AN EXPERIMENTAL TILE KILN AT NORTON PRIORY, CHESHIRE

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SUMMARY

A tile kiln was reconstructed on the basis of evidence provided by the excavation of an early fourteenth-century tile kiln at Norton Priory, Cheshire. The experiment established the probable form of the kiln, and it was successfully fired on four occasions. A temperature of 1000 degrees centigrade was achieved. Many problems concerning the production and firing of medieval line-impressed tiles were clarified. This paper describes the medieval kiln, the construction of the experimental kiln, the making of line-impressed tiles, the firing of the kiln and the laying of a replica floor.

THE EXCAVATED KILN

Norton Priory, an Augustinian foundation of 1134, has been the subject of a continuing series of excavations directed by Patrick Greene for Runcorn Development Corporation since 1971 (Greene 1972, 1974, 1975). An outstanding discovery was a line-impressed mosaic tile floor, eighty square metres of which survived in situ in the central part of the church. The floor can be dated on coin evidence (Greene, Keen and Noake, 1976, 58) to the beginning of the fourteenth century. In style it has much in common with other line-impressed mosaic floors in western England, and there are links with pavements in Eastern England such as Ely, which can be dated 1324-25 (ibid, 59)

In 1971 workmen erecting a fence fifty metres north of the priory church found some tiles that were subsequently identified as kiln wasters, tiles that were either under-fired or with faulty glazes. In 1972 an excavation took place on the spot where the wasters had been found and the remains of a kiln were discovered (illustrated in Webster & Cherry, 1973, fig. 56 and pl. XVIIIA and also in Greene 1975, 9). The following account is the first complete description of the kiln to be published.

The kiln had been constructed within a large flat based pit cut 0.5m. into the natural boulder clay. As a result the lower part of the kiln had survived the demolition or collapse, and subsequent ploughing, which had removed all trace of the upper parts of the structure. The kiln was rectangular in plan, 1.9m. long and 1.4m. wide measured to the outside of the walls. The side and back walls, about 0.3m. thick at the base, lined the construction pit. The front wall, 0.41m. thick, incorporated two short arched tunnels. These communicated between the pit and the two stoking chambers within the kiln which were separated by a spine wall 0.18m. thick at the base. Each chamber measured 1.1m. long by 0.35m. wide on average (they were not completely regular in plan). The overall internal dimensions were thus about 1.1m. by 0.9m., making the kiln much smaller than for example Kiln 1 at Danbury, Essex, which measured 2.2m. by 2.0m. internally (Drury and Pratt 1975, 105). The second kiln at Naish Hill, Lacock was 3.0m. long and 1.85m. wide (McCarthy 1971, 180); indeed all other excavated tile kilns (where the dimensions are known) appear to be larger than that at Norton.

All the walls were constructed primarily of clay, but they also incorporated waster tiles in large numbers in the case of the front wall, and as single courses in the side walls (for levelling up during construction ?). The back wall contained many wasters, with a facing of clay. There were also large pebbles which occur naturally in the boulder clay, but had clearly been deliberately built into the kiln walls. The wasters were mainly square tiles; occasionally rectangular, lozenge and shaped tiles were also used. The presence of the wasters implies either the existence of an earlier kiln in the vicinity, yet to be found, or else the complete re-construction of the excavated kiln during a series of firings. There was no independent evidence for the latter possibility, and the former theory is preferred by the writers. On the part of the spine wall that was most complete was some evidence for the springing of fire-bars which would have provided a perforated floor across each chamber. There were not sufficient remains to be certain of the number of fire-bars, but the spacing of the springers which survived suggested that five was the most likely number.

It was impractical to leave the kiln in situ, so with the assistance of the North West Museum and Art Gallery Service it was decided to move it. It was first strengthened by impregnation with polyvinyl acetate, and then cut into large sections. Open boxes were built round each section, which was covered with aluminium foil. Polyurethane was then poured into the box, and the foam which formed filled up the spaces between the kiln sections and the box sides. The kiln could then be removed for eventual re-assembly and display in the Norton Priory Museum.

During the dismantling more information about the structure of the kiln was revealed. It had clearly been affected by considerable heat, which was most marked in the spine wall. It was also found that the part of the front wall on the inside of the kiln over each tunnel was built of individual clay voussoirs, though there was no evidence of voussoir construction over the rest of the tunnels.

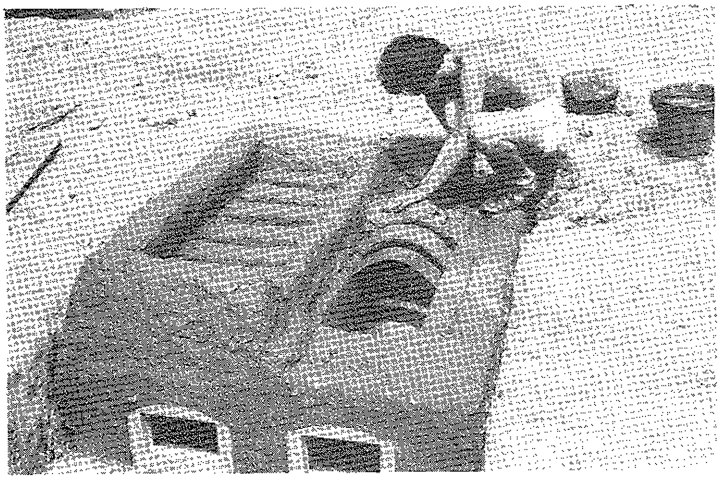
A thin layer of ash lined the base of the chambers, and spread into the stoking area. The latter was simply a continuation of the construction pit for the kiln. It also had a flat base and near vertical sides, about 0.5m. high. A block of sandstone was placed alongside the kiln on the north east side of the pit. Presumably it acted as a step. Many waster fragments were found above the charcoal in the kiln and stoking area, but no fragments of kiln furniture or pieces of the superstructure.

The kiln was built with its back to the north west. Its situation to the north of the church would have allowed the prevailing south westerly winds to blow any fumes away from the priory buildings.

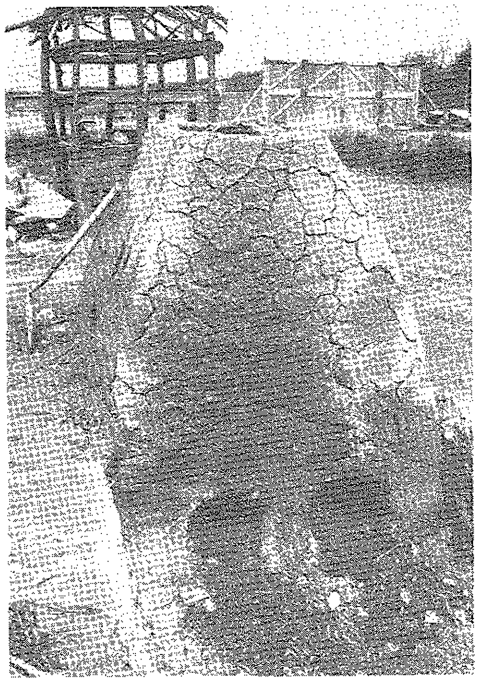
In 1974 an area of 48 sq. m. was excavated to the south and east of the kiln. No traces of structures were found, but pits dug into the natural clay were almost certainly used for the extraction and soaking of clay by the tile makers. In 1978 160 sq.m. were excavated to the west of the kiln; more large clay pits (up to 1.6m. deep) were discovered.

CONSTRUCTION OF THE EXPERIMENTAL KILN.

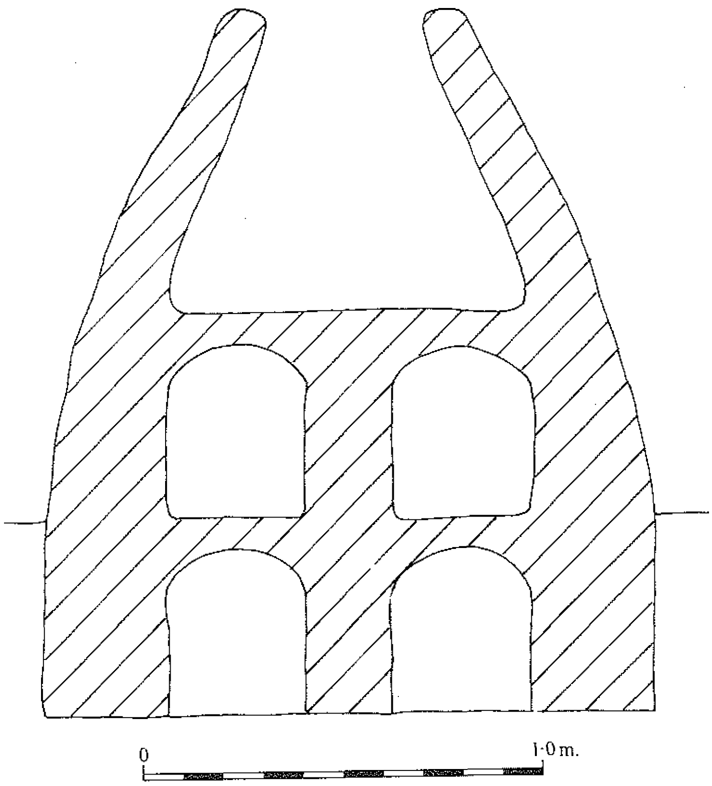
As an exercise during the 1977 teaching excavation organised at Norton Priory in conjunction with Liverpool University Institute of Extension Studies, it was decided to build a tile kiln based on the evidence from the 1972 excavation. Barry Johnson, archaeological conservator with Runcorn Development Corporation, directed the experiment. An identical flat based pit was dug and boulder clay was left to soak in water in another pit. The wet, plastic clay was used in the construction of the kiln, the ground plan of which corresponded exactly with that of the excavated kiln. The clay was used in approximately half kilo



Construction of the kiln in progress



The kiln, with stoking area in foreground and drying shed beyond.



Diagramatic section through experimental kiln.

quantities, which were puddled by hand. As the clay dried, it hardened sufficiently for the next layer of clay to be added, and shrinkage cracks were filled with more clay. Pebbles were incorporated into the walls, as they had been in the medieval kiln, but tiles were omitted.

It was decided to use simple wooden arched frames to create the tunnels through the front wall of the kiln. There is no direct evidence for the use of wood in this way, but it is difficult to conceive of any alternative. The tile makers would in any case have been familiar with the use of much more complex timber centring in the construction of masonry vaults. Clay was therefore laid across the pair of frames which were left in position to burn out during firing. Fire-bars, five of which formed the perforated floor of each chamber, were built in a similar way using pieces of wood, curved to the required profile of the bars. It was felt that a curved profile would prove stronger than a flat one. This wood was also left in position to burn out during firing. The only problem with the fire-bars was the opening of shrinkage cracks on drying, necessitating repair with more wet clay, when they opened. It is possible, in view of the presence of clay voussoirs in part of the tunnel arches of the excavated kiln, that those fire-bars were constructed of dried clay voussoirs to avoid the problem of cracking.

Up to the level of the springing of the fire-bars, i.e. to a height of 0.5m., construction was governed by the data from the excavated kiln. Above that level, construction was entirely empirical, though a series of constraints in fact virtually determined the design. One constraint was the shape of the lower part of the kiln. Another factor was the necessity to raise the walls of the kiln high enough, and narrow the gap between them sufficiently, to produce a chimney effect. Preliminary small-scale experiments by Barry Johnson had shown that this would be vital to create a through-draught great enough to raise the temperature to the required level (about 1000 degrees centigrade). A third constraint was the nature of the kiln material itself. To avoid collapse of clay walls it was necessary to slope them in gradually, and to provide some internal butressing. This was achieved by continuing the spine wall upwards, and installing a second set of fire-bars over each chamber. Thus three compartments were created in the kiln; two at the lower level either side of the spine wall with fire-bars above and below, the third between the upper fire-bars and the top of the kiln.

The top of the kiln was left open. The sloping sides of the kiln had narrowed the space between to 0.4m. wide by 0.6m. long, which was sufficiently small for a slab of clay to be used as a partial covering. During firing, the clay slab could be moved to vary the size of the opening, and thus to allow some regulation of the draught. There was no need for a complex vault of the type proposed for Meaux (Eames 1968, 5, fig. 1) or a roof of the kind suggested for the Danbury kiln 1 (Drury and Pratt, 1975, 143, fig. 61). This is not to say that the proposed Danbury roof is not a correct reconstruction. The Danbury kiln had plan dimensions twice as great as the Norton kiln, and had its furnace floor 1.5m. below contemporary ground level. Of necessity, therefore, the lowest 1.5m. of the kiln had vertical walls, and only above contemporary ground level would it have been possible to slope the sides. The superstructure would have thus been twice as high as that of the Norton kiln (2.70m. compared to 1.35m.) assuming that peg tiles set in clay would have required a similar inwards slope to that of the clay walls of the experimental kiln. That height would have made stacking, and regulation during firing, more difficult, and would have been avoided by the use of a roof at a lower level.

A total of 159 man-hours were required to build the experimental kiln. It is hardly necessary to stress that the builders, students on the teaching excavation, were all novices. An experienced group of tile makers would therefore have been able to build the kiln with much less effort. It should be remembered however that a limiting factor in the length of time involved to complete the kiln was the necessity to allow the clay to dry and harden from one stage to the next. The construction took place over a period of three weeks of mainly dry weather (July 1977).

MANUFACTURE OF THE TILES

Various writers have discussed the techniques used to produce mosaic tiles (e.g. Beaulah, 1929, 119; Eames, 1968). As part of the kiln experiment, these techniques were put to the test. Clay dug at Norton was used. After soaking to remove large inclusions, it was allowed to dry to the right consistency. Lumps were kneaded and pummelled to remove air. They were then rolled on a flat surface to produce sheets of clay suitable for cutting into tiles. To ensure uniform thickness, a strip of wood was placed on each side of the lump of clay. The roller therefore came to rest on the wood as the lump was flattened. The wood strips consequently determined that the thickness of all the tiles was constant (20mm.).

A characteristic of the Norton mosaic tiles is their embellishment with line-impressed designs. It has often been assumed that wooden stamps were used for decorating relief tiles, for this practice was in use as late as the eighteenth century in North Devon (Keen 1969). Whether wooden stamps could be used for impressed designs as complex and with lines as fine as the lion's face at Norton and Warrington (illustrated Greene, Keen and Noake, 1976, 56, fig. 32) was problematical. Therefore, a number of different designs were carved in relief on blocks of close-grained wood. The experiment proved that wood is an entirely suitable material. Adhesion between the stamp and the clay is reduced to a minimum by dusting the surface of the clay with fine sand. By using stamps of the right shape and size, a separate template or a box mould is unnecessary. A knife can be used to cut round the stamp while it is pressed into the surface of the clay, angled so that tiles with undercut splayed edges are produced. This procedure thus reduces the number of separate stages of production to a minimum. It also explains the presence of small spiked holes on the upper surface of some of the more complex Norton tiles. Spikes on the surface of the stamp when pressed into the clay would hold the stamp in position while the tile was cut from the clay sheet. It proved possible to produce tiles at a rate of one tile every five minutes.

A simple drying shed was constructed, with open sides but a roof to prevent over-fast drying by the sun. As much as one week is needed to thoroughly dry the tiles, so the availability of drying accommodation could determine the rate at which tiles were produced by the medieval tile makers. Glaze was applied to the fully dried tiles.

LOADING THE KILN

Fragments of broken ceramic material were placed on the fire-bars to provide a perforated floor.

Tiles from Norton Priory have shown clear evidence that they were stacked on edge. Many tiles have scars on the edges where the glaze had run during firing. Some wasters from the kiln have been fused together irretrievable by the glaze at the point where one tile had been stacked above another. Identical evidence was provided by the Danbury tiles (Drury and Pratt, 1975, 144) and at Meaux (Eames 1961, 157). For the experiment, therefore, almost all the tiles were stacked on edge, back to back so that the glazed surfaces were not in contact with each other. No spacing material was required. The top layer of tiles was laid flat. Each tile was marked with a number and its position in the kiln was logged so that the effects of firing could be judged in each case.

The top compartment in the kiln could be loaded by reaching down from the opening in the top of the kiln. A 'door' was cut in each of the side walls of the kiln to allow access to the two lower compartments. The doors were resealed with clay before firing, and then opened again to remove the fired tiles. The means by which the Meaux kiln and the Danbury kiln were loaded and unloaded have not been fully explained. In particular, the Danbury kiln reconstruction demands that if it was loaded from the top as suggested, the loader would have had to reach down 1.5 m. to stack the lowest tiles. It therefore seems probable that doors were present in that kiln also.

FIRING

A pre-firing of the kiln was carried out, to drive off moisture in the kiln structure and to warm it.

The kiln was fired twice in 1977, the first time with a load of 300 tiles, the second time with 500. The optimum load would have been about 750 tiles but the maximum load could have approached 1000. On the first firing charcoal was tried as a fuel at one stage. It was found to have no advantages and a major disadvantage; as a dense material it tended to clog the chambers and constrict the draught.

Timber chopped into firewood was also used in the first firing, but its disadvantage was the considerable labour required for the cutting and chopping. The most satisfactory fuel was undoubtedly brushwood collected from the Priory woodland. It was the main fuel for the first firing and the only fuel used on the second occasion. This experience is in accord with the suggestion that underwood rather than timber was used as the fuel for the medieval iron industry, being a regenerating fuel source and requiring less labour to prepare (Rackham, 1976). The quantities used were considerable. About 50 kilos per hour were required, a total for each firing of 600 kilos. There is documentary reference to a fourteenth century tile kiln requiring 100 faggots for one firing (Le Patourel, 1968). It was found that the brushwood was most efficient when completely dry. Damp brushwood had the effect of slowing down the rate of temperature rise.

Throughout the experiment the rise in temperature within the kiln was monitored by ten thermocouples placed at a series of locations in the kiln (listed in table I).

The pattern of temperature rise in the second firing is shown in the table.

During the first four hours the temperature rose steadily, efforts being made to prevent too great a rise at any one time. To achieve sufficiently high temperatures near the end, constant stoking was necessary, and small twigs were used. It was found that it was essential to rake out both stoking chambers four or five times during each firing to ensure a good draught. The kiln was fired for twelve hours on each occasion, and a sufficiently high temperature was reached for lead glaze to flux. The kiln was allowed to cool overnight before unloading commenced.

TABLE I : RECORD OF TEMPERATURE RISE. SECOND FIRING

TIME	THERMOCOUPLES										MEAN TOP	MEAN BOTTOM
	1	2	3	4	5	6	7	8	9	10		
SATURDAY				DEGREES CENTIGRADE								
6.30		80			70	130	55	74	34		64	78
7.00		185	95	60	230	230	90	68	109		83	133
7.30		65	120	210	340	280	110	84	149	100	103	185
8.00	INSTRUMENT FAILURE	465	190	280	450	425	150	137	201	125	150	315
8.30		385	230	300	490	395	190	200	229	175	199	316
9.00		450	275	330	510	420	235	235	291	205	237	360
9.30		445	305	360	540	435	265	264	320	240	268	420
10.00		455	350	400	560	465	300	300	349	275	307	486
10.30		550	370	450	660	525	320	337	420	320	337	521
11.00		560	390	460	625	535	345	350	405	340	356	517
11.30		660	450	500	710	610	395	393	500	385	406	596
12.00		670	460	530	795	650	430	420	515	420	443	632
12.30		765	515	580	860	725	475	465	602		481	706
13.00		750	520	625	875	740	500	INSTRUMENT FAILURE	600	LIMIT OF RANGE	520	718
13.30		750	570	650	870	750	540		605		555	725
14.00		805	610	680	880	795	580		690		595	771
14.30		840	690	720	945	860	630		739		660	821
15.00		885	660	750	915	845	630		708		645	820
15.30		810	675	745	915	830	660		778		668	815
16.00		830	750	800	950	870	690		758		720	842
16.30		900	810	875	995	937	725		795		769	900
17.00		875	710	825	905	885	680		742		710	846
SUNDAY												
9.00	91	118	65	104	85	112	65		83	24	68	99

Location of thermocouples

(1) Front, lower left firing chamber.
(2) Back, lower right firing chamber.
(3) Right side, top firing chamber.
(4) Back, lower left firing chamber.
(5) Side, lower left firing chamber.
(6) Side, lower right firing chamber.
(7) Back, top firing chamber.
(8) Front, top firing chamber.
(9) Front, lower right firing chamber.
(10) Top of kiln, vent.

RESULTS

THE TILES AND THEIR GLAZES

In both firings all the tiles became ceramic. There were very few wasters as a result of blowing - 6 out of 300 the first firing, 4 out of 500 on the second occasion. On the first firing modern commercial glazes were tried but proved unsatisfactory, partly because the tiles were slightly damp when fired. On the second firing lead glazes with additives for colours were tried and it was ensured that the tiles were absolutely dry. Tiles very close in appearance to medieval tiles were produced. Analysis of tile glazes at I.C.I. (Mond Division) Research Laboratories had established that lead glazes were used by the medieval craftsmen at Norton. The addition of copper produced green tiles; much copper resulted in a black glaze. On some differentially glazed mosaic tiles from Norton, iron was used to produce a dark brown glaze. Yellow glazes resulted from lead glaze over a cleam slip, and orange tiles were produced by applying lead glaze without additives to the clay, which when oxidised has an orange colour. The experiment therefore confirmed the results of the I.C.I. analysis. In addition, experiments with manganese as the additive produced a colour very different from that of the medieval tiles. Manganese had appeared as a trace element in the I.C.I. analysis, but the experimental kiln results rule it out as a deliberately added colouring agent. Examination of the tiles and their glazes confirmed the results of monitoring the temperature; the tiles that has the least satisfactory glazes were those from the 'cold spots' in the kiln.

THE KILN

The kiln survived its firings remarkably well. During firing cracks tended to open in the structure, but it was a simple matter to plug these with wet clay. The parts of the kiln most at risk were the fire-bars, but only one broke in the first firing and none in the second. They and the rest of the kiln could easily be refurbished between firings. The conclusion to be drawn is that a kiln of this type could be re-used on many occasions as long as minor repairs were carried out. The structure is unlikely to be affected by rain as long as puddles are not allowed to form around its base.

MODIFICATIONS

During 1978 two firings were organised, and opportunity was taken to modify the kiln in two ways. The top of the kiln was increased in height by 0.5 m., the slope of the existing structure being continued, thereby producing a taller chimney and consequently a smaller opening at the top. It was felt that this would improve the drawing power of the kiln, enabling temperatures in excess of 1000 degrees centigrade to be achieved more easily. The other modification was the building of two tunnels, 0.5 m. long, in the bottom of the stoking area as continuations of the two stoking chambers of the kiln. This modification was designed to test the practicality of the arrangement suggested for the kiln found at Chertsey Abbey (Eames and Gardner, 1954, 31-32), which we believed might reduce the two 'cold spots' in the front part of the two lower chambers.

The heightening of the kiln was found to have the desired effect with temperatures above 1000 degrees centigrade being achieved. Indeed, in the last firing the temperature in the top chamber reached 1200 degrees centigrade - rather higher than intended. Some of the tiles were overfired as a result, and this unexpectedly provided the answer to a problem previously unsolved. A small number of medieval tiles with a red glaze had been found during the excavation, but no distinct red colourant for the glaze had been identified. It was found that some of the tiles to which the copper containing glaze had been applied had, when overfired, turned red. Red therefore must be the colour produced by the formation of a copper compound at a temperature not normally reached in the kiln.

Loading of the top chamber was not possible through the smaller aperture of the heightened kiln. It was necessary to remove the top portion to stack tiles in the top chamber, and then replace it, sealing the join with puddled clay. The top was removed after firing to permit unloading.

The extension of the firing chambers did reduce the extent of the 'cold spots', but it did not completely eliminate them. Cold spots in which some of the tiles were underfired must have been tolerated in medieval kilns, for extended firing chambers are not a common feature.

The 1978 firings were carried out for a period of 14 hours in each case instead of 12. By holding the maximum temperature for the additional two hours, the quality of the glaze was markedly improved. The tiles made in 1978 are very similar indeed to the medieval tiles from Norton Priory, so it appears that the experiment had come close to reproducing the conditions under which the early fourteenth-century tiles were made.

LAYING THE FLOOR

It was decided to take the experiment to its logical conclusion by producing sufficient tiles to lay as a floor. A small Georgian summer house in the grounds of the museum was being restored by the Norton Priory Society. It lacked most of its original floor, so it was decided that here was a suitable place to lay a replica floor. The patterns chosen were those found in a chapel on the south side of the nave; they consisted of four different motifs laid in bands. The total area to be covered was 10 sq. m., and for this 1200 tiles were required. (The particular motifs used were probably the most elaborate ones found at Norton requiring a greater proportion of small tiles than the average). They were fired in the two kiln firings in 1978, and then laid in the summer house, set in a bed of mortar.

It took 24 man hours to lay the tiles. It was found that where there were minor distortions in the horizontal plane of the tiles, or minor differences in the thickness, the variation could be absorbed in setting into the mortar bed. However, where distortions to the shape of a tile occurred, this could lead to a disruption in the pattern which would escalate as laying of a band of a particular motif progressed. This emphasises the need for precision in the shaping of tiles - a precision which the makers of medieval mosaic floors in most cases adhered to.

CALCULATIONS

It is possible to calculate the number of firings required to produce the complete floor of mosaic tiles at Norton Priory. It is known that mosaic tiles originally covered all the choir, both transepts, the first bay of the nave, the chancel and possibly the East Chapel. Ploughing had removed all floor surfaces in the latter, but as window mouldings suggest a construction date at the beginning of the fourteenth century it seems probable that it too had a mosaic tile floor. The thirteenth-century chapter house also had a mosaic floor. These buildings had a total floor area of about 500 sq. m., though other buildings may also have had tile floors that have left no trace. The number of tiles used to make a particular pattern varies, but averages at 80 tiles per sq. m.; 40,000 tiles would have therefore required 54 firings assuming that an optimum load of 750 tiles was adhered to. With good organisation, one firing a week would be possible, so the making of the tiles would probably require two summers (problems of drying the tiles and fuel would prevent manufacture during the winter). During the winter the floor could be laid. Thus a group of two or three tile makers might have taken two years to complete the Norton floor.

The load can be contrasted with the maximum load of 11,000 tiles proposed for Danbury (Drury & Pratt, 1975, 147). Danbury kiln I had internal dimensions almost precisely double those of the Norton kiln, and a cubic capacity at lease eight times greater; the vertical sides proposed for Danbury would increase its relative capacity still further. The Danbury tiles were regularly shaped with straight sides so they would have been easier than the mosaic Norton tiles to stack efficiently. The number proposed for Danbury would seem therefore to be of the right order, and is a dramatic illustration of how doubling the plan dimensions could increase the potential capacity. The Danbury kiln could have produced the Norton floor in 4 firings, instead of 54 ! The reason for the contrast may well be the role of the itinerant Norton tile makers in producing tiles for one contract, including tiles of a specialist nature, such as shields and mosaic figurative panels, compared to Danbury's factory style production supplying a wide market.

ACKNOWLEDGEMENTS

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Note

A large selection of tiles from the experiment is in the collection of Norton Priory Museum and a variety of excavated medieval tiles is displayed at the museum. The replica floor is on permanent display in the summer house, where it will be kept under observation to monitor the effects of wear. The kiln is being permitted to disintegrate naturally; this too is being observed as it may illuminate other aspects of excavated kilns.

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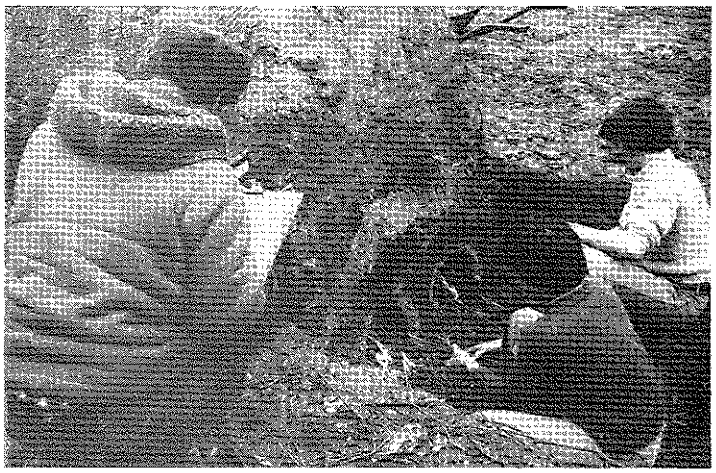
Des fouilles effectuées en 1972 par le Runcorn Development Corporation ont degagé les restes d'un four datant du 14 ème siecle situé a 50m. au nord de Norton Priory, où les carreaux imprimés au trait qui composent le dallage en mosaïque de cette église ont été fabriqués. La première partie de cet article comporte une description de ce four rectangulaire à deux canaux de chauffe, dont les dimensions complètes sont publiés pour la première fois. La seconde partie s'occupe de l'établissement en 1977 d'un four experimental modelé sur ce four mediéval, dont les deux fournées ont réussi à éclaircir plusiers problèmes concernant la fabrication, la glaçure et la cuisson des carreaux imprimés au trait du moyen age. Les températures de la deuxième fournée, laquelle a réalise 1000°, sont illustrées en forme de tableau.

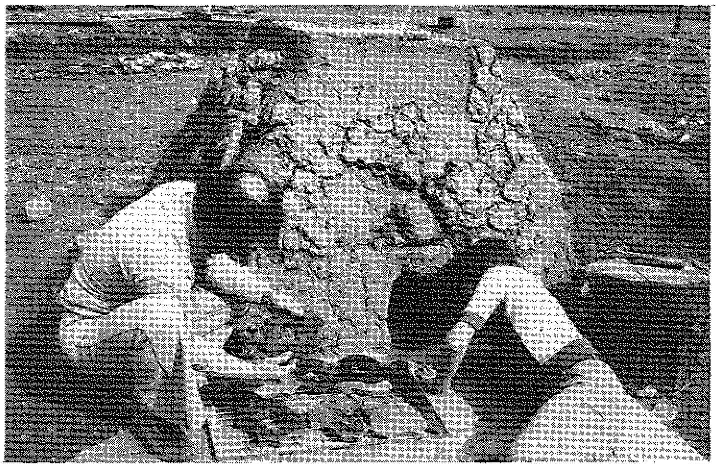
Das erste Teil dieses Beitrag verlegt zum erstenmal die genau Ausmasse eines in 1972 untergesuchten rechwinkligen zweiabzügigen Ofens aus dem 14ten Jahrhundert, wo die gestempelten Bodenziegel der Kirche von Norton Priory gebrannt wurden. Die Errichtung in 1977 eines experimentalen Oren, der auf dieser mittelalterlichen Ofen eingerichtet war, die Verfertigung und das Verglasen gestempelter Bodenziegel, und die zwei erfolgreichen Heizen werden sodann beschrieben, welche eine ganze Reihe Problemen der mittelalterlichen Produktionsmethoden solchen Bodenziegel abgeklärt haben. Die Temperaturen des zweiten Heizens, das 1000° erreicht hat, werden in Tabellenform verzeichnet.

Illustrations see over ..

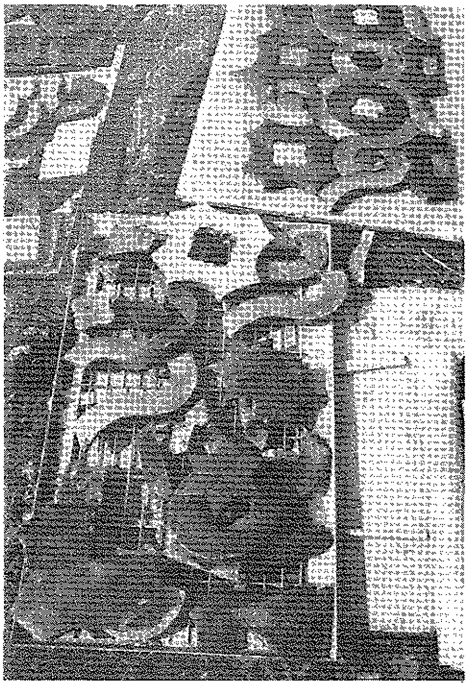
AN EXPERIMENTAL TILE KILN AT NORTON PRIORY, CHESHIRE



Firing the kiln.



Unloading the kiln.



Fired tiles.