Medieval Iron-Workings in Minepit Wood, Rotherfield, Sussex

By J. H. MONEY

FROM 1965 TO 1967 detailed excavations were carried out in Minepit Wood, Rotherfield, Sussex, on what proved to be a complete and undisturbed iron-working site of the 14th and 15th centuries. Two periods were distinguished. Except for part of the roasting-furnace nothing survived of the earlier structures. The remains of the later period (which followed closely on the earlier) included a dump of natural ore prepared for roasting; a stone-built roasting-furnace with attendant heap of ore-roasting refuse; a stone and clay smelting-furnace and slag-heap; the groundwalls of a timber-framed building, which had been partly roofed and enclosed the smelting-furnace and supplies of roasted ore and charcoal; the groundwalls of a small ancillary building; and a few pieces of iron and contemporary pottery. One of the many minepits, which gave the wood its name, was also shown to be late medieval.

THE SITE of the workings in Minepit Wood (TQ 523338) lies beside the headwater of a stream at around 360 ft. (109 m.) above sea level, about two miles (3·2 km.) north-north-east of Crowborough (FIG. 29). It is very remote; there is no public road within ¾ mile (1·2 km.); access is by tracks and across fields, which are often impassable in wet weather. It is undoubtedly this remoteness and the fact that the workings are in dense woodland that have saved them from modern disturbance.

Almost the whole of Minepit Wood is on a down-faulted tract of Wadhurst Clay abutting against Tunbridge Wells Sand divisions and a thin belt of Grinstead Clay where faulted on the north.

The position was no doubt chosen because of the plentiful supplies of iron ore which the Wadhurst Clay, particularly the lower part, provided. Building-stone was available from near-by exposures of Ashdown Sand and Tunbridge Wells Sand; there was abundant oak and other types of wood for fuel and construction; and, finally, the site was well drained and near fresh water.

The existence of early iron-workings in Minepit Wood was first detected by Straker,[1] who was impressed by a large and undisturbed slag-heap deep in the woods and took me to visit it in 1937. He gave me a copy of his book, *Wealden Iron*, and exhorted me to excavate the site, which I did in five seasons from 1963 to 1967.

During the first two seasons we dug what proved to be a two-period iron-working site of iron-age and Romano-British date (Site A), a report on which is to be published elsewhere. One of the near-by minepits (which gave the wood its name) was also examined and found to be late medieval (Site B).

[1] Ernest Straker, *Wealden Iron* (London, 1931), pp. 27 and 257, where it is called 'Orznash' (a near-by farm which then owned Minepit Wood): see FIG. 29.

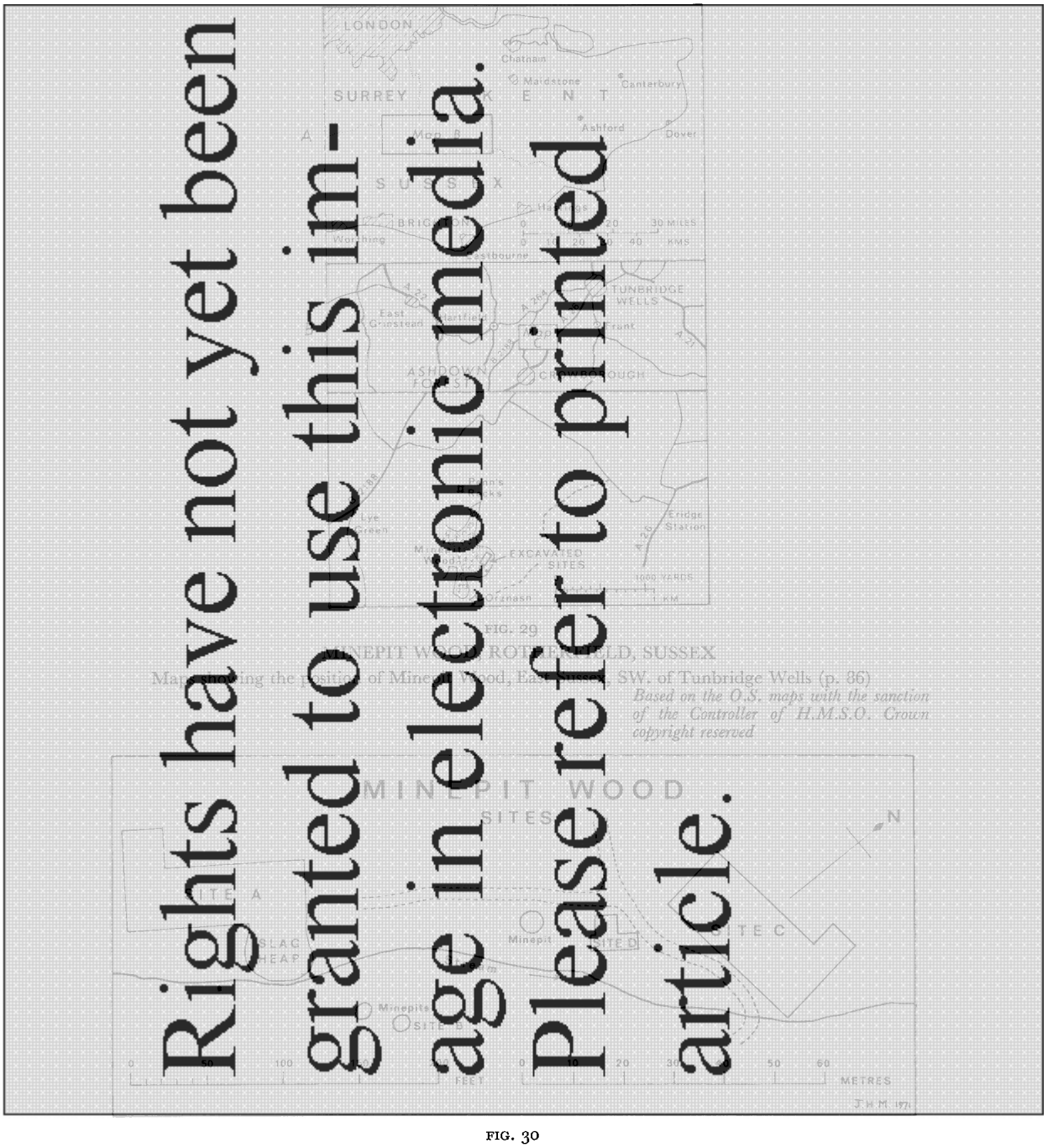

FIG. 30

MINEPIT WOOD, ROTHERFIELD, SUSSEX

Plan showing the position of Sites A (iron-age and Romano-British) and B–D (medieval). All four are surrounded by dense woodland (p. 88).

In 1965 considerable quantities of stone-work both above and just below the modern surface were detected in dense woodland about 110 yd. (100 m.) north-east of Site A. This new area was cleared and partially excavated in 1965, while the work at Site A was being brought to a close, and was completed in 1966 and 1967. A complete iron-working site of the 14th and 15th centuries, consisting of roasting- and smelting-furnaces within a rectangular timber-framed building (Site C) and a near-by shelter (Site D) came to light and, with Site B, are the subject of this report. The relative position of the four sites is shown in FIG. 30.

SITE B

There are many shallow bowl-shaped minepits in the area. During the work on Site A some digging was done in one of a pair of roughly circular minepits which lie on the other side of the stream bed, about 100 ft. (30 m.) east of Site A and 250 ft. (75 m.) south-west of Site C (FIG. 30). The pit, which is 12 ft. (3·6 m.) in diameter, was excavated to a depth of 2 ft. (0·6 m.); continuous rain caused the quest to be abandoned before the bottom was reached.

A trench was also cut through the heap of clay which the diggers of the pit had deposited beside it. On the old land surface, immediately under this spoil-heap, there was some charcoal, which by its position must be contemporary with or slightly earlier than the minepit; a sample (consisting of oak, beech, birch and ash) has been dated (BM-361) to 426 ± 40 years B.P. (late 15th to early 16th century).

SITE C

The detailed layout of Site C, the working area where roasting and smelting took place, is shown on the gridded plan (FIG. 31), reference to which is made throughout this report. An E.-W. section through Site C is shown in FIG. 32. Two periods were distinguished.

PERIOD I

Roasting-furnace I (J 5) (PL. XI, A; FIGS. 33–34)

Roasting of the ore was a desirable preliminary to effective smelting; it had the effect *inter alia* of removing the water content of the ore and breaking down the larger lumps.

In period I there was a roasting-furnace in J 5. It consisted of an oval-shaped hollow dug in the natural clay, with a maximum diameter of about 11 ft. (3·35 m.) and depth of 2½ ft. (0·76 m.) Half this furnace was demolished when a three-sided stone-built furnace was constructed in period II (p. 92f.). In the half which survived the clay had been burnt to a hard orange crust for a thickness of 2½ in. (6·3 cm.); behind this the clay became soft and pink for 5 in. (12·7 cm.) and then shaded into unburnt yellow and blue natural clay. Adhering to the clay wall at one point was a piece of slag. This is surprising in a roasting-furnace, where the general temperature would have been relatively low. H. F. Cleere suggests that there might nevertheless have been localized hot zones (e.g. in front of tuyères or

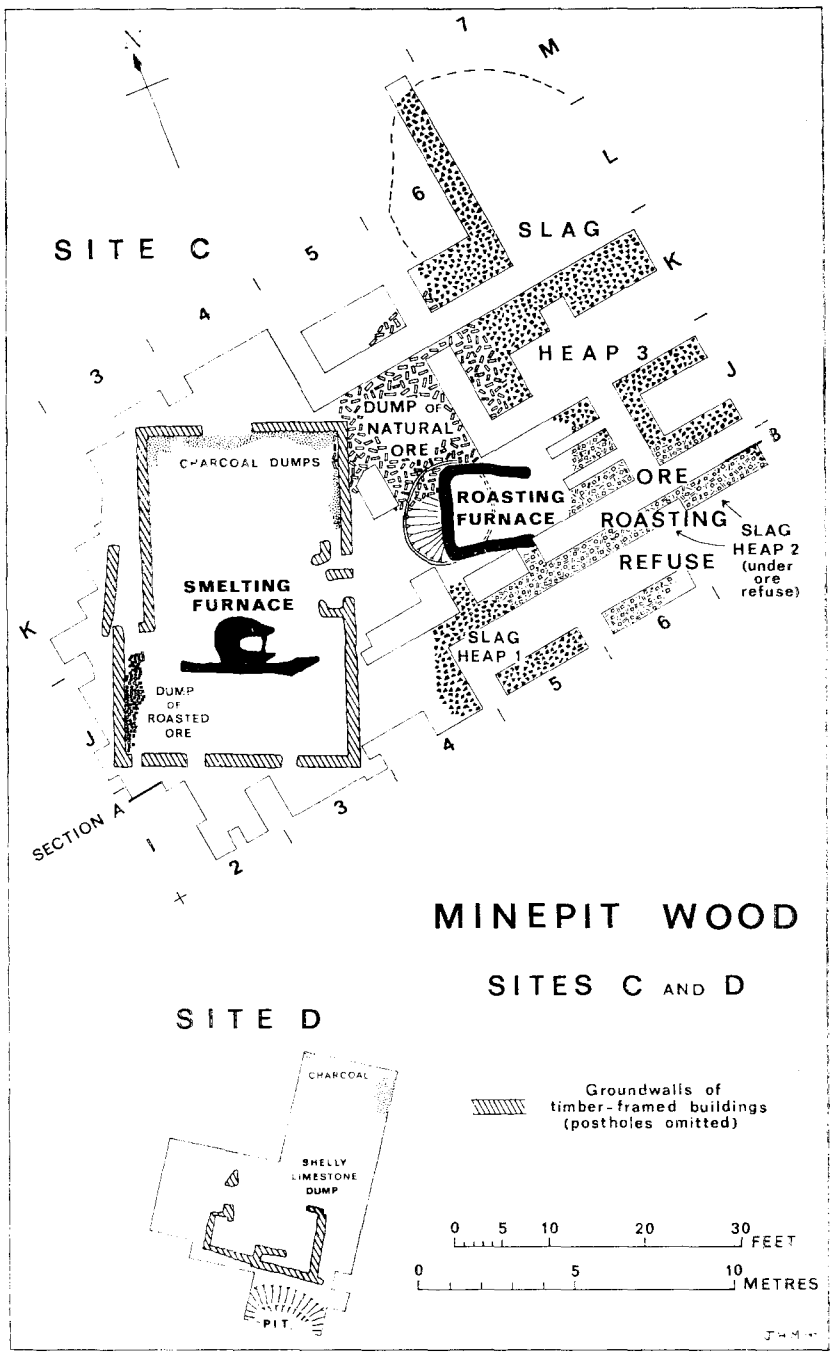

FIG. 31

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITES C AND D

General plan showing limits of excavated areas, and positions of timber-framed buildings, furnaces, and heaps of slag and roasting-refuse (pp. 88, 94, 101, 103, 105)

bellows) where the partial reduction of the ore and consequent formation of slag might have taken place (Appendix I, p. 106).

It is not possible to say whether in the demolished half there was a mouth through which the material was removed for dumping outside. The fuel used in this furnace included oak, beech and birch; a sample of it has a radio-carbon date (BM-364) of 532 ± 100 years B.P. (14th to 15th century). In view of the date given for the period-II roasting-furnace (p. 94) the earlier furnace is probably earlier rather than later in this 200-year bracket.

Beside the furnace there was a dump of prepared natural ore which, replenished when necessary, seems to have served both periods of the working. An analysis of samples of the ore, which was characteristic Wadhurst Clay siderite, is given in Appendix I (p. 103f.). That the dump existed in period I is clear from the fact that it runs under the NE. corner of the period-II timber-framed building (K 4/5) and clearly precedes it. Charcoal associated with the dump of ore has a radio-carbon date (BM-362) of 492 ± 48 B.P. (15th century).

A plan of what survives of the earlier furnace and a section through it are shown in FIGS. 33 and 34 respectively. The exposure of part of it is also shown in PL. XI, A.

Ore-roasting refuse (I 6)

The only part of the ore-roasting refuse which can reasonably be attributed to period I is a layer varying from 3 to 9 in. (7·6 to 22·8 cm.) thick which was encountered in I 6 lying directly on the natural clay. The edge of this layer (which does not occur in the section, FIG. 32) was overlaid by part of period-I slag-heap no. 1 (see FIG. 32 and pp. 902, 9). A sample of charcoal taken from the refuse was entirely of oak.

Smelting-furnace I (J 3) (FIGS. 38–39)

The remains of the earlier smelting-furnace (J 3) are very scanty. They consist only of a shallow depression, roughly circular and about 4½ ft. (1·37 m.) in diameter, together with some furnace-refuse, which was completely covered by the later furnace and its refuse (FIG. 38, and FIG. 39, plan A). Resting on the natural clay was a hard crusty surface consisting of a dried slurry of charcoal fines and clay, which does not appear to have been heated to a very high temperature. Above this was a layer consisting of crumbs of clay, charcoal and a very little tap slag. It is considered that these do not represent a structural feature of the furnace or the remains of its contents. They appear to be more consistent with a demolition of the earlier furnace (including the robbing of any stone-work which may have existed), perhaps a period of abandonment and then a tidying-up of surrounding debris for the construction of the later furnace (see Appendix I, p. 106).

Slag-heaps nos. 1 and 2 (I 4/I 5 and I 6)

It is reasonably certain that the slag-heap derived from the earlier furnace is that shown in I 4/I 5 (see FIGS. 31–32). This slag-heap (no. 1) is only 20 ft.

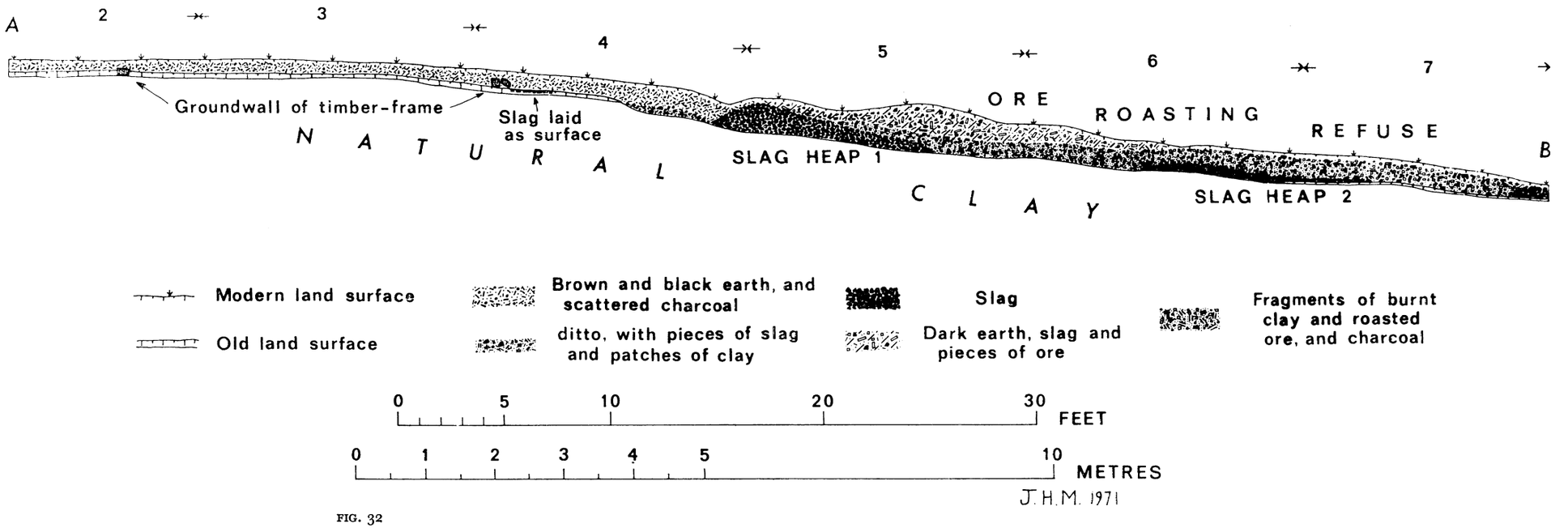

FIG. 32

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Section A–B (see plan, FIG. 31) showing heaps of slag and ore-roasting refuse lying in gently-sloping ground below the timber-framed building (pp. 88, 90, 92)

(6·1 m.) from the furnace and is placed where slag would naturally have been dumped before the timber-framed building was erected. There is a smaller heap (no. 2) in I 6 (FIG. 32), under the period-II roasting-refuse, which is probably also derived from the period-I smelting-furnace.

Both heaps contained cinder—in the form of complete 'furnace bottoms', with some baked clay adhering to the under side, and broken fragments—and bloomery-type slag. Slag-heap no. 1 also yielded one specimen of vitreous slag encased in the more conventional iron-rich slag; this would appear to be a very localized effect, which was due to the charging of an isolated lump of shelly limestone (Appendix I, p. 105f.). A charcoal sample from the I 6 slag-heap was mainly of oak, with some beech and a small piece of birch.

PERIOD II

In period II the site was transformed and enlarged, extensive use being made of stone-work (some possibly robbed from period-I structures), timber and clay. H. F. Cleere considers that this does not necessarily mean that a new technology was introduced, but rather that the site was established on a more settled basis. Its new status is indicated by the rectangular timber-framed building enclosing a new smelting-furnace of masonry and clay, together with dumps of charcoal and roasted ore, and a stone-built roasting-furnace just outside the enclosure.

Roasting-furnace II (J 5/J 6) (PL. XI, A; FIGS. 33–34)

A new three-sided masonry structure, designed to hold the heat of the fire more effectively, replaced the earlier roasting-furnace (pp. 88, 90). To accommodate the new furnace half the old one was cut away, enough clay being dug out on either side and in front to allow three courses of masonry to be bedded into and supported by a backing of natural clay. The clay and furnace-refuse removed in this clearing process were dumped between what was left of the curved side of the old furnace and the straight back wall of the new. A temporary timber frame supported by stakes held the stones of the back wall in position while the clay was being dumped and pressed down behind it. The inner surfaces of the stones in all three walls were carefully dressed and aligned; their backs, which were not visible, were left rough and in some cases protruding well into the clay behind them. The blocks which made up the lowest course of each side were larger than the rest, and, as might be expected, particular care was taken with their cutting and positioning. The resulting structure was about 8 ft. (2·4 m.) square internally, narrowing to about 5½ ft. (1·6 m.) at the mouth. Four post-holes found along its NE. side suggest either that it was shielded by a timber fence, or, more likely, that it was covered by a (possibly detachable) timber shelter. In the latter case these post-holes ought to be balanced by a similar line on the SW. side; no such line was detected during the digging, but it may lie under the unexcavated baulk.

FIG. 35[2] shows two late medieval German roasting-furnaces very similar in

[2] After Georgius Agricola, *De Re Metallica* (1556), trans. H. C. and L. H. Hoover (Dover Publications Inc., New York, 1950), fig. on p. 275; cf. also *ibid.*, fig. on p. 274, which shows a timber shelter over a roasting-furnace. It is true that these furnaces were used for lead and tin ore, but obviously they could have been applied with equal effectiveness to iron ore.

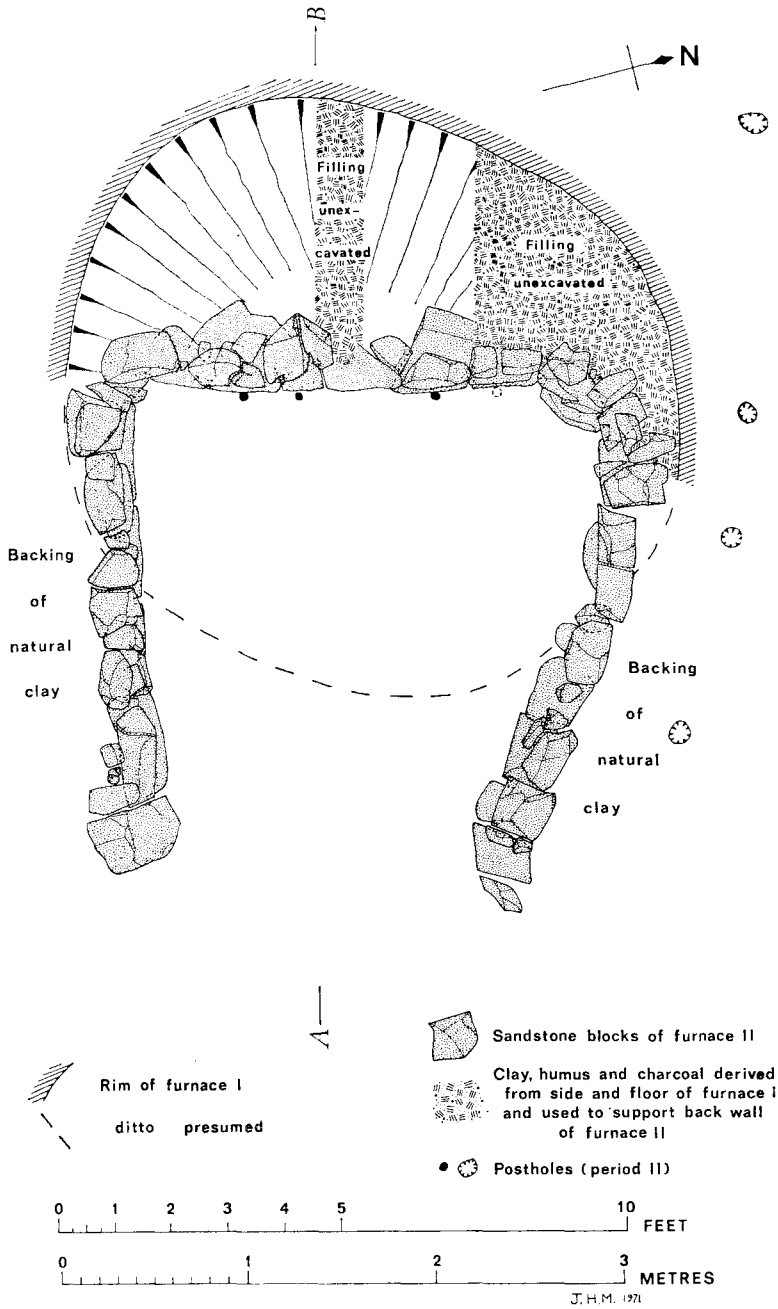

FIG. 33

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Plan of roasting-furnaces showing three-sided stone structure of furnace II lying in front of undemolished half of furnace I, the sloping side of which is visible where the filling behind furnace II has been removed (pp. 88, 90, 92)

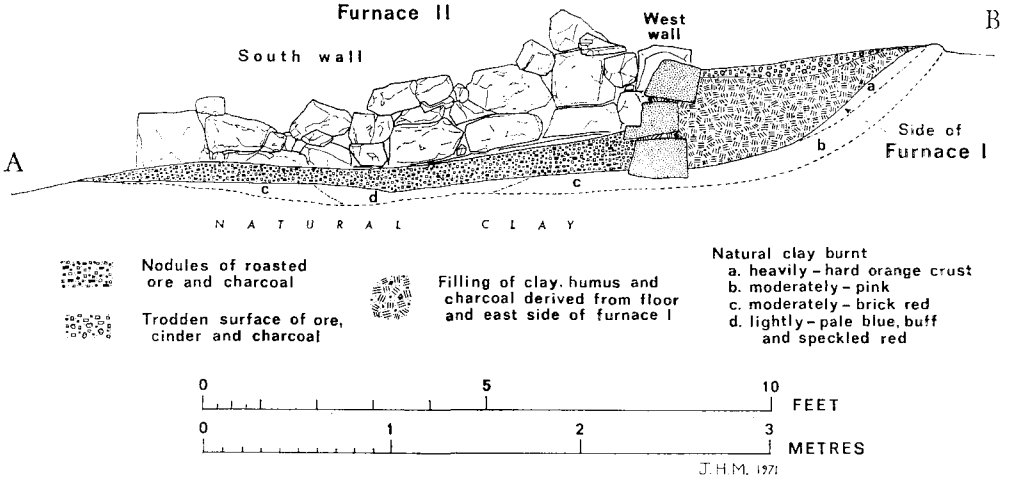

FIG. 34

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Section A–B through roasting-furnaces (see plan, FIG. 33) (pp. 88, 90, 92)

shape to that at Site C. On the left workmen are beginning to arrange the fuel. On the right the ore is being roasted over a carefully arranged pile ('crate') of wood.

The filling of the furnace was largely of small roasted nodules. When fractured these proved to have been well calcined, indicating perhaps that they remained in the bottom of the furnace during several roasting operations. Mixed with the nodules was charcoal which included oak and *populus* (poplar or aspen); a sample of it has a radio-carbon date (BM-366) of 570 ± 44 years B.P. (14th to 15th century).

Natural ore continued to be dumped north of the furnace (K 5/K 6), and a substantial quantity of unused ore was left on the site after it was abandoned (FIG. 31). A clear space seems to have been kept outside the mouth of the furnace, so that it could be fed without impediment with ore and fuel, and cleared out when necessary.

The refuse from the roasting-furnace (see Appendix I, p. 104) was dumped in the area south and south-east (I 5/I 6/J 6/I 7). In three charcoal samples taken from the refuse-heap there was a preponderance of oak, with beech, birch, ash and *populus* (poplar or aspen) also present.

Timber-framed building (FIGS. 36, 42; Appendix III, pp. 108ff.).

A partially roofed timber-framed building, aligned roughly south-west to north-east, enclosed the smelting-furnace and ancillary dumps of roasted ore and charcoal. It was 36 ft. (11 m.) long and in its final form varied in width from 23 ft. (7 m.) at its NE. end to 26 ft. (8 m.) at the SW. end. There were entrances and exits of varying sizes on all four sides. The ground on which it lies drops slightly to the

A—LIGHTED PYRE. B—PYRE WHICH IS BEING CONSTRUCTED. C—ORE. D—WOOD. E—PILE OF THE SAME WOOD.

FIG. 35

Illustration of two late medieval German roasting-furnaces very similar to that at Minepit Wood (pp. 92, 94)

After Agricola, De Re Metallica *(1556), trans. H. C. and L. H. Hoover, Dover Publications, Inc., 1950, by courtesy*

north and south-east, a fact which would have helped drainage. A plan of the building in its present form, which is preserved by rather feeble groundwalls, seldom more than one slab of sandstone high, may be seen in FIG. 36. In Appendix III S. E. Rigold shows how this building may have been walled and (in part) roofed. For a reconstruction drawing by him see FIG. 42.

It appears that in its original form the building was, or was planned to be, strictly rectangular, but that it was later decided to broaden the SW. part in order to provide a space for accommodating supplies of roasted ore. There was also a new entrance, approached through a porch (K 2), the outer wall of which was set on a slightly different alignment.

The NE. end of the building was used *inter alia* for storing charcoal, the remains of which were found lying along the sides (L 3/K 4). The interior was divided into five long bins of different widths, separated by hurdles or fences. Storage of equipment and material was probably the main function of this part of the building. There is no evidence that this part was roofed, but it is likely that there was some

sort of covering over the dumps of charcoal (possibly thatch or brushwood caulked with clay), if only temporarily in wet weather, since wet charcoal does not work in this type of furnace. It will be noted that in the N. corner there is a small gap in the stone substructure; this either was a narrow entrance to the bin or was, possibly, made in order to allow water to drain from the building. South-west of this storage-area was the smelting-furance (J 3) and the W. corner of the building was occupied by the dump of roasted ore prepared for smelting (J 2).

Six sherds of pink-buff pottery were found in I 3 and J 4 (see Appendix II, p. 107f.), and J 4 also yielded two iron nails and an indeterminate piece of iron 3 by 1½ in. (7·6 by 3·8 cm.).

It seems likely that the centre and southern parts of this building were eventually burnt down. Quantities of charcoal were found all over I 3, I 4, J 2, J 3 and K 2. Samples from I 3 and K 2 were all of oak, with a little birch.

The dumps of charcoal and of roasted ore, the smelting-furnace and the slag-heap are considered in detail in the following paragraphs.

Dump of charcoal (L 3/K 4)

Situated round the sides of the NE. end of the building are the remains of what must have been the source of fuel for the smelting-furnace. Samples taken in the N. corner (L 3) were of oak, beech and hazel, and have a radio-carbon date (BM-365) of 545 ± 40 years B.P. (14th to 15th century). Samples taken on the other side of the building (K 4) were mainly of birch, with some alder, oak and beech present in small proportions. None of the underlying soil was reddened, which proves that this was simply a dump and that no burning took place *in situ*.

Dump of roasted ore (J 2)

In the W. corner of the building was the remains of a dump of roasted ore, produced in the roasting-furnace (J 5) and broken up into lumps suitable for use in the smelting-furnace (J 3). The ore exhibited the characteristic maroon colour of the Wadhurst Clay siderite after roasting. The lumps overlay a deposit of fine particles which would have tended to filter through to the bottom of the heap.

Smelting-furnace II (J 3) (PL. XI, B; FIGS. 37–39)

In period II, to match the new stone-built roasting-furnace (J 5/J 6), a smelting-furnace facing south-east was built of masonry and clay on the site of its period-I predecessor. A detailed plan of what is left of the furnace in its final form may be seen in FIG. 37; FIG. 38 shows sections A–B and C–D and also includes a partial reconstruction; for the two phases of development see FIG. 39.

Since what is left of the furnace complex belongs to the end of phase 2, there can be no certainty about its exact appearance in phase 1. To judge, however, from the careful examination to which it was subjected, the basic design of the furnace itself remained the same in both phases; latterly, however, there were some additions to its structure and a hood or shelter was built over it.

From the outset the smelting-chamber, the floor of which was of 'furnace-bottom' material (see Appendix I, p. 106), was enclosed within a thick layer of

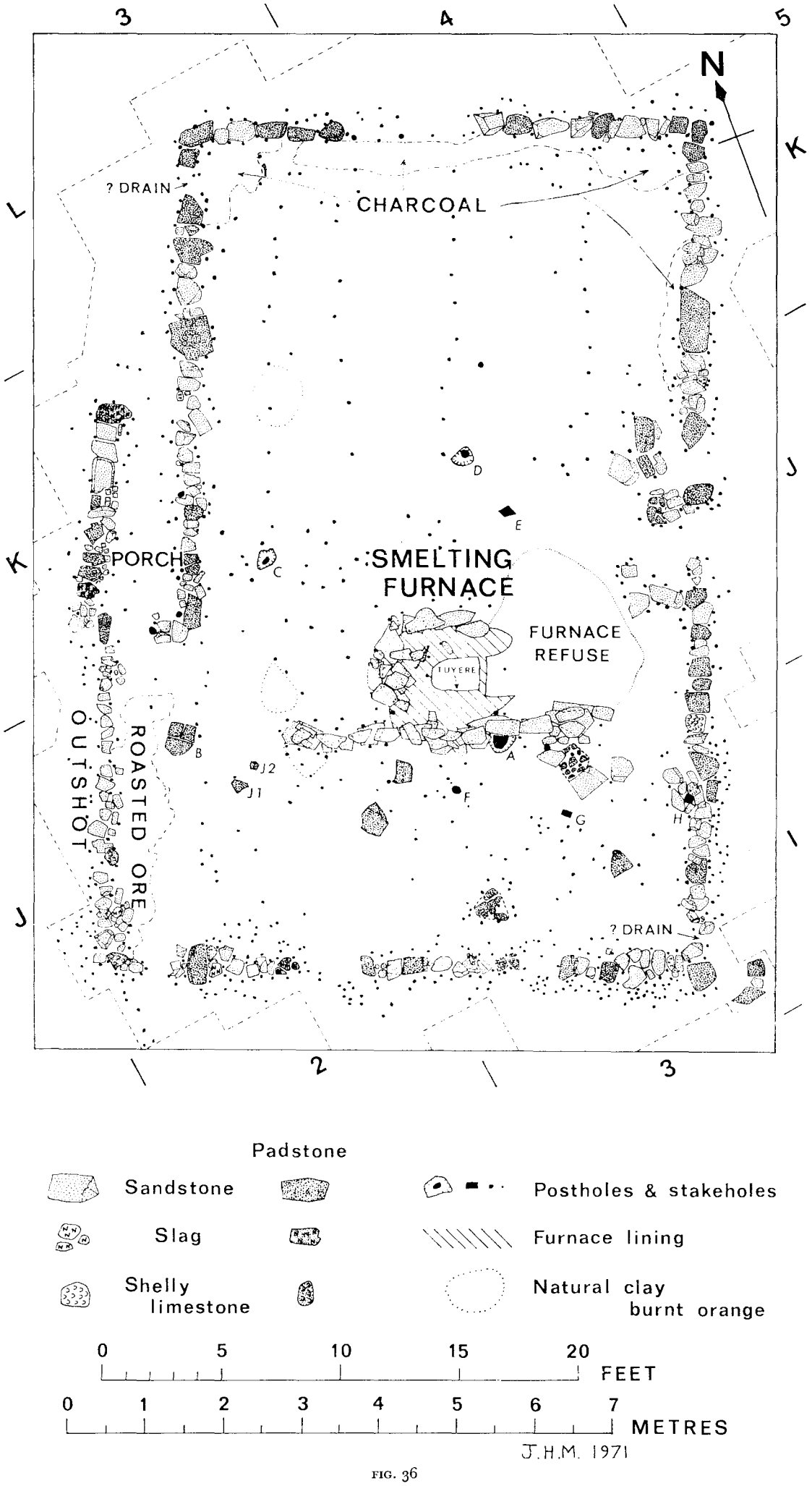

FIG. 36

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Detailed plan of groundwalls, padstones, post-holes and stake-holes of timber-framed building which enclosed the smelting-furnace and dumps of charcoal and roasted ore (pp. 94ff., 99, 108f.; Appendix III, p. 108ff.). For suggested reconstruction see FIG. 42.

[*face p. 96*

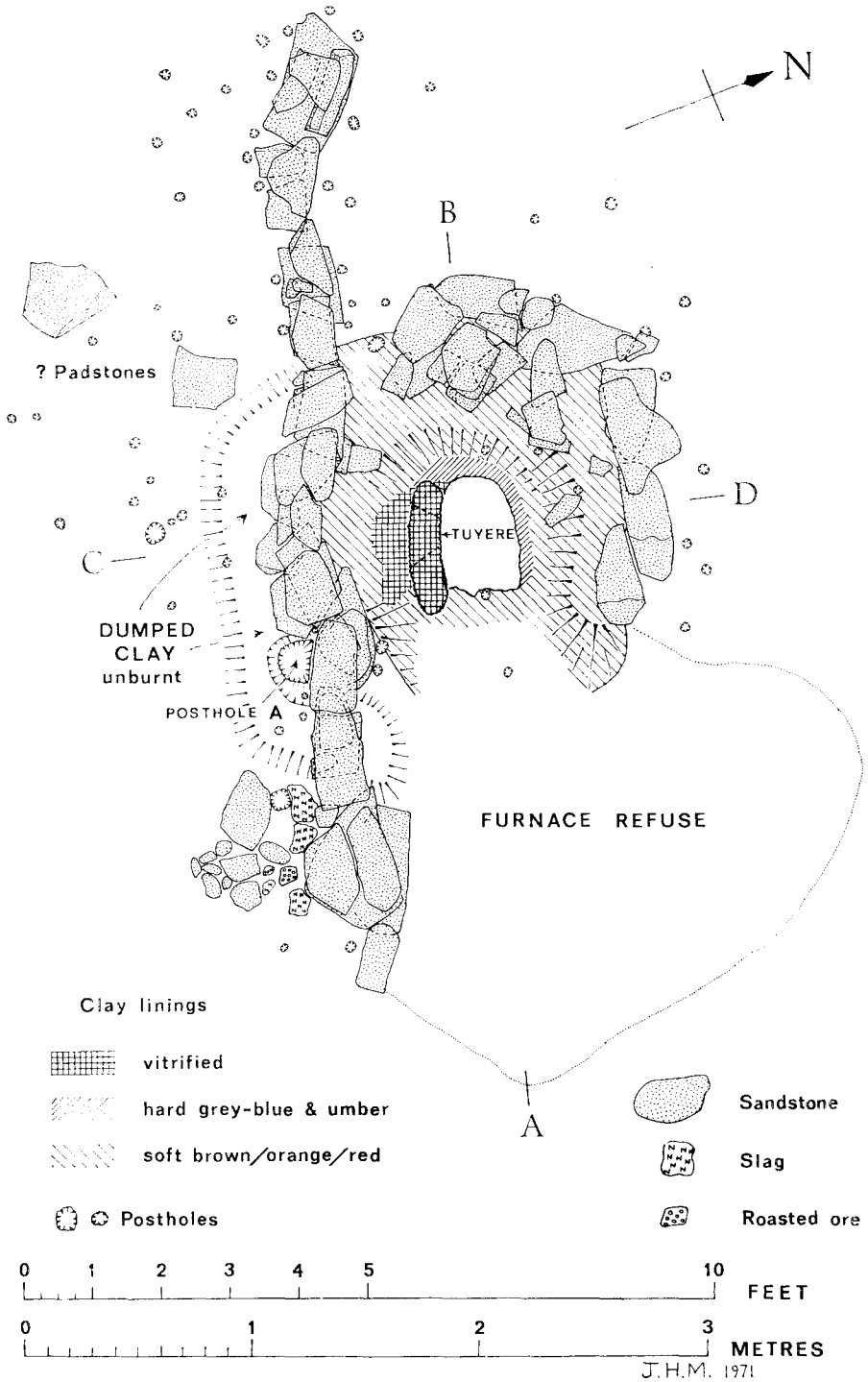

FIG. 37

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Detailed plan of smelting-furnace in final form (cf. PL. XI, B, and FIG. 38), with fireback on S. side (pp. 97, 99).

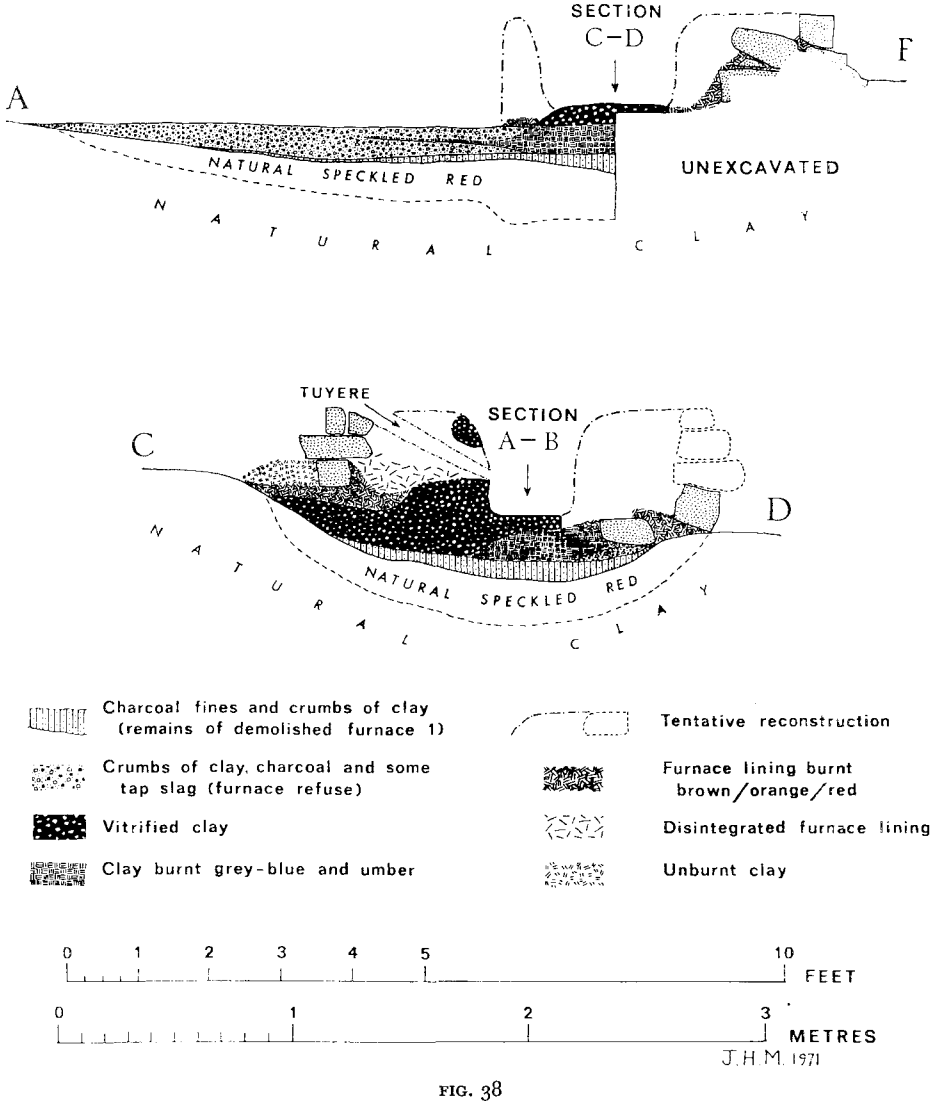

FIG. 38

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Sections A–B and C–D through smelting-furnace (see plan, FIG. 37), showing also a tentative reconstruction (pp. 90, 96, 98f.)

clay, which in turn was strengthened by masonry; the whole structure, which was arranged roughly in the shape of a horse-shoe, measured about 6 ft. (1·8 m.) across. Unburnt clay belonging to phase 1 was dumped around and against the masonry on the SW. side. If this was not part of the structure, it was possibly the remains of clay provided for renewing the linings of the furnace. It is likely that in phase 1, as in phase 2, the bellows were situated on this side. It is not possible to state with certainty whether the earlier furnace also was protected by a shelter

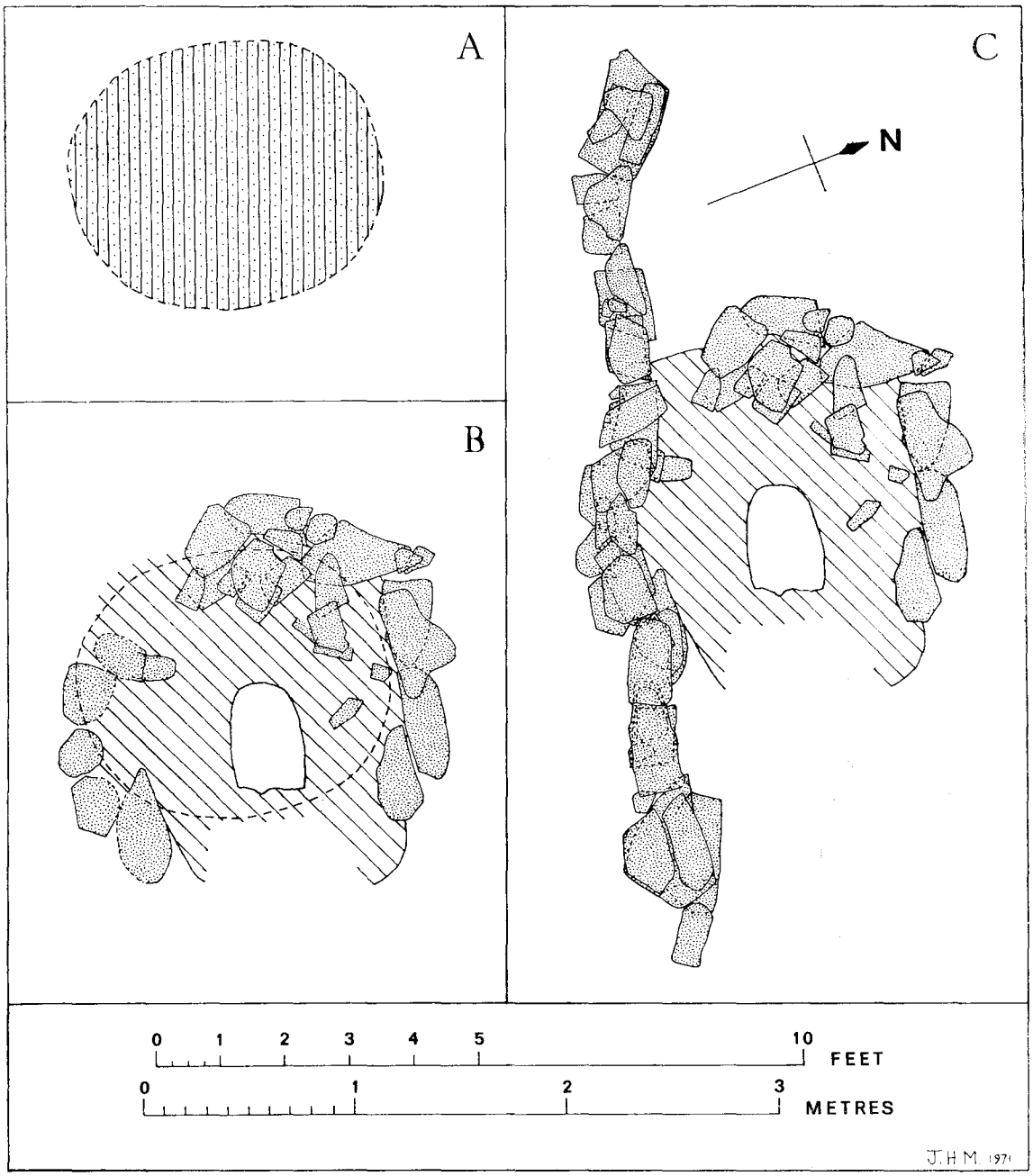

FIG. 39

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Diagrams showing development of smelting-furnace (pp. 90, 96, 98f.): A. Depression (dimensions approximate) which contained debris of furnace I; B. Phase 1, furnace II (dump of unburnt clay on S. site omitted); C. Phase 2, furnace II, with fireback on S. side (post-holes and stake-holes omitted)

and, if so, what form the shelter took; all one can say is that there are a number of post-holes surrounding it which could have held upright timbers for this purpose.

In phase 2 the stone-work on the SW. side was strengthened, heightened and extended for a few feet to the north-west and south-east—the whole forming a low partition-wall, 14 ft. (4·2 m.) long and 2 ft. (0·6 m.) high in the middle, athwart the timber-framed enclosure, but not reaching either of the longer sides. It was probably just a reredos, or fireback, to the furnace and not otherwise structural. It overlay the unburnt clay dumped on this side in phase 1.

A substantial timber hood or shelter was built over the furnace (FIG. 42). Some of the major post-holes near the furnace (e.g. C–H, FIG. 36) probably held uprights for the shelter; post-hole A, if it was contemporary with the stone fireback (which is not certain), may also have held a post which was part of the structure of the furnace or of its hood or shelter (Appendix III, p. 108).

As noted above, the bellows were on the SW. side, probably supported on a timber structure and/or the stone-work. They operated through a tuyère, the aperture of which has survived in the wall of the furnace. This part of the superstructure proved to be part of a large cake of tap slag which, with a hole chipped out for the tuyère, was ingeniously incorporated in the furnace (see Appendix I, p. 106).

S. E. Rigold suggests that, in order to enable it to withstand the heat of the furnace, the hood or shelter over the furnace was liberally plastered with clay. This suggestion is strengthened by the discovery of many lightly-burned clay fragments not only in the collapsed stone-work but also above and around the furnace. Two iron nails found in the vicinity of the furnace may have belonged to this structure.

H. F. Cleere deduces from the presence of vitreous slag in slag-heap no. 3 (which derived from this furnace) that pieces of limestone were occasionally added to the charge. He considers, however, that the iron-workers were unaware of the potential value of limestone as a flux (Appendix I, p. 105). In this connexion it is worth noting that pieces of ferruginous shell-bed were found at the mouth of the furnace, under collapsed furnace lining, and in the slag-pit.

PL. XI, B, shows the completely excavated furnace, and the slag-pit partly cleared. Behind the furnace is the stone fireback, partly reconstructed from the tumbled masonry which was found lying undisturbed where it had fallen.

Slag-heap no. 3 (M 6–I 7)

Slag from the smelting-furnace was dumped over a wide area beyond the roasting-furnace. The full extent of the slag-heap was not ascertained. It appeared from what was explored to be roughly oval in shape and to measure not less than 23 by 54 ft. (7 by 16·5 m.); it varied in depth from 12 to 18 in. (30 to 46 cm.).

Like slag-heaps nos. 1 and 2, slag-heap no. 3 contained cinder and bloomery-type slag. It also included examples of greenish-black vitreous slag containing a substantial proportion of lime, which must have been derived from shelly limestone added to the charge.

A sample of charcoal from the slag-heap in L 6 was entirely of oak, except for one fragment of beech. This compares well with a sample taken from the slag-pit of the smelting-furnace (J 3), which was predominantly of oak with a small amount of beech.

Apart from the six sherds found in the timber-framed building (p. 96) all the pottery discovered (ten sherds), including that illustrated in FIG. 41, came from various parts of the slag-heap.

SITE D

Site D (FIGS. 31, 40), the last to be excavated, was brought to notice by masonry projecting above the surface. Digging revealed a small timber-framed building (FIG. 40) measuring 8 by 13 ft. (2·4 by 4 m.), a short distance south-west of the roasting/smelting complex; there is a note on its construction in Appendix III, p. 109. It was probably wither a workmen's shelter or a store for iron-working materials (for reconstruction see FIG. 42). Except in winter it would usually have been upwind from the furnaces. This suggests that smelting may have been confined to the summer months.

Occupation-material in the hut included part of a strap-handle and thirteen other sherds (Appendix II, p. 108); three iron nails, a strip of iron (possibly part of a blade), $\frac{1}{4}$ in. (0·6 cm.) thick, measuring 5 by 2 in. (14·6 by 5·0 cm.), and other small pieces of iron; a few scattered pieces of natural ore and slag; and small bits of charcoal (including oak, beech, birch, hazel and ash).

Immediately outside the entrance on the NE. side there was a patch of natural clay, burnt orange—presumably the site of a hearth. A few feet away there were two small concentrations of charcoal, probably refuse from this hearth, a sample of which showed more than one-third birch, one-third oak and beech, and the rest poplar, hazel, alder and one piece of hawthorn—a typically random collection of firewood.

Above and around the site of the hearth and separated from it by an inch or two of soil were some thirty pieces of shelly limestone, some of it ferruginous. This probably came originally from the lower part of the Wadhurst Clay and could therefore have been obtained locally. The relative rarity of the vitreous slag (p. 105) would suggest that shelly limestone was not used deliberately as a flux in the smelting-furnace. There is evidence from Minepit Wood itself, where shelly limestone was used in the groundwalls of the timber-framed building, and other Wealden sites (e.g. the Roman workings at Bardown) that it was used for building; its use for this purpose in more recent times is well known and attested by the local name 'Bethersden marble'.

Immediately beside the SW. side of the hut there was a pit (presumably a minepit) which was partially explored and found to contain a mixture of silt and blocks of masonry. The date of this pit and circumstances of its filling are not known: some of the masonry may have come from the groundwalls of the hut.

A sample of charcoal from the occupation-material has a radio-carbon date (BM-367) of 534± 61 years B.P. (14th to 15th century).

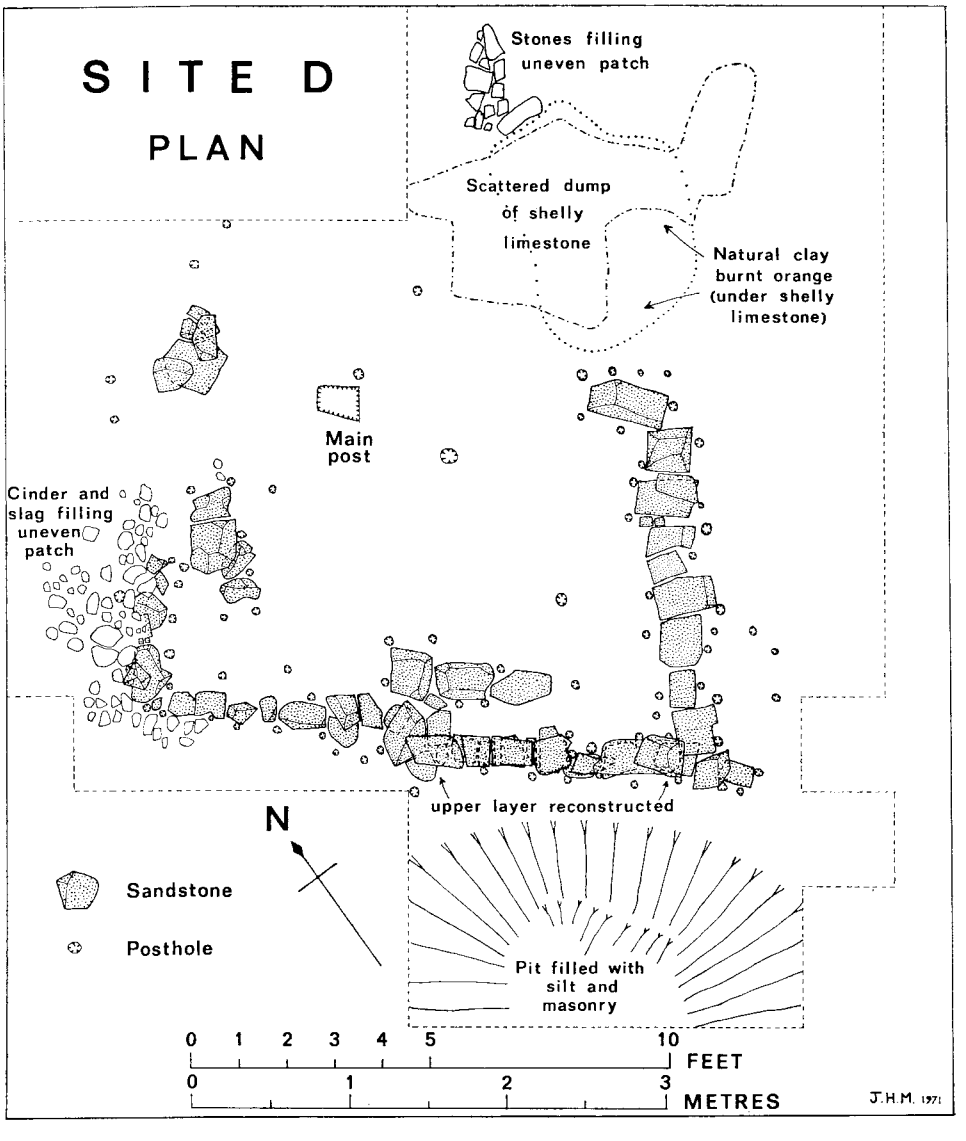

FIG. 40

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE D

Plan showing groundwalls of shelter and adjacent pit (pp. 101, 105, 109). The dump of shelly limestone contained some 30 pieces. For reconstruction of shelter see FIG. 42, top right.

COMPARATIVE MATERIAL

In looking for comparative material one's attention is drawn to the 14th-century iron-working site at Tudeley, near Tonbridge, Kent, which lies some 11 miles (17·7 km.) to the north-east. The workings, although not yet precisely located, are known from the accounts of the site itself and those of the manor of Southfrith (a large property covering roughly the same area as the present Somerhill estate), which owned the workings. These, which are in the Public Record Office, cover the Southfrith accounts in general terms from 1329 to 1375 and the iron-works on their own from 1350 to 1354.[3]

There are in fact points in common between Tudeley, which was probably a typical 14th-century site, and Minepit Wood, which on the evidence of radiocarbon dates and pottery was active during the 14th and 15th centuries. Tudeley was rebuilt or considerably repaired in 1343. The items of expenditure (which amounted to £1 10s. 4½d!) included carpenters hired to make the woodwork of the forge, 1,400 feet of boards for the roof, nails, and plastering the walls.[4] In 1350–1 fresh repairs included carpentry, nails and daubing. There are numerous mentions of the principal raw materials, charcoal and ore. Finally there is reference to 'elyng' (burning) the ore, i.e. roasting it in preparation for smelting.

All these points are reflected in Site C at Minepit Wood, with its timber-framed building (including remains of burnt fabric, plaster and nails) and the virtually intact roasting-furnace. Let us hope that one day Tudeley will be identified and explored, so that it can be set beside Minepit Wood.

APPENDIX I

IRON-MAKING MATERIALS

By H. F. Cleere

The material submitted for examination may be divided into three groups:

I. Iron ores and limestone
II. Slags and cinders
III. Structural debris of furnaces

References throughout are to the plan in FIG. 31.

I. IRON ORES AND LIMESTONE

1. *Iron ore* (*unroasted*). Specimens of the characteristic iron ores of the Wadhurst Clay came from the dump of natural ore in K 4/K 5/K 6 alongside the roasting-furnace in Site C. This is a nodular siderite ore (i.e. a fine-grained mudstone consisting of iron carbonate—$FeCO_3$), enclosed in a weathered 'box' of limonite (Fe_2O_3).

[3] M. S. Giuseppi, 'Some fourteenth-century accounts of iron-works at Tudeley, Kent', *Archaeologia*, LXIV (1913), 145–64, and Straker, *op. cit.* in note 1, pp. 34-6, 92, 220 and 221.

[4] Giuseppi, *op. cit.* in note 3, p. 148.

Analysis of a typical specimen of this ore gave the following composition (%):

FeO	Fe_2O_3	SiO_2	Al_2O_3	MnO	P_2O_5	SO_3	CaO	MgO	Na_2O	K_2O	Loss on ignition
0·5	64·6	10·6	5·3	2·7	0·37	0·07	0·4	0·7	nd	nd	11·8

This a very easily reducible ore (*c.* 1·05% per minute using the ISO Test).

There were also specimens of a tabular form of the same ore, lacking the enclosing limonite skin. This material is slightly lower in total Fe content, but it occurs in direct association with bedded Cyrene limestone (see below), making for greater ease of reduction.

The specimens varied in size between 2 in. and 5 in. cube; experiments[5] have shown that considerable degradation in size results from the roasting process. However, fragments of larger nodules point to there having been some crushing of the ore before it was stocked out beside the ore-roasting furnace.

2. *Roasted ore.* Samples from the pile of roasted ore within the timber-framed structure on Site C exhibited the characteristic maroon colour of the Wadhurst Clay siderite after roasting. The process involves prolonged heating in a furnace open to atmosphere at 500–600° C; the effects are three-fold:

i. Conversion of the $FeCO_3$ to Fe_2O_3,
ii. Expelling of the combined and uncombined water,
iii. Degradation in size of the larger lumps.

The degree of success of this roasting (or calcining) process varied: in some samples the maroon colour was seen, on breaking the lumps, to be consistent throughout, but on others it was confined to a thin (1/8 in.) outer layer.

The lump-roasted ore overlay a deposit of fine particles of roasted ore. This was a natural effect of stocking out the ore: the fine material tended to filter through to the bottom of the heap. There may have been some deliberate screening of the ore, as appears to have been the case at Bardown;[6] the use of large proportions of fine material might have the effect of clogging the furnace and thereby reducing the efficiency of the process. However, there is little evidence to indicate positively whether ore-screening was carried out deliberately or consistently; the presence of lump ore on the refuse-heap could be interpreted as evidence that the fine material was rejected, some lumps of ore being removed when it was shovelled away, but it is difficult to be dogmatic on this point.

The filling of ore-roasting furnace II in J 5 was largely of small roasted nodules, of 1–1½ in. cube. When fractured, these proved to have been well calcined, indicating perhaps that they remained in the bottom of the furnace during several roasting operations. This is confirmed by the fact that they were separated by a layer of crushed charcoal.

3. *Limestone.* A ferruginous shelly limestone known as Cyrene limestone or 'Bethersden marble' occurs naturally in association with iron ore in the Wadhurst Clay. Some of it is iron-stained and superficially appears to be an ore; its composition (%) is as follows:

FeO	Fe_2O_3	SiO_2	Al_2O_3	MnO	P_2O_5	SO_3	CaO	MgO	Na_2O	K_2O	Loss on ignition
2·3	2·3	3·3	1·9	1·3	0·20	2·02	46·0	0·8	0·35	0·20	37·8

At least one specimen of unroasted ore had this limestone adhering to it. As will be shown later, the use of this material in the furnace in small quantities together with the

5 H. F. Cleere, *Iron Smelting Experiments in a Reconstructed Roman Furnace* (The Iron and Steel Institute, 1970).

6 H. F. Cleere, *The Romano-British Industrial Site at Bardown, Wadhurst* (Sussex Archaeol. Soc. Occasional Paper no. 1, 1970).

siderite ore would greatly improve the efficiency of the process. There is direct evidence of its having been charged to the smelting-furnace, although this is believed to have been accidental and not regular practice.

II. SLAGS AND CINDERS

A great deal of slag was found on the site. Material was examined from slag-heaps nos. 1 (1 4/1 5), 2 (1 6/1 7), and 3 (J-K-L-M/6-7) on Site C (FIG. 31), and also from the 'hard standing' and the pit on Site D (FIG. 40). This may be classified as follows:

1. *Bloomery-type slag (tap slag)*. Material that was allowed to run molten from the furnace. It is black, glossy, dense material, the following being a typical analysis (%):

FeO	Fe_2O_3	SiO_2	Al_2O_3	MnO	P_2O_5	SO_3	CaO	MgO	Na_2O	K_2O	Loss on ignition
45·5	6·0	24·3	6·4	2·8	0·69	0·20	9·5	1·7	0·15	0·72	nd

In the bloomery process, the gangue (non-metallic portion of the ore) had to be removed physically from the metal. This was done by forming a low-melting-point material in combination with iron oxide (in the modern blast furnace, limestone is deliberately added to produce a slag.) Thus a high proportion of the available metal was sacrificed in order to separate the gangue.

This type of material occurred on all three slag-heaps, and also at the two locations in Site D.

2. *Cinder and/or furnace bottoms*. In the process, the earliest formed slag settles at the base of the furnace, where it solidifies. It is then exposed to considerable variations of temperature and pressure, whilst it collects debris, such as partially-reduced ore, charcoal, pieces of clay lining, etc., which have dropped or been brought down the shaft. The result is a porous cake of slag (chemically identical with tap slag), rather resembling clinker from a boiler, and containing other materials embedded in it. This is known as 'cinder'.

This material was also found in all three heaps, in the form of complete 'furnace bottoms', with some baked clay adhering to the under side, and broken fragments, but not on Site D.

3. *Vitreous bloomery slag*. The addition of increasing amounts of lime to the furnace burden reduces the amount of iron that has to be sacrificed, and changes the appearance of the slag. Slag-heap no. 3 showed examples of a greenish-black vitrified slag which had the following composition (%):

FeO	Fe_2O_3	SiO_2	Al_2O_3	MnO	P_2O_5	SO_3	CaO	MgO	Na_2O	K_2O	Loss on ignition
9·5	0·6	44·0	10·8	6·6	0·39	0·52	19·8	3·6	0·34	1·54	nd

The composition of the siderite ore shows that lime would probably need to be added to produce this result, and the obvious source would appear to be the shelly limestone referred to above. The relatively small proportion of this type of slag suggests that the iron-makers had not appreciated the value to them in terms of iron yield to be derived by charging this material; that depended on the ore being mined at the time whether this result was achieved. It is, perhaps, interesting to compare this establishment with the Bardown Roman site,[7] where shelly limestone was also found, as a by-product from ore-mining, but where it was used solely as a constructional material.

[7] *Op. cit.* in note 6.

There is no vitrified slag from slag-heap no. 2, but slag-heap no. 1 yielded one specimen of vitreous slag encased in the more conventional iron-rich slag; this would appear to be a very localized effect which was due to the charging of an isolated lump of shelly limestone.

It may be reasonable to postulate that slag-heap no. 3 is the latest of the three, not because it indicates a conscious improvement in technique, but—ironically perhaps—because an ostensibly poorer grade of ore was being worked, the pure siderite having been exhausted. The isolated find of one piece of vitrified material in slag-heap no. 1 would hardly justify, however, any conclusions about the relative dating of slag-heaps nos. 1 and 2.

III. STRUCTURAL DEBRIS OF FURNACES

A great deal of burnt clay was examined from different parts of the excavation. The natural clay in the area is yellowish, changing to red at about 500 °C. and grey at about 800–900 °C. as the iron oxides in the clay are changed by heat. Site C produced a number of specimens showing this heat-dependent colour-sequence from around smelting-furnace II.

One piece of grey-burnt clay from the occupation-layer of Site D was coated on one side with slag; experiments[8] have shown that slag collects on the lower walls of smelting-furnaces, attacking their structure and impregnating the layers in contact.

Interestingly, a similar sample from the wall of roasting-furnace I was examined. One would not anticipate this type of material forming in a relatively low-temperature process such as ore-roasting, but it is conceivable that localized hot zones might occur (e.g. in front of tuyères or bellows) where reduction of the ore and formation of slag might take place.

The other material from the roasting-furnaces was largely red-to-grey baked clay, some of it having a concretion of fine roasted-ore particles. It included filler material, dug out from part of furnace I and used as a backing material for the new furnace II. It would appear that the walls of furnace I were broken up and pounded quite small, the resulting baked clay crumbs being mixed, as a grog, with natural yellow clay, to produce a low-shrinkage backing. This shows that the iron-makers had considerable understanding of the properties of clay.

The putative remains of smelting-furnace I consisted of (*a*) a hard-baked surface of the natural clay; (*b*) a hard crusty surface, comprised of a dried slurry of charcoal fines and clay, which does not appear to have been heated to a very high temperature; and (*c*) a layer between this and the hearth of furnace II, comprised of crumbs of clay, charcoal, and a very little tap slag, similar in many ways to (*b*). It is felt that these do not represent a structural feature of furnace I or the remains of its contents. They appear to be more consistent with a demolition of furnace I, perhaps a period of abandonment, and then a tidying-up of surrounding debris for the construction of furnace II. They make the idea of seasonal operation and occupation of the settlement seem all the more probable.

The floor of smelting-furnace II is represented by two large lumps of undoubted 'furnace-bottom' material, as described in II, 2, above. Little of the superstructure remained. A curious feature was the large cake of slag with what was believed to be part of a tuyère-hole in it. On close examination, this proved to be part of a large cake of tap slag. There are signs that the tuyère-hole had in fact been chipped out. It looks, therefore, as though an ingenious iron-maker hit upon the idea of reusing a piece of tap slag as part of the wall of the furnace. To use tap slag at a tuyère was reasonable, since this area would be a relatively low-temperature one, and there would be little likelihood of remelting. However, no parallels can be found for this example.

[8] *Op. cit.* in note 5.

GENERAL COMMENTS

From the standpoint of technological development, the site is of interest in several ways. The use of a three-sided masonry structure to define ore-roasting furnace II has a striking parallel in medieval Germany (see pp. 92, 94, and references to Agricola's *De Re Metallica*).

The reuse of tap slag for building up a new furnace is so far unique, and shows some resourcefulness on the part of the iron-maker. Finally, the use of a limestone flux at such an early date is of great interest, although it must be admitted that the potential value of the shelly limestone was not comprehended.

Perhaps the most interesting feature of the whole complex is the fact that so little technological progress had been made since the period when the adjacent Roman site was in operation. The bloomery process was virtually unchanged, and even the furnaces appear to have been identical.

APPENDIX II

THE POTTERY

By S. E. Rigold

SITE C

Four or five vessels seem to be represented. Two or three of them, presumably cooking-pots, are ware with pink-buff, oxidized surface and, in some parts, a reduced core, tempered with dark sand and very sparse (? flint) grits. One has shallow applied strips and another some scratched decoration, both of which would be archaic features around 1400. These are thin-walled, as are the two others in rather different ware but both with straight necks and flattened rims, distinct from the rolled-over forms generally prevalent in Kent, and thus of a form more usual in Wessex, but possibly revived over a wider area. One (FIG. 41, no. 2) has an upright neck (diam. *c.* 25·7 cm.) and is of

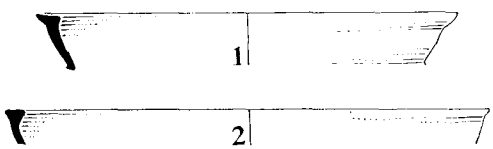

FIG. 41

MINEPIT WOOD, ROTHERFIELD, SUSSEX, SITE C

Fragments of two cooking-pots, *c.* 14th-century (p. 101, and Appendix II)

fabric like the foregoing, but harder, with pale grey core, pink-buff exterior and thin, olive, internal glaze. A sherd in similar ware may come from the shoulder of the same pot, or possibly be the base of a rounded bowl, though the rim in question is unlike those of comparable and relatively late round-bottomed bowls from other Sussex sites (e.g. Hangleton[9]). The other (FIG. 41, no. 1) is slightly more heavily gritted, has a much more everted neck (diam. *c.* 22·4 cm.), grey exterior on the same sort of pinkish body 'sandwiching' a reduced core, and slight splashes of glaze. Inner glazes on cooking-pots are generally a late medieval feature, but are known in the Isle of Wight by *c.* 1300 and something like the rim-form of no. 2 can occur, even in Kent, at that date. There are also sherds of a harder grey ware with traces of a dissolved shell or chalk temper, resembling

[9] J. G. and D. G. Hurst, 'Excavations at the deserted mediaeval village of Hangleton', *Sussex Archaeol. Collections*, CII (1964), 126, fig. 9.

the pottery prevalent in West Kent *c.* 1300, but not attested much later. However, the 13th-century traditions can linger, beside incoming late medieval forms, until the end of the next century, and we may well be in the presence of such survivals on both sites here.

SITE D

Not more than three or four vessels are represented. They include a jug, indicated by a piece of strap-handle with sparse stabbings; the others may be globular jugs or thin-walled cooking-pots, as at Site C. The fabric is the same fine, sandy ware, with extremely sparse (? flint) grits. The majority of the sherds come from one vessel, with smooth, grey exterior, pink-buff outer body and reduced core. Another eroded vessel may have borne fine combings. The fabric and the form of handle are consistent with the early 14th century, but again, not excluding a later date.

APPENDIX III

THE TIMBER-FRAMED BUILDINGS

By S. E. Rigold

SITE C (FIG. 36)

The building, or enclosure, is surprisingly rectangular, omitting the narrow outshot along part of the NW. side, later extended by a pentice or outer porch. The plan is preserved in feeble groundwalls, seldom more than one slab of sandstone high, with larger and horizontal slabs, not always certainly distinguishable, that appear to have served as padstones for posts and thus give some indication of the bay-arrangement. A rough partition-wall athwart the structure but not reaching either of the longer sides may well be simply a reredos, or fireback, to the furnace and not otherwise structural (PL. XI, B). The function of the large post-hole (A) is not clear. If contemporary with the fireback and the timber-framed buildings, which is not certain, it probably held a post which was part of the structure of the furnace or its shelter. Apart from the (unextended) lateral outshot, on the inner line of which is the most unequivocal padstone or stylobate (B), near the intersection with the line of the fireback, the groundwalls are interrupted at the NE. end (not centrally); at symmetrical intervals at the SW. end; near the middle of the SE. long side, where there are traces of short speres or wind-screens; and probably in the middle of the opposite long side, later blocked. There is also a fairly certain line of free-set padstones immediately south-west of the fireback, defining this part of the building as a separate enclosure running into the outshot.

The groundwalls are lined on the exterior and, less regularly, on the interior too, with several rows of stake-holes. The pattern of the padstones suggests that the structure was divided into four bays of about 9 ft. (2·7 m.), of which the area south-west of the fireback formed one. But it seems unlikely that the whole enclosure was roofed. Although the width is well within the possible tie-beam span of a strongly-framed building, it seems too much for something with very short bay-lengths and looking a good deal less solid than a minor aisled barn, and there are no traces of the aisle-posts that might be expected to help carry the transverse span. Three post-holes (C, D and E), placed quite irregularly, but with D almost in the centre of the consequently unroofed yard, only make sense as the emplacements of supports for a hood or shelter around the furnace. Three more post-holes (F, G and H) in a line perhaps continued by a padstone (J1 or J2) would seem to have carried the rear of the hood as well as the roof of the area south of it, clear of the furnace fireback. At this period any building in which post-holes were included must have been a very rude structure indeed.

Nevertheless, the regular layout suggests that it must bear some relation to a properly framed building. Unless the posts were embedded in solid walls of cob (which is unlikely in this case, but known in the West Country), they must have had some form of plates and braces to support them, even if they did not carry a roof throughout. There are fairly clear indications of door-posts in the apparent padstones flanking all the interruptions in the walls. An arguable interpretation is that the walls were of a passable but fairly light open framing throughout, but with no infill or cladding other than that represented by the wattle stakes outside them—hollow and insulating walls, in fact, with a thick casing of wattle-and-daub, but strong enough to take a roof over some part, and in particular the SW. bay, windward of the furnace, and its outshot. On the other hand, though cob walls with protective rooflets are known in the nearer parts of Wessex, there are no preserved examples of framed walls cased on both sides with rough parging. In the reconstruction (FIG. 42) the walls are represented as of some thickness and fully rendered, whatever their construction, and they are given rooflets to shed the water.

Both the SW. bay and the outshot may have had lean-to roofs, although 9 ft. (2·7 m.) is not too small for a light span-roof, such as is more likely to have covered the bay. There was also, almost certainly, a fairly capacious hood over the furnace, abutting the fireback, but the rest of the remaining three bays, which are divided into five long bins, two narrow, three broad, by lines of stake-holes indicating hurdles or fences, probably had no cover, except over the charcoal (which for technical reasons needed to be kept dry) in winter or whenever else conditions required it. Since no traces of roof-tiles or slabs were found, any roof covering was presumably of thatch or brushwood, but may have been thickly caulked with clay as protection.

SITE D (FIG. 40)

This small shelter had the same type of walling as the building on Site C—a single bed of sandstone slabs faced with stake-holes—except its SW. wall, which had at least two courses, partly *in situ* and partly tumbled. The walling seems to have been built in two halves, the south-east, with slightly larger slabs, overlapping the north-west. If the two parts were in use together, they formed a structure open to the north-east, with a post-hole or socket for a padstone for a single post that would have been quite enough to support the lintel over the opening. Nothing can be said about the covering save that even the meanest cart-sheds may have span roofs.

Reconstruction

My reconstruction of the buildings on Sites C and D is reproduced in FIG. 42. The following notes are relevant:

1. The shadows are those of early morning.

2. A permanent hood over the smelting-furnace is shown, on the strength of the post-holes and of widespread medieval practice. It may have extended to the side walls of the enclosure, and thus been squarer in appearance, but set diagonally to the enclosure. The alternative, but perhaps less probable, polygonal form has been chosen as less obscuring to the rest of the structure.

3. There is no indication of a hammering-place, which may have been behind the furnace or under the hood (an extended hood would allow more room for swinging) and must certainly have been near the furnace.

4. The enclosure walls are shown as faced in wattle-and-daub and with rooflets. Mr. P. A. Faulkner, whom I have consulted, agrees that this is the most probable interpretation of the evidence.

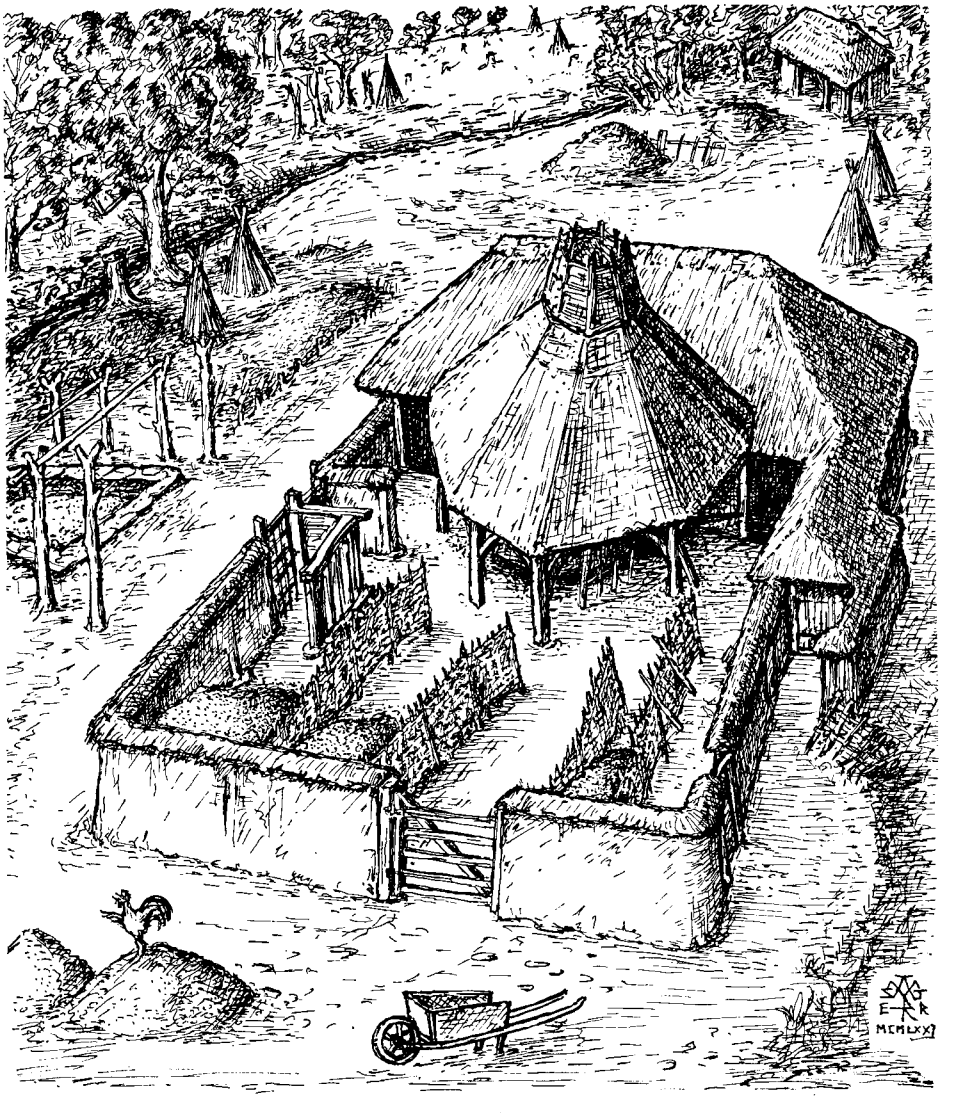

FIG. 42

MINEPIT WOOD, ROTHERFIELD, SUSSEX

Reconstruction of buildings of Sites C (foreground and centre) and D (top right) in their environment (pp. 94f., 99, 101, and Appendix III)

5. No attempt is made to reconstruct a shelter over the charcoal at the N. end, although for technical reasons this ought to have existed.

6. The form of the removable shelter over the roasting-furnace relies on 16th-century German analogies only.

ACKNOWLEDGEMENTS

First I must thank Mr. and Mrs. Patrick Gibson, who own Minepit Wood and the adjacent land, for giving us access and helping in many other ways.

Clearance operations, five seasons digging, filling in on all four sites and the production of reports (of which this is one) cost £459, of which £436 was provided by subscribers to the Excavation Fund. Thanks are due to all the societies and individuals who contributed, in particular Mrs. G. von Harten, Mr. I. D. Margary and Mr. John Rogerson, who were especially generous.

The work on Sites B, C and D was carried out entirely by volunteers. I am grateful to the supervisors, Mr. Franklyn Dulley, Mr. Frank Johns and Mr. John Rogerson; and to Miss Ann Costello, Mrs. D. F. Giles, Miss K. E. Leigh, Mr. F. J. Sheldon, Mr. Barry Steel and Mr. John Theobald, who were present throughout most of the work. Thanks are also due to Mr. Peter Rowley for reconstructing the stone-work beside the smelting-furnace in Site C.

When I started work my knowledge of the techniques of early iron-working and the special problems which the excavation of such a site would present was very small. I was fortunate in having the help and advice of Mr. Henry Cleere (Iron and Steel Institute) and Dr. R. F. Tylecote (Department of Metallurgy, University of Newcastle upon Tyne), who visited the work on many occasions and put their expert knowledge at my disposal. Mr. Cleere also arranged for tests on the samples of ore, slag, furnace-linings and furnace-refuse, and reported on the results (Appendix I). Thanks are due to the British Museum Research Laboratory for undertaking a number of carbon-14 determinations which provided vital dating evidence. I am grateful to Dr. E. R. Shephard-Thorn, Mr. B. C. Worssam, Mr. F. G. Dimes and Mr. S. C. A. Holmes (Institute of Geological Sciences) for help on geological problems; to Dr. I. W. Cornwall (London University Institute of Archaeology) for soil analysis; to Dr. M. Y. Stant (Jodrell Laboratory, Kew Gardens) and Miss J. Sheldon (London University Institute of Archaeology) for identifying the charcoals; to Mr. S. E. Rigold for reporting on the pottery (Appendix II), for help in interpreting the structure of the buildings (Appendix III), and for the reconstruction-drawing (FIG. 42); and to Mr. Henry Hodges (London University Institute of Archaeology) for reporting on the iron objects.

Dover Publications Inc., New York, have kindly given permission for FIG. 35 and the reference on p. 92 to be included.

The finds, site books, plans and section drawings are stored at the Tunbridge Wells Museum.