The Horniman Museum Kiln Experiment at Highgate Wood—part 2

A RECORD COMPILED BY THE PARTICIPANTS

THE POTTERY COPIED

It was clear that with only two weeks available to carry out the whole experiment only a limited range of vessels could be made. For simplicity production was restricted to vessels from the three Highgate categories 1, 2 and 4[1] and one actual pot from each category was taken as a model. The measurements of the models are given in Table 1.

Category	1 - Jar	2 - Beaker	4 - Dish
Rim Diameter	8.75	3.50	11.70
Height	7.80	5.25	2.50
Base Diameter	3.25	2.10	7.00

Table 1 — The measurement of the models (in inches)

The Clay Used

All the clay used came from a trench 10ft. long by 5ft. wide situated 250ft. west of the experimental area.[2] The top 1.5 ft. of the clay was discarded because of root contamination. The deposit below this (Batch 1)—from a depth of 1.5ft. to 2.5ft.—was used both for kiln construction and potting. The clay beneath this—(Batch 2)—from 2.5ft. to 3.5ft.—was used only for the kilns because it was considered to be too gritty for the pottery. A lower level (Batch 3)—from 3.5ft. to about 5ft.—was relatively more sandy and used for both purposes. The clay was dug as far as possible in slabs and precautions were taken to ensure that it was not made dirty during excavation.

Clay Preparation

The clay was prepared for potting within the experimental area. Two methods were tried:—

1. Some of the clay was reduced to lumps about one cubic inch in size, thrown into a bin of water and allowed to soak overnight.[3] It was then mixed with equal amounts of untreated clay. After only five minutes kneading the mixture became well integrated although tiny hard lumps persisted and remained throughout the consequent potting. Kneading was tried on two different surfaces, York stone slabs and wooden planks. The wood proved easier to work on as the clay tended to stick to the stone.

2. The majority of the clay was heaped, mixed with water, and puddled with bare feet. This method of preparation proved more efficient in getting rid of lumps and integrating the clay. It was then kneaded on wooden planks.

Throwing

Two direct drive kick wheels were provided for throwing the pottery. None of the eight potters had worked with this type of wheel before and only two of them had previous experience of repetition throwing. The dishes were thrown first, then the beakers, and finally the jars. Six of the potters worked on the dishes, all eight on beakers and six on jars. On average it took 7.5 minutes to throw a dish, 13.5 minutes for a beaker, and 19.5 minutes for a jar. It is probable that these figures are unrealistically slow in relation to the original throwing rate, and reflect the unfamiliarity of the potters with the wheels, clays and shapes of vessels. The fastest potter—who had previous 'production line' experience—was soon producing beakers in 8.5 minutes and jars in 12.5 minutes. It is possible that with greater experience even those times could be considerably reduced.

Turning

After the pots had become leather hard—about three days after throwing—they were turned. The beakers and jars were provided with a foot-ring; all the vessels had their sides shaved with a turning

1. *London Archaeol* 1 No. 3 (1969) 60-65 for fuller description of these categories.
2. Clay Pit 2 — *London Archaeol* 2 No. 1 (1972) 17 for a plan of the experimental area.
3. The water used in the production was tapped from the Keeper's office in the wood and taken to the experiment area in containers.

blade. On average the dishes—the simplest vessels—took about 2 minutes to turn, the beakers 6 minutes and the jars 9 minutes.

Decorating

No decoration was applied to the dishes. The beakers had a cordon at the base of the neck which was fashioned whilst throwing. After turning they were dipped into an imported white slip.[4] As soon as this had dried bands of dots were applied over it using Highgate clay slip. The instrument used for this was a wooden five-pronged comb. It took an average of 4 minutes to apply the slip and comb decoration to the vessel. The jars were also provided with cordons during throwing and dipped into white slip after turning. A band of vertical lines was scratched through the slip with a stick between the base of the neck and the shoulder. The slipping and scratching took an average of $1\frac{1}{2}$ minutes.

Drying

The vessels were laid on boards in the open air during the day and were placed in one of the huts at night to avoid being affected by moisture. To allow for even drying the vessels were upturned after the rims became sufficiently firm. The total drying process, even in the fine weather which lasted throughout the experiment, took as long as four or five days.

Production Total

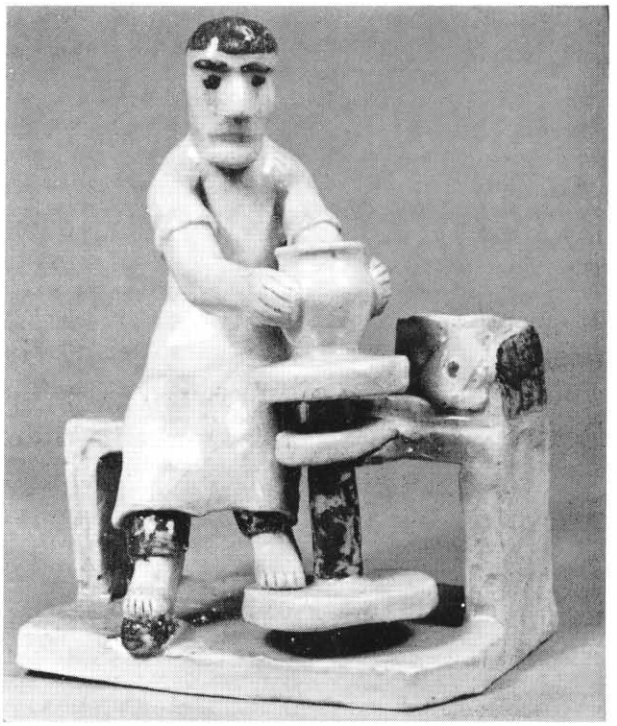
Two hundred and twenty-six vessels belonging to the three categories were thrown. Two hundred and thirteen (94 per cent) of these were turned, and one hundred and seventy (75 per cent) placed in the kilns for firing. It will be seen from table 2 that only about a third of the dishes (Category 4) survived to the firing stage. The remainder cracked in drying to the extent that the bases became detached from the walls and it was decided not to proceed with them further.

Category	1 - Jar	2 - Beaker	4 - Dish	Total
Thrown	57	109	60	226
Turned	57	98	58	213
Placed in kilns	57	94	19	170

Table 2 — The vessels produced

Kiln Loading

In each kiln the pots were loaded through the top of the nearly completed dome. They were stacked rim-to-rim and base-to-base in several layers with the bottom vessels resting on the pedestal and fire bars. Some beakers were placed inside the jars. Kiln 1 which was used for a test firing, contained only 18 vessels; Kiln 2 was loaded with fifty-three vessels during its first firing and seventy-eight during its second. Kiln 3, which was fired only once held fifty-four pots. These totals include about ten vessels not made in conformity with the categories and twenty scheduled vessels which were fired more than once. The former are excluded from the results and the latter included in relation to their first firing only. None of the kilns were fully loaded; it is probable that Kilns 2 and 3 could have taken one hundred and eighty to two hundred vessels. After stacking, the tops of the domes were completed.



Model of Polish peasant potter with kick-wheel

The Fuel Used for Firing

Hornbeam, birch and oak—which provide most of the tree cover in the wood—were used. The fine weather enabled both recently cut logs and fallen pieces to be utilized without fear of damp affecting the fuel. During each firing the size of the pieces burnt increased from twigs at the kindling stage to timbers three feet long towards the climax.

Pre-Firing

A major initial problem in an experiment undertaken over a short period and involving clay structures relates to the time required for their drying out. It was necessary to speed this process and with every kiln a pre-firing session took place in which a low fire was kept burning for some hours; in the case of Kilns 2 and 3 this continued overnight.

Firing of Kiln 1

The original technique involved the laying of

4. Iron free, but mixed with some Highgate clay in an attempt to ensure an even drying.

three or four pound-bundles of twigs, and later, logs along the flue. This however seemed to cause a loss in the air supply, and as the fire settled a technique of criss-crossing the wood was adopted. The temperature was measured by four thermocouples resting in iron pipes which were inserted into different parts of the kiln. They were connected to a pyrometer and normally checked at half-hourly intervals.

As the wood burned, ashes and embers were pushed along the flue into the furnace, until there was a bed of half-burnt material right round the base of the pedestal. As it heated the flue arch began to crack and then to collapse onto the fire. This made it difficult for the fire to burn well and also prevented the development of an effective draught through the kiln. This was shown by the difference between the temperature at the front of the kiln and at the back.

After five hours the temperature had reached 700°C at the front, and 425°C at the back. The fire was roaring and flames were leaping from the top of the kiln. The flue arch could not withstand such heat for long; a great crack appeared across the front of the dome and more and more wood was required, first to hold, then to arrest the decline in temperature which was down to 410°C at the front within an hour.

The flue was then blocked with earth and clay and the dome top was similarly plugged in the hope that reduction would take place. When the pots were unloaded it was found that none of them were properly fired, although those that had fallen into the fire were harder and greyer.

The Joint Firing of Kilns 2 and 3

These two kilns, which were set near to one another, were built to designs which incorporated the knowledge gained from the architectural damage to Kiln 1. The flue arches of both were comparatively short in an attempt to counter the problems of supporting a clay arch over a large space. This made it easier to push the ashes and embers right under the pots but also led to a poorer draught. As temperatures rose cracks began to appear in the back of Kiln 3; these were plastered over with clay. The same firing techniques were used as in the latter stages of Kiln 1.

In an attempt to get heat properly circulating inside the kilns various strategies were used. At the end of the fourth hour Kiln 3 was modified by the addition of a chimney over its air vent. This made little difference to the temperature but somewhat improved the circulation of air and heat. The kiln was also given an extra vent at the top of the dome but this made no difference and the hole was re-blocked with clay.

The temperature rose more steadily in Kiln 3 probably due to the larger flue and lesser problems with the arch. After eight and a half hours Kiln 3 had reached 900°C (its maximum) and it was soon blocked up. Kiln 2's stokers continued to build up their temperature until a maximum of 800°C was reached (after nine and a half hours). Half an hour later this kiln was also blocked off.

The Second Firing of Kiln 2

The advantages of re-using the kiln—to which a corbelled flue arch had been added—were soon apparent. Two and a half hours stoking raised the temperature to 680°C and after five and a half hours a temperature of 900°C was reached.[5] Throughout the firing the side air vent[6] was used for preventing ash and embers blocking the front of the kiln. During the operation a pile of sherds was placed on top of the oven dome — around the chimney hole — to act as a baffle. This appeared to improve the draught and also to keep in the heat. The kiln was blocked off after six and a half hours.

Bridging the Flue

The major structural problem, exposed in firing, was in the bridging of the space between the flue walls at the entrance to the furnace. This support carried the full weight of the front of the dome. A true arch (i.e. one in which the inward pressure from the sides is resisted by a wedge-shaped keystone) would have supported the dome satisfactorily. The original Highgate potters appear to have used something approaching a corbelled technique in their Kiln 2. Large and flatish pieces of pot were laid on their sides forming a rough arch shape. With no keystones there is little strength in such a structure and its success is something of a mystery.

Various methods were tried in the experiment. In Kiln 1 the bridge was of sticks formed into an arch and covered with clay. In firing the clay shrank, the wood burned away and the bridge collapsed. This was soon followed by most of the front of the dome and the firing had to be stopped.

With Kiln 2 the first bridge was a true arch built out of wedge shaped unfired clay blocks. Clay shrinkage led to its collapse though fortunately this occurred right at the end of the firing. Had the

5. It took eight and a half hours to reach this temperature in Kiln 3.

6. Each Kiln was provided with a vent at the base of the furnace just north of the flue entrance as in the original Highgate Kiln 2. It was thought that this was related to control of the draught within the furnace but tests in Kiln 1 indicated that its blocking and unblocking proved ineffectual. During subsequent firing it was found to be useful in redistributing burning material passed up the flue and for removing debris.

The first firing of kiln 2 and kiln 3.

bricks been prefired, the bridge would probably have been successful. Kiln 3's bridge was built using a cylinder pillar with a disc on top (in imitation of original Highgate Kiln 4). The bridge survived although there were difficulties in stoking round the pillar.

The re-constructed bridge for the second firing of Kiln 2 was an arch corbelled to within six inches of its apex at each side; the sides were then held apart by a wedge shaped tile. This structure withstood firing successfully.

The Results of the Firings

After the kilns had cooled down the dome caps were removed and the vessels unstacked. (The results are summarised in table 3).

KILN No.	1	2 (1st)	3	2 (2nd)	Total	%
vessels Loaded[1]	16	43	51	60	170	100
Vessels Unloaded[2]	12	33	46	53	144	85
Fired	—	17	21	53	91	54
Underfired[3]	12	16	25	—	53	31
Cracked	6	21	27	30	84	49
Uncracked	6	12	19	23	60	35
Fired & Uncracked	—	6	9	23	38	22

1. Excluding refired pots and a few odd ones made but not scheduled. Kiln 1, 2, Kiln 2(1) 10, Kiln 2(2) 18, Kiln 3, 3.

2. Disintegrated, presumably blown-up during firing.

3. Considered soft and brittle.

Table 3 — Statistics of firing (No. of Vessels)

Of the total vessels loaded just over a half were considered to be properly fired and almost a quarter both fired and uncracked. The second firing of Kiln 2 was individually the most successful probably because the structure was dry and warm, consequently requiring much less fuel to reach a high temperature.

Almost half of the vessels were cracked. Fissures were apparent in many of the dishes prior to firing and close examination may well have shown them in other pots at this stage of production. Probably clay prepared more expertly — over a longer period, and with a higher proportion of sand — would have allowed the vessels to shrink more evenly before and during drying.[7]

All of the pottery was oxidised. The grey (reduced) fabric characteristic of Highgate ware was not achieved. Only about a fifth of the vessels were grey to black on the surface, and this was apparently the effect of smoke. It is presumed that air circulated freely during the cooling-off period thus preventing reduction. This was tested in a second experiment conducted during the Highgate

7. The vessels are being compared with original Highgate ware in relation to their sand content by S. A. MacKenna.

Time in hours of firing	Kiln 1	Kiln 2 (first firing)	Kiln 3	Kiln 2 (Second firing)
0.00	Firing started	Firing started	Firing started	Firing started
1.00		Top air hole made smaller	Cracks in dome plastered up	
1.30	Piece of flue came off			
2.00			Dome caving slightly	Temp. 180°C
2.30	More flue came off. Fire technique changed			Temp. 680°C Air hole widened
3.00				
3.30				
4.00	Temp. 400°C		Chimney added at air hole	
4.30				
5.00	Temp. 700°C Dome collapsing			
5.30	Dome collapsed Kiln blocked off Temp. 340°C			Temp. 900°C
6.00				
6.30				Kiln blocked off Temp. at 710°C
7.00				
7.30				
8.00				
8.30			Temp. 900°C Air hole made at back of kiln	
9.00			Temp. at 840°C Kiln blocked off	
9.30		Temp. 800°C Flue arch collapsing		
10.00		Temp. at 740°C Kiln blocked off		
Kiln opened after	25½ hrs.	25¼ hrs.	24¾ hrs.	17 hrs.

Table 4 — Events during firing of pottery kilns

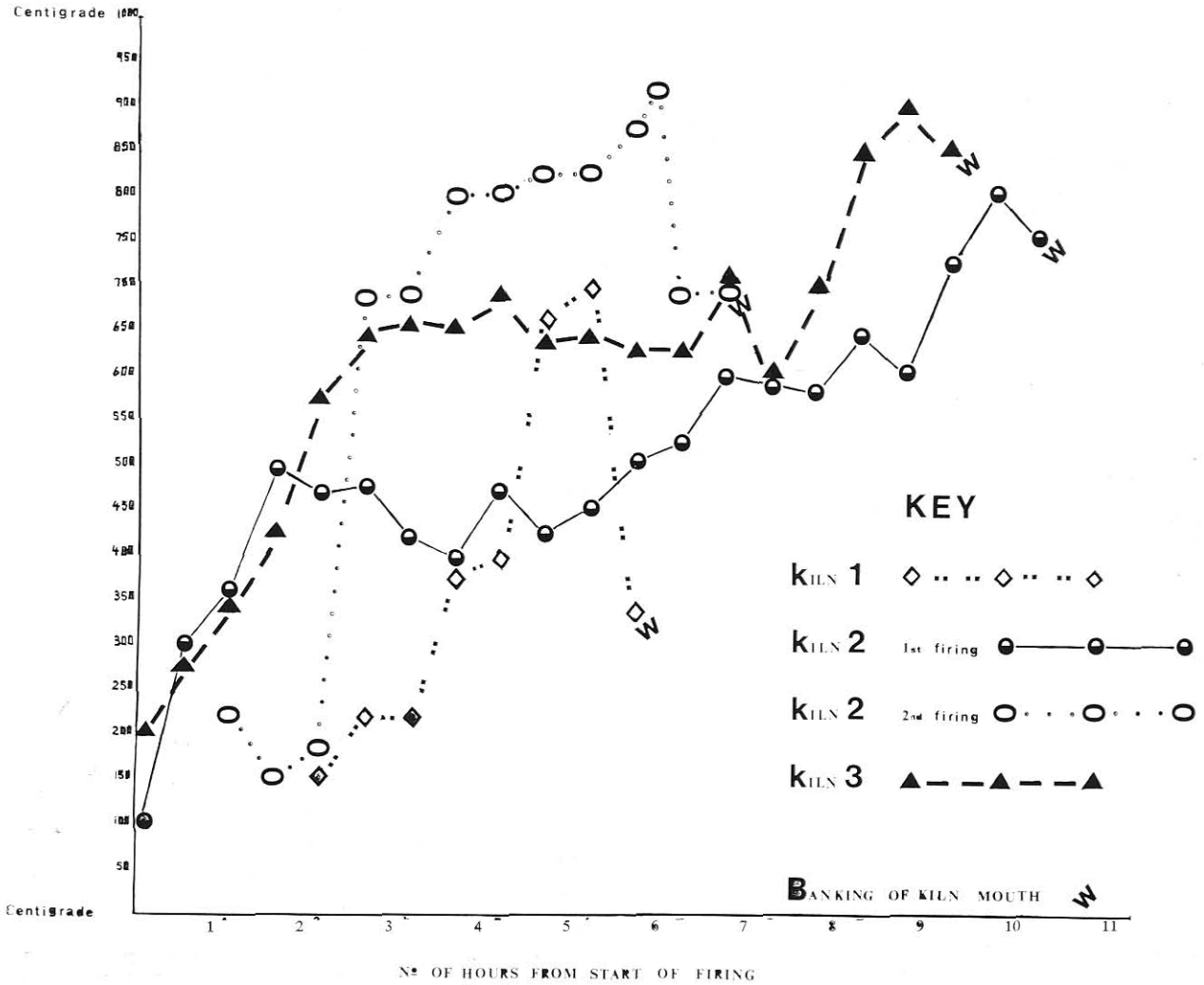
1972 excavation.[8] This indicated that a proper reduction could be achieved if, (i) the vessels were filled with humus before firing, (ii) humus was loaded into the kiln prior to sealing, and (iii) the kiln was kept thickly covered during the cooling-off period. A further experiment in 1973 will try to examine the importance of these three variables.

General Conclusions

The experiment showed that it was possible to set up a pottery making establishment, making use of the site's natural resources, reasonably quickly Most of the raw materials and tools were either at hand or readily fashioned. The seemingly essential imports were potters wheels and iron-free slip clay. For the experiment the water was taken from mains supply but it is assumed that it was originally provided from a spring or stream, or by the artificial ponding up of rainwater. Even on this small scale, and allowing for the inexperience of the course members, saleable vessels were being produced within a fortnight.

Assuming we set up "in business" it would be difficult on the basis of the experiment, to determine precisely a likely production rate. However, the most experienced potter — who had had no previous practice on a kick wheel nor familiarity with the vessel shapes—was throwing a beaker in eight and a half minutes and a jar in twelve and

8. By John Beatson Bell and Nicholas Peacey.



a half. He could, given time, probably throw fifteen dishes or jars, or twenty beakers, in an hour.[9] This rate could, in a ten hour day, six day week, result in the throwing of nine hundred jars or dishes, or one thousand two hundred beakers. These might take a further two to three days labour to turn, but if decorating was done by other personnel it is possible to envisage a skilled potter adequately serviced producing, say, one thousand vessels (five or six kiln loads) in just over a week.

It is clearly hazardous to relate this to Roman Highgate production for we have scant knowledge of who worked there and how their activities were organised. Yet six major excavation periods, seemingly covering most of the site, have yielded as few as eight kilns of which only three were relatively substantial. On this evidence alone we can assume that the site was not a major production centre. Further the digging has provided little which supports the idea of a permanent settlement; buildings are lacking and the small amount of non-industrial material could readily be accounted for as the potters' personal or domestic possessions.

In post-excavation analysis nearly 10,000 waster rim sherds have been worked on. This may represent about one-quarter of the rims dug up on a site that is possibly four-fifths excavated. Therefore, perhaps,

9. In the view of Andrew Appleby — one of the course tutors and a professional potter.

some 50,000 waster rim sherds occur. Our work indicates that, on average, a rim sherd represents about one-tenth of the vessels circumference. On this basis only some 5,000 waster vessels would exist. If a waster rate of 20% is assumed[10] then it is possible that the sites production totalled some 25,000 vessels. This might represent overall some twenty-five weeks production by one skilled potter — and considerably less if the working group contained more than one such craftsman.

The above figures must of necessity be hypothetical. However a belief in limited usage of the site — perhaps in the form of a small scale series of exploitations — by itinerant potters making enough to carry to the London market would be both congruent with the archaeological evidence and shown feasible by the experiment.

10. This is a figure assumed by Andrew Appleby. It is of interest that on the firing of 551 pots from four experimental RB kilns at two sites G. F. Bryant gave a waster rate which works out at 26.7% overall (see "Experimental RB Kiln Firings" in *CBA Research Report* No. 10 1973. This paper summarises published research to date).

Acknowledgements

The compilers of this report, Andrew Appleby and Harvey Sheldon (tutors), Audrey Brightwell, George Demetriou, Michael Massey and Nicholas Peacey, would like to thank the other students who by their skill and effort made this information available. We would also like to thank the Horniman Museum who organised the experiment on behalf of I.L.E.A., especially Bernard Brandham who compiled the film and photographic record, and George Jarvis who nobly and cheerfully refereed throughout. The Epping Forest and Open Spaces Committee of the Corporation of London gave permission for it to take place and their staff in the Wood gave consistent help. The graph in the report was drawn by Eddie Jeffreys and the text typed by Winn Exley.

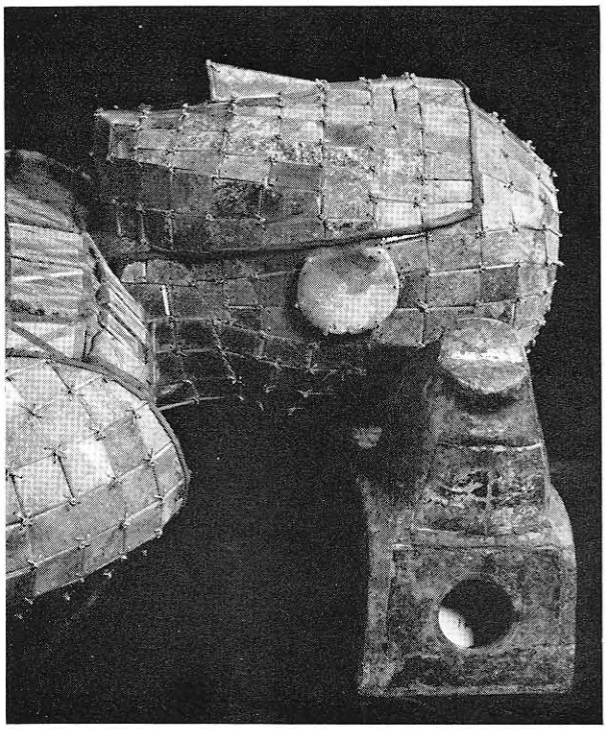
MORE ON THE CHINESE EXHIBITION

THE EXHIBITION at the Royal Academy is to be formally opened by the Prime Minister on 28th September; public viewing will start at 10 a.m. on the 29th September. From then on the exhibition will be open for 11 hours each day, seven days a week, with the exception of Christmas Day and Boxing Day. Admission prices inclusive of VAT will be 60p for adults and 30p for children, school parties, students and old age pensioners.

During term time the five hours between 10 a.m. and 3 p.m. every Monday will be reserved exclusively for prebooked school parties. Details of how to apply for school bookings have been sent to local education authorities and organisations representing independent schools.

A comprehensive and lavishly illustrated catalogue describing the exhibits will be available from the time the exhibition opens and will sell for less than £1. As mentioned in the last issue arrangements are to be made to avoid the Tutankhamun-type queues.

The most interesting object on view will undoubtedly be the jade funery suit of Queen Tou (Western Han Dynasty — c. 100 B.C.) found in a tomb at Man-ch'eng in Hopei Province. When the iron door of the well-constructed tomb was forced open, it was found that nothing remained of the Queen inside the suit apart from a handful of dust. However, the tomb also contained a large number of votive objects, some of which are expected to be on display.



Detail of the Jade funery suit of Queen Tou of Liu Sheng, excavated in 1968.
(Photo: Derek Witty)