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The Form and Construction of the Makotukutuku House, a Pre-European Dwelling in Palliser Bay, New Zealand

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ABSTRACT

Various lines of evidence are reviewed in order to describe in as much detail as possible the form and construction of a pre-European Māori house. The exact floor plan, the shape of the posts, and their material were known from archaeological evidence. Sparse archaeological evidence of other pre-European buildings and early historical records provided a basis for estimating details such as side wall height and slope, height of ridgepole and angle of roof. There is no firm evidence about the exact nature of the roof construction or the thatching of walls and roof. It is possible that in some details of its structure the house more closely resembled rectangular buildings in tropical Eastern Polynesia than historical Māori houses. The question of whether the house contained carvings and if so what they were like cannot be answered with confidence. Each aspect of the form and construction of the house is discussed and the basis for each proposed detail is documented.

Keywords: ARCHAEOLOGY, HOUSES, RECONSTRUCTION, WHARE PUNI, NEW ZEALAND, PALLISER BAY.

INTRODUCTION

This paper discusses the probable form and construction of the Makotukutuku or M4 house, a pre-European Māori dwelling in Palliser Bay, the plan of which was exposed by archaeological excavation in February 1971. The study was prompted by a proposal to build a reconstruction of this house as part of an exhibition in the new waterfront building of the Museum of New Zealand Te Papa Tongarewa. This led us to review all the lines of evidence that could be brought to bear on the house to establish a much more detailed description than had previously been attempted.

The M4 site (New Zealand Archaeological Association site numbers N168/29 [imperial] and S28/56 [metric]) is situated about 2.3 km inland in the Makotukutuku valley in Eastern Palliser Bay at the southern tip of the North Island. It consists of a garden area with stone walls and small stone-and-earth mounds, bounded on the east by a small ridge with a raised

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rim pit and a terrace visible on the surface (Fig. 1) (Leach 1976: 249 ff., 1979: 122 ff.). The terrace, which proved to be the site of the Makotukutuku house, was excavated as part of a major integrated programme of archaeological research in the southern Wairarapa between 1969 and 1972 (Leach and Leach 1979a). The excavation exposed the plan of the house, which had been burned down. The reason for the fire is unknown.

The Makotukutuku house and the Moikau house, which was excavated during the same research programme and provided the starting point for a major study by Prickett (1974, 1979, 1982), have been very influential in discussions of pre-European Māori houses. At the time these sites were excavated, archaeological evidence of houses was almost non-existent, most excavated sites yielding a bewildering array of postholes without clear patterning. Consequently, the two houses have frequently been described and illustrated. Several sketches depicting 'partial reconstructions' of both have been published on various occasions. However, these sketches are only impressions and do not cover many details of construction. Moreover, such depictions of the Makotukutuku house (Davidson 1984: 153; Prickett 1987: 98), which show the wall posts and rafters as slabs, connecting by means of a mortise and tenon arrangement, are probably not correct, as we demonstrate below.

The reconstruction of an actual pre-European timber building has not been undertaken in New Zealand before, although there are numerous precedents elsewhere in the world. In some cases, the building or buildings belong to a period for which there are no historical records, as in the case of the Iron Age settlement at Butser in England (Reynolds 1979). In others, a reconstruction may be based largely or entirely on historical rather than

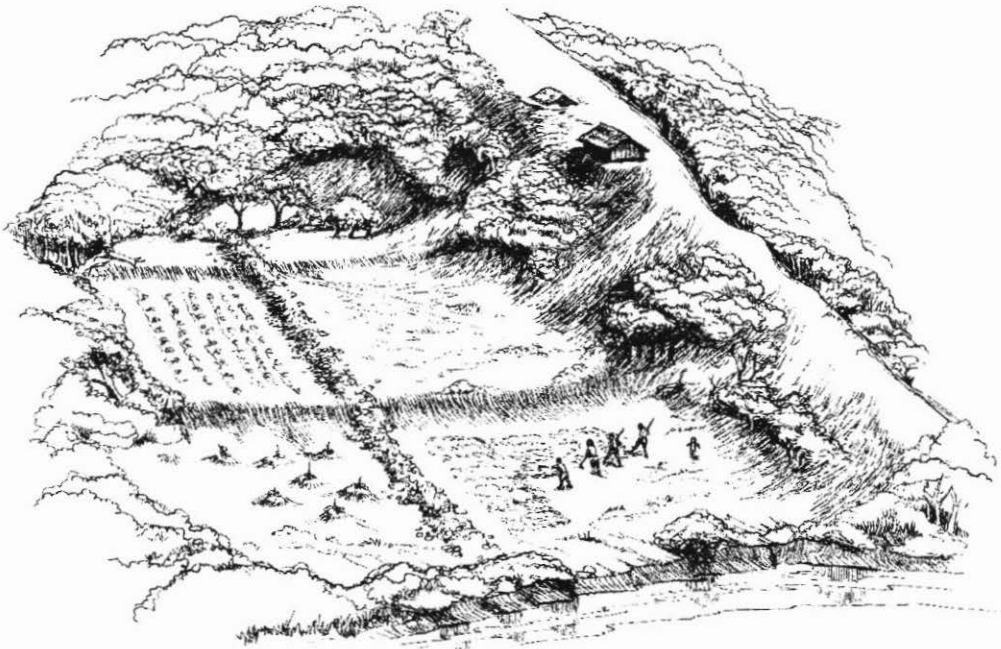


Figure 1: Artist's view of the Makotukutuku house site and associated garden area (from Leach and Leach 1979b).

archaeological records, as in the case of certain timber buildings on *heiau* (stone-constructed religious enclosures) in Hawai'i (Kirch 1996: 96–97, 108–11).

Thus there are two extremes which could be followed during reconstruction. At one end of the scale, such as the Iron Age example, strictly speaking there is only archaeological evidence available; at the other end of the scale, such as the Hawai'ian example, there is detailed historical evidence which can be used. The latter form of reconstruction is best referred to as applying *The Direct Historical Approach* to the problem (H. Leach 1969: 2; Steward 1942). In point of fact, in the former example, where no direct historical evidence exists, archaeologists attempting to reconstruct prehistoric behavioural forms (such as architecture) use a combination of archaeological information and *Ethnographic Analogy* (Davidson 1988). That is, they use ethnographic information from another historically recorded society. In the use of ethnographic analogy, the most accepted view is that one should look for a society which has a similar economic and technological system to the archaeological one being investigated, and if possible a modern society which is descended from the older one.

The Makotukutuku house was intermediate in age between the time when Polynesian settlers left their tropical homeland for New Zealand and the time when European voyagers first encountered Māori. There are therefore three primary sources of information which are relevant to any attempt to reconstruct the house:

- 1: basic factual information recovered from the archaeological excavation and from subsequent analysis of samples, such as the identification of charcoal species, using the *strict factual approach* (approach 1)
- 2: historical data on Māori house form using the *direct historical approach* (approach 2)
- 3: historical data on Polynesian house forms in Eastern Polynesia using *ethnographic analogy* (approach 3)

All these sources of knowledge and all three approaches are used during normal archaeological research.

When considering the details of the house construction, we started with the actual archaeological evidence of its floor plan and the identifications of charcoal recovered from the site (approach 1). We next reviewed the sparse archaeological data about the construction of pre-European Māori houses in other parts of New Zealand, particularly the house timbers recovered from waterlogged deposits at Mangakaware in the Waikato and Kohika in the Bay of Plenty, and the detailed reconstruction of a Kohika house proposed by Wallace and Irwin (2000).

The direct historical approach (approach 2) was used in assessing the form of early European descriptions and drawings of Māori houses. Studies by Prickett (1974, 1982), Martin (1996) and McCracken (n.d.) provide information derived from documentary sources on a number of aspects of house construction between AD 1769 and 1926.

Finally, we also employed approach 3, in considering the possible form of the tropical Polynesian houses from which Māori houses are descended. Archaeological evidence is poor on this point, and we were therefore forced to resort to *indirect analogy*: the ethnographic evidence about eighteenth and nineteenth century houses in Eastern Polynesia. It should be noted that our use of ethnographic analogy here is indirect in the sense that early historic

houses in tropical Polynesia have only indirect relevance to prehistoric New Zealand house forms compared with early historic records of Māori houses. What we are doing here is looking for common threads in tropical Eastern Polynesian house forms, which arguably may have prevailed at the time when New Zealand was first colonised from that region. This approach is related to that taken recently by Green, who has used linguistic and ethnographic data in attempting to reconstruct aspects of the material culture of ancestral Polynesian society (Kirch and Green n.d.).

TYPE OF HOUSE

This issue was discussed at length by Prickett in reference to both the Moikau house and the Makotukutuku house (Prickett 1974). He concluded that they should be regarded as *whare puni* (sleeping houses), not as an incipient form of *whare whakairo* or *wharenuī* (meeting house). Knowledge about the *whare puni* derives from two sources: oral narratives and written observations by early European visitors. A useful summary of the *whare puni* seen during Cook's first voyage was made by Banks, writing in AD 1770. If we ignore the somewhat derogatory tone, there are some very pertinent observations in the passage:

Their houses are certainly the most inartificially made of any thing among them, scarce equal to a European dog kennel and resembling one in the door at least, which is barely high and wide enough to admit a man crawling upon all fours. They are seldom more than 16 or 18 feet long, 8 or 10 broad, and five or 6 high from the ridge pole to the Ground and built with a sloping roof like our European houses. The materials of both walls and roof is dry grass or hay and very tightly it is put together, so that necessarily they must be very warm. Some are lined with bark of trees on the inside, and many have either over the door or fixed somewhere in the house a piece of Plank covered with their carving, which they seem to value much as we do a picture, placing it always as conspicuously as possible. All these houses have the door at one end and near it is generally a square hole which serves for a window or probably in winter time more for a chimney, for then they light a fire in the middle of the house. At the same end where this door and window are placed the side walls and roof project, generally 18 inches or 2 feet beyond the end wall, making a kind of Porch in which are benches where the people of the house often set. Within is a square place fenced off with either boards or stones from the rest, in the middle of which they can make a fire; round this the sides of the house are thick laid with straw on which they sleep. As for furniture they are not much troubled with it: one chest commonly contains all their riches, consisting of Tools, Cloaths, arms, and a few feathers to stick into their hair; their gourds and Baskets made of Bark which serve them to keep fresh water, provision baskets, and the hammers with which they beat their fern roots, are generally left without the door (Beaglehole 1963 (II): 17-18).

This form of house would measure 5182 x 2743 x 1676 mm. The Makotukutuku house measures 5590 x 3360 (3280 at the door), with a suggested height of 1755 mm, and is clearly close to Banks' estimate for the *whare puni*.

Another important early description of the *whare puni* was by Roux during the visit by Marion du Fresne in 1772. His observations refer to houses in the far north of New Zealand (Spirits Bay).

Among other things their houses prompted our admiration, so skilfully were they made. They were rectangular in shape and varied in size according to need. The sides were stakes set at a short distance from one another and strengthened by switches which were interlaced across

them. They were coated on the outside with a layer of moss thick enough to prevent water and wind from getting in and this layer was held up by a well-constructed little lattice. The interior was woven with a matting of sword-grass on which there were at intervals, by way of ornament as well as to support the roof, little poles or, more accurately, planks, two to three inches thick and rather well carved. In the middle of the house there was also a big carved pole which supported the weight of the roof (together with two others at the two ends). What surprised us still further was that the whole construction was mortised and very strongly bound together with their sword-grass ropes. On the central pole was a hideous figure, a sort of sea devil. As we have found this figure in all their houses and in this very same place, which seems consecrated to it, there is every reason to presume that it is their divinity that is represented under this form.

Each house had a sliding door, so low that we had virtually to lie down to enter. Above it there were two small windows and a very fine lattice. Running right round the outside was a little ditch for water to flow in. These houses are roofed with reeds; in some of them there was a rather poorly-made cot and inside it some very dry straw that they sleep on.

In front of each door three stones were to be seen, forming a sort of hearth where they would make a fire: there was another stone a little way off, which they used to grind their red pigment. I had the post taken from one of these houses; it was very well carved and made of the wood of the Sassafras, giving off a very pleasant smell. It seemed to me extraordinary that anyone could do such work without tools such as ours: however, nowhere did we find traces of any metals (Ollivier and Spencer 1985: 133).

Roux's description refers to a specific location almost as far away from Palliser Bay as it is possible to go in New Zealand. Banks' account, on the other hand, is a summary of houses seen in several parts of the country, including Queen Charlotte Sound, just across Cook Strait from Palliser Bay. Unfortunately, no detailed drawings of houses survive from Cook's first voyage, but John Webber, the artist on Cook's third voyage, made an excellent sketch of a house on Hippa Island in Queen Charlotte Sound (Fig. 2).

Fifty years after Banks was writing, a Russian expedition under Bellingshausen spent a week in exactly the same part of Queen Charlotte Sound. A number of the Russians visited a settlement in what is now Little Waikawa Bay. Bellingshausen described the chief's house as follows (Barratt 1979: 36):

The structure consisted of posts, placed in three rows. The central posts were twice as high as a man, and on each of them an ugly human figure had been carved and decorated with red colouring. On these posts and on the outer rows, which were a fraction lower than the shoulder of a man, transoms had been placed to support the roof, which consisted of beams covered with leaves. A screen six feet inside the entrance produced an ante-chamber. The whole interior was neatly covered with fine matting; several mats were also placed on the floor, where the inhabitants of that building usually sit and sleep. Pikes about 24' long were hung along the walls of the dwelling, also a staff, various insignia of a chieftain, and human figures carved out of wood and stained red.

Three of Bellingshausen's companions also described this house or the houses generally (Barratt 1979: 55, 60, 68, 1987: 25). As Barratt (1979: 84-90) and Trotter (1987: 119-20) have pointed out, there are discrepancies between their accounts, particularly about the size of the chief's house and the number and position of carvings inside.

The Māori in Queen Charlotte Sound in 1820 were not unaffected by contact with Europeans, and there would soon be more dramatic changes with the advent of invading northern tribes, followed by missionaries, whalers and eventually settlers. Although the Russians thought the Māori way of life was similar to that described by Cook and his companions, Barratt (1979: 89-90) considers that the majority of structures seen by the

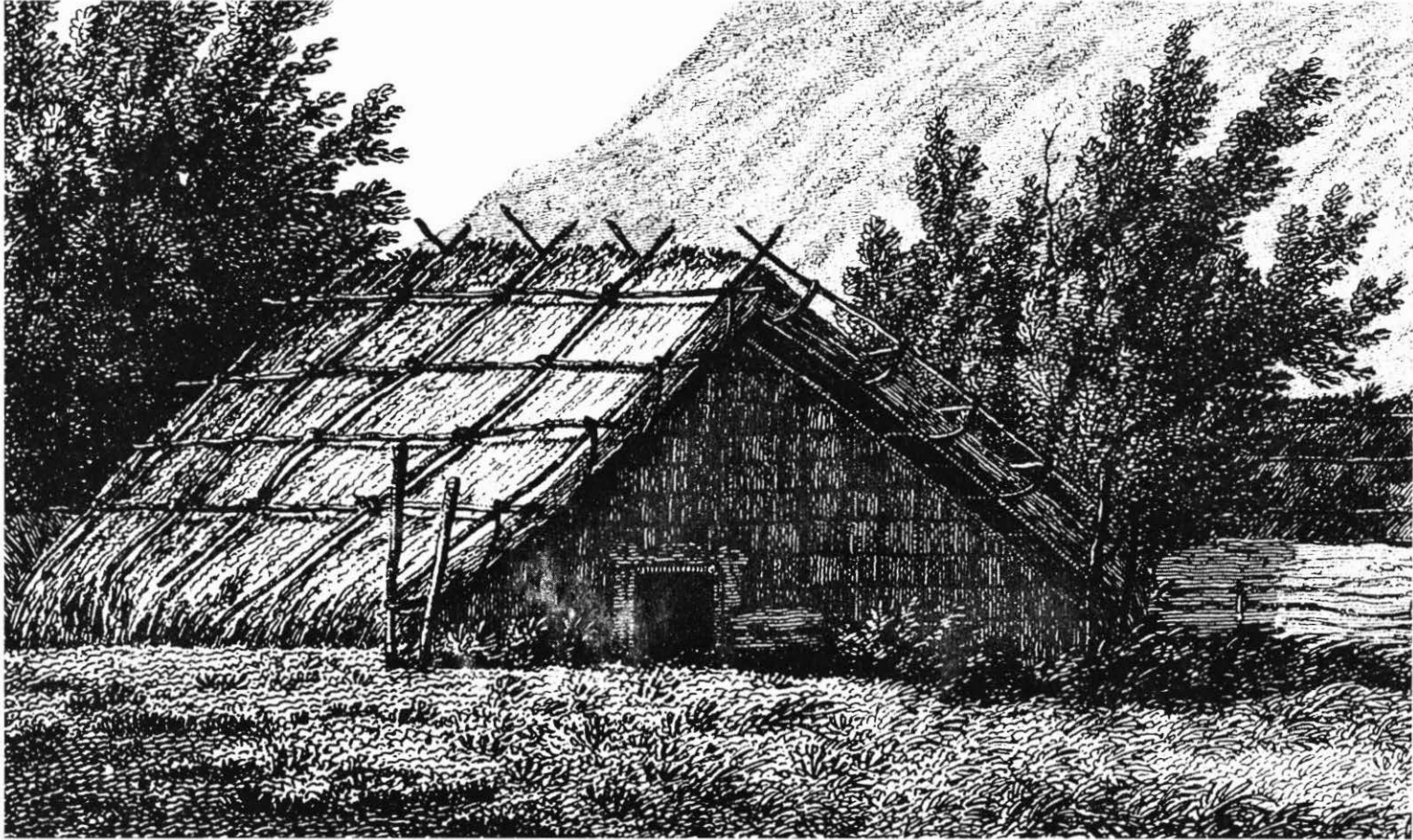


Figure 2: Engraving after John Webber's sketch of the interior of a pā in Queen Charlotte Sound in 1777, with a whare puni at the left.

Russians were unlike those seen by Cook 50 years earlier. Even so, the Russian accounts are worth considering, cautiously, in discussing the probable form of the Makotukutuku house.

THE AGE OF THE HOUSE

Radiocarbon dates were obtained from the carbonised butts of two of the central posts of the house. The two results of 333 BP \pm 69 (NZ1642, post 40) and 484 BP \pm 70 (NZ1643, post 33) were pooled to give an age of 411 BP or AD 1539 \pm 76 (Leach 1979: 124). It is on this basis that the house has previously been attributed to the sixteenth century. The samples were chosen following advice from Brian Molloy (who identified the charcoal in the potential radiocarbon samples) that the anatomical features of the wood suggested, but did not prove, that outer or sap wood had been used. In view of the possibility of inbuilt age, however, samples of seeds from the hearth have been selected for AMS dating. Results are not yet available.

THE PLAN OF THE BUILDING

The precise plan of the building is known from archaeological evidence. A thin layer of soil covered the natural bedrock (shattered deeply weathered greywacke) which had been levelled to form the terrace and the floor of the house. In most cases the actual posts of the house were represented by a very thin carbonised cap at the level of the floor or just below (Fig. 3); in remaining cases, postholes were located which sometimes contained charcoal fragments in the fill. It was concluded that the house had burned down either when it was still occupied or after it had been abandoned. The superstructure had been reduced to ash, which had long since disappeared from the exposed ridge top, presumably as a result of wind action. At the point where the posts reached the floor, however, charcoal had formed and remained in position. Beneath the charcoal, in most cases, where there had been no air to permit the buried part of the post to carbonise, there was an even thinner layer of bright red wood (Fig. 4).

The house faced up ridge. It is approximately rectangular in plan, with a porch at the front, like historical examples of *whare puni*. It is not symmetrical; the front is 250 mm wider than the back, and the west wall is 90 mm longer than the east wall. The placement of the posts and the stone-lined hearth is illustrated in Figure 5. A simple method of laying out the positions of the posts is given in Appendix 1.

SIZE AND SHAPE OF POSTS

The dimensions of the post butts are provided in Table 1, together with the dimensions of the post holes in which the posts were found.

Except for the two stakes in posthole 2 on the west wall, the side wall posts were all rectangular, with their long axes aligned with the house walls. They varied considerably in size: the smallest measured 60 x 20 mm and the largest 100 x 40 mm.



Figure 3: View of part of the excavation of the Makotukutuku house showing three carbonised post butts at the floor level of the house.

There were four posts along the centre of the house, which we assume held up a ridge pole supporting the rafters. At least two of these postholes were clearly larger than those along the side walls, possibly for symbolic reasons in addition to their functional role of supporting the bulk of the weight of the roof.

The largest post butt was in post hole 40 in the centre of the back wall of the house. The square butt measured 110 x 110 cm and was placed in a rectangular posthole 120 x 240 mm, its long axis aligned with the back wall of the house. A dog jaw had been carefully placed in this posthole, apparently as part of a ritual associated with the construction of the house. The posthole which had supported the centre post at the front of the house (posthole 42) was also aligned with its long axis parallel to the front wall. This post marks the northern end of the house, and there was no central post at the end of the ridge pole over



Figure 4: Close-up of post butt 30 showing the thin layer of preserved wood immediately underneath the carbonised cap.

the exterior porch. Posthole 42 was considerably smaller than the centre back post, and no butt was found. Only one of the two intermediate centre posts was present. Post 33 contained a carbonised butt which, like post 40, was practically square in cross-section. These two centre posts were unlike any other posts found. Posthole 43 was aligned with its long axes parallel to the side walls, and was almost identical in size and depth to the large central post at the rear of the house (Post 40). This post must also have been of special symbolic significance, in addition to its structural role. No carbonised butt was present. A central post in this position may have been a candidate for a carved post (see below); if so, it is possible this post was pulled out either before or at the start of the fire which destroyed the house.

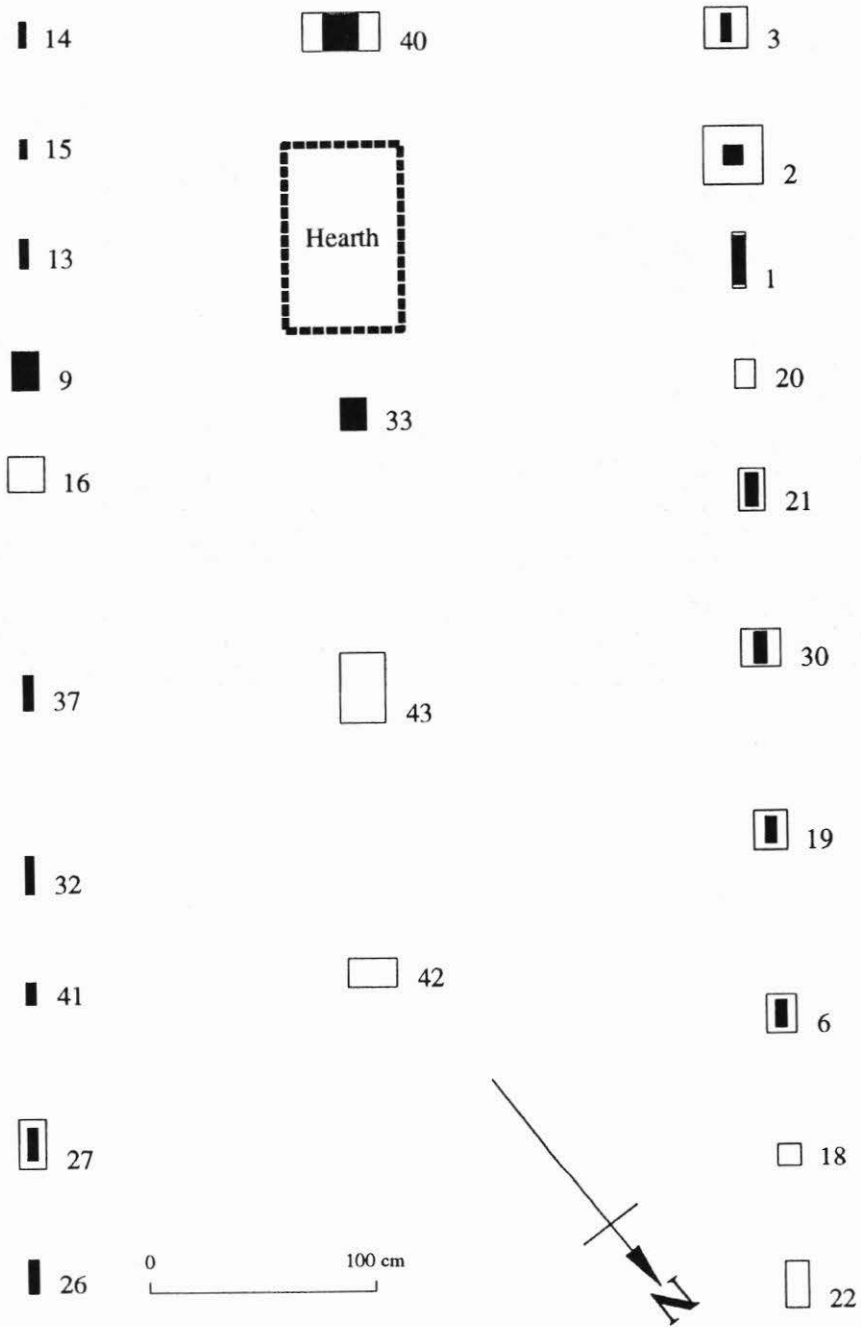


Figure 5: The floor plan of the house, with details of post numbering.

TABLE 1
Carbonised post butts and dimensions of features

Note: dimensions in mm

#31 is the stone-edged hearth

- means not able to be accurately estimated

NS = measurement in north-south direction

EW = measurement in east-west direction

No	Post Butt			Posthole/Feature			Comment
	NS	EW	Depth	NS	EW	Depth	
Eastern Row							
14	80	20	-	-	-	-	Carbonised butt
15	60	20	-	-	-	-	Carbonised butt
13	90	25	-	-	-	300	Carbonised butt
9	120	80	-	-	-	210	Carbonised butt
16	-	-	-	110	110	200	Posthole (with charcoal)
37	110	30	-	-	-	250	Carbonised butt
32	120	25	-	-	-	265	Carbonised butt
41	70	30	-	-	-	-	Carbonised butt
27	100	30	-	155	80	140	Carbonised butt
26	110	30	-	-	-	-	Carbonised butt
Central Row							
40	110	110	-	120	240	320	Carbonised butt and charcoal
31	-	-	-	570	360	-	Hearth (dimensions at centre of stone slabs)
33	100	80	-	-	-	240	Carbonised butt
43	-	-	-	220	140	330	Posthole (with small amount of charcoal)
42	-	-	-	90	150	250	Posthole (with charcoal)
Western Row							
3	90	30	35	130	130	160	Carbonised butt
2A	60	60	160	180	180	210	First carbonised stake in same post hole
2B	25	25	160	180	180	210	Second carbonised stake in same posthole
1	150	35	35	170	40	150	Carbonised butt
20	-	-	-	90	60	150	Posthole
21	100	40	-	130	80	240	Carbonised butt
30	100	40	-	120	120	220	Carbonised butt
19	80	35	-	120	100	210	Carbonised butt
6	85	35	-	120	90	170	Carbonised butt
18	-	-	-	70	70	130	Posthole (with charcoal)
22	-	-	-	150	70	200	Posthole (with charcoal)

TIMBER USED FOR POSTS

The identifications of the species of each post butt are given in Table 2³. Almost all were tōtara⁴. In posthole 2, there appeared to have been two tōtara stakes rather than a single tōtara post. It is almost impossible to distinguish between *Podocarpus totara* and *Podocarpus hallii* from charcoal, but Molloy considered that *Podocarpus totara* was the most similar species. He pointed out that although this identification is not certain it implies that the timbers were brought into this area from the lowland Wairarapa valley, since only *Podocarpus hallii* occurs in the Aorangi mountains. In three cases (posts 16, 18 and 22) where there was no carbonised butt, tōtara was identified from charcoal fragments in the fill of the posthole.

One carbonised butt (post 32) was identified as pukatea. Several species other than tōtara were identified from charcoal in post holes. These were:

- Post 26 mānuka was present as well as the carbonised tōtara butt
- Post 40 mataī was present as well as a partial carbonised tōtara butt
- Post 41 maire was present as well as the carbonised tōtara butt
- Post 42 mataī, maire and ngaio were all present

In all these cases the charcoal is likely to derive from parts of the house structure other than the actual post. It is notable that two of the central posts lacked carbonised butts. This suggests either that they were pulled out before the fire, or that there was adequate air in the vicinity for complete combustion of the wood.

WERE THE POSTS SPLIT AND ADZE-DRESSED?

It is important to distinguish between fact and guesswork here. The depth of the carbonised butts was extremely shallow — usually only 1–3 mm. Underneath this thin layer was an even thinner layer of residual bright red timber. It is impossible to identify any adze marks on such a thin carbonised butt face. In four cases (Table 1), the depth of the butts was somewhat greater, 35 mm in two cases and 160 mm in two cases. The latter were stakes made from tōtara, and certainly not adzed. The two cases where the butt was 35 mm deep unfortunately did not show clear evidence of adzing, and like all other post butts, these broke into numerous fragments during removal.

The carbonised post butts have the following characteristics:

- they are all rectangular in shape
- they all have sharp-edged corners
- they have variable length/breadth dimensions

If the log or logs from which these posts were derived were especially straight grained, which *P. totara* usually is, then all the posts could have been produced by splitting the logs,

³Identification of some of the charcoal from the hearth and some of the post butts was undertaken by Brian Molloy. The remainder of the charcoal from the excavation was identified by Rod Wallace.

⁴Scientific names of plants are given in Appendix 2.

in much the same way that modern fence posts and battens were made on farms until recently. It must be concluded that we do not know whether these posts were adzed into final shape or not. Whatever the case, there is no doubt that this house, like the Moikau house, was very carefully made. Square or rectangular posts seem to be characteristic of well built houses of the *whare puni* type, in contrast to the round poles of less substantial houses, for which archaeological evidence is more often found (Prickett 1982: 128–29; Davidson 1984: 151–58).

TABLE 2
Carbonised remains — species identifications

Notes: Identifications by Molloy = M; by Wallace = W
() Brackets means material recovered in the post hole, not the butt
#31 is the Hearth

No	Species	Identifier
Eastern Row		
14	tōtara	W
15	tōtara	W
13	tōtara	M
9	tōtara	M
16	(tōtara)	W
37	tōtara	M
32	pukatea	W
41	tōtara (maire)	W
27	tōtara	W
26	tōtara (mānuka)	W
Central Row		
40	tōtara (mataī)	M (W)
33	tōtara	M
43	Post hole only	
42	(maire, mataī, ngaio)	W
Western Row		
3	tōtara	W
2A	tōtara	M
2B	tōtara	W
1	tōtara	W
20	Post hole only	
21	tōtara	M
30	tōtara	M
19	tōtara	M
6	tōtara	M
18	(tōtara)	W
22	(tōtara)	W
Hearth		
31	(kōwhai, maire, fivefinger, mataī, coprosma, beech, hebe, ngaio, rātā, sevenfinger)	M and W

DOES THE SIZE OF THE CARBONISED CAPS REFLECT THE POST SIZE?

Is it possible that the actual posts had been larger than appeared from the dimensions of the carbonised caps? Could the outer part of the carbonised post butt have eroded, or could the post itself have shrunk during burning and conversion to charcoal?

The sharply rectangular shape of the carbonised butts supports the view that they do indeed represent the actual posts. If larger, carefully shaped posts had burned and the outer parts of them had somehow weathered or eroded away, the remaining cores might not have been so sharply rectangular. Could the carbonised post butts themselves have shrunk during the process of burning? To answer this question, we need to consider the life history of a typical post from the time it was standing and supporting the roof of the house to the time when the excavation took place (Fig. 6). In Figure 6A we see the complete post buried in its post-hole and standing. During the fire which razed the house (Fig. 6B) the post is progressively burnt away, temporarily leaving charcoal remnants which themselves burn down as far as the ground surface. When the fire has completely burnt away the structure (Fig. 6C), the wooden part of the post inside the posthole still remains; it cannot burn because of lack of oxygen underground. This wood is capped by a thin layer of charcoal. Since the charcoal is attached to the wood underneath it cannot shrink to a dimensional shape and size which is smaller than the post (Buchanan 1997 pers. comm.). Instead, fissures and cracks form in the surface of the charcoal, and stabilise in this form. In the course of time, the wood rots away and dust and soil fill in the gaps (Fig. 6D). Some

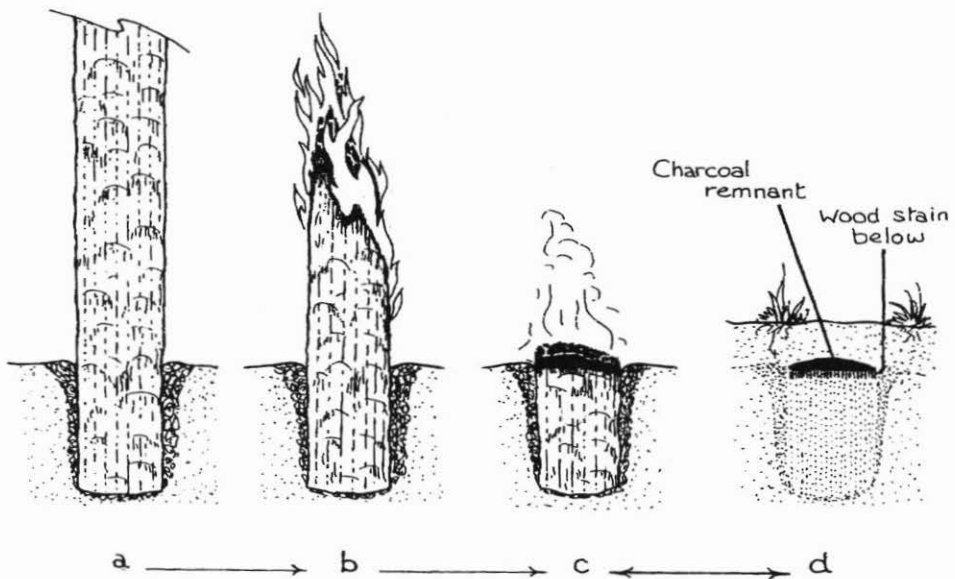


Figure 6: Diagrammatic interpretation of the transformation of a post to a carbonised butt found during excavation.

carbonised caps may well have fallen into the posthole during this process, making the original form of the post difficult to detect during excavation.

Wood is subject to dimensional change during drying out, and figures have been published for *Podocarpus totara* (Entricican *et al.* 1951: Table 3). From green wood to oven dry, tangential shrinkage is 6.8%, and from green to 12% moisture is 4.0% shrinkage. Unfortunately, radial shrinkage values were not investigated, but for other species are about half the values for tangential shrinkage. Thus, if the original post was of green wood it could have been slightly larger than the dried-out post butt found in the excavation. For example, post butt 30, which measured 100 x 40 mm, may represent an original green wood post of up to 107 x 43 mm. The field measurements of the carbonised post butts were made to the nearest 5 mm, which took into account variation from one side to another and the crumbling nature of the charcoal. The quoted shrinkage values are within the measurement error, and are therefore not significant.

By this interpretation, therefore, the sizes of the carbonised caps do adequately represent the original post sizes. These posts are small compared with the posts and planks of more recent Māori buildings.

SIDE WALL HEIGHT

This cannot be determined from the archaeological information because this building was burnt down in the prehistoric period. Instead, we must use early historical evidence of Māori houses to estimate what the wall height may have been. Studies by McCracken (n.d.) and Martin (1996) provided good evidence that wall height increased considerably during the historic period. Early (1769–1840) historical records suggest wall heights between 705 and 837 mm (Table 3).

TABLE 3
Wall heights of historic houses
(from McCracken n.d.)

Period	Number of Examples	Mean Wall Height mm
1769-1800	2	705
1801-1820	No records found	-
1821-1840	14	837
1841-1860	7	847
1861-1926	12	1317

Evidence of prehistoric house wall height is very rare. It requires complete wall posts or slabs to have survived and to be reliably recognised. Fortunately, there are two excellent examples which we can use. One is the wooden house remains found at Lake Mangakaware (Bellwood 1978); the other is the wooden house remains found at Kohika (Wallace and Irwin 2000).

Bellwood recovered a number of wall slabs at Mangakaware; "their lengths would suggest that house walls were 40-50 cm above ground on average" (Bellwood 1978: 61, 62). Slabs of vertical wall elements were also recovered at Kohika, and ranged from 500 to 1000 mm in length (Wallace and Irwin 2000: 80). These Kohika house timbers represent several

houses of different size. Wallace and Irwin have drawn on them to propose a reconstruction of a typical Kohika house. This house is considerably narrower than the Makotukutuku house, and whereas an elevation drawing of the Kohika house looks aesthetically balanced, an elevation drawing of the Makotukutuku house with a wall height of 500 mm does not. The roof looks too low in relation to the house width. The Kohika house has a ratio of width to wall height of 5.4 (2700 mm wide and 500 mm wall height). If this ratio is used for the Makotukutuku house, we obtain a wall height of 607 mm (3280 mm wide at the doorway divided by 5.4). An elevation drawing with these dimensions is much more satisfactory.

The suggested height of the side walls of the Makotukutuku House is therefore 607 mm.

WALL SLOPE

Māori houses of almost all kinds commonly had walls sloping slightly inwards. Wallace and Irwin (2000: 79–80) use a 5° inwards slope in their proposed reconstruction of the house at Kohika. We are suggesting this for the Makotukutuku house also. With a wall height of 607 mm, the top of each post would be 53 mm closer to the centre of the house than the base. It should be noted, however, that Pacific island houses generally have vertical side walls. It is possible that the method of attachment of roof and walls elements (discussed below) was critical to whether the walls sloped inwards or not. If the Makotukutuku house followed a tropical Polynesian pattern, it is more likely to have had vertical side walls.

RIDGE AND RAFTER ANGLE

McCracken (n.d.) collected ridge angles for 44 historically recorded Māori houses (Table 4). These range between 101 and 131°. The simple mean of these data is 118°, equivalent to a rafter angle of 31°. Wallace and Irwin found a wooden roof joint which enables the ridge angle of the Kohika house to be measured directly at 110°, with an associated rafter angle of 35° to the horizontal. Clearly, the prehistoric house had angles similar to the historic ones. In the absence of direct evidence at Makotukutuku, a rafter angle of 35° to the horizontal is considered to be a reasonable choice (Fig. 7).

TABLE 4
Ridge angles of historic houses
(from McCracken n.d.)

Period	Number of Examples	Mean Ridge Angle
1769-1800	1	101°
1801-1820	No records found	-
1821-1840	14	131°
1841-1860	11	111°
1861-1926	18	112°

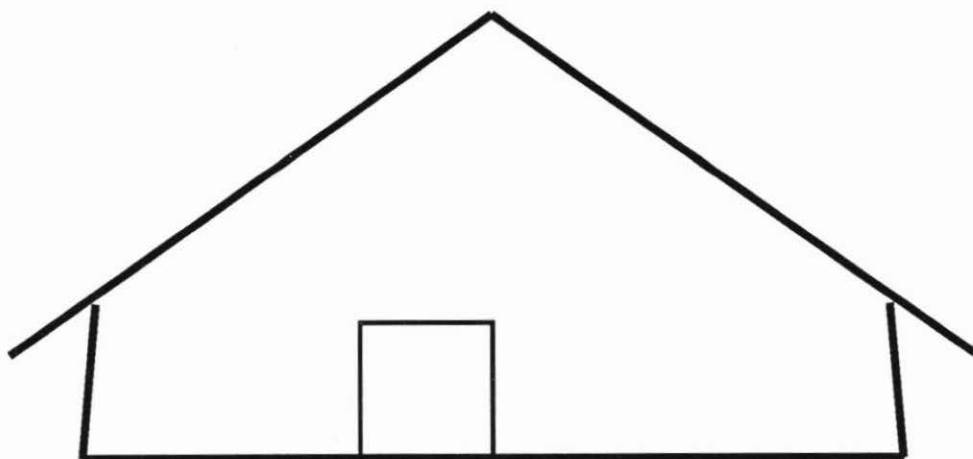


Figure 7: Suggested front elevation of the house. Estimated values are: house width = 3280 mm, wall height = 607 mm, wall angle = 5°, rafter angle = 35°, door width = 533 mm, door height = 533 mm. Derived values: house height = 1755 mm, ridge angle = 110°.

Sutton (1990: 188, 213–14) has presented evidence suggesting that rafter angles increased with latitude in New Zealand. However, it is not clear whether chronology was considered a factor in this study. Some of the evidence was drawn from historical photographs, and it seems quite possible that rafter angle increased as dramatically in post European times as side wall height did. For his type 1 houses at Pouerua in Northland, Sutton (1990: 213) calculated ridge height using rafter angles of 20° and 35° and opted for the mid point between these two. However, he also assumed a side wall height of 1 m, thus ending with a somewhat differently proportioned building than we are proposing here.

HEIGHT OF THE RIDGE

This can be calculated by simple arithmetic from the foregoing wall height and ridge angle, and is estimated at 1755 mm (5ft 9in.).

$$\text{Wall Height} + (\text{house width} / 2) * \tan (\text{rafter angle}) = \text{Ridge height}$$

$$607 + (3280/2) * \tan (35^\circ) = 1755$$

This is probably at the upper end of the range, but we believe it is a reasonable estimate. It conforms well with our experience of Pacific Island houses in remote areas where traditional materials are still in use.

DOOR POSITION AND SIZE

There is some archaeological evidence to suggest that the doorway was on the left of the house when facing into the porch from outside, although this is not certain. The earth on that side was more consolidated. The doorway is on this side in Webber's sketch (Fig. 2) and also in modern Māori meeting houses. However, there was fairly clear evidence that it was just to the right of centre in the Moikau house (Prickett 1979: 44). On balance, we suggest that the door of the Makotukutuku house was probably on the left.

The size of doorways was explored in considerable detail by Prickett (1974, 1982). The normal range for the earliest historically described Māori houses was 18 to 24 inches square (Prickett 1974: 84). A value of 21 inches (533 mm) is suggested for the Makotukutuku house.

In historic times, there was normally a sliding door, sometimes in a wooden sill. A timber identified as a door sill was recovered at Kohika (Irwin and Wallace 2000: 79). Prickett (1982: 135) notes that the door itself could be made of a wooden plank, of reeds, or of "mats". There is no archaeological evidence of the exact form or materials of the door of the Makotukutuku house.

Sliding wooden doors, sometimes with sills, were found in several parts of tropical Eastern Polynesia (including the Cook Islands) in the nineteenth century, and may have been in vogue during the period when Polynesian emigrants left for New Zealand. Buck (1944: 420) believed that this form was probably introduced by the first Polynesian colonisers of New Zealand.

WAS THERE A WINDOW?

No archaeological evidence exists on this point as far as the Makotukutuku house is concerned. However, Wallace and Irwin (2000) propose a small square window for the Kohika house on the basis of timbers thought to be a window facing board and a window sill. Both Banks and Roux describe a small window or windows in the same wall as the door (see above), and this is clearly indicated in Webber's sketch (Fig. 2). Such 'holes' were probably primarily for ventilation, as Banks supposed. It is likely that the Makotukutuku house had such a window. The presence of two windows seems to have been confined to the far north, as earlier discussed.

LASHING DETAILS OF WALL AND ROOF ELEMENTS

We have assumed above that this house, like the historically described *whare puni* and modern meeting houses, had a pitched roof supported by a central ridge pole. But how were the rafters joined to the walls and how were the components lashed together?

Unfortunately, there is no direct archaeological evidence on these points and early historical records are bereft of details. We consider that the use of mortise and tenon connection between wall post and rafter in this house is unlikely, partly because of the small size of the side wall posts, but also because of the positions of the posts. We are therefore assuming that there was a top plate on each side wall to which the rafters were lashed. The ridge pole and top plates may be what Bellingshausen was referring to when he mentioned

that transoms had been placed on the central posts and on the outer post rows to support the roof (see above).

Two alternative arrangements, one using mortise and tenon by which the rafters are attached to the posts, and the other using a top plate, to which rafters may be attached at the most suitable positions, are illustrated in Figure 8. In the left hand view, some of the rafters are markedly skewed, and it is not possible for rafters to meet above the three interior centre posts. The right hand view was set out as follows. Rafters were placed at the rear and front of the roof and over the three interior centre posts. Additional rafters were then placed between those already in place. This is not the only possible arrangement, as the use of top plates gives considerable freedom in the placement of rafters.

Archaeological evidence of house lashing was found at Kohika, and Wallace and Irwin (2000: 82–84) note that the methods were completely different from those described by Buck in Polynesia. They point out that the lashing methods used at Kohika were very similar to the techniques employed in canoe manufacture throughout the Pacific, where planks needed to be lashed firmly together for water-tight construction.

While this might be so for plank built houses in New Zealand, it would be unwise to assume that it applied to houses more in line with the Polynesian house-building tradition, which had posts rather than planks. The Makotukutuku house was definitely constructed

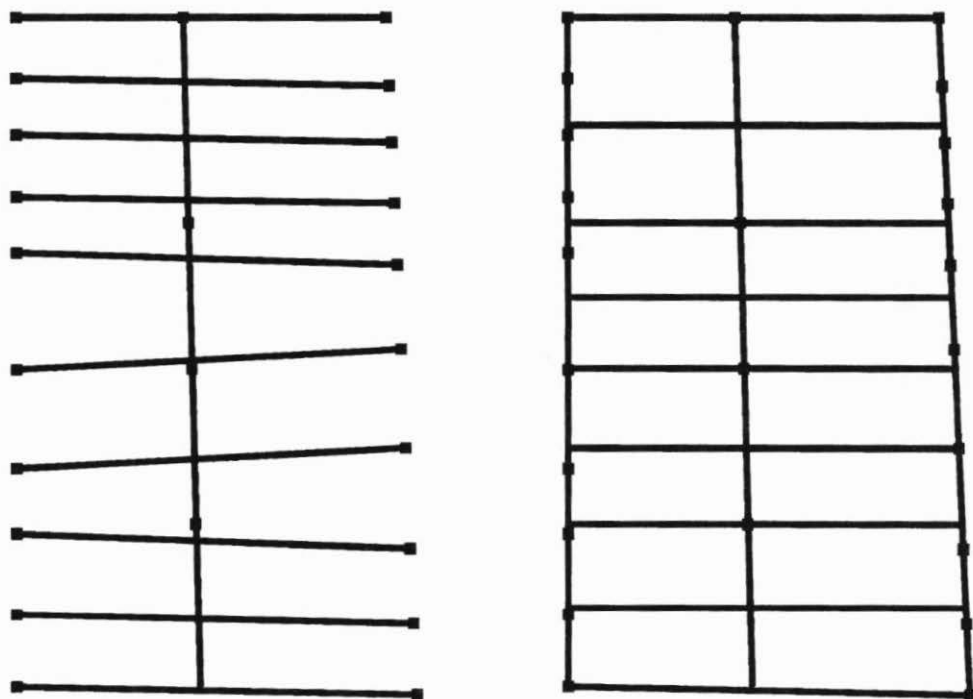


Figure 8: Two possible alignments of rafters, using mortise and tenon (left) and a top plate (right).

with small rectangular posts, not planks. The lashing methods are therefore more likely to find their closest parallel in the widespread techniques described for houses in tropical Polynesia. There are a number of detailed accounts of these, for example in Aitutaki (Buck 1927: 3 ff.), Tongareva (Buck 1932: 94 ff.), the Marquesas (Linton 1923: 275 ff.), the Society Islands (Handy 1932: 31 ff.), Hawai'i (Buck 1957: 75 ff.), Kapingamarangi (Buck 1950: 57 ff.) and Samoa (Buck 1930: 28 ff.).

Rectangular houses were widespread in Eastern Polynesia, and were very similar in their framework, although details of roof and wall thatch and placement of doors and open walls varied. The similarities extend to some of the key terminology. *Pou* (central or wall post) and *tāhuhu* (ridge pole) are widespread Polynesian terms. The Rarotongan term *oka* (principal rafter) has been displaced by *heke* in the Māori meeting house but survived into historic times as a term for the rafters of a kūmara store. The *kaho*, which in the Māori house is a purlin lying parallel to the ridge pole, is generally either a rafter or a member parallel to and above the rafters in tropical Polynesia. There are various names in Eastern Polynesia for the top plate which, like the ridge pole, rested on top of the posts, in contrast to the Māori *kaho paetara*, which was not a top plate but a stringer attached to the outside of the posts. The distribution of these terms is discussed in more detail in Appendix 3.

Although we have no archaeological evidence for the antiquity of the top plate in Polynesian houses, it was widespread in Eastern Polynesian houses of the ethnographic period. The construction of the historic Maori house described by Williams (1896), on the other hand, is unique in Polynesia. This gives some grounds for assuming that the ancestral Eastern Polynesian house had a top plate and that this form of construction was introduced to New Zealand by the first settlers. Moreover, the lack of detail about Maori houses in the early historic period makes it difficult to believe that the top plate was not present then.

The simple rectangular houses of Aitutaki in the Southern Cook Islands (Fig. 9) and Tongareva in the Northern Cook Islands (Fig. 10), described by Buck, may be not unlike the early New Zealand rectangular house in their construction. The principal differences between these Cook Island houses and the *whare puni* are the lack of a porch and numerous side posts in the Cook Island houses and the fixed position of the entrance at one end in the *whare puni*. These changes could have been early adaptations to the climatic conditions in New Zealand.

We suggest, therefore, that Buck's Cook Island houses provide a more reasonable basis for the superstructure of the Makotukutuku house than the tightly lashed, plank built Kohika house or the post-European Māori house described by Williams (1896).

CONSTRUCTION OF WALLS AND ROOF

McCracken (n.d.) compiled references to the materials used in walls, roof thatch and bindings of houses from 1769 to 1926. For the period 1769 to 1820, references are few and generally not specific. Walls were described as being of raupō, bark, moss, sword grass or reeds; and roof thatch as raupō, bark, straw, reeds or grass. There is a single reference to bindings of 'withes'. For later periods, raupō is by far the most frequently mentioned material for both walls and roof thatch.

Identification of charcoal fragments from the site by Wallace revealed some 19 different species (Table 5). Of these, only mānuka and kānuka could have been used as thatching materials. There was no sign of nīkau, toetoe or raupō. However, when such species are fired they produce extremely fine fragments of charcoal, which are unlikely to be recovered

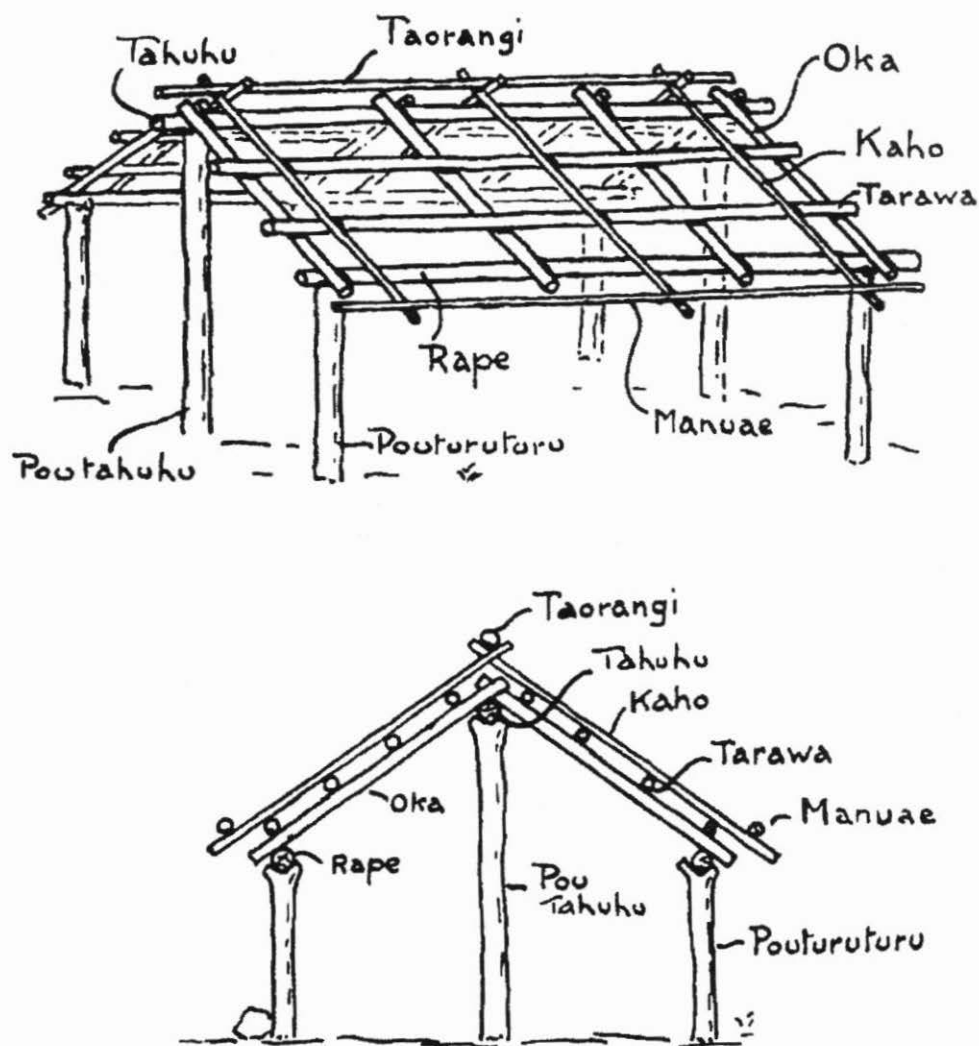


Figure 9: The framework of a rectangular house in Aitutaki, southern Cook Islands (after Buck 1927).

during excavation unless they occur in major concentrations or particularly protected contexts. For example, concentrations of very fine charcoal fragments from the excavation of a circular pit feature at the mouth of the Makotukutuku Valley were identified as fern fronds (Leach 1979: 112). This showed that these less durable materials can survive in charcoal form.

We have to accept that we do not know from direct archaeological evidence what the wall and roof thatch was made from. Mānuka brush might be the most likely, as this is abundant in the vicinity and when thatched with skill makes a superb weather-proof wall. One of us

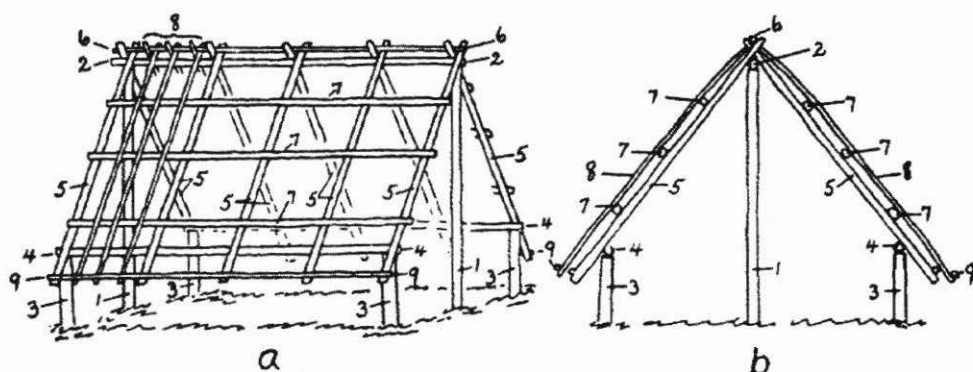


Figure 10: The framework of a rectangular house in Tongareva, northern Cook Islands (after Buck 1932). 1, supporting posts of ridgepole (*pou*); 2, ridgepole (*tahuhu*); 3, wall posts (*pou*); 4, wall plates (*hapai*); 5, principal rafters (*oka*); 6, upper ridgepole (*tamaiti*); 7, purlins (*torotoro*); 8, thatch rafters (*rau oka*); 9, eaves rod (*torotoro hiohio*).

(Leach) recalls from childhood days in the Wairarapa that mānuka brush was very commonly used as fencing to protect domestic gardens against wind. When trimmed, this was very neat and tidy as well as weather proof.

TABLE 5
Charcoal identifications by Wallace
(excluding the hearth charcoal, which contained some beech)

Species	No	Type	No	(%)
Mānuka	11	Shrubs	42	(32%)
<i>Hebe</i> sp.	14			
Fivefinger	6			
<i>Pseudopanax</i> sp.	1			
Kawakawa	2			
Sevenfinger	1			
<i>Coprosma</i> sp.	6			
<i>Pittosporum</i> sp.	1			
<hr/>				
Kānuka	9	Small trees	23	(17%)
Ngaio	9			
Pigeonwood	1			
Māpau	1			
Māhoe	1			
Kāwhai	2			
<hr/>				
Maire	28	Large trees	37	(28%)
Pukatea	1			
Rātā	8			
<hr/>				
Mataī	4	Conifers	31	(23%)
Tōtara	27			

WERE THERE CARVINGS IN THIS HOUSE?

This is an important question which unfortunately cannot be answered with certainty. It is notable, however, that the Kohika houses of *whare puni* type appear to have had only perfunctory decoration in the form of scalloping of the door and window lintels with a zigzag pattern.

House carvings have been reported from several parts of Eastern Polynesia, namely the Marquesas, the Cook Islands, the Australs and Mangareva (Buck 1938: 239). Linton (1923: 285–90, pl. XLIB,C) described end and front posts carved into *tiki* (human forms) in the Marquesas and also posts decorated with incised geometric and curvilinear designs. Buck (1944: 45, 1938: 233) mentions a carved door sill on Mangaia, carved centre posts in a large building on Rarotonga, and carved figures attached to rafters in community houses on Mangareva. These sparse accounts refer to nineteenth or early twentieth century buildings and seem in most if not all cases to refer to community buildings rather than dwellings. Even so, they suggest that the idea of embellishing buildings with carving as well as ornamental lashing was shared by the inhabitants of several Eastern Polynesian island groups, and could have been introduced to New Zealand by the first settlers. Similarly, canoe carvings are known from elsewhere in Eastern Polynesia. The profusion of carving in both houses and canoes in New Zealand was therefore probably an efflorescence of a pre-existing Eastern Polynesian idea, rather than a new departure.

From the comments by Banks and Roux cited above, it is evident that some form of carving was commonly present in the *whare puni* observed at the time of first European contact with Māori. Studies of the symbolism in Māori carving illustrate the profound importance of carvings in the house; they were not, as Banks suggested, comparable to the paintings hanging in the houses of Europeans such as himself, although these, too, often depicted ancestors.

Jackson (1972) studied the symbolism of *pare* (door lintels). He showed that the *pare* is placed at the crucial transition point between the outside and the inside of the house. It depicts the reconciliation of disparate elements into a coherent and unified whole, and on one level can be seen to symbolise the unity of the group of people who pass beneath it to enter the house.

What can be suggested for the Makotukutuku house? If it was decorated, there are four possible forms this could take taken:

- 1: It could have had a *tekoteko* (gable finial)
- 2: It could have had a carved door lintel
- 3: It could have had a carved centre post or posts
- 4: It could have had a carving or carvings somewhere else inside

Tekoteko and the related *koruru* were not mentioned in any of the earliest European accounts and none appear to have been collected on any of Cook's voyages. However, the *tekoteko* plays an important role today in the well known story of Ruatēpupuke and the origin of carving (Mead 1984: 65) and museum collections include some carvings of *tekoteko* form that are believed to have been collected before AD 1800. Two items described as *tekoteko* were collected in Queen Charlotte Sound in 1820 and are now in St Petersburg (Simmons 1979: 153, 1987: 54). It should be noted, however, that although the Russian accounts refer to carvings inside the houses there is no mention of gable ornaments. In

addition to Bellingshausen's comments, cited above, Novosil'sky, midshipman on the *Mirny*, mentioned that "Along the walls, which were covered with fine mats, hung lances 24' long, staffs, the insignia of leaders, and little idols decorated with red colouring" (Barratt 1979: 60). Perhaps the so-called *tekoteko* collected by this expedition (and other early examples) were attached to posts inside the house. Until better evidence is available it would be unwise to assume that the Makotukutuku house had a gable ornament.

Either a lintel or a carved centre post (or posts) seems more likely. Both are well documented in the earliest accounts and both are particularly important in the symbolism of the Māori house. Houses with carved central posts but no lintels were described by Roux in the far north in 1772 and by Bellingshausen and his officers in Queen Charlotte Sound in 1820. The possibility that two of the central posts of the Makotukutuku house were removed at or before the time the house was destroyed by fire could indicate that they were carved.

Banks seems to suggest that it was a matter of either/or: a carved plank over the door *or* a carving placed in a prominent position somewhere inside the house. The Webber drawing is strong evidence that the carved plank over the door was the typical *pare* or lintel.

The final possibility would be one or more carved figures (perhaps even detachable figures of *tekoteko* form) on the side walls or just inside the door.

Enticing those these possibilities are, there is no getting away from the fact that we do not know when house carvings of eighteenth and nineteenth century form developed in New Zealand. It may be quite wrong to propose an eighteenth century form of ornament on a house that in some important aspects of its construction was probably more like its tropical antecedents than like its eighteenth and nineteenth century descendants. Moreover, although we could suggest that established Māori principles of composition should apply to any carving, and particularly to a lintel, we could not describe the appropriate stylistic details. It therefore seems safest to suggest that ornamentation, if any, was probably more along the lines of the scalloped edges of the Kohika lintels.

BEDDING

Both Banks and Roux described 'straw' used for bedding inside the house and confined in some way to keep it clear of the central area. Bellingshausen mentioned mats on the floor on which the inhabitants both sat and slept. Prickett (1982: 138) cites later accounts suggesting that bedding consisted of loose fern or *raupō*, sometimes covered with mats. These accounts also state that the bedding was confined towards the sides of the house by poles or boards.

There was no archaeological evidence in the Makotukutuku house of bedding or of stakes which might have marked the edges of sleeping places. It is therefore difficult to suggest how much of the floor space might have been used in this way. It is also possible that mats were put down, moved around, and rolled up according to need, as is still customary in some tropical Polynesian houses. In considering the interior of the Makotukutuku house it is necessary to think how a family might live in a tent or small cabin and put aside thoughts of the sleeping arrangements in a modern meeting house.

DISCUSSION

In reconstructing an ancient building there is always a temptation to improve upon the work of the original builders. The first reconstruction of a Māori building based on good archaeological evidence was a mid-nineteenth century house at Opotaka in the central North Island, excavated during the Tongariro Power Development archaeological project and rebuilt as part of an interpretative project (Newman 1988: 43). This was undertaken without explicit consideration of most the issues discussed above and the resulting building was probably considerably higher and more robust than the original. More recently, the Blacksmith's Shop at Waimate North, one of the historic nineteenth century Bedggood buildings, was rebuilt. In this case, both archaeological evidence and photographs were available, as well as cladding salvaged from the building when it collapsed. But as the archaeologist involved commented:

Although precise post positions were determined, so that the building could be reconstructed authentically skewed, the members of the Bedggood family who voluntarily undertook the rebuilding constructed the new frame with precision, symmetrical and straight in line and level, in continuity with the Bedggood tradition of excellent trade skills (Challis 1993: 34-35).

Asymmetry runs counter to modern beliefs about how buildings should be built. In the case of both the Moikau and Makotukutuku houses, however, it is clear that asymmetry was an intentional aspect of houses that were carefully and soundly constructed. There is good ethnographic evidence for deliberate asymmetry (Prickett 1982: 129).

The only things we know for certain about the Makotukutuku house are its floor plan (including its asymmetry), and the material and shape of its posts. Other archaeological evidence and early historic accounts have enabled us to propose with varying degrees of confidence aspects of its form such as wall height, ridge height, wall slope and roof angle. The finer details of wall and roof construction are more difficult because of the lack of both archaeological evidence of material and historical (or indeed ethnographic) descriptions of such detail.

We have been led to conclude that although the Makotukutuku house had a floor plan similar to historical *whare puni*, it may have been more similar in some aspects of its structure and lashing to tropical Eastern Polynesian buildings than to post-European descriptions of Māori houses or to the Kohika houses (which conform more closely to the latter).

This raises issues which can only be resolved by better archaeological data about pre-European houses in both New Zealand and tropical Polynesia, better dating of such houses, and dating of Māori house carvings, believed to be pre-European, in museums. In the meantime, we believe that in any discussion of house form, it is important to place on record the issues involved and to show clearly what is known, what can be reliably inferred and what is simply conjecture.

ACKNOWLEDGEMENTS

We are grateful to Brian Molloy, of the former Botany Division, Department of Scientific and Industrial Research, for his initial work on the charcoal identifications, Roger Green for advice on Polynesian terms for parts of houses, and Dr Andrew Buchanan for advice on wood shrinkage and the formation of charcoal during fires.

APPENDIX 1

LAYOUT OF THE MAKOTUKUTUKU HOUSE

Describing where to place the posts in the ground for this house is not simple because the house is not square. On Figure 5, each post is labelled with a number. The post in the southeast corner is labelled number 14. In the following series of instructions, this post is used as the reference post, to fix the position of all other posts on the ground.

The posts along the 'east' wall are positioned as follows:

Post 14	0 mm
Post 15	500 mm
Post 13	960 mm
Post 9	1470 mm
Post 16	1930 mm
Post 37	2900 mm
Post 32	3710 mm
Post 41	4240 mm
Post 27	4910 mm
Post 26	5520 mm

The 'south' wall is exactly at right angles to the 'east' wall. The posts along this wall are positioned as follows:

Post 14	0 mm
Post 40	1400 mm
Post 3	3110 mm

The line of the 'west' wall is not at right angles to the 'south' wall and should therefore be laid out as follows:

Attach a string to the position of Post 3 and mark off a distance of 5590 mm along it. Now attach a second string to the position of Post 26, and mark off a distance of 3360 mm. The intersection of these two strings is the position of Post 22. This establishes the line of the 'west' wall, running from Post 3 to Post 22. The individual posts are situated at:

Post 3	0 mm
Post 2	560 mm
Post 1	1020 mm
Post 20	1520 mm
Post 21	2030 mm
Post 30	2730 mm
Post 19	3540 mm
Post 6	4360 mm
Post 18	4990 mm
Post 22	5590 mm

The line of central posts begins from Post 40 on the southern wall and ends at Post 42. The centre of Post 42 lies 1500 mm from the 'east' wall, and 1780 mm from the 'west' wall. The individual posts are situated at:

Post 40	0 mm
Post 33	1680 mm
Post 43	2890 mm
Post 42	4160 mm

APPENDIX 2

SCIENTIFIC NAMES OF PLANT SPECIES MENTIONED IN THE TEXT

Coprosma sp.	<i>Coprosma</i> sp.
Fivefinger	<i>Pseudopanax</i> sp.
Hebe sp.	<i>Hebe</i> sp.
Kānuka	<i>Kunzea ericoides</i>
Kawakawa	<i>Macropiper excelsum</i>
Kōwhai	<i>Sophora</i> sp.
Māhoe	<i>Melicytus ramiflorus</i>
Maire	<i>Nestegis</i> sp.
Mānuka	<i>Leptospermum scoparium</i>
Māpau	<i>Myrsine</i> sp.
Mataī	<i>Prumnopitys taxifolia</i>
Ngaio	<i>Myoporum laetum</i>
Nīkau	<i>Rhopalostylis sapida</i>
Pigeonwood	<i>Hedycarya arborea</i>
Pittosporum	<i>Pittosporum</i> sp.
Pseudopanax	<i>Pseudopanax</i> sp.
Pukatea	<i>Laurelia novaezelandiae</i>
Rātā	<i>Metrosideros robusta</i>
Raupō	<i>Typha orientalis</i>
Sevenfinger	<i>Schefflera digitata</i>
Toetoe	<i>Cortaderia</i> sp.
Tōtara	<i>Podocarpus totara</i> or <i>P. hallii</i>

APPENDIX 3

SOME POLYNESIAN TERMS FOR PARTS OF HOUSES

The following Māori terms for parts of the house, discussed above, are found in other Pacific languages. The following is a summary of information provided by Roger Green drawing on the computer data base POLLEX (Polynesian lexicon) established by Bruce Biggs at Auckland University.

Pou can be traced back to Proto-Eastern Oceanic where it is reconstructed as *mpou "post". It is found very widely in Polynesian languages and Fijian, meaning post, or occasionally centre post in a house.

Tāhuhu has a much more restricted distribution but can be traced back to Proto-Polynesian *taqufufu "ridge-pole". It is documented mainly in Eastern Polynesian languages, including Rarotongan and Tahitian, and is always glossed as ridgepole.

Kaho is a very old term which is probably traceable to Proto-Austronesian. It is reconstructed as Proto-Eastern Oceanic *kazo "rafter" and Proto-Oceanic *kaso "rafter". It is found widely in Polynesian languages and with very few exceptions means rafter, or a smaller runner parallel to the rafters.

Oka can be traced back to Proto-Oceanic *soka "bracing timber, crossbeam". It occurs in various Polynesian languages, with meanings ranging from crossbeam to king post. POLLEX lists the meaning "rafter" only for Rarotongan. As noted above, it is recorded as "rafters for the roof of a kūmara pit" in Māori (Williams 1971: 238).

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The Makotukutuku house during excavation. Doug Sutton has his arm down a tree root hole, not a posthole.



View of the Makotukutuku house site immediately below the two seated figures (Jim McKinlay on the left).