site. The first, which encompasses the majority of the pottery, dates from AD 43 to 120 and thus includes both furnaces and the ore-roasting pit. However, later Roman pottery suggests that activity continued at, or returned to, the site in the 3rd century.

POTENTIAL SOURCES OF IRON ORE

by Brian Herbert

Although there are three known patches of Wadhurst Clay, which is the main source of iron ore in the Weald, to the south of the Little Furnace Wood bloomery site, the problems of transporting the ore to the site suggested a potential unknown source closer to the site.

A small pit close to Little Furnace Wood (at TQ 5944 2430) was augered, but produced no sign of iron ore, and it was concluded that this was a post-medieval sandstone quarry. Several other potential locations in Little Furnace Wood were also augered, but none yielded evidence of iron ore.

One potential source of the Wadhurst Clay west of Newick Lane comprises ponds centred on TQ 589 232, and large, water-filled mine pits, together with bell pits, are found at TQ 5860 2360; however, a walkover of these sites found no iron ore. Newick Lane passes through the Wadhurst Clay outcrop to the southeast of Little Furnace Wood, and this is probably the best contender for the Roman source of ore.

Large, water-filled pits at TQ 5945 2392 and TQ 595 235, and others nearby, suggest quarrying at some point in the past, although post-medieval brickworks near the former may have created them. Unfortunately, this survey has not been able to confirm the source of the iron ore used in the Roman bloomery.

STRUCTURE AND WORKING OF THE FURNACES

by Jeremy Hodgkinson

Pleiner has set out the basic principles and functions of bloomery furnaces (Pleiner 2000, 141–2): heat-resistant construction materials with a refractory inner lining, air inlet(s) and gas outlet, physical separation of slag, and removal of the bloom. Air could be provided by forced draught through bellows or other apertures, or by induced natural draught by a chimney or advantageous location in relation to the prevailing wind.

Separation of the slag from the bloom could be at the end of the smelt, by running the slag out of the furnace periodically during the smelt, or by running the slag into a pit below the bloom.

Both furnaces in Little Furnace Wood appear to have been operated to allow the slag to run from the furnace during smelting, as no evidence was found of large masses of slag formed either within the furnaces or in a pit below. A substantial proportion of the slag found on the site showed, by the characteristic vermiform flow patterns on its upper surface, that it had been run or tapped from the furnaces. This is typical of many bloomery sites in the Weald.

Furnace 1 exhibited the characteristics of a domed furnace, a type seen in parts of Europe from the Early Iron Age. A good example of such a furnace was excavated by Money in Minepit Wood, Rotherfield, in the early 1960s (Money 1974), but that differed in several important respects from Little Furnace Wood.

Firstly, although both furnaces were set into revetted banks, at Minepit Wood the bottom of the furnace was a maximum of about 0.45m below the edge of the rim of the hollow, allowing room for three air inlets around the back and sides, while

Furnace 1 was set at a depth 1.3m below the rim of the bank, and no evidence was found of air inlets in similar positions.

The dimensions of the Minepit Wood furnace were smaller, with an internal diameter of approximately 0.6m and a height of just over 0.9m, compared with at least 0.75m by 1.15m for Furnace 1. In both cases, the domes were truncated, but a large curved fragment of furnace lining, with an internal diameter of about 0.55m, was found close to the remains of Furnace 1, offering the possibility that above its dome there may have been a chimney, which could have potentially enabled induced natural draught. It is not at all clear how Furnace 1 functioned without any obvious air inlets, such as those recorded at Minepit Wood.

Comparable, too, are the furnaces of similar date excavated at Laxton, Northamptonshire, which were somewhat larger than Furnace 1 (Jackson and Tylecote 1988, 279–86). The absence of the front of the furnace, presumably destroyed after the last smelt, had removed whatever evidence may have existed of air inlets there.

It is therefore impossible to predict where the bloom may have formed in the wide hearth, or whether, as proposed for the bloomeries excavated at Laxton, multiple blooms may have been produced during a single firing (Crew 1998, 49–50).

Short cylinders of slag, which were found in quantity at Little Furnace Wood, and have been noted at some other Wealden sites, as well as at sites elsewhere in Britain and Europe, have been proposed as evidence of *ad hoc* air inlets which subsequently clogged with slag. However, their analysis (*see* Archaeometallurgical Residues) does not confirm this. Nor had any remains survived from the last firing, the possible intention being to repair and reuse the furnace, but this did not occur.

Furnace 1 was substantially larger than other bloomeries excavated in the Weald hitherto, notably those by Tebbutt and Cleere (1973) and by Tebbutt (1979), although four furnaces of similar or larger dimensions have subsequently been excavated by Oxford Archaeology at Upper Wilting Farm, Crowhurst.

The introduction of larger bloomeries may have been a consequence of the expansion of the iron industry in the early 1st century AD. The Greek geographer Strabo, writing before the end of the 1st century BC, reported that iron had become one of the principal exports of Britain (*Geography* 4.5.2).

The Romanisation of Gaul would have provided a stimulus to Wealden ironmakers, and the incursion of Belgic tribes into southern pre-Roman Britain may well have led to the introduction of new techniques of iron production. Similar furnaces to Furnace 1, as well as to those at Laxton, were excavated at Le Clérimois in the French department of Yonne, where they were in operation from the Late Iron Age to the 2nd century (Dunikowski and Cabboi 1995, 48–80).

Greater reliance should be placed on the archaeomagnetic date (AD 40–60) for Furnace 1 than on the radiocarbon date (AD 70–250), the latter being for charcoal which may have been deposited in the furnace after it went out of use. The form of what survived of Furnace 2 suggested a small shaft bloomery constructed within the remains of a larger, possibly domed, furnace that had been shallowly cut into a bank. The shaft survived only to a height of 0.455m, and its internal diameter was approximately 0.28m. These dimensions are comparable to the shaft bloomeries excavated by Cleere at Holbeanwood (Cleere 1970, 16).

The limited survival of the structure of this furnace provided no evidence of air induction, although the recovery of a tuyère fragment suggests the use of bellows. Because of the overlap of two sections of the UK Master Curve, two archaeomagnetic date ranges were presented for Furnace 2. However, the close coincidence of one of them (AD 60–220) with the two radiocarbon dates suggests operation in that period, and the weighted mean of the radiocarbon dates indicates an 88.9% probability of a date range of AD 70–178.

The implication is that earlier occupation of the site, in the mid-1st century, involved the use of domed furnaces, which would have included Furnace 1 and possibly the furnace into which Furnace 2 was subsequently built. A different group of ironworkers in the next century, using a smaller, different type of bloomery, could have reoccupied what may have been an abandoned site.

This group could also, perhaps, have been responsible for the ore-roasting pit. The juxtaposition of these variants of bloomery technology and their apparent chronology demonstrates that iron production in the Weald did not develop as a unidirectional process of technological progress, but that several versions of the bloomery process co-existed, some more sophisticated, others less so, possibly determined by factors such as tradition and tribal allegiance.

Evidence of forging at Little Furnace Wood was very limited. A small hearth, probably used for consolidation of the bloom, was located immediately in front of Furnace 1, on the paved apron. The general lack of evidence for forging at bloomery sites in the Weald may be accounted for in several ways: a shortage of ironworkers skilled in forging, preservation of fuel supplies for smelting, or forging at settlement sites or at centralised locations such as Southwark (Hodgkinson 2008).

LITTLE FURNACE WOOD IN ITS CONTEXT

by Jeremy Hodgkinson

BLOOMERY IRON SMELTING IN THE WEALD

It is evident from the writings of Strabo that by the first decades of the 1st century AD, iron production in Britain had increased to the extent that it had become one of the principal exports of the island. Much of the impetus behind this can be attributed to the growth in consumption resulting from the Romanisation of Gaul.

Home demand for domestic, agricultural, and military ironwork would have been similarly stimulated following the Roman invasion, as illustrated by the percentage of dated bloomery sites in the Weald operating in each historical period: 13% in the pre-Roman Iron Age and 62% in the Roman period (Hodgkinson 2008). However, as many as 70% of the bloomery sites discovered remain undated, and archaeological evidence is uneven; the total number of sites is likely substantially greater than those recorded to date.

At Little Furnace Wood, the archaeomagnetic date of AD 40–60 for Furnace 1 suggests that the site may already have been in operation at the time of the Roman invasion. The presence of native pottery, which was in use from the Late Iron Age through into at least the middle of the Roman period, does not contradict this conclusion.

The radiocarbon date for the ore-roasting area and the radiocarbon and archaeomagnetic dates for Furnace 2, while all imprecise, nevertheless indicate the possibility that the site could have continued in use as late as the 3rd century. However, the calibration graphs indicate a likelihood that Furnace 2 was last fired in the decades around the end of the 1st century, and that the area was last used near the middle of the 3rd century.

This is consistent with the radiocarbon date obtained for the charcoal in the fill of Furnace 1, which indicates that the material was probably dumped there during the 2nd century. This more emphatically implies the presence of other furnaces on the site, and their probable operation over a long period, which had already been suspected from the distribution of waste slag.

ORGANISATION AND COMMUNICATIONS

Cleere's assessment that iron production in the Weald was divided into two areas, a coastal group of sites under the control, or at least influence, of the *Classis Britannica* (CLBR) and a central Wealden group under a different, possibly commercial, arrangement, has recently been strengthened by the discovery of two additional CLBR waterside sites at Kitchenham Farm, Ashburnham (Cleere 1974; Kevin Cornwell, *pers. comm.*).

The central group, in which Little Furnace Wood is geographically located, was postulated based on access to potential markets via the north–south Roman roads, particularly the route from Barcombe to London (Margary 1965). However, the sites in the vicinity of Little Furnace Wood do not lie close to any of these military or strategically commercial routes; instead, they are served by ridgeways that are likely to have predated the Roman invasion by many centuries (Margary 1965, fig 9).

Little Furnace Wood lies about 17km from the Barcombe–London road at Maresfield, along the ridgeway west through Hadlow Down. It is about the same distance along the ridgeway, through Burwash to the east, to the River Rother at Etchingham, where water transport downstream to the CLBR port at Bodiam might have been possible in the Roman period. It is also only a little further away (19.5km) from the CLBR site at Kitchenham Farm, where there would have been direct access to the sea, via the ridgeway to the south-east through Punnett's Town. Relatively similar distances apply to several of the sites in the area (Fig. 15).

It is also apparent that the ridgeways were likely key to the exploitation of the iron resources in the area around Little Furnace Wood. The group of ridges that converge on Cross-in-Hand form the watershed of the headstreams of the Rother, Ouse and Cuckmere river basins, and the predominance of bloomery sites close to headwater streams

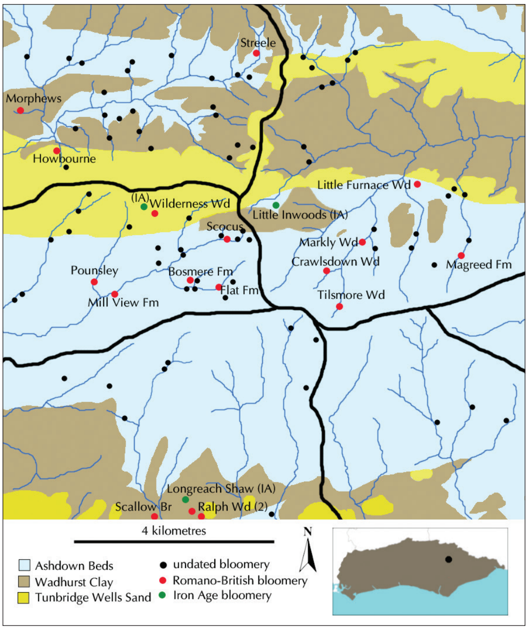

Fig. 15. Map showing Little Furnace Wood in context.

suggests that access along the ridgeways would have been key to prospection for suitable locations for smelting sites, as well as the subsequent movement of iron products.

It might also be expected that a location along one of the ridgeways would act as a hub for organisation and/or distribution. No such site has been identified, although evidence of a building associated with non-local Roman pottery at the ironworking site at Howbourne (TQ 5163 2488) implies a site of some importance.

Similarly, the discovery of a hypocaust tile at the Morphews bloomery site (TQ 509 256), tentatively suggests a similar arrangement. To the west of the main north–south ridgeway, at the bloomery sites at Pounsley and Mill View Farm, a short distance from each other, sherds of Samian ware hint at more than native interest in what was going on there.

These sites, however, are at some distance from Little Furnace Wood. Nearer is another potentially important site at Crawlsdown Wood (TQ 5735 2250), where slag covering about a hectare identifies it as a major production centre and possibly a hub for other satellite bloomeries. At the site in Markly Wood, close by, sherds of non-native fine ware were found.

Compared with an estimate of the quantity of slag remaining at other sites in the Weald in the Roman period, Little Furnace Wood was of modest size, suggesting either prolonged operation over a limited number of seasons or, more probably, in view of the spread of dating evidence, periodic operation over a long time (Hodgkinson 1999). A majority of the other bloomery sites in the area in the same period were of similar size and output.

CHOICE OF SITE

The location of bloomery sites in relation to the solid geology shows that the majority of sites in the area covered by Fig. 15 were located on the Ashdown Sand Formation, presumably exploiting pockets of iron-bearing clay. Where there was Wadhurst Clay, sites were generally located close to the interface between the clay and the Ashdown Sand, but often on the latter, the main layers of iron ore occurring near the base of the clay.

Iron ore also occurs in clay bands within the Tunbridge Wells Sand. Little Furnace Wood, as has been noted above, was sited on the Ashdown Sand, potential sources of iron ore lying uphill to the south, and beyond the fault-line stream to the north, where the upper level of the Wadhurst Clay appears from beneath the Tunbridge Wells Sand. The report on the archaeometallurgical residues indicates that more than one ore was used at the site, suggesting multiple sources. The preference for a sandy location can be accounted for by the need for well-drained working conditions, which is likely an influence at other sites as well.

The Little Furnace Wood site also lies close to a small stream, with, as the map shows, many other bloomeries occupying similar locations. Access to water is useful for puddling clay for furnaces and for obvious safety considerations. Another contributory factor will probably have been the spur ridgeway that is Newick Lane, linking the site to the main east-west ridge at Heathfield and facilitating the movement of raw materials and products to and from the site.

CONCLUSION

The excavations in Little Furnace Wood have provided significant new information about Romano-British ironworking in the Weald. They have revealed the remains of two Romano-British iron furnaces, together with ore-roasting pits and other related ironworking features, dating to AD 43–120. The extent of the slag heap was also established. The nature of the excavations, in a woodland setting, and past animal and tree root disturbance have resulted in a fragmentary record, with large parts of the site not possible to investigate.

Both excavated furnaces had been covered by the slag heap, suggesting that ironworking continued after they were abandoned and indicating the presence of at least one additional furnace further upslope, with the resulting slag tipped downslope to cover the disused furnaces. Pottery evidence suggests that ironworking activity in Little Furnace Wood may have continued into the 3rd century AD.

Supplementary reports can be found on the ADS website at http://archaeologydataservice.ac.uk/archives/view/sac

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Author: Chris Butler, CBAS Ltd, Unit 12, Mays Farm, Selmeston, Polegate BN26 6TS; chris.butler@cbasltd.co.uk

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