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Excavations at Otakanini Pa, South Kaipara Harbour

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Abstract

IN 1968, excavations were carried out along one of the main defensive lines of the earthwork *pa* at Otakanini in the South Kaipara Harbour. Otakanini was a major stronghold of the Ngati Whatua tribe in the eighteenth and nineteenth centuries, before which it belonged to either the Wai-o-hua or Kawerau tribe, with a period of Ngati Awa domination in the seventeenth century. The excavations revealed three periods of earthwork construction which may correlate with the traditional history of the site, together with well-preserved evidence for palisades, fighting stages, storage pits, and a possible shelter. Midden dumps, associated with a latrine, were also excavated. The Otakanini sequence shows interesting parallels with excavated sequences from other North Island *pa*, and these parallels are discussed. A number of artefacts were discovered, of Classic Maori type where diagnostic.

INTRODUCTION

IN prehistoric times the thousand-mile coastline of the Kaipara Harbour supported one of the densest populations in New Zealand, as will be evident from 130 *pa* whose positions are shown in Fig. 1. At the south end of the harbour, near the town of Parakai, the *pa* of Otakanini is situated on top of a small island separated from the mainland to the west by some 300 metres of mud-flats (now drained for pasture), and flanked to the south-east by a tidal creek. The defences of the *pa* surround the summit of the island and enclose an area roughly 250 metres long by 125 metres in greatest width.

Excavations on the *pa* were undertaken primarily to give information on defensive structures such as palisades and fighting stages, but both living and midden areas were also investigated. The main defended area of the site has been called area A (Fig. 2); this has strong ditch and bank defences on the north and south sides, and along the west side there is an unditched scarp some 3 metres high. The eastern sides drop sharply to the creek, and the south-eastern slope has been modified by the construction of a number of discontinuous terraces. Area B lies to the south of area A, and has a ditch and bank defence along its southern side, with an unditched scarp along the west side. The eastern side drops gently through three large terraces to the creek, and on the northern side area B abuts on to the southern defence of area A.

Altogether, over 300 square metres were excavated to bedrock, to a depth of up to 2.5 metres in the south-west corner of the area A defences. The bedrock is an orange to yellow stabilised dune sand, firm but easily excavated, of Holocene estuarine origin. This sand provided an ideal medium for the cutting of storage pits and defences.

EXCAVATION LAY-OUT

The line of trenches across the south end of area A, and extending outside area A to the west, was numbered G100–122 (Fig. 2). G100–110 lie along the top of the defensive ditch of area A, and were originally laid out as 3 by $1\frac{1}{2}$ metres, but extended as needed during the excavation. The three periods of defence construction around which this report centres were defined mainly on evidence from these trenches.

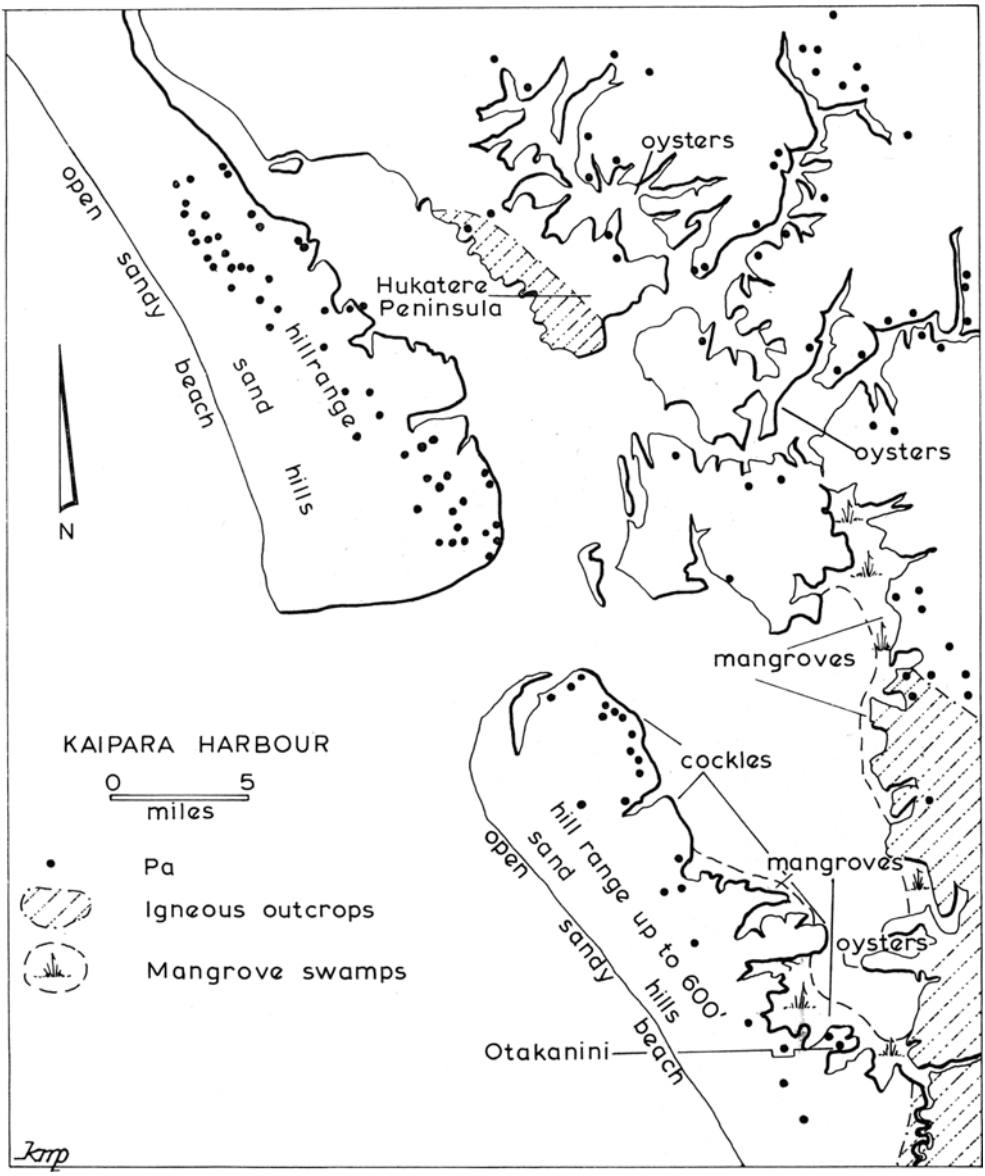

FIG. 1.—The Kaipara Harbour, showing the distribution of *pa* and of certain resources.

Trenches G111–122, running outside the *pa* to the west, revealed defensive ditches, with terrace and midden deposits outside the defences. Man-made deposits continued to G117, but G118–120 were sterile. G111–122 were laid out to 3 by 2 metres, and G121 was extended to 3 by 4 metres.

The trenches in area B revealed a series of structures sealed only by topsoil, so that these were impossible to relate to the three-period sequence for the defences. In fact, the excavations yielded three distinct units of data which, for stratigraphic reasons, were rather difficult to tie together. These units are from trenches G100–111, trenches G112–122, and the area B trenches. However, it proved possible to link the G100–111 and G112–122 sequences with a high degree of certainty, to give an overall three-period sequence of defensive periods.

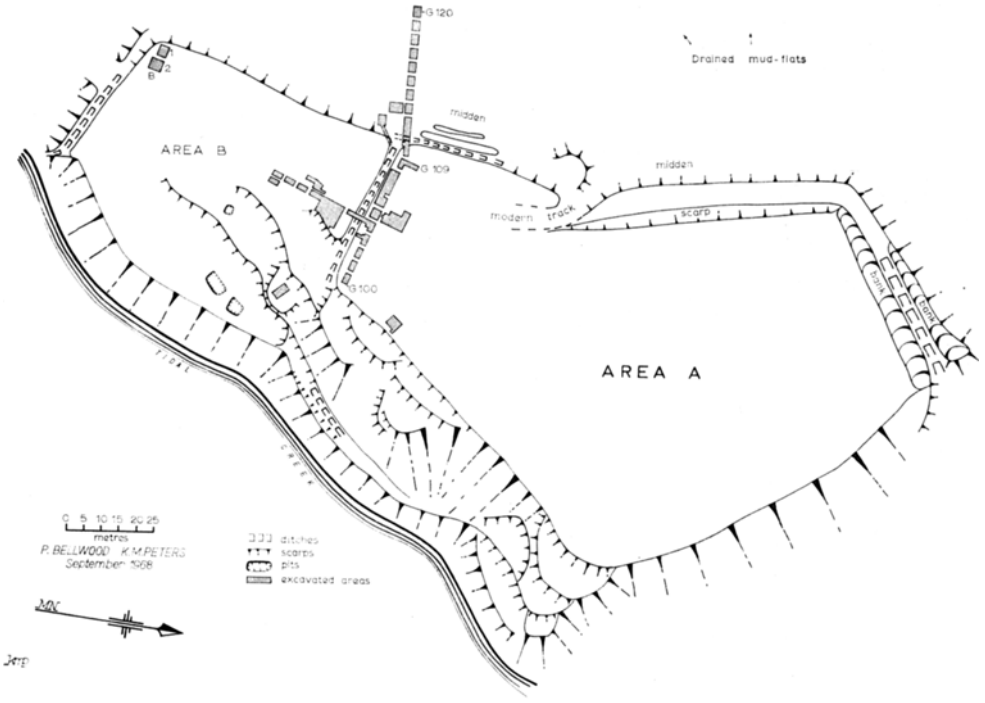

FIG. 2.—Otakanini *pa,* and the 1968 excavation trenches.

THE EXCAVATIONS

In the following detailed description of the excavations, the stratigraphic sequences of trench group G100–111 and group G112–122 will be considered, first separately and then in combination, after which structural details will be presented. The area B excavations will be considered last, since these are stratigraphically unplaced in relation to the rest of the site.

Description of Archaeological Layers—Trenches G100–122

The layers will be described first, with reference to Figs 3–7. They are not numbered in strict stratigraphical order since this cannot be determined with exactitude for all 46 layers. The term "earth" is used to denote friable crumbly deposits, as opposed to denser deposits denoted as "soil". There is no sharp differentiation between the two types of deposit.

Concerning the refuse deposits, J. M. Davidson (1964, p. 87) distinguishes three types for New Zealand—concentrated deposits (middens), non-concentrated deposits, and sparse deposits. Otakanini shell-midden layers are mainly of the concentrated type, consisting of loose shell, with little or no soil matrix.

Modern

1. Topsoil.
2. Modern disturbances and pits.

G100–112: Period III to modern

3. Concentrated midden and charcoal—this is the upper fill of the period I pit in G108, and is stratigraphically later than period III layer 7 (Fig. 5c).
4. Dark earth—backfill of two pits caused by digging out of period III posts K and N in G107–8 (Fig. 6).
5. Dark earth and scattered shell—final layer sealing the G112 ditches (Fig. 7).
6. Sand and dark earth—final layer sealing ditch in I104 (Fig. 5a).

7. Pale yellow sand containing lumps of coarse white consolidated sand, derived from the period III ditch that runs through I104. This is the period III bank, and backfills the period II ditch (B) in G112, and the period II post-holes in G100–111.
8. Loose humic soil filling the period III post-holes, derived from the rotting of these posts *in situ*, and the trickling of silt into the cavities left
9. Dark earth and shell—seals period III ditch in I104 (Fig. 5a).
10. Concentrated shell midden—period III ditch in I104.
11. Grey silt with charcoal—I104 ditch.
12. Clean grey-brown silt—I104 ditch.
13. Clean grey silt—I104 ditch base.

G100–112: Period II

14. Black soil and shell—caps period II bank in G107 (Fig. 6).
15. Brown soil and shell—lens immediately beneath 14.
16. Light-grey silt filling bowl-shaped feature in G107. Cuts 15, but is sealed by 14. Function unknown.
17. Black soil, charcoal and shell—part of upper fill of period I pit at G108. Stratified between bank layers 7 and 19.
18. Concentrated shell midden—caps period II bank in G110 (Fig. 6).
19. Orange sand—top horizon of period II bank.
20. Concentrated shell midden and charcoal—stratified within period II bank.
21. Yellow sand—middle horizon of period II bank.
22. Brown-orange sand—bottom horizon of period II bank.
23. Yellow clay beneath 22 in H104—possibly foundation of period II bank, derived from piled turves (Fig. 5a).
24. Concentrated shell midden—fill of pit in G109–110. Stratigraphically placed at end of period II (Fig. 6).
25. Dark earth, charcoal and orange sand—stratigraphically as 24.

G112–122: Period III to modern (Fig. 7).

26. Concentrated shell midden, with increasing volume of dark soil matrix towards base. Seals G112 ditches, G113–4 terraces, and G121 latrine.
27. Brown sandy soil lens—G112.
28. Dark earth with sand and shell—G112.
29. Dark earth and sand filling ditch A in G112—this is interpreted as a period II layer.
30. Red-brown clay lens—seals 26 in G113.
31. Concentrated shell midden—G113.
32. Orange and white sand lens in G113, possibly stained from contact with a hearth.
33. Concentrated shell midden—G113–4.

G112–122: Period II

34. Dark earth—incipient topsoil formed on terrace 35.
34a. Concentrated shell midden overlapping the end of terrace layer 35 in G114.
35. Terrace of orange sand—G113–114.

G100–122: Period I

36. Thin band of charcoal and shell between layers 35 and 37 in G114. Also separates midden layers 34a and 39 (Fig. 7).
37. Terrace of orange sand—G113–114.
38. Drain, with fill of mussel shells, in G114. Contemporary with 37.
39. Concentrated shell midden down slope beyond 38, G114–117.
40. Grey silty soil in G110. Grades into 41 (Fig. 6).
41. Grey silty soil with admixture of orange sand.
42. Band of dark soil in G111.
43. Concentrated shell midden in G106, 107, 109 and 111. Sealed by 42 in G111.
44. Orange sand—redeposited natural filling small pit in G110 (Fig. 6).
45. Old topsoil and turf.
46. Natural sand—yellow to white in area of excavations, grading to orange, as revealed in exposures towards the north end of the site.

Trenches G100–111—Stratigraphic Sequence (Figs 3, 4, 5, 6)

The lowest layer in these trenches above the natural is the buried topsoil (layer 45). This runs from G100 through to G108, but appears to have been scraped off in G109. This layer is not shown in the G108 section (Fig. 6) owing to its removal by the cutting of a storage pit across the line of the section. It can, however, be seen in the north–south section of G108 (Fig. 5c). Above this, in

G106, G107, and G111, lies a deposit of concentrated shell midden (layer 43), which represents the first activity in this area. This deposit is cut by ditch A in G112 (Fig. 7).

In G110, some half-way down the natural slope which extended from G109 to G112 before the bank and ditch defences were built, part of a small depression was excavated, which had been backfilled with natural sand layer 44 (Fig. 6, Fig. 9, feature d). The purpose of this remains unknown, but stratigraphically it may be related to the midden layer (43), since both the depression and the midden are cut by the backfill layer (41). Layer 41 is the backfill for a deep hole, here interpreted as a post-hole, but not fully excavated, and a shallow cutting uphill of this hole (Fig. 9, feature e). The north–south step in the section G110–111 reveals that the midden layer 43 is cut by this layer, and hence is earlier. This deep hole is of some importance, since the fill layer 41 consists of soil mixed with natural sand, and was probably derived from the stripping of the topsoil and underlying material in G109. There is no sign of a post socket, and the most likely conclusion is that the post was dug out, with the aid of a shallow trench dug from uphill, after which the whole area was backfilled and levelled, and sealed by the period II bank layer 22 (see below). The author interprets this post-hole as evidence for the earliest defence on the site, preceding the building of the first bank in period II. The implications of this single structure will be discussed below.

The chronologically following group of deposits in area A consists of layers 19–22. Layers 19, 21, and 22 consist of redeposited natural sand, while midden layer 20 is stratified between layers 19 and 21. The sand layers were quarried, but not from the ditches. The midden layer was probably brought from elsewhere to add to the bank build-up. The author attributes these four layers to a single uninterrupted construction period for the following reasons:

(a) The cross-section of the deposits shows that they belong to a defensive bank, and that the sand material was quarried from elsewhere, brought, and deposited. The period II posts in G104–110 were sunk from the top of layer 19. Layers 21 and 22 did not independently contain post-holes, so that if they represent chronologically different defensive stages, they supported no defences. The different colours of layers 19, 21, and 22 can be explained as due to quarrying from different areas. Insufficient of the natural sand was observed to say where these areas were, but for reasons to be given below, the author suggests the use of storage pit spoil-heaps.

(b) None of the layers were separated by incipient topsoil layers, which would indicate time gaps. The rapid sprouting of vegetation on the excavation dumps would indicate that topsoil would form if allowed to. Hence the midden layer 20 can best be interpreted as a structural part of the defences. In G109 it fills in hollows in layer 22 (layer 21 being absent here), which might well have been left during construction.

The above layers are here taken to represent the period II bank, into which was set the first series of palisade-posts. Layer 22, however, is of further importance because it conveniently seals four rectangular storage pits in G105a, G108 and G109. The features of these pits will be described below, but the stratigraphy must be noted here. In the case of the G105a pit, layer 22 was traced as it thinned out from G105 into G105a (Fig. 4), and continued to form the upper fill of the pit (Fig. 5d). On the floor of the pit was a drainage system which had been cleaned out and kept functioning through a deposit of silt (layer c) washed in by rain and ground water. After this, part of the east wall had collapsed (layer b) and this event must mark the abandonment of the pit. The base had been backfilled with midden (layer a), and then finally filled by layer 22. Clearly, the existence of a hole just behind the defences would have hampered rapid mobility, and the pit was filled in when the defensive bank was built.

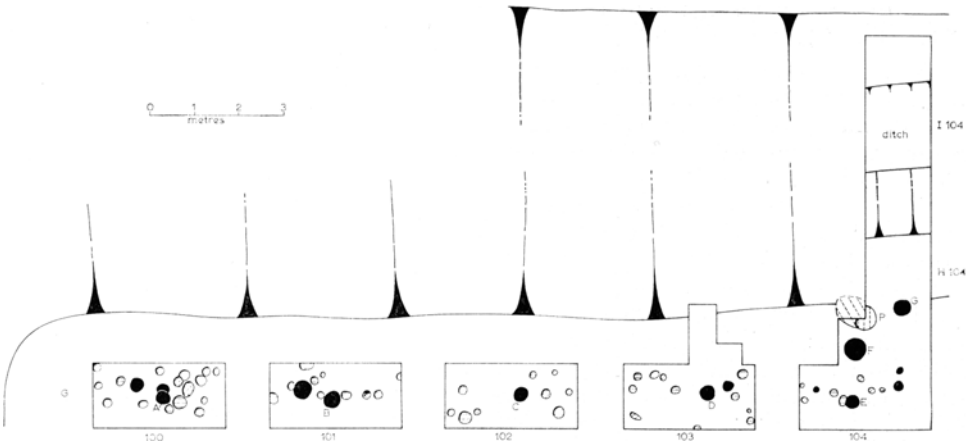

FIG. 3.—Plan of trenches G100–G104, H104 and I104. For post-hole notation see Fig. 4.

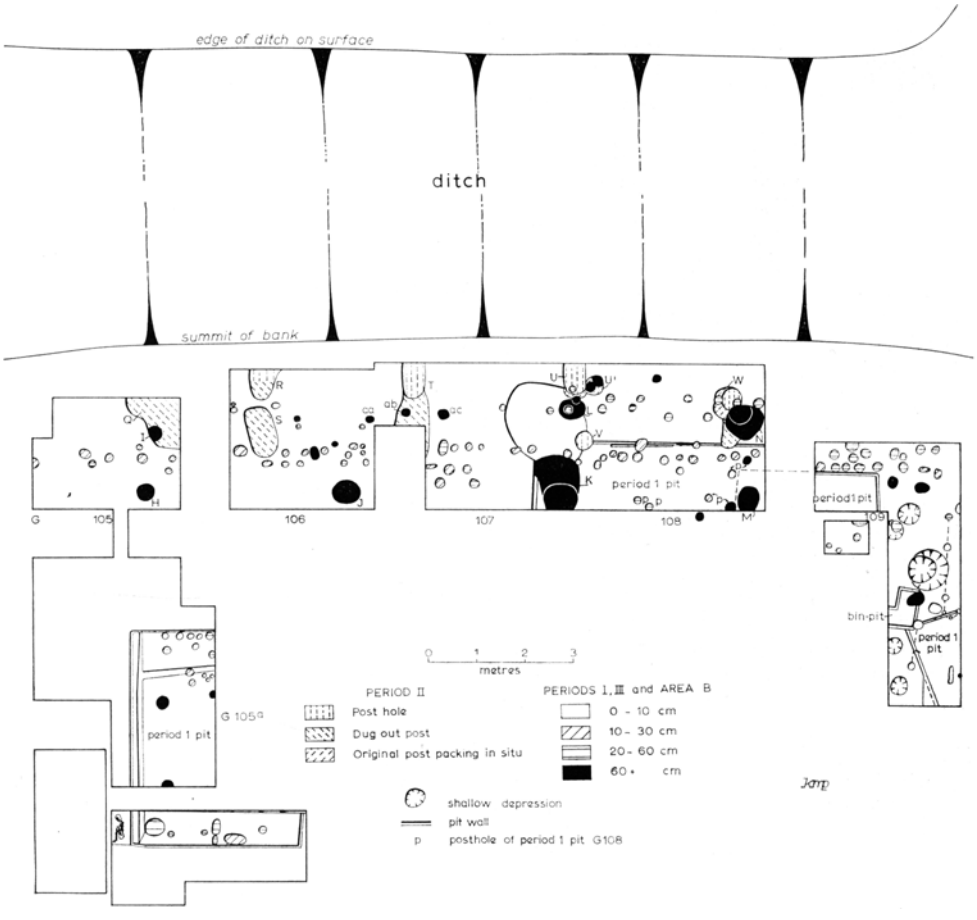

FIG. 4.—Plan of trenches G105–G109.

The section of the pit in G108 (Fig. 5c) shows that this, too, was sealed by layer 22, and the same situation obtained for the northerly pit in G109 with its attached bin-pit. The small pit running from G108 into G109 was filled with a different deposit consisting of soil and natural sand mixed, but it must pre-date the period II defences since the post-holes of this period intersect its southern edge, and the pit must have been filled and levelled by this time. The same applies to the pit in G108, since the period II posts here were cut into the fill up to 50 cm inside the southern edge.

Following the building of the period II defences, deposits of concentrated cockle midden were spread along the surface of the bank, in G107, G108 (filling the early storage pit), and G110. Late disturbances make it difficult to link these layers stratigraphically, but they are designated as layers 14, 17, and 18. Their position between the period II and III banks probably indicates contemporaneity.

Above these deposits comes a further layer of natural sand, of a lighter yellow colour than layers 19, 21, and 22. This completely fills all the post-holes of the period II bank, and there is no doubt that these posts were purposely dug out. This sand deposit is layer 7, and all the posts of the period III defences were sunk from its surface.

Unfortunately, recent gardening activities have completely removed any trace of layer 7 in trenches G100–106, although the lower parts of the post-holes of this phase still survive in the period II bank. This means that trenches G107–110 contained the bulk of the information for the interpretation of the sequence, and these trenches were extended to cover greater areas than the others.

Most of the period III posts rotted *in situ,* as many cavities indicate, but two were purposely dug out (K and N in G108, Fig. 4).

No further building activity followed the deposition of layer 7, and the subsequent history of the site is represented by modern rubbish pits and garden beds. From stratigraphical evidence (supported by structural evidence) trenches G100–111 show activity from three periods:

Period I —Storage pits, midden deposition, and a possible palisade (layers 40–44).

Period II —Earthwork and palisade defences (bank layers 19–23).

Period III—Earthwork and palisade defences (bank layer 7).

Trenches G112–122—Stratigraphic Sequence (Figs 7, 8)

In G112, the earliest feature is ditch A, which was filled by the sand and soil layer 29. Ditch A is cut by ditch B, which follows a slightly different line. Ditch B also has cut away any stratigraphical link between ditch A and midden layer 43, but since no shells have trickled into the fill of ditch A it must have been cut after the sealing of 43 by soil layer 42, which is probably spoil resulting from the excavation of the period I storage pits inside the *pa.* Therefore the pit (filled by layer 41) in G110, and ditch A, are both next in stratigraphic order following the midden layer 43.

Ditch B was backfilled, either immediately after construction or after a fairly thorough clean-out, for the fill—identical to the period III bank layer (layer 7)—rests on the base of the ditch with only a trace of an intervening layer of silt. The ditch B backfill is covered by recent layers, especially the midden layer 26, whose stratigraphical importance will be noted below.

Beyond ditch B lies the terrace, but an unfortunate stratigraphic break intervenes where midden layer 26 lies directly on the old topsoil.

The terrace consists of two distinct layers. The earliest, layer 37, extends into G114 where a drain runs along its edge (Fig. 8). This drain was filled mainly with mussel shells, an unusual circumstance, since these shells were found hardly anywhere else and later middens on the site consist almost entirely of cockles.

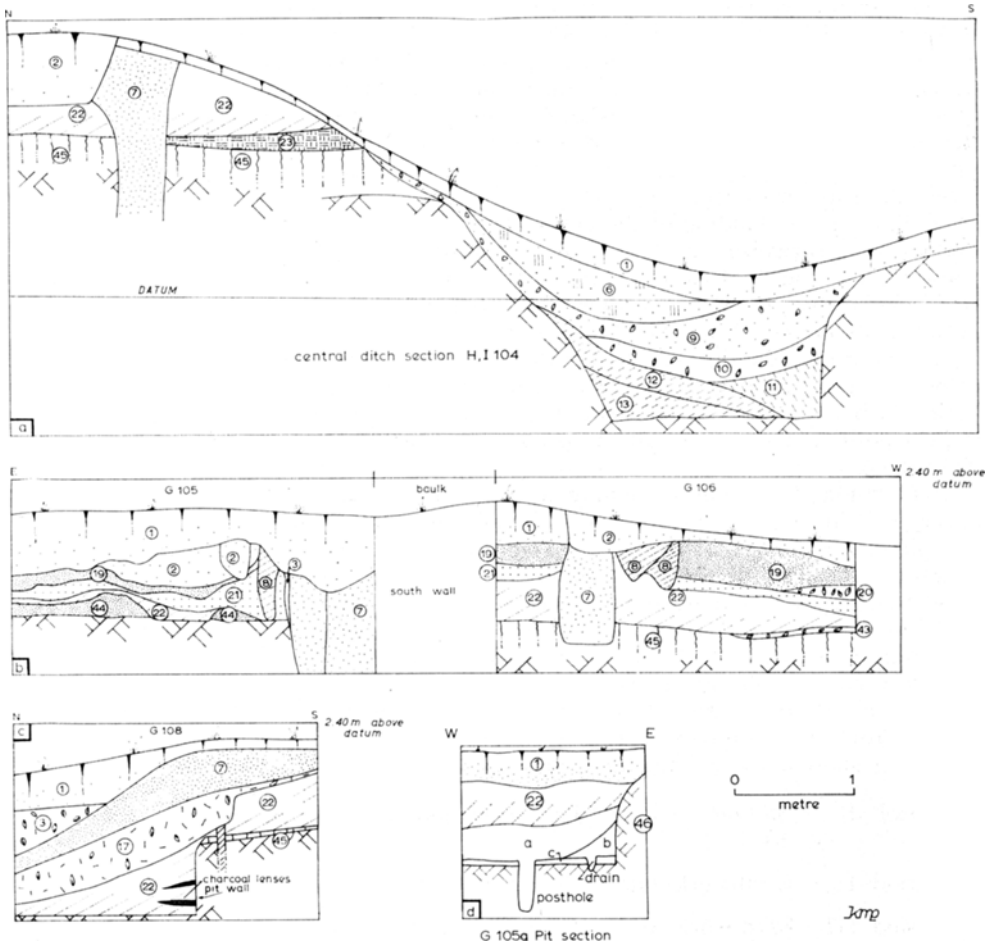

FIG. 5.—a. East section of trenches H104 and I104. b. South section of trenches G105 and G106. c. North-south section through trench G108 showing fill of period I pit. d. West-east section through period I pit in G105a. Layers a, b and c are described in the text.

Terrace layer 37 is separated in G114 from the later terrace by a thin layer of midden (layer 36). Above this lies terrace layer 35, which in G114 seals in the mussel-filled drain before fading out. It also seals the midden layer 39, which was deposited off the end of the first terrace, beyond the drain. This layer continues down to G117 before petering out.

Terrace layer 35 is capped by a thin soil (layer 34) which is evidently a rudimentary topsoil, and in G121 a latrine and drain were built on this layer (see below). Finally, in this area, ditch B, the drain, latrine and terrace were all covered by thick midden deposits extending as a series of dumps down the slope (layers 26–33).

Stratigraphic Correlation of the Banks and Ditches, Trenches G100–122

The period I backfilled palisade post-hole and the depression filled with natural sand in G110, have already been referred to in the section on the stratigraphical sequence. The palisade hole was 1.75 metres deep (Figs 6 and 9, feature e). Attribution of the hole to a palisade post conflicts with the author's opinions in a preliminary report (Bellwood 1969a, p. 40), but re-examination of photographs and plans have led to the above conclusion. The problem is: Do any of the ditches in G110–112 belong to this period I palisade?

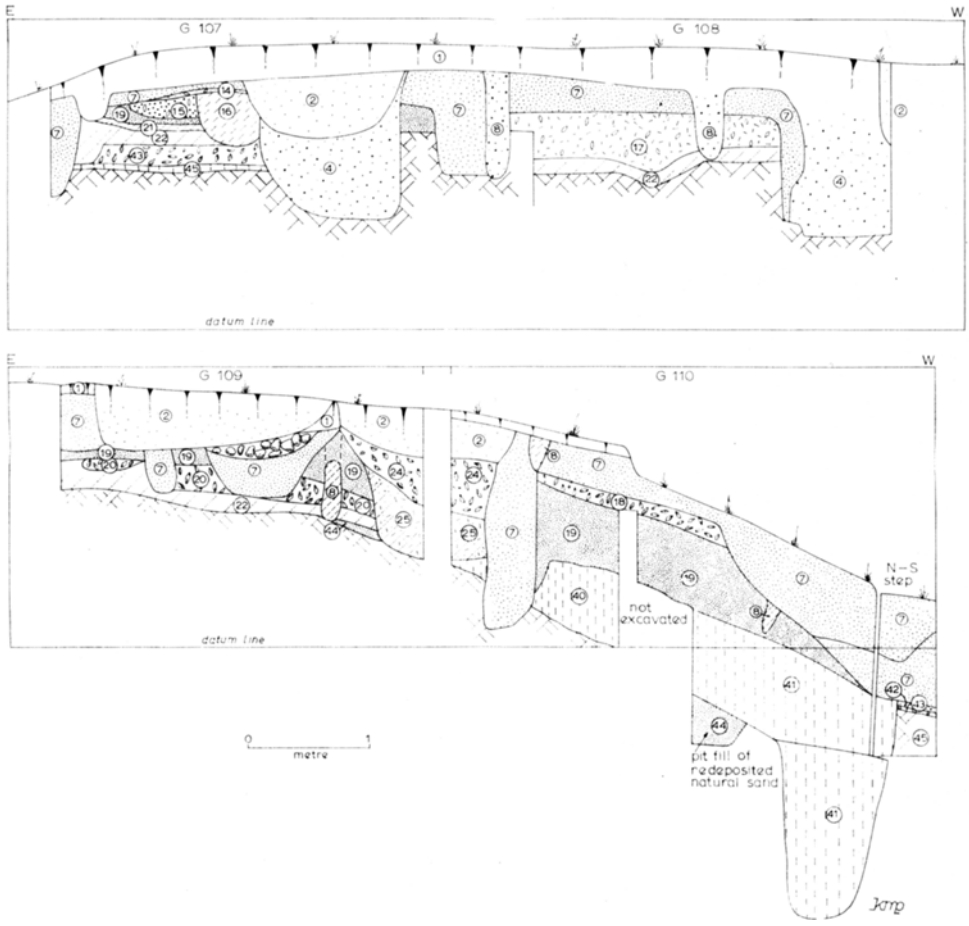

FIG. 6.—South section of trenches G107 to G110.

We may commence by referring to the sand layers 19, 21, and 22 of the period II bank. These are of soft sand of homogeneous texture, orange in 19, yellow in 21, and brown-orange in 22. This sand must have been quarried, yet bears little resemblance to the natural sand revealed in the excavation of the ditches in G112 and H104, I104. This last ditch is shown in cross-section in Fig. 5a and is a single period construction filled by natural silting and, later, midden deposition. There are no traces here of two ditches as there are in G112, although the possibility must be recognised that a later ditch might have completely removed an earlier. The natural sand revealed under the ditches is clearly that which composes layer 7—the period III bank. This is pale yellow and of varying texture, with blocks of soft white sandstone in a pale yellow matrix with occasional clay admixture. It bears little resemblance to the period II bank material, and its origin is uncertain. The period II bank material was not quarried from a defensive ditch in the excavated area, and it may have been taken from the spoil-heaps of period I storage pits elsewhere on the site.

The ditch in H104 and I104 (Fig. 5a) may have been the quarry for layer 7 of the period III bank. In cross-section this covers about 2 square metres. Where preserved (e.g., in G108–9) the bank layer 7 covers about 1 square metre in cross-section, and one must add to this the large amounts of this layer filling the period II post-holes (below). Although destruction by gardening does not

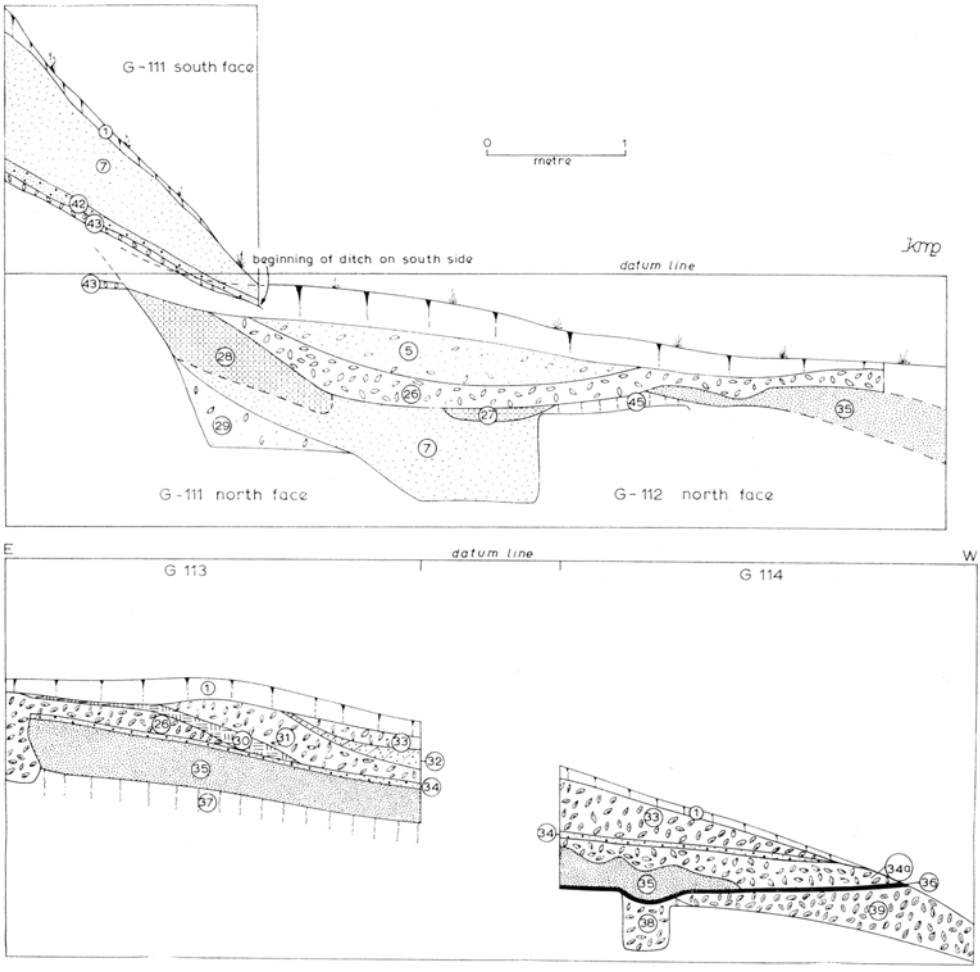

FIG. 7.—Upper: South section of trench G111, with reversed north face section of trenches G111 and G112. Lower: South sections of G113 and G114.

allow a very accurate determination, it seems likely that layer 7 would account for the amount of material taken from the ditch which runs along the south side of area A and peters out into a channel in G122 (Fig. 8).

This leaves ditch A and ditch B in G112. Ditch B (Fig. 8) is filled with layer 7—therefore it must have been filled when the period III bank (layer 7) was built and the southern ditch of area A cut. Hence it did not provide a quarry for the period III bank or the period II bank, for reasons referred to above. The same applies to ditch A, as this predates ditch B. The answer lies in the two terrace deposits—layers 35 and 37. These are of limited extent, and have cross-sections which would account for the mass of material quarried from the two ditches (Fig. 7). Hence for G111–114 the author infers the following sequence:

1. The cutting of ditch A. The bottom of this is only 50 cm below the level of the old topsoil and it may better be described as a terrace cut into the slope, deepening towards the back (perhaps for drainage). The material from ditch A was deposited to form the first terrace (layer 37), which had a drain at its outer edge (filled by layer 38). No structures were found on the surface of this terrace,

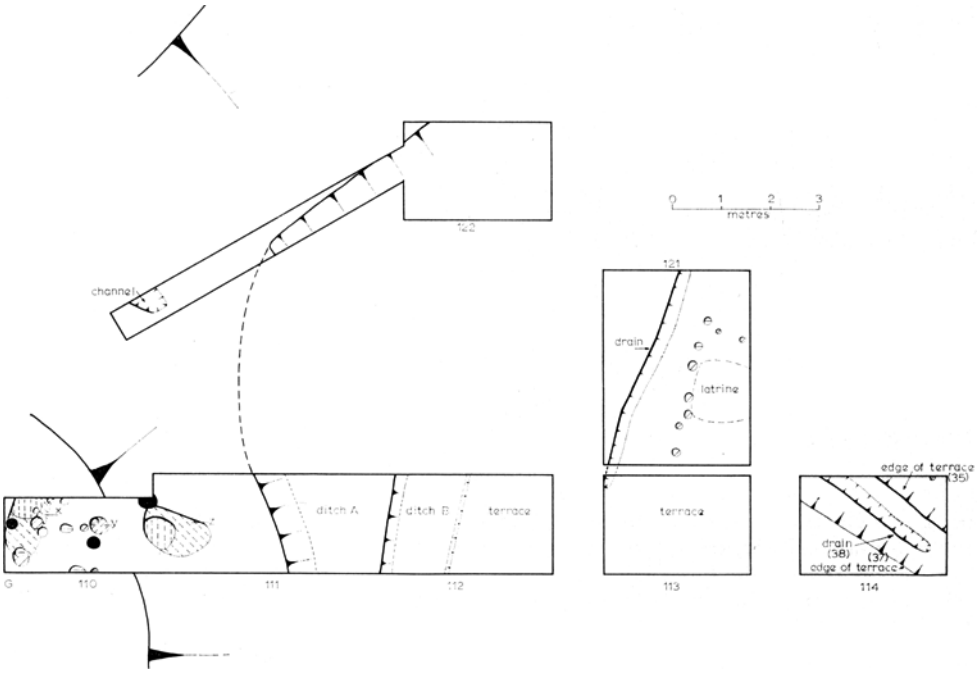

FIG. 8.—Plan of trenches G110 to G114, G121 and G122. For post-hole notation see Fig. 4.

but its extent is unknown and it may have been quite large. It may, however, have linked with the back wall of a terrace uncovered in G122 (Fig. 8), but there is no stratigraphical link.

2. A time interval, during which midden layer 36 was deposited on the terrace in G114.

3. The cutting of ditch B through the old ditch A. The material from ditch B was deposited as terrace layer 35, on which was placed the latrine in G121. Ditch B was then backfilled with layer 7, and this suggests that it was never planned as a defensive ditch at all but merely as a quarry for terrace layer 35. It may be that the ditch impeded access to the latrine, and that the opportunity was taken to fill it at the time of the burst of building activity at the beginning of period III, although the ditch is not continuous for it does not appear in G122, which it should do if it maintained a straight line.

Hence, for the excavated earthworks at Otakanini the following sequence may be inferred:

Period I—An initial phase was characterised by shell-midden deposition and *kumara* storage pits, followed by the digging of ditch A and the building of terrace layer 37, which may be linked to the period I palisade post in G110 on the grounds that all these structures predate period II. The palisade post would have stood on top of a scarp 2 metres high, formed by the cutting of ditch A. Later slumping from this scarp would account for layer 29, being the fill of ditch A, and consisting of a mixture of soil and natural sand.

Although no definite proof can be offered, it appears likely that the period I defences surrounded the whole area of the *pa* as it stands today. The scarp which defends the whole western side runs in a continuous straight line, broken only where it is met by the period II and III defence across the south side of area A. Because the line is so straight it may be that the scarp was built in a single period (it should be noted that the scarp is not straight today owing to the construction

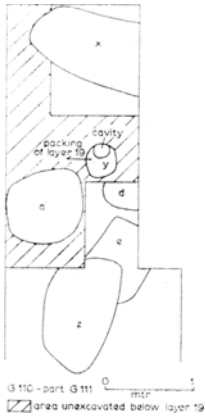

FIG. 9.—Detail plan of trench G110 and part of G111, showing post-holes of period I (d and e), period II (x, y and z), and period III (a).

of a vehicle track at an angle to the defences—see Fig. 2). The defence across the southern side of area A dates from period II, so that in period I the southern side of the *pa* would have lain undefended if the circuit was confined to area A. This implies that the period I defences may have enclosed both area A and area B before these were divided.

The plan of the *pa* (Fig. 2) shows many other discontinuous terraces round the east side and into area B which cannot be tied into the period I–III sequence here enumerated. However, suffice it to say that terracing is one of the earliest features of the *pa,* which parallels conclusions reached by the excavators of Kauri Point *pa* on the Tauranga Harbour (Golson, 1961; Ambrose, 1962), and also the more general suggestions put forward by Groube (1967, p. 19) that terracing is one of the earlier forms of defence in New Zealand, predating the rectangular ditched *pa.*

Period II—the building of the defensive bank across the south side of area A is represented by layers 19–22, the cutting of ditch B, and the construction of terrace layer 35. There is no ditch for this phase on the south side of area A, although a shallow ditch may have been obliterated by the period III ditch excavated in H104–I104. The source for layers 19, 21, and 22 is unknown, but it may possibly be the spoil-heaps of storage pits. The period I pits do not appear to have been flanked by spoil-heaps, and spoil may well have been used for this purpose, being brought from an unknown number of late period I pits over the site.

Period III—The building of the southern ditch and bank layer 7 belongs to this period. Ditch B in G112 was backfilled and the terrace area later used for midden deposition.

EXCAVATED STRUCTURES AT OTAKANINI

Period I Pits

Period I structures in area A have already been referred to in the section dealing with the stratigraphical sequence in trenches G100–111. Of the pits, that in G105a is the most completely excavated and covers an area of 4.5 by 3.5 metres. Its depth from the top of the natural is 1.5 metres, and it contains an interior drainage system, which was clearly necessary, as the thin layer of silt on the floor of the pit indicates the presence of standing water (Fig. 5d). The roof of the pit was supported by three rows of posts, some of the posts being of considerable strength, sunk up to one metre in the ground (Fig. 4). A cluster of very shallow holes at the south end of the pit perhaps supported some type of racking. Above the

north-east corner a crouched burial was found on a shallow shelf, but the shelf appeared to have been cut independently after the pit was backfilled. The burial was of a young girl aged 12-15 years. Sex was determined from the pelvis, using features listed as diagnostic by Brothwell (1963, p. 52), and age determined on tooth eruption (Brothwell, 1963, p. 59). The knees were drawn up to the chest and the legs fully bent. The head lay at the north end and faced west. The bones were fully articulated, and the absence of exhumation, and hence post-burial ceremony (Buck, 1958, p. 425), suggest that the body may have been that of a slave. Certainly, the orientation rules out the possibility that it may be Christian, although this does not necessarily mean that it is fully prehistoric.

The pit in G108 has only a short stretch of drain along its south wall, clearly because the natural sand in G108 and 109 contains less clay than that in G105a, so that water would soak away more quickly. Presence or absence of drains in pits seems to relate to soil type (Bellwood, 1969b). Although this pit was not fully excavated, it was at least 5 metres long, with a central post row, and perhaps some side posts (Fig. 4).

The pit in G109 which extends towards G108 is also undrained, as is the other pit at the north end of G109. The former was only partly excavated, and its length is unknown since it does not reappear in G108 and its relation to the G108 pit is hidden under an unexcavated baulk. The small excavation trench in the arm of the L which forms G109 revealed post-holes at the level of the floor of this pit.

The northern pit in G109, although again not completely excavated (pits under the later defences were eventually covered by up to or over 2 metres of deposit, so that extension was not really feasible in this area to this depth) is of rather more interest. It was only 40 cm deep, but an L-shaped bin-pit leads off from its excavated corner, dug to 30 cm below the level of the main pit (Fig. 4). Both pits were filled in during the building of the period II bank and their sites later covered by a deposit of midden 80 cm thick.

Near the south wall of the main pit, above the layer of silt which was probably deposited when the pit was used for storage, lay a hearth. This consisted of a lower patch of charcoal 20 cm in diameter, separated by a thin layer of sand from an upper patch 10 cm in diameter. This may indicate that the pit was used for habitation after it ceased to be used for storage. A sample of charcoal from this hearth yielded a carbon-14 date of A.D. 1351±78 (NZ 1279).

Also sealed by the layer forming the period II bank in G109 (layer 22) were a number of bowl-shaped depressions up to 30 cm in depth (Fig. 4). Best (1927, p. 100) records the use of hollowed blocks of *matai* wood sunk into the ground and used for water storage, and the G109 hollows may have supported some kind of round-based receptacle. Similar, but deeper and narrower hollows, were excavated by the author at Skipper's Ridge (Bellwood, 1969b).

Period II Palisades

Post-holes cut from layer 19 are situated close to the crest of the bank as it is preserved at present (in actuality the bank is hardly visible on the surface owing to build-up of garden soil behind it) and run from G104 to G110/1. They may extend as far as G100 to the east, but excavations were not made in this area.

The post-holes are lettered P to Z on Figs 3, 4, and 7. Owing to later digging out, actual positions of only two of the posts could be recorded. Post-holes P, R, T, U, U1, W, X, Y, and Z form a line along the front of the defences, the posts being about 3 metres apart, although the smaller post Y is equidistant from the two larges holes X and Z, which are 3 metres apart. Posts S (partner for R) and V (partner for U) are 1.5 to 2 metres behind this line. Unfortunately, the baulk between G106 and G107 was never fully removed, but the hole left by the digging out of T extends for 2 metres, suggesting that a partner for T might be located under the baulk. No trace survives of the post in position Q, but this may possibly have belonged to the rear line also.

Of the forward row, post R was unexcavated (the extension to G106 being made at the end of the excavation). For the rear row, extensions to reveal Q and S were also made at the end of the excavation, and both were only partially excavated.

Original post diameters can be reconstructed for post-holes P, T, and U (25 cm), and post-holes U1, W and Y (20 cm). Depths in metres for forward row posts are as follows, measured from the top of the period II bank layer 19: P, 1.15; T, 1.80; U, 1.80; U1, 1.00; W, 1.20; X, 1.40; Y, 1.30; Z, 2.00. Depth in metres for rear row posts are: Q, over 1.20; S, over 0.80; and V, 0.80. A slab of burnt wood from the base of the fill of posthole T gave a carbon-14 date of A.D. 1561±48 (NZ 1280).

During the construction of the period III bank and defences the posts listed above were dug out and the holes backfilled with layer 7. The post in Y, however, was left and allowed to rot *in situ*. This post was packed with layer 22, and traces of this packing survive in U and W. After U was set in position, U1 was placed at the side of it and the packing for U1 cuts that of U. U1, therefore, was probably an extra support, and like Y was never dug out.

Of the forward posts, T, U, and Z are the deepest. Z may have been more massive, due to its corner position, and the presence of the intermediate post Y may denote stronger palisading here. The depths of T and U, and the fact that U certainly has a partner in V, lead the author to infer the presence of a fighting stage in this area with heavier forward posts, perhaps to support some kind of breastwork. The stage would have been supported by pairs U and V, T and its possible partner, R and S, and Q and its possible forward partner (no excavation was made to reveal this). P does not appear to have a partner, and so this may continue the line of the single palisade. To the west, posts W, X, Y, and Z continue the line of the palisade, perhaps with a further post to the south of G109. If this view is correct, then the stage would have been 9 metres long and about 2 metres wide. Forward posts up to 2 metres in the ground may imply that the forward face of the stage was up to 6 metres high.

Assuming that no ditch was cut in this period, then the height of the terrace below the stage would have been 2–3 metres, and the total height of the defences perhaps 5–6 metres. No post-holes were found for the fencing of the palisade, but this may have been supported at ground level by horizontal stringers (Best, 1927, p. 66).

Two other features were cut into the period II bank before the subsequent reconstruction. In G105 a *haangi* (earth oven) was dug into the top of layer 19, one metre in diameter (not shown on plan), which was later cut by hole Q during the digging-out of the period II posts. In G109–110 (Fig. 6) a large pit was cut through the period II bank layers and filled with layers 24 and 25. Layer 25 appears to be an admixture of layers 19, 20, and 22, pushed in as backfill. This pit is cut by the excavation to remove post X. The *haangi* in G105 is in a position suggesting that it may have been used for cooking food for the men engaged in the period III reconstruction—it would hardly have been built directly beneath a palisade line that was still in use.

Period III Palisades and Other Structures, G100–110

The period III bank layer 7 was quarried from the south ditch of area A, which is 1.2 m deep and 1.8 m wide at the base (Fig. 5a). The posts of the period III palisade were set in from the top of layer 7 and were allowed to rot *in situ*, except for posts K and N in G108 which were later dug out. On the plans, the post-holes for this period are shaded according to depth (see key on Fig. 4), and fall into two distinct series—a series of small close-set post-holes less than 25 cm in diameter, and the evenly spaced large post-holes lettered A–N. Only in G106–110, where layer 7 is preserved, can it be seen that both these series are cut from the top of this layer (the surviving mould of post N commences from its surface).

The smaller holes were probably dug by means of a type of brush known as *matarau*—described by Best (1927, p. 61). However, the larger ones all had the marks of digging sticks (*ko*) in their sides. While the smaller posts perhaps fitted snugly into their holes, and needed no packing, the larger pots must have been supported by packing, since it is unlikely that they would fit their holes exactly. For this reason, it is strange that they are filled entirely with a homogeneous grey silt, perhaps formed by ground-water deposition in the cavity left after decay of the post (many of the smaller posts' holes still survived as cavities). Absence of packing in this context is difficult to explain, and it may be that worm activity has broken down the sides of the post-holes. However, this suggestion could not be verified without some kind of experimentation, and no clear answer can be given to this problem.

The large posts run from G100 to G108, and are 3.5 to 4 metres apart. In G100 to G104 they are on the same line as the smaller ones, but from G104 to G108 they are situated a little to the north of the line of smaller posts. Posts of this large series have not been found in G109–110, but since this was the corner area their line may have swung away from the excavation line. The posts in G104, G105, and the two in G108 all have partners 1.5 to 2 metres in front of the line, thus making two rectangles of four posts, separated by the single post in G106 (J). The post-holes of these rectangles were 1.5 to 2 metres deep, and the posts are interpreted as supports for two fighting stages, hypothetically reconstructed in Fig. 11. The stages have dimensions of 5 by 1.5 metres in G104–5, and 4 by 2 metres in G108. They are separated by an interval of 9 metres, and because the post J had no forward partner, it is unlikely that a continuous stage stretched from G104 to G108. Post J is reconstructed as a carving in Fig. 11—this should not, of course, be taken as a literal reconstruction, but the function of post J will be discussed below.

The smaller posts are in two rows. One row runs right through from G100 to G110, and in G105–7 and G109 consists of two sub-rows. These post-holes were for palisades, and the discontinuous double rows imply some replacement of posts which had rotted. One may note an observation from an early publication of Cook's first voyage, of a *pa* in Queen Charlotte Sound, where brushwood was bundled between two close-set rows of palisades (Becket, 1967, p. 97). The rather random arrangement of the two rows at Otakanini does not suggest a structure such as this. The other row of small posts runs from post N to post L in G108, and more scattered posts continue the line into G106. The row is double between posts L and N, but again this could be due to replacement. The two stages would therefore appear to be of the *puwhara* type, which straddles the defences, as described by Best (1927, p. 78). The forward row of small posts would be an extra defence, required between posts L and N of the fighting stage near the corner and perhaps continuing through the unexcavated area to the immediate south of G109. Just to the south of the baulk between G106 and G107 (Fig. 4) are three small deep holes (*aa, ab, ac*). Beyond these the forward row peters out, and it is possible that this forward row flanked an entrance, commencing at post *aa* and running under the G108 stage to enter the *pa* somewhere towards the corner. No evidence of a trodden path or specific entrance posts survives, however, but it would be a reasonable assumption that the entrance was in the most heavily defended area of the *pa*. Best's entrance diagrams in *The Pa Maori* (Best, 1927, p. 89; fig. 37, 1 and 2) correspond to the type of entrance suggested for Otakanini, and an entrance passage of this kind has more recently been excavated at Mangakaware site 2 (Bellwood, 1971a, fig. 6).

Mention has been made above of the fact that the small post-line in G100–104 follows that of the large posts A to E, while in G105 to G108 the large posts, H, J, K, and M run on a slightly different line. Post J has been reconstructed as a carving in the drawing (Fig. 11) since it does not seem to have belonged either to the stages or to the palisades. The author can see only one explanation for this. Large post-line A to M must have been raised first of all as a single palisade line—these large

posts originally being intended as supports for a palisade of small posts. None of the small posts were ever erected in trenches G105 to G108, and it would seem that there was a change of plan just when the large posts A to M were in the ground. The decision was made to build the two fighting stages, and therefore posts F, I, L, and N were raised. The palisade line was built as planned at first from A to E (G100–104), and then the small posts were extended alone as a more flimsy line between the fighting-stage posts. Hence J became obsolete, but was not pulled out of the ground—in fact it was allowed to rot *in situ* like the others. The post must have been free-standing, and on no other grounds than this has it been reconstructed as a carving. Post G in G104 is also set off from the palisade line; although this could have supported a forward jutting of the stage it has not been so reconstructed in the drawing.

Measurements for the larger period III posts are shown in Table 1. Depths may be too small in some cases since gardening activity this century has truncated

TABLE 1.—Depths and Diameters of Period III Posts

Post	Depth (cm)	Diameter (cm)
A	125	30
B	120	30
C	130	40
D	140	30
E	130	30
F	130	43
G	110	40
H	140	35
I	?	35
J	130	50
K	170	65
L	100	46
M	150	30
N	130	30

the stratigraphy in many places, and few posts can be related to their original ground surface. A sample of rotted timber from the cavity of post-hole I gave a carbon-14 date of A.D. 1493±49 (NZ 1281).

Post-hole L contained two water-worn stones, the larger with a maximum dimension of 30 cm. These must have been carried to the site from the mainland, perhaps by canoe. Best (1927, p. 109) describes the placing of a stone under the first post of a *pa* to be erected, whose purpose was " to preserve and retain the *ora* and *mana* (welfare and prestige, etc.) of the place ". This stone was called a *mauri*, and was normally placed under a corner post. Post L was not a corner post but it was the only post-hole to contain stones, and Best's above description may well apply. Furthermore, the hole was fairly deep and narrow, and the two stones seem rather large for packing. They were also at the base of the hole, rather than stuck in the sides, although they could presumably have fallen down when the post rotted if they were used simply for packing. The choice between packing-stones or *mauri* cannot be made with certainty.

Post-hole D in G103 was also of interest since this contained two complete adzes at its base (Fig. 12, nos. 7, 8). The post does not appear to have been dug out, so that the adzes must have been deposited before the post was sunk in its hole. The only feasible explanation is that the adzes were deposited as part of a construction ritual. In addition, post-hole *ac* in G107 contained a small flake tool (Fig. 13, no. 10).

One further point may be noted about the period III defences. It has been pointed out above that before the construction of the period III palisades the old period II posts were dug out and the holes left backfilled with the period III bank layer 7. A problem immediately arises here, for the process of digging out

must have given rise to several spoil heaps of a mixed material derived from the period II bank and the various period I and II midden layers. This deposit was not put back in the holes and must have been redeposited elsewhere.

Fig. 4 shows that trench G109 was extended inside area A for some two metres behind the defensive bank. Above the fill of the period I pit lay a deposit—some 80 cm thick—composed of shell, charcoal, and soil, all mixed with pockets and lenses of yellow or orange natural sand. During the excavations this layer presented a problem in interpretation since it showed no internal stratification which would indicate gradual build-up of midden and refuse over time. Instead, it appeared to be a dump, and the problem was to explain its presence.

Now G109 is in the south-west corner of area A—an area which was certainly very heavily defended. During the construction of the period III defences the decision may have been made to raise the level of this corner, thus making it into a low platform. But why not use the layer 7 material quarried from the ditch? The answer to this may be that the ditch is further from the corner to be raised than the old period II post-holes, and hence the soil would have to be carried further. With this and other evidence from the excavations in mind, one may reconstruct the sequence of events in the building of the period III defences as follows:

1. Period II posts dug out.
2. Spoil carried to raise corner.
3. Ditch to south of area A dug, holes backfilled, and bank layer 7 deposited.

This sequence would thus minimise the distances over which spoil would require to be carried.

Structural Features G111–122

The two terraces (layers 35 and 37) outside ditch B in G112 have been described above. The earlier of the two—layer 37—was bordered on the downslope by a drain in G114 (Fig. 8). This drain, 35 cm wide and 45 cm deep, petered out on to the old ground surface (layer 45) before reaching the north-east corner of trench G114. Finally, the drain was filled with mussel shell and overlain by the second terrace, layer 35.

In G121 (Fig. 8) a latrine was built directly on top of layer 35. Upslope from the latrine was a drain, which runs across G121 into the south-east corner of G113, where it stops abruptly. The purpose of this was apparently to stop water flowing out of the channel from the defensive ditch on the south side of area A (the end of this channel is shown in the extension to G122—Fig. 8) into the latrine. The latrine itself was shielded from the *pa* by a fence 3 metres long, with a short extension encircling it round the southern side, and a shallow hollow 1 metre in diameter had been scooped out to receive the excreta, which remained as a dense black organic deposit. Analyses of four samples of this deposit were carried out by Dr B. R. Cook of Leeston, Canterbury, who reported that they consisted mainly of decomposed fern-root fibre and contained no parasite eggs (B. R. Cook, personal communication, 29.11.68).

After the latrine went out of use it was buried beneath a series of concentrated shell-midden deposits. The stratigraphy of these deposits is shown in the G113–114 section (Fig. 7). Shell layer 26 is of importance here since it seals the layer 7 backfill of ditch B in G111, and also the drain running behind the latrine (see section G113). Ditch B was backfilled during the construction of the period III defences in G100–109. Terrace layer 35, as discussed above, seems to belong to period II, as does the latrine. Layer 26 seems to have been deposited very soon after the ditch B backfill and the construction of the period III defences, and, by sealing the latrine and terrace layer 36, provides additional and important proof that these features belong to period II. Hence, in period III the areas outside the G111 ditches was used merely for the deposition of shell midden.

The G113–114 section will show that these midden layers have a definite structure. Clay lens 30 seals midden layer 26, and layers 31–33 overlap in sequence down the slope. The layers thus represent chronologically separated deposits, but their shell contents are very homogeneous, consisting almost entirely of cockle (*Chione stutchburyi*). As a further point, a story recorded by Best (1927, p. 124) that the people of Mangere *pa,* Auckland, spread shells outside the defences so that approaching attackers would be given away by the resulting crunching, suggests that the Otakanini middens may not have been simply rubbish dumps. In fact, shell midden has been deposited right round the *pa* and does not appear just in localised dumps, so it would appear that the inhabitants went to some trouble to spread it strategically. However, there is little shell surrounding area B, and this supports the view that this area is an annexe to area A.

Structural Features in Area B

The structural features in area B (Fig. 10) could not be tied in with the 3-period sequence from the defences since they were covered only by topsoil—i.e., they survive only as features cut into the natural sand. The defensive ditch acted as a barrier to any attempt to relate these features to layers in G100–109.

The large trench immediately to the south of the ditch extension H–I 104 was formed by the amalgamation of trenches J102–104, K102–104, and L104. The area was levelled before any construction took place, and the spoil derived from the levelling was built out to the east to form a terrace. The edge of the built-out section of the terrace is shown by a dotted line in Fig. 10.

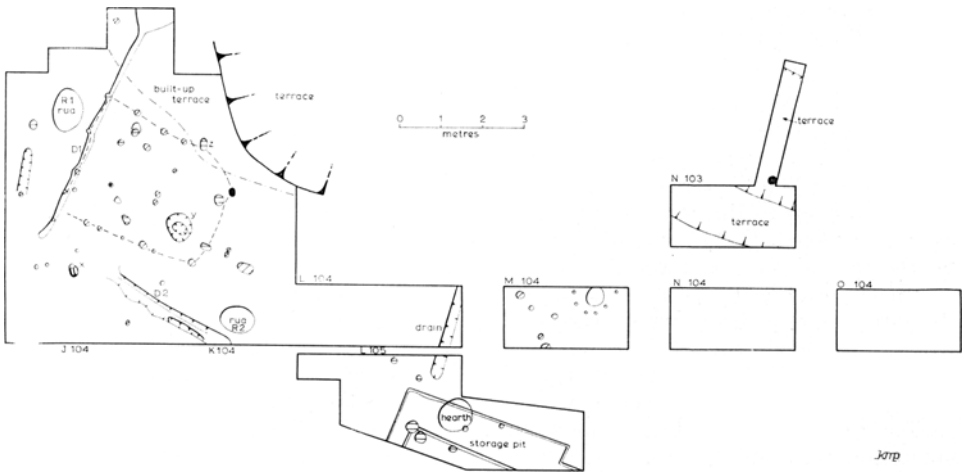

FIG. 10.—Plan of area B trenches. For post-hole notation see Fig. 4.

Two *rua* (bell-shaped store-pits) were constructed on this terrace, marked R1 and R2 in Fig. 10. R1 was 80 by 100 cm at the surface, 1 metre deep, and expanded inside to 1.60 metres diameter at the base. R2 was 60 by 80 cm at the surface, 75cm deep, and expanded to 1.20 metres diameter at the base. Bell-shaped pits such as these were certainly used for storage, and according to Best (1916, p. 79–81) were covered with a removable lid, entered by means of a ladder, and used for storing *kumara* (sweet potato) or, in European times, white potato. Functionally, therefore, they would seem to have been used for a similar purpose to the larger roofed rectangular pits, but reasons for the constructional differences between the two types remain unknown. Both *rua* had been kept scrupulously clean during useage and contained no midden debris whatever, being filled in with clean natural sand, possibly when the period III defences were constructed. R1 contained a discarded grooved polishing stone (artefact no. 9), which must have been tossed in during the backfilling.

The terrace is drained by two drains running at right angles (Fig. 10, D1 and D2). Between them is a small hole (*x*) which contained two identical water-rolled pebbles side by side. These showed no signs of having been used for rubbing or polishing, and no signs of modification—in the form of grooving—for use as net sinkers. No stone occurs naturally on the site at all, and so they must have been carried from the mainland. No suggestion can be offered concerning their function.

A number of small post-holes, ranging in depth from 10 to 60 cm, are situated centrally on the terrace. That marked *y* is a small pit 25 cm deep in the centre and resembles a fire pit, except that it contained no charcoal or stones. It may, on the other hand, have supported some kind of receptacle. The post-holes—five of which postdate the ditch D1—appear to form a rectangle with outer dimensions of 3.5 by 2.8 metres, with a line of centre posts across the shorter axis. Not all the posts fit this pattern, however, and this interpretation is not at all conclusive. The discovery of flimsy rectangular shelters without hearths in the excavations at Mangakaware site 2 in the Waikato (Bellwood, 1971b) makes it at least possible. Post-hole *z* contained at its base a dog canine modified for use as a fishhook point (Fig. 13, no. 13).

In L105 there is a rectangular storage pit, 4 metres long, of unknown width, and 40 cm deep. This contained a single central drain and a central line of post-holes, of which three were excavated. After it went out of use, a hearth 80 cm in diameter and 16 cm deep had been cut in its western wall. This contained no stones.

Other structures in area B consisted of a scatter of post-holes in M104, with one shallow pit surrounded by a ring of tiny stake-holes. This may have been to hold some kind of round-bottomed container, over which was built a light protective covering. A similar structure was excavated by the author at Skipper's Ridge, Coromandel Peninsula (Bellwood, 1969b). The back wall of a small terrace cuts across N103: this was some 60 cm high, and the terrace 3.5 metres wide. One post-hole was found, indicating the presence of a structure of some kind.

Area B Defences

The scarp defence along the west side of area A was continued along the west side of area B in a continuous straight line. This scarp is some 3 metres high, and there are no signs of a bank or ditch. However, a ditch and bank defence was constructed in the south-east corner of area B, which runs down to the creek (Fig. 2). The surface indications of the ditch suggest that it had roughly the same dimensions as the southern ditch of area A. In the south-west corner, the height of the defences from the base of the scarp to the level of area B is some 6 metres—the highest earthwork defence on the site. Clearly, there was a very steep slope here before the *pa* was built, and the scarp served to increase the height of the slope. On the edge of the south-west corner of area B, two small trenches were excavated (B1 and B2). These revealed a single series of post-holes, averaging 50 cm deep and 3 metres apart, running in a straight line roughly parallel to the top of the defensive scarp and about 1 metre inside it. One metre would not be the original distance since one must take into account a certain amount of erosion of the summit of the scarp.

These post-holes would have supported a rather flimsy palisade, and it is clear that the defences of this area depended on the exceptional height of the scarp to deter invaders. The palisade is really more of a fence, with no indication of extra strength from fighting stages. Indeed, area B seems to have functioned as little more than an annex to area A, and this point will be discussed below.

THE STRUCTURAL REMAINS—GENERAL DISCUSSION

Rectangular Storage Pits

Rectangular storage pits are common, both on defended and undefended sites, in the *kumara*-growing areas of New Zealand's North Island and the northern part of the South Island (Law, 1969). As a category, semi-subterranean food stores were described by Best as early as 1916 (Best, 1916, p. 71). Although a number of archaeologists have recently expressed the opinion that many of these rectangular pits functioned primarily as houses, Groube (1965, chap. 6) has shown that a *kumara*-storage function is more likely.

The single small bin-pit in G109 has parallels at five other sites, namely Sarah's Gully Settlement, Coromandel Peninsula (Golson, 1959, p. 45; Green, 1963, p. 66); Skipper's Ridge, Coromandel Peninsula (sites I and II, Parker, 1962, p. 231; Bellwood, 1969b); Kumarakaiamo, North Taranaki (Parker, 1962); and Ongari Point, Tauranga Harbour (Shawcross, 1964a, 1966). Chronological placement and association with the larger pits are dealt with in the above reports and in Bellwood (1969b).

All pits excavated at Otakanini were either of the bell-shaped *rua* type, or the larger rectangular type. However, in 1922, when the site was still inhabited, it was visited by Mr G. Graham (Graham, 1922). He observed and drew a number of structures called *rua kopiha,* built in rows on the terraces of the prehistoric *pa.* These were used for storing *kumara,* and Graham describes them as follows:

> "Those pits which were still in use were carefully and neatly made, and were thatched with *raupo* over a dome-shaped roof . . . The interior was neatly lined with braken-fern . . . The bottom of the pits were covered with a deep layer of *mingimingi,* and on this the *kumaras* were neatly stacked, forming a pyramidical heap. The pits were some three feet wide and deep, and the covering dome-like roof about four feet high."

Unfortunately, Graham was not precise about the exact location of these pits, although he reported seeing a good number of them out of use and silting up. Clearly, from his drawings, he is not referring to the bell-shaped *rua,* and none of these apparently numerous structures were found in the excavations. Perhaps some of the layer 2 disturbances in G100–110 belonged to pits of this type—but there is no evidence that they may be prehistoric.

The Defences

Descriptions of fighting stages by late-eighteenth-century explorers have already been discussed in a previous paper (Bellwood, 1971a, pp. 69–70), and it only remains to bring together comparative information relevant to the palisades themselves. Lieutenant Crozet's description of Paeroa *pa* on Moturua Island in the Bay of Islands as seen in 1772 is particularly interesting, for he describes palisades seven or eight feet high, a fighting stage, and also an important feature described as follows:

> "From that side from which they fear attacks they have a sort of outworks, equally well palisaded and surrounded by ditches, and which will hold four hundred to five hundred men. This work is only a palisaded oblong and is placed outside the village to act as a defence to the entrance" (Roth, 1891, p. 32).

A contemporary plan of Paeroa *pa* (Kelly, 1951, between pp. 72–73; Groube, 1964b) shows an outwork directly in front of the defensive ditch, consisting of a rectangular palisaded enclosure across the narrow approach to the *pa,* which in this instance was a promontory fortification on a high narrow peninsula. This outwork was not drawn with associated earthworks, except for the *pa* ditch behind it, and it was not actually separated from the *pa*—rather it seems to have been a double row of palisades in front of the ditch, closed off across the ends to give a rectangle. However, the shape and topography of outworks would vary with the positions of *pa* in the landscape, and the author feels that earthwork annexes like area B at Otakanini (in periods II and III) or the annex between the two fortified enclosures at Ongari Point, Tauranga Harbour (Shawcross, 1966, p. 53), and annexes at many

other *pa* recorded in the field, correspond in function to the outworks described by Crozet. Otakanini area B may therefore have retained light palisading throughout periods II and III in order to impede access to the southern defence of area A.

The descriptions by Cook and Banks of a *pa* at Mercury Bay on the Coromandel Peninsula in 1769 have been discussed previously (Bellwood, 1971a, p. 70), and it need only be noted here that Banks records the palisades as 10 feet high, and the fighting stage, which he calls a "Porava" (*puwhara*), as being built over the palisades (as at Otakanini), and 43 feet long, 6 feet 6 inches wide, and 20 feet 6 inches high (Morrell, 1958, p. 76).

If all the evidence for fighting stages is assembled, it becomes clear that these devices were in use over most of northern New Zealand. Apart from Otakanini, the Bay of Islands, and Mercury Bay, descriptions of them have survived for Hawkes Bay (Banks *in* Morrell, 1958, p. 147) and Queen Charlotte Sound (Becket, 1967, p. 98, for Cook's First Voyage).

Recorded palisade heights range from 7 feet (by Crozet—above) to 20 feet (Becket, 1967, p. 98). Layouts vary considerably according to the topographical position of the *pa* and the number of separate banks and ditches. Best (1927, p. 46) records an additional and important piece of information, although he does not quote any sources for it. The strong posts supporting the palisades were set on the outside of the *pa* (nearest the enemy). Horizontal rails were then lashed to the inside faces of these posts, and the thinner posts forming the body of the palisade were set inside the rails. There was a very good reason for this method, as described by Best (1927, p. 117). Attackers, using an instrument called *rou,* consisting of a wooden bar attached to a rope, could easily pull off the more flimsy palisade posts when this instrument was thrown over the defence and pulled on by a number of men. If, however, the larger posts and the horizontal rails intervened between the attackers and the smaller palisade posts, then the *rou* would be unable to function with so much effect. Following Best's illustrations (1927, fig. 43), the

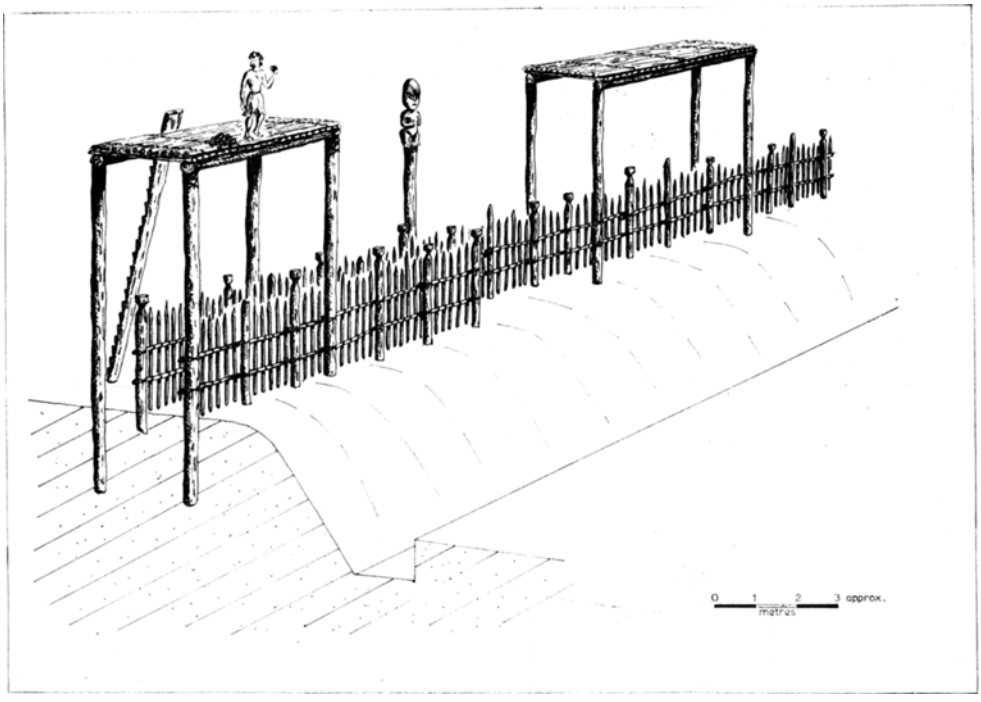

FIG. 11.—A reconstruction of the period III defences in trenches G104 to G109.

palisades have been reconstructed as shown in Fig. 11. This reconstruction is not meant to be, and cannot be, of 100 percent accuracy.

Mr R. G. Law kindly examined the ability of the Otakanini large posts to withstand attempts to pull them over, and his finding sare presented in the Appendix. On average, it would have taken 25 men hauling on a rope of 3-3½ inches circumference to pull down one of the main posts. In view of this, it is hardly surprising that the palisades showed no signs of forcible removal, and to storm the *pa* by this method would have been very difficult indeed.

Post-holes for palisades have been found in other New Zealand excavations, but without indication of fighting stages. At Kauri Point (Ambrose, 1962, p. 60), four large post-holes 10-12 feet apart were excavated along the summit of the period 2 bank, this bank being behind a flat-bottomed ditch 6 feet wide at the base. The spacing of the post-holes and the width of the ditch correspond well with the figures for Otakanini, and Kauri Point is a *pa* of the rectangular ditched type similar to Otakanini, which will be referred to again below.

THE OTAKANINI SEQUENCE AND ITS INTERPRETATIONS

This discussion takes as its starting point the tripartite classification for New Zealand *pa* published by Groube (1970). The three classes are as follows:

Class 1—*pa* with terraces only.

Class 2—*pa*, usually on promontories or ridges, with terraces, and one or more transverse ditches barring the route of easiest access, which in all cases is narrow.

Class 3—sites defended by ditches and banks on more than one side, usually delimiting a flat rectangular or sub-rectangular interior. This class has two subgroups:
Subgroup 3a—without associated terraces.
Subgroup 3b—with associated terraces (this group includes Otakanini).

Groube's Class 3 *pa* correspond to those grouped in Golson's 1A (ditched) and 2C categories (Golson, 1957, p. 73). Otakanini, Kauri Point, and Kumarakaiamo are all of this type, and the following discussion is within the context of Groube's Class 3.

Firstly, a review of the Otakanini three-period sequence is necessary. Period I comprised the rectangular storage pits in area A and the earliest terrace and possible palisade in G110–114; there is no evidence for a ditch and bank defence. The evidence suggests that the period I *pa* included both areas A and B and that the scarp defence running the whole length of the western side of the *pa* belongs to this phase.

Period II saw the division of the *pa* into areas A and B, with the construction of the period II defence across the south side of area A. This defence comprised a bank and fighting stage; if any ditch ever existed here it has been completely cut away by the period III ditch.

Period III witnessed the rebuilding of the palisade and fighting stages at the south end of area A and the dumping of extensive midden deposits along the western side of the *pa*.

The Otakanini sequence can be compared with sequences from two other *pa* of Groube's Class 3—Kauri Point (Tauranga) and Kumarakaiamo (North Taranaki). Excavations at the latter site yielded seven periods of occupation, the first four belonging to a terraced settlement area—possibly a *pa* of Groube's Class 1. In period V the site was modified into a *pa* of Groube's Class 3b, with a bank and ditch around the two sides of easiest access, a palisade along the inside of the bank summit, and a material culture including Duff type 2B adzes (Duff, 1956, p. 167). No carbon-14 dates have been published for the site, but 2B adzes are regarded as Classic Maori by Golson (1959). Although only preliminary reports have

appeared on the Kumarakaiamo excavations (Parker, 1962; Buist, 1964), the data recovered indicate replacement of an earlier Class 1 *pa* by a later *pa* of Class 3.

Excavations at Kauri Point (Golson, 1961; Ambrose, 1962) have yielded a five-period sequence, of which the first phase is unconnected with evidence for defences of any kind. In period 2 an area of at least 130 by 50 metres was defended by a bank and a 2-metre-wide flat-bottomed ditch, with palisade post-holes referred to above (Ambrose, 1962, p. 60). The construction of this ditch is bracketed by two carbon-14 dates of A.D. 1455±100 (ANU–25) and A.D. 1555±53 (ANU–46b—Polach *et al.*, 1967, 1968). On circumstantial evidence, it is possible that a number of terraces at the west end of the site belong to period 2, but the excavators were unable to demonstrate this (Ambrose, 1962, p. 65). In period 3 the defences apparently remained unaltered, but in period 4 the site was reduced to half its size and defended by a new bank and ditch. This may represent construction of a "citadel" within the earlier defences, as at Otakanini. In period 5, the period 4 defence of Kauri Point was remodelled into a double ditch and bank.

Further information is available from excavations at Ongari Point, a possible Class 3 *pa* close to Kauri Point in the Tauranga Harbour (Shawcross, 1964a, p. 92). Here, four phases of pit construction, with no evidence for defences, preceded the construction of a ditch and bank defence round at least the south-eastern end of the site—the only end where excavations were made on the defences. This period of construction seems to be associated with levelling and a cessation of storage-pit construction.

The general sequence of structural changes visible at the four above sites indicates that:

(a) Terraced structures or undefended sites precede the Class 3 *pa* at Kauri Point, Ongari Point, and Kumarakaiamo, although the period I defence at Otakanini is of Class 3 type, rather more amorphous than the two later Class 3 rebuildings.

(b) The *pa* of Class 3 were in use in each case to the end of site occupation, in each case possibly into the early nineteenth century.

(c) Available carbon dates for Kauri Point and Otakanini suggest construction of the main Class 3 defences in the fifteenth or sixteenth centuries, although the earlier period I defence at Otakanini might be viewed as a purely scarped version of a Class 3 *pa*.

Reasoning from the distribution of Class 3 *pa* and genealogies, Groube (1970) has suggested a novel historical role for *pa* of this class. The areas of distribution are almost exclusively self-contained, and three in number—firstly, the west coast of the north Auckland Peninsula from the Hokianga Harbour to the Kaipara (this area includes Otakanini); secondly, the southern Bay of Plenty from the Tauranga Harbour to Opotiki (this area includes Kauri Point and Ongari Point); and thirdly, the Taranaki coast from the Mokau River round to Wanganui (this area includes Kumarakaiamo). Groube's conclusions are as follows (1970, p. 155):

> "The earliest fortifications, relatively simple terraced structures (classes 1 and 2), became widespread throughout the North Island. In one region, the Northwest Coast, where warfare became particularly intense (the 'Awa period') a new style of encircling ditch fortification was developed (class 3). With the eventual expulsion of some of these Northerners the form was 'exported' to already settled regions, the Southern Bay of Plenty and Taranakai. . . . The successful transplanation of the northern Awa people into these regions can be conveniently explained by the new fort style, although at the present moment there is no evidence that it was, in fact, more efficient. In the areas of primary intrusion, Whakatane (Bay of Plenty) and Northern Taranaki, fighting and absorption with the original population involved the modification of many existing terraced forts to the Awa pattern, giving rise to the clumsy but spectacular class 3b forts. In the Whakatane Valley . . . some of the named sites traditionally associated with the Ngati Awa expansion can be identified as class 3b fortifications."

If Groube's hypothesis is correct, then the northern region between Hokianga and Kaipara should be the original home of the Class 3 fort, and genealogical evidence suggests that the expansion may have taken place in the late fourteenth and early fifteenth centuries. It is therefore most interesting that both Kauri Point and Otakanini should give evidence for Class 3 *pa* constructoin at this general time or a little later, but full verification of Groube's theory must await results from more excavations than those carried out to date.

OTAKANINI AND THE NGATI WHATUA

Traditions concerning the migrations of the Ngati Whatua people from the area of Kaitaia southward to the Kaipara have been recorded by S. Percy Smith (1896). More specific traditions relating to Otakanini have been recorded by Smith (1895) and by Graham (1918). Two tribes dominated the South Kaipara area prior to the arrival of the Ngati Whatua, namely the Kawerau tribe along the coast from Kaipara South Head to the Manukau Heads, and the Wai-o-hua tribe in the south-eastern Kaipara area extending into the Auckland isthmus. From Smith and Graham the main points of Otakanini traditional history may be reconstructed as follows:

1. Before c. 1625–1650 Otakanini was occupied by either the Wai-o-hua or the Kawerau tribe.
2. Ten generations before 1895 (c. 1625–1650) a Ngati Awa warrior from Waitara, New Plymouth, named Maki, visited Otakanini and after a quarrel with Hauparoa, the resident chief, expelled the latter. The tribal identity of Hauparoa is not very clear, but it appears that he was either Wai-o-hua or Kawerau. Maki's descendants occupied Otakanini until the Ngati Whatua conquest, although how many of the inhabitants were of direct Ngati Awa descent is unknown.
3. Seven generations before 1895 (c. 1700) a force of Ngati Whatua under a warrior named Hakiriri attacked and took Otakanini.
4. The *pa* was occupied as a defended site by Ngati Whatua until c. 1825, when a second *pa* was constructed on a nearby hill to withstand musket warfare. This second *pa* still stands in excellent condition, and is now used as a burial ground.
5. In 1841 the Ngati Whatua rebuilt one of the two *pa* (which one is not certain), against a threatened incursion from the Waikato. The excavations on the older *pa* described in this report showed no sign of any rebuilding which could be as late as 1841.

The main task of this section is to try to correlate archaeological and traditional evidence and carbon-14 dates. The archaeological evidence may be summarised as follows:

Period I —*Pa* of Groube's Class 3, with a single date of A.D. 1351±78.

Period II —*Pa* of Groube's Class 3.

Period III—*Pa* of Groube's Class 3, with dates of A.D. 1561±48 and 1493±49.

Although the traditions do not state for how long the Wai-o-hua or Kawerau had been at Otakanini before the arrival of Maki, the date for the period I defences suggests, on circumstantial grounds, that these belonged to one or other of these tribes. The two dates for period III are rather old for either Maki or the Ngati Whatua, but although both of these are from stratigraphically secure contexts there is a high possibility that they have been calculated on heartwood, and may be older than the events with which they are associated. It would not be exceeding the bounds of interpretation of carbon-14 dates to suggest that the period II defences were constructed by Maki, and the period III defences by Hakiriri and his

Ngati Whatua. Groube's suggestion that the Ngati Awa developed the class 3 *pa* becomes very reasonable when the evidence is interpreted in this light.

It might also be that the traditional dates, calculated on a 25-year genealogy, are too short. Roberton (1956) has shown that related genealogies can be correlated satisfactorily if one is prepared to adopt a varying generation length, although in a case such as this it would be unsound to manipulate genealogies to correlate with archaeological evidence. There is no *a priori* reason why any of the archaeological rebuildings should correlate with traditional events at Otakanini, but if one is prepared to follow a slightly unscientific hunch, the following tentative correlation may be suggested.

1. Initial construction of a Class 3 *pa* by Wai-o-hua or Kawerau.
2. Modification of the site into a Class 3 citadel with annex by a Ngati Awa group in the early seventeenth century.
3. Further modification of the Class 3 citadel by Ngati Whatua in the later seventeenth century.

The uncertainty behind this reconstruction needs no emphasis, but further information on the period of Ngati Whatua conquest in the South Kaipara area may lie in the analysis of data from the *pa* at Waioneke, excavated by Groube and McKinlay in 1969 (McKinlay, 1971).

PORTABLE ARTEFACTS

Portable artefacts found were few and all of stone, except for one bone fishhook. Descriptions of each artefact are presented below, all those known to be diagnostic belonging to Golson's Classic Maori period (Golson, 1959). Dr R. N. Brothers of the Department of Geology, University of Auckland, kindly examined the stone material under a hand-lens and his identifications are incorporated.

1. *Patu* (Fig. 12)

Recovered during removal of the baulk between G107 and 108, from just beneath topsoil, where it must have been deposited in period III or later. The butt is unribbed, plain, and transversely flat. The whole surface of the implement has received a fine, smooth polish. The break across the blade is ancient and the sharp rounded end, the working end of the weapon, has not been recovered. *Patu* are considered Classic Maori by Golson (1959, p. 48).

The material is greywacke, of Jurassic Age, and boulders of this material are found in Tertiary conglomerates around Albany, 20 miles south-east of Otakanini. This is the nearest and most likely source.

2–8. *Adzes* of Duff type 2B (Duff 1956, p. 167) (Fig. 12).

All these are of andesite, which probably comes from the series of late Tertiary igneous rocks extending from the Manukau Harbour to the south-eastern Kaipara, through Helensville (see Fig. 1). Other outcrops of the same series occur on the Hukatere Peninsula in the north-eastern Kaipara area. Dimensions are given in Table 2.

TABLE 2.—Dimensions of Adzes from Otakanini

No.	Type	Length (mm)	Thickness (mm)	Width, cutting edge (mm)	Width, poll (mm)	Cutting edge angle (degrees)	Bevel length (mm)
2	2B	117	32	58	38	50	30–50
3	2B	—	22	56	—	45	20
4	2B	52	14	40–45	30	46	16
5	2B	—	over 22	—	21	—	—
7	2B	121	30	60	31	60	30

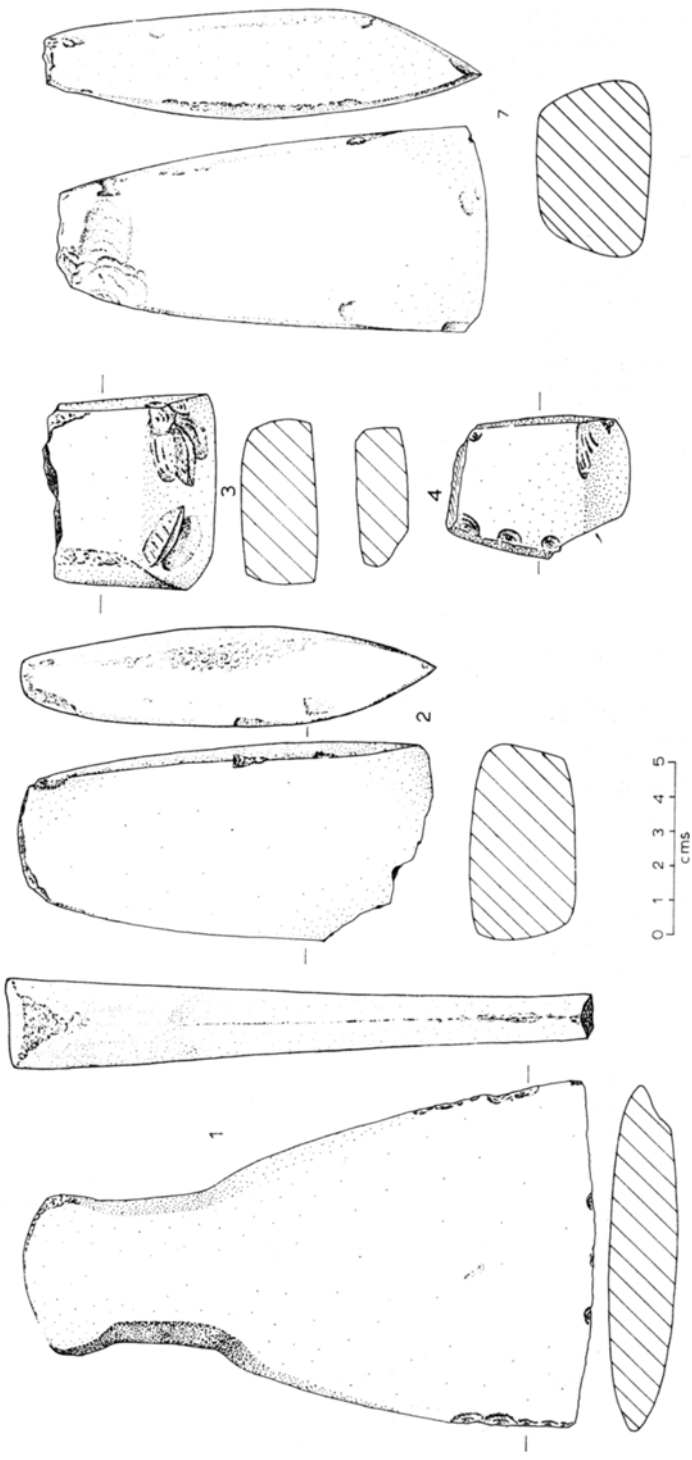

FIG. 12.—Artefacts from Otakanini, numbered as listed in text.

2. Polished 2B adze with asymmetrical bevel running at 60 degrees to the longitudinal axis of the adze, instead of 90 degrees, owing to resharpening. This was a surface find, dragged up by the tractor in backfilling (Fig. 12).
3. Adze, 2B, broken close to blade. This is of laminated and poor quality stone, accounting for the chips on the cutting edge, and presumably its breakage. The cutting edge shows a series of shallow close-set striations running at right angles to the line of the edge, which could have been produced by cutting wood. From a hearth on top of layer 7, recovered during removal of the baulk between G107 and G108, and hence of period III (Fig. 12).
4. 2B adze, almost complete, with slight use wear along edge. Polished all over. Surface find (Fig. 12).
5. Adze butt, 2B, not drawn. Hammer-dressed and slightly polished. Surface find.
6. Flake of a 2B adze, not drawn. Flake surface polished slightly, and polish along one edge suggests re-use as a type of scraper. No striations observable on cutting edge. Surface find.
7. Complete 2B adze from base of post-hole C in G102. Polished all over, edge shows no sign of use whatever, suggesting that the adze was deposited as an offering. Stratigraphically, this adze belongs to period III (Fig. 12).
8. 2B adze from post-hole C in G102, found with 7. Unfortunately this was mislaid during the moving of equipment in the Anthropology Department at Auckland University.
9. A polygonal grinding stone of Waitemata sandstone, which outcrops commonly along the south-eastern side of the Kaipara Harbour. This has five polished facets, one deepening markedly along the centre-line, indicating that an object was polished or sharpened with a two-and-fro movement. A sixth facet has four deep grooves 5–7 mm apart and 1–2 mm deep. These may have been formed by the sharpening of pointed instruments. The stone was found in the fill of *rua* R1 in J103, area B, and cannot be stratigraphically placed in relation to the three-period sequence.
10. Flake knife, or drill point, retouched along two sides, from period III post-hole *ac* in G107. The working edge is indicated by the arrows in the drawing (Fig. 13) and shows a small polished facet with no striation. The implement may have been used for scoring, cutting, or drilling some soft material. The direction of the flaking blow runs transversely across the flake, so that length is 30 mm, and width from butt to point is 65 mm. The thickness is 12 mm, width of striking platform 10 mm, angle of striking platform 130 degrees.

    The material is a baked mudstone, which may come from the vicinity of the igneous deposits on the Hukatere Peninsula on the north-east side of the Kaipara Harbour. This area was the source for the dacite rubber (11), and possibly for some of the adze materials.
11. Slab of dacite, from igneous outcrops at Tokatoka on the north-eastern side of the Kaipara Harbour some 30 miles from Otakanini by canoe. One side is polished smooth, so that this had evidently been used as a rubbing stone. Surface find.
12. Six chert flakes, found in topsoil in trench B1 at south end of area B. The chert probably comes from siliceous concretions in Cretaceous–Eocene limestone deposits on the east side of the Kaipara Harbour. Most of the flakes seem to have been snapped and show little sign of use. Only one, drawn in Fig. 13, shows any sign of secondary retouch, having small flake scars on either side of a crude point (see arrows for direction of flaking). However,

this shows no sign of use. The flakes do not have well defined flake surfaces and possibly they were picked from the surface in the hope that they would prove serviceable as tools. Evidently they were of no service, despite crude attempts to modify the example drawn, and were discarded together.

13. Point of a composite fishhook, made from the canine tooth of a dog and notched down the anterior surface of the root for attachment to a shank (Fig. 13). Length 37 mm—the dentine portion is unmodified. This came from the base of a post-hole in K103 (post-hole *z*—Fig. 10), and is stratigraphically unplaced. The base of the tooth has a small flat facet for junction with the shank. Morphologically, the point is close to Hjarno's type C.1a category of composite bait-hook points—these are slightly curving unbarbed points with basal notches (Hjarno, 1967, p. 24). Hjarno is unable to specify a date range for this type in southern New Zealand since the type is easy to make and widespread. Shawcross and Terrell (1967: 12) describe simple or barbless points for composite fishhooks from the Classic Maori–European sites of Oruarangi and Paterangi on the Hauraki Plains. These appear to be all of shell or dog jaw—no examples of dog canine are described, although they were used on the site for barbed points.

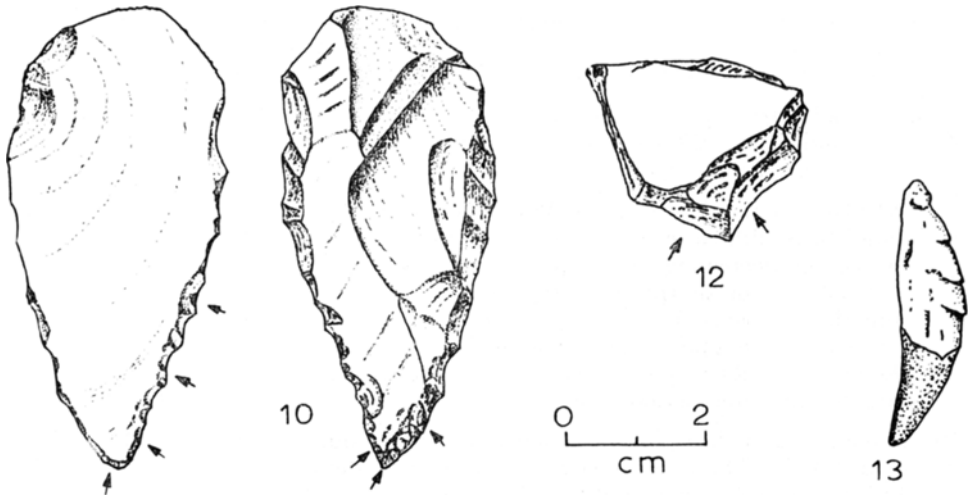

FIG. 13.—Artefacts from Otakanini, numbered as listed in text.

Three conclusions can be drawn from the Otakanini artefacts:

(a) All diagnostic artefacts are Classic Maori.

(b) No raw materials (except obsidian—see below) need have been obtained from a distance of more than 30 miles from Otakanini, and most can be found a good deal closer. Furthermore, most sources could have been reached partly by canoe across the harbour.

(c) All stratigraphically placed artefacts are from period III deposits.

The Obsidian Industry

Twelve flakes of obsidian were found during the excavations; all have been analysed for source determination by Miss G. C. Armitage and Dr R. Reeves of Massey University, and the results are: Great Barrier, four pieces; Huruiki, three pieces; Mayor Island, two pieces; and three pieces which could not be identified. Considering that only 12 pieces were found, the results show how complex the pattern of diffusion of obsidian may be expected to be (Armitage, Reeves and Bellwood, in press).

All the samples are from the area B excavations and are either from topsoil or from the base of the topsoil in association with a scatter of shell midden. Hence they are presumably contemporary with the utilisation of area B, but since this area cannot be placed stratigraphically, their position in the site sequence is unknown. Although only twelve in number, these pieces suggest that some obsidian-working was being carried out in area B, but no cores were found and so it is possible that they were imported already as flakes. Some of the pieces are broken unused flakes, suggesting that at least some modification took place on the site.

Studies of North Island obsidian industries have been made by Shawcross (1964b) and Bellwood (1969b). However, the Otakanini assemblage is too small for useful comparison and is most profitably viewed as a facet of on-site activity. Records of dimensions, cutting-edge angles and other details have been kept by the author.

CONCLUSIONS

The excavations at Otakanini took place mainly along the line of the southern defence of area A, and have revealed three periods of construction. During period I terrace defences with palisades were constructed and storage pits constructed within the *pa*. The long high scarp which runs along the western side of the site runs from area A into area B in a straight line, indicating that it was built in one operation. The earliest terrace discovered in G111 belongs to this scarp, and this suggests that the period I defences surrounded the whole area of the *pa*. Indeed, before the construction of the southern defence of area A (in period II) they must have done so, because the south end of the *pa* would otherwise be open to attack.

In period II the southern defence of area A was constructed, dividing the *pa* into the two units A and B. This period may be associated with a Ngati Awa element from Taranaki.

The period III defences may have been built by the Ngati Awa against attacking Ngatiwhatua, or perhaps by the Ngatiwhatua after they conquered the *pa* in the seventeenth century. The fighting stages of period II along the south side of area A were removed and new ones erected. A deep ditch was also added to this defence. Outside the defences, terraces and a latrine of period II were covered by large deposits of shell. These defences decayed *in situ* and no other reconstructions were carried out in this area of the *pa*.

Available economic evidence suggests that the *pa* was utilised all the year round, although there is no certainty on this point. Diet consisted mainly of shellfish, fernroot, and *kumara,* with some fish, and perhaps dog and rat. (See Bellwood, 1971a, for details on economy.)

The main contributions of the excavations lie really in the light they have thrown on techniques of prehistoric Maori fortification. The isolated nature of New Zealand in prehistory means that these findings are unlikely to be of direct cross-cultural value, although it is hoped that they will be of interest to students of earthwork fortifications elsewhere.

ACKNOWLEDGMENTS AND NOTES

Otakanini was selected for excavation in 1968 by Mr L. M. Groube because of its historical importance. Mr Groube directed excavations over Easter 1968, after which the author continued as director until July. Altogether, about 30 days were spent on the site, with an average of 20 volunteers from the University of Auckland Archaeological Society.

The author would like to express thanks to Mr Groube, and also to Mr Maki Moki, one of the owners of the land, who made the excavation possible. The Ngatiwhatua people of Otakanini gave welcome moral support during the excavations. Finally, Mr K. M. Peters drew all the illustrations, except Fig. 11, which was drawn by Miss Christine Thomson.

The small finds and records of the excavation are held in the Department of Anthropology, University of Auckland.

The grid reference of the site on the Lands and Survey 1 inch map, N37, is 919868. The site is N37/37 in the N.Z. Archaeological Association site-recording scheme. The sites plotted in Fig. 1 have been taken from N.Z. Archaeological Association Site Recording File and records made by Mr K. M. Peters during a recent survey of the North Kaipara Peninsula. The distribution may not be complete, as there may be hitherto unrecorded sites.

APPENDIX

THE CAPACITY OF THE PERIOD III DEFENCES TO WITHSTAND ASSAULT

by R. G. LAW

The main structural elements of the period III palisades in G100–109 are the large post-holes lettered A to N (Figs. 3, 4). Although these were once joined into a single defence by means of the intermediate smaller posts, it is now impossible to estimate the actual strength of this defence. However, since these intermediate posts appear to have been rather flimsy, it may be assumed that the strength of the palisades and stages was little more than the strength of the individual major posts. Accordingly, a statistical mean post with a mould size of 38 centimetres diameter, and a depth below the existing ground level of 131 centimetres, was analysed to determine its resistance against a team of men trying to pull it down with ropes. This method of attack is described by Best (1927, p. 117, fig. 43), who tells how the palisades might be pulled down with a machine called a *koromahanga* or *rou*:

> "This latter engine consisted of nothing more than a short stout wooden bar with a long and strong rope attached to the centre of it. The bar was thrown over the top of the stockade, and, on the rope being pulled taut, the bar would usually catch against the inner sides of the stockade timbers, in a more or less horizontal position, at the top of the upper rail. Then, while a number of assailants endeavoured, with long spears and stones, to prevent the garrison cutting the rope, a large number of men 'tailed on' to it, and, hauling vigorously to a chanted time song, they tried to pull down the stockade."

Since the palisades were lashed on the inside of the horizontal stringers, and since the latter were in turn lashed to the inside of the main posts, it follows that in order to pull over the palisades, the main posts must also be pulled over, since the construction of the defences throws most of the pull of the *rou* on to these main posts. Best records that they were often weakened by tunnelling along their bases, although there seems little reason to assume that this sort of activity took place in prehistoric times.

The statistical mean post would be susceptible to two types of failure in the ground: failure by bending, and failure by being pulled out.

Failure by Bending or Breakage

In this case the elasticity of the pile in relation to the ground is a relevant factor, as this controls the depth at which the maximum bending moment occurs. Bergfelt (1957, p. 10) states that when a pile length is less than $1.5\,[(4EI)/kB]^{1/4}$ the pile may be regarded as infinitely stiff. (E, modulus of elasticity; I, moment of inertia of the pile; k, modulus of soil reaction; B, width of pile). Taking reasonable values for E and kB, and calculating I for a 38 centimetre diameter post, this critical length is far in excess of the lengths of these palisade posts below the ground. Thus the rigid case holds, of calculating the maximum moment as the load by the distance above ground, plus one-third of the depth below the ground.

The ultimate moment of resistance is fI/r, where r is the radius of the post. Using a modulus of rupture (f) of 3.5 kg/sq.mm, which is a reasonable average for an unseasoned softwood, this ultimate moment is 19 200 kg metres. Thus for a palisade 2 metres high, the load required to fail to the post by pulling at the top is 7900 kg. However, unseasoned timber rots very rapidly, especially just above ground level, so that this value could be halved in a matter of 10 to 20 years. Nevertheless, using estimates given above, it would take over 50 men to exert a pull of 7900 kg, and it therefore seems very unlikely that the posts could ever have been broken, unless rotten.

Failure by Pulling Out

To calculate the pull-out load of a pile, Osterberg (1954, p. 36) gives the formula: $P = BD^2S/(2.36D+2.64H)$, where D is the pile length, H the height above ground, S the ultimate bearing stress of the ground, giving P, which is the failure load applied to the top.

The most critical material around the posts is the bank build-up, which is estimated to have an ultimate bearing stress of 40 000 kg/sq.m. For the 2 metre palisade considered earlier, the calculated load is 3000 kg. The variations in the figures for pull-out and breakage, according to the height of the palisade, are shown in the following table:

Palisade Height	Post Failing	Foundation Failing
2.0 metres	7900 kg	3000 kg
2.5	6500	2600
3.0	5600	2300
3.5	4900	2100

As some assumptions are involved in these calculations, and as the strengths of the natural materials vary greatly, these figures should be treated cautiously. In both cases it may be seen that there are disadvantages in building palisades too high, as they are more vulnerable. However, taking the lowest load in the above table, 2100 kg, for a 3.5 metres palisade, one may note that a modern hemp rope to take this load would need a circumference of some $2\frac{1}{2}$ inches. Prehistoric flax ropes would probably need a circumference of at least 3 to $3\frac{1}{2}$ inches, and ropes of this size would take a great deal of time to make. Assuming a good rope were available, and assuming that, with good footing, fit men of about 70 kg weight could pull twice their own weight, then it would take a team of some 25 men to pull 3500 kg—a sufficient force to pull over a post with some ease. However, since the posts were joined as a palisade, it may be that rather more force would be needed to rip them from their lashings.

Conclusions

It would require about 25 men to pull one of the Otakanini III major palisade posts from the ground. They would need a rope of at least 3 inches diameter, which they would need to attach to the palisade by means of a *rou* or a noose, and they would need to be protected from attack from within the *pa* while engaged in this activity. The strength of the palisades would decrease with time, but unfortunately it is impossible to estimate the time lapse between the periods II and III construction phases. The Otakanini posts never were pulled out horizontally; although it may be that no one ever tried to pull them out.

The Otakanini defences must have been built according to a design agreed upon by the society wishing to defend itself, and the builders must have had some idea of the type of opposition that the *pa* would have to withstand. As has been shown, 25 men would be required to effect an entry by pulling down the defences, and perhaps 25 others would be needed to cover the rope party. If the *pa* were fully defended, then a war-party of perhaps 50 men would be needed before an attack could hope to be successful, and it is of interest in this regard that Vayda (1960, p. 32) reckons the fighting capacity of the *hapu* (subtribe) to be between 50 and perhaps 400 men. Archaeological evidence from Otakanini can thus be used to give some independent confirmation to Vayda's minimum figure, since a war party of under 50 men would have little chance of success against a fully defended *pa* such as Otakanini. Foraging parties may have been smaller, however, and the calculations only refer to the specific case of a seige party.

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