'Nothing is more permanent than a post hole'
or:
A Contribution to the Archaeology of the Common or Garden Hole

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Abstract

Based on several excavations, this paper reviews thc archaeological evidence for house structures on Tongatapu. The only indisputable evidence for houses was encountered on Pangaimotu, where it seems likely that an oval-shaped building without central posts, as well as a rectangular building (*fale fakafefine* or *fale fakafuna*), can be documented.

The excavations at Ha'ateiho yielded a large number of circular discolourations which do not align into discernible patterns. Some of hese discolourations are postholes, while most are planting holes. Based on the distribution of the density of the holes, it seems likely that some buildings existed to the southeast of mound TO-At-85 and to the north and northwest of mound TO-AT-86. However, this study shows that trying to distinguish between postholes and planting holes in the non-mounded area is fraught with problems. Despite a range of approaches taken, no distinction could be made which was valid beyond reasonable doubt.

However, the excavations at TO-At-85, albeit unintentionally, have helped to understand matters I did not intend to find out: that the average Tongan yams planting hole is 53 cm deep, has a diameter of 30.5 cm, possesses a bowl- or basin-shaped bottom, has no slant, and is filled with soils of rather varied compactness.

When I was asked whether I might be prepared to write a contribution to a *Festschrift* for the occasion of Günter SMOLLA's 75th birthday, I was most delighted to oblige. It was suggested that I might have a backlog of papers written but not yet submitted and, given the overall short notice, that I might be able to send something of that sort. Tempted, I offered the editor a number of options. In the event I decided to settle on something entirely different, one written specially for the *Festschrift*, as it behooves the occasion.

More than a dozen years ago, I had written a contribution to the *Festschrift* for SMOLLA's 65th birthday, the publication of which is still lingering somewhere in the dark caverns — or taverns ? — of Biebrich. That contribution had set out a hyphothesis on settlement pattern changes over time on Tonga and Samoa. Going on to the actual fieldwork the hypothesis had been proven. This ruled out revitalising that one. However, I felt it to be a nice touch to link into that work for this new offering. SMOLLA had edged me on to conduct non-European archaeology (albeit not Africa) and had agreed to supervise a doctoral thesis on Tongan settlement patterns at Frankfurt University. Even though I eventually completed it in much expanded scope at the Australian National University, Canberra, I felt it only fitting to write something which was based on the work derived from back then.

During my undergraduate years I had heard SMOLLA expounding to all and sundry, to those who had ears to listen, and those who didn't, over and over again, during lectures, during seminars, and during excursions up and down those fortifications in the Taunus, that *'nothing is more permanent than a post hole'*. Thus, I thought it to be fitting to write a contribution based on this truism in archaeology, which I, in turn, now expound to my students.

Actually, I have fond memories of my first 'real' post hole, encountered as a first-year student learning excavation techniques with H.U. NUBER at the Roman fortification of Hofheim (NUBER & WAHL 1980). Seeing not only the post pit, but also the discolouration where once the post itself stood was exciting. From the acentral placing of the post discolourations within the post pits, one was able to reconstruct that such pits for the turrets had been dug by one work team, and the preassembled turrets had been set into them by another work team. Who would have guessed that the humble post hole could serve as a powerful source of information on Roman planning and organsiation of labour ? For me, Hofheim was an eye opener to the power of fine excavation skills and of archaeological deduction.

Subsequently I learned that post holes are everywhere, and that we all happily disentagle neotlithic, bronze age, iron age and medieval post hole complexes to sort out various phases of occupation,

ending up with neat little and not-so-little rectangular house plans arranging themselves seemingly effortless into settlement plans. And thus I set off into the 'big wide world', secure in my knowledge that post holes would be waiting for me, sometime, someplace. But then came Tonga, and the realisation that not all what looks like a post hole is a post hole, and that there be houses which are round(ish) and still possess a rectangular post hole pattern.
Ooops...

But before we embark on a voyage into that realm of archaeological reality, let us briefly look at where the post hole came from.

An ode to the humble post hole

Reducing all the glamour of archaeological discoveries to one or two key findings, which influenced the course our profession took, is not an easy task. Archaeological media-hype constantly shouts at us formulations such as *'The find of the century...' 'The find that changed the world...'* Sure, the find of the *'iceman'* melting out of the glazier is spectacular, and I for one was most intrigued by the tattoos. But — so what ? Does that single find **really** change the way we see the archaeological world ? Has that find any meaning for, let us say, the archaeology of Africa south of the Sahara, or the archaeology of the Phillippines ? I dare say not.

I believe, historically, the single most outstanding find was BOUCHER DE PERTHES' 1838 discoveries at Abbeville allowing to actually prove — and gain acceptance for — the presence of *"the antediluvial man"*, evidence that humankind had a history reaching back into the Pleistocene (BOUCHER DE PERTHES 1847).[1] That set the tone of work until today. In contrast, finding what was called *'The Great Flood'*, as WOOLLEY (1931) did in Ur, was a nice touch, media-wise spectacular, but not earth-shattering.

Close on BOUCHER DE PERTHES' heels, in my opinion, comes Carl SCHUCHARDT, and the work the *Reichslimeskommission* did in the 1890s to 1910s. It is somehow sad, that the significance of the conceptualistion, or 'discovery', of the post hole as an archaeological entity made by SCHUCHARDT when excavating wall-ditch fortifications in northern Germany (SCHUCHARDT 1909, 215 f.) has got lost with most modern archaeologists, and that international texts do not make reference to SCHUCHARDT. Amongst German University lecturers SMOLLA must be highly acclaimed for his 'obsession' with imparting information on the historical, philosophical, and ethical background of archaeological work. For many undergraduates this information was — and sadly still is — seemingly unimportant if one can learn about the intricacies of the variations of handle design in bronze age razors in some back valley of Upper Hessia and their implications for chronology. Once in a while I still have nightmares where miles and miles of book shelves filled with PBF-volumes figure prominently.

But, let it be said again, the 'discovery' of the post hole was **the** most outstanding archaeological discovery of the 20th century. Being able to reconstruct houses, fence lines, fortifications and the like, all originally made of perishable materials, advanced on a world-wide basis the ability for the spatial reconstruction of sites and activities. Post holes are truly an universal phenomenon, from North America to South Africa, from China to Tonga — if you can identify them ! And this shall be the topic of the following paper.

Post-Lapita Settlement Patterns on Tongatapu

In the following we will be concerned with the examination of the archaeological representation of Tongan settlement, in particular the spatial distribution of houses within settlement compounds. We will look at the archaeological record of such houses and the limitations in recognisability imposed by Tongan gardening practices. Before we do so, however, it is necessary to have an overview of Tongan settlement patterns.

Distribution of settlement

The end of the Lapita period until about AD 300 saw the change in settlement and economy from a shore-based settlement, heavily reliant on exploitation of marine resources, to an inland-based settlement, heavily reliant on horticultural production.

All European visitors arriving later than TASMAN (1643), who only saw parts of Tongatapu and Nomuka, mention that the Tongan islands they visited, usually Tongatapu, 'Eua, Nomuka or Lifuka, were laid out in a system of plantations. No villages existed except for the capital at Mu'a and the houses stood in the middle of well-fenced plantations

[1] Even though ESPER, a priest, has made similar discoveries in 1770 (ESPER 1774), his views could not gain acceptance (MÜLLER-KARPE 1975).

Fig. 1 Map of Tongatapu, Kingdom of Tonga, indicating the sites discussed in the text.

(COOK 1777, I, 194; 213-214; 1967a, 111; 141; WALES 1969, 812; ELLIOT 1984, 21; WILSON 1799, caption of map; LA PEROUSE 1799, II, 172; ANONYMOUS [VASON] 1810, 130). The Tongans refer to this as *fanongonongotokoto* (literally *'sending news while reclining'*), which indicates a dense, but dispersed settlement pattern. It consisted of independent, roughly rectangular, fenced compounds (*'api*) adjoining each other, which contained both habitation sites and plantations. Access to the compounds was provided by a system of roads. Burial mounds, often surrounded by trees providing shade, were placed in an unenclosed area of 50-100 metres square at the intersection of major roads (COOK 1969, 252; WALES 1969, 812).

Tongatapu seems to have been thickly settled, except for the area near the southern and southeastern *liku* coast, which ANDERSON describes as only sparsely inhabited (1967b, 1004-1005). The northern side of the island was densely populated, with plantations and houses extending directly to the shore (LEDYARD 1963, 28). ANDERSON mentions that, coming from the northern shore, the island was densely settled *'for above a mile'*. Behind this, for *'a mile or two'*, the plantations were bigger and more dispersed. Beyond this was uncultivated country covered with high grass, but also with occasional coconuts, which ANDERSON took as sign of some cultivation. The southern *liku* coast was uninhabited according to MARINER (MARTIN 1827, II, 228; 1981, 384), as one could not land a canoe there. Based on the sparse evidence of LEDYARD, ANDERSON and MARINER, it seems as if a tripartite settlement pattern existed on Tongatapu: a zone of densely set *'api* near the northern shore, about 1 km-1.5 km wide, a zone of larger-sized plantations about 1.5 km-3 km wide and a zone of limited cultivation and habitation beyond. The areas directly at the southern and eastern shores were completely uninhabited. KENNEDY (1959) and WIEMER (1985) assume that while settlement was dispersed, there would have been clusterings of habitations.

The compounds

The compounds (Tongan: *'api*) are the basic unit of the observed settlement pattern. The *'api* forms a household unit comprising basically one (extended) family and, depending on the family's status, retainers. Every household unit was essentially self-contained and consisted of housing, cooking facilities, food-storage units, both above and below ground, and plantations. Each *'api* was enclosed by a fence and bordered by roads at least on one side. WALES (1969, 812) mentions that the compounds were roughly rectangular in lay-out. The dimensions of the compounds are not usually mentioned but can be inferred from a comment by one of COOK's officers, BAYLEY, who in 1772 *'walked into the country'* of 'Eua with FORSTER and fellow officers: he speaks of the Tongan road system as a series of *'walks'* with small ones intersecting longer ones about every quarter-mile and so breaking up the plantations (COOK 1969, 246). If we assume a rectangular layout of the *'api* as indicated by WALES, that every

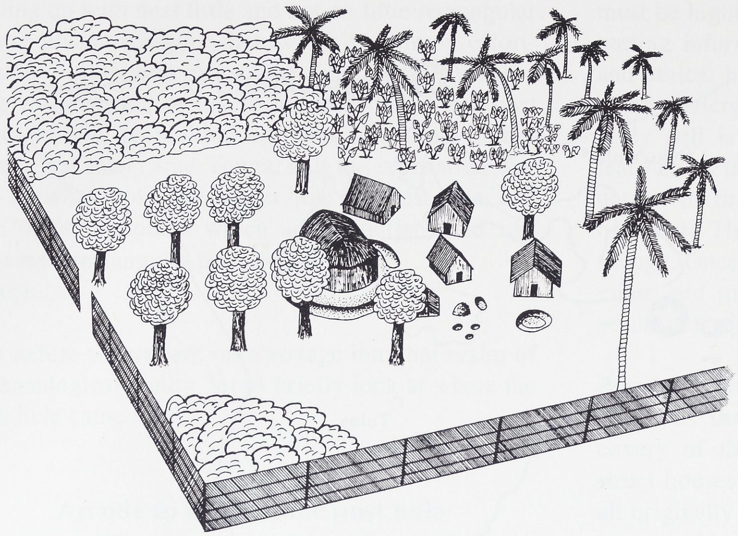

Fig. 2 Lay-out of a chiefly compound in the 18th century. Bird´s eye view.

'api had access to a road and that as little space as necessary was used up by roads (as indicated by COOK [1969, 252]), then three or four *'api* are likely to have been present between each intersection. This is equal to a road frontage of ~150 m for each *'api*, if three compounds were present, or ~115 m if there were four. The depth of the compounds is less certain. Tongan land law, which is in principle and spirit based on the Tongan Constitution of 1865, grants every male over 16 years of age a bush allotment (*'api uta*) of 8.25 acres and a town allotment (*'api kolo*) of 1 rood and 24 perches (~2/5 of an acre). If the dimension of the *'api uta* is any guide to the pre-1865 size of the commoners' compounds, then the average *'api* would have extend for ~220 m from the road if the road frontage was 150 m and ~280 m if it was 115 m.

Lay-out of compounds

We can distinguish three different kinds of compounds, depending on the societal status of the individual: compounds of commoners, compounds of members of the chiefly classes (i. e. *hou'eiki* and *matapule*) and the compounds of the *Tu'i Tonga, Tu'i Ha'atakalaua* or *Tu'i Kanokupolu*. The compound of the commoners forms the standard unit, to which several features are added with rising societal rank. We can also assume that the size of the *'api* was dependent on such rank.

Compounds of commoners

The available historical records are clear as to the general appearance of the *'api*: the compounds consisted of two parts, a living area, where the houses and food-storage and cooking areas were located, and a plantation area (MARRA 1775, 62; COOK 1777, I, 214). Based on European descriptions and Tongan traditions, we can attempt to reconstruct the lay-out (figure 2). The main building was erected somewhere near the entrance. Since most of the European vistors refer to chiefly compounds it is unclear whether the commoner's houses were erected on mounds or not. It was surrounded by fruit- and other utility trees (for flowers, oils etc.), which provided shade and also acted as a windbreak. There will have been at least one outhouse, used for food storage and for the accommodation of the young boys. The brother-sister avoidance practised in Tonga required the boys not to sleep under the same roof as the girls, who slept in the parents', i. e. main house. More probably, however, there were two outhouses, a boys' house and a separate storage house. We can also expect a separate cooking area, consisting of a cooking shed, most likely a *fale hunuki*, and an earth oven. Tongan traditions mention that cooking never took place in the main house. Storage pits are likely to have existed, though none of the European visitors talks about them. We can anticipate that the cooking areas were on the leeward side of the main buildings, so as to avoid the smoke of the cooking fires. Plantations existed behind this living area. It is probable that the plantations were fenced off from the living area in order to keep pigs out.

Chiefly compounds

The chiefly compounds were larger versions of the commoners' *'api* and differed from these only in three aspects of their lay-out: they had an open well-

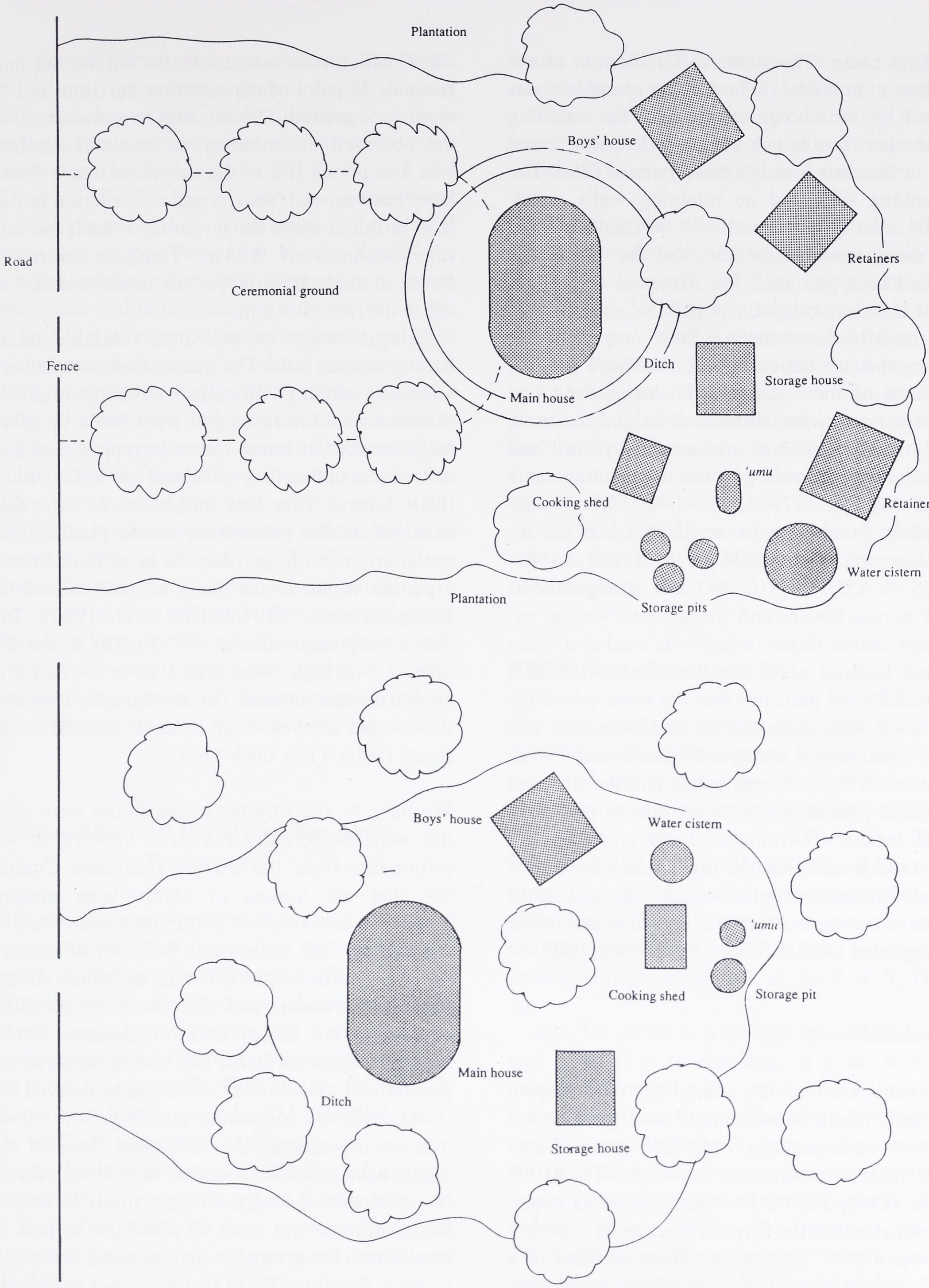

Fig. 3 Lay-out of compounds in the 18th century. Top: a chiefly compound; Bottom: a commoner's compound (compiled from variuos sources).

kept lawn, acting as a reception area (*mala'e*), between the entrance to the compound and the main house and bordered by trees providing shade; the main house stood on a mound or platform, and they had a greater number of outhouses to accommodate the retainers.

The main house was erected on a slightly raised floor of about one to one and a half feet (0.45 m) in thickness, which was larger than the actual house and provided a sort of verandah surrounding it. The floor was of beaten soil covered with a thick layer of grass, which in turn was overlain by thick mats. This provided for a relatively soft floor (*hulu*), which could also be kept clean. The status differentiation of the chiefly house mounds (*tu'unga fale, paepae*) was maintained by the choice of material for retaining walls, whether coconut logs (*paepae falo*), coral boulders or beachrock slabs (*maka paepae falo*). The lowest-ranking sites had no retaining walls at all. (McKERN nd.). The mound was surrounded by a shallow ditch from where the soil for the house floor(s) had been procured. We can expect the ditch to have at least two breaks, one near to, and possibly pointing towards, the entrance of the compound, and one leading towards the outhouses. The boys' houses, the buildings of the retainers and the cooking and food-storage areas were all located behind the main dwelling, which itself was surrounded by fruit and ornamental trees providing shade and acting as a windbreak (COOK 1777, I, 193-194; ANDERSON 1967a, 1004). In addition to the dwellings of the retainers (*kau nofo*; MARTIN 1817, II, 297; ANONYMOUS [VASON] 1810, 94) and storage facilities, both storage houses and storage pits, we can expect a water cistern (*lepa*), which was used as a water supply and bathing place for the chief (McKERN n.d.). ANDERSON indicates that the areas where the retainers lived were sectioned off by low fences. The plantation area, which contained banana and breadfruit trees as well as coconut palms and the like, but no substantial plantations of yams, taro or plantains, was again fenced off from the living areas. Such a lay-out would insure that the pigs were kept out of both plantation and reception areas. The quality of the houses of the dependents was less than that of the chief living there (ANDERSON 1967, 1004-1005).

House mounds

House mounds are circular, sometimes oval-shaped, heaps of soil. While most mounds have gently sloping, convex cross-section, some are more dome-shaped. Extensive excavations in mounds TO-At-85, TO-At-86, TO-Pe-21, TO-Fa-4 and TO-Pi-13 revealed their structure, in the form of a series of superimposed house floors. Each house floor consists of a construction horizon, which commonly varies between 0.1 m and 0.5 m in thickness, and a walking horizon, or house floor *sensu strictu*, of 0.05 m - 0.2 m thickness. The latter horizon is only the utilised surface of the first, where dust and dirt have become trampled into the surface. The material for the construction horizon is quarried from a borrow ditch, which runs concentrically around the mound. In total, 43 pairs of construction horizons and floors were encountered. Discounting two instances, where the observed thickness of the construction horizon was 1m, giving rise to the suspicion that a floor may have been missed, an average construction horizon is 0.39 m thick, while the house floor itself has an average thickness of 0.13 m. Thus, on average, one house-mound phase is 0.52 m thick, which I round off to the nearest 0.5 m.

Tongan house mounds thus resemble miniature Mesopotamian tells. The question arose whether very large and very high mounds, measuring up to 40 m in diameter and 5 m in height, were made up of a very large number of house floors or represented a status difference, in that they consisted of a few but very thick layers. This was suggested by the Samoan case, where the present-day house platforms of the *matai* are much larger than those of the commoners, a pattern which seems likely to have existed in pre-European times (JENNINGS et al. 1983). To find out, a very large mound (TO-Be-16) in the Beulah area, 3.5 m high, was tested by a 1 m x 1.5 m pit sunk from the summit. The stratigraphy revealed that the mound consisted of a large number of house floors rather a few thick ones.

We have to ask why the house floors were raised in this way. Some early European visitors, as well as informants from the Tonga Traditions Committee, say that the houses of chiefs were erected on mounds, while those of commoners were built on level ground. This could be an indicator of status, similar to platform height and size in Samoa. It appears possible, however, and that the main dwellings of any compound, as opposed to outhouses, were erected on artificial surfaces. The reason seems to be firm ground and cleanliness.[2] The tephra-derived subsoil is very infertile and would inhibit growth of vegetation on the mound. A compacted floor of subsoil would have provided a surface kept clean very easily, like a modern concrete or clay floor. In addition, a raised floor would have elevated the surface of the house from the ground, which in some areas is prone to sheet-flooding. These factors do not pertain, however, on sandy mounds, such as were built on Pangaimotu, an island composed entirely of sand. Nevertheless, as is evident at the floor of mound phase C of site TO-Pi-13, even here could one achieve a great degree of hardness.

[2] We can safely assume that COOK and his officers would have been led to chiefly compounds, where they would have observed that the chief's dwelling, as the main dwelling in the compound, was erected on the mound, while the outhouses, occupied by the retainers, would have bee built on level ground. They have no evidence to give, therefore, on the compounds of the commoners.

A different picture emerges for site TO-Pe-21, which is built on swampy ground liable to sheet flooding after heavy rain, totally isolating the site in the process. While we can only speculate on the compelling reasons for building site TO-Pe-21, and also neighbouring TO-Pe-20, at such an inconvenient spot, the Tongans clearly understood the structural problems they faced. The entire bottom part of the stratigraphy consists of an alternating series of layers of sandy mud and tephra-derived subsoil. While the sandy mud is a mixture of the natural mud and sand layers underneath the site, the subsoil comes from at least 150 m, and more likely 200 m south. Given the runniness of a wet mud and sand mixture, as well as the softness of the substrate, the construction of the initial house mound would have been doomed, were it not for the layers of compact subsoil, which act-like stringers, reinforcing the construction. It also is of interest to note in the case of TO-Pe-21 that no concentric borrow ditch exists, which would have created severe access problems after torrential rains, but there is a large borrow pit at the southern, landward side of the mound, which also acts as as a drain. Let us now look at some house mounds in the Ha'ateiho area, which have been excavated in detail.

Excavations in the Ha'ateiho Area, Tongatapu

The Ha'ateiho transect,[3] is located at the southern part of the western sector of Fanga 'Uta lagoon and runs the lagoon to the southern liku coast. This area was surveyed to provide a representative cross-section of a part of Tongatapu, taking in the various microtopographical regions. The area was chosen because several Lapita sites (GROUBE 1971; POULSEN 1987) and two burial mounds (DAVIDSON 1969) already had been excavated in the area and thus provided some basis to go upon. Within this 7.5 km^2 large transect, which was surveyed on foot in loops set about 30 m-50 m apart, all sites were mapped with the purpose to provide data on settlement density and distribution.

In the Ha'ateiho transect, a group of mounds was the focus of major excavations.[4] During 1986 four of a small concentration of mounds were test-excavated to varying extents. They comprise a house mound (TO-At-85), a burial mound which had started as a house mound (TO-At-86) and two incompletely excavated house mounds (TO-At-88, -89), one of them (-89) with evidence (eroding coral sand) for burial in lower layers. The area on top of and between mounds TO-At-85 and TO-At-86 was excavated in some detail.

Mound TO-At-85 consists of 3 phases, each comprising a construction layer and corresponding house floor. The house floor of the latest phase (III) was eroded. TO-At-85 is a rather low mound, measuring about 25 m to 30 m in diameter and 0.6 m in height. Mound TO-At-86 has two phases, a house mound and a burial mound. The surface of the house mound shows strong evidence for burning, probably, given that the layer beneath looks like a fossil soil, a bushfire after the mound had been abandoned, but perhaps a fire which engulfed the house. The house mound had then been capped with a thick layer of subsoil, providing room for the interment of at least two burials.

Excavations of the mounds

The sites are located in the Ha'ateiho transect, about 1.500 m south of the lagoon. It is situated in plantation land and at the time of excavation was overgrown with guinea grass (*Panicum maximum*). A group of four mounds TO-At-85, TO-At-86, TO-At-88 and TO-At-89 was excavated at the same time. Thus the excavation areas were not numbered individually for each site but in a consecutive manner. The following excavation areas belong to the site described here: areas 1, 2, 3, 3a, 7, 8, 9, 11, 12 and 14.

Site TO-At-85 is a circular mound with a convex top, 25 m-30 m in diameter, is a rather low house mound, 0.6 m in height, partly due to erosion of the latest of its three floors. The slope is so low that the available area is relatively large and permits the construction of buildings near the rim. Obviously this would have been even more the case in the earlier mound phases, when the mound was lower. TO-At-86 is a circular mound with a convex top, measuring about 15 m in diameter and 1.5 m in height.

[3] The Ha'ateiho transect comprises the entire 'Atele area, southern Pea area, as far north as Talangaholo, and the eastern Lakepa area, as far west as Matatoa.

[4] The Veitongo mound group was the focus of major excavations in 1986. Plans to complete them in 1987 were frustated by the fact that the landowner had planted the area in the interval.

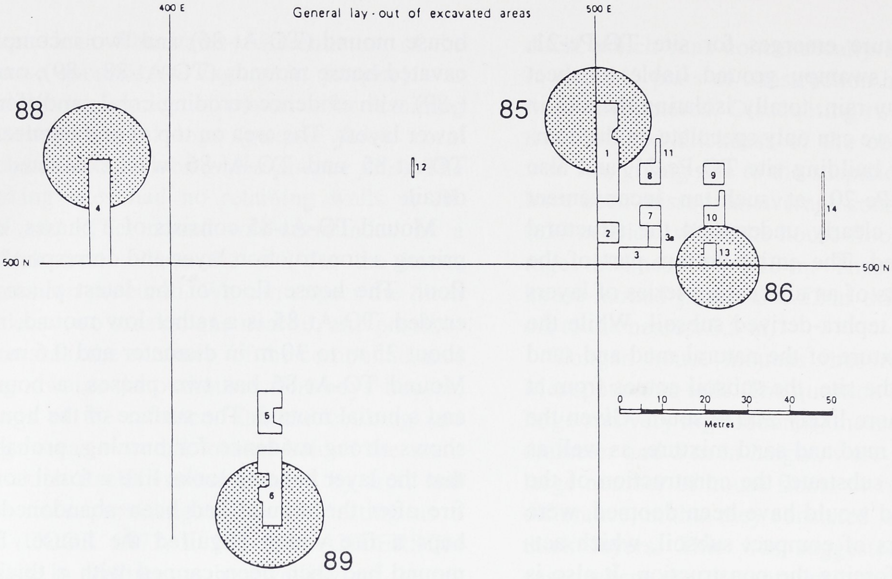

Fig. 4 Area excavations south of Veitongo, sites TO-At-85 and TO-At-86. Lay-out of excavation areas.

Description

Area 1 (mounded area TO-At-85). In total four plana were drawn. The plana are dominated by a plethora of disturbances (figures 5-6). None of these individual-phase plans gives any clue as to a general pattern. This may be due to the fact that the area excavated on top of the mound was rather limited in dimensions. It is interesting to note that on the surface of both mound phases I and II there is evidence for fires having been lit, in approximately the same locations. According to oral traditions, cooking never took place on top of a mound.

Areas 2 & 8

The planum is dominated by small circular discolourations, most of which are likely to be planting holes, though some may well be post holes. The holes were excavated and are incorporated in the statistical analysis presented further below. One disturbance (feature 8/1) is interpreted as a pit. Feature 8/1 is a circular disturbance, measuring 1.6 m in diameter and 0.2 m in depth below the planum (0.5 m below present ground surface). The pit has a basin-shaped bottom.

Area 3 / 3a / 7

The area consists of three subareas, 3, 3a and 7, where 3a was dug as an area connecting the other two, after it became apparent that one feature (3/1) extended into area 7. While the first planum was distinct enough for drawing features in areas 3 and 3a, area 7 needed two plana. Planum 1 of area 7 shows a few areas of subsoil outcropping. A discolouration of burnt soil can be made out in the centre, possibly representing a hearth (feature 3/3). The planum of all three areas is dominated by small circular discolourations, most of which are probably planting holes, though some may have been postholes. The holes of areas 3 and 3a, but not 7, were excavated and are incorporated in the statistical analysis presented below. The planum shows two major features, a large circular (?) pit (feature 3/1) which cuts a ditch (?, feature 3/2). Both features disappear into the eastern profile. Feature 3/1 is a flat-bottomed pit, measuring 1.1 m in depth and 5 m-6 m in diameter. The pit has evidence for subsoil material being washed in at the edges, before the pit became infilled with a homogeneous topsoil-like material. The pit fill is sterile. No clear function for the pit is apparent. Given that its large diameter precludes a function as a food-storage pit, for which diameters of about 1.5 m to 2.5 m are on record, water storage is possible. Feature 3/3 is a hearth, encountered in planum 1 of area 7. The hearth, visible as a discolouration of burnt soil, measures 0.3 m in diameter.

Area 9

The planum is dominated by small circular discolourations, most of which are probably planting holes, though some may have been post holes. The holes were not excavated.

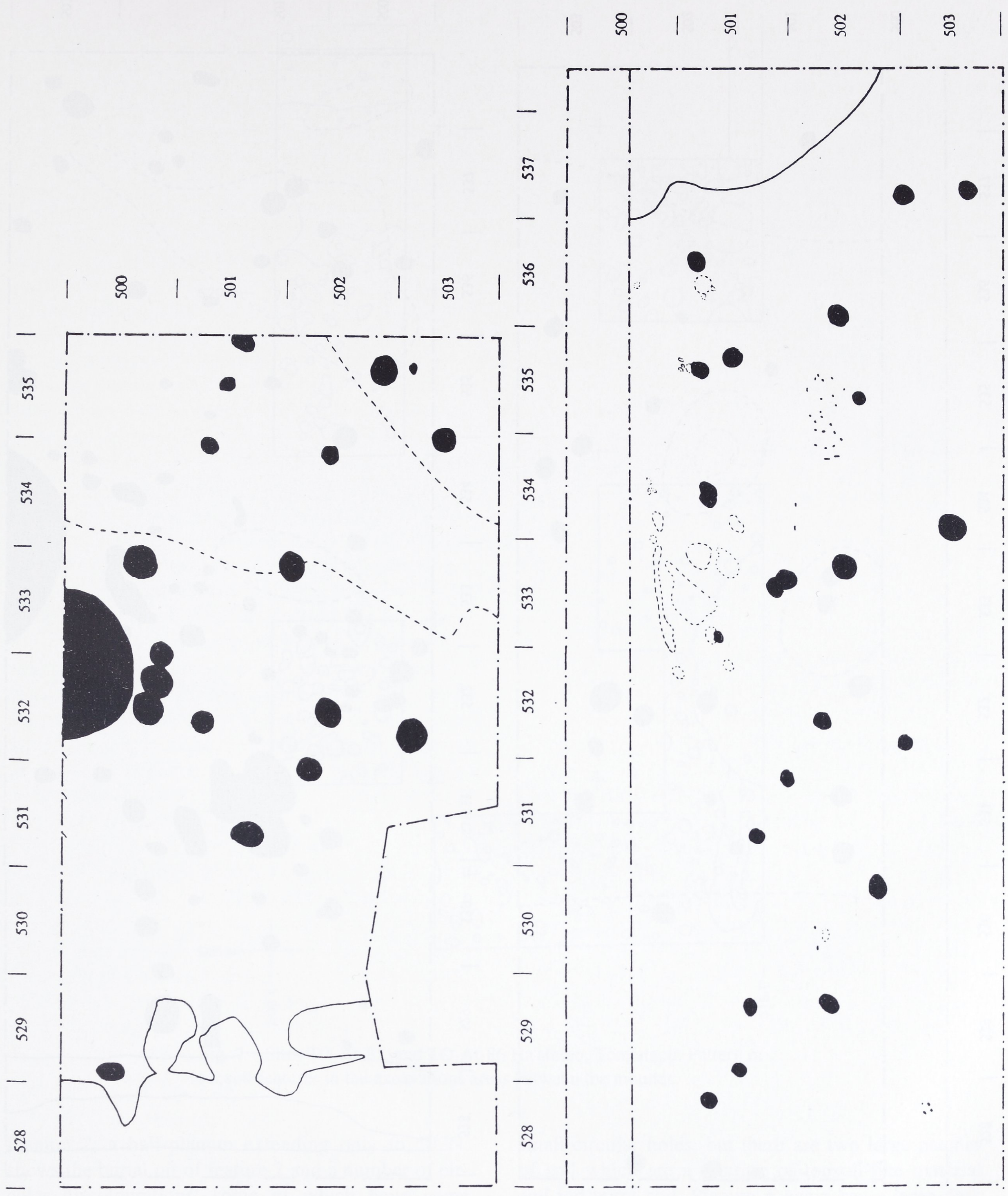

Fig. 5 Site TO-At-85, Ha'ateiho, Tongatapu. Pattern of discolourations in planum 1 (left) and planum 2 (right).

Area 10

Planum 1 shows a group of circular discolourations in the southern part, which may be post- or planting holes. The northern end shows a linear disturbance appearing as a discolouration of topsoil-like material. This represents the borrow ditch (feature 10/1) for one of the mound phases (see profile descriptions).

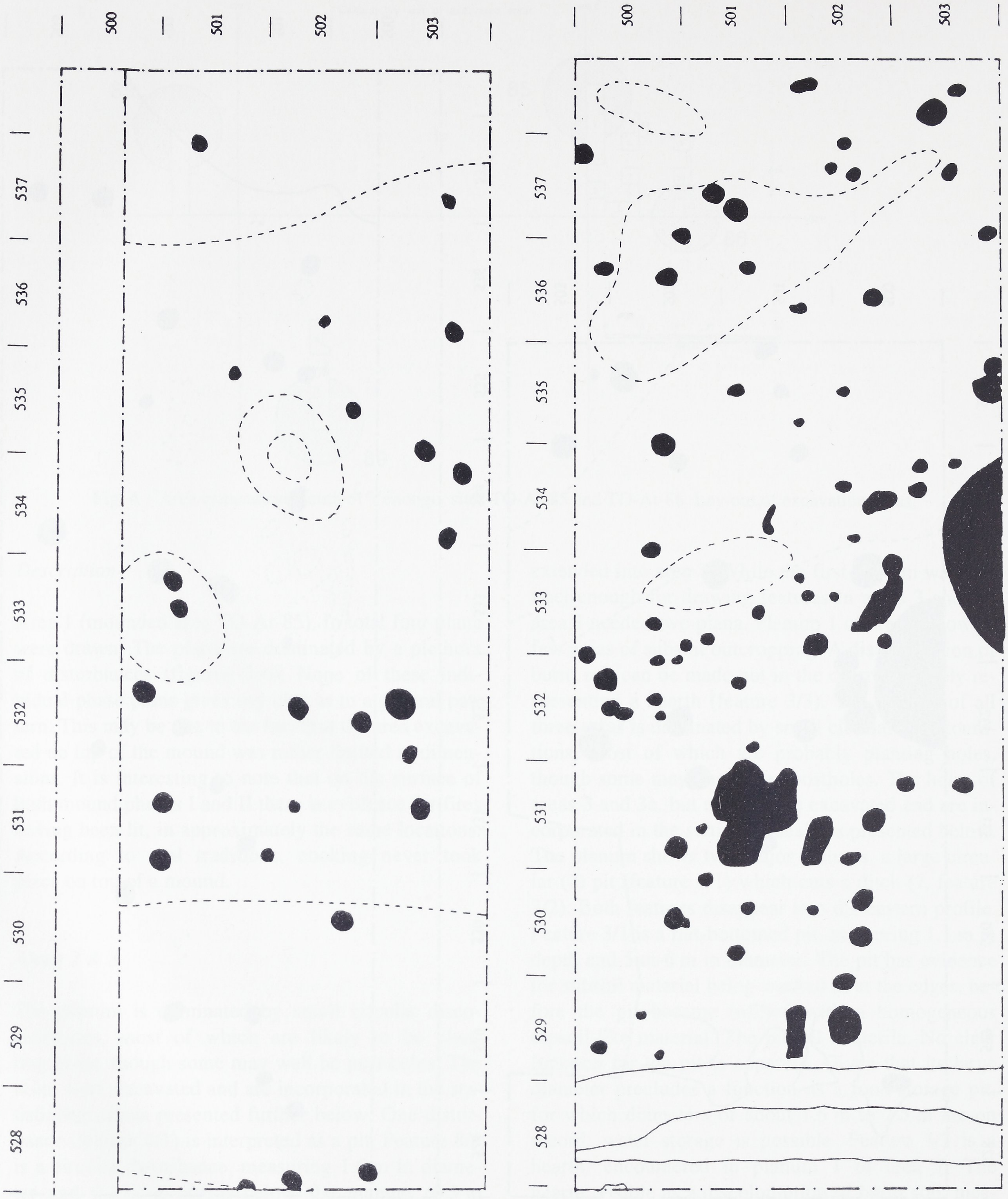

Fig. 6 Site TO-At-85, Ha'ateiho, Tongatapu. Pattern of discolourations in planum 3 (left) and planum 4 (right).

Area 11

The planum shows two circular disturbances and part of the borrow ditch encircling the mound (feature 1/1).

Area 13

Planum 1 shows two burials (features 1 and 2), a large brown discolouration, possibly from an intersected living horizon, and a group of circular discolourations, which may be post- or planting holes.

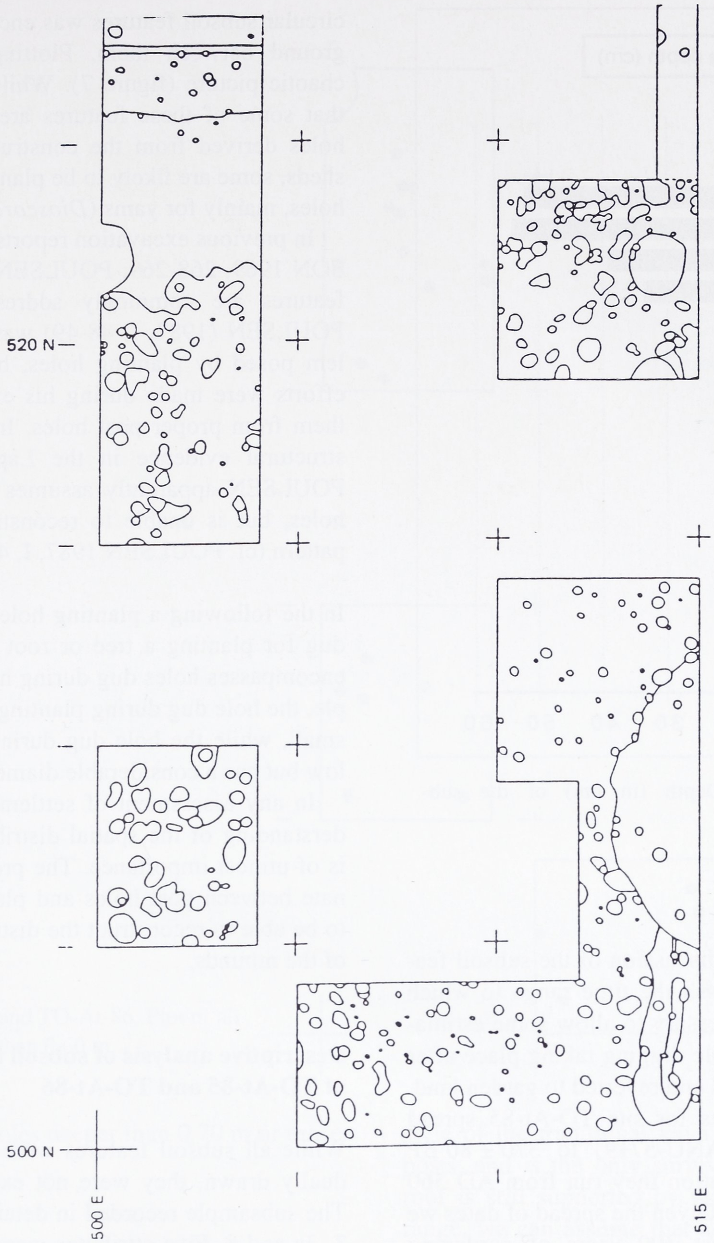

Fig. 7 Sites TO-At-85, and TO-At-86 Ha'ateiho, Tongatapu. Pattern of subsoil features in the excavations areas between the mounds.

Planum 2, a half-planum extending only to 502N, shows the burial pit of feature 2 and a number of circular discolourations, some of which have come down from the surface. Planum 3 shows a large patch of dark brownish soil in the northern part, possibly originating from an intersected house floor. In addition, a few circular features can be made out. The burial pit of feature 2 continues. In addition, two small circular holes show a fill of coral sand. Planum 4 presents basically the same picture, with the difference that the patch of coral sand belonging to feature 2 has become much smaller. Planum 5 shows only two small circular holes, but there are two large patches of soil which are a mixture of topsoil-like material and red-burnt soil. Planum 6 again has a large dark brown discolouration at the northern end, either originating from an intersected house floor or, at this depth, from an intersected borrow ditch. In addition, a large number of circular disturbances can be seen. Planum 7 has a ditch disturbance at the north. This is interrupted by an undug entrance way, against which the ditch segments end in a rectangular fashion.

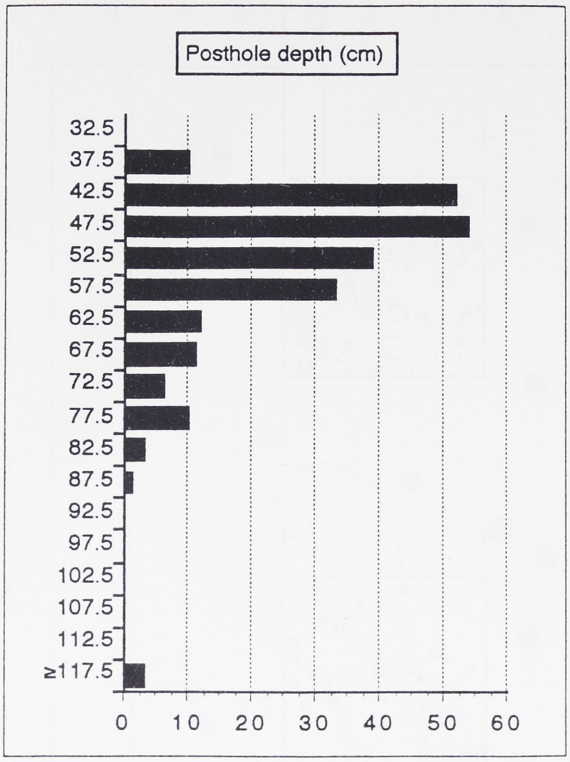

Fig. 8 Site TO-At-85. Depth (in cm) of the subsoil features (N = 234).

Chronology of the sites

Before embarking on a discussion of the subsoil features, we have to establish the time range to which they belong. This is necessary to allow some estimation of the amount of hole digging taking place after the sites were abandoned and reverted to garden land.

The radiocarbon dates for site TO-At-85 spread from 1270 ± 235 BP (ANU-5719) to 370 ± 80 BP (ANU-5718). On calibration they run from AD 560 to AD 1640 (1 s range). Given the spread of dates we can assume that at least 300 years of gardening were possible after the sites were given up. However, several holes were encountered beneath mound TO-At-85, indicating earlier pre-mound activity.

The pattern of subsurface features

From ethnographic evidence reviewed above, we know that a Tongan living compound contained several houses, one of them on a mound and the others standing on level ground. In their archaeological manifestation, the structures should remain visible in form of the post holes.

During the excavation of the habitation sites TO-At-85 and TO-At-86 a large number of small circular subsoil features was encountered in the level ground between them. Plotting them produces a chaotic picture (figure 7). While it can be expected that some of these features are without doubt post holes derived from the construction of houses and sheds, some are likely to be planting (and harvesting) holes, mainly for yams (*Dioscorea alata*).

In previous excavation reports on Tonga (DAVIDSON 1969, 268-269; POULSEN 1987, I, 21ff.) such features are commonly addressed as post holes. POULSEN (1987, I, 48-49) was aware of the problem posed by planting holes, but mentions that no efforts were made during his excavations to isolate them from proper post holes. In his sections on the structural evidence in the Lapita sites excavated, POULSEN apparently assumes all holes to be post holes, but is unable to reconstruct any meaningful pattern (cf. POULSEN 1987, I, 45 for TO-Pe-6).

In the following a planting hole is defined as a hole dug for planting a tree or root crop. The term also encompasses holes dug during harvesting. For example, the hole dug during planting sweet potato is very small, while the hole dug during harvesting is shallow but has a considerable diameter.

In any assessment of settlement patterns, the understanding of the spatial distribution of house sites is of utmost importance. The problem is to discriminate between post holes and planting holes in order to be able to reconstruct the distribution of structures of the mounds.

Descriptive analysis of subsoil features at TO-At-85 and TO-At-86

While all subsoil features were mapped and individually drawn, they were not excavated in all cases. The subsample recorded in detail covered areas 1, 2, 3, 3a and 8. Five attributes were recorded for a total of 234 circular and oval-shaped features: diameter; depth; shape of bottom; slant of hole; and type of fill.

Depth

The depth of the holes was measured from the planum (i.e the mapped horizontal level of an excavation spit) they became visible and recalculated as the total depth from the surface. The average depth of the 234 recorded holes is 0.53 m (SD = 0.14; median = 0.50 m), with 97 % of all features having a depth of less than 0.80 m (figure 8). Holes deeper than 0.60 m are plotted in figure 9. As can be seen from these plots, no clear-cut pattern emerges, nor

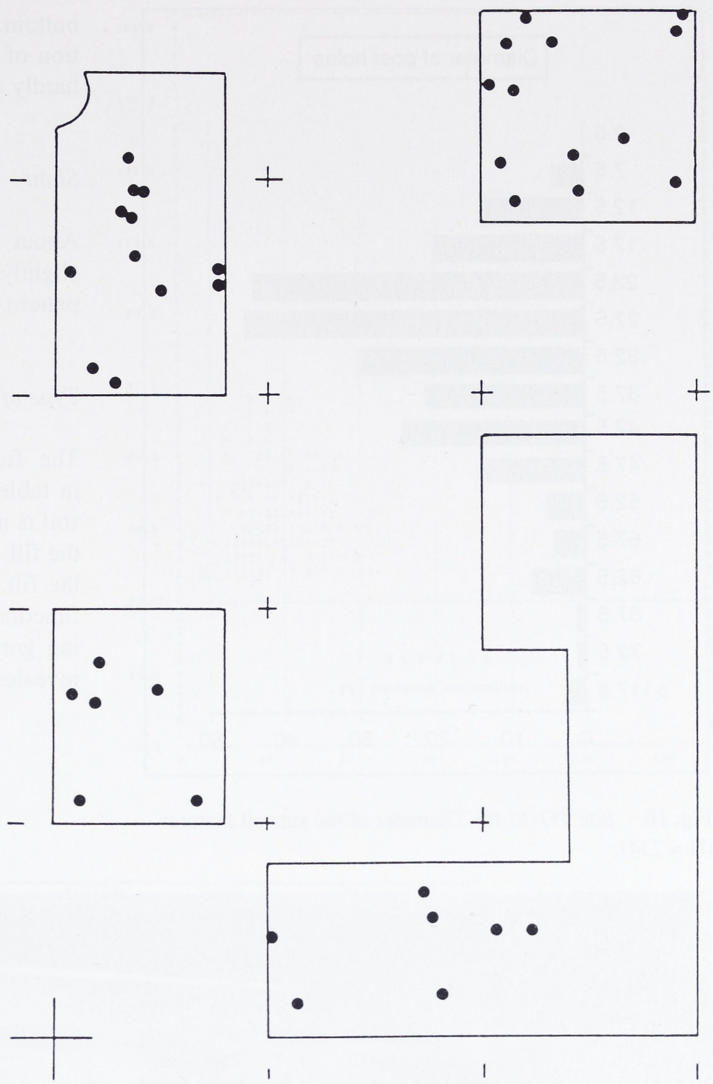

Fig. 9 Site TO-At-85 and TO-At-86. Plot of all subsoil features deeper than 0.60 m.

does it for plots for holes deeper than 0.70 m or those deeper than 0.80 m.

Diameter

The diameter of the holes was measured at the planum the holes become visible. The diameter at the surface was assumed to be the same. On average the 234 holes under analysis had a diameter of 0.30 m (SD = 0.14; median 0.28 m), with 92 % of the holes having a diameter of less than 0.50 m and only 5 (or 1.7 %) having a diameter greater than 0.60 m (figure 10).

The average thickness of the posts used for the construction of Tongan houses (*fale fakamanuka, fale fakafuna*) would not exceed 0.30 m. The large posts used for the kava house have a diameter of 0.60 m to 0.70 m, if we use the posts of the Christian Church at Ma'ofanga as a guide: this is built in the style of the traditional kava house, resting on eight posts, and is the only surviving example where the roof is still supported by wooden posts. Given this range, we can assume that all holes with a diameter larger than 0.50 m and which do not form a pattern (in an area large enough to recognise such a pattern) are either planting holes or pits. The differentiation between planting holes and pits is complicated by the fact that some harvesting holes, for example for sweet potatoes, can reach diameters of 1 m.

Depth vs. diameter

The bivariate plot depth vs. diameter (figure 12) the holes clustered nicely, with only a few holes being different. Of all holes, 95.73 % were less than 0.85 m deep and measured less than 0.60 m in diameter.

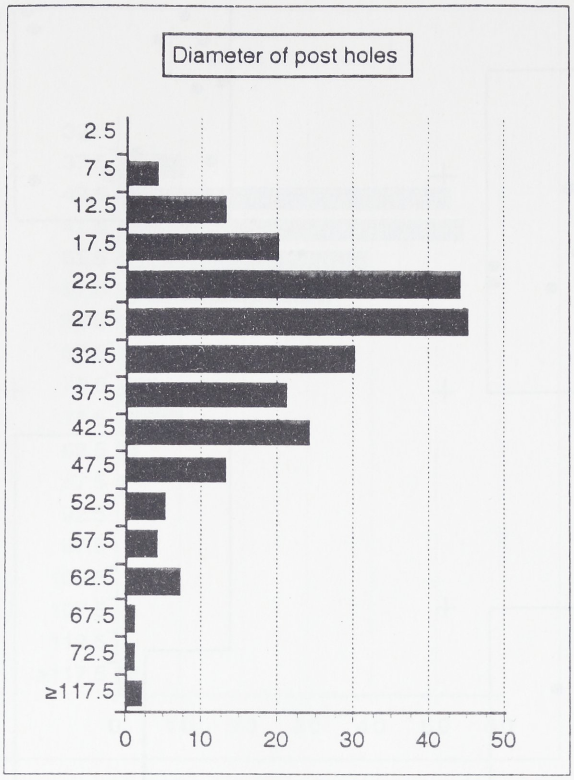

Fig. 10 Site TO-At-85. Diameter of the subsoil features (N = 234).

Fig. 11 Site TO-At-85, area 8. Photograph showing excavated planting holes.

Shape of the bottom

The frequency of the various shapes of the bottom are given in table 1, together with the average diameters and depths of the holes in each category. We note that the narrower and deeper the hole, the more cup-shaped the bottom, and the shallower and wider the hole was, the more basin-shaped the bottom. The shape of the bottom seems to be a function of the depth and diameter of the hole and thus hardly a significant discriminant feature.

Slant

About 10 % of the holes were not vertical but were slightly slanting (table 1). Again, the plot shows no pattern.

Type of fill

The frequency of the various fill types is given in table 1. The difference between earth and sticky soil is mainly determined by the amount of topsoil in the fill. The more topsoil is present, the less sticky is the fill. As can be seen from the table, this is not a function of depth, except for the single hole containing greyish clay. A plot of the individual fill types revealed no pattern.

Conclusions

As the descriptive statistics of the holes did not reveal any pattern, other avenues had to be tried in the attempt to distinguish between planting holes and post holes. Before we do so, let us first assess the Tongan houseforms at the time of contact, and how they may show up in the archaeological record.

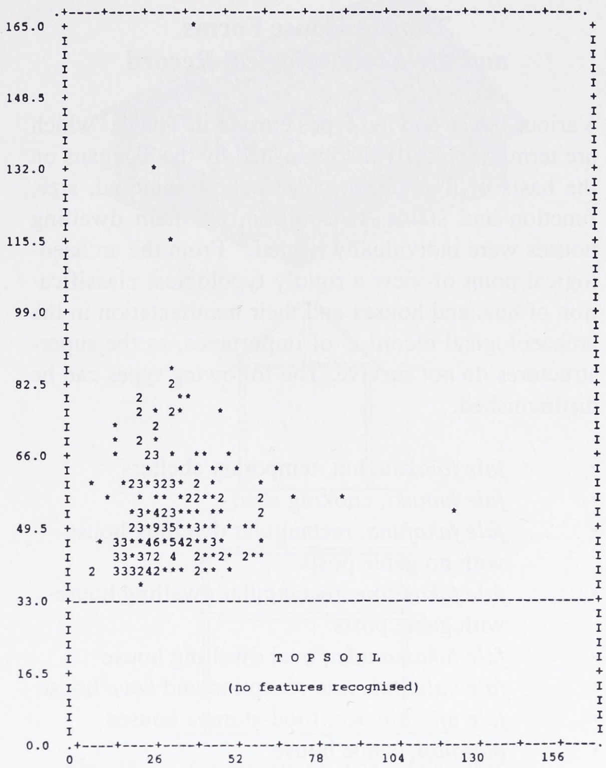

Fig. 12 Site TO-At-85. Subsoil features. Bivariate plot showing the relationship between diameter (across) and depth (down) in cm (N = 234).

	N	%	Diameter Mean	SD	Depth Mean	SD	Volume Mean	SD
Shape of bottom								
Unknown	3	1.3	16.00	6.55	47.33	7.50	0.010	0.008
Flat	1	0.4	40.00	----	56.00	----	0.070	----
Cup-shaped	20	8.5	23.45	8.21	68.10	28.70	0.039	0.046
Bowl-shaped	70	29.9	28.29	10.36	54.97	13.20	0.039	0.034
Basin-shaped	86	36.8	37.71	16.29	49.61	9.15	0.067	0.079
Digging stick *)	27	11.5	19.48	12.24	49.00	10.49	0.020	0.031
Irregular	27	11.5	32.30	8.46	52.22	11.53	0.045	0.023
Total	234	100.0	30.68	14.20	53.02	14.29	0.048	0.057
Type of fill								
Loose ash	1	0.4	23.00	----	48.00	----	0.019	----
Very loose soil	11	4.7	23.64	11.50	52.36	7.20	0.026	0.021
Earth, not compact	38	16.2	24.76	11.27	58.94	17.29	0.035	0.033
Medium compact	48	20.5	33.06	13.57	52.52	9.81	0.052	0.041
Earth, compact	12	5.1	29.08	14.36	62.58	33.80	0.056	0.065
Compact but friable	47	20.1	28.96	10.08	48.61	8.89	0.036	0.027
Sticky soil, loose	4	1.7	36.50	16.21	55.50	13.30	0.065	0.057
Sticky soil, compact	65	27.8	34.78	17.93	50.38	11.79	0.061	0.089
Sticky clay	7	3.0	32.86	6.28	60.28	15.26	0.051	0.019
Grey clay	1	0.4	20.00	----	68.00	----	0.021	----
Total	234	100.0	30.68	14.20	53.02	14.29	0.048	0.057
Slant								
No slant	211	90.2	30.46	14.36	52.56	14.64	0.047	0.058
To north	4	1.7	37.75	17.01	53.50	5.50	0.073	0.067
To east	3	1.3	26.67	12.58	53.33	7.37	0.035	0.031
To south	8	3.4	28.25	8.73	57.87	8.35	0.040	0.027
To west	2	0.9	36.00	11.31	51.00	1.41	0.054	0.031
To north-east	1	0.4	40.00	----	49.00	----	0.061	----
To south-east	2	0.9	54.00	8.48	63.50	16.26	0.141	0.008
To south-west	2	0.9	24.50	10.60	66.00	22.62	0.038	0.038
To north-west	1	0.4	25.00	----	70.00	----	0.034	----
Total	234	100.0	30.68	14.20	53.02	14.29	0.048	0.057

*) defines a pointed concave bottom, belonging to a hole of 0.10 to 0.20 m in diameter.

Table 1 Site TO-At-85. Statistical breakdown of the subsoil features for the parameters 'shape of bottom', 'type of fill' and 'slant'.

Tongan House Forms and the Archaeological Record

Various house and hut types existed in Tonga,[5] which are terminologically distinguished by the Tongans on the basis of their form, construction, material, size, function and status. In addition, all main dwelling houses were individually named.[6] From the archaeological point of view a rigidly typological classification of huts and houses and their manifestation in the archaeological record is of importance, as the superstructures do not survive. The following types can be distinguished:

- *fale foiakau*, hut, temporary shelters
- *fale hunuki*, cooking shed
- *fale fakafuna*, rectangular dwelling house with no gable posts
- *fale fakafefine*, rectangular dwelling house with gable posts
- *fale fakamanuka*, oval dwelling house
- *fale valu, fale hau* reception and *kava* house
- *fale ufi, fale oko*, food-storage houses
- *alafolau*, canoe house
- *fale fataki*, stilt house

The latter two building types need not concern us here. Let us now briefly look at each these house types and how they would show up in the archaeological record.

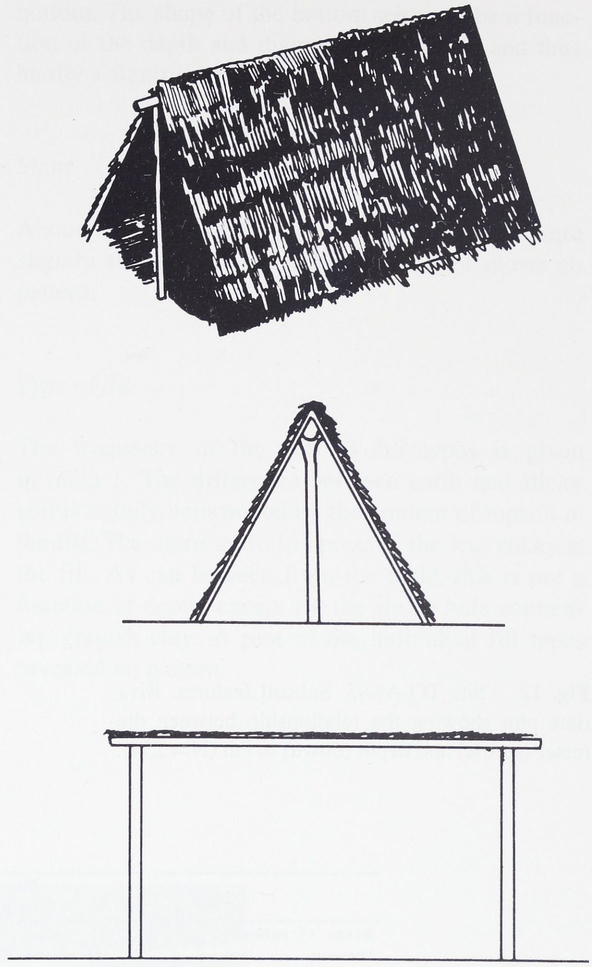

Fig. 13 Tongan house types: *fale hunuki*. Axiometric view, transverse and longitudinal cross-sections.

Fale Foiakau

Fale foiakau huts could be erected relatively quickly as temporary accommodation, as is evident from the accounts given by COOK and LABILLARDIERE (COOK 1967a; 1967b; LABILLARDIERE 1800, II, 103-104; McKERN nd.). They were also used as outhouses in the compounds (then called *peito*) and were used for food preparation. They were were erected with close-set timbers bent over and tied together at the top. Thin stringers were tied horizontally to the posts. The roof was covered with woven coconut fronds. The eaves of the building reached almost to the ground. The *fale foiakau* were about 3.5 m by 5.5 m (12' x 18') in size and supported by up to 12 posts. The *peito* were very variable in size, but usually smaller than the *fale foiakau*,

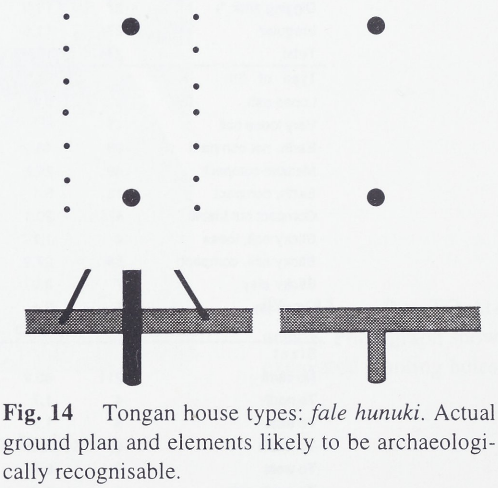

Fig. 14 Tongan house types: *fale hunuki*. Actual ground plan and elements likely to be archaeologically recognisable.

[5] Following the German ethnographic tradition I define a hut as a building without seperate walls and a house as one with seperate walls. Thus a building like the *fale hunuki*, which consists only of roof, is classified as a hut. McKERN (nd) distinguishes between type I and type II houses, which are houses and huts respectively.

[6] A new building replacing an old one would be given a new name; only houses of the Tu'i Tonga, the *Tu'i Ha'atakalaua* and the *Tu'i Konokupolu* had individual names which were perpetuated: Olotele, Fonuamotu and Langakali respectively.

ranging from 2.5 m to 4 m in length. They consisted of 4 to 8 posts.

Archaeological recognisability

In the archaeological record we can expect a series of closely spaced wall posts to show up. The number of post holes can vary from four, in the case of a small *peito*, to 12 in the case of the *fale foiakau*. Given the ad hoc nature of the *fale foiakau*, we can also expect that the post holes will not be in two totally straight rows but in a somewhat haphazard fashion, which is caused by the nature of the bent wood employed. It is also probable that at least some of the post holes will be slanted away from the centre of the building.

Fale Hunuki

The *fale hunuki* served predominantly as a cooking shed/shelter, but was also erected as a temporary shelter in the plantations. Similar structures were erected as deck houses (*fale vaka*) on the Tongan double-hulled canoe types, *tongiaki* and *kalia*. The building, which is typologically a hut, consists of two posts which support a ridge pole (figure 13), to which rafters are attached, the ends of which are buried in the ground. The whole structure is tied together with coconut fibre (*sennit*). The building covers about 2 m by 3 m in floor space. Larger *fale hunuki* are known, but are uncommon.

Archaeological recognisability

In the archaeological record we would expect only two postholes set about 2.5 m to 3 m apart, as the rafters do not penetrate the topsoil (figure 14). This makes the positive recognition of *fale hunuki* quite problematic.

Fale Fakafuna

The *fale fakafuna* is a rectangular building with distinct gable ends. It is not commonly referred to by European voyagers of the 18th century, but mentioned in Tongan traditions. The *fale fakafuna* was a universal building erected at the foot of the mound. It was commonly utilised as a boys' house but could also serve as a dwelling for retainers. The gable ends are high and the roof steep (figure 15). The standard *fale fakafuna* was erected on level ground and consisted of four posts (*pou*) set in the corners. Two

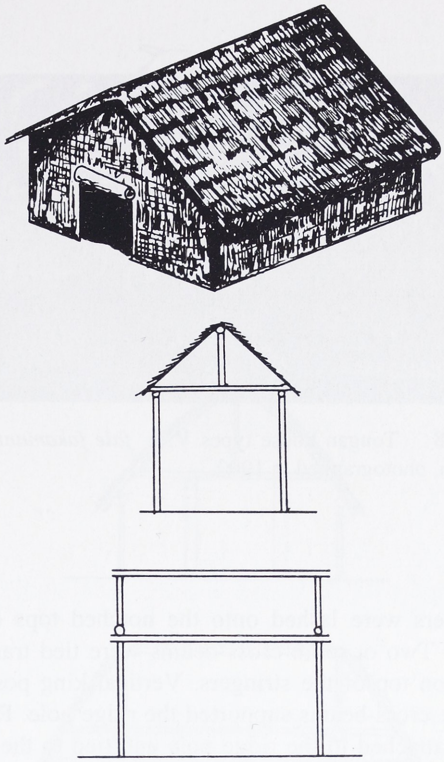

Fig. 15 Tongan house types: *fale fakafuna*. Axiometric view, transverse and longitudinal cross-sections.

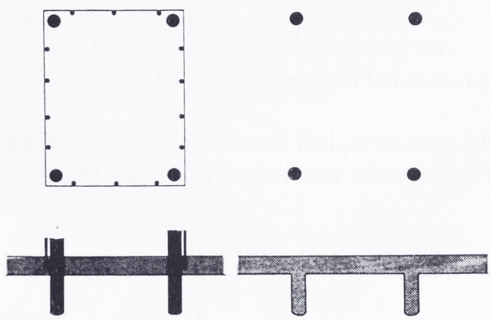

Fig. 16 Tongan house types: *fale fakafuna*. Actual ground plan and elements likely to be archaeologically recognisable.

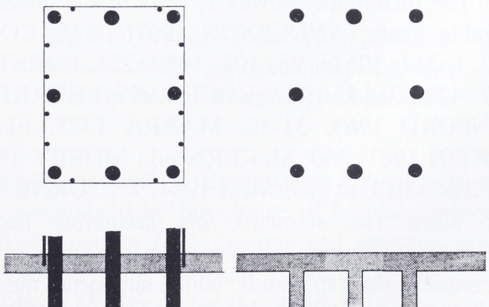

Fig. 17 Tongan house types: *fale fakafefine*. Actual ground plan and elements likely to be archaeologically recognisable.

Fig. 18 Tongan house types V: a *fale fakamanuka* on Vava'u, photographed in 1900.

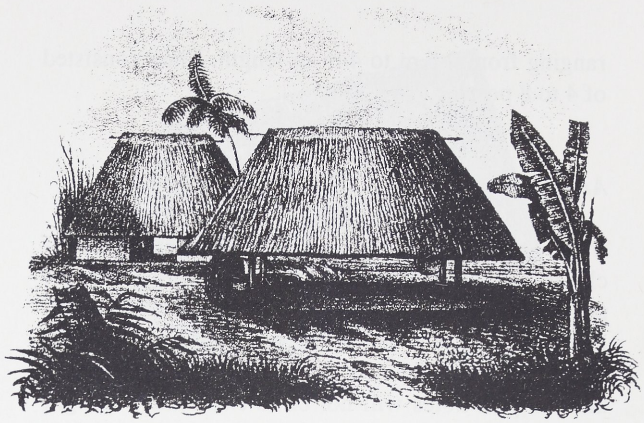

Fig. 19 Two *fale fakamanuka* on Tongatapu. Note that the house in the foreground is devoid of wall covering and that the roof is carried by the four central posts. (Drawing by L. de SAINSON in 1826; this figure reproduced from the German edition).

stringers were lashed onto the notched tops of the posts. Two or more cross-beams were tied transversally on top of the stringers. Vertical king posts set on the cross-beams supported the ridge pole. Rafters were attached to the ridge pole and tied to the stringers. The walls were supported by thin wall posts, which were lashed to the stringers and shallowly buried in the ground. Like the roof, the walls consisted of woven coconut fronds.

Archaeological recognisability

In the archaeological record only the holes for the four corner posts would survive (figure 16).

Fale Fakafefine

A variant of the *fale fakafuna* is the *fale fakafefine*, which also had two distinct gable ends and steep roof. The *fale fakafefine* is seen as a building (outhouse) for persons of medium rank by McKERN (nd). The difference, however, rests in the presence of gable posts (ANDERSON 1967b, 874; COOK 1777, I, 214; 1967a, 98; 108; 1969, 251; FORSTER 1777, 428; HELU 1987; KOCH 1955; LEYARD in MUNFORD 1963, 31-32; MARRA 1775, 61-62; MARTIN 1981, 360; McKERN nd.; MOREY 1804; PICKERSGILL in HOLMES 1984, 97; TURNBALL 1805, 326). The standard *fale fakafefine* had a total 8 posts, three on each side and two set at the centre of the gable ends, which supported the ridge pole directly (figure 17). Two stringers were lashed onto the notched tops of the corner posts. It is unknown whether cross-beams were tied transversally on top of the stringers. Given that the ridge pole was supported by the gable posts, this seems unlikely. Rafters were attached to the ridge pole and tied to the stringers. The walls were supported by thin wall-posts, which were lashed to the stringers and shallowly buried in the ground. Like the roof, the walls consisted of woven coconut fronds, but cane roofs were also known. Due to the assumed lack of cross-beams, the building was more spacious than the *fale fakafuna* and provided considerably more headroom. None of the sources indicate whether the *fale fakafefine* was ever erected as a central building on mounds or platforms.

Archaeological recognisability

In the archaeological record we would expect to find the post holes of all eight posts, with the holes for the gable posts having greater depth (figure 17).

Fale Fakamanuka

In both the *fale fakafuna* and the *fale fakamanuka* (literally *'house in the style of Manuka'*, Tongan for Manu'a, an island in eastern Samoa) the entire weight of the roof rests on four posts. But while the four main posts of the *fale fakafuna* demarcate the corners of the house, the four posts of the *fale fakamanuka* are located centrally and the area covered by the roof is much larger. The *fale fakamanuka* is the main Tongan house form and the descriptions of houses given by most of the early European visitors refer to this type of building. The house (figure 18) was erected on a slightly raised floor of about one to one and a half feet (0.45 m) in thickness, which was larger than the actual house and provided a sort of verandah surrounding it. The floor was of beaten soil covered with a thick layer of grass, which in turn was overlain by thick mats. This provided for a relatively soft floor (*hulu*), which could also be kept clean. The entire weight of the roof was supported by the four main posts (*pou*). The wall posts (*tokotu'u*), up to 0.10 m thick, were only needed to hold up the walls and so were not very deeply sunk. In modern examples, they usually penetrate the ground for 0.10 m to 0.20 m, and often as little as 0.05 m. The wall thatching consisted of woven coconut fronds (*pola*), woven reed or mats figure 18), which could be removed as desired, as can be seen from a drawing made during DUMONT d'URVILLE's visit (figure 19). While the walls were usually in place on the weather side, they were commonly removed on the leeward side of the house. The four main posts, 0.25 m to 0.6 m in diameter, were usually set in a rectangle of ~4 m by 2.5 m (14' x 8') and were buried to a fourth or third of their length in the ground and reached to about 3 m to 4 m above ground. They ended in notches (*nifoipou*), into which stringers *(lalango)* were placed, running along the long side of the building. On top of the stringers five cross-beams *(toka* or *utupotu*) were placed at regular intervals, protruding over the stringers between 0.3 m and 1.5 m. On top of the cross-beams three stringers (*faletuo*) were placed, one flush on each side and one in the centre, all protruding beyond the cross-beams. Two king posts (*hokatu'u*) erected on the central stringer supported the ridge pole *(tauolunga)*. The roof was fastened to these lateral stringers and the ridge pole. Rafters, usually bent roots of large mangroves or pandanus, were suspended from the ridge pole and tied to the lateral stringers, providing a curved roof. Several thin purlins were also added to strengthen the roof. The whole construction was lashed together with coconut fibre (*sennit*). The roof itself was covered with woven coconut fronds (*pola*) or, in the case of chiefly buildings, with cane. The way the roof was constructed resulted in a rigid, yet flexible unit, sitting on the four main posts like a hat, which could be lifted off in one piece after the lashings had been severed and transported in one piece to any location needed: *'...a house brought on mens shoulders a full quarter of a mile...'* (COOK 1967a, 109; see also SPENNEMANN 1989, figure 1.8). Thus the roof could be removed in the case of a cyclone and placed next to house, thus reducing the wind load. The interior of the house was divided into a number of compartments, depending on the size of the family, by the means of mats suspended from the roof and by room dividers placed on the floor. At the time of European contact, the *fale fakamanuka* was the main Tongan house type, used for accommodation

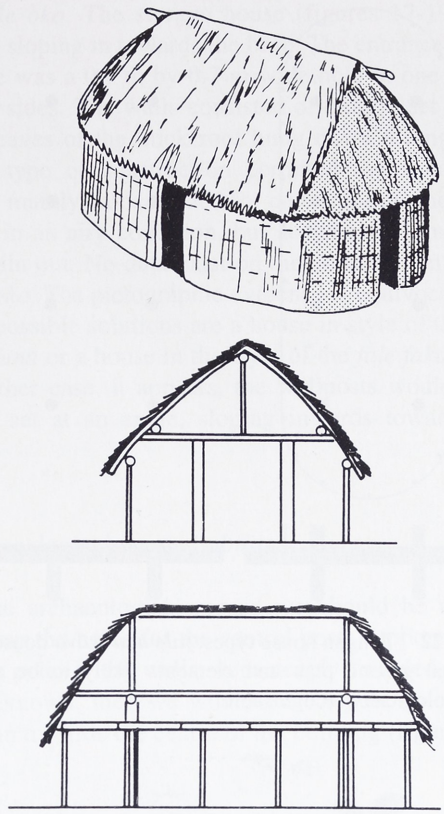

Fig. 20 Tongan house types*: fale fakamanuka*. Axiometric view, transverse and longitudinal cross-sections.

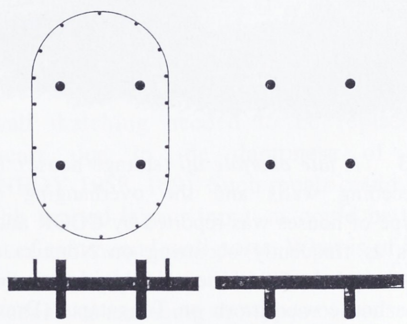

Fig. 21 Tongan house types: *fale fakamanuka*. Actual ground plan and elements likely to be archaeologically recognisable.

by all social strata. Differentiation between the strata was maintained by the choice of building materials, such as coconut posts, beams and stringers for the commoners (*fale niu*) and *Casuarina* (*fale toa*) or breadfruit (*fale mei*) for the chiefs. Also the material used for the roofs distinguished societal classes, i. e. banana leaves or coconut fronds or the commoners vs. sugar-cane leaves for the chiefs. While the former

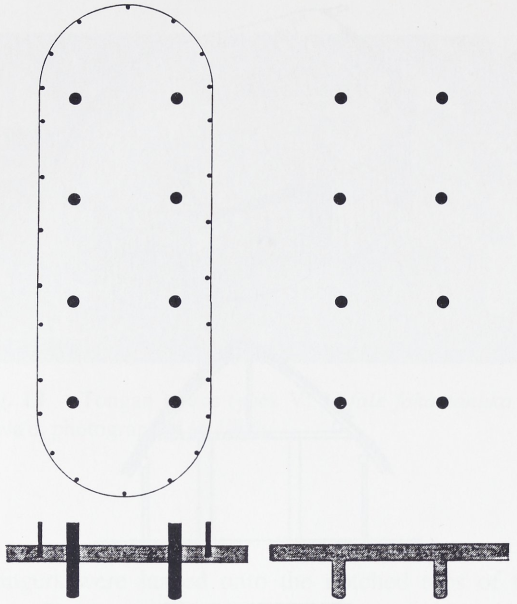

Fig. 22 Tongan house types: *fale hau (kava* house). Actual ground plan and elements likely to be archaeologically recognisable.

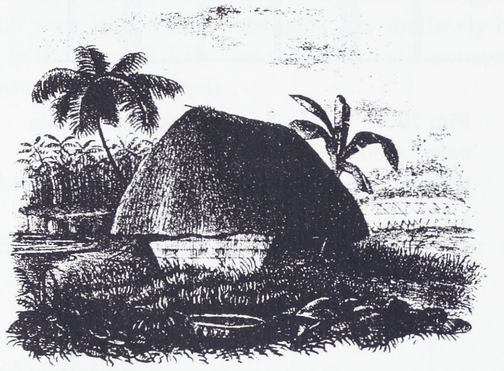

Fig. 23 A *fale oko/fale ufi* (storage house). Note the receding walls and the overhanging roof. This type of houses was reported by COOK and his officers as frequently occurring on Nomuka. The German caption of this French lithograph indicates that the house was drawn on Tongatapu. (Drawing by L. de SAINSON in 1826, on DUMONT d'URVILLE's first voyage to Tonga; this figure reproduced from the German edition).

material had to be replaced frequently, the latter was more durable and also provided a tighter roof. The wall thatching of the houses of higher-ranking people also tended to consist of reeds, which were often woven into ornamental designs, such as lozenges. Another differentiating factor was the overall size of the house. While the spacing of the four posts was usually maintained, the overhang provided by the horizontal rafters could be between 0.3 m and 1.5 m to each side, thus allowing dramatic increase of floor space. In addition, houses of lower ranking people would have been lower. A 'normal'-sized *fale fakamanuka* would be 9 m long, 6 m wide and about 4.5 m high. *Fale fakamanuka* measuring 7.5 m by 4.5 m by 3.5 m would be regarded as small. Large *fale fakamanuka*, erected for very high-ranking chiefs, are reported to have measured 15 m by 9 m by 7.5 m. While the houses of chiefs were commonly erected on raised floors of 0.30 m to 0.45 m thickness, the houses of the commoners were built on level ground. Status differentiation of the chiefly house mounds (*tu'unga fale, paepae*) was maintained by the choice of material for retaining walls, whether coconut logs (*paepae falo*), coral boulders or beachrock slabs (*maka paepae falo*). The lowest-ranking sites had no retaining walls at all. Small-scale houses of the *fale fakamanuka* type were built on top of chiefly over the burial chamber. Temple houses were also of the *fale fakamanuka* style. McKERN (nd., 84) refers to community houses, separate ones for men and women, which were called *fale fakakautangata* and *fale fakakaufefine* respectively. These buildings, apparently large *fale fakamanuka*, were erected in all villages. It is quite possible that this was a late development caused by the aggregation of people in fortified villages due to civil strife. However, it is of interest that the buildings erected were *fale fakamanuka*, which documents the universality of this type of house for Tongan needs. With increasing westernisation of Tongan housing, the *fale fakamanuka* was modified by adding wooden walls, corrugated iron roofs or both (KOCH 1955; KENNEDY 1958).

Archaeological recognisability

Apart from the mound and the ditches excavated for the mound fill, only the holes for the four main posts can be expected to survive in the archaeological record (figure 21). The wall posts were not deeply sunk and will be invisible in the topsoil. The post holes of the four main posts had diameters between 0.25 and 0.6 m and were between 0.6 and 1.0 m deep, if we follow McKERN's assessment. However, we can expect that the houses of societally less important people will have been less high and thus will have had shallower post foundations.

Fale Hau (Kava house)

The *fale hau* was owned by high-ranking chiefs and was used solely for ceremonial and associated purposes, a reception building, where *fono* meetings and *kava* circles were held (ANDERSON 1967b, 873; ERSKINE 1853, 113; McKERN nd.; SPENNEMANN, fieldnotes 1986; 1987; WILSON 1799, 251; photographs of churches in MOULTON 1921, opp. 46; SIERS 1978, 14-15). The building was commonly supported on eight posts and therefore sometimes referred to as *fale valu*.[7] The *fale hau* was erected on top of a large mound, in front of which was a large grassy space to accomodate the *kava* circle needed for the instalment of chiefs. Today no examples of traditional *fale hau* survive.[8] However, early Christian churches, some examples of which survive were built in the fashion of kava houses, as this was the largest fully enclosed building the Tongans had, the large examples reaching 30 m by 15 m in dimensions. WILSON mentions an extraordinarily large house, named *nafula*, which measured 36 by 17 metres. The principle of the standard *fale hau* is very similar to that of a normal *fale fakamanuka*. While the basic unit of the *fale fakamanuka* consists of four posts set in a small rectangle, the *fale hau* consists of two such units set against each other on the smaller sides. The similarity becomes obvious when we consider the roof structure, which consists of two sets of stringers set in notches on top of the posts. Even the five rafters are replicated on both sides. Only the lateral stringers and the ridge pole connect the two units.[9]

Archaeological recognisability

In the archaeological record *kava* houses should appear as a series of eight postholes set in two rows of four evenly spaced posts (figure 22). If the Wesleyan Church of Ma'ofanga is any guide, then the main posts would have had a diameter of about 0.6 m to 0.8 m.

Fale oko (food-storage house)

Food-storage houses were a vital part of every compound. These houses were usually called *fale oko*, but if yam was stored in them, they were termed *fale ufi*. Once the yams were removed, the name reverted to *fale oko*. The storage house (figures 17-19) had walls sloping in towards the base. The entrance to the house was a 0.7 m by 0.7 m wide hole in one of the short sides. The walls consisted of closely set canes. The eaves of the thick roof hung down a long way. This type of construction permited the storage of food, mainly yams needed for consumption and planting, in an airy condition, but at the same time kept the rain out. No data exist on the construction of the *fale oko*. The pictographic evidence is equivocal. The two possible solutions are a house in style of the *fale fakafuna* or a house in the style of the *fale fakafefine*. In either case, it appears, the wallposts would have been set at an angle, sloping inwards towards the base.

Archaeological recognisability

In the archaeological record we should be able to pick up the holes for the central posts supporting the ridge pole. If the walls were deeply founded, which is unknown, then we would expect post holes slanting in towards the centre of the building (figure 23).

Life expectancy of Tongan houses

The life expectancy of houses is obviously of enormous general interest to archaeologists for purposes of assessing the frequency of house replacements and, in the Tongan situation, the potential frequency of renewals of the raised house floors.[10] Obviously the houses and especially their roofing were in constant need of repair. KENNEDY mentions that roof and wall thatching needed to be replaced every 2-3 years due to the dampness of the *fale* (KENNEDY 1958, 169). Such repair could be achieved with limited labour input, as could be the replacement of rafters and wall posts. What is of interest is the time at which a house was replaced completely. While censuses assessing the types of houses in existence at a given time are not uncommon (KOCH 1955; KENNEDY 1959; KINGDOM OF TONGA 1976; RATCLIFFE & DILLON 1982; MULK 1983, 14-15), data on the life expectancy of houses are very

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7 Or *pouvalu* 'eight posts'. However, buildings with differing post configurations are known to have existed, such as the famous *Pouono* ('six posts'), where the Vava'u Code of 1838, the presecutor of the Tongan Constitution of 1865, was issued.

8 Sia'atoutai and Ma'ofanga, Tongatapu, Ltofoa, Ha'apai.

9 In surviving Christian churches built in the style the wall posts have taken over some load-bearing function as the weight of the corrugated iron roof is immense.

10 It is of course possible that a new house was built using an old house floor, though it seems unlikely that this would have been common practice.

rare. KOCH conducted a housing census on 'Uiha, Ha'apai, in 1951 (KOCH 1955). He counted 33 houses built in the European (traders) style, 44 *fale fakamanuka* in the traditional style, i. e. thatched roofs and thatched walls with proper roof construction, and 47 semi-traditional *fale fakamanuka*, using traditional materials but with slight modifications to roof construction and walls and employing some modern techniques like nails. They show the use of traditional and European (trader)-influenced buildings in the 1910s and a post-World War II building spree, mainly using traditional and increasingly semi-traditional styles. The data emphasise the potentially long life span of a *fale fakamanuka*. The average age of the all houses in the census was 21.2 years, that of the traditional *fale fakamanuka* being 24.6 years. Over a third of the latter were more than 45 years old. The 'Uiha housing census data indicate that on average we can equate the lifetime of a house with at least one human generation, possibly even with two. Thus it seems as if houses were not usually renewed as long as the original inhabitants lived in them.

Fences

All compounds were enclosed by fences of various kinds. In addition, low fences were built to keep pigs out of plantations and other areas (COOK 1977, I, 194; 1969, 246; 252; 295; BAYLGY 1969, 246, note 4; ANDERSON 1967a, 1004-1005; PICKERSGILL 1984, 97; MARRA 1775, 62; DUMONT d'URVILLE 1835; WILSON 1799, caption of map). The common fence enclosing a compound was constructed of a series of thin posts as support for the fencing material. Quite often the role of fence posts was performed by the stems of growing economic or ornamental trees, giving an appearance midway between hedge and fence. This practice served the practical need, saved on timber and provided shade. As fencing-material bamboo, reed, sugarcane leaves and woven coconut fronds are mentioned. Lashing was done with sennit. Some fences, apparently those along roads, were woven into patterns, commonly lozenges ('diamonds'), similar to the wall thatching of houses of high-ranking individuals (figure 15). The fences enclosing the compounds were commonly 3 m to 3.5 m high, but occasionally reached a height of up to 5.5 m (18'). The entrances into the compounds had raised sills to keep pigs out and pieces of trunk set on both sides of the sills were used as steps (cf. figure 7). The gates, which were usually higher than the fence, were hung in such a manner as to be self-shutting. Entry could be prevented by a stick set against the inside and footing on a large stone (presumably a coral boulder). The two posts for the gate were usually proper posts rather than growing trees. A minor sort of fence was the pig fence, usually low and consisting of a series of posts connected with reeds. Again, steps were provided.

The records are equivocal in terms of social differentiation, but it appears that the patterned fences belonged to societally higher-standing people, while the commoner's *'api* was more likely to be fenced in with utility shrubs rather than well-plaited reeds. Only those fences would show up in the archaeological record, for which proper posts had been set. One would expect to be able to pick up straight rows of more or less evenly spaced post holes, were it not for the preferred use of live trees, which makes the archaeological recognition of fences quite problematic, if not impossible.

Characteristics of Post holes and Planting Holes

The firm and cohesive tephra-derived soils of Tongatapu,[11] coupled with the mechanical properties of the Tongan digging stick, permit the excavation of deep post- and planting holes with a comparatively small diameter, where the sides would stand up with no danger of immediate collapse. Today, using steel spade, it is possible to excavate holes of 0.20 m diameter and 1.80 m depth, nearly equal to the entire length of the spade, which consists of a blade, 0.20 m long, welded to a 1.80 m length of pipe. The

[11] A total of six soil series has been distiguished on Tongatapu, three of them derived directly from volcanic ash or 'tephra' (Lapaha, Vaini, Fahefa soils), one of them from redeposited tephra (Fatai soil), two of them marine deposits (Nuku'alofa and Sopu soils). The volcanic soils exist in various phases depending on the degree of erosion and weathering (COWIE 1980; COWIE in press; CROOK 1967; GIBBS 1971; 1972; 1976; LEE & WIDDOWSON 1977; McGAVESTON & WIDDOWSON 1978; ORBELL 1971; 1977a; 1977b; 1983; WIDDOWSON 1977). The tephra layers increase in thickness from the east (~1.5 m) to the west of the island (where they may reach up to 5.5 m), indicating that they were deposited against the prevailing winds from volcanic sources west of Tongatapu. The source or sources have not been identified so far, but may well have been one or more of the occationally erupting submarine volcanoes. The Lapaha and occupy most of central and northeastern Tongatapu, while the Fahefa soils on the western end of Tongatapu are the youngest. None of the tephras has been dated in absolute terms, but guesses have been advanced, suggesting an age of 5,000 to 10,000 BP for the Vaini soil and about 20,000 BP for the Lapaha soil, on the basis of the relative degree of weathering. Once weathered, tephra soils are very fertile, while the soils derived from marine deposits are generally rather poor.

traditional Tongan digging stick was capable of about the same depth-to-width ratios.

Planting holes

The dimensions of planting holes depend on the variety of root and tree crop to be grown in them. Planting and harvesting holes for some root crop, such as sweet potato, would be shallower with a comparatively wide diameter. Holes dug during harvesting sweet potato have been seen to measure up to 0.50 m in depth and 1.00 m in diameter. Harvesting holes dug for the giant taro (*Alocasia macrorrhiza*) measure 0.50 m - 0.60 m in diameter and up to 1.00 m in depth. The planting holes most closely resembling postholes are the yam planting holes. POULSEN mentions that the dimensions of planting holes for early yam would vary from 0.10 m - 0.20 m to 2.00 m and even 2.50 m in depth, with a diameter of 0.40 m to 0.50 m and that the holes for late yam would be between 0.30 m and 1.30 m deep (POULSEN 1987, I, 49) Based on ethnographic observations made during fieldwork, yam planting and harvesting holes can be described as follows (see figure 24). A deep, circular hole is dug, a yam shoot is planted in the hole and the hole is backfilled. When it is time to harvest, two possibilities are open:

- digging round one half of the planting hole is the commonly employed method. In the archaeological record this method results in one hole cutting into the other. Several holes of this kind were encountered. However, where an initial planting hole had a large diameter and the grown yam was not very big, then the hole dug during harvesting could have stayed within the boundaries of the planting hole;
- digging all around the planting hole is the method used for harvesting very large yams, such as those grown for the annual Agricultural Show and the biggest yam competition[12] where the aim is to grow exceedingly large yam tubers, which can reach over 2 m length. This is achieved by digging very deep holes and backfilling them with topsoil, rather than a mixture of topsoil and infertile subsoil. When such a yam is harvested, two people are needed, one of them steadying the yam to prevent it from breaking. In the archaeological record the harvesting method results in wider holes, which may show a step near the bottom.

Two further possibilities have to be mentioned:

- a hole is dug, but no yams planted, and the hole is re-filled. Although this is an unlikely event, it may have occurred. It would result in well-defined holes with circular plan;
- a hole is dug, the yam planted but not harvested and the tuber rots in the hole. This can happen when a yam plant is destroyed during a torrential downpour in the wake of a cyclone. This hole would be indistinguishable from the previous case.

Post holes

Depending on the post to be set, post holes varied in diameter and depth. The resulting post holes overlap in their descriptive characteristics with the characteristics of several planting holes. Thus it is

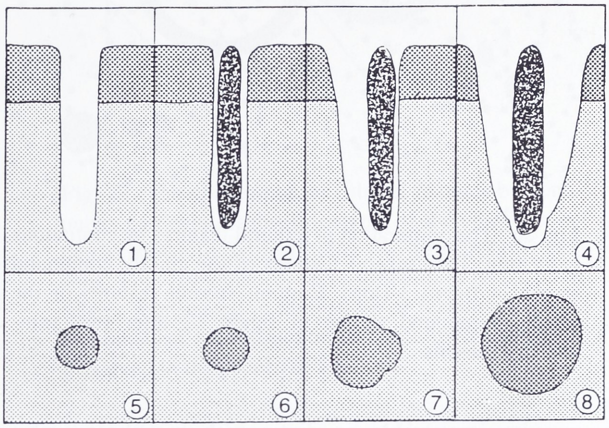

Fig. 24 Yam holes (upper row) and their manifestation in the archaeological record (bottom row). **1** hole dug, but no yams planted. **2** hole dug, yam planted, yam not harvested, rots in the hole. **3** harvesting by digging round one half of the planting hole (common method). **4** harvesting by digging all around the planting hole.

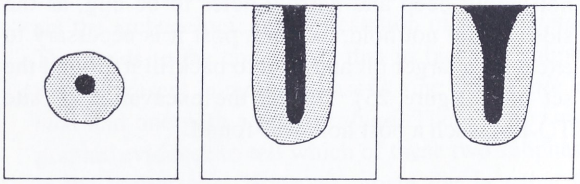

Fig. 25 P ostholes in compacted/cohesive earth: Left: plan; centre: profile, buried part of post was left rotting in the hole; right: profile, post was retrieved. Conventions: white: subsoil; light stippling: post hole; black: discolouration from post.

12 The annual Agricultural Show has to some extent taken over the function of the first-fruits presentation (*'inasi*). In both cases the best products were/are shown (and still sometimes presented) to the King: see also FA'ANUNU 1977. There is evidence of the same intention in early historic times. GEIL (1902, opp. 108) depicts himself and Rev. MOULTOW, the founder of Tupou College, with two very large yams of about 1.6 m (over 5') length. GEIL mentions yams up to 2.1 m (7') in length.

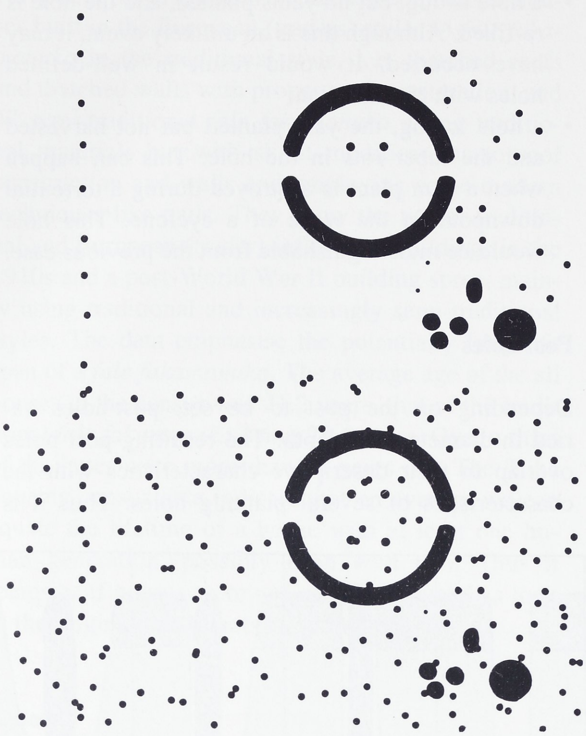

Fig. 26 The obliteration of cultural features by continuous gardening. Top: subsoil features of the chiefly compound shown in figure 3 (top). Bottom: subsoil features of the chiefly compound shown in figure 12 after two yam-planting seasons.

appears impossible to distinguish morphologically between a post hole, forming part of a construction, and a planting hole, dug for the planting of yams. An exception exists with sandy soils, such as are encountered on Pangaimotu. Here, the long and deep-rooting yam varieties do not grow, and other varieties with a more bulbous tuber are used. Sandy soils do not permit deep and narrow holes to be dug, as the sides would not hold. To set a post it is necessary to excavate a larger pit and then to backfill it around the set post (figure 25). During the excavation of site TO-Pi-3 such a post hole was found.

Obliteration of the visible archaeological evidence

Because of the complications in distinguishing post holes from planting holes any planting of yams on an archaeological site is likely to disrupt the archaeological post hole pattern, increasingly complicating the recognition of post holes and thus of buildings. This can be easily illustrated. Figure 3 (top) shows the plan of a chiefly compound as reconstructed from the ethnographic sources. Figure 26 (top) shows the subsoil features of this compound. All holes in the ground are post holes. One complete season of planting yams complicates the recognition of the post hole pattern. The series of post holes belonging to the fence still stands out. A second season of planting yams, however, has swamped the post holes completely (figure 26 bottom). Instead, several linear and rectangular patterns have developed which have nothing in common with the original archaeological post hole pattern or with the actual pattern of planting holes (figure 27). As can be seen, the interpretation of subsoil features looking like post holes can be very misleading.

An attempt to distinguish between post holes and planting holes

In the absence of any straightforward physical distinction between post holes and planting holes, we have to approach the question in a different way. The chance of distinguishing between a post hole and a planting hole is obviously better in the case of house mounds, as we can argue that at least some of the holes must be related to construction. Thus we will start with holes in mounded areas, before we turn to non-mounded areas.

Distinguishing post holes and planting holes in the mounded area

The mounded area of site TO-At-85 with its clearly defined layers allows the sorting of the individual holes into the phases of mound construction. If a hole penetrates a lower layer, it has to be later than the lower layer in question. If it starts from a given layer downwards, it can either be contemporary with that layer or chronologically later, as when the original top has been lost over time due to erosion or anthropogenic modification of the soil. While a separation of holes into chronological phases is possible, there is, of course, no guarantee that a hole encountered in one phase is actually a post hole rather than a planting hole. That is, a mound may have gone out of use for some time and have been used as a gardening site, before again becoming a living site. Change in the usage of mounds is documented in the archaeological record in other parts of Tongatapu (sites TO-Pi-2, TO-Pi-15, TO-Fa-5). Indeed, the neighbouring mound (TO-At- 86) to the one under discussion started off as a house mound, before it was re-used as a burial mound. Between these two phases of use the mound must have become overgrown with vegetation, possibly bush, because a thin layer of burnt soil, evidence of a large-scale fire, was encountered at the margin between the burial mound and the underlying house mound. However, since mounds consist of layers of infertile subsoil, they are usually not used for the planting of yams. Thus the likelihood is much greater that a hole encountered in a mounded area is a post hole than a planting hole.

The holes encountered in mound TO-At-85 were analysed with these considerations in mind. Since the mound was excavated in a succession of levels (henceforth: 'planum'), it was possible to superimpose the plana on top of each other and to follow the development of the pattern of holes. The mound consists of 3 phases, each comprising a construction layer and corresponding house floor. The house floor of the latest phase (III) has eroded.

Mound TO-At-85, measuring about 25 m to 30 m in diameter and 0.6 m in height, is a rather low mound. The slope is so low that the dwelling area is relatively large and permits the construction of buildings near the rim. Obviously this is accentuated in the earlier mound phases, when the mound was even lower.

The features visible in the excavated levels are plotted in figures 5 and 6. If we eliminate all those holes which have been dug from higher levels, we can reconstruct the pattern of holes dug from the mound surface at various phases of mound costruction. Figures 28 and 29 show the individual features assigned to the mound phases. None of these individual phase plans gives any clue as to a general pattern. This may be due to the fact that the area excavated on top of the mound was rather limited in dimensions. As mentioned earlier, it is interesting to note that on the surface of both mound phases I and II fires had been lit in approximately the same locations. According to oral traditions, cooking never took place on top of a mound.[13] Since a *fale hunuki* (cooking hut) can be expected near a fireplace it is possible that two holes spaced between 2 and 3 m apart may constitute the floor plan of a *fale hunuki*.

The plan of the features dug from the surface of mound phase II (figure 30) shows a rectangular array of holes in the top area of the mound. If we tentatively identify this array as belonging to one building, then we would arrive at a *fale fakafefine* (rectangular outhouse) which is about 3 m wide (N-S) and at least 3 m long (E-W) (Figure 30). Given the size of the

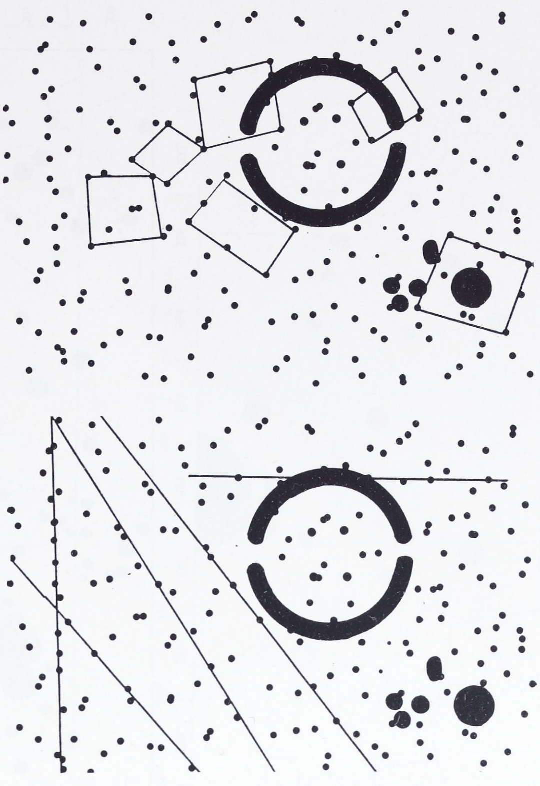

Fig. 27 The obliteration of cultural features by continuous gardening: subsoil features of the chiefly compound shown in figure 12 after two yam-planting seasons. Top: Hypothetical reconstruction of house plans falsely represented in the pattern of features. Bottom: Hypothetical reconstruction of fence rows falsely represented in the pattern of features.

mound, there would be sufficient space to accommodate another house in the unexcavated area. If we exclude the holes belonging to the assumed *fale fakafefine* then a clear pattern emerges of two holes between which a fireplace is situated. In addition, these two holes are marginal to a second fireplace (figure 30). It is reasonable to assume that these two posts are the archaeological manifestation of a *fale hunuki*. This leads to the conclusion that in fact two subphases are present in mound phase II, one with a *fale hunuki* and one with a *fale fakafuna*. There is no stratigraphic evidence to tell which of these two subphases is the earlier one. However, given the fact that the underlying mound phase I had fireplaces in almost the same position as phase II, the early mound phase II is likely to replicate the lay-out of mound phase I.

[13] These fires could either be hearths, lit for warmth or for food preparation, or shallow ovens. No traces of oven stones were found and the fireplacees were commonly recognizable as a thin scatter of blakish soil with a layer of red-burnt soil underneath. In neither case could the function, as a hearth or as an oven, be clarified. I thus use the neutral term 'fireplace'. It is also of interest that these fireplaces are on the southern side of the mound. It should be noted that a southern location is unusual as the prevailing winds would blow the smoke onto the house. A fireplace was also noted on mound TO-At-89 (SPENNEMANN 1989c, 89ff.) and on mound TO-Pi-13 on Pangaimotu (SPENNEMANN 1989c, 391ff.) indicating that fireplaces on mounds are not uncommon. In both cases the fire was placed on the northern side.

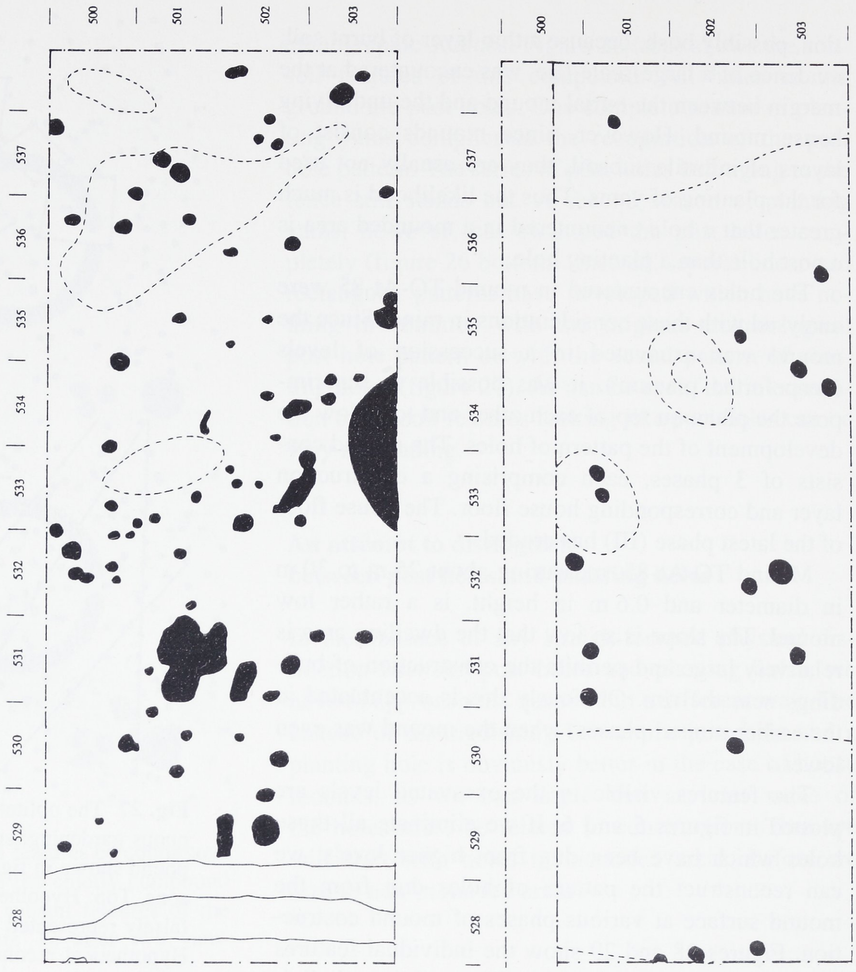

Fig. 28 Site TO-At-85. Holes dug from the original ground surface (left) and from the surface of mound phase I (right).

Thus it would seem that the *fale hunuki* is earlier than the *fale fakafefine*. While an interpretation of mound phase II is possible, mound phase I poses more problems: there is an apparent lack of features in the central area of the mound, while there is a concentration at the lower (southern) end. This could indicate that the main building was situated in the unexcavated area north of the trench, and such an interpretation would be strengthened by the lay-out of phase II mentioned above. If we again assume a *fale hunuki* to be present in the immediate vicinity of the fireplaces, then three potential pairs of holes exist (figure 31), all located at the southern side of the western fireplace. The posts of the three pairs are each spaced about 2 m to 2.5 m apart and suggest a sequence of three *fale hunuki*. A problem is posed by the two holes which have been dug into one of the fireplaces and appear to be features later than phase I. The fact that the location of the *fale hunuki* of mound phase II was shifted compared to those of the *fale hunuki* in mound phase I, although the location of the fireplaces stayed the same, may be due to the increased curvature of the rim of the mound, which makes that area less usable. Mound-phase III (figure 31) provides a number of holes which permit a number of reconstructions, but, as in the case of the holes in the non-mounded area, several of the holes are possibly and, perhaps likely, to be planting holes.

The holes of the pre-mound phase seem to be primarily oriented in a northeast to southwest fashion (figure 30). Obviously this does not account for all holes, but there is much less evidence for the holes being oriented in any other direction. It is quite probable that this row-like pattern is the result of planting procedures.

Given the ambiguity of the hole patterns observed, it should be stressed that the identification of the *fale hunuki* and *fale fakafuna* is only tentative. I believe that unless a mound is excavated in toto, no conclusive discussion about the structures on top of it can be undertaken.

No distinction could be made between the physical appearance of the holes likely to be post holes and those which appear to be planting holes. Thus the holes identified as likely to be post holes, i. e. those holes which could be tentatively assigned to one of the structures, cannot be used in the attempt to

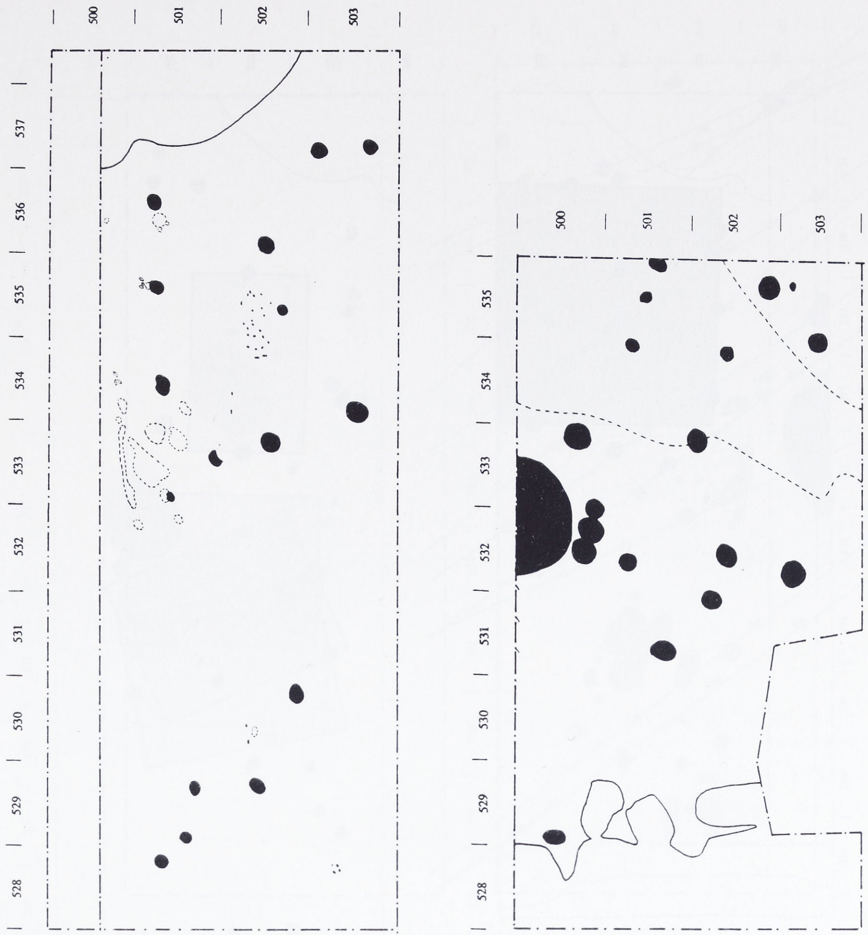

Fig. 29 Site TO-At-85. Holes dug from the surface of mound phase II (left) and from surface of mound phase III (right).

distinguish between post holes and planting holes in the non-mounded area.

Distinguishing post holes and planting holes in the non-mounded area

Site TO-At-85 consists of three phases and site TO-At-86 of one (not counting the burial mound). Thus we can anticipate for site TO-At-85 three sets of outhouses at the foot of the mound and at least one set for site TO-At-86. The main question, which cannot be answered with the limited evidence excavated, is as to where the houses would have been located. We can assume that the cooking area was located on the leeward side of the main house, so as to avoid the latter being engulfed in smoke from the cooking fires. Given the predominance of south-easterly and easterly winds on Tongatapu, we can therefore anticipate that the cooking area was located somewhere to the north and preferably to the northwest of the mound. This theoretical model is supported by the evidence that no earth ovens or storage pits, which can be assumed to be located near the cooking area, were encountered at the southern side of site TO-At-85. However, as noted in the discussion on the mounded area, fireplaces were discovered to the south on the house mound. This observation should serve as an indication that the lay-out of a compound should not be seen as fixed. One oven was encountered in the area north of site TO-At-89 and a series of pits, apparently storage pits, was encountered in trench 14, located north-east of mound TO-At-86. These two observations tend to support the lay-out model. At least a cooking shed, most likely a *fale hunuki*, would have been located near the earth oven and the storage pits. Based on the same assumption as above, we can assume that the boys' house would have been located on the windward side of the cooking area. This would indicate a position somewhere to the southwest, south, southeast or even northeast of the mound.

Some idea as to the orientation of the whole compound, and thus of the potential location of the outhouses, can be gained from the breaks in the ditch. The ditch, which was dug to quarry the fill for mound construction, had a gap in it allowing access to the house. Thus we can assume that the outhouses were located somewhere in the vicinity of the break. This is the more likely as we can assume that in case of a renewal of the main house on top of the mound the family would have temporarily moved into the

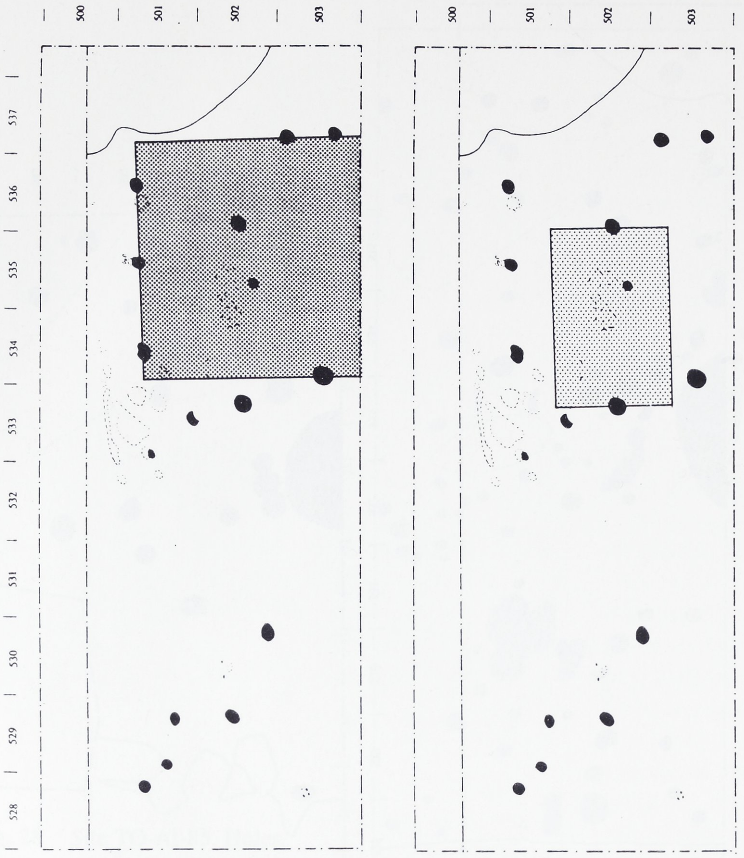

Fig. 30 Site TO-At-85. Plan of mound phase II: tentative identification of a *fale fakafuna* (left) and a *fale hunuki* (right).

outhouses. No gap in the ditch was encountered at the south of TO-At-85, but the excavated area may well have been too small. A gap in the ditch was encountered at the southwest of site TO-At-86. It is possible that another gap in the ditch may have existed somewhere on the opposite side where the storage pits were found. Based on this, we can also assume that the first phase of site TO-At-86 is older than site TO-At-85, as it would have made more sense to have a ditch opening leading to the other mound, rather than away from it. Alternatively, it is possible that a fence existed between these two sites and that they actually belong to two different compounds.

While this reasoning can provide some guide where the houses may have been located, the analysis of the characteristics of the holes encountered has not allowed us to make any decisions. Now let us turn to a location, where we can rule out the presence of extenisive yams plating due to the soil characteristics. This should provide us with pointers where to look.

Pangaimotu - A case study on sandy ground

Pangaimotu is the largest of the small sand cays off Tongatapu and, lying about 4.5 km northeast, also the closest to Nuku'alofa. It sits on the north to northeast trending fringing reef. The island is roughly triangular in shape and measures approximately 680 m north-south and up to 500 m east-west, with an total area of approximately 22.3 ha. The island is generally flat with a slightly higher rounded area in the north and a lower southern end which tapers out. The average height of the northwestern part of the island is 1.3 m above HWL, the maximum height, on top of one of the prehistoric mounds, being 4.96 m above HWL.

The earliest known date for Pangaimotu is 1,900 ± 160 BP* (ANU-6427) (calibrated age: 1 s: 100 B.C. [AD 87] AD 321), which dates a fireplace underneath the mound TO-Pi-6. The next oldest date is 1,800 ± 70 BP* (ANU-5726) (calibrated age: 1 s: AD 123 [237] 328). This date is on shells (*Anadara antiquata*) collected from layer 3 [old layer 10]) of site TO-Pi-7. The sample dates Phase B of the site, which is the first phase of mound construction. Human activity had taken place at the site before that.

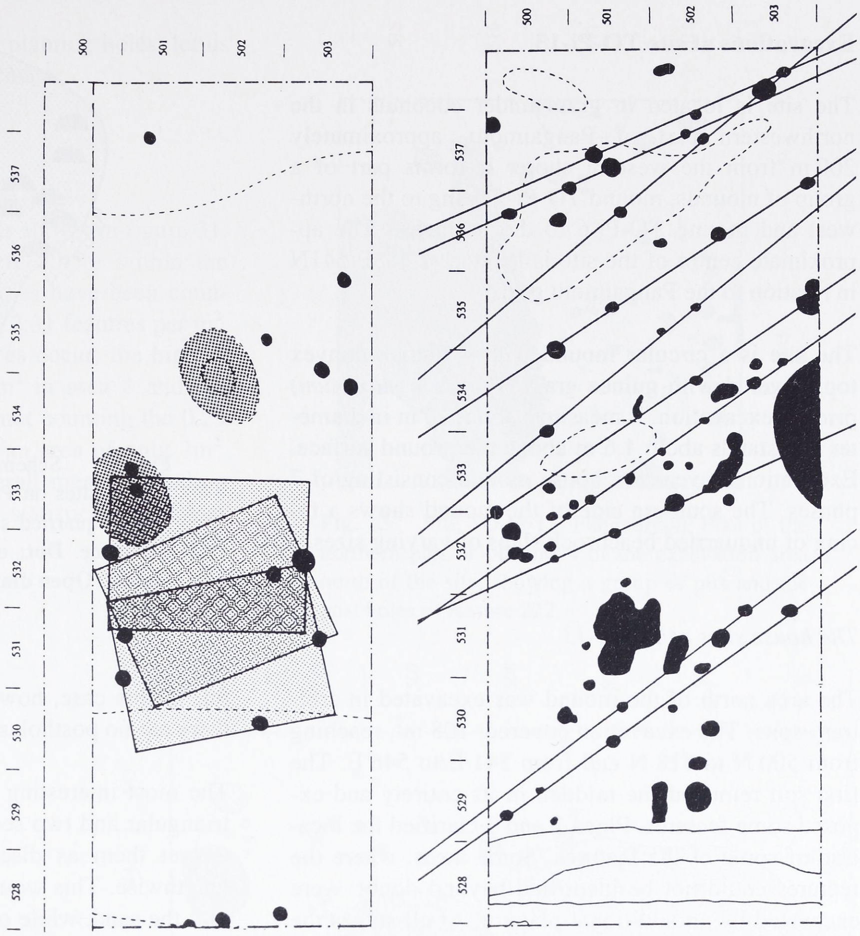

Fig. 31 Site TO-At-85. Plan of mound phase I: tentative identification of three *fale hunuki* (left). Pre-mound phase: alignment of holes.

Based on data on relative sea-level changes from Tongatapu, we can assume that the island as such would have not existed much earlier than 200 B.C. except as a sandbank.

Excavations on Pangaimotu

The first archaeological work on Pangaimotu was undertaken by William C. McKERN in 1920/21. He noted the quarry on the west side of the island (McKERN 1929: 5) and excavated a 'kitchen midden' (Site TO-Pi-1; ibid. 102-103) and a burial mound subsequently used as habitation site with earth ovens (TO-Pi-2; ibid. 104-106). The skeletal remains from this mound were analysed by the present author and showed severe cut marks probably resulting from a metal knife or bayonet (1991a). During the 1985/86 fieldseason Pangaimotu was surveyed thoroughly. Due to the dense cover of bush and thicket in the northeast some sites may have been overlooked. A group of eight mounds, the only mounds on the island, was seen at the western tip of the island, directly above the outcrop of beachrock.

At the western shore of the island there is an extensive outcrop of beachrock, running roughly north south. This outcrop has been extensively quarried, especially at its southern end, where it is at its widest. While the southern end shows large-scale quarrying with slabs quarried from a second and lower level of beachrock, the northern end is predominantly an area where though quarrying had been carried out, only few slabs had been completed and removed. Near the area of beachrock quarrying, there is a group of mounds. Most of them are aligned in a row running perpendicular to the shoreline. Two mounds are off this line (see figure 32). At the time of the survey most of the sites were covered with a dense cover of guinea grass. Of the sites, TO-Pi-13 has a facing of unquarried beackrock slabs on its southern side.

Site TO-Pi-5 was tested by a 2 m by 1 m area, all other sites by a 1 m x 1 m square (TO-Pi-3, -4, -6, -13, 14, -15). Site TO-Pi-13 was then chosen for excavation on a larger scale, mainly because of the discovery in the test pit of a hardened sand layer thought to be a buried house floor.

Excavations at site TO-Pi-13

The site is located in grass under coconuts in the northwestern part of Pangaimotu, approximately 200 m from the western shore. It forms part of a group of mounds, mound TO-Pi-5 being to the northwest and mound TO-Pi-6 to the northeast. The approximate centre of the site is located at 483E/541N in relation to the Pangaimotu grid.

The site is a circular mound with a flattish convex top, covered with guinea grass (*Panicum maximum*) prior to excavation. It measures about 20 m in diameter and stands about 1.6 m above the ground surface. Excavations revealed a house mound consisting of 7 phases. The southern side of the mound shows a facing of unquarried beachrock slabs of varying sizes.

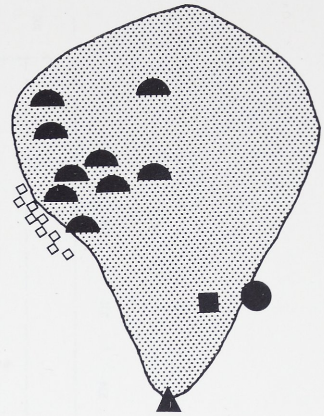

Fig. 32 Schematic distribution of archaeological sites on Pangaimotu. **Triangle:** stockpile of quarried slabs. **Square:** slab-lined burial place. **Dot:** eroded midden. **Semicircles:** mound. **Open diamonds:** quarry area.

The house sites at TO-Pi-13

The area north of the mound was excavated in arbitrary spits. The excavation covered 108 m^2, reaching from 500 N to 518 N and from 541 E to 546 E. The first spit removed the midden in its entirety and exposed some features. Plana 2 and 3 clarified the location of some of the features. Some areas, where the features could not be identified beyond doubt, were excavated by an additional planum. At all stages the plana were drawn to scale.

The area north of site TO-Pi-13 shows two concentrations of holes of small diameter, which are either post holes or yam-planting holes (features 222 and 224). Whereas such holes cannot be distinguished from each other beyond doubt in the tephra-derived soils of Tongatapu, the holes on Pangaimotu are very likely to be post holes, because the yam variety requiring deep planting does not grow in sandy soils.

The post holes of feature 222 form two clusters and seem to represent an oval type of building, with evidence for several renewals of wall posts but none for a central post (figure 33). These post holes could well repesent *fale faiokau*. Feature 224 is a conglomeration of post holes at the southern end of the excavation area (figure 34). These postholes can be sorted in a variety of patterns to suggest rectangular or oval-shaped houses or huts (figure 35). It should be kept in mind, however, that the area is only 4 m wide and that parts of any structure(s) is (are) certain to be located in unexcavated ground. There is a large brown discolouration directly north of a row of posts (figure 34). It is possible that this the row does not represent a house construction, but the shoring for a pit. In this case, however, it needs to be asked why there are no postholes on the southern side of the pit.

The most interesting aspects of feature 224 are five triangular and two semicircular discolourations. I interpret them as discolourations from timbers split lengthwise. This would imply that posts were driven into the sand, while others were apparently sunk in a prepared post hole. As a consequence of this, we might argue that the triangular and semicircular holes are not part of any structure, but either independent features or later additions, perhaps by way of repair. Given the location of feature 224 directly west and slightly northwest of TO-Pi-6, I would assume that it belongs to that site, rather than to TO-Pi-13. Since the postholes of feature 224 were present in planum 4, but did not show up in plana 2 or 3, we have to conclude that they are earlier than the structures in the latter plana, which in turn are overlain by the thick midden layer. Shells collected in an appropriate square (543E/517N) have been ^{14}C-dated to 1,440 ± 70 BP* (= 1,330 cal BP). An oven underlying the neighbouring site TO-Pi-6 provided a date of 1,860 cal BP. If we assume that the structures contained in the post hole conglomeration of feature 224 belong to site TO-Pi-6, we can conclude that they date between 1330 and 1860 cal BP (AD 90 AD 620).

Towards a Recognition of planting features

Having seen from historical data that houses existed at the bottom of mounds, and that they can be found by archaeological means if they have not been obscured by subsequent (of prior) planting holes, let us now attempt to use different avenues.

Density of subsoil features

The density of subsoil features is shown in figure 31. Excluded are all features underneath or within the mounds. Clearly overlapping holes have been counted as two. On average there are 2.31 features per m². As can be seen, some differences occur, the highest concentration being 3.4 holes/m² in area 8 and the lowest 1.56 holes/m² in area 7, not counting the 0.29 holes/m² in area 11, which has an area of only 7m². The difference between the overall mean, excluding area 11, and all other areas is statistically not significant.

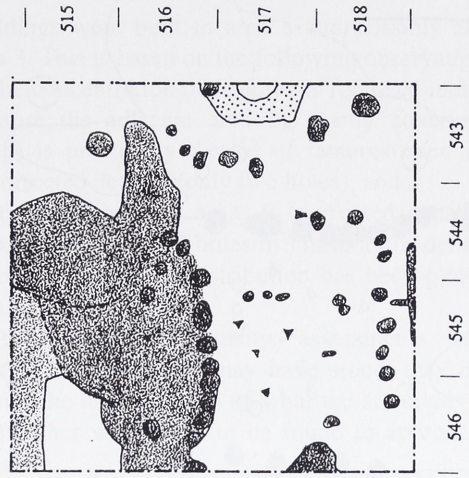

Fig. 33 Site TO-Pi-13, Pangaimotu. Plan of the northern part of planum 4 of the excavation area north of the site, showing a group of pits and the post holes of feature 222.

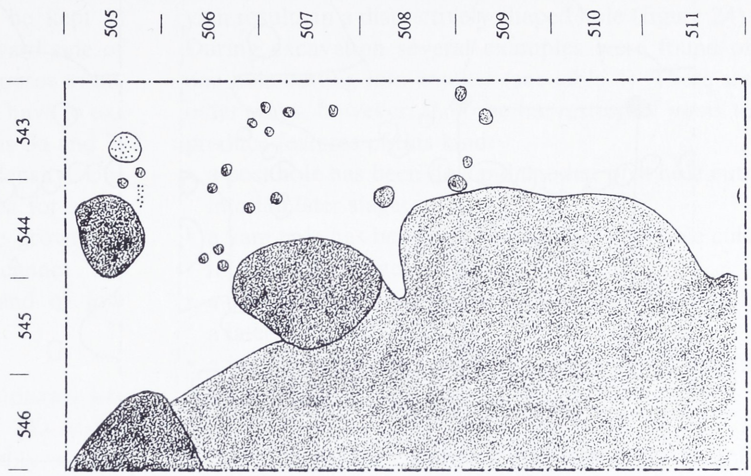

Fig. 34 Site TO-Pi-13, Pangaimotu. Plan of the southern part of planum 4 of the excavation area north of the site, showing a group of pits and the post holes of feature 224.

Were the area homogeneously gardened, we could expect an even density of holes per m². Before arguing for either a highly variable planting density or for the presence of post holes in the areas of higher density, we will have to compare these figures with those from other areas/sites on Tongatapu.

- The only non-mounded area in the immediate vicinity, i. e. area 5, north of site TO-At-89, shows a slightly lower density of 2.01 holes/m² (SPENNEMANN 1989, 113).
- The area underneath the buried topsoil at site TO-At-85 revealed 69 holes predating the first phase of the house mound. The density is 1.78 holes/m².
- The area underneath the buried topsoil of site TO-At-86 has a density of 1.85 holes/m² (SPENNEMANN 1989d, 130).
- The 25 m² area excavated at the late Lapita site TO-At-96 has a density of 4.12 holes/m² (SPENNEMANN 1989d, 159).
- The top planum of mound TO-At-89 revealed a density of 2.26 holes/m². The density of holes, however, increases towards the foot of the mound. In the area of the unexcavated ditch we encounter a density of 2.24 holes/m², while at the top of the mound there is a density of only 0.64 holes/m². This difference is due to the relative infertility of the mounds with their high content of subsoil from the agricultural point of view (SPENNEMANN 1989, 113).
- The 114 m² area north of site TO-Pi-13 on Pangaimotu has a density of 0.82 holes/m². Because of the sandy soil and its inappropriateness for planting deep-rooting yams, the deep holes can be assumed to be post holes (SPENNEMANN 1989, 391).

Comparing the mean density of holes at area TO-At-85 with the density of post holes at site TO-Pi-13

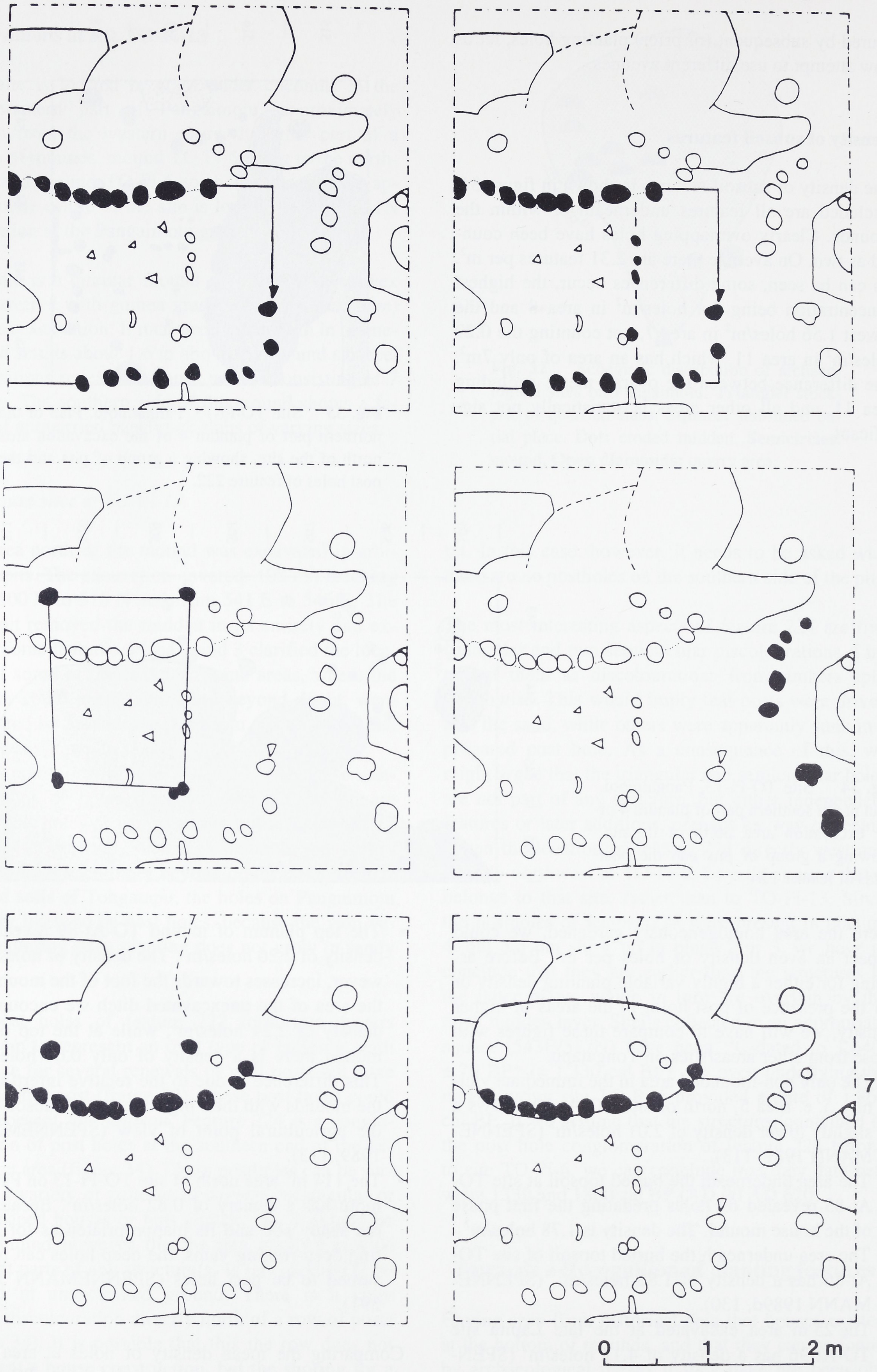

Fig. 35 Site TO-Pi-13, Pangaimotu, feature 224. Various reconstructions of possible posthole patterns.

on Pangaimotu, it becomes obvious that the density of holes in the areas where no yam-planting took place is significantly less (df = 1 c2 = 3.01; P = 0.075). The lowest density of holes at site TO-At-85 is still almost twice as high as that of an area where no gardening has taken place, although the difference is no longer statistically significant (df = 1 c2 = 0.548 P = 0.55).

The observed difference in the density of holes can be explained in two ways:

a) if we assume that the entire area has been gardened with the same intensity throughout, then the excavated areas which have a higher density are more likely to contain post holes;

b) the density of the gardening has not been the same through out the entire area under discussion.

If possibility a) were true, then we would conclude that areas 3a and 7, showing a low density, had not been built on, while area 8 with a particularly high concentration of holes (3.4 holes/m^2) would have seen several building phases. It should be kept in mind that area 8 is located on the windward side of TO-At-85, where one would expect the houses to be. If possibility b) were true, then we would have to explain the low density encountered in areas 3a and 7, which are surrounded by areas of high density. Unless a large tree was growing in this area for some time — which would have prevented the growth of yams underneath its branches — I cannot see any reasonable explanation for this island of low density of holes.

The matter is further complicated by the situation underneath the mounds of TO-At-85 and TO-At-86. Here the densities of holes are remarkably similar (1.78 and 1.85 holes/m^2). Some of the holes may well be postholes from structures erected on level ground. The majority of the holes is most likely due to planting. If we assume that the density of the holes encountered underneath the mounds to be the overall density of the pre-mound-building phase (i. e. 1.85 holes/m^2), then we can deduct this density from that of the other areas to arrive at the density of the holes dug during and after the mound occupation phases. This 'corrected' density distribution is shown in table 3.

Area 7, which has a lower density than the subsoil underlying sites TO-At-85 and TO-At-86, has been set to 0. This correction in density clearly emphasises the concentration of holes in area 8 and the appreciable density in area 3. We can assume that several buildings were built in area 8 and possibly also in area 3. This is based on the following observations:

a) the concentration of features is focussed in area 8, because the adjacent area 11 (partly covering the ditch) is practically devoid of features even in the uncorrected density (only two holes), and

b) the neighbouring areas 9 (corrected density 0.5 holes/m^2) and 2 (0.35 holes/m^2) have a low density of holes. The resulting distribution has been plotted in figure 36.

Although these density assessments suggest areas where buildings may have stood, they do not permit the identification of what the structures were. Thus other ways have to be found to approach this question.

Assessment of inter-cutting features

As previously discussed, the harvesting of a large yam results in a distinctively shaped hole (figure 24). During excavation several examples were found of one hole cutting into another (see table 4). There are other ways, however, than the harvesting of yams to produce features of this kind:

- a post hole has been dug and another post hole cuts into it a later stage;
- a yam hole has been dug and another yam hole cuts into it a later stage;
- a post hole has been dug and a yam hole cuts into it a later stage; or
- a yam hole has been dug and a post hole cuts into it a later stage.

Given Tongan yam planting and harvesting techniques, we can perhaps expect yam harvesting to be the most frequent cause of intercutting holes. However, since there are other possibilities no set of intercutting holes can be assigned with confidence as due to yam planting and harvesting.

However, we can undertake some statistical assessment of the situation. This is based on a series of assumptions. Since today yam is usually planted at a 1.8 m to 2 m spacing in a roughly rectangular grid (FA'ANUNU 1977), we have a density of 0.25 yam per m^2 per planting season.[14] This planting pattern is also said to be traditional. Based on the overall density of subsoil features in the assessed areas (1.5 to 3.4 holes per m^2; table 2), we can assume that the holes shown in figure 1 represent between 6 and 14 planting seasons.

[14] Since the size of the area on which yam is planted varies from family to family, while the planting areas of successive years may not overlap, I talk of planting season. I am well aware of the fact that overlapping planting areas can, over time, cause different concentrations per area.

Area	m^2	Features	Features/m^2
1 *)	28	61	2.18
2	20	45	2.25
3	40	109	2.73
3a	15	28	1.87
7	25	39	1.56
8	25	85	3.40
9	25	59	2.36
11	7	2	0.29
Total	185	428	2.31

Notes: *) non-mounded area only.

Table 2 Density of subsoil features per area at sites TO-At-85 and TO-At- 86.

Area	Density features/m^2	Corrected density features/m^2
1 *)	2.18	0.33
2	2.25	0.40
3	2.73	0.88
3a	1.87	0.02
7	1.56	0.00
8	3.40	1.55
9	2.36	0.51
11	0.29	0.00
Total	2.31	0.46

Notes: *) non-mounded area only.

Table 3 Density and corrected densityof subsoil features per area at sites TO-At-85 and TO-At- 86.

Area	Total Features	Intercutting features (n)	%	n/4m^2
1 *)	61	7	11.47	1.00
2	45	12	26.67	2.40
3	109	11	10.09	1.10
3a	28	1	3.57	0.26
7	39	0	0.00	0.00
8	85	23	27.06	3.68
9	59	5	8.47	0.80
11	2	0	0.00	0.00
Total	428	59	13.87	1.33

Notes: *) non-mounded area only.

Table 4 Density of intercutting holes per area at site TO-At-85.

Planting Season	Number of holes	Density per m^2
1	6.25	0.25
2	12.50	0.50
3	18.75	0.75
4	25.00	1.00
5	31.25	1.25
6	37.50	1.50
7	43.75	1.75
8	50.00	2.00
9	56.25	2.25
10	62.50	2.50
11	68.75	2.75
12	75.00	3.00
13	81.25	3.25
14	87.50	3.50
15	93.75	3.75

Table 5 Expected number of planting holes in a 25 m^2 area after n planting seasons and expected density of holes per m^2.

Area	Density of Features /m^2	Planting seasons	Intercutting features n/4m^2	Probability
1 *)	2.18	9	1.00	1.00
2	2.25	9	2.40	0.57
3	2.73	11	1.10	0.97
3a	1.87	8	0.26	1.00
7	1.56	6	0.00	1.00
8	3.40	14	3.68	0.95
9	2.36	10	0.80	0.97
11	0.29	2	0.00	1.00

Notes: *) non-mounded area only.

Table 6 Probability that the subsoil features per area at site TO-At-85 and TO-At-86 overlap by chance.

Number of overlaps	Planting seasons 0	1	2	3	4	5	6	7	8	9	10
6	26	35	29	9	1	0	0	0	0	0	0
9	6	17	20	33	15	8	1	0	0	0	0
12	1	2	6	16	24	32	13	5	0	0	0
15	0	0	1	4	8	14	23	18	22	9	1

Table 7 Observed number of intercutting holes after 6, 9, 12 and 15 planting seasons, based on 100 simulations each (see text).

Number of overlaps	Planting seasons 1	2	3	4	5	6	7	8	9	10
6	1.0	0.39	0.10	0.01	0.0	0.0	0.0	0.0	0.0	0.0
9	1.0	0.77	0.57	0.24	0.09	0.01	0.0	0.0	0.0	0.0
12	1.0	0.97	0.81	0.75	0.51	0.18	0.05	0.0	0.0	0.0
15	1.0	1.0	0.99	0.95	0.87	0.73	0.50	0.32	0.10	0.01

Table 8 Probability of obtaining n overlaps or more after 6, 9, 12 and 15 planting seasons, based on 100 simulations each (see text).

By running a series of simulations, we can calculate the likelihood of a yam planting hole of 0.3 m diameter (the average diameter of the holes recorded) of the second planting season hitting a hole of the previous season.[15] We can also calculate this likelihood for the third, fourth, fifth and following seasons. Obviously, the more planting seasons are represented, the greater is the chance that a hole will impinge on a previous one. Given the average density of yam holes per season (0.25 per m^2), we can calculate the resulting density of holes for a number of planting seasons (cf. table 5). It follows from a comparison of these figures with the actual density of planting holes in table 2 that we can limit the simulations to 14 seasons. Since it is assumed that yam planting holes are dispersed in a regular pattern with a spacing of 2 m x 2 m, we can limit the simulation area to the 2 m x 2 m area and extrapolate from there. This follows from the fact the planting holes of a particular season will be spaced in relation to the first hole dug.

The frequency of observed overlaps is given in table 5. This exercise was repeated for 6, 9 and 15 planting seasons, providing simulated frequencies which nicely bracket the number of planting seasons (cf. table 7).

Based on these observed frequencies, we can calculate the probability of obtaining n overlapping planting holes or more for n planting seasons (cf. table 8). The null hypothesis to be tested is that the frequency of the observed intercutting planting holes is not due to chance but due to a purposeful excavation technique during harvesting. As can be seen from table 7, this hypothesis is rejected in all areas, except area 2, at the 5 % level. Only in area 2 has the null hypothesis not been rejected at statistically significant level.

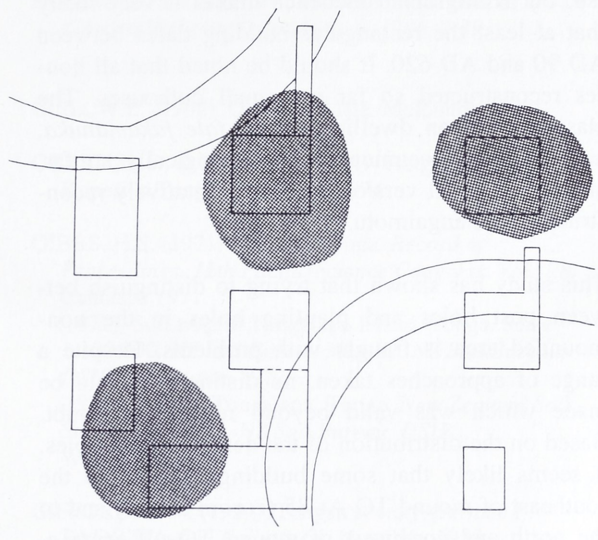

Fig. 36 Site TO-At-85 and -86. Possible location of houses based on corrected density of subsoil features per m^2.

[15] The initial simulation was run for 12 planting seasons and thus with 12 holes within the 2 m by 2 m square. 100 data sets of 12 x 12 values were generated, using uniform random numbers between 0 and 2, (using the Statistical Package for Social Sciences, SPSS[X], version 1.0). Each set was plotted in a bivariate plot. The number of intercutting holes was established by overlaying the plotted data-points with circles measuring (to scale) 0.30 m in diameter.

Therefore there is no justification for identifying the overlapping holes as planting holes and thus for excluding them from the pattern.

Conclusions

As is abundantly clear from the above discussion archaeological evidence for house structures is extremely limited on Tongatapu. Some tentative identifications have been made at site TO-At-85 of cooking huts, *fale hunuki*, as well as of a small rectangular house, *fale fakafefine*. The only indisputable evidence for houses was encountered on Pangaimotu, where it seems likely that an oval-shaped building without central posts, as well as a rectangular building (*fale fakafefine* or *fale fakafuna*), can be documented. The post hole pattern in the area of the rectangular building (figure 35) permits various reconstructions, among them a oval-shaped building with central posts. All buildings on Pangaimotu are undated, but stratigraphic evidence makes it very likely that at least the rectangular building dates between AD 90 and AD 620. It should be noted that all houses reconstructed so far are small outhouses. The classical Tongan dwelling house, *fale fakamanuka*, has not been documented archaeologically so far, although a small version has been tentatively reconstructed for Pangaimotu.

This study has shown that trying to distinguish between post holes and planting holes in the non-mounded area is fraught with problems. Despite a range of approaches taken, no distinction could be made which was valid beyond reasonable doubt. Based on the distribution of the density of the holes, it seems likely that some buildings existed to the southeast of mound TO-At-85 (i. e. in area 8) and to the north and northwest of mound TO-AT-86 (i. e. areas 2, 3 and 9). However, there is no conclusive way to identify the post holes of the presumed structures.

In summing up, the excavations at TO-At-85, albeit unintentionally, have helped us understand matters we did not intend to find out: that the average Tongan yams planting hole is 53 cm deep, has a diameter of 30.5 cm, possesses a bowl- or basin-shaped bottom, has no slant, and is filled with soils of rather varied compactness.

And the post holes ? They are still out there, waiting to be identified.

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