THE MAORI ADZE: AN EXPLANATION FOR CHANGE

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For many years the study of stone adzes has been an important aspect of archaeological research in the Pacific. The reasons are clear: the adzes, having been a necessary part of Polynesian life, are numerous, contain a great deal of information for the culture-historian, and are extremely durable, often the only aspect of material culture that survives.

In New Zealand, over 200 years has elapsed since the first Maori artefacts reached European hands. In 1912 Elsdon Best's comprehensive description of most of the adze forms present in New Zealand was published,[1] however, Best made little attempt at classification, and made no mention of location. In 1938 and 1943 Skinner developed the first formal classification system, grouping the adzes of the southern half of the South Island into 10 types and 7 varieties.[2] Sixteen years later, Duff[3] set up a typology which described adzes of any Polynesian group; in so doing he rearranged Skinner's categories into 5 types and 15 varieties. Since then only Simmons[4] has proposed an alternative typology, containing 22 forms, in an attempt to include adze forms that were awkward fits in the previous typologies.

Indicated in the above classifications, and recognised long before, is a basic division of all New Zealand adzes. Only one of Duff's and Skinner's varieties or Simmons' forms is needed to describe most of the adzes from the North Island; the remaining categories apply mainly to South Island adzes.

This difference was first formally expressed in 1921, when enough evidence had accumulated for Skinner to suggest two main culture divisions in New Zealand.[5] These were the Northern and Southern Culture Areas, corresponding to the North Island and the South Island including the Chathams. The former exhibited a "lack of variety in adze forms, which tend toward Melanesian types", and the latter contained "a great diversity

1. Best 1912.
2. Skinner 1938, 1943.
3. Duff 1956.
4. Simmons 1973.
5. Skinner 1921.

of types of adze showing, however, an overwhelming predominance of Polynesian forms".[6]

Teviotdale, writing in 1932 about the southern half of the South Island, stated that "the difference between a group of Melanesian adzes and a group of adzes from Polynesia can be recognised at a glance. The adzes found in Moa-hunter strata can be nothing else than Polynesian".[7]

When Duff proposed his typology in 1950, the adze form previously described as "Melanesian" was more clearly defined, as having a rounded quadrangular section, a full polish and lacking a grip. Of this adze (Type 2B) Duff says ". . . it is virtually absent from the large Wairau collection [less than one percent], and also quite unknown in all demonstrable moa-hunter adze caches from the South Island".[8] He also remarks that "[the 2B type] probably covers eighty percent of all adzes in North Island collections".[9]

During the time span covered above, archaeological interest and activity had been concentrated mainly in the South Island, where large river mouth sites yielded spectacular cultural material, and where the association between man and moa showed that at least the early stages of the island's prehistory were well represented.

In the North Island there were indications of this early stage from surface finds, mostly from the Far North and the Coromandel Peninsula, but the relationship between these and the vastly more numerous 2B adzes was not clear.

In 1959 Golson produced the first comprehensive synthesis of the available cultural material from both islands, and looked at the evidence for culture change. Proposing the term "archaic" to replace that of "moa hunter" he noted that: "No archaic adzes appear to have been seen in use by early European visitors."[10] In this connection, an archaic adze, Duff 4A, hafted for Sir George Grey and held in the Auckland Museum, is lashed on in reverse, indicating either complete unfamiliarity with the tool or a sense of humour. However, two archaic adzes do survive today, with 18 and 20 generation time depths, that are treated as sacred objects by the tribes that possess them, and have been used for symbolic work into recent times (see below).

Referring to North Island adzes, Golson goes on to say: "The prevailing type, to argue from the few specimens illustrated or collected in use to the predominance of similar examples in North Island adze collections, would appear to have been a quadrangular-sectioned adze, without grip, the front wider than the back and fully polished on all surfaces".[11]

Few sites demonstrating occupation from "Archaic" to "Classic" Maori are yet known. Two that do so in the South Island are the sites of Kai-Kai's Beach, Otago Heads, and Little Papanui, Otago Peninsula. At the former

6. Skinner 1921:74–5.
7. Teviotdale 1932:103. Teviotdale has probably recovered more archaeological material from the ground than any other excavator in New Zealand.
8. Duff 1956:167–9.
9. Duff 1956:140. Adze classifications used throughout this article are those of Duff 1956.
10. Golson 1959:48.
11. Golson 1959:48.

". . . strata extend vertically from moa-hunter . . . to recent Maori"[12] and for the latter an "evolutionary sequence" has been proposed for an assemblage where the archaic adze forms of the lowest layer are replaced by the classic forms in the topmost layer.[13]

In the North Island no assemblages of adequate size have yet been found in stratigraphic sequence. Only occasionally have archaic sites been re-occupied in more recent times. Such a situation occurred at the site of Mt Camel (N6/4) where the lowest layer, producing a charcoal sample that gave an age of 690±44 B.P. (NZ 914A)[14] and stated by the excavator to represent the end of that occupation, contained only archaic adzes, while in the topmost layer, an agricultural soil in use in historic times, was found the butt section of a 2B adze.[15]

Most of the evidence for the separation in time of the two adze forms in the North Island comes from C^{14} dates. Sites containing archaic adzes almost without exception fall before 450 B.P. and most are considerably earlier. The only adze form found in sites with either recent C^{14} dates or with secure historical connections is the 2B (although within the limits set by this type there are marked regional variations). Time depth for this adze is as yet uncertain; the earliest recorded occurrence is at Otakanini Pa (N37/37), from an occupation layer that provided two wood samples, giving ages of 389±48 B.P. (NZ 1280A) and 457±49 B.P. (NZ 1281A). However, the excavator states: ". . . there is a high possibility that [these dates] have been calculated on heartwood, and may be older than the events with which they are associated."[16]

On the evidence available to him in 1959, Golson concluded: ". . . very real differences exist between Archaic and Classic Maori . . . [such as] . . . the evident replacement of the varied Archaic adze kit, characterised by a range of cross sections and typically with grip, by a standardised type with quadrangular cross section, all-over polish and no grip."[17]

There is an associated dichotomy in the materials from which the early and late adzes were made; fine-grained rocks, such as basalt or argillite, were used for the early adzes, while more granular materials, such as gabbro or sandstone-greywackes, were used for the later tools. Examination of adzes from early sites, and of typologically similar specimens in museum and private collections, indicates that nearly all such adzes are indeed made from these fine-grained rocks. Reference to this situation in the South Island has been made by both Duff and Skinner.[18] In the North Island it is becoming apparent that a fine-grained basalt from a quarry on the Coromandel Peninsula, together with an argillite of as yet

12. Lockerbie 1959:79.
13. Simmons 1973.
14. Shawcross 1972:605. Radiocarbon dates are set out as advised by the New Zealand Radiocarbon Laboratory. NZ C^{14} numbers have letter postscripts of either A, B, or C, corresponding to old half-life, new half-life, or new half-life with secular correction, respectively, in years B.P. (before A.D. 1950).
15. Roe 1969:11–13.
16. Bellwood 1972:282.
17. Golson 1959:62.
18. Duff 1956:140–1; Skinner 1938.

unknown provenance, was the stone used for almost all of the adzes in early sites, at least in the Auckland and Northland area.

The 2B adze, on the other hand, is seldom manufactured from such materials, and is common in gabbro, sandstone-greywacke and other coarse-grained rocks. This has been noted by Duff, who writes:

> Since becoming aware of the prevalence of Variety B in northern collections, I have noted few adzes of the type worked in basalt, argillite, palla or other fine-grained materials which fracture readily like flint, and can take on a subtle form with skilful flaking. The great majority appear to be worked in coarse-grained resistant materials, some sedimentary (such as greywacke), other in resistant plutonic rocks of the granite, diorite type.[19]

It would seem, then, from the above that at the beginning of New Zealand's prehistory one set of adzes in one kind of rock were being used, which by the time of contact had completely disappeared and been replaced by a different adze in another type of rock.

To account for the above changes is often described as one of the problems in New Zealand's prehistory. Attempted explanations have included the effects of raw materials, technology, trade, invasion and function.

The working qualities of the stone itself have long been invoked as an explanation for the different adze shapes. The so-called "intractability" of a coarse-grained resistant rock has been stated to govern the shape of the 2B or classic adze[20], while the easily-worked materials such as argillite are said to have resulted in more complex adze forms.[21]

Jones has suggested that the role of technology in the change may have been important. The spread of a sawing technique for handling "intractable" rock developed for working the hard, tough greenstones of the South Island is said by Jones to have enabled other non-flakeable rocks to be brought into use.[22]

The inferiority of the coarser material is emphasised in the trade theory.[23] This states that a breakdown of the widespread trading system of the early period may have cut off supplies from the few, widely separated quarries of fine-grained stone, forcing the use of previously ignored and largely local sources.

The introduction from outside New Zealand of the later 2B adze itself, or the idea of it, is a facet of the invasion theory that has hovered in the wings of New Zealand prehistory for many years. This approach is most fully set out by Keyes, whose working premise was "that change was stimulated by intrusive addition from outside rather than through internal design".[24] The 2B adze form is cited as being one of the Melanesian trait introductions that inspired "a cultural revolution" in New Zealand.

19. Duff 1956:165–6.
20. Duff 1959:133; Duff 1970:24, 42; Skinner 1943:67–8.
21. Skinner 1953:81.
22. Jones 1972:20.
23. Leach, cited in Cassels 1974.
24. Keyes 1967:48.

That "internal design" or local innovation may indeed have been connected with the change has been suggested. Hints of a functional basis for the adze shapes have been thrown out over the years. The possibility of the early types representing a canoe-building kit has been proposed by Simmons.[25] The rise of the 2B adze has been linked with the advent of agriculture, the tool being described as "an ideal forest-clearing and grubbing instrument".[26] The similar distributions of 2B adzes and kumara agriculture, storage pits and fortifications has been noted; the adzes are described as "more than likely developed as tools for gardening and digging pits and trenches, rather than as woodworking tools."[27]

Many of these theories underestimate the importance of the adzes themselves to a pre-metal society. Colenso recorded a saying: "Though the adze be small, yet does it equal a man",[28] an indication of the functional importance of the tool. It was, after all, a vital link between the Maori and his environment. Somewhere in the maze of measurements that can be squeezed from an adze are those that refer solely to its woodworking ability. If these can be isolated, and changes through time noted, then changes in function may be postulated. The relative strengths of the different rocks used as adze material should also be studied.

My study approached the problem on three fronts. Firstly, the relationship between adze form and function was examined. Secondly, the distribution in time and space of both a fine and a coarse-grained rock were determined, thus establishing different regional and historical preferences for the materials. Thirdly, strength tests were conducted on the two materials and some of their contemporary rivals, and on the adze forms studied.

THE FORM OF THE ADZE

Although the majority of work on stone artefacts in New Zealand has been concerned with classification, some functional studies have been made,[29] though these have been restricted to flake material only. The vast amount of literature stimulated by the adze has been concerned with typology and chronology. Although investigators acknowledge that the numerous observations and measurements must include some functional aspects, no attempt has been made to isolate these prior to analysis. If such an attempt succeeded, it would give added significance to the remaining information.

A study of the adze collection in the Auckland Museum suggested that three traits could account for a massive difference in function. These were (1) facial reduction or angle of butt; (2) cutting edge gouge or arc of the cutting edge; and (3) angle of attack or striking angle, the minimum angle at which the blade will bite into the wood.

The adze types selected and measured were those considered most

25. Simmons 1973:5.
26. Groube 1970:164.
27. Davidson 1971:32.
28. Colenso, in Best 1912:134.
29. Bellwood 1969:215; Roe 1967:64–6; Moorwood 1974.

representative of the early and late periods: Duff types 1A and 4A for the former, 2B for the latter.

The reduction or angle of the butt is a discontinuous variable: always present in the 1A and 4A adzes, never present in the 2B adze. Results of the other two measurements can be seen in Figure 1, where the 2B adzes cluster together with high angles of attack and a minimal gouge depth, while the 1A and 4A exhibit lower angles of attack and considerable gouge depths.

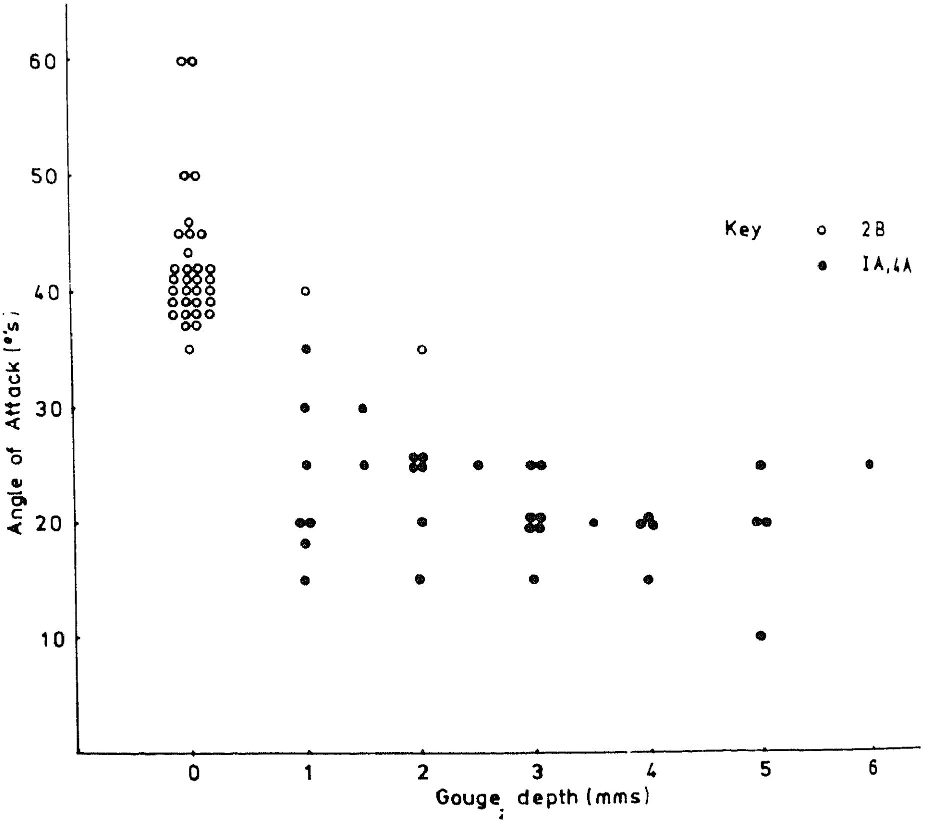

FIGURE 1
Angle of attack: gouge depth for Archaic and Classic adzes.

Function Tests

Three adzes from the Auckland Museum collection were selected and hafted. These were a 1A, a 2B from Northland (in which the cutting edge lay between the mid point of the adze and a plane projected straight along the face) and an equal-bevel 2B in which the cutting edge lay on the midpoint of the adze. These adzes had angles of attack of 20, 40 and 60 degrees respectively. Lengths of 15 × 5 cm rough-sawn green totara were then adzed with the implements. Results are shown in Plate 1.

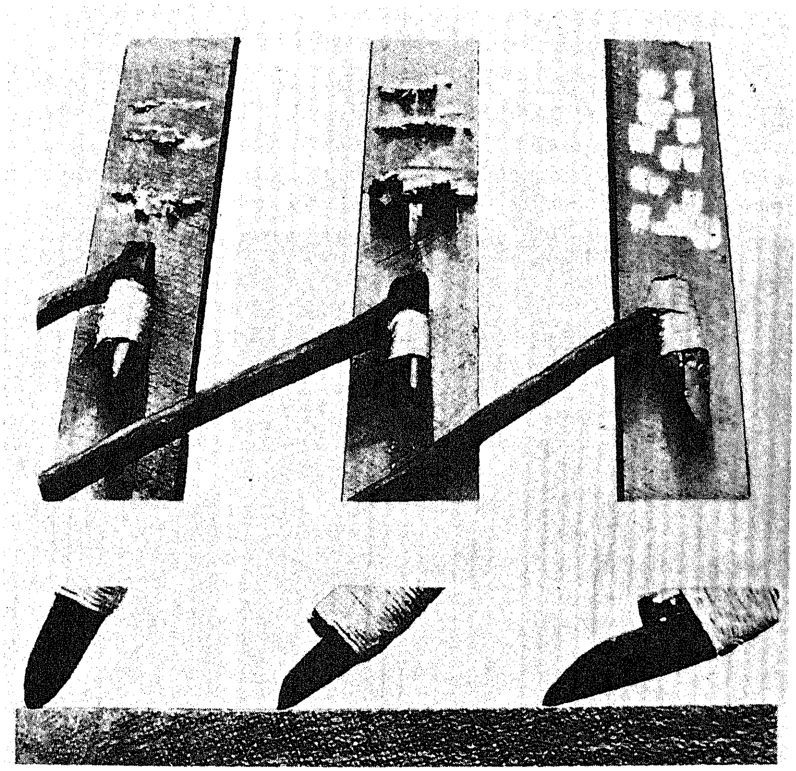

PLATE 1
Adze function tests: from left, equal bevel 2B, Northland 2B, and 1A.

The combination of low angle of attack, reduction or angle of butt, and some degree of cutting edge gouge, as clearly seen in the 1A adze, shows that this is a tool for slicing evenly into and out of the wood, removing a clean chip. The arc of the gouge acts as an aid to controlling the evenness of penetration throughout the stroke, and the reduction or angle of butt protects the lashing during the follow-through.

The Northland 2B adze, on the other hand, will not allow this type of adzing stroke. The shift of the cutting edge towards the midpoint of the adze results in a curved face, forcing the adze to enter the wood at a higher angle and with a chopping action. Once the adze has entered the wood the curve of the face acts as a fulcrum to lever the cutting edge up, splitting the wood for some distance ahead of the adze. Because of the high angle of attack, and therefore the inability of the adze to make a skimming stroke, the lashing is rarely in danger. On a normal sized adze, 15 cm long for example, the lashing may well come to within 7 cm of the cutting edge.

The equal-bevel 2B adze, with a 60 degree angle of attack was, not unexpectedly, impossible to use when hafted as an adze; it must fall functionally into the axe category and, as explained below, is most likely to have been hafted as such.

Stress Tests

The three adze shapes were then tested to find out how the stress incurred under work loading was distributed. Profiles of the adzes were cut from 4.6 mm Araldite C.T. 200 sheeting and stressed in an Instron Universal Testing Instrument, while being viewed through polarising screens (Plate 2). The black lines are contours of stress intensity.

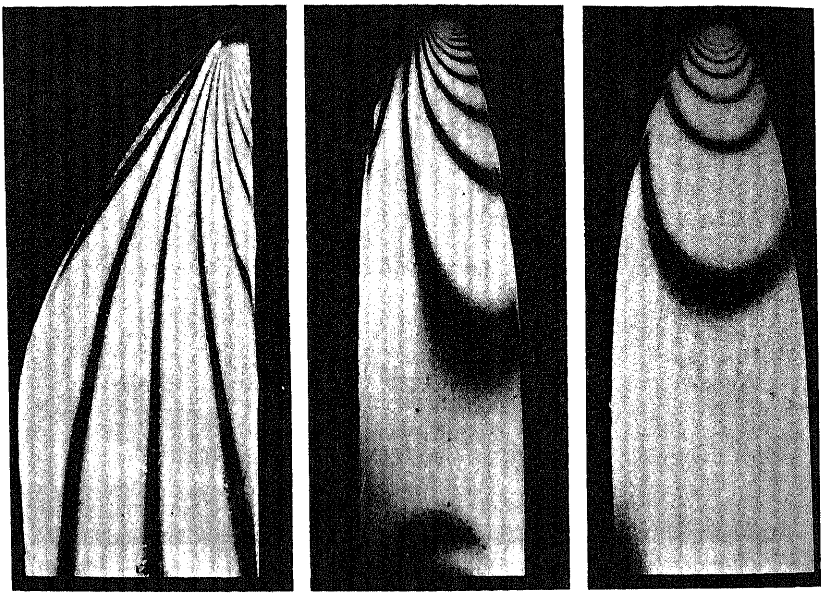

PLATE 2

Contours of stress intensity in adze forms: from left, 1A, Northland 2B, and equal bevel 2B.

As can be readily seen, the 1A and equal-bevel 2B adzes contrast most in performance; the Northland 2B is intermediate.

The equal-bevel adze is under almost pure axial stress. There is little tendency for flakes to spall off the cutting edge; rather a crumbling effect might be anticipated.

The 1A however is not under axial but bending stress, and is set for breaking in half. In addition, there is considerable stress set up on the cutting edge face, and thus a high probability of flake damage occurring.

The Northland 2B lies somewhere between the previous two; the possibility of flake damage at the cutting edge is lessened by the curving face, as is the tendency for the adze to break.

Conclusions

The tests indicate quite definitely the relative qualities of the adze shapes for working wood. The equal-bevel form is an axe, incapable of an adzing stroke, but very capable of absorbing shock with a minimum of damage. The 1A is unsuitable for such work and can only be effective if used in a skimming or shaving stroke, or at most with a very gradual entry into the wood, entailing a longer braking period. The Northland adze is a compromise, somewhat vulnerable to both flaking and breaking; however with its 40 degree angle of attack it is an extremely efficient tool for removing large amounts of wood from a face.

THE MATERIAL OF THE ADZE

Petrological study of stone tools has been employed in the service of archaeology for over 50 years.[30] Information arising from such studies has thrown light on trade, movement of people, site seasonality, and dating, both relative and absolute.

This study, however, used distribution patterns as a means for establishing, at certain points of time, the regional preferences for one rock over its competitors. The various materials were then tested for working qualities and performance. These results were then combined with the form and function tests before returning to the original question of changes through time of adze shape and material.

Fine-grained Rock: Tahanga Basalt

The source of this rock, Tahanga hill on Kuaotunu Peninsula, has been known for some time.[31] The rock was both quarried and obtained from boulders and talus slopes. An excavation has been carried out on one of the many talus streams used as a source for adze material,[32] and thin-sections have been studied of both quarry rock and adzes.[33]

During the course of this work a further source area was found. Recent erosion on a small rock-covered hill 150 metres east of Tahanga hill itself had exposed many hundreds of adze roughouts and flakes. A search of the end of the peninsula failed to reveal any further outcrops, and it is considered unlikely that any exist.

In order to establish the range of variation in the rock, and to be able to recognise the effects of different weathering on the adzes themselves, extensive thin-sectioning was carried out on quarry samples and archaeological specimens.

Characteristics and identification. Geological hand specimens vary in colour from medium grey to greyish black,[34] are fine-grained, dense and heavy,

30. Thomas 1923.
31. Shaw 1963.
32. Davidson nd.
33. Crosby 1963:47; Moore 1972:119–21.
34. Geological Society of America 1963.

and may show small phenocrysts. Archaeological hand specimens vary from the above, and from each other, because of burial in different soils for different lengths of time and also differential exposure to weathering processes such as sand-blasting. The colour of such specimens varies within limits set by the colours light grey, greyish-black, and dusky blue.

In a typical thin section the distinctive features are flow layering of the fine felspar laths, altered olivines with a reaction rim of opaques, a very fine matrix containing numerous small pyroxenes, and small opaques. Occasionally the flow layering may be absent, the olivines unaltered and the pyroxenes, felspars and opaques larger. The main body of the rock at the level exploited, on both Tahanga hill and the smaller outcrop, contains little variation. It would be reasonable to expect, from the preferential use of certain areas such as the main quarry, that a very large percentage of the artifacts in this material will demonstrate a small range of variation in thin section. This is, in.fact, the situation that occurs.

It must be mentioned here that although it is rare for relatively basic studies of thin sections to yield positive identification as to source, unless a unique feature is present, the growing amount of work on Tahanga basalt is indicating the soundness of such microscopic identification. Not only is the range of variation in the rock very limited, but also no comparable basalts have been described for the Auckland-Northland area, and, according to Moore, are extremely unlikely to occur.

Distribution in space. The distribution of Tahanga basalt, first established by Moore[35] and then supplemented by my own work, is shown in Figure 2. Some bias exists owing to the intensity of archaeological investigation of sites around the quarry itself. I also recognise that some locations may be inaccurate, a problem common to most museum collections of prehistoric material made from surface finds which were presented to or bought by the museum at varying periods after the initial discovery.

Distribution in time. Both C^{14} dates and typology indicate extensive and widespread use of Tahanga basalt in early times, and a marked reduction in its use during later periods. Adze forms most common in the material appear to be the 1A, 4A, 5, 3A, 3C and 2C, with the occasional small 2B also represented.

Not unexpectedly, early sites along the Coromandel coast, with C^{14} dates in excess of 400 B.P., contain quantities of the material: N44/2 at Tairua,[36] N40/7 at Skippers Ridge,[37] N40/9 at Sarahs Gully[38] and N44/69 at Hot Water Beach.[39] Undated sites with typologically "early" artefacts also contain large amounts of the basalt; Whiritoa N53/4[40] is an example.

What is surprising is the quantity of Tahanga basalt, and the high percentage of artefacts manufactured from this material, appearing in

35. Moore 1975.
36. Smart and Green 1962; Green 1967.
37. Parker 1962; Davidson 1974.
38. Green 1963.
39. Leahy 1974.
40. Crosby nd.

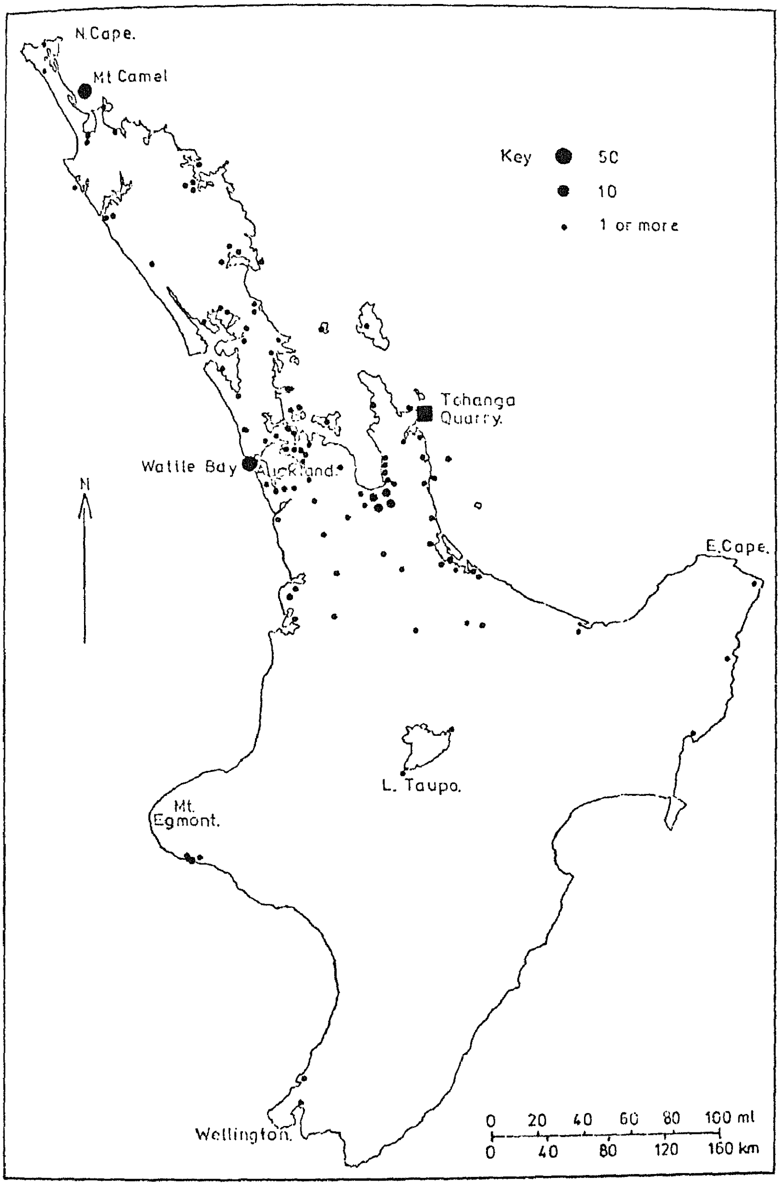

FIGURE 2
Distribution of artefacts in Tahanga basalt (after Moore 1975).

early sites at some distance from the Coromandel. Two of these have been identified: the Mt Camel site at Houhora, where the earliest date, from a charcoal sample, gave an age 796±56 B.P. (NZ 916A),[41] and the Wattle

41. Shawcross 1972:605.

Bay site (or sites) in the Manukau Harbour, which although undated has produced an artefact assemblage of very early appearance.

All 57 basalt adzes from the Mt Camel site now held in private collections north of Auckland were examined macroscopically and seven thin sections were taken. All 57 were identified as Tahanga basalt. The excavated material from the site, held in the Auckland Museum, was also examined. Thirty-eight thin sections were cut, two from fire-damaged flakes of a different basalt. All were identified as Tahanga, save the two fire-damaged flakes, which were similar to the local Mt Camel basalt.

Other artefactual material from the site was also examined, in view of the somewhat unexpected findings. The obsidian, combining colour in transmitted light and specific-gravity tests, was sourced as follows: 93.5 percent to Mayor Island, 1.5 percent to either Mayor Island or Kaeo, and 5 percent to Great Barrier, Whitianga, Taupo or Huruiki. The drill-point material from the site was identified as siliceous sinter. Both the geological history of the areas concerned and initial results from a new sourcing method indicate that the Coromandel Peninsula as a whole is almost certainly the source area; within this area the Kuaotunu Peninsula is the most likely source.(42) The argillite material used at the Mt Camel site was also sampled and was judged, on thin-section alone, to be different from the local rock.

Shawcross, in reconstructing the faunal environment of the Mt Camel area as it was at the time of the early occupation, described the snapper and shellfish population as virgin, and seals, moa and dolphins plentiful.(43) The presence, at such a place and at such a time, of a group of people whose stone resources appear to have been derived almost totally from the Coromandel Peninsula, some 320 km distant, may be of great significance regarding the pattern of early settlement in New Zealand.

Of more interest to this work, however, is that the inhabitants of Mt Camel had sited their camp directly in front of an outcrop of fine-grained basalt; however, this local source was apparently used only for *hāngi* stones.

The two Wattle Bay sites (N46–47/16 and 17, which may be contemporary)(44) have also produced large quantities of Tahanga basalt. A roughout and broken adze from N46–47/18 were sampled and identified microscopically as being from the Coromandel quarry, while over 50 adzes and adze fragments from N46–47/17 have been identified macroscopically as Tahanga basalt. A large amount of siliceous sinter and Mayor Island obsidian is also present at this site.

Two other excavated and dated sites outside the Coromandel area contained Tahanga basalt. From the Moturua Garden site in the Bay of Islands (N12/6+8) an adze butt, although unable to be tied in stratigraphically with the C^{14} dates for the site, was found in association with an obsidian flake whose hydration rim reading was practically identical to that of a flake found in the dated area. This flake occurred on the interface between layers 5 and 6. Two charcoal samples date these layers,

42. Best 1975.
43. Shawcross 1972.
44. Green 1970:22.

that from layer 5 giving an age 510±85 B.P. (ANU 543A), and that from layer 6 an age 720±100 B.P. (ANU 542A).[45]

From the excavated site of Kaupokonui (N128/3), near Hawera, two adze fragments were found to be of Tahanga basalt. The site has produced numerous remains of moa, dog and seal, together with artefacts such as a pumice reel, identical in shape to other stone reels from early sites. Again the artefacts are unable to be associated directly with the C^{14} dates; however, artefacts in the site were concentrated, with few exceptions, in the lower layers, and it is from these layers that the Tahanga material is considered most likely to have come.[46] A sample of bone, probably birdbone, from the lowest layer gave an age of 660±60 B.P. (NZ3934A), while a sample of moa tibia from the layer overlying this gave an age of 610±50 B.P. (NZ 3931A).[47]

To date few, if any, South Island assemblages have been examined for the basalt. Only one adze has been so identified, a 3C, in the Auckland Museum collection, originating from the Pareora River or Normanby No. 3 site (S119/2). There is little doubt as to provenance; the adze is described by the finder in his report.[48] The assemblage from this site, although undated, is assigned by Simmons through artefact typology to the earliest group of both his Canterbury and South Island divisions.[49] The distance of this adze from the quarry, some 1300 kilometres, is the furthest yet recorded for transport of the basalt. However, examination of South Island assemblages may be expected to reveal further instances, again with possible significance regarding early settlement throughout New Zealand.

Later sites containing Tahanga basalt are few and restricted almost entirely to the area close to the quarry. Even in these sites, the typical fully ground rectangular-section adze is extremely rare and most always under 7 cm in length. Opito site N40/73 contained two finished adzes, one of which was classified as a 2B, and this was 3 cm long. Two charcoal samples from the site produced the ages < 132 B.P. (NZ 904A), and <213 B.P. (NZ 905A).[50] From Red Mercury Island Moore collected a 2B adze blade. The site is undated.[51]

The sites of Oruarangi and Paterangi (N49/28 and N49/17) have produced what is potentially one of the most important collections of artefacts in New Zealand. However, the great bulk of the digging was done by amateur collectors; no stratigraphic records remain and, despite the rich collection from deposits up to 2.4 m deep, until recently there was no evidence of the site's age or time span.

According to Maori traditions, Oruarangi was occupied some 400 years

45. Peters 1975.
46. Personal communication.
47. These dates calculated with new half-life and secular correction are: 670±40 B.P. (NZ3934C) and 630±40 B.P. (NZ3931C).
48. Griffiths 1955:235.
49. Simmons 1973.
50. Bellwood 1969.
51. Moore 1972.

ago, and last used in the early 1820s.[52] However, Groube[53] places emphasis on the post-European evidence at the site, suggesting that many of the artefacts may reflect a proto-historic culture change. Green[54] and Shawcross and Terrell,[55] while recognising the post-European evidence, do not preclude the possibility that the bulk of the material from both sites may be from pre-contact times.

After this article was written, I carried out preliminary excavations at Oruarangi and Paterangi, and it has been possible to insert a brief report. Oruarangi is a natural island (or possibly a spur end) which was enlarged in area by the addition of up to 2 metres depth of shell fill. Paterangi, some 50 metres away, is on the end of a low-lying spur. The point of this spur has been enlarged and extended by shell fill; a ditch cut across the neck of the spur provided spoil for building up that side of the site. Six C^{14} dates have been obtained. The materials and their ages B.P. are as follows:

From the area of initial settlement at the centre of Oruarangi:

Charcoal—450±80 (NZ4176A), 470±80 (NZ4176B), 490±80 (NZ 4176C).

From the lowest occupation layer on the margin of Oruarangi overlain by 2.4 metres of deposit, which is mainly shell fill:

Charcoal—230±60 (NZ4177A), 240±60 (NZ4177B), 310±70 (NZ 4177C);

Shell—310±50 (NZ4178A), 320±50 (NZ4178B);

Bracken—280±50 (NZ4179A), 290±50 (NZ4179B), 320±50 (NZ 4179C).

From Paterangi in association with the ditch construction, which occurred before the main occupation:

Charcoal—270±80 (NZ4181A), 280±80 (NZ4181B), 370±70 (NZ 4181C);

Shell—250±50 (NZ4180A), 260±50 (NZ4180B).

Macroscopic examination of 157 adzes from these two sites, held in the Auckland Museum, identified 48 as of Tahanga basalt. Of these 48, eight were selected for thin sectioning. The criteria for selection were as many different shapes, and appearances through weathering as possible. All were identified in thin section as the basalt.

A representative selection from the two groups of adzes, Tahanga and non-Tahanga, exhibits marked differences in form (Plate 3). Prior to this work the adzes had been divided into two types, A and B, by Fisher, on the basis of different bevel slopes, widths, thicknesses and degree of taper towards the poll.[56] Shawcross and Terrell, placing all the adzes into the Duff 2B type, found that the differences between Fisher's type A and B were more apparent than real, although admitting that there might be some important differences in form.[57]

52. Teviotdale and Skinner 1947:346.
53. Groube 1964:21–2.
54. Green 1970:37.
55. Shawcross and Terrell 1966:428.
56. Fisher 1936.
57. Shawcross and Terrell 1966:420.

PLATE 3
Oruarangi-Paterangi adzes: upper Tahanga basalt, lower coarse greywacke.

In Plate 3, the adzes in Tahanga basalt exhibit considerable variety; all adzes over 7 cm in length are deep-bodied, with varying traces of flake scars, and possess angled, tanged, spade-shouldered and saddle-grooved butts. Cross sections vary from almost square to reversed-quadrangular and triangular. Adzes under 7 cm long in this material are typically 2B in type, fully ground and polished, and rectangular in cross section. (Two examples in Plate 3 are at the right-hand ends of the two upper lines.)

Width and breadth measurements at mid-point or estimated mid-point of the adze were taken for all measurable specimens, and the results plotted as a scattergram (Fig. 3). A very real difference exists between adzes made from Tahanga basalt and the rest of the Oruarangi-Paterangi collection (the bulk of which is in coarse-grained rocks such as sandstone-greywackes), both in the ratio plotted and in the range of shapes exhibited.

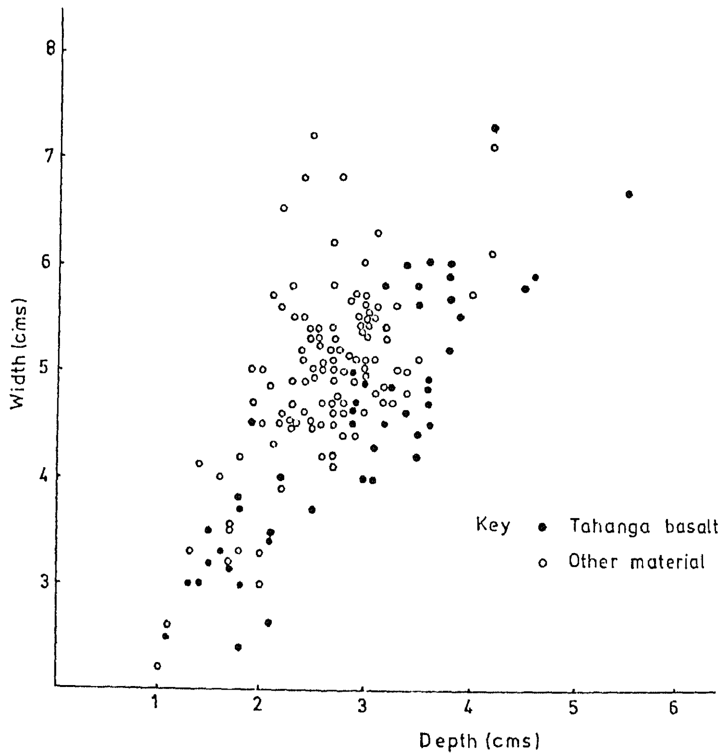

FIGURE 3
Width-depth measurements of Oruarangi-Paterangi adzes.

It is suggested here that the adzes of Tahanga basalt over 7 cm in length are earlier than the rest, and that the site records a transition, both in material and adze form.

A collection of 18 adzes, recorded by Copsey[58] and retrieved over a number of years from a flat area at the mouth of the Oruarangi stream near Ihumatao, and from a similar position 3 kilometres north at Ambury Point, was also examined. Five of these were deep-bodied, with reduced or angled butts, while the rest were 2B in type, fully ground and polished with rectangular section. The first five adzes were of Tahanga basalt, the rest of a coarse-grained rock, save for two both under 7 cm in length, which were also in the basalt.

Summary. On the basis of distribution in space and time one can propose that there was, in the early period, a centre of adze manufacturing using Tahanga basalt on the east coast of the Coromandel and the offshore islands, and at least one isolated outpost at Mt Camel. In addition, an as yet unknown quantity of the rock was transported along both coasts of the North Island, and possibly the length of the South Island.

Later in time the distribution seems to have become more limited, as the people further away found their own rocks.

Later still, for some reason, the basalt fell from favour, until Tahanga hill was no longer a force in the land.

Coarse-grained Rock: Northland Gabbro

Although it has been obvious from the sheer size of the known quarries that artefacts made from fine-grained rocks must have had impressive distributions, these are only now beginning to be confirmed and documented by petrological studies. Such, however, is not the case for coarser rocks. No widespread distribution pattern for this material, which was used in the manufacture of 2B adzes, has been described.

It has been apparent for some time[59] that the typical 2B adze from the north of Auckland often has a distinctive "particle-board" appearance caused by the etching, in the polished surface, of long slim randomly oriented crystals. Two hundred and twelve such adzes were selected from the Auckland Museum collection, 34 of which were examined microscopically.

Characteristics. The rock is a gabbro, which has a distinctive hand-specimen appearance caused by thin randomly-oriented felspar laths, most apparent when the surface of the adze has been weathered, but still visible under a high polish. Colour of the weathered surface varies considerably from the extremes of dark greenish-grey and greyish-black to those of light olive-grey and pale olive.

Microscopically the texture is hypidiomorphic-granular. Major minerals are plagioclase, augite, chlorite, hornblende and opaques. Minor minerals include sphene and apatite.[60]

58. Copsey 1974.
59. Simmons personal communication.
60. Briggs personal communication.

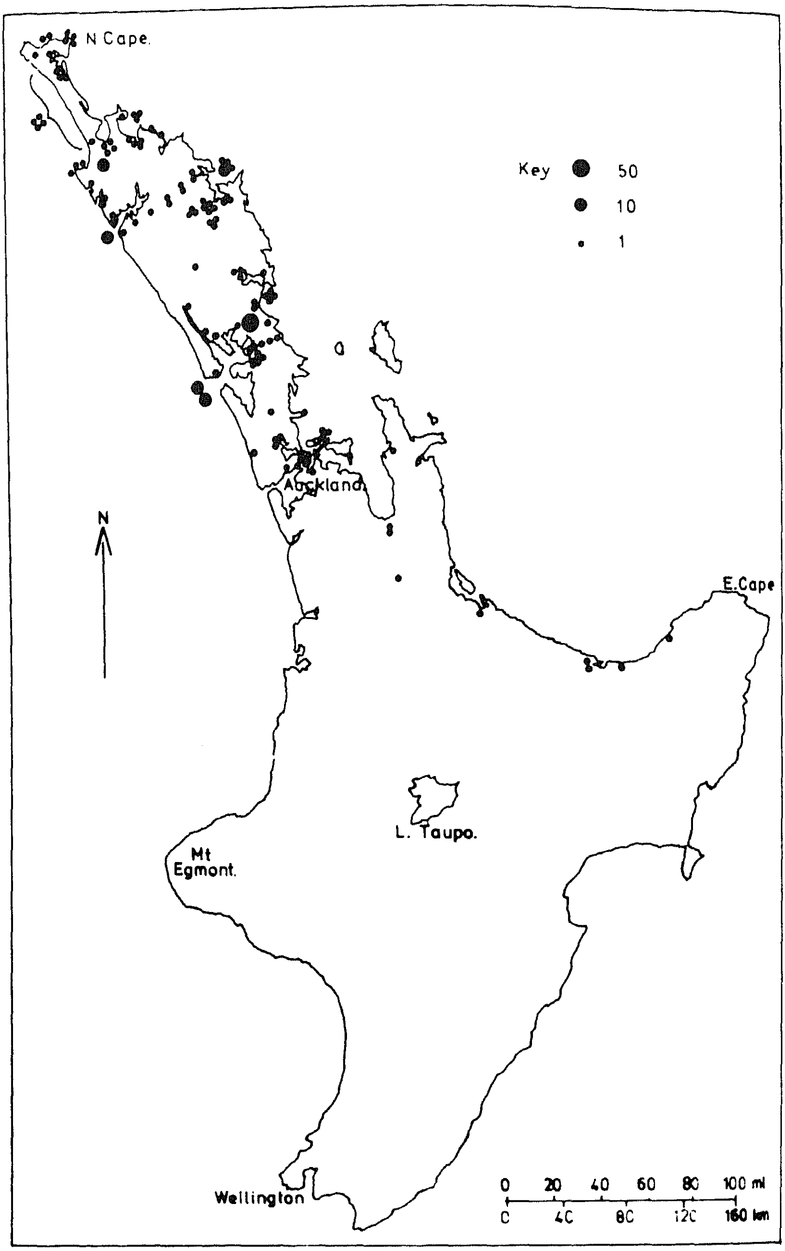

FIGURE 4
Distribution of artefacts in Northland gabbro.

Distribution in space. The distribution pattern of the adzes, biased as it may be, is shown in Figure 4. No quarry has yet been located for this material. The extensive field experience of Briggs enabled him to suggest a possible source area for the rock, which is similar to dyke material occurring in the Tangihua Massifs, situated at about the centre of Northland. The large opaques and alteration of augite to hornblende are typical of, and possibly unique to, some of the Tangihua intrusives. Two further features were noted: (1) the tips of the hornblende crystals were tinged blue, and (2) all adze material sectioned had a high chlorite-hornblende percentage, making the material different from any of the dyke rock yet examined from the Tangihua area.

The distribution pattern shows that adzes in this material were spread over a wide area 400 km in length, and occasionally appeared over 250 km further south along the coast. The distribution indicates a source somewhere between the Kaipara and Hokianga-Bay of Islands areas. Therefore, the Tangihuas, 60 percent of which have not yet been studied by geologists, are not rendered any less likely as a source by the distribution evidence.

Distribution in time. All the adzes are surface finds and, consequently, the evidence for their late status is derived from typology; specifically, no adze forms other than the typical 2B have been found in this rock.

Tests Comparing Fine and Coarse-grained Rocks

Some rationale must exist for the active seeking out and use of these rocks; one could suggest ease of manufacture, access to quarry, working performance or aesthetic value. Only tests of the rocks themselves will indicate which of the above is the most likely explanation.

Tahanga basalt was tested first against the alternative fine-grained rocks, known to have been used by the early settlers, and then against the gabbro. The various blade shapes were also included as variables. Qualities tested were hardness and homogeneity, cross section strength, susceptibility to edge damage, and flaking control.

Hardness was measured with a Shore Sclerescope; a diamond indenter is dropped from a fixed height on to the object and the rebound height indicated on a scale. Fine-grained rocks tested were from known Maori quarries: Tahanga basalt, Motutapu greywacke, D'Urville Island argillite and Great Barrier basalt. Also, Mt Camel basalt was tested, though there is no known Maori quarry. Of the coarse-grained rocks only the gabbro was tested.

Hardness and homogeneity appear, logically, to be two of the qualities sought after in the early tool rocks (Fig. 5). All the rocks tested were impressively hard, equivalent to a medium carbon steel.[61] However, homogeneity, as measured by Standard Deviation, varied considerably; the two most widely used fine-grained early rocks, argillite from D'Urville Island and basalt from Tahanga hill, scoring highest. It is of interest that the main quarry floor at Tahanga hill (T.D.) is both harder and more homogeneous than a smaller flaking area (T.B.) used less extensively.

61. Boyd personal communication.

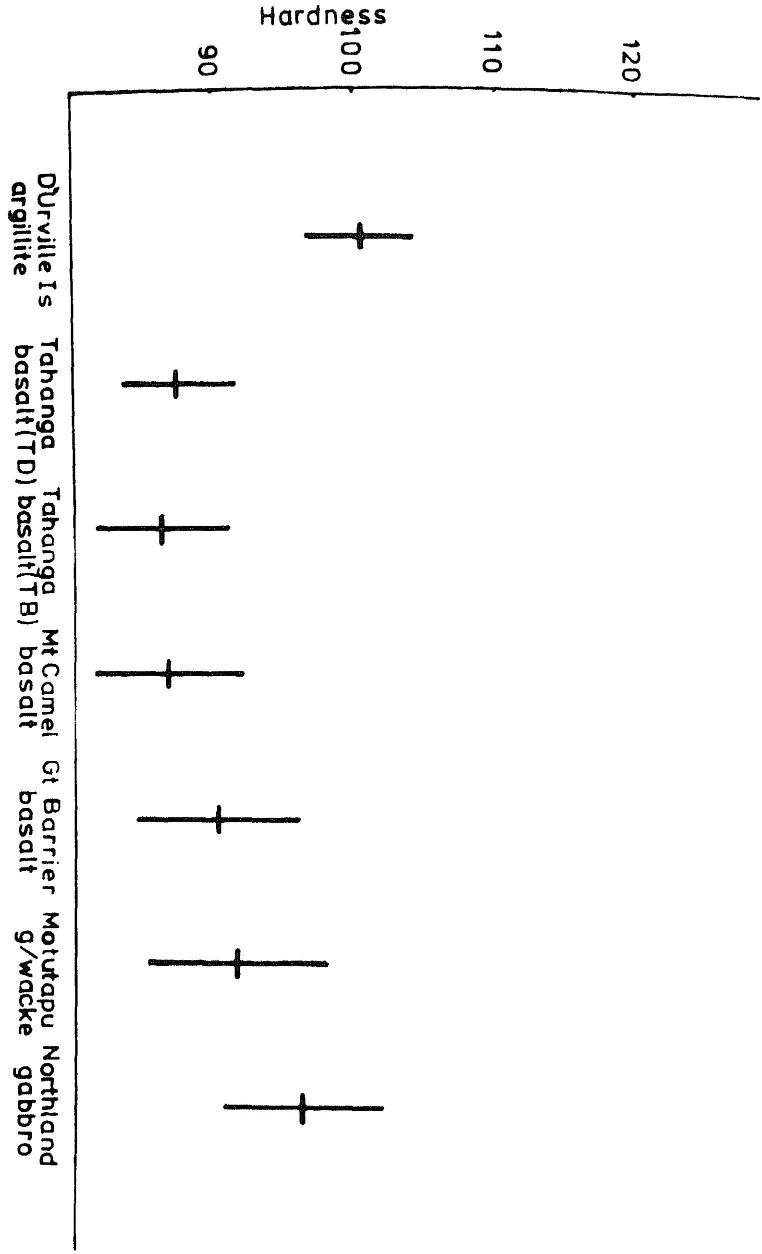

FIGURE 5
Means and Standard Deviations for Shore Sclerescope hardness tests.

The combination of hardness and homogeneity is not the whole story. The Mt Camel basalt which was not quarried for tools is only slightly inferior to that from the T.B. flaking floor at Tahanga hill.

Static and dynamic strength tests were carried out on blocks of the above rocks. The Instron Universal Testing Instrument (mentioned above) was used in the static tests, while a simple machine using a swing bar, adjustable both to height and weight, performed the dynamic tests.

TABLE 1
Results of Static Strength Tests

Rock type	Distance of load point from edge (mm)	Breaking point (newtons)	Flake size (cm)
BASALT			
Tahanga (T.G.)	1.8	1700	1.0×0.75
,,	2.5	2200	1.5×1.0
,,	3.0	3600	1.2×1.0
,,	3.0	3700	1.0×1.0
,,	5.0	5300	2.5×1.5
Tahanga (T.D.)	3.0	4300	2.0×1.5
,,	3.0	4350	1.25×1.25
Mt Camel	3.0	3800	1.0×1.0
,,	3.0	5400	2.5×2.5
,,	3.0	3650	2.0×2.0
Gt Barrier	3.0	4600	2.5×2.0
,,	3.0	3900	3.0×2.0
GREYWACKE			
Motutapu	3.0	4500	3.0×2.5
,,	3.0	4400	1.5×1.5
ARGILLITE			
Durville Is.	3.0	4550	3.5×2.0
,,	3.0	5800	3.5×2.0

note: T.D. is the main quarry; T.G. is an area of stone working activity north of T.D.

Results of the static tests are shown in Table 1. Due to the work load of the machine, the tests carried out were too few to produce any definite results. Indications of the rocks' qualities are nevertheless apparent. Tahanga basalt shows a marked relationship between size of flake and force required. In the duplication of tests, the similarity between forces required was, in these instances, accurate to between about one and three percent. The other rocks show greater variations in the relationship between force and flake. The D'Urville Island argillite result is surprising; unfortunately, the small size of the block and the difficulty in obtaining the material did not enable further tests to be made.

Because the relationship between static and dynamic strength may vary from rock to rock, the swing bar machine was used in tests of the rocks' dynamic strength.

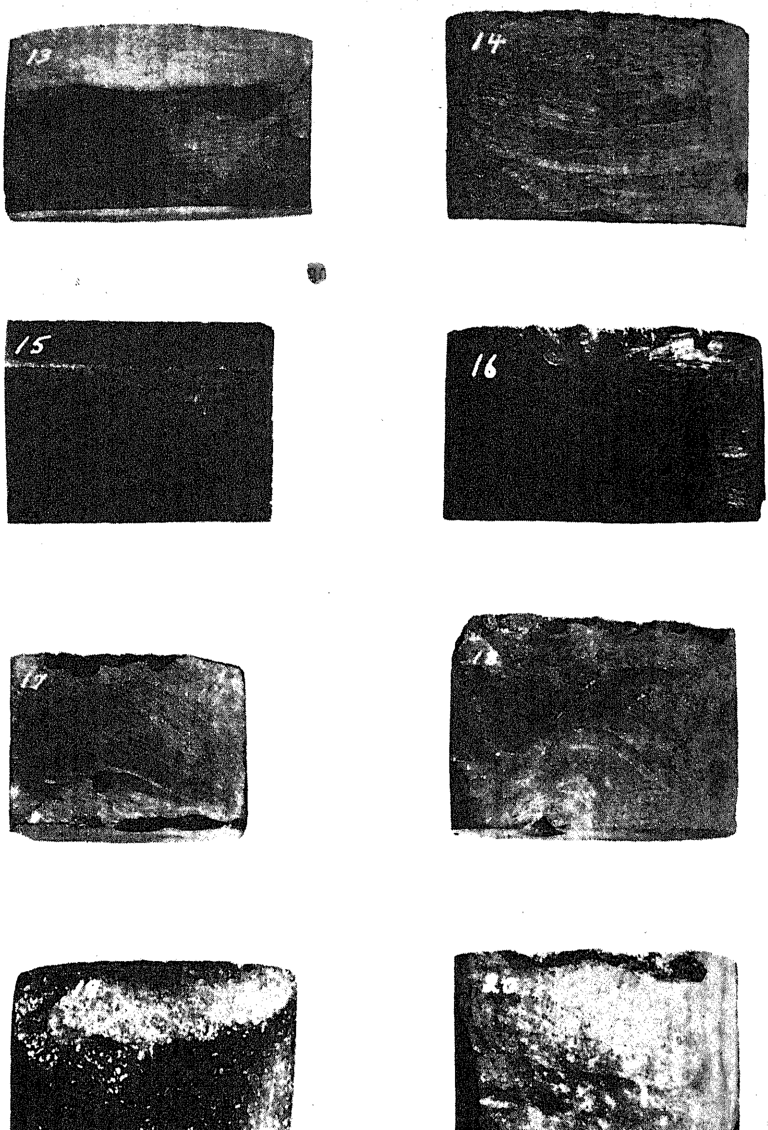

PLATE 4

Edge damage on adze-blade models: (13) Tahanga equal bevel, (14) Tahanga basalt single bevel, (15) Motutapu greywacke equal bevel, (16) Motutapu greywacke single bevel, (17) D'Urville Island argillite single bevel, (18) Great Barrier basalt single bevel, (19) Northland gabbro 2B, (20) Tahanga basalt 2B.

Findings were very much the same as for the previous experiment; Tahanga basalt flaked cleanly and reliably, as did, this time, D'Urville Island argillite, while the results for the others were more erratic.

By this time a piece of the gabbro was available (a result of the test described below) and attempts were made to flake this. Small jagged "flakes" of 0.5 cm maximum diameter were obtained only with difficulty.

The relative cross section strength of Tahanga basalt and the Northland gabbro were then tested. An unprovenanced adze in the gabbro was obtained from the Auckland Museum collection, and a duplicate manufactured from the basalt.

The cross section strength was tested by a drop-weight tester, using a weight of 70 kg. The basalt adze snapped when the weight was dropped from a height of 135 mm, whereas a height of 230 mm was needed before the gabbro adze fractured.

The strengths of the various rocks when coupled to different blade shapes were then tested. Single and double bevel models (the 1A and 2B shapes) of the bottom 3 cm of the blade were manufactured in both Tahanga basalt and Motutapu greywacke. Single bevels were also constructed from D'Urville Island argillite, Great Barrier basalt and Mt Camel basalt.

These were tested on the swing bar machine used in the flaking experiment. An impacter of soft steel was used; the total weight of the headpiece was 1000 gm, which was dropped from a height of 20 cm. The results are in Plate 4; neither of the equal bevels (No. 13 and No. 15) were damaged, while the rest had all flaked to some degree. The blade section of the gabbro adze (No. 19) which had been broken in the previous experiment was duplicated in Tahanga basalt (No. 20), and the same force applied to these two. No damage resulted, so the bar was dropped from the maximum height. Considerable damage occurred to the basalt, none to the gabbro (the small chips visible in the cutting edge of the gabbro adze were already present).

PLATE 5
Edge damage on adzes: from left Tahanga basalt 1A, D'Urville Island argillite 1A, Northland gabbro 2B.

Three unprovenanced adzes from the Auckland Museum collection were then tested: 1A's in D'Urville Island argillite and Tahanga basalt, and the gabbro 2A used in the wood-adzing experiment. Three times 1000 gm was dropped from the maximum height (Plate 5). Again the gabbro was undamaged.

A final test was run to assess the grinding qualities of the gabbro, basalt and argillite. This was achieved by manufacturing 7 mm^2 bars of the rocks and holding them with a given force on a diamond lapping wheel for five minutes. There was no difference in results obtained from the three rocks.

In the first section of this paper basic differences in woodworking qualities and ability to withstand stress were demonstrated between the adze shapes studied. In the second section the rocks from which the adzes were manufactured were shown to have very different qualities. Fine-grained rocks tested showed varying qualities of hardness, homogeneity and flaking ability; the material from the two largest known quarries, Tahanga and D'Urville Island, were both the most homogeneous and most consistent as regards the relationship between force applied and size of flake removed. The coarse-grained rock tested proved to be extremely hard, second only to D'Urville Island argillite, scored low in homogeneity and was virtually impossible to flake.

When the materials were tested in the different adze shapes, the results were as might be expected from the form and function tests mentioned above. The early 1A adze combines the most vulnerable shape and the weakest material. While a 2B adze in the same material showed less likelihood of edge damage, the combination of a coarse-grained rock and the 2B shape resulted in the strongest adze of all, capable of maintaining its edge despite considerable punishment. This material also greatly reduced the possibility of the adze body breaking in half.

EXPLANATION

The previous sections have demonstrated that the two basic adze shapes studied have radically different functions and strengths, that different rock types were preferred for each shape, and that the stronger rock was used in the stronger shape. How can this change in material and shape through time best be explained?

The importance of stone for cutting, drilling and adzing must again be stressed. Canoes, house-timbers, fortifications, spears, bird-snares, harpoons, clubs, digging sticks, fish-hooks and lures, art forms from notches to noseflutes — all relied entirely on the ability of stone to shape material. It would be unrealistic to credit the pre-contact Maori with anything less than a very thorough knowledge of the properties of stone; a knowledge probably held by few people today.

It is suggested here that the above work has indeed indicated the Maori's awareness of these properties. The concentration of early sites on the east coast of the Coromandel is likely to be connected with the occurrence in that area of exceptionally high quality obsidian, basalt and siliceous sinter.

There are indications, moreover, that fine discriminations within deposits were made, as noted above for Tahanga basalt and elsewhere[62] for Mayor Island obsidian and siliceous sinter. When, later in time, a hard tough rock is welded to a stronger adze shape, the process was both deliberate and functional.

The theory about to be offered for the change in adze form is not new; it has been advanced in general terms by previous authors (mentioned above) who based it on obvious associations between distributions of adzes and other features. But, it has never been explicitly stated or tested in any way.

The theory proposed here is that the early adze kit was primarily connected with the building of canoes. The later adzes, although suitable as general-purpose tools and used for a variety of functions, were mainly employed in woodworking, where the removal of quantities of wood quickly was of prime importance.

The connection between early adzes and canoes is made on two counts. The first is the find spots. These are strikingly coastal,[63] on navigable waterways, or, occasionally, some distance inland in forested areas at the heads of waterways large enough to permit or aid transport to the coast.[64] The second is the functional aspect of the tools as indicated by the tests. The most likely wooden object on the coast needing a variety of tools capable of controlled shaping adze work would have been a canoe hull; house posts or timbers would have required faster working tools with a higher angle of attack, such as the 1B or spade-shouldered adze, and possibly the 2A.

Of interest here are the two archaic adzes, mentioned at the beginning of this article, that have survived as sacred objects to their owners. On display at the Auckland Museum is *Iriperi*, an adze from the Gisborne area, although traditionally from the Bay of Plenty. Typologically closest to a 4A, it has a history of 20 generations, and was used for initiating work on important canoes.[65] The other adze, *Te Toki a te Maataariki*, is a 1A from the Waikato area, and is said to have been in the possession of the Arikis of Tainui for at least 18 generations. During this time it has been used for tapu symbolic action, such as taking the first and last chips from an important canoe or ridgepole, and was probably last used in the 1880s. Oral traditions state that even 18 generations ago the adze was referred to as "The gift from the ancestors".[66] *Iriperi* has been macroscopically identified as Tahanga basalt, while *Te Toki a te Maataariki* is said to be D'Urville Island argillite.

The 2B adze, typified in this study by the Northland 2B, is also assigned its function both by find spots and test results. Although found on the coast, overlapping the distribution of the 1A, the majority of specimens are found inland.[67] As described above, this adze is functionally a

62. Best 1975.
63. Green 1975:620–1; Golson 1959:68.
64. McKinlay 1974.
65. Simmons personal communication.
66. McKay 1973.
67. Golson 1959:69.

powerful woodworking tool; its main tasks probably being tree-felling, bush and scrub clearing, and reduction of timber for houses and fortifications. It is unlikely to have been used as an agricultural implement to any great extent; the blade is too narrow and short for efficiency. However, the adze would have been effective for removing tree-roots in newly-cleared areas, and in digging *rua*-pits and ditches in hard soil, such as clay, or in sandstone. It is of course highly probable that each adze went through different functional phases as it became more worn and damaged, so that each man might have at any one time three adzes of a specific type but in different stages of deterioration. An adze over time would be used for progressively coarser work, the final use resulting in massive and irreparable damage.

The equal bevel is useless as an adze. It was most likely hafted as an axe and used for splitting timber, or, possibly, as a chisel and used as a tree-scarfing instrument.[68] A splitting tool is best hafted as an axe, if hafted at all, or else the split wood is likely to smash the handle during the follow-through.

As the tests described above indicate, the shape of an adze and the material in which it is made are functionally related. These, in turn, must be part of a larger complex, a change in any part of which will affect the rest.

The early situation in New Zealand, in which fine-grained flakeable rocks provided the material for adzes with a low angle of attack, is postulated to be part of a technological complex built around a maritime economy. This might well have included many large ocean-going sailing vessels performing a variety of tasks: seasonal shifts involving extensive coastal movement, transport of quantities of bulky or heavy goods, exploitation of off-shore and deepwater fish by means of lures and hooks, and hunting of sea mammals.

The change to the later style adze in the tougher material is here said to reflect a shift in activities, from the maritime focus described above to one where for many groups, but not all, other activities become more important. Thus it is proposed that with population increase some groups moved inland and ceased to exploit marine resources intensively, while other groups, remaining on the coast, depended heavily on fern-root and agricultural products, and developed other techniques of marine exploitation.

This is not to say that the early settlers lacked agriculture, but rather that it could be carried out without the need for intensive forest clearance, by using, for example, unwooded areas such as river flats or terraces, or by burning and clearing light scrub. Neither does the above theory imply that the later Maoris lacked canoes or the capability of producing fine woodwork. It is suggested, however, that there was a very great difference between the canoes of the two periods.

The East Polynesian voyaging canoe described by the early explorers[69] which was probably similar to those in use early in New Zealand, was a

68. Best 1912:129–34.
69. in Parsonson 1962:36–9.

very different craft from the river, fishing and war canoes seen by the first Europeans, especially in the North Island. The double-hulled East Polynesian canoe was a fine sailing vessel, with extensive storage space, capable of speeds in excess of 15 knots and journeys measured in many hundreds of kilometres. The canoes seen in New Zealand waters by the first Europeans were mainly single-hulled and propelled by paddling, save for some double-hulled canoes in the South Island. Of these only the massive war canoes excited admiration, and, while fully as long and capable of carrying as many occupants as the East Polynesian canoe, they were specialised personnel transports and had no facilities for goods. Often the finishing adze-strokes on the outside of a war canoe hull left a series of transverse grooves across the timber grain.[70] While the increased drag would be of little hindrance to the reserves of manpower available in such a craft, a similar finish to the hull of a canoe under sail would seriously impede its progress. It is interesting to note that Cook remarks on three canoes seen between Mayor Island and Mercury Bay, a possible nuclear area of early settlement, as "being nothing more than trunks of a single tree hollowed by fire".[71]

The changes proposed above would not have happened at one time, nor in all places. In general, however, starting in the north of the North Island, and spreading south, various changes occurred, such as the abandonment of large quarries of fine-grained rock and the adoption of coarser material, the increasing use of inland areas for cultivation, and the change in canoe types. These changes were possibly later and less drastic in the South Island.

SUMMARY

This paper has attempted to explain a change in adze form and material that took place during New Zealand's prehistory.

Functional tests of the adzes themselves, the distribution of stress through the tool, and the strengths of the various rocks used as adze material, were all used. The 1A, or single bevel, can enter a wood face at an angle of 20 degrees and remove a shaving of wood, the reduced butt protecting the lashing. The distribution of stress through the profile of this adze shows that the shape is not suitable for any chopping or quick-braking entry into wood; this action would produce a concentration of stress at the tip of the front face, putting the body of the adze under bending stress. In addition, the fine-grained rocks from which these adzes were made maximised these effects. In short, the qualities inherent in the rock material that was actively sought after for making the adze, and the carefully constructed shape of the tool, made it imperative that the adze be used in a certain way.

At the other extreme the Northland adze, with its 40 degree angle of attack, maximises the angle at which it can enter and split wood, and minimises risk of damage by utilising an extremely strong rock, the gabbro.

70. Best 1925:61–2.
71. in Best 1912:128.

It must be reiterated that it is impossible to use a 2B in the clean skimming stroke of the 1A. Although it is possible to chop into wood with a 1A, the jarring sensation felt by the user makes it immediately obvious that the tool is being misused, with its concomitant risk of damage.

This evidence combined with the different find spots of the two adzes indicated that the functionally different tools were part of different economies. The maritime facet of the early economy is held to be the most likely reason for the existence of adzes which were mainly for shaping and trimming, while the clearing of large tracts of forest and the erection of wooden defences is likewise the most reasonable explanation for the later adze.

CONCLUSION

Archaeologists, while quick to defend the humanity of prehistoric man in general, sometimes underestimate his ability to handle aspects of the environment that are no longer part of present day life. Crabtree, in his study of obsidian blade manufacturing techniques, refers indirectly to this when, after years of experimentation and the removal of thousands of blades, he has " . . . only admiration for the aborigine's skill . . . ", and adds, as a prerequisite for lithic studies ". . . I recommend to each analyst the personal act of fracturing stone".[72]

This study has looked at adzes not as types but as tools, and has taken the approach that certain aspects of the shape of a functional tool, and selection of the material from which it is manufactured, are dictated by the resulting efficiency of the tool, and not by tradition, fashion or any of the other behavioural idiosyncracies that affect many of man's actions.

Where study of a functional artefact is undertaken it is suggested that at least some basic practical tests be carried out, prior to further and more detailed analysis.

With increasing evidence of tool-making and tool-using derived from studies of non-human primates, it is perhaps appropriate that more functional studies of man's abilities in this direction be undertaken, in order to maintain the popular image of the margin of skill separating human and non-human primates.

ACKNOWLEDGEMENTS

During the course of this work eight adze collections were examined and sampled. Without permission to do this the above research could not have been carried out. Special mention must be made of Dave Simmons, who allowed the Auckland Museum adze collection to be freely sampled. The Geology and Engineering Departments of the University of Auckland afforded much assistance. The first draft of this paper was critically reviewed by Roger Green, the second draft by Richard Cassels, both of the University of Auckland. Cyril Schollum kindly corrected and improved the writer's photographic work, and the technical assistance of Steve Rumsey in this area was greatly appreciated.

72. Crabtree 1968:478.

REFERENCES

BELLWOOD, P., 1969. "Excavations at Skippers Ridge, Opito Bay, Coromandel Peninsula, North Island of New Zealand." *Archaeology and Physical Anthropology in Oceania*, 4:198–221.

—— 1972. "Excavations at Otakanini Pa, South Kaipara Harbour." *Journal of the Royal Society of New Zealand*, 2:259-91.

BEST, E., 1912. *Stone Implements of the Maori.* Dominion Museum Bulletin 4. Wellington, Government Printer.

—— 1925. *The Maori Canoe.* Dominion Museum Bulletin 7. Wellington, Government Printer.

BEST, S. B., 1975. Adzes, Rocks and Men. Unpublished MA research essay, Department of Anthropology, University of Auckland.

CASSELS, R. 1974. Explanations of Change in New Zealand Prehistory. Paper prepared for presentation at New Zealand Archaeological Association Conference.

COPSEY, J., 1974. A Surface Collection of Maori Adzes from a Farm on Ihumatao Road, Mangere. Course Projects in New Zealand Prehistory, 33. Department of Anthropology, University of Auckland.

CRABTREE, D. E., 1968. "Mesoamerican Polyhedral Cores and Prismatic Blades." *American Antiquity*, 33:446–78.

CROSBY, E. B. V., 1963. "Preliminary Report on Whiritoa." *New Zealand Archaeological Association Newsletter*, 6:46–8.

—— MS. nd. Whiritoa: a Post-settlement Dune Midden Site on the Coromandel Peninsula.

DAVIDSON, J. M., 1971. "Early Man in New Zealand." *New Zealand Heritage*, 1:29–32.

—— 1974. "A Radiocarbon Date from Skippers Ridge (N40/7)." *New Zealand Archaeological Association Newsletter*, 17:50–2.

—— 1975. "The Excavation of Skippers Ridge (N40/7), Opito, Coromandel Peninsula, in 1959 and 1960." *Records of the Auckland Institute and Museum*, 12:1–42.

—— MS. nd. Excavation at, and Collections from Tahanga Hill.

DUFF, R., 1956. *The Moa-Hunter Period of Maori Culture*, 2nd edition. Wellington, Government Printer.

—— 1959. "Neolithic Adzes of Eastern Polynesia", in J. D. Freeman and W. R. Geddes (eds.), *Anthropology in the South Seas.* New Plymouth, Thomas Avery and Sons.

—— 1970. *Stone Adzes of South-East Asia.* Canterbury Museum Bulletin 3. Christchurch, Caxton.

FISHER, V. F., 1936. "The Material Culture of Oruarangi, Matatoki, Thames. 3. Stone Implements and Ornaments." *Records of the Auckland Institute and Museum*, 2:15–27.

GEOLOGICAL SOCIETY OF AMERICA, 1963. *Rock Color Chart.*

GOLSON, J., 1959. "Culture Change in Prehistoric New Zealand", in J. D. Freeman and W. R. Geddes (eds.), *Anthropology in the South Seas.* New Plymouth, Thomas Avery and Sons.

GREEN, R. C., 1963. "Summaries of Sites at Opito, Sarahs Gully, and Great Mercury Island." *New Zealand Archaeological Association Newsletter*, 6:57–69.

—— 1967. "Sources of New Zealand's East Polynesian Culture: The Evidence of a Pearl Shell Lure Shank." *Archaeology and Physical Anthropology in Oceania*, 2:81–90.

—— 1970. *A Review of the Prehistoric Sequence of the Auckland Province*, (2nd Edition). Dunedin, University Book Shop.

——— 1975. "Adaptation and Change in Maori Culture", in G. Kuschel (ed.), *Biogeography and Ecology in New Zealand.* The Hague, W. Junk.

GRIFFITHS, G., 1955. "South Canterbury Maori Camps, No. 3, Investigations at Pareora." *Journal of the Polynesian Society*, 64:233–6.

GROUBE, L. M., 1964. Settlement Pattern in Prehistoric New Zealand. Unpublished MA thesis, Department of Anthropology, University of Auckland.

——— 1970. "The Origin and Development of Earthwork Fortification in the Pacific", in R. C. Green and M. Kelly (eds.), *Studies in Oceanic Culture History*, vol. 1, no. 11. Honolulu, Bernice P. Bishop Museum.

JONES, K. L., 1972. Prehistoric Polynesian Stone Typology. Unpublished MA thesis, University of Otago.

KEYES, I. W., 1967. "The Ngatimamoe: A Western Polynesian-Melanesoid Subculture in New Zealand." *Journal of the Polynesian Society*, 76:47–75.

LEAHY, A., 1974. "Excavations at Hot Water Beach (N44/69), Coromandel Peninsula." *Records of the Auckland Institute and Museum*, 11:23–76.

LOCKERBIE, L., 1959. "From Moa-Hunter to Classic Maori in Southern New Zealand", in J. D. Freeman and W. R. Geddes (eds.), *Anthropology in the South Seas.* New Plymouth, Thomas Avery and Sons.

McKAY, A., 1973. "Te Toki a te Maataariki." *Journal of the Polynesian Society*, 82:412–3.

McKINLAY, J. R., 1974. "An Archaic Adze from Inland North Island." *New Zealand Archaeological Association Newsletter*, 17:171–4.

MOORE, P. R., 1972. "Maori Artifacts from Red Mercury Island." *Tane*, 18:119–21.

——— 1975. "Preliminary Investigation of the Tahanga Basalt, Coromandel Peninsula." *New Zealand Archaeological Association Newsletter*, 18:32–6.

——— and E. M. TILLER, 1975. "Radiocarbon Dates for New Zealand Archaeological Sites." *New Zealand Archaeological Association Newsletter*, 18:98–107.

MOORWOOD, M. J., 1974. Experiments with Obsidian: Functional and Typological Implications. Unpublished MA research essay, Department of Anthropology, University of Auckland.

PARKER, R. H., 1962. "Aspect and Phase on Skippers Ridge (Opito) and Kumara-Kaiamo (Urenui)." *New Zealand Archaeological Association Newsletter*, 5:222–32.

PARSONSON, G. S., 1962. "The Settlement of Oceania: An Examination of the Accidental Voyage Theory", in J. Golson (ed.), *Polynesian Navigation.* The Polynesian Society, Wellington, pp. 11–64.

PETERS, K. M., 1975. "Agricultural Gardens on Moturua Island." *New Zealand Archaeological Association Newsletter*, 18:171–9.

ROE, N., 1969. Archaeological Investigations. Unpublished MA thesis, Anthropology Department, University of Auckland.

SHAW, E., 1963. "Maori Quarry, Tahanga Hill, Opito." *New Zealand Archaeological Association Newsletter*, 6:34–6.

SHAWCROSS, F. W., 1972. "Energy and Ecology: Thermodynamic Models in Archaeology", in D. L. Clarke (ed.), *Models in Archaeology.* London, Methuen, pp. 577–623.

——— and J. E. TERRELL, 1966. "Paterangi and Oruarangi Swamp Pas." *Journal of the Polynesian Society*, 75:404–30.

SIMMONS, D. R., 1973. "Suggested Periods in South Island Prehistory." *Records of the Auckland Institute and Museum*, 10:1–58.

SKINNER, H. D., 1921. "Culture Areas in New Zealand." *Journal of the Polynesian Society*, 30:71–8.

——— 1938. "Maori Adzes, Axes, Chisels and Gouges from the Murihiku Region, New Zealand", in F. N. Chasen and M. W. F. Tweedie (eds.), *Proceedings of the 3rd Congress of Prehistorians of the Far East*, pp. 141–72.

——— 1943. "The Classification of Greywacke and Nephrite Adzes from Murihiku, N.Z." *Journal of the Polynesian Society*, 52:65–85.

——— 1953. "An Argillite Adze from Taranaki." *Journal of the Polynesian Society*, 62:81–3.

SMART, C. D., and R. C. GREEN, 1962. "A Stratified Dune Site at Tairua, Coromandel." *Dominion Museum Records in Ethnology*, 1:243–66.

TEVIOTDALE, D., 1932. "The Material Culture of the Moa-Hunters in Murihiku." *Journal of the Polynesian Society*, 41:81–120.

——— and H. D. SKINNER, 1947. "Oruarangi Pa." *Journal of the Polynesian Society*, 56:340–56.

THOMAS, H. H., 1923. "The Source of the Stones of Stonehenge." *Antiquaries Journal*, 3:239–60.