Cudworth Pasture, Castleshaw

Excavation Report

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1. Introduction

This interim report presents the results of the third and final season of archaeological investigation into medieval iron smelting in the Castleshaw Valley, Saddleworth, Oldham. The excavation examined the site of Wrigley's furnace on Cudworth Pasture at SD 997 105 (fig 1).

The excavation was generously supported by North West Water plc and conducted under the auspices of the Greater Manchester Archaeological Unit. The British Academy once again funded scientific analysis.

2. Results from the 1993 Excavations and a Research Brief for 1994

The 1993 excavations beside Spa Clough successfully located and recorded two iron smelting furnace bases together with an associated working hollow and post setting. These features were preserved under two deposits of slag, one roughly contemporary with the smelting, the other representing upcast from late 19th century digging connected with the construction of the reservoir. The dating evidence put the smelting activity firmly in the late medieval period, with a late 12th or early 13th century date being suggested; at this time the Cistercian Roche Abbey held the land in Castleshaw Valley.

The furnace base revealed by Ammon Wrigley in 1907 was located and shown by magnetic survey techniques to be a separate site from the one beside Spa Clough some 200m away. An exploratory excavation of a depression adjacent to Wrigley's furnace site revealed a storage area with deposits of unprocessed iron ore together with flatish stones (used in constructing the furnaces?) as well as a red clay and charcoal layer thought to represent the edge of a potentially significant feature.

Continuing investigation of the slag spoil heap beside Spa Clough would probably reveal further small islands of surviving medieval deposits. However, given the level of 19th century disturbance to the site, it was decided that the final season of field investigation should be limited to the Wrigley furnace site and its immediate environs. Although it was recognised that the furnace structure itself had been removed, it was hoped that other features associated with the smelting process would survive intact. Certainly the exploratory excavation of 1994 led us to believe that this was indeed the case and the evidence suggested that we may expect to find, amongst other things, a roasting hearth and perhaps an intact slag spoil heap.

3. The 1994 Excavations

Investigations concentrated solely on the Wrigley furnace site and associated features as indicated in last year's magnetic susceptibility and contour surveys and exploratory excavation (Redhead, 1993) (plate 1).

Initially, a trench measuring 6.5m by 10m was opened up south of and adjoining area 4 from last year. This new trench incorporated the site of Wrigley's furnace. As the excavation progressed further areas were opened up as required in order to properly understand archaeological features (fig 2).

Removal of turf and topsoil revealed three main deposits: dumps of slag and charcoal debris along the north and eastern edge of the excavation area, natural clay loam in the middle and western areas and the site of Wrigley's furnace with associated deposits in the southern portion of the trench (plate 2).

Last year two deposits: [405], mid yellow-grey silty clay loam containing around 30% small to large patches of charcoal and *c*10% small fragments of burnt red ironstone and shale, and [406] which was similar but with no charcoal, enclosed and appeared to be associated with a small patch of fire reddened clay [407] which disappeared under the edge of the excavation area. [407] appeared to register as an anomaly in the magnetic susceptibility survey and it was hoped that it may indicate the presence of a furnace or roasting pit. The 1994 excavation showed that these deposits were in fact spreads of dumped material, presumably related to waste from smelting or roasting. [407] proved to be just a small patch of fire reddened clay (fig 3). [405] was found to overlie a more extensive area of red clay which appeared to have been heated in situ, but there was no evidence for a furnace or roasting site at this spot. The red clay was amorphous and was perhaps created by [405] being extremely hot when deposited. Similar red clay patches, noted below, were exposed beneath [462] and [417].

Other spreads of waste debris occurred in this area, including [413] which contained *c*15% small fragments of fire reddened ironstone and [414] which seemed to represent the edge of this dumping activity, comprising mainly mid yellow brown friable silty clay loam with only occasional ironstone, charcoal and slag fragments.

Further deposits of iron working debris were encountered in a band against the east side of the excavation area. [415] and [416] contained substantial amounts of charcoal and slag petering out on the west side to natural clay loam [435].

The impression given by the direction in which these debris deposits lay was that they originated from activity to the east or north-east of the excavation area. Two exploratory slots, 4(b) and 4(c), 4m by 1m in size, were dug to identify the nature of this activity (fig 2).

4(b) was located on the site of a magnetic anomaly which was also noted as a slight mound in the contour survey of 1993 (Redhead, 1993, p4,25). Immediately upon removal of the turf a dense concentration of charcoal was encountered, terminating on its east side with a curved edge clearly defined against natural yellow clay loam. An area 5m by 5m was opened to reveal the full extent of the charcoal deposit (plate 3, fig 4).

The charcoal formed a low eliptical mound [F453] *c*4m by 3.2m, with a maximum depth of 20cm. But the mound comprised more than just charcoal: the top layer [441] was of deep red brown iron fines with 30-40% pieces of charcoal and moderate fragments of slag, beneath this was [439] which was almost pure charcoal 5-10cm deep and below this was the main, primary layer [440] of the mound which was made up of a gritty matrix of deep red-brown fines with 30% flecks or small pieces of charcoal, occasional small fragments of slag and sandstone. [440] also contained several fragments of ironstone with many tiny pieces picked up by magnet, as well as frequent lumps of conglomerated cinder and charcoal.

The east side of [F453] was bordered by natural yellow clay loam [412], whereas the north and west sides had mid brown silty clay loam with 20% small to large patches of charcoal and some brown cinder and slag. This latter material [442] was almost certainly derived from [F453], being washed or raked from the mound. To the south and south west of [F453] was a band of broken plates of tap slag [438] with charcoal pieces and occasional fragments of burnt red sandstone. [438], which was partly sealed by [440], ran east to west and continued into the main excavation area as [416] (mentioned above).

The mound was divided into quadrants with the east and west segments being excavated to provide two sections (fig 5 sect I-J and K-L). Subsequently, the north quadrant was also removed but the southern one has been preserved in situ. Samples were taken from the mound for radiocarbon dating and micro-analysis. The results of this work are reported on pages . There was a marked lack of structural evidence with neither a pit nor post holes being evident. [440] came off onto a natural creamy white-yellow silt clay layer [443] which was characterised by extensive mid-orange mottling. If this mottling effect was caused by heat then the temperature was not great and certainly in contrast to the intense oxidisation apparent around and under the smelting furnaces and tapping channels revealed in 1993.

Only 3 features of interest were sealed by [440]: 2 roughly circular depressions 5-10cm deep and a maximum of 80cm diameter and a small linear ridge 3-4cm high and 50cm long running south to north (fig 6). Considerable root activity was evident and an uneven curving ridge to the south east may be associated with this disturbance.

The composition of [F453] and its situation only 6m to the north west of the smelting furnace excavated by Wrigley and 7m south east of the dumps of ironstone found in 1993 indicated that it was a simple form of roasting bed. Investigations at other smelting sites have found more elaborate roasting hearths set into lined pits but at Castleshaw it appears that ironstone was simply roasted on a bed of charcoal placed on the existing ground surface (plate 4).

Roasting was a necessary part of the iron smelting process. At relatively low temperatures moisture was driven out of the mined blocks of ironstone which also fractured into much smaller pieces to facilitate a better smelt. Evidence from the exploratory Trench 4 in 1993 found unprocessed ironstone together with material interpreted as roasting debris. Another piece of the jigsaw has been fitted together with the discovery of this simple roasting bed.

Slot 4 (c) was located some 8m north-east of the 1994 Area 4 (fig 2). Its position was mainly determined by a strong reading picked up by metal detector which proved to be an iron-rich piece of slag. In fact three- quarters of the slot comprised sterile loam [412], whilst the remainder yielded a 5-10cm deep deposit of blocky tap slag fragments in a friable light to mid yellow brown silty clay loam soil [468]. This deposit was c1m wide and ran in a north-south direction, its edges were sinuous and gently sloping. Several very small pieces of hard red clay displaying inclusions of quartz/mica were found and one of these gave the appearance of a base sherd of pottery, although at 1/2cm across the fragment was too small to allow proper identification. [468] may have filled a run-off channel from a smelting furnace further north, however, there was no heat reddening on the base and sides of the channel.

The main thrust of the 1994 investigation was to examine the site of Wrigley's furnace excavation in 1907. Saddleworth Historical Society are known to have re-dug this site in the 1970s and it was anticipated that little evidence of the furnace structure itself would remain, especially as Wrigley recounts removing the furnace base (Wrigley 1912 p172). However, it was hoped that associated features adjacent to the furnace may have escaped unscathed.

Prior to de-turfing, the Wrigley furnace site showed as a shallow grassy depression with some large gritstone boulders around the edge. Upon cleaning the extent of previous excavations became readily apparent (plate 5, fig 3). A central depression [F420] of c1.6m diameter, backfilled with loose mid-brown grey silty clay loam [421], marked the position of the furnace shaft base removed by Wrigley. To the west this old excavation trench terminated in a square projection 80cm across [426]. It was evident from Wrigley's sketch of the furnace remains that he had dug a trench around the outside of the furnace base (fig 7); this survived as a dark grey silty clay loam filled trench [F422] forming a crescent with its open side facing south. It was separated from [F420] by a thin ridge of natural yellow clay (fig 5 sect A-B). The outer edge of [F422] was quite ragged and could be matched with the Wrigley sketch. The terminii of the crescent were filled with large quantities of red and yellow clay patches and shale [424] and [428], presumably derived from the furnace remains. Interestingly, these terminii cut into a large spread of in situ pure charcoal [430] which gave an indication that original smelting related deposits would survive. [430] was only a maximum of 7cm deep but occupied a substantial area *c*2m across, extending south from the furnace site to the excavation area edge (fig 5 sect C-D). On the southern side it was sealed by [432] which was a darker version of [435]. To the north [430] was separated from [F420] by a thin band of natural yellow clay 15cm wide. [F420] and [F426] (which cut the outer trench [F422]) seemed to represent the re-excavation carried out by the Saddleworth Historical Society. A number of large boulders that looked meaningfully arranged prior to de-turfing proved to be merely part of the excavation backfill (fig 5 sect M-N). Not one of the large stones could be associated with any smelting activity. Removal of the backfills [421] and [427] did, however, reveal a surprisingly high level of survival of smelting related deposits.

The impression of the shaft furnace base could still be identified in the way that the natural clay had discoloured through heat in the bottom of old excavation trench [F420] (fig 8). A triangular patch of very hard biscuit- like light grey clay and shale [450], which measured 48cm by 64cm, represented the position of the concave slag and cinder base pulled out by Wrigley (Wrigley 1912 p170,172 fig 7) and was very similar to material lying immediately under the slag accretions in the base of the two furnaces revealed in 1993 at Spa Clough (Redhead 1993). This is were the pipe shaft was located (plate 6).

Surrounding [450] was a ring of dark red coloured shale and clay of c1m diameter. This indicated the location of the furnace walls and closely parallels the dimensions of the Spa Clough remains. A slot was put through [448] to record it in section (fig 5 sect O-P) where it was found to be a maximum of 18cm deep. This deep reddening was caused by the tremendous heat and continuous re-use of the furnace. The reduced grey clay of [450] changed to a khaki coloured, slightly less hard clay [451] before merging into the deeper red of [448].

Evidence for a tapping channel existed in the form of a band of black gritty cinder 6cm deep, [444], spreading out to the west of the furnace base site. Unfortunately the old excavation trench was at its deepest in the crucial area where the tapping arch would have been located. At this point a deposit of reddened shale and clay interspersed with bits of biscuity yellow clay and frequent small fragments of sandstone [449] was deemed, by its mixed, loose nature, to be excavation backfill. It certainly came off cleanly onto [448], partly overlay [450] and filled a depression which cut [444] (fig 5 sect M-N).

Further to the west, [444] was also cut by the base of the crescent shaped old excavation trench [F422]. However, the trench had not removed the heated red clay and compact shale [445] which formed the base of the tapping channel at this point (plate 7). The depth of the heat reddening and black cinder is shown in figure 5, section Q-R. In the western edge of the old excavation trench [F426] it could be seen that a thick deposit, 30cm deep, of friable mid yellow-brown silty clay loam [435] formed a naturally accumulated layer infilling the depression created by the tapping channel. This layer was removed to reveal the full extent of the furnace complex.

From a narrow point of c40cm width close to the furnace base the tapping channel rapidly splayed out to a width of c80cm, running down a gentle slope for about 1.5m before terminating in a shallow slag collecting pit [F459] (plates 8 & 9). A deposit of densely concentrated slag in a matrix of brown silty clay loam [466], left in situ from the last firing of the furnace, formed the upper fill of [F459]. Beneath this was the black cinder layer [444], encountered on the base of the tapping channel, which reached a depth of 10cm here. [444] came off cleanly on to a mid-grey yellow clay loam [467] mixed with 20% flecks and pieces of charcoal and moderate lumps of burnt red clay (plate 10, fig 5 sect E-F, M-N). There seems to have been two phases to the ovoid shaped pit, with the top of [467] forming the base of a later hollow with fairly gentle sides and filled with [444] and [467]. An earlier pit, with a vertical or overhung edge on the west and south sides, was cut into loose natural shale and clay. The dimensions were 20cm deep by 1.3m across. [467] formed the fill of this pit and on the gently sloping east side there was heat reddening on the upper surface of [467] derived from hot cinders and slag from the last smelt. So although the furnace was no longer in place, there was good evidence for the process of removing slag and cinder waste from the smelt. Excavations south of the slag collecting pit provided further information on slag disposal.

Immediately under the turf and topsoil, at a point 90cm south of the slag pit, was a surface of flatly laid angular gritstones forming an oval shaped feature [F433] measuring 1.5m long by 1.3m wide (plate 11, fig 3 and 8). The stones had evidently been carefully laid to provide a level, slightly raised platform. There was neither evidence of a bonding matrix nor of foundations, it was simply a single layer of stones set into a shallow depression. Of note was the largest stone, 60cm long by 15cm wide, which was located at a north-west point of the platform and was clearly set at an angle dipping towards the centre of [F433]. On the opposite, south side of the platform there was again a stone pitched towards the centre, but this time smaller (22cm by 18cm) and packed around by pieces of shale and a little clay. There was some rabbit disturbance to the south side which may account for the extra packing material here.

There was no evidence for a post being set into or on [433] and it appeared to be too insubstantial to be a working platform (and certainly showed no signs of debris or damage one might expect from this activity). Two further features nearby gave a clue as to its function. Only 50cm from the stone platform, on its west side was the edge of large slag spoilheap [F455] which will be described shortly. Between this spoil heap and the slag pit was a roughly circular spread of tap slag [461] *c*60cm diameter mixed with black cinder [463] which filled a slight depression with a base of red clay. The cinder and slag had obviously been very hot when deposited as they had heated the natural yellow clay to a red colour. This spread of material was directly opposite and only 40cm from the large, pitched stone belonging to [F433] (plate 12). It seems likely that the stone platform was used as a secure footing for one of the smelters to rake out slag from the slag pit on to the slag spoil heat. This operation was undertaken at regular intervals and was essential to stop the run-off channel blocking up. The slag was evidently raked whilst extremely hot, therefore the stone platform gave protection from the heat as well as giving secure footing to the operative (the leading foot could be braced against the large angle stone).

This raking activity also explains the two phases to the slag pit. Constant pulling out of slag created a deep depression with an overhanging edge leading to difficulty in removing the slag efficiently (plate 13). A certain amount of clay infill was necessary to restore a smooth, gentle sided collecting pit.

A grassy knoll *c*10m from and south-west of the Wrigley furnace site, was prominent on the contour survey (Redhead 1993 p4,25) and gave very high readings on the magnetic susceptibility survey. It was not clear though, prior to excavation, whether this was an in situ slag spoil heap connected with the furnace or just a spoil heap from previous archaeological excavations.

In an extension of the south west corner of Area 4, intended to uncover all of the stone platform [F433], the curving edge of a very substantial slag spoil heap [F455] came to light (plate 12, fig 3 and 8). A 1m wide slot was cut east-west across this slag heap in order to record a section through it (plate 14, fig 5 sect G-H). At this point the mound measured 8.5m across and a maximum of 70cm deep. There was an upper layer [437], maximum 12cm deep, of mainly tap slag mixed with much brown humus from grass root action. A single rim sherd of late medieval Pennine Gritty Ware came from near the bottom of this layer. At the base of the mound was [457], a maximum of 11cm deep, which consisted of black cinder, grit, very fine bits of slag and charcoal. But the main bulk of the mound was almost pure slag [456]; mainly tap slag but also with slag from the furnace base and sides, and including some hard baked pieces of clay lining and a few lumps of conglomerated cinder. On the east side [456] tapered off on to black cinder and charcoal [457], to the west it thinned out downslope on to natural yellow-brown subsoil. Where overlain by the slag spoil heap, this natural subsoil displayed concentrated dark orange mottling derived either from iron staining or from the effects of hot slag.

It was possible to make a very rough calculation of the slag mound's total weight. Spoil from the slot excavated through the mound had been kept separate. An average wheelbarrow full of slag spoil weighed 70kg. About 70 wheelbarrow loads had been extracted from the excavated slot, which represented about 1/6 of the total mound area. Therefore 70 x 70 x 6 gave us a very approximate total weight for the slag spoil mound of 29400kg or 29.4 metric tonnes.

There was little doubt that [F455] was indeed an intact medieval slag dump contemporary with, and located close to, the furnace excavated by Wrigley. The whole smelting complex of raw material storage, roasting bed, smelting furnace, tapping channel, slag collecting pit, raking platform and slag spoil heap formed a neat, compact area of activity that points to the efficiency of the medieval smelters. The stratigraphy was shallow and of one phase (unlike Spa Clough in 1993) and gave a strong impression of one season of smelting. Of particular interest is the size of the slag spoil heap, which is large for the waste product from one furnace. This is discussed in more detail elsewhere (see p).

4. Analysis of Excavation Samples

Identification of Charcoal Samples by Julie Bond

Four samples were submitted for analysis. The samples were identified by microscopic examination of clean fracture surfaces, using the criteria of Schweingruber (1978).

CW 94 430
CW 94 439
CW 94 465 (Bag 2)
CW 94 465 (Area 4 (a))

CW94 430
A sample of very small charcoal fragments intermixed with many fine roots which some cases have grown through the charcoal. If used for dating, pretreatment would be required to remove these roots.

The most frequent charcoal type in this sample is Quercus (oak). The largest fragment has approximately 45 rings present, but no heartwood. Other fragments show approximately ten rings, although of course the tree from which they came may have been appreciably older. Several fragments of approximately 25 rings appear to come from small branches, and there are also three fragments which may be root wood, also of oak.

The second type of charcoal present in this sample (approximately 20%) appears to be Alnus (alder). The largest fragment has 22 rings, with heartwood present but no bark; this again could be from a much older tree.

CW 94 439
This sample was again composed of very small fragments of charcoal, the majority of which was Quercus from mature wood, but with no heartwood or bark present (a maximum of 30 rings was counted in any piece). There were also four fragments of oak twig, less than 1.5cm in diameter and with a maximum of 15 rings.

CW 94 465 (Bag 2)
There are twelve quite large and identifiable fragments of charcoal in this sample; the rest are very small. Two charcoal types are represented: Salix, which forms the bulk of the material, and Quercus. Both are mature wood. The willow fragments have between 15-30 rings present, whilst the oak has between 25-40 rings. The oak charcoal includes fragments which show evidence of the points of origin of twigs and smaller branches

CW 94 465 (Area 4 (a))
Three charcoal types were present in this sample: Quercus, Alnus and Salix (willow).

The largest fragment of oak charcoal has a maximum of 30 rings; and most of the fragments of alder and willow between 25 and 30 rings. A single large piece of alder has over 40 rings; all these pieces are, obviously, from mature wood. The large fragment of alder also has remaining bark; the outer surface of the charcoal appears degraded, and there is a void where the heartwood should be, suggesting that this wood was rotting before it was burnt. There is also a suggestion of working on the end of the piece, although it is not possible to say whether this was from the felling of the timber or from use as an artefact (eg. a stake). There are modern roots throughout this piece which require removal if it is used for dating.

Discussion

If the charcoal in these samples is to be used for dating, the fact that almost all is from mature trees, quite possibly appreciably older than the number of rings would suggest, must be taken into account. Most of the charcoal from these samples lacks heartwood or bark, and therefore the number of rings is no indication of the age of the tree from which it came, since it is not a complete radial section. Oak in particular may come from trees which are a hundred or more years old, and because of its durability as a construction material, may have been in use for a considerable time before being finally utilised for fuel. Rackham (1987, 90-91) believed that the distinction between wood used as timber and underwood used as fuel was clear and that there was no crossover between the two; modern work in radiocarbon dating has shown that this is not the case (Ambers pers. comm.). Old timbers, their primary use over, are often re-used in other constructions, or are recycled as fuel. Thus, the radiocarbon date of charcoal may be much older than the date of its use as fuel. However, several things suggest that in this case, the probability is that the wood utilised was cut for fuel, and was not older re-used timbers.

None of the charcoal examined (with the possible exception of a piece from sample 465 (Area (a) - see above) showed evidence of cut or saw marks or worked surfaces, which might be expected if the material was from re-used timbers. The frequency of origin-points of twigs or branches in sample 465 (Bag 2) also suggests that this is unlikely to be construction timber, whilst the oak twigs in 439, and the branch (or possibly young trunk) oak fragments in sample 430, with approximately 25 rings, also suggest a more varied origin. Although ideally a radiocarbon sample would be composed of these 25 year old and younger pieces, there is insufficient material for this, and so the possible age of the mature tree must be taken into account when evaluating any date from this charcoal. If sample 430 is used, pretreatment will be necessary to remove the modern root fragments.

5. Dating of the Site

As with the Spa Clough site, both archaeomagnetic and radiocarbon dating techniques were employed. Once again GeoQuest carried out the former and Beta Analytic the latter.

Archaeomagnetic Dating

Three deposits were sampled for archaeomagnetic dating: the light grey, reduced shaley material representing the imprint of the furnace base [450], orange-red clay from the base of the tapping channel near the furnace [454], and burnt red shale at the base of the tapping channel were it splayed out into the slag collecting pit [445].

The six samples from beneath the furnace base [450] produced well grouped vectors, with the two from [454] containing shallower magnetic variations (see Appendix A - fig 3). When combined and compared with the UK Master Curve these vectors suggested a date range of **1290-1330 AD**.

Although samples from context [445] were unsuitable for dating purposes due to field distortion, they still produced results of great interest:

"Most samples obtained from Context 445 (adjoining the slag pit) contained an anomalous magnetisation in which the inclination but not the declination was reversed. This unusual result is interpreted as providing evidence that a bloom was present in the nearby furnace during the last heating-cooling cycle of Context 445." This phenomenon is discussed in more detail in Appendix A (p , also fig 1).

Radiocarbon Dating

Two samples were submitted for radiocarbon dating. These were taken from a spread of densely concentrated charcoal [430] south of the furnace site and a charcoal rich layer [439] within the roasting bed. The results were:

LAB NO.	SAMPLE NO.	RADIOCARBON AGE
Beta-80629	430	910 +/- 60 BP
Beta-80630	439	680 +/- 50 BP

The calibrated age range, using two sigma statistics (95% probability), was:

430	**cal AD 1010 to 1260**	
439	**cal AD 1265 to 1400**	(see Appendix B).

Broadly speaking, these dating results marry reasonably well with those from the 1993 Spa Clough excavations. They re-inforce the suggestion of a late medieval origin for the iron smelting remains at Castleshaw. The radiocarbon dates are remarkably similar to the two derived from charcoal samples taken from the Spa Clough site. Again we have a dichotomy which may, to some extent, be explained by the relative maturity of the wood at the time of its use as fuel. Certainly, [439] appears to have been comprised of younger wood than [430] as is shown in the report on charcoal identification (p).

The archaeomagnetic date is about a century later than that for the furnace at Spa Clough, but given the difficulties of precise dating with this technique it is encouraging to note that both archaeomagnetic dates place the smelting activity into the period when Roche Abbey administered the Castleshaw Valley.

With the lack of dateable finds – a mere handful of pottery sherds, only one of which was stratified, in three seasons of excavation – scientific dating techniques have been essential in determining a reasonably confident date for the smelting process at Castleshaw. The body of evidence from the dating analyses has successfully given a late medieval date, perhaps of the 13th century. The dating techniques have also identified and encouraged analysis of other important aspects of the smelting process: with archaeomagnetic dating it has been the cooling affect on magnetic distortion and with radiocarbon dating the age and type of wood used for fuel.

Conclusion

The combined evidence from the two iron smelting furnace sites investigated in the Castleshaw valley provides a remarkable picture of late medieval bloomery production. Beside Spa Clough only a small island of medieval deposits survived amidst disturbance of the late 19th century reservoir construction. Yet that 'island' of intact archaeology produced two well preserved furnace bases. At Cudworth Pasture, on the other hand, the furnace structure itself had disappeared in previous excavations, but associated features survived very well; including a slag collecting pit, stone platform, slag spoil heap, roasting bed and storage area. Data derived from laboratory dating techniques has demonstrated the importance of using these methods for this category of site and highlighted some problems that archaeologists may encounter in their application as well as shedding light on some aspects of the smelting process.

Comparison with other hand powered smelting sites of this period is difficult given the sparsity of well dated, carefully excavated examples. The major iron production areas, such as The Weald and the Forest of Dean appear to have had a much higher level of organisation. Minepit Wood (Rotherfield in The Weald), was a 14th century smelting furnace within a rectangular enclosure in which charcoal and roasted ore were also stored (Money 1971). Here the site was used for a considerable period of time. The Castleshaw sites give no impression of this degree of permanence; indeed, no evidence for enclosing structures have been found at Cudworth Pasture and only one post pad came from Spa Clough (though here the level of disturbance must be taken into account).

The over-riding impression given at Castleshaw is one of itinerant, seasonal smelters exploiting the local fuel and ore resource and then moving a few hundred metres further on. Wrigley recalls several slag heaps within half a mile of the Spa Clough one, including ones now covered by the reservoirs. Recent research in West Yorkshire indicates a similar pattern of exploitation.

Charcoal making sites would certainly have existed in the Castleshaw Valley and are almost certainly going to be located fairly close to the furnace, as charcoal was such delicate material to transport and would have been needed in large quantities. A possible charcoal clamp was partially excavated in Area 1, beside Spa Clough (Redhead 1994). Apart from the lack of associated buildings, the iron production sites at Castleshaw are notable for the absence of evidence for primary smithing.

Initial slag analysis suggests that no primary smithing (in which the bloom was hammered on an anvil to remove impurities) was undertaken at the smelting sites and this is supported by the absence of any archaeological features that may be assigned a smithing function. It is possible that the blooms were taken to a local smith for treatment, perhaps even the abbey farm (grange) and it is interesting to note that a hamlet called Grange exists in the Castleshaw Valley about two kilometres from Cudworth Pasture.

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Thanks to Jayne for extra support and those cakes!

Key to Conventions

Mid yellow grey silty clay loam with 20% shale

Red clay

Dark brown silty clay loam

Mid yellow brown friable silty clay loam

Mid brown silty clay loam

Mid yellow brown silty clay loam with 15% patches cream silty clay

Very dark grey silty clay loam with patches yellow clay and peat

Mid orange brown friable silty clay loam

Charcoal

Very dark brown silty clay loam

Mid brown silty clay loam with 20% charcoal and mixed slag

Deep red brown cinder/fines with 30-40% charcoal

Deep red brown grit/cinder/fines

Tap and furnace slag debris

White/yellow silty clay with mottle orange patches

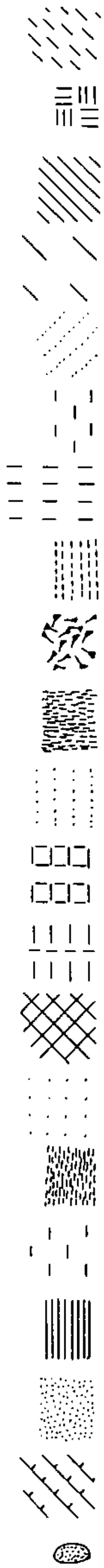
Black cinder and fine slag debris

Mid brown yellow silty clay loam

Khaki coloured biscuit-like clay and shale

Very hard biscuit-like light grey clay and shale

Mid grey yellow clay loam with shale and lumps of red clay/charcoal



List of Sections and Figures

The following sections are shown in Fig 5:

A-B: west facing through [F422, F420]

C-D: east facing through [430]

E-F: east facing through slag pit [F459]

G-H: north facing through slag spoil mound [F455]. Note: shown at half scale of other sections.

I-J: north-west facing through roasting bed [F453]

K-L: north-east facing through roasting bed [F453]

M-N: south facing through slag pit [F459], tapping channel, site of furnace base and [F422]

O-P: west facing section through site of furnace base

Q-R: west facing section through tapping channel

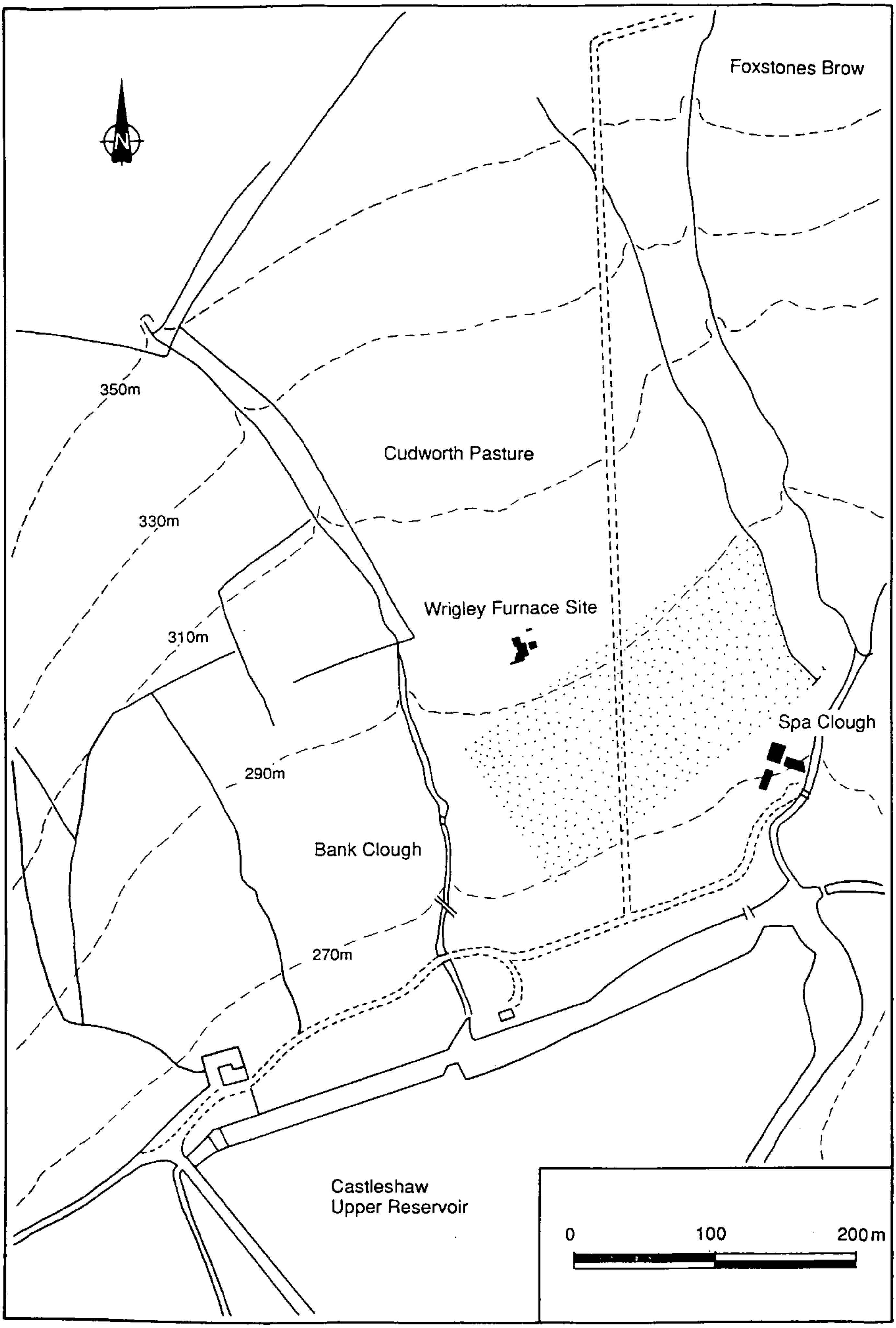


Fig.1 - Location of the Cudworth Pasture and Spa Clough furnace sites in the Castleshaw Valley.

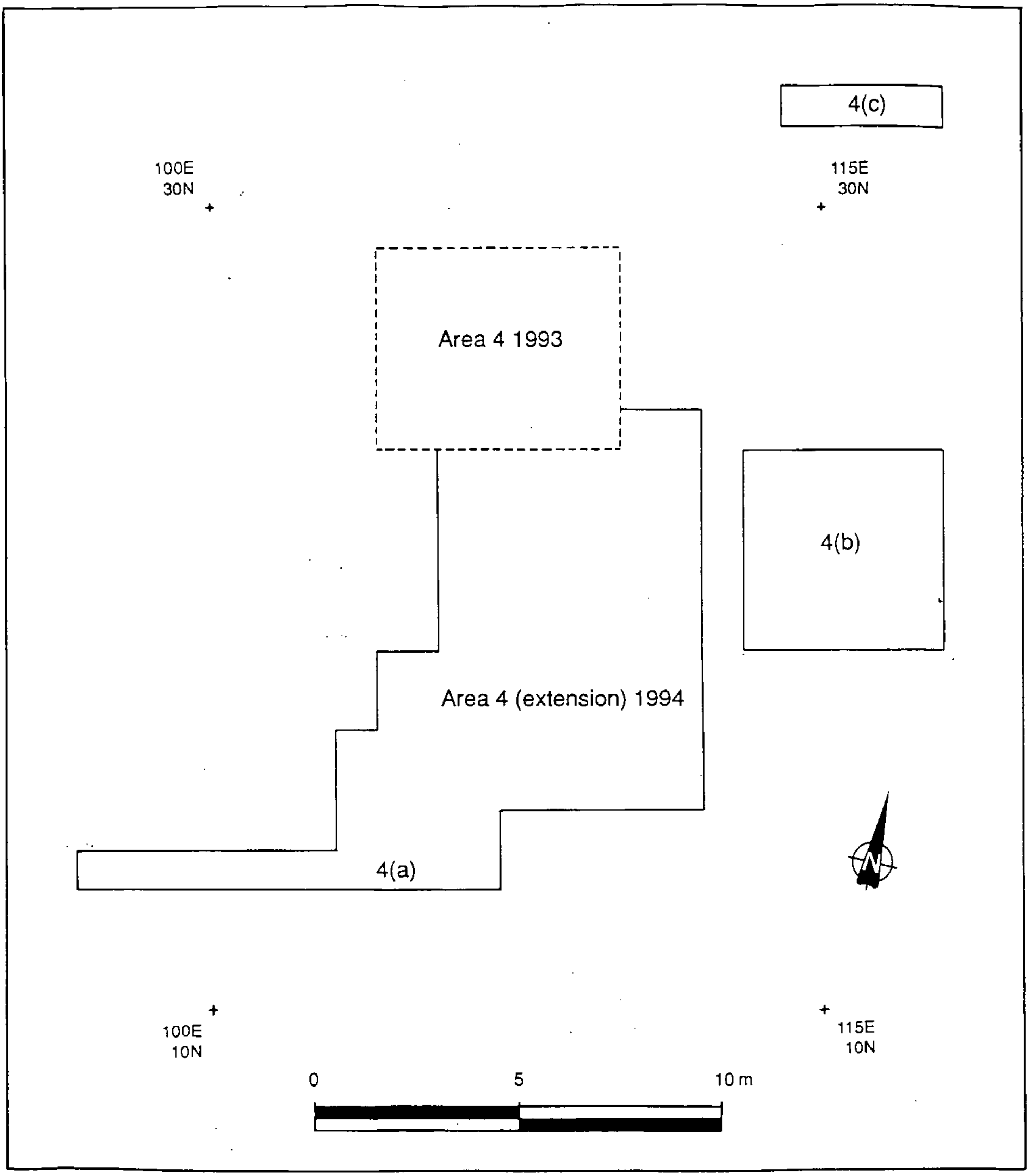


Fig.2 - Location of the excavation trenches.

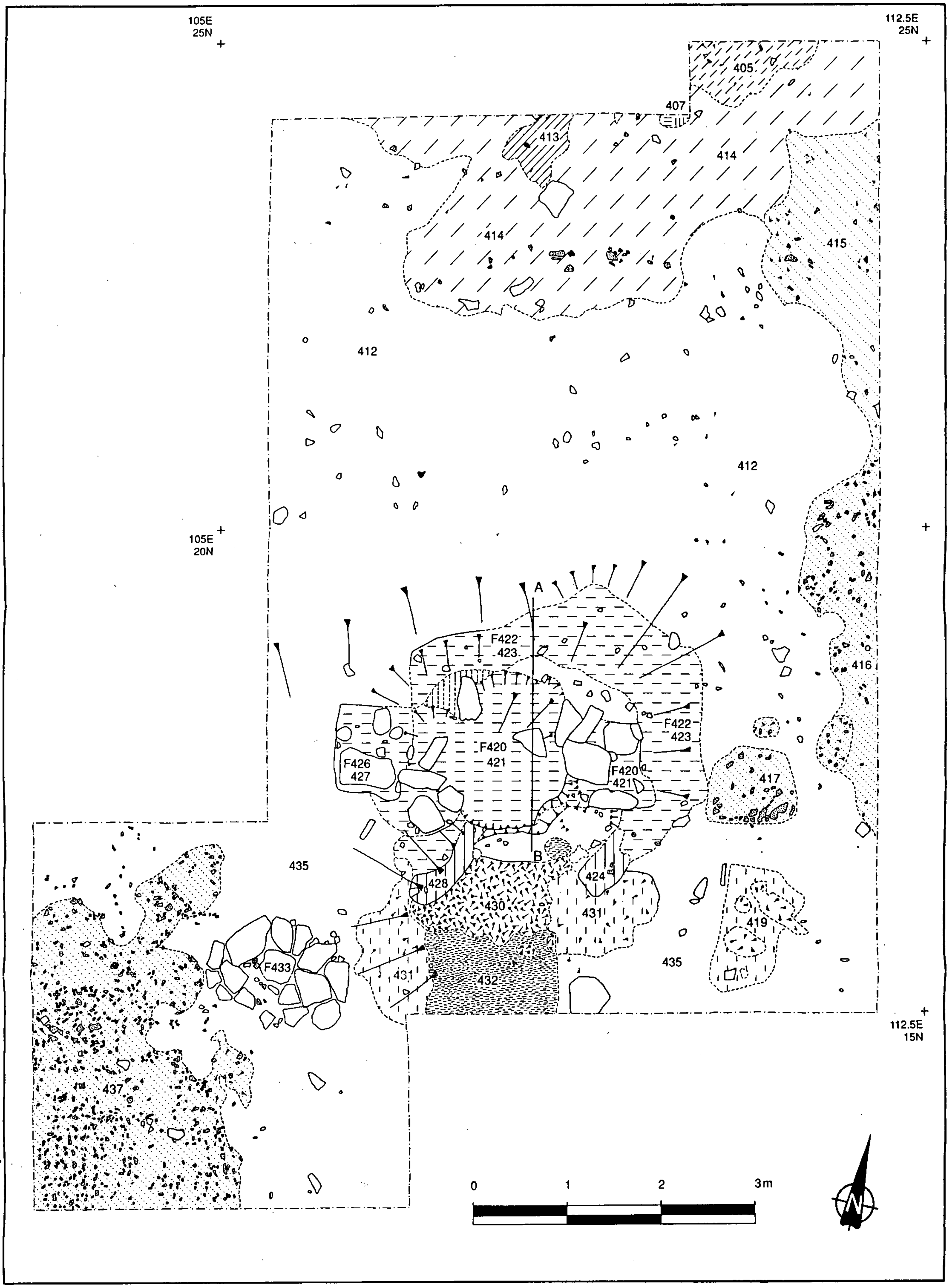


Fig.3 - Area 4 after removal of turf and topsoil.

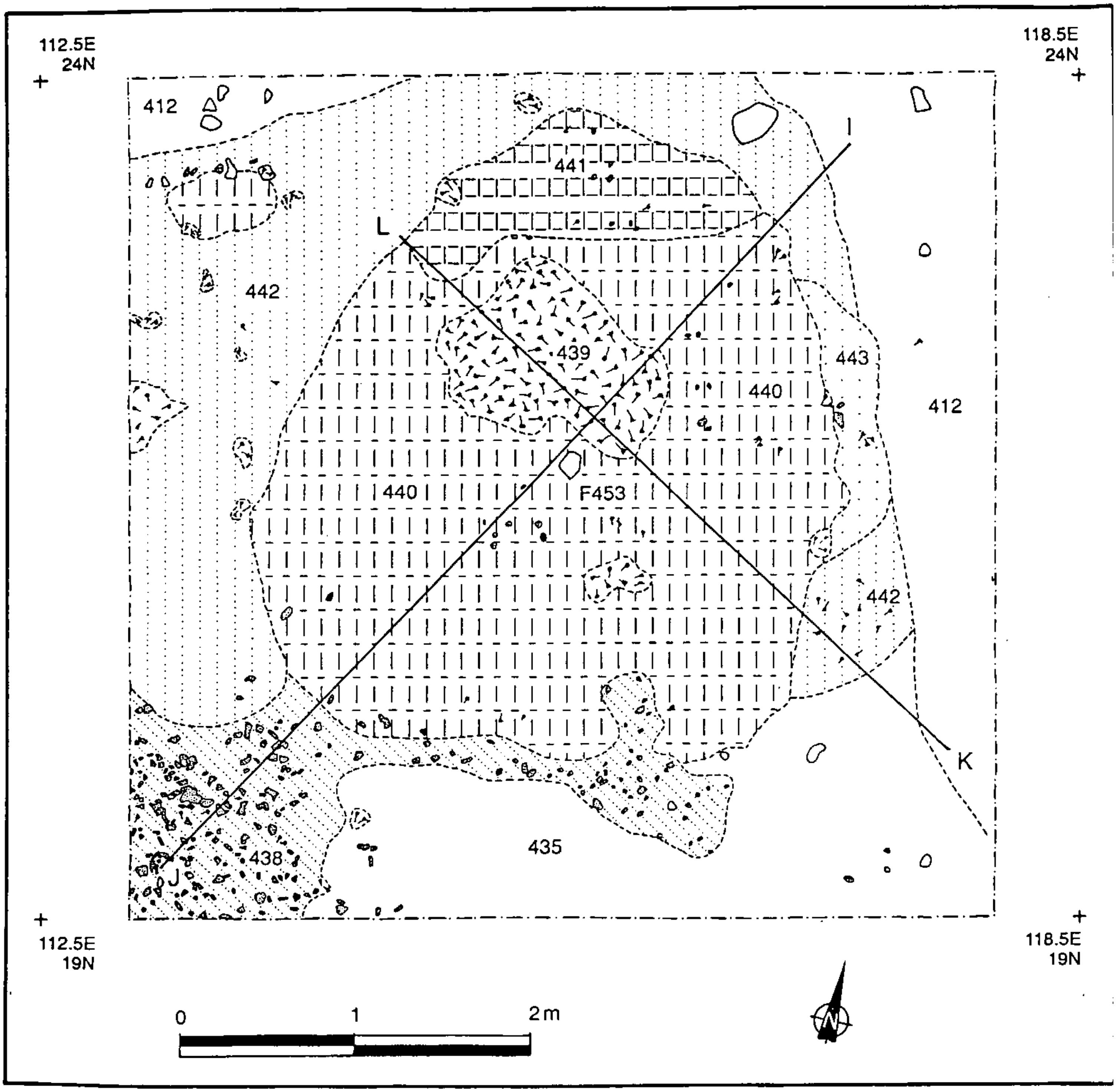


Fig.4 - Area 4 (b) after removal of turf and topsoil showing roasting bed pre-excavation.

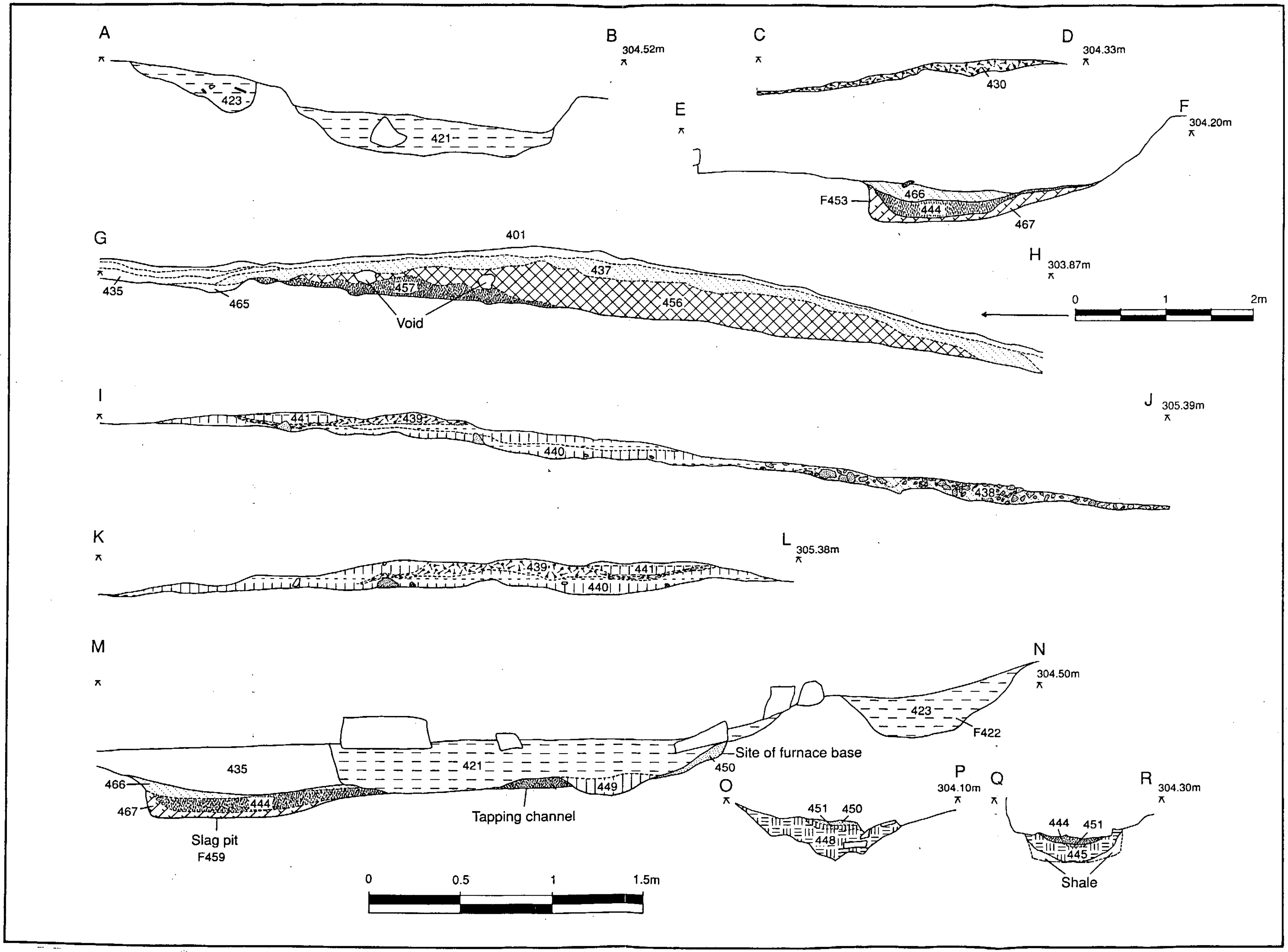


Fig.5 - Sections through features in area 4, 4(a) and 4 (b). See Figs 4, 6 and 7 for location.
Note: Section G-H through slag spoil heap is at half the scale of the others.

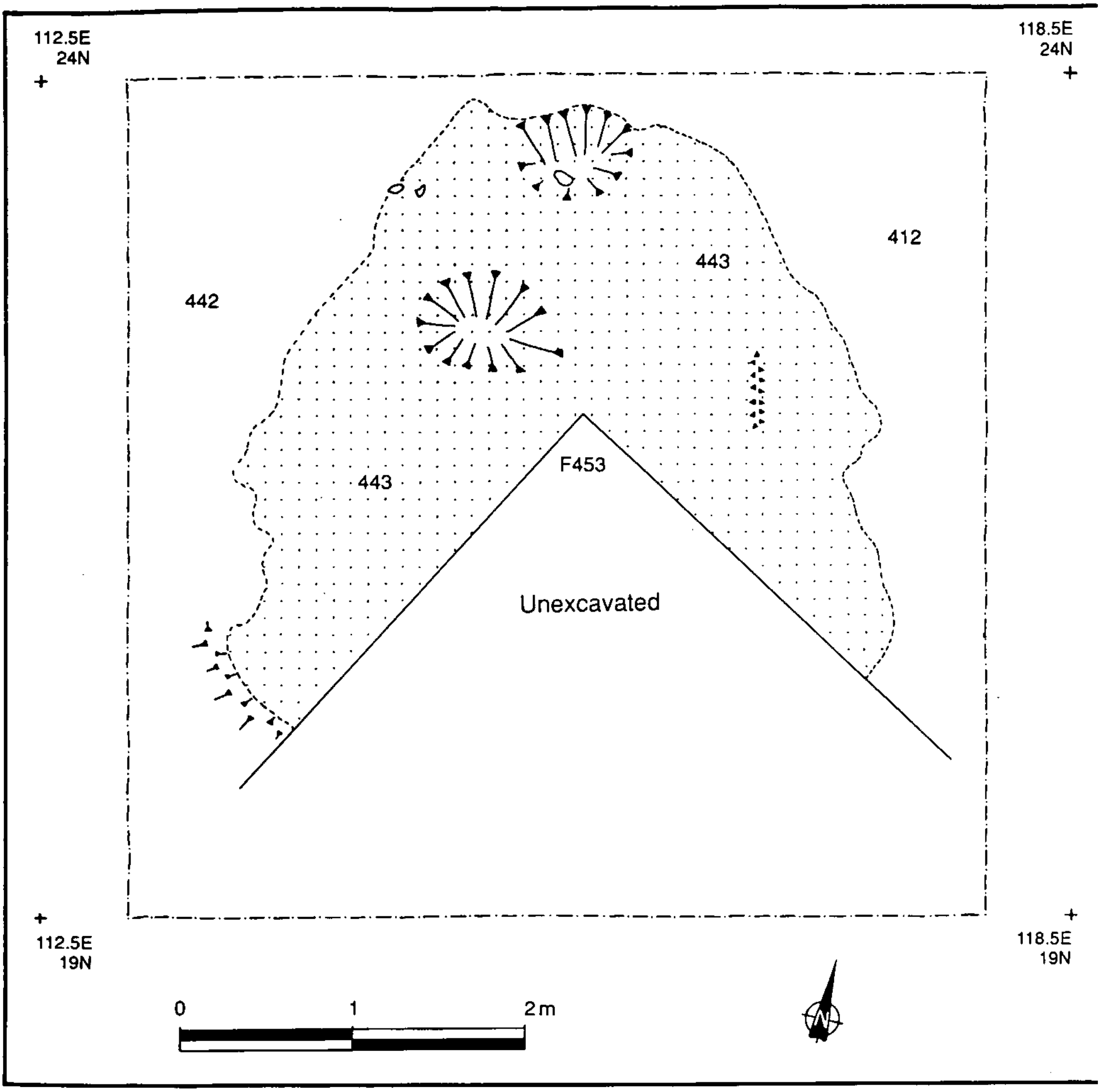


Fig.6 - Area 4 (b) after removing 3 quadrents of the roasting bed F453.

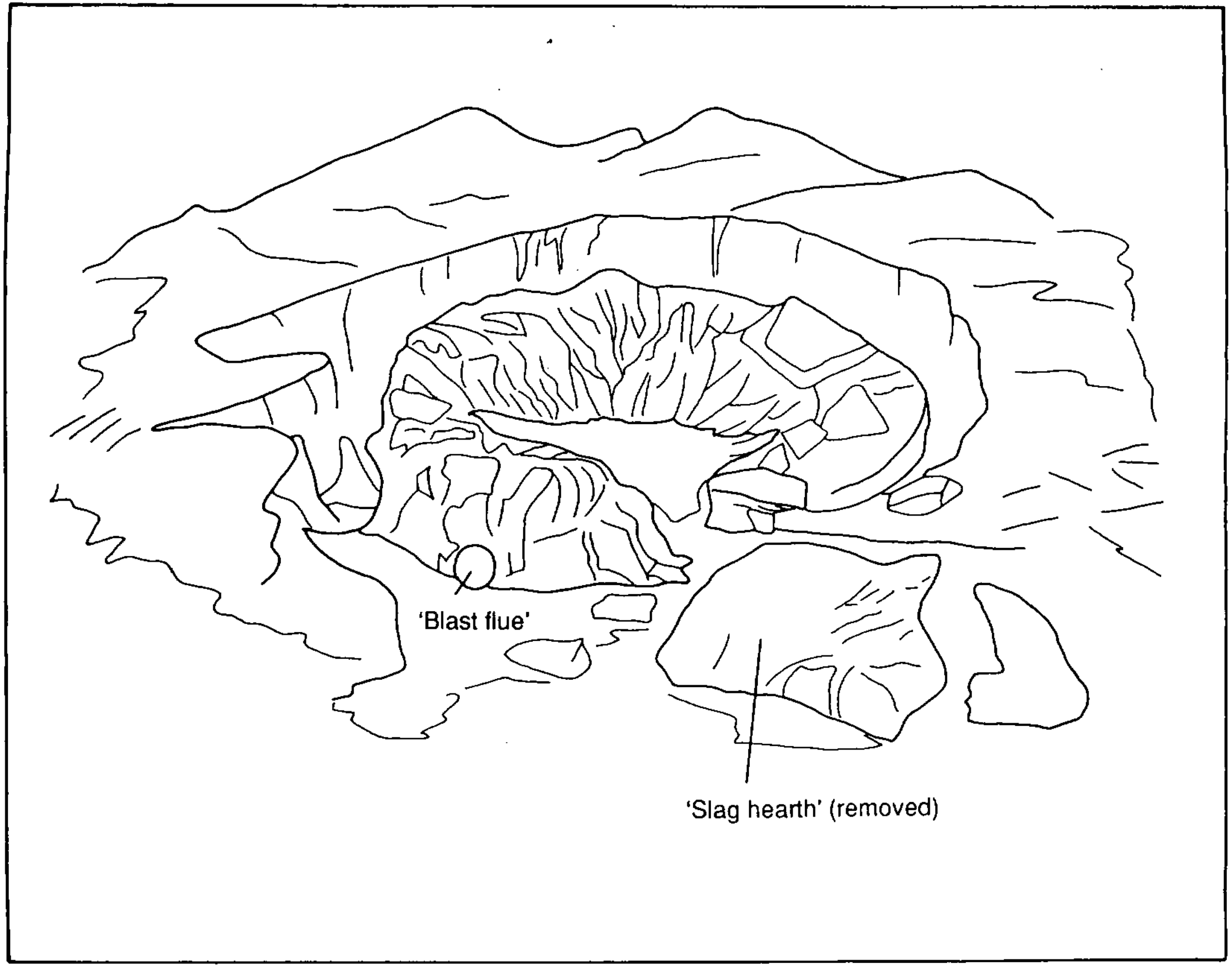


Fig.7 - Line drawing of the furnace excavated by Wrigley, based on his sketch in Songs from a Moorland Parish (1912).

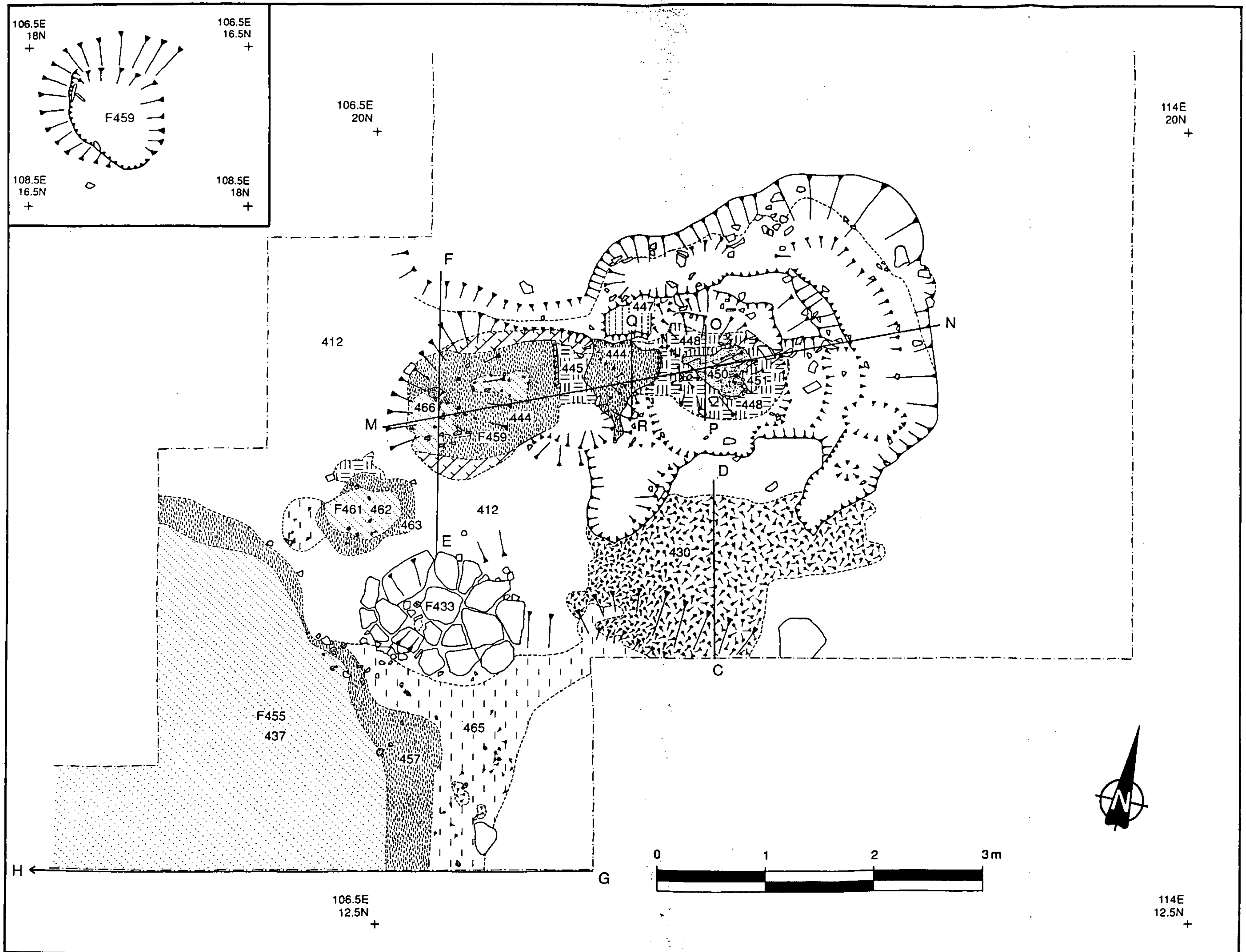


Fig.8 - Area 4 furnace complex after removal of excavation backfil and 435. Inset: Slag pit F459 post-excavation.

Plate 1 - The 1994 excavation site in its setting, high up on the slopes of Cudworth Pasture overlooking the Castleshaw Valley.

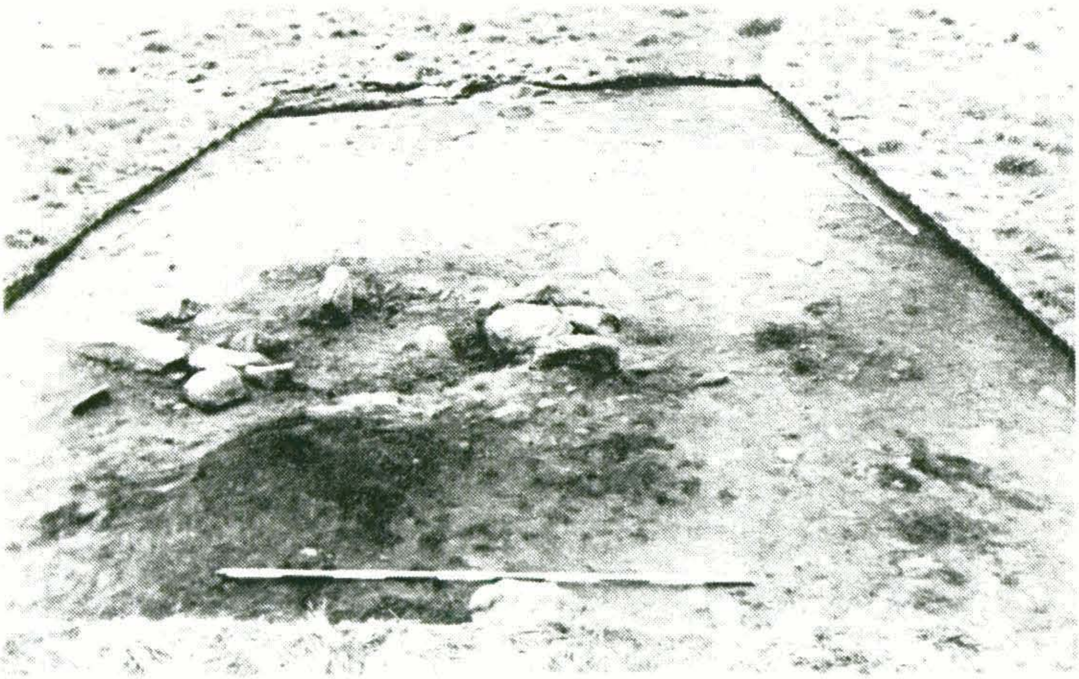


Plate 2 - Main Area 4 after removal of topsoil, looking north. Wrigley's furnace site **is marked** by the concentration of stones in the foreground.

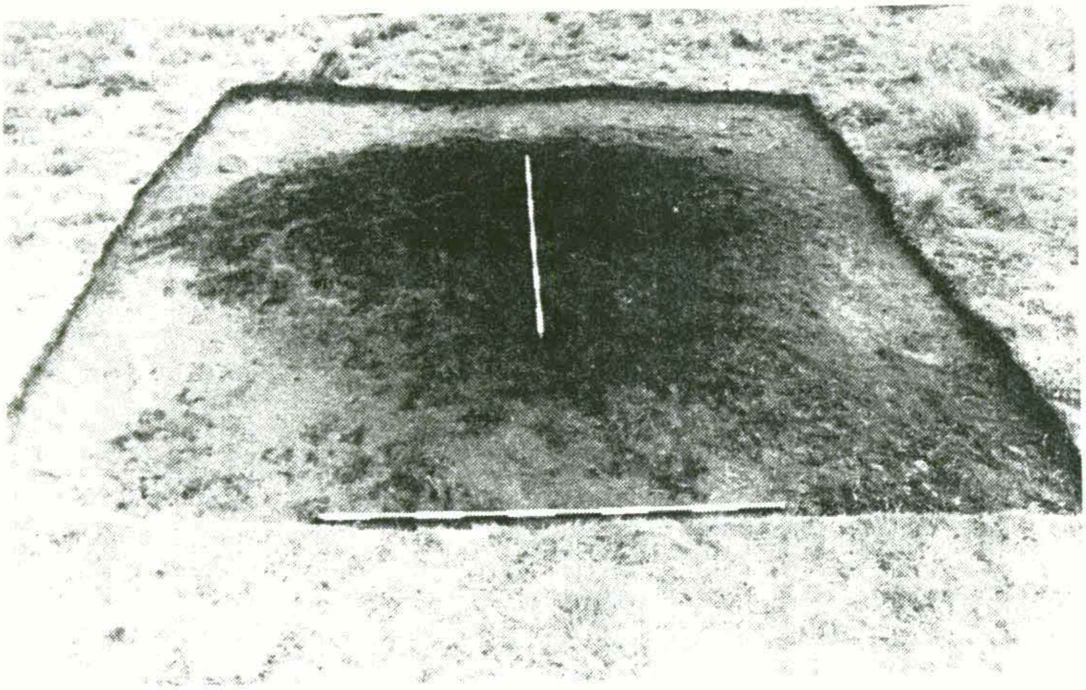


Plate 3 - Area 4(b) showing full extent of charcoal spread (roasting bed).

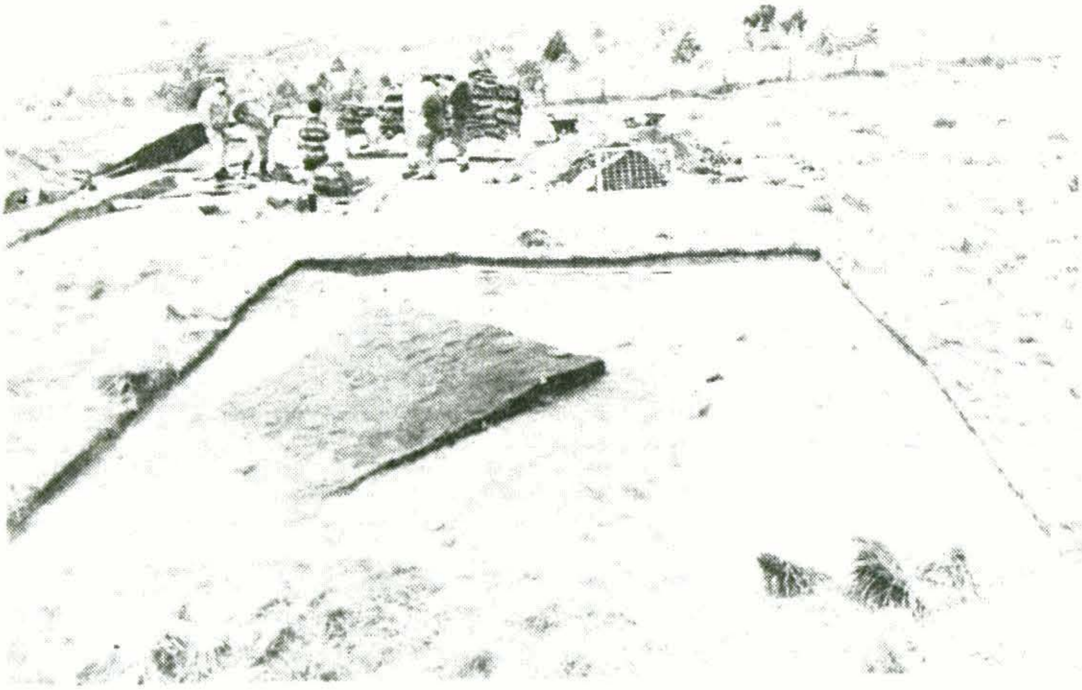


Plate 4 - The group of people mark the furnace site which is only 6m from the **roasting** bed evident in the foreground, with 3 quadrants removed.

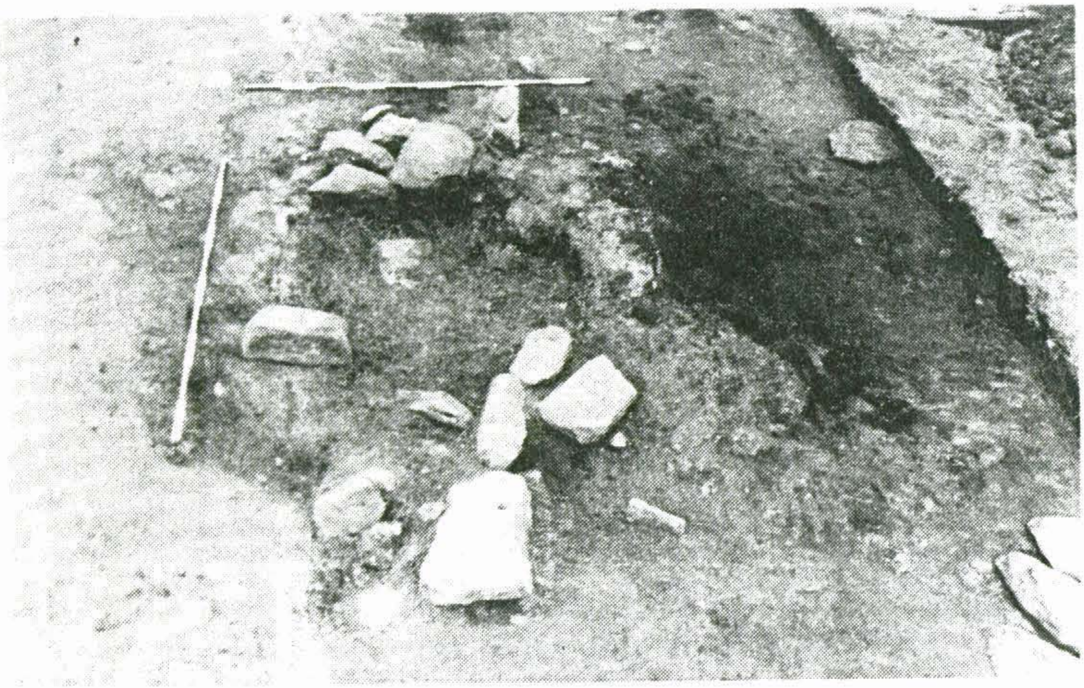


Plate 5 - Site of Wrigley's furnace after removal of turf and topsoil.

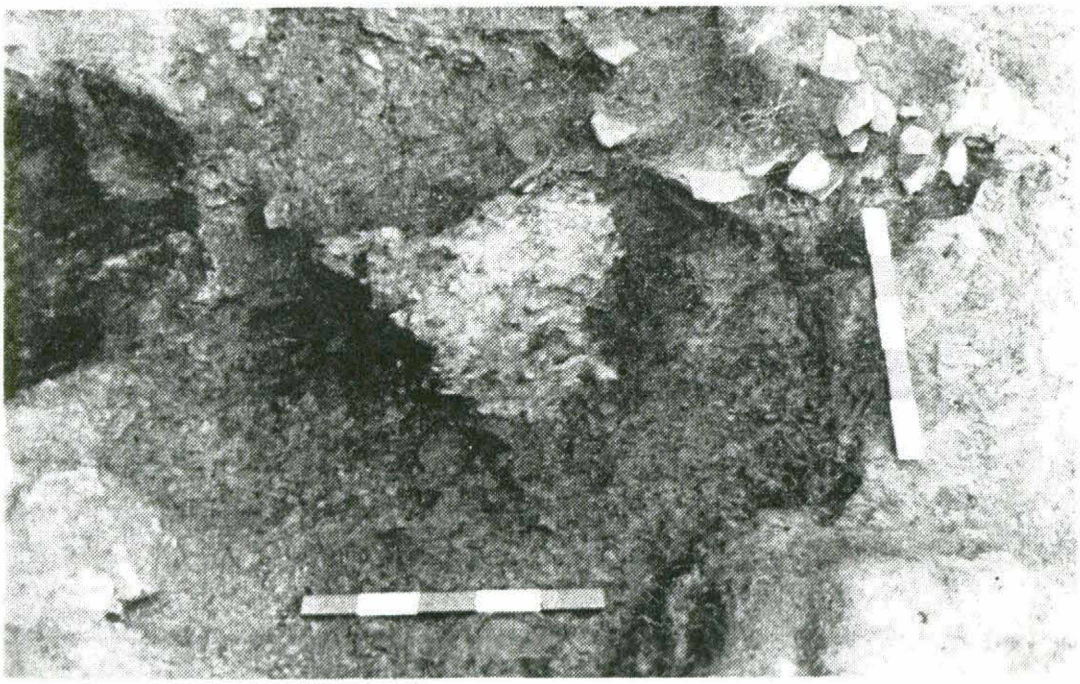


Plate 6 - Site of furnace base after removal of old excavation backfill.

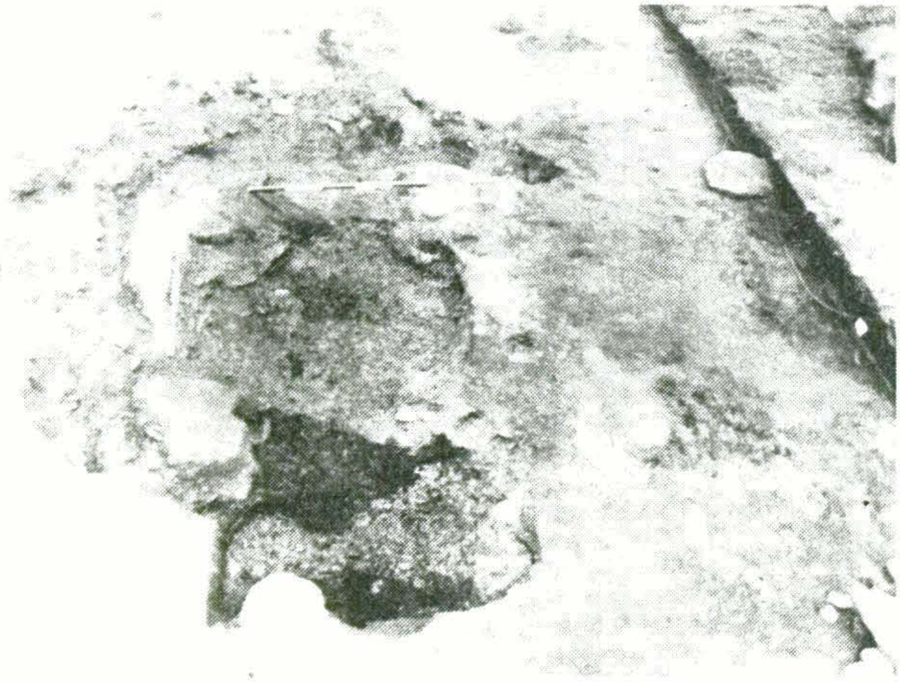


Plate 7 - Furnace site showing old excavation trenches and surviving black cinder [444] in foreground, indicating location of tapping channel.

Plate 8 - Furnace complex looking east, showing slag collecting pit in foreground.

Plate 9 - Furnace complex looking west. Beyond the hollow marking the furnace base can be seen black cinder in the widening tapping channel with the slag collecting pit beyond.

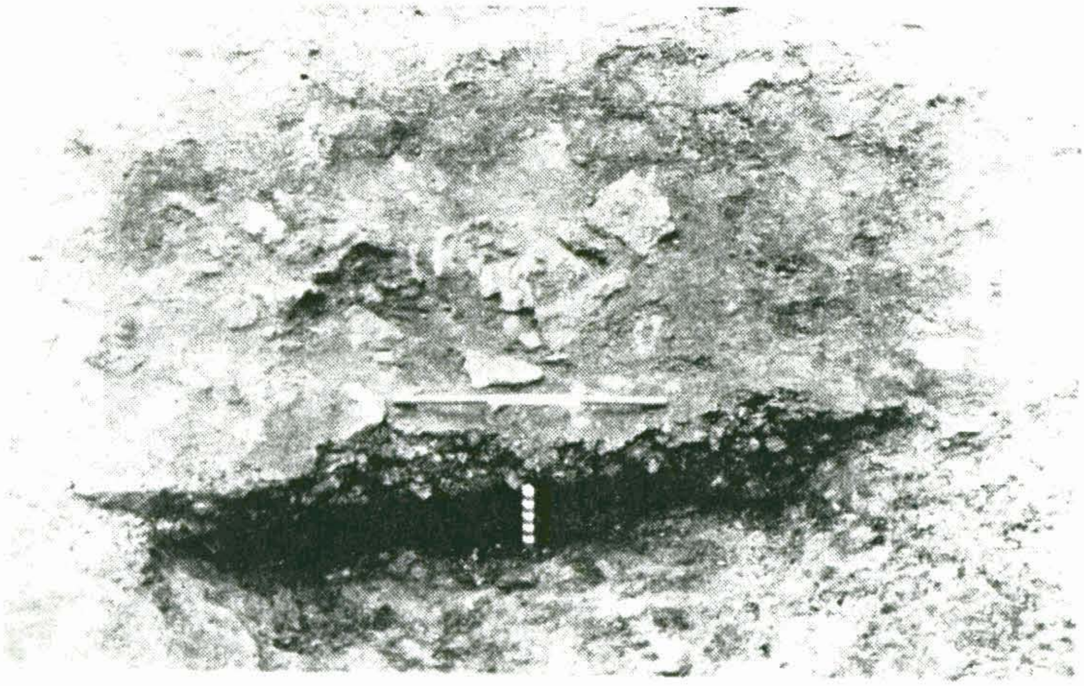


Plate 10 - Section through slag pit.

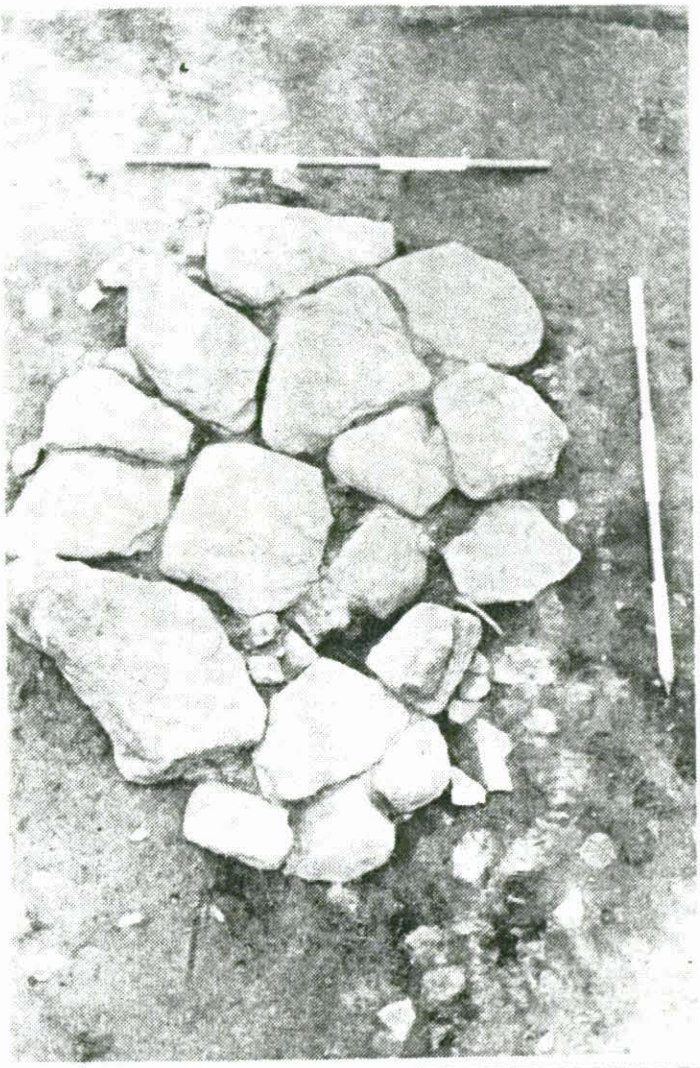


Plate 11 - The stone platform.

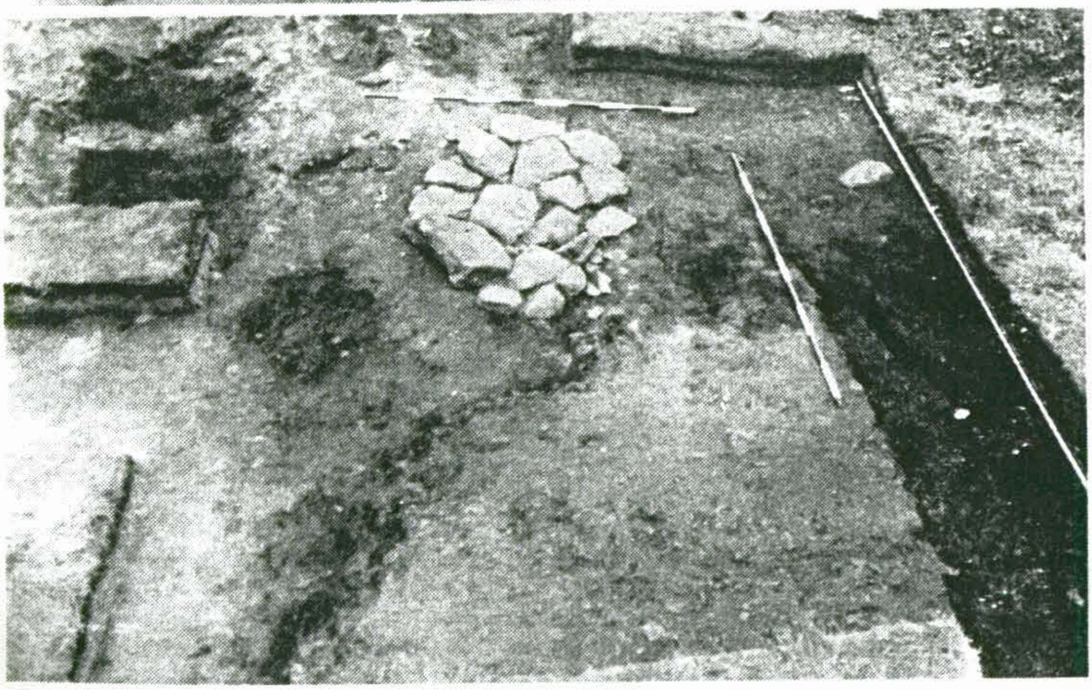


Plate 12 - The close relationship between the stone platform, slag collecting pit (partly under baulk on left) and slag spoil mound (marked by curving edge in foreground).

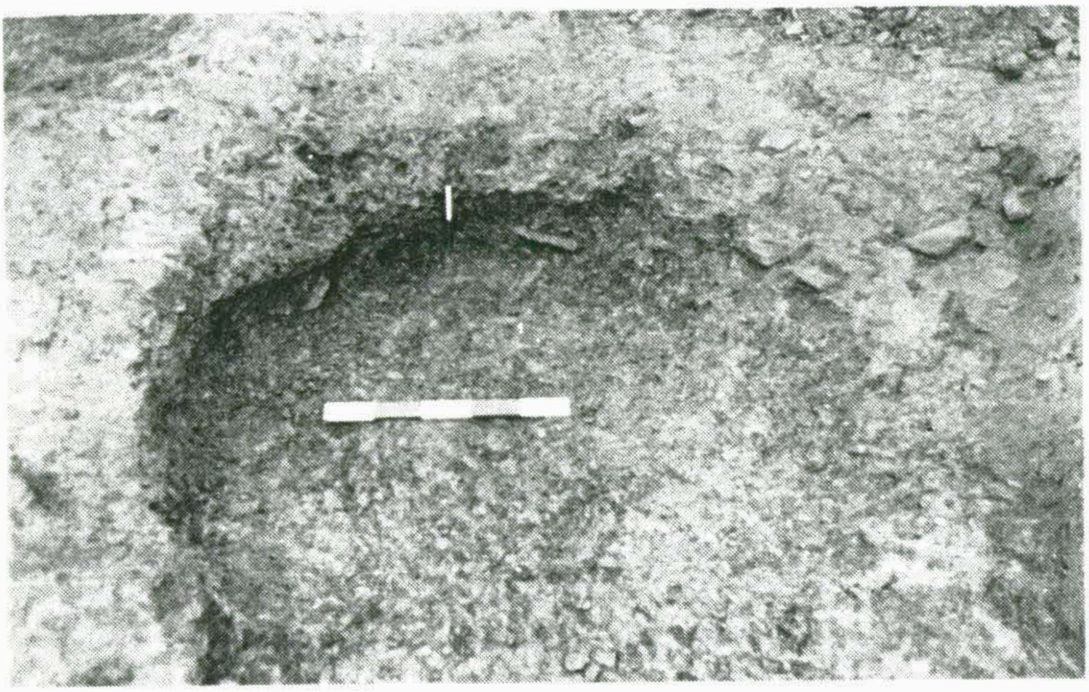


Plate 13 - Slag collecting pit post excavation showing overhanging western and southern edges.

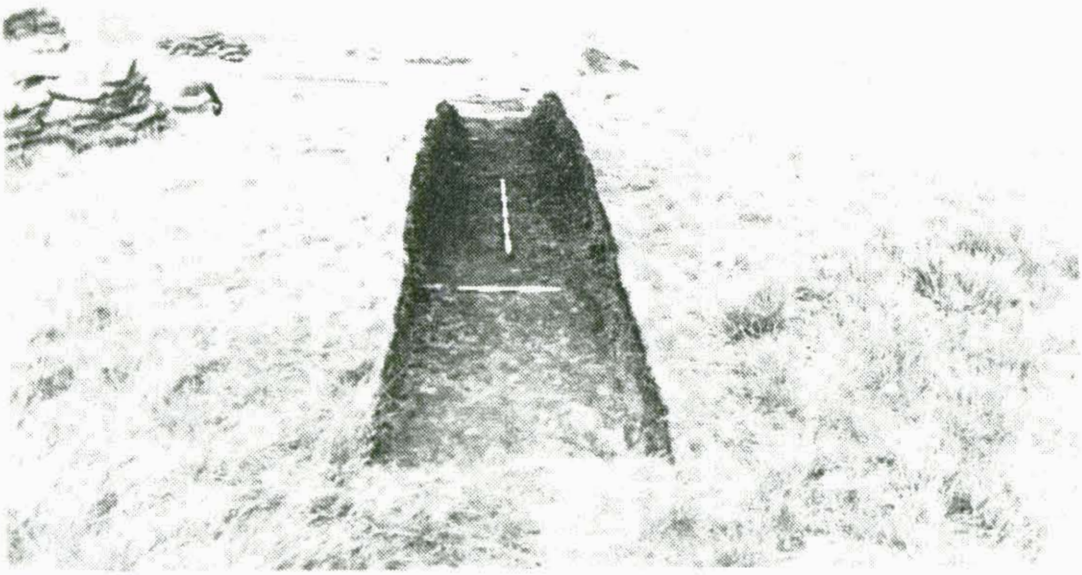


Plate 14 - Slot though slag spoil mound looking east.

ARCHAEOMAGNETIC STUDY OF CONTEXTS 445, 450, AND 454 AT WRIGLEY'S FURNACE SITE

A PROGRAMME OF RESEARCH CARRIED OUT
ON BEHALF OF

GREATER MANCHESTER ARCHAEOLOGICAL UNIT

By

GeoQuest Associates

INTRODUCTION

In a previous study we described the archaeomagnetic analysis and dating of samples of fired material from a Medieval iron smelting furnace at Spa Clough (GeoQuest, 1993). This report presents the results of an archaeomagnetic study of Wrigley Furnace Site, Cudworth Pasture (Grid Ref: SD 997105) exposed by The Greater Manchester Archaeological Unit during July 1994. This feature had previously been excavated by Wrigley (reported in *Songs of a Moorland Parish*, 1912) and again by the Saddleworth Historical Society in the 1970s. These studies and the latest phase of excavation indicated that the structure once comprised a free standing shaft furnace adjacent to a substantial slag collection pit and a stone platform for a raker to remove hot slag from the slag pit and deposit it on the adjacent slag spoil mound. Although much of the furnace structure had been cleared by Wrigley, sufficient material remained *in situ* for an attempt at directional archaeomagnetic dating, the principles of which are again described in Appendix A.

SAMPLING

Figure 1 shows a plan of the excavated furnace with locations of archaeomagnetic samples which were positioned to examine three separate contexts:

Context 450: Samples 1-6, comprising the imprint of the furnace base in a light grey, reduced, shaley material.

Context 454: Samples 7 & 8, of orange-red fired clay, on the axis of the tapping channel.

Context 445: Samples 9-23, of burnt shale, immediately adjacent to the slag collection pit.

Photographs of the feature are shown in Figure 2. Oriented specimens were again recovered using the *button method* devised by Clark, Tarling & Noel (1988) according to the procedure described in our previous report (GeoQuest, 1993). After orientation with a magnetic compass, the set of sample orientation arrows were checked for errors due to 'magnetic refraction' caused by the remanent magnetisation or strong magnetic susceptibility within the furnace; no significant angular error was detected.

Finally, a sun compass reading was taken as an independent check on the value of local magnetic variation used to correct for the samples' orientation.

In the laboratory the specimens were slowly dried and then coated or impregnated using a dilute solution of PVA in acetone. Finally, the samples were cut with a diamond saw until each button retained a fragment which fitted the standard 25x25mm holder inside the magnetometer.

MEASUREMENT

A Molspin fluxgate spinner magnetometer was used to measure the natural remanent magnetisation (NRM) of each sample (Molyneux, 1971) and remanence directions were then corrected for the geomagnetic variation using data published by the British Geological Survey (verified using the sun compass readings). All vectors are listed in Table 1 and plotted on stereograms in Figure 3.

The technique of stepwise, partial demagnetisation, using alternating magnetic fields was again employed to investigate the components and stability of the remanent archaeomagnetism. Figures 4 and 5 show the effect of this process as applied to specimens 5 and 16 from Contexts 450 and 445 respectively. The latter sample was selected in order to investigate the nature of negative archaeomagnetic inclination within that part of the furnace adjoining the slag collection pit (see results in Figure 3).

From a study of the pilot sample behaviour, optimum alternating magnetic fields were selected for the removal of unstable, secondary components of remanence in the remaining samples. After partial demagnetisation the samples were then remeasured in the spinner magnetometer and the results are given in Table 1 and Figure 6.

RESULTS AND DISCUSSION

Intensities of the natural remanence ranged from $0.22\text{-}69.08 \times 10^{-4} Am^2kg^{-1}$. No significant correlation was noted between lithology and remanence intensity. Table 1 shows that the reversely magnetised samples in Context 445 corresponded to those with the weakest NRM intensities.

Contexts 450 & 454

The group of samples from the furnace base produced a set of well-grouped NRM vectors, while the two specimens from near the tapping channel contained shallower magnetic inclinations (Context 454; square symbols in Figure 3). Demagnetisation of a pilot sample from Context 450 indicated that the furnace base material contained a stable primary component of remanence with a weak secondary component which was removed in an alternating field of 5mT (Figure 4).

Partial demagnetisation of the remaining samples significantly reduced the scatter of archaeomagnetic directions while removing the difference between vectors from the tapping channel and the furnace base (Figure 6). Table 1 lists the statistics computed from the set of partially demagnetised sample vectors.

Context 445

Samples from this Context were of particular interest since most were found to contain archaeomagnetic vectors with *negative* (ie. upward) magnetic inclination but *northward* magnetic declination. The zone of negative inclinations is shown yellow in Figure 1. In a geological context such directions would be interpreted as reflecting a geomagnetic field in transition between polarity states. However, in the case of Medieval material, these anomalous results can only arise as follows:

Disturbance: Inclinations may be reversed if the material has been inverted as a block, perhaps as a result of the earlier excavations. However, this explanation seems unlikely in view of the friable nature of the deposit.

Self-Reversal: An intrinsic and rare phenomenon in which the material contains two magnetic phases with differing characteristics such that the remanence polarity reverses upon cooling. However, it is difficult to use this mechanism to account for inclination reversal only.

Field distortion: In this process the Context acquires a primary archaeoremanence, at high temperature, in a field which is undisturbed by the iron bloom cooling in the adjoining pipe furnace. A secondary remanence is then acquired at lower temperatures and at a time when the bloom is below the Curie temperature and thus distorting the local geomagnetic field. Strong evidence for this mechanism is provided by the demagnetisation behaviour of Sample 16 which reverts to normal archaeomagnetic polarity upon demagnetisation in a field of 10mT (Figure 5).

The evidence therefore suggests that the archaeomagnetism in Context 445 *was* acquired during a final heating-cooling cycle during which a bloom, of sufficient size to distort the local geomagetic field, was present in the base of the pipe furnace. This effect does not appear to be present in samples from Context 450 from the furnace base in which remanence must have been acquired while cooling after the bloom had been removed.

ANALYSIS

A standard correction was used to convert the mean archaeomagnetic directions in both Contexts to Meriden, the reference locality for the British Master Curve (Noel & Batt, 1990). Unfortunately, the effects of the field distortion in Context 445 have yielded a mean archaeomagnetic vector which is too shallow for comparison with the UK Master Curve.

Figure 7 compares the mean archaeomagnetic vector in Contexts 450+454 and the associated error envelope to the Master Curve segment 600 AD - 2000 AD. The archaeomagnetic vector intersects the curve during the Medieval period giving a date centred on 1310AD with a probable age range of 1290-1330AD.

CONCLUSIONS

The results of this research can be summarised as follows:

1 Samples from Contexts 445, 450 and 454 were found to contain thermoremanent magnetisations caused by heating in the Earth's magnetic field.

2 Most samples obtained from Context 445 (adjoining the slag pit) contained an anomalous magnetisation in which the *inclination* but not the *declination* was reversed. This unusual result is interpreted as providing evidence that a bloom was present in the nearby furnace during the last heating-cooling cycle of Context 445.

3 Archaeomagnetic vectors in Contexts 450 and 454 were combined and compared to the UK Master Curve to suggest a last firing date range of 1290-1330 AD.

Note: A programme is currently underway whereby all UK archaeomagnetic data are being used to synthesise a revised Master Curve. Should this lead to revision in the above estimates then we will provide adjusted archaeomagnetic dates as part of this service.

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Clark, A.J., Tarling, D.H. & Noel, M., 1988. Developments in archaeomagnetic dating in Britain, *Archaeometry*, 15, 645-667.

GeoQuest Associates, 1993. *Archaeomagnetic study of contexts 347, 353 and 359 at Spa Clough, Castleshaw*. Report for the Greater Manchester Archaeological Unit.

Molyneux, L., 1971. A complete result magnetometer for measuring the remanent magnetisation of rocks, *Geophys. J. R. astr. Soc.*, 24, 429-433.

Noel, M. & Batt, C.M., 1990. A method for correcting geographically separated remanence directions for the purpose of archaeomagnetic dating, *Geophys. J. R. astr. Soc.*, 102, 753-756.

Songs of a Moorland Parish, (1912).

Credits
Sampling: M.J. Noel
Analysis & report: M.J. Noel
Date: 30/7/94

TABLE 1
ARCHAEOMAGNETIC RESULTS FROM SPA CLOUGH

Sample	LITH	J	D	I	A.F.	D	I
Context	450						
SPA1	LGS	8.76	6.5	52.5	10	7.2	52.0
SPA2	LGS	1.71	29.1	68.9	10	36.3	68.6
SPA3	LGS	1.75	356.1	52.7	10	357.5	52.7
SPA4	LGS	0.22	311.5	81.8	10	354.5	78.6
SPA5	LGS	0.35	358.9	71.9	10	358.0	69.9
SPA6	LGS	0.28	17.3	59.7	10	346.7	57.7
Context	454						
SPA7	ORC	15.33	351.1	45.6	10	349.9	58.6
SPA8	ORC	10.47	3.2	7.6	10	328.5	61.9
<u>Mean of Feature</u>			356.3	63.5			
	$alpha_{95}$ =8.6 k=42.7						
		c.s.e=3.4					
AT MERIDEN					**356.4**	**62.6**	
Context	445						
SPA9	BSH	19.95	328.4	19.9	20	338.0	25.8
SPA10	BSH	27.15	352.5	49.0	20	349.8	53.1
SPA11	BSH	69.08	1.9	30.9	20	357.5	32.1
SPA12	BSH	62.32	350.9	48.3	20	349.5	45.5
SPA13	BSH	46.82	9.1	28.7	20	8.1	33.4
SPA14	BSH	15.12	334.6	-63.1	20	354.0	41.2
SPA15	BSH	12.71	300.7	-77.2	20	351.3	44.2
SPA16	BSH	7.28	357.1	-73.8	20	353.8	31.0
SPA17	BSH	12.18	340.1	45.6	20	344.4	51.9
SPA18	BSH	9.86	335.9	-60.0	20	7.6	43.5
SPA19	BSH	7.07	53.1	-68.8	20	2.7	57.8
SPA20	BSH	5.49	49.8	-79.4	20	3.6	32.9
SPA21	BSH	DISINTEGRATED					
SPA22	BSH	12.61	22.3	-50.3	20	358.8	21.3
SPA23	BSH	7.74	23.1	-77.1	20	5.5	53.2
<u>Mean of Feature</u>			355.2	40.9			
	$alpha_{95}$ =6.7 k=36.5						
		c.s.e=3.6					
AT MERIDEN					**355.3**	**39.3**	

<u>NOTES</u>:
LITH = Lithology 'LGS' is light grey, reduced shale, 'ORC' is orange-red clay, 'BSH' is burnt shale. D = declination, I = inclination, J = intensity, $Am^2kg^{-1}x10^{-4}$. A.F. = peak alternating demagnetising field in milliTesla. $alpha_{95}$ is the semi-angle of the 95% cone of confidence, c.s.e. is the circular standard error and k is the precision parameter.

CASTLESHAW 1994

Iron Smelting Furnace

Location of Archaeomagnetic Samples

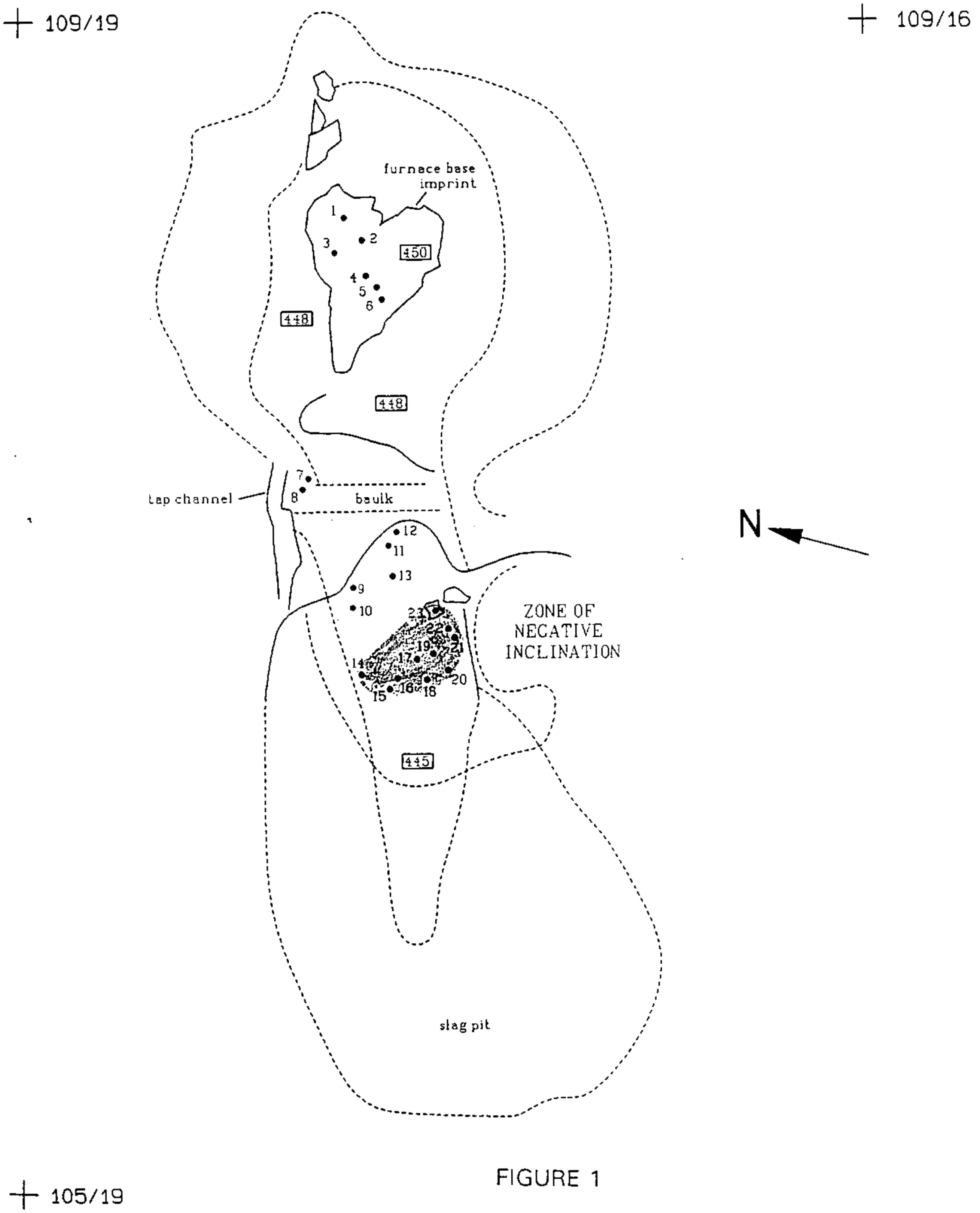


FIGURE 1

Location of archaeomagnetic specimens in the pipe furnace first excavated by Wrigley in 1907. The yellow zone marks the area of negative remanence inclinations.

CASTLESHAW 1994

Iron smelting furnace, NRM

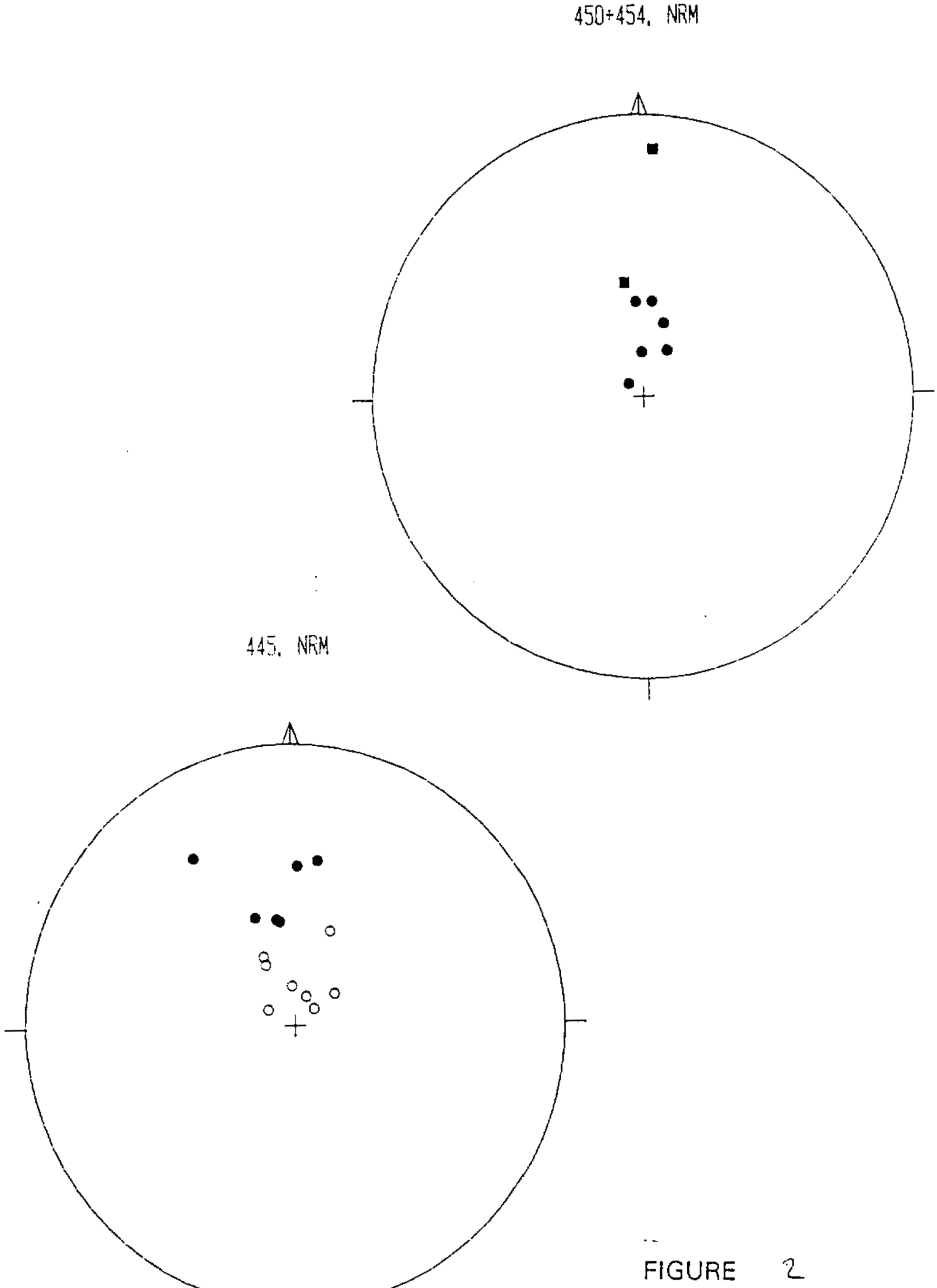


FIGURE 2

Directions of natural remanent magnetisation within the furnace base imprint and tapping channel (top) and adjacent to the slag pit (bottom) plotted on equal area stereographic projections (lower hemisphere). The two samples shown by the square symbols were from Context 454 (tapping channel).

CASTLESHAW

Sample 5

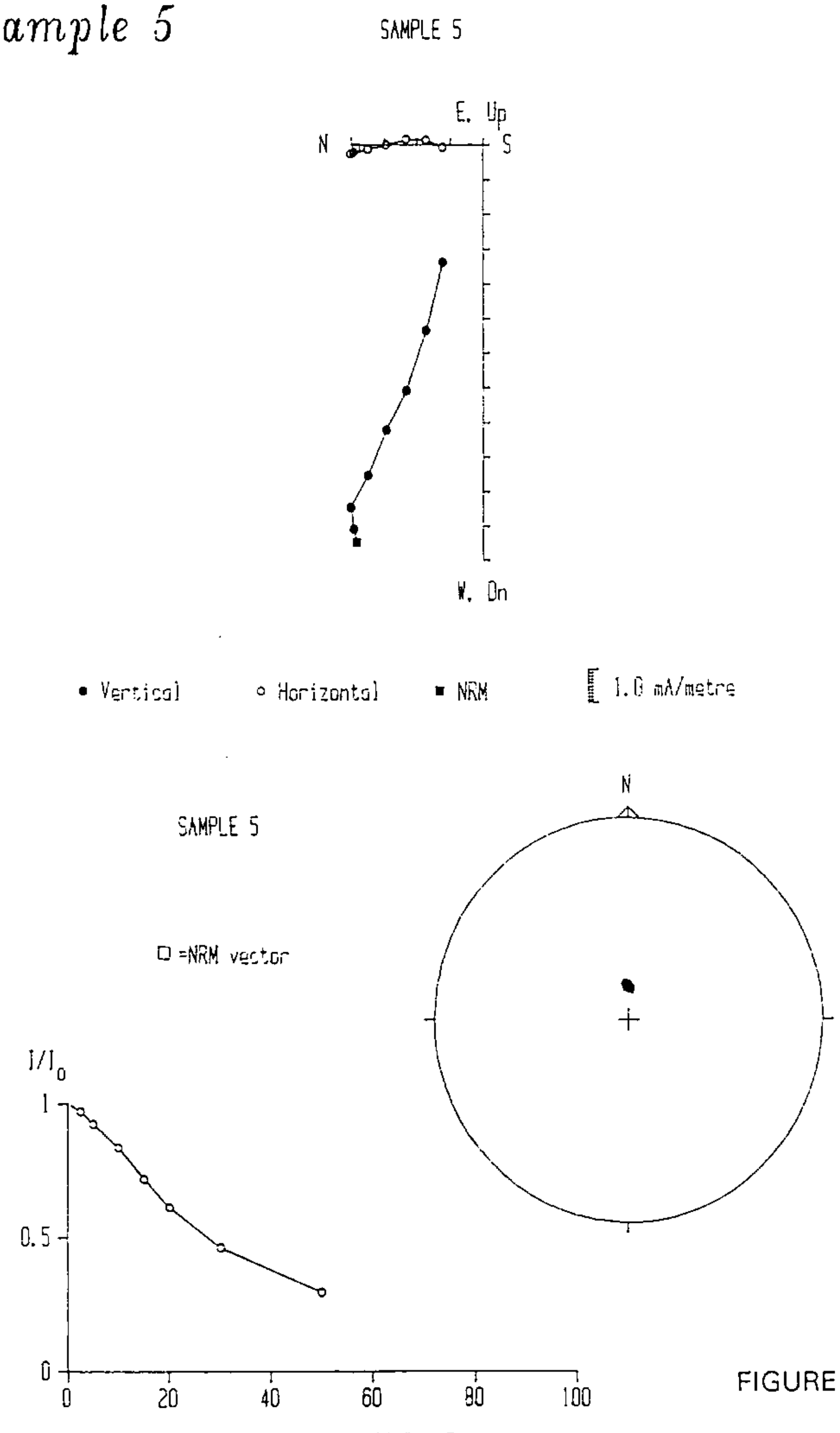


FIGURE 3

Changes in the strength and direction of the magnetisation during partial demagnetisation in a pilot specimen from the furnace base. Results are portrayed as normalised changes in remanence intensity with a stereogram, and as a vector endpoint projection.

CASTLESHAW

Sample 16

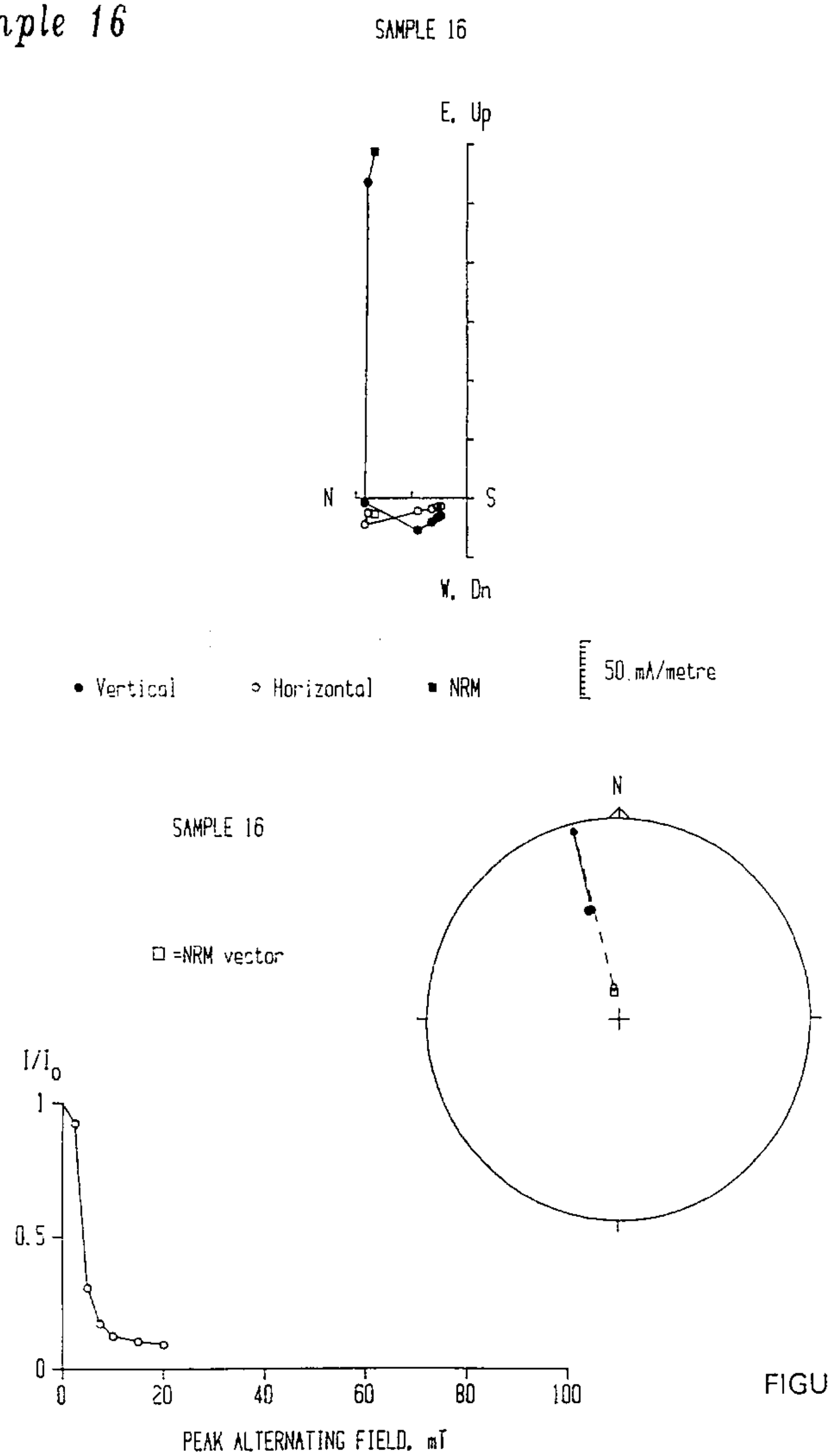


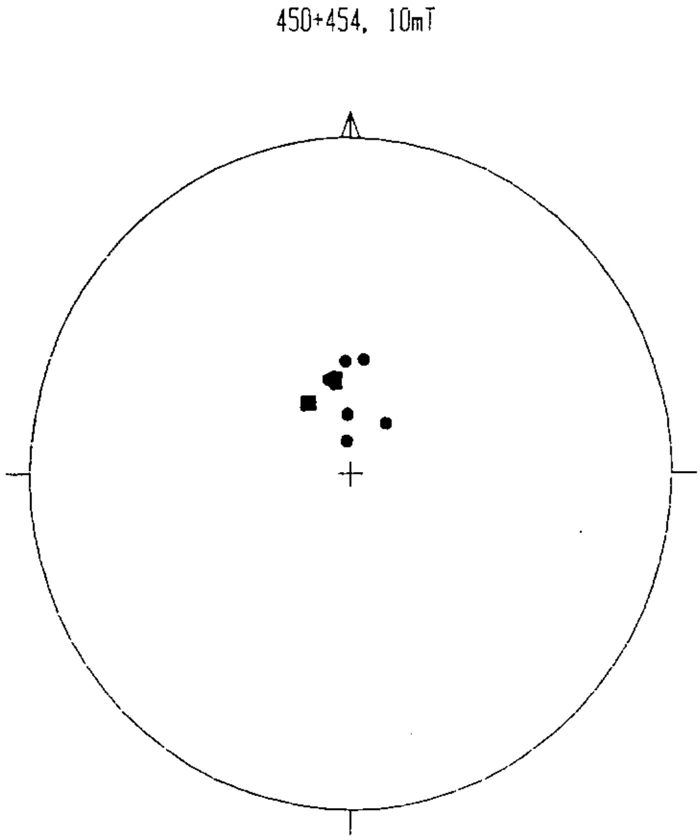
FIGURE 4

Changes in the strength and direction of the magnetisation during partial demagnetisation in a pilot specimen from the material adjoining the slag pit. Results are portrayed as normalised changes in remanence intensity with a stereogram, and as a vector endpoint projection.

CASTLESHAW 1994

Iron smelting furnace

demagnetised



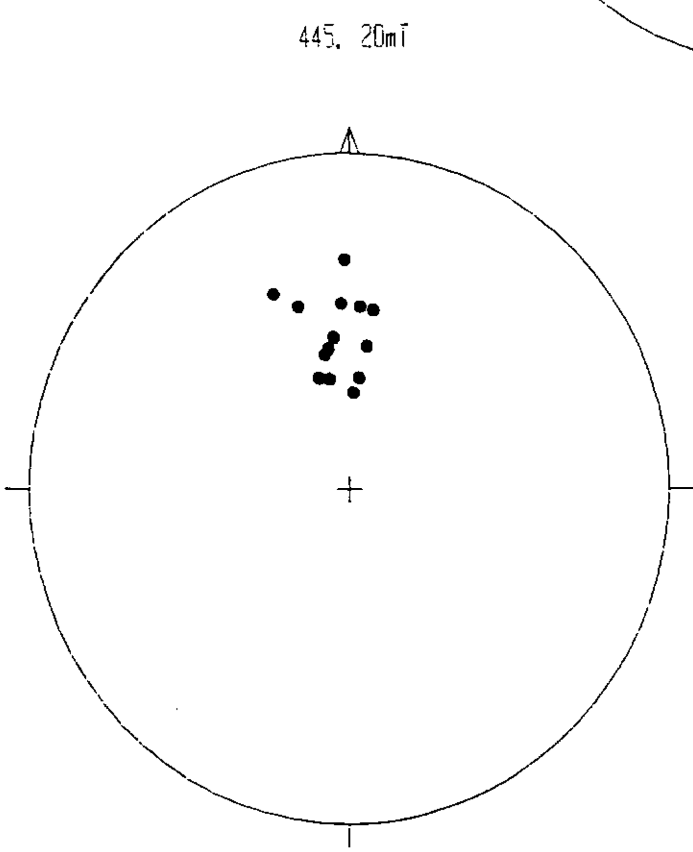


FIGURE 5

Directions of natural remanent magnetisation within the furnace base imprint and tapping channel (top) and adjacent to the slag pit (bottom) plotted on equal area stereographic projections after partial demagnetisation. The two samples shown by the square symbols were from Context 454 (tapping channel).

CASTLESHAW 1994

Archaeomagnetic Dating

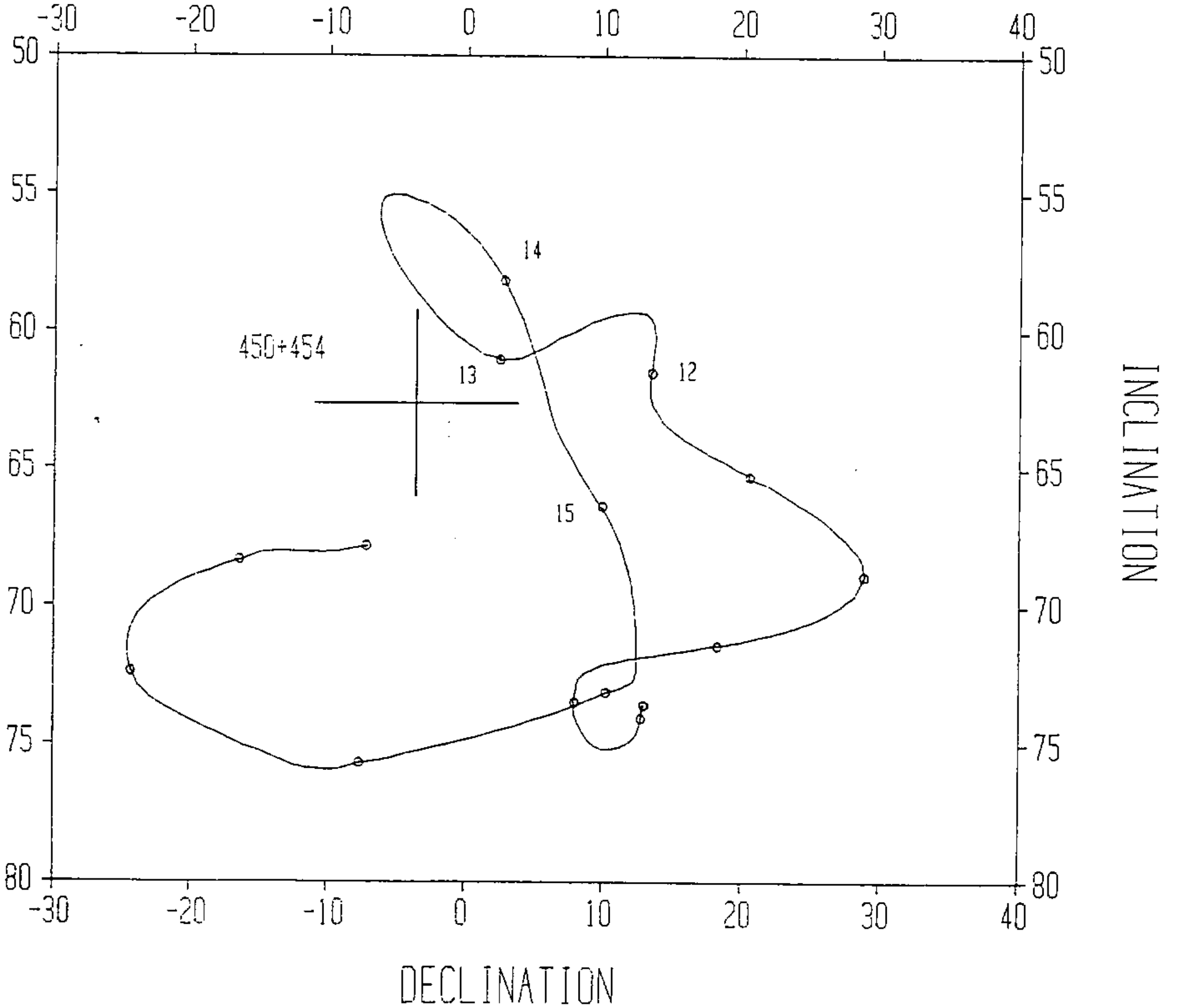


FIGURE 6

Comparison between the mean archaeomagnetic vector for Contexts 450+454 and the UK archaeomagnetic curve.