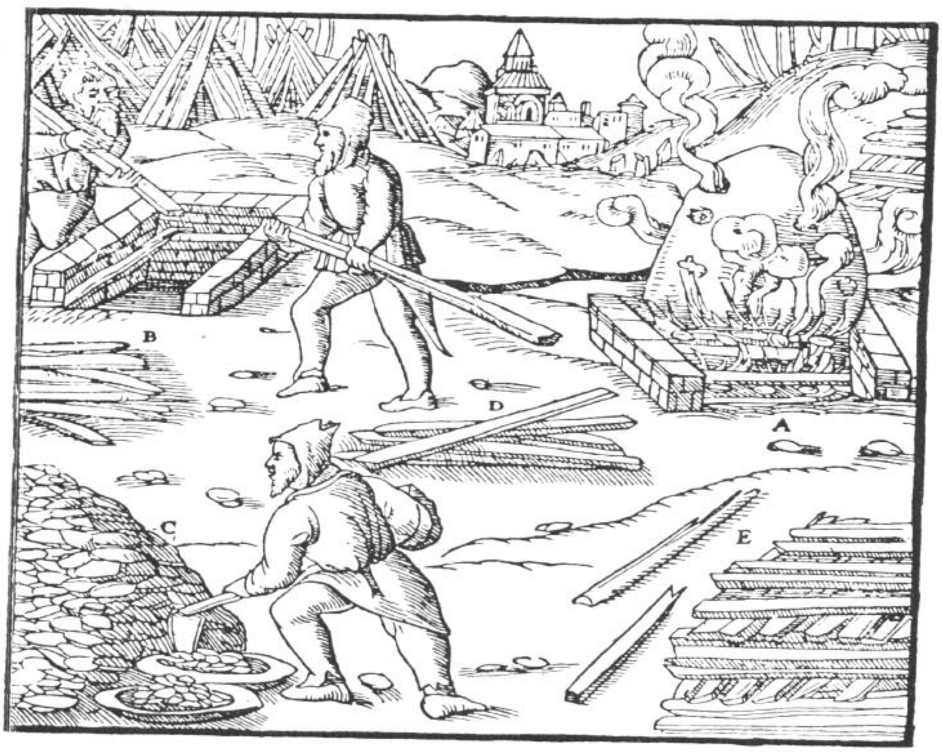
CBA RESEARCH REPORT

No 40

MEDIEVAL INDUSTRY

edited by
D W Crossley



1981

Medieval industry

edited by D W Crossley

1981

Research Report No 40 Council for British Archaeology

ISBN 0 906780 07 1

Published 1981 by the Council for British Archaeology
112 Kennington Road
London SE 11 6RE, United Kingdom

Designed by Allan Cooper FSIA and Henry Cleere

The publishers acknowledge with gratitude grants from Imperial Chemical Industries Ltd and the Rio Tinto-Zinc Corporation Ltd towards the publication of this volume.

British Library Cataloguing in Publication Data

Medieval industry.-(Research report/Council for British Archaeology, ISSN 0589-9036; no. 40)
1. Industrial archaeology--Great Britain-Congresses
I. Crossley, D. W.
609'.41 T26.G7

ISBN 0-906780-07-1

PRINTED BY CLARK CONSTABLE LTD,
HOPETOUN STREET, EDINGBURD EH7 4NF

Contents

Contributors

Dr I S W Blanchard, Dept of Economic History, University of Edinburgh, William Robertson Building, 50 George Square, Edinburgh EH8 9JY

13 W Crossley, Dept of Economic and Social History, University of Sheffield, Sheffield S10 2TN

P J Drury, Chelmsford Excavation Committee, The Old Cemetery Lodge, 1 Writtle Road, Chelmsford, Essex

Alison R Goodall, 22 Elmlands Grove, York Y03 0EE

Ian H Goodall, RCHM(E), The White House, Clifton, York

T A P Greeves, Dartmoor National Park, Parke, Haytor Road, Bovey Tracey, Newton Abbot, Devon

Dr J K Hunter, School of Archaeological Sciences, University of Bradford, Bradford BD11 1HX

Dr D J Keene, Department of Urban Archaeology, Museum of London, London Wall, London EC2Y 5HN

S A Moorhouse, West Yorkshire County Archaeology Unit, County Hall, Wakefield, West Yorkshire WF1 2QW

Professor P A Rahtz, Department of Archaeology, University of York, Micklegate House, York YOl 1JZ

Dr M L Ryder, A R C Animal Breeding Research Organisation, Field Laboratory, Roslin, Midlothian EH25 9PS

Professor R F Tylecote, Institute of Archaeology, 31-34 Gordon Square, London WC1H 0PY

Editor's introduction

It was the wish of the late Professor Eleanora Carus-Wilson that a review should be undertaken of the scattered archaeological evidence for medieval industry. Unfortunately she did not live to see the arrangement of a conference or the publication of its proceedings. Nevertheless, the example she set in urging the juxtaposition of documentary and field evidence for early industry was much in the minds of those who arranged the meeting of which this volume is a record.

The spread of topics discussed in the following pages forms apt comment on certain achievements and problems in medieval archaeology. There has been, for example, no difficulty in securing contributions in the fields of ceramics or glass, metal smelting and smithing, or milling. Metal smelting and grain milling logically extended to the early use of power. Yet both in planning and in retrospect there arc fields where further work is seen to be necessary. For example, in textile manufacture, the industry far and away largest in terms of employment and value added, archaeological studies arc in their infancy. The documentary lead Professor Carus-Wilson herself gave to the study of the fulling mill has given rise to few field studies or escavations. It was decided that here, in present circumstances, there was much to be said for setting out with a contribution on the major raw material, wool, as a basis for future discussion of processes in which it was used.

There was also an awareness of the difficulty of giving proper attention to the wood-using crafts. Unfortunately it has not been possible to include Dr Ellmers's paper on medieval shipbuilding in this volume, nor was it possible to secure a more general contribution on the scope and methods of medieval woodworking. It is, therefore, heartening to set' that by the time this volume is in print the National Maritime Museum will have held a symposium on woodworking techniques before AD 1500.

A large but less easily defined field was also seen to lack proper coverage. It was felt by organizers and participants that there are many unanswered questions about methods and evidences of a multitude of urban crafts. The contributions relating to ferrous and non-ferrous artefacts do, of course, enter this field, but there is clearly scope for assembling escavated and documentary material sufficient to give the archaeologist guidance in identifying the occupational remains of trades and crafts, whether they used metals, wood, or animal products.

Finally, the contributions to this volume show the varying approaches which topics within the subject of early industrial history have generated. The reader will find examples of evidence dominated by artefacts, by physical indications of processes, or by the documentary record of occupations and locations. In some cases the emphases are inevitable but in others they are the consequence of neglect, whether in the field or amongst the archives.

It is the object of this note to emphasize that these proceedings stand as no more than an early stage in the study of medieval industry, pointing explicitly or implicitly in directions which could usefully be taken in the future.

Milling is one of the most intriguing of all medieval industries, utilizing prime movers of natural and animal origin — human and animal power, wind, river and tide, with the watermill making considerable use of gravity. Only in comparatively recent times, and still not everywhere, has fossil-fuel power supplemented the older energies. When fossil fuel is exhausted, there may be nuclear or solar-powered mills; but if not, it may be as well to be familiar with the mechanics of the medieval mill, which in its simpler forms are within the skill of any survivor.

Mills are not only of importance in the history of technology, but they also have a wider appeal both on account of their working parts, which have all the attraction of clockwork, Meccano, and steam engines, and also aesthetically — the latter evident from at least the 12th century in sculpture and painting. Recent and surviving mills are surprisingly similar to their medieval and classical ancestors, and so ethnographic observation is fundamental to our understanding of the medieval mill. This paper is about mills rather than milling, and it is appropriate that I should have been given this topic in the conference, since my first excavation 33 years ago was of a medieval windmill in Somerset. I didn't dig it for this reason, however — I thought it was a Bronze Age barrow; it was only when a visitor pointed out some rather odd stones on the spoil heap which had ground surfaces and holes in them that an alternative hypothesis was formulated (Rahtz & Rahtz 1958).

We are principally concerned in this subject with the milling of corn, an activity of basic subsistence. The mill as a machine came to have other uses, but it still retained its name as a corn-grinding machine even after it was used for pumping or grinding gunpowder.

We need not consider here the other activities of the agricultural cycle, the processes whereby the grain has been grown and harvested and finally, by a variety of means, separated from its husk; the most usual medieval method was that of threshing with a flail, itself a simple machine for increasing the effectiveness of muscle power. From this point the collected grain has to be pulverized or ground to bring it to a suitable state for cooking or eating, especially in the form of coarse or fine flour to be made into the staple food of bread. This can be done by simple pounding with a pestle and mortar, usually of wood or stone, or by grinding between two stones. The pre-medieval techniques and typology have themselves been the subject of much study, ranging from the simplest saddle or roller quern to the hand-operated rotary quern, and the final inclusion of the latter into powered machinery (Curwen 1946, ch 8). The stones themselves are of course one of the most durable artefacts for the archaeologist, and provide an unusually complete series which may be studied in form, material, and function. They were the subject of a recent day school at Manchester (December 1978), one of the most interesting aspects of which was the specialization of quern manufacture at centres where high-quality stone could be quarried. Especially of interest was a lecture by Frau Roder on the basaltic lava querns of Mayen and Niedermendig in the Rhineland (considerably updating her earlier paper, Crawford *et al* 1955). These quarries began quern-making in Hallstatt times and between then and modern times consumed an estimated five million cubic metres of rock. They exhibit the change from saddle to rotary form by the 1st century BC and were being exported to England by the 1st century AD; as we shall see they continued to be imported into early medieval times. They are especially suitable for milling, being vesicular and hard, yet light in weight.

Rotary querns, once established, became the usual type in Europe, and were normally worked with a handle in the side or top-rim. This would usually be done by a simple arm movement and human muscle power, therefore limiting the size of stone to 300-400 mm, though a medieval illustration shows a way of increasing leverage by means of a ceiling attachment (Horn 1975, 234).

When mechanization developed by the use of animals, water, or wind, it was available only to those people with more resources than the average home, and so we find the simple rotary handmill continuing in use right down to the present day in some areas.

These simple machines are, of course, common in Roman contexts; however, at present insufficient data exist to show whether any were being made, or new types developed, in the immediately post-Roman centuries. Nor is there yet any full publication of Anglo-Saxon handmills, though Jonathan Parkhouse is currently working on this matter, especially on the imports, which he believes are mostly from Mayen; he is comparing the British material from Hamwih and other sites with that from the great excavations at Dorestad, with material found on the shore at Domberg, and with the ton of querns found at Hedeby by Jankuhn and Schietzel. The latter include half-finished stones, suggesting that this was a redistribution point, though oddly they have not been found on the more northerly sites such as Birka. Parkhouse has been able to find references to querns at a fifth of the English (Anglo-Saxon) settlement sites (in Rahtz 1976); a recent addition of the late Saxon period are the fragments of several stones from Bidford-on-Avon (Warwickshire) found by Susan Hirst (pers comm), close to the well known earlier cemetery. Little work has yet been done on the petrology except that of the lava imports, though interestingly the stone for the Bidford querns came from Lilleshall in Shropshire (inf S Hirst).

The mechanics of exchange are still not clear, though Parkhouse believes that the lava trade is part of the much wider expansion of North Sea and English Channel trade from the 8th century onwards. Some handmills of course found their way from their original location by processes similar to those related to pottery, ie as part of baggage trains of the army or aristocracy. A pair of querns was part of the equipment list of Charlemagne's army in AD 802. Bloch (1967, 149) takes this to imply (to look ahead in this paper a moment) that watermills were not yet com-

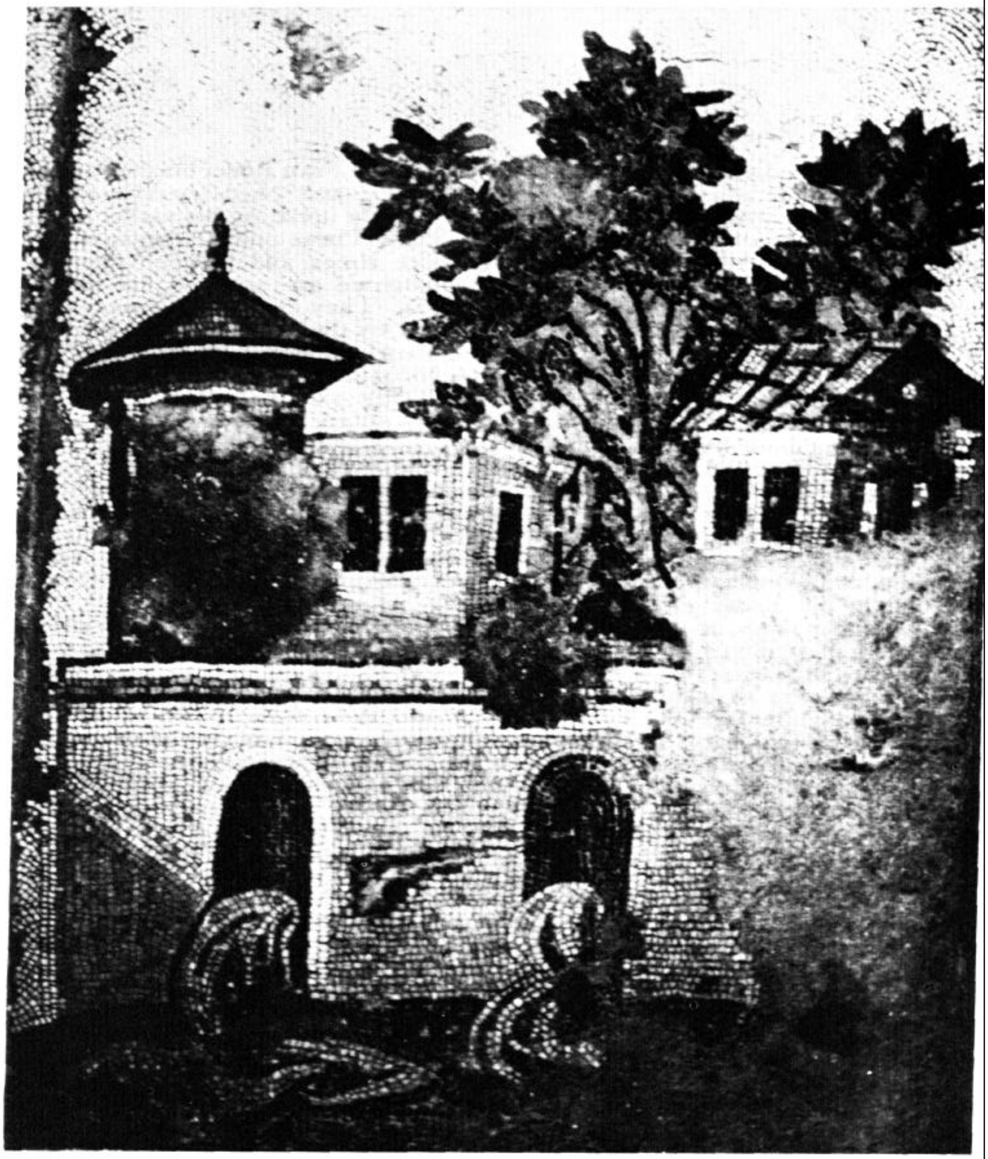


Fig 1 Mosaic from the Great Palace of Byzantium possibly depicting a *double horizontal-wheeled watermill; 6th century (reproduced from Rice 1958, frontispiece)*

mon in Germany, being present only in towns or aristocratic centres.

Handmills, from having been a normal domestic adjunct, became a cause of considerable tension in society. As we shall see, the powered mill, from having been an invention to save the labour of men, became an instrument of taxation and oppression: Even in monastic estates this was so - the monks of Jumièges in 1207 were breaking up handmills, whose numbers were enough to threaten feudal monopoly (Bloch 1967, 154).

In England the same restrictions developed. When we were digging at Upton, one of the archaeological features that Rodney Hilton found exciting was the numerous quern fragments (Hilton & Rahtz 1966; Rahtz 1969) which, as a historian, he would have expected to have been little if at all in evidence. The most famous conflict was of course that at St Albans, after 1274, again on a monastic estate. Artisan tenants rebelled against the monopoly of both the lord's cornmills and his fulling-mill. Millstones and lengths of cloth were confiscated, and there was violence, but on this occasion the rebels gave in. In 1326 there was a full-scale revolt, in which the monastery was twice besieged. Stalemate followed, with the handmills still working, but a new abbot in 1331 took a more forceful line by legislation. From all over the town millstones were brought into the monastery, and the monks paved their parlours with them; one wonders whether archaeologists would have determined the origin of these curious floors. For 50 years they stayed there, but in the Great Revolt of 1381 the townsfolk again attacked the abbey. They destroyed the millstone-paved floors, broke them up, and took fragments away as a sign of victory and solidarity. The struggle went on, and ax late as 1789 Breton peasants were protesting against milling exactions. In 1896 Russian villagers were still using them, hiding from strangers as they did so, from some earlier tradition of tax evasion (Bloch 1967, 156-9).

From this time we have photographs of the use of handmills in the Northern Isles even though by then they had long been extinct in England (Curwen 1946, 110 and fig 19). To see them today, one does not need to go too far. Mally were seen in Crete in 1976 (eg at Anopolis, Fig 5) though in the larger villages they were by then becoming archaic.

The first stage in mechanization was animal power, well known in Roman times in the Mediterranean, such as in Pompeii (Horn 1975, 231-2); two fragments of animal-powered mills are claimed from Dorset, and several larger stones up to *c* 800 mm in diameter may be from these or other powered mills (inf A McIllwain at Manchester).

They continued into the Middle Ages; in 1295 in France a certain Brother John de Charpentier constructed a horse-mill of a new type which he thought could be driven by a single horse; when it was finished. however, the animal could not move it, so it was abandoned (Bloch 1967, 171).

The use of animal and waterpower developed during the Roman period (perhaps from water-lifting devices in areas further east) and later spread widely through Europe (Bloch 1967, 139). Some historians believe that these inventions are related to the decline in slave manpower in the early medieval period; the desire to save men the drudgery of hand-milling is explicit in several often-quoted written sources (cf Bloch 1967, 144).

Gregory of Tours (Kahtz & Bullough 1977,20) tells us that Ursus, Abbot of Loches, built a mill in the River Indre: 'He made a weir with wooden stakes packed into large stones, and a sluice-gate to control the flow of water into a channel in which the mill-wheel stood'; this sounds like a *vertical-wheeled mill.* This type, described by Vitruvius (Moritz 1956), was widely spread throughout Europe; a well preserved late Roman example was excavated in the Agora at Athens (Parsons 1936); a late Roman mosaic in the Great Palace of Istanbul clearly depicts a vertical wheel (conveniently in Brett 1939, or Reynolds 1970, 12). The magnificent series at Barbegal dates from the 4th century, producing for Arles 28 tons of flour in 24 hours (Horn 1975,233). There is no evidence that any of the fourteen or so watermills claimed in Roman Britain (lecture by Adam Wellfare at Manchester) were anything but vertical-wheeled, and some were certainly of this type (such as those discussed by Simpson 1976).

The origins of the *horizontal-wheeled watermill* are obscure. Literary references to watermills are mostly ambiguous when dealing with the subject of a vertical or horizontal wheel; I have already quoted Gregory about Abbot Ursus and the possibility that this 6th century mill was vertical-wheeled; the only other reference I know in the early medieval period also seems to refer to a vertical wheel. This is in Aelfric's treatise *De temporibus anni* of *c* AD 992. The rotation of the heavens ('as deeply under the earth as overhead') is said 'to be swifter than any mill-wheel' (refs in Rahtz & Bullough 1977, 22). There is only a single Anglo-Saxon reference to even a 'mill-wheel', and no others until the 15th century (Rahtz & Bullough 1977, 22).

Visual evidence does not help us much - the mosaic in Fig 1 from the Great Palace of Byzantium (Rice (ed) 1958, frontispiece and pl 46A) dates from the 6th century - it may depict a towered double mill of a type now seen in Cyprus and Crete (Appendix A, p 8 below and Fig 6), apparently with characteristically twisted plumes of water emerging from the double arched exit. There are no more representations of mills after this until the 12th century, and these and late medieval illustrations are exclusively of the vertical-wheel type, though we know that the horizontal wheel continued alongside these.

Archaeological evidence is increasing steadily. The evidence of a horizontal-wheeled mill at Bolle in Denmark (Steensberg 1952, 294-8), tentatively claimed by him to be of the 1st century AD, is not at all conclusive and the earliest examples we can be sure of are those recently dated to the 7th century and later by dendrochronology in Ireland (Baillie 1981), and Tamworth in England, dated to the mid 9th century (Rahtz & Sheridan 1972; Rahtz 1976, 93; Rahtz & Bullough 1977; *Curr Archaeol,* 3 (1971), 165-8; Baillie 1981) (also see Fig 8). Reconstructions of the latter in Figs 2 and 3 are virtually certain, based on much surviving evidence (Fig 4) and many archaeological and ethnographic parallels. We shall now consider the mechanism of Tamworth to illustrate the type.

The water supply was obtained from a leat taken off the River Anker at a point several hundred yards NE of the site. Crossing Bolebridge Street, where it was examined by R A Meeson in 1978, it fed a wood-framed pool, much of the structure of which was found in the 1971 excavation. The front wall of the pool (possibly a metre or more in height originally) was also probably the lower part of the NE wall of the millhouse above. There were two exits for the water from the pool. The driving flume was directed into a chute or trough, possibly a closed tapering box like that discovered at Knocknagranshy (Lucas 1969). This must have narrowed at its end to direct a jet of water on to the paddles of the wheel, which revolved in a clockwise direction. Patterns in the destruction debris and in the sands on the wheelhouse floor show that the wheel was *c* 1.2 m in diameter, which would accommodate at least twelve paddles, of which a complete example was fortunately found in the excavation. It is comparable with other paddles of the type with a curved side and flat base (cf Moycraig, Lucas 1953; or Reynolds 1970,61), but the upper rim of the side is curved to give maximum torque for a given impact of water (Rahtz & Sheridan 1972, fig 3).

The wheel assembly ran in a steel bearing; the seating for this, a reused block of high-quality steel (Trent 1975), with its worn spindle-socket, was found set into one end of a plank, the sole plate. This would have been flexibly attached at its shorter end to the bolster, allowing free movement of the plank and bearing, by means of the lightening tree, attached (probably by rope or leather) to the other end, and extending upwards through the floor of the millhouse. Its upper end, the sword, could be set at different heights by means of a wedge, this in turn lifting the sole plate, millwheel, shaft, and upper stones. In this way the gap between the millstones could be varied to alter the coarseness of the grind, and to take up wear in the upper or lower stones. In the Tamworth mill, the ratio of plank lengths in the sole

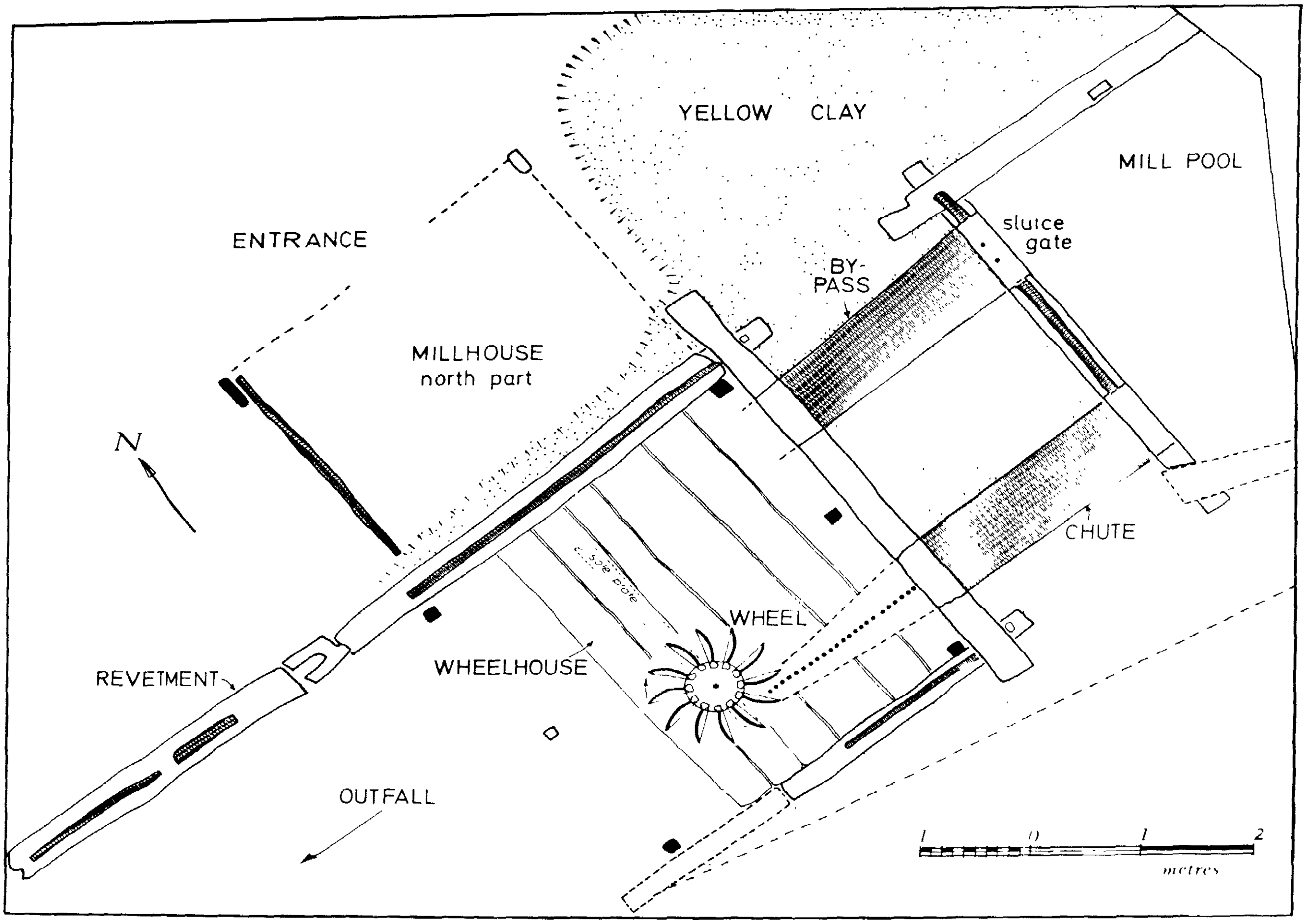


Fig 2 Tamworth Saxon water mill - dragrammatic plan

plate on either side of the bearing was 5:1; thus a raising of the lightening tree by 50 mm widened the stone gap by 10 mm.

The other exit for the water from the millpool was through a movable sluice gate on the other side of the pool, of which the two guide holes for iron runners (c 100 mmX30 mm) were found in the sluice-gate seating. When the gate was lifted, the pool would empty, the water would rush away on the upper side of the wheel to the outfall, and the mill would stop working. Since the leat was fed from a river, the pool could be quickly recharged when milling was resumed.

The water which either drove the wheel, or escaped past it, had to be prevented from finding its way anywhere else. To achieve this end, the whole wheelhouse and pool were enveloped in a dense yellowish clay, which effectively sealed it. The water also had to be prevented from splashing or soaking up into the millhouse where milling took place, and where grain or flour might have been stored for a while. There must have been a substantial floor, perhaps a double one between millhouse and wheelhouse, possibly plastered.

The lower stones were set in a circular bed of damp clay, with a hole in the centre to allow the main shaft spindle to extend upwards to turn the upper stone by means of a rynd. The butterfly shape of the latter was indicated by the slots made for it in the stone; the material of the rynd is uncertain, but was probably of hardwood rather than metal.

Most of the grain would have been fed into the quern assembly from a hopper by way of a shoe into the quern's eye; but some evidently found its way down past the spindle, as grains and grain impressions were found in the inner edge of the clay seating for the lower stones.

The stones themselves were *c* 600-700 mm in diameter, the only ones known of this size from Anglo-Saxon England, though some roughouts of this size are known from Mayen (inf Roder). They are of two kinds: some of a fairly local North Midland gritstone (identified by Professor F W Shotton), the others of basaltic lava from the Khineland. It has been suggested that this dark grey stone is the *'petrae nigrae'* of Charlemagne's famous letter to Offa, in which comments are also made on the cloth exported from Mercia at that time (Whitelock 1955, 779).

The structure of the wheelhouse was of substantial timber, based on upright posts with horizontal planked walls and a very substantial floor of thick planks (Fig 4). The timbers were held by carefully cut

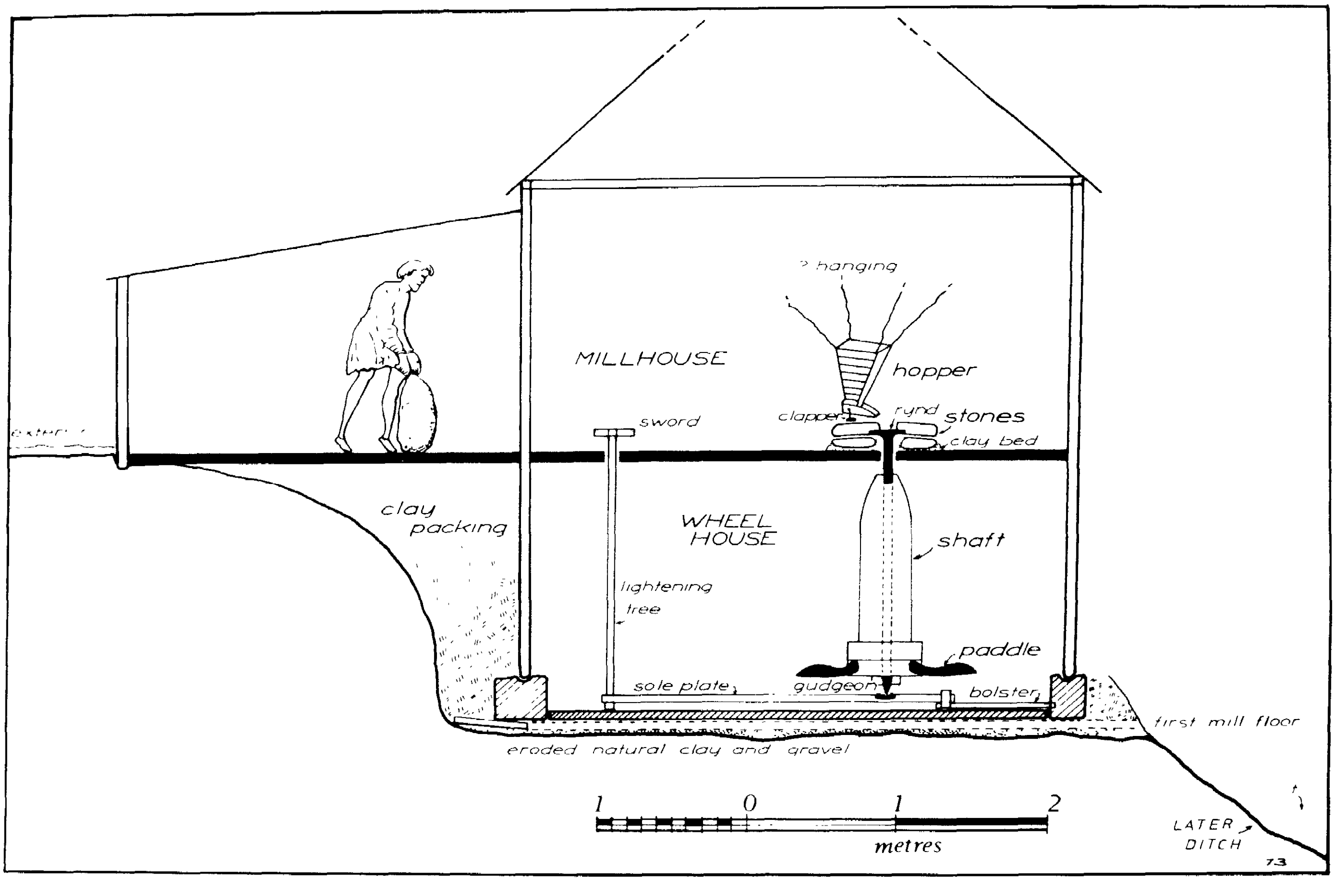


Fig 3 Tamnworth Saxon water mill - diagrammatic section N-S

joints and pegs (Rahtz & Sheridan 1972, fig 2; Rahtz 1976, 93). Th e millhouse, in effect a first storey, extended not only above the wheelhouse but also as far as the end of the millpool, and also on to higher ground to the NW, which had been partly cut away to provide a level area for the wheelhouse. The nature of the roof is uncertain- The only other evidence possibly relating to the superstructure is that of some half-melted residues of what look like diamond window-leading. However, no traces of glass were found by analysis (kindly done by the Pilkington Glass Museum), but the windows may alternatively have been of horn; or the lead may have served some other purpose in the mill, such as that of balance-weights.

It will be some time before the Tamworth evidence can be fully studied and published, and many questions remain to be answered, which may be grouped under two headings. The first concerns the technical efficiency of the mill in terms of its hydrodynamics and potential output; the second is the function of the mill in the local society. Was it the mill of a royal palace at Tamworth in the middle of the 9th century, providing flour for the royal household and retinue, and on occasion for larger gatherings of lay and ecclesiastical aristocracy? Or was it a more 'normal' mill of a nucleus of rural settlement or even of one with some urban pretensions at this date (before its fortification by Aethelfleda in AD 913) - the latter possibly associated with the royal palace?

Some answers to the first group of questions will come from further study of the archaeological evidence, and also from studies currently being undertaken by F W Charles in connection with a feasibility study by Tamworth Borough Council for a possible full-scale working replica, to be erected in the town as a cultural resource. He has already made a model and working drawings, and if the project is finally carried through (at an estimated cost of £20,000 plus upkeep costs) this piece of experimental archaeology will undoubtedly generate data which could not be obtained by theoretical studies (cf Reynolds 1978). Further comparative data can also be gathered from ethnographic parallels, which are in this case surprisingly relevant (see below).

Answers to the second group of questions will, it is hoped, come from several lines of enquiry. Firstly, we need to know more about the local communities, the palace, and associated rural or urban settlement; much progress has already been made in this by Meeson (1979). Secondly, we need more evidence from other excavated Anglo-Saxon mills, to see if the Tamworth mill was indeed of unusual quality, as its structure and fittings currently tend to imply. We should now consider what comparative data may be cited.

One of the best parallels to the Tamworth wheel and paddle assembly is that from Moycraig; it is preserved in the Ulster Museum at Belfast. It has been well known and often illustrated (eg Lucas 1953, pl 1;

Fig 4 Tamworth Saxon watermill - the wheelhouse from the NE

or Reynolds 1970, 61) since its 19th century discovery in an Irish peat-hog, but only recently has it been dated (Rahtz & Bullough 1977, 18), and this makes it a near-contemporary parallel; the paddles are remarkably similar to the Tamworth one, except, as already observed, for its less efficient flat top to the rim of the side wall. Another important point to be noted about the Moycraig wheel and shaft assembly is its weight. Even in its present dry state and without the rynd or upper stones it weighs 62.6 kg; it is difficult to believe that such a weight, perhaps as much as 80 kg originally with the stones, could have been carried by the Tamworth bearing set in its plank, and perhaps a lighter reconstruction must be envisaged.

Other comparative evidence from excavations comes from Ireland (earlier discoveries are described by Lucas 1953; see now Baillie 1981). The most important evidence from England is provided by the discoveries made by Dr Brian Hope-Taylor at Old Windsor *(Medieval Archaeol,* 2 (1958), 183-5). Here he found a triple vertical-wheeled mill powered by a leat taken off the Thames (1100 mx6 mx4 m deep) with a secondary horizontal-wheeled mill above. These again may be in royal context; a full report on them will obviously be of the greatest interest. Finally, mill-paddles similar to that from Tamworth were found in a road disturbance near Stroud (inf Carole Morris, finds in Stroud Museum).

Further information may come from written sources. Professor Bullough has recently considered all the Anglo-Saxon references to mills (Rahtz & Bullough 1977) and these help to put the-physical evidence and mill terminology into a wider social. political, and juridical framework.

We should also consider here the Plan of St Gall. drawn before *c* AD 820, for its importance in the problem of the extent to which monaiteries may have been responsible for technical innovation and-diffusion. The plan is a schematic layout for a reconstruction of the monastery at St Gail (Switzerland), and embodies not only a functional layout reflecting the entire liturgical, economic, and social needs of the ideal Carolingian monastery, but also detail which reflects current ordinances concerning monastic discipline (Horn & Born 1979). Professor Horn believes that although the plan is schematic it was in fact capable of adaptation to the topography of the site, which is a triangular promontory with two streams, one on either side; the upper one takes the effluent from the monastic *necessaria,* and the lower provides a Dower source for the mills and workshops. Professor Horn believes that the sketch illustration (Horn 1975. fig 5) of the mills depicts the stones driven by a vertical wheel, but I wonder if they could in fact be depicting a pair of horizontal wheels? The other installation (Horn 1975, fig 5) he believes to represent a vertical water-wheel-driven pair of trip-hammers. also of interest to readers of this volume.

The potential of archaeomolinology (to coin a word) in the Anglo-Saxon period is also indicated by the presence of at least 6000 mills in Domesday (Hodgen 1939; Rahtz & Bullough 1977, 19), not one of which has been located. I suspect that many will prove to be of the horizontal-wheeled type, as I am sure will be many of those which will turn up on DMV sites of later date. Certainly the type continued - our next evidence comes from 16th century engravings (eg Reynolds 1970,64), which show detail remarkably similar to those in the earlier period. They bridge the gap between the excavated examples and ethnographic observations. These begin with travellers' descriptions in the Northern Isles in the 18th century, and continue through the 19th centurydown to our day, with records of horizontal mills in Scotland. Shetland. Ireland. Orkney, Faeroe. France. Germany, Norway,' Sweden, Russia, Turkey, China, Syria, Yugoslavia, Persia, Roumania, Greece, Crete, Cyprus, the Balearics. Morocco. South Africa. the Canaries, and the United States of America (Bennett & Elton 1899: Calvert 1972-3: Clutton & Kenny 1977: Curwen 1944: Goudie 1886: Lucas 1953: MacAdam 1856; Rahtz & Bullough l977; Reynolds 1970; Steensberg 1952; Williamson 1946).

Few of these have been adequately described or photographed, and there is an urgent -need for fieldwork in these areas while so many exist either in ruins or in working order. While the former often contain substantial remains of the building and its machinery, the latter have a wider range of fittings and tools, and the socio-economic context can be ascertained by interviewing the miller.

While most surviving mills in these areas are of comparatively recent date, perhaps extending back to the 16th century at best. their study is important in two aspects. First they are important for their own sake. as evidence of specialization and mechanization in recent rural and urban societies - the most recent material for the history of technology and its socio-economic effects. Second they are so closely similar to their medieval predecessors as to demonstrate that they are the end of a continuous evolutionary sequence. They provide a massive data base over a very wide geographical area for the consideration both of the range of water-mill technology and fittings, and of the directions of diffusion of the type, or the extent to which independent invention played a significant role in their development in each-area. Some idea of the potentiality of even superficial fieldwork is indicated in Appendix A on the watermills of Crete.

We may at this point consider the role of the miller. Up to the Middle Ages he was a shadowy figure but now he emerges as a grasping, dishonest thief, alike master and agent of manorial exploitation (cf Bloch 1967, 140). In present-day Crete and in Chaucer's England he lives in a single room, and we may illustrate both this and his character in the following extracts from the *Reeve's Tale,* of a miller who lived near Cambridge (trans by Nevill Coghill in Penguin Classics)

'At Trumpington, not far from Cambridge town, A bridge goes over where the brook runs down, And by that brook there stands a mill as well . . . .' (There was a miller lived there many a day.) . . . 'Round was his face and priggish was his nose, His head was bald on top, just like an ape, He was a market bully in such shape, None dared hand on or come too near, Without him swearing that they'd buy it dear, He was a thief as well of corn and meal, And sly at that; his habit was to steal, Simpkin the swagger he was called all round.. . . "A room?" the miller said. "There isn't any, My house is small but you are learned men, And by your arguments can make a place, 20 foot broad as infinite as space". . . . In his chamber made a bed, 10 foot from his upon a sort of shelf. His daughter had a bed all by herself, Quite close in the same room; they were to be all side by side, no help for it, and why? Because there was no other in the house.'

We may now consider the type of mill with which we are all much more familiar, the vertical-wheeled mill. We have seen the Roman development of this, Gregory's 6th century example, that from Aelfric's homily and from Old Windsor. The question is how usual was this type by the late Saxon period, and what proportion of Domesday mills were vertical-wheeled? By the time we return to visual evidence (eg the 12th century capital at Vézelay (Singer *et al* 1957), or that in the Luttrell Psalter *(ibid,* 596, fig 543), they are wholly of the vertical-wheeled type. Does this reflect a massive takeover by this type of mill, or were they more picturesque in illustration (together with windmills)? Archaeological evidence will, we hope, elucidate. There is at present surprisingly little before the 16th century. Philip Mayes found a probably vertical mill at S Witham *(Medieval Archaeol,* 11 (1967), 275) and John Hurst and his colleagues at Wharram Percy are excavating a mill site, whose type is uncertain, though there are pre-Conquest finds. At Bordesley Abbey there exist the earthworks of a great pond and, I suspect, wheelpit and tail-race; we have not dug this yet, but close by there is evidence of iron and copper working, so doubtless this mill was multi-purpose (Aston in Rahtz & Hirst 1976, 119 and fig 43). The best medieval example so far excavated is, however, that at Batsford, where the timber structure of the wheel-pit survived intact (Bedwin 1980).

Much work needs to be done on the numerous references in medieval accounts to the building or repair of mills, which may indicate not only the parts of a medieval mill (vertical or horizontal) but also the scale of the capital expenditure it represented. For example, a mill on the Kingsland estate in Herefordshire (Woolhope 1955), built in 1389, cost £11 5s 7d, and included expenditure on labour, the bed of the millstone, carriage of 38 cartloads of timber, the cost of hiring 24 oxen to carry one alder for the watercourse under the mill, bread and ale for the carters, 96 gross of nails, one hoop and spindle, tallow for the mill axle, moss, metal weights and two iron griddles for the mill axle, one cauldron, and two iron hoops.

The later industrial mills like those at Batsford and Chingley (Bedwin 1980) are all of vertical-wheeled type, and of course ail later standing and ruined mills are universally with vertical wheels (cf Reynolds 1970; Syson 1965). When and why, therefore, did the transition become so universal?

Finally, windmills: these do seem to be a medieval invention, believed to have originated in Arab areas (Reynolds 1970; Wailes 1954). The earliest appear in Europe simultaneously in the later 12th century, and provide an alternative to watermills which can be frozen, flooded, or may dry up; the Abbot of St Albans replaced one of his monastic watermills in the 13th century by a very fine horse-driven mill (Bloch 1967, 149).

The archaeological evidence of windmills is whol-

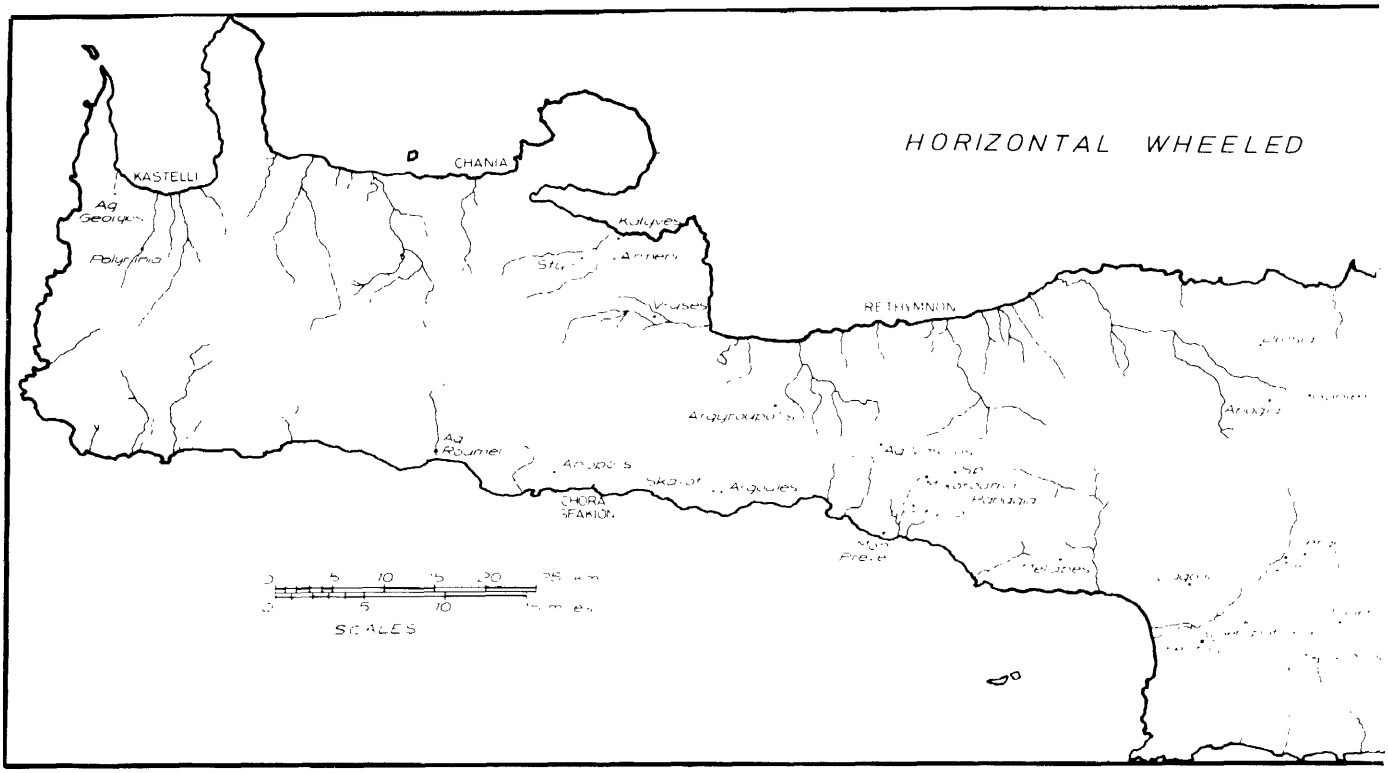


Fig 5 Map of horizontal-wheeled watermills an Crete

ly consistent with the now prolific visual evidence (Wailes 1954, App B, 188), first of all for the post-mill set in a mound with cross-trees, and later with stone ground-walls. Examples of the former have been excavated at Butcombe (Rahtz & Rahtz 1958), Puriton (*Medieval Archaeol,* 16), in Somerset, and an example of the latter at Lamport,

We need not dwell on the later development of the windmill, since it is very well understood and published (Wailes 1954) and numerous examples survive or are being erected at Folk Museums, like the superb example from Danzey Green, at Avoncroft. Like those watermills whose mechanism can be studied, the machinery is of peculiar fascination and any mill is worth studying closely, such as the famous 10,000 water-pumping windmills on the plain of Lasithi in Crete (Calvert 1975) or those surviving on Mykonos.

I have not attempted to do more than hint at the many uses of mills for purposes other than corn grinding. The power of the watermill especially has been extensively used for trip-hammers (for which the invention of the cam was crucial), or by conversion to reciprocal motion so that they could be adapted for fulling, tanning, sawing, crushing, and forging. These industrial processes are discussed by other contributors to this volume.

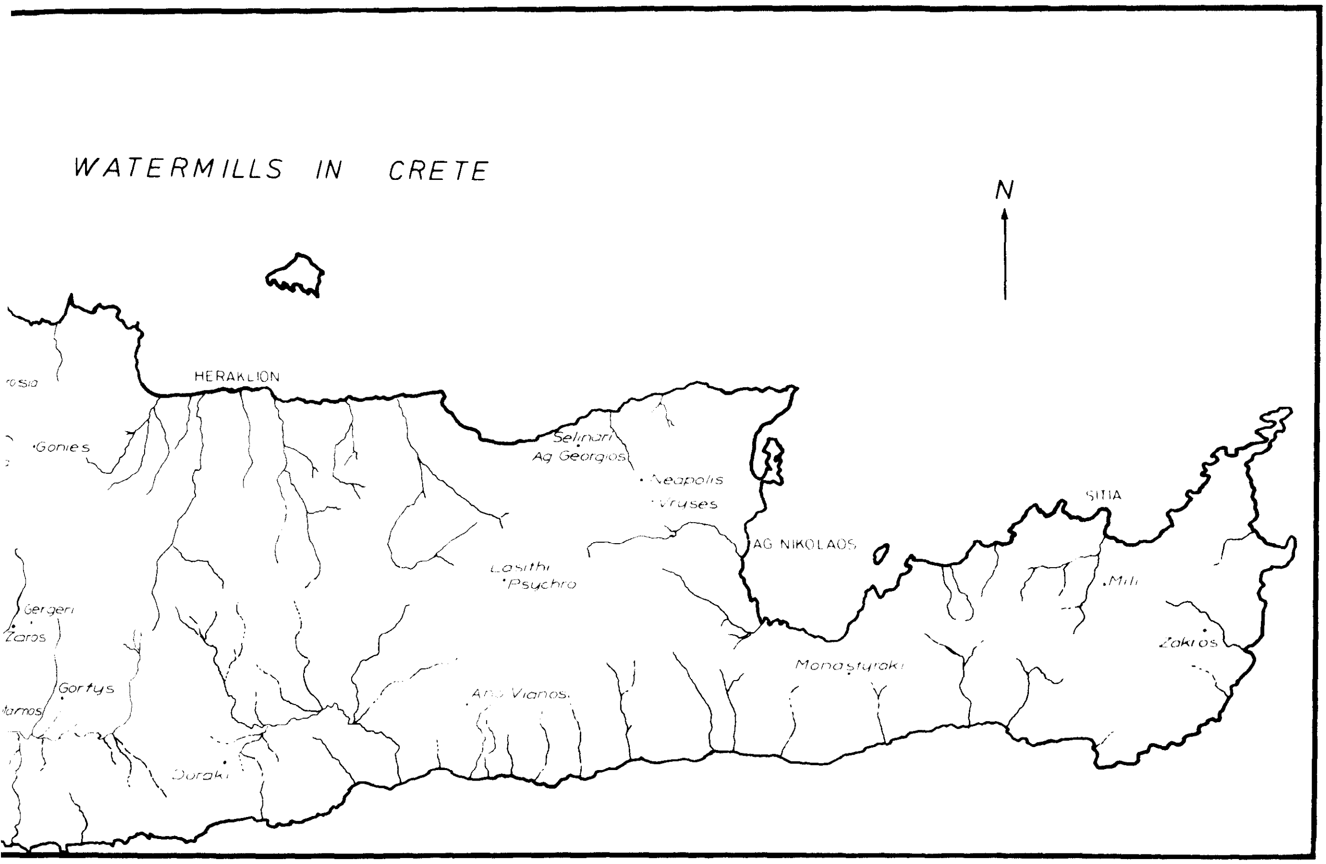
Appendix A
Horizontal-wheeled watermills on Crete,

by Philip Rahtz and Lorna Watts

Crete, in contrast to many other islands in the Cyclades or Dodecanese, is amply supplied with water, drawn from its mountains and their extensive snow cover (Fig 5). In consequence, watermills are prolific, though the windy terrain has also been favourable to the development of windmills (p 8). With very few exceptions, Cretan watermills are of the horizontal-wheeled type, and of a design found elsewhere in the Mediterranean, incorporating a tower-like structure, the so-called Aruba penstock (cf Reynolds 1970, 62). They have not been given any attention by archaeologists, since Cretan archaeology tends to be dominated by Minoan studies, even the fine Greco-Roman sites being neglected. Their technical aspects have been studied by Calvert (1972-3), and more recently by Clutton and Kenny (1977), who have carried out extensive fieldwork in Crete, and have examined many mills.

In 1976 the present writers spent eight weeks in Crete, principally looking at ethnographic and archaeological material, and especially at the watermills, because of their close analogy to the one excavated at Tamworth. The immediate value was to gain a knowledge of the working parts, functions, and tools of horizontal-wheeled mills, albeit relatively modern ones, and to suggest a possible range of interpretation for the material evidence excavated at Tamworth; and secondarily to consider the wider problems of the distribution of the mill type from its beginnings in the earlier part of the first millennium AD to the present day.

Whereas Calvert was principally concerned with Cretan mills as an aspect of industrial archaeology and hydrodynamics, Clutton and Kenny were interested also in the geographical, economic, and historical aspects of the mills. They discussed the gradual abandonment of the watermills in favour of



cheap electrical and internal combustion power after about 1950, and the rapid destruction of their buildings and fittings in the face of modern development. They considered it doubtful whether any mills were still in work by 1966, but, as we shall see below, this was over-pessimistic; indeed Calvert (1972-3, 217) reported working examples. They surveyed and described in detail a derelict mill (near Drosia) which yet contained most of its fittings, and Fig 6 is based on their drawings. It is reproduced here since the publication in which their paper appeared is not readily accessible to English readers.

Some consideration is given in their papers to the technology of the Drosia mill, but also to its probable speed (100-150 rev/min=1-2hp), its output (by analogy *c* 13 kg of oatmeal per hour), the material ground (human/animal grain and foodstuffs: bread grain, barley, maize, and vetches), and the economy, the mill being owned by a professional miller who lived in a village 1 km away, and took in work from a number of local farmers. The latter facts were gleaned from a rather atypical archaeological find, a notebook found in the mill.

The geographical aspects discussed include the nature of the water supply in mountainous and non-mountainous districts (using microrelief) and the presence of flights of six or more mills in the steeper streams of the former.

Most of the mills seen by Clutton and Kenny were of the Drosia type, which is of relatively recent date (see below, pp 10-11). However, two were patently more ancient: the mill at the foot of the hill of Festos, of dressed stone embellished with carved ornament, and claimed by its owner to have been in his family for at least 200 years, and that at Gortys, which we also examined (p 11 below).

Beyond these observations, they do not speculate on the absolute age either of these last two mills or of the Drosia type, but they do quote an earlier opinion (1977,118) that the stonework of the vertical-wheeled mills of the island was characteristically Venetian. They conclude that the number of mills seen or heard of by then number at least 50, and there are probably over 200 in the island, a conclusion we would reinforce and perhaps multiply as a result of our observations.

The historical problem to be solved is the derivation of the Cretan/Cypriot type of towered mill, and its relationship to the horizontal-wheeled mills of other parts of Europe, with whose working it has very much in common, except for the tower-like penstock which brings water from a reservoir, aqueduct, or stream to a height of *c* 6 m above the wheel, thus delivering a formidable jet through the nozzle on to the wheel paddles. Although the Drosia-type mills are of the period of Turkish occupation or more probably after that (ie post 1898), the Gortys and Festos mills, which are essentially the same in structure and principle, may well be pre-Turkish, pre-16th century, ie Venetian. If we can thus take the type back to the Middle Ages, can we make any link with Byzantium? We have already suggested (p 3 above) that it is a mill of this type which is figured in a mosaic of the 6th century from the Great Palace of Constantinople (Istanbul) (Rice 1958, frontispiece, reproduced here as Fig 1). This hypothesis can only be proved by further fieldwork coupled with excavation, and by work on the almost totally neglected Byzantine archives,

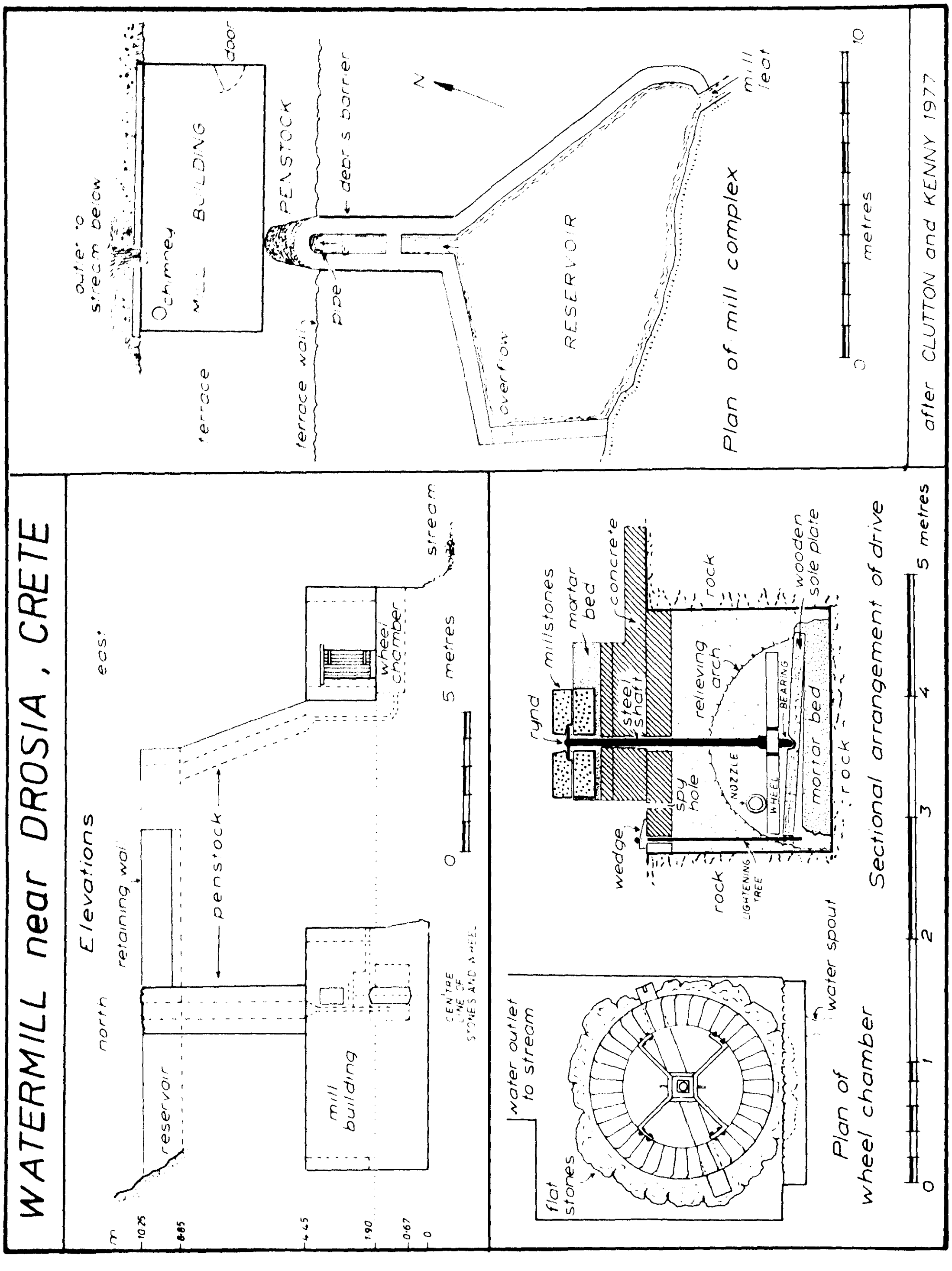


Fig 6 Watermill near Drosia, Crete (redrawn from Clutton & Kenny 1977)

themselves in as much danger from neglect, as are the field monuments (inf Prof A M M Bryer). These may well contain much material on the economy and structure of the Byzantine watermill, and detail that may show a correlation with the type now under discussion. If this were achieved, then one line of diffusion/invention in the history of the watermill would have been defined. Meanwhile the obvious task is the recording of the visible field monuments in every area.

Our own fieldwork in Crete was limited by a very slight knowledge of modern Greek and by transport problems. Most of the mills are in areas other than those easily accessible by bus, and we had to rely on lifts from American or German tourists' cars, farm vehicles, once-a-week Cretan buses, or, as a last resort, walking. We knew of Gortys, our starting-point, but were not familiar with the work of Elizabeth Clutton or André Kenny (who is bilingual) so most of the mills in Fig 5 were located by local enquiry, helped in some cases by an ancient person extracted from the nearest *taverna* who had actually worked in the mill when it was operating, and with whom we conversed in pidgin American/ German/Greek.

Our fieldwork was superficial linguistically, spatially, and technically. We did not take any measurements (other than the Gortys wheel referred to below), but relied entirely on photography, in the hope that a better-equipped expedition would be encouraged by our pictures to make a proper survey. In the very small proportion of Crete we were able to cover, we located over 30 mills, and took photographs in greater or less detail of 7. Examination varied from observation from a bus window to poking about in rubbish or ruins, or crawling into the wheelhouse, and finally at Zaros actually seeing the mill working, inspecting the price-list for grinding different grains, and talking to the miller. The condition of sites verged from overgrown heaps of rubble with the odd millstone lying about (probably abandoned many decades or more ago), through ruined but intact mills which had been in use in living memory, with many of their fittings still in position, and finally to fully working mills, with all parts in working order, and the whole range of maintenance tools and gear.

Local information suggested that some at least of the mills dated from the earliest years of independence after the expulsion of the Turks in 1898, and were paid for with the help of finance from Russia, France, and England. This was confirmed by a building (or restoration?) date of 1902 carved in relief above the lintel of the mill at Gonies, and by the observation of machine-produced paddle wheel assemblies of steel running in a modern bearing. Most mills were destroyed in the 1939-45 war. When American and German aid helped to restore the economy in the 1950s, spending was on fuel-powered mills and it was at this time that most of the watermills became obsolete. The only ones that survived did so because their water supply was so prolific and constant that it would have been foolish to change them. The Germans actually used the outfall water at Zaros to make a swimming pool for their troops.

Among the mills we examined, three sub-types could be defined. The first, type A (as Drosia, Fig 6), was characterized by a tapering rounded end to the penstock, looking like a semicircular castle or town wall bastion from a distance. Type A could be twin-towered, driving two wheel assemblies (eg Mixorouma). Type B was similar, but the penstock tower was more squared and angular (eg Vryses near Rethymnon). Type C had a penstock in two parts, one integral with the reservoir, the other with the mill building; they must have been linked by a trough or pipe (eg Aghia Roumeli). The three sub-types are, however, only variants of one main type. There is no reason to think that there is any chronological difference, though it may be noted in passing that if indeed the Great Palace mosaic does depict a mill of this type, it may in fact be nearest to type B.

Gortys, the first mill examined, is of type B. It was said by the local guide (of the famous nearby Odeum —see Clutton & Kenny 1977) to be of 16th century date (ie of the period of Venetian rule) and to have been abandoned in 1966. Its water, still flowing, was derived from the Roman aqueduct which served classical Gortys. The mill was ruined, but is to be restored since Gortys is a tourist site. In the wheelhouse (accessible by crawling and wading) were the last remnants of the wheel, the circular outer iron band, and one wooden paddle. These we dragged out into the open, photographed, and made a measured drawing of (Fig 7). They were certainly more primitive than the factory-made wheels seen in some other mills, but could not have survived since the 16th century. This date for the structure can doubtless be maintained by further research in Greek archives, and by a study of the crosses and other devices carved on the stonework in prominent places (one is shown in Fig 7), which are certainly not Turkish and may well be Venetian.

The other mills listed in the catalogue below exhibited a similar range of structure and fittings to that described by Clutton and Kenny at Drosia, or those described by Calvert (1972-3). A surprising amount was left behind on some sites; at Mixorouma for example, there were intact a wheel assembly, shaft, lightening gear *in situ,* the hopper/shoe/clapper assembly, the stones, the flour box, the lifting gear to raise the stones on edge for recutting of the grooves, the seat for the recutter, the miller's brush, and even the mousetrap. Such a complete technical assemblage is rare in archaeology; it will not withstand the passage of decades. A further wasting cultural resource is the number of Cretans old enough to remember and communicate the exact location of mills, their age, and the details of their operation and function in the local economy. Such local knowledge as we gathered suggested that the mills served a number of communities over an area of many square kilometres. The great double mill at Mixorouma, down by the river, about 1 km from the village, had been replaced by a petrol-driven mill conveniently situated in the middle of the village, with a staff of several people still catering for the milling needs of a scattered rural area. Although fuel-driven, its parts were remarkably similar to the mill by the river, even to the 'miller's damsel' (the piece of wood on a string 'bow' which jumps about on the upper stone and keeps the grain in the shoe and hopper from jamming).

It was satisfying after seeing so many ruined mills to find two that were fully operational. The first one, at Zakros, the village some distance inland from the famous Minoan site, has a splendid water supply from the hills above the village, led away below the mill into irrigation channels. The mill building appeared to be of some (relative) antiquity, but the penstock, pipe, and water channel above had recently been rebuilt in reinforced concrete, retaining little of the aesthetic quality of its stone predecessors. The second is at Zaros, in the foothills of western Mount Ida, not far from Festos. Here the stream drove at least three mills. The upper is derelict, the lower has been converted to a wool-washing machine (the village is famed for its 'bridal blankets'), but the middle mill is splendidly intact, some 500 m above the village. Its rounded penstock towers above the trees and the German swimming pool. A sluice can divert water off the tower to the east, but normally this flows via a debris trap to drop 6-8 m into the wheelhouse to strike a steel wheel assembly at about 120 rev/min anticlockwise. To stop the wheel the miller draws across the jet a cylindrical tube which then passes the water to the exterior where it emerges as a plume 1-2 m long. When the mill is working the whole wheelhouse is full of whirling spray, which can be observed (at the cost of a very wet face) by removing a spherical iron or

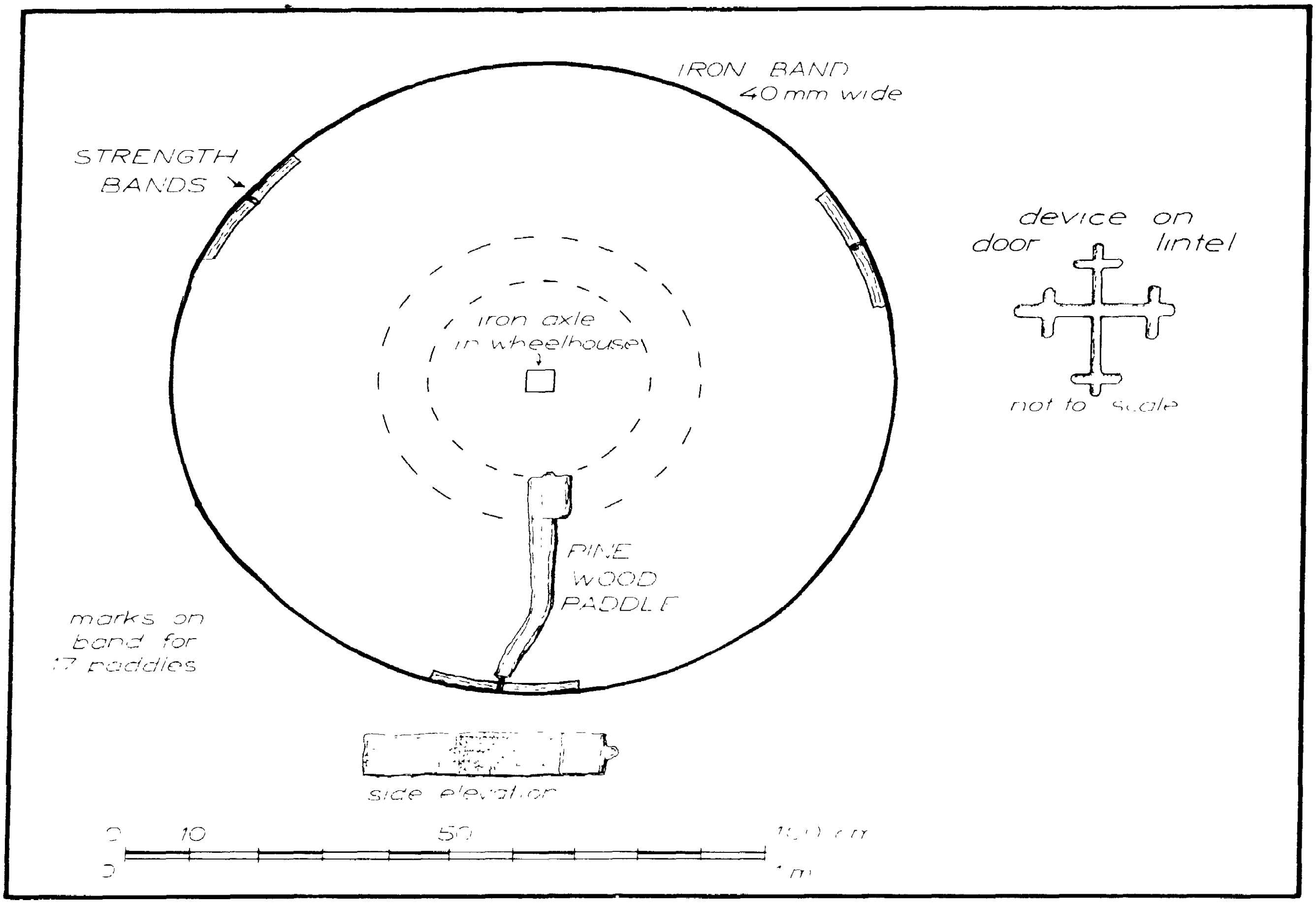


Fig 7 Mill wheel at Gortys, Crete 1976

stone ball from the spy-hole in the mill floor. The mill makes a roaring whirring noise, and there is a slight smell of burning (of ?stone or ?grain).

Outside the millhouse is a disused stone of composite type, with a steel outer band and a massive wooden square core set centrally, into which there fits a propeller-shaped steel rynd. A pair of stones costs *c* £140 and lasts four or five years. On the door is a notice, giving grinding prices for four different kinds of grain (av 70-80 leptera per kg).

Inside the millhouse are all the fittings and tools, a raised store at one end (with a prominent cat), the mill in the middle, and a living area at the other end, with chairs, bed, fireplace, and cooking area - the whole room no bigger than that at Drosia (Fig 6). The lifting gear is set on the wall by the mill; the miller sharpens the grooves in the stone every 2-3 weeks, depending on use. The lightening gear is operated by a screw-wheel.

The miller is full-time in the sense that he serves Zaros and other nearby villages, who bring grain by donkey to his mill, but he also has a dozen hens, a vegetable garden, and a small vineyard, so can be seen as a part-time smallholder producing part of his own food.

This mill would be worth an extended study by someone with a good knowledge of Greek, to amplify through the agency of the miller the mass of technical data which can be recorded in disused sites elsewhere in the island.

Our estimate of the numbers of watermills on Crete based on our own observations and hearsay was several hundred, and probably in excess of the 200 postulated by Clutton and Kenny, though many will lie in mountainous areas difficult of access. They comprise a neglected and unknown body of data of considerable interest in the history of technology, and in this case of direct relevance to our understanding of the watermill in medieval northern Europe. They do not (unlike the windmills) figure in any guidebooks; the most prominent (English) archaeologist of (Minoan) Crete never noticed them; but they await the energetic molinologist.

In conclusion, the Cretan/Cypriot type of tower-penstock watermill may possibly have its origins in the Byzantine Empire, though all the country mills seen in fieldwork in Turkey are of a more primitive kind nearer to those of northern Europe (inf A A M Bryer). Their origins should, however, be sought in Arab areas and in those of Venetian influence. They were probably present in Crete before the Turkish invasions and continued through this period, to be restored, revived, and multiplied in the Cretan renaissance of the early part of this century. Their proliferation at that time may have been associated with the decline in the hand-mill, now only in use in remote areas and villages (eg Anopolis above Chora Sfakion). They suffered much damage in the war, thus facilitating their almost total replacement by modern fuel-powered mills in recent decades.

Catalogue

1 Ag Giorgios (2-3 km west of Kastelli). Two mills in village, type B, ruined, few fittings; one in village, one below road on south side near west outskirts.
2 Ag Roumeli (south end of Samaria Gorge). Mill type C in old semi-deserted part of village; mill collapsed into wheelhouse; leat from river. Another in new part of village by coast; collapsed. A third only 20 m away, also ruined.
3 Ag Vasilios (on Rethymnon-Mires old road 2 km to NE, *c* 1 km north of Plakias junction). Type A, ruined, rubble; some large millstones nearby look too large; also a massive grindstone.
4 Anogia. Not seen, local informant, said to have wooden wheel.
5 Argoules/Skaloti. Not seen, local informant; between these two places.
6 Armeni. Not seen, local informant.
7 Frituria. Between here and sea; not seen, local informant.
8 Gonies (c 100 m east of road from Tylissos, halfway). Type A, water from slight source fed into big walled pool and channel. Carved marigold slab over door with date 1902. Wheel gone, sole plate 100-120 mm square section; main bearing iron block *c* 80 mm square held with nails, and in this a cup-bearing of *c* 50 mm diameter with raised knob in centre.
9 Gortys. See above, p 11 and Fig 7 for wheel and Glutton & Kenny 1977, 145-6.
10 Kalyves (NE of Armeni). Not seen, local informant.
11 Lagolio (vicinity, NE: of Tybaki). Not seen, local informant.
12 Melabes (Ag Galirli-Rethymnon road). Type A, seen from bus, being buried by rubbish being tipped down hillside.
13 Mili (*c* 8 km south of Sitia). Type A, seen from bus.
14 Mixorouma (west of Spili along Rethymnon road, 400 m south of road). Double mill type A, two mill houses, separate fittings (see above, p 11); west wheelhouse intact wheel, outer band, and iron paddles; east wheelhouse at lower level, choked by silt. Extra drives in millhouses with pulleys, belts, etc.
15 Monastyraki. Three mills off one stream in arca; described by Markos, guide at Gournia.
16 Moni Preveli (inland member). Ample water and millstone's around monastery, but no mill located among ruins.
17 Neapolis. Between here and Vryses. Type A seen from bus travelling from Ag Nikolaos to Heraklion.
18 Panagia (SE of Spili). Not seen, local informant, possibly one mentioned by Calvert (1972-3, 220) or one of five near Spili mentioned by Clutton and Kenny (1977, 148).
19 Polyrinnia (1 km, below present village, well below classical city, close to river). Totally ruined, but ?type B.
20 Stylos (2 km west of Aptera). Not seen, local informant.
21 Vryses (1 km east of town on old road to Rethymnon, 200 m north of road). Double mill, single tower type A, many fittings; cast-iron wheels in both wheelhouses identical.
22 Zakros (end of bus route). Working type C, see above, p 11.
23 Zaros. Three mills, above, p 11. All type A, middle one fully operational.

Total: 23 locations, 29 or 30 mills

Other mills mentioned in Calvert 1972-3:
(Almyros - vertical-wheeled mill).
Ano Vianos - working mill.
Dorakion - working (plus another derelict), not located in Fig 5.
Gergeri - working mill.
near Panagia,?as no 18 above.
Total: 5 locations, 5 mills.

Other mills mentioned in Clutton & Kenny 1977:
Ag Giorgios - below monastery; now destroyed by new road through Selinari Gorge.
Drosia (Fig 6) - on south side of old road from Rethymnon to Heraklion c 37 km west of latter, beyond Drosia.
Festos - at foot of hill.
Psychro - eastern Crete; 6 mills in flight.
Sclinari - in plain below gorge.
R Geropotamos - built into bank of river (in the Messara).
Argyroupolis - flight of 6 mills.
Spili — 5 mills fed by canal from Spili springs.
Total: 8 locations, 22 mills, others known to total of 50

Appendix B

The origins of horizontal-wheeled water-mills in the light of recent dendrochronological dates for Tamworth and Irish mills

Figure 8 gives the dendrochronological dates obtained by Dr M Baillie and published in *Current Archaeology* (Baillie 1981). The Tamworth date is AD 855-9. This is based on the dating of the outermost surviving rings, not only of several of the main mill timbers, but also of others recently excavated by R A Meeson from associated structures a few metres behind the millpool. These are consistently of the years 820-5: to the average of these has been added the standard Belfast allowance of 32±9 for sapwood missing from the excavated timbers. The most likely felling date is thus likely to be between X46 and 864.

This date is somewhat later than the 8th century one suggested by radiocarbon determinations, but lies within the limits of two standard deviations. The mill can no longer be associated with the historical *floruit* of Tamworth in the reign of Offa, and any discussion of its relationship to the royal estate of that time is now redundant. The felling date gives only a *tcrminus post quem* for the building of the mill, after *c* 846. It is however given a *terminus ante quem* by the layer which sealed its destruction. This yielded a few sherds exclusively of pre-Conquest date including Stamford Ware and Stafford-type Ware; a closer dating for these has yet to be ascertained.

Of especial interest too are the other dates obtained

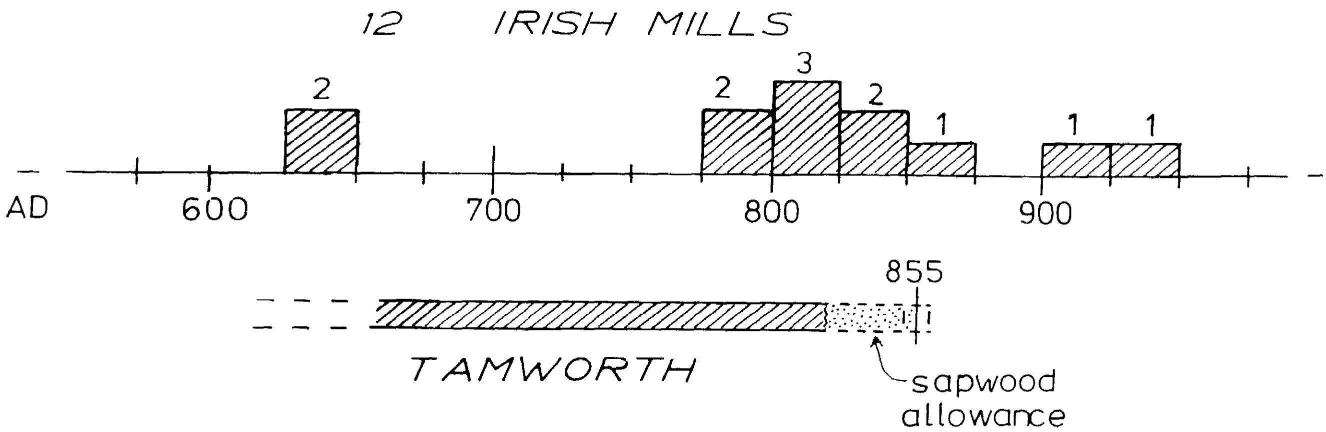


Fig 8 Dendrochronological dates of horizontal-wheeled watermills in Ireland and Tamworth, Staffs (Courtesy of Dr. M Baillie and the Palaeoecology Department of Queen's University, Belfast

by Belfast for Irish mills. Sixteen have been dated, and twelve of these are shown on the histogram in Fig 8. It will be seen that there is a very clear phase of mill building; in the later 8th and earlier 9th century. The Tamworth mill construction may be seen as part of this activity on both sides of the Irish Sea. It should also be noted that the design and building of the Tamworth mill must be seen as part of a tradition extending back for over two centuries. The earliest Irish mill of *c* 630 is, as far I am aware, now the earliest dated horizontal-wheeled mill in Europe.

A further date may also be added to the European examples discussed above. Field work in Majorca by the writers in 1980 showed that the Cretan type of tower mill was represented by many examples there. Correlation between topographical and documentary evidence showed, moreover, that at least one flight of seven mills, near Pollensa, had its origins before the reconquest of Majorca in 1229, and is likely to have been introduced into the Balearics by the Arabs.

Another example was seen in SE Spain in 1981, north of Murcia, near Fortuna. Gerald Brenan in his *South from Granada* (1954) describes other horizontal-wheeled watermills in the area around Granada. He explains (without unfortunately giving any references) that the type was introduced into southern Spain by the Byzantines, and spread from there to Galicia. From here the idea was introduced into Ireland, whence it was taken up by the Vikings and introduced into northern Europe. This hypothesis fits the new archaeological evidence well, and will be worth testing by fieldwork and observation.

Bibliography

Baillie, M G L, 1981 Dendrochronology — the Irish view, *Curr Archaeol,* **7,** 61-3

Bedwin, O, 1980 The excavation of Batsford Mill, Warbleton, East Sussex, 1978, *Medieval Archaeol,* **24,** 187-201

Bennett, R, & Elton, J, 1899 *A history of corn-milling*

Bloch, M, 1967 *Land and work in medieval Europe,* chs 5 & 6

Brett, M 1939 Byzantine water-mill, *Antiquity,* **13,** 51, 354-6 and pl VII

Calvert, N G, 1972-3 On water mills in Central Crete, *Trans Newcomen Soc,* **45,** 217-22

——— 1975 The *Mono-Kairos* windmills of Lasithi, *Annu Brit School Athens,* **7,** 51-7

Clutton, A E, & Kenny, A, 1977 A vertical-axle water mill near Drosia, Crete, *Kretologia,* January-June 1977, 139-58

Crawford, O G S, *et al,* 1955 The quern quarries of Mayen in the Eifel, *Antiquity,* **29,** 68-76

Curwen, E C, 1944 The problem of early water-mills, *Antiquity,* **18,** 130-46

——— , 1946 *Plough and pasture*

Goudie, G, 1886 On the horizontal water mills of Shetland, *Proc Soc Anuq Scot,* **20,** 257-97

Hilton, R H, & Rahtz, P A, 1966 Upton, Gloucestershire, 1959-1964, *Trans Bristol Gloucestershire Archaeol Soc,* **85,** 70-146

Hodgen, M T, 1939 Domesday water mills, *Antiquity,* **13,** 261-79

Horn, W, 1975 Waterpower and the plan of St Gall, *J Medieval Hist,* **1,** 219-57

Horn, W, & Born, E, 1979 *The plan of St Gall* (3 vols)

Lucas. A T, 1953 The horizontal mill in Ireland, *J Roy SoC Antiq Ir,* **83,** 1-36

——— , 1969 A horizontal mill at Knocknagranshy, Co Limerick, *N Munster Antiq J,* **12,** 12-22

MacAdam, R, 1856 Ancient watermills, *Ulster J Archaeol,* **4,** 6-15

Meeson, R A, 1979 *The origins and development of Tamworth,* MA thesis, Univ Birmingham

Moritz, L A, 1956 Vitruvius' water-mill, *Class Rev,* **6,** 193-6

Parsons, A W, 1936 A Roman water-mill in the Athenian Agora, *Hesperia,* **5,** 70-90

Rahtz, P A, 1969 Upton, Gloucestershire. 1964-1968, *Trans Bristol Gloucestershire Archaeol Soc,* **88,** 74-126

——— , 1976 Buildings and rural settlement, in *The archaeology of Anglo-Saxon England* (ed D M Wilson), 49-98 and Gazetteer

Rahtz, P A, & Bullough, D, 1977 The parts of an Anglo-Saxon mill, *Anglo-Saxon England,* **6,** 15-37

Rahtz, P A, & Hirst, S, 1976 *Bordesley Abbey, Redditch, Hereford - Worcestershire.* BAR **23**

Rahtz, P A, & Rahtz, M H, 1958 T40: barrow and windmill at Butcombe, north Somerset, *Proc. Univ Bristol Spelaeol Soc,* **8,** 89-96

Rahtz, P A, & Sheridan, K, 1972 A Saxon water-mill in Bolebridge St, Tamworth, *Trans S Staffs Archaeol Hist Soc,* **13.** 9-16

Reynolds, J, 1970 *Windmills and water-mills,* new edn 1974

Reynolds, P, 1978 *Archaeology* by experiment, a research tool for tomorrow, in *New Approuches to our past* (ed T C Darvill *et al),* 139-56

Rice, D T (ed), 1958 *The great palace of the Byzantine emperors,* **2**

Simpson, F G (ed Simpson, G), 1976 *Watermills and military works on Hadrian's Wall*

Singer, C, Holmyard, E J, Hall, A R, & Williams, T I (eds), 1957 *A history of technology*

Steensberg, A, 1952 *Farms and watermills in Denmark over 2000 years, Copenhagen*

Syson, L, 1965 *British water-mills*

Trent, E M, 1975 Examination of bearing from Saxon water-mill, Hist Metall, **9,** 19-25

Wailes, R, 1954 *The English windmill*

Whitclock, D (ed), 1955 *English historical documents,* **1**

Williamson, K, 1946 Horizontal water-mills of the Faeroe Islands, Antiquity, **20,** 83-91

Woolhope, 1955 The bailiff's accounts for the Manor of Kingsland, 1389-90, *Trans Woolhope Natur Fld Club,* **35,** 168-76

Introduction

The approach to be followed in this paper will be first to outline the classification and grouping of modern British breeds into broad types so that the extent to which their ancestry can be pushed back towards the Middle Ages can be demonstrated. Then a brief consideration will be given of the meagre pre-medieval evidence, and the origin of British sheep. Finally, the Middle Ages will be covered in greater detail taking each source of evidence in turn. Relatively new sources will be used, and it must be said at the outset that it has been virtually impossible as yet to relate the new findings to the wool cloth descriptions frequently quoted by economic historians.

Since there has been much discussion about the distinction between shortwools and longwools during the Middle Ages, it will be useful to point out at this stage that these are distinct groups of breeds (Fig 9). In other words the main cause of differences between fleece types is genetic, and although better feed will make a shortwoolled fleece grow somewhat longer, it cannot change it into longwool type; Fig 10 emphasizes this point further by showing that each fleece type has a characteristic staple form, that arises from the intermingling of varying proportions of different fibre types.

Breeds back to the 16th century

A classification of British breeds based on face colour, the presence or absence of horns, and fleece type is shown in Table 1, which is taken from Ryder (1964) and Ryder & Stephenson (1968). The white-faced, horned, hill group tends to comprise old breeds that are horned in the rams only. The wool is generally coarse, but not hairy. The Shetland breed is the most primitive member of this group and has a finer fleece. The related white-faced shortwool group has breeds with finer wool than the white-face horn, and those with horns are horned in both sexes.

The black-faced, horned group has breeds with longer, hairy fleeces, and horns in both sexes. The black-faced shortwools lack horns and are mostly of moderately recent development, being named Down breeds.

Figure 11, also from Ryder (1964), summarizes some of the relationships and lines of evolution of British breeds. The recent stages are based on breed records of the last 150 years, and so more reliance can be placed on them than on the earlier stages for which records do not exist. The lines do not necessarily imply direct links. The diagram does, however, imply three main types or waves of introduction. The first type was the prehistoric sheep which survives today as

Fig 9 Different breed types of British sheep: right, black-faced, horned hill type (Scottish Blackface); centre, white-faced hill sheep (Welsh Mountain); left, lustre longwool (Lincoln breed)

Table 1 Classification of British breeds

Breed	Frequency	Group
White-faced, horned hill		
Orkney x	—	
Shetland x	0.69	
Herdwick x	0.71	'Green Hill' breeds
Cheviot x	0.54	'Green Hill' breeds
Welsh Mountain x	0.54	'Green Hill' breeds
Radnor x	0.47	'Green Hill' breeds
White-faced, shortwools		
Kerry Hill	0.42	
Ryeland	0.23	
Whiteface Woodland xx	—	
Wiltshire Horn xx	0.14	
Dorset Horn xx	0.49	
Portland xx	—	
Exmoor Horn xx	0.65	
Devon Closewool		
Demi-lustre longwools of medium length		
Romney Marsh	0.53	White-faced polled
Border Leicester	0.12	White-faced polled
Lustre longwools		
Teeswater	0.54	White-faced polled
Wensleydale	0.59	White-faced polled
Ielcester	0.06	White-faced polled
Lincoln	—	White-faced polled
Cotswold	—	White-faced polled
Dartmoor	0.13	White-faced polled
Devon Longwool	0.13	White-faced polled
South Devon	0.20	White-faced polled

Breed	Frequency	Group
Black-faced, horned hill		
Scottish Blackface xx	0.72	heather hills
Rough Fell xx	0.81	heather hills
Swaledale xx	0.62	heather hills
Dalesbred xx	0.63	heather hills
Lonk xx	0.45	heather hills
Derbyshire Gritstone	0.57	heather hills
Black-faced, shortwools		
Clun Forest	0.41	
Shropshire	0.25	
Norfolk	1.0	
Suffolk	0.42	Down breeds
Oxford	0.26	Down breeds
Southdown	0.44	Down breeds
Hampshire	0.54	Down breeds
Dorset Down	0.49	Down breeds
Miscellaneous		
Wild Mouflon	0.70	
Soay	0.96	
Manx Loghtan	—	4-horned
Jacob	—	4-horned
St Kilda (Hebridean)	—	4-horned

The Southdown has almost lost its face colour, and like the Ryeland has a woolly face

xx both ewes and rams horned; x only rams horned

The gene frequencies for high blood potassium shown in this table and those for haemoglobin A shown in Fig 11 provide supporting evidence for the affinities of different breeds.[1] But too much reliancc should not be placed on these frequencies alone because they are likely to change by selection in different environments. Haemoglobin A gene frequencies are likely to change less, however.

[1]Both from Evans *et al* 1958

Table modified from Ryder 1964

the small, brown, Soay breed. The second was the white-faced polled type, and the third type was the black-faced horned. The source and evolution of these types will be discussed in greater detail below.

The map shown in Fig 12 (from Ryder 1964) plots the distribution of the main types of British sheep at the end of the 18th century when accurate breed descriptions first begin to appear. It owes much to the summaries of Trow-Smith (1957; 1959) on which are superimposed the county by county sheep descriptions of such authors as Youatt (1840). The white-faced horned type was concentrated in Scotland and the western parts of Britain. The longwools extended through a wide area of the Midlands, and the black-faced, horned type was found mainly in the east and north of England, whence it was entering Scotland to become the Scottish Blackface. Finally, two small areas, the counties of Hereford and Sussex, were noted for fine wool. In Hereford the breed in question had been known as the Hereford, and this emerged as the modern Ryeland breed (Fig 13). In Sussex the fine-woolled breed was the Southdown, which was used in the development of all the other Down breeds and is still noted for fine wool, although this is of course of British shortwool type and not as fine as that of the Merino.

Ryder (1964) showed that these broad groups went back to the 16th century as regional types which gave rise to the native breeds of each county that were evident at the end of the 18th century. The 16th and 17th centuries were a time of change from the subsistence farming of the Middle Ages to the commercial agriculture carried out by yeoman farmers.

Sheep before the Middle Ages

The domestication of sheep did not take place in Britain, so the first domestic sheep were introduced by Neolithic settlers about 4000 BC. The prehistoric breed of Europe is thought to be represented today by the small, brown Soay sheep that survives in a feral state on St Kilda off north-west Scotland. Evidence for this comes from the similarity of Neolithic bone remains with those of the Soay, and the similarity of wool in Bronze Age cloth with the fleece of the Soay (Ryder 1969).

The primitive features shared by the Soay with the wild ancestor are a short tail (all modern breeds have a long tail), a coloured fleece in which the belly is white (most modern breeds are completely white), and an annual moult (the wool of virtually all modern breeds grows continuously). To these major and obvious differences between wild sheep and modern domestic breeds can be added the change from a hairy coat to a woolly fleece; the wool of the Soay is already much less hairy than the coat of the wild sheep, but there are hairy and woolly types.

This change is evident in Fig 14 (from Ryder 1969) which shows histograms of wool fibre diameter distributions in microns (one micron, 1 μm, = 0.001 mm). The diameter is shown along the horizontal axis

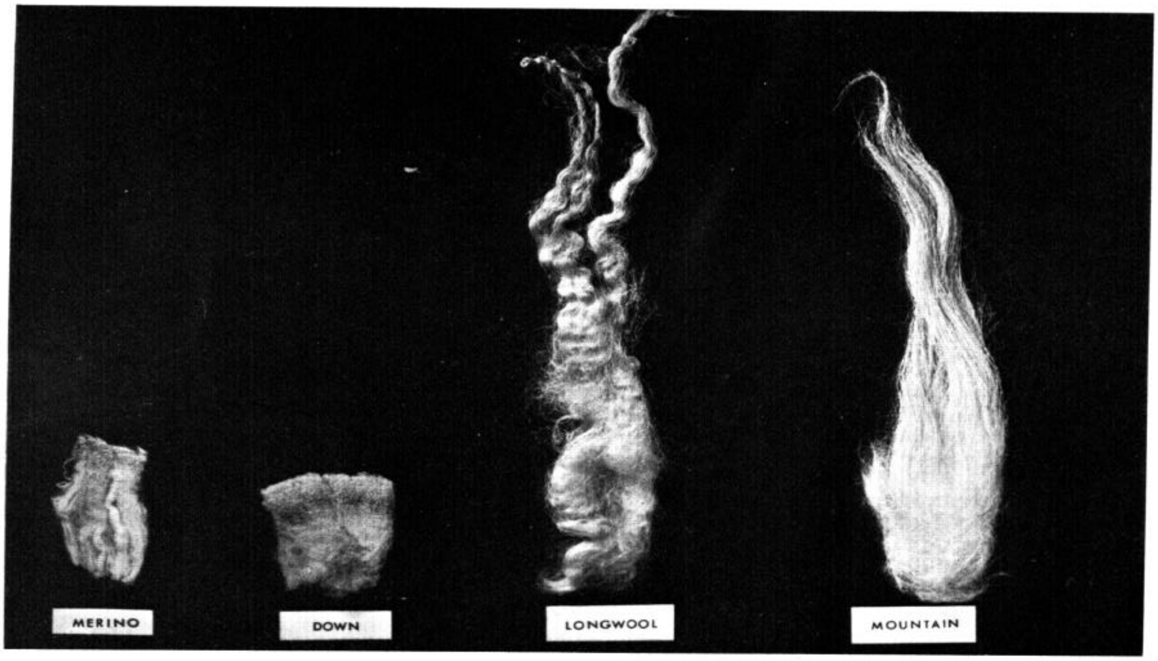


Fig 10 Wool staples of different fleece types; the fine-woolled Merino is not a native of Britain; the Down type is a modern representative of the shortwool; the longwool has a characteristic curl and lustre, and the fibres are coarse but not hairy; the mountain type is illustrated by a staple from the Scottish Blackface in which long hairy *fibres obscure an undercoat of fine wool (from Ryder & Stephenson 1968)*

and the number of fibres on the vertical axis. The fibre diameter distribution of the wild sheep is shown at the top; the big difference in diameter between the coarse, hairy outer coat of fibres known as kemps and the extremely fine woolly undercoat is very striking. The first evolutionary change following domestication was a narrowing of the coarse, hairy outer coat kemps to produce the hairy medium fleecy type of the hairy Soay. Further narrowing of these hairy fibres, presumably as a result of selective breeding by man, changed them into wool fibres of medium diameter, the result being the fleece type of the woolly Soay.

In evolutionary terms this is a generalized type forming an important link between more primitive hairy fleeces and more highly evolved modern fleece types. The diameter distributions of surviving sheep are shown in Fig 14 but the lower five distributions have all been found in wool from ancient textiles. The hairy medium and generalized medium types appeared first in the Bronze Age, and were common until after the Middle Ages. The modern types on the bottom row began to appear in Roman times.

Colour changed next with the appearance of white sheep in the Iron Age, but there was in fact a range of colour: black, white, and grey in addition to the brown of the Soay. This varicoloured sheep still had hairy as well as woolly fleece types, and a spring moult. It appears to have been common until after the Middle Ages and widespread throughout Europe, since small pockets of relic breeds survive in isolated areas (Ryder 1979). Many of the surviving breeds have a short tail, but only the rams are horned; the skeleton is, however, otherwise similar to the Soay (see below). But the wild-pattern white belly has gone (or at least is extremely rare) and so this marks the Soay as truly unique among domestic sheep. Grey animals are, however, a notable feature, and the type could be described as 'European grey or varicoloured'.

The surviving breeds of this type in Britain are the Orkney and Shetland. During the 19th century these two breeds formed a single population, but the Shetland has since been selectively bred for white, woolly fleeces, and so only the Orkney retains the full range of colour and fleece type (Ryder 1968a). The tendency to shed meant that in the past the wool had to be obtained by plucking (Ryder 1966) but this has mostly been bred out today, so that most sheep are shorn.

Roman textiles from Britain and the Continent show that more changes in fibre diameter were taking place at that time. The new fleece types that appeared are shown in Fig 14. The predominant wool type during the Roman period, in addition to being white, is fine to the naked eye, but microscopic examination reveals that the wool contains medium fibres and so is of generalized medium type. Hairy medium wools were still common, however, at Vindolanda on Hadrian's Wall, for instance (Ryder 1977a) (Table 2). The probable way in which the new types evolved can be followed in Fig 14. If the medium fibres of the generalized medium wool had become narrower by selective breeding, then the fibre diameter distribution of the true fine type seen in the modern Merino would have been produced. The development of the true fine wool began in the Middle East probably soon after 1000 BC (Ryder 1969). But the emergence of the Merino as a distinct breed occurred in the late Middle Ages in Spain.

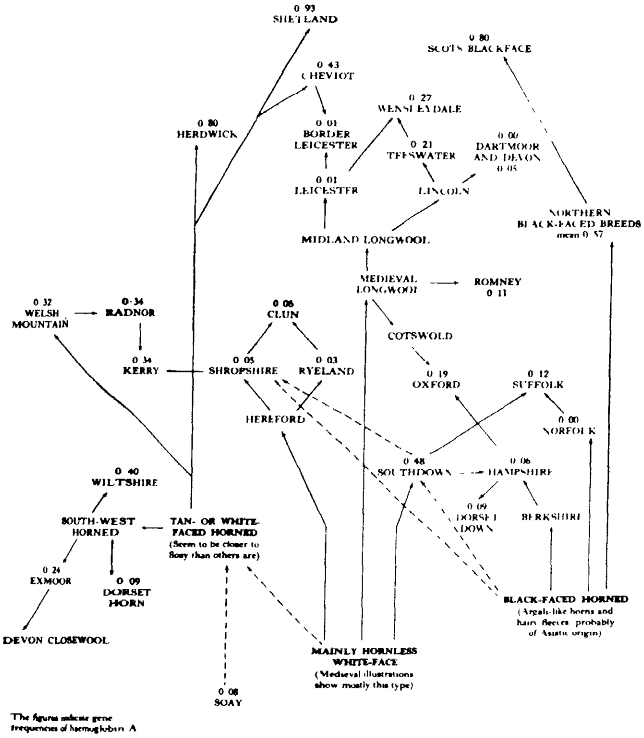


Fig 11 Probable recent lines of evolution of British breeds of sheep from three possible main introductions of stock into the British Isles (from Ryder 1964)

If, on the other hand, the finer fibres had become coarser by breeding, then the true medium wool diameter distribution of the modern longwool would have been obtained. Furthermore, if both changes had taken place together, and the range of fibre diameter had become shortened, with a mean between the fine and medium values, the distribution would be comparable with that of the modern shortwool. Textile remains indicate that a few medium wools and shortwools had developed during Roman times, but neither became common in Britain until after the Middle Ages (Ryder 1969).

These changes are summarized, along with other evidence, in terms of breed type in Fig 15. Following the prehistoric Soay, the next main influx of sheep into Britain is likely to have come with the Remans, and textile remains show that many of the sheep were white. It has always been assumed that the Romans introduced improved livestock, although there is little direct evidence for this. Introductions of white sheep were probably made by the Belgae before the Romans, for instance. Illustrations on Roman mosaics and sculptures indicate white-faced sheep with a tail of medium length, and there are horned and polled individuals which could be rams and ewes as in some modern breeds such as the Merino.

It is possible that crosses between this white Roman sheep, and the brown, native Soay gave rise to types that later emerged as breeds such as the Cheviot and Welsh Mountain in the north and the west. These are horned in the rams only, and they tend to have tan fibres.

Then, as already indicated, evolution within the Roman generalized type itself, by a coarsening of the fine fibres, could have produced a primitive longwool. It is possible that this had a fleece similar to that of the modern Romney breed (Fig 16), which has a shorter fleece than the true (lustre) longwools; this will be considered again below.

A shortening of the diameter range of the generalized type could have given the shortwool, and evidence for this sheep in the Middle Ages will be discussed later. As stated above, the main evolution of the true fine wool appears to have taken place on the Continent.

The third main type to reach Britain was the black-faced, horned group, but when these sheep arrived is not clear. Because this type is superficially similar to many Asiatic sheep, it has long been thought to have originated in Asia; there are similar breeds in Europe that would provide a link, but no real evidence exists on its origin. Further discussion on the possible date of entry will be given below.

Sheep were found everywhere in England during the Saxon period, as judged by the number of place names which embody a reference to sheep. There are also indications that wool cloth was exported, as it had been during Roman times, and of course its increased export during the Middle Ages was to form the major economic activity of the country.

The Saxon wools examined by Ryder (1969) were comparable with those of the Roman period (Ryder 1974; 1977a) ranging from hairy medium, through the generalized medium type, to fine wools, and the Sutton Hoo burial yielded some particularly fine fleece types (Table 2). Many northern areas were occupied by the Vikings, the Lake District for instance, and it is probable that the Herdwick breed of that area contains Norse influence. Most of the Norse wools measured were from Scotland (Ryder 1968b) and the general impression gained was that they were more hairy, but had less pigmentation than Roman and Saxon wools. Orkney and Shetland were occupied by Norsemen until the 15th century, and it has already been indicated (above) that the surviving native breeds of these islands not only contain Scandinavian influence, but appear to belong to a

Table 2 Comparison of Roman and Saxon wools

	Vindolanda	*All other Roman (including Europe)*	*Saxon (England only)*
Hairy	(1)	—	
Hairy medium	34% (19)	14% (12)	23% (10)
Generalized medium	34% (19)	15% (13)	23% (10)
Fine, generalized medium	18% (10)	39% (34)	30% (13)
True medium	2% (1)	3.5% (3)	5% (2)
Short	4% (2)	1.5% (1)	—
Fine	9% (5)	27% (23)	19% (8)

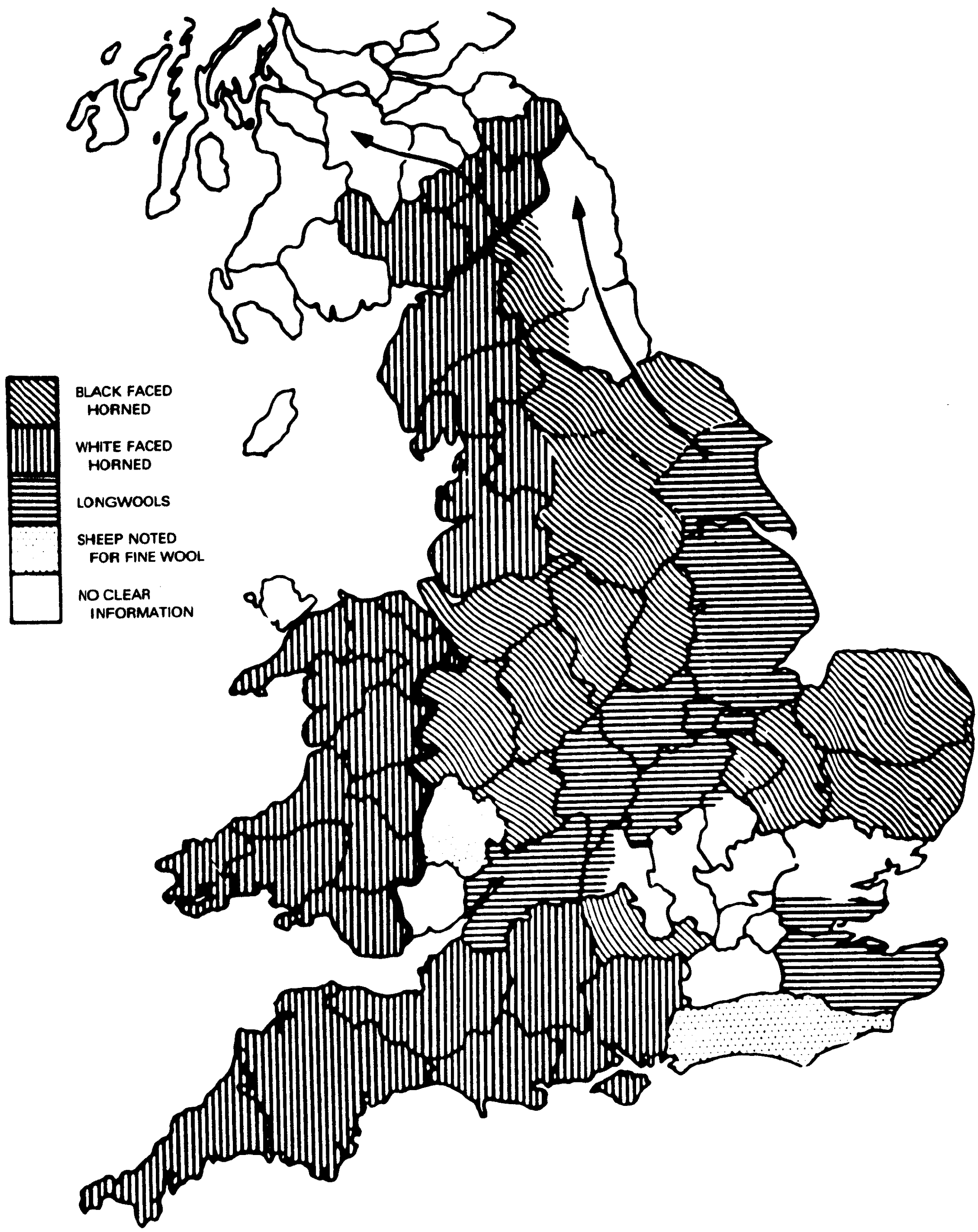


Fig 12 Distribution of four main types of sheep about 1800 (from Ryder 1964)

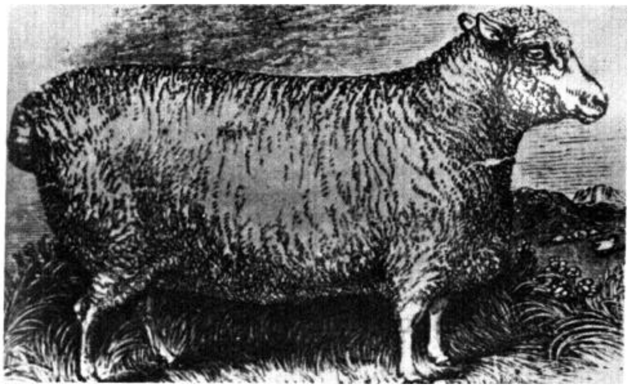


Fig 13 The white-faced, polled, Ryeland breed that may be a survivor of the English medieval fine-woolled type (from Youatt 1840)

more primitive varicoloured stock that was once widespread throughout Europe.

The area occupied by the Danes before the Norman Conquest corresponds very roughly with the area in which the black-faced, horned type later emerged into history (Ryder 1972), and this has led to the suggestion that this main stock was introduced by the Danes. Support for this can be gained from the existence of a similar sheep in the past in Denmark. The German and Polish Heath breeds were once thought to be of the same general type, but these have grey individuals and a short tail, and so appear to belong to the varicoloured group. Some Danish textiles excavated in York in fact contained true hairy wool (Ryder 1974).

Medieval sheep (1066-1550)

Evidence from records

The Domesday survey made soon after the Norman Conquest showed that there were then more sheep than all other livestock put together (Trow-Smith 1957). The sheep's main function at that time was to provide milk to make cheese for winter food; wool, manure, and meat were by-products in that order of importance. records of that date provide no clue as to the size or type of livestock, and the similarity in price between the rams end ewes bought for royal manors in the 12th century indicates a lack of breeding policy There was, however, a difference in price between fine-woolled sheep at 10d each and coarse-woolled animals at 6d. This demonstrates an interest in fine wool, but fewer than 1% of manors had such a flock, which suggests that fine-woolled sheep were scarce.

Ryder (1964) wondered whether these coarse-woolled sheep were of black-faced, horned, or white-faced, horned type. The evidence summarized in the present account leads to the conclusion that they had hairy medium fleeces, ie were comparable with the hairy variety of the modern Orkney or Shetland breeds.

Since breeding in isolation and wide out-crosses are regarded by animal geneticists as two important ways in which breeds originated, it is of interest to note that there are records of considerable stock movement during the Middle Ages. In 1323, for instance, several hundred sheep were driven from East Anglia to Yorkshire to re-stock royal manors in the north (Trow-Smith 1957, 109).

Such introduction of new and presumably improved stock into an area constituted one form of selective breeding, and it is no doubt the way in which the Cistercian monks obtained sheep for the monasteries established in the north and west during the 12th century (Trow-Smith 1957,111). Although wool must have received considerable attention during the period when it was of great economic value, there are no records of selective breeding for wool. There are monastic records of the numbers of sheep kept, as well as the value of their sheep and wool, but little remains to show what the animals were like.

The account books of Fountains Abbey, Yorkshire for 1457 and 1458 (Fowler 1918) provide an illuminating breakdown of wool qualities and prices. About 70% of the wool grown was 'optima' quality at 2d a lb, 12% was 'media' at 1½d a lb, and 8% 'grisia' (grey and brown) also at 1½d. Among the poorer qualities was 4% 'black' at¾d. This together with such expressions as 'a sheepes russet gowne', indicates the persistence of the natural colours already discussed.

Carcass conformation was apparently never considered; when a sheep was too old to produce wool it was merely fattened for slaughter (Trow-Smith 1957, 160). Breeds in the modern sense did not exist, but a classification of sheep by wool typewas already in use by buyers in the Middle Ages when Britain produced the finest wool in the world, ie that with the thinnest fibres. Fine wool fetched the highest price because the supply did not meet the demand; much wool of other type and lower price was also produced. Henry Best wrote in 1641 that where fine wool was in short

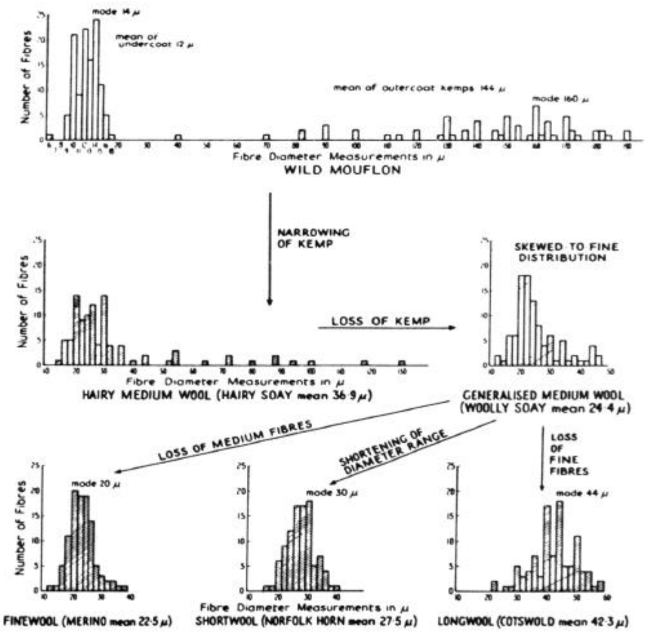


Fig 14 Probable changes in wool fibre diameter distribution during fleece evolution: one μ (micron) = 0.001 mm *(from Ryder 1969)*

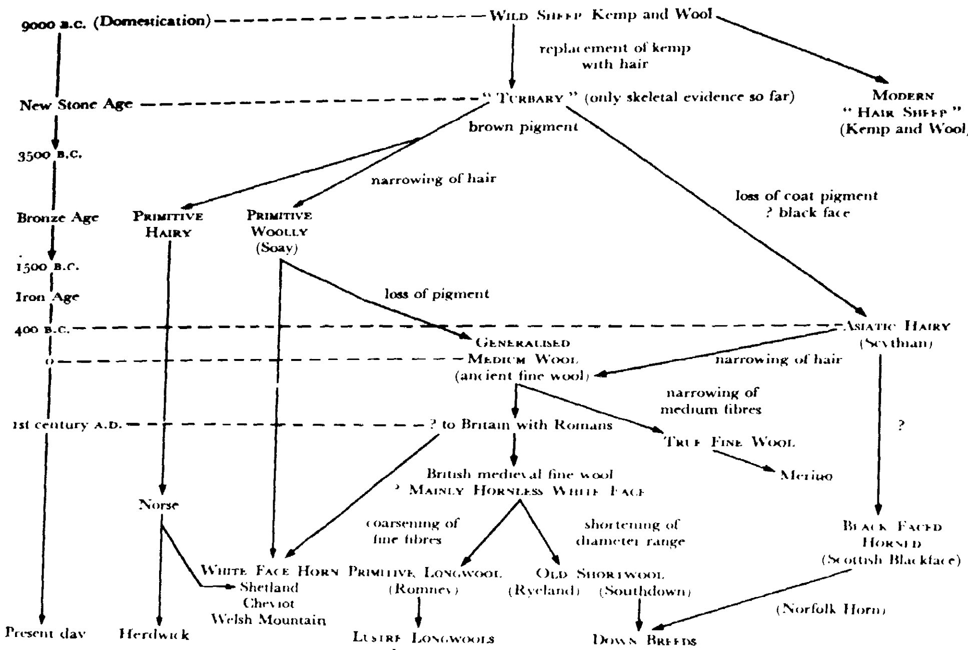


Fig 15 Suggested lines of evolution of different fleece types in terms of breed types and historical periods (from Ryder 1969)

supply it was often worthwhile shearing lambs (at six months) to supply the need, and one wonders whether this was ever done during the Middle Ages.

According to Lipson (1953, 28) the uniqueness of British wool lay in its length, which enabled it to be combed to make worsteds, since there was plenty of fine wool on the Continent. The question of length provides a recurring theme in English medieval wool. Breed (heredity) has an overwhelming influence on such fleece characteristics as length, but the environment (eg feed) can have some effect, and it was known in the 16th century that better pasture resulted in longer and therefore heavier fleeces. Some of the extra length recorded may therefore be due to the richer British pasture acting on a basically shortwool type. It should be mentioned that better feed also tends to make the wool less fine.

One would not, however, expect nutritional variation to give the almost twofold difference in fleece weight of from 1·1 to 2·1 lb recorded by Trow-Smith (1957, 167), and so breed variation is implied. (His medieval average fleece weight of 1·5 lb appears low in comparison with the figure of 2·5 lb obtained from surviving primitive breeds such as the Orkney. A mean of 2-3 lb calculated by the present author from figures given by Waites (1977) for one estate appears more realistic.)

The range of fleece weight discussed above accords with the much repeated statement of Power (1941) that long wool was produced by a different breed type from that which grew short wool during the Middle Ages. Ryder (1964) considered that this statement was only acceptable if the longwool was a breed such as the Romney (see above) which has a fleece about seven inches long today, and not a breed like the modern Leicester which has long, lustrous, and curly wool, a foot or more in length. How the lustre longwools originated will be discussed in greater detail below. There is no conclusive evidence for their existence in the Middle Ages.

Ryder (1964) attempted to link up the broad types of sheep traced back to the 16th century (above) with the medieval sheep deduced mainly from wool prices and listed by Trow-Smith (1957), actual measurements of wool remaining in textiles or sheepskin parchments being used by Ryder to provide new and irrefutable evidence.

There are three 14th century wool price lists in existence, and two from the 15th century. The lists for 1343 and 1454 are detailed by Trow-Smith (1957, 162). The average price for each county in 1343 is shown cartographically by Felham (1948, 245) who also mapped the English counties noted for coarse wool around 1400 (Fig 17). These were: Cumberland, Westmorland, Northumberland, Durham, Wiltshire, and the south-west except Somerset.

The eastern and southern counties, including Cambridge, Surrey, and Sussex, also had coarse wool. The rest of England, from Hampshire through the Midlands to Yorkshire presumably had finer wool. During the 14th century wool ranged in price from £4 13s 4d to £18 13s 4d per sack. By the 15th century the price had fallen, ranging from only £2 10s to £97s 7s 6d per sack.

The list of 1454 had 50 wool grades; and in this list and that of 1343 the most highly priced, and presumably therefore the finest wool, came from the Welsh border counties. In 1454 the dearest wool came from around Leominster in Herefordshire, and much has been written about the fineness of 'Lemster' wool. It is very likely that Leominster wool was grown by the ancestor of the Hereford, which is now the Ryeland breed (Fig 13), and this area had a reputation for fine wool until 1800. But Hereford in common with other

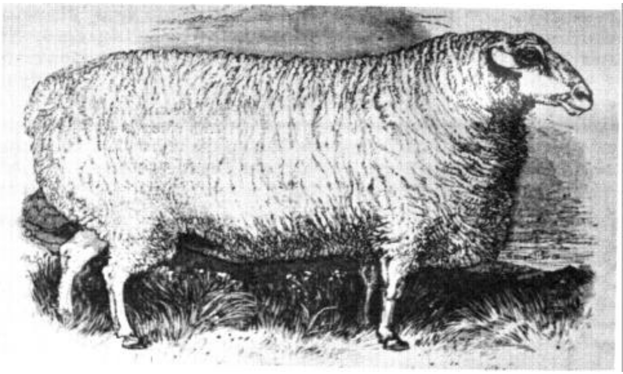


Fig 16 White-faced, polled Romney breed. l-his has wool of medium length and may be a survivor ofthe medieval longwool (from Youatt 1840)

counties also grew presumably coarser wool that did not fetch such high prices.

The next highest priced in 1454 were Cotswold and Lincoln wools; this must mean that they were shorter and finer than the fleeces of the breeds with these names today, which are lustre longwools. Canterbury wool from Kent and Sussex was on the other hand relatively low in price. The export of Canterbury fleeces from Staffordshire and Nottinghamshire in the 13th century suggests a link between the Midland Longwool (see above) and the possible forerunner of the Romney breed (Fig 16), which remains a primitive longwool with wool intermediate in length between the modern shortwool and the longwool types. The wool elsewhere in Kent and Sussex was of average price, and it was here that the fine-fleeced Southdown breed emerged later.

Evidence from the skeleton

Medieval archaeology is a relativelyrecent subject, so, as yet, few and inadequate studies have been made on the size and type of sheep from bone remains. Ryder (1961) described the sheep bones from four medieval sites in Yorkshire; he found the animals to be small and slender, with apparently no difference from those of earlier periods. A similar survey made by Ryder (1968b), with the emphasis on bones from Scottish sites, revealed little change in size until after the Middle Ages, most bone remains being the same as those of the Soay or Shetland which were themselves indistinguishable. Further measurements summarized by-Ryder (1980b) do not alter these conclusions.

More recently Noddle (1975) found the size of medieval sheep to be moderately uniform, with no evidence of a change from Saxon sheep. She found that the length of the neck of the scapula bone provides a useful indication of breed type, primitive short-tailed breeds having a long scapula neck, and modern long-tailed breeds having a short scapula neck. In the Welsh Mountain the neck of the scapula is of intermediate length, and this was regarded as supporting the conclusion of Ryder (1964) (outlined above) that the Welsh Mountain breed originated from an amalgam of local short-tailed stock and imported sheep. Among the eight sites she studied in southern Britain including Bristol, Hereford, and King's Lynn, she found that most of the sheep scapulae had a neck of intermediate length, but each site had some of short-tailed type, and some sites had a few scapulae approaching those of modern mutton sheep.

The measurement of leg bones from King's Lynn (Noddle 1977) and others from Baynard's Castle, London (Armitage & Goodall 1977) suggested a sheep little bigger than the Soay, with slightly more robust bones, but in addition similar body proportions to the Soay, ie comparable with the juvenile conformation of modern breeds.

When horned and hornless skulls were found at Kirkstall Abbey (Ryder 1961), it was thought the horned skulls might indicate hairy, black-faced, horned Pennine sheep, and the polled skulls longwools. But they could have come from general variability within the same type of sheep; or the horned skulls may have been from the rams (or wethers = castrated males) and the hornless skulls from the ewes of a single breed, possibly of the white-faced, horned type (cf Welsh Mountain and Orkney/Shetland) or the generalized medium wool that the monasteries kept to grow good quality fleeces.

Noddle (1975; 1977) found that most sheep skulls were horned, but there was evidence of each type of horn inheritance. First, there was a horned breed, or breeds since she found considerable variety of horn shape; second, there was evidence of horned rams and polled ewes; and third, evidence of a hornless breed which she identified as the medieval fine wool (generalized medium wool) of Ryder (1964).

Despite the fact that few medieval illustrations of horned ewes are known (see below), Armitage & Goodall (1977), too, were able to demonstrate that some horned skulls were from ewes. The same breed type had horns of intermediate size which were identified as coming from wethers. It was deduced that the hornless skulls were from a different breed type in which both sexes were polled. Agricultural writers of the 16th century refer to hornless rams.

Skeletal evidence therefore indicates that medieval sheep were small, and that the three types of horn inheritance were already in existence. These are horned in both sexes, horned in the rams only, and polled in both sexes. This does not necessarily indicate distinct breeds since the different types could have existed within a variable interbreeding population.

Evidence from illustrations

Ryder (1964) listed 43 sheep illustrations ranging in date from Roman times to the 18th century which were used to provide evidence of appearance.

Most of the medieval paintings or miniatures showed white-faced, hornless sheep, with occasional horned animals that are probably rams. The sheep are invariably shown with short wool, and often appear like the modern Merino, Ryeland, or Romney breeds. Although no illustrations of longwoolled sheep have been recorded, some fleeces have short curls like those of a recently shorn longwool. Likewise no picture of a sheep with a hairy fleece or a black face was found before the 18th century.

Although Armitage & Goodall (1977) criticized the fact that only sixteen of these originated in England and not on the Continent, a further fifteen depictions dating from the 11th to the 18th centuries found more recently have not greatly changed the above conclusions. Paintings are a valuable source of historic information, and I think that they can provide

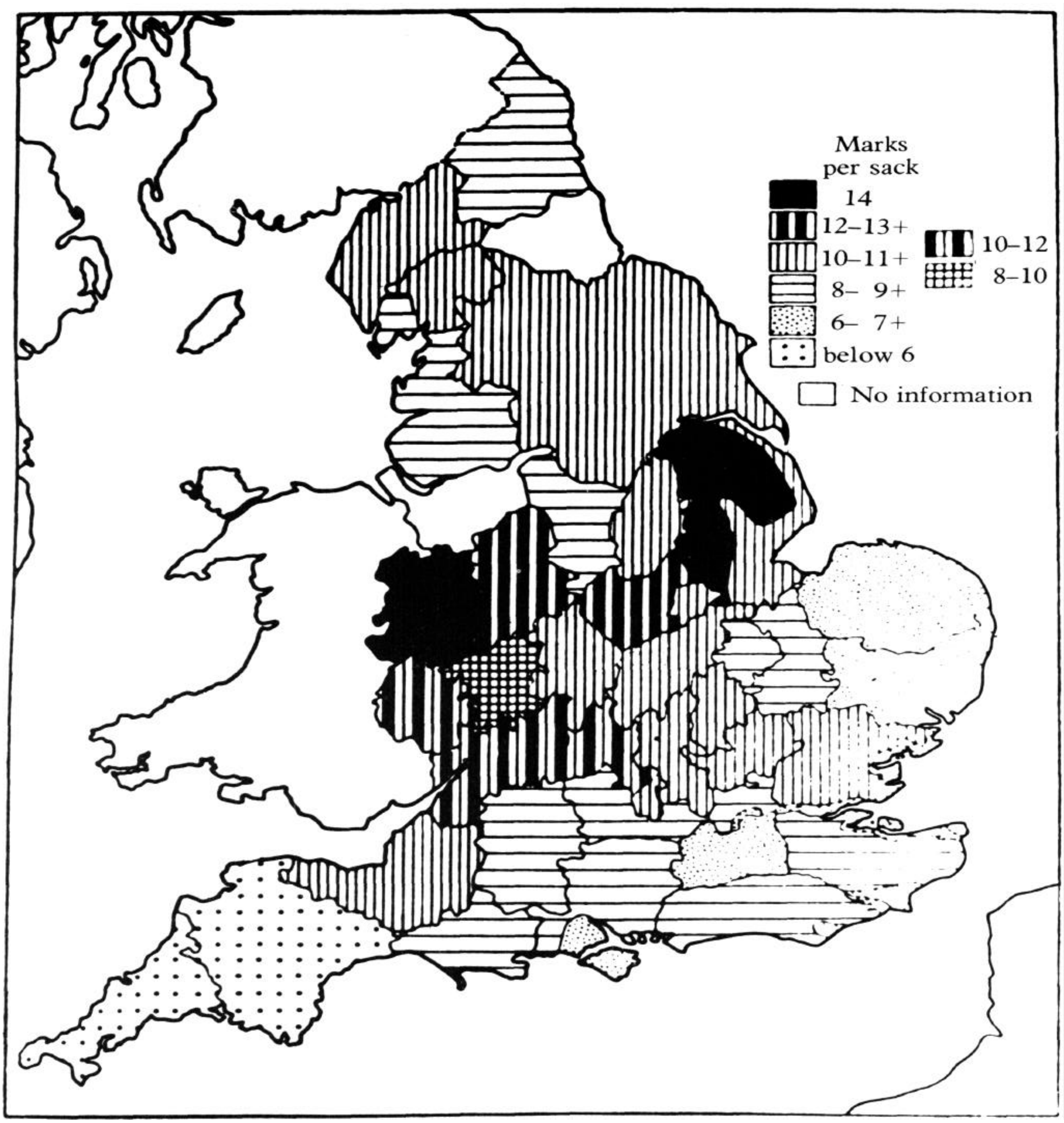


Fig 17 Distribution of English wool prices in 1343. The price is assumed to be directly related to the fineness of the fibres. Note the high prices on the Welsh border where the Ryeland breed (Fig 13) later emerged. The Midlands and Lincoln were later known for longwoolled sheep with coarser wool (Figs 9 and 12). Wool from the Romney area of Kent was low in price (from Pelham 1948)

biological evidence too. The excellent detail in other objects and clothing does not support the idea that there might have been some artistic convention which decreed that all sheep should be painted in a certain way.

Armitage & Goodall (1977) used art history sources to confirm the author's suspicion that illustrations such as zodiac signs and bestiary illustrations tend to follow patterns and traditions, and are less reliable than Nativity scenes and depictions of monthly agricultural tasks.

The monumental brasses of the Fortey family at Northleach church in the Cotswolds *(c* 1450) each depict a person with one foot on a woolsack and one foot on a sheep, which is a large, polled animal. The fleece is depicted by short curls like those on a shorn longwool, and is uncannily like that of the modern Cotswold breed. The brass of Thomas Bushe (1526) has several small, horned sheep shown with shorter staples, which appear to be shortwools.

Three of the Bushe sheep have wool shown by short flecks, which Armitage & Goodall (1977) consider to indicate that they have been shorn. They also consider that the horn size and shape indicate wethers. The tails are long, but that of the fourth sheep, with ram's horns, is of medium length. This could be due to natural variation in length rather than to docking, as Armitage and Goodall thought. Docking usually results in a short tail, whereas, in addition to natural breed variation, a tail of medium length can result from a cross between a long-tailed and a short-tailed sheep. These authors consider that the illustrations provide evidence of different kinds of sheep, but not of regional variation, since all the brasses were made in London.

They discuss two more polled sheep on brasses at Northleach; one to John Taylor *(c* 1490) has a tail of medium length which they again consider to have been docked, in the author's view erroneously. They also consider that the wavy lines on the body indicate long wool, but the author has always considered that this common depiction of wool is too generalized to indicate a particular fleece type. It could, however, be a primitive longwool like the Romney. The second sheep, on the brass of an unknown woolman *(c* 1485) has wavy but pointed staples that indicate a hairy, or at least hairy medium fleece, and not a longwool as Armitage and Goodall suggest (Fig 18).

Since they considered that there were no medieval illustrations of horned ewes it is worthwhile pointing out what appears to be a horned ewe on the late 16th century Bradford Table embroidered carpet in the Victoria and Albert Museum. This has a heavy-horned ram, the sex of which is confirmed by the depiction of a scrotum; there are also five polled ewes plus a sheep with smaller horns than the ram. The detail is, however, insufficient to be sure that this is not a wether.

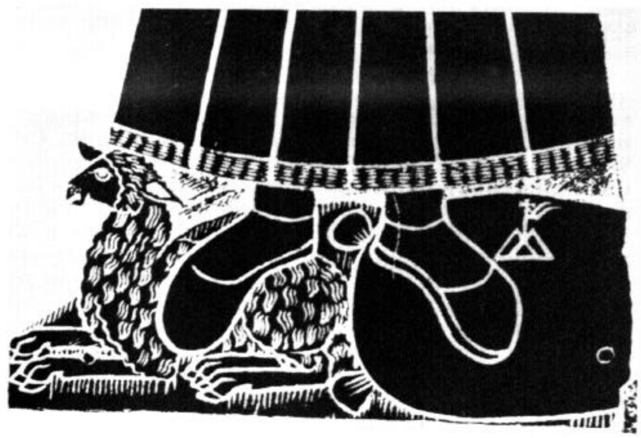


Fig 18 Sheep on brass to an unknown woolman in Northleach church (c 1485). The pointed wool staples in the fleece are probably an indication of hairiness (from Armitage & Goodall 1977)

Evidence from wool remaining in parchment and textiles

Microscopic examinations of parchment have provided incontrovertible evidence of the reputed fineness of much medieval wool. In the fleece types in parchments dating from 1193 tabulated by Ryder (1964) hairy sheep were found from the 14th to the 18th centuries. Pigmented wools originally described as 'Soay' would now be regarded as coloured short-tails, and these were found up to the 17th century. Fleece types described as fine and fine-to-medium would now be named generalized medium wools. They predominated in the Middle Ages and reached a peak in the 14th century. Medium (diameter) wools, which are likely to have been longwools first appeared in the 14th century, and increased steadily to reach a peak in the 18th century.

Ryder (1973) considered the question of parchment dimensions; he found that some medieval parchments were already larger than the largest size that

Table 3 Summary of fleece types in British medieval wools

		Hairy	*Hairy medium*	*Generalized medium*	*Fine-generalized medium*	*True medium*	*Short*	*Fine*
Winchester	11th century	14%(1)	57% (4)	29% (2)	—	—	—	—
London, Baynard's Castle	1200	—	25%(2)	63% (5	—	—	—	12%(l)
York	12th-13th century	27%(3)	37% (4)	27% (3)	—	9%(1)	—	—
Southampton	13th-14th century	—	11% (2)	58%(11)	—	5%(1)	5%(1)	21%(4)
Baynard's Castle	14th century	13%(3)	8% (2)	8% (2)	38%(9)	4%(1)	13%(3)	16%(4)
Baynard's Castle	15th century	7.5%(2)	11%(3)	15%(4)	18%(5)	11%(3)	30%(8)	7.5%(2)
Yorkshire	15th century	—	33%(2)	66%(4)	—	—	—	—
Perth	12th-14th century	19%(17)	44%(39)	18%(16)	6%(5)	8%(7)	5%(4)	—
Aberdeen	13th-14th century	12.5%(2)	19% (3)	44% (7)	6%(1)	12.5%(2)	—	6%(1)
	Average	10%	27%	36%	8%	6%	6%	7%

could be made from a Soay skin, thus supporting the above skeletal evidence that medieval sheep were already larger than the Soay.

Despite the increased preservation of textile remains from the Middle Ages onwards, those made available for study come mainly from recent excavations. Samples measured by Ryder (1974) from the Winchester excavations of Martin Biddle comprised three tufts of raw wool and four yarns dated to the 11th century. The fleece types of these are shown in Table 3, and the true hairy sample was the only one with natural pigmentation. The fibre diameter measurements are shown in Table 4. The raw wool was of special interest in being rare. Only one specimen had a clear staple, which was narrow, and the crimp took the form of a shallow wave. The staple length was 60 mm (2.3 in) but this was not necessarily the maximum fleece length since the fibres had root ends, with none of the brushes that are formed when the wool of primitive sheep ceases to grow in winter. The other two pieces were similar, but one had only cut ends and the other had only one fibre with a root end; so whereas the last two appear to be shorn wool, the root ends in the former (in the context of a possible tannery pit) suggest 'skin wool' that is pulled from a skin by a fellmonger after the death of the sheep.

Another raw wool specimen from the waterfront site of Baynard's Castle, London, and dated about 1200 was described by Ryder (1977b). This had a narrow staple 40 mm (1.6 in) long with 8 crimps per inch which tended to form small curls, as seen in some modern, fine-woolled Shetland sheep, and the wool appeared to be from a shorn fleece. The fibre diameter measurements, plus a symmetrical diameter distribution, defined the fleece type as a true fine equivalent to modern 64s Merino.

Ryder (1977b) discussed the possibility that this was Merino wool imported from Spain, but it seems more likely to have come from an export. Merino wool of this quality would be expected to have about 12 crimps per inch, and occasional true fine fleeces are found among surviving Orkney/Shetland sheep. The details of seven yarns from cloth found with this wool are shown in Tables 3 and 4 and one of them had natural pigment.

Also shown in these tables are the measurements of eleven wools from Petergate, York, dated 1200 ± 50 years and described by Ryder (1974). The coarsest fibres of the hairy fleeces were pigmented, indicating a grey sheep. The range of fleece types was therefore the same as at Winchester, except for the true medium wool. Another yarn from York dated 1400 but not shown in the tables was of true medium type. This accords with the suggested existence of primitive longwools during the Middle Ages.

In two groups of yarns from Southampton (Ryder & Hedges 1975) dated from the end of the 13th century and the middle of the 14th, the wools were on the whole finer than those from Winchester and York (Tables 3 and 4).

Baynard's Castle in London has yielded a collection from the early 14th century, and another from the late 15th century. Although the samples provided by Miss E G Crowfoot were representative of the range of cloths found, they were unfortunately not 'truly random. The 14th century group contained the first fine-generalized medium wools from an English site and also, like Southampton, had true fine wools. The 15th century wools were of similar type, with an indication of fewer fine-generalized medium wools, and more shortwools.

The wool in some cloth of 15th century date from Huddersfield appeared to be of generalized medium type, and that in some cloth of the same date from Halifax was hairy medium, in which the coarser fibres had natural pigment showing it to be grey (Ryder 1974). Two 15th century yarns from Mytonside, Hull, were generalized medium wools with natural pigment. In two Tudor (16th century) caps in the Royal Scottish Museum the wool was of shortwool type, and in the third it was true fine wool.

The considerable number of cloth finds from the excavations by Nicholas Bogdan in Perth have provided the first adequately large and random medieval

Table 4 Wool fibre diameter measurements and incidence of hairy and pigmented fibres
(the measurements are in microns, ie thousands of mm)

		Overall diameter range	*Modal diameter range*	*mean*	*Mean diameter range*	*overall mean*	*Medullated (hairy) fibres (%) range*	*mean*	*Pigmented fibres (%) range*	*mean*
Hairy medium										
Winchester	(4)	12-78	19-30	22.5	23.7-30.5	28.5	0-1%	0.5%	0	0
Baynard's Castle 1200	(2)	14-72	24-40	3 2	32.4-45.6	39	21-24%	22.5%	0	0
York	(4)	10-66	20-22	20.5	23-29	26	10-37%	22.25%	0	0
Southampton	(2)	13-97	23-26	24.5	26.8-30.5	28.7	0-1%	0.5%	0	0
Baynard's Castle 14th century	(2)	14-62	22-30	2 6	25.6-33.8	29.7	1-7%	4%	0	0
Baynard's Castle 15th century	(3)	12-72	20-24	22	28.1-30.4	29-2	0-2%	1.3%	0-52%	19%
Yorkshire	(2)	measurements not available								
Perth	(39)	12-100	20-40	26.3	26.4-43.3	34-S	0-51%	17%	0-100%	57%
Aberdeen	(3)	14-90	24-30	26.6	26.8-32.8	29.6	5-9%	7 %	2-10%	5%
Greneralized medium										
Winchester	(2)	12-53	17-25	21	20.4-29.2	24.8	0	0	0	0
Baynard's Castle 1200	(5)	14-62	20-26	22.6		28.4	0-2%	1%	1 sample pigmented	
York	(3)	12-56	16-20	21.3	25-30	27.3	29–44%	34%	0	0
								narrow		
Southampton	(11)	7-57	18-25	21.1	22.5-27.6	24.1	0-1%	0.2%	4 samples pigmented	
Raynard's Castle 14th century	(2)	12-54	20-28	2 4	26.8-27.1	27.1	0-3%	1.5%	0	0
Baynard's Castle 15th century	(4)	10-56	22-27	24-3	25.9-31.1	28.1	0-2%	0.75%	0-49%	17%
Yorkshire	(4)	measurements not available								
Perth	(16)	10-60	20-31	24.9	244-33.3	29.5	0-10%	4 %	0-100%	25%
Aberdeen	(7)	10-58	20-24	22.6	216-30.8	26-7	0-11%	3.3%	0-21%	6%

sample. Although they range in date from the late 12th to the 14th century, most were from the 13th century. A collection of similar date from Aberdeen was supplied by Mrs Helen Bennett. The identifications and measurements shown in Tables 3 and 4 indicate a predominance of hairy types at Perth, whereas the generalized medium predominated in the smaller sample from Aberdeen.

Only 30% of the yarns from Perth lacked natural pigmentation but as few as 14% showed evidence of dye, and these included some wools with slight natural pigmentation. Eleven of the sixteen Aberdeen samples had slight natural pigmentation, indicating a light grey or roan wool.

It is clear from the textile evidence that the reputed fine wool of the Middle Ages was, as in antiquity, of generalized medium type, although some were fine-generalized medium wools, and some even true fine wools. These fine wool cloths were not necessarily imported since fine fleece types are occasionally found in primitive breeds such as the Orkney (Ryder 1968a). Even if the introduction of Merino sheep referred to by Trow-Smith (1959, 39) can be substantiated, it did not take place until the 16th century. At the same time many hairy medium wools remained, particularly in Scotland. By the 18th century the hairy medium/generalized medium type had declined as the shortwool and medium diameter (longwools) had developed. and in that century the latter predominated, while the fine wool was virtually absent from Britain.

Conclusions

Taking all the evidence together, it appears that the predominant sheep type of the Middle Ages was of hairy medium/generalized medium type perhaps comparable with the surviving short-tailed and varicoloured Orkney/Shetland breeds in which only the rams are horned. Skeletal remains support the size of such an animal, although no illustrations of short-tailed sheep have been recorded. Records and textiles confirm the persistence of some coloured sheep, although illustrations indicate only the occasional black animal. In most illustrations, the only horned sheep appear to be rams (or at least wethers), whereas skeletal evidence suggests two other types in addition, either horned in both sexes or polled in both sexes. This, and the other anomalies in the evidence, can probably be explained by the presence of much greater variation in the past, coupled with evolution towards new types as shown by medium and shortwool fleece remains.

Evolution of the lustre longwool

Bowden (1962) showed from historical records that the supply of long wool increased during the 16th and 17th centuries. This, coupled with a reduction in the supply of short wool, led him to conclude that longwoolled sheep originated directly as a result of the improved pasture that followed the enclosure of common land. But as already indicated there is a limit to the length of wool that can be grown as a result of better nutrition, and in any case the lustre longwool is a distinct type of sheep. The biologist's interpretation of the historical evidence is therefore that the better pasture allowed larger, longwoolled sheep to be kept, ie it allowed the full expression of a genetic tendency to grow long wool (Ryder 1964). The enclosures also allowed the segregation of inferior animals, thus making selective breeding easier. But the emphasis was now on meat, which became as valuable as wool.

There is an indication that Cotswold wool was already longer (and coarser) than that of Hereford in Drayton's 16th century poem:

> 'Our Cotswold's lengthy locks;
> Tho' Lemster loin exceed in
> finess of her ore ... '
>
> (Trow-Smith 1959, 146)

Whereas the surviving Cotswold (along with the shortwoolled Norfolk) has a symmetrical fibre-diameter distribution (Fig 14) it is interesting that the surviving Portland and Whiteface Woodland breeds have a skewed distribution (Ryder 1968a).

The origin of the lustre longwool is, however, such an intriguing biological problem that it will be worthwhile outlining one or two of the possibilities (Ryder 1964). One suggestion is that the lustre longwool originated as mutant in the Romney breed. But although a lustre mutant has been observed in the Merino breed, the only mutants that have been observed in the Romney are hairy types, one being the N-type Romney, now named the Drysdale (Ryder & Stephenson 1968).

The other suggestion of Ryder (1964) is that lustrous wool might have originated with the introduction of non-lustrous, polled stock, since the introduction of different hereditary factors can sometimes upset the constant expression (canalization) of a character. According to Youatt (1840) the Romney was horned as late as 1750, but the hornless character is not always associated with long wool.

This mention of the complexity of the biological problems involved in fleece evolution is a good point to end this consideration of the medieval 'melting pot' of breed types. New sources of evidence are beginning to throw light on this important period. But we are a long way from a complete understanding of the way in which modern breeds developed. The whole question is discussed at length in a forthcoming book by Ryder (1981).

Bibliography

Armitage, P L, & Goodall, J A, 1977 Medieval horned and polled sheep: the archaeological and iconographic evidence, *Antiq J,* **57,** 73-89

Bowden, P J, 1962 *The wool trade in Tudor and Stuart England*

Evans, J V, Harris, H, & Warren, F L, 1958 The distribution of haemoglobin and blood potassium types in British breeds of sheep, *Proc Roy Soc B,* **148,** 249-62

Fowler, J T (ed), 1918 Memorials of Fountains Abbey, *Publ Surtees Soc,* **130**

Lipson, E, 1953 *A short history of wool and its manufacture*

Noddle, B A, 1975 A comparison of the animal bones from 8 medieval sites in southern Britain, in *Archaeozoological Studies* (ed A T Clason), 248-60

———, 1977 The animal remains, in *Excavations in King's Lynn 1963-1970* (eds H Clarke & A Carter), Soc Medieval Archaeol Monog Ser, **7,** 378-400

Pelham, R A, 1948 Fourteenth century sheep farming, in *An historical geography of England before 1800* (ed H C Darby), 244 ff

Power, E, 1941 *The wool trade in English medieval history*

Ryder, M L, 1961 The livestock remains from four medieval sites in Yorkshire, *Agr Hist Rev,* **9,** 105-10

———, 1964 The history of sheep breeds in Britain, *ibid,* **12** (l), 1-12; **12** (2), 65-82

———, 1966 Shetland sheep and wool, *J Bradford Textile Soc,* 1965-6, 91-9

———, 1968a Fleece structure in some native and unimproved breeds of sheep, *Z. Tierzücht. ZüchtsBiol.,* **85,** 143-70

——, 1968b The evolution of Scottish breeds of sheep, Scot Stud, **12,** 127-67
——, 1969 Changes in the fleece of sheep following domestication (with a note on the coat of cattle), in *The domestication and exploitation of plants and animals* (ed P J Ucko & G W Dimbleby), 495-521
——, 1972 The wools of Britain, in *The wool textile industry of Great Britain* (ed J G Jenkins), ch 4
——, 1973 The size of paper and the size of sheep, *J Soc Archivists,* **4** (7), 599
——, 1974 Wools from antiquity, *Tertile Hist,* **5,** 100-10
——, 1977a The Vindolanda wools, in *Vindolanda, 3, The* textiles (ed J P Wild), 34-42
——, 1977b Some miscellaneous ancient fleece remains, *J Archaeol Sci,* **4,** 177-81
——, 1979 The primitive breeds of domestic sheep of Europe, *Proc 3rd Int Archaeozoological Conference,* Poland. 1978 (in press)
——, 1980 Livestock, in *Theagrarian history of England & Wales* (ed S Piggott), **1** (1), 301-410.
——. 1981 Sheep and man, forthcoming
Ryder, ML, & Hedges, J W, 1975 The wools, in *Excavations in medieval Southampton 1953-1969* (eds C Platt & R Coleman-Smith), **2,** 339-40
Ryder, M L, & Stephenson, S K, 1968 *Wool growth*
Trow-Smith, R, 1957 *A history of British livestock husbandry to 1700*
——, 1959 *A history of British livestock husbandry 1700-1900*
Waites, B, 1977 Pastoral farming on the duchy of Lancaster's Puckering estate in the 14th & 15th centuries. *Yorkshire Archaeol J,* **49,** 77-86
Youatt, W, 1840 *Sheep*

Iron production in medieval Europe underwent two major changes. In the first, the traditional small smelting concerns, whose bellows and hammers were operated manually, were gradually replaced by larger units employing water power. Then late in the Middle Ages certain types of bloomery were developed to produce a high-carbon molten iron. This was suitable for casting, and, with the development of a refining stage, could be converted into wrought iron.

The bloomery before the advent of water power

For seven centuries after the break-up of the Roman Empire in the west there are few signs of technical change in the European iron industry, and the methods used differ little from those of the Roman period. Until the 8th century it is far from clear how much smelting went on, but towards AD 1000 there is growing evidence that districts formerly active were again producing iron.

The economic background

It is important to establish the economic background to this revival. The European economy expanded between the Carolingian period and the end of the 13th century. Population grew without any apparent check until about 1270, and new lands were cleared, accommodating and further encouraging population increase. Growth began to falter in some places by 1300 as opportunities for fresh colonization dwindled, although there were many where it could and did continue until the onset of the pandemics in 1348. The need for more and improved agricultural equipment is implicit in this growth. Axes and scrub-clearing tools were required when preparing new ground; iron ploughshares and coulters were desirable to break up the new lands and to make more intensive use of the old. Yet despite the advantages it is not always certain how much iron and steel was used for tools. In France there is a contrast between documentary evidence from the Carolingian period and from after about 1100. In 9th century monastic inventories references to iron tools are rare, but by late in the 11th century the picture is changing; iron is also more frequently mentioned in town toll tariffs and more smiths are recorded as making objects such as ploughshares. This is also the period when references to smelting in eastern France become more numerous (Duby 1968, 20-1, 107).

From 'the 11th century the use of heavier ploughs appears to increase, and many were equipped with iron shares or at least an iron tip to the share or the coulter. It is hard to determine materials from illustrations, but the type of equipment used is indicated by the wheeled plough in the Bayeux Tapestry and the wheel-less but relatively heavy ploughin the Luttrel1 Psaltar. However, the spread in the agricultural uses of iron can be overstated. On the lighter soils the ard remained in use for ploughing, often sufficiently robust when made of hardwood. Indeed the availability of hardwoods allowed the joiner or millwright to produce many satisfactory objects without recourse to iron. Many harrows still had wooden teeth in the 16th century, 'iron-bound' carts remained worthy of note in post-medieval English probate inventories, and water-wheels could still be entirely constructed and pegged with wood as late as 1550.

Apart from agriculture there were increasing outlets for iron in other parts of the European economy. The scale of building grew with lay and monastic lords' incomes. Although iron was hardly a spectacular part of their structures the quantity used was significant when considered in terms of the small output of contemporary furnaces. In urban centres the construction of houses, shops, public buildings, and bridges provided new outlets for the smith. Trade required wagons, the shoeing of pack-horses, and the building of river and coastal vessels. The shipbuilder, as a user of nails and fittings, was a growing customer, in particular as longer routes came into more frequent use in the 13th century.

Of all the markets for iron its use for military equipment is perhaps the best documented. In England large quantities of nails, horseshoes, and arrowheads were purchased in the Weald; high-quality Spanish iron was imported for the weapons and armour of the better-off. Nevertheless, these requirements were sporadic, and the underlying upward trend in the demand for iron came from a general expansion in economic activity.

Early medieval smelting in England (Fig 19)

Information on the early stages of the development of the medieval iron industry comes largely from archaeological sources; indeed in Britain little is known from any source before the 8th century. In East Anglia there are three instances of smelting in early Saxon contexts. Slag bottoms from furnaces of north-German type (Fig 20) have come from Aylsham in Norfolk (Castle Museum, Norwich) and Mucking in Essex (Wilson & Hurst 1969, 231). Slag from the early Saxon habitation at Witton, Norfolk appears to be from smelting (Wilson & Hurst 1965,173). Also of this period are tap-slags and furnace bottoms from a 6th-7th century deposit at Shakenoak, Oxfordshire (Brodribb 1972, 117-18). There is a possible furnace bottom of Middle-Saxon date from Northampton (Williams 1979, 279), and Middle-Saxon smelting debris from Maxey, Northamptonshire (Addyman 1964, 68-9). From the 8th century the evidence is more firm. Ramsbury, Wiltshire, has produced what is as yet the best preserved site of the period, dated by radiocarbon samples to the late 8th century. Here there were substantial remains of low-shaft furnaces from which slag could be rapped (Haslam 1980, 19-30). One, well preserved, showed signs of considerable use, having been patched and rebuilt on several occasions. Also in the south-west, there is the late 10th or early 11th century evidence for smelting at the royal palace of Cheddar (Rahtz 1979, 91-5, 252-3, 381). Apart from these, there are numerous references in the archaeological literature to slags and cinders: apparently they come from ferrous metallurgical

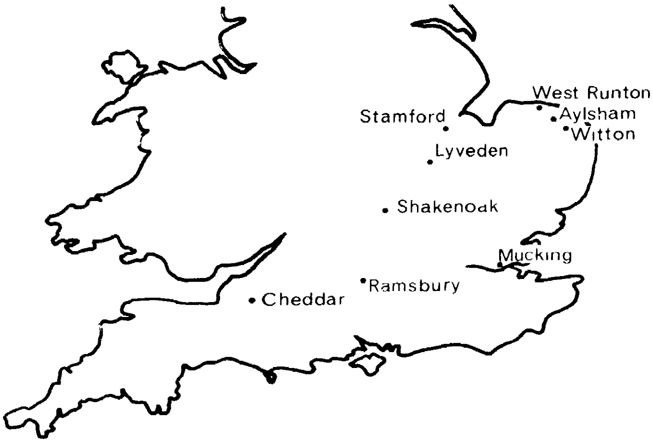


Fig 19 Saxon and Saxo-Norman iron smelting

operations, but in all too many cases attribution to smelting or smithing has not been made clear.

It is in the Saxo-Norman period that the evidence for smelting in Britain becomes more plentiful. Furnaces have been excavated at West Runton, Norfolk (Tylecote 1967, 187-214), Stamford, Lincolnshire (Tylecote 1970, 24-7), and Lyveden, Northamptonshire (Steane & Bryant 1975, 4-9). At West Runton (Fig 2la) there was an 11th century developed bowl-hearth 500 mm in diameter set on-the natural clay. It was clear, even from the fragmentary remains, that slag was tapped from the hearth during smelting; and that two bellows had been used, their tuyeres set at right-angles to the slag notch. It has been suggested that the sunerstructure formed a low dome, curving: inwards to limit the exposure of the ore and charcoal in the furnace. Of further interest are the results of examination of ore pits close to the furnace. The effort required to extract ores from the parse local quaternary deposits was seen to be considerable. It was calculatedthat in order to recover one cubic metre of ore nodules and about the same quantity of iron pan about 50 cubic metres of sand would have to be dug. Such painstaking extraction suggests that the local needs-for iron had to be met from nearby resources, whatever the labour intensity required,-and that a carrying trade in iron from lower-cost districts was absent. At Stamford (Fig 21b) operations were on an altogether larger scale. Ore-roasting and smelting furnaces have been excavated, and there are extensive deposits of slag, a striking indication of the extent of working. The shaft furnace excavated in 1964 is perhaps the best early medieval example seen in England. Fragments of its wall, reconstructed, showed a height of over 1 m and a diameter of 400 mm. Here, as at West Runton, slag was tapped, as shown by the form of the furnace and by the waste deposits. The summary publication at present available dates the furnaces to the 11th century, with a magnetic date for the final firing perhaps as late as the early 12th. At Lyveden, Northamptonshire, there were two furnaces. One was a bowl-hearth, probably with some form of domed top. The other was a shaft furnace similar in form to that at Stamford, with a diameter of 500-550 mm. However, there is some doubt as to how much slag could be tapped from these particular furnaces, for although the authors describe finds of tap-slag close to each, they sum up by placing both in the general category of non-tapping furnaces. The dating appears to be much the same as for Stamford, between 1050 and 1150.

It is of particular interest that these three sites lie within the area of Viking settlement in eastern England. It is dangerous to draw firm conclusions from such small numbers, but this distribution, together with the Domesday references to iron-working in Lincolnshire and Northamptonshire (Fig 22) do lead us to seek further evidence for an active market for iron among the urban and rural inhabitants of the Danelaw.

Medieval English smelting furnaces (Fig 23)

The later evidence for smelting is relatively scattered, and there are few excavated furnaces. Nevertheless, when these are set against the documentary evidence, which must of course begin with the Domesday distribution, it may be seen that there is a great deal of scope for further work. Of the excavated examples, we may begin with the 13th century furnace at High Bishopley, on the estates of the Bishops of Durham (Tylecote 1959, 26-34). This had a well preserved dome profile and a slag-channel at right-angles to the tuyere. It had succeeded two rather larger furnaces, both with means for tapping slag. It is hard to say whether this domed form was typical by the 13th century, for elsewhere insufficient remains of superstructures survive. At Baysdale, North Yorkshire, four early 14th century furnaces and a possible forge have been excavated (Fig 24). Only their bases remained, indicated by fragments of the lowest parts of the vitrified linings, and in two cases also by stone footings for superstructures. Slag, again, could be tapped, into adjacent pits, but there was no evidence for the number or form of the tuyeres (Wilson & Hurst 1965, 218). An interesting group from this period are

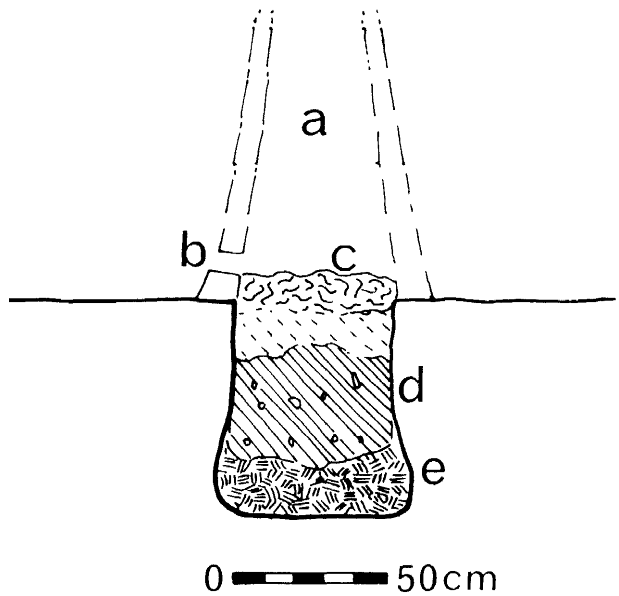


Fig 20 Slag-pit furnace of north German type: a shaft; b tuyere; c bloom; d slag; e charcoal, unsmelted ore, and slag

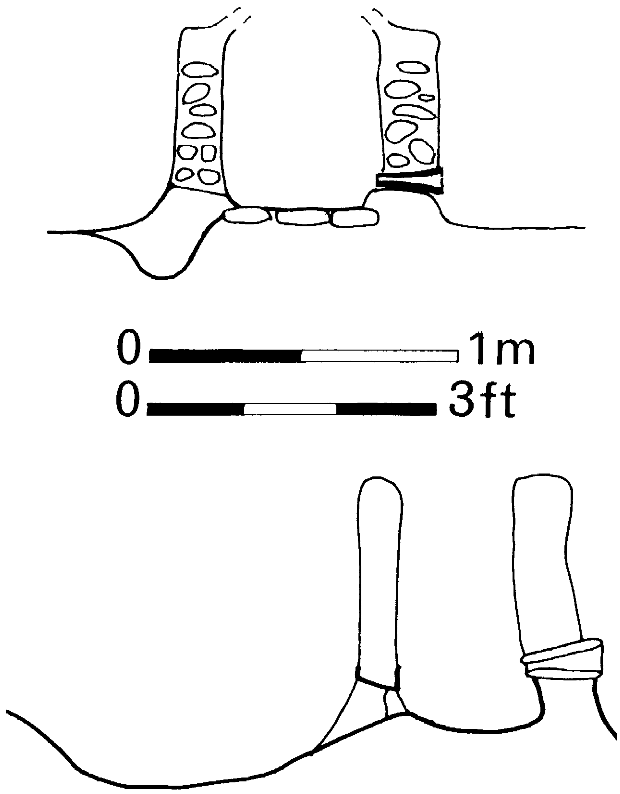


Fig 21 Saxo-Norman smelting furnace: A West Runton: B Stam ford (after R F Tylecote)

the 13th century furnaces from Godmanchester (Webster & Cherry 1975, 259-60). These are particularly significant as being part of a roadside blacksmith's establishment (Fig 25). They thus suggest that primary and secondary operations could be carried out on the same premises and that a subdivision of skills between smelting and smithing should not necessarily be assumed. Finally, the Wealden industry is represented by two early 14th century bloomeries. One is at Withyham, Sussex, where there was one smelting furnace, and although none of the clay superstructure remained, a fragment of wall which had formed part of the base incorporated an opening for the bellows-tuyere (Money 1971, 86-111), The second is at Alsted, strictly outside the Weald (Ketteringham 1976, 17-31). Here on the top of the North Downs, smelting and smithing were carried out at a manorial establishment, although the remains of the smelting furnace were fragmentary. It is significant that the nearest ore on the estate lay ten miles to the south-west at Charlwood, within the Weald.

Withyham and Baysdale are important in illustrating the preparation of ores by roasting (Fig 26). Clay platforms were bordered by low stone kerbs and bore copious fines of ore, a red dust resulting from the fracture of ore nodules during heating. The way that this was done is illustrated by Agricola in the 16th century (Fig 27). The benefits of roasting are considerable; water is removed, the sulphur content is reduced, and fracturing facilitates the charging of lumps of ore of optimum size. The practice can be seen at Thundersfield on the northern edge of the Weald (Hart & Winbolt 1937, 147-8); here a patch of burnt clay 3 m in diameter was covered in charcoal and ore. In Yorkshire a hearth at Glaisdale measured 2 m by 1·3 m; it seems most likely to have been used for roasting, as such a size would have been too great for smelting (Stainthorpe 1966, 47-8). At Rockley, also in Yorkshire, there were copious deposits of fines in a context of about 1500, with burnt clay pads amidst them (Crossley & Ashurst 1968, 18-22). It is possible that a circular patch of stones in the Lyveden smelting area should also be added to this list.

Field and documentary surveys in Britain

To supplement the small number of excavations of medieval furnaces, a generalized and perhaps more representative picture of smelting activity may come from surveys linking surface indications and documentary sources. An early example of such work was Collingwood's exploration (Collingwood 1901, 1-22) of parts of the Lake District, where the slags and cinders which he discovered correlate with Fell's work (Fell 1908, *passim)* on 13th century and later records of smelting on the lands of Furness Abbey and Conishead Priory. In Yorkshire the combined approach has proved fruitful (Fig 28), particularly in the districts covered by entries in the Court Rolls of the Manor of Wakefield. There are, for example, references to forges at Stanley and Hipperholme and smiths at Erringden. References to smelting in the park at Rothwell stretch for 50 years from 1321, and show a forge making a substantial contribution to

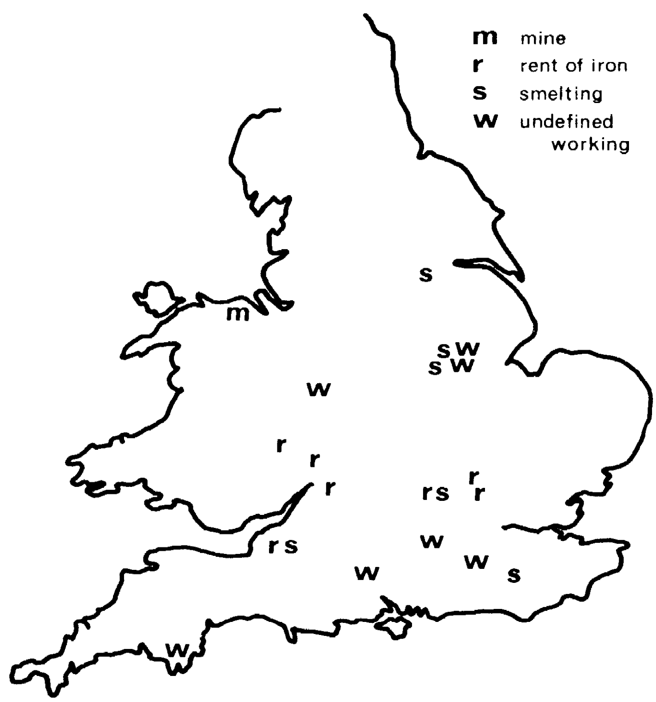


Fig 22 References to iron-working in Domesday

Fig 23 Excavated blomeries 1200-1350

estate income.[1] Further to the east, around Hemsworth and Ackworth, fieldwalking and small excavations have produced considerable evidence of smelting in the form of plough-scatters of slag and furnace fragments. In an area such as Yorkshire where modern urban and industrial development, with large-scale open-cast mining, has radically altered the landscape, documentary references are of particular importance. Here they show the intensity of iron-working in the Middle Ages, not only on lay estates but on the Cistercians' lands on the coal measures. However, in these districts modern open-cast coal extraction can produce valuable results, by exposing medieval mine workings dug to extract iron ores.

The problems which fieldwork in this subject can involve are well illustrated by experience in the Weald of Sussex, Kent, and Surrey (Fig 29). At first sight the documentary evidence is impressive, with 13th century references to purchases of iron and arms by the Crown. Further, there are occupational surnames in this period which suggest more than usually large concentrations of smiths. Apart from these, ores and timber were abundant, and have been intensively worked at other times. However, a more detailed investigation raises questions. On the documentary side Domesday is virtually silent, with only a single reference to an ironworks near East Grinstead. Later in the period there are few documentary indications, although the character of clearance and settlement was not such as to produce many comprehensive sources. The only set of accounts relates to bloomery furnaces on the lands of the Clares at Tudeley, near

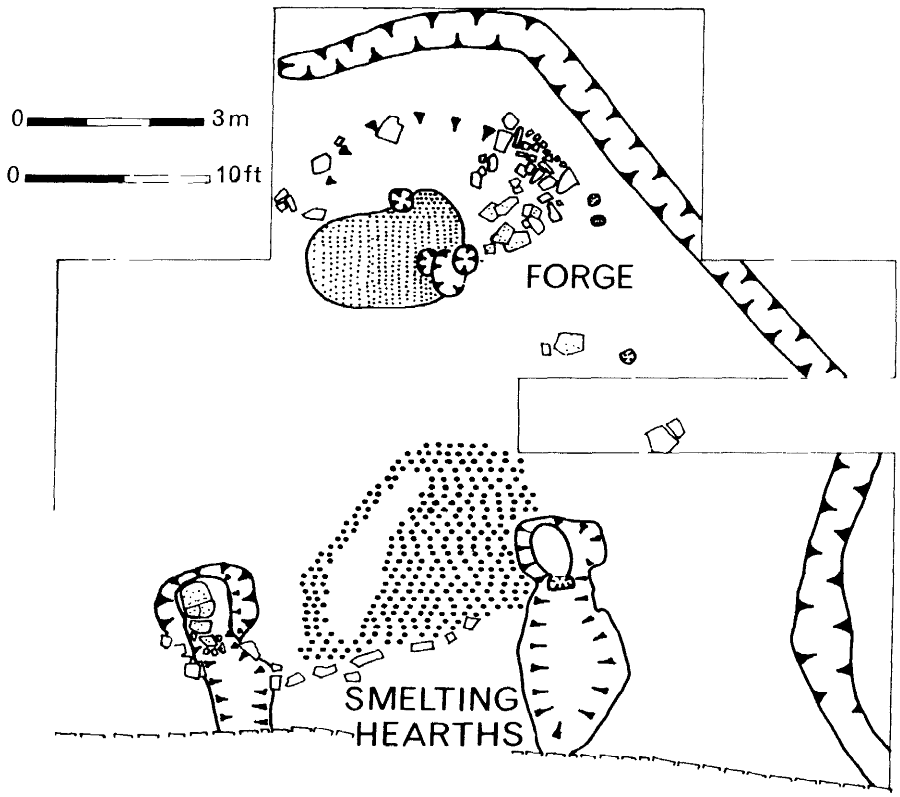


Fig 24 Baysdale: forge with two smelting-furnace bases (after FA Aberg)

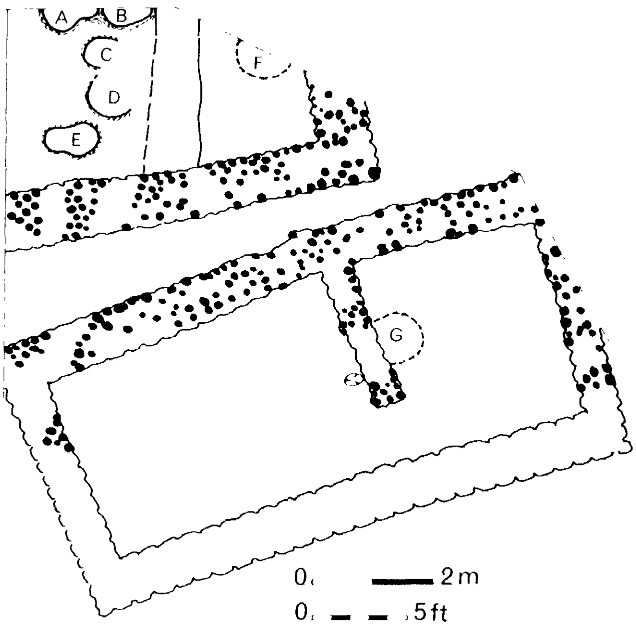


Fig 25 Godmanchester: A, B, and E: furnace bases with slag pits; C and D: slag pits: F and G: smiths hearth (after H J M Green)

Tonbridge, where operations were recorded for a number of years in the period 1329-54 (Giuseppi 1912, 145-64). This is in fact one of our prime sources for medieval iron smelting, recording consumption, production, and costs, even if reckoning by the bloom rather than by stated weight makes calculations risky. If, as has been suggested, a bloom weight of 13-14 kg is assumed, we find the level of output varying between 1520 and 3160 kg in a year. Such a small scale of operation may explain to some degree why so little field evidence of medieval smelting has appeared. An intensive survey of the region around Ashdown Forest has revealed many scatters of bloomery slag, but recent sampling has yielded Romano-British rather than medieval dating evidence for the majority. Nevertheless, medieval material has appeared both within and outside the study area, particularly in the East Grinstead, Hartfield, Buxted, and Rotherfield districts. Of great interest is the example at Parrock near Hartfield, where scatters of slag and medieval pottery lie close to habitation sites abandoned at the end of the Middle Ages.'

Iron smelting in early medieval Europe

Early medieval iron production in continental Europe poses problems similar to those encountered in Britain. The level at which ore deposits in use during the Roman period were subsequently exploited is far from certain. There are circumstantial arguments for some volume of production being maintained. These come from the extent of manufacture of iron artefacts rather than from knowledge of actual smelting sites. Iron objects, particularly arms, were held in high esteem by the Germanic invaders. The tradition of pattern-welding in the manufacture of swords was maintained, and the technique spread to items such as spearheads. The Frisian merchants traded iron objects on some scale, as has been shown by finds from the port of Hedeby in Schleswig. Pattern-welding suggests a range of sources of iron, for the technique involved the use of bars of varying composition. In particular iron with differing phosphorus content was used, ranging from high-phosphorus material typical of the bog-ores of north Germany, through the range of mineral ores found east and west of the Rhine, to high-manganese irons of the kind traditionally produced in the region of Roman Noricum, in the Austrian Alps.

Reported -field evidence does not yet match such indications. In north Germany there are large groups of slag-block furnaces (Fig 20), but those so far excavated lie within the Roman period. In France there are two interesting furnaces- of north-German slag-pit type in the Sarthe district, Ségrie and Lavardin (Comité PSA 1973. 456). The latter has been given a radiocarbon date late in the 7th century. Otherwise there is little field evidence until documentary indications appear in the Carolingian period. Then, in Germany, rents in iron are recorded as having been received by the Abbey of Lorsch in 788, and in the early 10th century the Abbey of Fulda received renders in iron on some scale. At this time the German field evidence begins to appear. Sönnecken's work in the Sauerland shows many smelting sites in use between the 10th and the 14th centuries (Sönnecken 1971, *passim)*. In the north, in the Flensburg and Middle Holstein areas, Hingst has found evidence for 12th century shaft furnaces originally 1-2-1-4 m high (Comité PSA 1970, 357).

To the west of the Rhine the increasing references to iron objects must suggest smelting- in eastern France towards the end of the first millennium AD. Gilles has recorded the base of a shaft furnace at Lanthertal, in the Saar, which he dates to the 11th century (Gilles 1956, 59). However, this is an isolated case and we rely largely on documentary sources of the 12th century. By then most of the ores of eastern France were in use. There were important centres in Champagne, around Troyes, in the Forêt de I'Othe, around Vendoeuvre, as well as in the valleys of the Blaise and the Marne. The Cistercians were as active in mineral exploitation in those districts as they were in northern England: they secured land-grants on ore-bearing lands in the Forêt de I'Othe, in the Vosges mountains, and in Burgundy and Lorraine. Unfortunately there is no record of field surveys to follow such references, and it is only in the Swiss border area around Schafthausen that furnaces have been excavated and published. At Bargen Hofweisen and at Berslingen, Guyan has excavated stone-built furnaces dated to the early 14th century (Guyan 1957, 159-74; Comité PSA 1971, 337). Their full profile is uncertain, but it is suggested that they were developed bowl-hearths whose low shafts permitted removal of blooms from the top rather than the base.

By contrast, the archaeological record is more substantial in central Europe. In the Roman period there had been two important areas of smelting outside the Limes. South of the Carpathians there had been a thriving industry in Moravia; to the north, in southern Poland, intensive use of the ores of the Holy Cross Mountains had occurred at the eastern end of a wide spread of smelting communities stretching as far as Jutland, and using slag-block furnaces. Over these areas there passed the great movements of peoples, Germanic and Slav, with consequent changes in the patterns of settlement and cultivation. To the north, the Slav settlements of

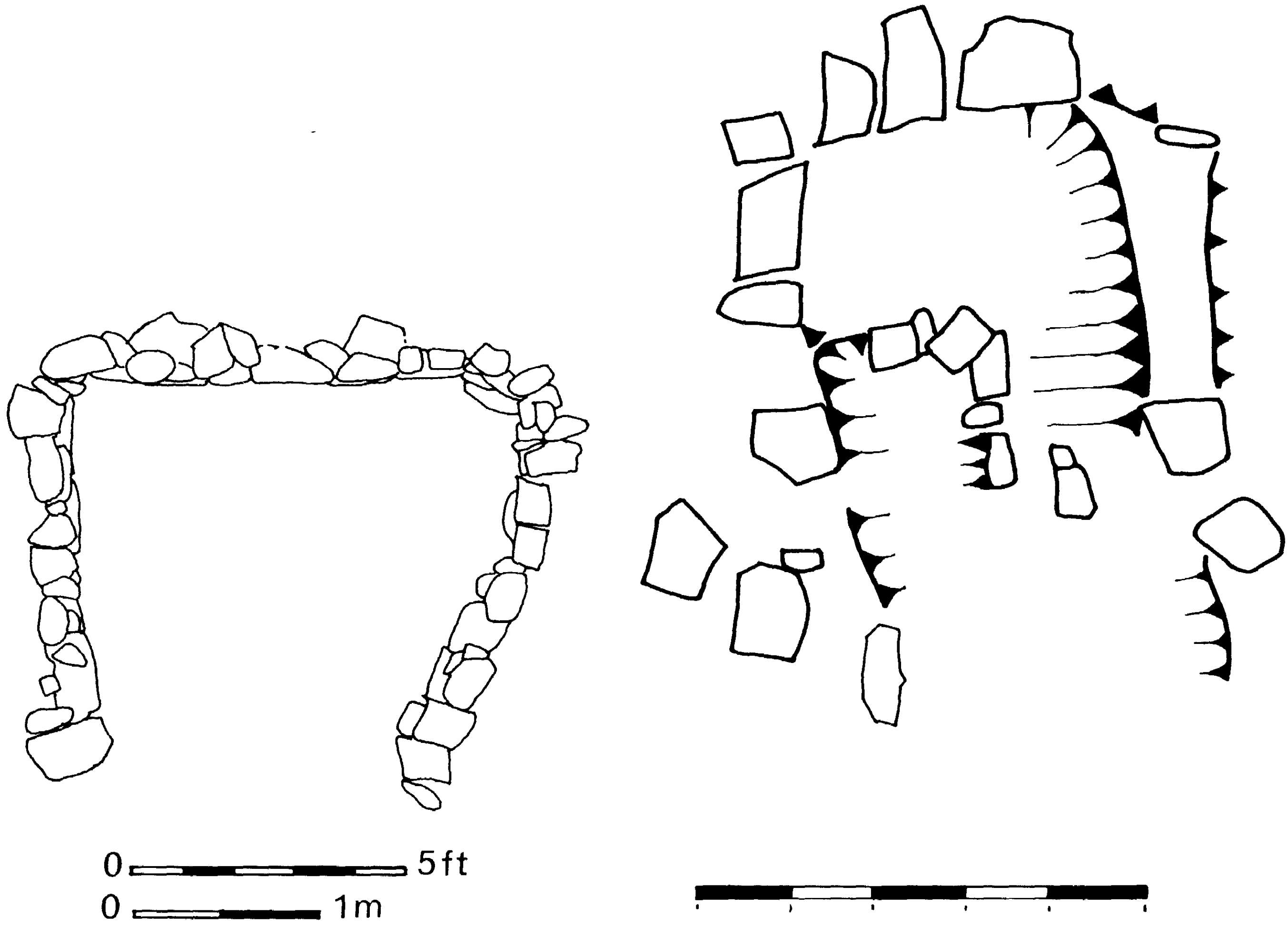


Fig 26 Roasting furnaces at Withyham (left) and Baysdale (right) (after J H Money & F A Aberg)

Poland and eastern Germany were based on a shifting agriculture which required relatively few tools. Thus the industry of the Holy Cross Mountains became less active after the 6th century; tools and weapons came to be provided by small-scale smelting scattered over wide areas of Poland and Silesia.

However, to the south of the Carpathians other groups of Slavs, founders of the Moravian Empire, built their Burg-wall settlements and practised an agriculture whose intensity required iron tools in some quantity. Ample evidence is to be found for the production of iron to meet those needs. There have been important excavations of large groups of shaft furnaces dated to the 8th and 9th centuries. Zelechovice is the most important so far, with 24 shaft furnaces, 18 built in a line (Pleiner 1962, 179-95). They were set into banks, with bellows operated from a high level through tuyeres sloping downwards into the shaft. The hearths were built with rear chambers into which blooms could be pushed in the later stage of a smelt (Fig 30). This lessened the risk of re-oxidation and resulted in iron with a relatively high carbon content. Trizs and Nemesker, in Hungary, are examples of complexes on a comparable scale operated at much the same time: fieldwork in both Czechoslovakia and Hungary has shown the wide spread of this industry.

Meanwhile, in Austria, there are interesting indications that the traditions of Noricum survived, even if widely dispersed. Four significant 10th century furnaces at Hirschwang were built as one structure, and it is possible that the good thermal insulation which should result would give good yields of high-carbon iron (Coghlan 1959, 284-6). Pleiner has suggested that traditional Roman-style shaft furnaces survived in Styria and Carinthia and that their 10th century successors eventually developed into the large shaft furnaces known in the area in the late Middle Ages and beyond. Unfortunately there is little published field evidence for the period.

A major question is the extent of disruption of iron production caused by the Magyar invasions. There is no doubt that in Hungary, Bohemia, and Moravia the break was virtually complete. The large sites went out

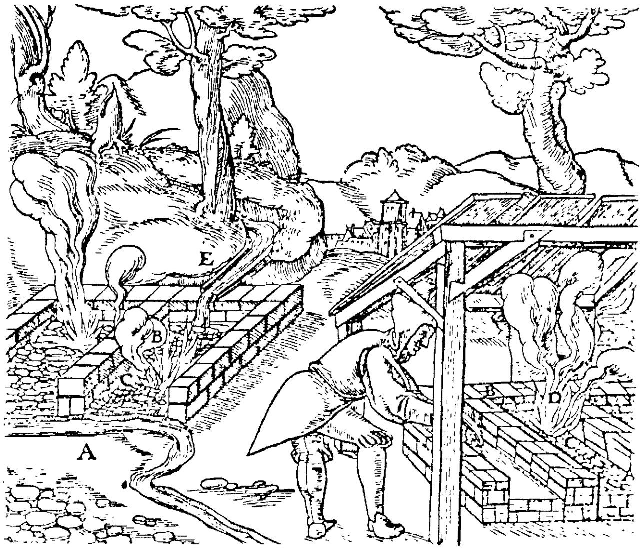


Fig 27 Roasting furnace shown by Agricola

of use, and smelting seems to have become small-scale and scattered. Shaft furnaces have been excavated in the Borsod area of northern Hungary, in the Burgenland and Bohemia; and although traditional Slav features survived, the scale was altogether smaller (Heckenast *et al* 1968, *passim).* The decline went even further at the time of German colonization in the 13th century, for few indications of smelting remain from after 1300. It has indeed been argued that at this time the products of Styria and Carinthia were increasingly competitive and were traded on some scale to supply the feudal estates established in lands formerly self-sufficient in iron.

If Styria and Carinthia emerged as the specialist suppliers to southern and central Europe during the Middle Ages, the north-western seaboard found its high-quality supplies in Spain and Sweden. At present we can say virtually nothing of the archaeology of the Basque industry, except by inference from our knowledge of post-medieval Iberian methods. Nevertheless Spanish iron was held in high esteem and figures in the trading records of the ports of France, England, and Flanders. It is unfortunate that the field evidence cannot match this.

By contrast in Scandinavia (Fig 31) the field material for iron smelting is under active study (Serning 1979, 70), and any survey runs the risk of being out of date. In Sweden the earliest smelting has been traced back to the 1st or 2nd centuries BC, and three migration-period furnaces are known in Jämtland. It is in the Dalarna region that Viking material is most plentiful, with excavated furnaces dating from the 7th century at Trut and Gryssen, and the 9th at Sunnanäng among others. By the end of the first millennium smelting had also developed in Norway, for furnaces dating from the 9th century onwards have been excavated in Telemark, notably at Mosstrond (Martens 1972, 111-13). Scandinavian demand for iron grew through the period. Some had formerly been met from overseas, by Frisian merchants. But by the period of Viking expansion there was a thriving industry able to equip the campaigns into Russia and western Europe. It is significant that with this expansion of peoples well equipped with iron weapons and tools came the fresh development of iron smelting and fabrication in the areas in which they settled, notably in the English Danelaw, Dublin, and Novgorod. Later in the Middle Ages the Norwegian industry remained relatively small and localized, based on bog-ores. Swedish smelting, however, continued to develop, forming an exporting industry of increasing importance by the 13th century. For while Swedish iron was not mentioned by Adam of Bremen in his 11th century description of Sweden, it appears in Flemish toll tariffs in the 1250s, and formed a prominent part of the trade of the Hanseatic merchants from this time.

The adoption of water power (Fig 32)

A major advance in the increase of the capacity of the bloomery came with the use of the water-wheel for driving hammers and bellows. The earliest reference comes from the Berry region of France in 1116, when a tannery was replaced by an iron mill, which is assumed to have been a powered hammer. In the 12th century there were iron mills in Spain, notably in the Barcelona district where fourteen had been built by about 1200. During the early 13th century their use spread over France; for example water power was used at Evry in 1203, Nogent-sur-Marne in 1249, Allemont in Dauphiné in 1226, and Boussagnes in the Massif Central in 1237. In Germany there are recorded instances in the Ruhr and the Harz in the 13th century, with further examples in Moravia and Hungary. It is significant that a Hungarian reference of 1227 suggests not only hammers but powered bellows, and it is odd that the next explicit reference to the use of water power for blowing comes as late as 1362, when the King of Navarre contracted with a Florentine craftsman for the repair of a forge containing a water-wheel-operated bellows (Duby 1968, 107; Gille 1954, 11-12; Anon 1960, 23-32; Heckenast 1967, 73-94).

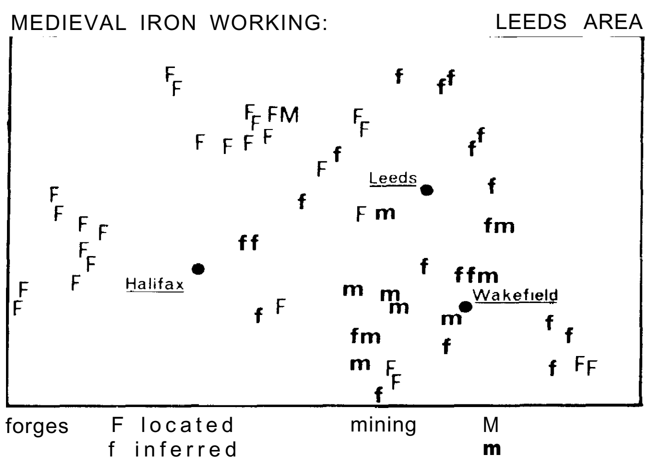


Fig 28 Documentary and field location of iron mining and working in West Yorkshire

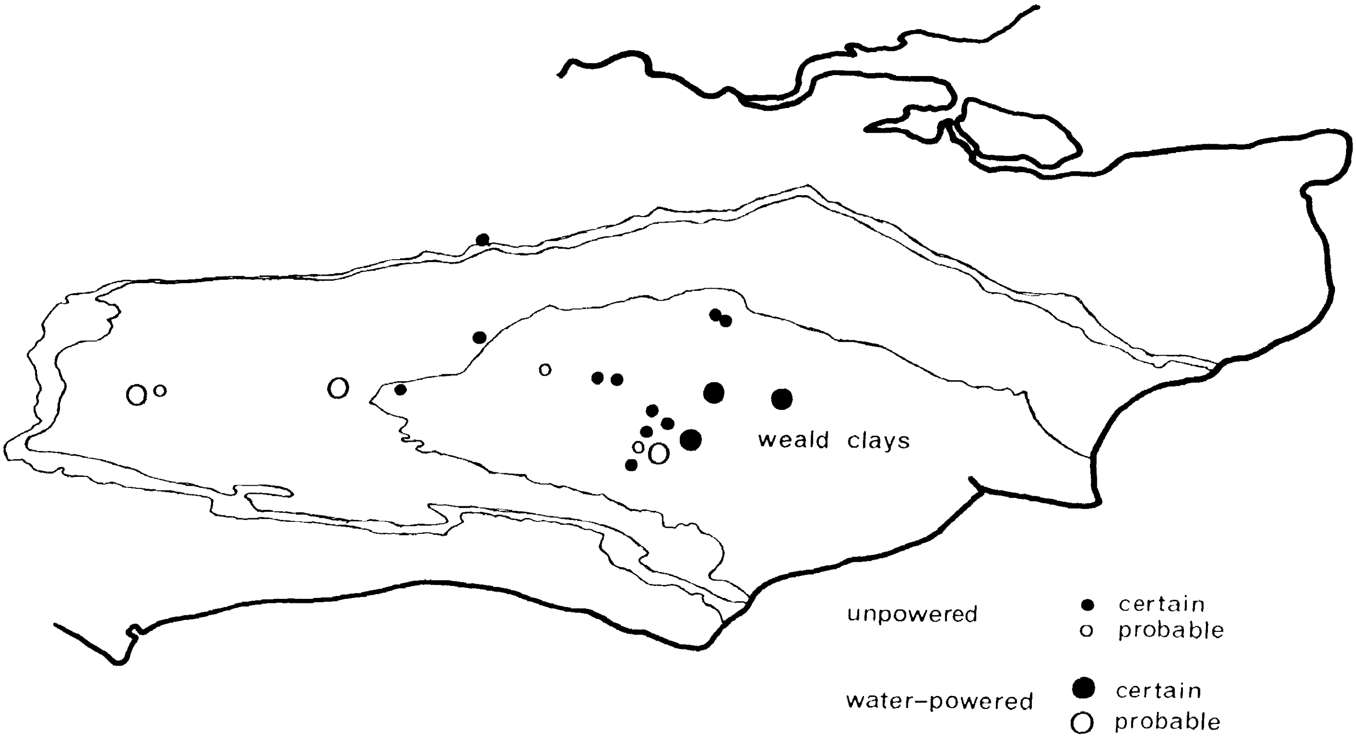


Fig 29 Medieval bloomeries in the Weald

There must be some doubt over the rate of innovation in Flanders and in England. There are no references to the use of power in the Liége district until the 14th century, and in England there are no certain 13th century examples. The earliest case of an English hammer forge is at Chingley, on the Kentish lands of Boxley Abbey. This is dated to the first half of the 14th century, and provides evidence for hammering blooms, but not for smelting. The main surviving structure was a timber wheel-race on which was mounted a massive frame assumed to be the foundation for a hammer (Fig 33). The anvil position could be estimated, but had been destroyed by post-medieval features. Large quantities of charcoal were present, for reheating the blooms in hearths which, it is suggested, may have been blown by water-powered bellows. It must be assumed that the iron shaped by such a hammer came from unpowered bloomeries in the surrounding woods (Crossley 1975, 2, 6-17).

The increase in bloom-handling capacity which such forges provided corresponds with the growing demand for iron in the 13th and early 14th centuries. However, later in the 14th century the incentives were rather different. A reduction in population at the time of the Black Death and succeeding epidemics curtailed the supply and increased the cost of labour, and the use of power was important in restraining the costs of production.

The powered bloomeries of the 15th century have received little archaeological attention. In County Durham, the documented site at Byrkeknott has been identified at Harthope Mill, and has been excavated as far as later structures allow (Tylecote 1960,45 1-8). A Staffordshire example, Bourne Pool, has been excavated. This had a water-wheel which seems more likely to have worked a hammer than bellows, and appeared to date from the last quarter of the 15th century (Gould 1969-70, 58-63). In West Yorkshire

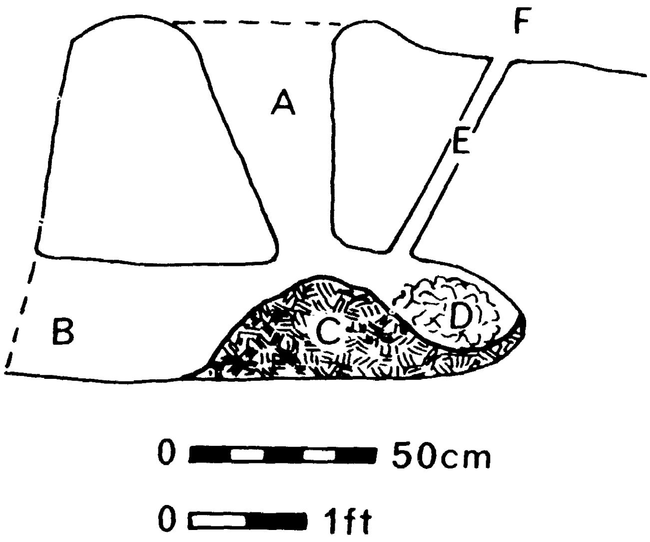


Fig 30 Furnace at Zelechovice: A shaft; B slag-tap passage; C chat-cod to assist reduction; D bloom; E tuyere passage; F bellows position

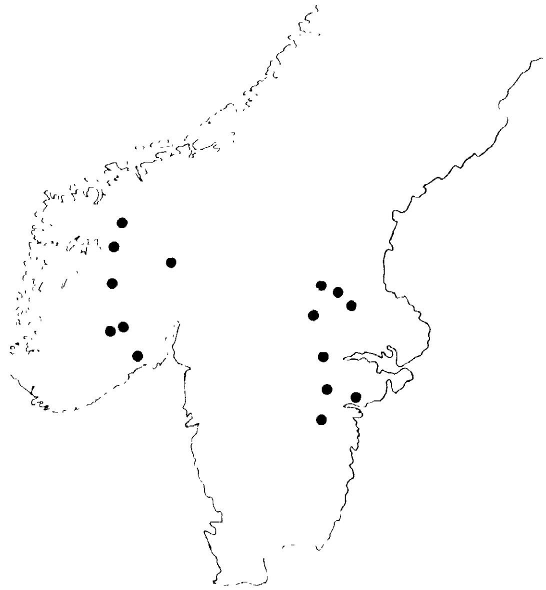


Fig 31 Principal areas of smelting in Scandinavia

documentary evidence suggests considerable potential. For example water-powered forges are referred to at Creskeld in 1395, and at Tong, Clayton West, and Crigglestone in the 15th century.' However, the re-use of water-powered sires causes confusion in the field. Where a totally different process succeeded the bloomery the survival of slags may provide the clue to the original function: however, water-powered bloomeries seem often to have been converted into refining forges in the 16th and 17th centuries, processing pig-iron from blast furnaces. Cinders and furnace bottoms from the two processes can be hard to distinguish, unless appreciable quantities of bloomer-y tap-slag have remained visible. A useful example of this is a Wealden forge, Brookland, where a stream-cut section shows bloomery tap-slag below finery cinder.'

In its final powered form the bloomery persisted well beyond the Middle Ages. In southern England the method largely died out by the middle of the 16th century but in the north and west it still had a part to play where local needs did not justify the scale of output of the blast furnace. In Yorkshire there are documented 16th and 17th century examples, notably the excavated bloomery at Rockley whose final phase dated from the years 1600-1640 (Crossley & Ashurst 1968,18-22). Here, two if not three wheels were used to power bellows for smelting and reheating, although it was doubtful whether a powered hammer was in use. Even later, the small size of the market in north-west England and in Scotland justified the survival of the bloomery. In 1636 a complete new works with lengthy races, a hearth, and a hammer was built on the Cumbcrland Esk at Muncaster Head (Tylecote & Cherry 1970,69-109). It served a market which was not to attract blast-furnace construction until about 1700, and is paralleled by the bloomer-y at Stony Hazels, Furness, converted to a finery forge as late as the early 18th century (Davies-Shiel 1970, 28-32).

On the Continent the late survival of the bloomery is also seen in areas where demand remained small, as shown by 18th century examples in Norway. In Spain large bowl-hearths with developed forms of water blowing gear could be seen into the 19th century. In addition, certain specialized processes used variants of the bloomery into the 18th century. In Sweden the Osmund furnace was a high bloomery 2-2·5 m high, producing iron suitable for wire-making. In Styria high bloomeries likewise survived, producing high-grade iron in structures which grew to the size of blast furnaces (Evenstad 1968, 61-5; Percy 1864, 278-315).

The beginnings of the indirect process

In Britain we are apt to associate the second major change, to the blast furnace, with the period after 1500. It is important to remember that this new method was available in a fully developed form on the Continent by the middle of the 15th century, There it had evolved from one strand of the bloomery tradition, the high shaft furnace. Bloomeries of this kind had grown to the point where ore and charcoal, if in suitable proportions and in contact for sufficient time, could produce iron carbide. This alloy has a lower melting point than bloomery iron, and thus could form as a liquid in the hearth. This might first happen by accident, but once the uses of cast iron were realized, experiment would lead to consistent production, with furnaces built expressly for the new product (Fig 34). By contrast, in districts where low dome furnaces or bowl-hearths were used this evolution

Fig 32 English water-powered bloomeries and hammers

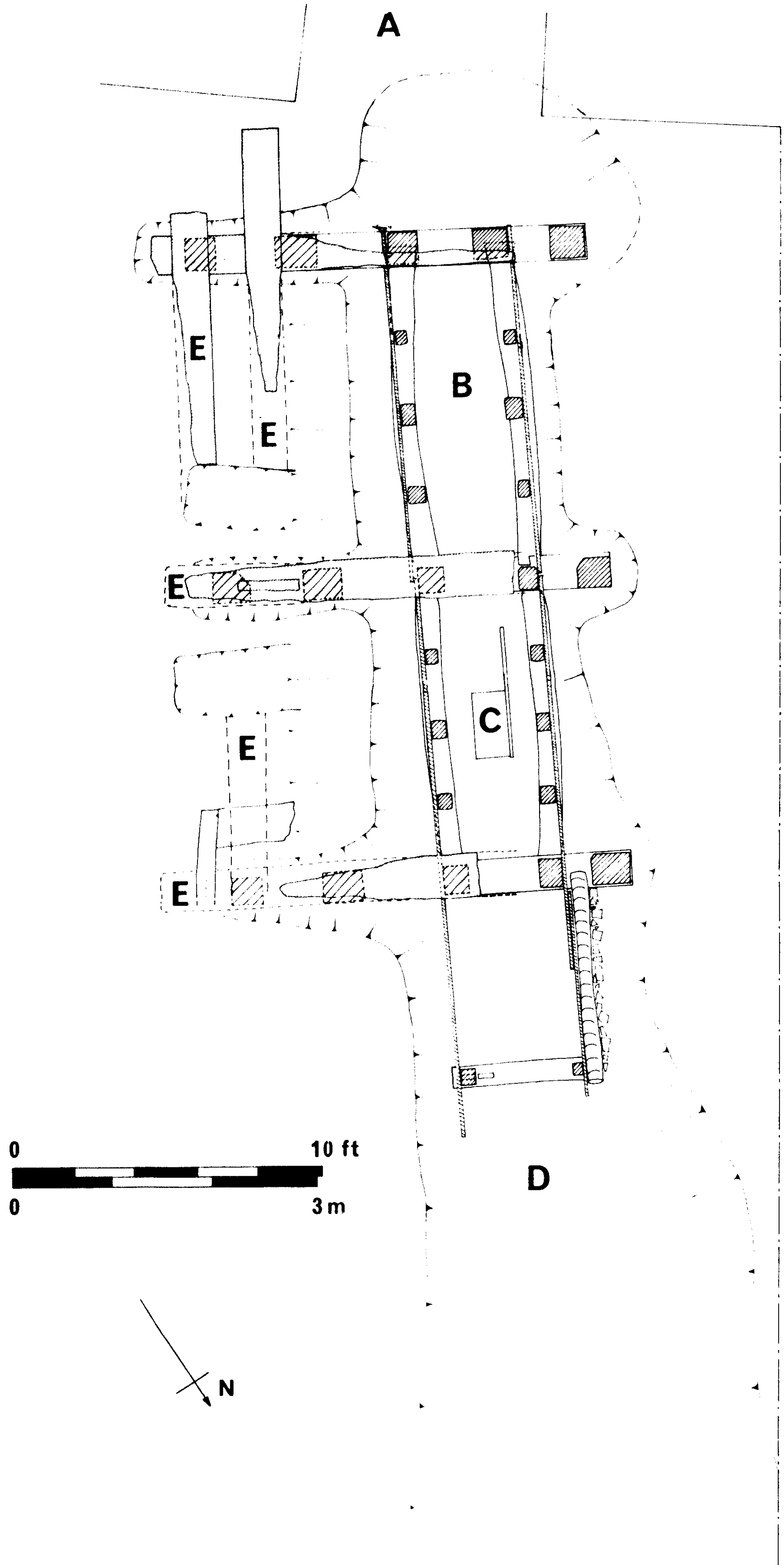


Fig 33 Chmgley, Kent: timber wheel-race and hammer frame. A dam; B wheel-race; C wheel fragment; D tail-race; E timbers and beam-slots for hammer base

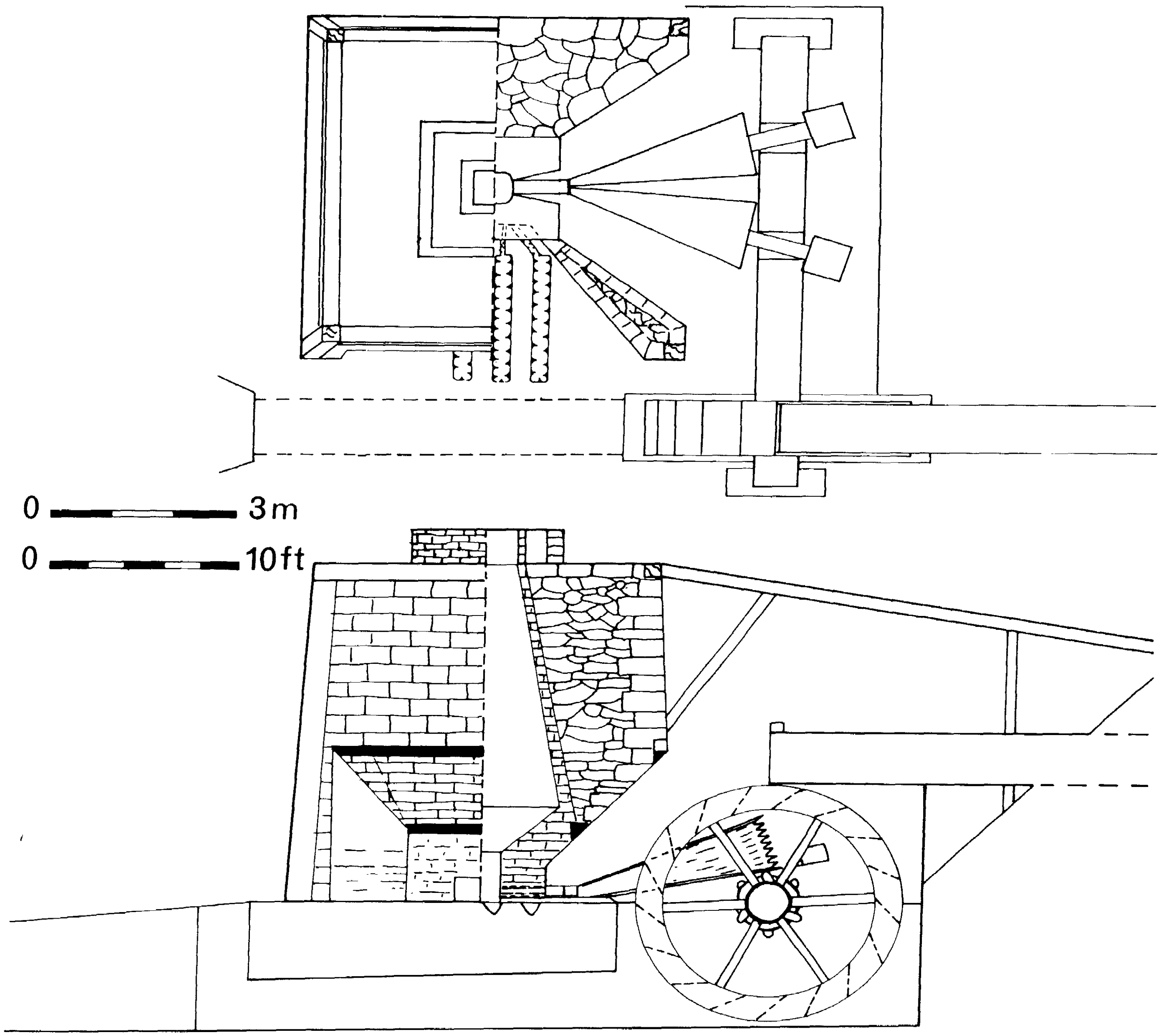


Fig 34 The charcoal blast furnace (based on Chingley furnace)

would not occur and here the blast furnace would represent a clear break with tradition. Not only was this aspect of smelting new, but the product presented problems. No difficulty arose if iron was cast into moulds to provide functional shapes; but if required for working by the smith the iron had to be melted in oxidizing conditions to remove carbon, the cause of brittleness. Such refining was also perfected by the mid 15th century. The best confirmation of both smelting and refining comes from Antonio de Filarète's Italian account. Not only does he describe a furnace built as a high stone tower, charged at the top, blown by large water-powered bellows, and producing molten metal, but also the secondary process, refining. The account is a convincing one, whether the observation on which it was based was in Italy or elsewhere (Filarète 1464 (1960), 57-60).

It is not clear where the blast furnaces had evolved. West Germany has been suggested, but 14th century references are ambiguous. A 15th century furnace has been excavated at Haus Rhade; its external diameter of 3.5 m suggests something more than a bloomery, but its superstructure has not survived, nor is there published confirmation from slags or associated features. Nevertheless slags from this area have been suggested as resulting from 14th and 15th century blast-furnace operation (Sönnecken 1977, *passim).* In Sweden it appears that late medieval developments were proceeding in this direction; glassy slags have been found in Dalarna, although it cannot be proved

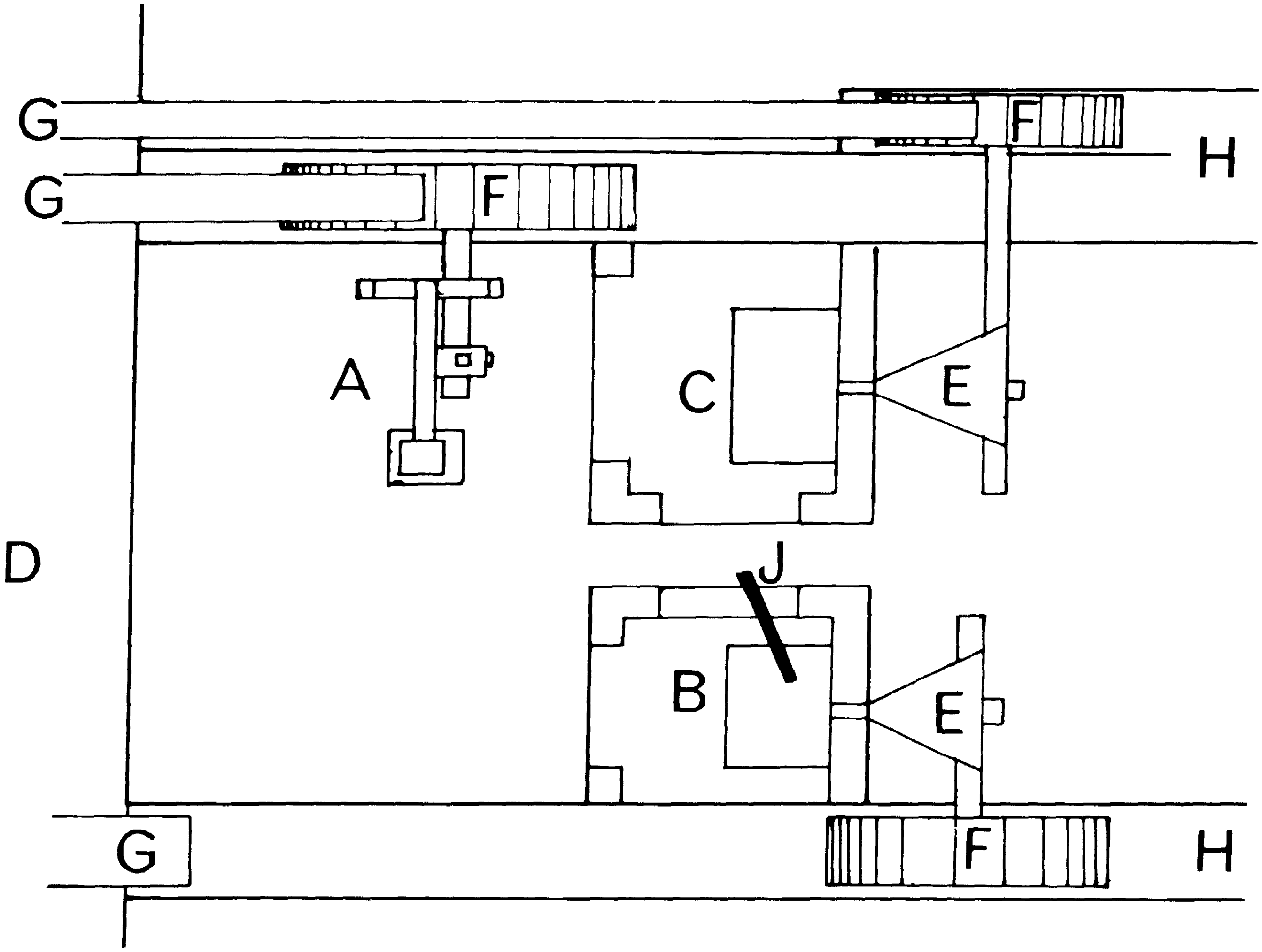


Fig 35 Finery forge: A hammer: B finery hearth for melting pig tron in oxidizing conditions to remove carbon: C chatery hearth. for reheathing during hammering: 1) dam: E bellows: G water-wheels: J pig-iron (after Chingley Forge

that cast iron was produced. This suggestion must be placed with documentary indications that the Swedish blast furnace was developing well before the arrival of German and Walloon immigrants early in the 17th century (Hildebrand 1974, 2; Bohm 1974, 6-7, 42).

The most consistently held tradition of early blast-furnace operation comes from southern Flanders, althoughit is here that the archaeological evidence has received least attention. Several writers have noted references apparently to blast furnaces near Liege, at Grivegnèe and Les Vennes, from about 1400. Unfortunately there is no confirmation in the field, for the most likely sites have long histories of later use, obscuring any medieval material (Evrard 1956, 19-27). However, the circumstantial support is considerable. There was a strong tradition of non-ferrous working and casting in Dinant and Namur, from which the use of cast iron would be a logical development. There are references to cast-iron ammunition and guns in the early 15th century, particularly in eastern France (Jenkins 1920-1, 77). One, of 1415, mentions 'le plus gros canon de fer de fondue' at Strasbourg. In addition, the method of refining the cast iron from the blast furnace has always been known as the 'Walloon' process (Fig 35). The workers who brought casting and refining to England at the end of the 15th century, described as French, have been suggested as coming originally from the Liege district. Finally, what is in some ways the most striking evidence comes from the paintings of Henri Blès, the Flemish artist who, at the beginning of the 16th century, produced a series of views of ironworks which derive from his youth spent in the Liege district. In them we see the full chain of processes, from blast furnace to refined bar iron. By the time of his work there were between 30 and 40 furnaces in southern Flanders, as many as 17 being in the Liege district.

Thus the first English blast furnace, built at Newbridge, Sussex, in 1496, came after a century of Continental development. This evolution overlaps with the introduction of water power in the traditional bloomery; the contrast in scale thus apparent is apt comment on the great differences in the level of demand between the iron-making areas of Europe. In many districts a small-scale discontinuous process was still appropriate; in others economic development generated altogether greater needs, to which the continous output of the blast furnace was appropriate, despite all its logistic complexities.

Notes

1 I am grateful to Stephen Moorhouse for this reference.
2 Interim results of these surveys are published in the Bulletins of the *Wealden Iron Research Group*.
3 I am grateful to C F Tebbutt for his observations on Brookland.

Bibliography

Addyman, P V, 1964 A dark-age settlement at Maxey, Northamptonshire, *Medieval Archaeol,* **8,** 20-73

Anon. 1960 Les origines du moulin à fer, *Rev Hist Sidér,* **1** (3), 23-32

Bohm. I, 1974 *The Swedish blast furnace in the 19th century,* Stockholm

Brodribb, A, 1972 *Excavations at Shakenoak Farm, Wilcote, Oxon,* pt 3

Coghlan, H H, 1959 Review of *Studie Palaeometallurgica in honorem Ernesti Preuschen,* Archaeologica Austrica B.3 (1958), in *Proc Prehist Soc.,* **25,** 284-6

Collingwood, W G, 1901 Ancient ironworks of Comston Lake, *Trans Hist Soc Lancashire Cheshire,* **53,** 1-22

Cormite pour la sidérurgie ancienne (Comité PSA) Reports: 1970 *Archeologtcké Rozhledy,* 22; 1971 *ibid,* 23; 1973 *ibid,* 25

Crossley, D W, 1975 *The Bewl Valley ironworks*

Crossley, D W, & Ashurst, D, 1968 Excavations at Rockley Smithies, a water-powered bloomery of the 16th and 17th *centuries, Post-Medieval Archaeol,* **2,** 10-54

Davles-Shiel, M, 1970 Excavation at Stony Hazel, High Furness, Lake District 1968-9: an interim report, *Bull Hist Met* Gp, **4** (1), 28-32

Duby, G, 1968 *Rural csonomy and country life in the medteval west*

Evenstad, O, trans, Jensen, N L, 1968 A treatise on iron ore as found in the bogs and swamps of Norway and the process of turning it into iron and steel, *Bull Hist Met Gp,* **2,** 61-5

Evrard, R, 1956 *Forges anciennes, Liège*

Fell, A, 1908 *The early iron industry of Furness and district*

Filarete, A A, *c* 1464 Treatise on architecture, *Rev Hist* Sidér, **1** (4) (1960), 57-60

Gille, B, 1954 Le moulin a eau, une révolution technique médiéivale, Techniques *et Civilisation,* **3:1,** l-15

Gilles, J W, 1956 Les fouilles aux emplacements des anciennes forges dans la région de la Sieg, de la Lahn, et de la Dill, in *Le fer à travers des ages,* Nancy, 47-81

Giuseppi, M S, 1912 Some 14th-century accounts of iron works at Tudeley, Kent, Archacologia, **64,** 145-64

Gould, J, 1969-70 Excavation of the 15th century Iron-mill at Bourne Pool, Aldridge. Staffordshire, *Trans S Staffordshire Archaeol Hist Soc,* **11,** 58-63

Guyan, W U, 1957 Die Eisenöfen in Hoftal bei Bargen, *Zeitschr fur Schweiz Archaol und Kunst,* **17,** 159-74

Hart, E, & Winbolt, S E, 1937 Thundersfield Castle, Harley, a medieval bloomery, *Surrey Archaeol Collect,* **45.** 147-8

Haslam J, 1980 A Middle Saxon iron smelting site at Ramsbury, Wiltshire, *Medieval Archaeol,* **24,** l-68

Heckenast, G, 1967 Redevelopment of the water wheel drive in the Hungarian iron and steel industry. *Rev Hist Sidér,* **8** (2), 73-94

Heckenast, G, *et al,* 1968 *The history of iron-working in early medieval times,* (in Hungarian: Review in *Bull Hist Met Gp,* **3** (2). 1969, 69-70). Budapest

Hildebrand, K G, 1974 Das schwedische Eisen 1500-1650, in *Schwerpunkte der Eisengewinnung und Eisenverarbeitung in Europa,* 1500-1650 (ed H Kellenbenz), Cologne, 1-16

Jenkins, K, 1920-1 The rise and fall of the Sussex iron Industry, *Trans Newcomen Soc.,* **1,** 16-33

Ketteringham. L L, 1976 *Alsted: the excavation of a 13th-14th century sub-manor house with its Ironworks in Netherne Wood, Mersthum. Surrey.* Surrey Archaeol Soc, Res Vol. **2**

Martens, I, 1972 Mosstrond in Telemark: an iron-producing mountain community before the Black Death, *Viking,* **36,** 83-114

Money, J H, I971 Medieval iron-workings in Minepit Wood, Rotherfield, Sussex, *Medieval Archaeol,* **15,** 86-111

Percy, J, 1864 *Metallurgy: iron and steel*

Pleiner, R, 1962 La sidérurgie dans les pays tchèques au moyen age, *Rev Hist Sidér,* **3,** 179-95

Rahtz, P A, 1979 *The Saxon and medieval palace at Cheddar,* Brit Archaeol Rep, **65**

Serning, I, 1979 Prehistoric iron production, in *Iron and man in prehistoric Sweden* (ed H Clarke), Stockholm, 50-98

Sönnecken, M, 1971 *Die mittelalterliche Rennfeuerverhüttung im märkischen Sauerland, Munster*

———, 1977 *Forschungen zur spatmottelalterlichen frühenzeitlichen Eisendarstellung in Kierspe, Märkischer Kreis,* Düsseldorf

Stainthorpe, G, 1966 A medieval bloomery on Postgate Hill, Glalsdale, Ryedale Hist, **2,** 47-9

Steane, J M, & Bryant, G F, 1975 Excavations at the deserted medieval settlement at Lyveden, *J Northampton Mus,* **12**

Tylecote, R F, 1959 An early medieval iron-smelting site in Weardale, *J Iron Steel Inst.,* **192,** 26-34

——— 1960 The location of Byrkeknott: a 15th-century iron-smelting site, ibid, **194,** 451-8

———, 1967 The bloomery site at West Runton, Norfolk, *Norfolk, Archaeol,* **34,** 187-214

———, 1970 Recent work on early ironworking sites in the Stamford area, *Bull Hist Met Gp,* **4,** 24-7

Tylecote, R F, & Cherry, J, 1970 The 17th-century bloomery at Muncaster Head, *Trans Cumberland Westmorland Antiq Archaeol Soc,* **70,** 69-109

Webster, L E, & Cherry, J, 1975 Medieval Britain in 1974, *Medieval Archaeol,* **19,** 220-60

Williams, J H, 1979 *St Peters Street Northampton excavations* 1973-6

Wilson, D M, & Hurst, D G, 1965 Medieval Britain in 1964, Medieval Archaeol, **9,** 170-220

———, & ———, 1969 Medieval Britain in 1968, *Medteval Archaeol,* **13,** 230-87

The smith's role in society

The smith, or 'blacksmith' to distinguish him from the 'bloomsmith' who made the iron, was responsible for the manufacture of all the iron and steel artefacts needed for peace and war in a medieval society. This was a position of great responsibility and it was recognized by his position in the Royal Court.

In Anglo-Saxon times he was treated as an officer of the highest rank and was awarded the first place in the presidency; after him ranked the maker of mead and then the physician. In Wales he sat with the king and queen next to the domestic chaplain. A similar exalted position is shown in the table seating plan at the banqueting hall at Tara. Here the smith comes fourth, after the verse-maker, brewer, and teacher, on the king's right hand with the chamberlain and flute-player on his (the king's) left (Best *et al* 1954, 116-17).

His range of production embraced the more prosaic ironwork, such as horse-shoes, stirrups, knives and other edge tools, locks, and finally the welded tubular guns of the 14th century. By this time the amount of work had increased so much that there was a division of labour, and specialists such as lorimers (armourers), locksmiths, and bladesmiths appeared. The original country blacksmith became more of a shoeing smith with responsibility for the repair and maintenance of agricultural tools. Different areas began to specialize; Sheffield in blades because of the need for water power for grinding wheels, and the Black (Country in chain-making where all the work was done by hand.

Smithing hearths

The object of the smithing hearth is to provide a means of reheating a piece of iron so that it can be shaped efficiently. Metallurgically there are two basically different methods that can be used. The metal can be worked cold, whereupon it hardens and in due course becomes embrittled. To overcome this an annealing hearth is required which does not need to go higher than 700°C for iron.

This technique is practised widely in Africa today where it is used for the shaping and repair of small agricultural tools. It must be backed up by smiths who have facilities for hot working at temperatures of about 1200°C. Most of the early work involved in shaping a tool is done hot, and the heat treatment of steel requires temperatures in the range 700-950°C. So most of the early smithing hearths were capable of temperatures of the order of 1200°C and needed a forced, bellows-blown draught.

The minimum equipment for this purpose is a pile of burning charcoal with a tuyere inserted to raise the temperature locally. If this is to be done in the open a few stones are needed to prevent the winds from blowing away the light charcoal. But the most important piece of equipment may be a protection for the bellows. This can be provided by making a bowl hearth with the bellows placed above and to one side of the hearth (Fig 36, reconstruction of Huckhoe), or by using an *Essestein* which is portable and can be carried on a pony or donkey by an itinerant smith. This can be refractory stone or a plate of clay. In some cases the tuyere and hearth are integral (Fig 37, from Meroë), in others two or three separate stones can be made both to hold down the tuyere and to protect the bellows.

In the Roman period evidence is found of two types, a bowl or pit in the ground into which a tuyere was directed, and a platform on which it was supposed that a fire was built and a tuyere inserted. Manning (1977) has recently cast doubt on this rather facile explanation by calling attention to Roman illustrations of smithing hearths such as the one in the catacomb of Domitilla. He believes that a waist-level hearth was probably sited on these platforms. I suspect that a large number of different types were erected on those platforms, including the one shown in the author's book (Tylecote 1962, 233, fig 59) based on the finds at Wilderspool (May 1905; Fig 38).

Medieval sites, such as Goltho (Beresford 1975) give evidence of pits or bowls and there is little doubt that the floor-level smithing hearth, like the bloom hearth, persisted well into the medieval period.

Miss Ketteringham in her report on Alsted (Netherne Wood, Surrey) (Ketteringham 1976) has found evidence for the gradual development on one site from the bowl or pit to the waist-level hearth with a timber-framed house, all between the middle of the

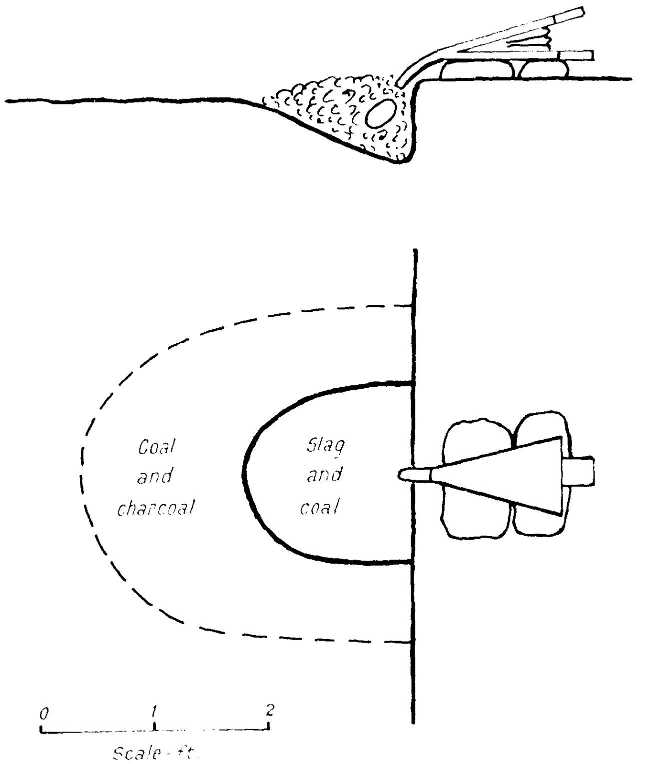


Fig 36 Reconstruction of smithing hearth found at Huckhoe Northumberland

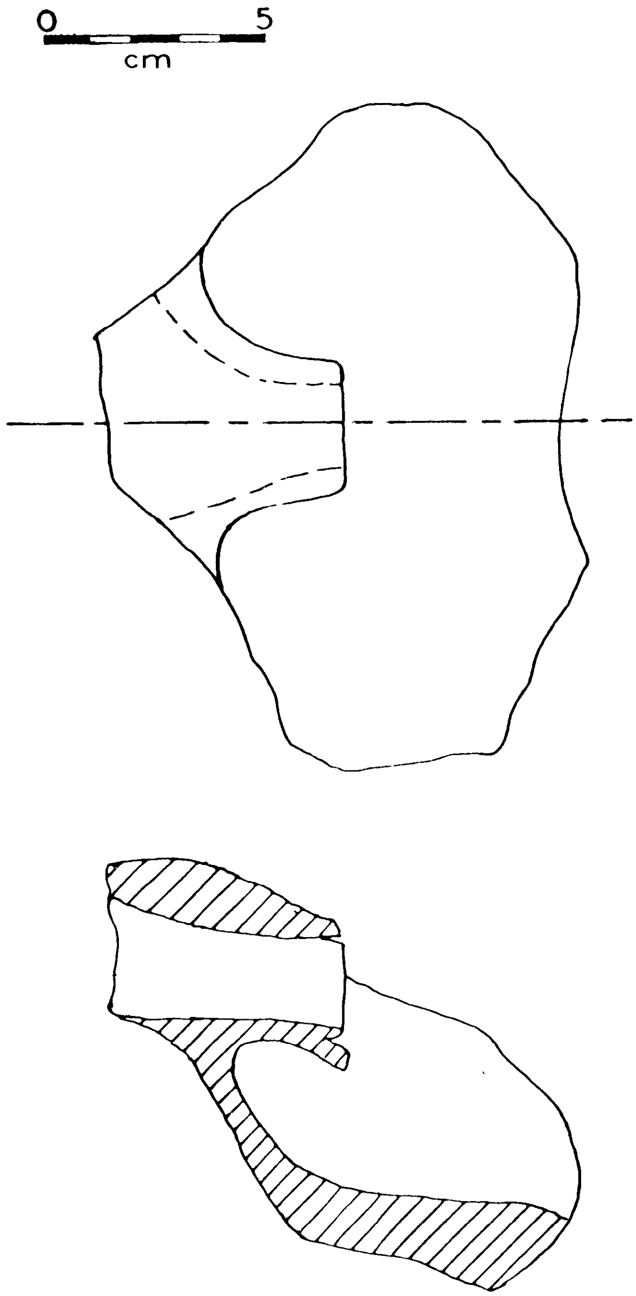


Fig 37 Piece of smithing hearth lining from Meroë, Sudan

13th to the end of the 14th century. MS illuminations in the British Library and the Bodleian show smiths kneeling at low, nearly floor-level hearths (Fig 39) and a waist-level hearth very like that from Rome (Fig 40). One of the best preserved earlysmithing hearths today is to be found in the White Swan Hotel at Heddon-on-the-Wall from which the Amos brothers moved in the 1960s to a modern custom-built smithy nearby.

Smithies are usually equipped with a water cooling device called a 'bosh', mostly used for cooling the tools rather than the products, and anvils and bellows. The products will be hammer scale (Table 5, Fig 41), which is usually found round the base of the anvil, and smithing furnace bottoms which consist of a vitrified mass of fuel ash and hammer scale and which have a composition close to that of smelting slag

Table 5 Composition of iron smithing products and smelting slags (%)

	Ashwicken hammer scale	*Haithabu smithing furnace bottom*	*Ashwicken smelting slag*
Fe	–	0.37	
FeO	–	58.62	62.1
Fe_3O_4	85.8	–	–
Fe_2O_3	–	3.34	7.7
SiO_2	9.94	30.91	21.2
CaO	1.2	1.99	0.4
$A1_2O_3$	0.90	4.58	3.2
MgO	0.30	0.18	1.4
P_2O_3	0.73	tr	1.72
MnO	–	tr	0.5
	(Tylecote 1962)	(Pleiner *et al 1971)*	(Tylecote 1962)

(Table 5). They are, however, more or less plano-convex. But they can be removed from the hearth at any stage in their growth and therefore vary from thin 'shells' to something more like a ball. A good deal of work needs to be done on the subject, but at the moment the best report is in the series on Haithabu where Pleiner reports on one found at the base of an *Essestein* (Pleiner *et al* 1971).

Raw materials

On the whole the blacksmith did not make his iron, although the author has met a Slovak smith who claimed that his father made his own blooms and that he himself knew how, if necessary. The iron was made by bloomsmiths who finally worked it in the string-hearth to standard bars (in the 14th century bloomery in Weardale, Co Durham, these weighed about 8 kg, according to Schubert 1957). Hut in fact the precise weight of the bar supplied to the smiths is not known; it probably varied somewhat. Before the advent of water-powered bloomeries the blooms weighed less than 14 kg, but after the 14th century their weight increased to several hundredweight and considerable work went into cutting them up. It is almost certain that the weight of the billet, piece, or 'gad' increased accordingly.

We have a 'gad' from Winchester weighing 1.28 kg (Biddle & Keene 1981) and a bar from Chingley weighed 15 kg (Crossley 1975b). Bars from the Viking site of Haithabu were similar in shape and weighed 58, 67, 620, and 1450 g respectively (Thomsen 1971a). It is possible that these bars were those called 'Osmunds' in Sweden which decreased in weight from some unknown size in the 13th century to 300 g in the 16th century (Tholander 1975).

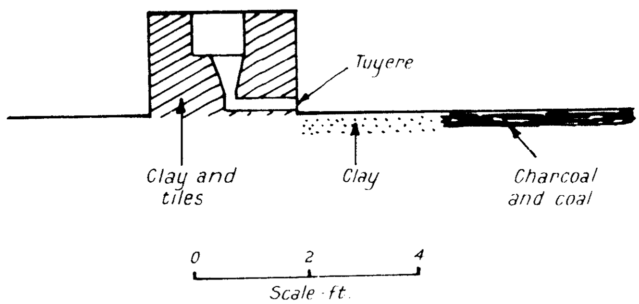


Fig 38 Reconstruction of waist-level hearth from Wilderspool (after May 1905)

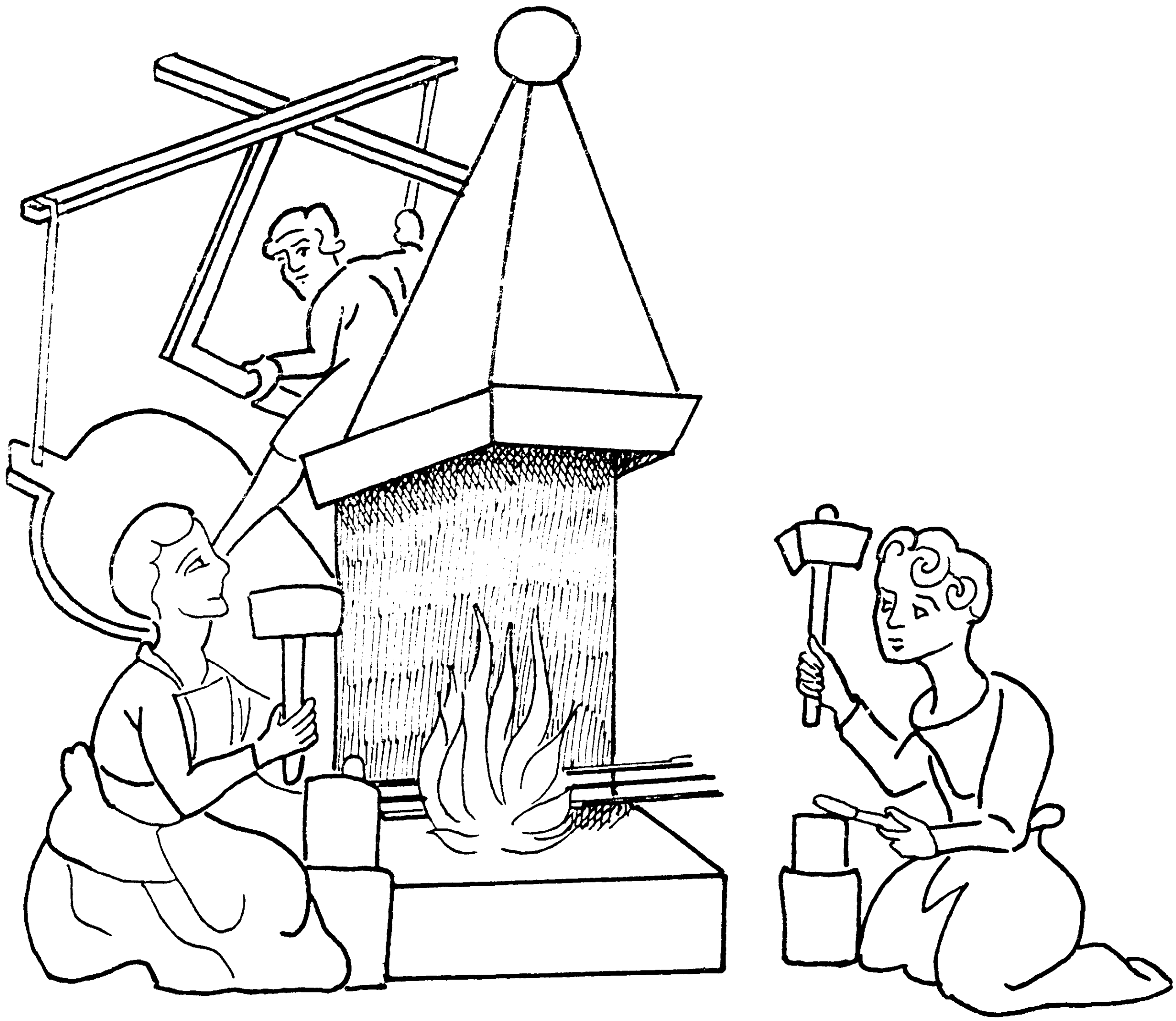


Fig 39 Ground-level hearth (from Romance of Alexander, AI) 1340, Bodleian Library Ms 264 f 84T

Fuel

The Roman smith was in some cases able to use coal (Webster 1955) which, although not suitable for smelting, is suitable for working iron once a high degree of consolidation has been achieved so that the metal is not able to absorb sulphur easily. Many medieval smithing sites such as Goltho (Beresford 1975) etc have yielded coal and it is clear that this is often 'sea coal' which has been brought from the nearest coast.

While oak is the wood most used for iron-working in Roman times, this is not vital for smithing and a wide range of woods was used throughout the medieval period. Peat charcoal is another possibility and Highland smiths have used it up to recent times. Here again, the high sulphur content is no detriment (Woolner 1965; Crawford 1964, etc).[1]

Steel

A high-phosphorus iron can be work-hardened to give a cutting edge with a hardness of the order of 250 HV which is as good as any bronze tool. To get a blade harder than this the iron has to be carburized to convert it to steel which can then be further hardened by quenching and tempering.

Phosphorus slows down the diffusion of carbon into iron (Table 6), so in order to get the most efficiently carburized iron, a good-quality ore has to be selected; such an ore was, on the whole, rare in these islands. For this reason, by the medieval period, steel was largely imported from Sweden, Russia, and Spain. No doubt a small amount was a by-product of the bloomery process which tended to produce rather

Table 6 Effect of phosphorus on the diffusion of carbon

Starting material	*%C absorbed in a given time*
Fe	0.94
Fe+0.6%P	0.60
Fe+1.2%P	0.52

(Stead 1918)

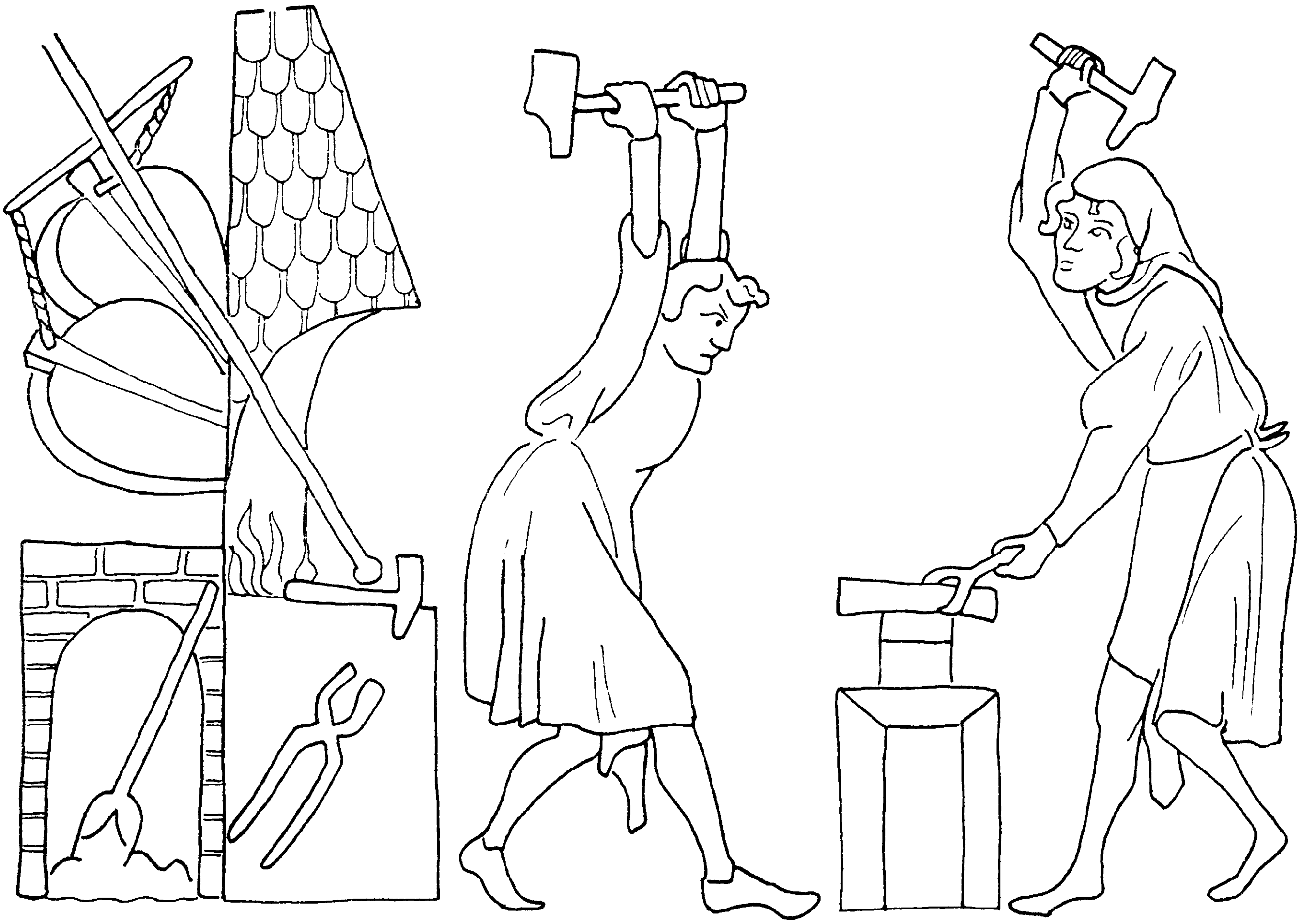


Fig 40 Waist-level hearth (from British Museum Sloane Ms 398.3 f 5r)

heterogeneous metal from which the high-carbon parts could be removed.

Later on, in the 18th century, the bloomery and the finery could be adjusted to give steel directly, so giving 'natural' steel. It is of course possible that this process was used much earlier.

Other processes exist such as the Brescian process which mixes cast iron and wrought iron, the latter, a solid, absorbing carbon from the former in its liquid state. A very skilled smith could make his own steel from imported good-quality iron by carburizing it in his hearth, but this would be slow.

The diffusion of carbon in iron even at temperatures as high as 900°C is very slow (Table 7; Fig 32). To a certain extent the process is sensitive to the medium used, and some accelerating effect is probably obtained from the alkali carbonates of the wood ash that form as charcoal is consumed. The metal to be carburized is immersed in fine charcoal a slight distance away from the tuyere to avoid rapid oxidation of the charcoal, but with enough consumption of the charcoal in front of the tuyere to maintain a temperature of 900-1100°C. Under these circumstances, it will take five hours to raise the carbon content at a

Table 7 Effect of temperature on the thickness of the carburized layer after 2 h

(minimum carbon = 0.3%)

Temperature, °C	*Thickness, mm*
950	1.14
1000	1.64
1050	1.90
1100	2.66

(Bramley & Lawton 1927)

Fig 41 Scale formed by the oxidation of wrought iron at 1050°C (×125)

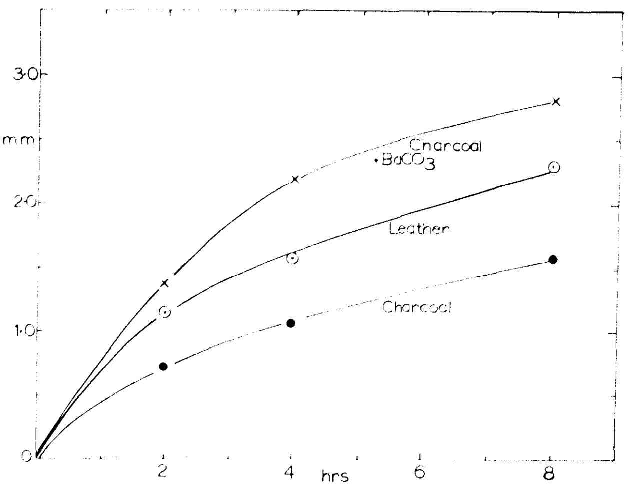


Fig 42 Rates of carburizing in various media at 900°C (depth to give, 0.85°C mean: after Shaw Scott 1907)

position 0.10 in (2 mm) below the surface to 0.45% C (Fig 42). To do this consistently requires a very skilled smith; that is why carburizing is best done first and a piece of satisfactory steel obtained before a tool is made. Then the good piece of steel can be built into or on to the tool that is being made. Because the diffusion of carbon into steel is so slow it was necessary to beat the iron thin and then, when the carbon had been absorbed, to fold it over and weld it into a piece thick enough to make the artefact required. Evidence of this is shown in the 'piled' structure of both iron and steel. Subsequent heating after folding can even out the variations in carbon content, thus eliminating evidence of piling except for linear slag inclusions and arsenic enrichment lines (see below). This gives a homogeneous piece of steel. Early examples of the process are to be seen in the Llyn Cerrig Bach chariot tyre (Fox 1946).

The cost of steel

In view of the problems outlined above, it is hardly surprising that steel was a good deal more expensive than iron. Around AD 1300 steel was costing about £3 per ton while wrought iron was only about £0.60 per ton (Schubert 1957). In 1546 bar iron in the UK was up to £8-9 per ton, and steel at Robertsbridge in 1566 was about £7 per firkin of about 5-6 cwt, ie about 3-4 times the price of wrought iron. In 1608 a barrel of Swedish steel which contained about 600 kg cost £23, or £38 per ton. At the same time Irish bar iron cost £16 per ton giving a relative price of 2.4 times (Rogers 1866). This ratio was maintained according to Le Play until at least 1840 (Le Play 1843; Fig 43).

Owing to the fact that wrought iron was so cheap in Britain, as it was made with coal and phosphorus-containing ores, the price of steel tended to be much higher in the late 19th century relative to the price of iron. The raw materials for steel (low-P iron) had to be imported. Thus Barraclough (1979 forthcoming) gives a ratio of 4:1 for the price of tool steel/iron for 1878.

It would seem that a high ratio was maintained until the mass-production of liquid steel by the open-hearth process.

The structure of knives

There is now a great deal of published material available on this subject. Naturally, knives are by far the commonest implements found on sites where conditions are amenable to their preservation.

The techniques used stem from the need to use steel as sparingly and as efficiently as possible. By the Roman period two techniques, ie that of direct carburizing and that of welding-on pieces of steel were known and employed, as one can see from the masons' chisels examined by Pearson and Smythe (1938) and the knives from Winchester examined by the author (*Winchester studies*, 1981, eds Biddle & Keene).

The effects of carburizing and heat treatment were not very consistent in the Roman period and it is difficult to be certain as to the intended technique. By Anglo-Saxon and Viking times a great improvement is seen in consistency of technique. Both the steel-making technique and the subsequent heat treatment are more consistently carried out and four basic ways of making steel or mixing iron and steel to give a good cutting edge using the minimum amount of steel can be distinguished:

A By having a layer of steel covered with two plates of iron in such a way that the steel projects at the thinned cutting edge. Sharpening such a knife will always give a steel edge to the blade.

B Welding-on a steel strip to the edge of a piece of iron, sometimes made by piling. The steel edge will wear away with sharpening until eventually there is no steel left and the knife becomes useless and is discarded.

C Using a piece of piled material which consists of alternate layers of iron and steel. Given sufficient heat after welding, these layers may be homogenized so that the blade consists of a piece of homogeneous steel.

D By having an iron core around which a piece of steel has been wrapped, ie the reverse of type A. This seems comparatively rare perhaps because it uses more steel than A in most cases and, more importantly, the lasting qualities of the tool are not much better than in the case of B.

The results of using these four techniques are shown diagrammatically in Fig 44.

These techniques were more or less international and their knowledge must have spread widely during the Roman period. Thirteen knives from the 8th

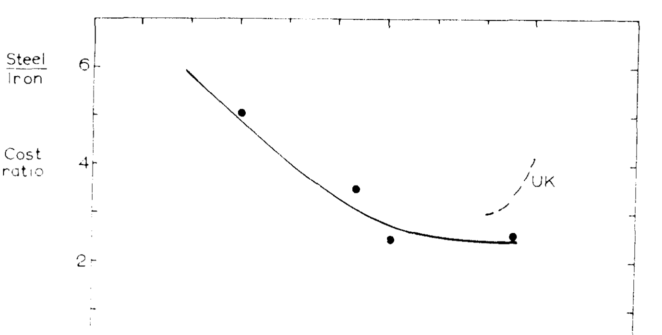


Fig 43 Cost ratio of steel to iron in Europe. Dotted line indicates increasing ratio in UK due to low cost of coal-produced wrought iron compared with tool steel produced from imported iron.

century Swedish site of Helgö have been examined (Tomtlund 1973). Half of these are homogeneous and the rest are split between the three other types. It is of course difficult to distinguish the iron-cored type from the surface-carburized.

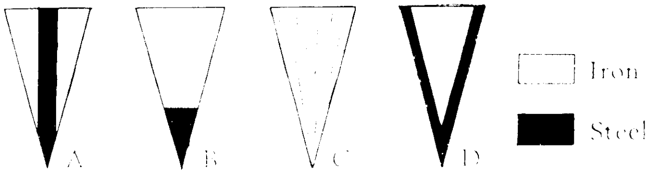


Fig 44 Methods of combining iron and steel to produce edge tools

Table 8 Typology of Russian knives

(after Kolchin 195.3)

Century	*Type*			
	A steel-cored	*B* steel-edged	*C* piled	*D* iron-cored
9th-10th	8	1	0	0
10th	5	1	0	0
10th-11th	2	3	0	2
10th-11th	1	2	0	0
11th	1	0	0	0
11th-12th	0	6	0	2
12th	1	0	0	0
12th-13th	1	2	0	0
13th	1	1	0	0
13th-14th	0	1	0	0

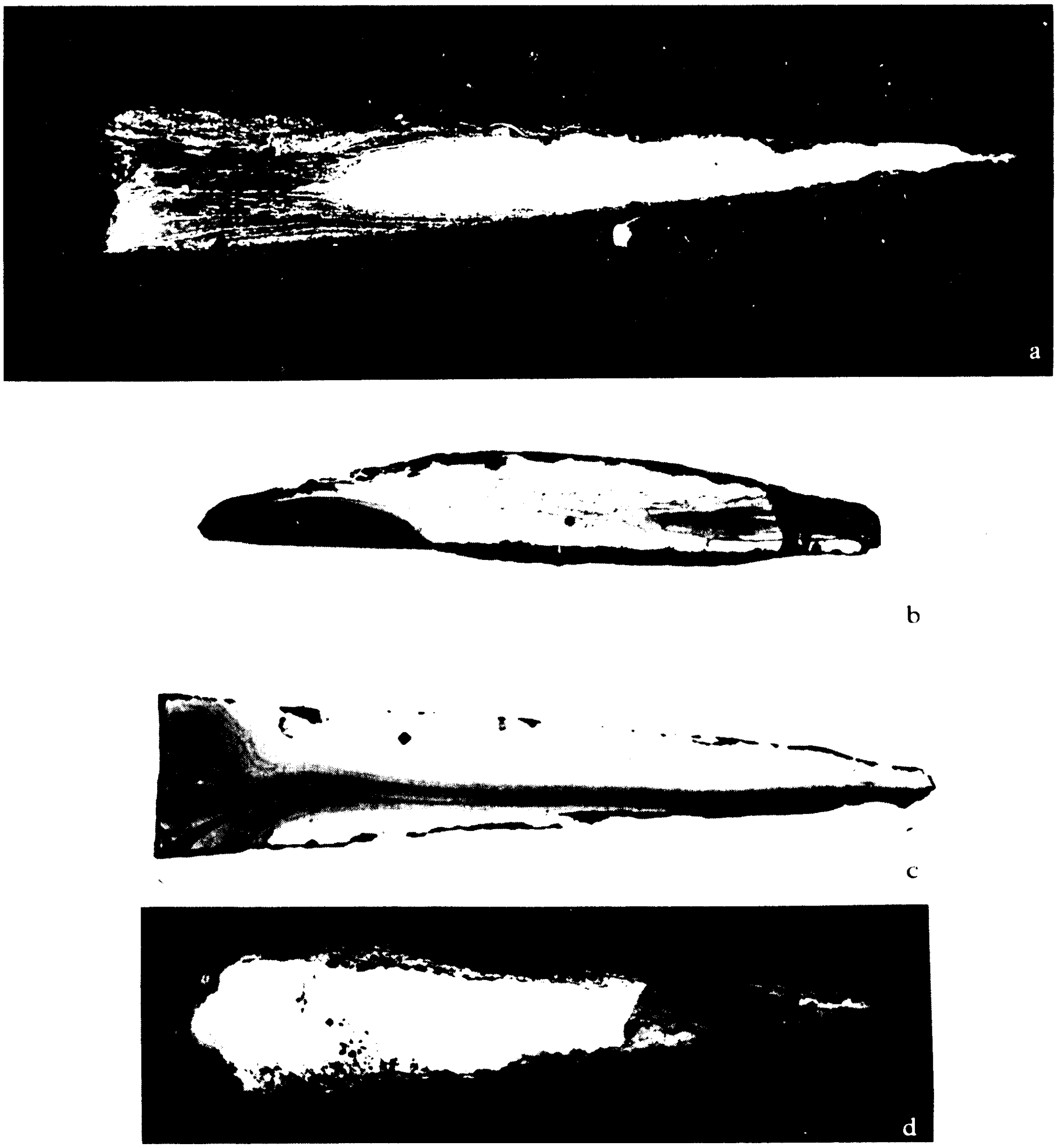


Fig 45 Examples of the macrostructure of blades: a Type A knife blade from Goltho, Lincs (14-15th century). White, steel; black, tron (length 21 mm); b Type B scissors blade from Chingley (17-18th century). Left-hand black area is cutting edge; hardness 857 HV (length 16 mm); c Type A knife blade from Chingley (steel, dark; iron, light) (length 18 mm); d Type B knife blade from Barton Blount (14th century) (steel, dark; iron, light) (length 12 mm)

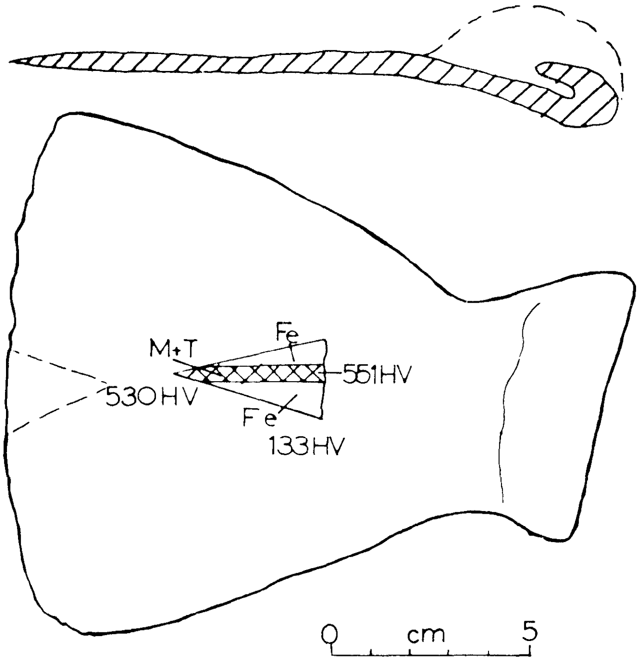


Fig 46 Axe blade from Lymm slitting mill (17th-18th century) with structures shown inset

Thompson's work (1967) has shown more evidence of the type A or sandwich type (Fig44). Some of these show the familiar 'white' arsenic enrichment lines dividing the steel core from the iron exterior; in one case the As concentration reached ~ 1% (discussed by Tylecote & Thomsen 1973). One of the most intensive investigations is that of the Novgorod material by Kolchin (Kolchin 1953; Thompson 1967). The results are given in Table 8, and it is seen that in the early period the steel-cored type predominated while the steel-edged type became more-common in the 12th and 13th centuries.

To a certain extent this is what is found in the Winchester material. But verv little of this antedates the 11th century and by the 13th century most of the knives are being made-by the steel-edged (B) process. This process uses the minimum of steel but, of course, as soon as this has worn away the implement is useless. Perhaps that is what is being referred to in 1582: 'This argument cuts like a Leadenhall knife where as they say in common speech if one pour on steel with a ladle, another comes and wipes it off with a feather' (Lloyd 1913).

Recent work on nine medieval Irish knives (Scott 1976) showed that four or five were steel-edged (type B) and that the rest were of homogeneous, rather low-carbon, material. Only one was made by the sandwich-type construction. The four heat-treated steel edges gave hardnesses in the range 351-468 HV which would make really usable knives.

Later sites yielding knives include Goltho, Barton Blount (Beresford 1975), Holyoak, and Chingley. Nineteen knives from Goltho (14th-15th century) showed a fairly even distribution between the four basic types. Two examples of type A are shown in Fig 45a and c. In the first the iron side plates have been almost completely ground away. The second, from Chingley, shows a well made sandwich. Unfortunately this has not been well hardened (HV = 239; low % C or over-tempered) while the first has an edge with a hardness of 557 HV.

Another medieval site (15th century) is that of Barton Blount where the four relatively rust-free examples were probably all steel-edged, Even so the hardness of the best one reached 701 HV.

The Tudor site of Holyoak (Gwen Brown forthcoming) yielded six good knives and most of these were of type D which, since it is an uncommon type generally, suggests that they were probably all obtained from the same local smith. Four of the six had edge hardnesses in the range 420-640 HV, a remarkable level of consistency for such a small sample.

Some of the cutlery from the 17th-18th century site of Chingley (Crossley 1975b) includes scissors, which were, a medieval introduction (Novgorod has produced many). Some of these seem to be no more than pure ferrite with hardnesses in the range 121-195 HV. Others (Fig 45b) have been steeled to give an edge with a hardness of 857 HV. Yet another is like a type A knife with a core of tempered martensite with a hardness of 460 HV.

Other edge tools

Wooden spades have been edged with steel from the medieval period. One such from Winchester had a carburized edge of pearlite and ferrite with a hardness of 210 HV (Biddle & Keene 1981).

The chisel-peen of a hammer head of the 17th century had been made by inserting a piece of steel with a hardness of 430 HV into the ferritic body. A 10 mm flat head had been welded on to the other end and it had a maximum hardness of 630 HV. This was well up to the standard of a modern solid steel hammer.

A carpenter's axe from 9th-10th century Winchester had been made by inserting a piece of steel (390 HV) between the folded-over back making the shafthole. An 18th century axe (Fig 46) from Lymm seems to have been made in the same way. The sandwiched steel giving the cutting edge was of tempered martensite and troostite and had a hardness of 530 HV. Such an obvious and simple technique of fabrication would not be amenable to change (Johnson & Bearpark forthcoming).

Mortise chisels are also steeled. One from 17th century Chingley had a piece of steel only 12 mm long and 2 mm thick welded to the ferrite body. The steel had a hardness of 701 HV and the ferrite 139 HV. A similar chisel (Fig 47) from the 18th century Lymm slitting mill had a hardness of 690 HV (Johnson & Bearpark forthcoming); clearly a standard type had evolved by the 17th century.

Finally, to complete this picture, there are the spoon auger from Letchworth (Tylecote 1968), which

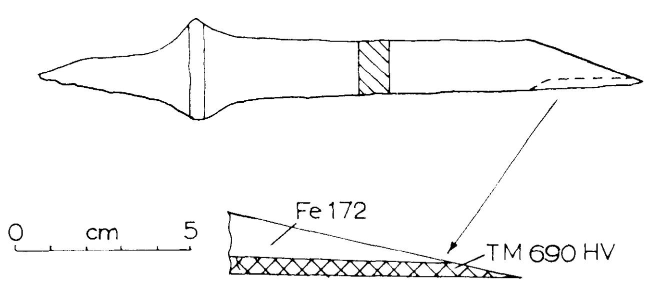


Fig 47 Chisel blade from Lymm with steeled edge shown inset

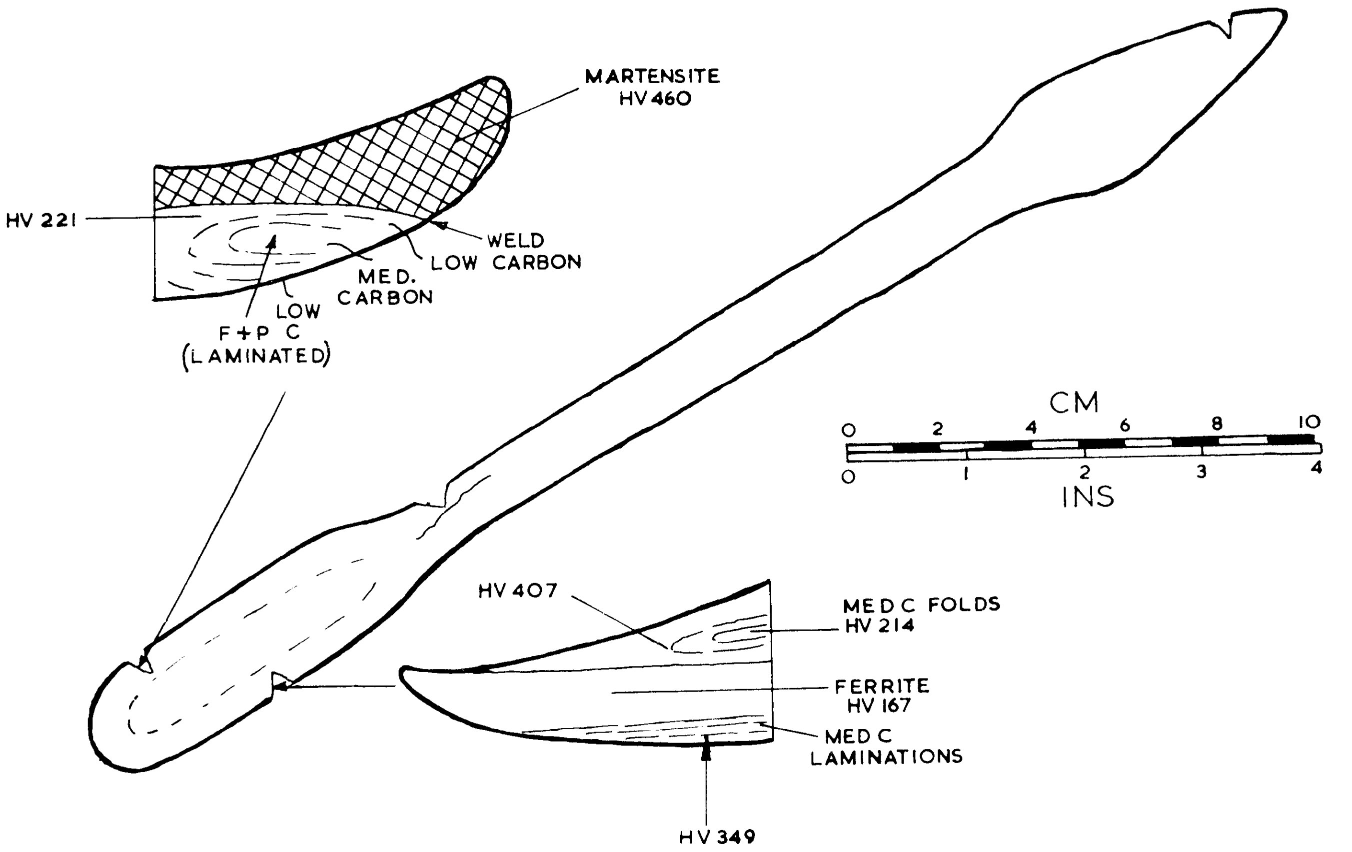


Fig 48 Spoon auger from Letchworth showing hardened steel cutting edge

had steel welded to the cutting edge and hardened to martensite (460 HV) (Fig 48), and the boring bit from Chiddingly, which was one of four bits or cutting edges inserted into a cannon boring bar. It had been made like the chisels by welding a 2.5 mm thick plate of steel to a piece of wrought iron 40 mm ×70 mm ×10 mm thick. The composite bits were held in place with shims and the tool rotated in such a way that the steel did the cutting. The structure of the steel was that of martensite and nodular troostite with a hardness of 713 to 326 HV which indicated slow quenching from above 800°C (Fig 49).

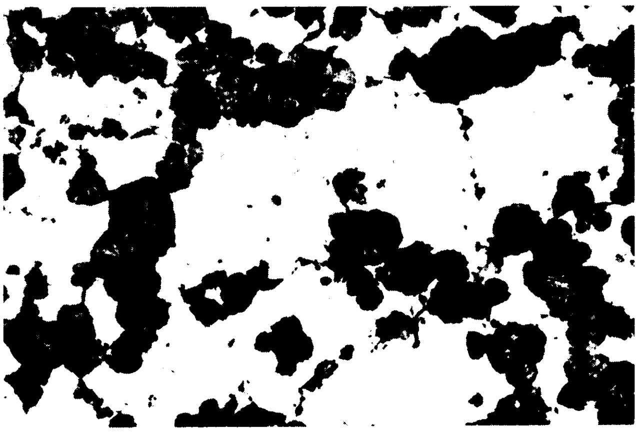


Fig 49 Metallurgical structure of Chiddingly boring bit (×325). Dark, hard martensite; light, softer troostite

Summary and conclusions

We have traced the development of the smithing hearth from the pre-Roman bowl and the introduction of the waist-level hearth to Britain in the medieval period. The steady improvement in the standard of heat treatment of edge tools is clear from examination of the artefacts; by medieval times heat treatment was both widespread and consistent.

The methods of using steel are most interesting and varied; the use of a particular technique is rarely indicated in the artefacts from a single site, thus suggesting that the material has actually come from a number of sources practising different methods of combining expensive steel with cheap iron.

This material could be made by carburization in the bloomery process, and the existence of many high-carbon blooms or billets of the Roman period (Brown 1964) tends to support this view. Or, alternatively, strips of low-carbon bloomery iron could be carburized in bundles as was done in the 18th century cementation furnace. Occasionally the smith would carburize a single strip in his hearth, but this would be a very inefficient method.

The question of the phosphorus level of the steel needs to be explored further to see if steel was always made with low-phosphorus iron.

Acknowledgements

I would like to thank all those who have helped in various ways to make this paper useful. In particular I would like to thank Dr W H Manning for calling my attention to the drawing in the catacombs of Domitilla. I also wish to thank Miss Lesley Ketteringham for drawing my attention to and lending me copies of the illustrations in the British Library and the Bodleian Library; and I thank these two libraries for permission to reproduce these illustrations.

The work was assisted by a grant from the Historical Metallurgy Society, to whom I am extremely grateful.

Note

1 It is worth noting that the S content of charcoal ash is quite high (SO_3 = 1.87-21.6%). But it is probably present as $CaSO_4$ in which the S is not easily dissociated and therefore is not available to the smelting process (Roy 1978).

Bibliography

Barraclough, K C, 1979 The setting of the stage for Sidney Gilchrist Thomas, *J Hist Met Soc*, **13** (1), 7–10

Beresford, G, 1975 *The medieval clay-land village; excavations at Goltho and Barton Blount*, Soc Medieval Archaeol monogr ser, **6**

Best, R I, Bergin, O, & O'Brien, M A, 1954 *The Book of Leinster*, Inst for Advanced Studies, Dublin

Biddle, M, & Keene, S (eds), 1981 forthcoming *Winchester studies*, **7** (2), *Crafts and industries other than ceramics*

Bramley, E, & Lawton, C, 1927 The gaseous cementation of iron and steel, *Carn Schol Memoir, Iron and Steel Inst*, **14**, 35–100

Brown, Gwen, forthcoming *Excavations at Holyoak, Northants*

Brown, G T, 1964 The Roman bloom from Cranbrook, Kent, *J Iron Steel Inst*, **202**, 502–4

Crawford, I A, 1964 Gual Gaidhealach: peat charcoal, *Scot Stud*, **8** (1), 108

Crossley, D W, 1975a Cannon manufacture at Pippingford, *Post-Medieval Archaeol*, **9**, 1–37

———, 1975b *The Bewl Valley ironworks, Kent c 1300–1730 AD*, Roy Archaeol Inst Monogr

Fox, Sir Cyril, 1946 *Llyn Cerrig Bach*, National Museum of Wales

Ketteringham, L L, 1976 *Alsted: excavation of a 13th-14th century sub-manor house with its ironworks in Netherne Wood, Merstham, Surrey*, Surrey Archaeol Soc Res Vol, **2**

Kolchin, B A, 1953 *Chernaya metallurgiya ye metalloobrabotka v drevnii Russi*, Moscow

Le Play, F, 1843 Rapport sur la fabrication de l'acier en Yorkshire, *Ann des Mines*, 4 ser, **3** (trans K C Barraclough, in *J Hist Met Soc*, **8** (1), 1974, 49)

Lloyd, G I H, 1913 *The cutlery trades*

Manning, W H, 1977 *Catalogue of Romano-British ironwork in the Museum of Antiquities*, Newcastle upon Tyne, Dept Archaeol

May, T, 1905 Britain's earliest iron furnaces and moulding floors, *Iron Coal Trades Rev*, **71**, 427

Pearson, C E, & Smythe, J A, 1938 Examination of a Roman chisel from Chesterholm, *Proc Univ Durham Phil Soc*, **9** (3), 141–5

Pleiner, R, Pelikan, J, & Bartuška, M, 1971 Untersuchungen einer Eisenschlacke aus Haithabu, in *Ausgrabungen in Haithabu* (ed K Schietzel), Bericht **5**, 110–12

Rogers, J E T, 1866 *History of agriculture and prices in England*

Roy, N B, 1978 *An analytical study of early iron smelting technology*, M Phil thesis, Univ Southampton

Schubert, H R, 1957 *History of the British iron and steel industry*

Scott, B G, 1976 Metallographic and chemical studies on a group of iron artefacts, *Ulster J Archaeol*, **39**, 42–52

Scott, G Shaw, 1907 Case-hardening, *J Iron Steel Inst*, **3**, 120–36

Stead, J E, 1918 Iron, carbon and phosphorus, *ibid*, **97**, 389–415

Tholander, E, 1975 Comments on medieval Swedish Osmund iron, *J Hist Met Soc*, **9** (2), 68–70

Thompson, M W, 1967 *Novgorod the great*

Thomsen, R, 1966 Metallographic studies of an axe from the migration age, *J Iron Steel Inst*, **204**, 905–9

———, 1971a Metallographische Untersuchungen an wikingszeitlichen Eisenbarren aus Haithabu, in *Ausgrabungen in Haithabu* (ed K Schietzel), Bericht **5**, 9–29

———, 1971b Essestein und Ausheizschlacken aus Haithabu, in *ibid*, 100–9

Tomtlund, J-E, 1973 Metallographic investigation of 13 knives from Helgö, *Early Medieval Stud*, **5**, 52–63

Tylecote, R F, 1962 *Metallurgy in archaeology*

———, 1968 A spoon auger from Letchworth, Herts, *Bull Hist Met Soc*, **2** (2), 68–9

Tylecote, R F, & Thomsen, R, 1973 The segregation and surface enrichment of As and P in early iron artefacts, *Archaeometry*, **15**, 193–8

Webster, G, 1955 A note on the use of coal in Roman Britain, *Antiq J*, **35**, 199–216

Woolner, D, 1965 Peat charcoal, *Devon Cornwall Notes Queries*, **8** (5)

The medieval blacksmith and his products

Ian H Goodall

The medieval blacksmith produced the many tools and fittings used in everyday life, as well as more specialized items such as church doors and screens, weapons, and armour. These specialist classes are excluded from the following discussion which concentrates on material excavated in Great Britain. The term medieval is restricted to finds of post-Conquest date, earlier material being more specifically described. Pagan Saxon material is not considered.

Ironworking tools (Fig 50)

Smithing slag, incomplete forgings, and tools are the most common forms of evidence for ironworking, and smithing is known at the late Saxon settlement at St Neots, Cambs (Addyman 1973, 75)[1] as well as at a range of medieval sites including Southampton, Hants (Platt & Coleman-Smith 1975, 238, 267, 349) and Bramber Castle, W Sussex (Barton & Holden 1977, 38, 67). Excavated smithies include those at Waltham Abbey, Essex (Huggins & Huggins 1973), Netherne, Surrey (Ketteringham 1976, 17-32), and Goltho, Lincs (Beresford 1975, 46, 90-l).

The blacksmith's raw material was bar iron, no doubt with the addition of available scrap which was forged down on an anvil. A piece of iron was first cut from the bar with a chisel or set and then the blacksmith, holding the iron with tongs, used a sledgehammer, lighter hammers, and other tools, including punches and drifts, to complete the forging. The 11th century Caedmon manuscript (Wilson 1976, 264, p1 XIII) and 14th century Holkham Bible (Hassall 1954, 131-2, f31) show anvils, but no block or beaked anvil has yet been found. Tongs, a chisel-cut length of bar iron, a sledgehammer (Fig 50,l-3), a broken chisel, an axe (Fig 51,4), and iron slag were found together at Deganwy Castle, Gwynedd, and may be from a smithy.[2] The other tools are represented by a light hammer from Wintringham, Cambs (Fig 50,4; Goodall 1977a, 257, fig 46,62), a chisel from Waltham Abbey (Fig 50,5; Goodall 1973, 170, fig 11,14), and a set from Goltho (Fig 50,6; Goodall 1975a, 87, fig 41,90). The punch from Kettleby Thorpe, Lincs (Fig 50,7; Goodall 1974a, 33, fig 1812) was used for driving holes in iron, whilst a punch and drift (Fig 50,8-9), the latter for enlarging and smoothing holes, are known from the smithy at Waltham Abbey (Goodall 1973, 170, fig 11,20,18). This smithy also produced much bar iron and some incomplete forgings, including blanks for auger bits and a key (*ibid*, fig 11,12,30), the latter yet to have its bow welded, wards cut, and be finished off with a file similar to that from the Manor of the More, Herts (Biddle et al 1959, 184, fig 19,36). Blacksmiths' tools of earlier date include a hammer and punch from Thetford, Norfolk (Wilson 1976, 264, fig 6,6d & b).

Woodworking tools (Fig 51)

Wood was the basic material of the carpenter and of many specialist craftsmen including the cooper, cartwright, and shipwright, and between them they used a wide range of tools. Large wedges similar to that from Stretham, E Sussex (Fig 51,1)[3] were used in

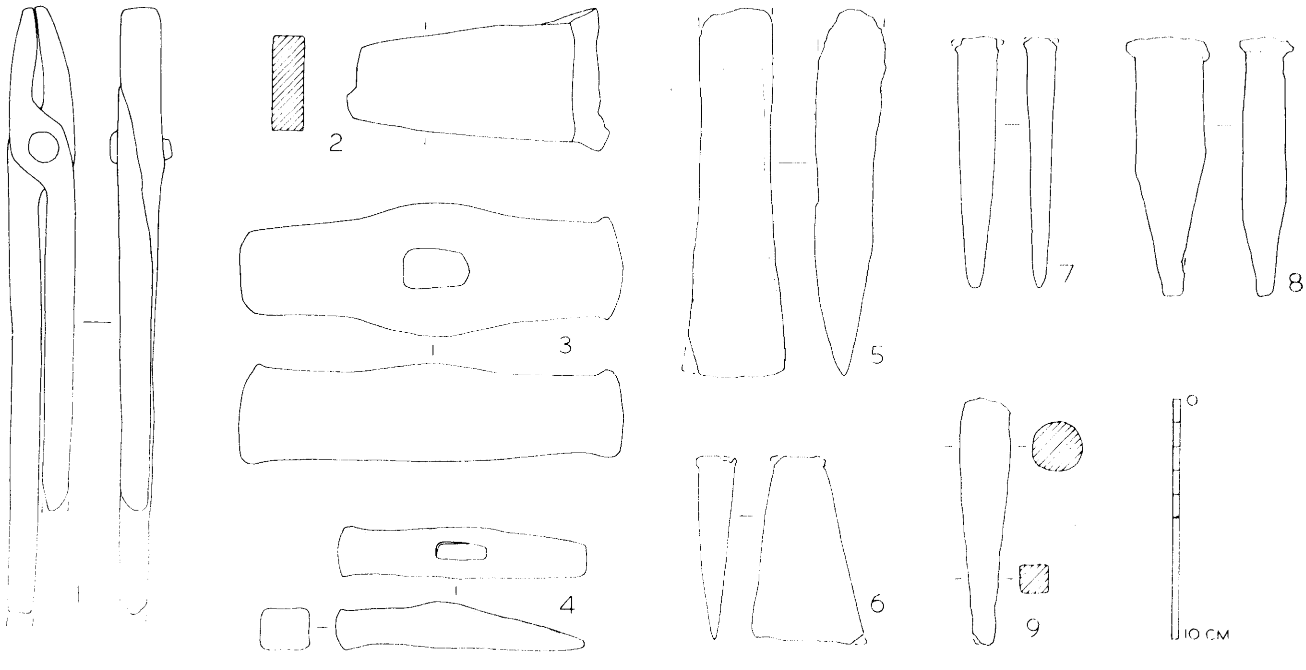


Fig 50 Ironworking tools

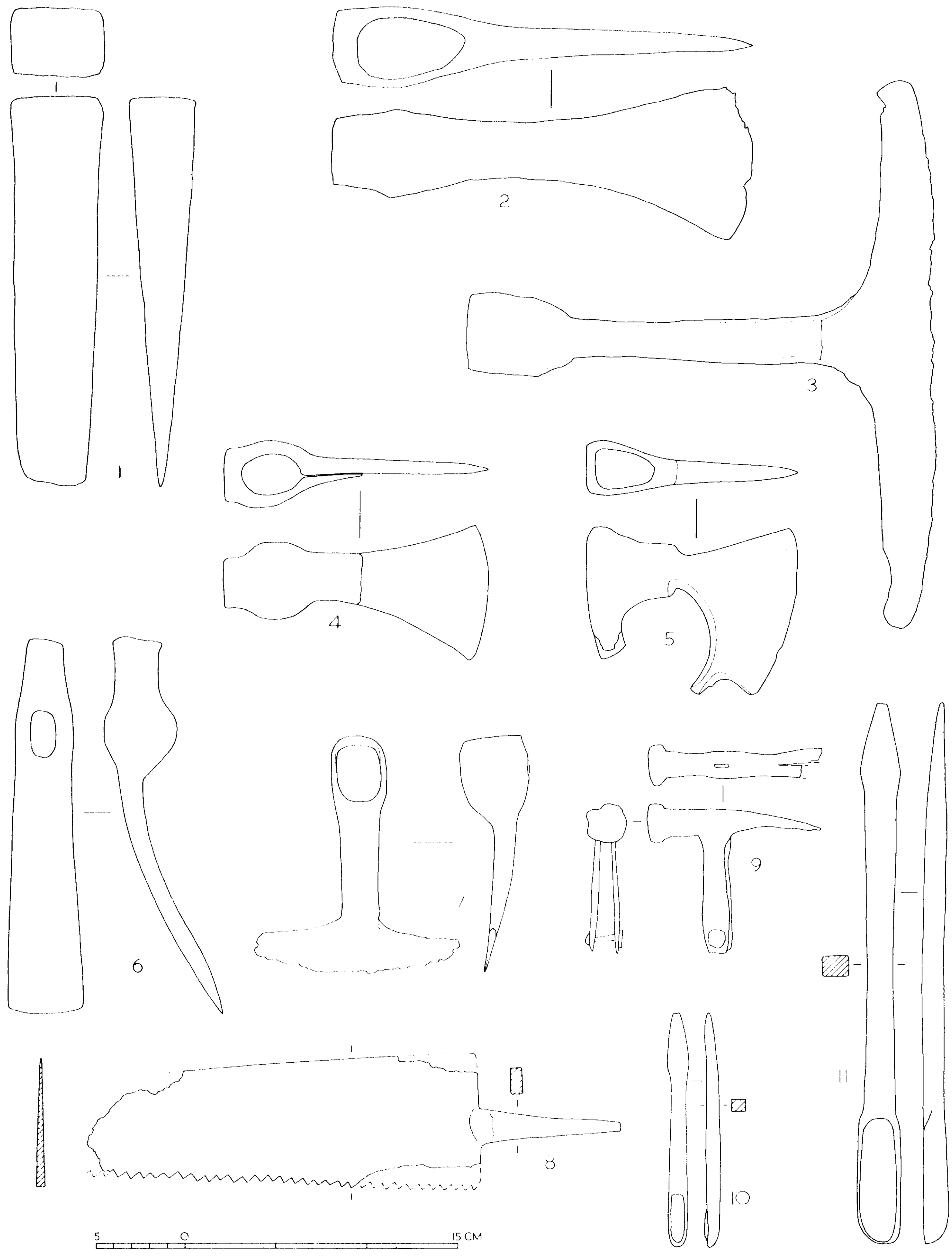


Fig 51 Woodworking tools

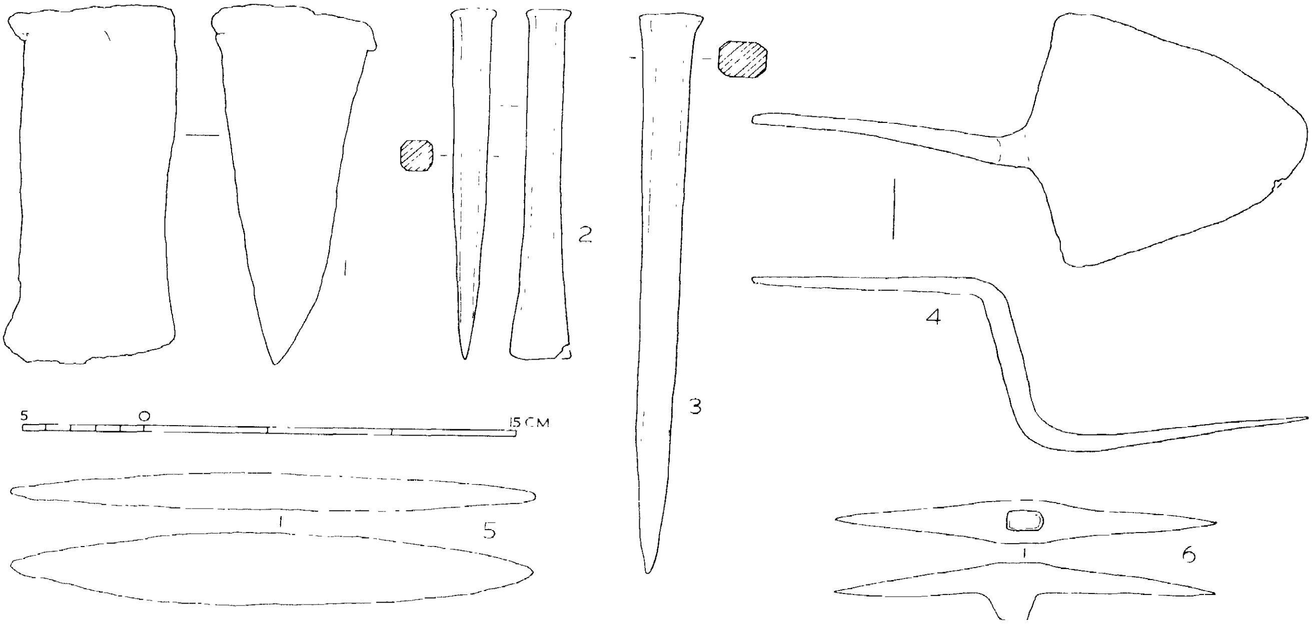


Fig 52 Stoneworking tools

conjunction with axes for felling trees and, when they were not sawn on trestles or in pits, for splittini trunks. Axes were also used for dressing timber, and whilst certain classes must have been used solely as tools or as weapons, others might be suitable-for either use. The woodman's axe from Weoley Castle, W Midlands (Fig 51,2),[4] a general-purpose tool suitable for lopping and felling, resembles an earlier example from Hurbuck, Durham, found with other tools and weapons including a T-shaped axe (Fig 51,3).[5] Both types of axe are depicted in the Bayeux Tapestry (Stenton 1957, 169, pls 38, VII), the latter dressing timber, an appropriate use for the axes from Deganwy Castle (Fig 51,4; Alcock 1967) and Wroughton Copse, Wilts (Fig 51,5).[6]

Adzes such as that from Goltho Manor, Lincs (Fig 51,6),[7] and a similar one from Thetford (Wilson 1976, 257, fig 6,1d), were used for removing heavy waste and for levelling and trimming the surface of timber, as was the T-shaped example from Hurbuck (Fig 51,7; *ibid,* 257, fig 6,1f). A long slender adze from Hurbuck *(ibid,* 257, fig 6,lc), not unlike another from Rochester, Kent (Harrison 1970, 112, fig 6), may have been used to cut mortices. Saws are rare finds but include the double-edged blade from Thetford (Wilson 1976, 257, fig 6,4b) and the medieval hand saw from Windcliff, Isle of Wight (Fig 51,8; Dunning 1939, 135-7, fig 3). The claw-hammer, although also used by farriers, may be regarded principally as a carpenter's tool which was as capable of withdrawing nails as of driving them in. The hammer from North Elmham Park, Norfolk (Fig 51,9; Goodall 1980a, 513, fig 266,54), with its side straps, is the most common form.

Augers with iron bits set in transverse wooden handles were used to drill holes in wood, and the surviving spoon bits range in size from examples as small as that from Somerby, Lines (Fig 51,10: Mynard 1969,84, fig 13, IW.88) to that from Cheddar, Somerset (Fig 51,11; Goodall 1979a, 267, fig 90,146). The larger bits were ideal for drilling pegholes in structural timbers, or in the preliminary stages of cutting a mortice, whilst the smaller ones may have been used for furniture, panelling, and drilling tool handles prior to the insertion of tangs. Gouge bits and twist bits are found, but less frequently than spoon bits. The chisel from Glastonbury Tor, Somerset (Rahtz 1970, 53, fig 23,11) is one of a very small number of woodworkers' chisels; other tools found include shaves (Waterman 1953, 213, fig 1,22) and reamers (Goodall 1975a, 87, fig 41,91).

Stoneworking tools (Fig 52)

Stone required for building, unless reused from existing buildings, had to be quarried, and documents provide much information about this and about the tools employed (Salzman 1967, 119-39, 331-3). Wedges, mauls, crowbars, picks, and axes used in rough dressing are mentioned, but actual examples are rare; they include the wedge from Castell-y-Bere, Gwynedd (Fig 52,l; Butler 1974, 97, fig 8,13).

The chief tools of the mason are the axe with two vertical edges, the axe-hammer with one edge and a hammer head, the punch, and the chisel. Documents also mention saws and borers for cutting up and piercing blocks of stone, and trowels so constantly used in building. Masons' tools are rare in the early medieval period, perhaps not unexpectedly when buildings were generally timber-framed, but medieval tools include a chisel from Barton Blount, Derbyshire (Fig 52,2; Goodall 1975a, 97, fig 46,6) and a punch from King's Lynn, Norfolk (Fig 52,3; Goodall 1977b, 295, fig 134,38). Castell-y-Bere also produced a trowel (Fig 52,4; Butler 1974, 97, fig 8,14).

Millstones required dressing with picks and bills mounted in wooden handles, and a mill-pick (Fig 52,5)[8] is known from the mill-sluice at South Witham, Lincs (Freese 1957, 102-7). Stone slates were quarried and trimmed by specialist craftsmen, and the slater's pick from Kirkcudbright Castle, Dumfries and Galloway (Fig 52,6; Dunning *et al* 1957-8, 137-8, fig 7,1) would have been used to make holes.

Textile manufacture (Fig 53)

Iron was used for various implements involved in textile manufacture, not least for sheep shears like those from Cambokeels, Durham (Hildyard 1949, 199, fig 6,4). With both wool and flax fibres, a common requirement was the need to disentangle them with a woolcomb or heckle. Individual teeth resembling that from Eaton Socon, Cambs (Fig 53,l; Addyman 1965, 65, fig 11,3) are not infrequent finds, but complete heckles are rare, since they were usually composite objects with one or more rows of iron teeth set in a wooden stock. An unusual find is the plate from Thetford (Fig 53,2; Goodall forthcoming a), which must have fitted a rectangular stock. An early 16th century heckle from Pottergate, Norwich (Carter *et al* 1974-7,47) has two rows of teeth set in a semicircular backplate.

After weaving and fulling the wet cloth was stretched on tenters, the most tangible remains of which are tenter hooks similar to that from Brixworth, Northants (Fig 53,3; Goodall 1977c, 94, fig 9,15). Over 70 tenter hooks are known from medieval layers at Winchester (Goodall forthcoming b). Tenters comprised pairs of horizontal rails set between posts; hooks were set in rows along each rail, those in the upper rail pointing upwards, those in the lower downwards. Cloth was attached to the hooks and the tension was adjusted by moving the rails between housings on the posts. The final process in finishing woollen cloth involved raising the nap of the cloth with teazels and then triming it with shears similar to those which appear in carvings at Cullompton, Devon (Carus-Wilson 1957, 104-9, pls XII, XV-XVI). Hooks like that from Goltho Manor (Fig 53,4)[7] secured the cloth to the shearboard in the manner shown on a bench-end at Spaxton, Somerset (Carus-Wilson 1957, 106, pl XVc), and the finished cloth went to various people, including the tailor. No broad-bladed scissors of the type shown in illuminations are yet known although some of the larger pairs of shears, including those from Seacourt, Oxon (Fig 55,13), may have been used in tailoring. Sewing needles of iron, such as those from King's Lynn (Goodall 1977b, 295, fig 134,40) and London (Fig 53, 5-6; Henig 1974, 195, fig 39,87), are not uncommon-

Leatherworking tools (Fig 53)

A varied group of tools was used during the tanning and working of leather. These included large blades to remove the hair and flesh from hides and eventually to split them. Tanned leather was cut with a half-moon-shaped knife similar to that from Badby, Northants (Fig 53,7)[9] and it is possible that smaller knives of the type found at Wallingstones, Hereford and Worcester (Fig 53,8; Bridgewater 1970-2,100, fig 16,12) were used likewise- A different type of knife was used by the shoemaker to trim leather and cut soles and an example from Oakham Castle, Leics (Fig

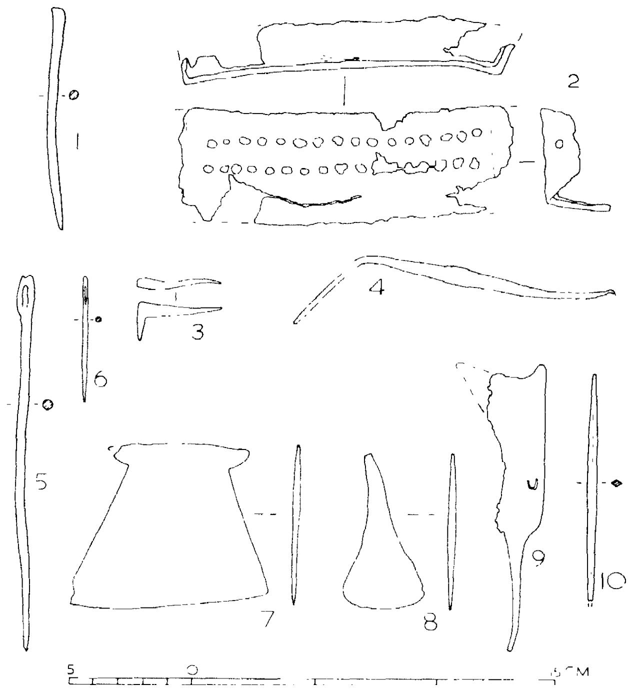


Fig 53 Textile manufacturing and leatherworking tools

53,9; Gathercole 1958, 33, fig 10,1) was found in a deposit with leather shoes and offcuts. The spike is inconvenient for use as an awl and may have been used for piercing thongs. Awls, generally straight and shaped like that from Northampton (Fig 53,10; Goodall 1979b, 273, fig 119,57), were used to pierce holes.

Agricultural and gardening equipment (Fig 54)

The form of ploughs is known from manuscript illuminations and descriptions, but the archaeological evidence is meagre and includes a ploughshare from St Neots (Addyman 1973,94, fig 19,30) and two coulters from London (London Museum 1954, 123-4, pl XXII). Scythes and sickles used in harvesting are often broken, but fairly complete examples include those (Fig 54,1-2) from King's Lynn (Goodall 1977b, 295, fig 138,35) and West Hartburn, Durham (Still & Pallister 1964, 200, fig 6,31). Pruning hooks and weedhooks, the latter often used in conjunction with a forked stick (Higgs 1965,8, pls 15a, 17b), are tanged, flanged, and socketed and display a variety of blade forms, as those (Fig 54,3-5) from St Neots (Addyman 1973, 93-4, fig 19,26), Wallingstones (Bridgewater 1970-2, 100,114-15, fig 16,32), and Somerby (Mynard 1969,85, fig 13, IW.94) demonstrate. Heavier lopping and hedge laying, if not carried out with an axe, might have involved the use of a billhook like that from North Elmham Park (Fig 54,6; Goodall 1980a, 513, fig 266,50). Ayton Castle, N Yorks (Rimington & Rutter 1967, 60, fig 11,37/20) produced a pitchfork (Fig 54,7) found with a group of scythes and an axe. Socketed spuds similar to that

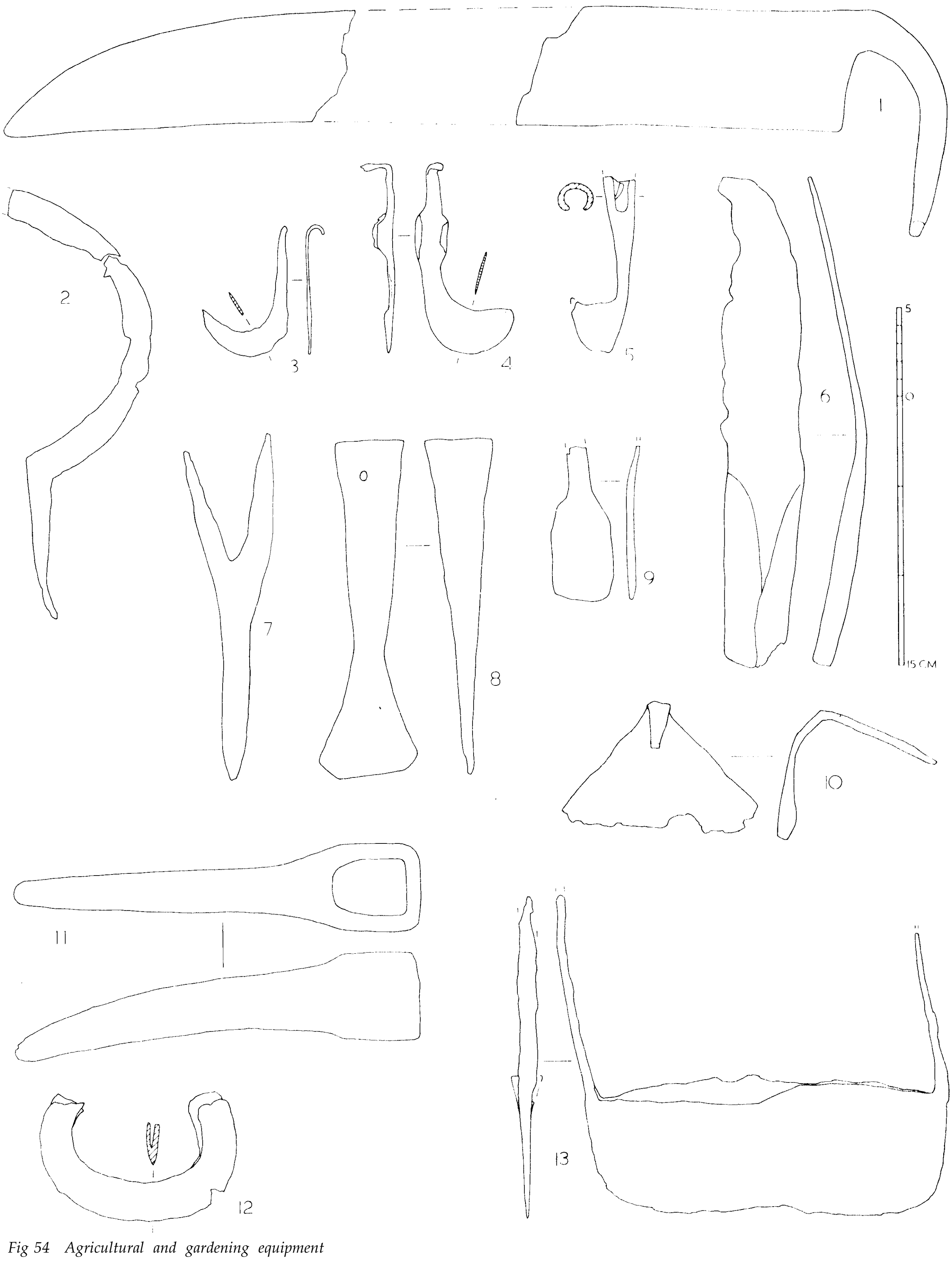


Fig 54 Agricultural and gardening equipment

from Upton, Gloucs (Fig 54,8; Rahtz 1969a, 108, fig 12,87) may have fitted shepherds' staves (Salzman 1957, 91-4) and been used to throw clods of earth; tanged spuds like that from Barton Blount (Fig 54,9; Goodall 1975a, 98, fig 46,7) were used for weeding. Hoes, although obviously gardening tools, could have been used for mixing mortar; that from Brandon Castle, Warwicks (Fig 54,10; Chatwin 1955, 81, fig 11,17), found in a garderobe pit, evidently had another use. Single-ended picks such as that from Lydney Castle, Gloucs (Fig 54,11; Casey 1931, 252, pl XXV,7) had several uses, not all agricultural. Illuminated manuscripts depict a wide range of shapes of spade iron on the blades of wooden spades (Hassall 1970), and they are matched by a late Saxon round-ended spade iron from Ufton Nervet, Berks (Fig 54,12; Goodall 1973-4,55-6, fig 31,3) and by medieval rectangular and triangular spade irons from Northolt Manor, Greater London (Fig 54,13)[10] and Lydford Castle, Devon (Goodall 1980b, 165, fig 18,3). Garden forks are occasionally found, as at Askett, Bucks (Beresford 1966-70, 366, fig 22).

Knives, shears, and scissors (Fig 55)

Knives were used for a wide variety of purposes in daily life, and the range of types and of size and shape is consequently considerable. The two main types of knife have whittle tangs inserted into handles and scale tangs with riveted handles, but a small group with pivoting blades is known from several sites with 10th and 11th century occupation. A complete example of this latter type of knife from Northampton (Fig 55,l; Goodall 1979b, 268, fig 118,31) has a decorated bone handle held together by three iron rivets, one of which also acts as a pivot and another as a stop when the blade is successively opened and closed. These knives are quite slender and cannot have been subjected to forceful use.

Whittle-tang knives have a continuous history during the period under review and the main blade forms are shown in Fig 55,2-7. Knives with rising or flat angled backs, exemplified by those from Oxford (Goodall 1977d, 142, fig 25,6) and Cheddar (Fig 55,2-3; Goodall 1979a, 264, fig 90,18) were in use until at least the 13th century; the remainder (Fig 54,4-7), represented by those from Cheddar (*ibid*, *266*, fig 90,190), Goltho (Goodall 1975a, 79-82, fig 37,14), York (Richardson 1959, 83, fig 18,5), and Bramber Castle (Barton & Holden 1977, 66, fig 20,4), continued in use for a longer period. Scale-tang knives, common from the 13th or 14th century, characteristically have straight backs in line with the back of the tang, although a few, such as that from Barrow Mead, Somerset (Fig 55, 8; Goodall 1976a, 34, fig 11, 17), copy the whittle-tang form with a shoulder at the junction of blade and tang. The blades are otherwise often slender, their form like those from Goltho (Goodall 1975a, 79-82, fig 37,37) and Wintringham (Fig 55,9-10; Goodall 1977a, 257, fig 43,15).

Whittle-tang knives must generally have been regarded as utilitarian objects mounted in simple wooden or bone handles, but they were also sometimes embellished. The blade of a knife from Oxford (Hinton 1977, 142, fig 25,5) is inlaid, as is one from London (Cowen 1971), and another from Brooklands,

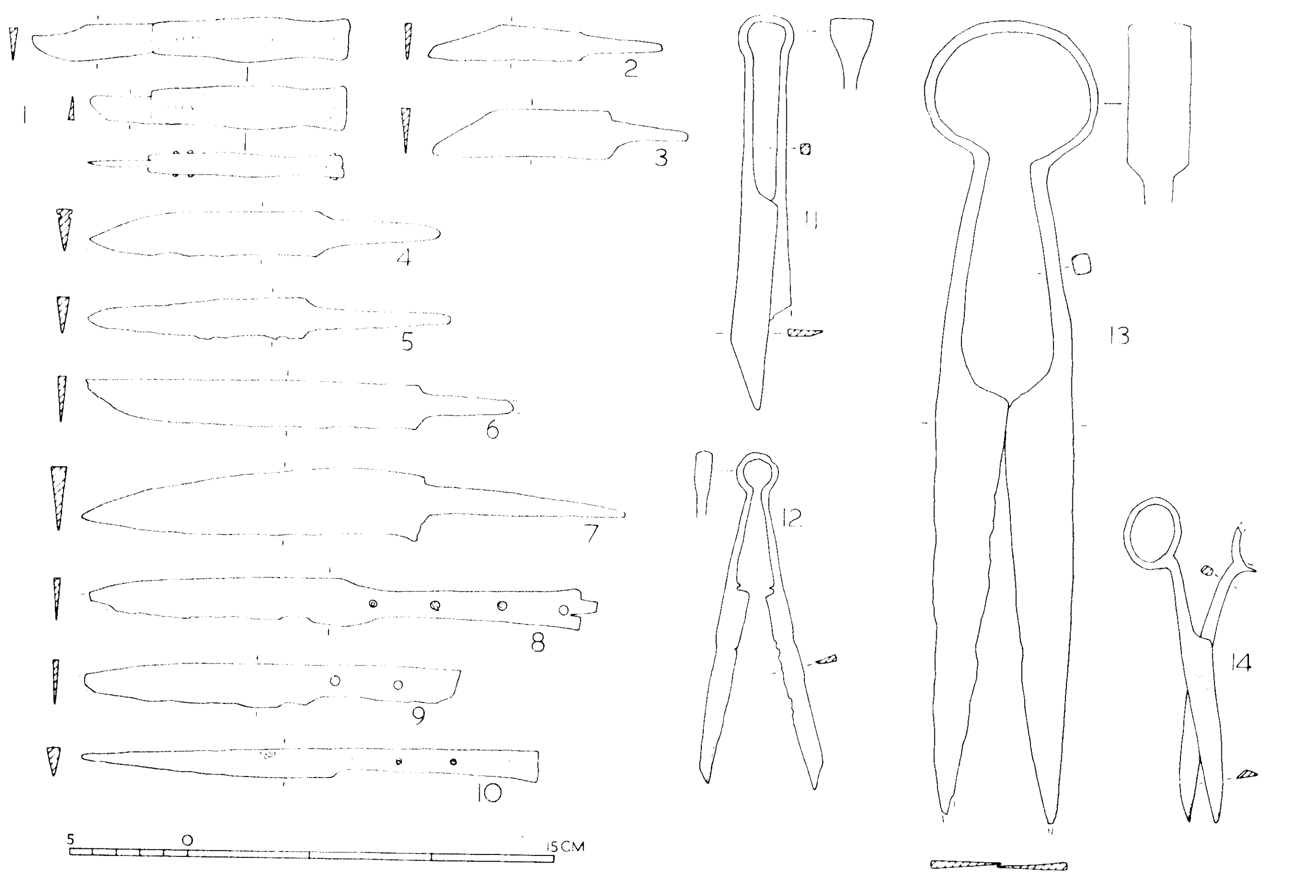


Fig 55 Knives, shears, and scissors

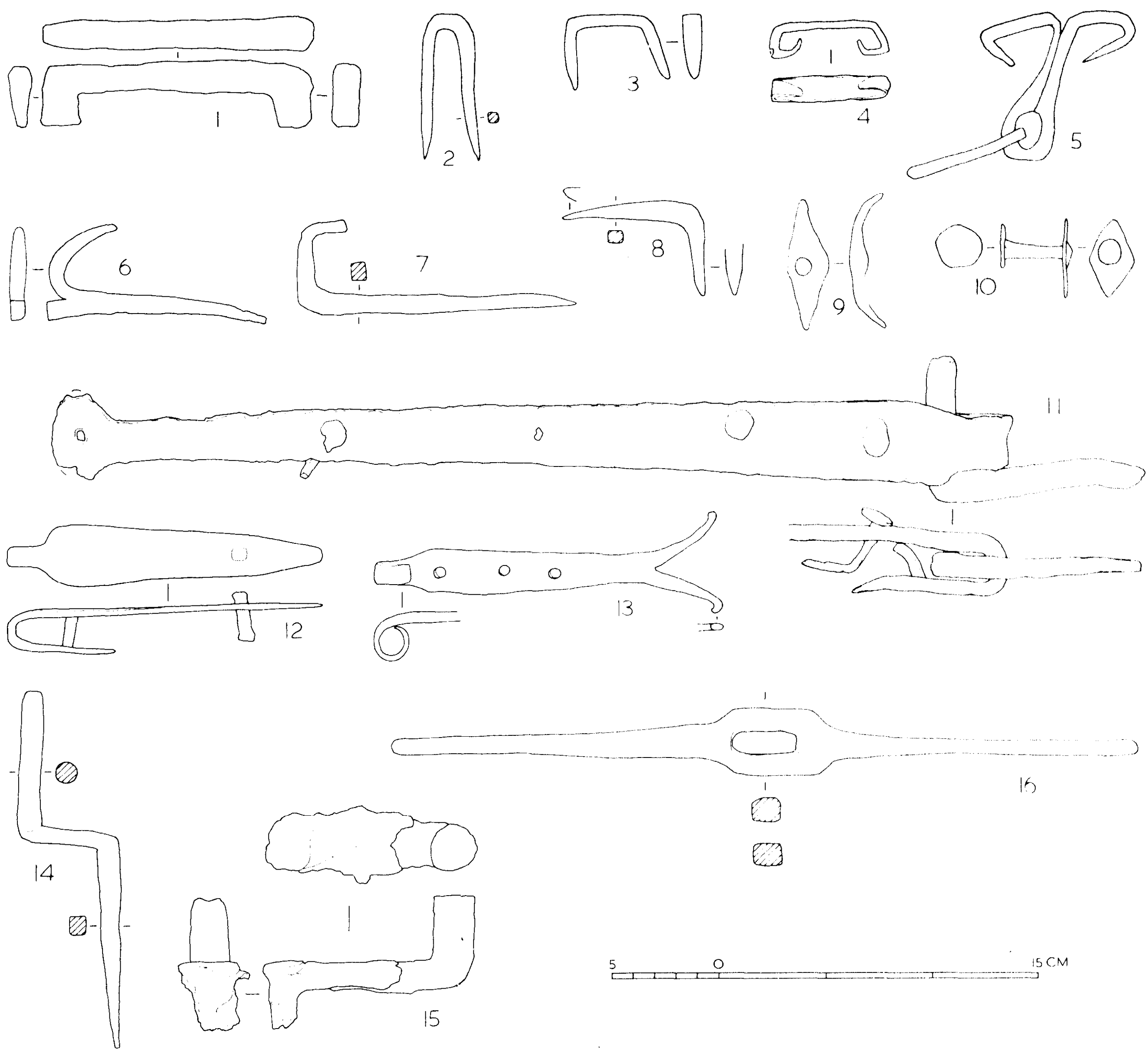


Fig 56 Building ironwork

Surrey (Goodall 1977e, 73, fig 45,4) has a series of sheet metal plates at the base of its handle which originally alternated with organic plates. Another from Wythemail, Northants (Hurst & Hurst 1969, 200, fig 60,15) has a single plate over the inner handle end. Caps on the ends of handles and non-ferrous shoulder plates fronting each side of the handle are occasionally found on whittle-tang knives but are more appropriate to those with scale tangs. One such knife from Rievaulx Abbey, N Yorks (Dunning 1965, 58-60, fig 6) has an inlaid pattern of pins set in its handle and a solid end cap.

The cutlery trade, in its most organized form, was divided into the four main sections (Hayward 1957, 5-6) of bladesmith, hafter, sheather, and cutler, the latter putting the parts together and selling the finished article. The work of the cutler is demonstrated by marks, normally inlaid in the medieval period, struck on knife blades. The Wintringham knife (Fig 55,10) has such a mark, as have others from Goltho (Goodall 1975a, 79, p1 VII).

Shears, as noted above, were used for shearing sheep and napping cloth, but the bulk are smaller and more appropriate to domestic uses such as cutting thread and hair. Most are plain, like those from Cheddar (Fig 55,11; Goodall 1979a, 266, fig 90,198), while others, including some from Goltho (Fig 55,12; Goodall 1975a, 82, fig 37,45), have cusping in imitation of more elaborate bronze examples (London Museum 1954, 155-8, pl XXXII, 11, 13-15). The incipient bow of the Cheddar shears recalls that of others, including a pair from the Middle Saxon settlement at Maxey, Northants (Addyman 1964,60, fig 16,11), and foreshadows the full bow characteristic of most medieval shears. The large pair of shears from Seacourt, Oxon (Fig 55, 13; Biddle 1961-2, 172, fig 29,1) may have been used for cutting cloth. Domestic scissors, which include the pair from Cheddar (Fig

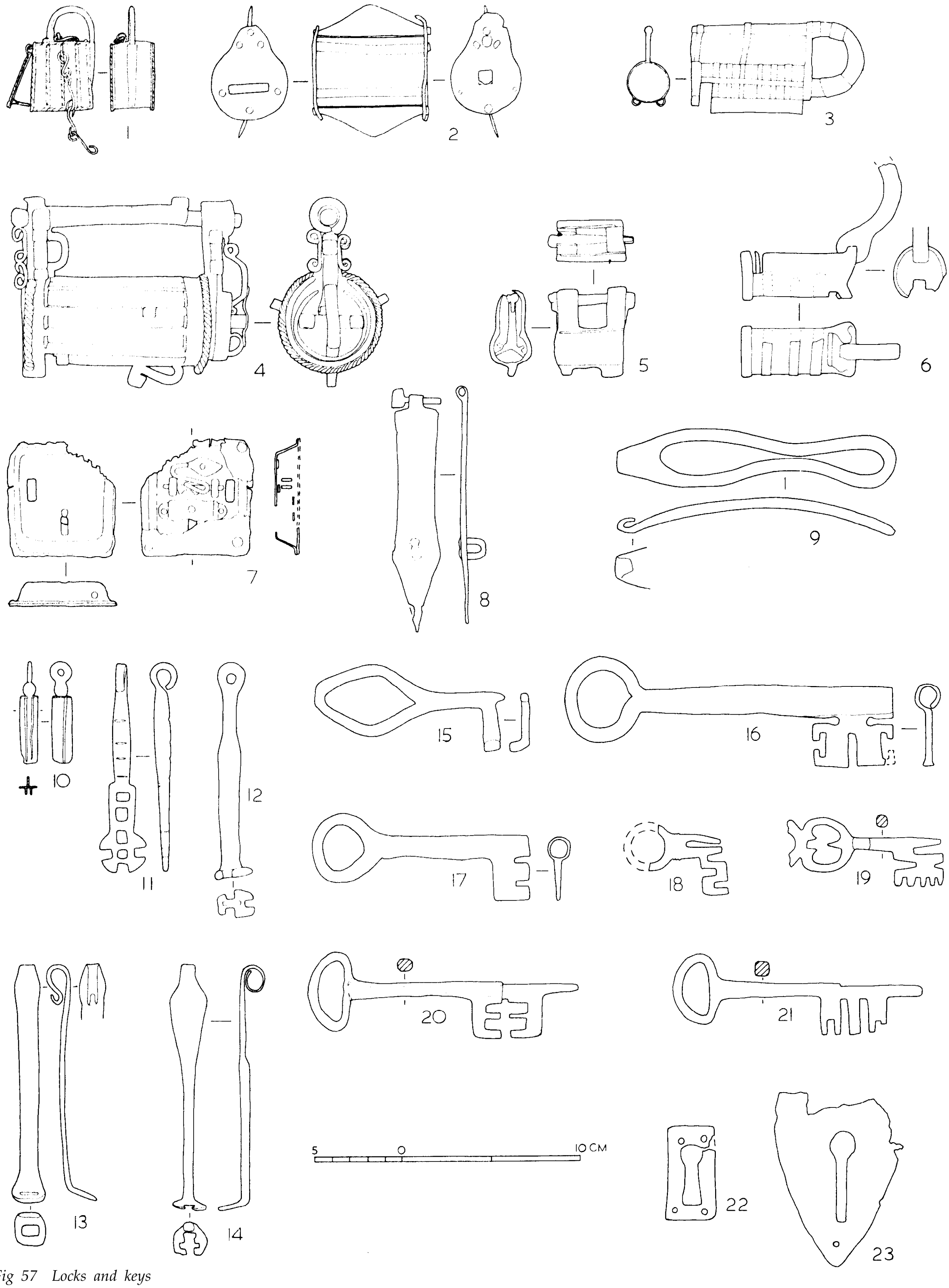


Fig 57 Locks and keys

55,14; Goodall 1979a, 266, fig 90,3) occur occasionally but it is clear that shears were in more widespread use.

Building ironwork (Figs 56, 57)

Iron had little place in the structure of buildings. whether timber-framed or stone built, but its importance in fitting them out is indicated both by documentary references (Salzman 1967, *passim)* and archaeological finds. Masonry cramps similar to that from Goltho (Fig 56,l; Goodall 1975a, 86, fig 40,78) were often set in lead to secure them and prevent their rusting and splitting the stonework they held; staples such as those from King's Lynn (Fig 56,2-3; Goodall 1977b, 296, fig 134,52,55), Wintringham (Fig 56,4; Goodall 1977a, 257, fig 45,51), and Brandon Castle (Fig 56,5; Chatwin 1955, 81, fig 11,ll) served many functions including securing hasps and chains. Wall-hooks, whose forms include those of examples from Pleshey Castle, Essex (Fig 56,6; Goodall 1977f, 177, fig 38,22) and Norwich (Fig 56,7; Hurst & Golson 1955, 99, fig 24,7) were driven into timbers or wall crevices as required, whilst angle ties like that from King's Lynn (Fig 56,8; Goodall 1977b, 296, fig 134,58) strengthened the junction of timbers. Nails are ubiquitous finds on most sites, and classified groups include those from Waltham Abbey (Goodall 1973, 175, fig 13,1-9). Shaped roves as from Goltho (Fig 56,9; Goodall 1975a, 86, fig 40,83) or complete clench bolts like that from King's Lynn (Fig 56,l0; Goodall 1977b, 297, fig 135,69) are commonly associated with ship construction, although they were also employed in buildings, as at Yeavering, Northumberland (Hope-Taylor 1977, 193, fig 91,10-20). They were also used in such double-thickness timber construction as the ledge and batten door at St Helen, Stillingfleet, N Yorks (Addyman & Goodall 1979,90, fig 9) and the Lydford Castle well-cover (Geddes 1980, 165, fig 17).

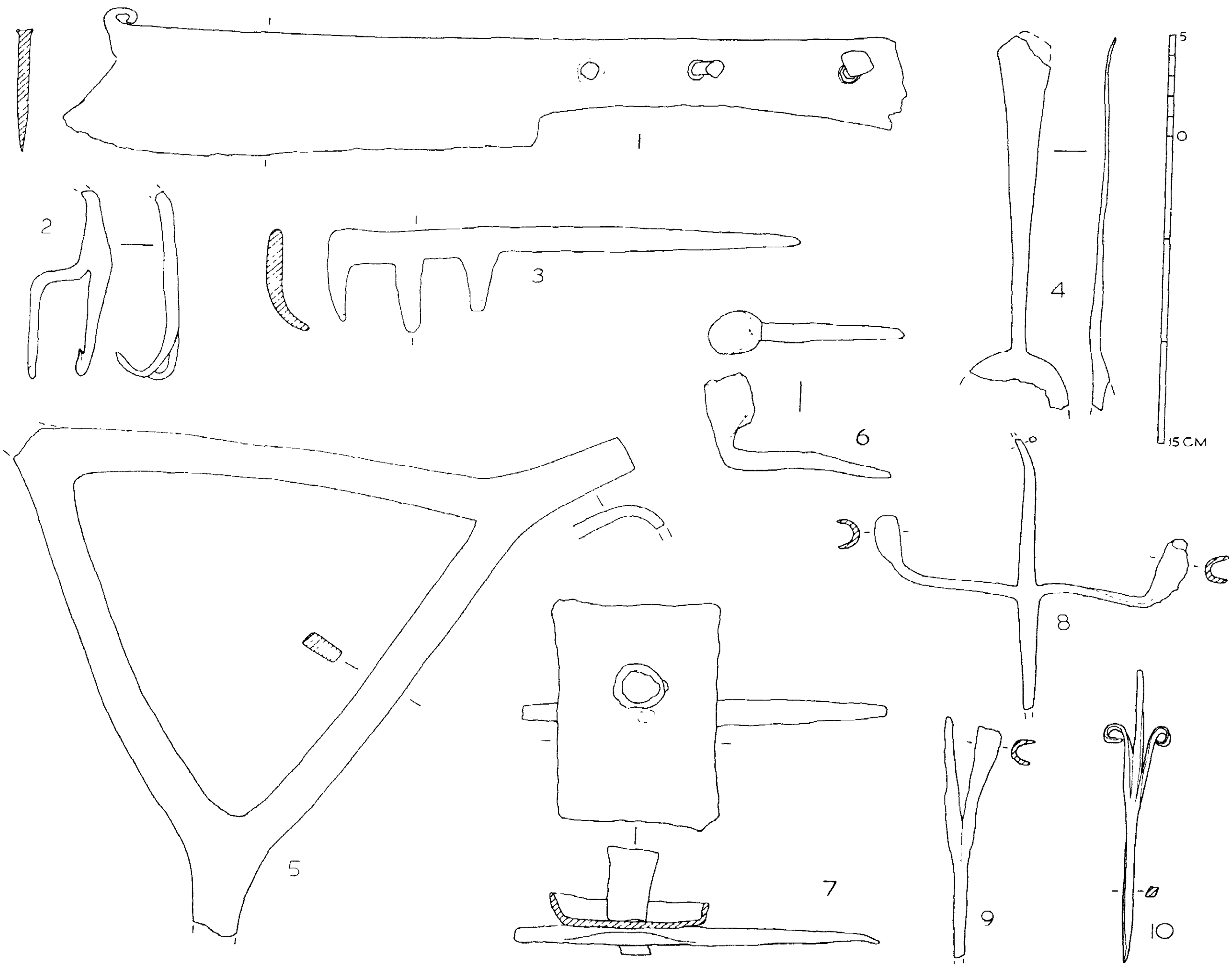


Fig 58 Domestic ironwork

Doors in castles and manor houses as well as in churches had elaborate hinges, although most surviving strap hinges are simpler, as those (Fig 56,11-13) from Wintringham (Goodall 1977a, 257, fig 44,30), Netherne (Ketteringham 1976, 56, fig 34,5), and Goltho (Goodall 1975a, 86, fig 40,75) indicate. The supporting hinge pivots are of varying sizes, reflecting the range of doors, shutters, and gates which they carried. The pivot from Rievaulx Abbey (Fig 56,14)[11] supported a harr-hung door, that is one supported on pivots top and bottom, in contrast to the common type used with the Wintringham hinge (Fig 56,ll) which was driven into the masonry or timber frame. Pivots set in rebates in masonry are often like that from Penhallam, Cornwall (Fig 56,l5; Goodall 1974b, 139, fig 46,3) which has a downturned end and retains its lead caulking. An alternative type, typified by an example from Hen Blas, Clwyd (Leach 1960, 14, fig 10) has a split shank. Window ironwork is occasionally found and includes the horizontal bar from Kirkcudbright Castle (Fig 56,16) with its eyelet for a vertical member (Dunning *et al* 1957-8, 138, fig 7,3).

Strap hinges were used on chests and armoires (Eames 1977, 7-54, 108-80) as well as on doors, and all required lock fittings. Early medieval padlocks are few in number but include the box padlock from York (Fig 57,1)[12] and a more unusual example from Northampton (Goodall 1979b, 268, fig 116,2) which was operated by a revolving key. During the medieval period the barrel padlock was in almost universal use and five main types can be isolated, the two most common and practical types being represented by padlocks from Winchester (Fig 57,3; Cunliffe 1964, 189, fig 66,8) and King's Lynn (Fig 57,6; Goodall 1977b, 291, fig 132,4), the latter having a shackle. The other types (Fig 57,2,4-5) are represented by padlocks from Christchurch, Hants (Goodall forthcoming c), London (Waddington 1928, 524-6), and Alvechurch, Hereford and Worcester (Oswald 1954, 8, pl 5,4). Barrel padlocks with shackles were used to secure human and animal limbs, and to avoid chafing the cases were generally plain; the other padlocks, however, often have cases decorated by attached straps or ribs, as on those illustrated and another from Boston, Lincs (Goodall 1972, 40-1, fig 7,l). Locks with sliding bolts known from Goltho (Fig 57,7; Goodall 1975a, 84, fig 39,65) and Oxford Castle moat (Goodall 1976b, 300, fig 28,59) have rectangular openings in their cases for stapled hasps. The Goltho lock, as the hole in the bottom of the case indicates, had an integral hasp, but the Oxford lock must have had an independent hasp similar to one from Barrow Mead (Fig 57,8; Rahtz 1960-1, 76, fig 8,l).

Padlocks were often used in conjunction with figure-eight hasps such as that from Kettleby Thorpe (Fig 57,9; Goodall 1974a, 33, fig 18,7). Padlock keys were drawn or pushed along the springs of padlock bolts, compressing them and enabling the bolt to be withdrawn from the case. The main types are shown in Fig 57,10-14,[13] whilst nos 15-21 reflect the range of key used principally with locks with sliding bolts.[14] Shaped keyhole escutcheons on doors and chests are sometimes emphasized in illuminated manuscripts, and excavated examples (Fig 57,22-3) include those from Barrow Mead (Goodall 1976a, 35, fig 11,20) and Brandon Castle (Chatwin 1955, 81, fig 11,l0).

Domestic ironwork (Fig 58)

Iron was important in the kitchen where it was used for a wide range of implements and fittings, including cleavers like that from Huish, Wilts (Fig 58,l; Shortt 1972, 120, fig 4,24). Fleshhooks with two and three arms and short tangs are known from both pre- and post-Conquest contexts, as at York (MacGregor 1978, fig 26,l0) and Brooklands (Fig 58,2; Goodall 1977e, 73, fig 45,18); the later type of fleshhook has a long handle with hooks set at right angles, as at Northolt Manor (Fig 58,3; Hurst 1961, 289, fig 76,16). The spoon from Broughton, Lincs (Fig 58,4; Goodall 1974c, 11, fig 3,25) is a rare example in iron. Iron vessels include the pan (Dunning 1962, 184-6, fig 8) and some ladles (Goodall forthcoming b) from Winchester and a griddle plate from Beere, Devon (Jope & Threlfall 1958, 138, fig 34,l). No cauldron similar to those shown in illuminated manuscripts has been found, but a pot-crane from Pottergate, Norwich (Carter *et al* 1974-7,47) and a tripod from Northampton (Fig 58,5; Goodall 1979b, 273, fig 120,85) are known. Handles and escutcheons from buckets are not infrequently found, and complete buckets include that from Castell-y-Bere (Butler & Dunning 1974, 100-6, fig 10).

Other fittings from within buildings are candleholders, that from Wintringham (Fig 58,6; Goodall 1977a, 258, fig 46,48) being an example of the commonest type. The candleholder from Grenstein, Norfolk (Fig 58,7)[15] combines socket and wax pan in the manner of copper alloy examples such as that from Writtle, Essex (Rahtz 1969b, 91, fig 51,118), while two from South Witham (Fig 58, 8-9)[16] combine pricket and open socket in differing ways. The simple pricket candlestick from London (Fig 58,l0; Henig 1974, 191, fig 38,70) is both practical and decorative.

Personal equipment (Fig 59)

Buckles were made in every metal from gold to iron, and while the most utilitarian in iron are plain, shaped frames are not uncommon. Iron buckles have a wide variety of shapes, as a sample from Somerby (Fig 59,1-5; Mynard 1969, 81-2, fig 11, IW.34,39,46,37, 41) indicates. Many buckles were plated to avoid

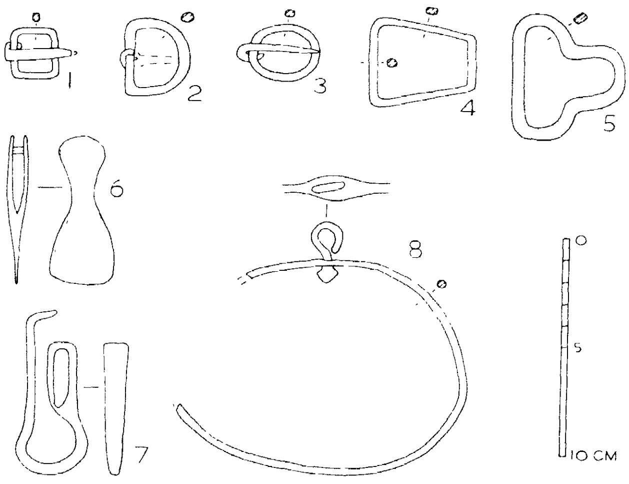


Fig 59 Personal equipment

corrosion and no doubt to simulate more noble metals. Other types of belt fitting occur most frequently in copper **alloy,** but iron finds include the belt end from Cheddar (Fig 59,6; Goodall. 1979a, 271, fig 91,58), a belt hook from Salisbury, Wilts (Fig 59,7),' and a simple purse frame supported by a swivel hook from King's Lynn (Fig 598; Goodall 1977b, 295, fig 134,48). Highly elaborate iron purse frames are also known (London Museum 1954, 166-7, pl XXXVI), but tweezers from London (Henig 1974, 191, fig 3855) and Cheddar (Goodall 1979a, 267, fig 90,22) were probably used for non-domestic purposes.

Horse equipment (Fig 60)

Horseshoes with countersunk nailholes and usually with the consequent wavy edge are found in pre-Conquest contexts **and were** not supplanted until the 13th century by the type with rectangular nailholes and a plain edge. The earlier type, typified by a horseshoe from Ellington (Fig 60,l; Goodall 1971, 68, fig 12,3), was almost invariably nailed with fiddle-key nails with semicircular heads no thicker in profile than the shank; the later nails had an eared, enlarged head which developed into a different form in the late medieval period when shoes were forged from broader iron, like that from Somerby (Fig 60,2; Mynard 1969, 80, fig 10, IW.12).

Bridle bits, stirrups, and spurs are discussed in detail elsewhere (London Museum 1954, 77-112). Medieval currycombs, used in grooming horses, took the form of a sheet-iron comb of angular or semicircular section with toothed edges to which a two- or three-armed handle was riveted. Currycombs from Southampton (Fig 60,3; Goodall 1975b, 282, fig 254,2049) and Wharram Percy, N Yorks (Goodall 1979c, 121, fig 63,65) each have two arms.

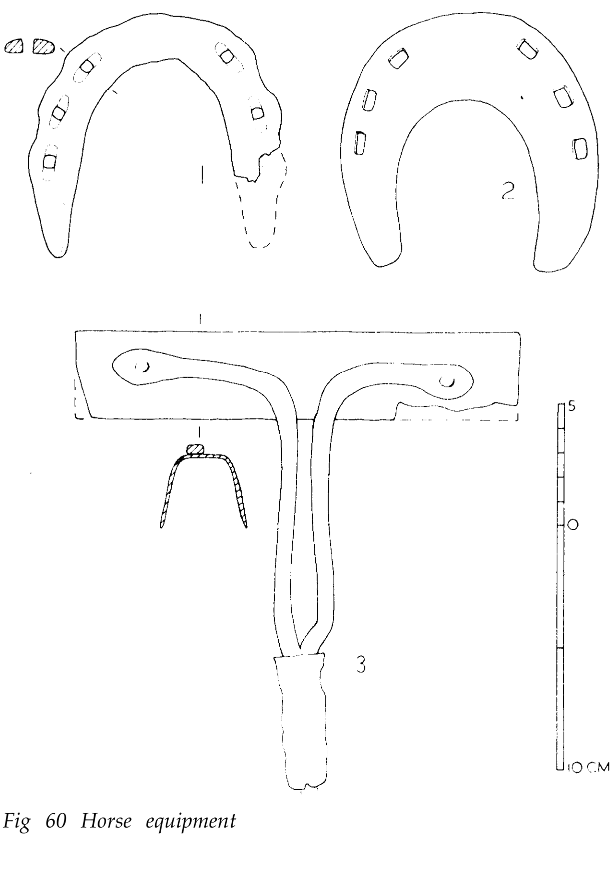


Fig 60 Horse equipment

Notes

1 Information from L Biek.
2 Found in Bailey area of castle of 1245-65 built on site with earlier occupation. For site see Alcock 1967.
3 Excavated by A Barr Hamilton.
4 Birmingham City Museum & Art Gallery, WC 364; for site see Oswald 1962.
5 Wilson 1976, 255-7, fig 6,1h (caption location incorrect).
6 Excavated by P J Fowler.
7 Excavated by G Beresford.
8 Pick excavated by P Mayes.
9 Excavated by Mrs M Gray.
10 Excavated by J G Hurst.
11 Dept Environment, Dir Ant Mon Hist Bldgs reserve collection, RVA 226(A).
12 Richardson 1959, 81-3, fig 18,4 (full size, not half).
13 10: Excavated by Mrs M Gray at Badby, Northants; 11: Goodall 1977b, 293, fig 133, 7; 12: Goodall 1971,67, fig 12,1; 13: Goodall 1974a, 30, fig 18,1; 14: Goodall 1977b, 293, fig 133,5.
14 15: Goodall 1979a,263,fig90,96; 16: Casey 1931, 252-3, pl XXXV, 8; 17: Butler 1974,97, fig 9,24; 18: Harvey 1975, 279, fig 252,2022; 19: Bridgwater 1970-2, 102, no 10 (in Hereford City Museum & Art Gallery); 20: Shortt 1972,166, fig 2,6; 21: Goodall 1977f, 174, fig 38, 1.
15 Excavated by P Wade-Martins.
16 Excavated by P Mayes.
17 Salisbury & S Wilts Museum, Salisbury Drainage Collection.

Bibliography

Addyman, P V, 1964 A Dark-Age settlement at Maxey, Northants, *Medieval Archaeol*, **8**, 20–73

———, 1965 Late Saxon settlements in the St Neots area: 1, The Saxon settlement and Norman castle at Eaton Socon, Bedfordshire, *Proc Cambridge Antiq Soc*, **58**, 38–73

———, 1973 Late Saxon settlements in the St Neots area: 3, The village or township at St Neots, *ibid*, **64**, 45–99

Addyman, P V, & Goodall, I H, 1979 The Norman church and door at Stillingfleet, North Yorkshire, *Archaeologia*, **106**, 75–105

Alcock, L, 1967 Excavations at Degannwy Castle, Caernarvonshire, 1961–6, *Archaeol J*, **124**, 190–201

Barton, K J, & Holden, E W, 1977 Excavations at Bramber Castle, Sussex, 1966–67, *ibid*, **134**, 11–79

Beresford, G, 1975 *The medieval clay-land village: excavations at Goltho and Barton Blount*, Soc Medieval Archaeol Monogr Ser, **6**

———, 1966–70 The Old Manor, Askett, *Rec Buckinghamshire*, **18**, 343–66

Biddle, M, 1961–2 The deserted medieval village of Seacourt, Berkshire, *Oxoniensia*, **26–7**, 70–201

Biddle, M, Barfield, L, & Millard, A, 1959 The excavation of the Manor of the More, Rickmansworth, Hertfordshire, *Archaeol J*, **116**, 136–99

Bridgewater, N P, 1970–2 The medieval homestead of Wallingstones, *Trans Woolhope Natur Fld Club*, **40**, 75–116

Butler, L A S, 1974 Medieval finds from Castell-y-Bere, Merioneth, *Archaeol Cambrensis*, **123**, 78–112

Butler, L A S, & Dunning, G C, 1974 in Butler 1974

Carter, A, Roberts, J P, & Sutermeister, H, 1974–7 Excavations in Norwich 1973. The Norwich Survey third interim report, *Norfolk Archaeol*, **36**, 39–71

Carus-Wilson, E, 1957 The significance of the secular sculptures in the Lane Chapel, Cullompton, *Medieval Archaeol*, **1**, 104–17

Casey, D A, 1931 Lydney Castle, *Antiq J*, **11**, 240–61

Chatwin, P B, 1955 Brandon Castle, Warwickshire, *Trans Birmingham Warwickshire Archaeol Soc*, **73**, 63–83

Cowen, J D, 1971 The Southwark knife reconsidered, *Antiq J*, **51**, 281–6

Cunliffe, B W, 1964 *Winchester excavations 1949–60*, **1**

Dunning, G C, 1939 A thirteenth-century midden at Windcliff, near Niton, *Proc Isle Wight Natur Hist Archaeol Soc*, **3.2**, 128–37

———, 1962 in Excavations near Winchester Cathedral, 1961 (M Biddle & R N Quirk), *Archaeol J*, **119**, 150–94

———, 1965 Heraldic and decorated metalwork and other finds from Rievaulx Abbey, Yorkshire, *Antiq J*, **45**, 53–63

Dunning, G C, Hodges, H W M, & Jope, E M, 1957–8 Kirkcudbright Castle, its pottery and ironwork, *Proc Soc Antiq Scot*, **91**, 117–38

Eames, P, 1977 *Medieval furniture: furniture in England, France and the Netherlands from the twelfth to the fifteenth century*

Freese, S, 1957 *Windmills and millwrighting*

Gathercole, P W, 1958 Excavations at Oakham Castle, Rutland, 1953–54, *Trans Leicestershire Archaeol Hist Soc*, **34**, 17–38

Geddes, J, 1980 in Lydford Castle, Devon (A D Saunders), *Medieval Archaeol*, **24**, 123–86

Goodall, I H, 1971 in Excavation of a moated site at Ellington, Huntingdonshire (C F Tebbutt, G T Rudd, & S Moorhouse), *Proc Cambridge Antiq Soc*, **63**, 31–73

———, 1972 in Finds from excavations in the refectory at the Dominican Friary, Boston (S Moorhouse), *Lincolnshire Hist Archaeol*, **7**, 21–53

———, 1973 in Huggins & Huggins 1973

———, 1973–4 in Excavations on Late Iron Age, Roman and Saxon sites at Ufton Nervet, Berkshire, in 1961-3 (W H Manning), *Berkshire Archaeol J*, **67**, 1–57

———, 1974a in Excavations on the site of the deserted medieval village of Kettleby Thorpe, Lincolnshire (E Russell), *J Scunthorpe Mus Soc*, 3 ser (Archaeology), **2**

———, 1974b in The medieval manor of Penhallam, Jacobstow, Cornwall (G Beresford), *Medieval Archaeol*, **18**, 90–145

———, 1974c in A late medieval domestic rubbish deposit from Broughton, Lincolnshire (S Moorhouse), *Lincolnshire Hist Archaeol*, **9**, 3–16

———, 1975a in Beresford 1975

———, 1975b in Platt & Coleman-Smith 1975

———, 1976a in *Barrow Mead, Bath, 1964 excavation* (J Woodhouse), Brit Archaeol Rep Brit Ser, **28**

———, 1976b in Excavations at Oxford Castle, 1965–73 (T G Hassall), *Oxoniensia*, **41**, 232–308

———, 1977a in Excavation of a moated house at Wintringham in Huntingdonshire (G Beresford), *Archaeol J*, **134**, 194–286

———, 1977b in *Excavations in King's Lynn 1963–1970* (H Clarke & A Carter), Soc Medieval Archaeol Monogr Ser, **7**

———, 1977c in Excavations in the vicarage garden at Brixworth, 1972 (P Everson), *J Brit Archaeol Ass*, **130**, 55–122

———, 1977d in Archaeological excavations in St Aldates, Oxford (B Durham), *Oxoniensia*, **42**, 83–203

———, 1977e in *Brooklands, Weybridge: the excavation of an Iron Age and medieval site 1964–5 and 1970–1* (R Hanworth & D J Tomalin), Surrey Archaeol Soc Res Vol, **4**

———, 1977f in *Pleshey Castle, Essex (XII-XIV century): excavations in the bailey, 1959–1963* (F Williams), Brit Archaeol Rep Brit Ser, **42**

———, 1979a in *The Saxon and medieval palaces at Cheddar. Excavations 1960–62* (P A Rahtz), Brit Archaeol Rep Brit Ser, **65**

———, 1979b in *St Peter's Street, Northampton. Excavations 1973–1976* (J H Williams), Northampton Development Corp Archaeol Monogr, **2**

———, 1979c in *Domestic settlement 1: areas 10 and 6* (eds D D Andrews & G Milne), Vol 1 of *Wharram. A study of settlement on the Yorkshire wolds* (ed J G Hurst), Soc Medieval Archaeol Monogr Ser, **8**

———, 1980a in Excavations in North Elmham Park (P Wade-Martins), *East Anglian Archaeol*, **9**

———, 1980b in Lydford Castle, Devon (A D Saunders), *Medieval Archaeol*, **24**, 123–86

———, forthcoming a in Excavations at Thetford, 1948–59 and 1977 (A Rogerson & C Dallas), *East Anglian Archaeol*

———, forthcoming b in *Winchester studies*, Vol 7, Pt 2 (M Biddle & S Keene)

———, forthcoming c in *Excavations in Christchurch 1969–1976* (K Jarvis), Dorset Natur Hist Archaeol Soc Monogr

Harrison, A C, 1970 Excavations in Rochester, *Archaeol Cantiana*, **85**, 95–112

Harvey, Y, 1975 in Platt & Coleman-Smith 1975

Hassall, W O, 1954 *The Holkham Bible Picture Book*

———, 1970 Notes on medieval spades, in *The spade in northern and Atlantic Europe* (eds A Gailey & A Fenton), 30–4

Hayward, J F, 1957 *English cutlery*

Henig, M, 1974 in Excavations at the Custom House site, City of London, 1973 (T Tatton-Brown), *Trans London Middlesex Archaeol Soc*, **25**, 117–219

Higgs, J W Y, 1965 *English rural life in the Middle Ages*, Bodleian Picture Book, no **14**

Hildyard, E J W, 1949 Further excavations at Cambokeels in Weardale, *Archaeol Aeliana*, 4 ser, **27**, 177–205

Hinton, D, 1977 in Archaeological excavations in St Aldates, Oxford (B Durham), *Oxoniensia*, **42**, 83–203

Hope-Taylor, B, 1977 *Yeavering. An Anglo-British centre of early Northumbria*, Dept of Environment Archaeol Rep, **7**

Huggins, P J, & Huggins, R M, 1973 Excavation of monastic forge and Saxo-Norman enclosure, Waltham Abbey, Essex, 1972–73, *Essex Archaeol Hist*, **5**, 127–84

Hurst, J G, 1961 The kitchen area of Northolt Manor, Middlesex, *Medieval Archaeol*, **5**, 211–99

Hurst, J G, & Golson, J, 1955 Excavations at St Benedict's Gates, Norwich, 1951 and 1953, *Norfolk Archaeol*, **31** (1), 1–112

Hurst, D G, & Hurst, J G, 1969 Excavations at the medieval village of Wythemail, Northamptonshire, *Medieval Archaeol*, **13**, 167–203

Jope, E M, & Threlfall, R I, 1958 Excavation of a medieval settlement at Beere, North Tawnton, Devon, *ibid*, **2**, 112–40

Ketteringham, L L, 1976 *Alsted: excavation of a thirteenth-fourteenth century sub-manor house with its ironworks in Netherne Wood, Merstham, Surrey*, Surrey Archaeol Soc Res Vol, **2**

Leach, G B, 1960 Excavations at Hen Blas, Coleshill Fawr, near Flint—Second report, *J Flintshire Hist Soc*, **18**, 13–48

London Museum 1954 *Medieval Catalogue*

MacGregor, A, 1978 Industry and commerce in Anglo-Scandinavian York, in *Viking Age York and the north* (ed R A Hall), CBA Res Rep, **27**, 37–57

Mynard, D C, 1969 Excavations at Somerby, Lincs, 1957, *Lincolnshire Hist Archaeol*, **4**, 63–91

Oswald, A, 1954 Excavation at Alvechurch, Worcestershire, 1951–2, *Trans Birmingham Archaeol Soc*, **72**, 5–9

———, 1962 Interim report on excavations at Weoley Castle, 1955–60, *ibid*, **78**, 61–85

Platt, C, & Coleman-Smith, R, 1975 *Excavations in medieval Southampton 1953–1969*, **1**, *The excavation reports*, **2**, *The finds*

Rahtz, P A, 1960–1 Barrow Mead, Bath, Somerset, *Proc Somerset Archaeol Natur Hist Soc*, **105**, 61–76

———, 1969a Upton, Gloucestershire, 1964–1968. Second report, *Trans Bristol Gloucestershire Archaeol Soc*, **88**, 74–126

———, 1969b *Excavations at King John's Hunting Lodge, Writtle, Essex, 1955–57*, Soc Medieval Archaeol Monogr Ser, **3**

———, 1970 Excavations on Glastonbury Tor, Somerset, 1964–6, *Archaeol J*, **127**, 1–81

Richardson, K M, 1959 Excavations in Hungate, York, *ibid*, **116**, 51–114

Rimington, F C, & Rutter, J G, 1967 *Ayton Castle. Its history and excavation*, Scarborough Dist Archaeol Soc Res Rep, **5**

Salzman, L F, 1957 Some notes on shepherds' staves, *Agr Hist Rev*, **5**, 91–4

———, 1967 *Building in England down to 1540. A documentary history*, 2 edn

Shortt, H de S, 1972 in Excavations on a medieval site at Huish, 1967–68 (N P Thompson), *Wiltshire Archaeol Mag*, **67**, 112–31

Stenton, F (ed), 1957 *The Bayeux Tapestry*

Still, L, & Pallister, A, 1964 The excavation of one house site in the deserted village of West Hartburn, Co Durham, *Archaeol Aeliana, 4 ser*, **42**, 187–206

Waddington, Q, 1928 Padlocks from the City, *Antiq J*, **8**, 524–6

Waterman, D, 1953 A group of twelfth-century pottery and other finds from Knaresborough Castle, *ibid*, **33**, 211–13

Wilson, D M, 1976 Craft and industry, in *The archaeology of Anglo-Saxon England* (ed D M Wilson)

The medieval bronzesmith worked with a number of alloys whose principal ingredient was copper, mixed with varying proportions of tin, zinc, and lead. For cold-worked material the alloy contained small amounts of tin and zinc while for cast material brass was used, a yellow alloy of copper and zinc together with small quantities of lead and tin to give greater fluidity to the molten metal (Tylecote 1962, 57-8). Since the composition of the alloy cannot be determined satisfactorily by visual examination but only by analysis, it is more accurate to speak of copper alloy rather than bronze, brass, or latten. Although all the raw materials were available there is very little evidence for the manufacture of brass in Britain until the post-medieval period. Before then brass is known to have been imported from the Continent as sheet metal, cullen (Cologne) plate, and as fine, tableware, Dinanderie, from Dinant on the Meuse. No doubt other finished artefacts were also imported although there is no reason why some scrap metal should not have been used as the raw material for small-scale casting.

Archaeological evidence for the working of copper alloys is not common and suggests working on a domestic scale rather than in an organized industry. many sites produce small pieces of slag and spillage and larger quantities of scrap metal and off-cuts. Crucible fragments have been found, for example, in Oxford, dating to the 11th and 12th centuries (Jope 1952-3, 96-7, fig 37; 1959, 72), York, dating to the late 12th to 13th centuries (Dyer & Wenham 1958, 423), and London, dating to the late 14th to 15th centuries (Blurton 1977, 86, nos 601-3). Another crucible found in York was associated with two 15th century hearths (Wenham 1972, 70, 73 and 92). Where such crucible fragments have been analysed it is suggested that they were used for melting copper or its alloys rather than for smelting the ore.

Recent excavations in York have uncovered hearths and furnaces and numerous fragments of clay moulds all relating to the casting of bells, and other cities have produced similar evidence. Stone moulds for casting buckles, brooches, etc have been found for instance at Rochester, dated to the 14th century (Spencer in Harrison & Flight 1968, 102-3, fig 18, 4a-b, pl IVB), York, from 13th to 15th century levels (Richardson 1959, 100, fig 28, 10), and West Whelpington, Northumberland (Jarrett & Belcher in Jarrett 1970, 292, pl XXXI, 2). In some cases matrices are cut into both sides of the stone. The tools used in working copper alloy have not so far been identified in the post-Conquest period although some small iron chisels and tongs (above, p 51) may have been used in non-ferrous metalworking. With other information being comparatively scarce the most important evidence for medieval working of copper alloys is, therefore, the artefacts themselves.

The range of copper-alloy objects excavated from post-Conquest sites in Britain is large and demonstrates a wide variety of manufacturing techniques, the primary methods being the casting of molten metal and the cold working of sheet metal and wire.

Casting was perhaps the most versatile technique and was used to produce objects from church bells, mortars, and cannon to small personal ornaments. Simple objects were cast in open or two-piece moulds while hollow wares required more complex moulds with a central core. These latter moulds often had to be broken to release the casting and could therefore be used only once, although further moulds could sometimes be made from the original pattern. Vessels of sheet metal could be formed by hammering or by spinning on a lathe, while wire was made, for example, into pins and chain links. The surface of finished objects was smoothed by filling and rubbing with an abrasive.

Decoration was often applied to the surfaces of objects, sometimes during casting, sometimes after finishing. A strap-end from Goltho, Lincs (Fig 61, 1; I H Goodall in Beresford 1975, 91, fig 43, 3), of approximately 14th century date, has a zoomorphic design engraved on it. In many cases incised lines are not cleanly cut but were probably made by repeated pecking using a fine punch and a hammer. The very characteristic curving zig-zag line, used as a border design and as infilling and seen on a buckle-plate from Oxford (Fig 61, 2; AR & I H Goodall in Durham 1977, 148, fig 30, l), was probably produced by rocking a chisel-like tool from side to side as it was pushed across the surface of the metal. Lines of opposed triangles made with a roulette or perhaps a small punch were used as borders or in simple decorative schemes as on the buckle-plate from Stockbridge Down, Hants (Fig 61, 3; Hill 1937, 249, pl Ia) and the tweezers from Pleshey Castle, Essex (Fig 65, 10; Williams 1977, 185, fig 41, 9) and Old Sarum, Wilts (Fig 65, 11; Salisbury Museum OS AS). The repoussé decoration of thin sheet metal would have required a range of different punches and stamps and it is unfortunate that none of these tools has as yet been recognized. Raised lines and pellets were produced using a round-headed scriber or punch while the cabled lines were made with a rectangular or parallelogram-headed punch, or possibly with a roulette. Daisy and rosette stamps were also used. All these motifs are demonstrated by material from a buckle-maker's workshop found in a rubbish pit on the site of the Blossoms Inn extension, Cheapside, London (Fig 61, 4-9; Museum of London acc no 21111) and dated by pottery *c* 1500. The openwork motifs within scribed circles were made either with a multiple punch (Fig 61, 8) or, in less regular examples, with a single punch.

The final appearance of the copper alloy was sometimes enhanced by gilding, probably using gold leaf, or by plating with white metal: the plating on the strap-end from Oxford (Fig 66, 11; A R & I H Goodall in Durham 1977, 148, fig 30, 19) consisted of 70% tin and 30% silver. A black coating having the appearance of a paint or lacquer was also sometimes used, for instance on some of the strap-ends from the Blossoms Inn site, but so far its composition has not been determined. Inlaying with enamel and niello seems to have been reserved for fine decorative pieces and the gemstone settings on copper-alloy jewellery

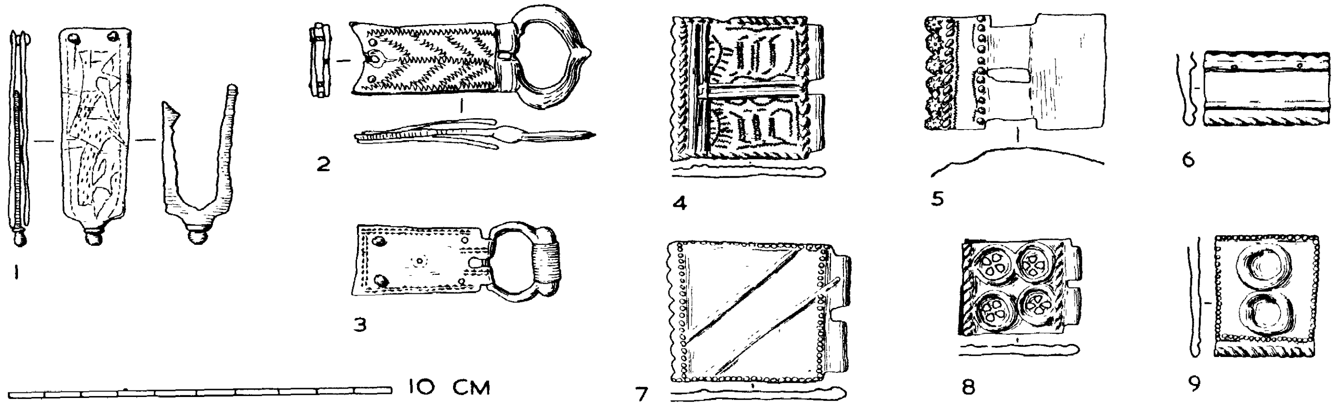


Fig 61 Techniques of decoration on copper-alloy objects

appear to have been filled with vitreous paste as the embellishment of base metals with precious stones or metals was forbidden (Salzman 1964, 139).

The standard of workmanship of the medieval bronzesmith seems to have been variable. Although the gilds of craftsmen exercised a strict control over the quality of their members' products, much decorative work is crudely executed and castings are often rough. It may be that most excavated copper-alloy ornaments represent merely cheap copies of the precious metal examples worn by the wealthy and were not intended to be viewed closely.

A survey of a few of the objects most commonly found on post-Conquest sites illustrates the techniques and skills of the medieval bronzesmith and indicates the range of his products.

Objects used in trade and commerce

Small balances of copper alloy were used by money-changers, shop-keepers, and druggists, for example. They comprise a beam, usually of cast metal, but occasionally of rolled sheet (eg one from Southampton, Harvey in Platt & Coleman-Smith 1975, 257, fig 241, 1748) and sometimes with the arms hinged as in the example from Goltho (Fig 62, l; I H Goodall in Beresford 1975, 95, fig 44, 37), which was suspended in a stirrup; from the ends of the arms hung the pans of sheet metal, commonly either round or triangular in shape. The form of these balances seems to have changed very little throughout the medieval period: pre-Conquest examples come from Thetford, Norfolk (A R Goodall in Rogerson & Dallas forthcoming) while a similar balance is shown in Holbein's portrait of the merchant, Georg Gisze, dated 1532 (Staatliche Museen, Berlin-Dahlem; Gombrich 1966, 275, fig 231). The trebuchet type of balance was used to check the weights of specific coins: the weight and weighing platform are integral with the beam. The example from Alsted, Surrey (Fig 62, 2; I H Goodall, Dolley, & Ketteringham in Ketteringham 1976, 62-3, fig 38, 18) was found in a 13th century context.

The weights found on archaeological sites are more often of lead than of copper alloy and may be difficult to identify with certainty. Lead-filled pear-shaped steelyard weights have been found at Writtle, Essex (Rahtz 1969, 91, fig 51,121) and Castell-y-Bere, Gwynedd (Butler 1974, 93, fig 6, 1), the latter in a 13th century context: neither has the heraldic shields characteristic of the type (Renn 1959, 148-9).

Seal matrices often have only a small, perforated lug handle, as on two late 14th century examples from Southampton (Harvey in Platt & Coleman-Smith 1975, 255, fig 240, 1722-3) but the characteristic form is conical, either plain or faceted, with a loop for suspension. The seal matrix from Penhallam Manor, Cornwall (Fig 62, 3; Rigold in Beresford 1974, 143, fig 48), has a faceted cone and has been dated to the 13th or 14th century, although the 16th century portrait of Georg Gisze (above) illustrates a seal of the same type which evidently remained in use for a long period,

Domestic objects

Fragments of copper-alloy vessels are frequently found in excavations although intact vessels are rare. Basins and dishes of sheet metal are particularly unlikely to survive but may perhaps be represented by numerous fragments of sheet, often patched: cast

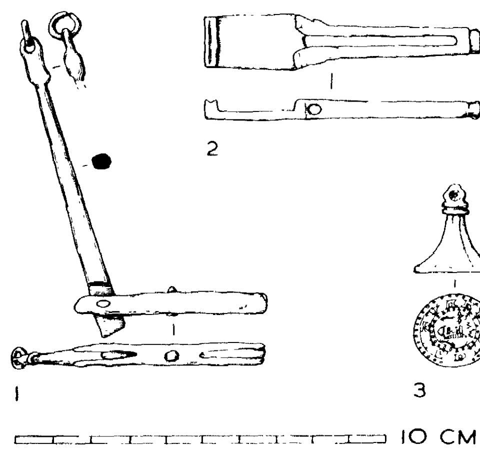


Fig 62 Objects used in trade and commerce

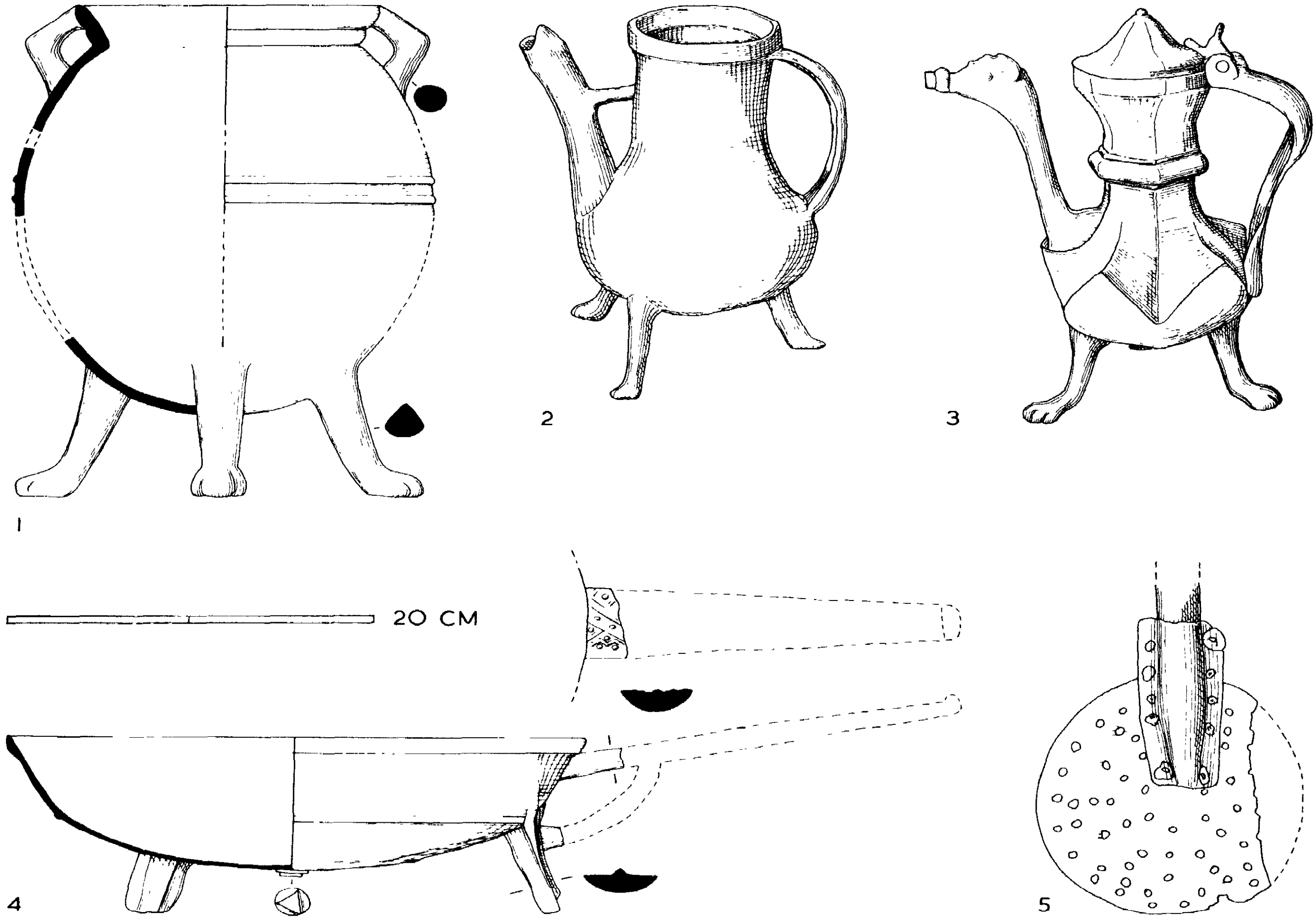


Fig 63 Jugs and kitchenware

metal vessels would have had a longer life. Household inventories and wills suggest that metal pots were valuable possessions which would be handed down from one generation to the next.

The cauldron was perhaps the most important item of kitchenware and is illustrated in many contemporary manuscripts (London Museum 1954, 206, fig 68). Early medieval cauldrons were probably more or less hemispherical in shape with a loop handle for suspension, but in the late 12th century the characteristic form of cast cauldron appeared and continued with very little modification until the 18th century when cast iron cauldrons began to be made. The body is usually globular or bag-shaped; the latter type is thought to be the insular variety while the more globular cauldrons were probably imported from the Continent (Lewis 1978, 32). They have flaring rims, a pair of handles at the rim for suspension, and three legs. Later examples often have raised cordons around the belly and the feet may be elaborated. The cauldron from Southampton (Fig 63, 1; Harvey in Platt & Coleman-Smith 1975, 260, fig 242, 1782) shows both these features; it has a somewhat bag-shaped body and is probably of the 16th century. A detailed study of cauldrons has been made by Drescher (1968).

The cauldrons can be seen to have been cast in two-piece moulds around a solid core (Marshall 1950, 66-75). The round print which often survives at the base of the body indicates where the molten metal was run into the mould, and a vertical line around the outside of the body results from inaccuracies in making the outer mould pieces. The handles and legs were generally cast in one piece with the body by inserting false cores into the mould.

Skillets most commonly have a body form similar to that of cauldrons: they have three legs but the two handles are replaced by a single strip handle, braced underneath to provide extra strength. An example of this type, dated to the 15th century, comes from Pateley Bridge, N Yorks (Gilks 1979,147-50, fig 5). A second, rarer, type with a shallower body and longer handle is represented by a skillet from Stanford in the Vale, Berks (Fig 63, 4; Dunning 1962).

Excavated fragments of cooking vessels usually have no indication of plating but it seems likely that the internal surfaces would have been tinned to prevent the copper from being attacked by acids in the food; this was certainly done in the 17th century (Rowlands 1975, 34-5).

Perforated spoons were used to skim off the fat from the surface of the stew in the cauldron and these have been found for example at Strood, Kent (Rigold 1965, 125, fig 12, 3) and at Norwich (Fig 63, 5; Hurst & Golson 1955, 99, fig 24, 14) where they probably date to the 15th century. They have round flat bowls with a socket of sheet metal riveted on to the back. Contemporary illustrations, for example in the 14th century Luttrell Psalter (London Museum 1954, 206, fig 68, 8) and the early 16th century Grimani Breviary (*Grimani* 1972, f 642r), show that they would have had long wooden handles. Spoons are otherwise more commonly of pewter than of copper alloy and excavated finds are usually of post-medieval date.

Jugs and ewers of copper alloy occur in the later medieval period and appear to have been used for washing the hands; similar vessels of pewter or the more noble metals were used to contain wine. The different forms of later medieval jug have been studied by Theuerkauff-Liederwald (1975); they are often ornate, having for example reeded decoration on the body and spouts formed into birds or animals. Many of the jugs have hinged lids and they may have flat bases, pedestals, or three feet as in the examples illustrated, from Fortrose (Fig 63, 2; Geddie 1879-80, 182) and Ashkirk, near Selkirk (Fig 63, 3; *Proc Soc Antiq Scotland,* 83 (1948-9), 240, pl XXXVII, 1). Sometimes the spout and handle were not cast in one piece with the body of the jug, and detached spouts showing no fracture line are not uncommon finds.

Medieval candlesticks were more commonly of iron although examples in copper alloy are known and many contemporary illustrations show what appear to be gilt candlesticks of simple form. Both socketed and pricket types were in use throughout the period. Earlier candlesticks had three legs, sometimes hinged for folding as in the 13th century example from York (Fig 64, 1; Wenham 1972, 95, fig 20, 7), while the cylindrical or conical base of the London candlestick (Fig 64, 2; London Museum 1954, 182, fig 55, 2) seems to be characteristic of the late medieval period.

Small domestic objects

This class of objects comprises such groups as needleworking tools and toilet implements. Needles are not commonly found in dated medieval contexts and so it is difficult to identify characteristic features. They are normally made from wire, although an example from Wharram Percy, N Yorks (Fig 65, 1; A R Goodall in Andrews & Milne 1979, 112, fig 57, 81) is made from tightly rolled sheet metal: the flattened head is found on other needles of the period. for instance a late medieval example from Ospringe, Kent (A R Goodall in Smith 1979, 142, fig 27, 162). Triangular sectioned tips occur on late and post-medieval needles as on that from Southampton (Fig 65, 2; Harvey in Platt & Coleman-Smith 1975, 260, fig 242, 1781), dated to the 15th to 16th century. Thimbles from medieval contexts have short, nearly vertical sides and domed tops. Often they are of cast metal and are thick in section as in the example from Brixworth, Northants (Fig 65, 3; A R Goodall in Everson 1977, 93, fig 8, 8) or they may be of sheet metal like that from Goltho (Fig 65, 4; I H Goodall in Beresford 1975, 93, fig 44, 31). The pits are normally arranged in a continuous spiral. An illustration dated 1425 (Treue *et al* 1965, pl 13) shows the pits being made in a thimble using a drill. Ring-shaped thimbles with tapering sides and no ton are also known.

Pins are less common in the medieval period than in the 16th and 17th centuries. The normal type was probably that with a head of coiled wire, though the heads were not necessarily stamped as they were in the later period; they may be illustrated by examples from Hadleigh Castle, Essex (Fig 65, 5-6; I H Goodall in Drewett 1975, 144, fig 29, 366 and 379). Large dress pins with ornamental heads are more likely-to date from the pre-Conquest period although later examples, like that from Staines, Middlesex (Fig 65, 7; Barker in Crouch 1976, 121, fig 24, 4) are found.

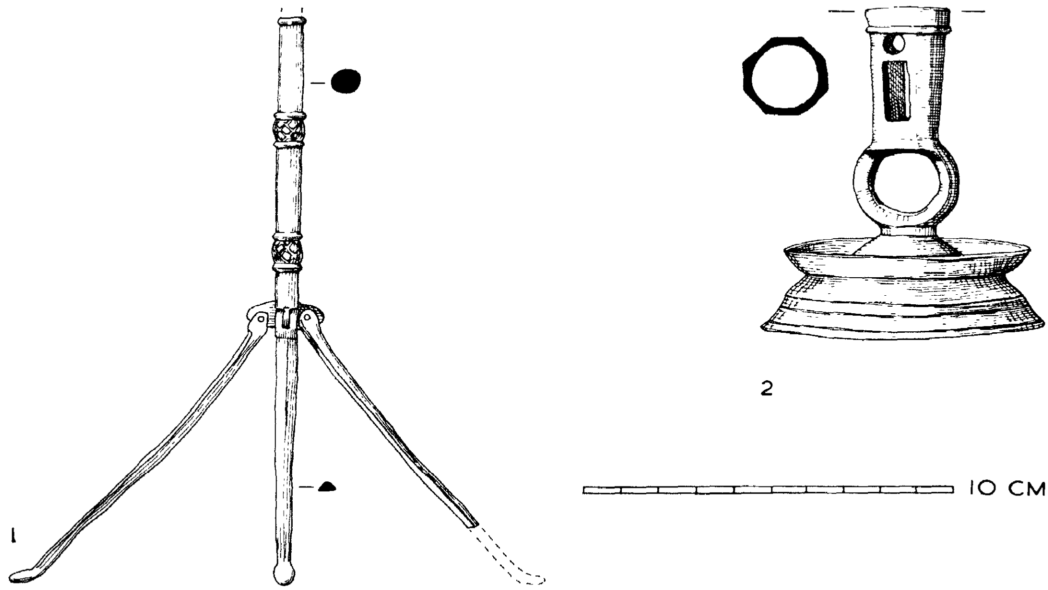


Fig 64 Candlesticks

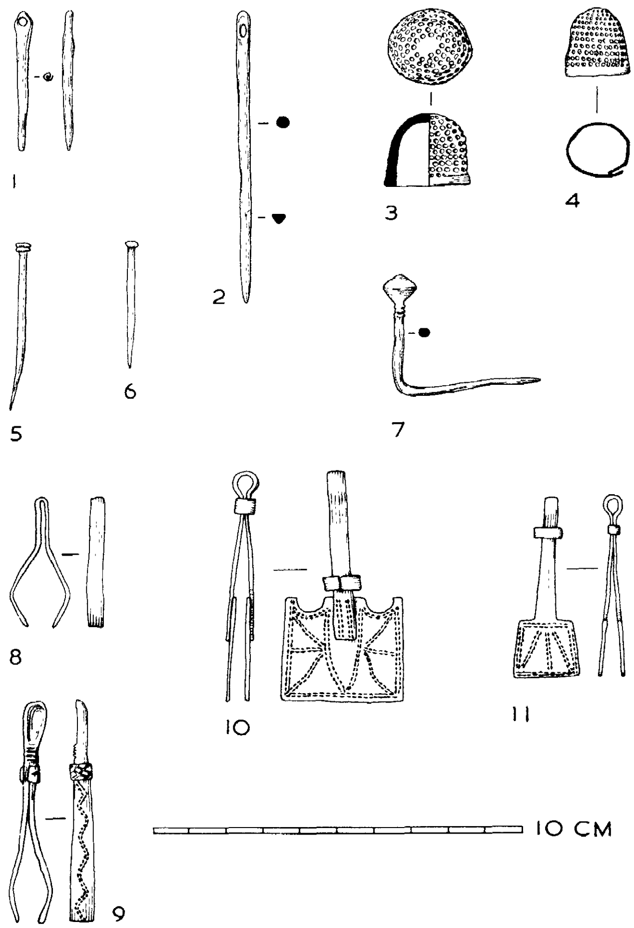


Fig 65 Needleworking and toilet implements

The simplest tweezers were made from a folded strip of sheet metal as illustrated by an unstratified pair from Goltho (Fig 65,8; I H Goodall in Beresford 1975,93, fig 44,35); a similar pair from Eaton Socon, Beds (Lethbridge & Tebbutt 1951, 58, fig 1,4), dated to the 12th century, is decorated with incised zig-zag lines. More elaborate examples, such as a pair from Waterbeach Abbey, Cambs (Cra'ster 1966,83, fig 4b), have a handle formed by twisting the folded end. Tweezers could also be combined with other toilet implements, as in the hinged manicure sets from Lyveden, Northants (Steane & Bryant 1975, 114, fig 43,49) and Rye, E Sussex (Vidler 1933, 57, pl IX,5), and the combined tweezers and scoop, dated *c* 1250-1350, from Alsted (I H Goodall in Ketteringham 1976,62, fig 38,13) and another from Old Sarum (Fig 65,9; Salisbury Museum, OS A6a). The elaborated tweezers with expanded rectangular ends, found for instance at Pleshey (Fig 65,10; Williams 1977, 185, fig 41,9), Old Sarum (Fig 65,ll; Salisbury Museum, OS A5 - 2 examples), and Bayham Abbey, E Sussex (A R Goodall in Streeten forthcoming) probably did not have a toilet use: it has been suggested that they may have been used to hold open the pages of a book (Rahtz 1960,27) or for handling gold leaf. Unlike the examples from Old Sarum, those from Pleshey and Bayham have the plates brazed or soldered on to the arms.

Personal fittings

Buckles and strap fittings are frequent finds on medieval sites : they may come from men's or women's girdles, shoes, armour, spurs, or horse harness. An authoritative study of belt fittings has been made by Ilse Fingerlin (1971), based on the major museum collections of Britain and Europe.

Buckle frames are most often made of cast metal while the pin may be cast or made from sheet or wire. The buckle may be attached to the end of the strap by means of a buckle-plate and the other end of the strap is often finished with a similar strap-end or pendant. A buckle from Grenstein, Norfolk (Fig 66,l; A R Goodall in Wade-Martins 1980, 127, fig 74,2) is of a type with uncertain dating which has the frame and plate cast together. Buckles with heavily moulded frames, such as those from Wharram Percy (Fig 66,2; A R Goodall in Andrews & Milne 1979,108, fig 55,5) and Old Sarum (Fig 66,3; Salisbury Museum, OS E8, 128/1946) and one with slighter moulding from London (Fig 66,4; Museum of London, 4264), may be dated to the 13th and 14th centuries, as may those with revolving cylinders on the front of the frame (Fig 66,5; London Museum 1944, 272, pl LXXV,6). Another example from Wharram Percy (Fig 66,6; A R Goodall in Andrews & Milne 1979,112, fig 57,70), in which a triangular sectioned bar is attached to the front of the frame by a cylinder of sheet metal, is probably related to the latter type. These buckles often have decorated plates, sometimes with large domed heads to the rivets (Fig 66,4-5). A distinctive group of buckles and strap-ends of slightly later date has its plates soldered on to a forked spacer plate (Fig 66,7 from Filkins, Oxon, *Antiq J,* 13 (1933), 469, fig 1; Fig 66,8 from Oxford, A R & I H Goodall in Durham 1977, 148, fig 30,20; Fig 66,9 from Bassingbourne, Cambs, *Antiq* J, 15 (1935), 204; Fig 66,10 from London, Museum of London, 4508). Detached plates usually retain traces of solder on the inner surface while the prongs of the spacer are left with rough file marks which would have provided a key for the solder.

Lyre-shaped buckles and strap-ends, such as one from Oxford (Fig 66,ll; A R & I H Goodall in Durham 1977,148, fig 30,19), date from the later 14th century; they are often elaborately ornamented with cast scrolls and foliage, and incised decoration or an inscription on the box-like strap attachment. Double-looped buckles seem to become more common in the 14th century: they are usually of circular or rectangular form or figure-eight shaped. The circular buckle from London (Fig 66,12; Museum of London, 36, 146/ 10) has cast decoration and is a type occurring on a number of sites, for example Waltham Abbey, Essex (A R Goodall in Musty 1978,161, fig 24,1) where it is dated to the later medieval period. Fig 66, 13 and 14 also shows buckles from London (London Museum 1954,278, pl LXXIX, 7 and 5). The buckles from the Blossoms Inn site represent a late 15th to 16th century type having a bow-shaped frame with separate pin-bar. The pin and pin-bar are often of iron. The buckle frames may be cast but the Blossoms Inn examples are made from folded strips of sheet metal (Fig 66, 15A-C).

Belts and other straps were often decorated with small mounts of copper alloy some of which may also have served to reinforce the strap. They take the form

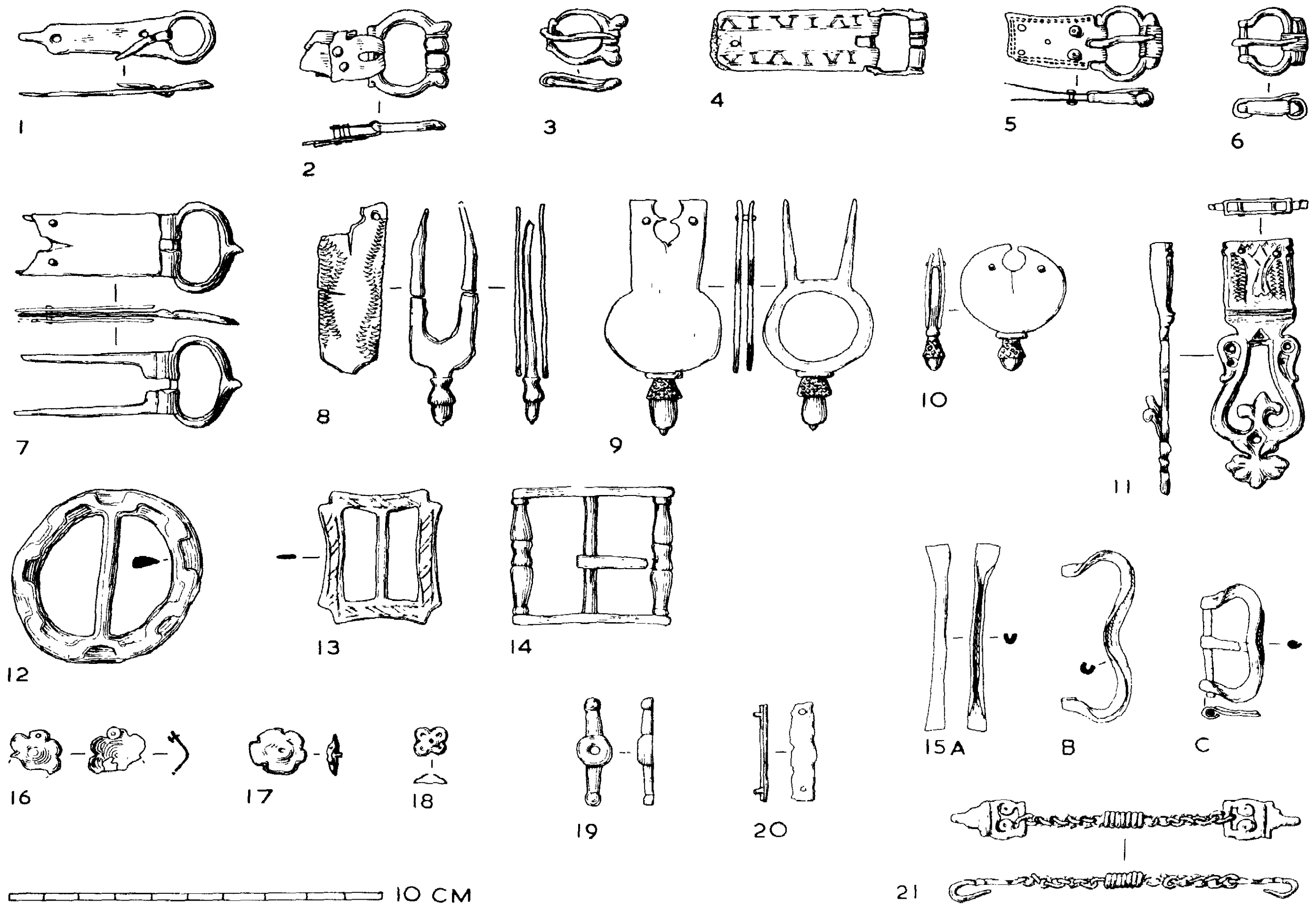


Fig 66 Costume fittings

of plain circular studs, rosettes like those from Oxford (Fig 66,16-17; A R & I H Goodall in Durham 1977, 151, fig 31,67-8) and wharram Percy (Fig 66,18; A R Goodall in Andrews & Milne 1979,112, fig 57,75; see also London Museum 1954,197, fig 63,7), and bars as in the examples from York (Fig 66,19; Wenham 1972, 96, fig 21,26) and Oxford (A R & I H Goodall in Durham 1977, 151, fig 31,70). Bars similar to Fig 66,19 are shown on the belt on the effigy of Edmund Crouchback (1290) in Westminster Abbey. The bars illustrated are made by casting, but similar ones are made from sheet metal, for example two late 13th century mounts from Strixton, Northants (Hall 1973, 113, fig 4,20 and 23): the rosettes are always stamped out of sheet metal and would have been secured to the strap by one or two rivets. Sometimes the rivets have been hammered over small washers at the back of the strap, and it was in fact required by the Articles of the London Girdlers of 1344 that no-one 'shall make girdles or garters barred unless there be a rowel beneath the bar' (Riley 1868, 216).

Hooked fasteners of thin cast metal, usually with an ornamental plate and a rectangular loop at the head, occur in 15th and 16th century contexts. They may have been strap attachments but the example from Wharram Percy (Fig 66,2 1; A R Goodall in Andrews & Milne 1979, 111, fig 56,25), in which two identical hooks are linked by a length of chain, suggests that they may have been used as cloak fasteners. At about the same date garments were commonly fastened by lacing and ornamental ribbons and points were tied on to the costume. Archaeological evidence for this takes the form of numerous cylindrical lace-ends of rolled sheet metal: sometimes they retain the end of the ribbon, cord, or leather thong and many have one or two pins pushed through one end to prevent them from slipping off the lace.

Metal-framed purses, such as that from Netherton, Hants (Fig 67; Fairbrother 1975, 13, fig 5,1), were used in the later medieval period. The purse comprised one or two fabric bags slung between a rigid bar and hinged hoops: the frame usually has a perforated flange to which the pouches were laced or stitched. A swivel loop in the centre of the bar enabled the purse to be suspended from the belt.

Brooches in the medieval period were probably functional rather than purely decorative and were often used as a fastening at the neck of the tunic or kirtle. They are almost exclusively annular or a derivative of this form. A simple, entirely functional type is found in 13th and 14th century contexts (Fig 68,1; Museum of London, 4084); it has a heavy,

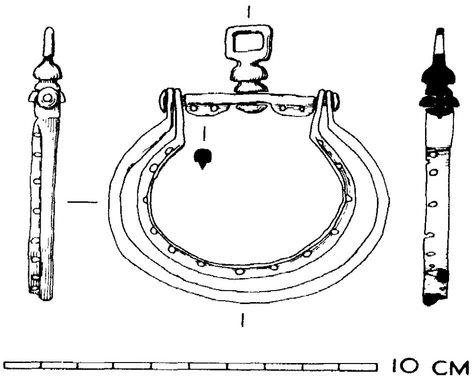


Fig 67 Purse frame

oval-sectioned ring and the rectangular-sectioned pin has a ridged or decorated moulding just below the hinge. In more ornamental examples the pin usually swivels on a recessed bar. The ring may have a variety of cast or incised decoration. Fig 68,2, from London (London Museum 1954, 276, pl LXXVII,3) is made from sheet metal and has simple rocked-tracer ornament while a relatively common type is represented by Fig 68,3 (Museum of London, 4081) in which half of the ring has a twisted square cross-section. Still more elaborate brooches have ornamental bosses, cast with the ring or soldered on to it, which sometimes have settings for paste or enamel as in the examples from Exeter (Fig 68,4; excavated by Exeter Archaeological Unit), dated c 1250-1300, and London (Fig 68,5; Museum of London, 4082). Finger rings of various forms were made in copper alloy, some having settings for gemstones; examples may be quoted from

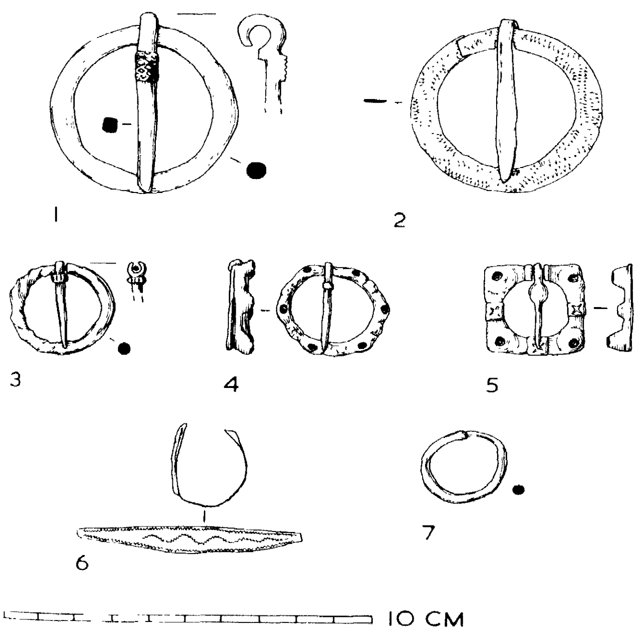


Fig 68 Brooches and rings

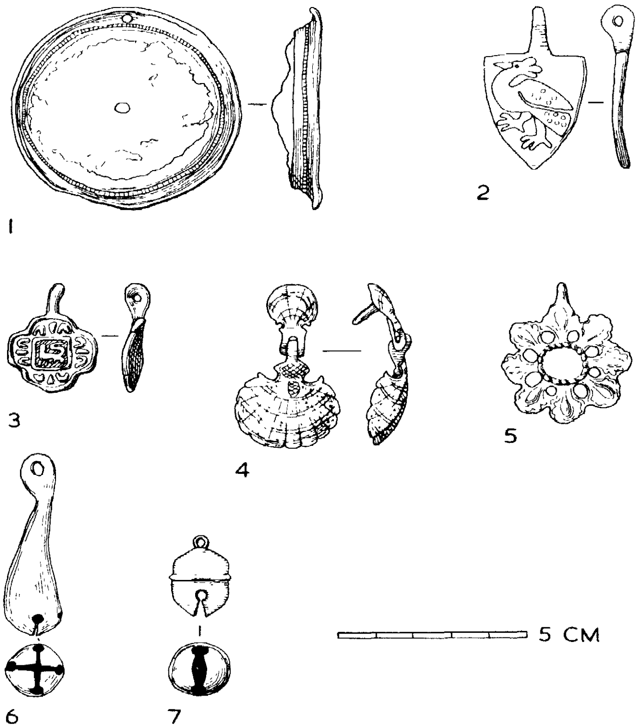


Fig 69 Harness ornaments

Brixworth (Fig 68,6; A R Goodall in Everson 1977, 93, fig 8,7), Lyveden (Steane & Bryant 1975, 114, fig 43,51-2), Goltho (I H Goodall in Beresford 1975,93, fig 44,29), and Wallingstones, Hereford and Worcs (Bridgewater 1970, 103, fig 15,44). The round-sectioned penannular rings with tapering ends, one of which is often pointed, such as one from Oxford (Fig 68,7; Hassall forthcoming), may be earrings, although a similar ring has been identified as a finger-ring (Biddle 1961-2, 169, fig 28,9).

Decorative fittings

Ornamental fittings other than personal objects cannot always be identified with certainty: many come from horse harness and book-bindings while others may be bindings from caskets or wooden vessels. Contemporary illustrations show horses in trappings richly embellished with metal ornaments: bridle bosses have been found for example at East Haddlesey, W Yorks (I H Goodall in Le Patourel 1973,93, fig 36,6-8) and in an unstratified context at Goltho Fig 69,1; I H Goodall in Beresford 1975, 95, fig 44,38). Harness pendants are frequently armorial and decorated with champlevé enamel to depict the heraldic tinctures, while the raised field is gilded or plated to represent the metals (Fig 69,2 from Penhallam Manor, I H Goodall in Beresford 1974, 139, fig 46,6; Fig 69,3 from Goltho, *ibid* 1975,93, fig 44,33). Some of the forms of heraldic pendants were classified in the London Museum Medieval Catalogue (1954, 118ff). Non-heraldic pendants may take the form of scallops, such as a fine, gilt example from

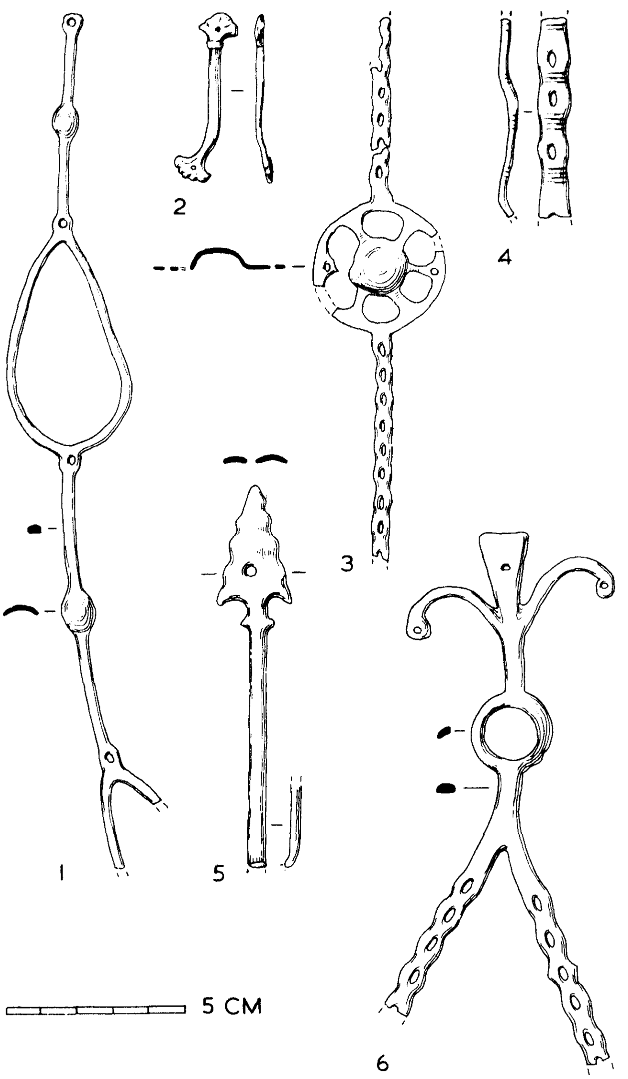


Fig 70 Gilt binding strips

Castle Acre Castle, Norfolk (Fig 69,4; AR Goodall in Coad & Streeten forthcoming), or foliate ornaments like that from Netherton (Fig 69,5; Fairbrother 1975, 13, fig 5,3). The means by which the pendant was suspended varies from the simple arrangement of the Castle Acre example to the complex head-stall ornaments discussed by Ward-Perkins (1949).

Small bells were likewise hung from horse trappings but are also shown suspended from men's and women's belts in 15th century illustrations and attached to the collars of net does. Rumbler bells made from two pieces of sheet metal enclosing an iron pea are the most common type, occurring as early as the late 13th century at Southampton (Fig 69,7; Harvey in Pratt & Coleman-Smith 1975, 255, fig 240,1726) and Hadleigh (I H Goodall in Drewett 1975, 145, fig 29,392) and continuing almost unchanged to the present day. More elongated bells have been found at Thruxton, Hants (Fig 69,6; Salisbury Museum, 41/1957) and Whittington, Glos (O'Neil 1952, 81, fig 14,6); similar bells are shown in 15th and 16th century illustrations elaborated with spiral reeding. All these forms of bell are shown ornamenting the trappings of the horses in the Westminster Tournament Roll of 1511 (Marks & Payne 1978, 82-3, pl 74) together with larger bells probably of cast metal.

Of the pieces of decorative binding strip one group can be isolated. The strips are characteristically D-shaped in section, usually with gilding on the upper, curved, surface: they are ornamented with gadrooning, elongated perforations, bosses, sometimes with openwork, and shaped terminals. The strips bifurcate, curve, and rejoin, and at intervals there are pin-holes through which they would have been attached, perhaps to caskets of wood overlaid with leather or to book-bindings. They occur regularly on sites of the 12th and 13th centuries such as Goltho Manor (Fig 70,1-5; excavated by G Beresford), Castle Acre Castle (Fig 70,6; AR Goodall in Coad & Streeten forthcoming), Castle Neroche, Som (Davison 1972, 41, fig 17,2), and Ascot Doilly, Oxon (Jope & Threlfall 1959, 267-8, fig 21). More certainly from book-bindings are the late medieval clasps such as that from Basing House, Hants (Moorhouse 1971, 59, fig 25,162) and perhaps an openwork-decorated boss from Writtle (Rahtz 1969, 103, fig 49,103) dating to the 14th to early 15th century.

Acknowledgements

The author expresses gratitude to all those who gave permission for the reproduction of drawings of objects from their excavations, to the Society of Antiquaries of London for Fig 66,7 and 9, and to the *Berkshire Archaeological Journal* for Fig 63,4.

Bibliography

Andrews, D D, & Milne, G (eds), 1979 *Domestic settlement, 1: areas 10 and 6*, Vol 1 of J G Hurst (gen ed), *Wharram: a study of settlement on the Yorkshire Wolds*, Soc Medieval Archaeol Monogr Ser, **8**

Beresford, G, 1974 The medieval manor of Penhallam, Jacobstow, Cornwall, *Medieval Archaeol*, **18**, 90–145

———, 1975 *The medieval clay-land village: excavations at Goltho and Barton Blount*, Soc Medieval Archaeol Monogr Ser, **6**

Biddle, M, 1961–2 The deserted medieval village of Seacourt, Berkshire, *Oxoniensia*, **26–7**, 70–201

Blurton, T R, 1977 Excavations at Angel Court, Walbrook, 1974, *Trans London Middlesex Archaeol Soc*, **28**, 14–100

Bridgewater, N P, 1970 The medieval homestead of Wallingstones, *Trans Woolhope Natur Fld Club*, **40**, 75–116

Butler, L A S, 1974 Medieval finds from Castell-y-Bere, Merioneth, *Archaeol Cambrensis*, **123**, 78–112

Coad, J G, & Streeten, A D F, forthcoming Excavations at Castle Acre Castle, Norfolk, 1972–77

Cra'ster, M D, 1966 Waterbeach Abbey, *Proc Cambridge Antiq Soc*, **59**, 75–95

Crouch, K, 1976 The archaeology of Staines and the excavation at Elmsleigh House, *Trans London Middlesex Archaeol Soc*, **27**, 71–135

Davison, B K, 1972 Castle Neroche: an abandoned Norman fortress in south Somerset, *Somerset Archaeol Natur Hist*, **116**, 16–58

Drescher, H, 1968 Mittelalterliche Dreibeintöpfe aus Bronze, in *Rotterdam Papers, a contribution to medieval archaeology* (ed J G N Renaud), 23–33

Drewett, P L, 1975 Excavations at Hadleigh Castle, Essex, *J Brit Archaeol Ass*, 3 ser, **38**, 90–154

Dunning, G C, 1962 The bronze skillet from Stanford in the Vale, Berkshire, *Berkshire Archaeol J*, **60**, 98–100

Durham, B, 1977 Archaeological investigations in St Aldates, Oxford, *Oxoniensia*, **42**, 83–203

Dyer, J, & Wenham, L P, 1958 Excavations and discoveries in a cellar in Messrs Chas Hart's premises, Feasegate, York, 1956, *Yorkshire Archaeol J*, **39**, 419–25

Everson, P, 1977 Excavations in the vicarage garden at Brixworth, 1972, *J Brit Archaeol Ass*, **130**, 55–122

Fairbrother, J, 1975 *Netherton, Hampshire: an interim report on the research in 1975*, City of London Archaeol Soc

Fingerlin, I, 1971 *Gürtel des hohen und späten Mittelalters*, Berlin

Geddie, W S, 1879–80 Notice of the discovery of a hoard of groats of Robert III, enclosed in a ewer of brass, and buried in the Cathedral Green, Fortrose, *Proc Soc Antiq Scot*, 2, 182–6

Gilks, J A, 1979 A fifteenth-century bronze skillet from near Pateley Bridge, *Yorkshire Archaeol J*, **51**, 147–50

Gombrich, E H, 1966 *The story of art*, 11 edn

Grimani, 1972 *The Grimani Breviary*

Hall, D N, 1973 A thirteenth century windmill site at Strixton, Northamptonshire, *Bedfordshire Archaeol J*, **8**, 109–18

Harrison, A C, & Flight, C, 1968 The Roman and medieval defences of Rochester in the light of recent excavations, *Archaeol Cantiana*, **83**, 55–104

Hassall, T G, forthcoming Excavations at the Greyfriars, Oxford 1968–1975, *Oxoniensia*

Hill, N G, 1937 Excavations on Stockbridge Down, 1935–36, *Proc Hampshire Fld Club*, **13**, 247–59

Hurst, J G, & Golson, J, 1955 Excavations at St Benedicts Gates, Norwich, 1951 and 1953, *Norfolk Archaeol*, **31** (1), 1–112

Jarrett, M G, 1970 The deserted village of West Whelpington, Northumberland: second report, *Archaeol Aeliana*, 4 ser, **48**, 183–302

Jope, E M, 1952–3 Late Saxon pits under Oxford Castle mound — excavations in 1952, *Oxoniensia*, **17–18**, 77–111

———, 1959 The Clarendon Hotel, Oxford. Part I, the site, *ibid*, **24**, 1–83

Jope, E M, & Threlfall, R I, 1959 The twelfth-century castle at Ascot Doilly, Oxfordshire: its history and excavation, *Antiq J*, **39**, 219–73

Ketteringham, L L, 1976 *Alsted: excavation of a thirteenth–fourteenth century sub-manor house with its ironworks in Netherne Wood, Merstham, Surrey*, Research Vol of Surrey Archaeol Soc, **2**

Le Patourel, H E J, 1973 *The moated sites of Yorkshire*, Soc Medieval Archaeol Monogr Ser, **5**

Lethbridge, T C, & Tebbutt, C F, 1951 Excavations on the castle site known as 'The Hillings' at Eaton Socon, Bedfordshire, *Proc Cambridge Antiq Soc*, **45**, 48–60

Lewis, J M, 1978 *Medieval pottery and metal-ware in Wales*

London Museum, 1954 *Medieval Catalogue*, London Museum Catalogues, **7**

Marks, R, & Payne, A, 1978 *British heraldry from its origins to c 1800*, British Museum

Marshall, K, 1950 Cast bronze cauldrons of medieval type, *Ulster J Archaeol*, **13**, 66–75

Moorhouse, S, 1971 Finds from Basing House, Hampshire (*c* 1540–1645): Part II, *Post-Medieval Archaeol*, **5**, 35–76

Musty, A E S, 1978 Exploratory excavation within the monastic precinct, Waltham Abbey, 1972, *Essex Archaeol Hist*, **10**, 127–73

O'Neil, H E, 1952 Whittington Court Roman villa, Whittington, Gloucestershire. A report of the excavations undertaken from 1948–1951, *Trans Bristol Gloucestershire Archaeol Soc*, **71**, 13–87

Platt, C, & Coleman-Smith, R, 1975 *Excavations in medieval Southampton 1953–1969*, **2**, *The finds*

Rahtz, P A, 1960 *Pleshey Castle: first interim report*, Essex Archaeol Soc

———, 1969 *Excavations at King John's Hunting Lodge, Writtle, Essex, 1955–57*, Soc Medieval Archaeol Monogr Ser, **3**

Renn, D F, 1959 Steelyard weights: a postscript, *Proc Dorset Natur Hist Archaeol Soc*, **81**, 148–9

Richardson, K M, 1959 Excavations in Hungate, York, *Archaeol J*, **116**, 51–114

Rigold, S E, 1965 Two camerae of the military orders: Strood Temple, Kent, and Harefield, Middlesex, *ibid*, **122**, 86–132

Riley, H T, 1868 *Memorials of London and London life in the XIIIth, XIVth, and XVth centuries*

Rogerson, A, & Dallas, C, forthcoming Excavations at Thetford, 1948–59 and 1977, *East Anglian Archaeol*

Rowlands, M, 1975 *Masters and men in the West Midland metalware trades before the industrial revolution*

Salzman, L F, 1964 *English industries of the Middle Ages*, new edn

Smith, G H, 1979 The excavation of the Hospital of St Mary of Ospringe commonly called Maison Dieu, *Archaeol Cantiana*, **94**, 81–184

Steane, J M, & Bryant, G F, 1975 Excavations at the deserted medieval settlement at Lyveden. Fourth report, *J Northampton Mus*, **12**, 3–160

Streeten, A D F, forthcoming *Sussex Archaeol Collect*

Theuerkauff-Liederwald, A-E, 1975 Die Formen der Messingkannen im 15. und 16. Jahrhundert, in *Rotterdam Papers II, a contribution to medieval archaeology* (ed J G N Renaud), Rotterdam, 177–96

Treue, W, *et al*, 1965 *Das Hausbuch der Mendelschen Zwölfbrüderstiftung zu Nürnberg*, **2**, *The plates*, Munich

Tylecote, R F, 1962 *Metallurgy in archaeology*

Vidler, L A, 1933 Medieval pottery and kilns found at Rye, *Sussex Archaeol Collect*, **74**, 45–64

Wade-Martins, P, 1980 Fieldwork and excavation on village sites in the Launditch Hundred, Norfolk, Part II: fieldwork and excavation at Grenstein (Greynston), *East Anglian Archaeol*, **10**, 93–168

Ward-Perkins, J B, 1949 A medieval harness-mount at Termoli, *Antiq J*, **29**, 1–7

Wenham, L P, 1972 Excavations in Low Petergate, York, 1957–58, *Yorkshire Archaeol J*, **44**, 65–113

Williams, F, 1977 *Pleshey Castle, Essex (XII–XVI century): excavations in the Bailey, 1959–1963*, Brit Archaeol Rep, **42**

Emancipated from tutelage to its regal relation, the lead industry of England and Wales only emerged with a separate and discrete identity in the last quarter of the 12th century. Until that date the major sources of supply of the base metal were the silver industries of England, central Europe, and Sardinia, where the precious white metal was obtained by cupellation from 'fertile' or argentiferous lead, the residual litharge being resmelted in order to extract its plumbiferous content.' Particularly during the years 1130-70 supplies of this by-product were abundant. Seemingly limitless quantities of lead issued forth from the Tyne, the product of workings scattered about the slopes below Nenthead, whilst each of the lesser continental centres also produced prodigious amounts of 'sterile' lead. European markets were swamped. In England major construction sites, which proliferated in numbers during the mid century, were amply supplied with lead, the wares of the 'Carlisle mine' dominating all markets save those of the Severn Valley where lead from Llanymynech held sway. Yet paradoxically, whilst the northern English mines produced the largest output of lead in Europe, their wares, because of relatively high domestic prices and a 'hard' exchange, were but little known on international markets. Even the Crown, able to buy where it wished, shunned the English product in obtaining supplies for works in its French possessions. In western Europe Harz lead dominated the market and each year merchants flocked to Cologne to acquire supplies of the metal. Similarly, in the western Mediterranean the English product, uncompetitively priced, made few inroads in the market dominated by the producers working on the mountain of Argentiera in northern Sardinia. Even if the products of the northern English mines made little progress outside the domestic market, within it, as on the Continent, the market situation was transformed. Lead was abundant and cheap and at prevailing prices the exploitation of non-argentiferous lead, either from worked-out silver mines or pristine deposits, was totally unviable. Only with the destruction of the northern English mining complex, at the time of the 1172-3 Scots incursions, were the preconditions established for the development of an indigenous non-argentiferous lead industry - and then only in the north-east. During the years 1172-8, consequent upon the diminution of production in the northern mines, prices doubled in all markets save those of the south-west which continued to be dominated until 1189 by lead from the Welsh silver mines. The market was thus transformed and whilst in the south-west the opening up of the Mendip deposits was delayed, elsewhere a completely new industry was born.[2]

The primary technology: the 'bole'

New mines were opened up in the 1170s (Fig 71; see Appendix). Instead of the complex system of tunnels and shafts which had characterized the deep silver-lead workings, they were simple trenches *(grova)* cut into outcropping lead rakes. With the opening of a new vein/rake ownership rights were delineated and each miner then scooped out the galena from within the confines of his *meer*.[3] Unfortunately, subsequent excavations to greater depths, as for instance at Dirtlowe Rake in Derbyshire, have obliterated the remains of medieval workings (Kirkham 1968, 18). Nor are ore-dressing facilities likely to have survived the centuries any better. Following excavation the ore had to be prepared for smelting, a process which was normally done at the 'washing place' (Fig 72; Blanchard 1974). The object of this operation was to grade and concentrate the ore:

1. After an initial hammering the larger ore stones — *bing* — were set on one side.
2. The remaining ore — *bouse* — was carried to the 'knocker' stone. This was a large round flat stone on which the ore was crushed by a man using a 'bucker' — a heavy piece of iron with a curved undersurface and a handle — who by rocking the implement produced small pieces of ore and rock.
3. The ore was then treated in a large water-filled trough by a man with a long-handled 'scrubber' — the action of the water against the *bouse* causing the heavier lead to be deposited at the head of the trough, the lighter limestone at the base.
4. The resultant deposit was then graded by a man using a sieve or 'riddle' of about a half-inch mesh to divide smeltable *water* or *wash* ore from unutilizable *riddlings*.

A complex of operations thus existed at the washing place but few of them have left material remains. Only the 'knocker' stone and *riddlings* are likely to have been left when the site was deserted. The latter probably disappeared with the improvement of washing techniques in the 16th century, the *riddlings* being converted into *smitham* (*see* p 79). Moreover, no identifiable stones seem to have been discovered or washing places excavated.

If material returns, generated by mining and ore-dressing activities, seem to be singularly lacking, the new technology, evolved for smelting ores during the 1170s and subsequently employed for the next 400 years, has left bountiful evidence scattered about the landscape. Paradoxically, however, despite the abundant body of material evidence available, more is known about the nature of the 'bole' from manuscript sources than from excavations. Of the hundreds of 'bole' sites only one, identifiable as medieval, seems to have been excavated -and then accidentally. Excavations near Beeley in Derbyshire in the summer of 1967 of a triple cairn revealed a medieval 'bole', probably of the mid 15th century, set into the west facing end of the third most westerly cairn (Fig 73).[4] The structure was an extremely simple one.

1. The hearth floor (A), measuring 1-4 m by 760 mm, was scooped out of the cairn and contained a deposit made up of layers of slag and burnt wood about 150-200 mm thick.
2. On the north-west side, away from the prevailing winds, was a taphole (B), near which a small piece of lead was found.
3. On the opposite side was a carefully constructed wind-tunnel (C), its entry facing south-west and

Fig 71 Major areas of medieval lead mining in England and Wales

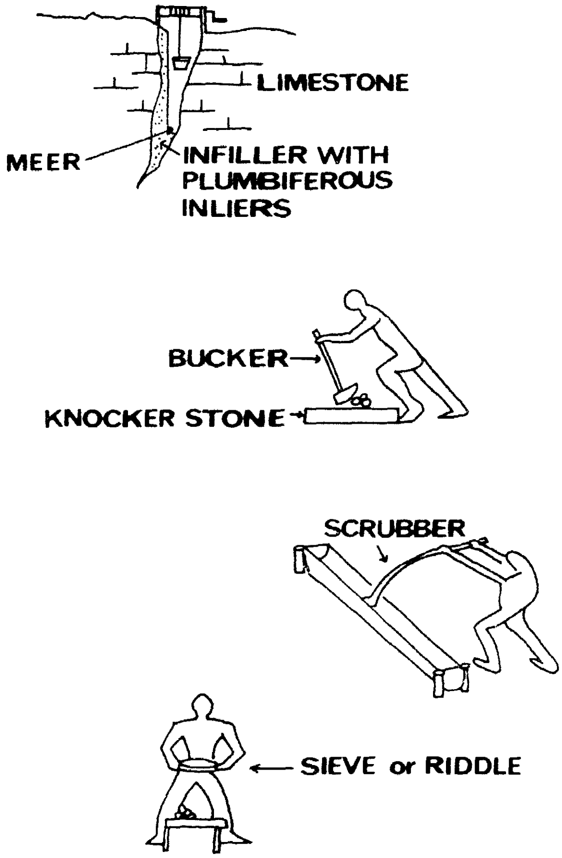


Fig 72 Methods of grading and concentrating lead ore (reproduced from Blanchard 1974 by kind permission of the editors)

entering the hearth, at an indeterminate height, at its most southerly extremity.

A simple but efficient mechanism had been evolved.'

1 A foundation of logs — 'blocks' -was laid across the hollowed-out hearth upon which were piled layers of brushwood and ore, the former being woven into a dense interlocking mesh in order to prevent the heavy ore sinking into the hearth before being oxidized.

2 With suitably strong winds the hearth was fired.

3 Reduction involved the galena being converted into an oxide by roasting in the top of the 'bole'. The oxide then reacted with the unroasted ore: $2PbO+PbS = 3Pb+SO_2$.

4 The sulphur dioxide was dispersed into the air at low concentration.

5 The lead was collected in the bowl-shaped hollow at the bottom of the hearth and was then ladled out through the taphole.

6 Finally the residual yellow slag and the remnants of charred wood, which had collected on the 'blocks', were shovelled out.

A simple low-cost method, the 'bole' proved to be remarkably effective. Extraction rates amounting to 58% of the ore's metal content were achieved, a figure which was some 15% more than with the preceding method, and which was not surpassed until the 1690s.[6] Equally, per load of ore 'boled', the method was highly economical in the use of fuel.[7] Only in the types of ore which could be utilized did it suffer from significant limitations. Because of the method of loading the charge the 'bole' worked best with large pieces of *bing,* and its efficiency diminished as the size of the ore decreased until ores smaller than a half inch were totally unutilizable." The type of ore which could be used was thus restricted by the prevailing methods and the resource base of the industry was accordingly finite.

In the last quarter of the 12th century, however, such limitations were of but scant significance. With the new technology available and in the transformed market conditions a wide range of previously unutilizable ores were opened up for exploitation by producers. Mining activity accordingly began in almost all of the areas known to later ages (see Appendix). A finite resource base had been delineated and patterns for future production set. For 400 years that base was depleted at a pace conditioned by the existence of exogenously determined demand cvcles. How this resource depletion manifested itself in particular locales was determined by the specific mineralogical situation of the 'rakes', and the lack of inter-spatial homogeneity often resulted in a truncation of production and created a situation of endemic migration in the industry. For 400 years the foci of production therein were continually on the move and each migration left its heritage of material remains.

In Derbyshire, for instance, at the end of the 14th century, the once great industry was in decay (Fig 74; Blanchard 1971; in press). The easily worked High, Long, Hard, and Coast Rakes were exhausted and the onus of supplying the nation's needs had shifted to new mining areas. At the centre of the new national industrial complex was Mendip. Elsewhere deposits previously unutilized because of inherent difficulties were opened up in Yorkshire, Flint, Durham, and Derbvshire. In the last centre it was the workings of Hucklowe, previously abandoned because of flooding after an ephemeral existence from 1242-8, which now came to the fore. From 1360-1420 these workings provided the focus for the industry supplying 'boles' 9.5 kms away at Baslow (A). With the exhaustion of these deposits the industry migrated southward and many of the Baslow 'boles' were abandoned in the face of competition from that quarter. The opening up of workings on the Mandale Rake/Black Sough and the Cheprake during the years 1420-50 and the emergence of new smelting centres at Haddon/Stanton (B) and Beeley Moor (C) dependent on the production of the mines sounded the death knell for the Baslow complex. With the decline of the more southerly workings the same fate seemed ready to befall the associated smelting complex. It was not, however, to be. The ability of 'bolers' to participate in external economies deriving from falling freights allowed them to extend their supply networks to engross the production of newly emergent mining centres. During the years 1450-70 the Baslow 'bolers' increasingly drew on the ores of the Earl-Shuttle Rake and new smelting establishments were built there and across the manorial border in Holmesfield. Similarly the Haddon-Stanton 'bolers' during the same years diversified their supply systems to encompass the ores of the Nestor and Ravenstor Rakes. The industry was thus subject to an endemic process of migration, modified only where producers could benefit from external economies. Each move, moreover, created its own complex of washing places, storehouses and 'boles', most of which are still awaiting excavation.

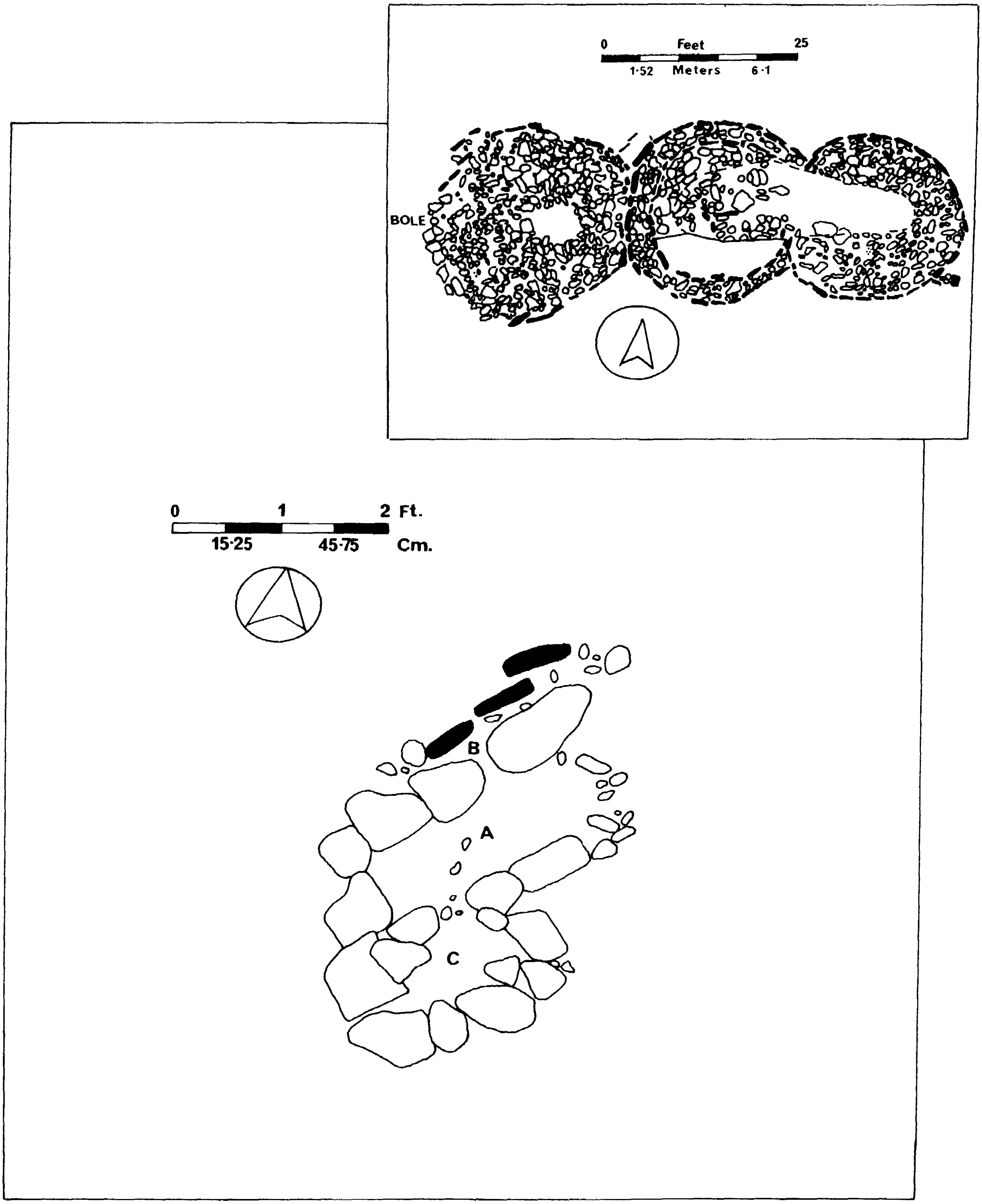


Fig 73 'Bole' (adapted from information in Radley 1969 and reproduced by kind permission *of the editors)*

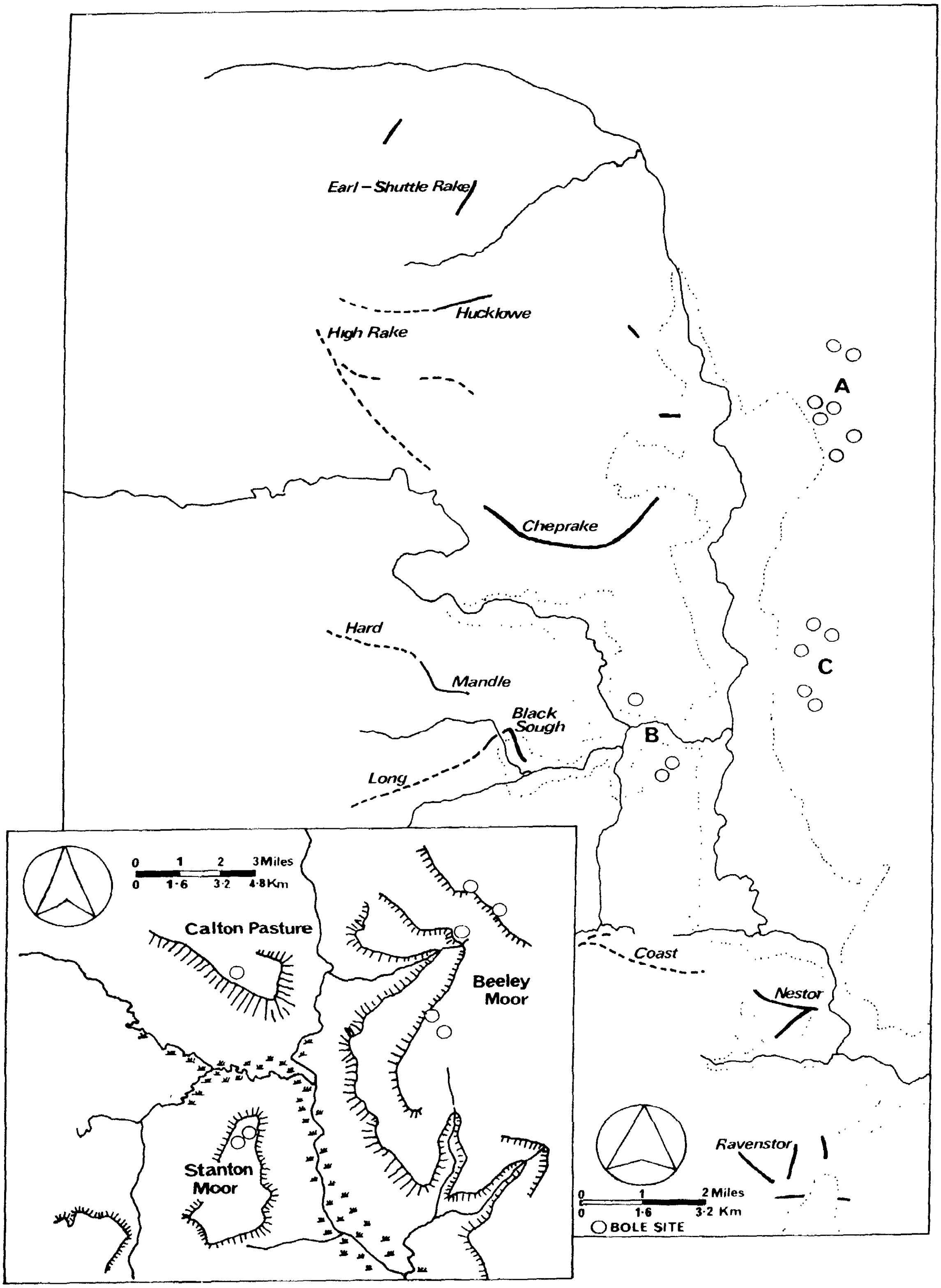


Fig 74 The Derbyshire lead industry 1360-1470

Technological change: the 'turnbole' and the problem of inter-spatial cost variation

The problems posed to producers were not, however, confined to those inherent in the successive depletion of their mineral resource base and the associated exploitation of a constantly moving mining frontier. The simple process whereby producers transposed an existing technology to new locations was modified where they were faced with regional variations in the cost of another input - timber. Until the 1360s high fuel costs, engendered by unfavourable conditions for timber growth, interposed a barrier in the peripheral regions of the north and west to the exploitation of the mineral resources of these areas which might be ignored only at the producer's risk.' Transgression of these market constraints, moreover, could prove extremely expensive. In Flintshire, for instance, the production cycle of the Holywell mines, commenced in the 1280s, was prematurely truncated as smelting was brought to a halt in 1305/6 'due to a deficiency of wood' (PRO SC6/771/6). Until resolved, the problem of high regional fuel costs thus prevented the exploitation of a significant sector of the industry's mineral reserves and confined it to working ores with sub-optimal yields. The answer once more lay in the realm of technological change but in this instance innovation originated from outside the industry. The establishment of silver-lead production at Bere Ferrers and Coombe Martin in Devon during. the 1290s had engendered fuel-cost problems similar to those which plagued the contemporary lead industry in Wales. In response to these problems a new technology was evolved, *le turnebole,* a hearth about 5 ft high set upon a timber platform which could be turned, like a windmill, to take advantage of the wind from whichever direction it came (see note 6). The effect was not to reduce the amount of fuel used per ton of ore 'boled' under normal conditions of constant blast, but to eliminate irregularities in consumption caused by shifts of the wind.[10] The gains which could be achieved by the introduction of the new technology were, accordingly, dependent upon the mode of operation of the preceding one. In the silver-lead industry, where 'boling' was continuous throughout the year, the costs imposed by the vagaries of the wind were considerable. Variable costs were enhanced by each change of the wind, which brought reduction of the ore to a halt and left a partially consumed charge of fuel. In order to ensure continuous operation, moreover, capital costs were inflated by the necessity of maintaining a number of 'boles' each facing in a different direction which could be fired with each change in the wind. In such circumstances the introduction of the 'turnbole' was clearly advantageous. Differences in capital costs were small and the reduction in the wastage of brushwood could be considerable, amounting to as much as one-third of consumption each year (PRO E372/142m. 30 *et seq* and associated particulars). In the lead industry the gains were not as clear. The 'bole' was utilized only once or twice a year for 'campaigns' of one or two slays. Discontinuity of use thus obviated the necessity of maintaining multiple 'boles' and opened up a differential in capital costs between the old and new methods. Again changes in the wind could lead to a considerable wastage of fuel but these losses could be minimized by a skilful 'boler' who knew when to fire his hearth, Accordingly the gains which could be achieved by the introduction of the new technique were reduced and at the prevailing timber prices and capital costs of the early 14th century, the method made little headway in the lead industry. Only with the transformation in timber prices during the years 1360-1520 did it become viable. The rapid rise in the unit cost of brushwood engendered sufficient savings in fuel costs to offset the greater capital costs of the 'turnbole', and the late 14th century thus witnessed its adoption in Flint and Durham, eliminating fuel-cost differentials within the industry (DU. 190016; PRO SC6/771/22). If north-country and Welsh producers were thus incorporated into the migratory pattern of the industry from the 1360s, the complexes created in these areas were quite different from those elsewhere, the 'turnbole' leaving only the ephemeral traces generated by its wooden structure.

Technological change: the 'blackwork' oven and the problems of structural oncost and temporal yield instability

Inter-spatial variations in input costs related to differences in the efficiency of raw material suppliers were not the only problems confronting producers, however, as they moved from one location to another. Each site posed its own problems in relation to structural on-costs. Responses to these were various. Some took place within the framework of the existing technology, attempting to achieve economies in the process of 'boling'. Yet whilst documentary evidence provides insights into the extent of these changes, how they were achieved remains a mystery explicable perhaps only by the creation of a chronological typology of existing bole sites. At other times attempts were made to manipulate ore markets in order to obtain industrial raw materials at sub-market prices." The impact of these changes, however, was either slight or ephemeral. Of much greater importance in the intra-industrial equilibrization of costs between enterprises exploiting similar-yielding ores was the introduction of a new method - that of the smelting hearth or 'blackwork' oven - which was employed to extract lead from the slags left over from the primary 'boling'. These yellow deposits still contained almost half the lead in the original ore and by judicious working at high temperatures these residual wastes could be made to yield a significant proportion of their lead content. The 'boler' thus had at his disposal various means of offsetting small inter-site variations in costs and of achieving cross-industrial equilibrization.

If the new methods could be used to achieve inter-site equilibrization in conditions of varying on-costs, they could also be deployed to maintain temporal intra-field stability. As has been noted, instability was inherent in the endemic process of migration which characterized the industry (see pp 74, 82). Migration took place when an existing production centre was subject to diminishing returns, rising costs, and prices. The 'blackwork' oven permitted the impact of these changes to be alleviated, thereby allowing production to be maintained in existing centres when the frontier moved on. With the emergence of depletion problems in a particular locale, declining yields engendered an increase in the amount of 'blackwork' smelting; at the prevailing 'boling' ratio the amount of lead produced from slag increased in proportion to the declining ore yield (DU. BD 190013-190020). Indeed evidence of slag smelting is often the first symptom of mining prob-

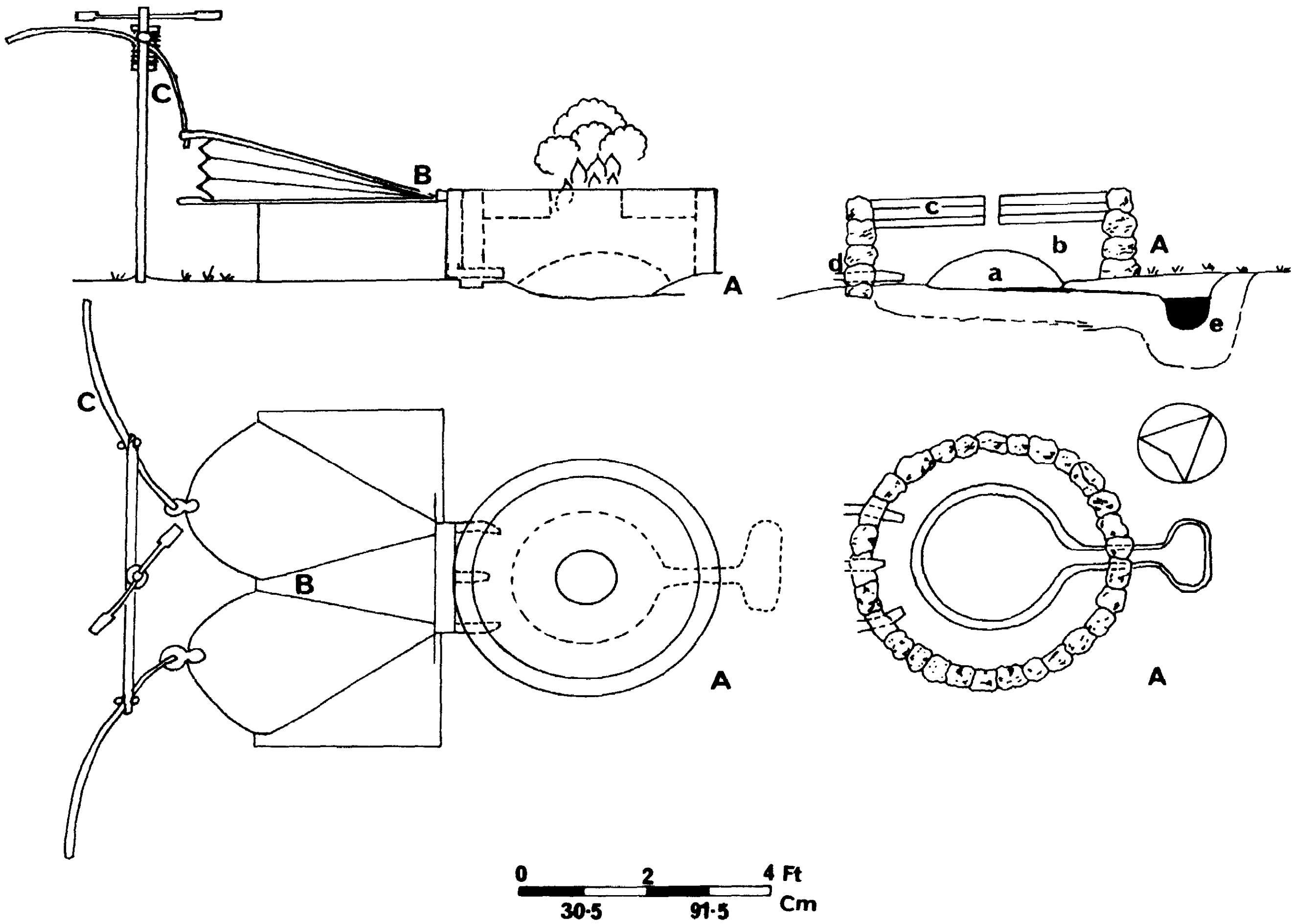


Fig 75 'Blackwork' oven (adapted from information in Kaisrrick 1927 and reproduced by kind permission of the editors)

lems in a particular locality that is revealed to historians. After the introduction of the new technology such evidence of 'blackwork' smelting can be found in almost all mining areas.

During the first phase of its development, during the years 1290-1360, when smelting took place in the 'bole' using a mixture of brushwood and charcoal as fuel, the only material evidence adduced by this activity are the black glassy slags that the process produced. With the improvement of the method after *c* 1360, however, such remains are augmented by the existence of a separate 'blackwork' oven located next to the 'bole' it served, and often mistaken for it. Today all that remains of these complex edifices are the hearths (Fig 75 A).[12] These are circular stone structures about 1·5 m in diameter and 600 mm high.

1 The floor is of puddled clay with a bowl-shaped hollow in the centre in which the charge (a) was laid.
2 Charcoal (b) was then packed around it.
3 The hearth was finally sealed with a layer (c) of clay.
4 Once ignited the charcoal was maintained at a high temperature by an intense blast of air from bellows whose nozzles (d) passed through the side of the hearth.
5 The molten lead, extracted from the slag, then ran off into a mould (e) outside the hearth and linked to the bowl-shaped hollow by a channel.

When operating, however, the hearth formed only part of the technology complex, for the bellows and the power source operating them also existed; but being wooden structures they have now disappeared. Power for the bellows was provided either by water or manpower. The latter method involved two men alternatively depressing two bellows (B) which then returned to their original position, for the process to begin again, through the action of tensioned saplings (C). The impact of the new technology was impressive. In the first stage of development it permitted the extraction of 45% of the metal remaining in the slag. In the second phase the yield was raised to 54-64% (cf, for example, PRO SC6/1146/11 and SC6/773/7). Yet it could only act as a temporary palliative to the problems which beset the industry in the prevailing conditions of chronic depletion. It could be deployed to compensate for deviations in costs from those of the most efficient existing producer amounting to about 20% before 1360 and to about 50% thereafter, but beyond that point the supply of slag was not self-generating. Accordingly production would then come to a halt unless there was a pre-existing stock of unworked slag. The periodicity of short-term fluctuations could thus be extended but their inherent nature remained unaffected by the *new* technology.

Technological change: the 'Durham system' and the problem of long-term resource depletion

Nor, in addition, did that technology provide any solution to the long-term problem of declining yields. With a prevailing extraction rate of 2·2 tons of ore per ton of lead (9 loads per fother), set by the producer working the richest ores, 'bolers', till about 1360, deployed the new technology to maintain long-term cost stability in conditions of specific depletion. Similarly from 1360-1530, when the mining industry moved to working ores from deeper and more fragmented veins, which would yield a ton of lead from 3·73 tons of ore (15 loads per fother), 'blackwork' smelting was employed in the same manner. Yet even if the problems of individual producers, faced with specific problems of depletion, were resolved thus allowing them to exploit ores in the 15th century which would yield as little as 11% metal, those of the industry as a whole were not. As the yield of the richest ores fell by some 40% (from 9-15 loads per fother), so costs rose proportionately and, in the prevailing market conditions, were passed on to consumers in higher prices. During the years 1360-1530 a new equilibrium was achieved, but even as it was attained the seeds of its dissolution were being sown. In conditions of long stability, specific problems of depletion once more occurred. From the 1460s the onus of maintaining the prevailing yield ratio rested on producers in Derbyshire and on Mendip, and with the emergence of depletion problems in those leading sectors the dilemma of long-term declining yields once more reasserted itself. From 1528-36 even in the fields yielding the richest ores returns were no more than a ton of lead from 9 tons of ore (37 loads per fother) utilizing the basic 'bole'. Costs rose and, as in the 1360s, were passed on to the consumer in higher prices. The pattern of the previous long-cycle seemed ready to repeat itself (see Appendix). That, however, was not to be the case. The late 1530s saw a transformation of the market situation; a flood of monastic lead swamped the market, forcing prices down to levels comparable with those prevailing in the first quarter of the century.[13] What had been the exception half a century earlier became the normal smelting practices in the late 1530s. In those fields where 20% ores could be exploited combined 'bole'/'blackwork' oven smelting allowed the maintenance of costs at a level compatible with the new price level. With the emergence of specific depletion problems, however, the existing technology could afford no answer to rising costs.

Relief came through the adoption of a technique evolved more than half a century earlier to resolve precisely this problem. During the years 1458-60 Wear-dale 'bolers' and smelters had been faced with problems of specific depletion which had taxed the existing method to its limits. Yields had fallen to the point where slag supplies were no longer self-reproducing and producers, threatened with a cessation of production, cast around for a means of extending the resource base of their enterprise. The result was a metamorphosis of the basic technology. Whilst elsewhere the industry continued to operate on the basis of the 'bole'/'blackwork' oven complex, in Weardale two new developmental paths were explored. In 1460 a portion of ore was set aside for smelting in a separate oven with charcoal at Fernilee, whilst at Knightlaw ore and 'blackwork' were mixed in a ratio of 1 : 2·4, the powdered charge being reduced in the 'blackwork' oven there. The former method proved abortive, as it had at Bere Ferrers over a century earlier; the latter method, however, was absorbed into the technology complex and was utilized throughout the period 1460-1530 (DU. BD 190016 and 190022). In the early 16th century, therefore, whilst Derbyshire and Mendip producers, utilizing the simple 'bole', assumed price leadership in the industry exploiting ores of 45% metal content, at Durham the 20% ores were smelted in the normal 'blackwork' oven/'bole' complex and lesser ones were processed by the new method at rates of extraction some 7-10% over those attained by the 'bole'. The exploitative margin had been extended and when conditions of specific depletion once more emerged in the years after 1536 there was a rapid diffusion of the 'new' Durham technology.

Technological transition: the ore hearth and the 'Durham oven'

The gains were, however, relatively small and the periodicity of the production fluctuation, already acutely shortened, was extended but little. In the absence of further technological change long-term problems of depletion would soon re-emerge. In the event it was not to be, yet paradoxically innovation which spelled the end of the medieval technology also preserved its existence for more than a century. The ore hearth, developed on Mendip in the 1530s, freed the industry from its traditional resource base. Though less efficient than the 'bole', both in terms of ore extraction rates and fuel consumption, it could reduce ores totally unutilizable with the old technology. By the judicious use of the sieve these 'riddlings' could be retrieved and smelted. The waste tips of centuries, containing pure galena, suddenly became exploitable, thus freeing the industry from dependence on exhausted mines and paving the way for a production boom of unprecedented dimensions.[14] In the process, however, the 'new' industry provided the environment for an expansion of the 'old'. If the 'bole', restricted to using diminutive 'wash' ores, could not compete with the ore-hearth using high-grade 'smitham', and disappeared, the latter technology provided a burgeoning flood of raw materials for the 'blackwork' oven. The lead-rich slags, generated by the ore hearth, were most effectively processed in the oven where, using the techniques pioneered in Durham, they would yield almost two-thirds of their metal content. 'Blackwork' ovens accordingly increased in numbers and provided an outlet for those low-grade ores which, when mixed with the slag, also yielded a high proportion of their metal content. Accordingly whilst a new sector of the mining industry emerged in the late 16th century to service the needs of the ore-hearth smelting complex, that technology, by providing a new lease of life for the Durham variant of the 'blackwork' oven, opened up a new epoch in the history of the old medieval mine workings in which production expanded rapidly, at least until the second quarter of the 17th century. The ore-hearth thus did not signal the end of the Middle Ages; that only came in the 17th century when the second phase in the development of the ore-hearth led to an enhancement in the efficiency of both sectors of the smelting industry and the incorporation of both processes in the new smelt-mills. At that point one phase in the industrial archaeology of the lead industry came to an end - and another began.

Appendix

Notes on the topography of the principal lead fields of England and Wales in the period prior to the introduction of the ore-hearth (Fig 71)[15].

England

a *Derbyshire* (see map in *Derbyshire Archaeol J,* 91 (1971), 126; Carruthers & Stratham 1923)

The focus of the newly emergent lead industry of the 1170s, situated as it was on the High Rake (A'-) *(Derbyshire Archaeol J,* 91 (1971), 1224) at the node of the Dirtlowe, Moss, White, Tideslow, and Hucklowe rakes, was far removed from the production centres of the old silver-lead industry.' The site posed major problems. To the north and west increasing depth vitiated working the deposits, which contained a significant element of carbonate ores, Accordingly production, during the years 1170-1260, was concentrated on the High Rake and its eastern extension towards Hucklowe as well as its south-eastern branch which passed through Tideslowe, Wardlowe, and Stoney Middleton (PRO DL 39/l/3 and 5; C.135/127/12), From the 1240s, however, these workings which had sustained an enormous output, particularly during the boom years of the late 12th century, began to experience difficulties as production recovered from the depression of the early 13th century. In 1248/9 mining at Hucklowe came to a halt because of flooding (PRO DL39/1/5). At Wardlowe production, after a brief recovery, declined and the subsequent extension of the workings eastward to Eyam and Middleton during the closing years of the 13th century provided but little compensation (PRO C135/127/12; C-.33/37.7).

In the boom conditions of the late 13th century the industry became located in two entirely new locales. Within the High Peak the workings within the royal forest were eclipsed and from 1260-1360 production became concentrated on the Hard/Mandale Rake, between the Wye and the waters of Lathkill within the manors of Bakewell and Ashford, and on the Hard Rake (A^1B^1-) within the Peak jurisdiction of Leicester Abbey. Even these workings, however, which produced *c* 2300 loads of ore each year in the 1340s were overshadowed by the mines of the Low Peak situated on the Coast Rake ($A^1$2.2.B'3.1), which was exposed in the west at Hartington and in the east at Winster, where production was about double that of the other major centre. This, however, was the heyday of the Derbyshire industry (PRO SC6/1146/11; DL29/1/3; Bodleian Ms Laud Misc 625, fo 161; Lichfield Joint Record Office, Mss of Dean and Chapter E4-5,9,13,16,26-7; PRO C.134/103/7; BL Harley Ms 4799; PRO C-135/24, 118/18).

During the next major production cycle of the industry from 1360-1460 the onus of supplying the nation's lead requirements passed elsewhere to Mendip, Flint, Durham (1360-1420), and Yorkshire (1420-60), where production continued but under conditions of enhanced costs, ensured by the necessity of working lower-yielding ores obtained at greater depths (see p 00). In such circumstance the contribution of the Derbyshire mines was diminutive. From 1360-1420 mining was restricted to the more difficult sections of rakes which had long been worked, at Hucklowe, where the fight against water was continuous, and on the easterly extensions of the Mandale situated on both sides of Lathkill water. Only in the 1420s was a new vein opened up - the Cheprake ($A^1B^2$3.73) - and from that date until the 1460s mine workings proliferated all along the new, deep rake at Great and Little Longstone, Rowland, Hassop, and Calver (Blanchard 1971; in press). By 1460, however, the impetus was spent and the final act in the story of the medieval Derbyshire workings was about to be played out.

Once again migration shifted the foci of production to new locations, but this time the wheel had moved full circle. The new workings were all situated on the deep easterly rakes of the Derbyshire limestone syncline - in the general vicinity of the ancient Saxon silver-lead mines. Of prime importance were the Low Peak workings (A^1B^2- 1460-1528, 3.73; 1528-36, 9.$B^3$1536- 10.25) on the Nestor Rake near Matlock bridge and on the more southerly Ravenstor, Yokecliff, and Gang Rakes situated about Wirksworth and extending eastward towards Crich. At their height, during the period 1460-1530, these mines produced about 3360 loads of ore annually (PRO DLl/l0F2; DL3/18F35-8; STA/CHA 2.15/141-50, 23/307). Of lesser significance were the deep workings situated on the Earl-Shuttle rakes (A^1B^2) within High Peak (Blanchard 1971; in press). Together these mines, with a maximum annual output of *c* 3800 loads of ore, dominated the English industry during the years 1460-1530.

b *Durham* (see map in *Business Hist,* 15, 2 (1973), 99)

Impeded in their development by high fuel costs and the presence of low yielding ores the plumbiferous deposits of the episcopal hunting forest, which extended from Weardale into the upper reaches of Teesdale, were reopened in the 1370s after a lapse of 150 years. At the centre of the mining complexes, which emerged during the years 1370-1420, were the old 12th century mines, on the Red and Burtree Pasture veins near Rookhope and Stanhope. The deep shafts and complex of tunnels which characterized these mines, however, contrasted with the new, shallower workings opened up on two groups of pristine deposits during these years. The first lay far to the south amongst the head waters of the Burnope and Ireshope burns where miners worked the Ashgill Head/North Langtry and Greenlaw West veins. The second was concentrated about Saint John's Chapel and encompassed the most northerly section of the Greenlaw West vein, the Slit vein, and workings on the Bracken Sike.

The renaissance of the ancient mines was ephemeral, however, and by the late 1420s production was entirely concentrated on the newer workings, although already by that date miners were being forced to excavate ores at depths of up to 50-60 ft. As yet, however, it was the shallow workings at Blackden on the Split vein which contributed by far the greatest proportion of total output. The deeper mines on the Sedling vein and the Greenlaw West rake at Harthope and Ireshope provided only 9% and 7% of total production respectively *(Business Hist,* 15, 2 (1973), 98-100). Such was the structure of mining operations until 1460. In the interim, however, Blackden made a steadily decreasing contribution to total output as working was extended to the deeper east and west cloughs. The corollary was the increasing importance of the Sedling and Greenlaw workings ($A^2B^2$5, 7·5, 9), but as deeper working led to the excavation of an increasing proportion of carbonate ores, yields fell and the supply of slags ceased to be self-generating (DU.BD 190022, 190016).

At this point the possibility of further extensive growth was impossible and the years 1460-1530 witnessed the reworking of existing mines. Until the end of Henry VII's reign the focus of attention was the westerly workings of Rookhope, Sedling, and Welhope Head (DU.BD 190289). During the first half of his son's reign the Slit and Red Vein mines were once more reopened. The onus of maintaining production in conditions of declining yields thus, during the years 1460-1530, fell on the smelters ($A^2B^2$9, B^3 10.25) who, by innovation, proved remarkably successful - until the cataclysmic changes of the 1530s (DU.BD 190020).

c *Mendip* (see map in Blanchard in press and Dewey 1921)

The basis for mining activity on Mendip was the lodes and veins of galena ore, coursing in two main rakes east-west through the carboniferous limestone. These rakes were highly fragmented owing to major structural displacements causing marked geographical discontinuity in mining activity. Along the northern edge of the hill, therefore, the main vein, so clearly distinguished from the geological maps, broke up into three main outcropping deposit complexes. In the far west the rake terminated in the Banwell-Sandford Hill complex. Moving eastward there were the deposits situated on the hill above Shipham where the main vein split into northern and southern branches, the former terminating, at its eastern extremity, beyond Blackdown, in a vast straggling group of rakes and lodes, often juxtapositioned at right-angles to each other, ranging the full east-west extent across the Harptree parishes and outcropping in small deposits within the Litton and Enborough boundaries. The southern section was even more fragmented. Beyond Black Down the first complex centred upon Charterhouse, where one branch of a dry valley cut north-eastwards across the rake exposing the inliers of grey crystalline material. The next easterly deposit was at Priddy Hill and beyond it was the final mining area on the southern vein, extending from the lower slopes of Stock Hill, within the liberty of St Cuthbert, to Red Quar. These then were the main Mendip galena deposits, widely dispersed, highly fragmented, liable suddenly to disappear below thick carboniferous limestone beds, which provided the basis for the medieval lead industry and which also ensured that it should have one basic characteristic: a high degree of geographical mobility.

The earliest medieval workings date from the 1190s when the Bishop of Bath's workmen unearthed the galena outcroppings in a dry valley above the Cheddar gorge within the waste known as 'Hydon'.[17] These initial discoveries took place within the southern section of the area, which lay within Cheddar parish, but it was not long before, continuing up the valley, the workmen opened up new deposits within that conglomeration of holdings from which the Mendip forester drew revenues.[18] Thus the first Mendip mineries came into existence during the closing years of the 12th century.

Thereafter each century witnessed a relocation of the industry; the next phase took place during the last quarter of the 13th century within the lands of northern 'Hydon'. Here, owning the land in which lay the as yet uncharted mineral deposits, were many lords. By a charter in which the Carthusian monastery of Witham was founded by Henry II, the monks received an extensive grant of pasture on Mendip in the vicinity of 'Hydon' thereby endowing the place with the name 'Charterhouse Hydon' (Gough 1928). Adjacent to this and between it and the Ubley boundary was a messuage, meadow and pasture on 'Hydon' for 1000 sheep and 60 beasts which Robert de Gurney, Lord of Harptree had granted to the Templars, thereby endowing the place with the name 'Temple Hydon' which became a sub-member of Templecombe preceptory (Winchester College, Longload Ms 12843 2 81-3; Lees 1935). The first signs of mining within these properties which may be specifically dated are for 1283, when, in order to exploit their mineral resources free from the royal forester's interference, the Witham monks obtained a charter to 'work all mines of lead which they might find in their own several ground [ie Charterhouse Hydon] and to take and have for their own use the profits accruing from them, as might seem most expedient to them without let or hinderance' (Gough 1930, 53). A new minery had sprung up amongst the ruins of the old, and at some date during the early years of Edward I's reign production was again resumed in the then derelict Bishop's mine, heralding the heyday of the 'Hydon' mining complex. Alone in producing lead ore on Mendip hill, the small dry valley incised into the chalk uplands was littered with workmen each summer excavating the grey-blue ores from the southern branch of the main Mendip rake. Yet production therein, if the Bishop's minery is not atypical, was slight and by the 1330s had probably ceased altogether.[19] Thereafter, apart from an ephemeral growth of production east of Priddy in 1339-42, the Mendip industry lay moribund until the Black Death (Gough 1930, 50). The old workings at 'Hydon', which had lived throughout their existence in the shadow of the silver producers of Wales (1170-89,1227-80) and Devon (1292-1348), faded in men's memories and when mining was resumed after the great pandemic the production focus had shifted elsewhere.

The origins of mining at the new location are unclear, yet for the closing years of Edward III's reign the documents reveal the industry in full expansive spate. Within the old mining area, at its north-eastern extremity continuing along the main rake's southerly branch, a new working was opened up within the properties of the Hospitallers at Temple Hydon (see note 19). Adjacent but over the border, within Richard Cheddar's manor, were the Ubley workings[20] These two formed the permanent elements which were to survive through to the 16th century.

Less permanent were the new early 15th century centres. During the early 1410s the old 'forester's mine' passed into the Crown's hands during the minority of Edmund Mortimer and, on 3 February 1418, letters patent were issued empowering John Bays and William Milward Jnr to reopen the derelict workings (Gough 1930, 58-9).[21] However, political good fortune was not enough when confronted with unfavourable economic circumstances and a mineralogy of low-grade galenas in highly fragmented veins. Having excavated during the summer enough ore to produce some nineteen hundredweight of lead the lessees decided to abandon the unfruitful work (Gough 1930). Equally ephemeral were the workings which grew up on the basis of a rich find far to the west within Banwell parish during the 1430s (Lambeth Palace ED/l 187-9, 222-3; Bodleian, Somerset Rolls 4-5). This village was included in the Bishop's north-western manorial complex, separated from the main mining area by the Lox-Yeo Valley, where the river flowed from above Winscombe to join the Axe.[22] Here miners working Banwell hill at Dalby discovered a rich ore pocket near the 'caves' which provided the resource base for the industrial complex which grew up here during the years 1430-40 but soon disappeared. All that remained, therefore, from the previous relocation were the shattered remnants from the late 14th century growth centres - Hinton alias Hydon and Ubley.

From the 1440s industrial relocation, whilst not obliterating the Ubley-Hinton complex, pushed the focus of mining further and further eastward, thereby integrating the industry into a whole series of villages stretching in an arc from Hinton Charterhouse to Priddy above Wells. During the years 1442/61, as Ubley's production returned to the levels attained in the 1430s, workmen started to exploit the deposits at Priddy and Compton (Dean and Chapter of Wells, unnumbered account of 1457/8). Thereafter, following a lull in production and a period of intensification new deposits were opened up in the immediate pre-Dissolution period. During the years 1525-33 the Chewton rakes were discovered and from 1532-6 workings were established within Enborough, Litton, and Harptree parishes (Somerset RO C924/DD/WG 16/3; PRO E315/385; Bodleian, Somerset Rolls no 7). This then was the locational pattern in 1536, the product of two centuries' migration. The workings stretched fan-like along the northern edge of Mendip, concentrated about four geological complexes which formed the natural focus for the 1540 administrative divisions. In the west lay the late 14th century workings at Ubley and Temple Hydon alias Hinton, which when coupled with the mid 15th century growth centre at Compton Martin formed the west minery. Eastward lay the second concentration - East Harptree, Litton, and Enborough - which formed the East or Harptree minery. Swinging south the two largest groups within the 16th century workings follow next in sequence. First, one comes to Chewton minery, founded in the second quarter of the 16th century, and then on to the complex established in the mid 15th century within Wells and Chewton lordships - Priddy Minery. Such was the form that the Mendip field had assumed by 1540, so familiar from the ancient mining maps, the product of a gradual locational migration which only assumed a stable form at that date.[23]

d *Yorkshire and the central Pennine fields*

The development of the Yorkshire fields began almost contemporaneously with those of Derbyshire, the pristine deposits of Arkengarth and Nidderdale being first opened up in the 1170s. Unfortunately the enigmatic entries on the Pipe Rolls provide no detailed information about the exact site of the 12th century Richmond mines (*Pipe Roll Society,* 36 (1915), 83). Indeed their history throughout the Middle Ages is obscure and only a sketchy outline of their evolution may be gleaned from the documentation available. The story is a gloomy one. Each successive production cycle witnessed a decline in the amount of lead produced in the area, from about 90 fothers in the 1190s to 25 a century later, and to about 5 fothers in the 1390s (PRO SC6/1116/9m.5; SC6/ 1086/l-3). The 15th century witnessed a renaissance in the industry, however, and production, now' centred 'in "Marrykmore" and in other diverse places in the "New Forest"', briefly attained a level of about 10 fothers a year before collapsing in the 1490s (PRO SC6/ 1086/4,6; DL 29/649/10500-8).

Thanks to the litigious nature of successive abbots of Fountains and Byland and the legalistic exactitude of the priors of Bolton, information concerning the mines of Nidderdale and the adjacent workings in Wharfe, Aire, and Wensleydale is altogether more abundant. During the 12th century the initial focus of production lay about Heathfield alias Stoney burn in Nidderdale. Here thanks to successive grants from the Mowbrays of rights within the forest the two Cistercian houses opened up workings in the 1170s - Byland north of the burn on Heathfield Moor, Fountains to the south close to their lodge at Coldstones (BL Egerton Ms 2823; Lancaster 1915, nos 5, 7, 11-12; Mss of Yorke family, Halton Place, Skipton, nos 55-60, 62-68). For three centuries working continued here, each demand-induced boom leading to renewed activity in the area, when not impeded by competition from Derbyshire lead.[24] With successive re-exploitation of the veins, however, production was pushed further and further south, until in the 1480s the focus of production centred upon Greenhowe Hill where the workmen of Fountains Abbey met up with miners, working for Crown lessees, who had begun excavating the outcropping veins in Knaresborough Forest, and with that group of workmen who were working eastward along the vein which crossed the Prior of Bolton's lands in Appletreewick.[25]

Mining activity in this latter centre had begun in the 1260s, during the second major industrial cycle, when central-Pennine lead producers had commenced on a diaspora which, during the next 250 years, would establish workings throughout the area. Initially located (1260-1320) at Galgarth in Appletreewick, production in Wharfedale subsequently migrated eastward towards Greenhouse (1480-92, 1502-) and northward to Bukden (1360-90), Kettelwell (1502-15), and Langstroth (1440-92).[26] Nor was this pattern of ephemeral exploitation exceptional in the area. Equally impermanent were the mining camps established in Airedale at Cononley (1528-), in Rossendale at Baxenden (1290s), and in Ribblesdale (1530) and Wensleydale (1360-90) (Kershaw 1969,46; PRO DL42/30 fo 74; Jennings 1967,58-66; Lyons 1884). Few if any of these centres made more than a peripheral contribution to central-Pennine lead production which continued to be dominated throughout the period under consideration by the workings of Arkengarth and Nidderdale.

Wales

The massive programme of castle building undertaken by the first three Edwards after the conquest of North Wales provided a direct stimulus to the development of an indigenous industry within the principality. Initially supplied at high cost from England, the building sites increasingly drew on local sources from the 1280s. From that date until the second decade of the 14th century it was only in the south that English lead continued to predominate (PRO E101/501/25; E372/202; E101/486/6). In West Wales there was a brief opening up of production at Llanbadarn in the commote of Genau'r-glyn during the years 1301-6, but this was only a passing interlude occasioned by a crisis in the major lead centre within the principality - Flint (PRO SC6/1218/1-2, 9). From 1284-1320 Flintshire dominated the market, its products supplying not only north and west Wales but also Cheshire and even penetrating as far south as Builth. Production here (A') was initially concentrated on the Grange-Penyball rakes, which, though rich, suffered from a chronic shortage of fuel which impeded production in the early 1300s and finally brought it to a halt in 1327 (PRO SC6/771/1 *et seq).*

The stage was set for a major restructuring of the industry. From 1327 to 1351 the focus of production shifted eastward. During these years mining activity was concentrated in a series of fields extending north-west from Minera, through Eryrys to Hopedale.[27] Finally, however, after the great pandemic, the workers, continuing north-west, once more entered Flint. From 1354-1420 the southern section of the Flintshire field once more established the county as the premier Welsh production area. At this time mining was concentrated in two areas. The first and largest mining camp was situated just to the north of Hopedale at Vaynol, the ore being transported from there to Buckley for smelting (A^2B^1 1354-90 2.2-3.73. A^2B^2 1390-1420 3.73-9). Of lesser importance were the workings on the Old Rake, extending from Halkin to Moel y Gaer near Culken. Both, however, were subject to diminishing returns as the proportion of 'wash' ores increased until the final extinction of the mines in 1420 (PRO SC6/771/20 *et seq).* Henceforth the market in Wales was supplied exclusively from English sources.

Notes

1 Lopez 1936, 18–19, 28; Molenda 1963, 45, quoting the Bull of Innocent II concerning the *rusticis argentifossoribus* of Zversov before Bytom; Maleczynski 1951; Neuberg 1892; Boyce 1920, 17; and see note 2.

2 The author hopes shortly to publish a study of metallurgical production and markets in the 12th century.

3 On the *meer* and the jurisdictional framework within which the miner worked see *Victoria County History,* Derbyshire, **2**, 326; *Cal Inq Misc,* **3**, 222; Jones 1913, 9; BL Add Mss, 10013, fos 33–34v

4 Radley 1969, 2–3, 9; and personal observations of author on the occasion of a visit to the site in the summer of 1968.

5 PRO SC6/1146/11, *Calendar of Carew Mss* (1867), 270; Mss of His Grace the Duke of Rutland, Belvoir Castle 1012, 1014–7, 1025, 1098.

6 On extraction rates obtained in the cupelation hearth, see PRO E372/142m.30, E372/145/m.22, *et seq*; in the 'bole' see also PRO SC6/1146/11; on the furnace see note 7.

7 On the fuel consumption of the 'bole' in Durham and Derbyshire 1520–70 (*c* 3 cords of brushwood per ton of ore) see manuscripts of the Bishopric of Durham, preserved in the Department of Palaeography, Univ Durham (henceforth DU.BD), 190019 and PRO E134/24 Eliz Hil.4 evidence of Robert Smith and William Taylor. In smelting galena *bing* this meant a consumption of *c* 8–9 cords per ton of lead. The phase-one furnace utilized half the timber consumed in the contemporary 'bole' which was used to reduce ores with 15% metal content, viz 19 cords per fother. As that furnace smelted pure galena *smitham* at an extraction rate of 50% (2·5 tons of ore per ton of lead), consumption of fuel was 7·6 cords per ton of ore, or 2½ times the consumption of the 'bole' utilizing similar ore; Lambeth Palace *Ms Tenisoniani,* 710, fo 70. The 'bole' had a consumption comparable with that of the early blast furnace which utilized about 3 loads of charcoal per ton of pig, made from 9 cords of wood; Crossley 1975, 17–22.

8 On the consumption of 'bole' utilizing pure galena *bing* which yielded 58% of its metal content, see the sources listed in note 6. On the impact of increasing proportions of *wash* ore on yields, see PRO SC6/771/22–3, 772/1.3. With a charge comprising purely *wash* ores extraction rates amounted to no more than 1 or 2%. For an interesting modern experiment in smelting 12–25 mm cubes of galena see Tylecote 1962, 76.

9 The impact of diminishing timber growth rates and lengthening maturation periods, by reducing the supply available for cutting, could lead either to an enhancement of the price of wood 'on the stub' or, if prices were held stable, to excessive cutting thereby preventing the renewal of the 'stand' and ultimately causing the destruction of accessible woodland.

10 The costs imposed by the failure of the wind or its shifting into another quarter were particularly noted in descriptions of the 'bole' during the period of high timber prices which began in the 1570s; PRO E134/24 Eliz Hil.4 evidence of John Smith and William Taylor.

11 For an example of such market manipulation see 'Seigneurial entrepreneurship: the Bishops of Durham and the Weardale lead industry, 1406–1529', *Business Hist,* **15**, 2 (1973), 105–6.

12 PRO SP12/122/63; and for the remains of a 'blackwork' oven hearth, misidentified as a 'bole', see Raistrick 1927, 85, fig 14.

13 On market conditions in the early 16th century see Blanchard 1979.

14 On the process of technological change in the 16th century, see the work referred to in note 13, and for its effect on production, Blanchard 1978, 24.

15 The character of the material evidence which might be expected, on the basis of documentary sources, to be found in each location is indicated by the following abbreviations:
A^1 simple 'bole'; A^2 'turnbole'; B^1 'blackwork' smelting, phase 1 (slags only); B^2 'blackwork' oven: B^3 *ibid,* 'Durham' variant. The figures following each abbreviation (2.2, 3.1, etc) indicate ore yields in tons of ore per ton of lead.

16 The old silver-lead mines were located on the deep easterly rakes of the Derbyshire limestone syncline.

17 The name 'Hydon' seems not to have been related to one particular place of human settlement as

suggested in Gough 1930, but to have been a general place-name relating to the pastures. Thus in the south 'Hydon' lay within the manor of Cheddar (see the charter of 1235 quoted in *ibid*, 50–1). Continuing north one comes to Charterhouse Hydon (*ibid*, frontispiece) and then Temple Hydon (Winchester College, Longload 12843 2 no 83).

18 On the properties comprising the forestership, see PRO SC6/972/28, and for its early history, MacDermot 1911, 107–74, 441–2. The descent of the property from the de Wrothams until it finally came into Mortimer hands during 1359 is traced in Krauss 1932, 60–9.

19 BL Add Ch 26430; Larking 1857; PRO C134/76.3, C135/151/8; Somerset RO C795/DD/SAS/BA1; Lambeth Palace ED 1177/8, 214.

20 The earliest reference to the Ubley workings dates from 1372/3, Somerset RO DD/S/HY/B2.

21 It is perhaps worthy of note that the phrase used in the letters patent of 1418 is the same as the heading in the Mortimer accounts, PRO SC/1113/1.11; 972/28.

22 On the administrative structure of the episcopal estates, see Dunning 1963 and Hembry 1967.

23 Gough 1930, frontispiece. Throughout the history of the medieval mines on Mendip the ores, which yielded a ton of lead from 2·2 tons of ore to *c* 1360 and from 3·7 tons thereafter, were reduced in the simple 'bole'.

24 Jennings 1967, 61; Memorials of Fountains Abbey, *Surtees Soc*, **42** (1863); PRO SC6/1148/17m.2, 23m.3. Whilst the early organization of smelting remains obscure from the 1370s at least, it is apparent that the industrial complex servicing the requirements of the Nidderdale industry comprised an indeterminate number of 'boles' and a water-powered 'smeltmylne' ('blackwork' oven).

25 Yorke Mss, 1027, 1030–3. PRO DL1/7. D3; 21/K3; 22/3–6, 10–11; 30P2. DL5/5 fos 390–1. DL30/490/9 *et seq.* DL39/3/29; 4/16. DL41/7/10. DL42/19 fos 31, 38^{v}, 72^{v}, 21, fo 89^{v}; 30, fo 74^{v}. SC6/ HRY8/7452.

26 Yorke Mss, 1–3, 5–7, 9, 11–13. Chatsworth Ms 73A from a transcript kindly provided by Dr Ian Kershaw. PRO SC6/1087/6mm.2–6d; HRY8/4170–2; SC11/730m.19; Bean 1958, 15, nn7–8.

27 Pratt 1962; BL Add Ms 10013, fos 33–34^{v}; Salop RO 552/1A/1. *Register of Edward the Black Prince*, 3, Palatinate of Chester, **3**, 67, 70–1, also Appendix 4. Evans 1925–6, 107–10.

Bibliography

Bean, J M W, 1958 *The estates of the Percy family 1416–1537*

Blanchard, I, 1971 Derbyshire lead production, 1195–1505, *Derbyshire Archaeol J*, **91**, 119–140

——, 1974 Stannator fabulosus, *Agr Hist Rev*, **22**, 1, 62–74

——, 1978 Labour productivity and work psychology in the English mining industry, 1400–1600, *Econ Hist Rev*, 2 ser, **31**, 1, 1–24

——, 1979 England and the international bullion crisis of the 1550s, in *Precious metals in the age of expansion* (ed H Kellenbenz)

——, in press Industrial employment and the rural land market, in *Land, kinship and life cycle* (ed R Smith)

Boyce, H, 1920 *The mines of the Upper Harz from 1514 to 1589*, Menasha, Wisconsin

Carruthers, R G, & Stratham, A, 1923 Lead and zinc ores of Durham, Yorkshire and Derbyshire, *Mem Geol Survey*, **26**, 41–103

Crossley, D W (ed), 1975 *Sidney ironworks accounts, 1541–1573*, Camden Soc, 4 ser, **15**

Dewey, H, 1921 Lead, silver-lead and zinc ores of Cornwall, Devon and Somerset, *Mem Geol Survey*, **21**, 60–72

Dunning, R W, 1963 *The administration of the diocese of Bath and Wells, 1401–1491*, unpubl PhD thesis, Univ Bristol

Evans, D L, 1925–6 Some notes on the history of the Principality of Wales at the time of the Black Prince, 1343–76, *Trans Hon Soc Cymmrodorion*

Gough, J W, 1928 The Witham Carthusians on Mendip, *Proc Somerset Archaeol Soc*, **75**

——, 1930 *The mines of Mendip*

Hembry, P M, 1967 *The Bishops of Bath and Wells 1540–1640*

Jennings, B, 1967 *A history of Nidderdale*

Jones, A (ed), 1913 Flintshire ministers' accounts, *Flintshire Hist Soc*, **3**

Kershaw, I (ed), 1969 *Bolton Priory rentals and ministers' accounts 1473–1539*, Yorkshire Archaeol Soc Rec Ser, **132**

Kirkham, N, 1968 *Derbyshire lead mining through the centuries*

Krauss, R, 1932 Chaucerian problems: especially the Petherton forestership and the question of Thomas Chaucer, in *Three Chaucer studies*, New York

Lancaster, W T, 1915 *Chartulary of Fountains Abbey*

Larking, L B (ed), 1857 *The Knights Hospitallers in England*, Camden Soc

Lees, B (ed), 1935 *Records of the Templars in England in the twelfth century*

Lopez, R, 1936 Contributo alla storia delle miniere argentifere di Sardegna, *Studia Economico Guiridici*, **35**, 17–28

Lyons, P A (ed), 1884 Two compoti of the Lancashire and Cheshire manors of Henry Lacy, Earl of Lincoln, *Chetham Soc*, **112**, 1–56

MacDermot, E T, 1911 *History of the Forest of Exmoor*

Maleczynski, K (ed), 1951 *Codex diplomaticus nec non epistolaris Silesiae*, **1**, Wrocław

Molenda, D, 1963 *Gornictwo Kruszcowe na terenie złoz slasko-krakowskich do połowy xvi wieku*, Wrocław-Warszawa-Krakow

Neuberg, C, 1892 *Goslars Bergbau bis 1552*, Hannover

Pratt, D, 1962 The lead mining community at Minera in the fourteenth century, *Trans Denbighshire Hist Soc*, **11**

Radley, J, 1969 A triple cairn and a rectangular cairn of the Bronze Age on Beeley Moor, *Derbyshire Archaeol J*, **89**, 1–17

Raistrick, A, 1927 Notes on lead mining and smelting in west Yorkshire, *Trans Newcomen Soc*, 7, 81–96

Tylecote, R F, 1962 *Metallurgy in archaeology*

Introduction

This paper is about only a small part of southern England, yet the area in question is historically of national if not international importance as, with Cornwall, it forms the only tin-producing zone in Britain and one of few such zones in Europe as a whole.

Tin was widely used in medieval society for the manufacture of pewter and other tin-rich alloys, both for secular and religious purposes (Hatcher 1973, 2742).

The tin industry of south-west England has been relatively well studied from an historical point of view, notably by Lewis (1908), Finberg (1949), Hatcher (1970; 1973), Hamilton Jenkin (1927), and Barton (1967), but very little work has so far been done on relating the surviving field evidence to the historical data, or even on describing the field evidence. It is the aim of this paper briefly to consider the known documentary evidence for the medieval period, to indicate the richness of the field evidence still available for study in Devon and how it relates to the documents, and to show what potential there is for future archaeological work.

The tin-bearing zone of Devon is shown in Fig 76. Both lode and alluvial deposits of cassiterite are concentrated on the granite mass of Dartmoor and its surrounding metamorphic aureole, but the rivers and streams running off this area also contain important alluvial deposits. At a rough approximation, 1000 sq km of land within the county of Devon contain tin-bearing ground. Also shown on Fig 76 are the bounds of the four stannary districts of Devon based on the towns of Chagford, Ashburton, Plympton, and Tavistock from at least the early 14th century.

There is documented history of the exploitation of tin in Devon from the 12th to the 20th century, the greatest prosperity of the industry being in the first half of the 16th century, for many years of which over 200 tons of tin metal were produced annually within the county. Unlike its Cornish counterpart, the Devon industry was relatively small in scale in the 18th and 19th centuries with the result that many relics of earlier periods were not obliterated then.

Evidence to c AD 1500

Before the 12th century there is no documentary record of tinworking in Devon and the archaeological evidence is minimal, At Dean Moor on southern Dartmoor a pebble of cassiterite was found in the mid 1950s in a prehistoric context in the floor of one excavated hut, and a minute bead of tin slag was found in the hearth of another (Fox 1957,30-l). So far, this is the only direct evidence for prehistoric tinworking in Devon. However, the evidence for iron smelting at Kestor (Fox 1954, 39-44) on north-east Dartmoor indicates that there were other metallurgically aware people in later prehistoric Devon. Perhaps more important is the inferential evidence for the exploitation of tin. The density of prehistoric settlement on Dartmoor is well known, much of it concentrated in valleys which have been extensively worked for alluvial tin. Finds of prehistoric bronze objects and of moulds on and around Dartmoor indicate metallurgical expertise (Burnard 1888-9; Spooner & Russell 1953, 197, 200; Barber 1970, 67, 73; Pearce 1976, 26-8, 34).

Perhaps surprisingly there are no recorded finds of either prehistoric or Roman objects from the post-medieval streamworks or mines of Devon as there are, for example, from Cornwall (Carew 1602, 26-7; Worth, R N, 1874; Hencken 1932, 158-88; Hatcher 1973, 16).

From the mid 12th century the documentary record of the Devon tin industry is unbroken, but until the 15th century there is very little detailed evidence surviving. The extent of our historical, as opposed to archaeological, knowledge of the medieval period is constrained by the availability of relevant documentary material.

We can be most confident when speaking of the annual production of tin metal in Devon throughout the period. Hatcher (1973, 152-63) has published detailed figures for the years 1243-1549, and a certain amount of data is available for earlier periods. From these figures it is clear that throughout the second half of the 12th century production of tin in Devon was greater than in Cornwall, but that at some time in the 13th century the Cornish level of production overtook that of Devon and thereafter never lost the lead. In the second half of the 14th century and early 15th century production in Devon was sometimes as little as one-tenth that of Cornwall. Production in Devon increased in the second half of the 15th century, but even at the peak of the industry in the early 16th century it was only one-third to one-half of the Cornish level. Despite this, the scale of working in Devon throughout the medieval period was never insignificant.

Although the above figures are useful they provide only a general picture. They do not, for example, indicate fluctuations between different stannaries nor do they reveal where tinworks or smelting mills were located. Indeed, we cannot even be sure how reliable the data are.

The general administration of the medieval stannaries is also relatively well documented. William de Wrotham's letter of 1198, King John's charter of 1201, and Edward I's charter of 1305, confirmed in 1327 by Edward III, are well known (see Lewis 1908, 233-41 for transcripts). In broad terms they recognized and confirmed the ancient rights of the tinners and allowed them considerable freedom of operation.

The Devon stannary courts appear in the Pipe Rolls as early as 1243 (Lewis 1908, 90), and it is likely that local stannary administration had been set up at the time of King John's charter of 1201. Several late 14th century and early 15th century stannary court rolls survive for Chagford, Ashburton, Plympton, and Tavistock (PRO/SC2/165/38; 166/22-3; 168/9-l 11, 334). Although these have not yet been looked at in detail, superficial study indicates that they do not contain much information that will have an

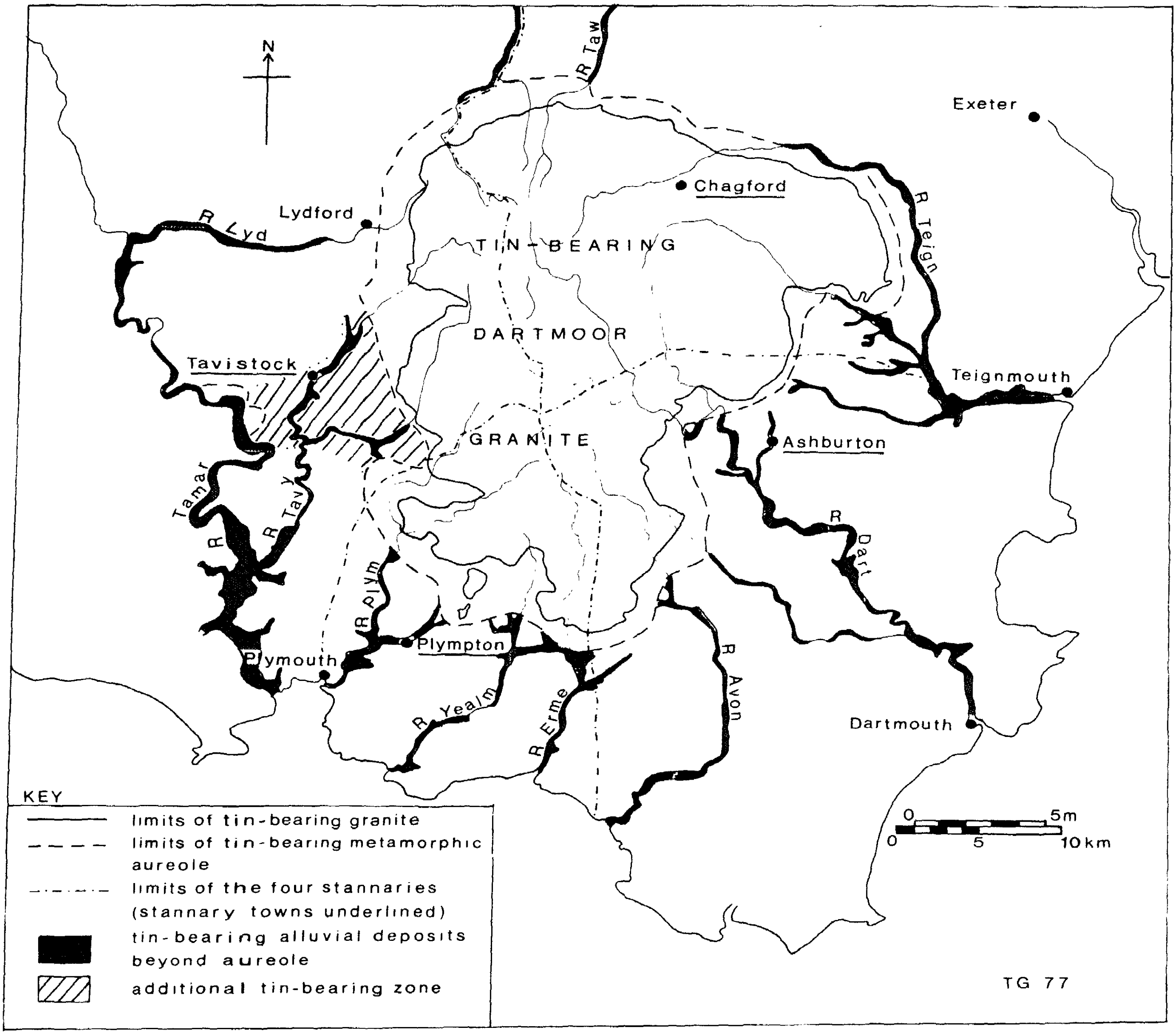


Fig 76 Map showing extent of tin-bearing ground in Devon

archaeological bearing on the industry (Finberg 1949, 166).

The earliest extant coinage roll for Devon is dated 1303 (PRO/E 101/260/24). These rolls record the names of persons presenting tin at the stannary towns and also the number of pieces and weight of tin that each presented. However, only about 20 rolls survive for the period between 1303 and about 1450 and so the evidence, especially for the 14th century, is sadly incomplete. What the rolls do indicate is the small amount presented for coinage by the majority of individuals '(often less than 2 cwt), and also the considerable fluctuation in production between each stannary district. For example, from the late 14th century until the mid 16th century the output of Plympton stannary is almost invariably dwarfed by the output from the other three (for data up to 1523 see Finberg 1949, 171). This is not the inference one would make from a superficial glance at the archaeological evidence, as the area of Plympton stannary has the greatest number of surviving mill structures dating to before *c* 1700 (see Fig 82).[1]

Besides the above evidence of a fairly general nature, a few documents do provide some insight into specific medieval tinworks and smelting practice.

As early as *c* 1150 Hugh of Chagford and Alice his wife granted land next to Chagford Bridge, with the exception of the mill, mill leat, and 'mines of tin if by chance they should be found' (DR0/314M/T62). This shows that there was at least an interest in tinworking in the area at that time. In 1168 Guy de Bretteville and the lord of Brisworthy were both fined for the illegal digging of tin near Sheepstor on south-west Dartmoor (Finberg 1949, 157), and at much the same time tin was being raised on the Earl of Devon's Plympton estates (Finberg 1951, 169 n4). A group of Chagford tinners was fined for the illegal smelting of tin in 1185 (Pipe Roll Soc, 34, 1913, 160-1).

The sites of several tinworks mentioned in the 13th century can be identified today. Among the bounds of the Forest of Dartmoor in 1240 was 'la Dryeworke' (Moore & Birkett 1890, 6, 53; Somers Cocks 1970, 279); this corresponds to modern Dry Lake (SX 660710) which has been extensively worked for tin. The bounds also include 'Furnum Regis' (modern Kings Oven at SX 675813) which may well be an early smelting site though there is only the name to suggest it. In 1280/l a man was killed at a tinwork called 'Mewyhent' (DuCo London/Dartmoor Case Papers etc (Box)/Pleas of the Crown 9 Edw I) which was probably located in the upper reaches of the modern River Meavy on south-west Dartmoor. A more or less contemporary document refers to a tinwork called 'the Haghelonde' which should possibly be identified with modern Drakeland (SX 568586) near Hemerdon Ball (Stevens 1962-4, 47; PWDR0/72/279).

In the 12th century all tin was smelted twice. After the first smelting, which presumably took place near the tinwork itself, a tax of 30d per thousandweight (1200 lb) had to be paid; it was then taken to a market town for a second refining smelt after which it could be sold (Finberg 1949, 156). From 1198 an additional tax of one mark per thousandweight had to be paid on tin of the second smelt (Hatcher 1973, 20). By 1303 both these taxes had been abolished and replaced by one on the finished metal of 1s 6¾d per hundredweight (120 lb).[2] This suggests that at some time during the 13th century there had been an improvement in smelting technique which obviated the need for two smelts, and it may well be that the blowing house, or tin blast furnace, which survived in its basic form until the 19th century, was evolved at this time.

Peat charcoal was the main fuel used for smelting and there are two early 13th century references to tinners being given permission to dig for peat on the Forest of Dartmoor (Spooner & Russell 1953,327-8; Moore & Birkett 1890, 4). There are also frequent references in 13th century Ministers' Accounts for Dartmoor to 'carbonarii' who were the charcoal makers (Moore & Birkett 1890, 9, 11, 13, 26, 27, 32, 33).

The 14th century is remarkable for the number of complaints made against the tinners. In 1314 it was claimed that Devon tinners were destroying 'good farm land, including arable, wood, and meadow, as well as houses and gardens, at the rate of more than three hundred acres a year', and many other grievances were listed later in the century (Lewis 1908, 93-8; Finberg 1949, 161-2). This perhaps reflects the scale of activity within the county.

Not surprisingly, surviving specific references to tinworks from all over Dartmoor are more frequent in the 15th century. For example, in the first half of the century there was a dispute in the court of Chancery over a 'Teneworke in Dowmore in Bovyhethfeld' on the south-east side of Dartmoor (PRO/C1/17/185). In 1444 a tinwork in 'Newelcombe' (modern Newleycombe) on south-west Dartmoor is mentioned (BM Add 24771 fo 116-7). On northern Dartmoor tinworks at 'Bobhill and Bobhill Coombe' on the upper reaches of the East Okement River are mentioned frequently from 1450 onwards, and a tinwork at Taw Marsh is mentioned in 1487 (Lega-Weekes 1902, 635; DRO/1429A/PW1--4 *passim;* DRO/DD 32193(b)/Okehampton Town Chest no 67b). It is important to note that all these tinworks were located in areas which were reworked again and again in succeeding centuries and there is little reason to doubt that this pattern of continuity existed in previous centuries.

Previous archaeological work

The first archaeological work on the Devon tin industry was carried out in the mid 19th century. The tinners' mill below Yealm Steps (no 18, Fig 82) was described in the 1840s, although it was misinterpreted as a hermitage (Rowe 1848, 152-3). In 1866 Thomas Kelly published a plan of the mill above Yealm Steps (no 17, Fig 82) with plans and sections of mouldstones from both the Yealm mills (Kelly 1866-7). At much the same time the field remains of the mill at Gobbett (no 23, Fig 82) were described and illustrated (Amery PFS 1870).

Burnard and Crossing were the most active fieldworkers identifying and describing remains in the 1880s and 1890s (Burnard 1888-9; 1891; Crossing 1889-92). Baring-Gould (1900), Woodhouse (1901), and Falcon (1903) continued this work, but the really solid foundation of scholarship was laid by R Hansford Worth who published fifteen papers relating specifically to tinning remains on Dartmoor (1889; 1892; 1910; 1912; 1914; 1925-6; 1927; 1929; 1931; 1932; 1933; 1938; 1940a; 1940b; 1946). His main preoccupation was with the identification and recording of tinners' mills. More recently, additional work has been published by Parsons (1956), French & Linehan (1963), and Greeves (1969; 1971).

No mill has yet been professionally excavated although three have been 'cleared', namely, the lower mill at Week Ford (no 24, Fig 82; Burnard 1888-9, 226-7), the mill at Thornworthy (no 28, Fig 82; Crossing 1889-92, 10), and the one at the Avon Dam (no 21, Fig 82; Parsons 1956, 191-2). A probable tinners' building at Deep Swincombe (SX 642719) was also cleared in the late 19th century (Baring-Gould 1900, 114-17).

As with earlier work, the emphasis of recent fieldwork has been on the mills rather than the tinworks.

Field evidence for Devon tinworking

Tinworks

Tinworks can be divided into three broad categories:
a streamworks ;
b openworks; and
c shafts.

a *Streamworks*

A streamwork is the working of an alluvial deposit of cassiterite. These deposits occur most frequently in valley bottoms, and practically every valley within the tin-bearing zone of Devon has been worked at some time. The evidence for this working takes the form of heaps of waste material which can be classified under two distinct types. The first type, consisting of apparently random heaps of smallish rounded stones,

Fig 77 Tinners' heaps in *parallel ridges on left bank of Ducks Pool Stream, SX 628679, 2.6.1976. Scale: 2 m*

sometimes now covered with vegetation, is widespread over Dartmoor. Good examples can be found on the moorland reaches of the River Plym. The second type consists of parallel or concentric ridges of waste material with a retaining wall along one side. This type, too, is widespread, with good examples on the Blacklane Brook on southern Dartmoor (Fig 77). These ridges must in some way reflect the practice of systematic trenching, though no contemporary description of the method has yet been found. It is possible that the difference between the parallel ridges and the apparently haphazard heaps is a chronological one, though perhaps it is more likely to be connected with the nature of the deposit being worked and the availability or otherwise of an adequate water supply. The practice of tin streaming in Devon continued on a very small scale until at least the 19th century, but as the field evidence is so widespread we can be sure that most remains must relate to the period before *c* 1600.

One sometimes finds retaining walls associated with the haphazard heaps, usually where they border a stream or leat edge; clearly their purpose was to prevent waste material falling into a channel of water that needed to be kept free of debris. In other instances the channels of streams have been artificially straightened and lined with courses of drystone walling to increase the flow of water either for the purpose of washing ore or for draining flat marshy areas at a higher level. These have previously been noticed on the Wallabrook and on the East Dart (Ormerod 1866, 111; Crossing 1912, 240, 476; Spooner & Russell 1953, 22). Other examples exist and they seem to be more common on northern Dartmoor.

Recorded small finds associated with streamworks are very few. A twisted jug handle with slash marks at the junction of the rim and handle was found among

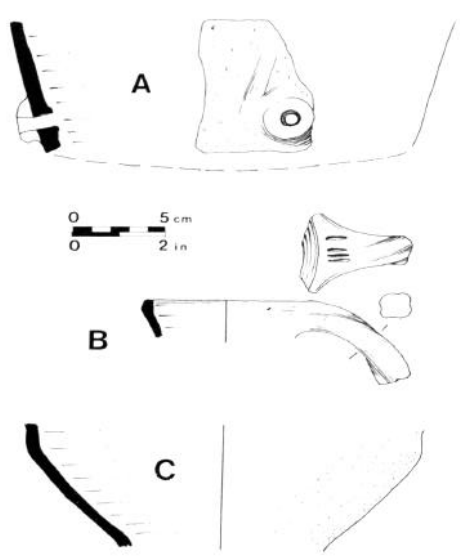


Fig 78 Pottery from sites connected with Devon tinworking. A = sherd of 'cistern' from lower mill at Week Ford; B = jug handle from Golden Dagger streamworks; C= sherd of 'chafing dish' from tinners' building in Deep Swincombe

'Ancient Stream Works' at Golden Dagger Mine in the late 19th century (Plymouth City Museum Accession no 873). Its probable date range is between 1450 and 1600 (Fig 78). An iron hammer with circular shaft-hole, very worn through use at both ends, was found about 3 m below the river bed during construction of the weir for Fernworthy reservoir in 1928. It weighs approximately 2·4 kg. A horseshoe was also found at the same depth (Torquay Natural History Society Museum Register nos 1425 and 1424 respectively).

b *Openworks*

There is a logical progression from working alluvial deposits of tin to working the parent lode material by opencast methods in the hillsides overlooking the valleys. Many of these opencast excavations for tin exist in Devon. They seem to have been generally known as beamworks, and the name of the tinwork thus became . . . Beam. In a few instances the names are still attached to openworks in Devon, eg Gibby's Beam (SX 667677), Kerbeam (SX 561845), Owlacombe Beam (SX 766734), Piper's Beam (SX 656659), and Willow Beam (SX 593701). The documentary evidence is far more impressive, as almost 150 beamworks have now been recorded. The earliest reference is to Joysbcme in 1511 (PWDRO/72/990/5 & 6). Curiously, 'beam' names appear to be rare in Cornwall.

Most of the openworks now have the form of deep V-shaped gullies usually aligned roughly east-west, which is the prevalent direction of tin-bearing lodes in the county. Extensive examples occur in the Birch Tor and Vitifer area near Postbridge. When being worked many must have had near-vertical sides, and some may well have been 25 m or more deep. At Hexworthy Mine at the end of the 19th century, workings were found to extend to a depth of eleven fathoms (20 m) although they were under a surface gully of no more than two or three fathoms (3·6 - 4·6 m) (Worth, R H 1892, 183).

Relatively few artefacts have been recorded from these openworks and those that have cannot be closely dated. At Redlake on central southern Dartmoor a light iron pick still with its wooden handle, and part of an oak strut between 1·8 and 2·1 m long, with notches at each end, were found in old tinners' gullies during exploitation of china clay early this century (Worth, R H 1914, 288). Another piece of oak was found at a depth of 12-13 fathoms (22-24 m) at Great Week tin mine near Chagford in 1887 (Broughton 1967,455).

There is as yet no evidence that tin was mined by large-scale opencast methods in the late 18th or 19th century In Devon; apart from a little streamworking it was all done by adits and shafts. So it is probably safe to assume that all opcncast lodeworks in Devon date to before *c* 1700.

c *Shafts*

The earliest underground mines in Devon are almost certainly those associated with the medieval working of argentiferous lead deposits on the Bere Alston peninsula in west Devon, and at Combe Martin in the north of the county. Detailed accounts of the Bere Alston mines survive from the end of the 13th century and, among other things, they mention old adits, pumps, etc even then (BM Add 24770 fo 167-86, 202-7). But these ores are geologically very different from those of cassiterite with its extensive alluvial deposits and relatively shallow lodes. So how early might tin have been worked by underground methods in Devon?

In Cornwall, contemporary 16th and 17th century writers mention, or imply, underground tin mining to a considerable depth; 50 fathoms (91 m) in the case of Carew (Norden 1584, 13-14; Carew 1602, 36, etc). Hooker's description of the Devon tinner in the 1590s also implies underground working, for he writes:

> 'His lyffe most commonly is in pyttes and caves under the grounde of a greate depth and in greate daunger because the earthe above his hedd is in sundry places crossed and posted over with tymber, to keepe the same from fallinge' (Blake 1915, 342).

However, one of the earliest specific references to a shaft connected with tinworking in Devon is to one at Bottle Hill mine as late as 1715 (Hamilton Jenkin 1974, 125-6). An 'old Auditt' (ie adit) is mentioned near Ashburton in 1689 in connection with Kingsbeame tinwork (DRO/DL) 3553 l(2)).

More important, there are several recorded instances of 19th century miners breaking through into old workings (Hamilton Jenkin 1974, 96, 99, 123, 129). In the 1860s old workings were discovered at Furzehill Mine (SX 5 17692) near Horrabridge in west Devon at a depth of almost 100 m (Hamilton Jenkin 1974, 83-5). This tinwork is documented in the early 16th century when it was known as 'Fursse Hill als Fursseball', In a dispute in the court of Star Chamber, Walter Langeford stated that in 1521 he owned one-eighth of the tinwork and that for a long time before then he had been a part-owner of the work. Moreover, he and the other owners

> 'causyd the sd. Tynworke to be wroste att their costs in soe moche that they hadde goottyn *above gronde* blacke Tyne to the valewe of a c[li] . . .' (PKO/STAC 2/151153 - author's italics).

The tinwork was clearly an important one at this time. Indeed it had its own tin mill which 'wasse & ys sett appon the Grounde parcel1 of the sd. Tynworke' (PRO/STAC 2/15/153). Taken together with the 19th century evidence it is reasonable to infer that Furzehill tinwork was being worked underground on a relatively large scale by the early 16th century if not before. Furzehill is peripheral to the main granite mass of Dartmoor and is not so remote from routes of communication or centres of population as the high moorland sites. Thus one might well expect the earliest attempts at deep shaft mining for tin to have been in the valleys of the Tamar, Tavy, and Walkham, and in the mineralized zone around Ashburton and Buckfastleigh.

Recorded finds of artefacts in underground workings are very rare. For example, in the late 18th century a pick was found in 'Wheal Unity tin mine' in a part of the mine that had definitely not been worked for more than 80 years (Taylor 1799,360). This mine was located in the Marytavy area. Iron tools were found in underground workings at Hexworthy Mine in the late 19th century (Burnard 1891, 97-8).

Tin mills

Of all relics of the Devon tin industry the mills have probably the greatest archaeological potential. The term 'mill' is the most correct for all types of structure connected with the processing of tin from the moment the ore is dug out of the ground until the metal is ready to be taken to the stannary town for coinage.

All lode tin ore, and possibly some stream tin, had to be crushed and concentrated before it could be smelted. The mills in which the ore was mechanically crushed by water-powered stamps falling on to a mortarstone were known as knocking, knacking, stamping, or clash mills. *Knocking/knacking* is by far the commonest term used in surviving documentary sources for Devon between about 1500 and 1700.

Crazing mills were those in which the ore was further reduced by being ground between two horizontal millstones, presumably worked by a waterwheel. Worth recorded these millstones at Gobbett, Outcombe, and Yellowmead (Spooner & Russell 1953, 319), but only those at Gobbett are still visible today (no 23, Fig 82). No documentary reference to a Devon crazing mill has yet been found. This type of mill remained in use in Cornwall until at least the end of the 17th century (Anon 1670, 2111) though by the time Tonkin wrote in about 1733 the crazing mills in Cornwall were 'left down throughout the county' (Carew 1602, 1811 edn, 39). Their demise clearly reflects an improved stamping technique and so their discovery might always be a clue to an early mill site.

Blowing mills are those where ore was smelted in a blast furnace. The term 'blowing house' was rarely used in Devon before the late 17th century, though in Cornwall a 'Blouynghous' at Lostwithiel is mentioned as early as the first half of the 14th century (Hatcher 1970, 239).

Sometimes these mills were referred to as plain 'tin mill' or 'mill' without any qualifying descriptive term. From an archaeological point of view any documentary reference to a mill within the tin-bearing zone of Devon must be considered as a possible reference to a tinners' mill. Field names with a 'mill element such as Mill Park, Mill Place, or Mill Ware provide important clues as can less obvious place-name elements such as 'Smithy'. At many of the mills the functions of stamping and smelting were combined.

The mills are almost always situated within a few metres of streams and are usually built against or into the natural bank of the ground as it falls to the stream. They are of drystone, often massive, construction with stones only roughly dressed if at all. They are usually rectangular or subrectangular and their internal dimensions are often approximately 10m x 5m. However, several undoubted mills are significantly smaller, eg Outcombe (no 10, Fig 82) which has internal dimensions of 4·5m x 4·2m. All true mills would have had a leat course leading to them and a small probably overshot waterwheel would have powered stamping machinery and, if necessary, bellows for a blast furnace (Fig 79).

The most characteristic finds associated with Devon tinners' mills are the so-called mortarstones which are blocks, usually of granite, containing smoothly worn hollows, mostly two or three in a line. They are the stones on which tin ore (probably lode ore) was crushed by mechanical means. Approximately 170 of these stones have been recorded and about 55 of them are in a more or less complete condition-Double mortarstones (ie those with two hollows) are by far the commonest. The mortars have a characteristic oval shape but can vary quite considerably, sometimes having remarkably 'straight' edges to them. The diameter of the double mortars ranges from 100-240 mm and their depth from 30-90 mm. Many of the triple mortarstones are over 1m long and more than 0·5 m wide. Their mortars can be up to 300 mm in diameter and are frequently over 100 mm in depth. Sometimes stones with four mortars on one plane can be found, but these can usually be resolved into two pairs, the position of the stone having been shifted. The great majority of mortarstones are of granite which must have been carefully selected for hard-wearing properties. Many mortarstones have been turned over to expose new working faces and in at least three cases, when finally abandoned as mortarstones, they have been put to USC as bearing stones for the axles of waterwheels.

No contemporary mention of mortarstones has yet been found. Carew writing of Cornwall in *c* 1600 describes 'three, and in some places six great logs of timber, bound at the ends with iron, and lifted up and down by a wheel driven with the water' (1602, 1811 edn, 39) but does not say on to what they fell. Similarly, Agricola, writing of central European practice in the mid 16th century, describes nothing resembling mortarstones despite his meticulous attention to detail (1556, 1950 edn, 312).

Over 30 definite mouldstones are known from Devon. They contain the moulds in which ingots of tin were formed. Twenty of the stones are in a relatively complete state and they often have approximate dimensions of 1000 mmx700 mmx400 mm. The moulds themselves are neat rectangular troughs with bevelled sides. Their top dimensions are often approximately 400 mmx300 mm and their base dimensions 300 mmx200 mm. A depth of between 100 and 130 mm is common. Moulds of this size would hold up to about 300 lb (136 kg) of metal. Until about 1550 the average weight of ingots presented for coinage in Devon was between 100 and 120 lb (45-55 kg) so that sites with small moulds may possibly be earlier than sites with large ones.[3] Occasionally two moulds are found on one stone,

Some mouldstones also have 'sample moulds' on their top surface. They are usually small, rectangular, and shallow excavations, discrete from the moulds themselves. They have been recorded at twelve sites and often have approximate dimensions of 85 mmx60 mmx25 mm depth. At most they would hold a few pounds weight of tin.

Moulds sometimes have a groove in one short side which was probably for resting a green stick or bar of iron when pouring the tin so that the ingot could be more easily lifted out once cool. More rarely, some moulds have slight ridges protruding a little way into the base of the mould and likewise up the short sides of the mould. So far these have been recorded at only five sites. The ridges would give a characteristic groove to the finished ingot and their purpose may well have been to facilitate handling and transport.

There is no known surviving tin ingot from Devon, and there are only two recorded instances of ingots having been found. In about 1832 one was found near Dartmeet (Bray 1879, 2, 376) and in 1879 another (possibly two) was found near Slade, Cornwood (Worth, R H 1940b, 239-40; Burnard 1888-9, 102). The latter measured 14 in (355 mm)x8 in (203 mm) and was about 3 in (76 mm) thick. It weighed 51½ lb (23.4 kg) (Rowe 1896, 175).

Information about the furnaces of tin mills is very scanty. At only two sites are there obvious field remains of probable furnaces: the lower left bank mill above Merrivale Bridge (no 3, Fig 82), and the Avon Dam mill (no 21, Fig 82). The former has been well recorded (Worth, R H 1931, 361-4, figs 1-4; 1940b, 227-8,235, fig 5), and the latter is normally inundated (see Fig 79). At both sites there are two 'furnace

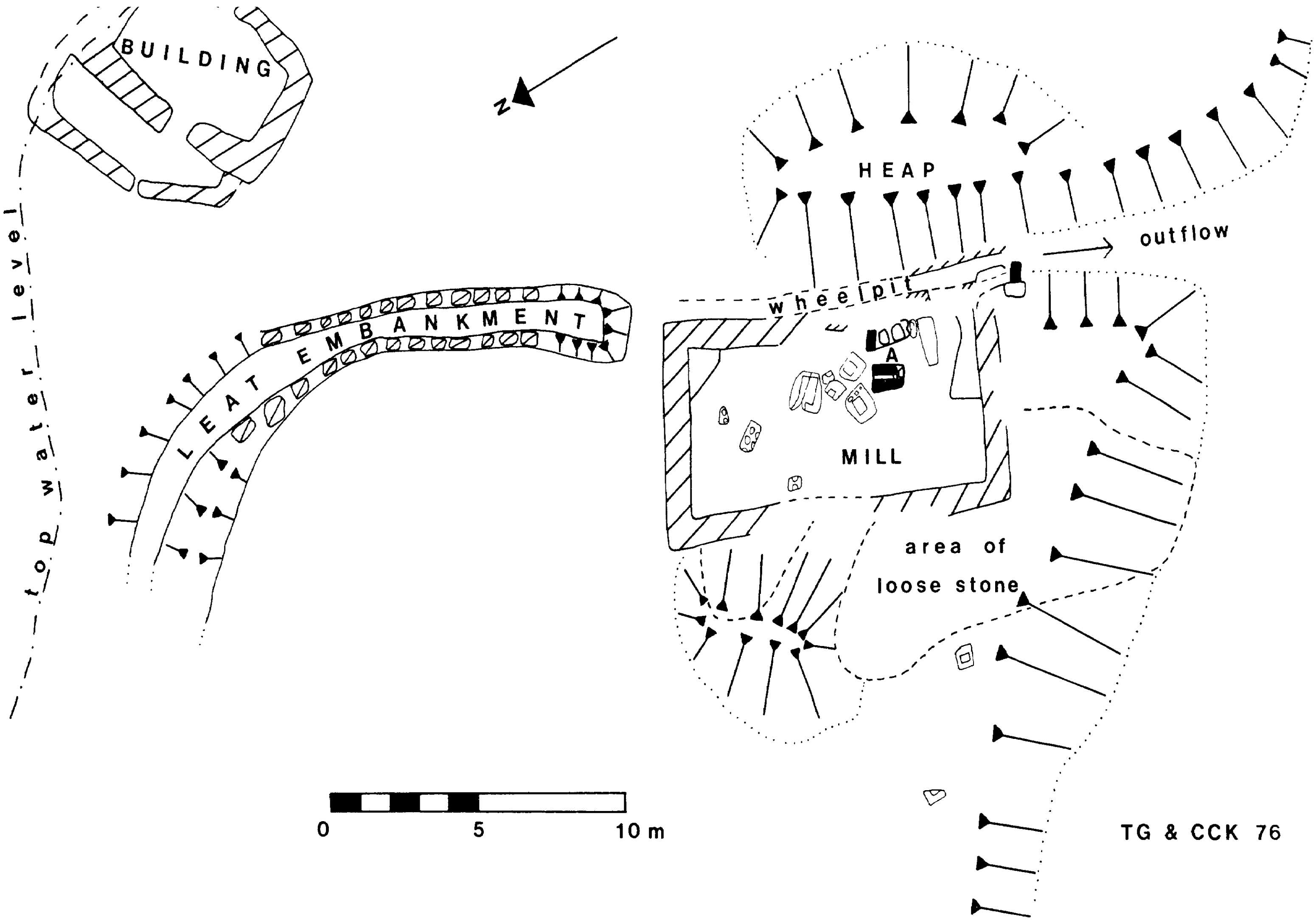


Fig 79 *Plan of tinners' mill at the Avon Dam (SX 67226553). Solid black indicates stones set vertically. Stones on the leat embankment are shown schematically. A = probable furnace structure*

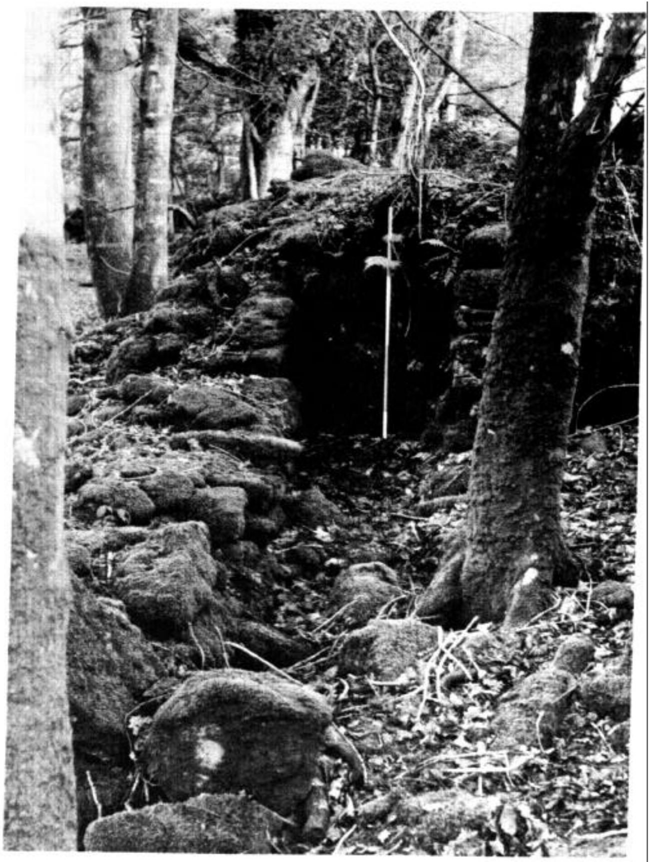


Fig 80 Wheelpit at Eggworthy mill, looking east, SX 54357183, 2.1.1978. Scale: 2m

blocks' of granite with a space of not much more than half a metre between them. These blocks are massively constructed and there can be little doubt that they represent the framework within which a fairly temporary, presumably blast, furnace would have been constructed. Without excavation. it is doubtful that much more can be learnt from these structures.

A potentially important source of information about the technology of tin smelting is contained in the slag which has so far been discovered at twelve mill sites and which has also been found in secondary (ie late medieval) contexts in three prehistoric hut circles (Anon 1898, 100; Worth, R H 1935, 124-7; 1937,1467, 1940b, 213). Most of the slag has so far come from surface unstratified contexts. XRF analysis of slag from Outer Down near Chagford (no 29, Fig 82) gave a tin content of 13·5% and, in Professor Tylecote's opinion, indicates very poor smelting conditions with insufficient fuel and iron flux.[4] Besides slag, pieces of vitrified or partially vitrified granite with slag adhering to them have been found at five mill sites. These may represent parts of the furnace lining.

Finds of pottery associated with mills are extremely rare as is our knowledge generally of medieval and post-medieval pottery on Dartmoor. However, the potential can be seen to be quite great, as surface finds of pottery have been made at a number of sites. At the lower mill at Week Ford (no 24, Fig 82) an unglazed body sherd of a large globular 'cistern' complete with bung hole was found recently (Fig 78). It is of 'St Germans type' ware and its date range is from the end of the 15th century to *c* 1550. The sherd is from a mill for which the earliest documentary evidence yet known dates to 1608 when it and its companion were known as 'Wikeford Milles' (DuCo London, Dartmore Proceedings 1203-1735 fol 29). A sherd from a large unglazed vessel, probably a bowl, has recently been found within Outcombe mill (no 10, Fig 82) and it, too, is probably of late medieval or 16th century date. This mill is particularly interesting as there is clear evidence of reconstruction of the wheelpit at some time as a mortarstone is built into the back of the pit.

The average size of some ten well preserved mill wheelpits is 3·8 mx0·77 m (Fig 80). The wheels, which appear to have been overshot, would obviously have been smaller than this, perhaps measuring 3·0 mx0·5 m. Stones with the bearings for the iron axle or spill of waterwheels are known from the sites of fourteen Devon mills which can be dated before 1700. With one exception, all the bearings are 'open'; their width is between 35 and 50 mm (Fig 81).

The subjects of leats and storage of water is of considerable interest but will not be discussed here. Similarly, there will be no discussion of settling pits or buddles within or outside the mill structures.

Fig 81 Stone with bearing at Yellowmead mill, SX 57426755, 28.7.1975. Scale: 15 cm

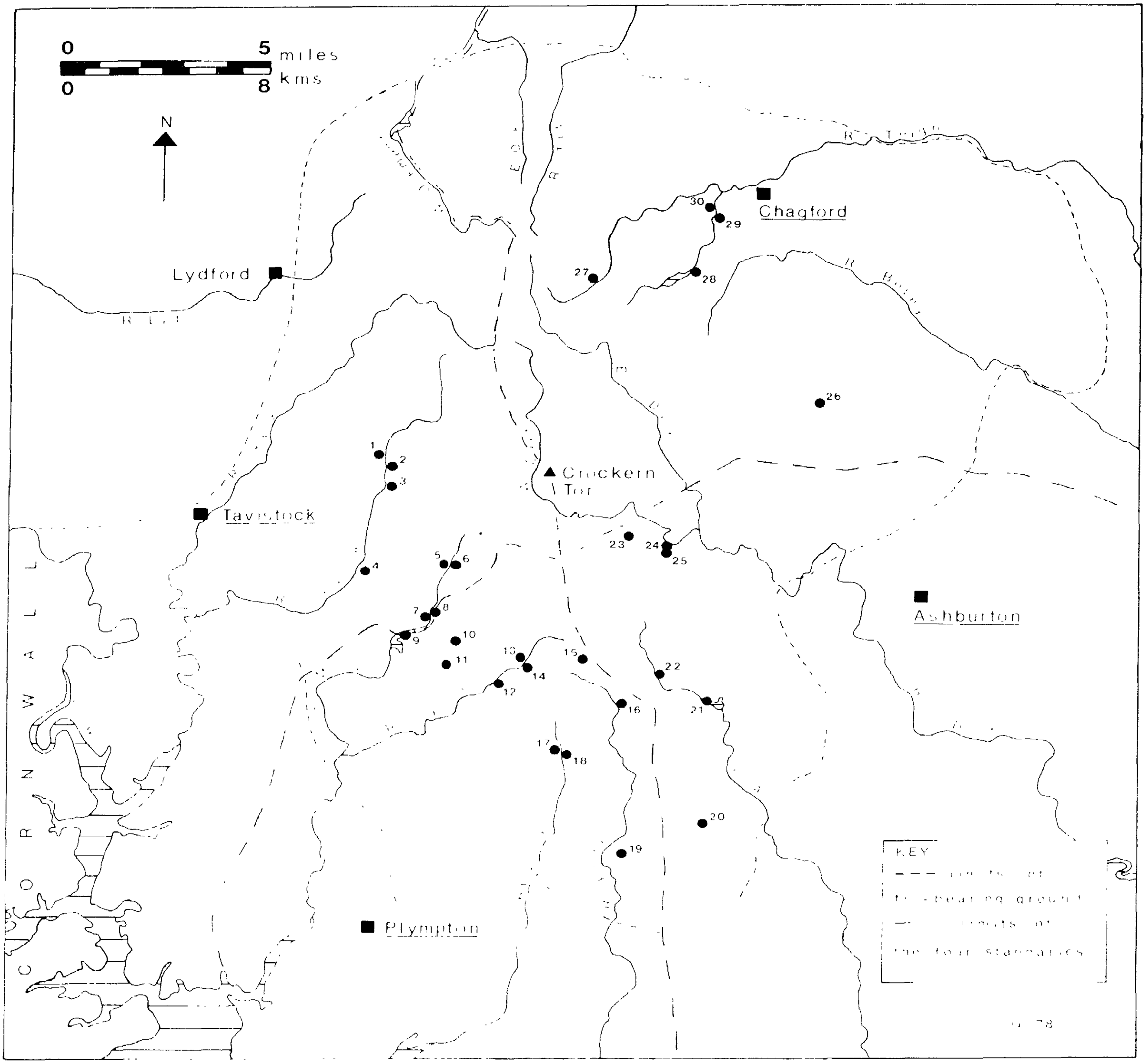


Fig 82 Map showing sites of Devon tin mills dating to before c 1700 which have visible structure surviving

Tinners' buildings

The buildings which accommodated tinners or their tools are another potentially important source of archaeological information. Small, non-prehistoric structures can be found in almost every Dartmoor valley, often directly associated with tinworkings. Although they have never been studied in detail they are usually rectangular or subrectangular and smaller than true mills. Pottery of a similar date to that found at the mills has been recovered from two sites. That from a structure in Deep Swincombe (SX 642719) was 'excavated' in the late 19th century and was originally thought to be of early medieval date (Baring-Gould 1900, 116; Burnard 1907, 199), but it is more likely to be late 15th or 16th century. A large body sherd from the same site may well be from a chafing dish (Fig 78).

The relationship between documentary and field evidence

Documentary sources which have been studied so far provide dates by which some of the visible remains of the Devon tin industry must have already existed.

Tinworks are documented as far back as the 13th century but they are known to have existed before then. The earliest reference to an opencast work is to Joysbeme in 1511, and the earliest probable evidence of underground working for tin in Devon is at Furzehill in the early 16th century. This suggests that opencast and underground mining must have begun in the 15th century if not sooner.

The earliest reference to a blowing mill site is an indirect one to Yellowmead (no 11, Fig 82) in 1502 when Thomas Pohill smelted tin of false metal 'at Oldmede within the parish of Chittestor' (DuCo London/Ministers Accounts (Copies) Cornwall & Devon, 18, 19,23 Hen 7/Vol6,93). A 'blowyng my11 and knakkyng myll' had been recently built at Dartmeet in 1514 (DRO/48/14/40/3). It has already been mentioned that there were blowing mills in Cornwall in the 14th century, and that there is inferential evidence for a change in smelting technique in the 13th century. The sites of medieval blowing mills must exist in Devon. In a few instances there is evidence for mills going out of use quite early in the 16th century and some of them may well have had medieval origins. For example, in 1566 'an old house sumtyme a Blowynge house' is mentioned at Blackaton near Widecombe (French & Linehan 1963,176). Similarly, a blowing mill at Lustleigh known as 'Caseleigh Smitha' in *c* 1600 may well be medieval in origin as the tenement of Caseley was occupied by smiths named Caseley from at least 1378 (DRO/1837Z/add Z7).

Knocking or stamping mills may not have quite such a high antiquity. Their precursors may have been in the form of handmills as in central Europe; but it is likely that their introduction relates to the beginning of opencast and underground mining of lode deposits, as much of the stream tin, especially in Devon, was pure enough to require little or no dressing. One would therefore expect the earliest of them to be at least 15th century in date in Devon. The earliest date provided by the present documentary evidence is 1504 for a 'knacking mill' at Ashburton (Amery, J S 1924, 51). In 1511 there is mention of an estate 'cum uno molendino pulsatili ad stannum pulsandum' (DRO/DD 22484). This may well be a reference to one of the known mills near Nosworthy (nos 7 or 8, Fig 82). The earliest documented stamping mills in central Europe appear to date to the end of the 15th century (Majer 1970, 15). Pottery so far found in Devon indicates dates in the early 16th century or before.

In general we can be sure that many of the visible field remains of the Devon tin industry date to at least the late medieval period if not earlier. Systematic fieldwork on the tinworks themselves, on a scale similar to the work of the present Dartmoor Reave Project on prehistoric land boundaries, might well provide information about the methods of alluvial and opencast mining and might indicate the relationship between these workings and the so-called tinners' buildings and/or mills.

Figure 82 is a map of 30 definite tin mills with some structure still surviving and which can certainly be dated to before 1700.[5] They are obviously prime sites for future detailed study. Excavation should yield valuable information on dating, technology, pottery, etc.

In 1951 Finberg wrote that 'the mining records of Devon remain virtually unexplored' (1951, v). This statement is less valid today but there is still plenty of scope for further work on medieval documentary sources. Indeed, what I hope to have indicated is the enormous potential still remaining in Devon for future archaeological work which should ultimately give considerable insight into the medieval tin industry of England.

Appendix

List of definite tin mills with visible structures which date to before 1700 and which appear on Figure 82

	Mill	*National Grid* Reference
1	Merrivale Right Bank	SX 55187665
2	Merrivale Left Bank Upper	SX 55277624
3	Merrivale Left Bank Lower	SX 55277535
4	Eggworthy	SX 54357183
5	Black Tor Falls Right Bank	SX 57487162
6	Black Tor Falls Left Bank	SX 57497161
7	Nosworthy Right Bank	SX 56746954
8	Nosworthy Left Bank	SX 56786958
9	Longstone	SX 56076880
10	Outcombe	SX 58016860
11	Yellowmead	SX 57426755
12	Mill Corner (Colesmills)	SX 59376676
13	Lower Hartor Tor	SX 60486743
14	Langcombe	SX 60376723
15	Ducks Pool Stream	SX 62936766
16	Hook Lake	SX 63936509
17	Yealm Steps Upper	SX 61726385
18	Yealm Steps Lower	SX 61796352
19	Butterbrook	SX 64225921
20	Glazemeet	SX 66836031
21	Avon Dam	SX 67226553
22	Broad Falls	SX 65456692
23	Gobbett	SX 64537280
24	Week Ford Lower	SX 66197234
25	Week Ford Upper	SX 66187232
26	Pitton	SX 72107852
27	Teignhead Farm	SX 63778426
28	Thornworthy	SX 67238443
29	Outer Down	SX 68218658
30	South Hill	SX 68018710

Acknowledgements

I am most grateful to John Allan for identifying and drawing the pottery shown in Fig 78, to Cynthia Gaskell-Brown of Plymouth City Museum for loaning the sherds from Deep Swincombe and Golden Dagger, and to Nigel Heard for printing the photographs from my negatives.

Notes

1 In the early 17th century Plympton stannary was also a relatively small producer though it sometimes overtook Ashburton. However, total quantities are very small compared with those of the 16th century. In 1610 Plympton stannary produced roughly as much tin as it had in 1456 (*c* 15000 lb) (PRO/E101/265/19 and 23; E101/281/1).

2 The rate of tax in Cornwall was different — 5s per mwt (1000 lb) in the 12th century (+one mark from 1198), and 4s per cwt (100 lb) from the early 14th century.

3 The average size of ingots was larger in Cornwall. In 1305 they averaged 120 lb each but by the late 15th century they weighed 200–250 lb each, and by 1600 300–400 lb.

4 I am most grateful to Professor Tylecote for undertaking this analysis.
5 There is some field evidence for about 40 other mills of the same period.

Abbreviations

BM - British Museum, London
D R O - Devon Record Office, Exeter
D u C o - Duchy of Cornwall Office, Buckingham Gate, London
P K O - Public Record Office, London
PWDRO - Plymouth & West Devon Record Office, Plymouth

Bibliography

Agricola, G, 1556 *De re metallica*, 1950 edn
Amery, J S, 1924 Ashburton of past days, *Rep Trans Devonshire Ass*, **56**, 43–102
Amery, P F S, 1870 Stones found at Swincombe (Dartmoor) . . ., *ibid*, **4**, 136–7
Anon, 1670 An accompt of some mineral observations . . ., *Phil Trans*, **5**, 2096–2113
Anon, 1898 Dartmoor Exploration Committee, Fifth Report, *Rep Trans Devonshire Ass*, **30**, 99–100
Barber, J, 1970 Early men, in *Dartmoor, a new study* (ed C Gill), 55–75
Baring-Gould, S, 1900 *A book of Dartmoor*
Barton, D B, 1967 *A history of tin mining and smelting in Cornwall*
Blake, W J, 1915 Hooker's synopsis chorographical of Devonshire, *Rep Trans Devonshire Ass*, **47**, 334–48
Bray, A E, 1879 *The borders of the Tamar and the Tavy*, 3 edn, 2 vols
Broughton, D G, 1967 Tin working in the eastern district of the Parish of Chagford, Devon, *Proc Geol Ass*, **78**, 447–62
Burnard, R, 1888–9 On the track of the 'old men', Dartmoor, *Trans Plymouth Inst*, **10**, 95–112, 223–42
———, 1891 Antiquity of mining on Dartmoor, *ibid*, **11**, 85–112
———, 1907 The ancient population of the Forest of Dartmoor, *Rep Trans Devonshire Ass*, **39**, 198–207
Carew, R, 1602 *Survey of Cornwall*, 1811 edn
Crossing, W, 1889–92 Crockern Tor, and the ancient stannary parliament, *Western Antiquary*, **8–11**, *passim*
———, 1912 *Guide to Dartmoor*, 2 edn
Falcon, T A, 1903 Dartmoor mining, *Devon Cornwall Notes Queries*, **2**, 225–7
Finberg, H P R, 1949 The stannary of Tavistock, *Rep Trans Devonshire Ass*, **81**, 155–184
———, 1951 *Tavistock Abbey*
Fox, A, 1954 Excavations at Kestor, an Early Iron Age settlement near Chagford, Devon, *Rep Trans Devonshire Ass*, **86**, 21–62
———, 1957 Excavations on Dean Moor in the Avon Valley, 1954–56, *ibid*, **89**, 18–77
French, H & Linehan, C D, 1963 Abandoned medieval sites in Widecombe-in-the-Moor, *ibid*, **95**, 168–79
Greeves, T A P, 1969 A mine in the Deancombe Valley, *ibid*, **101**, 197–201
———, 1971 A tinners' mill in Walkhampton Parish, *ibid*, **103**, 197–9
Hamilton Jenkin, A K, 1927 *The Cornish miner*
———, 1974 *Mines of Devon*, **1**, *The southern area*
Hatcher, J, 1970 *Rural economy and society in the Duchy of Cornwall 1300–1500*
———, 1973 *English tin production and trade*
Hencken, H O, 1932 *The archaeology of Cornwall and Scilly*
Kelly, T, 1866–7 Celtic remains on Dartmoor, *J Roy Inst Cornwall*, 2, 125–8
Lega-Weekes, E, 1902 Neighbours of North Wyke, Part II, *Rep Trans Devonshire Ass*, **34**, 578–647
Lewis, G R, 1908 *The stannaries*
Majer, J, 1970 Die Hauptzüge der Bergbautechnik des Böhmischen Zinnbergbaus im 16 Jahrhundert, in *Cin v Dějinách Vědy, Techniky a Umění (Tin in the history of science technology and art)* (ed J Majer), **2**, 7–27
Moore, S A, & Birkett, P, 1890 *A short history of the Rights of Common upon the Forest of Dartmoor . . .*
Norden, J, 1584 *Speculi Britanniae pars; a topographical and historical description of Cornwall*, 1728 edn
Ormerod, G W, 1866 On the traces of tin streaming in the vicinity of Chagford, *Rep Trans Devonshire Ass*, **1**, 110–15
Parsons, H, 1956 The Dartmoor blowing house — some recent investigations, *ibid*, **88**, 189–96
Pearce, S, 1976 The Middle and Late Bronze Age metalwork of the south-west, and its relationship to settlement, *Proc Devon Archaeol Soc*, **34**, 17–40
Rowe, S, 1848 *A perambulation of the Antient and Royal Forest of Dartmoor . . .*
———, 1896 *ibid*, 3 edn
Somers Cocks, J, 1970 The forest boundary, in *Dartmoor, a new study* (ed C Gill), 277–81
Spooner, G M, & Russell, F S (eds), 1953 *Worth's Dartmoor*
Stevens, J, 1962–4 The Newnham cartulary, *Devon Cornwall Notes Queries*, **29**, 41–50
Taylor, J, 1799 Sketch of the history of mining in Devon and Cornwall, *Phil Mag*, **5**, 357–65
Woodhouse, H B S, 1901 The blowing-houses in Hartor Valley, *Rep Trans Devonshire Ass*, **33**, 114–16
Worth, R H, 1889 The moorland Plym, *Trans Plymouth Inst*, **10**, 289–310
———, 1892 The Erme, Yealm and Torry, *ibid*, **11**, 173–83
———, 1910 The stannaries, *ibid*, **15**, 21–45
———, 1912 Tin streaming and tin mining on Dartmoor, in *Beautiful Dartmoor and its interesting antiquities, Part 2* (H H Breton), 58–67
———, 1914 Stray notes on Dartmoor tin-working, *Rep Trans Devonshire Ass*, **46**, 284–9
———, 1925–6 The moorland Plym: 36 years after, *Trans Plymouth Inst*, **17**, 117–21
———, 1927 A blowing house in the Parish of Chagford, *Rep Trans Devonshire Ass*, **59**, 343–5
———, 1929 Stray notes on Dartmoor tin-working, Part 2, *ibid*, **61**, 401–3
———, 1931 Blowing-houses in the Valley of the Walkham (Moorland), *ibid*, **63**, 361–7
———, 1932 Blowing-houses in the valleys of the Sheepstor Brook and the Glazebrook, *ibid*, **64**, 273–8
———, 1933 Blowing-houses in the valleys of the Sheepstor Brook, the Meavy, the Erme, and the Avon, *ibid*, **65**, 307–21
———, 1935 Dartmoor Exploration Committee, Twelfth Report, *ibid*, **67**, 115–30
———, 1937 Dartmoor Exploration Committee, Thirteenth Report, *ibid*, **69**, 143–50
———, 1938 Dartmoor blowing-houses. Stray notes, 3, *ibid*, **70**, 451–4
———, 1940a Notes on some Dartmoor blowing-houses, *ibid*, **72**, 201–7
———, 1940b The Dartmoor blowing-house, *ibid*, **72**, 209–50
———, 1946 Dartmoor blowing-houses (supplement), *ibid*, **78**, 281–4
Worth, R N, 1874 The antiquity of mining in the west of England, *Trans Plymouth Inst*, **5**, 120–40

Introduction

The study of medieval pottery has developed rapidly in recent years. The interest originally developed in the 18th century amongst collectors in London and was followed during the 19th century by a wider circle, who not only collected the pottery but tried to interpret it from medieval documentation. The studies of R L Hobson around 1900 were significant (Hobson 1902; 1903). However, only in the 1940s and 1950s with the work of Gerald Dunning, John Hurst, and Professor Jope did the recent development of the subject begin. More recently there have been further approaches using scientific techniques, particularly in the location of pottery to its source either by the petrological analysis of the pot's body (Hodges 1977; Vince 1977) or by neutron activation (Aspinall 1977). Thermoluminescence is being used for dating pottery sherds, while remanent magnetism is used in the dating of kiln structures themselves.

The wealth of evidence contained in the written records of the Middle Ages has been examined. The most notable contribution has been Mrs Le Patourel's fundamental paper on the organization of the pottery industry (Le Patourel 1968). Dr Francis Celoria first drew attention to the wide range of documentary sources useful for identifying the uses of medieval pottery in his study of the urinal (Amis 1968), while the many uses of medieval ceramics have been studied in a preliminary paper (Moorhouse 1978b). The role of medieval pottery as an indicator of social change has also been examined (Le Patourel 1976).

Various general articles of synthesis on medieval pottery have appeared in the last 20 years, ranging from Professor Jope's analysis of the regional characteristics of medieval pottery (Jope 1963) to David Hinton's more recent discussion of what he terms 'rudely-made earthen vessels' (Hinton 1977). Derek Renn's important study of documentary evidence, pottery, and kilns for the Hertfordshire industry appeared in 1964 and, along with Professor Jope's study of Berkshire (Jope 1947), heralded modern approaches to the subject. The awareness of pottery development at a local level has prompted a number of important regional studies (Barker 1970; Barton 1979; Davey 1977; Hurst 1955; 1956; 1957; Jope 1947). The formation of 'models' within which research can take place is as important to a particular study as the minutiae of detailed analysis. Professor Jope has recently discussed the Middle Ages in these terms (Jope 1972), incorporating the evidence of pottery.

The broadening of interest in the subject in the early 1970s led to the formation of the Medieval Pottery Research Group in 1975. The first regional group was established in Scotland in 1972 and now most of the British Isles is covered by groups. At a layman's level the upsurge of interest is reflected in the publication of a new and updated edition of Rackham's classic *English medieval pottery* (Rackham 1972), a number of museums have published picture books of complete pots in their collections (Hinton 1973; Lewis 1978), and popular works of synthesis have appeared (Barton 1975, 102-18; Haslam 1978). While increasing our knowledge of medieval pottery, it is important that we should understand how medieval pottery studies have developed before we can lay the foundations for future research. This aspect of medieval pottery has been sadly neglected (but see Hurst 1962-3, 135-6). Recent studies (Hinton 1977; Rhodes 1979) have shown the scope of the material available and how marginallv our-ideas, particularly on dating, have changed since people first seriously started looking at medieval pottery over two centuries ago.

The recovery of large quantities of pottery, particularly by urban archaeology units, over the past decade has created a major problem in the study of medieval pottery. The traditional methods of studying the material were no longer adequate for the vast quantities being recovered, and the new questions being asked of the material were demanding new approaches in its study. To meet this growing crisis, the Department of the Environment sponsored a working party in 1976 to prepare guidelines on a wide range of topics, including methodology, principles of approach, methods of analysis, scientific techniques employed, and methods of publication (Blake forthcoming). These will not be-rigid principles but guidelines, and only when methods and approaches have been tried and tested can they be used universally. The establishment of such systems is important if material from different sites is to be reliably compared. However, before this we must ask ourselves 'why do wc study medieval pottery and what do we hope to achieve from it?': These questions are essential because their answers will determine the methods by which the material is handled. analysed. and finally published. Pottery has much more to offer than current techniques will allow. Our aim should be to recognize the products of a single potter or workshop, locate the source of manufacture, investigate the distribution of the pots themselves, and define their usage. At this stage questions of relative date then become meaningful. An understanding of these questions and the problems they pose is of the greatest importance for future work.

Production sites

Location and size

A primary factor in the siting of any pottery-making complex is an adequate supply of workable clay, other important considerations being an accessible water supply and a ready market for the pottery produced. The use of a geological map will therefore locate areas where kilns may be expected. It is probable that former small pockets of clay have been worked out through potting activity, leaving a kiln site in an area where clay no longer exists. Modern geological surveys rarely record small outcrops. Minor pockets of clay, either existing or worked out, may be suggested by a variety of minor field- and place-names which describe clay and which came into use during the Middle Ages; for example, apart from the more widespread *clacg *klegg, leirr* is particularly common in the north of England. The existence of a name containing such an element may provide a clue to a kiln site whose existence is recorded through other evidence. Mrs Le Patourel has discussed the problem of the potter element used either in place- and field-names or as a surname (Le Patourel 1968, 102-3, 121). Places where medieval pottery was made are in fact rarely intentionally mentioned in the documents. It is therefore the incidental references which provide evidence for their existence, many sites being unrecorded. Because of this it is not surprising that a number of kiln sites have been discovered accidentally, through fieldwork, farming activity, or construction work, where no documentary evidence for them has been known. Further problems arise from the documents. The form of tenure in an area during the Middle Ages determined the range and quantity of documentation produced, while the survival rate of the material varies widely from area to area, and in some cases within different holdings in the same township. Despite these problems Mrs Le Patourel has shown the wealth of information contained in manorial documents for the location and understanding of the medieval pottery industry (Le Patourel 1968). Detailed work is required on long runs of manorial court and account rolls covering manors in which pottery making is known to have taken place, such as the work currently in progress under the direction of Paul Drury and Dr K N Bascombe in Essex or the detailed study by Mrs Le Patourel of the Cowick industry.

The size of some potting communities can be suggested from documentary evidence. Mrs Le Patourel has shown the value of licenses and rents for determining the number of potters working a site at any one time (Le Patourel 1968, 123, table II). The prefix 'Potter' in front of a place-name indicates a community of potters working in the territory covered by that name shortly before the earliest recorded name with the prefix. Payments to potters recorded in medieval accounts can be surprisingly revealing. For example, William of Worcester's memorandum to *the* potter of Henham (see p 107) implies a single potter working at Hanham Abbot's, 3½ miles east of Bristol in 1478. A community of potters is suggested at either Great or Little Horkesley[1] in southern Suffolk in 1466. Here a memorandum in Sir John Howard's household account for that year records money delivered to 'one of the potters of Horkesley to pay himself and his fellows for 11 dozen pots, 4s 6d' (Botfield 1841b, 326). The development of an industry at any one site, however, clearly fluctuated and such references can only provide a clue to its extent at the time of the record. Occasional references in accounts frequently provide the only known documentary evidence for local pottery making.

The kiln

Once the surface of a kiln site has been disturbed, the most obvious evidence for its existence is the large quantities of waste material discarded by the potter as waste heaps around the kiln. It is the kiln structure that has received attention in the past and very little work has been carried out on the associated features. Concentration on the kiln structure has led to two major problems in the interpretation of the material recovered. First, unless the contents of a kiln are found *in situ,* as at Kiln 6 at Laverstock (Musty *et al* 1969, 89, fig 4, and pl XIII), or that recently excavated at Carrickfergus, Northern Ireland (Simpson *et al* 1979), the material recovered from the fill of the kiln cannot be regarded as having been made there. Where more than one kiln has been fired on a site, a redundant structure could be filled with old material from adjacent waste heaps. At Nuneaton, in fact, kilns were built into existing waste heaps and the dumps themselves dislodged many times during the life span of the site. Second, the kiln is only a small part of an integrated group of structures and features associated with the pottery-making process. The kiln cannot be properly understood unless it is interpreted along with other contemporary features in the same complex, particularly as it has been suggested that the working life of one kiln may be as long as twenty years (Bryant 1977, 119-20). The traditional processes involved in pottery making are known from recent practising country potters (Brears 1971), and from medieval documentation (Le Patourel 1968, 109, 116). The open-excavation techniques used at Lyveden (Bryant & Steane 1969; 1971; Steane & Bryant 1975; Fig 83 here), Nuneaton (Fig 84), and Olney Hyde (Fig 87) have shown their complexity.

The large number of kilns investigated have produced a wide variation not only in shape, structure, and the number and positions of the flues, but also in internal features such as pedestals and arched supports. These have been classified by Musty (1966; 1974). The problems of trying to define regional types of kilns and their development are demonstrated at Nuneaton, where almost every known shape of kiln plan was found on one site (Wilson & Hurst 1968, 209, fig 58). Early excavations of kilns were far from satisfactory by modern standards, with little attention being paid to the details of the structure; exceptions occur, as at Cheam (Marshall 1924). Recent excavations have shown that in some cases additions to the lining of the oven after successive firings have eventually altered its internal shape. For example, Kiln D 1 at Lyveden started life as a roughly rectangular oven and finished almost oval in shape, with a change not only in the size but also the shape of the central pedestal (Bryant & Steane 1971, fig 8). Such instances are now frequently being recognized, and give the impression that the medieval potter was constantly trying to improve his firing techniques by changing not only the shape of the oven and its internal features, but also the position and number of flues in the kiln. Despite these 'experimentations' there appears to have been no change in the colour of the fabric, which is due to the oxidizing and reducing atmosphere in the kiln. This suggests that it was not the character of the structure which produced the consistently distinctive fabric types but the potter's method of firing his kiln.

While the physical remains of the kiln structure often leave little doubt about their plan, methods of firing the kiln and achieving consistent results are little understood. Experiments over the past ten years have gone a long way towards answering a number of problems about medieval kiln technology. One of their most notable contributions has been to the understanding of open-topped kilns, pioneered by the Barton-on-Humber experiments (Bryant 1977). Previously it was assumed that most pottery kilns would have permanent igloo-type domes. The work at Barton has shown that most forms of structured kiln could be open-topped, capped during the firing process with peat or turves laid on a tile base and bonded with clay, the top being removed after each firing.

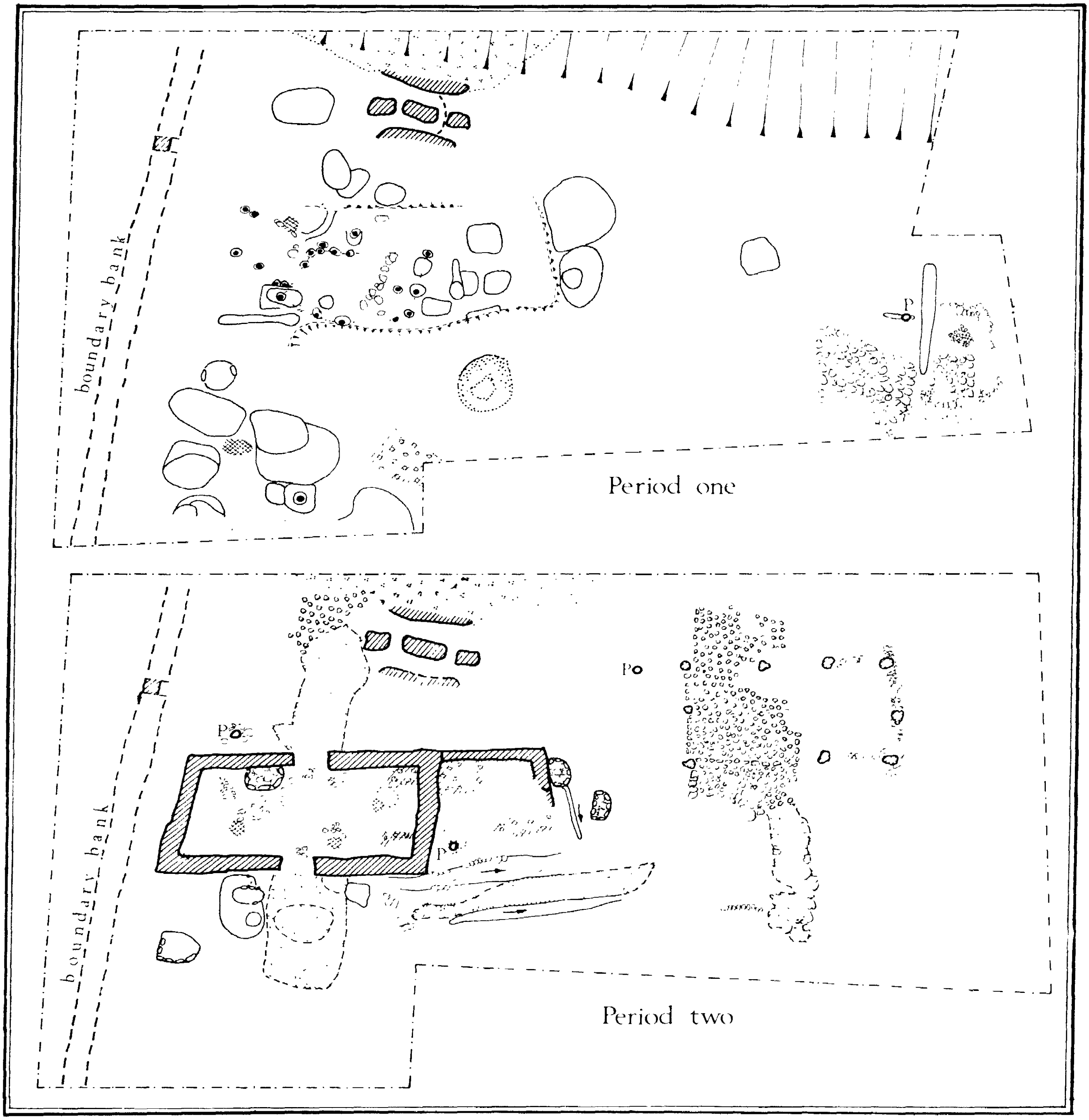


Fig 83 Lyveden, Northamptonshire, development of Site D (after Bryant & Steam 1971, figs 3, 5, 7). A above, periods one and two, dated one c 1240; two, c 1250-70. B opposite, period three, dared c 1275-early 14th century

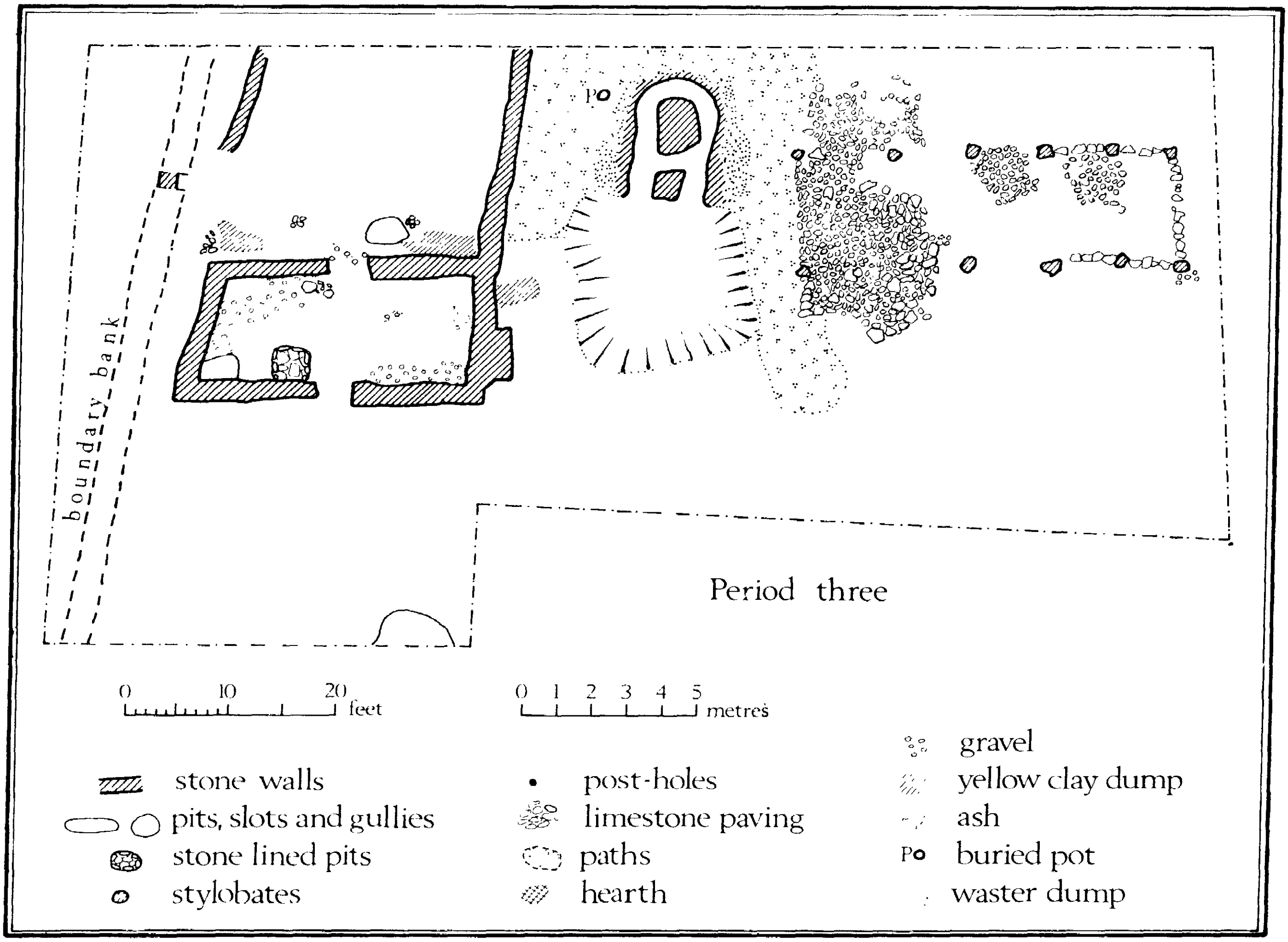


Fig 83B

Such kilns would only require a vertical wall of varying height rising above the rim of the oven (Steane & Bryant 1975, 12, fig 7; Bryant 1977, 108, fig 38). While experiments have shown the probability of open-topped kilns, similar evidence has been postulated from excavated kilns, as at Chichester (Wilson & Hurst 1969, 286, fig 88). Large multi-flued kilns, particularly those with walk-in entrances, suggest permanent igloo-type domes, although it is possible that even these kilns had tall vertical walls covered during the firing process, as seen in the modern open-topped tile kilns still visible on the southern banks of the Humber. As many medieval kilns are destroyed to below the top of the oven chamber, it is rarely possible to suggest the form of cover from the kiln structure, but such evidence may be forthcoming from a careful examination of waster-heaps for roof fragments.

Most sizeable collections of finds from kiln sites have produced examples of kiln furniture, pots or objects used to aid stacking in the kiln. The range of forms is now extensive and almost every new kiln excavated adds to this. Although John Musty included kiln furniture in his survey of the range of forms produced at excavated kilns (Musty 1966; 1974), no detailed study of the relationship of particular types of kiln prop to types of kiln has been carried out (but see Brooks & Haggerty 1976-7). The fact that a number of distinctive types of prop exist at only one site suggests that kiln furniture is as regional as the distribution of the kilns and of medieval pottery in general. A sample of the range of forms can be demonstrated by props from the Downpatrick kiln in Northern Ireland (Pollock & Waterman 1963, 99, fig 15). Most kilns with pedestals used rough long cylindrical pots to support the kiln bars against the kiln wall. Sophisticated methods of separating or supporting the pots are known. One example was used in the kilns at Nuneaton. Here small crudely-shaped pots about the size and shape of a modern plant pot had a diagonal slice cut from their bases. Their function was demonstrated by a collapsed jug which had one of these pots fused to it, showing that the pots were placed in threes to support the lowest layer of jugs in the kiln stack. They were inverted with the cut on their bases placed against the shoulder of the inverted jug. It is probable that equally inventive methods were employed elsewhere.

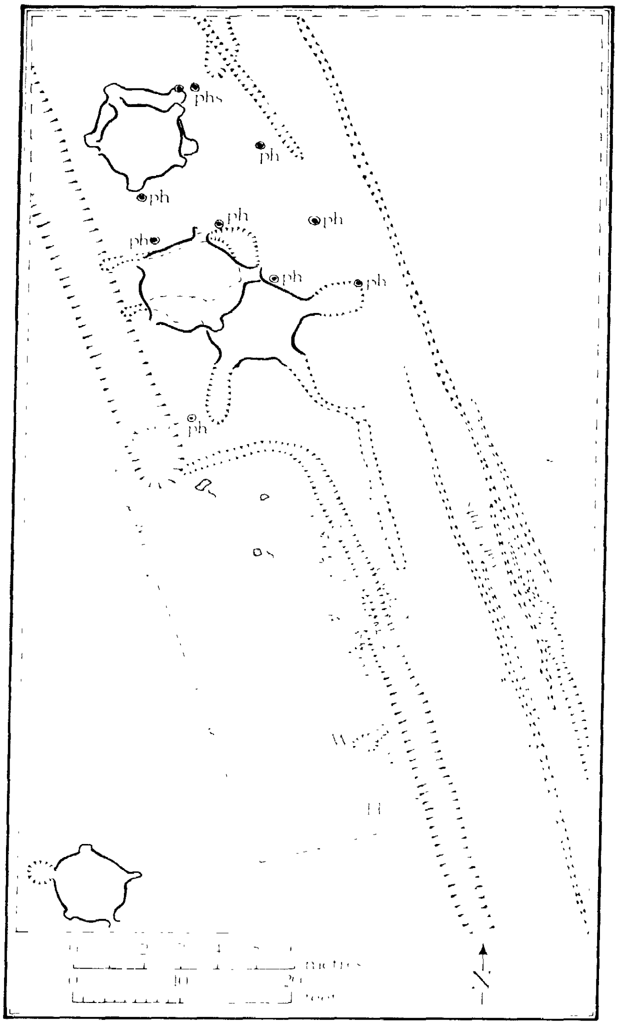


Fig 84 Harefield Lane, Nuneaton, Warwickshire. Poterry kilns and associated features of probable late 14th-early 15th century date. Key: II hearth: S stylobate: W water pit.

The method of stacking is not only reflected on the kiln site but can also be detected on the portery. One example is the reduced interiors of jugs that were stacked directly on top of each other during firing; overlapping jugs would allow free circulation of oxygen and would probably, though not always, create an oxidized interior. Evidence for stacking also comes from marks, impressions, or scars left on the surface of the pot, as with the triple scars on the shoulders of the Nuneaton jugs already mentioned. Such detail may add a further clue to the identification of the products of an individual workshop or potter.

Clamp kilns are occasionally found on pottery-making sites close to more substantial kilns. For example, at Nuneaton a clamp kiln was found adjacent to a multi-flued kiln producing Cistercian Ware in saggars. Clamps are more common on tile-kiln sites, where they may have been used to fire tiles from which the structure of the adjacent tile kiln was made. Pottery kilns were, however, frequently made from stones bonded with clay or from solid clay. Possibly clamps near to structured pottery kilns may have been used to fire kiln furniture, for at most sites where the association has been noticed kiln furniture was used, as at Nuneaton. Only future work will show if such relationships are meaningful or coincidental.

Drainage was a major problem particularly where kilns were built on solid clay, for water had to be kept away from the kiln and from where the pottery was made and stored. A variety of methods was adopted to channel water away. The most frequent were simple 'U' shaped gullies around the kiln, as at Nuneaton (Fig 84; Webster & Cherry 1972, 207, fig 56). Occasionally more permanent stone-lined drains were constructed, as at Olney Hyde (Fig 87), while potters utilized waste products, such as the 'drain' of pots found at Nuneaton, where the mouth of one pot had been pushed into the knocked-out base of the next.

The long life of some kilns might suggest that protective coverings were constructed around them when not in use, particularly kilns with open tops. Permanent structures to protect either the working or firing areas are found on other types of industrial site, as at the 16th century glass-working site at Hutton le Hole, North Yorkshire (Crossley & Aberg 1972, fig 51, 119, fig 57). These are well known on post-medieval pottery-making sites, as at Donyatt, Somerset (Cherry 1972, 220, fig 92), but no such structures have been identified around medieval kilns. There was no evidence at Lyveden, but a temporary covering may be represented by the postholes found around the kilns at Harefield Lane, Nuneaton (Fig 84).

Other structures

The contents of a medieval pottery-making complex can be inferred from those features found necessary by recent practising country potters. A potter would require a workshop, a kiln. and a covered area to dry his pots and store them after firing. A separate grog store would be necessary in areas where inclusions were added to the raw clay. A place to store fuel would be required, but the form and extent of the storage area would depend on the fuel used. Clay pits may be found elsewhere, but certainly some facility for preparing the clay for working should exist close to where the pots were made. Most of these features should exist within the tenement of one potter, but recent country potteries show that regional variations exist, particularly in the preparing of the clay for working.

A few early excavations produced evidence for buildings on medieval kiln sites, but the results were either inconclusive or ambiguous and in some cases it is doubtful whether they were associated with pottery making. One such site was excavated at Chicksands Priory between 1932 and 1934 (Westell 1932; 1935). The large quantity of pottery from the site in Letchworth Museum (acc no 6582) includes a majority of wasters.[2] Although considered a potter's workshop (Renn 1964, 11, 12), the building uncovered has a plan which suggests domestic rather than industrial use (Westell 1935, fig 2); no kiln was located and no fragments of kiln structure or kiln furniture are present amongst the surviving pottery from the site. Although undoubtedly a kiln site, the use of the structure must remain in doubt.

A number of more recent excavations have produced buildings and structures associated with the various processes of pottery making. The most important of these are the excavations at Lyveden, which

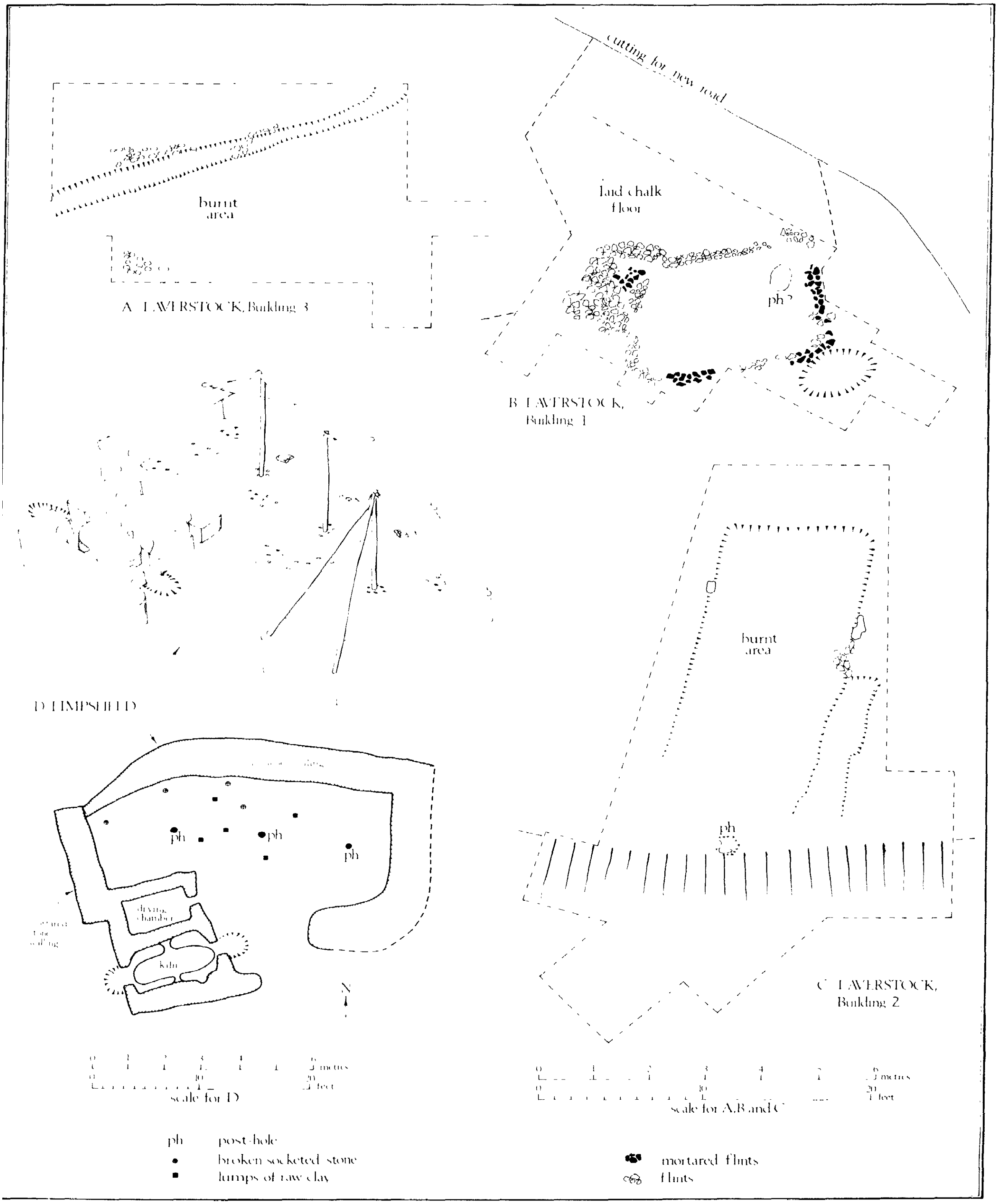


Fig: 85 Late 13th-early 14th century structures associated with pottery making. A-CLaverstock, Wiltshire (after Musty et al *1969,94, fig 5.96. fig 6); I) Limpsfield, Surrey (after Jope 1956, 285, fig 266)*

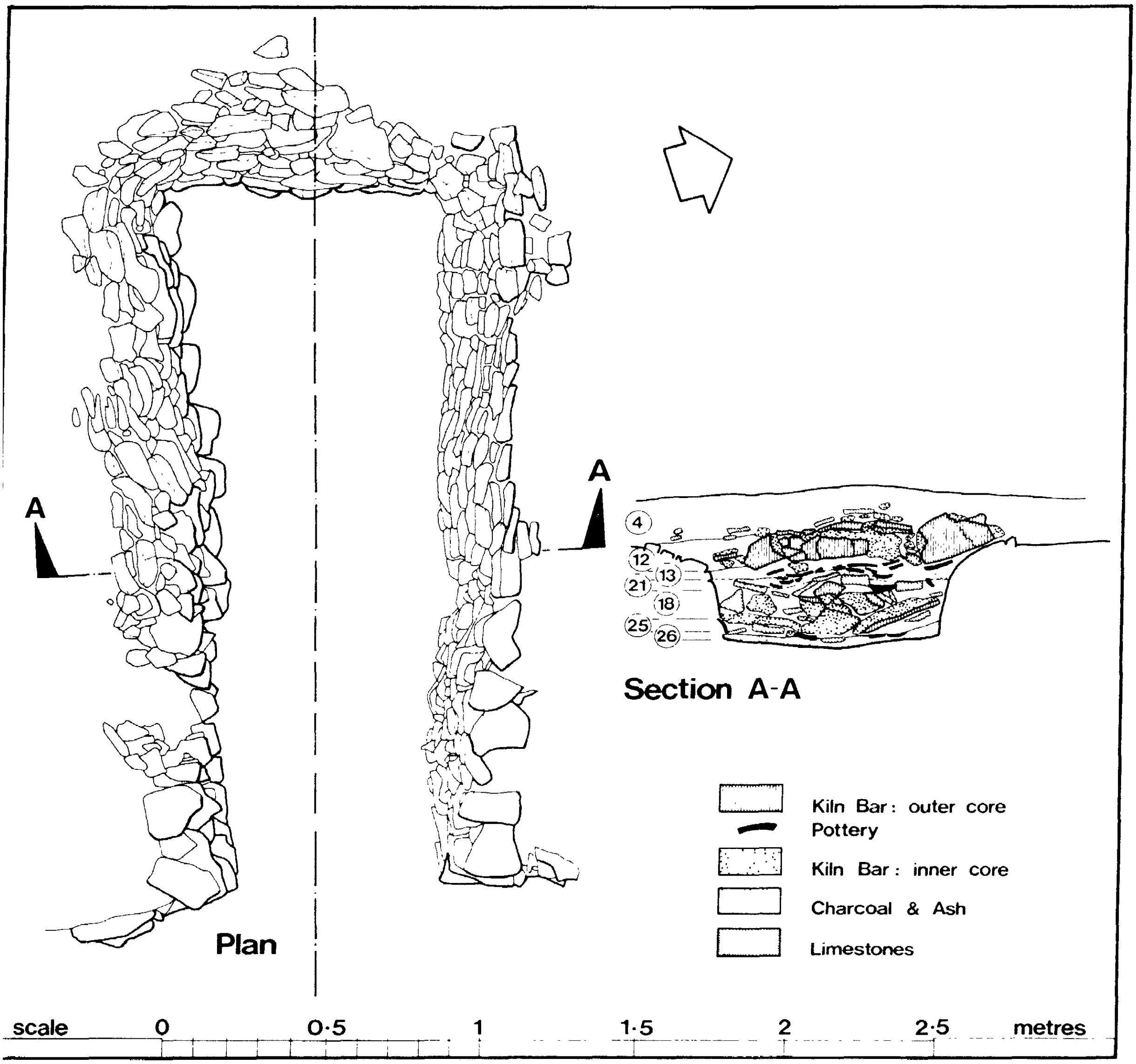


Fig 86 Yardley Hastings, Northamptonshire, 13th/14th century (?)pottery drying kiln

will be discussed below. Other structures have been excavated at Laverstock (Musty *et al* 1969, 95, fig 5, 96, fig 6; Fig 85, A-C here), Nuneaton (Wilson & Hurst 1970,205; Fig 84 here), Limpsfield (Jope 1956, 285, fig 266; Fig 85D here), Bourne (Wilson & Hurst 1968, 206; Fig 88 here), Saxton (Wilson & Hurst 1965, 218), Yardley Hastings (Fig 86), and Olney Hyde (Wilson & Hurst 1968,206; 1970,203; Brown 1970, 19-21; Fig 87 here). Each of the structures is different not only in plan but also in its method of construction. This may probably be explained by the regional variations in traditional building techniques. At Laverstock, buildings were excavated in isolation, while at other sites, although substantial areas were uncovered, complete potting enclosures were not examined, making any interpretation of the use of the structure hazardous. It would be fair to say that many of the sites were excavated under threat of destruction often at very short notice, and the little time available for work prevented any planned and systematic approach. Perhaps the only exception to this is Lyveden.

The published buildings associated with kilns have been called 'workshops'. This attribution is doubtful in the case of Laverstock and Limpsfield. Because the three Laverstock structures (Fig 85, A-C) lack the signs of industrial activity present in the Lyveden workshops, they may have been used to store the pots either before or after firing. In the case of Limpsfield, the published plan (Jope 1956, 285, fig 266) shows that the only internal features of the structure were four broken socketed stones and clay lumps on the

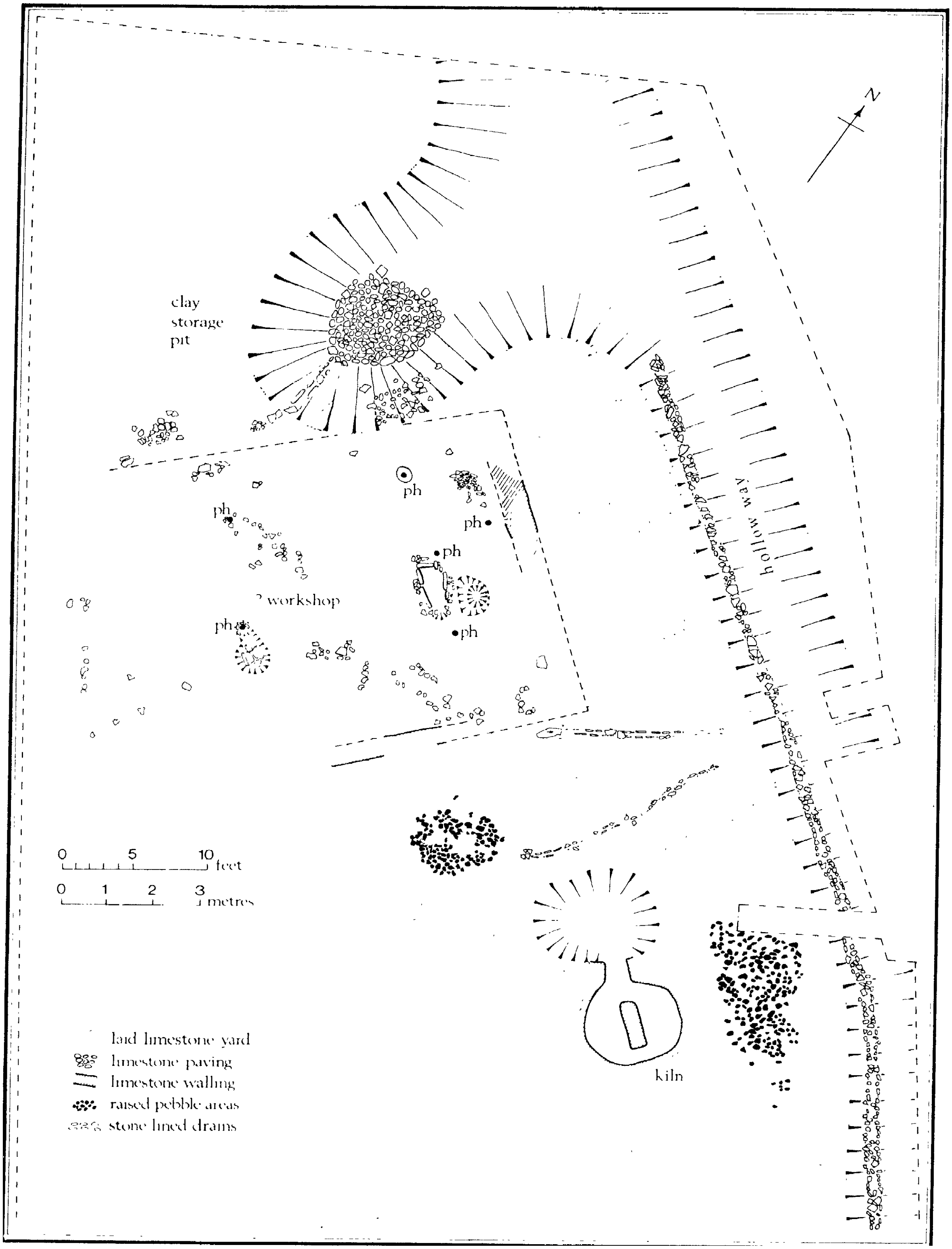


Fig 87 Olney Hyde, Ruckinghamshire, 14th century pottery-making area with kiln, (?)workshop, clay pit, and fuel stands

floor. The opposed-flued kiln with its adjacent drying chamber was built into the western side of the structure, projecting from the only open side. The heat generated by the kiln would have hardened any raw clay in the area, making it difficult to work, so a more probable interpretation of this unique combination of features would be as a drying shed, where the freshly-made pots were stored in the open-sided structure, while green pots were given their final drying in the drying chamber, both being heated from the adjacent kilns. A structure recently excavated at Yardley Hastings, Northamptonshire (Fig 86), is possibly a drying oven. It was filled with layers of waster pottery and near-complete kiln bars but, despite careful examination of the surrounding area, no other structure associated with pottery making was found. Detailed examination of the pottery has yet to take place, and only then may the true function of the structure be known.

At Olney Hyde large-scale excavation has revealed a near complete potter's working complex (Fig 87; Wilson & Hurst 1968,206-7; 1970,203; Brown 1970, 19-21). Unfortunately the plough had removed parts of the site examined and made others difficult to interpret. The croft contained at least two kilns, one excavated in 1967 (Fig 87) and another two years later (Wilson & Hurst 1970,203; Brown 1970,19-20). The same enclosure contained a (?)workshop with associated features and at least one other building, with an adjacent clay pit (Fig 87), but plough damage had resulted in little vertical stratigraphy thus making it difficult to associate these features. Trial trenching over the rest of this extensive pottery-making site revealed much evidence for other stone structures associated with kilns but, apart from the close parallel trenching of one, which proved to be 12 ft wide and of uncertain length, time did not allow examination of them. It was uncertain whether they were workshops or domestic buildings (Brown 1970, 20-1).

In most areas of the country raw clay could not be used by the potter before being put through various stages of refinement. Peter Brears has shown that country potters still practising traditional techniques employed a number of methods to work the clay (Brears 1971,83-94). These sophisticated techniques have yet to be recognized in the medieval period, if they ever existed at all. Small stone-lined pits have been found in quantity at Lyveden (Bryant & Steane 1969; 1971; Steane & Bryant 1975; Fig 83 here), some in pairs, and most associated with the workshops. Two were found on the heavily-ploughed site at Olney Hyde (Fig 87). It is significant that identical stone-lined pits have been found in Roman contexts, at the 4th century Oxford kilns (Young 1977, 18-19, 25, fig 6B; a survey of Roman pottery-making sites is given in ibid, 15-50), and the 4th century kilns at Stibbington, Peterborough (Wild 1973,136-7), where four small stone-lined pits, one of which was full of raw potting clay mixed with freshwater mussel shell, were found against the southern wall of the workshop. The large paved clay-pit found to the north-west of the (?)workshop at Olney Hyde (Fig 87) was probably used to store and settle clay before it was taken away for final working. The fact that the pit was approached from the hollow-way, where carts could back in to tip their load of raw clay, might suggest that the clay-pit was used by two or more potters. The 16th century complex at Bourne (Fig 88) had a large puddling pit in an open-ended structure attached to the end of the potter's workshop. The techniques used by medieval potters to refine their clay can only be resolved by the excavation of complete pot-making complexes.

The excavations at Lyveden have demonstrated that even in a settlement devoted to pottery making the life-span of a particular toft was not restricted solely to potting activity. After the initial use of Site J for pottery making and iron smelting, the second phase was purely agricultural, with the construction of a long-house and small farm complex, and no apparent association with pottery making. The final phase saw the amalgamation of two adjacent crofts for the establishment of a tile-making complex, incorporating a tile-kiln, workshop, and tile maker's house. In fact at least one phase in the history of each of the four excavated crofts at Lyveden was not devoted solely to pottery making. These changes in their use probably occurred when the holdings changed hands. Unfortunately, however, the documentary evidence for this is lacking despite the existence of late-medieval court rolls (Steane & Bryant 1975, 53-9). However, court rolls in other areas frequently show potters exchanging holdings (Le Patourel 1968, 110-11).

Some structures on a kiln site, particularly those used for storing the pot both before and after firing, were no more than framed shelters rather than substantial buildings. Their remains will therefore be ephemeral; in some areas traditional building techniques would leave very little evidence even for

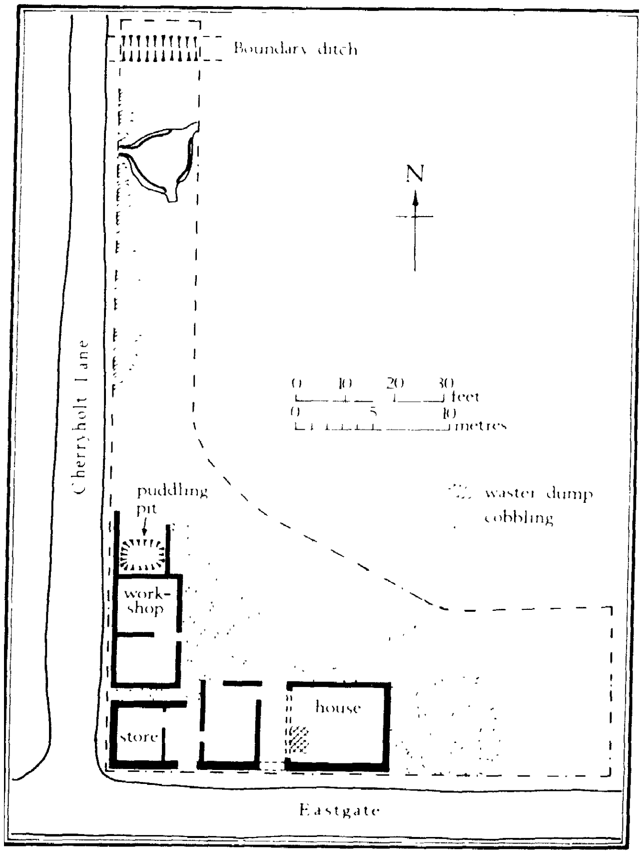


Fig 88 Bourne, Lincolnshire, 16th century pottery-making complex showing potter's house, workshop. store, puddling pit, and kiln

substantial buildings. Medieval illustrations can help in the interpretion of some of the buildings excavated. A Flemish illustration of *c* 1400 shows a brick-making complex with the brickmaker working in an open-sided roofed structure (Harvey 1975, pl 40), while Georgius Agricola's *De re metallica,* published in 1556 and describing German mining techniques, has an illustration of a potter working in an open-ended building making pots in which iron pyrites were roasted (Hoover & Hoover 1950, 227); both illustrations show the close association of the various features involved in the respective processes. Similar sheds still exist today on the southern banks of the Humber associated with tile-making kilns, in which were stored the green and fired pan tiles. The building in the Flemish illustration and the Barton structure would leave archaeological remains almost identical to those found on Site D at Lyveden: pairs of stylobates and areas of paving (Bryant & Steane 1971, 23, fig 6,40-l); the Lyveden structure was interpreted as a store shed. It is therefore likely that the remains of some structures on pottery-making complexes will be very slight, even under optimum conditions for preservation.

Little is known about the domestic quarters of medieval potters. The post-medieval units at Pot-ovens in modern West Yorkshire incorporated the potter's house (Brears 1967; Bartlett 1971,4, fig 2) and the 16th century potter's tenement excavated at Bourne (Fig 88) included a substantial house. Lyveden is the only site where enough has been uncovered to reveal any evidence for potters' houses. Here, out of all the phases of the four crofts excavated, only one had any suggestion of a house within the croft enclosure (Bryant & Steane 1971, 39-40). It was the earliest phase of Site D and the excavators thought that even this was questionable. The evidence from those crofts excavated at Lyveden suggests that the houses of the potters working there lay elsewhere in the village. Only a small number of the known enclosures have been examined, however, and these may not be typical of the village. It would seem reasonable to assume that a potter may not wish to live near his kiln, as those who have worked on kiln experiments will appreciate.

A constant and easily-accessible fuel supply would be essential for each kiln firing. Documentary and archaeological evidence shows that three types of fuel were used: wood, coal, and peat (Le Patourel 1968, 117-19). The fuel would have to be stored close to the kiln where it was used and the type of fuel would determine the method by which it was stored. Experimental kiln firings have shown that where wood was used it was essential to have a stack adjacent to the kiln during firing, for a steady supply is required, particularly when the upper limits of the firing temperature are being reached. The two raised pebble areas adjacent to the kiln at Olney Hyde (Fig 87) were probably for the storage of wood to be used during the firing. An area of laid limestone slabbing to the north of the tile-kiln on Site J at Lyveden may also have served as a fuel stand. The slabbing was bounded on the north by a shallow ditch and a trodden area lay between the slabbing and the stoke pit to the kiln (Steane & Bryant 1975, 37, pl 23, fig 12). Documentary evidence shows that large quantities of fuel were purchased at a rime by potters; for example a late 14th century dispute at Cowick involved the non-delivery of 20,000 turves (Le Patourel 1968, 118). Modern traditional potters using wood fuel frequently store it to allow it to dry (Brears 1972, 51). It is probable that medieval potters may have had two types of store, a long-term store area perhaps not within the potting enclosure, and a short-term stack for immediate use close to the kiln.

On two kiln sites buried pots have been found. At least ten were found in the various phases of the excavated crofts at Lyveden;[3] one was found beside the hearth in the long-house on Site J in a phase not associated with pottery making (Steane & Bryant 1975,28,31, figs 10, 11). Three were found in one pit at Grimston, Norfolk (information from the excavator, Keith Wade). Documentary and archaeological evidence shows that earthenware pots were buried in the ground during the Middle Ages for a variety of reasons, such as good-luck charms under building foundations, or for use in the fermentation process of medical and craft recipies (Moorhouse 1978b, 12-13; Fig 90 here). Most of the pots at Lyveden (both bowl and cooking-pot forms) and the three from Grimston were buried upright, as if they had acted as containers. The Lyveden pots, however, were found in a variety of different circumstances suggesting more than one function. It is possible that some of these vessels found on kiln sites were used in the preparation of glazes, for a number of glaze recipes written down during the Middle Ages specify the burial in the ground of a pot during part of the prescription (see De Bouard 1974 and sources given in Thompson 1935, 422, 'Glazes for pottery'). Possibly Pot 3 on Site D at Lyveden, found adjacent to the east gable of the workshop in the open-sided extension, and surrounded by ash (Bryant & Steane 1971,20, fig 5), was used for this purpose. Some vessels containing residues have been found on kiln sites. A shelly-ware vessel, a non-kiln product, from the Hallgate kilns, Doncaster, contained residues of lead compounds, and was interpreted as having been used to produce glaze (Buckland *et al* 1979, 12, 51, fig 19, no 528,53). One of the numerous crucibles made at the early 16th century kiln at Lower Parrock, East Sussex (Freke 1979, 103, fig 15, no 102; material in Barbican Museum, Lewes), containing (?)particles of clay and glaze, may have been used in either glaze or slip preparation.

The potter's equipment

The potter would clearly require a range of tools. Few have been found, except at Lyveden where there were a large number, from a wide range of types (Bryant & Steane 1969,42, pl 17). They were found mainly in and around the potters' workshops. Many of the knives which were found (Bryant & Steane 1971, 54, fig 13; Steane & Bryant 1975, 20, fig 46) were almost certainly used in the pot-making process because the domestic quarters of the crofts excavated lay elsewhere in the village (see above). These knives are, however, no different from those used for domestic purposes, which draws attention to the danger of identifying such objects as purely domestic. Similarly, domestic-looking combs when found on a kiln site could have been used for making incised parallel lines. Various other tools found at Lyveden show how features on the pots were made. For example, a number of worked and pointed antler tines were found. These were almost certainly used for piercing the bung holes found on the cisterns and curfews and also to pierce the backs of thick strap handles; this served both as a decorative feature and an aid to firing

(Bryant & Steane 1971, 65, 66, 64, fig 18, 92). The large number of sheep's tibiae and metapodials, which were mainly found in the workshop area, are explained by their use as templates to form the characteristic Lyveden-type rim profile (Bryant & Steane 1971,92). Bones found on other sites have also been interpreted as tools; at Ashton, as at Lyveden, small long-bones were interpreted as having been used to form incised decoration.[4] The rudimentary nature of the tools found shows that they were not purposely made by other craftsmen, but adapted from objects in domestic use and created from materials readily available, such as wood or bone. The evidence from Lyveden shows that these more durable tools are unlikely to be found unless the pot-making area is excavated. The ingenuity of a particular potter in adapting unlikely materials or objects to serve as tools may characterize his products.

Stamps and moulds were widely used, particularly on finer wares, and most pottery traditions employed them in their repertoire of decoration. They have the advantage that complex designs can be repeated many times. A few stamps have been found: three made from earthenware and depicting human heads were found at Lincoln' during the last century (Trollope 1850, xliii and facing illustration; Jope 1956,293, fig 277 (one only)); a piece of rough oolite from the Rye kilns in Sussex has two dies, one on each side, both depicting running animals (Vidler 1936, 112, fig 5); and a number of earthenware stamps were found during the last century in Parliament Street, Nottingham, one having a stylized human face and a rosette-boss die on the same stamp (Parker 1932, 85, pl V, nos 5, 6; Rackham 1972, 25). Pottery dies for making the distinctive rosette stamps found on Cistercian Wares have been found at Nuneaton and Potovens, the latter having a notch cut in its side as a registering mark to help the potter position the die on the pot (Brears 1967, 35, fig 13, no 11). Different materials were used for the stamps. Fired clay and stone have already been mentioned. Bone was also used, as at Lyveden, where one of the dies which produced the distinctive Lyveden grid stamp found on the decorated jugs was shaped from the end of a sheep's phalange (Bryant & Steane 1969, 37 m); the bone piece was found, significantly, trodden into the workshop floor. Stamps are particularly important to the archaeologist because they reproduce precisely the same design, providing evidence not only for the range of products of one potter or workshop, but also for their distribution. Because of the wear factor, the dies are likely to have had a much shorter working life than the potter who used them. Stamps can frequently have small flaws in their design, enabling their impression to be identified more easily. Rouletted designs with flaws are even more important, for not only can the same wheel be recognized but the flaw will be repeated each full revolution, enabling the diameter of the rouletting wheel to be calculated, a factor which may help to distinguish pots with visually similar designs. A vessel with such a flaw has recently been published from Wharram Percy, where a defect in one of the units of a rouletted design was repeated every 50 digits, with a length of 160 mm, producing a wheel diameter of about 50 mm (Le Patourel 1979, 103, fig 51, no 113, 105). While the Wharram vessel is drawn accurately, and is a true reflection of the pot, the wide variation in drawing styles between different reports makes such subtleties difficult to detect without looking at the original pot. In addition, the angle of application and pressure on the die can frequently make it difficult to identify products from the same mould. The shrinkage rate of each pot during firing may vary, and while a number of impressions may have been made with the same die, they could be of different sizes once fired. Despite these drawbacks, stamps could prove extremely useful for determining products of the same potter or workshop. The finding of a stamp in a datable context on a kiln site should provide a terminal date for products bearing the impression of its die. There is now a large enough body of material available for detailed work on individual stamp designs to prove very rewarding.

The potter's methods

The excavation of kiln sites can often help explain techniques of manufacture. It is now apparent that hand-made pottery was frequently produced in large quantities in many parts of the country during the Middle Ages (Hayfield 1980), but manufacturing techniques are more clearly seen in waste products. For example, it was not appreciated that Lyveden-type wares were coil-constructed until the kiln site was excavated. Potters producing the highly decorated pots in the early phases at Nuneaton were coiling necks on to thrown bodies, a technique known in the Oxford and Coventry areas on the earlier tripod pitchers (Tebbutt *et al* 1971, 52-4, pl I-III). The spoiled products on a kiln site can offer much information on pot technology which would be difficult to piece together from pots found elsewhere. Individual peculiarities of construction, and their combinations, can help to isolate particular groups of Pots, as for example where bases were applied separately to thrown vessels or where handles were applied in a particular way. More detailed observation may identify the products of an individual potter. Finger and thumb impressions found on pots at the kiln sites at Bourne, Lincolnshire (information from the excavator, Nigel Kerr) and from Ingatestone, Essex (Sellars 1978) are being examined, in the hope that this method may be useful in the future. Most medieval pottery was thrown using the right hand, but a small proportion was thrown using the left hand. Pottery made and decorated by either left or right hand can frequently be recognized. While a potter may not be consistent in his lead hand on one pot, it is probable that he would approach each pot in the same way, making it possible to recognize his products (Moorhouse in preparation c). The identification of a left-handed potter or the recognition of finger or thumb prints on a kiln site may help to identify the range of products, the output, and the distribution of the products of an individual potter; the careful excavation of undisturbed waste heaps of isolated kilns may reveal the effect of lead poisoning on the quality of his products. While the latter may sound a little far-fetched, Mr G F Bryant has detected such a phenomenon in waste material at an 18th century kiln near Halifax; the effects of ability to control the hands when affected by lead poisoning arc now well known from modern medically controlled tests (Koplan *et al* 1979). These and other features of pots can be identified from occupation sites, but kiln sites offer the best opportunity for their analysis.

Most kiln sites have produced one or more vessels not made there. On site D at Lyveden, products were found from Brill, Nottingham, Stamford, and at least two other unlocated centres in the eastern Midlands. There are many explanations for their presence, but three are perhaps the most likely: they were brought in either for domestic or industrial use on site; they were used as models by the potter; or they were disturbed from earlier occupation on the same site. While some of the imported pottery at Lyveden was sooted and probably used for domestic purposes, most of the non-kiln products were copied by the potters. Most of these copies were extremely crude and did not approach the technical and aesthetic quality of their standard coil-made products. The technically superior components of the Lyveden imports were not incorporated into the potter's conventional wares. These features have been noted on other kiln sites, and they reflect the conservatism of the medieval potter, and cast some doubt on the comparison of decorative and constructional techniques between pottery traditions for seeking the source of influence for traits in pottery styles. This is not to say that the medieval potter did not derive his ideas from elsewhere. Copies of metal and glass vessels were more than the occasional product in a number of centres, the two-handled cooking pot copying the bronze cauldron and the aquamanile being obvious examples. It has been suggested that a distinctive type of handled bottle or cruet found in the Midlands was modelled on pewter originals (Lewis 1968; Dunning 1969a; but see Hinton 1973, (28), 16) and the various forms of annular brooch motif used in decoration on jugs were freely adapted from dress brooches in precious and non-precious metals (Dunning 1969b).

Even the most meticulous excavation techniques can only present the material remains for the interpretation of potting activity. Documentary evidence can add further information. An example of this is the special requirements given to potters by their customers. A memorandum written down by William of Worcester in 1478 records that a child of John Wey, a waxmaker of Wine Street, Bristol, should speak to the potter at Hanham (Abbot's) to ask him to make two pots similar to those made before for William, save that the mouths of the pots be ¼" less in diameter; further, William provided a wooden template to which the potter should work (Harvey 1969, 76, 77). Another special order is probably represented by the two ridge tiles *(crests)* 'made in the fashion of mounted knights' bought from John Pottere of Cheam for the re-roofing of the hall at Banstead, Surrey, in 1372/3 (Lambert 1912, 128, 352; see also Marshall 1924, 93, and Salzman 1967, 231). Archaeological evidence is beginning to suggest that customers' instructions to the medieval potter were perhaps more extensive than is suggested by the documentary evidence. Vessels have been found bearing the insignia of individuals or organizations. Jugs bearing stamps of the arms of either the Clare or Manny family have been found in London, where both families held property and had connections (Thorn & Thorn 1972; Thorn 1978, 133, fig 51, 137-40). Excavations at the preceptory site at Etton (North Humberside) produced a jug of late 13th century date with an applied cross beneath the tubular spout, possibly a potter's attempt at copying the double cross of the Knights Hospitallers who held the site from at least 1324 (noted in Wilson & Hurst 1968, 171-2). An increasing number of pottery distillation groups are also suggesting that the potter was given specifications. Most groups found have produced a range of forms not found in any other assemblage, and all groups used glass vessels in various combinations (Moorhouse 1972). Pottery chemical apparatus has been found on at least twelve kiln sites.[6] Special vessels received extra attention from the potter during firing, so that far fewer wasters from occasional products were created; the complete distillation unit from Nuneaton was discarded because the potter neglected to pierce a hole in the alembic spout! It therefore seems that, as far as specialized pottery industrial equipment is concerned, evidence for special orders to potters for them will have to come from domestic sites. Mention of earthenware pots with a specific capacity, the quart, pint, pottle (two quarts), gallon, and bushel, is frequently found in the documents, the most common being the quart, the pottle, and the gallon,' while attention has been drawn to vessels of these sizes (Hinton 1968,66; 1977, 22 l-2), suggesting that the potter responded to social requirements. This combined evidence suggests that the customer had a much closer working relationship with the medieval potter than has been appreciated.

The existence of waster material on a site may not presuppose the existence of kilns. Warped or otherwise distorted vessels are occasionally found on occupation sites, reaching there either as seconds sold off by local potters or used as packing in kiln load consignments. A distinctive ring prop used only in the Farnham area was found at Sandal Castle, West Yorkshire, and probably reached the site amongst a consignment of Tudor Green pots, of which fragments from nineteen were found there (Moorhouse 1979a, 55-6). Occasionally large collections of isolated wasters are found, such as a group from a tenement in Walmgate within the medieval city of York (information from P V Addyman and Miss C Brooks), or a group from the foundation trench of the church of St Peter's, Bristol (Dawson *et al,* 1972). Documentary evidence suggests that large quantities of waster tiles were sold for a variety of uses. The accounts of the Vicars Choral in York show that sherds *(scarthes),* wasters *(wasschers),* cracked tiles *(craktiel),* and warped tiles *(bendtiel)* were occasionally sold off as rubble (Kaner 1980, 6). Accounts for building works at Windsor Castle refer to other uses. In 1350 5s 3d was paid for sixteen quarters of broken tiles *(tegule defracte)* for 'filling up in the walls of the said (chapter) house', nine quarters of *tilsherdes* were bought in 1354/5 at the important tile centre of Penn for mending an oven, and in 1439/40 45s 2d was paid for the carriage of tile and tile-sherds (Hope 1913,135 (162), 156, 229). Broken tiles continued to be used during the post-medieval period for hardcore and foundation fill. In 1527 Trinity Guild in Luton accounted for the carriage of 'a load of *tyle sherdis'* to underpin a wall, and in 1533 the same quantity of *Tylesherdes* was bought for levelling up the underpinning of a wharf foundation (Murray *et al* 1933, 27). Archaeology shows that end-set tiles were frequently used for making hearths, and this is supported by documentary evidence.* A contract for building a shop in London in 1370 stipulated that the hearths of ten fireplaces should be made of stones and *Tylescherd* (Salzman 1967, 444). While documentary evidence is at present lacking, it seems unlikely that potters did not take advantage and make profit from the large quantities of waste material which they produced, an act which may account for pottery wasters and kiln debris found on occupation sites, such as those from the foundation trench for St Peter's Church, Bristol.

The close working relationship between tile makers and potters is seen on a number of sites where pottery, floor, and roof tiles were made in the same complex but fired in separate kilns. That some craftsmen applied their hand to two or more of these ceramic types is now being recognized, particularly at Nuneaton, where inlaid floor tiles were produced in the pottery firing kilns; this is demonstrated not only by waster inlaid floor tiles being found with waster pottery in a kiln fill, but by pots in the same dump which bore scars from the floor tiles. Ornate roof furniture was produced by both potters and tilemakers. The occasional documentary reference to the purchase of roof furniture from potters, such as the two mounted knights purchased from a potter at Cheam for the hall at Banstead in 1372/3 (see p 107), is supported by the finding of louvers, chimney pots, ventilators, and finials on pottery kiln sites, as at Naish Hill, Laycock, Wiltshire (McCarthy 1974,130, fig 22, no 1-4, 131, fig 23), Laverstock, Wiltshire (Musty *et al* 1969, 141, fig 25, no 202-3, 143, fig 26, no 204-5), and Nuneaton, Warwickshire (Mayes forthcoming). Tilers also supplied furniture for the ridge of a roof, for in 1357 the Merchant Adventurers in York paid 5s for an unspecified number of *loveres* from John Sampole (Sellers 1918, 16), whom the York freemen's rolls record in 1350 as the earliest freeman *tighler* in the city (Collins 1897, 45).

Frequently medieval craftsmen of different skills worked together, either through necessity, like the charcoal burner and iron smelter, or because the different raw materials they used occurred close together. Probably the second reason could explain the presence of iron making and pottery making on the same site. The initial iron-working phase on Site D at Lyveden was superseded by the pottery-making phases (Steane & Bryant 1975 ,4-9). On other sites the evidence is not so clear, as at Hope Farm, Baildon, West Yorkshire, where large quantities of iron slag mixed with the pottery wasters have been found over many years on the site (Moorhouse 1980, 788 n81). Documentary evidence suggests that the resourceful potter did not rely solely on pottery making for his livelihood (Le Patourel 1968, 110-11), and this may be reflected in the initial phases of Site J at Lyveden, which contained an apparently contemporary blacksmith's workshop and pottery kiln (Steane & Bryant 1975, 21-2, fig 8).

The importance of kiln sites, either as a source of a particular type of pottery or as a means of assessing the relevance of pottery distribution, has long been realized. The few large-scale excavations of medieval pottery-making sites have shown that successive phases within each potting enclosure could be replanned with an alteration of the plan and arrangement of features and structures; boundaries could vary, changing the area of the enclosure; and each phase of a potter's working enclosure need not necessarily be totally or even partially devoted to pottery making. Because the potter would require a range of contemporary elements within his work area, the details and development of a single croft in which pottery was made could be far more complex than those of a contemporary rural peasant domestic site. Total excavation of the sites will allow the pottery to be placed in the context in which it was made, allow a much clearer understanding of the mechanics of medieval pottery manufacture, and provide a firm basis for the dating and development of the pottery made there.

Pottery distribution

Channels of distribution

The distribution of a particular type of pottery can be defined by plotting the different places at which it is found. This can be improved by plotting assemblages which do not contain the type in question, a technique first used successfully by Professor Jope (Jope 1952, 75, fig 11). Interpretation of such distributions is fraught with problems, because they are not the result of just one method of marketing. Archaeology can show that pottery was made at one place and used elsewhere, perhaps many miles away, but cannot show how it reached its destination. On the other hand documentary evidence can show how pottery travelled. The most obvious method was through local markets, and is revealed not only through a potter holding a stall in the market, but through the tolls chargeable on the entry into a town or market of cartloads of pots for sale. Regional fairs and more distant markets were used, and pottery was hawked around the country either by potters or middlemen (Moorhouse 1978b, 16). Accounts show a surprisingly large number of purchases direct from kiln sites (see p 110). The importance of common domestic pottery being circulated as containers is perhaps underestimated. Private letters and accounts reveal that spices were purchased in pottery containers from merchants and apothecaries in the ports through which the vessels were imported (see p 110). Distribution by water, whether along rivers, by coastal ship, or through commerce from overseas is well attested by the archaeological and written evidence (eg Dunning 1968; Clarke 1973; Dunning 1962-3, 236, fig 16; Farmer 1979,2, fig 1). Many other methods are hinted at in the documents. These include gifts of pottery, and references to sets of pottery vessels being hired out. Neither of these were of wide importance and therefore they are not likely greatly to affect distribution patterns, but they could create anomalies in the general picture. Each of the principal methods mentioned above would in fact produce its own distribution pattern in relation to the kiln site. The problem of interpreting pottery maps is made even greater when centres of production are not known. It is certainly not enough, and indeed misleading, to interpret a pottery distribution solely from market centres, where the market catchment areas are shown as a fixed radius centred on the market site.

Sources of pottery

One perhaps obvious statement, although difficult to prove at the moment, is that a household or community would obtain its supply of earthenware from different sources. This is hinted at in those few accounts where a long enough run survives. Perhaps the best illustration of such diversity comes not from earthenware vessels, but from references to tiles of different types purchased from different centres for use on the same building. Such an example occurs in the accounts rendered for the repair of the hall roof at Banstead, Surrey, in 1372/3 (see p 107). The sources of the different types of tiles and quantities purchased are shown in Fig 89. References to tiles bought from named people, either merchants or tilers, at particular places, are much more common than similar references to purchases of pottery. The buying of tiles from different centres for the same building might be reflected in the archaeological record. When more kiln sites are known, it might be possible to suggest a

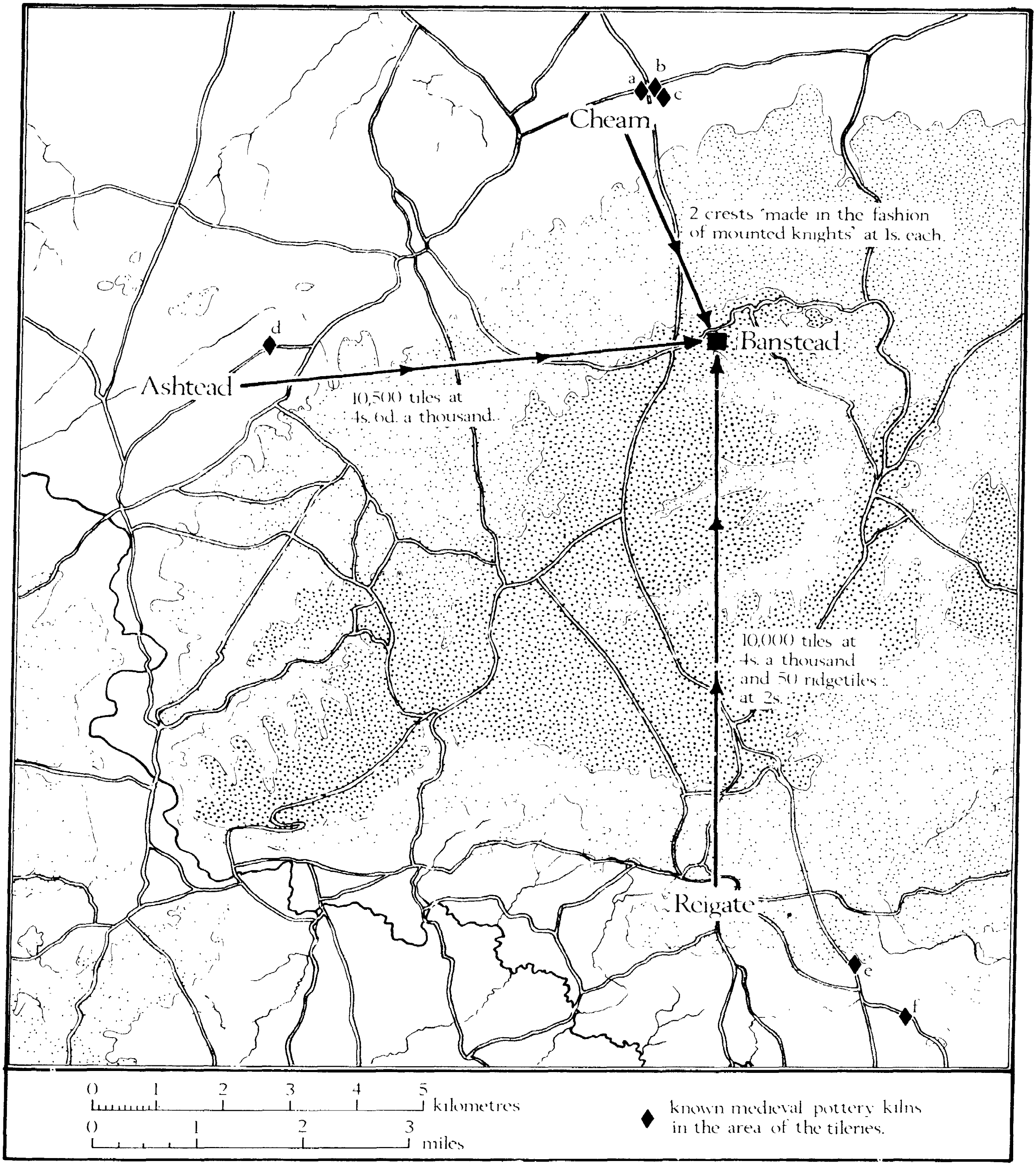


Fig 89 The sources of ceramic roof covering for the repair of the hull roof at Banstead, Surrey, in 1372/3 (from Lambert 1912, 129. 352). The map shows assumed and probable medieval roads and the contours are shown at 76 m and 152 m intervals. Sources for the pottery kiln sites in the area of the purchases arc: a, Marshall 1924; b-c. Marshall 1941; d, Frere 1941; e, Hooper 1926; f, Webster & Cherry 1975, 258

similar diversity in the contemporary purchases of pottery for the same household.

Account rolls provide most of the evidence for one cause of anomalies in pottery distribution - the hiring of pots. The most frequent type of entry refers to the hire of a garnish of vessels, a set of twelve each of dishes, plates, and saucers, mostly of pewter. For example, in 1448 the Norwich treasurer's account records 6d being spent on the hire of 'pewter vessels for the cook of 3 *garnysch'* (Tingey 1910,72). Vessels of the most rudimentary materials were hired, as demonstrated by the cellarer's roll of Battle Abbey when in 1435/6 8d was paid for five dozen dishes and wooden platters, hired for the use of the tenants collecting hay at Bodiam (Searle & Ross 1967,116). It is therefore not surprising to find references to the hiring of earthenware vessels. For example, in the household accounts of John Howard, 1st Duke of Norfolk, 8s was recorded in 1467 for the hire of 20 dozen *stone pottes* (Botfield 1841b, 400); this is certainly a reference to German stonewares. The two most common reasons for hiring vessels were for use in feeding the tenants while they were performing their customary harvest duties, as shown at Bodiam in 1435/6, and for funeral gatherings, where the short-term requirements of the frequently large numbers in attendance could not be met from the household store of tableware. For instance, for the burial of Richard Parentyn, Prior of Bicester Priory, Oxfordshire, in 1434, 3s 4d was spent on thirty dozen dishes *(disci)* and twelve dozen platters *(parapsides),* almost certainly made from wood, 'hired against the same time' (Blomefield 1882, 177). Sufficient evidence exists to show that the hiring of earthen pots was perhaps more than a rare occurrence, and that the use of pots by contract should be considered as a means by which pottery was circulated.

Because the majority of kiln sites would supply most of the basic earthenware vessels for the immediate area, defining concentrations in a distribution pattern can help locate production sites. But potters also supplied areas many miles from the kiln. An example of this is the large quantities of Surrey wares found in London. There are many references to the purchase of pottery from a kiln many miles from where it was to be used, despite the presence of much nearer kilns. One example is recorded in 1391 when a carter was paid for two days' work carting 229 pots from Farnborough to Windsor Castle (Salzman 1967, 276), a distance of more than fifteen miles over difficult terrain, while contemporary potteries existed at Maidenhead, less than five miles up the Thames (Pike 1965-6). The pots were bought for the royal bath suite at Windsor, so it is possible that the Farnborough potters specialized in such vessels, although a number of other explanations are possible. While it can often be shown that customers went long distances to buy pots, potters also travelled many miles to sell their wares. Mrs Le Patourel has drawn attention to the Toynton potters, who sent cartloads of pots to Whaplode and Spalding, 30 miles from Toynton, and retained a stock of pots at Spalding for future sale (Le Patourel 1968, 119).

There are many instances of exotic wares being purchased directly from merchants in coastal towns, through which the pottery would have been imported. London is the centre most frequently mentioned. Many of the references are to pots being bought either already containing or in order to contain green ginger or treacle; treacle was an important medicinal salve used during the Middle Ages as an antidote to poison. Frequently the pot and its contents are recorded as being bought together, but it seems clear that pots of a special type were often bought on their own to contain green ginger. The shop inventory of 1446 of Thomas Gryssup, a chapman of York, included eight pots for green ginger valued at 8d and four pots for green ginger valued at 8d (Raine 1865, 103), the separate valuations possibly implying pots of different sizes. A more typical reference is shown by an entry in Sir John Howard's household accounts, where a memorandum of 1466 records that an apothecary in London should 'keep a pot of Genoa *(geene)* to put in green ginger *(grene gynger)'* (Botfield 1841b, 369). The mention of Genoa, in northern Italy, occurs many times in accounts and letters as the source either of a pot or its contents when either spices or syrups were being purchased. These pots are almost certainly the tin-glazed albarelli found in medieval contexts in this country. Recent work has shown that 15th century English references to pots of delicacies from Genoa are probably referring to Spanish wares imported by Genoese merchants as containers for their spices and syrups which were then exported.[9] Sometimes mention of an exotic pot can be very explicit as to where the pots were to be bought and how they should be cared for. One of the most specific occurs in a letter written in 1479 by John Paston II to Margaret Paston concerning three pots of treacle from Genoa, bought in London (Davis 1971,512-13, no 313). The letter describes at some length the condition of the pots and how they can be distinguished, even down to the mention that one of the pots has the initials 'MP' (for Margaret Paston) scratched on the base (Appendix 1h). It has been argued in the past whether imported pottery found in this country was the result of commercial trade or the product of a gift from abroad. The numerous foreign shiploads containing large quantities of pottery recorded in customs accounts and the special orders of the type mentioned above argue that a small but significant quantity of the imported pottery reached our shores through organized trade.

Factors affecting the patterns of pottery distribution

Apart from the numerous ways in which pottery was circulated, at least two important independent factors governed its distribution: the medieval road system, and the land and property divisions in the form of administrative and tenurial units. Apart from the geographical factors, the administrative units of the township, manor, and parish were major influences in the development of the local road system.[10] Access was essential to various parts of the farming landscape within each township. The workings of the ecclesiastical parish and the manor, particularly the latter, imposed many additional obligations on the people: they frequently had to travel long distances to places such as the church, manor court, the corn mill, or the common bread oven; in some parts of the country these were separated by many miles. Commercial centres and the need for communication between the administrative centres of large or dispersed estates were two of many factors which determined major routes. Ranges of hills also acted as effective barriers to pottery trade, through medieval routes travelling parallel with and rarely traversing them; for example, the Cotswolds and the South Downs define the main north-south distribution of

Brill-type wares (Jope 1952, 75, fig 11), and the Chilterns define the southern limits of the black wares introduced into the eastern Midlands during the early 15th century (Moorhouse 1974, 52, fig 1). Some routes which were important during the Middle Ages went out of use or were superseded during the post-medieval period. In some areas of the country the modern road systems, and even those existing a century ago, bear no relation to the principal medieval routes in that area. This can be seen in the industrial regions of the Pennines. Such a dramatic change has also taken place in some parts of southern England. This may be illustrated in the area around Banstead, Surrey, by comparing Fig 89 with the modern OS map of the area. It is therefore important to identify routes which existed in the Middle Ages before trying to interpret pottery distributions from modern map sources.

An understanding of the structure and distribution of secular and monastic land-holding patterns in an area can explain the siting of particular kilns and the distribution of their products. Fountains Abbey held a large estate in the adjacent townships of Kirkheaton and Huddersfield in modern West Yorkshire, with its centre at the grange of Bradley in the latter township (Lancaster 1915, 121-59, 353-67; Clay 1929). The distribution of the monks' property in Kirkheaton township suggests that the kilns at Upper Heaton (Manby 1964) lay on the Abbey's lands. It is probable that the kilns were sited to supply the needs of both Bradley and its sister grange at Ainley three miles away to the west, both granges being nuclei of a large dispersed estate which exploited the mineral wealth of the property. The relationship of the kilns to Fountains Abbey could help explain the concentrated distribution of Upper Heaton products, which is limited to the Huddersfield area. Unfortunately Fountains' manorial records for its West Yorkshire property have not survived, leaving any possible evidence for the monks' initiative in the balance. Elsewhere, kiln sites are known which lie on monastic property, as at Winksley, North Yorkshire (Bellamy & Le Patourel 1970, 111). Royal records show that pottery for use by the royal household was purchased from places held as royal demesne (Le Patourel 1968, 119-20; Giuseppi 1937, 151-2). It is probable that lesser landlords encouraged pottery production on their lands.

The movement of royal and seigneurial households around the country is well documented during the Middle Ages. Mrs Le Patourel has drawn attention to the movement of pottery created by such travels (Le Patourel 1968, 119-20). At a much lower level, the movement of manorial officials between estates separated by hundreds of miles could explain the presence on a site of pottery produced elsewhere in the country. This is probably why a tripod pitcher of southern Marches type came to be used at Almondbury Castle, West Yorkshire, the upper half of which was found in the lower filling of the main well on the site (material in the Tolson Memorial Museum, Huddersfield). Until *c* 1200 Almondbury formed the administrative centre of six and a half demesne townships in the extensive honour of Pontefract, which was held by the Lacys.[11] The same family held a considerable area of property in the Midlands, mainly in Herefordshire and Oxfordshire (Wightman 1966, 117-94, 118-19, map). The concentration of demesne property lay in Herefordshire, centred on Weobley, the region from which the Almondbury pitcher originated. A similar explanation can also be given for the fragment of a plaited handle from a pitcher of similar origin found at Kirkstall Abbey, near Leeds (Le Patourel 1961,26, fig 10, no 11; material in Leeds City Museum), a house not only refounded but also endowed by a member of the Lacy family.

More detailed examination of the distribution of family estates and of the officials who ran them can often help explain pottery anomalies on a site, The Warennes, Earls of Surrey, were an important and influential family until their lands were divided after the failure of the male line in the mid 14th century. They held considerable estates in many parts of the country, with major holdings in Yorkshire centred on Wakefield and Conisbrough, in Sussex centred on Lewes, in Wales, in Norfolk, and in the Midlands. Excavations at Sandal Castle, their administrative centre and principal seat for the extensive manor of Wakefield in West Yorkshire (Faull & Moorhouse 1980), have produced large quantities of pottery types found further south in Yorkshire. At least 40 vessels of a type found in the Conisbrough area, and particularly at Conisbrough Castle (Thompson 1968, 1969), were found in 13th and 14th century levels, while the bulk of the fine wares, numbering over 120 vessels, in later 12th and early 13th century phases almost certainly came from the Hallgate kilns in Doncaster, over 20 miles from Sandal. The castles at Conisbrough and Sandal were the administrative centres for the two large holdings of the Warennes in Yorkshire, surname evidence suggesting that there was a strong link between the two areas, while the demesne lands of the honour of Conisbrough lay close to Doncaster (Clay 1949, map facing p 137) providing one explanation for the Hallgate material reaching Sandal and other sites further west in the manor of Wakefield (Moorhouse 1979b, 110-11). Fragments of two vessels of West Sussex ware have also been found there, and this can almost certainly be explained by similar connections with the Lewes estates, which lie on the eastern fringes of the main distribution area of West Sussex wares (Barton 1979, 102, superseding Barton 1969,63, fig 13). Other forms of manorial tenurial connections can explain odd vessels of non-local type on a site. High-ranking manorial officials of large and important estates were frequently brought in from another centre elsewhere in the country. Henry de Walda, a steward of the manor of Wakefield during the early 14th century, originally came from Buckinghamshire, where the Warenne family held the manor of Wing (Clay 1922, 155-6). Although Henry was granted a substantial estate within the manor of Wakefield *(ibid),* the family still retained their Buckinghamshire property *(ibid,* 93, no 277), thus suggesting that contact between the two areas was maintained. It is possibly through this link that the sherd from a Brill-type vessel found during excavations at Sandal can be explained.

Not only manorial officials moved around large estates. The Earl Warenne's Welsh property is reflected by the Llewelyn family recorded from the late 13th century in Sandal (Baildon 1906, 243 index; Walker 1945, 211 index) and the de Wales family recorded from 1324 in Northowram (Turner 1893, 332 index), both demesne townships in the manor of Wakefield (Faull & Moorhouse 1980, map 25). Members of both families were free tenants, but there is no evidence that they ever held any official, position in the manorial hierarchy. The extensive holdings of the Warenne family in Norfolk (Clay 1949), centred on

Castle Acre, are reflected by the presence in Wakefield during the early 14th century of a family called Norfolk (eg Baildon 1906, 86), and help explain the existence amongst 13th century deposits at Sandal of at least four vessels made at the important pottery-producing centre of Grimston, seven miles north-west of Castle Acre. There are many other ways in which the manorial and estate framework may affect pottery dispersal. Two examples of this can be given: witness lists to charters frequently show that scribes covered large areas, and on dispersed estates manorial accounts often record auditors who had travelled long distances for the occasion. It was not only the larger baronial families like the Lacys and Warennes who held property scattered throughout the country. Minor families could have equally extensive estates, such as the Clere family who had possessions in Hampshire, Lincolnshire, Norfolk, Surrey, Sussex, and Yorkshire (Clay 1975). A number of minor gentry families holding property in two areas, like the tenurial links between Yorkshire and Lincolnshire (Clay 1960), may account for the unusually high preponderance in one area of pottery made elsewhere. Little work has been carried out on the effect of manorial organization on the movement of pottery. The evidence from Sandal in relation to the Warenne estates elsewhere in the country shows that similar work on material from manorial administrative centres may prove rewarding.

Many other reasons for long-distance travel helped in the movement of pottery around the country. The most obvious was the domestic pottery used by travelling households (Stretton 1935), the most prodigious of which were those of the reigning monarchs,[12] in particular Edward I (Safford 1974; 1976; 1977), and bishops, perhaps the most famous journey being that undertaken by Baldwin, Archbishop of Canterbury, on his six week tour of Wales in 1188 to raise support for the Third Crusade, immortalized in Geraldus Cambriensis' 'The Journey through Wales' (Thorpe 1978, 74-209,30-6 route, 32 map). The wool trade offered many opportunities for pottery movement. For example, merchants had frequent contact with coastal ports through the export of wool and, later, cloth (eg Donkin 1976, 122, fig 30). The inland trading circle of many ports was extensive. Bristol merchants reached Shrewsbury, Coventry, London, and Southampton (Carus-Wilson 1933, 186 map), Southampton merchants had commercial contact with Exeter, Bristol, Gloucester, Leicester (via Oxford), and London (Platt 1973, 152-64,161, fig 9), while the ports of the Wash had both a very wide collecting area for products which they exported and a distribution area for those foreign goods which entered this country through them (Carus-Wilson 1962-3, fig 68). The often extensive and widely scattered estates of monastic houses, particularly their granges, necessitated frequent contact with the mother house (see Donkin 1963). Frequent contact would be essential for any organization with dispersed holdings, as is demonstrated by the journeys made by the Warden and fellows of Merton College, Oxford, to their possessions in the north and east of England, journeys for which they occasionally drew provisions to be self-supporting (Martin 1976). Military activity probably provided an underestimated influence. Edward I drew on workmen and supplies from a wide area of the country for the construction of his Welsh castles (Taylor 1961). Political unrest was common during the medieval period, and kings were frequently involved in campaigns covering great distances, such as those carried out by William I between 1068 and 1070 (Beeler 1966, 45, map 3) or the march of King John between September 1215 and March 1216 which took him to Scotland and back (Warren 1961, 271, map IX). Many other long-distance travellers could have unintentionally moved pottery around the country.

Work in recent years has established a wide range of pottery imported into Great Britain from many parts of Europe and the Mediterranean during the medieval period.[13] The most obvious explanation for it reaching these shores is organized trade. This is clearly demonstrated by the quantities of some types found, like the south-western French polychrome jugs (Dunning 1933; 1968, 45, fig 21; Butler 1974, 109-12, 110 fig 17; Evans 1978), almost certainly made for the English market, or the large quantities of stonewares from various centres in central northern Europe, particularly the Rhineland (Hurst 1977a). Documentary work is complementing and expanding the range of pottery imports (Le Parourel forthcoming). Trade is the usual explanation for continental pottery found here, but there are other interpretations. One of these is the frequent European travels enjoyed by merchants and politicians, documented in their detailed itemized accounts covering the costs of their journey. Such accounts provide a great deal of information on the sources and uses of pottery bought. An example is the accounts kept by the treasurer of Henry of Bolingbroke, Earl of Derby (later Henry IV) on his military and political expeditions to north-eastern Europe and the Holy Land in 1390/l and 1392/3 (Smith 1894; Stretton 1924). The prince's travelling household was large and was administered and organized through the various offices of a land-based household (Smith 1894, lxxxvii-xcviii), purchases frequently being listed under the office for which they were required. In some cases, therefore, it is possible to say a great deal about the pottery purchased. Various quantities of earthenware pots were purchased along the routes, and these are set out in Table 9, along with entries for tiles bought for the construction of hearths and ovens in the ships. It is probable that many more earthenware pots were bought, because no earthenware pots were specifically mentioned amongst the large quantities of provisions bought for the start of the second campaign (they could have been listed under the general purchases of supplies) (ibid, 151-63). Other purchases of pottery are probably lost in vague descriptions such as the 41 solidi spent on drinking glasses and pots at Portogruaro, near Venice, on 26 November 1392. Some of the containers for *wine* may have been of pottery, particularly where ambiguous terms describing both vessels and measures were used: a vessel *(uase)* of malmsey wine was bought at Venice in preparation for the sea voyage to Palestine *(ibid,* 222/3l), and a pitcher of Gascony wine was purchased at Rochester for 8d on the return from the second expedition (ibid, 256/267).

The uses of some of the vessels are given. An earthen pot was bought at Calais for holding wine, while wine was purchased for earthenware pots at Putzig, and at Famagusta on the return leg of the second voyage 'a great pot of oil' was bought. Although water was stored on board ship in a variety of wooden barrels and casks *(ibid,* 23/17-19, 153/12-14), it was carried to the ships at Rhodes on at least two occasions in consignments of 20 jars *(jarre)*

Table 9 Journeys of Henry Bolingbroke to northern Europe and Palestine, 1390-3, showing purchases of earthenware

Place of purchase: Modern	Place of purchase: Medieval	Modern country	Date of purchase	Office of purchase	Entry	Price	Reference Page/line (Smith 1894)
First journey: accounts covering 6 May 1390–30 April 1391							
Outward voyage							
Calais	Calais	France	13–16 May	Buttery	a clay pot for putting wine in	2d	10/11
Boston	Boston	England	8 July	Scullery	John Tyler for one *herthe* by his making in the ship, 7s 8d, and for carriage of the tiles for the said *herthe*, 4d		23/24–6
Pudz	Putzig	Poland	9 August	Buttery	wine for clay pots	5 scot	39/11
Kaliningrad	Königsberg	Russia	5 Nov–7 Jan	Scullery	20 pots of earth	4d	60/31
Second journey: accounts covering 16 July 1392–16 July 1393							
Outward voyage							
Barton on Humber	Barton on Humber	England	19 July	Kitchen	for (?) threshold (*limen*) tiles for the kitchen	3s 7d	157/33
Niemce	Niemes	Poland	10 Oct	Buttery	2 clay pots	2 gr	189/21
	Schönkirken		3 Nov	Scullery	8 clay pots	8 gr	194/10–11
Vienna	Vienna	Austria	7 Nov	Scullery	firewood, coal, and clay pots	10 flor	196/7
Knittelfeld	Knittelfeld	Austria	14 Nov	Scullery	clay pots	6 gr 4d	198/16
Portogruaro	Portogruaro	Italy	26 Nov	Scullery	dishes, plates, saucers, and pots of earthenware	1 duc 15s	206/30
Portogruaro	Portogruaro	Italy	26 Nov	—	glasses and pots	41s	208/28–9
Venice	Venice	Italy	?mid Dec	Spicery	3 clay pots, 3 ladles, and salt	21s	219/6
Venice	Venice	Italy	?mid Dec	—	bowls, cups, and pots of earthenware for the ship	2 duc 40s	224/10
Rhodes	Rhodes	Greece	?early Jan	—	. . . and 8 pots	16 asps	225/14–15
Rhodes	Rhodes	Greece	?early Jan	—	carriage of 20 jars (*jarre*) of water to the galley	6 asps	225/16
Return voyage							
Rhodes	Rhodes	Greece	?mid Feb	—	12 clay pots	7 asps	228/14
Rhodes	Rhodes	Greece	mid Feb	—	carriage of 20 jars (*jarre*) of water to the sea, 9 asps, and shipping of the same to the galley, 6 asps		228/17–18
Rhodes	Rhodes	Greece	mid Feb	Spicery	. . . and for 1 pot of *sitronade*	3 duc	228/25
?Famagusta	Famagusta	Cyprus	?9 Feb	—	a great pot of oil	6 duc	229/18–19
Venice	Venice	Italy	10 April	—	clay pots	3 lir 3s	235/30

Note: The price of each purchase has been given in the currency as entered in the accounts. They have not been translated into the English equivalent as not enough is known about the relative values of these currencies during this period, and therefore any comparison between the costs of individual vessels bought could be very misleading (on the currencies used in the accounts, see Smith 1894, xcviii-cv)

each time, almost certainly for filling up the barrels of drinking water in preparation for the homeward voyage. The provisions acquired at Rhodes for this voyage included one pot of *sitronade,* a conserve of lemons. Large quantities of spices were bought not only as part of the initial stores for each journey, but also en route. Some of these were almost certainly stored in earthen pots. Provisions bought in England for the start of the outward journey in July 1392 included 7', pounds of green ginger *(ginger viridis)* in two pots *(ibid,* 154/ll), which may be the albarelli of Genoa mentioned above. Large quantities of honey were bought, its syrupy nature suggesting that it might have been stored in earthen containers. Other uses of pottery can be implied. The six clay pots *(olle lutae)* bought with six spits *(spets)* amongst other items for the scullery at Portogruaro *(ibid,* 205/23) were possibly earthen dripping pans, and the purchase at Venice of three clay pots, three ladles, and an unspecified quantity of salt for the spicery *(ibid,* 219/6), probably represents three earthenware salt containers with ladles for scooping out the contents.

It seems likely that not all the pottery bought reached England, particularly that used for ordinary domestic purposes on board ship or in the lodgings of the prince on land. Those more likely to survive are unusual pots bought containing items such as spices. Earthenware pots for the prince's household were bought in France, Poland, Russia, Austria, Czechoslovakia, Italy, Greece, and Cyprus in the campaigns during the period May 1390 to April 1391 and July 1392 to July 1393.

Henry was one of many Englishmen with large retinues touring the Continent during the medieval period. Many foreigners either visited or passed through England with equally large households which required supplies from the places at which they stopped. For example, between 1465 and 1467 the Bohemian Baron Leo von Rozmital went on a peace mission to raise support for his war-torn country. Starting from Prague in November 1465 with a retinue of 40, he visited Germany, Flanders, England, France, Spain, Portugal, and Italy (Letts 1957, maps facing 1, 81). Some of these large households are likely to have brought with them pottery from the Continent.

More general political ties can also influence the type and uses of pottery found in an area. French political connections with Scotland are historically well known, a link that is reflected in many fields such as literature and architecture. Many instances have occurred in Scotland of pots found with medieval burials (Robertson 1974, with references to earlier literature), a tradition found in medieval France (Delmaire 1969) but not in England. Until 1296 Berwick on Tweed, on the border between Scotland and England, was in Scottish hands, but in that year it was taken by the forces of Edward I and became part of England, in which country, with short intermittent breaks before 1482, it has since remained. Recent excavations by Dr John Hunter in Oil Mill Lane produced an extensive stratified sequence of pottery which divided in the late 13th century, the earlier material coming predominantly from south-east Scotland. The post-late 13th century material came mainly from various centres along the east coast of England, reflecting the use of Berwick by the English as a staging port for their various campaigns in Scotland and as a store base for provisioning numerous Scottish castles in English hands (Moorhouse in preparation b). More local political differences can cause anomalies in pottery distribution. An extreme case occurred in medieval Coventry, where tenurial division of the town into the Earl's Half and the Prior's Half, so called from the two principal landowners (Lancaster 1975, 3-9, map 3), resulted in the separate economic development of each part,[14] a social and commercial difference that is reflected in the medieval pottery (information from R G Thompson).

The uses of medieval pottery

Sources

It is difficult to assess the relative importance of pots to vessels in other materials either from documents or from archaeology. The types of documents most likely to contain information on the usage of earthenware vessels were kept by the wealthy and this small part of the population was likely to have used pottery least. Vessels in other materials are frequently referred to in accounts and inventories, whereas pottery is scarcely mentioned. In the case of accounts this is because pottery is frequently listed under a general heading which groups expenditure on small items, while in inventories and wills pottery vessels were not considered of sufficient value to be recorded. By contrast, in the archaeological record, pottery is by far the most common of the medieval artefacts. Pottery neither disintegrates organically, like wood[15] or leather, nor can it be recycled like glass and non-ferrous metals.

Despite the wide use of other materials, pottery did have an important and varied role to play as a material for medieval containers and objects. This importance is perhaps obscured by *two* principal factors: first, conservatism in the shapes of basic pottery forms, and second, the functional terminology used by modern students to describe the vessels. The most commonly found shapes are the 'cooking pot', the 'jug', and the 'bowl', thus giving the impression that the major uses of medieval pottery were for cooking in, holding liquids, and preparing food. With most of the types produced, however, a study of their forms alone will not reveal what they were used for.

Medieval documents can reveal a wealth of information on the uses of earthenware (Moorhouse 1978b). Most references to a pot's function come in one of two forms: either by describing what the pot was to be used for or by giving some descriptive term such as its shape. Many references to pots do not describe their use, but when these occur in accounts, a use can be deduced by their position in the document. Reeves presented annual accounts to the steward of the manor, listing expenditure under a series of headings. The purchases for the dairy, for example, frequently include a variety of earthenware vessels for butter and cheese making, with an occasional detailed description of their uses (Moorhouse 1978b, 8-9; Hellier & Moorhouse 1980, 10-11). The annual accounts submitted by obedientiary officials in monastic houses conveniently limit the uses of recorded pots to the range of duties for that obedientiary. For example, infirmarers bought earthen pots for use in monastic hospitals,[16] and gardeners occasionally purchased pots for unspecified purposes (Moorhouse 1978b, 9-10).

Pots as containers

One of the most common uses was as containers. There are references to the purchase of earthen pots as containers for a wide variety of commodities used in the kitchen and on the table, and a selection of these have been given elsewhere (Moorhouse 1978b, 7). The most likely vessel form used as an all-purpose container was the 'cooking-pot', a suggestion strengthened by the large numbers of vessels of cooking-pot form which have no sign of external sooting and had clearly not been used either on a fire or hearth. Pots were purchased for many uses around the house. These range from earthen bowls used for washing clothes, as those bought for the launderer at Merton College, Oxford, in 1297 demonstrate (Highfield 1964, 258), to earthen pots, presumably jugs, bought for heating the water of the stews or bath house, illustrated by one of many examples from Methley, West Yorkshire, where 25 earthen pots were purchased 'for *stywyng'* in 1416/17.[17] Earthen pots were used in different parts of the farm complex. The extensive use of pottery vessels in the diary for butter and cheese making has been mentioned above. While audited accounts provide evidence for the use of pots in the dairy, it is the reeve's draft accounts which contain the details of the range of vessels purchased and what they were used for. Bowls are by far the most frequent form mentioned, but earthen jugs are also occasionally specified. Such references are so frequent that earthen bowls should be a feature of medieval dairies when excavated. Treatises and occasionally accounts show that the potter supplied the medieval gardener and horticulturalist with earthen pots in which not only plants, flowers, and trees were grown, but also their fruits preserved (Moorhouse 1978b, 9-10). The importance of medieval gardening is reflected in the manufacture of two distinct types of pottery watering vessels. These have been found archaeologically, are referred to in the documents, and appear in medieval illustrations (Moorhouse 1978b, 9). The potter provided many branches of the building profession with essential materials. Dr Dunning has drawn attention to the different types of roof fittings and roof ornaments (see his bibliography in Evison *et al* 1974, 17-32, esp 17, 'Medieval roof-fittings'; Dunning 1974a; 1977). That these were in demand is supported by documentary evidence; an example is given on p 107 of the purchase of two mounted knights for the ridge of the hall at Banstead, Surrey, in 1372/3. The medieval potter also supplied building craftsmen with a wide range of less obvious materials. One example is acoustic pots, frequently used in churches because it was thought that they aided resonance during singing (Harrison 1967-8, which contains many references to earlier literature; Biddle 1962-3; Minns 1872). A wide range of other craftsmen used the potter's products. Some of their uses were specialized and required purpose-made shapes, such as the earthen pots required for various chemical and industrial processes (Moorhouse 1972).

Medieval recipes of all types show that large quantities of earthenware pots must have been used in the preparation of materials, ranging from the glue used by bookbinders to medical prescriptions. Recipes, as an important source for pottery usage, are discussed in more detail below.

The use of pots as storage containers has already been mentioned, but it might be useful to examine some evidence for one particular commodity to show the range of information that documentary evidence can offer. Oil was an extremely important item during the Middle Ages. It had a variety of uses, ranging from a basic ingredient for many paints to the major source of fuel for artificial light. The Middle English translation of Palladius' treatise on husbandry, which probably dates to the late 14th century (Rodgers 1975; Howlett 1977), advises that oil should be kept in earthenware containers (Lodge 1872, 219). Similar advice is given in John Trevisa's Middle English translation of Bartholomew the Englishman's 13th century Latin encyclopaedia *De proprietatibus rerum,* which was completed on 6 February 1398. When discussing oils, he writes 'Oil pierces *(thurleth)* and spreads itself and is better kept in a glasen vessel than in a wooden vessel or in a vessel that is porous' (Seymour 1975, 1006, lines 5-7). Oil was used in great quantities in churches to fuel lamps kept burning before the altar. The purchase of oil is therefore frequently recorded in monastic accounts and in particular church wardens' accounts. They record not only the quantities of oil purchased, but frequently the vessel bought at the same time either to contain the oil or to transport it. Frequently the container is described as a 'pot', but that many of these were probably of pottery is suggested by their price, as at St Andrew's, Canterbury, in 1493, where the churchwarden's accounts record an entry 'Item for a quart pot for the oil for the lamp, ½d' (Cotton 1917, 218). Earthenware vessels are frequently mentioned, as in the churchwarden's accounts for St Ewen's, Bristol, in 1454/5, when 1d was spent on an earthen pot 'to put lamp oil in' (Maclean 1890, 156). The frequent use of oil for fuelling lamps kept burning before the altar meant that large stocks could have been kept in reserve for use in the monastic and ecclesiastical church. The accounts of the Dean and Chapter at Wells in 1457/8 recorded the use of 28 jars of oil, but nothing was paid for them as they had been drawn from the church store (Baildon 1914, 86). Occasionally, the particular type of oil is specified, as in the 1450/l accounts for St Radegund's Priory, Cambridge, where a gallon and a half of rape oil *(oleum de Raap)* was bought at King's Lynn, 'with one earthen pot for putting this oil in' (Gray 1898, 166). The importation into this country of German stonewares during the Middle Ages provided a more impermeable container for oil. A number of late-medieval accounts specifically mention the purchase of 'stone pots' for oil. The cellarer's account for Bromholm Priory, Norfolk, for 1415/16 records under the expenses of the kitchen the purchase of two stone pots bought from Martin Spycer of Yarmouth to contain half a gallon and one pint of oil which had also been bought from him (Redstone 1944, 85); the purchase of two pots for two different quantities suggest that the oil was of different types. Similarly the churchwarden's accounts for St Mary at Hill in London in 1478/81 record lid spent on a stone pot 'to put oil in' (Littlehales 1905, 101). Accounts show that oil was purchased at markets and fairs many miles from where it was to be used; St Radegund's Priory, Cambridge, is about 45 miles from King's Lynn. It is likely that much of the oil would be carried by horse pannier. Indeed in 1356 four earthen pots and two *calathi,* possibly a pair of wicker-work containers," were bought at a cost of 15d for the painters at Windsor Castle 'for putting the oil in to carry it from London to Windsor' (Salzman 1967, 158).

The kind of detail revealed by the documents for the use of pottery vessels is perhaps demonstrated by references to the use of the earthenware dripping pan. These are usually long, narrow containers with shallow sides, a pouring lip or lips in one or both narrow ends, and a handle or handles of various form midway or along one of the long sides. They have frequently been referred to as fish-dishes, which some may have been, but when found on domestic occupation sites many are fire blackened under the base and in particular along the long side opposite the handle. These pans were used to catch the dripping from meat on a spit and they were placed under the spit adjacent to the fire. The traditional method of using a spit, where the meat is kept constantly rotating against, and not over the fire, with a dripping pan beneath the meat to catch the juice, is well demonstrated in a number of medieval manuscripts and paintings, notably in an illustration accompanying a mid 15th century French version of the Decameron (Pognon 1978,72), and in Peter Bruegel the Elder's Netherlandish Proverbs, painted in 1559 (Grossmann 1966, pl 13). In both these, the dripping pan is almost certainly made from metal, but in other illustrations, such as a 14th century manuscript (Bennett 1948, pl facing 234), they appear to be of earthenware. Documentary evidence suggests that dripping pans were usually made from metal, but this is almost certainly because documentation records primarily details of the upper classes. That earthenware ones were as common, if not more so, is shown by the large numbers now being identified from excavations. Pottery dripping pans are referred to in the documents, particularly household accounts. Some entries are specific, such as the four earthen pans 'for receiving the dripping of the flesh' bought by the steward of Lady Alice de Bryene for the kitchen in 1419 (Dale & Redstone 1931, 123). In others, earthen dripping pans can be implied, as in the accounts of Henry Bolingbroke at Venice on 25 November 1392 when six earthen pots *(olle lutae)* and six spits *(spets)* were bought for the scullery (Smith 1894, 205/23). Medieval cookery recipes occasionally mention pots of an unspecified material being placed under the spit to catch the liquid from which sauce was made (Austin 1888,97; Morris 1856,37). A recipe for lamprey sauce, written down during the mid 15th century, is more explicit and describes how the blood from a freshly killed lamprey should be collected in an earthen pot which should then be placed under the spitted lamprey to catch the juice while the meat was roasting (Austin 1888, 99). The recipes frequently describe the liquid juice as being poured into another vessel to prepare the sauce, so analysis of the residues from such pans is unlikely to reveal the particular sauce for which the dripping pan formed part of the preparation.

References to pottery in recipes

Recipes are an example of a class of vernacular medieval documents which contain a considerable amount of information for the uses of medieval pottery. Recipes of three basic types were produced and recorded during the Middle Ages for medical cures, craftsmens' materials, and cookery. The sources for Middle English medical recipes have recently been brought together and discussed by Professor Robbins (Robbins 1970a); those for craftsmen's materials have been similarly treated by Daniel Thompson (Thompson 1935), while William Mead has discussed medieval cookery recipes (Mead 1931, 49-128). None of these contributions has mentioned the wealth of information in the recipes for the implements and vessels used in the prescriptions, particularly the wide use of earthenware vessels. The recipes describe not only the ingredients and the sequence in which they were prepared, but also the types of vessels used and the materials from which they were made. Many variations occur of the same basic recipe and these describe in detail different parts of the process, providing collectively a wealth of accurate information on one particular procedure. Two of the many descriptions for making white lead are given in Appendix lc, d. In some instances it is clear that earthenware vessels in preference to vessels in other materials were used for a particular purpose, as in the case of the preparation requiring intense heat where vessels in another material might have disintegrated.

Medical and craftsmen's recipes are particularly detailed in describing the vessels, their materials, and how they were used. Earthenware pots were used extensively. New earthen pots are frequently mentioned, suggesting a rapid turnover of vessels which were discarded once they had been used, possibly preserving evidence of their contents. Internally-glazed pots are occasionally specified. A number of distinct forms are described, including pots with pierced bases, some forms of which have not yet been recognized amongst pottery collections. Methods of sealing pots are frequently described, not only with covers of different materials, but also by luting the joint tightly with different agents (Moorhouse 1978b, 14-15). Many of the recipes involving a long distillation or fermentation process describe how earthen pots should be buried in the ground, often one on top of another within pits of given dimensions, and left there for anything up to a year.[19] A typical example is given in Appendix lb and four units drawn from descriptions in recipes are illustrated in Fig 90. The detail given in the recipes can frequently help identify vessels which were used in their preparation. For example, one of the many variant recipes for making white lead, given in Appendix lc, describes the boring of holes in an earthen vessel in almost exactly the same position as those in a large pottery vessel found in a substantial industrial group of pottery and glassware from St Leonard's Priory, Stamford.[20]

Because they were important to the development of modern medical research, a number of the major medieval medical recipe collections have been published (most are listed in Robins 1970a, but see also Robbins 1970b). Unfortunately the same interest has not been shown in the much wider variety of craftsmen's recipes (Thompson 1935), very few of which have appeared in print (Brickley 1928,417-32, with modern texts in Clemens 1933; Wright 1844a; 1844b; Halliwell 1855, 72-91). The published extracts of a typical collection preserved in the archives of the Rawdon Hastings family (Bickley 1928, 417-32; Clemens 1933) give some indication of the detail they contain and the range of subjects covered. Detailed work on recipes for craftsmen's materials is not only widening our knowledge on the very many industrial uses of medieval pottery, but is revealing how the many different craftsmen practised their work.

Medieval cookery recipes are less common than those used for medical or craft purposes. A number of the major compilations of recipes have been published.[21] However, the surviving recipes are those prepared for major households and were not the fare of the common people. The vessels and materials described in the recipes are therefore associated with the kitchens of the wealthy, and earthenware is only occasionally mentioned, when it has a particular part to play in the preparation. As with the other two classes of recipe, a large number of versions are known for the most popular dishes. Occasionally long detailed recipes not only specifically comment on the uses of pottery vessels but describe how they should be treated. Two such recipes for different dishes arc given in Appendix 1f, g.

Visual evidence

Turning from the documentary evidence for the uses of pottery, the information from the vessels themselves has not been fully explored. Although a large percentage of the medieval potter's products were vessels of cooking pot, jug, and bowl form, he made a wide range of others. Apart from roof furniture and specialized industrial vessels, the work for the glossary for medieval pottery forms for the Medieval Pottery Research Group has identified 34 distinct types whose use can be identified, while another 20 cannot. The wide range of the potter's occasional products was first pointed out by John Musty, following his work on kiln products (Musty 1974, 59-61). Since then the range has been extended, and it is likely that many more specialized forms await either recognition or discovery. Amongst the more utilitarian, such as the 'cooking pot', surface treatment can betray a pot's use. Many of the materials or foodstuffs stored in earthenware pots would leave some residue on the surface.[22] 'Certain uses would leave wear marks, particularly when a lid was used. Surface blackening on a particular part of the vessel's surface could be helpful. A vessel with external sooting on the base or walls was probably used for heating its contents, but a pot heated externally on the rim only could have served as the lower part of a fermentation unit as illustrated in Fig 90. Earthenware pots heated on a trivet or brandreth could also leave distinctive sooting marks under the base.[23] As the recipes indicate that many of the earthen pots were used once and then discarded, it is likely that sooting marks survive. Internally sooted vessels are unlikely to have been used for heating, but are more likely to have been used as containers. Documentary evidence suggests a number of alternatives, ranging from a fire pot, used to contain the embers of a fire overnight in place of a curfew, to a receptacle for a variety of medicinal cures which involved placing herbs in a pot with glowing embers, which was placed under a siege, or stool with a hole in it, on which sat the ailing person (Moorhouse 1978b, 13). All these features, and more, can help identify a pot's use. It is hoped that work on wear marks on medieval ceramics will prove as rewarding as that recently carried out on Canadian pottery of the 17th to 19th centuries (Griffiths 1978).

Decoration is commonly found on some medieval ceramic forms, particularly jugs, but a wide range of symbols and marks found on medieval pottery has more significance than aesthetic value. Many were created before the pot was fired. A few are applied, like the arrow on the side of a jug found outside the meat kitchen at Kirkstall Abbey, West Yorkshire (Le Patourel 1961, 39, fig 13, no 1), the arrow facing the user if the jug is held in the right hand. Single-letter stamps have also been found. Two almost identical stamps, but from different moulds, with either the letter B, or more probably letter R, occur on jugs found at Oxford (Hassall 1969, 12, fig 2, no 2, 13) and Nottingham (Rackham 1972, 25, pl 63); both letters are reversed and that on the Oxford jug is on its side. The majority of the pre-fired designs are incised.[24] The meaning of many has yet to be identified, bur at least one, found on a vessel from Keighton, Nottinghamshire (Coppack 1968, 53, fig 2, no 6, 54) is possibly either a potter's signature or batch mark. Other markings were almost certainly magical in significance, such as the wide range of symbols incised before firing into pottery chemical vessels from Sandal Castle, West Yorkshire (Moorhouse in preparation a). Most alchemists devised their own set of symbols as a charm for the success of the process and as a ward against evil spirits (Burland (1967; De Rola 1973), and Georgius Agricola illustrates such a symbol incised into the base of an earthenware crucible (Hoover & Hoover 1950, 453). An exorcism for water, a spell against poison, or general sorcery has been suggested for stamped and incised inscriptions found on a small group of jugs from the Midlands (Dunning 1967; 1974b). Numbers, letters, and other symbols were also incised into the body of pots after firing, probably by their users or owners. They are typified by a six-pointed star below the handle of a jug in the Museum of Archaeology, Cambridge (Rackham 1972, pl 27). Accounts show that pottery was bought to contain a wide variety of foodstuffs and other items (Moorhouse 1978b, 6-7), the obedientiaries of monastic houses and the officers of lay households occasionally accounted for earthenware pots for use within the sphere of their duties (see p 114), and pottery was bought for use in specific rooms of a building or farm complex.[25] Direct evidence for identifying a pot with a particular use comes from a letter written by John Paston II in 1479, referred to above (p 110), which identified one of three pots of treacle bought in London by the letters MP scratched on the base, the letters being the initials of the recipient of the pot of treacle, Margaret Paston. It therefore seems possible that some of the marks incised after the pot was fired were recognition marks to identify the contents of a pot or part of the building in which the vessel was used.

In keeping with many illustrations, a great deal of the zoomorphic and anthropomorphic decoration found on medieval jugs was based on imagery, and this may have been the influence behind many of the designs found on pottery, ranging from the simple incised motifs mentioned above to the larger and more complex scenes of the type found on the Rye kiln products (Vidler 1933, 54, pl 7, 56, pl 8; Barton 1979, 199-200,220-3,233-6, figs 70-3,249, fig 87, no 3). Much of this imagery was familiar to contemporaries, but most of it has fallen into obscurity and may only be explained by documentary work. These points are particularly well demonstrated by the relating of scenes on jugs found in London to the activities associated with contemporary brothels (Dunning 1971, esp 14-17, pl II; Thorn 1978, 130, fig 50, no 1, 131-2). Although we may no longer understand some of the symbolism, what is certain is that some of it may have been associated with the use of the vessel on which it is found. The potter may have been following instructions from his customer when the symbols were created before firing, as in the case of magical marks found in industrial pottery, while the users of the pots were probably responsible for those incised after firing. It is likely that further work on these many and varied insignia and designs created both before and after firing would add to our knowledge of the uses of medieval pottery.

It is evident that both the limited range of common forms produced by the medieval potter and the functional terminology applied to the forms by modern students have created an unbalanced view of the extremely wide range of uses for medieval earthenware. Further work on documentary sources and continued work on more detailed visual, chemical, and mechanical analysis of the pottery will undoubtedly extend our knowledge of the many uses of medieval pottery.

Appendix 1

Medical recipes

a For dropsy, palsy, dysentery, and pleurisy

Take a handful of sage or a greater quantity and half as much of brown fennell and just as much cumin as you can hold between your two fingers and thumb, and boil them in a pot of brass and clean it in water as long as you boil a capon or hen. When it is hot, cast the water of herbs into an earthenware pot and seal the mouth with many cloths so that no air escapes. Bind the neck of the pot tight around the cloths so that the heat is retained. Then lie down in your bed and let the pot be placed in your bedstraw at your feet, so that your can set your feet on the hot pot or at the sides of the pot. Lay a cloth between the pot and your feet, and hold your feet against the pot as hot as you can bear it until it gets cold. Repeat the process every night for a week, for this is good for a fever of the stomach.
Source: Schoffler 1919, 226, lines 7-22.

b To make oil of Juniper

Take a new earthen pot and bury it in the ground up to its mouth. Take another earthen pot whose mouth will fit into the mouth of the pot in the earth. Take a pipe of iron and pierce the base of the upper pot so that the pipe protrudes into the vessel in the earth. Take dry sticks of Juniper, cut them into small pieces and put them into the upper pot. Seal and lute the mouths of both pots with clay mixed with horse dung, and make a fire around the upper pot. The oil produced should then distill through the iron pipe into the lower pot. Keep it until required, for it is good for aches, for all manner of gout, and the palsy.
Source: Power 1910, 96, lines 3-15, no 37. For a hypothetical reconstruction of the unit described in this recipe see Fig 90B.

Craftsmen's recipes

c How to make white lead

Take a vessel of earth or of wood *(treo)* of about a gallon size. Bore holes across the four sides, that is the first four holes about 5 inches above the bottom *(grount)* of the vessel. Bore another four holes about 3 inches above these at another level, and so on until

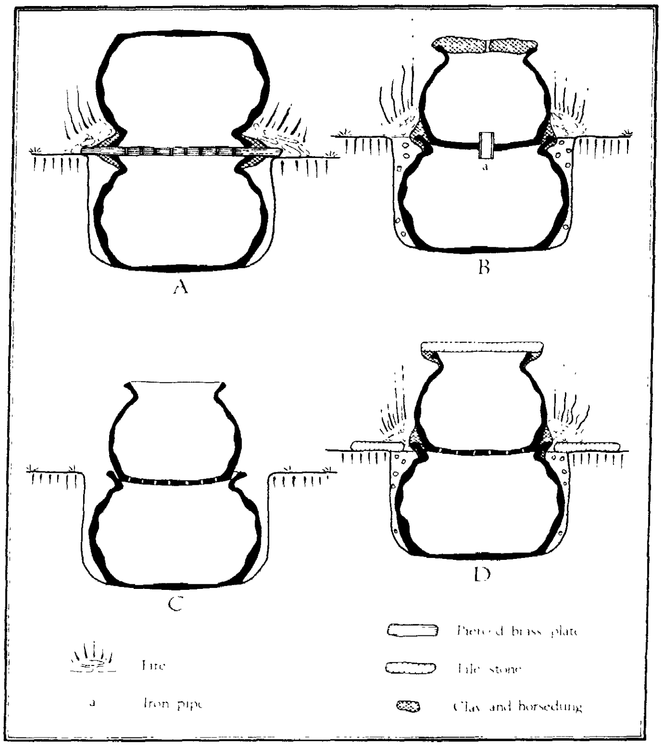


Fig PO Reconstructions from descriptions in Middle English medieval recipes, written down in the 14th and 15th centuries, of buried earthenware pots used in various distillation and fermentation processes. The sources for the individual recipes are: A, Fleischhakker 1894, 195, lines 6-16; B, Power 1910, 96, lines 3-15, no 37 (see Appendix lb); C, Ogden 1971, 425, lines 13-26; D, Ogden 1938,64, lines 16-26

your reach the top of the vessel. And then take lead and melt it and if it is not fine and clean enough throw it into clean water, and unless it is fine and clean then melt it afterwards and throw it into water and so purify it until it is fine and clean enough. Melt it again and cast it into an empty basin, or whatever vessel you like of brass, so that it flows out thin. If it is not thin enough take a hammer and beat it as thin as you can. Take sticks and put them across in the four holes at every level. Upon every stick hang the (plates of) thin lead, as many as you can from level to level, but they must not touch each other. Take vinegar and pour it into the vessel so that the lowest lead plate does not touch the vinegar. Then take a stone or a board that will cover the vessel, and close it well. Take fine clay and lute the vessel all over so that the holes and lid ar sealed, allowing no air to come out. Take your vessel and set it deep in horse dung for nine nights or more. Then take up the vessel and take off the lid. If you find any lead undissolved upon the sticks then you have put in too little vinegar, but if your lead is dissolved and you find vinegar in the base (of the vessel), then all is well. Gently pour the vinegar out. Take up the white lead and do with it as you want. If you find any lead undissolved, keep it for another time until you want to make more.
Source: Wright 1844a, 65-6, early 14th century from British Library Harleian MS 2253, fo 52v.

d How to make white lead

Take a large earthen pot or a barrel, and put into it a portion of dregs of good strong red wine. Hang in the pot clean broad plates of new lead so that they do not touch each other and hang an inch above the wine. Enclose it in hot horse dung so that no air can get in or out. Let it stand for six weeks or longer, for the longer it stands the better it is. When you want to open your vessel and take out all your plates of lead, take a hammer and strike off all the white lead which has collected above on to a clean (piece of) white leather or a clean vessel. Then you will have a good white lead. But if you want to make this white lead into pieces as some (people) are accustomed to sell, take the white powder of lead that you have obtained from the plates and put it into a new earthern pot. Pour clean water into the pot so that the lead will be washed in the water, stirring it well. Then cover your pot well and let it stand undisturbed until the water is soaked up, reaching a consistency of thick gruel *(pappe)*. Then gather it out of the pot with a spoon and spread it out on sheets of paper *(papere leves)* or on a clean table. Then set it in a bright clear sun and let it dry out, after which break it up into square lumps.
Source: Wright 1844b, 154, early 15th century from British Library Sloane MS 73, fo 213r.

e How to make vermilion

Take a pound of quick silver and five pounds of quick brimstone and put them into a pot of earth. See that your pot has a wide mouth so that you can see right to the bottom. See that you have a wooden lid *(lid of tree)* upon the pot's mouth well closed. Set the pot on a few coals, keeping your eye on the pot, stirring it occasionally. When you see a flash come out of the pot, strike (smut) down the lid at once, holding down the flash two or three times until you see that the material in the pot has become thoroughly black, for then is your quick silver slain *(sleyn)*. Take the pot off the fire and grind it (the contents) well on a stone. Make a good coal fire. See that you have a good thick jordan of glass. Take good clay and horse dung and make a good lute from it and daub it all about the jordan about half an inch thick. Put all the material in the jordan and hang it over the fire by the neck so that the jordan is almost a hand's breadth from the coals. Take another glass whose mouth is almost the same size as the jordan's. Place the mouths of both the little glass and the jordan together so that the little glass is inverted. Then you will see the flash of light from the matter flash into the upper glass. Make a slow burning fire first and afterwards a good fire, always blowing the fire. Stir the jordan sometimes with a rod *(zerde)* of iron at the bottom of the jordan so that the heat rises out of the matter. Then you will see the flash rise into the upper glass in many different colours. When you see the flash arise right blood red, then is the vermilion made. Then break your jordan to see what is in it. I warn you that the jordan should be on the fire no longer after the light begins to turn red for then all is lost. Another thing that I warn you of, the day that you make vermilion, do not abstain from food *(fastynge) for thou schalt fynde a wickid breeth of smel,** and therefore eat a morsel and drink. Also another thing, make a fire slow burning the first time.
* The meaning of this passage is not clear.
Source: Wright 1844b, 152-3, early 15th century from British Library Sloane MS 73, fo 138v.

Cookery recipes

f Prepared *(appraylere)* pork, meat loaf

Take the flesh of lean pork and boil it well, and when it is well boiled cut it into small pieces. Then take saffron, ginger, cinnamon, salt, galingale, old cheese, and bread crumbs and beat them in a mortar. Put the pork into the spicery, making sure that it is well ground and bring to the correct consistency with raw eggs. Take a long pitcher *(longe Pecher)* and see that it is cracked *(ransched)* all over. Then pour out the grease and fill the pitcher with forcemeat *(farsure)*. Take a piece of clean canvas and double it so that it covers the mouth of the pitcher and bind it fast about the rim *(berde)*. Put this to boil with the great flesh in a lead or cauldron so that it is well boiled. Then take the pitcher and break it, but save the force-meat. Have a clean spit *(broche)* and pierce it through the spicery and lay it on the fire. Then have a good batter of spices, saffron, galingale, cinnamon, and plenty of them, and flour. Grind these small in a mortar and bring to the correct consistency the mixture with raw eggs, adding sugar of Alexandria. As the meat dries baste it with batter and serve it up.
Source: Austin 1888, 39, early 15th century from British Library Harleian MS 279, fo 31.

g Stewed capons

Take parsley, hissop, sage, rosemary, and thyme. Break them between your hands and stuff your capons with them, colouring them with saffron. Put the capons in an earthen pot or a brass pot, but an earthen one is better. Lay splints underneath the capons and all around the sides of the pot so that the capons touch neither the sides or bottom. Cast the herbs into the pot amongst the capons, together with a quart or pint of the best wine you can get. Place a lid upon the pot that will fit within the brim. Make a batter of white of eggs and flour and put between the brim and the lid a piece of paper leaf or a linen cloth so that when the batter is applied and dried no air can get out. See that the batter is thick. Set your pot upon the side of a charcoal fire and see that the lid does not rise with the heat. Let it stew for a long time and when you think it is cooked take it from the fire. If it is in an earthen pot set it upon a whisp of straw so that it does not touch the cold ground. When the pot has cooled take off the lid and take out the capons with a stick and lay them on another vessel. Make a syrup of wine, mince, dates, and cinnamon brawn with the same wine. Add currants, saffron, and salt. Boil it a little and cast in ginger powder with a little of the same wine. Add the same to the above syrup and pour upon the capons and serve them up with a rib of beef for every capon on a dish.
Source: Hodgett 1972, 14-15, 15th century from Magdalene College, Cambridge, Samuel Pepys's Library, Pepys MS 1047, fos 14-15. For a variation of this recipe, of similar date, see Austin 1888, 72-3.

Private correspondence

h Part of a letter from John Paston II to Margaret Paston, written about May-June 1479, concerning the purchase of three pots of treacle in London.

'Please it you to know that I send you by Barker, the bearer thereof, 3 pots of Genoa treacle, as my apothecary sweareth to me, and moreover that they were never opened since they came from Genoa. Whereof you shall take (of the 3 pots) as many as pleaseth you. Nevertheless, my brother John sent me for 2; therefore I must beseech you that he may have at least one. There is one pot that is marked under the bottom twice with these letters 'Ml?' for Margaret Paston, in which pot I have best trust and next to it the covered *(wryghe)* pot. And I mistrust most the pot that has a (?) piece broken out *(kotte)* above in the top, lest it has been opened. And also the other two pots be stamped *(prented)* twice on the covering with a merchant's mark. The other pot is but once marked with one stamp *(prent)*. Nevertheless I had similar oath and promise for one as for all . . .'
Source: Davis 1971, 512-13, no 313.

Acknowledgements

I would like to thank a number of people who have helped in the preparation of this paper. John Cherry provided information on a number of sites, particularly where the material was held by the British Museum. John Musty has discussed with me the interpretation of the excavated structures at Laverstock. Much of the information on recent work on residues was supplied by Leo Biek. Evelyn Baker, Penny Spencer, and Sarah Bagshawe provided information on the material from the Chicksands Priory site. Dr C J Young provided information on Roman pottery-making sites. The material from Conisbrough Castle was kindly shown to me by Dr M W Thompson during his work there. David Michelmore has helped with the Latin translation of some of the passages quoted, while Miss E G Williams of the School of English, Leeds University, has checked the texts used in Appendix 1, as well as freely giving advice on their translation. A number of people have provided information and plans from their excavations and allowed use of them here in advance of their own publications: Nigel Kerr (Bourne, Lincolnshire), Keith Scott (Harefield Lane, Nuneaton, Warwickshire), Phil Mayes and Dennis Mynard (Olney Hyde, Buckinghamshire), and Kevin Brown (Yardley Hastings, Northamptonshire). Keith Wade supplied plans and notes for his excavations at Grimston, Norfolk; the plan is not reproduced here. Information for the excavations on the kiln sites at Saxton (Yorkshire) and Limpsfield (Surrey) was not available. I am also grateful to Dennis Turner for supplying information about the medieval road system in the Banstead region, on which Fig 89 is based. Finally, I would like to thank John Hurst for reading this paper in first draft and making a number of valuable comments.

Notes

1 Horkesley lay in the royal forest of Kingswood, which sustained a major pottery-making industry during the Middle Ages; information from Paul Drury and see Le Patourel 1968, 113.
2 I am grateful to Miss Sarah Bagshawe for providing details of the material in Letchworth Museum.
3 References to the individual pots are: for Site D, Bryant & Steane 1971, figs 3, 5, 7, pp 20 (x2), 22, 28; for Site G, Steane & Bryant 1975, fig 5, pp 14, 15 (x2), 16.
4 Newstead 1934; material in the British Museum. I am grateful to John Cherry for drawing my attention to these finds and for providing a slide of the worked bone pieces (not published).

5 I am grateful to John Cherry for the original references to these finds, and for providing a slide of the stamps, which are housed in the British Museum. The stamps were found in 1847–8 close to a pottery kiln in the parish of St Mary le Wigford, in Lincoln.

6 These include: Nuneaton, Warwickshire (Moorhouse 1972, 108, fig 31, nos 7–8); Brill, Buckinghamshire (*ibid*, 112, fig 32, no 3); Toynton, Lincolnshire (*ibid*, no 5); Bentley, Hampshire (*ibid*, no 7); Biddenden, Kent (*ibid*, no 9); Lyveden, Northamptonshire (*ibid*, no 11); Cheam, Surrey (Marshall 1924, 85, fig 5); Ashtead, Surrey (Frere 1941, 63, fig 5, no 16); Laverstock, Wiltshire (Musty *et al* 1969, 131, fig 21, no 171); Laycock, Wiltshire (McCarthy 1974, 111, fig 8, no 29); Kingston-upon-Thames, Surrey (information from Mr S Nelson); and, the largest known group from a kiln site, Lower Parrock, East Sussex (Freke 1979, 96, fig 10, nos 29, 30; 106, fig 17, no 116; and unpublished material in Barbican Museum, Lewes).

7 The following will give some idea of who used pots of a gallon size and what they were used for: the surgeon John Ardenne wrote in the mid 14th century that a remedy for the loss of use of both arms and legs should be stored in 'a gallon (*galoune*) pot of earth' (Power 1913, 111); an early 14th century recipe for making white lead describes that it should be made 'in a vessel of earth or of wood of about a gallon size' (Wright 1844a, 65–6; see Appendix 1c); in 1416/17 the Abbot of Jarrow had in his custody seven 'gallon (vessels) of earth' (Raine 1854, 91); a mid 15th century cookery recipe prescribes the use of 'a pot of oil of a gallon' (Morris 1865, 26); and there are a number of references in Middle English translations of the Bible, for example in Isaiah 30, 14, where a simile of 'a gallon of the crocker' is used (Forshall & Madden 1850, 3, 277).

8 Tiles were also used for hearths on board ship. The accounts of Henry of Bolingbroke show that they were bought for constructing ovens at the commencement of each journey: at Barton-on-Humber, Lincolnshire, in 1390 the office of the scullary accounted for 7s 8d paid to John Tyler for making one *herthe* in the ship, and 4d was paid for the carriage of the tiles for making the hearth (Smith 1894, 23/23–6). In 1392 an unspecified number of (?)threshold (*limen*) tiles were bought at Barton-on-Humber for the galley kitchen (*ibid*, 157/33).

9 The references suggest that the pots were made in Genoa or its hinterland, but recent work in northern Italy has shown that the local pottery in the Genoa region was coarse. On the other hand, recent work has also shown strong links between Genoese merchants and Spain during the Middle Ages, with evidence for much Spanish pottery reaching northern Italy (Blake 1972, 84–7, citing earlier literature; Mannoni 1972; Hurst 1977a, 72), demonstrating that much of the Spanish pottery found in this country reached England via Genoa. References in medieval English sources to pots from Genoa as containers cannot, therefore, be taken literally, but support the evidence for the indirect route via northern Italy of medieval Spanish tin-glazed lustrewares found in this country. The large number of 15th century English references of the type mentioned above reflect the increase in trade from the Andalusian and Valencian factories through northern Italy (Hurst 1977a, 72). The most likely Spanish form to be used as a sealed container is the albarello, and it is not surprising that albarelli are one of the most common forms of medieval Spanish pottery found in this country (Hurst 1977a, 76, table II). I am most grateful to John Hurst for initially pointing out that the 'pots from Genoa' were probably Spanish in origin.

10 Many aspects of the layout and use of medieval roads in England and Wales are discussed in Hindle 1973; 1976; Martin 1976; Hindle 1978.

11 Certainly two, and possibly all six and a half townships were sub-infeudated during the period 1193–1211, after which date there would have been no need to maintain a major demesne administrative centre at Almondbury, and any contact with more distant property of the Lacy family would have been broken. The pitcher therefore probably reached Almondbury before 1193–1211. The tenurial evidence is discussed in detail in Faull & Moorhouse 1980, 255, 302.

12 The following itineraries have been compiled for the early Plantagenet kings: Henry II (Eyton 1878); Richard I (Landon 1935); King John (Hardy 1829); Henry III (Craib 1923); Edward I (Safford 1974; 1976; 1977; superseding Hartshorne 1871, & Gough 1900 — for Edward's itinerary in France 1286–9 see Trabut-Cussac 1952); Edward II (Hartshorne 1862).

13 The movement of medieval pottery around the North Sea is discussed in Dunning 1968. The large quantity and wide variety of stonewares imported into medieval Britain from numerous centres in the Rhineland is reflected in the Langerwehe products (Hurst 1977b). The work of K J Barton in France has resulted in a series of important articles on regional types (Barton 1977, with references to earlier works in *ibid*, 47, note 1), many of which are found in this country. A wide range of types came from the Mediterranean, for example from Spain (Hurst 1977a) and the eastern Mediterranean (Hurst 1968).

14 References to recent discussions of the early history of medieval Coventry, providing an alternative to the traditional views on the development of the Earl's Half and the Prior's Half, are given in Phythian-Adams 1979, 118, note 1.

15 Wooden vessels were used extensively during the Middle Ages. Different types of accounts frequently record the purchase of large quantities of treen vessels for domestic, farming, and horticultural use. A wide range of terms specifically describing wooden, basketry, and wickerwork containers is also frequently used in accounts. Large numbers of turners and other more specialized makers of wooden objects and containers are recorded through their surnames (see Birrell 1969). The importance of treen vessels and basketry is perhaps underestimated by the failure of wood to survive in all but waterlogged deposits in this country.

16 One aspect of the importance of Infirmarer's Rolls, the history of medicines, is discussed in some detail in Hammond 1965, from the Westminster Infirmarer's Accounts, where sources for other extensive runs of Infirmarer's Rolls are given.

17 Le Patourel 1976, 170, from Leeds City Archives / MX / manorial documents / Methley / accounts / 9, m4. References to earthen pots bought especially for the bath house are not uncommon. Salzman brought together a number of 14th century references to pots purchased for the bath suites of English royal residences (Salzman 1967,276; the price of the Windsor pots at 3d each is incorrectly given as 8d (Hope 1913, 196, 209, note 45)). Earthen pots were purchased for cooking herbs for a medicinal bath for Prince Henry (1271-4), second son of Edward I (Salzman 1926, 18), and the household accounts of Eleanor of Castile, queen of Edward I, for 1 August 1289, record 13d spent on earthen pots and mending the coffins of the queen's bath chamber, itemized under the heading of the 'bath of the queen's chamber' *(aquarius camere Regine)* (Parsons 1977, 79/12-14). Earthen pots for warming bath water continued to be used into the 16th century. John Musty has discussed such pots bought for Hampton Court and Hanworth in the 1530s (Musty 1977), and the Scottish High Treasurer's accounts for 1503 record the purchase of 'pots of clay *(lamme)*' for the furnaces at Stirling Castle (Balfour 1904, 393). The Methley accounts show that the houses of lesser lords possessed bath suites during the Middle Ages. These references to pots for the stewes, ie the bathroom, should not be confused with other references to stewes, meaning brothels, a meaning which developed from the association of bathing with brothels.

18 John Trevisa, in translating Bartholomew the Englishman's *De proprietatibus rerum,* defines *calathus* as 'a basket made of splints to bear figs therein' in the section of the encyclopaedia dealing with weights and measures (Seymour 1975, 1375).

19 Some recipes specify that it is the distillate that is required, while others state that it is the residue that should be used. The required substance would determine the archaeological evidence for the process, for the former meant that the lower pot had to be taken out of the ground while in the latter the upper pot could be removed, leaving the lower pot abandoned in the earth.

20 I am grateful to Miss C M Mahany for allowing me to examine this important group; see Moorhouse 1972, 114, n 86.

21 Austin 1888, with modern translations in Webb 1937 and Mitchell 1958, and a discussion of the vocabulary in Sergeantson 1938; Napier 1882; Morris 1865; Pegge 1790; Warner 1791. For a discussion of the sources for English medieval cookery recipes see Dickenmann 1904.

22 Work on residues found in earthenware pots has been sadly neglected in the past. Until recently, early work (eg Dunning 1942) has not been followed up. A number of different approaches are now being tried. Some work has been carried out on residues left in charred remains (eg Holden 1963, 166-7; Green 1977, 92), and this offers great potential. Similarly David Whitehouse has reLently shown that some 5th century Egyptian amphorae carried beer and not wine as previously thought American work is examining the different forms of amino acid left in both residues and the body of vessels. Leo Biek and John Evans are shortly to publish a paper on over-cooked residues in containers (Evans & Biek forthcoming). Dr F Celoria has discussed some recent work on various aspects of food history (Celoria 1970).

23 A recipe for making hair grow, probably written down about Christmas 1443, advises that the ingredients should be sealed in an earthen pot and then heated on a grid iron *(brande yren)* (Dawson 1934, 148, 149, no 447). Instructions for making ochre colour contained in John Trevisa's Middle English translation of Bartholomew the Englishman's *De proprietatibus rerum,* say that ochre is sometimes burnt red in new *crokkes,* well sealed with horse dung (fenne) or clay, adding 'the more it is burnt in the brazier *(chimene)* the better it is' (Seymour 1975, 1294-5); *crokke* is the southern dialect term for an earthenware pot (John Trevisa was born in Cornwall, educated at Oxford, and was vicar of Berkley, Somerset, for over 40 years).

24 The range of insignia is seen on the vessels from Peckwater Quadrangle, Christ Church, Oxford (Durham & Mellor 1977, 267, fig 5, PL/O/l, P1/O/4), the Great Cloisters, St Albans, Hertfordshire (Renn 1964, 10, PCl; 14, fig 4, PCl, pl 3), and Gold Street, Northampton (Mynard 1970, 51, fig 1, no 1). A few have been found on kiln sites, such as the two, possibly from the same vessel, found at Lacock, Wiltshire (McCarthy 1974, 125, fig 20, nos 255, 256).

25 Manorial accounts show that earthenware pots were frequently purchased for the dairy, and were used extensively in the making of butter and cheese (seep 114 above). The following is a sample of many references which may restrict the use of an earthenware pot to a specific room or building: on 4 April, 5, 20, 28 June, and 26 July 1265, an unspecified number of earthen pots were listed under purchases for the kitchen in the household roll of Eleanor, Countess of Leicester (Botfield 1841a, 16, 43, 51, 53, 76), 10d was spent on earthenware pots under the heading of the buttery in Bishop Ralph of Shrewsbury's household roll for 1337/8 (Robinson 1924, 103), in 1450/l, l½d was spent on 'one earthen pot called a butter pot *(Spensepot)* bought for the lord's refectory' at St Radegund's Priory, Cambridge (Gray 1898, 166), and at Bicester Priory in 1412, three earthen pots were purchased for the prior's hall (Blomefield 1882, 169).

Bibliography

Amis, P, 1968 Some domestic vessels of southern England: a social and technical analysis, *J Ceramic Hist*, **2**

Aspinall, A, 1977 Neutron activation analysis of medieval ceramics, *Medieval Ceramics*, **1**, 5–16

Austin, R (ed), 1888 *Two fifteenth-century cookery books*, Early English Text Soc, orig ser, **91**

Baildon, W P (ed), 1906 *Court rolls of the manor of Wakefield*, **2**, *1297–1309*, Yorkshire Archaeol Soc Rec Ser, **36**

———, 1914 *Calendar of MSS of the Dean and Chapter of Wells*; **2**, Hist MSS Comm

Balfour, J (ed), 1904 *Acts of the Lord High Treasurer of Scotland*, **2**, *1500–04*

Barker, P, 1970 *The medieval pottery of Shropshire from the Conquest to 1400*, Shropshire Archaeol Soc Monogr

Bartlett, K S, 1971 Excavations at Potovens, near Wakefield, 1968, *Post-Medieval Archaeol*, **5**, 1–34

Barton, K J, 1969 Three groups of medieval jugs and their wider significance, *Proc Hampshire Fld Club Archaeol Soc*, **24**, 62–70

———, 1975 *Pottery in England from 3500 BC–AD 1730*

———, 1977 Some examples of medieval oxidized and decorated earthenwares occurring in north-eastern France, *Medieval Archaeol*, **21**, 47–67

———, 1979 *Sussex medieval pottery*

Barton, K J, & Holden, E W, 1977 Excavations at Bramber Castle, Sussex, 1966–67, *Archaeol J*, **134**, 11–79
Beeler, J, 1966 *Warfare in England 1066–1189*
Bellamy, C V, & Le Patourel, H E J, 1970 Four medieval pottery kilns on Woodhouse Farm, Winksley, near Ripon, W Riding of Yorkshire, *Medieval Archaeol*, **14**, 104–25
Bennett, H S, 1948 *Life on the English manor: a study of peasant conditions 1150–1400*, 3rd corr impr
Bickley, F (ed), 1928 *Report on the manuscripts of the late Reginald Rawden Hastings Esq, of the Manor House, Ashby de la Zouche*, **1**, Hist MSS Comm
Biddle, M, 1962–3 Acoustic pots: a proposed study, *Medieval Archaeol*, **6–7**, 304
Birrell, J R, 1969 Peasant craftsmen in the medieval forest, *Agr Hist Rev*, **17**, 91–107
Blake, H, 1972 La ceramica medievale spagnola e la Liguria, *Atti del V Convegno Internazionale della Ceramica*, Albisola, 55–105
——— (ed), forthcoming *Medieval pottery guidelines*, HMSO
Blomefield, J C, 1882 *History of the present deanery of Bicester, Oxon: part 2, The history of Bicester*
Botfield, B (ed), 1841a Household roll of Eleanor, Countess of Leicester, AD 1265, in *Manners and household expences in England in the thirteenth and fifteenth centuries* (ed B Botfield), Roxburgh Club, 3–85
———, 1841b Accounts and memoranda of Sir John Howard, first Duke of Norfolk, AD 1462 to AD 1471, in *ibid*, 149–621
Brears, P C D, 1967 Excavations at Potovens, near Wakefield, *Post-Medieval Archaeol*, **1**, 3–43
———, 1971 *The English country pottery, its history and techniques*
———, 1972 Techniques of the Truro pottery, *Folk Life*, **10**, 47–54
Brooks, C M, & Haggerty, G R, 1976–7 Notes on Scottish medieval kiln furniture from Rattray, Aberdeenshire, *Proc Soc Antiq Scot*, **108**, 379–82
Brown, A E (ed), 1970 Archaeology in Northamptonshire, *Bull Northamptonshire Fed Archaeol Soc*, **4**, 2–34
Bryant, G F, 1977 Experimental kiln firings at Barton-on-Humber, S Humberside 1971, *Medieval Archaeol*, **21**, 106–23
Bryant, G F, & Steane, J M, 1969 Excavations at the deserted medieval settlement at Lyveden: a second interim report, *J Northampton Mus*, **5**
———, & ———, 1971 Excavations at the deserted medieval settlement at Lyveden: a third interim report, *ibid*, **9**
Buckland, P C, Dolby, M J, Hayfield, C, & Magilton, J R, 1979 *The medieval pottery industry at Hallgate, Doncaster*, The archaeology of Doncaster, The medieval town, 2/1
Burland, C A, 1967 *The arts of the alchemist*
Butler, L A S, 1974 Medieval finds from Castell-y-Bere, *Archaeol Cambrensis*, **123**, 78–112
Carus-Wilson, E M, 1933 The overseas trade of Bristol, in *Studies in English trade in the fifteenth century* (ed E Power & M M Postan), 183–246; also printed in E M Carus-Wilson, *Medieval merchant venturers*, 2 edn (1967), 1–97
———, 1962–3 The medieval trade of the ports of the Wash, *Medieval Archaeol*, **6–7**, 182–201
Celoria, F, 1970 Food and archaeology in Britain 1900–1970, *Sci & Archaeol*, **4**, 8–14
Cherry, J, 1972 Post-medieval Britain in 1971, *Post-Medieval Archaeol*, **6**, 208–23
Clarke, H, 1973 King's Lynn and east coast trade in the Middle Ages, in *Marine archaeology: proceedings of the twenty-third symposium of the Colston Research Society held in the University of Bristol 4th April to 8th April 1971* (ed D J Blackman), 277–92
Clay, C T (ed), 1922 *Yorkshire deeds: vol 3*, Yorkshire Archaeol Soc Rec Ser, **63**
———, 1929 Bradley: a grange of Fountains, *Yorkshire Archaeol J*, **29**, 97–106
———, (ed), 1949 *Early Yorkshire charters, vol 8: the honour of Warenne*, Yorkshire Archaeol Soc Rec Ser, Extra Ser **6**
———, 1960 Some medieval Lincolnshire and Yorkshire connexions, *Lincolnshire Hist*, **2**, no 7, 1–15
———, 1975 *Notes on the family of Clere, with a bibliography of his* [Sir Charles Clay] *writings: presented to the author for his ninetieth birthday in friendship and admiration*, privately printed
Clemens, J R (ed), 1933 Fifteenth-century English recipes for the making of pigments, *Art & Archaeol*, **34**, 206–10
Collins, F (ed), 1897 Register of the freemen of the city of York: I 1272–1558, *Publ Surtees Soc*, **96**
Coppack, G, 1968 A medieval well and associated pottery from Keighton, Nottinghamshire, Trans Thoroton Soc, **72**, 51–8
Cotton, C (ed), 1917 Churchwarden's accounts of the parish of St Andrews, Canterbury, from AD 1485–AD 1625, pt 1, *Archaeol Cantiana*, **32**, 181–246
Craib, T (comp), 1923 *Itinerary of Henry III, 1212–1272* (typescript), Public Record Office, Round Room, press 22/44
Crossley, D W, & Aberg, A, 1972 16th century glass-making in Yorkshire: excavations at Hutton and Rosedale, North Yorkshire, 1968–1971, *Post-Medieval Archaeol*, **6**, 107–59
Dale, M K (trans), & Redstone, V B (ed), 1931 *The household book of Dame Alice de Bryene ... 1412–1413*, Suffolk Inst Archaeol Natur Hist
Davey, P J (ed), 1977 *Medieval pottery from excavations in the north-west* [of England]
Davis, N (ed), 1971 *Paston letters and papers of the fifteenth century: pt 1*
Dawson, W R (ed), 1934 *A leechbook or collection of medical recipes of the fifteenth century, by Archippus (pseud)*
Dawson, D P, Jackson, R G, & Ponsford, M W, 1972 Medieval kiln wasters from St Peter's church, Bristol, *Trans Bristol Gloucestershire Archaeol Soc*, **91**, 159–67
De Bouard, M, 1974 Observations on the treatise of Eraclius, *De coloribus et artibus Romanorum*, in Evison *et al* 1974, 67–76
Delmaire, R, 1969 Persistance des inhumations avec vases à Saint-Omer au XIVe siècle, *Revue du Nord*, **51**, 350–2
Dickenmann, J J, 1904 Das Nahrungswesen in England vom 12. bis 15. Jahrhundert, *Anglia*, **27**, 453–515
Donkin, R A, 1963 The Cistercian order in medieval England: some conclusions, *Trans Papers Inst British Geog*, **33**, 181–98
———, 1976 Changes in the early Middle Ages, in *A new historical geography of England before 1600* (ed H C Darby), 75–135
Dunning, G C, 1933 Inventory of medieval polychrome jugs found in England and Scotland, in Kidwelly Castle, Carmarthenshire; including a survey of polychrome found there and elsewhere in Britain (C Fox, & C A Ralegh Radford), *Archaeologia*, **83**, 126–38
———, 1942 A medieval jug and its contents, *The Lancet*, 11 July 1942, 56
———, 1962–3 Report on Scarborough ware found at Kildrummy Castle, in Excavations at Kildrummy Castle, Aberdeenshire, 1952–62 (M R Apted), *Proc Soc Antiq Scot*, **96**, 208–36
———, 1967 Late medieval jugs with lettering, *Medieval Archaeol*, **11**, 233–41
———, 1968 The trade in medieval pottery around the North Sea, in *Rotterdam papers: a contribution to medieval archaeology* (ed J G N Renaud), 35–58
———, 1969a Medieval church cruets in pottery, *Medieval Archaeol*, **13**, 226–7
———, 1969b Medieval jugs decorated with brooches, *Antiq J*, **49**, 388–90
———, 1971 *A medieval jug found in London decorated with human and animal figures*, dedicated to Professor C F A Schaeffer (Paris)
———, 1974a The horse and knight roof-finial, with a discussion of knight finials and rider finials in England and on the continent, in Excavations in the area of Mill Street, Bedford, 1971 (D Baker), *Bedfordshire Archaeol J*, **9**, 112–22
———, 1974b A late medieval jug with lettering from Canons Ashby, Northamptonshire, *Medieval Archaeol*, **18**, 160–3
———, 1977 The chimney pots, in *Pleshey Castle, Essex (XII–XVI century): excavations in the bailey, 1959–1963* (F Williams), British Archaeol Rep, **42**, 124–43
Durham, B, & Mellor, M, 1977 Pottery from Peckwater Quadrangle, Christ Church, Oxford, *Oxoniensia*, **42**, 265–7
Evans, D H, 1978 French medieval pottery in Wales, *Medieval and later pottery in Wales*, **1**, 45–53
Evans, J, & Biek, L, forthcoming *Over-cooked food residues*, Proc 1976 Edinburgh Archaeometry Conference
Evison, V I, Hodges, H, & Hurst J G (eds), 1974 *Medieval pottery from excavations: studies presented to Gerald Clough Dunning*
Eyton, R W, 1878 *Court, household and itinerary of Henry II*
Farmer, P G, 1979 *An introduction to Scarborough Ware and a reassessment of knight jugs*, privately printed
Faull, M L, & Moorhouse, S (eds), 1980 *West Yorkshire: an archaeological survey up to AD 1500*, 3 vols and 1 map folder
Fleischhakker, R (ed), 1894 *Lanfrank's Science of cirurgie*, Early English Text Soc, orig ser, **102**
Forshall, J, & Madden, F (eds), 1850 *The Holy Bible ... in the earliest versions made by J Wycliffe and his followers*, 4 vols
Freke, D J, 1979 The excavation of a 16th-century pottery kiln at Lower Parrock, Hartfield, East Sussex, 1977, *Post-Medieval Archaeol*, **13**, 79–126
Frere, S, 1941 A medieval pottery at Ashtead, *Surrey Archaeol Collect*, **47**, 58–66
———, 1975 *Principles of publication in rescue archaeology: a report by the working party of the Ancient Monuments Board for England Committee for Rescue Archaeology*

Giuseppi, M S, 1937 Medieval pottery in Kingston-upon-Thames, *Surrey Archaeol Collect*, **45**, 151–2
Gough, H, 1900 *Itinerary of Edward I, 1272–1307*, 2 vols
Gray, A (ed), 1898 *The Priory of St Radegund, Cambridge*, Cambridge Antiq Soc
Green, C, 1977 Excavations in the Roman kiln field at Brampton, *E Anglian Archaeol*, **5**, 31–95
Griffiths, D, 1978 Use-marks on historic ceramics: a preliminary study, *Hist Archaeol*, **12**, 68–81
Grossmann, F, 1966 *Bruegel: complete edition of the paintings*, 2 edn
Halliwell [-Phillips], J O (ed), 1855 The craft of lymnynge bokys, in *Early English miscellanies in prose and verse* (ed J O Halliwell), Wharton Club, **2**, 72–91
Hammond, E A, 1965 The Westminster Abbey Infirmarer's rolls as a source of medical history, *Bull Hist Medicine*, **39**, 261–76
Hardy, T D, 1829 Itinerarium Johannis regis Angliae, *Archaeologia*, **22**, 124–60; also printed in T D Hardy, *A description of the Patent Rolls to which is added an itinerary of King John* (1835)
Harrison, K, 1967–8 Vitruvius and acoustic jars in England during the Middle Ages, *Trans Ancient Monuments Soc*, **15**, 49–68
Hartshorne, C H (comp), 1862 The itinerary of Edward II, *Collectanea Archaeologica*, **1**, 113–44
———, 1871 The itinerary of Edward I, *ibid*, **2**, 115–36, 311–41
Harvey, J H (ed), 1969 *William Worcestre Itineraries: edited from the unique MSS Corpus Christi College, Cambridge, 210*
———, 1975 *Medieval craftsmen*
Haslam, J, 1978 *Medieval pottery*
Hassall, T G, 1969 Excavations at Oxford 1968: first interim report, *Oxoniensia*, **34**, 5–20
Hayfield, C, 1980 Techniques of medieval pottery manufacture in Humberside and North Lincolnshire, *Medieval Ceramics*, **4**, 29–43
Hellier, R, & Moorhouse, S, 1980 *Medieval dairying*, Medieval Section, Yorkshire Archaeol Soc Occas Publ
Highfield, J R (ed), 1964 *The early rolls of Merton College, Oxford*, Oxford Hist Soc, n ser, **18**
Hindle, B P, 1973 *A geographical synthesis of the road network of medieval England and Wales*, unpub PhD thesis, Salford Univ
———, 1976 The road network of medieval England and Wales, *J Hist Geog*, **2**, 3, 207–21
———, 1978 Seasonal variations in travel in medieval England, *J Transport Hist*, n ser, **4**, 3, 170–8
Hinton, D A, 1968 A medieval cistern from Churchill, *Oxoniensia*, **33**, 66–70
———, 1973 *Medieval pottery from the Oxford region*, Ashmolean Museum, Oxford
———, 1977 'Rudely-made earthen vessels' of the twelfth to the fifteenth centuries AD, in Peacock 1977, 221–38
Hobson, R L, 1902 Medieval pottery found in England, *Archaeol J*, **59**, 1–16
———, 1903 *Catalogue of the collection of English pottery* [in the British Museum]
Hodges, R, 1977 Some early medieval French wares in the British Isles: an archaeological assessment of the early French wine trade with Britain, in Peacock 1977, 239–56
Hodgett, G A J (ed), 1972 *Stere htt well: a book of medieval refinements, recipes and remedies from a manuscript in Samuel Pepys' Library* [Pepys MS 104]
Holden, E, 1963 Excavations at the deserted medieval village of Hangleton: pt 1, *Sussex Archaeol Collect*, **101**, 54–181
Hooper, W, 1926 Mediaeval jug from Earlswood, *Surrey Archaeol Collect*, **37**, 245
Hoover, H C, & Hoover, L H (eds), 1950 *Georgius Agricola de Re Metallica*, New York
Hope, W St J, 1913 *Windsor Castle: an architectural history*, **1**
Howlett, D R, 1977 The date and authorship of the Middle English verse translation of Palladius' *De re ructica*, *Medium Ævum*, **41**, 245–52
Hurst, J G, 1955 Saxo-Norman pottery in East Anglia: pt 1, general discussion and St Neots ware, *Proc Cambridge Antiq Soc*, **49**, 43–70
———, 1956 Saxo-Norman pottery in East Anglia: pt 2, Thetford ware, with an account of Middle Saxon Ipswich ware by J G Hurst and S E West, *ibid*, **50**, 29–60
———, 1957 Saxo-Norman pottery in East Anglia: pt 3, Stamford ware with a report on recent finds from Stamford by D P S Peacock, *ibid*, **51**, 37–65
———, 1962–3 White Castle and the dating of medieval pottery, *Medieval Archaeol*, **6–7**, 135–55
———, 1968 Near eastern and Mediterranean medieval pottery found in north east Europe, *Archaeol Lundensia*, **3**, 195–204
———, 1977a Spanish pottery imported into medieval Britain, *Medieval Archaeol*, **21**, 68–105
———, 1977b Langerwehe stoneware of the fourteenth and fifteenth centuries, in *Ancient monuments and their interpretation, essays presented to A J Taylor* (ed M Apted, R Gilyard-Beer, & A D Saunders), 219–38
Jope, E M, 1947 Medieval pottery in Berkshire, *Berkshire Archaeol J*, **50**, 49–76
———, 1952 Medieval pottery, in Whittington Court Roman villa (H E O'Neil), *Trans Bristol Gloucestershire Archaeol Soc*, **71**, 61–76
———, 1956 Ceramics: medieval, in *A history of technology*, **2** (eds C Singer & E J Holmyard), 284–310
———, 1963 The regional cultures of medieval Britain, in *Culture and environment: essays in honour of Sir Cyril Fox* (eds I L Foster & L Alcock), 327–50
———, 1972 Models in medieval archaeology, in *Models in archaeology* (ed D L Clarke), 963–90
Kaner, J, 1980 Medieval brickmaking [principally in York, Beverley, and Hull], *Sciant Presentes* (Bull Medieval Section, Yorkshire Archaeol Soc), **8**, 3–7
Koplan, J P, Wells, A V, Diggory, H J P, Baker, E L, & Lidle, J, 1979 Lead adsorbtion in a community of potters in Barbados, *International J Epidemiology*, **6**, 225–9
Lambert, H C M, 1912 *A history of Banstead in Surrey*
Lancaster, J, 1975 Coventry, in *The atlas of historic towns*, **2**, *Bristol, Cambridge, Coventry, Norwich* (ed M D Lobel)
Lancaster, W T (ed), 1915 *Abstracts of the charters and other documents in the chartulary of the Cistercian abbey of Fountains* . . ., 2 vols, privately printed
Landon, L, 1935 *The itinerary of King Richard I, with studies on certain matters of interest connected with his reign*, Publ Pipe Roll Soc, **13**
Le Patourel, H E J, 1961 The pottery, in *Kirkstall Abbey excavations, 1955–59* (D E Owen), Publ Thoresby Soc, **48**
———, 1968 Documentary evidence and the medieval pottery industry, *Medieval Archaeol*, **12**, 101–26
———, 1973 *The moated sites of Yorkshire*, Soc Medieval Archaeol Monogr Ser, **5**
———, 1976 Pottery as evidence for social and economic change, in *Medieval settlement* (ed P H Sawyer), 169–79
———, 1979 Medieval pottery, in *Wharram: a study of settlement on the Yorkshire wolds*, **1**, *Domestic settlement, 1: areas 10 and 6* (ed D D Andrews & C Milne), Soc Medieval Archaeol Monogr Ser, **8**, 74–107
———, forthcoming Documentary evidence for pottery imported into Great Britain during the Middle Ages, in *North European pottery imported into Great Britain AD 1200–1500* (ed P J Davey & R Hodges), Medieval Pottery Res Group Occas Publ
Letts, M H I (ed), 1957 *Travels of Leo von Rozmital*, Hakluyt Soc Publ, 2 ser, **108**
Lewis, J M, 1968 Medieval church cruets in pottery, *Medieval Archaeol*, **12**, 147–9
———, 1978 *Medieval pottery and metalware in Wales*, Nat Mus Wales guidebook
Littlehales, H (ed), 1905 *Medieval records of a London city church* (*St Mary at Hill*): *1422–1559*, Early English Text Soc, orig ser, **128**
Lodge, B (ed), 1872 *Palladius on husbondrie*, Early English Text Soc, orig ser, **52**
Maclean, J, 1890 Notes on the accounts of the procurators or church wardens of the parish of St Ewin's, Bristol [1454–1515], *Trans Bristol Gloucestershire Archaeol Soc*, **15**, 139–82, 254–96
Manby, T G, 1964 Medieval pottery kilns at Upper Heaton, West Yorkshire, *Archaeol J*, **121**, 70–110
Mannoni, T, 1972 Nuove analisi techniche e mineralogiche della ceramiche medievali di importazioni rinvenute in Liguria, *Atti del V Convegno Internazionale della Ceramica*, Albisola, 107–29
Marshall, C J, 1924 A medieval pottery kiln discovered at Cheam, *Surrey Archaeol Collect*, **35**, 79–97
———, 1941 The sites of two more thirteenth-century pottery kilns at Cheam, *ibid*, **47**, 99–100
Martin, G H, 1976 Road travel in the Middle Ages: some journeys of the warden and fellows of Merton College, Oxford, 1315–1470, *J Transport Hist*, n ser, **3**, 159–78
Mayes, P, forthcoming *The medieval pottery kilns at Chilvers Coton, Nuneaton*, Soc Medieval Archaeol Monogr Ser, forthcoming
McCarthy, M R, 1974 The medieval kilns on Naish Hill, Lacock, Wiltshire, *Wiltshire Archaeol Natur Hist Mag*, **69**, 97–160
Mead, W E, 1931 *The English medieval feast*
Minns, G W W, 1872 Acoustic pottery, *Norfolk Archaeol*, **7**, 93–101

Mitchell, R J (ed), 1958 *The medieval feast: the glory of the coronation feast banquet of King Henry IV in Westminster Hall, 13th October 1399*

Moorhouse, S, 1972 Medieval distilling apparatus of glass and pottery, *Medieval Archaeol*, **16**, 79–122

———, 1974 A distinctive type of late medieval pottery in the eastern Midlands: a definition and preliminary statement, *Proc Cambridge Antiq Soc*, **65**, 46–59

———, 1978a Medieval pottery studies: the future, *Medieval and later pottery in Wales*, **1**, 1–9

———, 1978b Documentary evidence for the uses of medieval pottery: an interim statement, *Medieval Ceramics*, **2**, 3–22

———, 1979a Tudor Green: some further thoughts, *ibid*, **3**, 53–62

———, 1979b Review of Buckland *et al* 1979, in *ibid*, **3**, 109–11

———, 1980 The rural landscape of West Yorkshire during the Middle Ages, in Faull & Moorhouse 1980, **3**

———, in preparation a The medieval pottery, in *Excavations at Sandal Castle, West Yorkshire, 1964–1973*, P Mayes & L A S Butler

———, in preparation b The medieval pottery, in Excavations at Berwick-on-Tweed, 1976 (J Hunter), *Archaeol Aeliana*

———, in preparation c The incidence of left handed potters in medieval pottery manufacture, *Medieval Ceramics*

Morris, R (ed), 1865 *Liber cure cocorum ad 1440 AD*, Philological Soc Early English Volume

Murray, J A H, Bradley, H, Craigie, W A, & Onions, C T, 1933 *A new English dictionary on a historical basis*: **11**, *T–U*, 2nd corrected reissue

Musty, J W G, 1966 *The medieval pottery industry in Great Britain*, MA thesis, Univ Bristol, partly published in Musty 1974

———, 1974 Medieval pottery kilns, in Evison *et al* 1974, 41–66

———, 1977 Pots for the hot houses at Hampton Court and Hanworth, *Post-Medieval Archaeol*, **11**, 102–3

Musty, J W, Algar, D J, & Ewence, P F, 1969 The medieval pottery kilns at Laverstock, near Salisbury, Wiltshire, *Archaeologia*, **102**, 83–150

Mynard, D C, 1970 Medieval pottery of Potterspury type, *Bull Northamptonshire Fed Archaeol Soc*, **4**, 49–55

Napier, A (ed), 1882 *A noble boke of cookery* [c 1467]

Newstead, R, 1934 Medieval pottery and kiln at Ashton, near Chester, *University Liverpool Annals Archaeol Anthropol*, **21**, 5–26, & pls I–VI

Ogden, M (ed), 1938 *Liber de Diversis Medicinis*, Early English Text Soc, orig ser, **207**

———, 1971 *The Cyrurgie of Guy de Chaulic*, Early English Text Soc, orig ser, **265**

Parker, A, 1932 Nottingham pottery, *Trans Thoroton Soc*, **36**, 79–124

Parsons, J C (ed), 1977 *The court and household of Eleanor of Castile in 1290: an edition of British Library Additional Manuscript 35294 with introduction and notes*, Pontifical Inst Med Stud Toronto, Stud & Texts, **37**

Peacock, D S P (ed), 1977 *Pottery and early commerce: characterization and trade in Roman and later ceramics*

Pegge, S (ed), 1790 *'The Forme of Cury': a roll of ancient cookery, compiled about 1390 by the master cooks of King Richard II*

Phythian-Adams, C, 1979 *Desolation of a city: Coventry and the urban crisis of the late Middle Ages*

Pike, G, 1965–6 A medieval pottery kiln site on the Camley Garden estate, Maidenhead, *Berkshire Archaeol J*, **62**, 22–33

Platt, C, 1973 *Medieval Southampton: a port and trading community, AD 1000–1600*

Pognon, E, 1978 *Illustrated manuscripts: Boccaccio's Decameron*

Pollock, A J, & Waterman, D M, 1963 A medieval pottery kiln at Downpatrick, *Ulster J Archaeol*, **26**, 79–104

Power, D (ed), 1910 *'Treatises of fistula in ano, haemorrhoids and clysters' by John Arderne*, Early English Text Soc, orig ser, **139**

———, 1913 The lesser writings of John Arderne, *XVIIth International Congress of Medicine: Gen vol 23; history of medicine*, 107–33

Rackham, B, 1972 *English medieval pottery*, rev ed by J G Hurst

Raine, J (ed), 1854 *The inventories and account rolls of the Benedictine houses or cells of Jarrow and Monk Wearmouth, in the county of Durham*, Publ Surtees Soc, **29**

———, 1865 *Testamenta Eboracensia: a selection of wills from the registry at York, pt III* [AD 1395–1491], Publ Surtees Soc, **45**

Redstone, L J (ed), 1944 The cellarer's account for Bromholm Priory, Norfolk, 1415/16, *Norfolk Rec Ser*, **17**, 47–91

Renn, D F, 1964 *Potters and kilns in medieval Hertfordshire*, Hertfordshire Local Hist Council

Rhodes, M, 1979 Methods of cataloguing pottery in Inner London: an historical outline, *Medieval Ceramics*, **3**, 81–108

Robbins, R H, 1970a Medical manuscripts in Middle English, *Speculum*, **45**, 393–415

———, 1970b A note on the Singer survey of medical manuscripts in the British Isles, *Chaucer Rev*, **4**, 66–70

Robertson, N, 1974 Report on pottery found at Innerpefray church, Perthshire, *Glasgow Archaeol J*, **3**, 19–25

Robinson, J A (ed), 1924 Household roll of Bishop Ralph of Shrewsbury (1337–8), *Somerset Rec Soc*, **39**, 72–174

Rodgers, R H, 1975 *An introduction to Palladius*, London Univ Inst Classical Stud Bull, supplement 35

De Rola, S K, 1973 *Alchemy, the secret art*

Safford, E E (comp), 1974 *Itinerary of Edward I: pt I 1272–1290*, List & Index Soc, **103**

———, 1976 *Itinerary of Edward I: pt II 1291–1307*, List & Index Soc, **132**

———, 1977 *Itinerary of Edward I: pt III index*, List & Index Soc, **134**

Salzman, L F, 1926 *More medieval byways*

———, 1967 *Building in England down to 1540*

Schöffler, H (ed), 1919 *Beitrage zur mittelenglischen Medizintelibratur*, Halle

Searle, E, & Ross, B (eds), 1967 *The cellarer's rolls of Battle Abbey 1275–1513*, Sussex Rec Soc, **65**

Sellars, E, 1978 Pottery jottings, *Essex Archaeol News*, Winter 1978, 17

Sellars, M, 1918 *York mercers and merchant adventurers 1356–1917*, Publ Surtees Soc, **129**

Sergeantson, M S, 1938 The vocabulary of cooking in the fifteenth century, *Essays and studies by members of the English Ass*, **23**, 25–37

Seymour, M C (ed), 1975 *On the properties of things: John Trevisa's translation of Bartholomew Anglicanus' De Proprietatibus Rerum*, 2 vols

Simpson, M L, Bryan, P S, Delaney, T G, & Dickson, A, 1979 An early thirteenth century double-flued pottery kiln at Carrickfergus, Co Antrim: an interim report, *Medieval Ceramics*, **3**, 41–52

Smith, L T (ed), 1894 *Expeditions to Prussia and the Holy Land made by Henry Earl of Derby . . .*, Camden Soc, n ser, **52**

Steane, J M, & Bryant, G F, 1975 Excavations at the deserted medieval settlement at Lyveden: fourth report, *J Northampton Mus*, **12**

Stretton, G, 1924 Some aspects of medieval travel, notably transport and accommodation with reference to the wardrobe accounts of Henry, Earl of Derby 1390–3, *Trans Royal Hist Soc*, 4 ser, **7**, 77–97

———, 1935 The travelling household in the Middle Ages, *J Brit Archaeol Ass*, n ser, **40**, 75–103

Taylor, A J, 1961 Castle-building in Wales in the later thirteenth century: the prelude to construction, in *Studies in building history: essays in recognition of the work of B H St J O'Neil* (ed E M Jope), 104–33

Tebbutt, C F, Rudd, G T, & Moorhouse, S, 1971 Excavation of a moated site at Ellington, Huntingdonshire, *Proc Cambridge Antiq Soc*, **64**, 31–73

Thompson, D V, 1935 Trial index of some unpublished sources for the history of medieval craftsmanship, *Speculum*, **10**, 410–31

Thompson, M W, 1968 A single-aisled hall at Conisbrough Castle, Yorkshire, *Medieval Archaeol*, **12**, 153

———, 1969 Further work at Conisbrough Castle, Yorkshire, *ibid*, **13**, 215–16

Thorn, J, 1978 Medieval and later pottery, in [Excavations at] 201–211 Borough High Street (F Ferretti & A H Graham), in *Southwark excavations 1972–74*: **1** (ed J Bird, A H Graham, H Sheldon, & P Townend), London & Middlesex Archaeol Soc & Surrey Archaeol Soc Joint Publ, **1**, 128–40

Thorn, J, & Thorn, D, 1972 Heraldic jugs of forgotten potters, *London Archaeol*, **1**, 16, 372–7

Thorpe, L (trans & ed), 1978 *Gerald of Wales: 'The Journey through Wales' and 'The Description of Wales'*

Tingey, J C, 1910 *The records of the city of Norwich*, **2**

Trabut-Cussac, J P, 1952 Itinéraire d'Edouard I^er^ en France, 1286–1289, *Bull Inst Hist Res*, **25**, 160–203

Trollope, A, 1850 Mediaeval pottery, decorative tiles, etc, *Memoirs illustrative of the history and antiquities of Lincoln communicated at the annual general meeting of the Archaeological Institute of Great Britain and Ireland, held at Lincoln, July, 1848*, xliii

Turner, J H, 1893 *History of Brighouse, Rastrick and Hipperholme*

Vidler, L A, 1933 Medieval pottery and kilns found at Rye [pt II], *Sussex Archaeol Collect*, **74**, 44–64

——, 1936 Medieval pottery, tiles and kilns found at Rye: final [third] report, *ibid, 77*, 107-18
Vince A 1977 The medieval and post-medieval ceramic industry of the Malvern region, in Peacock 1977, 257-305
Walker, J W (cd), 1945 *Court rolls of the manor of Wakefield: vol 5, 1322-1331,* Yorkshire Archaeol Soc Rec Ser, 109
Warner, R (ed), 1791 *Antlquitates culinariae*
Warren, W L, 1961 *King John*
Webb, M J (ed), 1937 Early *English recipes, selected frorn the Harlelan MS 279, of about 1430 AD*
Webster. L, & Cherry, J (eds), 1972 Medieval Britain in 1971, *Medieval Archaeol,* 16, 147-212
——, & ——, 1975 Medieval Britain in 1974, *ibid,* 19, 220-60
Westell, W P, 1932 Hertfordshire, in Notes from county correspondents, *J Brit Archaeol Ass,* n ser, 38, 343-5
——, 1935 A medieval kiln site at Chicksands, Shefford, Bedfordshire, *Trans East Hertfordshire Archueol Soc,* 9, 33-7
Wightman, W E, 1966 *The Lacy family in England and Normandy 1066-1194*
Wild, J P, 1973 A fourth-century potter's workship and kilns at Subbington, Peterborough, in *Current research in Romano-British pottery* (ed A Detsicas), CBA Res Rep 10, 135-8
Wilson, D M, & Hurst, D G (eds), 1965 Medieval Britain in 1964, *Medieval Archaeol,* 9, 170-220
——, & 1968 Medieval Britain in 1967, *ibid,* 12, 155-211
——, & ——, 1969 Medieval Britain in 1968, *ibid,* 13, 204-87
——, & ——, 1970 Medieval Britain in 1969, *ibid,* 14, 155-208
Wright, T (ed), 1844a Early English recipes for painting, guilding etc, *Archaeol J,* 1, 64-6
——, 1844b Early English artistical receipts, *ibid,* 1, 152-5
Young, C J, 1977 *Oxfordshire Roman pottery,* British Archaeol Rep, 43

Bricks and tiles are building materials rather than finished products in their own right; hence their introduction to, and continued use in medieval England was intimately connected with the changing standards, techniques, and styles of contemporary buildings. This review of the industry which produced them must therefore begin by considering when, and from where, the principal types of ceramic building material were reintroduced after the end of the Roman period.'

First, however, a general note of caution with regard to early documentary references is required. In the 10th century, *tegulae* is given as the translation of *hroftigla* (roof tiles), which are classed as a variety of stone (Lloyd 1925, 2). The reference is clearly to 'stone tiles' or slates. This is underlined by the place-name *Tigel Leage* (the lea where tiles are made), which occurs in a charter of AD 940 relating to Wootton-under-Edge, Glos, and which has been identified with quarries for stone tiles still worked in the medieval period (Lindley 1952). Early references cannot therefore be taken to imply ceramic tile unless the context makes such a meaning certain, especially since archaeological evidence is beginning to show that stone and slate 'tiles' were traded into areas of England distant from sources of such material from the later 12th century onwards.' An associated problem is the interpretation of the word *tiler,* latin *tegulator.* Throughout the medieval period, he could be a man who made tiles or one who fixed tiles and, consequent on the foregoing, not necessarily ceramic tiles in either case.

Bricks

The massive numbers of wall tiles or bricks used in Roman structures must have provided a supply ample to fulfil early demands. However, the change in central Essex, probably in the first half of the 12th century, from reused tiles to Caen, Barnack, and other stones for the quoins and dressings of parish churches was probably connected as much with the exhaustion of sources of good Roman tiles as with stylistic preference.[3] In other areas similarly lacking in good local building stone, supplies may have been exhausted at about the same time. In contradiction to this view, however, we have the preliminary results of thermoluminescence tests on the apparently Roman bricks used in the Saxon church at Brixworth, Northants. These seem to suggest that essentially similar bricks may have been produced in Roman, Saxon, and possibly even late medieval times (Everson 1977, 99; McWhirr & Viner 1978, 371; Everson & Parsons 1979). However, many more thermoluminescence dates and fabric analyses are needed before this remarkably wide date range can be understood with confidence.

Coggeshall Abbey provides probably the earliest English example of the use of contemporary wall tiles or 'great bricks' in the medieval period: Gardner (1955, 24, n 1) associates their introduction to the Abbey with its transfer in 1148 to the Cistercian order, by then established in England for twenty years (Knowles 1949, 230), and bricks were certainly used in the church, dedicated in 1167. The production, on

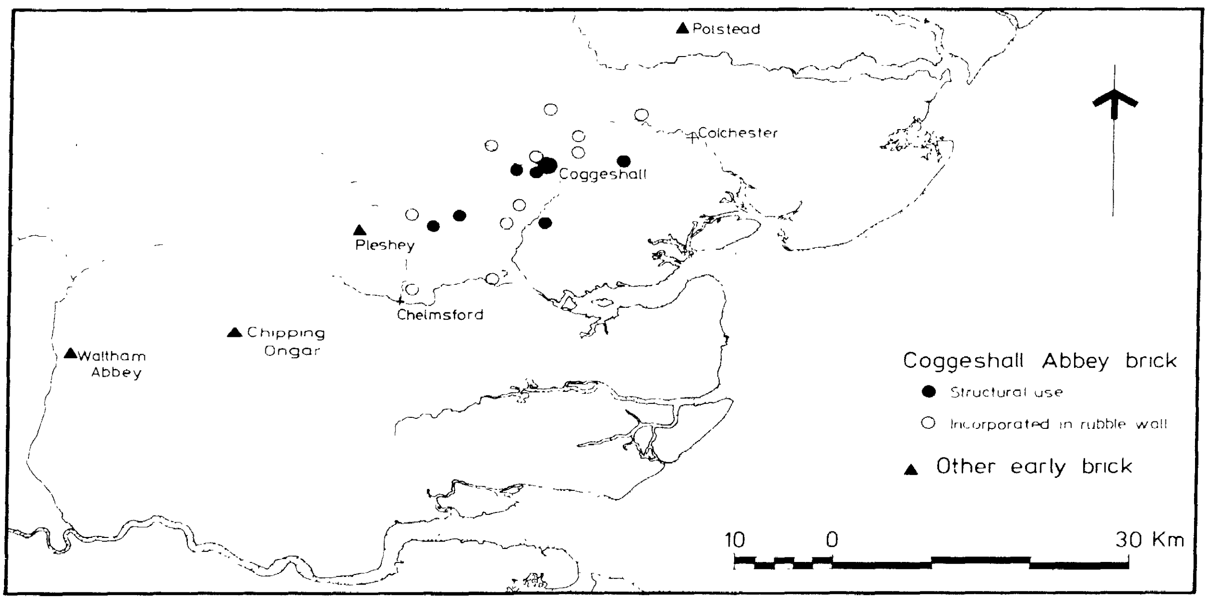


Fig 91 Distribution of Coggeshall Abbey brick, based on information supplied by Dr W J Rodwell. Other sites mentioned in the text as having produced similar early bricks are also shown

an adjacent site," of a remarkably sophisticated range of moulded bricks for door and window jambs with nook shafts, columns, etc (Gardner 1955, esp pl xiii) implies the importation of craftsmen. They were perhaps themselves monks, since continental houses of the Order used similar large bricks (France: Brooks 1939, 153, citing Enlart 1924; Low Countries. Hollestelle 1961, 27l), and the involvement of monks in the production of floor tiles (probably but not certainly ceramic) at Beaubec in Normandy in 1210 is attested (Ponsonby & Ponsonby 1934, 24). Warwick Rodwell has traced the distribution of these 'Coggeshall Abbey bricks', all identical in dimensions and fabric, in sixteen churches (eg Bradwell-juxta-Coggeshall, Gt Braxted), distributed over an area of *c* 300 sq km centred on the Abbey (Fig 91; Rodwell forthcoming). These churches generally had no direct connection with the house, and it must be supposed, therefore, that brick surplus to the needs of the Abbey was sold to provide revenue. All examples in primary architectural contexts, either at the Abbey (Gardner 1955) or elsewhere (Kodwell forthcoming), can be dated *c* 1150-1225.

Other early centres for the production of similar wall tiles must exist, for they occur and were probably made at the Augustinian Abbey of Waltham Holy Cross (Huggins 1972, 111-4), and they have been found in late 12th century contexts at Pleshey Castle (Drury 1977, 91), to quote but two examples.[5] Such bricks represent a revival of the Roman tradition, reintroduced into northern Europe probably via monastic chapters, ultimately from those areas of southern Europe where the craft did not die out. They reached England, the Low Countries (Hollestelle 1961, 271), and north Germany (Nesbitt 1863, 94-7) at about the same time: approximately the third quarter of the 12th century. Although occasionally made and used as late as the end of the 14th century,[6] they were to be completely supplanted by the 'Flemish' type brick, capable of being held in one hand.

Another instance of the revival of the Roman tradition in England is provided by glazed *tegulae* and *imbrices* from Southampton (Platt & Coleman-Smith 1975, 2, fig 212, 1386-90). These are close copies of Roman roof tiles, although the *tegulae* have a single central hole for fixing (a feature indeed found on some Roman *tegulae* : Drury 1976, 59) and all have a patchy amber or green glaze. These objects are assigned by Platt and Coleman-Smith to *c* 1200, and appear alongside slate at a time when a general conversion from thatch to fireproof materials for roofing is evident, but before the appearance of standard peg-tiles, by *c* 1250 (Platt & Coleman-Smith 1975, 1, 240). More recent excavations provide a *terminus ante quem* of the 13th century (Thomson in Walker 1978, 205). These tiles are seemingly of local manufacture, and closely similar examples are now appearing at other (largely monastic) sites in central southern England (A Streeten, pers comm). The type also appears at Scarborough, Yorks, as early as the mid 12th century (P Farmer, pers comm), in a fabric which makes manufacture in the vicinity highly likely. Both English groups may be inspired by the use of such tiles in southern France (R G Thomson, pers comm).

Whether the 243,000 *quarellarum de Flandria* imported from Ypres to the Tower of London in 1278 (Salzman 1952, 140) were 'Flemish' or 'great' bricks it is impossible to say, but there is no doubt about the use of Flemish-type bricks, probably imported,[7] at Little Wenham Hall, Suffolk, *c* 1260-80 (Lloyd 1925, 4,107). In Southampton, such bricks were reused in a building destroyed in 1338 (P Holdsworth, pers comm). 'Flemish' bricks appeared in King's Lynn by about 1275 (Clarke & Carter 1977,441). Holy Trinity church, Hull, has brickwork of the end of the 13th century (Bilson 1896, 48), and by 1303 the Hull Corporation brickyard was in operation (Brooks 1939, esp 153). Archaeological evidence from Boston (Mayes 1965) indicates simple clamp firing of bricks there early in the 14th century, immediately followed by the firing of tiles in a through-draught kiln. This structure finds parallels in temporary brick-kilns at Deersum in Friesland in the 13th century (Halbertsma 1963) and t'Goy, Houten, near Utrecht in the 14th (de Keyzer 1973).[8]

Lynn, Hull, and Boston, together with London, Ipswich, Norwich, Yarmouth, York, and Bristol (Fig 92) had substantial communities of Hanseatic merchants. In London, the merchants of Cologne had received permission to form a guild in 1157 (Salzman 1931,98). The rise of the Hanseatic towns during the 13th century, and the importance of the trade generated by their merchants, led in 1303 to a charter greatly extending their privileges (Postan 1973, 193) and which dealt with the German merchants in England as a single body. From the later 13th century, there occurred a gradual transformation of the informal alliance of the separate *hanse* of the German cities into a formal alliance of the towns themselves, which emerged during the 1360s as the Hanseatic League (Postan 1973, 159-60, 195). One manifestation of this coalescence was the mutual similarity of the architecture of the confederate cities, particularly the use of brick, even in those areas not lacking in good building stone at a reasonable distance (Perry 1894). Against this background. it would be surprising if some influence did not appear in the English ports concerned in the Hanseatic trade, whether by example from the buildings of the steelyard, or as a result of personal knowledge gained by those involved.'

The east-west traffic of the Hansa was only one of two major orientations of trade probably relevant to the spread of the use of brick. The other was the wool trade with Flanders, which reached its peak late in the 13th and early in the 14th centuries (Postan 1973,350, 358-9). In discussing trade in medieval northern Europe, Postan (1973, 102) has said, 'Its essential feature was trade in bulk, its characteristic commodities were the essentials of life and industry'. Given bulk exports of wool to Flanders, it need occasion no surprise that large quantities of bricks were exported to southern and eastern England in return. The conventional interpretation of the brick trade as being primarily due to the need for a return, 'ballast', cargo, has, in the opinion of the writer, been overstressed.

Bricks 'figure in practically all the accounts for London and the eastern ports' (Salzman 1931, 360). including Scarborough in the later 14th century (Bellamy & Le Patourel 1970, 118, n 50). One might suspect that it was the combination of these two influences, as much as the general but not universal absence of good building stone at a reasonable distance, which established the tradition of brick building in and around the English east-coast towns, and the rather less emphatic early use of the material along the eastern south coast, in ports like Southampton.

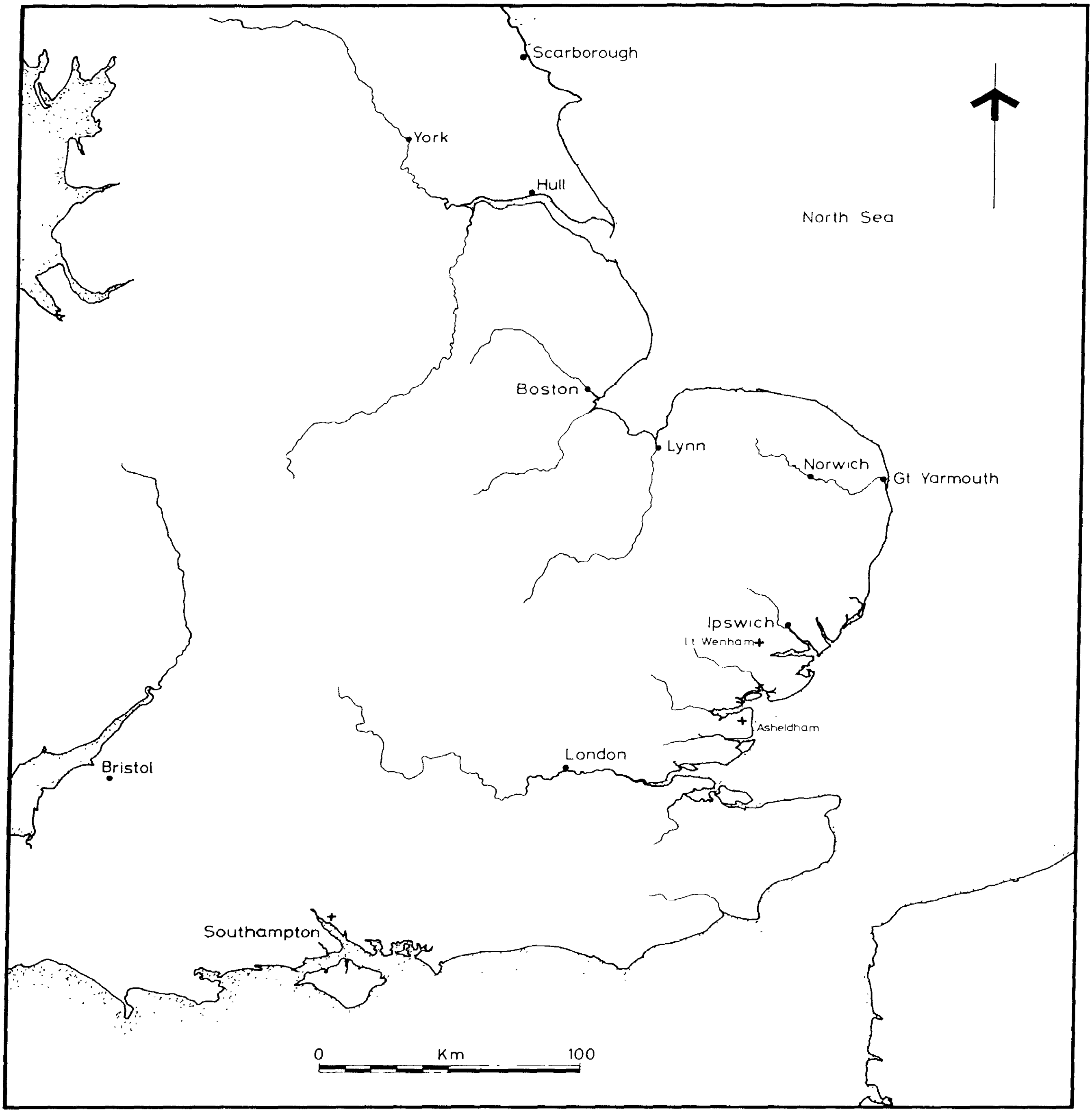


Fig 92 Map to show towns and sites mentioned in the text in connection with the use of 'Flemish' type bricks in the 13th and 14th centuries

There were two types of 'Flemish' brick: a larger (c 230-270 mm x 130-165 mm x 40-50 mm: 9-10½"x5-½"X1½-2"), found mostly in the hinterland of the east-coast towns, and a smaller *(c,* 230X115x50 mm: 9"x4½"x2"), found mostly further south, although their distributions are far from exclusive. They were probably evolved from the great brick in northern Europe and particularly in the Low Countries; in the latter both sizes could be produced simultaneously, to locally defined standards, for use in public and domestic buildings respectively (Hollestelle 1961, 273).[10] During the 14th century their use seems to have spread outside the hinterland of the ports, since probably imported small 'Flemish' bricks were used, for example, in churches like Dengie, Southminster, and Asheldham, on the east coast of Essex, from the middle of the century onwards (Drury & Kodwell 1978, 143; Drury 1977, 84).[11]

By 1414 brick was used at Old Thorndon Hall (Ward & Marshall 1972, 1, 17), in south-west Essex, and a brick kiln was established at Writtle in 1427,[12] probably connected with the reconstruction of much of the nearby (originally royal) hunting lodge on brick foundations (Rahtz 1969, 24-5, fig 9). During the 1430s and 1440s a group of elaborately decorated brick buildings, which T P Smith (1976, 56), has suggested are the work of a single *atelier* of German craftsmen, spread brickwork beyond the coastal regions, and formed the basis of a regional style which persisted for the following 150 years (Smith, T P 1976; Drury 1977, 84).

Documentary evidence suggests that foreigners were substantially involved in brickmaking during the 15th century. In 1416 *'les Flemynges'* Crockernend were making bricks for Stonar (Salzman 1952, 142; Salter 1913). Henry Sondergyltes, *brykeman,* was operating his 'tilkylne for making bryke' at Deptford for the wardens of London Bridge from 1418 onwards (Salzman 1952, 142). In 1430, three brickburners in Bury St Edmunds were called *teutonici* (Salzman 1952, 142) and Henry Herryson, 'brikemaker, born in Teutgonic parts,' lived in Ipswich in 1436 *(Cal Pat Rolls,* 1429-36, 566). As late as 1483, Anthony Docheman was the brickburner at Kirby Muxloe, Leicestershire, where many of the bricklayers were also foreign (Thompson 1916, esp 265, 268, 307). Is there perhaps a connection between the decline of wool exports in favour of insular cloth production, in which Flemings were significantly involved, and the rise of insular brickmaking in eastern England largely in the hands of Flemings and Germans?

Floor tiles

The introduction of decorated floor tiles followed a different course. Polychrome relief tiles were used sporadically during the later 10th and 11th centuries. Keen (1979a) lists the following sites known to date: St Albans (Ward-Perkins 1937, 146, fig 5.1, 2, 4), Coventry Priory (Chatwin 1936, 35, figs 1-2), Peterborough, Winchester (Biddle 1964, 209-10), Bury St Edmunds Abbey, and All Saints Pavement, York. Their similarity suggests production at a limited number of centres as yet unlocated. Subsequently, there appears to have been a virtual hiatus in the production and use of tile pavements until the 13th century.[13] The introduction and subsequent insular manufacture of inlaid tiles of considerable sophistication seems to stem directly from the marriage of Henry III to Eleanor of Provence in 1236. The earliest record of tile paving in an English royal residence is at Westminster Palace in 1237 (Eames 1958, 98, 105), and parts of pavements of 1244 (Eames 1963) and 1250-2 (Eames 1958) have been recovered from Clarendon Palace.

There is no clear evidence for the extensive use of mosaic tile pavements in Britain prior to the introduction of inlaid tiles, despite their use in France by the early 12th century (Norton 1980). The date of the tiling at the east end of the Corona chapel at Canterbury Cathedral, formerly placed at *c* 1220 (Eames 1977, 1, 4) has now been corrected to *c* 1280 (Norton 1980). The earliest documented dates for the series of mosaic pavements in the northern Cistercian houses are 1220x1247 (Fountains) and 1249x1269, the latter for the abbey church at Meaux (Knight & Keen 1977, 71-2 and refs cited; Eames 1961, 141).

Until recently it was usual to regard techniques of slip-decoration as 14th century commercial innovations associated with the mass production of low-quality tiles, exemplified by Penn products (for which see Hohler 1942). It is now clear that these were not produced by 'printing' as Haberley (1937, 55) suggested, but largely by two methods, *slip-over-impression,* involving the substitution of a thin layer of slip for inlay, and *stamp-on-slip,* involving the innovation of stamping the design after a layer of slip had been applied to the tile (Drury & Pratt 1975, 139-40). This latter technique was in use in central Essex by *c* 1260-80 (Drury & Pratt 1975, 149-51). Moreover, inlaid tiles were apparently never made in Essex, whereas slip-decorated tiles were rare in, for example, Hampshire before the late 14th century (see, for example, Norton 1976).

An explanation for this regional difference in the techniques used to produce two-colour tiles in south-eastern and central southern England" cannot be justified in terms of increasing distance from the source of the white clay used for the inlay or slip, encouraging economy in its use. This was suggested by Drury and Pratt (1975, 142, 161), but refuted on historical grounds by Hinton (1977, 308) and by the scientific work on white clays in progress (Biek & Evans 1979). Since on economic grounds one might expect a mixture of durable (inlaid) and less durable (slip) tiles in each area, it seems that an explanation must be sought in terms of the introduction of these techniques from the adjacent Continent during the 13th century, and their naturalization in the regions concerned. It is perhaps relevant that the localization of two-colour techniques is largely confined to the southern and eastern coastal regions of England, both occurring contemporaneously in and beyond the Midlands. The size of the zones in which the various techniques were used, and the diverse material produced by the different factories within them, seem too great to support Hinton's suggestion that such zones reflect the areas of influence of patrons who first introduced tilemakers to a region (Hinton 1977, 310). This is as true of 'line-impressed' tiles as two-colour tiles, especially as the products of the various sub-schools of the former are defined (Drury & Norton forthcoming).

The only slip technique not yet identified on the Continent is stencilling.[15] Two 14th century English production centres are implied by the restricted distributions of tiles decorated in this way. One group is found in north Essex, southern Suffolk, and

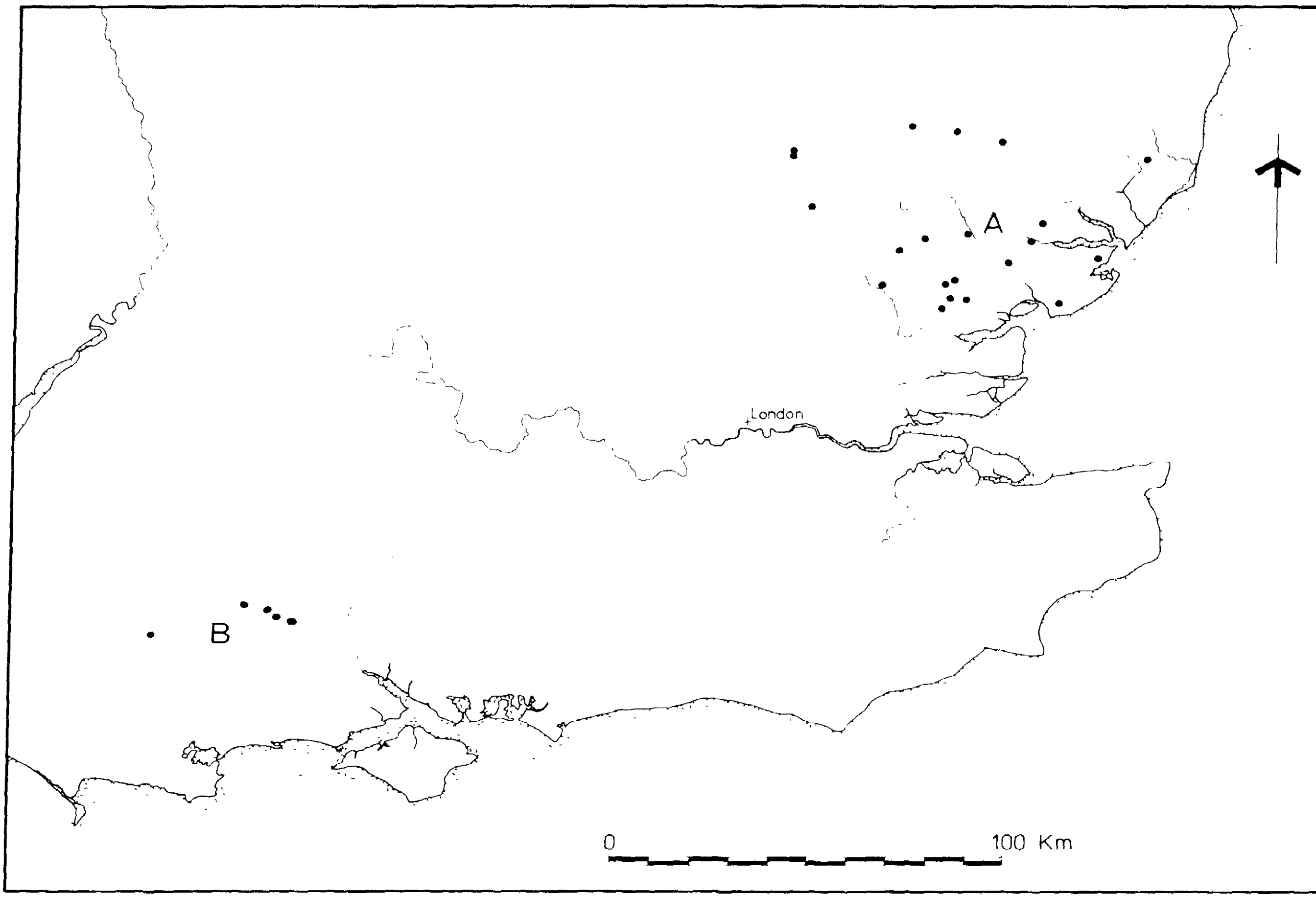


Fig 93 Distribution of stencilled medieval floor tiles in England

south-west Cambridgeshire (Fig 93, A), the tiles apparently being produced alongside line-impressed quarries (Drury forthcoming; Keen 1971, 147). The other occurs in the Salisbury-Shaftesbury area (Fig 93, B; Stevens 1935, 359; Drury & Pratt 1975, 161; Salisbury Museum, unpublished; Emden 1977, 89-90, nos 245-9, technique misunderstood). The designs used in the two groups are not closely related, but a link between them seems more likely than simultaneous evolution of the technique.

Relief tiles provide a clearer example of the importation of a technique and its concentration in particular areas of England. Such tiles seem to have originated on the upper Rhine, in Alsace, by 1150, and to have appeared in England, perhaps via the lower Rhineland, during the 13th century, mostly in the Midlands and East Anglia (Ward-Perkins 1937, esp fig 1). Later and certainly indigenous production was concentrated in Norfolk and Suffolk (Ward-Perkins 1937, fig 3; Eames 1955; Keen 1971, 149-50; Keen forthcoming), and to a lesser extent the Midlands (Ward-Perkins 1937, 148-52; Whitcomb 1956, 119-26).

Floor tiles may have been imported throughout the medieval period, but archaeological and documentary evidence points to large-scale importation only during the late 14th and 15th centuries (Salzman 1952, 146; Keen 1971, 148). During that period, plain-coloured Flemish tiles were used extensively in eastern England (Drury &: Norton forthcoming), and appear in southern England, eg at Southampton, in substantial numbers (P Holdsworth, pers comm; Coleman 1960, 30). The reasons for this Flemish domination of the market may be partly economic and partly stylistic. More research is required, particularly into the possibility that some of these tiles may have been made by Flemings settled in England. To date, all definitely insular copies of these plain Flemish tiles lack the nail holes in the face characteristic of the Flemish products. These were caused by the use of a nailed board as a template in trimming the tiles (Lane 1960). Kiln sites producing such copies include Radwinter and Blackmore. Essex, early and late in the 15th century respectively (Cherry 1980, 262; Drury 1978, 235).

Roof tiles

The London building regulations of 1212 include tile in the list of permitted roof coverings (Salzman 1952, 223; Chew & Kellaway 1973, x-xi); tile fragments occur in London in contexts dating from the late 12th century onwards.[16] Roof tiles appear sporadically elsewhere around 1200, for example the nibbed tiles

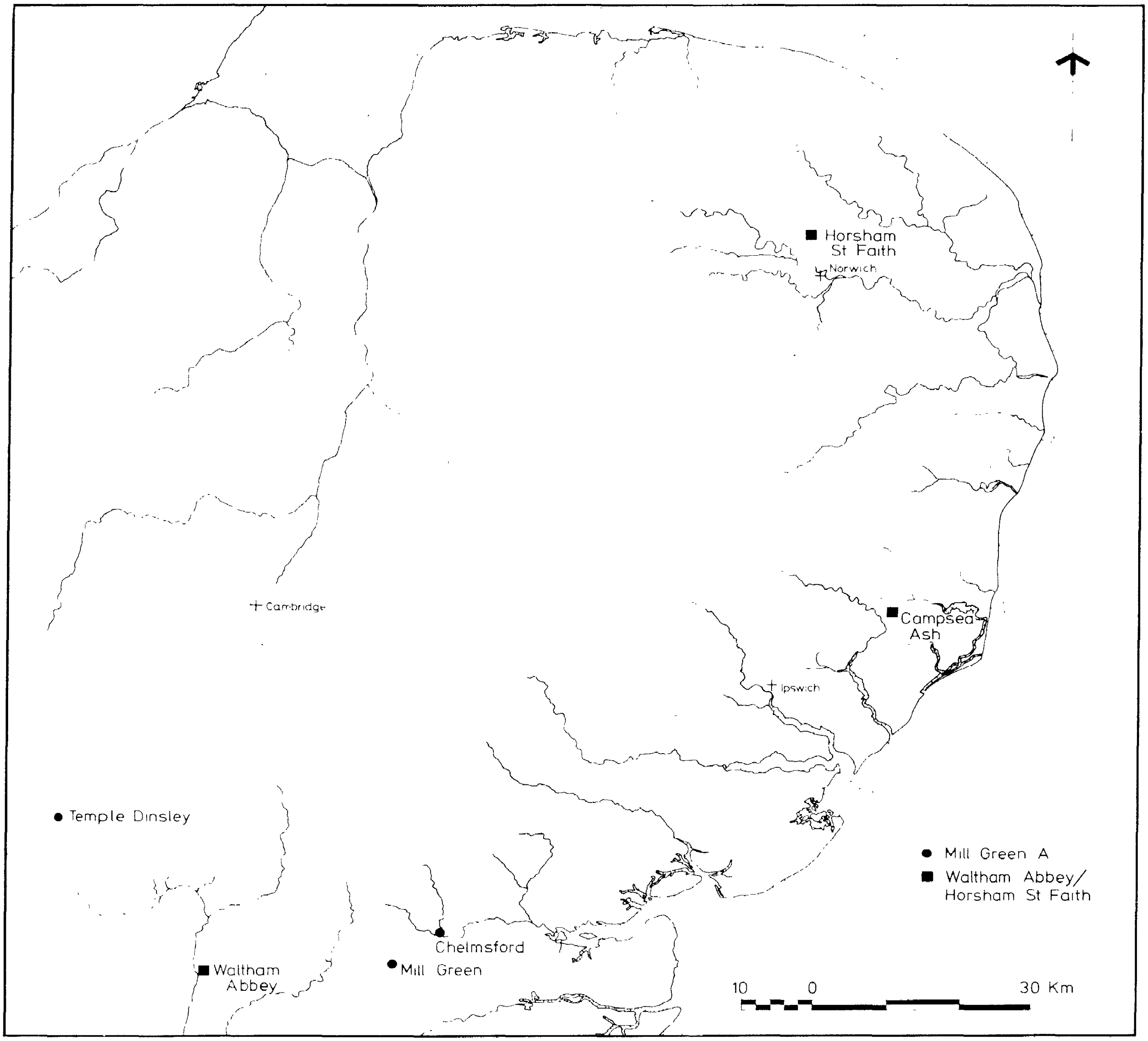


Fig 94 Distrtbution of Mill Green A and Waltham Abbcy/Horsham St Faith floor tilcls; ti1es at Broomholm Priory, Bacton, Norfolk, were discovered too late for inclusion

at Bordesley Abbey (Rahtz & Hirst 1976, 172-5, fig 34), and at the camera at Wharram, Yorks, built *c* 1180 and demolished *c* 1250 (Hurst 1979,29-33,66); but they seem only to have come into general use in southern and eastern England by the middle of the 13th century.[17]

Early roof tiles were generally large, and were hung by means of projecting nibs, but smaller peg-tiles had become almost universal, in south-east England at least, by the beginning of the 14th century. Their dimensions and quality were confirmed by statute in 1477 (17 Edw IV, c iv), following earlier localized attempts to enforce standardization.[18] Whether the production of nibbed tiles was generally related to the production of 'great' bricks is not yet clear. There is an association at Chipping Ongar (note 5, p 127), but the peg-tile superseded them as thoroughly as the Flemish brick superseded the great brick in all but a few areas, eg Southampton in the 16th century (I' Holdsworth, pers comm) and the Severn Valley, where nibbed tiles are known (glazed) in the 16th and 17th centuries (Vince 1977, 275).

Organization of production and distribution

The whole range of ceramic building products was rarely made by a single producer; but floor tiles were commonly made alongside roof tiles, for example at Danbury (Drury & Pratt 1975). Pottery and tiles were sometimes produced by the same permanent establishment, especially in Kent and Sussex, for example at Hastings (Lower 1859), Rye (Vidler 1932), Binsted (Wilson & Hurst 1967, 316-8), and also at Lyveden, Northants (Steane & Bryant 1975,33). In the last case a normal tile kiln was seemingly used for both purposes, but the odd structures at Binsted and Rye seem to be conjoined pottery and tile kilns (Musty 1974, 47). The association is perhaps surprising in view of the fundamentally different techniques of fabrication involved: tiles are moulded and pots thrown. That this distinction was often scrupulously observed is suggested by the absence of louvers, etc from Danbury.

The first organizational model for tile production which must be considered is that of the itinerant craftsman, who produced tiles,probably with the help of local labour, at or near the site where his products were required. The introduction of an industry to a new region often seems to have been effected by such men: for example, some of the earliest inlaid floor tiles known to have been produced in England were made on site at Clarendon Palace *c* 1237-44 (Eames 1958, 103-4; 1963, 42; 1968, pl xv, xvi). The kiln excavated there was built of tile and stone, but such temporary structures were often largely clay-built, for example one at Norton Priory, Runcorn, Cheshire, which produced floor tiles in the early 14th century (Webster & Cherry 1973, 153-4, pl xxviii, A; Greene 1975). Ancillary buildings probably existed, but were perhaps of too slight a form to leave remains detectable in excavation. The notion of an extremely short firing life for 'temporary' clay kilns must, however, be tempered by the experience of Barry Johnson, who has successfully fired a reconstruction of the Norton kiln in two successive seasons (Greene & Johnson 1978).

By careful study of decorated floor tiles it may be possible to trace the progress of an itinerant tilemaker. This is particularly true of the earliest inlaid tiles (Eames 1968, '7-16). In another instance, a craftsman or group of craftsmen produced tiles from identical stamps at Waltham Abbey in Essex, Horsham St Faith Priory, and Broomholm Priory, Bacton, the latter both in Norfolk, around the third quarter of the 13th century (Fig 94). Two groups of tiles with designs derived from the primary group occur (Drury & Norton forthcoming), one at Waltham Abbey, and the other at many sites in Norfolk and northern Suffolk (including Campsea Ash Priory; Keen 1976); but significantly, these derived groups are different from each other.

But the activities of such men were not confined to the introduction of products to areas in which they were previously unknown. In the 14th century floor tiles of greater quality and sophistication than anything available locally occur at Temple Dinsley, Herts (BM 504) and Chelmsford Dominican Priory (unpublished). Wasters have been found at the tile and pottery-making centre at Mill Green, Ingatestone, some eight km to the south-west of Chelmsford, but neither tiles nor wasters are known elsewhere in either county.[19] Here it seems reasonable to suggest that the Chelmsford Priory tiles were made by an itinerant specialist at the nearest suitable industrial centre, and perhaps fired in an existing kiln (Fig 94).

Two other variants of this model may be mentioned. First, the erection of massive brick buildings in the late medieval period could make it worthwhile to set up kilns on or near the site, for example at Windsor Castle in 1430 (Salzman 1952, 143) and at Belsize, Middlesex, in 1496 (Harvey 1975, 142). Second, the proprietors of a settled tilery might set up a subsidiary kiln at the site of a distant contract, an arrangement recently suggested by Alan Vince on petrological grounds for the supply of some Welsh sites by tilers based in the Severn Valley.-'"

Settled production could be organized in two ways. First a kiln could be set up by corporations or major lay or ecclesiastical landowners to supply their own needs and be worked by men on daywork or taskwork, the surplus being sold. Hull Corporation evidently worked their *tegularia* in this way in the 14th and 15th centuries (Brooks 1939, 161-3), and similar arrangements prevailed at Battle Abbey between 1307 and 1466 (Searle & Ross 1967, 48, 144). In 1441-2, the Prior of Colne Priory, Essex, paid £3 6s 8d to 'diverse me[n] hyred at diverse tymes to make plane and hollow tyle this year'. In the same year the house received £3 5s 8d for tiles sold, but how many more were used by the priory or held in stock is not clear.[21] The practice survived until the 19th century, for example on the Audley End Estate in Essex." On archaeological grounds a factory in close physical association with a monastic or major lay house might be suggested as fitting this model, if the structures imply a degree of permanence not usually associated with itinerant production, eg at Shouldham, Norfolk (Smallwood 1978). Close proximity is not, however. essential, and was lacking at Meaux, Yorkshire (Eames 1961, 141-2).

Finally, the enterprise could be wholly commercial, the tilery being set up either in the curtilage of a tenement, or on a site acquired for the purpose. By means of leases many sites earlier worked by direct labour probably moved into this category after the middle of the 14th century, following the general change from demesne cultivation to leasing, and for the same basic reasons (for which see Platt 1978, 126-9). But when the manor of Ingatestone was leased to Richard Pakyn in 1368 the *Tyle kelle ad aulam* (at the hall) was reserved, as was the right to carry fuel to it.[23] In the 1370s Peter at Gate leased kilns at Wye, Kent, at 20s each, and operated them with hired workmen (Salzman 1913, 123). Late in the 14th and early in the 15th centuries the manorial tilery at Moulsham, Essex was leased for terms of 5,7, 10, or 13 years, part of the rent being payable in tiles, but not all leases ran their full term (Appendix, p 138). The municipal tile works at Aldebeck, Beverley, was leased at a rent of 6000 tiles per annum for four years in 1370 (Salzman 1913, 125). In the same area clay pits could be leased separately for a rent payable in tiles (eg in 1391 and 1440; Salzman 1913, 125).

Tilemaking was a seasonal occupation, largely since green tiles are damaged by frost and arc hard to dry in winter. Its occasional combination with another seasonal occupation, agriculture, is testified as early as 1332 at Penn, Buckinghamshire (Hohler 1942, 22, n 15). In 1368, John Horn of Danbury, *tighlere,* and Agnes his wife, acquired a messuage and 11 acres of land in Danbury - by no means a small holding below subsistence level (Drury & Pratt 1975,

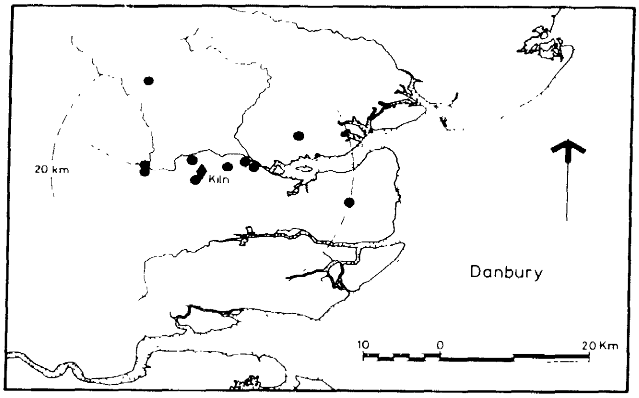


Fig 95 Distribution of tiles made at Danbury in the late 13th and early 14th centuries Based on Drury & Pratt 1975, fig 64, with additions; finds from the slte of the royal manor in Windsor Great Park are omitted

160). Similarly, some tilers at Ingatestone, another important tile and pottery-producing centre in Essex, can be shown to have had substantial holdings of land and cottages late in the 14th and early in the 15th centuries, some of which they let on lease." The practice is illustrated later by a probate inventory of 1708 from Danbury (Drury 1975, 208-9). But by contrast, when two tofts in the by then almost deserted settlement of Lyveden, Northants, became a tileyard late in the 15th century, only the living end of the longhouse was retained and refurbished (Steane & Bryant 1975, 33).

Most products of medieval tileries are not distinctive, so it is normally impossible to plot the distribution of their products on the basis of surviving or excavated material. Building accounts may give the sources of bricks and tiles purchased, but, even if these places were the actual manufacturing sites, a warped impression of normal trading areas is probably given, since extant accounts generally relate to major, often royal, works for which a large area might be scoured for materials.

It seems probable that one must envisage a situation which has been demonstrated in the case of Roman pottery in Oxfordshire (Young 1977) and suggested for medieval pottery in Yorkshire (Bellamy & Le Patourel 1970, esp fig 43), in which a number of closely spaced centres produced mundane products, and a few of these centres also produced fine products which were traded over correspondingly larger areas. When the distribution of decorated floor tiles is plotted, therefore, it must be remembered that we are seeing only this upper level of distribution. Further, it must be borne in mind that evidence so far suggests that decorated floor tiles generally formed only a small proportion of the output of permanent centres making them (Drury & Pratt 1975, 160). It is also worth noting that in clay areas, wasters could be sold over a wide area for use as rubble and in foundations, as they were at Danbury (Drury & Pratt 1975, 156).

Danbury floor tiles are generally distributed within 20 km of the factory, save for some from the site of the royal manor in Windsor Great Park (Drury & Pratt 1975, 154-8), illustrating the point made above about the atypical supply patterns to royal sites (Fig 95). The factory which produced them was of substantial size (Fig 98). If there is any connection between distributional area and size of factory, one would expect a larger establishment at Tyler Hill, Kent (Fig 96), and something vast at Penn, Bucks, whose products are found over the whole of southern central England (Hohler 1942). Yet the tilers of Penn recorded in 1332 were hardly rich men (Hohler 1942, 22, n 15), although the industry was then probably in its infancy. At Tyler Hill, kilns have been found over a wide area, and several produced floor tiles in the same style (M Horton, pers comm). The archaeology of the Penn region is less well understood, but a characteristic of Penn tiles is the existence of several variants essentially of the same design. Is it possible, therefore, that the products of these major centres were made by several tileries operating in the same locality - one particularly suited to the trade — and jointly marketed by entrepreneurs? A similar situation may have prevailed in the Oxfordshire potteries in the Roman period, although there the landowners may have been the controllers of the industry (Young 1977, 241). Hinton (1977, 311) suggests that such middlemen may well have received much of the profit of the trade.

This brings us to the methods by which tiles were sold. A London ordinance of 1362, reflecting a royal proclamation, directed manufacturers to continue normal production and expose the tiles for public sale 'as heretofore they used to do', at the usual prices, after serious damage to roofs by a 'great tempest' (Riley 1868, 309; Sharpe 1905, 138). But since most kilns were in the countryside and the major markets were in the towns, one would expect middlemen to exist. The bricks for the North Bar, Beverley, were purchased from twenty different persons, some specifically called merchants, in 1409 (Bilson 1896, 44), suggesting a general market in such materials. But in the case of roof tiles at least, the tile-fixers, called, like the manufacturers, 'tilers' in the records, probably often fulfilled this role. They were significant enough to form guilds, for example in Lincoln, where the gild of the Tylers, commonly called 'Poyntours' was founded in 1346 (Toulmin Smith 1870, 184-5). 'Poyntours' may derive from the practice of sealing the gaps between the tiles with mortar, which persisted down to the 19th century, or from the pointing of joints between wall tiles (ie bricks) which were often laid by tilers.

The Worcester ordinances of 1467 forbade tilers to form a 'parliament' in restraint of free trade (Woof, n d, 43). Paviors may similarly have dealt in floor tiles. If they were the entrepreneurs behind Penn, then the Essex (Drury & Norton forthcoming) and Kent (M Horton, pers comm) distributions of Penn tiles suggest that some, at least, were London-based.

But it is clear that many tile pavements were specially commissioned from the manufacturers, to fit a particular apartment or to include tiles with a personal rebus or armorial bearing. In some cases, for example the manufacturers of our finest group of line-impressed mosaics in the south Midlands (for which see, for example, Keen & Thackray 1974), it seems doubtful whether work was undertaken on any other basis. Large orders for more mundane products also seem often to have been placed direct with makers, and stage payments could be involved. For example, Richard Blomefeld of Hemgrave, 'brekemaker', was to be paid in the following manner for 240,000 bricks made in 1505 for Little Saxham Hall, Suffolk: 'At the casting of his earth 40s, and when he begins to strike 40s, and within a month after 40s, and when he has burnt 120,000 then another 40s, within

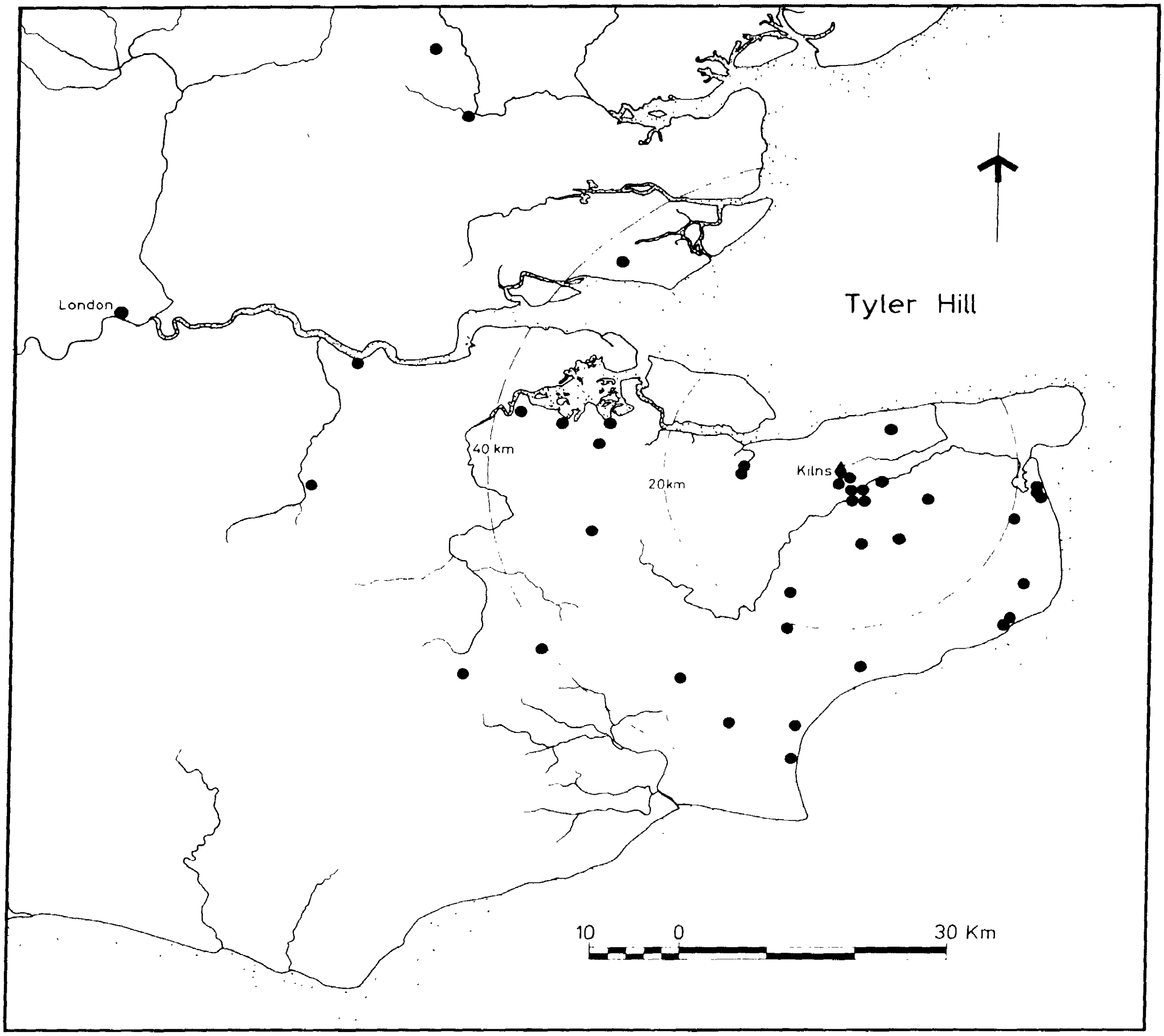


Fig 96 Distribution of floor tiles made at Tyler Hill, near Canterbury, Kent, in the 14th century, Based on fieldwork in Kent by Mark Horton and in Essex by the author: for London see Ward-Perkins 1940, fig 82.69

three weeks after that 40s, within a month after that 40s, and when he has finally finished his bargain, burnt and set out in stacks all the said brick, then to have the whole sum of £16 4s 4d' (Gage 1838, 141).

By whatever means they were distributed, it is apparent that floor tiles from a wide variety of sources reached many religious and large secular houses in south-east England from late in the 13th century until early in the 16th century. The pattern illustrated for Chelmsford Dominican Priory is not atypical of Essex houses (Fig 97).

From this survey of the industry, it is clear that the status of tilemakers varied enormously . The producers of the famous tiles at Chertsey Abbey were in the first rank of artists in England in the 13th century (Gardner & Eames 1954), whilst the literacy of both the makers and layers of the *opus sectile* and mosaic pavements at Warden Abbey is demonstrated by descriptive latin words and phrases, scratchched on the edges and backs of the raw segments, in an accomplished hand (Baker 1974). At the other extreme, the establishment at I.yveden (Steane & Bryant 1975, 38-43) lies firmly among the realms of lowly peasant craft, above which, in the opinion of Hodges (1974, 40) and Le Patourel (1968), the contemporary pottery industry rarely if ever rose.

Raw materials, techniques, and production centres

A picture of the physical nature of the production sites and the methods used is emerging from excavations and documentary study, despite a tendency for

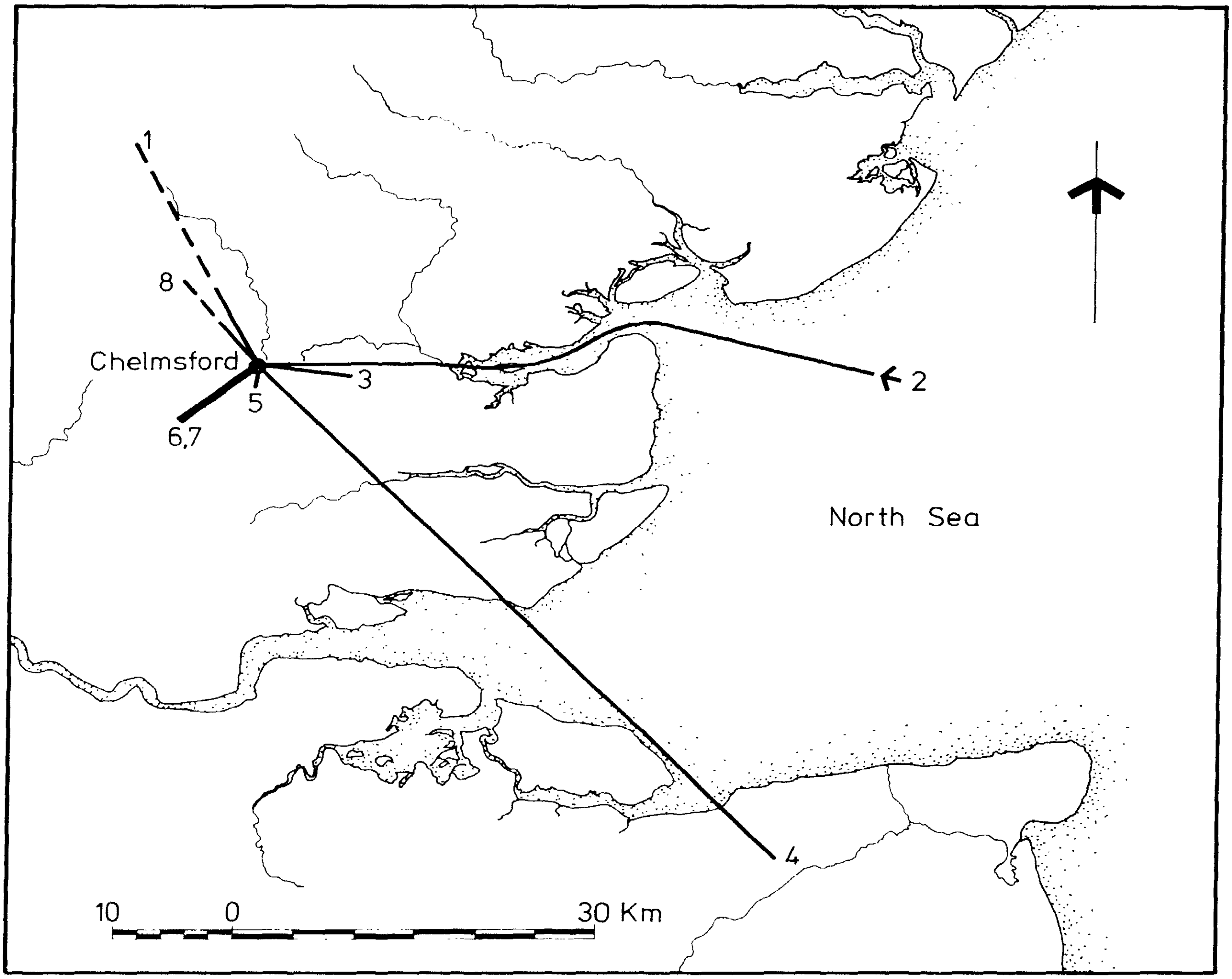


Fig 97 Know sources of floor tiles used at the Dominican Priory in Chelmsford during the medieval period; where dotted lines are used, the location of the factory site is uncertain. The groups shown an as follows: 1 Essex group of line-impressed mosaic pavements: 2 inlaid tiles, imported from northern France: 3 Danbury: 4 Tyler Hill: 5 Moulsham on documentary evidence a source of roof tiles, and almost certainly a source of floor ules): 6,7 Mill Green A and B: 8 Central Essex group. Source: Drury & Norton forthcoming

excavation, guided by geophysical survey, to concentrate on kilns alone (eg Nash Hill, Wilts; McCarthy 1974). Permanent tileries tend to be sited near a supply of clay and sand (or brickearth), of water, and a source of fuel, generally wood; a substantial and well-drained working area is required, with easy access to road and perhaps water transport, and proximity to a marketing hinterland capable of supporting the enterprise. In Essex, these factors are apt to result in the concentration of the industry in areas like Danbury, on marginal land with mixed gravel and clay subsoils, much of which was (and still is) managed woodland. Three market towns — Maldon, Chelmsford, and Witham — lie within 8 km.

Elsewhere, kilns are often found on the limits of large towns, but the problems of such locations are underlined by regulations drawn up at Beverley in 1461, ordering that 'on account of the stench, fouling the air and the destruction of fruit trees, no one is to make a kiln to burn tile nearer to the town than the kilns now are, under penalty of a fine of 100s' (Salzman 1913, 126). The kilns were probably used to fire glazed tiles, which would produce lead fumes capable of killing trees.

Materials needed by the tilers in relatively small quantity could be brought from some distance. These included sand, for example at Hull in the 15th century (Brooks 1939, 160), white clay for slips and inlays, known to have been transported at least SO km,[25] and lead for glazing, doubtless acquired from markets in the larger towns,

By a statute of 1477 (17 Ed IV, c iv), which probably codified current good practice, the clay had to be dug by 1 November, turned before the beginning of February, and not be made into tiles before March. The act was prompted by a concern about the poor quality and deficient size of many tiles produced. Earlier, in 1468, men of the Mistery of Tilers petitioned the Mayor, Alderman, and Common Council of London that, following the ordinance of 1461 declaring that tilers of the city should be reputed as labourers, and not be incorporated (Sharpe 1912, 12), tiles were so ill-made as to last for no more than 3 or 4 years rather than the 40 or 50 years which they used to do. They stated that the clay should be dug at Michaelmas, turned at Christmas, and made into tiles in the following March, the cause of the poor quality being that tiles were now being made 'soo hestely not havying the wether and process of tyme'. Their petition for the restoration of the franchises to the Fellowship of the craft was agreed, including provision for the election of two wardens to present falsely made tiles; all tiles were to conform to samples in the custody of the City Chamberlain (Sharpe 1912, 76-7). Here, it seems that the city tilers were involved in manufacture, but usually perhaps as the direct employers of tile-burners working outside the city, rather than as individuals making and firing tiles in London itself. A tile kiln was discovered near Farringdon Road, Clerkenwell, to the west of the walled city, about a century ago (Price 1870).

In 1595 the justices of Essex appointed two 'men of goode experyence and knowledge in thoccupacion of tyle making' to inspect the 46 tile kilns operating in the county, under powers vested in them by the 1477 Act. The products of all the kilns were found to be defective, either because they were not of full size, contained 'maulme marble & chalklyme', were underfired, or were made from unweathered clay. The tilemakers were warned about these bad practices, and were inspected again in the following year, by which time all but ten had mended their ways. Of these, Martin Diamante of Gosfield had 200 roof tiles 'wanting iij ynches lengthe'.[26] At Worcester in 1467, it was ordained that all tiles sold in the city should bear a maker's mark, to enable the manufacturers of defective tiles to be traced (Woof, n d, 43).

At Danbury (Fig 98) the clay as dug was probably stacked in the northern part of the enclosure; elsewhere clay stacks have been identified close to the workshops. In the spring the clay would receive the minimum of preparation before being made into bricks or tiles in the 'workhouse' or 'tilehouse'. Evidence from excavation at Danbury indicates that the workshop (Building B) was timber-framed in all its phases, and it is possible that its roof was thatched rather than tiled (Drury & Pratt 1975, 135-7). The probable workshop excavated at Boston was also apparently timber-framed (Mayes 1965, 86). Documentary evidence suggests similar buildings elsewhere. At Moulsham, Essex, the workshop was timber-framed, with wattle and daub infilling and a tiled roof; the mention of iron fastenings for corner tiles in 1373 suggests that the roof was hipped (Appendix, p 139). At Battle Abbey, carpenters were paid 8s for making a new house for the tilery in 1278-9 (Searle & Ross 1967, 46). In two phases, 1423-5, the tilehouse at Hull was rebuilt, of timber with daub infilling and a tiled roof (Brooks 1939, 158-9; but his interpretation of the result as a 'rough barn-like structure' is not justified by the evidence).

The equipment of the workshop at Hull in 1425 included four wheelbarrows, three sand tubs, three forming stocks, one trough, and five wooden moulds (bound with iron), and at other times, shovels and water tubs are mentioned (Brooks 1939, 157). Specifically industrial pottery is known from Meaux, Yorkshire (Eames 1961, 163-6).

Bricks and tiles were normally made by throwing a wedge of clay into a bottomless wooden mould or 'form' moistened and covered with sand to prevent the adherence of the clay. The form was either placed straight on the stock table, or on a palette or moulding board, itself also sanded, or located on a stock, a block of wood fixed to the table. The bases for these tables have been recognized in excavation at Danbury, Boston, and possibly Lyveden. At the former site other features were found within the workshop; their possible functions arc discussed in the report (Drury & Pratt 1975, 99-104, 135-6). The surplus clay was struck off the top of the form, and the resultant brick or tile, on or transferred to a palette board, would then be taken to the 'hackstead' to dry. At its most substantial this was probably a large, open-sided, timber-framed structure, such as Building C at Danbury; but at Hull and elsewhere it seems that the moulded bricks were covered with cloths called *nattes* supported on spars (Brooks 1939, 160). There are a few late medieval illustrations of the process (eg Wight 1972, pl I).

Firing of the dried tiles or bricks took place in kilns (in Kent sometimes called 'tyleostes': Salzman 1913, 124), or occasionally clamps. An updraught kiln with a single stoking pit and two firing tunnels was normally used (eg at Danbury; Drury & Pratt 1975), but larger kilns, eg at Nuneaton (Platt 1978, 119 & co1 pl N), could be fired from both ends. The tiles were stacked on the oven floor, formed of a series of arches over the firing tunnels, with sufficient intervening space for the hot gases to pass through. These then passed through the load and escaped through the open top, or through vents left in a temporary covering. The requirement was for a substantial, though controlled, blaze that would take the kiln up to *c* 1200°C and down again over a cycle of several days, the temperature being built up gradually to expel the remaining moisture from the bricks or tiles.

Wood was the usual fuel. At Kirby Muxlow in 1443, 9s 9d was paid for 'Fellyng and Brekyng of 78 loode of Wood', and another 2s 4d for 'a lode of spyldyng [refuse wood] to brene among the Grene wood in the kyln' (Thompson 1916, 307). Faggots were used at Wye in 1355 (Salzman 1913, 121) and at Little Saxham Hall in 1505 (Gage 1838, 142), whilst 'brush furs & broom' was in the stock of Samuel Moody at Runsell Green, Danbury in 1708 (Drury 1975, 209). *Turborum marisc-* - 'fen turves', ie peat-was used at Ely in 1334 (Chapman 1907, 2, 67) and at Hull in the 15th century (Brooks 1939, 159). Turf was occasionally used at Ingatestone, Essex in the 14th century," and coal could be used, for example at Boston (Mayes 1965, 96). Surprising as it may seem, archaeological and documentary evidence makes it clear that kilns were often housed inside buildings, generally of timber-framed construction. Traces of such a structure have been found at Radwinter, Essex (Cherry 1980, 262), whilst contemporaneously at Moulsham in Essex, the tenant in 1425 covenanted to keep the workshops and kiln covered with tile (Appendix, p 139). Some kilns, however, seem not to have been so protected, since at Wye in 1377 heavy autumn rain brought firing to a premature halt (Salzman 1913, 123).

At Danbury, there was no sign of occupation on or immediately adjacent to the site, and the only traces of 'domestic' occupation came from the vicinity of the small Building A, perhaps best interpreted as a lodge. The site at Boston (Mayes 1965), although not fully

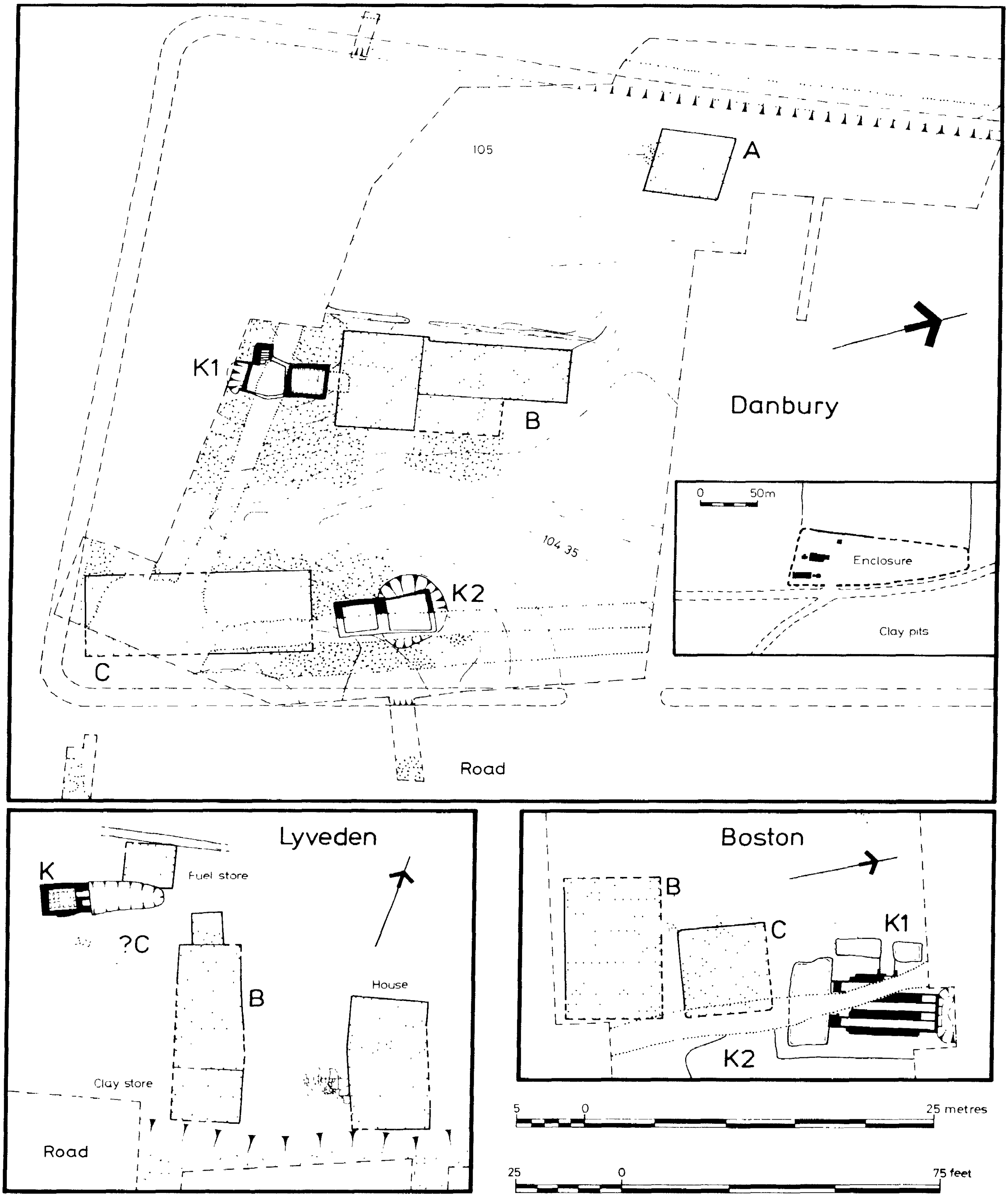


Fig 98 Comparative plans of literies: Danbury (after Drury & Pratt 1975, figs 35-6); Lyveden (after Steane & Bryant 1975, fig 12); Boston (after Mayes 1965, fig 2); The plans are interpretative and no internal or constructional features of the buildings are shown. key: A. loadge; B, workshop; C, drying shed; K, Kiln. Contours on the Danbury plan are in metres. Seale 1: 400, except inset, 1 : 5000

explored, produced little evidence of adjacent occupation and it is likely that the tilers concerned lived in the nearby town. The essential features of the site in its later phase are the same as those at Danbury - two kilns, with traces of a workshop and drying shed (Fig 98). Underlying this were the remains of a temporary clamp.

In clamp firing, bricks are normally stacked with fuel between them, or fossil fuel is incorporated into the brick clay (or may even occur naturally in it, as in Oxford clays). The stack is then ignited and allowed to burn under control. The resultant bricks are termed *fired or burnt* respectively (Mayes 1965, 91, and refs cited, esp Dobson 1903). The outer bricks are not well burnt;, and for this reason large clamps are more economical than small ones. Except as a temporary expedient, as seems to be the case at Boston in the early 14th century *(ibid),* their use seems to be little testified in England before the 16th century, although there was a 'brek clampe' at Calais in 1441 (Salzman 1952, 143). Clamps of about 180,000 bricks are recorded at Hunsdon House in 1525 and another (of about 125,000 bricks) in 1530 (Salzman 1952,144). At Wijk bij Duurstede, in the Netherlands, three brick clamps probably of late 15th century date have been found, probably associated with work at the adjacent castle (Hollestelle 1974). Here the green bricks at the base of the stack were used to form firing tunnels similar in layout to those of contemporary Dutch kilns (above, p 127). This is a more sophisticated arrangement than that usually envisaged in clamp firing; the capacity of the clamps was estimated at 50-60,000 bricks.

The only other published English site where the layout of the establishment is discernible is that at Lyveden, Northants (Fig 98; Steane & Bryant 1975). Here, an existing longhouse was shortened to form a normal dwelling, with a kiln, workshop with clay store (under cover?) to the south, and probably a drying shed alongside. The products were mostly roof tiles, and some plain floor tiles. The enterprise presumably served a very local market.

Conclusions

In this paper it has been possible to offer only an outline of the subject, based largely on secondary sources, as documentary research has been small in scale and wholly confined to Essex. Nonetheless, it seems clear that what is needed to further our knowledge of the manufacture and use of ceramic building materials in England is multi-disciplinary study, involving archaeologists, economic historians, technologists, and architectural historians, to draw together a subject which has latterly become extremely fragmented. Archaeology has a crucial role in such studies, but only if we can excavate factories rather than kilns, publish our building materials comprehensively, and relate the foundations of which they often form Dart to architectural traditions. Johnson's work at Norton has shown the value of experimental archaeology, and we can look forward to his impending reconstruction of a permanent type tile-built kiln.

Acknowledgements

Many colleagues have been kind enough to discuss various aspects of the subject with me, and have provided information in advance of their own publications; the end product has, I hope, benefited greatly as a result, but responsibility for the remaining errors is wholly mine. I must thank, in particular, Mrs J A Buck, J Clarke, Elizabeth Eames, Dr T J Hoekstra, Mark Horton, Philip Holdsworth, Barry Johnson, Laurence Keen, Christopher Norton, Dr Warwick Rodwell, and R G Thomson; information from them, and others, on specific points is acknowledged in the text. I am also grateful to Steven Freeth, Gillian Sheldrick, and Sarah Welch for documentary research in the Essex Record Office, some specifically undertaken in connection with this paper.

Appendix: The manorial tile kiln of Moulsham, Chelmsford, Essex

A detailed study of the manor of Moulsham, within the parish of Chelmsford and including the principal medieval suburb of the town, is being undertaken by Chelmsford Excavation Committee in connection with the excavations undertaken there during the past decade. The research was begun by Steven Freeth and has been continued by Gillian Sheldrick and Sarah Welch, financed by the Manpower Services Commission under JCP and STEP; the results will be published in the Chelmsford Excavation Committee Reports series, within the CBA Research Report series.

The manor of Moulsham was held, until the dissolution, by Westminster Abbey, and the following notes are derived from documents now in the Essex Record Office. Leases of the tilery, in existence by 1373, are recorded in the court rolls as follows:

D/DM M30: 21 Dec 1390: To John Made11 'tylere' for 5 years at 13s 4d and 2000 tiles *per annum.* On 24 July 1398, Roger Pack, Prior of the Dominican Friars of Moulsham, commenced a suit against John 'Madil' for failure to supply 4000 roof tiles as agreed.

D/DM M30: 19 Dec1397: To John Madell for 12 years at 13s 4d and 3000 'tegulae planae' *per annum.*

D/DM M30: 26 Sept 1399: To John Serle 'de yengerafes' (Ingrave), 'tyler', his wife Joan, and his sons William and John for 12 years at 20s and 100 'holwerke' tiles *per unnum.*

D/DM M31: 27 Sept 1403: To Robert Typpe for 7 years at 13s 4d and 50 'holwerke' and 1000 'playnewerke' tiles *per annum.*

D/DM M31: 24 July 1410: To Robert Typpe for 12 years at 13s 4d and 50 'holwerke' and 1500 'playnewerke' tiles *per annum.*

D/DM M32: 24 Sept 1422: To John Atteffeld for 10 years at 10s and 1000 tiles *per annum.*

D/DM M33: 29 May 1425: To John Atteffeld of Moulsham 'tyler' for 10 years at 10s and 1000 'playnewerke' and 100 'holwerke' tiles *per annum.*

D/DM M33: 17 Dec 1427: To John Sheryng of Moulsham 'tyler' for 10 years at 10s and 100 'holwerke' and 1000 'playnewerke' tiles *per annum.*

Thereafter, the bailiff's accounts simply recite John Sheryng in the rent list until the 16th century; no new leases are recorded.

The *compoti* record the rents paid, in cash and kind, each year, and the use of the 'tiles received for the maintainance of manorial properties. The types of tile are consistently recorded in latin as *tegulae planae* and *tegulae concavae,* ie flat (normal roof) tiles and concave (ridge) tiles, corresponding to the 'playnewerk' and 'holwerke' normally used in the court rolls.

The lease to John Atteffeld, 29 May 1425, is sufficiently informative to be worth quoting in translation:

> At this court the lord granted and leased to John Atteffeld of Moulsham, tiler, his tile kiln *(torale tegularum)* with the workhouses built upon it *(cum domibus superedificatis)*, to have and to hold the same from the lord at farm . . . from Michaelmas next to come until the end . . . of 10 years . . . paying yearly to the lord at the usual terms 10s and 1000 tiles of 'playnwerke' at the feast of the birth of St John the Baptist and at the same feast 100 of the tiles called 'holwerke'. And the said tiler will keep the aforesaid workhouses and kiln well covered with new tiles at his own costs. And the lord will find 'lathys' and 'tylepyns' and 'lathenayles' at his own cost for strengthening and covering the said workhouses with tiles etc, at the start of the said term, and will also provide the timber for structural repairs *(ad dictas domos edificandas et reparandas)* to the said workhouses when necessary during the said term. And the farmer shall have all the 'loppes' and 'chippys' falling upon the said timber during the said term . . .

The *compoti* provide further details of the tilehouses or workshops: the following entries are particularly informative:'

1373: D/DM M83		
To 5000 plain tiles bought to cover the tile-house	20s	
To the tiler working on the tile-house	4s	2d
To six bushels of lime bought for the said roofer		10d
To 150 iron fastenings to attach corner tiles		9d
1424-5: D/DM M115		
For repairing and daubing the wall(s) of the tile-house	1s	4d
1427-8: D/DM M117		
To 1000 tiles bought for the tile-house from J Attewelle	3s	4d
To carriage of the said tiles by the farmer		8d
To timber cut down for the same house		3d
To carriage of the said timber for the same house		16d
To 2000 tiles* bought from Phil Yngelfeld	6s	8d
To carriage of the same	2s	
To fixing 3500 tiles upon the said house with 'tilpyns' and nails to the same	4s	6d
To 2 'motldyngebord' bought for the tile-house		14d
To 800 'concav' tiles bought	2s	4d
To 'dawbynge' and 'pynynge' [the walls there]	2s	
To 200 nails bought for the corner 'angular' tiles	[missing]	
To wages of Wm Adam, carpenter, mending and 'grouncilling' the tile-house	7s	4d

* 'fir toral' written above - possibly means 'farmer of the kiln' and may refer to the accounting system, ie may be an item deducted or added to the overall cost of the kiln.

Notes

1 For a recent review of the production of tiles in Roman Britain see McWhirr & Viner 1978; and for a wider view, McWhirr 1979.

2 The trade in Devon slates, first described by Jope and Dunning (1954), provides perhaps the best example. Since that paper was written, their distribution has been extended into London (eg Tatton-Brown 1974, 204–5), and Essex, at Waltham Abbey (Huggins 1972, 115; 1976, 124, in a context dated *c* 1250–1350), Latchingdon Church (Couchman 1979, 26), and Colchester Castle (Drury *et al* 1981). Their use at a royal castle so distant from their source causes less surprise than their appearance at the small rural church of Latchingdon, where they seem to have covered the roof of the earliest masonry building on the site, probably erected early in the 13th century. Such use suggests that ceramic roofing tiles were not yet available in the area. However, slates were imported from Salcombe in Devon to Thorndon Hall, Essex, in 1587 to cover the roof of the banqueting house (Ward & Marshall 1972, 3). This is evidently a reflection of a fashion for their use on parts of a number of grand Elizabethan houses in south-east England, including also Theobalds, Herts (Summerson 1959, 118–9).

3 Rivenhall (Rodwell & Rodwell 1973, 223–5) provides an example of the use of Roman tile around the beginning of the 11th century, Copford and Easthorpe churches of its use early in the 12th (RCHM, *Essex*, **3**, 76, 91). Asheldham, Phase II, with stone dressings, belongs probably to the late 11th or early 12th centuries, perhaps pre-1135 (Drury & Rodwell 1978, 141), and Hadleigh belongs to the middle of the 12th century (RCHM, *Essex*, **4**, 62–3). Great Tey church has a Saxo-Norman tower with tile dressings, surmounted by a Norman belfry with stone dressings (Taylor & Taylor 1965, **2**, 609–11; RCHM, *Essex*, **3**, 129–31). Dr Rodwell has also pointed out that the use of Roman brick in Saxon churches in Essex was selective — there are several examples of churches, eg Hadstock (Rodwell 1976, 60) and Chickney, where all quoins were formed in flint despite the undoubted local availability of Roman material.

4 Gardner (1955, 31) suggests that the kiln found in 1845 at Tilkey, to the north of Coggeshall village, in fact produced the early bricks, quoting Cutts, who in 1858 stated that it was associated with 'moulded bricks like those of the abbey'. But manuscript notes by G F Beaumont (Essex Record Office, accn 5548) record the discovery in 1887 of early brick wasters immediately north-east of the abbey, in what seem to have been old clay pits. It is probable that the Tilkey kilns are later; the use of 15th century moulded brick at the abbey (Gardner 1955, 30, pl xii.1, xiv.4) might explain Cutts' observations.

5 Mention should also be made of Chipping Ongar Church, Essex, the quoins and string courses of which are of broken and in some cases wasted wall tiles and glazed nibbed tiles. Whilst it is not as early as the RCHM suggest (*Essex*, **2**, 52, where the tiles are said to be Roman), a date in the second half of the 12th century seems probable. I am grateful to Warwick Rodwell, who is studying the building, for bringing it to my attention. Polstead,

Suffolk (Wight 1972, 374), presents many problems which cannot be considered here.

6 For example, in the carriageway of the gateway at Waltham Abbey, *c* 1360; Huggins 1972, 112; RCHM, *Essex,* 2, 244; Drury 1977, 84.

7 But note that Hollestelle (1961, 273) regards all such small bricks in the Low Countries as being post *c* 1300.

8 I am grateful to Dr T J Hoekssa, City Archaeologist, Utrecht, for discussing these structures with me, and for drawing to my attention the kiln at t'Goy.

9 One dominant feature of the later medieval architecture of the Hanseatic towns was the gable, considered in itself as a decoration and used even in unsuitable situations, for example as the basis of a gatehouse (Perry 1894, esp 490-l). Might, therefore, the rather alien feeling of the brick gatehouse of Thornton Abbey, Lincs (1382-9), which presents an external facade in the form of an immense truncated gable, have some basis in fact, although its stone dressings are thoroughly English (Harvey 1978, 139, 142)? Thornton lies on the Humber estuary, not far from Hull. For descriptions and illustrations of Thornton see Wight 1972, 304-5 and pl 14; Clapham & Baillie Reynolds 1961.

10 Harley's suggestion (1976, 138-41) that the small 'Flemish' type of brick was inspired by those of Crete, Rhodes, and the Middle East seen by Europeans on the Crusades seems unnecessary.

11 But at this date were not always meant to be seen; eg, at the Sacrist's camera in the infirmary at Ely, for which bricks were burnt in 1334-5, and which had external walls of stone (Chapman 1907,1,36, 138-40; 2, 67). For another example at Ely, see Fletcher & Haslop 1969, pl xix B.

12 Newton 1970, 71; after 1427 the rent of the demesne lands of the manor was reduced by 6s 8d in respect of part taken from the lessee to form the site of a brickfield and kiln: *'p[er]fuctores de Bryke [et] conburac[i]o[n]em eor[un]d[e]m e[t] vstringa ib[ide]m constructa'*

13 I am grateful to Mark Horton for drawing to my attention a plain triangular glazed tile from pre-1163 levels in the Cathedral precinct at Canterbury, which presently seems to stand alone both in date and type in England, and may point to connections with contemporary *opus alexandrinum* work in Belgium.

14 The differences are being confirmed by Mark Horton's work on the riles in Kent, in progress.

15 The use of *stamp-on-slip* and *slip-over-impression* in Normandy is noted in Keen 1979b. C Norton (per-s comm) has now noted a single stencilled tile during his study of French tiles.

16 Information from C R Orton, who stated that the earliest fragments are too broken to be identified as nibbed or pegged; to date no definite nibbed examples have been identified from the City.

17 For mid 13th century production at Winksley, nr Ripon, Yorks, see Bellamy & Le Patourel 1970, 111.

18 In London, a City Assize of 1277-8 stipulated that tiles be well-burnt and well-leaded, and of ancient pattern (Bell 1938, 5); 'well-leaded' must refer to the practice of glazing roof tiles, as at the almost contemporary site at Danbury (Drury & Pratt 1975, 111). At Colchester in 1426 'Great compleynt is made . . . of the Tylemakers, the whiche maken her tyll bi diverse fourmes, more and less, none of hem accordaunt to other. . . wherefore hit is ordeyned and enstablished by the said Bailifs and the Generall Counseill that no maner Tylemaker of the said town of Colchester . . . make no maner tyll, but all of one lengthe and of one brede, suffisauntly made after a fourme thereto made, acordaunt to a standard abidying in the moot halle of the said toun, upon peyne of xx s as often tyme as he is foundyn in defaut ...' (Benham 1902,49, also quoted in VCH, *Essex,* 2, 356).

19 The tiles from Temple Dinsley, Herts are in the British Museum, nos 504 and 1160; I am grateful to Elizabeth Eames for drawing them to my attention, and to Laurence Keen for confirming their unique nature in the county. Those from Chelmsford Dominican Priory were found in unpublished excavations by Mrs E E Sellers, D J Biglin, and the writer, 1968-76, and will be included in Drury & Norton forthcoming. The fragments from Mill Green were found by Mrs Sellers in excavations in 1968 (Sellers 1970), and are briefly mentioned in Drury 1977, 106, where they are designated 'Mill Green A' to distinguish them from later 14th century products of the same area.

20 In a lecture given to the Cambridge Tile Seminar, November, 1978.

21 ERO, D/DPr 59, p 75.

22 Here the firing of bricks on the estate probably began *c* 1763 in connection with the reconstruction of the house by Sir John Griffin Griffin (Williams 1966,9-11), but continued through the following century, the products partly meeting estate needs and partly being sold; ERO, D/DBy, A352-6.

23 ERO, D/DP M21.

24 The best example seems to be Robt Tyllere, who in 1369 was involved in a suit over 5 acres of land (ERO, D/DP M21). In 1379 he was admitted, with Alice his wife, to a messuage, 7 acres of land formerly Hurtes tenement and a toft and 15 acres formerly of Peter Capse (D/DP M22). In 1386 he was licensed to let on lease a cottage and 2½ acres of land (D/DP M24); in 1398 he similarly received licence to lease a messuage and three crofts adjoining to Thomas Sleyther (D/DP M29). In 1413 he conditionally surrendered a messuage and 6 acres called Harryes to his son Thomas Tilere and his wife Laurencie (D/DP M32), and in 1416 he was admitted with his (second?) wife Katherine to a tenement and ten acres formerly Capses and Hurtes in Capseslane on their own surrender (D/DP M33).

25 There are two documented instances; carriage from Leeds to Thornton Abbey, Lincs, in 1313 (quoted in Keen & Thackray 1974,154, n 12); and from Farnham, Surrey to Otterbourne, Hants, in 1395-6 (Norton 1976, 30).

26 The offenders are listed, but not, unfortunately, those who amended their ways; ERO, Q/SR 137/73, brought to my attention by Bob Wood of the ERO.

27 In 1385, Wm Tyler was granted licence to dig sand *(zabulane)* and turf *(turbar)* on Hanleywood Common, Ingatestone, to make tiles, for ten years, at a rent of 2d pa. In 1387 Robt Tyler dug turves in the lord's common at 'Hanlewode' without licence, and was fined 2d; ERO, D/DP M24.

Bibliography

Baker, D, 1974 Bedfordshire Rescue: Round up, *Curr Archaeol*, **4.12**, 369–72

Bell, W G, 1938 *A short history of the worshipful company of tylers and bricklayers of the City of London*

Bellamy, C V, & Le Patourel, H E J, 1970 Four medieval pottery-kilns on Woodhouse Farm, Winksley, near Ripon, W Riding of Yorkshire, *Medieval Archaeol*, **14**, 104–25

Benham, W G (ed), 1902 *The red paper book of Colchester*

Biddle, M, 1964 Excavations at Winchester 1962–3: second interim report, *Antiq J*, **44**, 188–219

Biek, L, & Evans, J, 1979 Characterisation of white clay inlay and slips, in Drury, 1979, 5–7

Bilson, J, 1896 The North Bar, Beverley, *Trans East Riding Antiq Soc*, **4**, 38–49

Brooks, F W, 1939 A medieval brick-yard at Hull, *J Brit Archaeol Ass*, 3 ser, **4**, 151–74

Chapman, F R (ed), 1907 *Sacrist rolls of Ely*, 2 vols

Chatwin, P B, 1936 The medieval patterned tiles of Warwickshire, *Trans Birmingham Warwickshire Archaeol Soc*, **60**, 1–41

Cherry, J, 1980 Medieval Britain in 1979: 2 Post-conquest, *Medieval Archaeol*, **24**, 236–64

Chew, H A, & Kellaway, W (eds), 1973 *The London Assize of Nuisance 1301–1431*, London Rec Soc, **10**

Clapham, A, & Baillie Reynolds, P K, 1961 *Thornton Abbey, Lincolnshire*, DoE Guidebook

Clarke, H, & Carter, A, 1977 *Excavations in King's Lynn 1963–70*, Soc Medieval Archaeol Monogr Ser, **7**

Coleman, O (ed), 1960 *The brokage book of Southampton, 1443–44*, Southampton Rec Ser, **5.4**

Couchman, C R, 1979 Excavations at St Michael's Church, Latchingdon, 1976, *Essex Archaeol Hist*, **11**, 6–31

de Keyzer, L M J, 1973 Middeleeuwse Steenoven in t'Goy, *Spiegel Historiael*, **1973. 1**, 45–50

Dobson, E, 1903 *A rudimentary treatise on the manufacture of bricks and tiles*, 4 edn, now reprinted by Celoria, F, *J Ceramic Hist*, **5**, 1971

Drury, P J, 1975 Post-medieval brick and tile kilns at Runsell Green, Danbury, Essex, *Post-Medieval Archaeol*, **9**, 203–11

——— (ed), 1976 Braintree: excavations and research, 1972–6, *Essex Archaeol Hist*, **8**, 1–143

———, 1977 *Brick and tile*, in Williams 1977, 82–124

———, 1978 A Saxon loomweight and medieval tile-kiln at Blackmore, *Essex Archaeol Hist*, **10**, 234–6

——— (ed), 1979 *Synopses of papers presented to the Cambridge tile seminar, November 1978*

——— (ed), 1980 *Synopses of papers presented to the York tile seminar, December 1979*

———, forthcoming The floor tiles, in Rodwell & Rodwell forthcoming

Drury, P J, Hull, M R, & Niblett, B R K, 1981 Contributions to the study of Colchester Castle and the Temple of Claudius, *Essex Archaeol Hist*, **13**, forthcoming

Drury, P J, & Norton, E C, forthcoming *Medieval floor tiles in Essex, Cambridgeshire and Suffolk*, BAR, forthcoming

Drury, P J, & Pratt, G D, 1975 A late 13th and early 14th century tile factory at Danbury, Essex, *Medieval Archaeol*, **19**, 92–164

Drury, P J, & Rodwell, W J, 1978 Investigations at Asheldham Essex: an interim report on the Church and the historic landscape, *Antiq J*, **58**, 133–51

Eames, E S, 1955 The products of a medieval tile kiln at Bawsey, King's Lynn, *ibid*, **35**, 162–81

———, 1958 A tile pavement from the Queen's Chamber, Clarendon Palace, dated 1250–2, *J Brit Archaeol Ass*, **20–1**, 95–106

———, 1961 A thirteenth-century tile kiln site at North Grange, Meaux, Beverley, Yorkshire, *Medieval Archaeol*, **5**, 137–68

———, 1963 A thirteenth-century tiled pavement from the King's Chapel, Clarendon Palace, *J Brit Archaeol Ass*, **26**, 40–50

———, 1968 *Medieval tiles: a handbook*, British Museum

———, 1977 General foreword, in Emden 1977, 1–12

Emden, A B, 1977 *Medieval decorated tiles in Dorset*

Enlart, C, 1924 *Manuel d'archéologie française*, Paris

Everson, P, 1977 Excavations in the vicarage garden at Brixworth, 1972, *J Brit Archaeol Ass*, **130**, 55–132

Everson, P, & Parsons, D, 1979 *Brixworth Church — are the bricks really Roman?* in McWhirr 1979, 405–11

Evison, V I, Hodges, H, & Hurst, J G (eds), 1974 *Medieval pottery from excavations*

Fletcher, J M, & Haslop, F W O, 1969 The west range at Ely and its romanesque roof, *Archaeol J*, **126**, 171–6

Gage, J, 1838 *The history and antiquities of Suffolk: Thingoe hundred*

Gardner, J S, 1955 Coggeshall Abbey and its early brickwork, *J Brit Archaeol Ass*, **18**, 19–32

Gardner, J S, & Eames, E S, 1954 A tile kiln at Chertsey Abbey, *J Brit Archaeol Ass*, **17**, 24–42

Greene, J P, 1975 *Norton Priory* (guidebook, published by Norton Priory Museum Trust)

Greene, J P, & Johnson, B, 1978 An experimental tile kiln at Norton Priory, Cheshire, *Medieval Ceramics*, 2, 30–42

Haberley, L, 1937 *Medieval English paving tiles*

Halbertsma, H, 1963 Een Middeleeuwse Steenoven bij Deersum, Friesland, *Berichten ROB*, **13**, 326–35

Harley, L S, 1976 Bricks of eastern England to the end of the Middle Ages, *Essex J*, **10.4**, 134–41

Harvey, J, 1975 *Medieval craftsmen*

———, 1978 *The perpendicular style 1330–1485*

Hinton, D, 1977 Fashions in floor-tiles, in Peacock 1977, 307–12

Hodges, H, 1974 The medieval potter: artisan or artist? in Evison *et al*, 1974, 33–40

Hohler, C, 1942 Medieval paving tiles in Buckinghamshire, *Rec Buckinghamshire*, **14**, 1–49, 99–132

Hollestelle, J, 1961 *De Steenbakkery in de Nederlanden tot om streeks 1560*

———, 1974 Soil marks of late medieval brick clamps at Wijk bij Duurstede, *Berichten ROB*, **24**, 185–9

Huggins, P J, 1972 Monastic grange and outer close excavations, Waltham Abbey, Essex, 1970–1972, *Essex Archaeol Hist*, **4**, 30–127

———, 1976 The excavation of an 11th-century viking hall and 14th-century rooms at Waltham Abbey, Essex, 1969–71, *Medieval Archaeol*, **20**, 75–133

Hurst, J G (ed), 1979 *Wharram: a study of settlement on the Yorkshire Wolds*, **1**, Soc Medieval Archaeol Monogr Ser, **8**

Jope, E M, & Dunning, G C, 1954 The use of blue slate for roofing in medieval England, *Antiq J*, **24**, 209–17

Keen, L, 1971 Medieval floor-tiles from Campsea Ash Priory, *Proc Suffolk Inst Archaeol*, **32**, 140–51

———, 1976 The floor tiles, in Discoveries at Horsham St Faith Priory, 1970–3 (D Sherlock), *Norfolk Archaeol*, **36.3**, 202–23

———, 1979a Late Saxon polychrome relief tiles, in Drury 1979, 27–8

———, 1979b Normandy tiles, in Drury 1979, 25

———, 1980 The medieval floor tiles, in *Excavations at Denny Abbey, Cambridgeshire* (eds P M Christy & J G Coad), *Archaeol J*, **137**

Keen, L, & Thackray, D, 1974 A fourteenth-century mosaic tile pavement with line-impressed decoration from Icklingham, *Proc Suffolk Inst Archaeol*, **33**, 153–67

Knight, S, & Keen, L, 1977 Medieval floor tiles from Guisborough Priory, Yorkshire, *Yorkshire Archaeol J*, **49**, 65–75

Knowles, D, 1949 *The monastic order in England*

Lane, A, 1960 *A guide to the collections of tiles in the Victoria and Albert Museum*, HMSO

Le Patourel, H E J, 1968 Documentary evidence and the medieval pottery industry, *Medieval Archaeol*, **12**, 101–26

Lindley, E S, 1952 Stone tiles, *Trans Bristol Gloucestershire Archaeol Soc*, **71**, 167–8

Lloyd, N, 1925 *A history of English brickwork*

Lower, M A, 1859 A medieval pottery at Hastings, *Sussex Archaeol Collect*, **11**, 229–30

Mayes, P, 1965 A medieval tile-kiln at Boston, Lincolnshire, *J Brit Archaeol Ass*, **28**, 86–106

McCarthy, M R, 1974 The medieval kilns on Nash Hill, Lacock, Wiltshire, *Wiltshire Archaeol Natur Hist Mag*, **69**, Part B, 97–160

McWhirr, A D (ed), 1979 *Roman brick and tile*, BAR **S68**

McWhirr, A D, & Viner, D, 1978 The production and distribution of tiles in Roman Britain with particular reference to the Cirencester region, *Britannia*, **9**, 359–77

Musty, J, 1974 *Medieval pottery kilns*, in Evison *et al* 1974, 41–66

Nesbitt, A, 1863 On the brick architecture of North Germany, *Archaeologia*, **39**, 93–111

Newton, K C, 1970 *The Manor of Writtle*

Norton, E C, 1976 The medieval paving tiles of Winchester College, *Proc Hampshire Fld Club Archaeol Soc*, **31**, 23–42

———, 1980 *French mosaic tiles of the twelfth and thirteenth centuries*, in Drury 1980, 4–5

Peacock, D P S (ed), 1977 *Pottery and early commerce — characterisation and trade in Roman and later ceramics*

Perry, J Tavenor, 1894 The influence of the Hanseatic League on the architecture of northern Europe, *J Roy Inst British Architects*, 3 ser, **1**, 473–94

Platt, C, 1978 *Medieval England*

Platt, C, & Coleman-Smith, R, 1975 *Excavations in medieval Southampton 1953–69*, 2 vols

Ponsonby, Lord, & Ponsonby, M, 1934 Monastic paving tiles, with special reference to tiles discovered at Shulbrede Priory, Lynchmere, *Sussex Archaeol Collect*, **75**, 19–64
Postan, M M, 1973 *Medieval trade and finance*
Price, J E, 1870 Medieval kiln for burning encaustic tiles discovered near Farringdon Road, Clerkenwell, *Trans London Middlesex Archaeol Soc*, **3**, 31–6
Rahtz, P A, 1969 *Excavations of King John's Hunting Lodge, Writtle, Essex, 1955–7*, Soc Medieval Archaeol Monogr Ser, **3**
Rahtz, P A, & Hirst, S, 1976 *Bordesley Abbey, Redditch, Hereford-Worcestershire: first report on the excavations, 1969–73*, BAR **23**
RCHM Royal Commission on Historical Monuments, *Essex*, 4 vols, 1916–23
Riley, H T, 1868 *Memorials of London life in the XIIIth, XIVth, and XVth centuries*
Rodwell, W J, 1976 The archaeological investigation of Hadstock Church, Essex: an interim report, *Antiq J*, **56**, 55–71
——, forthcoming *Coggeshall Abbey bricks*
Rodwell, W J, & Rodwell, K A, 1973 Excavations at Rivenhall Church, Essex: an interim report, *Antiq J*, **53**, 219–31
——, & ——, forthcoming *Rivenhall: investigations on the villa, church and village 1950–77*
Salter, H, 1913 An early mention of bricks, *Berkshire Buckinghamshire Oxfordshire Archaeol J*, **19**, 91
Salzman, L F, 1913 *English industries of the Middle Ages*
——, 1931 *English trade in the Middle Ages*
——, 1952 *Building in England down to 1540*
Searle, E, & Ross, B, 1967 *The Cellarer's Rolls of Battle Abbey, 1275–1513*, Sussex Rec Soc, **65**
Sellers, E E, 1970 Ingatestone-Mill Green TL 643002, *Trans Essex Archaeol Soc*, 3 ser, **2**, 337–8
Sharpe, R R, 1905 *Calendar of letter-books of the City of London: letter-book G*
——, 1912 *Calendar of letter-books of the City of London: letter-book L*
Smallwood, J, 1978 A medieval tile kiln at Abbey Farm, Shouldham, *E Anglian Archaeol*, **8**, 45–54
Smith, Toulmin, 1870 *English guilds*, Early English Text Soc, **40**
Smith, T P, 1976 The early brickwork of Someries Castle, Bedfordshire and its place in the history of English brick building, *J Brit Archaeol Ass*, **129**, 42–58
Steane, J M, & Bryant, G F, 1975 Excavations at the deserted medieval settlement at Lyveden, Northants: fourth report, *J Northampton Mus*, **12**, 1–161
Stevens, F, 1935 The inlaid paving tiles of Wilts, *Wiltshire Archaeol Natur Hist Mag*, **47**, 358–78
Summerson, J, 1959 The building of Theobalds, 1564–1585, *Archaeologia*, **97**, 107–26
Tatton-Brown, T, 1974 Excavations at the Custom House site, City of London, 1973, *Trans London Middlesex Archaeol Soc*, **25**, 117–219
Taylor, H M, 1978 *Anglo-Saxon architecture*, **3**
Taylor, H M, & Taylor, J, 1965 *Anglo-Saxon architecture*, **1–2**
Thompson, A H, 1916 The building accounts of Kirby Muxloe Castle, 1480–1484, *Trans Leicestershire Archaeol Hist Soc*, **11**
Vidler, L A, 1932 Floor tiles and kilns near the site of St Bartholomew's Hospital, Rye, *Sussex Archaeol Collect*, **73**, 83–101
Vince, A, 1977 The medieval and post-medieval ceramic industry of the Malvern region: the study of a ware and its distribution, in Peacock 1977, 257–305
Walker, J S F, 1978 Excavations in medieval tenements on the Quilter's Vault site in Southampton, *Proc Hampshire Fld Club Archaeol Soc*, **35**, 183–216
Ward, J C, & Marshall, K, 1972 *Old Thorndon Hall*, Essex Record Office Publ, **61**
Ward-Perkins, J B, 1937 English medieval embossed tiles, *Archaeol J*, **94**, 128–53
——, 1940 *London Museum medieval catalogue*, HMSO
Webster, L E, & Cherry, J, 1973 Medieval Britain in 1972, *Medieval Archaeol*, **17**, 138–88
Whitcomb, N R, 1956 *The medieval floor tiles of Leicestershire*
Wight, J A, 1972 *Brick building in England from the Middle Ages to 1550*
Williams, F, 1977 *Pleshey Castle, Essex (XII–XVI century): excavations in the Bailey, 1959–63*, BAR **42**
Williams, J D, 1966 *Audley End: the restoration of 1762–1797*, Essex Record Office Publ, **45**
Wilson, D M, & Hurst, D G, 1967 Medieval Britain in 1966, *Medieval Archaeol*, **11**, 262–319
Woof, R, nd (pre-1870) Worcester guilds and ordinances, *Worcester Tracts*, **2**
Young, C J, 1977 *The Roman pottery industry of the Oxford region*, BAR **43**

Since this paper went to press, Elizabeth Eames's *Catalogue of medieval lead-glazedearthenware tiles in the Department of Medieval and Later Antiquities, British Museum* (2 vols, 1980) has appeared. This work is of fundamental importance to the study of any aspect of the production of floor tiles in medieval England.

The evolution of most industrial processes can be traced by the passing of technological milestones, and glass-making is no exception. Unfortunately, by the time glass first seems to have been produced in this country many of these milestones had already been passed. As a result, and even within the most elastic confines of the medieval period, there are few consistent criteria available for defining a suitable starting point or a suitable end point. This is confirmed by the surviving manuals on glass-making whose contents reflect traditions that remained essentially unchanged over a period of 1600 years. Only in the use of specific types of material is there any significant alteration to the standard pattern, and even here there is no clear-cut dating. Archaeological examination is equally difficult. It is possible to examine sites where glass-making took place, but the operation was semi-nomadic and is a poor archaeological survivor. Trying to understand the medieval glass industry by archaeological means is no different from trying to understand Roman military architecture by examining marching camps. The problem is complicated further by the presence of two product types. On the one hand there arc vessels and on the other hand windows. They have their own typologies, their own histories, and their own production techniques yet both belong to the same art. Art is an appropriate word for at this time neither science nor industry seems a fitting term.

The only sensible starting place is after the cessation of Roman dominance because it was then that Britain was lett technologically unarmed and it was on the basis of the reintroduction of glass-making into this country that medieval production developed. From the earliest times it was a technique to which the English found great difficulty in adapting. The work that took place in this country was carried out for the most part by foreigners, and there is much evidence to show that even by the 16th century the English were unfamiliar with glass-making principles. In theory the process is a simple one - it requires the fusion of two natural materials, sand and an ash product. Both were readily available and the techniques of production which lay somewhere between ceramics and metallurgy required only the slight modifications of processes already known and used throughut the Middle Ages.

Anglo-Saxon England

It may be assumed that from the effective end of Roman Britain the art of glass production in Britain for either vessel or window was unpractised on a commercial basis for a considerable time, possibly until as late as the 1220s. The barbarian-occupied Rhineland houses such as those in Belgium investigated by Chambon and Arbman (1951-2) still flourished, and the pagan burials from most areas of Germanic Europe are evidence enough of their output. It is conceivable that certain Anglo-Saxon types such as the bag-beaker may have been produced in Britain and that Kent may have had its own production centre. I have maintained elsewhere (Hunter 1980) some possibility of localized manufacture for part of the Hamwih material, although on a smaller commercial basis than the only contemporary centre known, at Cordel near Trier. I have argued the same case for Scandinavia (Hunter 1977a) --a region where the levels of technological development were directly comparable. In all cases the argument is conjectural and based on distribution, typology, and some elemental analysis, but not on archaelogical site evidence because there is virtually none available. Glass-working at a more rudimentary level is better supported archaeologically. From the 5th to 7th centuries, particularly in the Highland Zone, such sites as the-Mote of Mark and Dinas Powys appear to show glass fragments used for melting down in the production of beads and other objects. Similar activities were carried out slightly later at Ribe, Denmark. and Heleö, Sweden. None of these sites has yielded any evidence that glass itself was being produced.

The problem of vessels is not helped by the advent of Christianity from the late 7th century, which successfully removed the most valuable of all archaeological contexts, the pagan burial. Our knowledge of--glass of the pagan period has not progressed significantly over recent years, certainly little since Dr Harden's typology drawn up in 1956 (Harden 1956a). The great hall of Heorot would doubtless have fostered the kind of social market that sustained the high-class houses of the Continent, yet at the same time one suspects it was a market which was adapted rather than intended. Our knowledge of Anglo-Saxon settlement is perhaps insufficient to say whether the later vessel forms were entirely appropriate for the settings in which they must have been used. From the 7th century they become noticeably more fragile and without standing bases. Their capacity too becomes less, a fact which Hartshorne first observed (1897, 24) pointing out that 'the historical and proverbial insobriety of their users was brought about not by deep draughts from great cups, but by the more perilous process of reiterated appeals to small ones'. When one considers glass in Anglo-Saxon England there is a strong element of incongruity between product and environment, perhaps sufficient at least to suggest that there was no home-based supply. It must be maintained that glass was a commodity of some value and according to burial evidence throughout north-west Europe a material which was particularly fitting to the higher end of the social scale (Hunter 1975). Nevertheless, I have always found it disturbing that arguably the two greatest visions we have of the Dark Ages (Sutton Hoo and *Beowulf)* are both devoid of any glass evidence.

The Christian era did, however, bring with it two distinct advantages. First through the early writings and hagiographies, it gives us the early recorded evidence for the use of glass, albeit mostly inexplicit, and second it provided patronage for the growing technology of window glass. Bede's much-quoted account (Bede *HA, 5)* of the glazing of the monastic buildings at Monkwearmouth carried out by continentals towards the close of the 7th century is perhaps the closest we come to a contemporary record. At about the same time Wilfrid's restoration of King Edwin's church at York had glazed windows *(Vita S Wilfride,* 2, 59, 16), while by the early 8th century Wilfrid, Bishop of Worcester, had substituted glass in the openings of his church in place of wooden lattices (Hartshorne 1897, 113). Glazing was new to Anglo-Saxon England. It depended on stone-built structures (by definition ecclesiastical) which themselves usually required continental expertise. Window glass production did not take place on a large-scale basis and has to be seen as an ecclesiastically orientated temporary activity. There is the added complication of establishing whether the craftsmen brought their raw materials with them, or indeed the finished product, or whether they managed to find their requirements locally. Certainly at Glastonbury the windows seem to have been made on the site (Radford 1958, 167). There was doubtless a stimulus for building *in more Romanorum,* but to what extent it continued is quite another matter. The apparent ease with which the knowledge could pass away can be inferred from the letter sent by Cuthbert, Abbot at Monkwearmouth some 80 years after the foundation, to Bishop Lul at Mainz requesting further expertise because the art of glass-making had been lost (Whitelock 1955, 185, 766). He referred specifically to vessels, but the techniques for producing both vessels and windows at that time were so similar that it would have been impossible to forget one technique without the other. One might justifiably conclude that the original windows were still *in situ* and that therefore replacement was not yet necessary.

Artefactually Anglo-Saxon window glass has only emerged comparatively recently. Several hundred fragments arc now known. Some are well stratified but many occur in residual levels. As far as one can tell, and the evidence is typological as much as anything else, it seems clear that in the late 7th or early 8th century a spate of glazing occurred as a consequence of ecclesiastical building. The practitioners were not English and their visit was of relatively short duration. Whether or not efforts were made to pass on their knowledge to local craftsmen remains unknown, but as far as the archaeological evidence shows, if they did so it was unsuccessful. The early glass is finely cut, precisely grozed, and produced in a shower of colours and shapes. Beyond this time, and one is tempted to say almost within a generation, the quality drops. The products are cruder, badly executed, and in colour pale and anaemic. Window glass is seen at its best at Monkwearmouth and Jarrow (Cramp 1970) with some examples of comparable quality from Kepton St Wystan (Hunter forthcoming a), Brixworth All Saints (Hunter 1977b), and Winchester (Hunter forthcoming b). When the craftsmen returned home they took with them their skills. Cuthbert's observations appear to be true not only for Northumbria but also for the rest of the country. Only one renaissance occurs, in the building of Wolvesey Palace at Winchester where according to the fragments discovered some real attempt was made to glaze to standards admittedly inferior to, but at least approaching those achieved some 300 years earlier.

Early methods

The processes of glass production are relatively well recorded from Pliny through to the more detailed work of the Benedictine monk Theophilus, *De Diversis Artibus,* written in Germany in the early 12th century. The earliest illustration of a furnace is in a manuscript attributed to Hrabanus Maurus, Bishop of Mainz and adviser to Charlemagne. He died in 856, about 100 years after Cuthbert's request to the same location. It can be no coincidence that Mainz should appear on two separate occasions as an acknowledged centre of expertise. A copy of the manuscript dated to the 11th century survives and shows a vessel furnace in production (Fig 99). The furnace itself has three tiers, the lowest probably being for fritting (the solid state reaction between the sodium carbonate in the plant ash and the silica in the sand which occurs at temperatures between *c* 700° and 850°C). Pliny, Theophilus, and even Neri who wrote in the 17th century emphasize the moderate temperatures needed. Theophilus recommends that the process should continue for one night and one day (Theophilus 2, 4). Once the reaction had taken place the frit could be melted to produce glass at temperatures little in excess of 1000°C -certainly within the capabilities of a relatively simple furnace - and presumably in the central tier where the flame was hottest. After the melting had been achieved the vessel could be blown. Annealing, the process of controlled cooling, took place in the top tier.

Anglo-Saxon window glass was made by a process which was an innovation of glass-blowing and was the normal Roman method for producing flat glass (Harden 1961, 44-52). The glass was blown and manipulated into cylindrical form. The ends were then severed and the cylinder cut down the long axis and folded out until it was flat. This was the only method recorded by Theophilus and he describes the furnace specification in full (Theophilus 2, 1). The main furnace was rectangular and appears to have had two separate chambers on the same level, one for fritting and a hotter one for melting. A separate smaller furnace was used for annealing and a third furnace is described for opening and flattening the cylinder. There was, however, a second method, that of crown production, by which molten glass was spun rapidly on the end of a rod until centrifugal force drove it into a flat disc suitable for cutting into window quarries. Theophilus, who dwells in some detail on most aspects of glass-working from furnace construction to painting, fails to mention this method - a fact which has often been used as evidence for a later date of introduction in the 14th century. The invention of the method was at one time attributed to Philippe de Caqueray, squire of Sainte Imme, to whom Philippe IV had given patronage, but recent research has disproved this (Lafond 1969). Examples of crown glass are now known from the Cathedral at Rouen from the 13th century and Dr Harden has cited important examples from San Vitale at Ravenna (Harden 1971, 84) probably from the mid 6th century. The gap is one which only archaeology can fill. The Theophilus manuscript is incomplete and this is possibly one reason why the method is not described. Archaeological evidence for either type of window glass is relatively recent and it has not been possible to add significantly to the argument. There was, for example, no crown glass used at Canterbury before the 14th century while on the other hand possible crown fragments from Winchester and Brixworth, both admittedly from residual levels, tend to suggest that the process was certainly used in this country

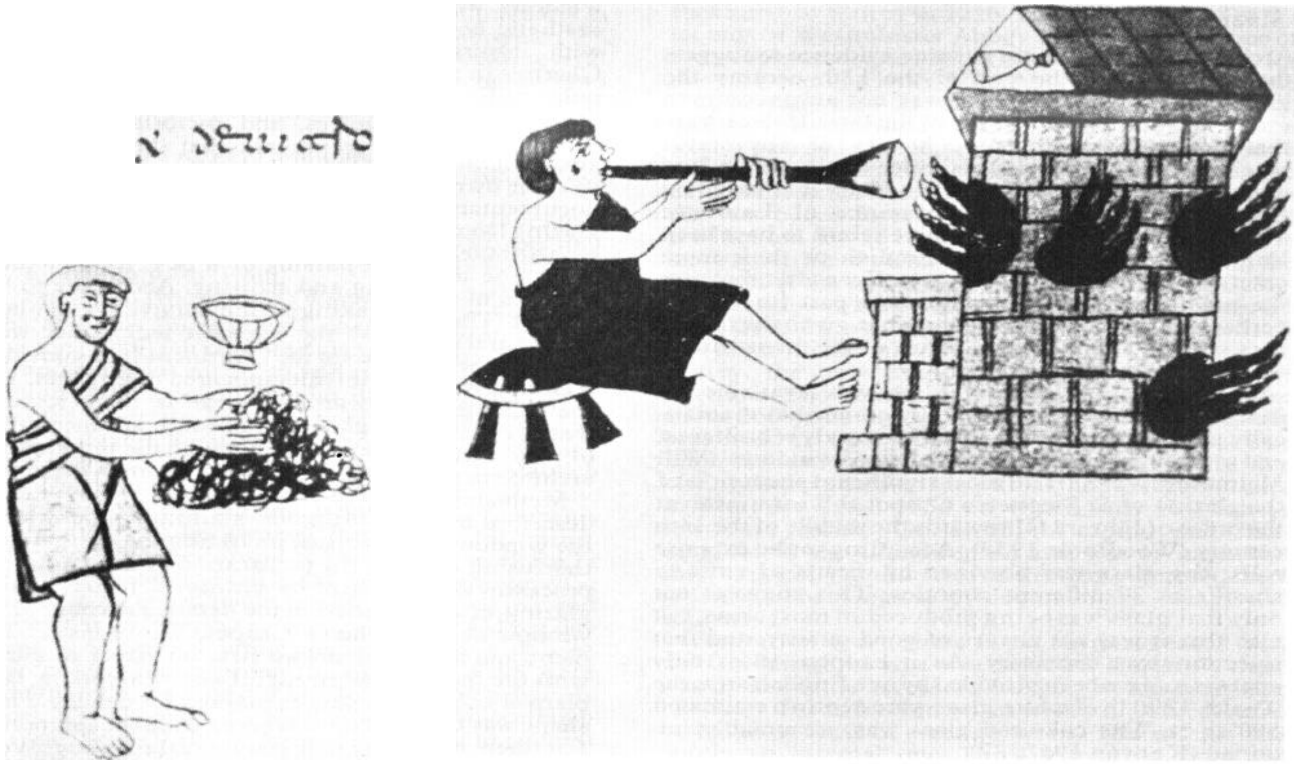


Fig 99 Furnace illustration of the 9th century. Reproduced by courtesy of the Department of Ceramics, Glasses and Polymers, University of Sheffield

considerably earlier than generally believed and certainly before the time of Vitrearius in the 1220s. It has always been a classic example of absence of evidence being used as evidence in itself.

There is without doubt an obvious gap in our knowledge of glass and glass production for both vessels and windows for a period of some 500 years after the glazing of Monkwearmouth. There are two reasons: first that there was very little, if anything, being produced in this country, and second that it was somewhere in the last half of this period that the basic materials of production are known to have changed. The resulting glass, far from being durable in what was essentially still the Roman tradition, was of a composition that might last no longer than two generations, and which in a buried context could wholly decompose. Anglo-Saxon glass was the fusion of a silica composition (sand) and an alkali supposedly derived from the ash of sea plants. Towards the end of the millennium -and it is impossible to tie it down closer than that - ash from bracken and woodland sources was introduced in place of marine ash. Among other differences, the new alkaline components contained a high potassium content and produced a glass composition more susceptible to weathering and decay.

There is no absolute date at which the traditions changed, and that is the main reason why it is impossible to give a definite starting date to medieval glass. For a period the two traditions were parallel. The durable windows of the early ecclesiastical buildings continue through Wolvesey Palace to a 12th century window at York Minster, on which Professor Newton has commented in some depth (Newton 1976). The use of marine ash was still recorded at a Sunderland factory in the 19th century; woodland glass on the other hand was seen by Dr Harden and others as being introduced by around the 10th century (Harden 1956b, 325f) and certainly Theophilus' treatise is based solely on those materials. However, it is possible to bring the date forward. Recent evidence, particularly from Flaxengate, Lincoln, has shown the presence of non-durable glass in what appear to be 9th century levels alongside fragments of more durable composition. Both methods seem to have been known, and this is also apparent from the Winchester material. Dr Dekowna's excavations in Poland have likewise confirmed 9th century forest glass at Szczetin Castle, where glass manufacturing also took place (Dekowna 1973). By the 13th century woodland glass was dominant, although the Swedish monk Peder Mansson (1460-1534) who lived in Rome for sixteen years wrote of both types and was aware of the different materials needed for each. The period 900-1300 is one in which our knowledge of glass production needs stratified archaeological support. It hardly needs adding that this is just the period where there seems to be none, which is all the more unfortunate as that period is arguably the most crucial phase in glass history until the industrial revolution.

Glazing

Archaeology apart, there is some evidence to suggest that certainly by the end of the 12th century the glazing of church windows was not an uncommon event, although it was not until the later 15th century that domestic windows of houses of any status reached the same level. It is, once again, difficult to assess the extent to which the industry was based on English soil. Until the appearance of Laurence Vitrearius in Surrey in 1226 there seems to have been little activity either by the English or their more enterprising continental brothers. Even after that year the practitioners were in the most part foreign, or perhaps more accurately, history has given the foreigners greater attention as a result of the disturbances they appear to have caused.

From the 12th century glass was available, as indeed William of Malmesbury somewhat dramatically pointed out in describing the newly rebuilt west end at Canterbury as a 'blaze of glass windows' (Will Malmesbury 138). The most significant account is of the glazing of St Stephen's Chapel at Westminster at the order of Edward III towards the middle of the 14th century (Woodforde 1933). According to the expense rolls, the glass was obtained by means of writs to sheriffs in 27 different counties. This suggests not only that glass was being produced in most areas, but also that it was not always of good quality, and that selection was necessary. As it happens glass only appears to have been provided by one English area, the Weald; 1290 lb of white glass were sent, an estimated 500 sq ft. The coloured glass was presumably imported (Kenyon 1967, 27).

Much of the glass used at this time was doubtless foreign, for example at Exeter Cathedral in 1317-18, where the glass was imported from Rouen (Bishop & Prideaux 1922, 39). Even by 1447 the contract for the chapel at Warwick Castle stipulated that only the best glass obtainable from overseas should be used (Salzman 1952, 183) - an order happily reversed in the construction of King's College Chapel, Cambridge, where the decision to use Normandy glass was eventually abandoned in favour of using native products (Hartshorne 1897, 160). On the other hand, at Witney 9d was spent on linen cloth for the windows of the church in 1217, while some two centuries later the accounts of St (George's Chapel, Windsor, detail to one Thomas Staynour the sum of fourpence for painting a linen window to look like glass (Salzman 1952, 173f). The admittance of light was probably less important than ventilation, or even the exclusion of pigeons, for which a net rather than glass was used at Penshurst in 1470. A compromise was reached by Henry III who installed an opening window of white glass in his garderobe at Westminster Palace. Shortly afterwards the operation was repeated at Sherborne and at Clipstone (Salzman 1952, 174). The concept of glazing was established, even to the extent that Peterhouse, Cambridge, found it necessary to glaze the pigeon house on their estate at Thriplow in 1441 (Salzman 1952, 176f). Meanwhile the unfortunate Walter de Godeton, found guilty of taking a cargo of wine without the owner's consent in 1314, was in punishment required to build a lighthouse with glazed windows in the Isle of Wight. The grooves for the glass are still visible (Harden 1961, 56f).

The growth of glazing in medieval England was essentially a product of ecclesiastical and royal patronage. The functional benefits of having glass in windows were almost immediately replaced by the aesthetic benefits of painting or staining, no doubt with inspiration being drawn from St Denis or Chartres in the mid 12th century, and reaching a high point in England over 200 years later. References to heraldic motifs, figures, and pictorial scenes are plentiful, so much so perhaps that the traditionally austere Cistercian order eventually prohibited them in their own churches. We can establish, even from documentary sources, the tremendous acceleration in glazing from the 13th century-a surge which cannot be attributed to the passing of a new technological milestone in glazing and staining. According to the treatises of glass-making which survive (particularly that of Theophilus) the relevant techniques were known and practised on the Continent for a considerable time before their fruits appeared in England. The stimulus was purely architectural. In many respects the technology of glazing was more advanced than that of construction. It was only with the introduction of the early Gothic style that stained glass and architecture became truly symbiotic.

Methods of painting or staining windows arc described by Theophilus, including the designing of the window scenes, the preparation of the paints, and the fusing of the paint by additional firing. Similar processes are amplified in the detailed account of the glazing of St Stephen's Chapel, Westminster. The window design was drawn first on paper or parchment, and then transferred full-size to a working table with the individual shapes marked for colour. Where plain or colouted glass was being used the appropriate shape was traced in chalk on one surface, roughly cut, and then grozed until it was the right shape. For painted quarries, appropriate oxides were mixed to achieve the proper colour and an ingredient was added to make it insoluble. This was painted on pre-cut quarries and heated in a furnace until the paint and the glass had been fused. there is some evidence to show that reused coloured glass was utilized as a type of enamel. In 1471 William Teele of York provided 40 strings of beads of yellow glass for heraldic glazing in the Minster (Salzman 1952, 180). Silver- and gold as either foil or filings are also known to have been used. When all the shapes had been laid in the correct place on the table they were fitted together with lead cames and packed with tallow to make the window weatherproof.

These methods seem to have been generally adopted in buildings where glazing took place and Salzman cites several examples (1952, 175-81). An inventory at the stores at Westminster in 1443 lists 25 shields painted on paper as patterns for the use of glaziers working there. Two tables of poplar and eleven trestles used for glazing work are also mentioned. At Guildford Castle in 1292 the sum of 8d was paid for 'making a furnace to burn glass', presumably to fuse the paint to the glass, while grozing irons are recorded among the tools at Durham in 1404. In the absence of archaeological evidence for processes these and similar references must indicate that glazing was a craft practised at many ecclesiastical centres, and that at least some glass was produced locally. The Abbey of Vale Royal in Cheshire was carrying out its own manufacture between 1284 and 1309, and judging from the amount of sand that was carried to Salisbury Cathedral from late 15th century accounts it would seem that glass was being made there too. English glass was used at Durham in 1397, although the source of origin is not specified. Certainly there is evidence that at Guildford Castle as early as 1292 thirteen windows were made on the spot.

The cost of window glass is mentioned in several places. John Prudde, the King's glazier between 1445 and 1447, seemed to charge according to complexity of design:

Glass with figures of prophets	8½ per foot
with roses, lilies and certain arms	10d per foot
wrought with different figures and borders	1 s per foot
subject windows	1s 2d per foot
diverse pictures (Eton)	1s 4d per foot
very finest type of work (Warwick)	2s per foot

The accounts for glazing a chapel at the Tower of London (1286) put coloured glass at 8d, white glass at 4d, and old glass made up and renewed at 2½d. John Deylon of Peterborough, who inadvertently misrepresented a certain heraldic beast as an antelope in Lady Margaret Beaufort's Manor at Collyweston in 1505, was paid 7s to change it, and 20d was paid for a new design to be drawn. It is interesting to establish the nature of the glazing labour force and some information can be gleaned from the St Stephen's accounts under the control of Master John de Chestre. He and five master glaziers did the design work for 1s per day each, ten to twelve painters were employed at 7d per day, fifteen were required for breaking and fitting at 6d per day, while apprentices at 4½d per day were needed for grinding the paint. The task took eight months and cost £240, of which £195 were wages, £34 for glass, £1 10s 0d for painting materials and tools, and £9 10s 0d for iron work and miscellaneous. From the accounts there is nothing to suggest that the glass was actually fabricated on site. At York the accounts can be usefully synthesized in the period 1371-1497. Calculations made by Knowles show that the average number of men employed per year was two, the average time worked was three months two weeks, and that over the whole period the average time per man year was only seven weeks (Knowles 1936, 27). The accounts mostly relate to painting, which may imply that this type of work was beyond the scope of the Dean's small glass workshop. Painted glass may only have been used as the result of specific donation and hence there was no call for permanent expertise.

The Weald

Architecture had clearly provided a new stimulus for glass manufacture, but the ability to produce on a relatively large scale both for vessels and windows was the direct result of a technological innovation which enabled woodland as opposed to marine alkalis to be used as a basic raw material. Beechwood was a critical component and an equally valuable fuel. As a result the industry tended to prosper in those areas where the resources were best, notably in the Weald of Surrey and Sussex. To some extent the industry was nomadic, moving from area to area as supplies became exhausted, and hence providing an archaeologically frustrating picture. Winbolt's antiquarian survey in 1933 (Winbolt 1933) identified 27 sites either from archaeological remains (approximately two-thirds) or from documentary evidence. This number was increased to 42 by Kenyon in his work on the Weald industry (Kenyon 1967).

The first glass-master known by name to have worked in England was Laurence Vitrearius, who arrived from Normandy and established himself at Pickhurst in Surrey in 1226. His name appears in the records of Westminster Abbey in 1240 as being one of the people associated with the production of glass for the east end of Henry III's Abbey. It is conceivable that he may also have been involved at Salisbury, where work started at about the same time. Vessels too were a part of his repertoire, the king himself being a regular customer. France, as we have seen, was the natural historical starting point for the industry where the vast beech forests had created major centres of production. By 1550 no fewer than 168 houses are known, with even Charles VI recorded as visiting the furnaces at the age of fourteen (Hartshorne 1897,89). The exodus which Vitrearius unwittingly started came from the nucleus of activity in Normandy, but it was not until the mid 14th century that Chiddingfold, Surrey, the new English centre, began to receive attention, and held a small but important position for about 260 years until the Weald tradition was finally broken down in favour of coal-producing areas. The importance of the Weald might be gauged from a map of England painted on the wall of the Palazzo Vecchio in Florence dated 1556 on which only two Surrey towns are marked, Guildford, the capital, and Chiddingfold. If the Chiddingfold area was so important internationally at this time as the map suggests, there is little archaeological or documentary evidence to support it.

Vegetation apart, there is no obvious reason why the Chiddingfold area was selected. Certainly there was no maritime access, and export would have been unsuccessful as foreign wares were still considered to be better at least in prestige terms. The market was purely an internal one. Until Vitrearius there was demand but little supply, and what was available was costly. One must mark a significant cause of the Weald progress down to Vitrearius's commercial enterprise and economic acumen. He was in every respect a pioneer.

It is not easy to trace the movement of glass production either in England or abroad. The problem is made more complex by the continual need of the glass-workers for fresh supplies of wood. Their movements within an area can to some extent be more keenly traced not by archaeological remains but by the complaints of the local inhabitants (especially the townsfolk of Guildford) objecting to the loss of woodland. Rent in kind is a record of movement especially on the Continent, where in 1466 a delivery of glass from the works at La Ferrières to the Abbess of Sainte Croix at Poitiers consisted of twelve dozen glasses and one dozen ewers in payment for the liberty of collecting fern on her lands (Hartshorne 1897,89). Towards the end of the 15th century 25 glasses were given by the Mehlis glass-workers in the Thüringer Wald in Saxony to the king, in lieu of rent (Kühnert 1967, 114). The Mehlis glasshouses were operated from the surrounding villages until the supplies of timber had been exhausted - a common enough occurrence and a hazard of the work, but one which never seemed to affect the English Weald. Even despite the later encroachment of the Tudor blast furnaces with equally large appetites for timber, there is little evidence that the supplies of fuel ran out, or indeed ever looked like running out. This itself may be a reflection of the small size of the industry. The continual movement of the workers also guaranteed great variability in composition producing differences in colour and quality. As a result there are inherent dangers in assessing compositional variation and significance either regionally or chronologically. This has been discussed by Professor Turner (1956) who pointed out that potential compositional variation exists between different sands, and an even greater variation elementally between different forest alkalis.

The quality of the Weald glass is perhaps open to question, particularly with regard to the manufacture of coloured glass, which might suggest that domestic production was not very advanced. Salzman's synthesis of the evidence (Salzman 1952,183-5) shows that the chief sources of coloured and best white glass were reputedly Burgundy, Flanders, Lorraine, and Normandy, but certainly not the English Weald. A Dutchman, John Utyman, was brought over from Flanders at the request of Henry IV to make coloured glass for the windows at Eton College. Later York accounts show glass of various colours bought in 1457 and 1530 from Germany, from Burgundy in 1536, and from Normandy a year later. From the technological point of view it is the colouring of glass which may signify the extent to which the craft had evolved. Coloured states could be achieved not so much by the addition of specific chemical compounds as by regulating the time in the furnace and the conditions of oxidization. Elements which existed quite fortuitously in the raw materials were, given time, capable of colouring effect on oxidization. It was a knowledge derived purely from experience rather than from an understanding of chemistry, and one which indirectly signifies the variability of raw material and hence the potential for colouring differences. As Theophilus pointed out, 'If it (the melt) happens to turn a tawny flesh-like colour, heat for two hours and it will become a light purple. Heat for three to six hours and it will become reddish-purple and exquisite' (Throphilus, 2, 8). The medieval glass-masters in England were certainly able to melt glass. However, according to the general evidence which suggests the absence of coloured glass made in England, one could conceivably infer that they had yet to realize the potential of their raw materials and had yet to achieve complete mastery of their furnace conditions, the subtle distinction between an art and a science.

There is other evidence to support the contention that techniques were less than perfect. The Weald glass can be divided into two types, a poorer and less durable early type and a later version which is seemingly indistinguishable from modern glass. Much effort has been spent in trying to understand why this difference occurred and how it was caused. Elementally the differences are slight, but they are clearly sufficient to produce a noticeable effect in quality. Various different theories have been put forward, but the answer may be relatively simple. It lies not perhaps in a trend towards new materials, but in the ability to select from those existing. As in any other industry care in selection of raw materials is just as important as the technological process itself. Merrett pointed out in 1662 that fine white sand from Maidstone was necessary for high-quality glassware, while a coarser sand from Woolwich would suffice for green glasses (Douglas & Frank 1972, 56). As far as one can tell the change in the Weald glass occurred in the second half of the 16th century, roughly coinciding with the inroads of Carré and his followers - a time beyond our specific period, but an essential changing point to indicate the somewhat dubious nature of the medieval English product. Professor Turner, who examined sand from the Weald, commented that it could not be considered a first-quality sand, or even of second-quality judging by our present standards, although it could have furnished material for making glass of a pale colour (Kenyon 1967,35). Even by 1565 there were still problems. A letter written on behalf of glass-master Cornelius de Lannoy who had apparently undertaken to improve the English manufacture of glass relates: 'All our glass makers cannot fashion him one glass though he stood by to teach them. They know not how to season their stuff to sustain the force of his great fires' (Kenyon 1967, 83). There is little to suggest anywhere that local English glass technology, certainly before 1500, was by continental standards anything but inferior.

Winbolt's account of the industry has been supcrseded by Kenyon in all respects but local knowledge, but probably owing to lack of firm archaeological evidence neither fully comes to terms with the nature of the industry itself, and it is easy to see why. It is a study plagued with difficulties, not least archaeologically since, because they were in a predominantly stoneless area, the sites were heavily robbed. Documentation is generally poor and the scanty records relate mostly to the activities of certain families, the Schurterres (14th), the Peytowes (mid 15th), and the Strudwicks (15th). Not until the presence of Carré at Fernfold in the second half of the 16th century does the situation improve. In fact the number of positively identified sites in the Wcald prior to 1500 barely exceeds double figures. Beyond the Weald the evidence is even sparser and is mostly documentary. Several have been discussed by Crossley (1967, 44--7), but with the exception of Bagot's Park, Staffordshire, which may conceivably have been worked in the late 15th century, they remain mostly unverified.

After Vitrearius, whose presence can be said to be little more than ephemeral, the best evidence for the industry comes from the 1351 Kolls relating to the building and maintenance of royal palaces. There are six entries for English-made glass and all relate to Chiddingfold or the Weald, suggesting that those areas were the principal sources of glass in medieval England (kenyon 1967, 27). The supply seems dominated by John Alemayne but there is no evidence that he actually mad e the glass himself; indeed the archaeological evidence, such as it is, indicates that no window glass was actually finished in the Weald. Glass found among the furnace waste showing painted or leading marks was in all probability imported as cullet. Window glass seems to have been the main industry, although the lack of obvious furnace remains for opening out glass cylinders may suggest that crown production was the only method used. Of the 42 sites that Kenyon lists, 27 arc proven, 10 are probable, and 6 possible. Thirteen of the total he considers to lie within the 13th and 14th centuries, although they are notoriously hazardous to date. Melted glass, waste from both window and vessels, and fragments of crucibles are the common site indicators, although there is some evidence that waste fragments were collected for reuse when the site moved on.

The best example is from Blunden's Wood and has been extensively excavated (Wood 1965, 54-79). The site showed three furnaces dating to about 1330, all of which lacked foundations, and the archaeological survival of this type relies entirely on parts of the superstructure remaining. The main furnace was 3·5 mx20·7 m, with a unique cavity-insulation feature, and was presumably for the melting. The other two small furnaces were probably for fritting and annealing in the Theophilus tradition. It is possible that the main furnace was barrel-vaulted and Wood's reconstruction of two stone benches on which the crucibles stood is probably fairly accurate. One can usefully compare it to the illustration of an early 15th century Bohemian forest glasshouse (Fig 100). The main furnace is to the right, being stoked by a small boy, and the annealing furnace is attached to the left and contains vessels. This is a particularly informative illustration. It shows glass being collected from the melt and being blown and marvered by the person in the centre. Behind the furnace the master inspects one of the wares and in the background sand is being quarried and carried to the working area. Wooden billets for the furnace are being dried on a rack to the right. There is no reason to suggest that the activities of the Blunden's Wood craftsmen were any different. Indeed some 300 years later at Jamestown, Virginia, where one finds a colonial copy of a current English type, the layout and structures have changed little (Harrington 1952). Some of the later Wealden furnaces were built of brick but the design of the working furnace was basically the same. The majority of the remaining Weald furnaces of the medieval period proper are all relatively small, barely more than 2m in either dimension. In comparison to the glassworking sites excavated recently by Lambert in Hérault, France (Lambert 1972) they could justifiably be considered poor relations. Blunden's Wood is really the only survivor from before 1500 of an enigmatic and somewhat intangible activity.

Fig 100 Illustration of 15th century Bohemian glasshouse. Reproduced by permission of the British Library, Add Mss 24189, f 16

Vessel glass

Vessel glass, to judge from the waste of the Weald furnaces, seems to have been little more than a crude sideline until the mid 16th century. There is no evidence to suggest otherwise, and the archaeological remains which survive are generally in poor condition and of dubious quality. The prestige end of the market was monopolized by continental manufacturers until the impact of Carré and Verzelini became apparent towards the end of the 16th century and Venetian ships were openly encouraged to trade their glass custom-free at English ports. Local wares lacked appeal and specific prestige-appeal was probably more important than quantity of output. Vessels such as the Luck of Edenhall cup, whose workmanship was so fine that the English attributed its manufacture to fairies, were the result of long-established contacts with the Mediterranean areas, particularly Italy and the East. Some reflection of the strength of the European trade can be seen from the vessels retrieved from the Gnalic wreck which, sailing from Venice in 1583, sank off the Dalmatian coast. Crown window panes, fine glass vessels, together with mercury, sulphur, linen, and brass, were the main items of cargo; the glass was a recognized item of trade (Gasparetto 1973). It is difficult to establish to what extent the English industry could have broken the Venetian stronghold. Certainly by 1580 when glass of English making was carried to China (Hartshorne 1897, 164) some progress had been made. At about that time a principal worker from a Normandy family in England could earn 18s per day compared to the 1s per day earned by carpenters, plumbers, and masons. This was no doubt reflected in the price of the finished product, which must have been of some. quality.

The lower end of the market was more accessible and the remains from several of the Weald furnaces, not to mention an increasing number of remains from excavations, often in lamentable condition, are evidence of this. Vessel production took place on a relatively large scale and clearly satisfied some demand. One must consider also that glass vessels were in direct competition with vessels of differing, cheaper, and more durable materials, the nature of which can be gauged from Heywood's *Philocothonista,* written in 1635:

> Of drinking cups divers and sundry sorts we have, some of elme, some of box, some of maple, some of holly etc, mazers, broad-mouth'd dishes, noggins, whiskins, piggins, cruizers, ale-bowles, wassell-bowls, court dishes, tankards, kannes, from a bottle to a pint, from a pint to a gill. Other bottles we have of leather, but they are most used among shepheards and harvest people of the countrey; small jacks wee have in many ale-houses, of the citie and suburbs, tip't with silver, besides the great blackjacks and bombards at the court (Heywood 1635,45).

One small aspect of the vessel industry deserves mention, namely that of marketing the wares. A German woodcut illustration from the middle of the 16th century is particularly relevant. It belongs to Agricola's *De Re Metallica,* a work on metallurgy and related subjects. The furnace he illustrates is remarkably similar to that of Hrabanus some seven centuries earlier, suggesting that the peripheral activities are unlikely to have changed significantly either. There are several activities taking place which occur on all such illustrations almost as artistic conventions, but there is one particular innovation, that of the packing and transportation of the finished vessels. These are shown being packed into a wooden crate, probably for transportation by cart - an activity only recorded briefly in English documents, where the accounts for the glazing of the chapel at Windsor Castle (1351-2) included payment for hay and straw for packing (Salzman 1952, 181). An individual trader is also shown complete with basket on back loaded with wares, presumably for selling in a hawking capacity.

The quiet persistence of the Weald was broken by Jean Carré, a glassmaker from Lorraine, a man with the same commercial perspicacity as Vitrearius and who had already become established in the Weald. His coming would be an appropriate end point in itself, for it was at that time and presumably due to his influence that the term 'industry' first becomes fitting. His death in 1572 marked the beginning of the gradual migration of his Lorraine and Venetian followers from the Weald. The movement of the industry can be traced through Hampshire, Somerset, Gloucestershire, up the Severn Valley into Shropshire and Staffordshire, and ultimately into the coal regions of the north-east. Carré had been granted his licence on the understanding that with his guidance the English would be able to make glass as well as the foreigners. This was probably an accurate reflection of the total inability of the English to learn a new craft properly and came over 800 years after Abbot Cuthbert at Monkwearmouth had said virtually the same. In the intervening years there is little to suggest that the English medieval glass industry was anything more than a pale imitation of that on the Continent in terms of size, knowledge of technology, and quality of output. The term *industry* may indeed not be appropriate at all.

Acknowledgements

The author would like to express his thanks to the Society of Glass Technology, Mr David Sanderson, Miss Christina Colyer, Mr David Crossley, and Mr Stephen Dockrill for their assistance in the preparation of this paper. Figure 99 appears by courtesy of the Department of Ceramics, Glasses and Polymers, University of Sheffield. Figure 100 is reproduced by permission of the British Library.

Bibliography

Bede Plummer, C (ed), 1896 Bede, *Historia Abbatum*

Bishop, H E, & Prideaux, E K, 1922 *The building of Exeter Cathedral*

Chambon, R, & Arbman, H, 1951-2 Deux fours à verre d'époque Merovingienne à Macquenoise, *Meddelanden från Lunds Universitets Historiska Museum*, 199-232

Cramp, R J, 1970 Decorated window-glass and millefiori from Monkwearmouth, *Antiq J*, **50**, pt 2, 327-35

Crossley, D W, 1967 Glassmaking in Bagot's Park, Staffordshire, in the sixteenth century, *Post-Medieval Archaeol*, **1**

Dekowna, M, 1973 Problème de l'existence d'un atelier verrier à Szezecin au haut moyen âge, *Annales du 6 Congrès de l'association internationelle pour l'histoire du verre*, 143-58

Douglas, R W, & Frank, S, 1972 *A history of glassmaking*

Gasparetto, A, 1973 The Gnalić wreck: identification of the ship, *J Glass Stud*, **15**, 79-84. See also Petriocioli, S, The Gnalić wreck: the glass, *ibid*, 85-92

Harden, D B, 1956a Glass vessels in Britain and Ireland AD 400-1000, in *Dark Age Britain* (ed D B Harden), 132-67

———, 1956b *A history of technology*, **2** (eds C Singer *et al*)

———, 1961 Domestic window-glass, Roman, Saxon, and medieval, in *Studies in building history* (ed E M Jope), 39-63

———, 1971 Ancient glass 3, *Archaeol J*, **128**, 78-117

Harrington, J C, 1952 *Glassmaking at Jamestown*

Hartshorne, A, 1897 *Old English glasses*

Heywood, J, 1635 *Philocothonista*

Hunter, J R, 1975 Glass from Scandinavian burials in the first millennium AD, *World Archaeol*, **7: 1**, 79-86

———, 1977a *Scandinavian glass of the first millennium AD — a typological and physical examination*, unpubl PhD thesis, Univ Durham

———, 1977b Glass report, in Excavations at Brixworth 1971 and 1972 (R Cramp *et al*), *J Brit Archaeol Ass*, **130**, 104-7

———, 1980 The glass, in *Excavations at Melbourne Street, Southampton, 1971-76*, Southampton Archaeological Research Committee Rep **1**, CBA Res Rep **33**, 59-72

———, forthcoming a Glass report in interim excavations report by M Biddle, *Antiq J*

———, forthcoming b *Winchester Studies*, Vol 7 (eds M Biddle & S Keene)

Kenyon, G H, 1967 *The glass industry of the Weald*

Knowles, J A, 1936 *The York School of glass-painting*

Kühnert, H, 1967 The Mehlis glasshouse in the Thuringer Wald, *J Glass Stud*, **9**, 113-17

Lafond, J, 1969 Was crown glass discovered in Normandy in 1330? *ibid*, **11**, 37f

Lambert, N, 1972 La Seube: témoin de l'art du verre en France méridionale du Bas-Empire à la fin du Moyen-Âge, *ibid*, **14**, 77-116

Newton, R G, 1976 12th century soda glass at York Minster, *CV Newsletter*, nos 19, 20, and 22

Radford, C A R, 1958 The excavations at Glastonbury Abbey 1956-7, *Notes Queries, Somerset, Dorset*, **27**, pt 263, 165-9

Salzman, L F, 1952 *Building in England down to 1540*

Theophilus Hawthorne, J G, & Smith, C S (eds), 1963 Theophilus, *De diversis artibus*

Turner, W E S, 1956 Studies in ancient glass and glassmaking processes, 5, Raw materials and melting processes, *J Soc Glass Technol*, **40**, 277-300

Vita S Wilfridi Gale, T (ed), 1691 *Vita S Wilfridi*, Rerum Scriptores Veteres

Whitelock, D (ed), 1955 *English historic documents c 500-1042*

Will Malmesbury Hamilton, N E S A (ed), 1870 *Willelmi Malmesbiriensis Monarchi de Gestis Pontifium Anglorum libri quinque*

Winbolt, S E, 1933 *Wealden glass, the Surrey-Sussex glass industry*

Wood, E S, 1965 A medieval glasshouse at Blunden's Wood, Hambledon, Surrey, *Surrey Archaeol Collect*, **62**, 54-79

Woodforde, C, 1933 Schools of glass painting in King's Lynn and Norwich in the Middle Ages, *J Brit Soc Master Glass Painters*, **5: 1**, 4-18

In this final contribution I have rejected a number of options, the most obvious of which is to attempt a straightforward summary of the papers presented. Such a summary could hardly do justice to the mass of technical evidence, and so I have decided to ask three questions : How should we define the scope of the subject? How should we handle the evidence? And where should we go next?

This is not to deny the compelling fascination of detailed technical expositions, for they are the very foundation of the subject; but it may be appropriate briefly to preach against the temptation to use (or at least to use in public) a secret language for each of these specialisms. Our contributors have notably resisted this tendency, which, nevertheless, marks the proceedings of many of the groups engaged in this type of study. With a topic such as medieval industry, where there are contributions to be made from an exceptionally wide range of disciplines — botany, chemistry, metallurgy, and zoology, to name but a few, in addition to those of the archaeologist, geographer, and economic historian — it is essential that both evidence and inference should be presented clearly and in a way that is intelligible to the non-specialist. Otherwise there can be little hope for that cross-fertilization of ideas which is surely intended to be the major outcome of such a conference and its published proceedings.

It is worth emphasizing that students of medieval industry should have a primary concern for the personal and individual rather than the theoretical aspects of their subject. We need to ask what people actually did and how and why their activities changed. There is certainly room for the quantitative approach (although we should be aware that the foundation for this is often shaky), but it is doubtful whether the abstract constructs which are the working tools of many economic historians will produce many insights into medieval industrial production. Of all the specialists involved, the archaeologist, whether he is dealing with a structure or an artefact, is the one most closely in contact with the activities of his industrious ancestors. In defining the scope of the subject we should also beware of drawing too sharp a distinction between industry on the one hand and agriculture and commerce, those traditional concerns of the medieval economic historian, on the other, for many people during the Middle Ages were actively engaged, as craftsmen or entrepreneurs, in more than one of these areas of activity.

There is an important truth in the statement that industry was the 'Cinderella of the medieval economy', but these words themselves indicate that in the context of the study of medieval society the term 'industry' has misleading modern connotations. Perhaps it would help us to rid ourselves of these misconceptions if, while conceding that the word 'industry' has a useful shorthand function, we turned our thoughts more directly to the physical objects made by individual craftsmen. These were the things which to most men, even those solely engaged in tilling the soil, represented many of the most essential achievements and attributes of the society of which they formed part, They included ploughs, tools, equipment for transport, furnishings, and clothing. They did not differ in kind from the products of modern industry, and in addition to utilitarian articles included items such as jewellery, fine robes, and liturgical equipment which reflected the social and spiritual bonds and aspirations of medieval man.

In its scope, this conference clearly falls far short of this broadly sketched agenda. Dr Ryder suggests that this is because organic materials are not being considered. My own feeling is that the root of the difficulty lies in the force of the word 'industry' itself, which, as in the Soviet five-year plans or the Chinese 'great leap forward', has been taken principally to define such 'heavy' activities as mineral extraction and crude processing. Even here, however, the processing of organic materials is not covered. Another suggestion is that a conference on light industry or crafts might redress the balance, but it should be clear by now that my own preference would be not to erect yet another potential barrier to understanding along this very uncertain line of demarcation.

From the tyranny of concepts it is appropriate to move to the tyranny of the evidence. Here the too obsequious subject of the surviving historical document has much to answer for. Many aspects of daily life in the Middle Ages-are covered by the surviving written records and to believe that all the answers will be found there is a great temptation. But the archacologist's emphasis on the appeal of the physical object, an appeal to which not all economic historians are sensitive, is important, for it is by exploiting their rapport with this type of evidence to the full that archaeologists can make their most stimulating contribution to knowledge. As we have seen in several papers, there arc economic historians whose thoughts are stimulated by the physical evidence, but it is above all on the archaeologist's imagination that we must depend if the physical object is to be used as more than a mere illustration of conclusions drawn from the written record.

But the artefact, too, can exercise a tyranny, most obviously in its ready susceptibility to formal classification and typological study. These approaches have real value in making some initial sense of the many thousands of artefacts recovered from archaeological excavations, and they will sometimes provide an accurate guide to the chronology of the deposits. Typology, however, has its own pitfalls. We have seen, for example, the frailty of the formal distinction between the bowl furnace and the shaft furnace. This points to the fundamental need for an agreed vocabulary in such matters and the 'glossary of pottery terms' being prepared by the Medieval Pottery Research Group is a good example of the sort of aid to understanding which some other groups of specialists could adopt. But the archaeologist should always take full account of the context in which artefacts are found as well as their form. It is a good start accurately to describe the 25 different kinds of knives recovered from an excavation; but we also need to know whether they represent the output of a particular smith's workshop, or a cutler's stock-in-trade, or were deposited as tools used in a particular manufacturing operation. To answer such questions we need also to take account of the nature of the structures and soils in which the knives were found, their spatial and chronological distribution, and the other tools and artefacts found with them.

We are now well into the second of my topics, which concerns the handling of the archaeological evidence. The basis of this is a proper understanding of the technological expertise which lay behind each particular industrial process. Two examples chosen at random from the conference papers illustrate the way in which technological understanding can lead to wider archaeological and historical conclusions. Professor Tylecote's painstaking investigations have demonstrated the very high quality of the steel produced by the medieval smith and the considerable advances in metallurgical understanding which appear to have been made since the Roman period. Mr Crossley is able to draw an important conclusion on the organization of iron production in medieval Kent from the absence of tap slag in the excavations at Chingley forge, for this demonstrated that the bloomery hearth and the water-powered hammer were not situated in the same place and that the hammer may have provided a centralized forging service for several smelting sites.

These examples clearly show the nature of the insights which can be obtained by archaeologists who are prepared to take an imaginative leap beyond the technicalities of their specialism. Such generalizations, however, should take account of the full range of possibilities, which may not always be indicated by the evidence immediately to hand. When considering the evolution of watermills, for example, it would seem important to consider whether there was not a range of technological options available during the early Middle Ages, so that the occurrence of horizontal- or vertical-wheel mills might have been determined as much by local topography and the other uses to which the stream was put as by the spread of a mechanical innovation. It seems possible, too, that the widespread adoption of the vertical-wheel watermill was influenced by the spread of water-powered fulling mills. Their mechanism was no more elaborate than that of the horizontal-wheel corn mill, which on Professor Rahtz's hypothesis is the earlier in the medieval sequence. If this was so, the critical technological innovation would have been the gearing which converted a horizontal to a vertical drive rather than the vertical wheel itself.

Many medieval archaeologists seem, somewhat wistfully, to be economic historians *manqués,* and perhaps for this reason may accept too readily as a basis for their generalizations the theories and assumptions of the more purely documentary historians. Yet often these assumptions are themselves of considerable antiquity and have no more than a slight factual basis. Even apparently well-founded generalizations in economic history may be a misleading guide to the interpretation of archaeological evidence, for medieval society was so varied and localized that it is nearly always possible to find exceptions to the general trend. A further difficulty arises from the chronological imprecision of much archaeological evidence, particularly that for which an economic interpretation might be most appropriate. Archaeologists, too, must be able to distinguish the passing *jeu d'esprit* from the sober fact in the historian's narrative (that they sometimes fail to do so is not always their fault). The passage in which Georges Duby associates the decline of slavery in the early Middle Ages with the spread of water-powered corn mills (the slaves had been the source of power for grinding the corn in hand querns) provides a case in point, for it contains an idea with much apparent archaeological potential. Yet Professor Rahtz's paper has clearly demonstrated the sophistication of water-powered mills in this period and their presence in places where slaves would have been readily available. By far the most substantial future contribution to our knowledge of the industry, and even of the wider economic development of this period, is likely to be provided by the archaeologist and it is up to him to provide the framework of interpretation most appropriate to the evidence.

Is there any obvious agenda for the next stage in the archaeological study of medieval industry? Except in certain specialized areas, it seems unlikely that an attempt to synthesize already published material would result in a significant addition to knowledge. This is probably true, except in a preliminary sense, of further attempts to classify iron-smelting furnaces, although it was a salutary indication of a sympathetic non-archaeologist's view of the discipline to hear Dr Blanchard's conclusion that the archaeologist might produce a typology of lead-smelting boles. First, it is worth emphasizing that the written records have not yet yielded up all that they might on the subject of medieval industry. The papers on the pottery and glass industries made interesting use of the more conventional sources for economic history, notably manorial, household, and building accounts, and there is still need for more work on these records which contain, for example, detailed technical information on mill construction. Narrative sources, in particular saints' lives and devotional literature, could be more systematically exploited for their incidental accounts of industrial activity and attitudes towards it. Personal names, certainly for the earlier Middle Ages, can do much to illuminate the range and variety of manufactures practised at a particular time or place, and the archaeologist has an important potential contribution to make towards a major question faced by economic historians of the Middle Ages: just what was it that those many men with specialized occupational bynames did in order to earn their living?

From the more purely archaeological point of view we should face the question of whether adding more of the same to the existing stock of evidence will result in real additions to knowledge. The students of medieval pottery seem certainly to have taken this in, for there has been a striking decline in the annual incidence of pottery-kiln excavations since the Ceramic Research Group was founded. Mr Moorhouse's paper shows how their interest has been turning towards the overall pattern of distribution in the manufacture and marketing of the product and Mr Drury's paper on tiles displays the same encouraging concern. When recovered in sufficient numbers to provide an adequate sample, and from satisfactorily dated contexts, artefacts can be a valuable source of data for such geographical and quantitative approaches to economic history. They may also be used to demonstrate some long-term trends with wide implications for economic history, such as the scale of the use of iron or of copper alloys. Obviously, archaeological discoveries of lead or pewter objects, both metals which were regularly recycled, would be less significant from this point of view. Urban archaeological deposits have a particular significance here for they contain large numbers of artefacts in potentially datable contexts. While many medieval industries may have had a rural setting the greatest proportion of their products was lost in the town.

There are a number of aspects of medieval lind ny not adequately covered in these proceedings, where archaeological investigations seem likely to make important contributions to knowledge. The most substantial concerns the textile trade, which during the Middle Ages was probably the most important of all manufacturing enterprises, as an employer of labour, of capital, of technical expertise, and of business skill, as well as a creator of wealth. But this challenge has elicited a relatively muted response from British archaeologists. From time to time the quest has been raised for the fulling mill, but I suspect that the archaeological traces of most medieval fulling mills, slight structures sited on fast-flowing streams with undershot vertical wheels or incorporated within corn mills, would be exceptionally difficult to recognize. Textile remains are being recovered in increasing quantities from excavations and offer fertile ground for the study of weaving and finishing techniques and perhaps, through the application of Dr Ryder's expertise, of sheep breeding. Major questions on the evolution and practice of weaving techniques have yet to be answered: when was the horizontal loom introduced? and was it used concurrently with vertical looms or the warp-weighted or two-beam type? The loom weights of the warp-weighted loom are familiar to British medievalists, but it seems only to have been in Scandinavia, Poland, and Russia that the wooden components of the other two types of loom have been identified in archaeological contexts. Given the quantities of preserved wood which have recently been excavated on medieval sites in Britain, similar discoveries are likely soon to take place here. Already in this country, however, the discovery of specialized tools and structures and their contextual associations has produced new insights not only into the techniques of weaving and of such finishing processes as dyeing, shearing, and tentering, but also into the ways in which these activities were organized and coordinated.

So far archaeology has contributed relatively little to our understanding of the manufacture of leather, one of the main raw materials for medieval manufactures, although more has been learned of the finished products for which leather was used. Further discoveries on the lines of those at Northampton and Winchester could provide more conclusive information on the scale and sophistication of the activities of the medieval tanner. There reniain, however, many technical problems in the diagnosis of tanning residues, and the environmental evidence recently cited as evidence for a medieval tannery in York seems to be capable of other interpretations.

Until recently the manufacture of wooden implements and domestic articles has been another neglected topic. Turners and various types of furniture-makers occur not infrequently in medieval records, and their products are now being recovered in increasing quantities from excavations. At York and Novgorod the sites and waste products of turners' workshops have been discovered. We should study these products, as well as charcoals, fencing materials, and constructional timbers, with the eye of the botanist as well as that of the archaeologist and architectural historian. If we combine this with the investigation of woodland landscape and settlement patterns, we may come to understand how one of the principal resources of medieval industry was managed from its origin to its final consumption, and the part each stage played in both rural and urban life.

I wish to conclude with a further look at the production of metals, not because I think that the topic is necessarily more important than the others on which there is work to be done, but because careful work in the past suggests an appropriate way forward. Clearly there is much scope for the archaeological investigation of tin and lead-smelting sites, particularly if chronological and regional patterns can be established, but from the methodological point of view work on iron-working sites offers an attractive example to follow. Extensive fieldwork and selected excavations in the Weald have suggested that iron-working was less important there during the Middle Ages than in Roman or more modern times. It now seems appropriate, therefore, to apply similar techniques to the study of the Forest of Dean, which written records suggest is at least as likely as the Weald to have been the major area of iron production in medieval England. Programmes of investigation planned on these lines are surely likely to produce more useful results than the indiscriminate collection of information.

Index

compiled by R J Dowe

References to figures are in bold type* 40. *Individual places not in the index will be found under county references.