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PREHISTORIC USE OF OBSIDIAN

IN MURIHIKI

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A thesis presented in fulfilment of the requirements for the degree of Master of Arts, in Anthropology, University of Otago, Dunedin, New Zealand

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ABSTRACT

A series of functional experiments are carried out with standardised obsidian tools cut to specific dimensions, on prepared shafts of wood. The wear patterns obtained are photographed at prescribed stages of use. The results are then compared with edge damage on prehistoric obsidian tools from various sites in southern New Zealand (Murihiku), in an attempt to identify the original tool functions. Those prehistoric tools which display use-wear on their edges are then subjected to uni- and multivariate analyses to try to identify morphological types of edges from metrical parameters. Finally, the artefacts are investigated in their respective archaeological contexts, in order to examine economic differences or similarities between the sites considered.
He tohu aroha ki ngaa uri a Tuu-mata-uenga i noho ra i Murihiku. Ko Tangaroa taatou ko Haumia-tiketike ko Taane-Maahuta aa raatou kai. Ahakoa kua ngaro i te Poo, e noho-aa-vairua ana raatou i roto i ngaa taonga tuku iho. Ma aua taonga poohatu e hohonu ai too maatou mochio ki ngaa aahuatanga o too raatou noho i teenei takiwaa i ngaa raa o mua.

(To the vanished hunter-gatherers of Murihiku - your spirit lives on in the stone tools you left behind. Through these, we may come to better understand your bygone lives).
I would like to express my appreciation and thanks to the various people below, without whose assistance and advice, this thesis would not have been possible.

The Department of Anthropology (Otago University) generously provided the raw materials for this thesis. Bill Mooney (Photographic laboratories, Department of Geography, University of Otago), M. Fisher (Photographic laboratories, Department of Anthropology, University of Otago) and Ian Bilsen (professional photographer, Dunedin) skillfully executed the photographic record of the experimental and archaeological obsidian tools, with great efficiency. Dr G. Hamel and Ms W. Harsant (Otago Museum) kindly advanced the four Murihiku obsidian assemblages from the Otago Museum for analysis. G. Mason (Archaeological laboratories, Department of Anthropology, University of Otago) assisted in making the experimental obsidian tools and the apparatus for enhancing their photographic perspective, while Dr G. Hamel supplied the fresh kanuka. I.W.G. Smith, Dr G. Hamel, W. Harsant, Drs A.J. Anderson and B.F. Leach, P. Bain, M. Till, Professor R.C. Green (Department of Anthropology, University of Auckland), and Dr P. McCoy (Bishop Museum, Hawaii) all gave many helpful suggestions throughout this research. Lastly (but by no means least) I would like to express my gratitude to Ann Trappitt for typing the manuscript, and to my two supervisors Drs A.J. Anderson and B.F. Leach (Department of Anthropology, University of Otago) for their inexhaustable patience and incentive where the terra incognita of microwear analysis is concerned.
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INTRODUCTION

Murihiku is the name given to an area of the South Island of New Zealand south of the Rangitata River (Skinner 1974. See Figure 1 of this thesis). The prehistory of this region has been slowly pieced together during the last decade by systematic excavation of many coastal and inland archaeological sites. Some recent examples are the sites of Tiwai Point (S181-2/16), Pounawea (S184/1), Long Beach (S164/20), and Hawksburn (S133/5). These sites have yielded considerable information concerning the economic and industrial activities of their inhabitants, and this thesis is concerned with one aspect of their stone industry - that involving obsidian.

The application of various physical methods of examination and sourcing to the lithic assemblages of these sites has now established that these prehistoric Polynesians were involved in considerable exploitation of other regions of the South and North Islands (see for example, Park 1972, Jones 1972, Huffadine 1978, Bain 1979, Anderson 1979, Hamel 1980, Leach and Leach 1980). In particular, the sources of the obsidian found in the four sites above, all lie in the North Island (Ward 1974). The obsidian itself probably served as a stimulus for contact and exchange during the early prehistoric period. Hutton reports and infers use of various types of stone flakes including
FIGURE 1: Location of lithic sources and sites mentioned in the text. The area south of the Rangitata River is known as Murihiku.

- Silcrete (orthoquartzite) source zone
- Porcellanite source zone
- Nephrite source zone
- Argillite source
- Obsidian source
obsidian, for spear sharpening, sawing wood and bone, cleaning kumara (*Ipomoea batatas*), and cutting flesh and hair (1897:130-134). Mitchell (1939) records the finds of several North Island obsidian artefacts he calls scrapers, and Knapp cites 'rasping and burnishing' (1938), and 'sawing' (1941) as possible uses. It is expected that early prehistoric Polynesians would have used obsidian for a similar range of tasks.

Many archaeological sites have yielded obsidian flakes whose function is not clear. It is the purpose of this study to examine the obsidian assemblages from the aforementioned sites, and to identify their function within the provenance of the economic and industrial activities of the prehistoric people who occupied them.

These four Murihiku sites (above) were chosen for this study because they are hitherto the only sites from this region with relatively large numbers of obsidian artefacts, which have been subjected to systematic excavation. They also constitute a reasonable sample of the variety of coastal and inland sites which typify the Archaic and Classic periods of Murihiku.

There have been numerous functional studies of stone tools in recent years (see for example, Semenov 1964; Keller 1966; Bordes 1968; Wilmsen 1968a, 1968b; Crabtree 1972, 1975; Crabtree *et al.* 1968; Tringham *et al.* 1974; Bonnichsen 1977; Kay 1977; Hayden (Ed.) 1979; Bain 1979; Hartmann 1980).
A few New Zealand examples are especially pertinent to this thesis. Roe (1967) conducted replication experiments with fresh obsidian flakes to determine whether striations could be produced when they were used as saws or spokeshaves. He found it impossible to produce striations without the presence of sand. He then examined the obsidian assemblage from the prehistoric North Island site of Houhora (N6/4), and found some of the flake edges had striations suggestive of a spokeshave or whittling action performed in sandy conditions. Bellwood (1969) examined the dimensions of used edges, and their edge angles (see Figure 2), of obsidian tools from the site of Skippers Ridge 2 (N40/73); finding high and low edge angles with striations suggestive of scraping or whittling. Lastly, Morwood (1974a) undertook some functional experiments using freshly flaked obsidian scrapers and saws, on raw fish, wood, and bone. His results (ibid. :29) suggest that there was some degree of overlap in the functional tasks performed with these tools. He then examined prehistoric obsidian flakes from four North Island sites - three on Great Barrier Island (N30/3, N30/4, N30/5), and one at Tokoroa (N75/1) - and concluded that some of these flakes had been used for the tasks of 'light usage, woodworking, and burnishing or barking'. He also suggested that some tools in the Tokoroa assemblage had been used as spokeshaves for scraping narrow shafts, and that one flake from the N30/4 site exhibited evidence of hafting.
So far as this thesis is concerned, three important points emerge from these studies. Firstly, there has been a general lack of standardisation in the experimental work. This is partly the result of an inherent lack of control over replicating experimental obsidian tools by flaking. Although this process no doubt mirrors prehistoric fabrication techniques more closely, it is not conducive to producing an identical array of dimensions which would give the degree of uniformity necessary for good experimental control.

Secondly, prehistoric obsidian tools are not easily identified as formal tool categories such as those which have been found in Europe. Furthermore, these morphological categories have often been postulated as having a direct bearing on a tool's function, although this has been hotly debated (see Bordes 1969, Semenov 1970, Tringham et al. 1974:172). New Zealand obsidian flakes are generally of an amorphous shape, their function being associated with the type of edge rather than overall shape (see for instance Leach 1979:147). They often appear to have been of a multipurpose nature – either having more than one variety of working edge on the same flake, or possessing an edge which would be suitable for two or more different tasks.

Thirdly, the Effective Edge Angle (EEA - see Figure 2) appears to have a direct bearing on the function of a tool. Experiments such as those of Morwood (above) have shown that tools with sharp edges (with EEA's approximately 20°)
are suitable for sawing and have good penetration up to 3 or 4 mm, but are not good for scraping (because of the fragile edges). Tools with blunt edges (with EEA's approximately 70°) have poor penetration and are not suited for cutting operations, but are good for scraping. In the light of these data, it was regarded as important to establish a higher degree of experimental control through more precise standardisation.

The central questions of this thesis, which are posed with respect to the obsidian assemblages from the four Murihiku sites, are as follows:

1. How many tools are there amongst the total number of flakes in each assemblage?
2. What were the obsidian tools used for; and in particular were they multipurpose tools?
3. Are there any formal tool types which could be identified; and is there any correlation between tool morphology and function?
4. Do the tools form part of a kit appropriate to hunting activities or were they used for home-based work?
5. Is there any significant difference or similarity between one tool assemblage and another? If so, how might this relate to the different economic and industrial activities represented?
FIGURE 2: The main morphological attributes of used obsidian flakes from Murihiku. EL is the Edge Length of the working edge A, and EEA is the width over which edge damage (unifacial or bifacial) can be seen on the tool (usually about 3 mm). B is the original unused edge, and MD is the Maximum Dimension measured at right angles to the working edge - a measure of how easy the tool is to hold. Angle UVW is called the Effective Edge Angle (EEA, after Jones 1972). Angle UU'V is called the Planar Edge Angle (PEA).

The research strategy adopted to solve these questions is presented in detail in the following chapter. In brief, it may be outlined as follows. Firstly, it is necessary to carry out a series of standardised experiments, and then to identify and record the wear patterns obtained on them.
It should then be possible to compare these with the prehistoric implements in order to identify functional categories of damage. Once the used tools are selected out of the total assemblages, a uni- and multivariate analysis will be performed in order to search for discrete tool types. The information obtained will then be examined in the context of the known economic pattern of each site, in order to more adequately understand the prehistoric material culture of Murihiku.
ARCHAEOLOGICAL BACKGROUND

Tiwi Point (S181-2/16)

This site was excavated by Park in 1968-69 and is bracketed by radiocarbon dates clustering around AD 1200 (Park 1978). It is located near an estuary at the western end of the Tiwi Peninsula and lies on an undulating plain broken by a series of beach ridges and a narrow lagoon. At the time of its prehistoric occupation the peninsula would have been lightly forested, with podocarp cover on the nearby hills (Hamel 1981 pers. comm.).

The site consists of several activity areas containing ovens and midden, some concentrations of stonedebitage, and an associated green argillite flaking floor close by. The main constituents of the middens in probable order of importance, are sea mammals, forest and marine birds (especially the fatty mutton bird (Puffinus griseus)), and a small number of moa, dog, and shellfish.

Sutton and Marshall have examined the seasonal evidence and suggest that the site was occupied most of the year round (1980:38-39); however, if one takes the minimum seasons represented by the presence of the major bird, fish, and sea mammal species in the site, the most likely period of occupation was probably during the subantarctic spring/summer
of southern Murihiku (Higham 1976:228).

The lithic remains consist of broken adzes and preforms; flakes with use-modification, hammer-dressing, and retouching; awls and saws of green argillite; drills of green and grey argillite; hammer and grindstones; and some specialised fishing gear (two minnow lures of petrified wood and one trolling lure of 'semi-nephrite'). The presence of obsidian and grey argillite imply northerly contacts. The argillite debitage is suggestive of adze fabrication on a reasonably large scale, with the lack of finished adzes implying possible export to other Murihiku regions (Huffadine 1978:61). The obsidian is considered below.

Pounawea (S184/1)

Moving north along the east coast of Murihiku, the next site concerned is Pounawea. This site is located 2 km from the open sea on what is now a narrow sand islet jutting out into the Catlins River estuary, and has been severely eroded by stormy seas in the recent past. It was first excavated by Lockerbie in the 1950's and extensively (and finally) by Hamel in 1979. It is bracketed by radiocarbon dates falling between AD 1000 - 1500, and can be considered to have been occupied throughout most of this period (Hamel 1979:119, 1980:63). The site was bounded by a mosaic of podocarp-hardwood forest during prehistoric times, and its seasonal evidence suggests that it was often occupied most
if not all year round (ibid.:1980).

There are deep shell middens within the site (90% of which are cockles (*Chione stitchburyi*) and pipi (*Paphies australis*)), and many sea mammals are represented. Several species of forest and marine birds occur, and five species of moa have been recorded; these being somewhat more abundant in the lower levels. Barracouta (*Thyrsites atun*) forms about 80% of the fish remains (which are of a lesser significance compared to the other food remains), with crayfish (*Jasus edwardsii*), dog, and a few moa eggs being present as well.

There is little evidence of many concentrated activity areas, although some ovens and postholes in alignment have been recorded by Lockerbie, and Hamel. On-site activities probably included the working of bone artefacts (for example; awls, reels, fishhooks, needles), minor woodworking, and the possible scraping of skins and wood (Hamel 1980:33). A large worked silcrete core testifies to the fabrication of blades. Several varieties of argillite from the Tiwai-Riverton-Bluff area imply local exploitation, while D'Urville Island argillite, the presence of obsidian (see below), and silcrete (possibly from the Oturehua source on Central Otago) suggest trading or exploitation in a northerly direction.
Long Beach (S164/20)

Further up the east coast, to the north of the Otago Peninsula, is the site of Long Beach; excavated by Leach and Hamel in 1977. It has two major levels (separated by a sterile layer of sand containing some intrusive cultural detritus from both levels): a lower Archaic one bracketed by radiocarbon dates spanning AD 1100 to 1300; and an upper Classic one with radiocarbon dates from AD 1400 to 1500 (Leach and Hamel 1979:128).

This open bay site has been extensively fossicked in the past, with over 1300 artefacts registered from the area prior to the 1977 excavation. It is located on an ancient boulder beach now prograded with recent overgrown sand dunes which extend for some distance to the present open beach. Low hills flank the other side of the site and some unexcavated cultural areas may extend back toward their margins. Coastal forest and/or scrub existed close to the occupied area throughout its sequence (Wallace 1981). No seasonal data has yet been published, but as this seems to be primarily a site for the seasonal exploitation of barracouta, the seasons when this fish would be most readily available were probably summer/autumn (Anderson 1981 pers. comm.).

Extensive wave-disturbed barracouta midden with a few moa and tuatara bones (Sphenodon punctatus) plus many small birds, is predominant in the Archaic layers. This midden
also contains an infant burial, and some bait and lure hooks.

There are flakes of chalcedony from a local source, a few flakes of obsidian, and some schist files, adze preforms, and a few blades. The presence of flakes of argillite, silcrete, and porcellanite in this instance points to contact with central and southern areas of Murihiku.

A sterile layer separates the lower Archaic material from the upper Classic. This layer contains a number of intrusive stone and bone artefacts which have been interpreted by Leach and Hamel to have been the result of redeposition due to wind action after Archaic abandonment, plus later Classic activity. Thus the artefacts from this layer are seen to come both from Archaic and Classic occupations. The stone artefacts are comprised of flakes of obsidian, porcellanite, chalcedony, silcrete, chert, some fragments of a modified igneous rock, and a fragment of schist.

The Classic layers contain the posts and postholes of a house (which was probably burnt out), several ovens, bone artefacts, and lenses of ash and midden. The most important food remains (as in the Archaic levels) were those of barracouta; and a few sea mammals, albatross, small birds, shellfish, and dogs are also represented.
The lithic components of the Classic layers comprise flakes of obsidian, silcrete, porcellanite, chalcedony, local opaline-jasper, chert, and D'Urville Island argillite, as well as sandstone abraidors and drills of porcellanite, silcrete, and chalcedony. Twenty two pieces of nephrite were found, one of which resembles a chisel, and another which is probably an amulet.

Hawksburn (S133/5)

The Central Otago site of Hawksburn is located in a valley about 670 m above sea level in the Carrick Ranges, not far from the historic gold-mining town of Cromwell. This site was partially excavated by Lockerbie in 1954-55, and extensively by Anderson in 1979. It is bracketed by radiocarbon dates falling between AD 1200 to 1300 (Anderson 1981).

It seems likely that the site was near open totora forest (Podocarpus hallii) in the early prehistoric period (see Hamel 1977:81). This site is most aptly called 'moa-hunter' in character, as its faunal evidence indicates that moa were the mainstay of the occupants' subsistence; there being a large number represented in contrast to a very few juvenile and adult dog bones, small birds, and fragments of freshwater mussel (Hyridella mensiesi). Anderson suggests that the moa of this area may have been transhumant; moving down to the valleys in early winter,
and back up to the forest in spring (1979:52). As the remains of moa feet, vertebrae, and tracheal rings were found in the site, it seems probable that they were killed close by.

This site is similar in many respects to a number of smaller inland Murihiku Archaic sites in terms of their subsistence and settlement patterns; that is, ovens (and in the case of Hawksburn - possible hut floors) adjacent to a stream, with associated moa midden and stone tools (such as blades of porcellanite and silcrete). Anderson concludes that the hunter-gatherers of Hawksburn were undertaking the "...jointing and cooking of some [moa] for immediate consumption, and the butchering out of others to obtain meat for preserving, after which the fresh bones were deliberately burnt" (1979:55).

The lithic components of the site comprise thousands of small waste flakes of porcellanite and silcrete strewn over a wide area. There are many well formed and retouched silcrete blades (although no cores were found) - some of which seem to have been deliberately snapped into convenient hand-size lengths. Some smaller porcellanite blades occur as well (also retouched for use). Part of the site has a cluster of ovens, and both varieties of blades were occasionally found in the ovens and their rakeout. Some of these were still in a usable condition
despite having been burnt. Silcrete and porcellanite drills, one flake of nephrite, flakes of obsidian, and small polished chisels of green argillite (possibly from the southern Murihiku sources) were also found.

The site exhibits stratigraphic evidence of two occupations, probably not very far apart in time (Anderson 1979, pers. comm.), and the material throughout these is similar.

The Obsidian Artefacts from the Four Sites

The obsidian artefacts from the four sites are set out below in Table 1. Two surface collected flakes from the beach at Pounawea found during the 1979 excavation were not included for analysis as they were not considered properly provenanced to the last excavation. A large block of obsidian measuring approximately 50 cm by 40 cm, 20 cm in thickness was handed in to the Otago Museum from Long Beach environs in the 1920's, but was not included here as it was a surface find and not properly provenanced to the 1977 excavation. No obsidian cores were found in these four excavations.

An initial examination of the Effective Edge Angles of those artefacts which appeared to have been used, suggested a bimodal distribution of sharp and blunt edges (see Figure 3). It is proposed here that an EEA range of 10° - 49° would be suitable for cutting operations and
used edges falling within this range could be called 'knives', while the range 50° - 120° would be more suited to spokeshave action - used edges falling within this range could therefore be called 'scrapers'. The following experimental section in Chapter 2 was expected to determine whether these two ranges of EEA were in fact appropriate to the two varieties of edge function assigned.

<table>
<thead>
<tr>
<th>SITE</th>
<th>OBSIDIAN FLAKES</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;3 x 2 mm</td>
<td>&gt;3 x 2 mm</td>
</tr>
<tr>
<td>Tiwai Point</td>
<td>16</td>
<td>98</td>
</tr>
<tr>
<td>Pounawea</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>Long Beach:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Archaic</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Sterile</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Classic</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Test pit (probably Classic)</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Hawksburn</td>
<td>6</td>
<td>42</td>
</tr>
</tbody>
</table>

**TABLE 1**: Summary of the obsidian flakes recovered from recent excavations of four Murihiku sites.
FIGURE 3: Size frequency histogram (20 cells) of the Effective Edge Angle (EEA) on those prehistoric edges (from the four sites) which appeared to have been used; prior to comparison with experimental results (N=97).

EXPERIMENTAL OBSIDIAN STANDARDS

Introduction

The point has been raised in the Introduction that prehistoric obsidian tools found in New Zealand are edge-oriented where their shape, selection, and use are concerned. Therefore, instead of using for example, a polar system of co-ordinates which would record use-wear in relation to complete morphology (see Tringham et al. 1974:186, Odell 1979:336), the edges of each archaeological flake were treated as separate units for experimental comparison and multivariate analysis. This latter concept was suggested by Wilmsen (1970) and employed by Tringham et al.,
as a possible means of resolving the problem of multiplicity of function:

"... the problem is alleviated by treating the various edges of a flake separately... each unit may be considered separately (i.e. each used edge counting as a separate artifact) or interdependently with each used edge on a flake being considered in relation to other used edges..." (1974:193).

In order to resolve the various problems attendant on the prehistoric obsidian tool kits, it was first necessary to undertake some practical experiments with obsidian. The following experiments with standardised obsidian tools were consequently directed towards cataloging the different varieties of microwear produced on each edge as per assigned task, for comparison with the edges of the Murihiku flakes.

**Problem 1:** "How many tools are there amongst the total number of flakes in each assemblage?"

Experiments 1 to 8 (see Table 2) were designed to aid in the discrimination between used and unused prehistoric flakes, most of which displayed differing degrees of edge damage (that may not all have been sustained through use). Another experiment (number 9, below) with non-functional edge-damage was also expected to resolve this problem.
Problem 2: "What were the obsidian tools used for; and in particular were they multipurpose tools?"

Experiments 1 to 6 were generally directed towards resolving prehistoric function. Experiments 7 and 8 were especially designed to establish the kind of microwear that results when an edge which is mainly suitable for a certain range of tasks, is used for a different task outside of that range. Each used prehistoric flake was also examined for the occurrence of two or more different ranges of Effective Edge Angles on the same flake. Once the results of experiments 7 and 8 were obtained the question would be examined, of whether a prehistoric obsidian edge could have been used for a 'light' task (inflicting minimal edge damage) followed by a 'heavy' task producing greater damage (which could obliterate the wear caused by the first task). It is doubtful that a task resulting in major edge alteration would be undertaken before turning to a task that created only minimal damage, as this would not be technically possible nor culturally logical. Once the function of the prehistoric obsidian edges had been resolved, the relation of morphology and function (in problem 3) would be reviewed.

Problem 4: "Do the tools form part of a kit appropriate to hunting activities or were they used for home-based work?"

Once the percentage of used tools and the range of probable functional tasks for which they were used had been
established, it was expected that their role in the economic subsistence of each site would be established, and this problem is re-examined in Chapter 3 (Discussion).

The results of the experimental microwear analysis would have some bearing on problems 3 and 5, which concern matters of typology, economy, and industry within the four sites. However, these matters are discussed in detail in the section (this Chapter) dealing with the uni- and multivariate analyses of the prehistoric tools, as this is the main avenue of inquiry which was expected to resolve them.

Making the Tools

In order to solve the problems relating to the function of the prehistoric tools, a series of standardised obsidian blanks were produced for use on wooden shafts. The significant variable chosen to be replicated for the experimental tools was the Effective Edge Angle (EEA), one of the most important physical attributes of the prehistoric tools. The experimental tool was multipurpose, with two angles - a knife edge of 20° and a scraping edge of 70° - which were combined on the one tool (Figure 4).
FIGURE 4: The experimental multi-purpose blank showing the knife edge (X) with an EEA of 20°, and the scraping edge (Y) with an EEA of 70°. C and D show the direction of photographic views of the knife edge taken throughout the experiments. A and B show similar views relevant to the scraping edge. The edge X is used for sawing and slicing, while edge Y is used for scraping. The scale in this figure is equivalent to 1 cm.

The blanks were cut from a large block of obsidian which was largely free of vesicles and inclusions. After initially being cut with a diamond saw into oblongs 3 cm x 2 cm with a triangular cross section, they were ground on two diamond lapping wheels (coarse and fine). This caused a slight variation in the final EEA's (see Table 2) but they still remained within acceptable limits. They were then finely ground by hand on glass plates coated with wet carborundum abrasive (mesh numbers 350, 600, and 800 successively). This final grinding phase did not produce an extremely sharp edge comparable to that which could have been produced by flaking, but the final edges were sharp enough for the tasks to which they were assigned.
Mode of Action

FIGURE 5: Oblique and schematic views of the experimental tool in use as a scraper. The arrows indicate direction of movement - 20 cm in each direction. One 'stroke' is equivalent to 20 cm scraping action.

FIGURE 6: Oblique and schematic views of the experimental tool in use as a saw, showing direction of movement. One 'stroke' is equivalent to moving the edge its entire length across the wood surface. The wooden shaft is slowly revolved so that continual penetration from about 1 - 3 mm occurs.

When an edge was used as a unidirectional scraper (Figures 5 and 7); the angle between the 'Trailing Face' of a tool, its point of edge contact, and the horizontal shaft was called the Angle of Attack (AA; after Best 1976). As it is
possible to vary the AA of a scraper and still achieve removal of wood shavings, two experimental variations of this were chosen - 30° and 45°. When a scraping edge was used in a bidirectional motion, the tool was held in exactly the same attitude and pressure for both advancing and retreating strokes on the shaft (and here the AA referred only to the advancing stroke). Bidirectional motion was included firstly because it is probable that this action was performed by an early tool user, and secondly, in order to see if any difference in edge damage patterns (such as unifacial versus bifacial) could be produced.

FIGURE 7: Angles of Attack (AA) for scraping edges. HP is the direction of Hand Pressure, at right angles to the shaft; M is the motion along the shaft (bidirectional in the left example and unidirectional in the right example). The left example shows a scraping edge used with an AA of 45°, and on the right the AA is employed at 30°. When a unidirectional motion is used the face which advances along the shaft is called the Leading Face (LF), and the face which trails behind is called the Trailing Face (TF) - for purposes of recording microwear data.
When an edge was used as a knife (Figures 6 and 8) the concept of an AA was no longer appropriate. Here the angle between the direction of hand pressure on the tool, and the shaft, was maintained at $90^\circ$ to the wood surface. Two modes of action were chosen for this edge. A sawing or bidirectional motion and a single slicing or unidirectional motion were considered the most likely and effective modes in which an edge of this type would have been used. In experiments 1 to 8 (Table 2 below) Hand Pressure (HP) was applied at $90^\circ$ to the shaft. Measured on a coarse balance, this was in the order of $21 \pm 3$ g/cm$^2$.

![Diagram](image)

**FIGURE 8:** The knife edge used in slicing (unidirectional) and sawing (bidirectional) actions. The concept of Angle of Attack is not strictly relevant in the case of these modes of action. The Hand Pressure (HP) is directed through the edge at right angles to the wood surface. All edges used in sawing or slicing actions are thus employed at right angles to the wood surface. These actions may here be visualised as being at right angles to the page.
Another functional category chosen was the multi-purpose use of an edge (Figures 9 and 10). In these experiments this did not mean using a knife edge for sawing and then scraping, or vice versa (this possibility is discussed in the following chapter); but rather it was to gauge the performance and edge damage of a knife edge used as a unidirectional scraper (where it had an AA of 30°), and a scraper used as a saw (at 90° to the wood surface). Thus, eight categories of experimental function were selected for analysis (Table 2 below).

FIGURE 9: Multipurpose edge. A knife edge with an EEA of 20° is used as a unidirectional scraper with an AA of 30°. HP is the direction of Hand Pressure, and M indicates motion along the shaft.

FIGURE 10: Multipurpose edge. A scraping edge with an EEA of 70° is used as a saw. The Hand Pressure (HP) and the edge are employed at right angles to the wood surface.
<table>
<thead>
<tr>
<th>NUMBER</th>
<th>TYPE</th>
<th>EEA RANGE</th>
<th>ACTUAL EEA</th>
<th>MODE OF ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scraper</td>
<td>70°</td>
<td>74°</td>
<td>Bidirectional, AA=45°</td>
</tr>
<tr>
<td>2</td>
<td>Scraper</td>
<td>70°</td>
<td>72°</td>
<td>Bidirectional, AA=30°</td>
</tr>
<tr>
<td>3</td>
<td>Scraper</td>
<td>70°</td>
<td>71°</td>
<td>Unidirectional, AA=45°</td>
</tr>
<tr>
<td>4</td>
<td>Scraper</td>
<td>70°</td>
<td>71°</td>
<td>Unidirectional, AA=30°</td>
</tr>
<tr>
<td>5</td>
<td>Knife</td>
<td>20°</td>
<td>18°</td>
<td>Bidirectional (sawing) at 90° to wood surface</td>
</tr>
<tr>
<td>6</td>
<td>Knife</td>
<td>20°</td>
<td>17°</td>
<td>Unidirectional (slicing) at 90° to wood surface</td>
</tr>
<tr>
<td>7</td>
<td>Multi-purpose edge</td>
<td>70°</td>
<td>73°</td>
<td>Scraping edge used as a saw at 90° to wood surface</td>
</tr>
<tr>
<td>8</td>
<td>Multi-purpose edge</td>
<td>20°</td>
<td>18°</td>
<td>Knife edge used as a unidirectional scraper, AA=30°</td>
</tr>
</tbody>
</table>

**TABLE 2:** Categories of function selected for experimental obsidian tools

Native wood was selected as a suitable medium, intermediate in hardness between flesh and bone, for obsidian to be used on. Shafts of green kanuka (*Leptospermum ericoides*) were chosen for each experiment, measuring 3 cm in diameter by 30 cm in length (roughly comparable to the diameter of a robust spear shaft). The bark was first removed by hand (an easy operation not requiring the assistance of a stone flake for this species), presenting a moist but firm workable wood surface with occasional small knotty protrusions along each shaft. The knots caused a slight variation in the magnitude of hand pressure
during scraping action, and possibly accelerated some of the edge wear. However, judging by the feel of the edges operating on the wood, it was felt that pressure variation could be kept to an acceptable minimum and maintained as uniformly as possible throughout each operation.

When the prehistoric assemblages were first examined, it was noted that some of the flakes had been cleaned with steam after post-excavation sorting. On the edges of a few of those which had not been cleaned there were some flake scars with a shiny new appearance, next to old dirt-encrusted scars (for example, in the Hawksburn assemblage). This was assumed to be recent edge damage incurred during or after excavation. Similarly, when the Long Beach obsidian flakes were examined, it was noted that many of them had been bagged together, occasionally with foreign lithic material, which could have damaged their edges. It was also considered that the prehistoric tool users might have subjected their obsidian flakes to incidental damage during portage, and on the sites. Jones suggests that damage ('snapping') to a light specimen is difficult to achieve by accidental means (1972:129). However, many of the flakes too small to have been used as tools, and which did not appear to have been broken off larger tools, had small portions of their edges broken off.

This suggested that further experimental work on the matter of non-functional edge damage was needed, hence
experiment number 9 was executed. This involved six freshly sharpened blanks being shaken vigorously together in a tough plastic bag, then dropped on a wooden floor and lightly stepped on. In this case there was some slight size variation with the blanks and they were only finished on the fine diamond grinding wheel (as an overall standard size and finish was not considered necessary for this experiment). This treatment was considered to be representative of an accelerated degree of major non-functional edge damage which archaeological obsidian flakes might have received over time (incidental to being used as tools) during portage, general rough treatment on the site, and through excavation etc. After this, they were then examined closely for any damage, which was recorded (see below). This experiment was expected to aid in the discrimination of prehistoric waste and use-flakes with damaged edges.

Recording the Results

The edge damage resulting from experiments 1 to 9 was photographed with Polaroid black and white '665 Positive-Negative' film. This produced an instant print and large contact negative, giving close control over the quality of the photographic record. Photographs of experiments 1 to 8 were taken of each 'view' (see Figure 4) of a face which sustained damage; at intervals of 50, 500, and 1000 strokes, between which it was carefully cleaned.
FIGURE 11: Apparatus for enhancing the photographic perspective of obsidian. One test tube is partially filled with concentrated hydrochloric acid, and the other is partially filled with a concentrated solution of ammonium hydroxide. Air is blown into the mouthpiece on the left, and ammonium chloride sublimate is formed and expelled on the right, onto the obsidian. With a little practice, the density of the sublimate can be carefully controlled; varying in colour according to its thickness (from a thin light blue to a thicker ivory white). The sublimate can then be washed off the obsidian after use. The apparatus should be dismantled for storage, otherwise it will slowly form a blockage in the inlet-outlet glass pipes. This is taken from Bassler 1953:G20.
A few damaged edges were coated with a thin soluble layer of ammonium chloride sublimate (after Bassler 1953, see figure 11) to see if this would enhance the photographic perspective of the damaged edges. However, it was found that the matt-grey finish on the ground faces of the blanks enabled the damage to stand out well enough without the need for coating.

Striation Analysis

Obsidian has a hardness of 6 on the Mohs scale of 1 to 10 and is not easily scratched. Several researchers in microwear analysis have concluded that striations do not generally occur on obsidian flake tools unless small extraneous particles of sand (or material with a hardness greater than 6) are present during the operation of the tool (Semenov 1964:88; Jones 1972:128-129; Morwood 1974a:14,15; Tringham et al. 1974:175). It is also possible that striations are occasionally the result of the interference of microflakes becoming detached from the tool during use (Fedje 1979:183). However, it is likely that striations are also produced by activities not directly associated with function; such as fabrication, portage, and post discard damage like slope transport. After examining the four Murihiku assemblages under a zoom binocular microscope (of magnification 7 - 40 times), many flakes too small to have been used as tools (of which a considerable number did not seem to have been broken off larger tools) appeared
to have striations. These usually occurred away from the margins of the flake and were of a random criss-cross appearance, suggesting that they might have been produced while the flakes were still attached to a core. Other flakes from these assemblages large enough to have been used as tools, but with no heavy damage to their edges, had random striations away from their margins; again suggestive of some sort of 'core-scuffing'.

The above examples highlight some of the problems attendant on striation analysis. New Zealand experimental research into this field has not yet proved very successful, and an alternative approach is offered in this thesis - that of analysing flake scars diagnostic of various functions.

Despite the many problems that the presence of striations on obsidian tools raise, there is no doubt that they sometimes do occur through use (for example, in sandy conditions) and can be an additional aid towards establishing tool function. Several of the 'graspable' flakes from the four sites, which had heavy edge damage suggestive of use, also had striations about their edges. Therefore, although no experimental striation analysis was undertaken it was considered that any prehistoric striations found during microscopic examination should be included for study as additional clues to the function of these flakes.
UNIVARIATE AND MULTIVARIATE ANALYSES OF THE OBSIDIAN ASSEMBLAGES

This section deals with the selection of various metrical attributes with which to measure the prehistoric assemblages. However, it was first necessary to have an objective means (in the form of the experimental data) of assessing the prehistoric assemblages, before attempting to proceed with further analysis of used flakes. Examination of the Murihiku assemblages before the experiments, was of course necessary, and influenced the experimental strategy (as did the findings of other archaeologists in this field).

Given that tools with use-wear on their edges could now be selected out of the four assemblages, their used edges were measured (below) for five different variables. These were plotted out in 20 cell size frequency histograms, and then compared on a univariate level by using the two-tailed Students t statistic.

Where the multivariate analysis of the five edge parameters was concerned, sufficient work had been done by others to indicate that factor analysis of artefactual assemblages is a viable means of clustering tools (the Q mode), and clustering their metric variables (the R mode); (Binford and Binford 1966, Glover 1969, Jones 1972, Park 1972, Gunn 1975). Following research undertaken by Jones (1972)
and Morwood (1974a) on various parameters affecting the suitability of obsidian tools for specific tasks, five metric variables were chosen for factor analysis on those prehistoric edges which appeared to have been used (after experimental comparison).

Each used edge was treated as a separate 'entity' by the factor program. This analysis was expected to establish a typology of used edges, thus circumventing the inherent problem of lack of specific flake categories met with in previous study of New Zealand obsidian tools.

The above analytical procedures outlined were expected to solve problems 3 and 5 identified in the Introduction:

**Problem 3:** "Are there any formal tool types which could be identified; and is there any correlation between tool morphology and function?"

**Problem 5:** "Is there any significant difference or similarity between one tool assemblage and another? If so, how might this relate to the different economic and industrial activities represented?"

**Variables Selected for Edge Measurement**

The following variables were selected for measuring the prehistoric flakes with used edges:
1. The Edge Length (EL, Jones 1972:94). The length of a used edge was measured with a set of calipers, to ± 2 mm (see Figure 2).

2. The Radius of Curvature (RC, *ibid.*:92). This was a measurement of the curvature of an edge which was concave, convex, or straight; expressed as a radius. As the edges of flakes seldom describe perfect arcs, this became a measurement of the average RC. The RC was taken by placing the used edge of an artefact on the circumference of a series of circles with marked radii (illustrated in Figure 12), until the one with the closest fit was found. This measurement is accurate to ± 10 cm.

3. The Effective Edge Angle (EEA, see Figure 2). This was taken by using a thin cardboard sheet having a 3 mm margin series of accurately cut notches from 10° to 120° along its edge. These were at 2° intervals (giving an accuracy of ± 4°). As the EEA varies between 3° - 5° on some used edges, several notches were tried (under a 10 x binocular microscope) until the best average fit was found. This method adopted here was found to be repeatable with a higher degree of accuracy than measuring cross-sections of wax impressions, by estimation with the naked eye (compare the apparatus used by Movius *et al.* 1971 which can compensate for parallax errors in naked eye estimations of edge angles), or by using a
contact goniometer (where the bulk of a flake often interferes with the measurement of its edge). For a detailed summary of the problems inherent in measuring the angle of a used edge see Odell 1979: 333-342.

4. The Maximum Dimension (MD, see figure 2). This was adapted from Morwood (1974a) and here simply measured as the maximum distance (to ± 1 mm) at right angles from a used edge to its flake's margin. This recorded the index of 'graspability' of a flake, and was considered a part of the edge parameters which affect function. The minimum figure for the MD is about 1 cm where dimensions of these small Murihiku assemblages were concerned, and below this it would not be possible to properly grasp and use these obsidian flakes. Any flakes from the four assemblages which had use-damage on their edges, having MD's below 1 cm, were not included as usable edges for analysis.

5. The Weight (Wt). This was a measurement of the weight (+ 0.1 grams) of a flake with a used edge on it. However, as the analysis was directed towards separate used edges, it was considered here as another edge parameter (an 'edge-weight'). It was included to see if there might be some correlation with function, and with the other four parameters.
FIGURE 12: Measuring the convexity or concavity of a used edge; expressed as a Radius of Curvature (from Jones 1972:92). Three hypothetical examples are shown above. To obtain a fit with the circumference of one of the above circles, an edge is repeatedly turned through 180° to determine if it is concave (here recorded as a negative value) or convex (positive). Then various circles are sampled until the one with the best average fit is found. If an obsidian edge exceeds the value of ±110 mm it is considered here to be 'straight'. Example A has a value of -90 mm, B is -15 mm, and C is +15 mm. This method of measuring RC is accurate to ±10 cm, and has also been used in measuring potsherd rim RC's.
CHAPTER 2: RESULTS

INTRODUCTION

This chapter is divided into two main sections: the first part presents the results (in summary form) of the experimental work with the standardised obsidian tools, including photographs of edge damage sustained after 50, 500, and 1000 strokes. The significant varieties of edge damage throughout each different operation are described using fracture classifications adopted from Crabtree (1972) and Hayden et al. (1979). These are illustrated in Figure 13. The second section covers the selection of prehistoric obsidian tools which have used edges (based on experimental comparison). There follow the results of the multivariate and univariate analyses applied to them.

FIGURE 13: The 'Ho Ho' fracture classification used to describe edge damage on the experimental and prehistoric obsidian tools. When describing damage on obsidian edges, an 'initiation/termination' format is used. Thus, for example; 'cone/feather', or 'bending/feather-step' (after Hayden et al. 1979:134 "The Ho Ho classification and nomenclature committee report").
THE EXPERIMENTAL WORK WITH STANDARD OBSIDIAN TOOLS

1. Bidirectional Scraper, AA=45° (Figure 14)

![Bidirectional Scraper Images](image)

FIGURE 14: Bidirectional scraper with an AA of 45°. A represents the edge (shown here with its two faces) in an unused state. A standard unused control edge is shown for each of the undamaged faces in this and the following figures of experimental tools. B represents the edge damage after 50 strokes; C after 500 strokes; and D after 1000 strokes. The Trailing Face is shown on the right face from A to D (and is maintained for all the following figures of experimental scrapers). Scales in Figs 14-24 = 1 cm.

Most of the edge damage was sustained on the 'Trailing Face' (see Figure 7). The damage across the edge was in the form of connected scalar flake scars ranging in size from 0.5 - 2 mm. This variety of damage occurred throughout the other edges used as scrapers (see below). About 50% of the Trailing Face was damaged after 50 strokes (Figure 14B). After 500 strokes the scraper would not remove shavings.
as smoothly and evenly as before, and bifacial edge
damage began to appear thereafter to 1000 strokes (Figure 14D).
Flake scars initiations were mostly of the cone/ (and
occasionally bending) -feather variety. One very small
type 2-step termination also occurred (see Figure 13).

2. Bidirectional Scraper, $\alpha=30^\circ$ (Figure 15)

![Bidirectional Scraper Images](image-url)

**FIGURE 15**: Bidirectional scraper, $\alpha=30^\circ$. A shows the tool
in an unused state; B after 50 strokes; C after 500 strokes;
and D after 1000 strokes. The Trailing Face is on the right
side of each sequence.

The damage was mostly unifacial, occurring on the
Leading Face. Some slight bruising appeared on the
Trailing Face after 1000 strokes (Figure 15D). It was
easier to remove wood shavings bidirectionally with an AA of $30^\circ$, than with an AA of $45^\circ$ (experiment 1), and the tool was still usable after 1000 strokes. Scalar flake scar size ranged from 0.5 to 2 mm. Flake scars were of the cone/feather variety. Again, a line of scalar flake scars was formed along the edge.

3. Unidirectional Scraper, AA=$45^\circ$ (Figure 16)

![Figure 16: Unidirectional scraper, AA=$45^\circ$. A shows the tool in an unused state; B after 50 strokes; C after 500 strokes; and D after 1000 strokes.](image)

The damage was unifacial throughout; a continuous line of scalar flake scars appearing on the Trailing Face. This pattern, whether unifacial or bifacial, can now be confidently
associated with wood scraping activities; and it should be possible to identify this action with prehistoric obsidian tools which have similar edge damage. Throughout the 1000 strokes this scraping action was able to be performed without any severe impediment, and the tool remained in a usable condition at the end of them. Flake scars were of the cone/feather variety and their size ranged from 0.5 - 1 mm.

4. Unidirectional Scraper, AA=30° (Figure 17)

![Figure 17: Unidirectional scraper, AA=30°. A shows the tool in an unused state; B after 50 strokes; C after 500 strokes; and D after 1000 strokes.](image)
The edge damage was unifacial throughout the 1000 strokes, and occurred on the Trailing Face. It was also much more reduced than the damage on the edges of the other three scrapers; covering only about 30% of the entire edge after 1000 strokes (Figure 17D). Because of this difference in the degree of damage, depending on the four different modes of scraping employed here, it is not possible to quantify the amount of work done with a prehistoric tool on the basis of the amount of damage to its edge. Throughout the 1000 strokes the scraping action was able to be performed very smoothly with minimal damage, leaving the edge perfectly usable for at least a further 1000 strokes. Using a unidirectional motion with an Angle of Attack of 30° proved to be the most comfortable and economical mode of using these scraping edges. It therefore seems likely that after some experimentation, early tool users could well have adopted this particular mode of action for scraping with their obsidian flakes. Flake scars were of the core/feather variety, in the 0.5 to 1.5 mm size range. These flake scars - here in the form of connected scalar flake scars - seem to consistently occur with scraping activities, and can now be confidently associated with them in the examination of prehistoric obsidian tools.
5. Bidirectional Knife; Sawing (Figure 18)

By 10 strokes the thinnest portions of the edge began to snap off (with bending initiations) and to slightly impede the sawing action, as some of them embedded into the wood (causing the removal of further small flakes). Isolated scalar flakes (cone/feather) were removed off each face. The major type of edge damage was largely in the form of fairly regular serrations or hollows 3 - 6 mm across; leaving a bifacially denticulated edge. This damage occurred progressively through to 1000 strokes. By 50
strokes (Figure 18B) most of the original sharp edge had been broken off, although wood penetration continued to be 2 - 3 mm up to about 800 strokes. Thereafter it became difficult to sustain a smooth sawing action. By 1000 strokes (Figure 18D) the edge had become quite blunt (or 'stabilised') - about 1 mm of cross section having been exposed - and it would no longer function as a saw. About 90 mm$^2$ of original edge had disintegrated by 1000 strokes, leaving cone-bending/feather denticulation.

6. Unidirectional Knife; Slicing (Figure 19)

FIGURE 19: Unidirectional knife; slicing (at 90° to the wood surface). A shows the tool in an unused state; B after 50 strokes; C after 500 strokes; and D after 1000 strokes.
The edge damage and degree of unimpeded operation here was similar to experiment 5 (the saw). After about 10 strokes the thin parts of the edge began to snap off, some microflakes embedding in the wood. Isolated scalar flake scars (cone/feather) appeared on both faces. By 50 strokes (Figure 19B) a few of these scalar flake scars clustered around each other. But the major damage pattern was again one of bifacial denticulation - quite different to that obtained on the scrapers in experiments 1 - 4. Damage of this type here can now be confidently associated with a sawing or slicing action using an edge with an EEA of 20° perpendicular to the wood surface. But it does not appear possible to discriminate between slicing and sawing modes of action when the final damaged edges of experiment 5 and 6 are compared with each other. By 500 strokes (Figure 19C) wood penetration was still in the order of 2 - 3 mm, and one end of the knife edge had been sheared off in a bending/feather form. By 800 strokes, wood penetration became severely reduced (although it was still marginally better than the saw at this stage). By 1000 strokes (Figure 19D) the edge had become 'patchy' - blunt in most places with about 1 mm of cross section exposed. One or two small portions of the edge retained some degree of sharpness (due to bifacial damage). Again, an average area of about 90 mm² of original sharp edge had disintegrated, and the edge would no longer operate in the slicing mode.
7. Multipurpose Tool with an EEA of 70° Used as a Saw (Figure 20)

FIGURE 20: Multipurpose tool with an EEA of 70° used as a saw (at 90° to the wood surface). A shows the tool in an unused state; and B after 50 strokes. C shows an oblique view of a similar edge selected for this task, after 50 strokes. The damage pattern is very similar to B.

After 21 strokes small fragments began to flake off each face leaving a specific pattern of isolated bifacial clusters of scalar flake scars. These were of the cone/feather variety and ranged in size from 1.5 - 3 mm. Two small type 2 step terminations also occurred. Wood penetration was not very deep - about 1 mm. After 50 strokes the tool had become quite unsuited to this task,
therefore the experiment was halted at this point (Figure 20B). An identical unused edge was again selected for this task in order to determine how repeatable the above damage pattern was (Figure 20C). Performance and damage were very similar. An edge of this type is unsuited to this task, and overall performance could be rated as very poor compared to the knife edge used as a saw. It therefore seems unlikely that early tool users would continue to select an edge with an EEA of about 70° for the task of sawing wood, but if they did it would produce a unique damage pattern which can now be positively associated with such activity; providing of course that this pattern was not obliterated by subsequent scraping tasks.

8. Multipurpose Tool with an EEA of 20° Used as a Unidirectional Scraper, AA=30° (Figure 21)

As experiment 4 proved to be the most effective way in which an edge with an EEA of 70° could be employed as a scraper, this unidirectional motion with an AA of 30° was adopted for determining the results of using a knife edge as a scraper. After 50 strokes (Figure 21B) a now familiar pattern associated with scraping - that of a regular line of scalar flake scars - formed along the edge. These were of the cone/feather variety in the size range of 1 - 3 mm, and they occurred on the Trailing Face. By this stage scraping began to leave small parallel
gouge marks along the wooden shaft. By 200 strokes the unifacial line of scalar flake scars extended further along the edge and smooth scraping at a constant pressure became difficult. By 300 strokes a 'chattering' movement in the scraping action was felt, and by 500 strokes (Figure 21C) this had become so pronounced as to render further scraping with this edge impossible. At this stage, a few very small isolated scalar flakes had been removed from the leading face, but the major damage occurred on the Trailing Face. Two small step flakes (type 2) also occurred. This unifacial edge damage conflicts with Morwood’s view that if an acute edge is used for scraping then bifacial damage results (1974b:82). The overall damage effect was the distinctive connected line of scalar flake scars identical to patterns of wear produced on scraping edges with an EEA of 70°. This formed a significant contrast to the bifacial denticulate variety of edge damage on the knife edges when they were used for sawing and slicing (experiments 5 and 6). It is therefore possible to associate this scalar damage pattern (which could occur on either knife or scraping edges) with a scraping action. It is probable that any Effective Edge Angle between 20° and 70° would produce similar wear if used as a scraper. However, as noted above, the knife edge was not at all suited to this scraping action on wood, and it is likely that prehistoric tool users would have rapidly determined this as well—saving their sharp obsidian edges for other tasks.
FIGURE 21: Multipurpose tool with an EEA of 20° used as a unidirectional scraper with an AA of 30°. A shows the tool in an unused state; B after 50 strokes; and C after 500 strokes.

9. Accelerated Non-Functional Edge Damage (Figures 22, 23)

In the case of the experiment with tools being badly treated in a plastic bag; wear along the knife edges appeared superficially similar to that produced after 50 – 100 strokes of sawing (compare Figure 18B). However, on closer examination there were a number of important differences. Whereas the used knife edges (experiments 5 and 6) had most of their thin edges broken off by 100 strokes, in the present experiment there remained (in a somewhat bruised
condition) about 70% of the very thin portions of the edge. The degree of scalar flaking on these edges was even lower than that of the used knife edges. Where any denticulation occurred on the thin edges in the present experiment, it was of a much more irregular nature. It therefore appears possible to distinguish used from unused edges within the knife range of $10^\circ - 49^\circ$.

![FIGURE 22: Accelerated non-functional edge damage. This shows views of the damage to the knife edges.](image)

Wear along the scraping (and other blunt) edges also appeared superficially similar to that produced by use. However, on these edges there was no formation of a regular connected line of flake scars (scalar or otherwise). A few scalar flake scars of the coné/feather type were scattered randomly over the blunt edges. But the majority of flake
damage here was approximately 80% triangular shaped flake scars (randomly scattered) with cone initiations, and hinge (type 1 and 2) or step (type 1) terminations.

FIGURE 23: Accelerated non-functional edge damage. This shows views of the damage to the scraping edges. Note the heavy damage on the extreme right.

This compares favourably with the results of Kamminga; who carried out experiments on trampling, seiving, and bag transport damage (in Hayden (Ed.) 1979:371 discussion). He found that "in all these experiments, 90% or even as much as 99% of all the fractures on nonacute edges were hinge and feather types". Flake scar size in experiment 9 ranged from 0.5 - 7 mm across. One tool sustained heavy damage to one of its scraping faces, in the form of large
conchoidal flake scars (bending/feather) about 6 - 8 mm across. However, these were suggestive of percussion rather than pressure.

It is also relevant here to compare the results of the experiments of Tringham et al. (1974:191-192). After agitating five pieces of freshly flaked flint in a plastic container filled with water, sand, and stones; they obtained a random bifacial distribution of scalar and triangular flake scars along the edges of the flints. A unifacial distribution of similar scars on the upper surfaces of ten flint flakes buried just under the surface of the earth, was created by having several people trample on them for 30 minutes. Their conclusions from these experiments are the same as those reached here. It is the regularity and concentration of scar orientation on flake edges forming a connected series of scars, which are the hallmarks of a used edge. Used edges within the scraping range of 50° - 120° can now be confidently distinguished from unused ones.

Summary

Edges with EEA's of 70° are well suited for the task of scraping wood, but not sawing. They are most effective when used in a unidirectional motion with an Angle of Attack of 30° to the wood surface. Use-damage to these edges occurs in the form of a regular connected line of scalar flake scars (usually of the cone/feather variety); about 80%
of which occur on one of the two faces forming the scraping edge (see Table 3). Scraping edges are not at all suited to sawing action at right angles to the wood surface - a mode of action which produces different distinctive patterns of isolated clusters of scalar flake scars connected in a bifacial manner.

<table>
<thead>
<tr>
<th>Mode of Action</th>
<th>AA = 45°</th>
<th>AA = 30°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unidirectional</td>
<td>Damage to Trailing Face</td>
<td>Damage to Trailing Face (minimal)</td>
</tr>
<tr>
<td>Bidirectional</td>
<td>Damage to Trailing Face</td>
<td>Damage to Leading Face</td>
</tr>
</tbody>
</table>

**TABLE 3**: Location of major edge damage (after 1000 strokes) on scraping edges with EEA's of 70°.

Edges with EEA's of 20° are suitable for sawing and slicing up to about 800 strokes, after which they rapidly become so blunt (or stabilised) as to be of no further use for these tasks. The damage pattern produced is a distinctive bifacial denticulation (different from all other patterns produced in the other experiments). These edges are not suitable for scraping wood in a unidirectional motion with an AA of 30° (perhaps the term 'whittling' best describes this mode of action). If this is attempted, a different pattern is obtained, identical to that produced on the scrapers (in experiments 1 - 4).
Non-functional edge damage can be distinguished from that produced by use. It is characterised by random isolated flake scars and some irregular snapping of the thin parts of an edge. The flake scars (usually scalar and triangular) occur on every edge of a flake, and there is also a much higher percentage of hinge and step termination in the flake scars.

Extrapolating the functional ranges of the Effective Edge Angle from the above experiments, it can now be confidently stated that the range of 10° - 49° is the minimum and maximum limit to which an edge could be used in sawing and slicing tasks (producing bifacial damage), and these can now be referred to as 'knives' when prehistoric assemblages of used edges are examined. The minimum and maximum EEA range with which an edge could be used for scraping tasks (producing unifacial damage) is 50° - 120°, and prehistoric used edges within this range can now be called 'scrapers'. Morwood's experimental work with obsidian is therefore not substantiated where he claims that the optimal angle ranges for scraping and cutting wood are the same (1974a:22). Furthermore, his statement that "functional significance can only be attributed to the differing angle distributions [within prehistoric assemblages] if a perfect unifacial/scraping, bifacial/cutting correlation is assumed, and experimentally the assumption is not valid" (1974b:82); is itself rendered invalid. The experiments of this study have demonstrated that unifacial/scraping and bifacial/cutting are acceptable correlations for the analysis of prehistoric obsidian assemblages.
FIGURE 24: Selection of used edges from the four Murihiku assemblages. These have all been coated with ammonium chloride sublimate to enhance their photographic perspective. A shows a knife (2.1) from Hawksburn. B shows a knife (2.1) from Pounawea. C shows a scraper (8.1) from Tiwai Point, and D shows another scraper (5.1) from this site. E shows a scraper (1.1) from Long Beach, and F shows another scraper (3.1) from this site.

Having established specific varieties of edge damage with different modes of action and Effective Edge Angles, it is now possible to select edges which seem likely to have been used on a medium at least as hard as green kanuka (after comparison with the above experimental results). Some examples of these from the four sites are shown in Figure 24. Table 4 gives the percentage of used
edges out of the total number of usable edges (between 10° - 120°) on 'graspable' flakes; which are flakes having a Maximum Dimension of not less that 1 cm (at right angles to a usable edge). The number of used flakes are expressed as a percentage of graspable flakes with usable edges, because it is the total number of flakes which could have been used as tools that need to be considered separately from the small waste flakes (see Table 1) which would otherwise affect these ratios.

Those edges which appear to have been used are described below, and their probable function is then suggested from the varieties of edge damage found on them. Each used edge is given a flake number, followed by an edge number; thus '1.2' refers to flake number 1 which has used edge number 2. The Effective Edge Angles and Radius of Curvature are given at the start of each description.
TABLE 4: Selection of prehistoric obsidian flakes after comparison with experimental edge damage. Flakes in the four Murihiku assemblages have been examined for usable edges which have Maximum Dimensions of approximately 1 cm or greater (at right angles to an edge). Effective Edge Angles between 10° - 120° are considered a usable range for an obsidian edge to be used on a hard material like wood. The edges selected as having been used are expressed as a percentage of the total number of edges which fall within the 'usable' range of MD and EEA.

**Tiwai Point**

1.1 (EEA=32°, RC=straight): This has a denticulated edge with a few scalar flake scars (cone/feather), and the damage is bifacial. There are a few random striations, which occur away from this edge. The damage is suggestive
of the edge having been used as a knife.

2.1 (EEA=42°, RC=straight): A connected series of scalar flake scars occur on the edge (cone-bending/feather, with a size range of 1 - 1.5 mm), and the damage is 90% unifacial. No striations are visible near the edge. The damage is suggestive of a knife edge having been used as a scraper.

2.2 (EEA=20°, RC=convex): Small denticulations with some scalar flake scars occur on the edge; with an associated bruising of the sharp parts of the edge. Random striations occur away from the edge. The damage is bifacial, and is suggestive of the edge having been used as a knife.

3.1 (EEA=62°, RC=convex): There is a connected series of bifacial scalar flake scars, in the size range of 0.5 - 2.5 mm (cone/feather). About 80% of the damage is unifacial, and there are some random striations away from the used edge. It appears to have been used as a scraper.

4.1 (EEA=68°, RC=convex): There is a connected series of scalar flake scars in the 0.5 to 1 mm size range (cone/feather variety) along the edge, and 98% of the damage is unifacial. No striations are visible near the used edge; however, one face of this edge has some parallel striations aligned at right angles to the used edge, which are probably concurrent with the edge having been used as a scraper.
5.1 (EEA=62°, RC=straight): There are a connected series of scalar flake scars from 1 - 2.5 mm in size (cone-bending/feather variety). The damage is unifacial, and no striations are visible. This edge appears to have been used as a scraper, and is illustrated in Figure 24D.

6.1 (EEA=40°, RC=convex): There is a denticulated edge, with isolated scalar flake scars, and the damage is bifacial. There are no striations visible near the edge, although there are some parallel striations on the ventral surface suggestive of scuffing (probably while still attached to its core). The edge appears to have been used as a knife.

7.1 (EEA=68°, RC=concave): There are a connected series of scalar flake scars in the size range of 0.5 - 6 mm (cone-bending/feather). The damage is unifacial, and quite heavy - having modified much of the edge. There are heavy short parallel striations at right angles to this edge, suggestive of scraping. However, there are also some striations (about 1 cm in from the edge) which run parallel to the edge; these may or may not be the result of use. The overall damage suggests that this edge had been used as a scraper.

8.1 (EEA=52°, RC=convex): On one face there is a connected series of scalar flake scars of 1 - 2 mm size (bending-cone/feather variety). As well as these scars there are some larger scalar flake scars in the 3 - 4 mm range (cone/feather).
This edge (and face) is illustrated in Figure 24C. On the reverse face an overlapping cluster of scalar and triangular scars with bending initiations and step terminations occur. A few small striations near the edge run parallel to it. However, these are interrupted by the flake scars, suggesting they occurred before use. The overall damage is suggestive of the edge having been used as a scraper, with heavy pressure and/or a series of 'chipping' blows (using the same Angle of Attack) – this probably caused the flake scars with step termination (which, as a result of experiment 9, can now be correlated with percussion).

9.1 (EEA=33°, RC=convex): The edge has a denticulated appearance formed by small crescent-shaped scars. When the reverse face is examined this denticulation is seen to occur through a small series of connected scalar flake scars in the 0.5 - 2 mm size range, and this damage is 90% unifacial. One face of this used edge has many random criss-cross striations. On the reverse face there are heavy striations visible to the naked eye, at right angles to the edge; running from the edge right across the surface of the flake. The damage and striation components suggest that this is a knife edge which had been used as a scraper.

10.1 (EEA=77°, RC=convex): Along the edge there is a well defined series of small scalar flake scars about 1 mm in size (cone/feather variety). Behind these there is a
larger series of scalar flake scars about 2 - 3 mm in size (cone-bending/feather variety). The damage is unifacial, and there are striations on both faces of this edge, at right angles to it. The damage is strongly suggestive of this edge having been used as a scraper; and the flake appears to have been broken off a larger scraper. However, it is still usable in its present form.

10.2 (EEA=69°, RC=straight): On the edge there is a well connected series of scalar flake scars 1 - 2.5 mm in size (cone/feather with a few step terminations). There is some crushing and bruising of the apex of the edge as well. A few random striations occur well away from this used edge and 98% of the damage is unifacial. This edge appears to have been used as a scraper; after the flake on which it occurs probably became detached from a larger piece - of which flake/edge 10.1 was a part.

Pounawea

1.1 (EEA=44°, RC=convex): An interrupted series of scalar flake scars from 1 - 3 mm (cone-bending/feather variety) has formed a slightly denticulated edge, and 90% of the damage is unifacial. Some striations extend inward from the edge at an angle of about 45°. This appears to be a knife edge that has been used as a scraper.
2.1 (EEA=16°, RC=convex): The edge is well denticulated, and the damage is bifacial. There are no visible striations. This edge appears to have been used as a knife; and is illustrated in Figure 24B.

**Long Beach**

1.1 (EEA=82°, RC=concave): This edge occurs on a flake that came from the interface of the Archaic and sterile levels of the site (of which the latter has both Archaic and Classic intrusive cultural material in it - see below). There is a connected series of overlapping scalar flake scars along the edge, and the damage is bifacial. A few random striations occur on the flake ridges away from the edge (from portage?), and it appears to have been used as a scraper. This is illustrated in Figure 24E.

2.1 (EEA=74°, RC=convex): This, and the remainder of the used edges from this site occur on flakes provenanced to the Classic layers. There is a connected series of scalar flake scars forming a unifacial damage pattern, and no visible striations. The edge appears to have been used as a scraper.

3.1 (EEA=94°, RC=straight): There is bifacial damage in the form of connected scalar flake scars (cone/feather variety; with some step terminations as well). No striations are visible. The edge appears to have been used as a scraper, and is illustrated in Figure 24F.
3.2 (EEA=95°, RC=convex): The damage is very similar to the other used edge on this flake (3.1), and there are no visible striations. This edge also appears to have been used as a scraper.

4.1 (EEA=98°, RC=concave): There is a series of connected scalar flake scars 0.5 - 2 mm in size (cone/feather variety). About 99% of the damage is unifacial, and there are parallel striations at right angles to the worked edge. This edge is quite concave (having an RC of -5 mm) and seems likely to have been used as a scraper for working narrow shafts.

4.2 (EEA=68°, RC=convex): There is unifacial damage in the form of a connected series of scalar flake scars, as well as some bruising of the edge. Some random striations occur away from the used edge, which appears to have been used as a scraper.

**Hawksburn**

1.1 (EEA=90°, RC=straight): There is unifacial damage along the edge in the form of a connected series of scalar flake scars (cone-bending/feather variety). No striations are visible, and the edge appears to have been used as a scraper.

2.1 (EEA=30°, RC=convex): There is bifacial damage in the form of denticulation and isolated scalar flake scars, and the flake on which this edge occurs has been broken
in two. Striations occur near the edge, aligned between 50° - 80° with it. The major damage is suggestive of this edge having been used as a knife, and it is illustrated in Figure 24A.

3.1 (EEA=85°, RC=concave): A connected line of scalar flake scars 1 - 1.5 mm in size, occurs along the edge (cone/feather-step variety). The damage is bifacial, with no visible striations. The occurrence of step termination together with some degree of edge bruising is suggestive of this edge having been used as a scraper with some heavy 'chipping' blows in its operation.

3.2 (EEA=75°, RC=concave): About 80% of the edge damage is unifacial, in the form of a connected series of scalar flake scars 0.5 - 1.5 mm in size (cone/feather variety). Some striations occur near the edge and are aligned at about 45° to it. This edge appears to have been used as a scraper.

RESULTS OF THE MULTIVARIATE ANALYSIS OF THE USED OBSIDIAN

Figure 25 illustrates the symbols used in the plot of the Q mode of the factor analysis. These symbols are combinations of what are considered to be the two most important variables which directly affect the function of an edge; the Effective Edge Angle, and the Radius of Curvature. The EEA determines whether an edge is suitable for a range of scraping or cutting tasks. The RC also
affects this, although to a lesser degree. For example, a scraper's edge which is very concave would be more suitable for working shafts, than a convex one. Edge Length is of only minor importance; although there is a minimum of about 1 cm below which an edge is probably too small to be used properly. However, the Maximum Dimension is of more importance than the Edge Length, as it determines whether an edge can be grasped properly or not. As this has a minimum value of about 1 cm and since it is only edges over the minimum value of EL and MD which can be used, it is not necessary to incorporate these variables in the symbols used in the Q mode plots. The weight is also of lesser consequence, and is probably another expression of the MD and EL, but was incorporated in the factor analysis in case there was some degree of independence between it and the other four metric variables. The data was standardised before Q and R mode analyses.

The results of the Q mode analysis of the used prehistoric edges (depicting EEA and RC) are shown in Figures 26 - 28. The Q mode analysis produced a four factor matrix. However, the Eigenvalues given for these four factors (which are 10.2, 6.3, 6.0, and 1.4 respectively) indicate that 90% of the variance is accounted for by the first three factors (and so the fourth factor is not plotted out). In plotting out combinations of these three factors, the varimax solution was used.
The cutoffs used in plotting out the EEA's in Figures 26 - 28, are $10^\circ - 49^\circ$ (now considered to be the minimum and maximum range within which an edge could be employed for slicing and sawing), and $50^\circ - 120^\circ$ (now considered the minimum and maximum range within which an edge could be employed for scraping). The cutoffs for the Radii of Curvature are as follows. Those edges with RC's from 0 to $+110$ mm are called convex, while edges falling within the similar negative range of 0 to $-110$ mm are called concave. RC's exceeding these two ranges are called straight.

Figure 12 illustrates the decreasing edge curvature as the radii approach $\pm 110$ mm. Convex edges are given the prefix 'nose' when their final lable is used which incorporates EEA and RC (for example 'nose-scraper', or 'nose-knife'). Concave edges are given the prefix 'spokeshave'. These combinations of EEA and RC are depicted in Figure 25.

The three plots of the used edges in the Q mode analysis indicate that the used obsidian edges within all four sites cluster into three major groups of nose-knives, nose-scrapers, and spokeshave-scrapers.

Figure 29 shows a varimax plot of the two factors (with Eigenvalues of 2.4, and 1.0) given by the R mode analysis of the five metric variables. As can be seen, the EEA and RC stand out well on their own, indicating their dissociation from the other three variables. Edge Length, Weight, and Maximum Dimension cluster together fairly closely, indicating that they may be considered as
one variable in the multivariate analysis. The most important of these three, for future studies; is the Maximum Dimension.

10° - 49°  50° - 120°

A

B

C

D

E

F

G

H

FIGURE 25: Symbols incorporating Effective Edge Angle and Radius of Curvature, used in the Q mode factor plots (Figures 26 to 28). Cutoffs for the EEA are 10° - 49°, called knives (symbol A shows this in cross section); and 50° - 120° called scrapers (symbol B). Cutoffs for the RC are as follows: 0 to ±110 mm is called convex (symbols E and H) or concave (symbols C and F); >±110 mm is called straight (symbols D and G). Incorporating the EEA and RC which are the two variables that have the most immediate effect on the way in which an edge can be used, symbol C is therefore called a 'spokeshave-scraper', D is called a 'straight-scraper', and E is called a 'nose-scraper'. Symbol F is called a 'spokeshave-knife', G is a 'straight-knife', and H is a 'nose-knife'.

FIGURE 26: Varimax Q mode factor analysis (factors 1 and 2). Symbols (depicted in Figure 25) incorporating EER and RC are used to depict used edges. The letters inside them are first letter abbreviations for each site (T = Tiwai Point, L = Long Beach, P = Pounawea, and H = Hawksburn). Lines have been drawn around clusters for added emphasis.
FIGURE 27: Varimax Q mode factor analysis (factors 1 and 3). Symbols (deicted in Figure 25) incorporating EEA and RC are used to depict used edges. The letters inside them are first letter abbreviations for each site (T = Tiwai Point, L = Long Beach, P = Pounawea, and H = Hawksburn). Lines have been drawn around clusters for added emphasis.
FIGURE 28: Varimax Q mode factor analysis (factors 2 and 3). Symbols (depicted in Figure 25) incorporating EEA and RC are used to depict used edges. The letters inside them are first letter abbreviations for each site (T = Tiwai Point, L = Long Beach, P = Pounawea, and H = Hawksburn). Lines have been drawn around clusters for added emphasis.
FIGURE 29: Varimax R mode factor analysis (factors 1 and 2). This shows the clustering of the five metric variables with which the used edges were measured. The Effective Edge Angle (EEA) and Radius of Curvature (RC) stand out as independent variables, while the remaining three (Maximum Dimension, Edge Length, and Weight) are fairly close together, showing their similar discriminatory function.
RESULTS OF THE UNIVARIATE ANALYSIS

Size frequency histograms of twenty cells are shown in Figures 30 - 34, of the five metric variables used to measure the four assemblages of used obsidian edges. As the sample from Pounawea is comprised of only two used edges, no histogram is shown for this. The sample from Long Beach is comprised of five used edges from the Classic layers, plus one used edge from the interface of the Archaic, and the sterile level (which contains both Archaic and Classic intrusive material). Because of the possibility of this flake with a used edge having come from the sterile level (which would mean it could be of either Archaic or Classic provenance) it is included in the Classic assemblage.

Relevant statistical data is included with each histogram; that is, sample (N), mean ( x̄ ), standard deviation (σ), standard error of the mean (SEx), and standard error of the standard deviation (SEσ). The data is then further examined by comparing each of the assemblages of used edges with the others, for the five variables (below). This is done by employing the Students t test (Thomas 1976:227-260); which compares the independent means of two sample populations (while compensating for sample size) and determines whether there are any significant statistical differences between them. The results of this test are set out in Table 5 (and summarised in Table 9).
Effective Edge Angle (EEA)

The Tiwai Point edges show a bimodal distribution; with one group of knives from 20° - 40°, and one group of scrapers from 50° - 80° (Figure 30A). The Long Beach used edges all cluster in the scraping range between 65° - 95° (Figure 30B). The two used edges from Pounawea fall in the 15° and 40° areas. The Hawksburn assemblage is bimodal; with one edge falling in the knife area of 30°, and three other edges in the scraping range of 75° - 90° (Figure 30C). Figure 30D shows the distribution of the EEA's of all four assemblages (N=24), showing a well defined bimodal distribution of knives between the 15° - 40° range, and scrapers between the 50° - 95° range. This should be compared to Figure 3, which was an estimate of the number of used edges (N=97) in the four assemblages before experimental comparison. Surprisingly the histogram in Figure 3 compares reasonably well with the post-experimental one in Figure 30D).

Table 5A shows significant differences in the EEA's between the Long Beach and Tiwai Point assemblages, and also between the Long Beach and Pounawea used edges.
FIGURE 30: Size frequency distributions of the Effective Edge Angle (EEA) of used obsidian edges. Shown here are Tiwai Point (A); Long Beach (B); Hawksburn (C); and all four assemblages (D).

Radius of Curvature (RC)

The Tiwai Point edges fall in a trimodal distribution of concave, straight, and convex forms (Figure 31A). The used edges from Long Beach also display this trimodal pattern (Figure 31B). The two used edges from Pounawea are both convex, while those from the Hawksburn assemblage form another trimodal distribution (Figure 31C). This trimodal distribution is most evident in Figure 31D showing RC's of used edges from all four assemblages.

Table 5B shows only a possible significant difference between the RC's of Hawksburn and Pounawea.
FIGURE 31: Size frequency distributions of the Radius of Curvature (RC) of used obsidian edges. Shown here are Tiwai Point (A); Long Beach (B); Hawksburn (C); and all four assemblages (D). '-' indicates a concave edge, 'I' a straight edge, and '+' a convex edge.

Maximum Dimension (MD)

The majority of the MD's in the Tiwai Point assemblage fall within the 22 - 36 mm range, with one also in the 10 - 12 mm range (Figure 32A). The MD's of the Long Beach assemblage are generally smaller, falling within the 10 - 18 mm range (Figure 32B). The two used edges from Pounawea fall in the 18 and 28 mm areas. The used edges from Hawksburn fall between the 14 - 30 mm range (Figure 32C). Figure 32D shows the MD distribution for all four assemblages; between 10 - 36 mm.
Table 5C shows highly significant differences between the MD's of Long Beach and Tiwai Point; with the mean of the former being much lower.

![Graphs showing size frequency distributions of the Maximum Dimension (MD) of used obsidian edges.](image)

**FIGURE 32**: Size frequency distributions of the Maximum Dimension (MD) of used obsidian edges. Shown here are Tiwai Point (A); Long Beach (B); Hawksburn (C); and all four assemblages (D).

**Edge Length (EL)**

The Edge Lengths from the Tiwai Point assemblage suggest a vague bimodal distribution of one group in the 10 - 27.5 mm range and the other edges falling within the 37.5 - 45 mm range (Figure 33A). The EL's
of the Long Beach assemblage (like their MD's) cluster in one group of 10 - 17.5 mm (Figure 33B). The two used edges from Pounawea fall in the 20 and 27.5 mm areas. The Hawksburn assemblage presents a bimodal distribution; with two edges falling within the 15 - 22.5 mm range, and the other two within the 35 - 37.5 mm range (Figure 33C). The distribution of EL's from all four assemblages shows a bimodal distribution; one group within the 10 - 27.5 mm range, and a smaller group in the 35 - 45 mm range (Figure 33D).

Table 5D shows no significant differences between any of the four assemblages.

![Figure 33](image-url)

FIGURE 33: Size frequency distributions of the Edge* Length (EL) of used obsidian edges. Shown here are Tiwai Point (A); Long Beach (B); Hawksburn (C); and all four assemblages (D).
Weight (Wt)

The weight here refers to the weight of the whole flake on which a used edge occurs. As each used edge is treated independently in this analysis, it is here given an 'edge-weight' for the purposes of indicating the distribution of flake weight per used edge.

The distribution of Weight in the Tiwai Point assemblage is bimodal, with one group falling within the 1.5 - 5 grams range, and the other within the 7.5 - 9 grams range (Figure 34A). The Weights from the Long Beach assemblage are in the low range of 0.3 - 3 grams (Figure 34B). The two used edges from Pcunawea fall within the 1.5 - 2 grams range, and 3.5 - 4 grams range. The Hawksburn assemblage Weights fall within the 2 - 5 grams range (Figure 34C). Figure 34D shows a definite bimodal distribution of Weights in all four assemblages; with one group in the 0 - 5 grams range and the other in the 7.5 - 9 grams range.

Table 5E shows significant differences between the weights of Hawksburn and Long Beach, and highly significant differences between Tiwai Point and Long Beach. Tiwai Point also displayed the most heavy waste flakes amongst the obsidian debitage from the four sites.
FIGURE 34: Size frequency distributions of the Weight (Wt) of obsidian flakes with used edges on them (here expressed as 'edge-weights'). Shown here are Tiwai Point (A); Long Beach (B); Hawksburn (C); and all four assemblages (D).
TABLE 5: Results of the Students t-test. TW stands for Tiwai Point; HB for Hawksburn; LB for Long Beach; and PN for Pounawea. Combinations of any two sites (from left to right) are for the Effective Edge Angles (A); Radius of Curvature (B); Maximum Dimension (C); Edge Length (D); and Weight (E). Symbols used for the results of the Students t-test are as follows: '-' indicates no significant difference; '?' possible significant difference; '*' significant difference; and '**' highly significant difference.
SUMMARY

It is now possible to identify obsidian edges which have been used for scraping and sawing/slicing activities on wood; on the basis of the edge damage which is specific to these actions (as demonstrated by the experimental obsidian tools). These are summarised in Table 6. Except in a few cases (including the use of a knife edge as a scraper) the presence of striations on the used prehistoric artefacts has not been of great assistance in correlating probable function with edge damage.

<table>
<thead>
<tr>
<th>SITE</th>
<th>MODE OF ACTION</th>
<th>TOTAL USED EDGES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Knife Use</td>
<td>Scraper Use</td>
</tr>
<tr>
<td></td>
<td>(N=3)</td>
<td>(N=9)</td>
</tr>
<tr>
<td>Tiwai Point</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>(Archaic)</td>
<td>(N=1)</td>
<td>(N=1)</td>
</tr>
<tr>
<td>Pounawea</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>(Archaic)</td>
<td>(N=1)</td>
<td>(N=1)</td>
</tr>
<tr>
<td>Hawksburn</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>(Archaic)</td>
<td>(N=1)</td>
<td>(N=3)</td>
</tr>
<tr>
<td>Long Beach</td>
<td>-</td>
<td>100%</td>
</tr>
<tr>
<td>(Classic)</td>
<td></td>
<td>(N=6)</td>
</tr>
</tbody>
</table>

TABLE 6: Proportion of use of the two varieties of edge-tool with just the Effective Edge Angle represented here. Where a knife edge has been used as a scraper, it is included in the 'scraper use' column.
Expressing the numbers of used edges as a percentage of potentially usable ones on those flakes which equal or exceed the minimum values of MD (Table 4), it can be seen that the percentage of used edges from all four sites falls within the low bracket of 10 - 25. Why this should be so low is as yet unclear. It may be a reflection of excavation bias — other used tools may not have been excavated, or may have been carried away by their original owners to parts unknown. The Tiwai Point assemblage is especially puzzling as the proportions of the overall size of unused flakes are much higher when compared to the size of the used flakes. This may indicate an abundance of available obsidian or other material suitable for the tasks obsidian was used for. The matter is further discussed in the following chapter.

The plot of the R mode factor analysis (Figure 29) shows that the Effective Edge Angle and Radius of Curvature are independent variables from the remaining three; which, being of only secondary importance, may be considered together as one variable. The Maximum Dimension and Edge Length are only important in that to be properly grasped and used, a flake must not fall below their minimum (here postulated as 1 cm respectively). The Weight may now be considered as an expression of MD and EL. The EEA and RC are the two most important variables (at least where the use of obsidian is concerned) that affect the function of an edge. The EEA determines whether an edge is suitable for a range of
cutting (10° - 49°) or scraping (50° - 120°) operations; while the RC affects the way in which these two operations could be performed. For example a straight edge (with either high or low EEA values) would be suitable for a more broader range of tasks than a concave edge which would be suitable for a more restricted range of tasks.

Incorporating the two most important variables (EEA and RC) which directly affect the function of an obsidian edge, Table 7 summarises the six possible combinations of EEA and RC which occur in the four used obsidian assemblages. A complete absence of spokeshave-knives is noticable, and probably due to the early tool user's cognisance of the fact that this tool form would be comparatively fragile (where its edges could easily be sheared off). No evidence was found in any of the assemblages, of the use of a scraping edge as a saw. There was also no evidence in any of the four assemblages, of edge polish or abrasion which might have been the result of burnishing (cf. Knapp 1938). Nor were there any microcracks associated with localised edge-crushing which usually results from hafting (Morwood 1974b:95). All of the edge damage also appears consistent with that sustained through use rather than retouch (cf. Jones 1972:151), and overall, there has been minimal edge angle modification through use.
TABLE 7: Summary of the functional edge-types with suggested ranges of possible activities. This incorporates the two variables (EEA and RC) which have the most immediate effect on the manner in which an obsidian edge can be used. Edges with EEA's between 10° - 49° are called knives; suitable for slicing and sawing. Edges with EEA's between 50° - 120° are called scrapers. Edges with convex RC's (0 to +110 mm) are given the prefix 'nose'; edges with straight RC's (>±110 mm) are given the prefix 'straight'; and edges with concave RC's (0 to -110 mm) are given the prefix 'spokeshave'. Those categories marked with an (*) asterisk are the three main types which are formed into clusters (out of the four assemblages) by the Q mode factor analysis (in Figures 26 - 28).

<table>
<thead>
<tr>
<th>Edge Type</th>
<th>Tiwai Point</th>
<th>Long Beach</th>
<th>Pounawea</th>
<th>Hawksburn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spokeshave-Knives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Light working of shafts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N=2</td>
<td>Res: 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting and sawing</td>
<td>(one used as a scraper)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light to heavy work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nose-Knives</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>(more restricted range of tasks; detailed work, carving)</td>
<td>N=3</td>
<td>N=2</td>
<td>N=1</td>
<td></td>
</tr>
<tr>
<td>Nose-Scrapers</td>
<td>33%</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(working of shafts)</td>
<td>N=1</td>
<td>N=2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straight Scrapers</td>
<td>17%</td>
<td>17%</td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>(Wide range of light to heavy work)</td>
<td>N=2</td>
<td>N=1</td>
<td>N=1</td>
<td></td>
</tr>
<tr>
<td>Nose-Scrapers</td>
<td>33%</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(more restricted range of tasks; chipping, detailed work)</td>
<td>N=4</td>
<td>N=3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
It was not possible to identify specific damage caused by a knife edge first used for sawing and then scraping, or vice versa. However, most of the damage to the knife edges is consistent with that produced by sawing/slicing. The possibility remains of multipurpose use where an edge was first used for a light task followed by a heavy one (subsequently obliterating the damage caused by the former). It is possible that the heavy step damage on two of the scrapers (suggestive of heavy chipping action) could have removed earlier edge damage. However, examples of this amongst the four assemblages are rare. Seven flakes were found with evidence of multipurpose use. These are illustrated in Table 8.

<table>
<thead>
<tr>
<th>TIWAI POINT</th>
<th>POUNAWEA</th>
<th>LONG BEACH</th>
<th>HAWKSburn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knife used as Scraper/Knife (2.1-2)</td>
<td>Knife used as Scraper (1.1)</td>
<td>Scraper/Scaper (3.1-2)</td>
<td>Scraper/Scraper (3.1-2)</td>
</tr>
<tr>
<td>Scraper/Scaper (10.1-2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knife used as Scraper (9.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 8: Occurrence of multipurpose obsidian tools from the four Murihiku assemblages. Flake and edge numbers are given for each used example. In this context, ‘multipurpose’ has three related interpretations:**

1. an edge (such as a knife) which is suitable for one range of tasks is used for another (such as scraping). An above example is 9.1 from Tiwai Point.

2. The occurrence of two ranges of EEA on two or more used edges from the same flake. No examples of this can be found above.

3. Two or more used edges on the same flake. An example of this is 3.1-2 from Hawksburn.
The used tools from the Tiwai Point assemblage suggest a wide range of activities with knives and scrapers of various kinds. The type of edge damage and presence of striations oriented at right angles to the used edge of two of the knives is strongly suggestive of their having been used as scrapers; although they undoubtedly did not prove very satisfactory for this task (as demonstrated in experiment 8). The used tools from Long Beach are confined to the three different varieties of scrapers, suggesting the working of shafts with spokeshave-scrapers, as well as general and detailed use of straight- and nose-scrapers. The Pounawea sample is confined to two used nose-knives; one apparently having been used as a scraper. The Hawksburn used tools are suggestive of some detailed work (perhaps carving) with a nose-knife, and the scraping of shafts with spokeshave- and straight-scrapers.

The plots of the five metric variables in the multivariate Q mode (Figures 26 - 28) with the six combinations of edge types (of EEA and RC; see Figure 25) show that three main clusters of edge-tools are formed out of the four assemblages. These are nose-knives, nose-scrapers, and spokeshave-scrapers. The other forms do not appear to factor out into definite clusters. This demonstrates that multivariate analysis of an obsidian edge, as opposed to a flake, can establish discrete clusters of tools. Furthermore, by analysing the prehistoric
assemblages as edge-tools rather than flake- or core-tools, a definite correlation between morphology and function is clearly demonstrated.

When the four assemblages of used tools are compared with each other on a univariate level (using the Students t test) it can be seen that significant statistical differences exist between the EEA's of Long Beach and Tiwai Point, and also between Long Beach and Pounawea (Table 5). There are no significant differences between any of the four assemblages in their Radii of Curvature. Despite the R mode plot (Figure 29) which shows that Maximum Dimension, Edge Length, and Weight can be considered integrated as one variable in the multivariate analysis; the Students t test results summarised in Table 9 show that as far as univariate analysis is concerned, significant differences do exist for these three variables, between some of the sites. These are between the Weights of the Long Beach and Tiwai Point, and Long Beach and Hawksburn; whereas there are no significant differences between the Edge Lengths of these sites. Significant differences are also indicated between the MD's of Long Beach and Tiwai Point used edges (the latter being somewhat larger).

In the following chapter (Discussion) the various functional possibilities mentioned in the above results will be discussed in the archaeological context of each of the four Murihiku sites, and the problems outlined in the
Introduction will be reviewed with a view to resolving them.

<table>
<thead>
<tr>
<th>EFFECTIVE EDGE ANGLE</th>
<th>RADIUS OF CURVATURE</th>
<th>MAXIMUM EDGE LENGTH</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LB/PN</td>
<td>-</td>
<td>LB/TW</td>
<td>LB/TW</td>
</tr>
<tr>
<td>LB/TW</td>
<td>-</td>
<td>-</td>
<td>LB/TH</td>
</tr>
</tbody>
</table>

TABLE 9: Summary of the results of the Students t test; comparing the four assemblages of used edges, in terms of each of the above five metric variables. This table lists significant and highly significant differences between any two sites. Where nothing is entered, this indicates that there are no significant differences between any two assemblages. Possible significant differences are not included here, but are set out in Table 5. First letter abbreviations are used above for Tiwai Point, Pounawea, Long Beach, and Hawksburn.
CHAPTER 3: DISCUSSION

INTRODUCTION

Having ascertained the percentage of used obsidian edges within the four assemblages, the five problems set out in the Introduction could now be reviewed. Firstly, some discussion is necessary regarding the possible sources of error attendant on the experimental analyses and the excavated assemblages. Following this, the first four problems are evaluated for each of the four Murihiku sites. Finally, the fifth problem concerning differences and similarities between the analysed assemblages is considered in the light of an overview of the economy and lithic industry of each site.

SOURCES OF ERROR

Sample Universe

It is more than likely that the total assemblages of used and unused obsidian flakes from each site are not fully represented here. Some flakes may have remained unexcavated, or may have been removed by natural or human agencies prior to excavation. By various means the analysed assemblages have been further reduced subsequent to excavation. Prior to this study, four edges on Tiwai Point flakes were destroyed through sectioning for hydration dating. Definite evidence of recent damage to three edges from Hawksburn and one from Long Beach required that these also be excluded from analysis.
There is also the problem of material which cannot be provenanced directly to the excavated assemblages. Two unused flakes picked up from the beach at Pounawea, and a large obsidian block from Long Beach fall into this category. In each case it is not clear to what extent these items can be employed to expand upon the picture of obsidian use derived from the excavated assemblages. However, with regard to the Long Beach example, the quantity and size of flakes which one would expect in association with such a large core does not fit comfortably with the small size and conservative use of obsidian tools provenanced to the 1977 excavation. Thus it seems likely that this item was associated with one of the other areas of prehistoric occupation at Long Beach.

While it is almost certain that this analysis has not been able to deal with the total obsidian assemblages from each of the sites, and that the conclusions drawn may therefore be biased in some way, it has been possible to correlate most of the damage patterns found on the prehistoric tools with those produced by the experimental use of obsidian on wood. The findings of this research are therefore relevant within the context of the sample universe of the available archaeological data.

**Experimental and Prehistoric Tools**

In the use of the experimental tools, it was not possible to standardise every variable. Thus, the forces generated by hand pressure and motion along or across the
wooden shafts would vary slightly according to the mode of action employed, and the rate at which the edges began to disintegrate. It is therefore likely that the formation of edge damage on these tools has not progressed at an entirely constant rate. Then there is the possibility that there was some variation in the hardness of the kanuka shafts when being scraped or cut, due to variation in the moisture content inside the wood. The protrusion of occasional small knots along the debarked shafts probably accelerated the wear on the scraping edges, as well as affecting the application of the various forces to these tools. It should also be noted here that in making the tools, it was not possible to keep the Effective Edge Angles constant; there being a variation in the region of $\pm 4^\circ$ (see Table 2).

The application of various names such as 'straight-knife' or 'spokeshave-scaper' to the used obsidian edges may in some cases be somewhat imprecise. There may have been some degree of task-mixing with some of these tools; perhaps where an edge was used lightly on wood in one mode, and then roughly in another mode (thereby obliterating the former edge damage). For example, when Bellwood examined the Skippers Ridge 2 obsidian, he found striations which suggested that edges with high and low EEA's had been used for scraping. In examining the obsidian component of the Washpool assemblage from Palliser Bay, Leach suggests that where the obsidian spokeshave scrapers which appear to have been used on narrow shafts are concerned "...the high edge
angles of what might at first be identified as spokeshaves would indicate that the notched [concave] flake was a by-product of shaft scraping, not an intentional tool type" (1979:148, emphasis added). However, it is suggested here (and further discussed below in Problem 1) that where the edge form of spokesh ave-scraper occurs in the Murihiku assemblages, this was formed mainly by incidental flaking, and only partially accentuated by use. There is evidence (see Table 8) of three knives having been used as scrapers. This suggests that in the minds of early Murihiku tool users, the division made here between 'scrapers' and 'knives' was not always well defined or adhered to. Indeed it is possible (though improbable) that the use of these obsidian tools was not entirely restricted to wood (this is further discussed under Problem 2).

Finally, the selection of prehistoric used edges based on comparison with the experimental results may have been too conservative, while the measurements of their EEA's must be taken as an average index only (due to slight variation of the angle along a used edge).

Multivariate and Univariate Analyses

Given the above sources of error in the analysis of the prehistoric obsidian assemblages, it is obvious that the results of the multivariate and univariate analysis could consequently be biassed. They must therefore be treated as results representative of the available material recovered
from excavation which were subjected to the present methods of analysis outlined in Chapter 1.

**PROBLEM 1: USED OBSIDIAN TOOLS**

> "How many tools are there amongst the total number of flakes in each assemblage?"

As can be seen from Table 4, the actual number of used edges on all the obsidian flakes from each of the four sites is in the low bracket of 10 - 25%. The twelve (14%) used edges from Tiwai Point occur on flakes that are generally of the same size (occasionally smaller) as the large number of waste flakes (or 'spare parts') present. Many large flakes with usable edges in this assemblage have not been used. There are only two (10%) used edges from the Pounawea assemblage, and as Table 4 shows, there is a smaller number of unused flakes than that of Tiwai Point. The used edges from Long Beach number six in all (23%); with five of these from the Classic layers, and one provenanced to either the Archaic or Classic levels. No waste flakes were recovered from the Archaic layers, but there is one from the sterile level (intrusive Archaic and Classic), and eight from the Classic layers. The used edges from the Hawksburn assemblage number four (22%), and there are a small number of unused flakes (as with Long Beach) in contrast to Tiwai Point.

It is clear that the full potential for utilising obsidian edges was not realised. Why was this so? One
explanation is that this conservative use indicates a reliable supply of obsidian; hence a number of spare tools kept on hand. While this might have been the case for the three coastal sites, it does not fit comfortably with the site of Hawksburn - a seasonally visited moa hunting camp which would have been well away from the regular supply systems that provided obsidian. Contrarywise, conservative edge utilisation plus the presence of multipurpose tools could suggest a limited or restricted supply of obsidian (Leach 1979:148). However, this hypothesis does not account for why large numbers of flakes/edges were not utilised. Another possibility is that such a high percentage of unused edges suggests that obsidian tools were being made as well as used there (Morwood 1974b:92). While the lack of obsidian cores does not strengthen this hypothesis, it should be considered as a viable one. Jones suggests that such a low percentage of used flakes implies an opportunist use of edges "...fortuitously formed rather than actual manufacture or modification of edges to suit the task in hand" (1972:66).

Leach has suggested that the obsidian spokeshave-scrapers from the Washpool assemblage, with concavities of 9 mm or less were the resultant end-products of shaft scraping. However, the majority of the Murihiku spokeshave-scrapers from the four sites are less concave than this (with one exception of a very concave scraper (4.1) from the Long Beach site). It is postulated here that while scrapers
with high edge angles used on very narrow shafts may produce some degree of concavity, the thickness of this sort of edge would mitigate against the formation of deep narrow concavities. As an alternative hypothesis to spokeshave-scrapers being end-products of shaft scraping, it is suggested here that (as far as the Murihiku assemblages are concerned) there was an opportunist selection and use of obsidian flakes with concave edges (and other forms) that were incidentally formed by prolonged flaking activity. Desirable edge-forms would then be selected out of a 'heap of possibilities'; several of which are probably represented in the numbers of unused edges in at least the Tiwai Point assemblage.

It seems probable (and is argued below) that the obsidian component of the total compliment of stone tools in each site, represents a specialised part of the activities connected with the economic subsistence of each site. The nature of these activities is reviewed in Problem 2 concerning tool function.

PROBLEM 2: TOOL FUNCTION

"What were the obsidian tools used for; and in particular were they multipurpose tools?"

In considering the range of possible tasks obsidian might have been used for, it is first necessary to determine the medium for which they would have been most suitable. Is it likely they were used for butchering? The relative smallness of the used obsidian flakes plus their smooth
glassy nature would preclude this, as they would become too slippery from blood and fat to be able to be used effectively for cutting fresh meat and bone. In all four sites there are larger stone flakes of more robust material which could be grasped firmly for use as butchering tools. There remains the possibility that the obsidian edges could have been used for working bone. However, as Bain's results (1979) with experimental porcellanite tools show that this material disintegrates rapidly when used on bone, it is most unlikely that obsidian (an even more brittle and fragile material than porcellanite) would prove effective when used for this. It should be noted however, that Crabtree has experimented with obsidian core-tools on bone. By using very high Effective Edge Angles (>90°) formed by the ridges on a core, he has successfully removed shavings from dry bone (1977:40,43). Although 83% of the EEA's from the four assemblages fall below 90° (Figure 30D), the possibility that obsidian might have been used on bone, as well as wood, cannot entirely be ruled out.

Is it possible that obsidian was used on fibre such as flax (*Phormium tenax*)? Harsant's experiments with shell scrapers show that while they appear to be satisfactory for scraping prepared fernroot (*Pteridium aquilinum* var. *esoulement*), debarked manuka, and fish; they appear only marginally satisfactory for scraping cooked kumara, and flax fibre (1978:45-49). She further notes that the "removal of even one or two flakes [from the shell's edge]
would damage the flax fibres" (ibid.:96). Morwood’s experiments (1974a:27) with obsidian on flax also appear to substantiate the probability that obsidian edges (whether sharp or blunt) would prove unsatisfactory for scraping fibre. Many other stone types normally available to early and late Murihiku communities (such as porcellanite, chalcedony, or silcrete) would have provided sharp robust edges for cutting fibre if needed. Obsidian scrapers with EEA's >75° have been used successfully to scrape animal (opossum) skins (Morwood 1974a:28), so this possibility (for example on dog skins) cannot entirely be ruled out either.

Could the obsidian tools have been used to scale or gut fish? Morwood found that this could be done with knives with EEA's between 25° - 40°. However, some difficulty was caused by the slippery body juices from the fish (1974a:25). Again, the relative smallness of size in all four Murihiku assemblages would mitigate against this, while in all four sites there are larger sharp flakes of other material which would probably prove adequate for this task.

The most likely medium on which the prehistoric obsidian tools were used is that of wood. All of the damage patterns found on the edges of the used proportions of each assemblage bear a very close resemblance to those produced on the experimental tools described in Chapter 2.
As no wooden artefacts have been recovered from the four sites, the precise nature of those on which the obsidian tools were used is not known. However, there are a number of other Murihiku sites which have yielded such items as wooden bowls, and fire-ploughs; and these (plus several other possibilities) are suggested below in the light of other artefactual evidence from each site.

As noted in the results, at Tiwai Point both knives and scrapers were used. Two multipurpose tools were present (see Table 8). One flake has a knife edge that appears to have been used as a scraper (2.1), and the other used edge on the same flake (2.2) has been used as a knife. One other flake has two edges on it which have both been used as scrapers (10.1-2). Thus both cutting and scraping (and probably whittling) of small wooden artefacts seems indicated. Many forest birds are represented in the site's midden (Sutton and Marshall 1980:30 Figure 4), implying the use of small spears in their capture. It is quite possible that the obsidian tools were used in the manufacture of long narrow spear shafts for bird hunting. There are a few ethnographic references to the scraping of wooden spear shafts with shells (Colenso 1891:451, Maning 1906:67, Cowan 1930:170). However, as there is such a close correlation between the experimental obsidian damage patterns and those on the prehistoric edges, it is proposed here that obsidian rather than (or as well as) shell was used where the four Murihiku sites are concerned. It is
Further suggested that the tools could also have been used for the working of small wooden amulets, bowls, and fire-ploughs.

As far as Pounawea is concerned, the sample of two used obsidian edges from this heavily fossicked and eroded site is rather too small to draw many significant conclusions about use. As several small forest bird species occur in the site's middens (Hamel 1980:52), the fabrication of bird spear shafts is a possibility. There is one multipurpose tool; where one of the knife edges (1.1) has been used as a scraper.

In the Classic layers of Long Beach the used obsidian tools are all scrapers of one form or another. Two of the flakes are multipurpose tools; one (3.1-2) with two used scraping edges, and another (4.1-2) with one scraping edge and one very concave scraping edge. While bone and ivory lure and bait fishhooks occur in the site (some with serrations), these are not likely to have been made with the obsidian tools (as is argued above). Sharp stone knife edges would have been required to produce these, and as the used obsidian tools were all scrapers, it is more likely that these fine serrations on the fishhook points were produced with other tools (perhaps the sharp flakes of chalcedony also present in the site). From the sterile layer (containing intrusive Archaic and Classic material), the tip of a bird spear was recovered. The Classic layers
also yielded three well formed bird spear points of worked bird bone. As well as these, there have been over 88 bird spear points handed in to the Otago Museum from Long Beach in the past (Leach and Hamel 1981:120). It is likely that some of the small obsidian scrapers were used to form the thin long wooden shafts for these spear points. One of the scrapers (4.1) has a very concave edge with damage around it which is highly suggestive of the working of narrow shafts. The large numbers of barracouta fish bones in both Archaic and Classic middens in the site indicates that Long Beach was primarily a fishing camp. Several barracouta points have been recovered from the Classic layers (ibid.:125); and it is suggested here that the obsidian scrapers were also used to fashion the wooden lures for these trolling fishhooks.

At Hawksburn, subsistence differed from the other three sites. Instead of being something of a 'mixed bag' (involving the varied exploitation of sea mammals, birds, fish, moa, dogs, and shellfish), the most important resource at Hawksburn was obviously the moa. It is probable that the large numbers of silcrete blades abandoned there were used for butchering moa carcasses. Bain suggests that the use of porcellanite artefacts at this site was directed towards such activities as the light working of bone, butchering, and above all - woodworking (1979:53-54). She further suggests that they could have been used to fashion spear shafts. A small number of forest birds are
present in the site's midden; and it is tempting to suggest that the three used scrapers and one knife were in some way connected with the fabrication of bird spear shafts. The diameter of the kanuka shafts used in the experiments (Chapter 1) was about 3 cm, which probably approximates the minimum size required for a large throwing or jabbing spear in order that it would withstand the rigours of use without breaking. It is possible that the obsidian tools (as well as the porcellanite) were therefore also used for the fabrication of large wooden spear shafts for the hunting of moa. There is one multipurpose tool in this assemblage; with two used scraping edges on the same flake (3.1-2).

In summary, the used obsidian tools from Tiwai Point and Pounawea were probably used for making bird spear shafts, fire-ploughs, and perhaps small wooden bowls and amulets. At Long Beach (Classic layers) it is probable that bird spear shafts and fire-ploughs were also being made, as well as wooden barracouta lures. The presence of bird spear points and barracouta barbs is further supportive evidence for this hypothesis. At Hawksburn, the use of obsidian was probably confined to the fabrication of small (and possibly large) spear shafts, and fire-ploughs.

PROBLEM 3: TOOL MORPHOLOGY

"Are there any formal tool types which could be identified; and is there any correlation between tool morphology and function?"

By treating the used edges of an obsidian flake as independent univariate and multivariate entities, it has
been possible to establish categories of used tools. Here, the morphology of an edge has a direct and integral bearing on the manner in which an edge can function. Thus, the problem created by the absence of recognisable standard forms of flakes in any of the four assemblages can be resolved by treating them as assemblages of used edges. This in turn strengthens the hypothesis put forward under Problem 1 of this chapter; that there was an opportunist use of obsidian which was edge-oriented rather than flake-oriented.

The results of the experiments with standardised tools in Chapter 2 show that there is ample justification in calling edges with EEA's between 10° - 49° 'knives', and edges with EEA's between 50° - 120° 'scrapers'. Analysis of the damage patterns and EEA's present on the used edges in the four prehistoric assemblages replicates this division (despite the small number of edges suitable for one activity range which have been used for another). The univariate histograms depicted in Figures 30 - 34 show well defined distributions of used edges within the knife and scraper ranges, and Figure 30D (where all four sites are represented) shows a definite bimodal distribution of used edges into these two ranges.

When the obsidian tools are subjected to multivariate analysis, and plotted out by expressing combinations of the two most important variables that affect function (EEA and RC; see Figures 26-28), three main clusters of nose-scrapers, spokeshave-scrapers, and nose-knives are
factored out. The various proportions of these edge-tool types are set out in the preceding chapter (Table 7).

The nose-scaper form has some evidence of popularity outside of Murihiku. Near the mouth of the Athenree estuary in the Bay of Plenty, six obsidian artefacts with EEA's within the scraping range were found (Mitchell 1939:56-59). These have all been deliberately fashioned into disk forms - thereby giving all the usable edges a convex aspect. As some of these nose-scrapers (from 3-4 cm in diameter) have used edges, it appears to have been a desirable edge form. At the Washpool site in Palliser Bay the obsidian spokeshave-scaper form was popular too. Leach (1979:148) records twenty obsidian edges of this type which she suggests were used to scrape narrow shafts (bird spears?). As some chert edges of this form were also recovered, Leach further suggests that (at this site) obsidian and chert were functionally interchangeable (for scraping tasks), but that obsidian was the more highly valued of the two materials (ibid.:150). While Table 7 of this thesis shows that no spokeshave-knives occur in the four Murihiku assemblages, Morwood's analysis of obsidian flakes from the Archaic site of Tokoroa show this edge form was apparently used for the working of shafts; that is, spokeshave-knives used as spokeshave-scrapers (1974b:82). However, these Tokoroa edge forms are probably end-products rather than pre-use selected edge forms; as repeated scraping with a knife edge along very narrow shafts would no doubt produce
concavities on the edge (as opposed to the spokeshave-scaper proper, which - as argued in this present study - is too robust to be considered as an end-product of shaft scraping).

**PROBLEM 4: HUNTING OR SITE BASED WORK?**

"Do the tools form a part of a kit appropriate to hunting activities or were they used for home-based work?"

The hypothesis has now been put forward that the obsidian tools from all four Murihiku sites were in part used for the fabrication of small wooden spear shafts for bird hunting (as well as for making other wooden artefacts). If this was the case, then something can now be said regarding the above question. It is likely that the obsidian assemblages did form a part of a tool kit appropriate to bird hunting activities. However, whether these tools were used in the home-based production of spear shafts remains an open question. It is possible that there was some on-site working of spear shafts, and equally likely that a few usable obsidian flakes and extra spear points were taken along for a bird hunting foray (in case new weapons were needed for on the spot replacement).

It is also argued that the use of obsidian tools was not entirely confined to the fabrication of spear shafts. It is possible that this attractive dark glassy material may have been accorded a certain degree of ritual status amongst the spectrum of rock types available for the
manufacture of stone tools. Its brittle nature would confine its use to activities involving only a moderate degree of applied force; compared to that to which the other flake materials present in each site could be subjected. Ritual, prescribing obsidian for the fabrication of hunting weapons, barracouta lures, fire-ploughs, and possibly other domestic artefacts, may have set the scene for its conservative use in the working of select wooden artefacts.

PROBLEM 5: INTERSITE COMPARISON

"Is there any significant difference or similarity between one tool assemblage and another; if so, how might this relate to the different economic and industrial activities represented?"

When the two assemblages of Long Beach and Tiwai Point are compared, a number of differences can now be seen. Table 6 shows that while 75% of all used edges from Tiwai Point were employed as scrapers, all the used edges from Long Beach have been used for scraping. These Long Beach tools (half the number of Tiwai Point) are also the smallest in size out of the four assemblages. Does this imply restriction in obsidian supply as others have previously suggested (Leach 1979:148)? Probably not, as there were also several unused flakes with good workable edges (see Table 4). What the small size of the Long Beach scrapers suggests is a deliberate selection for smaller working edges; perhaps for finer work. Given
that only two used edges occur in the Pounawea assemblage, any differences that might be present are probably compounded or obscured by the sampling error. Comparing the assemblages of Hawksburn with Long Beach, the major difference is again the absence of used knives and the smallness in size of the latter group.

Overall, there appear to be as many similarities as there are differences in comparing each assemblage within its archaeological provenance. For example, obsidian tools in all four sites seem to have been used for woodworking and little else. In all four sites there has been a conservative use of obsidian, suggesting among other things that it was treated as a special commodity.

The Archaic site of Tiwai Point seems primarily to have been a settlement concerned with the fabrication of large argillite adzes for export, and the exploitation of seals, muttonbirds, plus a few other forest and marine food resources. The Archaic site of Pounawea with its long period of seasonal occupation may well have been an esturine base camp for foraging expeditions to the nearby coast, river, and forest. At Long Beach, faunal evidence from both Archaic and Classic levels suggests that this was a fishing campsite with major reliance on barracouta, supplemented by other marine and forest resources. The Archaic site of Hawksburn was probably a transitory base camp for hunting moa, seasonally occupied for a few years. Despite the differences in period of occupation and economic
subsistence, the evidence of the used obsidian tools from these four sites spanning the Archaic and Classic periods of prehistoric Murihiku, shows that the Polynesians who lived there were approaching obsidian use in much the same way - a conservative and opportunist edge-oriented use for a limited range of woodworking tasks.
CHAPTER 4: CONCLUSIONS

The use of standardised experimental obsidian edge forms has enabled the compilation of a catalogue of edge damage according to the various modes of action on wood. By using these for comparative analysis of the four prehistoric obsidian assemblages from Murihiku, and by treating each prehistoric used edge as a separate tool form, it has been possible to establish a discrete functional morphology of used obsidian tools. This study of microwear on obsidian edges provides an alternative to striation analysis. However, a suggestion for future research is that more experiments be undertaken with similar standardised obsidian tools on a variety of materials (such as green and aged bone, and different woods). If the experimental tools were finished with a polish smooth enough to highlight coarse striations, then sand could be introduced during their use. This would produce a succession of striations which could then be catalogued with their corresponding edge damage. Further avenues of experimental research on stone tools could be the calculation of actual edge loss as a quantitative measure of work done (see Tomenchuk 1979:123-131), and analysis of organic edge residues indicative of functional variance (Holloway and Shafer 1979:385-400, Broderick 1979:375-384).

Another matter arising from this study is that evidence of recent damage to several edges was noted after initial
examination with the naked eye and low power binocular microscope. In all but one case this damage was highlighted by the patina of ancient dirt on the obsidian artefacts. Another assemblage had been partly bagged together with other foreign lithic material (and had one recently damaged edge). It is recommended here that in future, obsidian artefacts recovered from excavation be bagged separately and individually (where economy permits) from any other material. No cleaning of any sort (whether by scrubbing, brushing, or with steam) should be applied until the obsidian artefacts have first been subjected to close scrutiny.

Analysis of the Murihiku assemblages, aided by the experiments in this study, has shown that the most likely material they were used on was wood. In all four sites it is likely that woodworking with obsidian was confined to the fabrication or finishing of small wooden artefacts such as spear shafts, fire-ploughs, barracouta lures, etc. It has been possible to establish how many used tools occur in each assemblage, and the range of tasks for which they were most suitable. Whether they were used exclusively in hunting or site-based work has not been fully resolved (and it seems probable that there was some degree of overlap in these two economic spheres of activity). By treating the used obsidian as edge-tools, an integral correlation between morphology and function has revealed discrete
tool types which were probably deliberately selected for by early stone tool users. When the respective economies and obsidian assemblages of each site are compared, the most outstanding fact to emerge is that there is no significant difference between the use of obsidian in the Archaic and Classic phases of prehistoric Murihiku (based on the existing sample). Throughout the pre-European era the hunter-gatherers of Murihiku were approaching the selection and use of obsidian tools in the same conservative and opportunist edge-oriented manner, and this orientation toward stone tools is similar to that observed elsewhere in the Pacific (White 1967, 1969).
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