THE EXPLOITATION OF MAYOR ISLAND OBSIDIAN IN PREHISTORIC NEW ZEALAND

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ABSTRACT

Obsidian in New Zealand was exploited from a variety of sources, and has been found in the majority of New Zealand archaeological sites. The presence of obsidian from the Mayor Island sources in most sites has been noted by archaeologists, and it has been assumed that a complex exchange system was responsible for its distribution. The purpose of the present thesis has been to evaluate the importance of Mayor Island as the main supply source of obsidian in prehistoric New Zealand, and to study the pattern of exploitation and distribution of the obsidian.

The analysis employed two separate approaches: site-oriented and regional. On a site-oriented basis, the quarries on Mayor Island were examined, particularly the production and procurement strategies. Ethnographic and comparable archaeological data on quarry exploitation were reviewed in order to test for evidence of access restrictions to the resources.

For the regional analysis, archaeological obsidian assemblages from 58 sites were sourced using energy dispersive XRF spectroscopy. Sourcing results indicate a changing pattern of source utilization throughout the temporal depth of New Zealand prehistory. The pattern of source utilization also varied according to site function.

The regional analysis of Mayor Island obsidian investigated further the importance of the Mayor Island obsidian in in the total lithic assemblages of the sites studied, and the nature of the manufacturing techniques in relation to geographical distance from the source, by means of fall-off curves.

Using this combined methodological approach it was possible to conclude that the exploitation of Mayor Island obsidian varied between the North and South Islands of New Zealand. While direct access seems to be the most probable way of acquiring the raw materials in the North Island, down-the-line exchange seems to be indicated for the South Island.

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CHAPTER I

INTRODUCTION

In the past decade archaeological studies of trade or exchange all over the world have significantly increased. A growing number of publications treat topics such as exchange mechanisms and their role in socio-political systems, or deal with detailed studies of particular items exchanged in the past. This growing interest is partly due to the increasing importance and development of models of cultural processes, but most importantly to the development of a wide range of scientific techniques capable of identifying sources of raw material. Only 16 years ago, Renfrew (1969a:151) commented on the fact that archaeology had almost completely neglected the role of trade as an element of economic growth and cultural change, or discussed prehistoric trade mechanisms or attempted to set up the facts on a quantitative basis. Since the new analytical techniques have become available on a routine basis to the archaeologist, an increasing number of studies have applied them to the study of the distribution of traded items and hypothesized on the probable exchange mechanisms.

Obsidian, of all traded materials, is the item that probably has received the greatest attention in the last decade, in terms of the number and variety of techniques applied to it, and the number of studies of it as an important exchange item. Obsidian has been the object of numerous characterization studies, and most theoretical discussions of the relationship of archaeological distriabutions and the surrounding cultural processes in operation, have been based on the results of obsidian exchange studies.

New Zealand archaeologists have not remained aloof from these developments. The identification of the sources of lithic materials found at archaeological sites have been the focus of interest of numerous studies in New Zealand archaeology in the past years, and are becoming increasingly popular (Anderson n.d.; Brassey 1985; Coster 1983; Fox 1982; McFadgen and Sheppard 1984; Prickett 1975; Ritchie 1984; Sutton and Campbell 1981). The increase in the number of sourcing studies is probably directly related to the large number of attempts by New Zealand archaeologists to implement routine sourcing techniques, especially for the sourcing of obsidian artefacts. No less than 12 different methods for sourcing obsidian in New Zealand have been employed. (For a complete summary of the analytical techniques employed refer to Bollong 1983:35-50). Sourcing studies based on the physical properties of obsidian have been carried out by Green

(1962), and Reeves and Armitage (1973). On the basis of element analysis the range of studies include emission spectroscopy (Green *et al.* 1967), wavelength dispersive XRF (Ward 1972, 1974a, 1974b, 1974c; Leach 1973, 1976; Leach and Anderson 1978; Chigdey 1981), and neutron activation analysis (Leach and Warren 1981; Chigdey 1981).

Obsidian in New Zealand was exploited from a variety of sources and is nearly ubiquitous in New Zealand archaeological sites. The prehistoric Polynesian population had access to a particularly abundant supply of obsidian sources, compared to other prehistoric Oceanic people. Ward (1972:123-127) identified 42 separate locations where obsidian occurs naturally. On the basis of chemical similarity they can be grouped into 19 major source regions. These 18 source areas are all located within a limited region of the North Island of New Zealand (Figure 1.1).

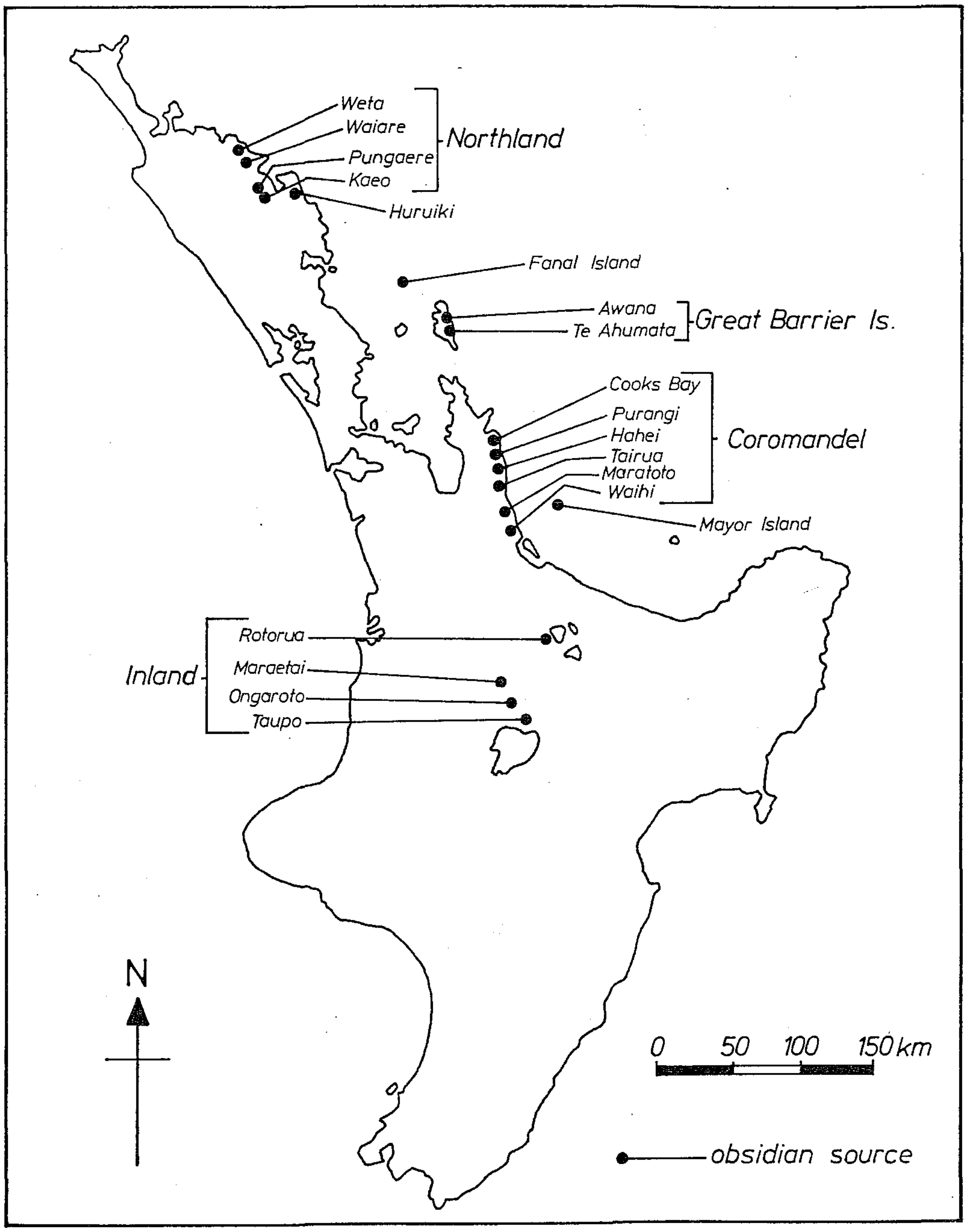


Figure 1.1. : Location of obsidian sources and source regions in New Zealand.

Obsidian was used mainly as a cutting tool. Some of the earliest visitors to come to New Zealand noticed that the Maori used a type of sharp stone as a carving and cutting tool. Joseph Banks in 1772 (1962 Vol.2:25) on Captain Cook's first visit to New Zealand remarked that,

> their nicer work which requires nicer edge tools they do with fragments of Jasper, which they break and use the edges of it that are sharp like flints till they are blunt, after which they are thrown away as useless, for it is impossible ever again to sharpen them...

A similar observation was made by Captain Cook on the same voyage.

> In working small work and carving I believe they use mostly peices of Jasper breaking small peices from a large lump they have for that purpose. As soon as the small peice is blunted they throw it a way and take another(1955:284).

It is quite probable that both Cook and Banks saw obsidian tools being used for cutting and carving of wood. Although no further descriptions of obsidian usage were made during that or the following two voyages, Johann George Forster noted during Cook's second voyage the eagerness of the Queen Charlotte Sound Maori to trade for bottles and bottle glass.

> Glass bottles, which they called tawhaw, were however particularly valuable to them; and whenever they saw any of them, they always pointed to them, and then moved the hand to their breast, pronouncing the word *mokh*... (1777:205).

Later again he observed,

> The chief object of their commerce were shirts and bottles, of which last they were remarkably fond... (1777:220).

This statement is also corroborated by Johann Reinhold Forster's diary (1980:290-91) and by Captain Furneaux's narrative (1961:738). The name bestowed on bottles and bottle glass of *tawhaw*, probably refers to *tuhua* the Maori name for obsidian.

Very few further instances of the use of obsidian are found in the early New Zealand literature. Obsidian was often used for cutting hair and during mourning. The earliest reference to this is probably given in Anderson's Journal kept on the third of Cook's voyages in 1777,

> ...[they] bewail them [the dead] with the most dolefull crys, at the same time cutting their foreheads and cheeks with a shell or piece of flint in large gashes until the blood flows plentifully... (1967:815).

Other references of obsidian being used for such purposes are almost 100 years later. The Reverend Mr Taylor (1855:102) noted that as a sign of grief people cut their foreheads and faces with pieces of obsidian. Obsidian was also used for the cutting of hair (ibid.). J. White (1874:337-38) observed at Hokianga the use of obsidan flakes during a hair cutting ceremony. Finally Manning (1875:103) observed that obsidian flakes were also used

> ... for cutting of flax, flesh, hair and surgical operations. The edge soon came off, when another chip would be split off the large lump of obsidian, which every family that could afford it would have lying by the house, or concealed somewhere near at hand. These blocks were usually brought from the Island of Tuhua by the Ngapuhi, when returning from southern expeditions, and were articles which fetched a considerable price in the way of barter.

He further recalls that,

> When I first came to the colony, in many inland villages the obsidian knife was still much used; it was merely a sharp chip, but when split off artistically extremely sharp (ibid.).

From the very first reports, ethnographic accounts of New Zealand mentioned a long standing network of communication. A large range of goods such as *kumara*, birds, preserved fish, berries and fern roots were exchanged, as well as manufactured goods and a variety of stone resources, including obsidian.

The importance of obsidian to the prehistoric population has long been recognized by archaeologists, especially the obsidian from Mayor Island flows. Green (1964) recognized that it could be easily distinguished from all other New Zealand sources by its translucent green colour under transmitted light. Initial inspection of obsidian flakes recovered from archaeological sites using the above technique showed an apparent predominance of Mayor Island obsidian in the early New Zealand sites. Green (ibid.) advanced the thesis that the Mayor Island obsidian flows were the first to be discovered by the Polynesian settlers; the other sources were discovered later and started to replace Mayor Island obsidian in archaeological sites. Green (ibid.:137) also noted that the presence of "obsidian in sites indicate an imbricated system of regional and inter-regional trading networks which are seemingly possible of definition given a sufficient amount of quantitative information".

Although the spatial distribution of obsidian, and in particular Mayor Island obsidian, has been noted for some time, the cultural mechanisms responsible for its spread have never been studied in New Zealand. Proposals concerning the possible methods of exchange have been put forward, but, so far, no attempt has been made to document properly and test the validity of theories using a systematic analysis of the existing archaeological data. The changing proportions of obsidian through time have been noted, first by Green (ibid.) and later by Leach (1978), but again no attempt has been made to test the data sets with the available theoretical information on prehistoric exchange mechanisms. Most studies in New Zealand have focused on the documentation of the movement of particular goods, especially of lithic resources, during the prehistoric period. (Leach 1978, Leach and Anderson 1978, Best 1972, Prickett 1975). However, the identification of such movements does not provide the information on the actual exchange mechanisms. As Leach and de Souza have commented,

> Attempts to disclose prehistoric trade and communication patterns have been carried out with high expectations of results. After about a decade of active research in developing sourcing techniques in New Zealand it is a moot point just how much has been revealed about prehistoric social and economic relationships (ibid.:44).

At this point one may ask why no such study has yet been attempted in New Zealand, as studies of lithic source utilization have been carried out for a number of years. The source allocation of a large number of artefact assemblages from a wide range of dated sites is one of the pre-requisites for attempting any study of prehistoric trade or exchange.

The lack of the regular use of source characterization in New Zealand archaeological studies has been mainly due to the complexity of some of the techniques or the costs involved in using them on a routine basis. The recent development and setting up of an obsidian sourcing laboratory at Otago University, capable of processing a large number of samples in a non-destructive manner, has made it possible to source a larger number of obsidian assemblages than previously possible. The sourcing facility allows for the distinction between several New Zealand sources as well as between some Central and Eastern Pacific volcanic glasses. Discrimination within the New Zealand sources using the Otago University XRF facility, is clear between the Mayor Island sources and those of Inland, Coromandel and Great Barrier, although separation within these last three is not so succesful (Bollong 1983:156-157). Separation between the Mayor Island and Northland sources is clear, on the basis of relative element concentrations. However, certain problems due to source sampling were encountered (see Brassey 1985, Brassey and Seelenfreund 1984). The system is therefore best suited to discriminate accurately the presence of Mayor Island obsidian from all other New Zealand sources.

The sourcing facilities set up at the Otago University Archaeometry Laboratory have made possible extensive sourcing of New Zealand archaeological obsidian assemblages, and has therefore also provided the materials for the study of the prehistoric obsidian exchange mechanisms in New Zealand.

Although several studies in New Zealand have dealt with the lithic source utilization patterns, no explanation of the factors involved in the acquisition and exchange mechanisms have yet been attempted. The presence of some type of exchange mechanism is usually taken for granted, and the presence of foreign material has been usually taken as evidence of communications and external connections. The present research attempts therefore to fill some of these gaps in our understanding of prehistoric source utilization in New Zealand. The main points on which the present research is focused are:

1) the understanding of the role that Mayor Island played as a source of obsidian within a regional exchange network, and its overall importance in New Zealand prehistory.

2) Mayor Island was the largest exploited source of obsidian in prehistoric New Zealand. The process of lithic procurement should be reflected in the artefacts discarded at the quarries. Working patterns there should also be determined to a large extent by the type of exchange mechanism by which the raw material was distributed. Therefore, the study of the pattern of source exploitation is explored.

3) The present work also attempts to examine some of the factors involved in prehistoric obsidian exchange in New Zealand, and attempts to answer a number of questions concerning the exchange mechanisms in operation.

The problems proposed here are not easy to solve. The archaeological data necessary for this type of research on a wide regional scale are not uniform. Excavation techniques are of the most diverse types, and the information of the site reports is often incomplete for the purposes of this type of study (for example data on abundance - absolute or relative - of lithic artefacts). In addition the archaeological fieldwork proposed for Mayor Island as part of the present research had to be cancelled, since permission to excavate was refused by the Maori Trust Board which administers the Island.

Given these factors, it was not possible to use a number of methodologies employed by other researchers to study obsidian exchange processes, and it became necessary to find alternative ways to study the importance of Mayor Island and its quarries in the New Zealand wide exchange network.

Alternative methodologies were therefore employed, based on existing theoretical frameworks. Using the data that could be collected from the archaeological assemblages, a deductive framework was developed in which the exchange network was seen as an interlinking system directly related to human behaviour, in which the quarries and workshops on Mayor Island represented one end of a system and the obsidian found in the archaeological sites the other. The study of the obsidian dispersal and use should allow predictions of the character of the system as a whole to be made. Inferences made about the nature of feedback among different components of the system should shed light on the behaviour of the whole. Thus, the process of lithic procurement and exchange should be both reflected at the quarries and the archaeological sites to which the raw material was distributed to.

For the present research a combined study of the quarries of Mayor Island and the archaeological obsidian assemblages was used. The obsidian studied was obtained from a number of collections excavated from as early a 1920, up until the present day. They represent sites from all over the two main New Zealand islands, covering different time periods and they involve open settlements, temporary camps, defended settlements and lithic workshops.

The lithic assemblages studied are made up of a large quantity of small unretouched flakes, core fragments, waste flakes and very few actual retouched 'tools'. The analysis is based on the study of a very large quantity of amorphous flakes. Few studies have used this sort of information, but Torrence's (1981) study on Aegean obsidian exchange is based largely on the analysis of similar obsidian debitage.

ORGANIZATION OF THE THESIS

The study has been organized into seven chapters, including the Introduction. Chapter II is devoted to a study of the ethnographic background to trade in New Zealand. A review of the early contact literature and later ethnographic sources is used to present a picture of the general exchange patterns observed by Europeans. In this chapter, the archaeological evidence relating to trade is also examined.

In Chapter III a general analysis and critical review of the theories on prehistoric exchange put forward by a number of scholars is undertaken. The chapter delineates the main components of exchange mechanisms : 1) the institutions employed in the transactions of exchanged goods and 2) the modes by which these goods were transported and their application to the study of archaeological materials. The methods used by other authors to study prehistoric exchange on regional and site oriented bases are discussed in order to develop the analytical tools appropriate for the study of obsidian exchange in New Zealand.

Chapter IV discusses several aspects of quarry analysis, such as the identification of quarry ownership and type of exploitation. The chapter further discusses the quarries and general settlement pattern of Mayor Island in order to understand its importance and role in the New Zealand exchange network.

Chapters V and VI are devoted to explaining the methodology involved in the analysis of the obsidian assemblages studied and the presentation of the sourcing results, as well as the results of the regional obsidian distribution study and their interpretation.

The final chapter returns to the main points posed in this introduction.

Little previous analytical work on New Zealand obsidian exchange is available on which to build. The combined approach in which regional data and data from a single site are used (particularly the study of the sites of procurement) have been useful in providing information on the functioning of the system as a whole. It is hoped that future studies can refine the analytical techniques and theoretical approach used in this dissertation.

CHAPTER II

THE TRANSFER OF GOODS IN PREHISTORIC AND PROTO-HISTORIC NEW ZEALAND: ETHNOGRAPHICAL AND ARCHAEOLOGICAL EVIDENCE

INTRODUCTION

The environmental diversity encountered in New Zealand by the earliest Polynesian settlers provided a large variety of resources that could be exploited. Ethnohistorical records of New Zealand indicate that lithic materials and other items, including foods, were obtained from a variety of sources and by various means. Captain Cook on his second visit to New Zealand in 1773 met a group of North Island traders on a visit to the South Island for the purpose of obtaining greenstone. He reflects on the knowledge and communications between the different areas of both the North and South Islands. On his return to New Zealand and arrival at Queen Charlotte Sound in 1773 he was greeted by a group of Maori asking for Tupaia (Cooks'

Tahitian interpreter on his first trip), whom they had never met before but had knowledge of his first visit to the Sound. He writes:

> It may be ask'd, that if these people had never seen the Endeavour or any of her crew, how they became acquainted with the Name of Tupia or to have in their possession such articles as they could only have got from that Ship, to this it may be answered that the Name of Tupia was at that time so popular among them that it would be no wonder if at this time it is known over great part of *New Zealand*, the Name of Tupia may be as familiar to those who never saw him as to those who did...by the same way of reasoning the Articles left here by the Endeavour may be now in possession of those who never saw her. I got from one of the people I am now with an Ear ornament made of glass very well form'd and polished (Cook 1961:172).

He also commented on what seemed to him a far reaching network of communications which he had had the opportunity to experience during his first visit to Palliser Bay, reached after having landed only at a few places on the east coast of the North Island, when he remarked:

> it appear'd from the behaver of these people that they had heared of our being upon the coast, for they came along side and some of them on board the Ship without shewing the least signs of fear: they were no sooner on board than they asked for nails: but when nails were given them they asked Tupia what they were which was plain that they had never seen any before...These people asking so readily

> for nails proves that their connections must extend as far North as Cape Kidnappers...for that was the southermst place on this side of the coast we had any traffick with the natives... we have no reason to think that the inhabitants of any part of this land had the least knowlidge of Iron before we came among them (Cook 1955:250).

Cook was also surprised not to see any of the items his people had given to the Maori in exchange for fish, greenstone artefacts, and other 'curios' in the houses on the several occasions he visited the native villages. He remarked that these must be used in some sort of transactions:

> I beleive they must give away many of the things they have at different times got from us, to their friends and Neighbours, or else purchass Peace with them of their more powerfull Enemies; for we never see any of them after they are once in their posession and every time we have visited them, they have been as much in want of Hatchets, Nails ca to all appearence as if they never had had any amongst them (Cook 1961:578).

A year later Crozet (1891:48) commented on the same fact when stopping at Queen Charlotte Sound after arriving there from Tasmania.

> It is very surprising that savages, who in the preceding year had seen and traded with a French and an English vessel [De Surville and Cook], and who must necessarily have obtained from these ships iron, cloth, and other European goods, should never have allowed us to notice anything about

> this,... It is true that the goods we gave them daily were never seen again by us, nor did we see traces of them in overrunning their villages and on visiting their houses.

These early European visitors did not have much of a chance to observe the manner in which transactions were carried out among the Maori nor how foreign non-European goods were acquired. They were usually not much inclined to inquire about the sources of a number of items they observed among them. The only exception to this was in respect of greenstone, which they noticed had a great value attached to it. Johann Reinhold Forster on inquiry was told that the greenstone was

> brought by the natives from the interior parts of Queen Charlotte's Sound to the South West, in which direction they pointed. We asked for its native place and they called it *Poenamoo* from whence probably the abovementioned part of the country obtained the denomination of Tavai Poenamoo (J.R. Forster 1778:18-19).

Cook also recorded during the third voyage that the stone was not only gathered somewhere from the West Coast of the South Island but that it was traded to localities in the North Island.

> Thus it is that a trade for *Poenammoo* or green talk is carried on throughout the whole Northern island, for they tell us there is none of this Stone but at a place which bears it[s] name, some

> where about the head of Queen Charlotte Sound, and not above one or two days Journey at most from where we lay with the Ships... (Cook 1967:72).

Evidence of the extensive knowledge of the country by the Maori surprised the first Europeans, and indicates a high mobility of parts of the population. On a visit to the Bay of Islands in 1822, Bishop Marsden talked to some people who described to him the mountains, lakes and hot springs to the south on the North Island, about 400 km distant (Firth 1929:429-30). Marsden also remarked that chiefs travelled often and were absent at times for periods of almost a year. Marsden's informants also described to him the resources, people and the special skills of places as far south as Tongariro and Roturua and Taupo, places from where they obtained certain garments and carvings.

Similarily, Shortland (1851:205-07) was told about the appearance of the interior of the South Island by Huruhuru, when they met at the Waitaki River on the East coast of the South Island.

> He drew with a pencil, the outline of four lakes by his account, situated nine days journey inland of us, and only two from the West Coast, in a direction nearly due west of our position... I was persuaded that this information was to be relied on, as I had the benefit of hearing discussions between him and another old man, who also knew the country, on the propriety of halting at this or that place on account of either of them being more or less convenient for catching eels or

wekas...

Ethnohistorical records indicate that the goods were obtained by various different mechanisms, including exploitation of sources, inter- and intra-group exchange, confiscation by warfare and through the custom of *muru* (Firth 1972:400-01). From the ethnohistorical record it is also evident that groups often had exploitation rights over geographically widespread areas (H. Leach 1969; Mair 1972; Shawcross 1966). In the following sections of the present chapter the evidence on the type of products exchanged and a summary of the exchange mechanisms in existence as recorded by the New Zealand ethnographers will be presented. It will be followed by an examination of the archaeological evidence of traded goods in prehistoric archaeological sites over New Zealand.

ETHNOGRAPHIC EVIDENCE OF TRADE AND EXCHANGE

The transfer of goods and the acquisition of items produced at distant places was a common occurrence among prehistoric and protohistoric Maori communities. Firth has documented and analyzed the different ways by which goods were transferred between individuals and groups in Maori society. Firth (1972:402-403) recognized the presence of both intra-group and extra-group exchange, and that these were carried out under what Firth has termed the 'gift-exchange', the main points of which will be briefly referred to here.

Gift-exchanges were commonly made between parties with the aim of strengthening political relations or social ties between people or tribes. On occasion they were also made for economic reasons. The giving and receiving of gifts took the form of a reciprocal exchange - for every gift that was made a return gift of at least the same value from the recipient was expected. The return gift was usually given at some later time, a few days after the original gift had been given, and the time when this return gift was given was decided upon by the receiver of the first present (Firth 1972:409-11). Colenso (1868:354-355) also states, when describing the exchange of foodstuffs, canoes and other items, that

> a chief would give to one of his own, or a friendly tribe, some article as an acknowledgment or equivalent for building of a canoe, carving, etc., but always without any kind of stipulation or fixed price. Or he would make a present...to some other chief, generally to one of higher, or equal rank than himself; but all without anything like price stated. And when the return gift was made, it was always

> stated to be such, for if not so stated it would not be so considered... A return gift was always expected to be a larger one than the one which occasioned it.

It was very rare for objects to be directly exchanged for one another. On occasion though, special trips were made with the particular objective of obtaining certain goods by exchange at the spot. This apparently was done when a certain type of object was desired (Firth 1972:410-11). The return gift was usually a just equivalent so that if the original giver desired a particular item, he could express this in an indirect manner, and in return the receiver could not refuse to give that object. But etiquette also meant that an unwanted return gift could not be refused, since it would tarnish the social position of the receiver. Firth (ibid.:402) distinguishes two types of gift exchange; one, carried out for purely economic reasons in which objects of practical utility were exchanged, and a second one, ceremonial, in which the exchange of goods was carried out to fulfil some kind of social purpose. Firth suggests though that the distinction is not clearcut, and exchanges often involved elements of the former and vice versa (ibid.). Firth states that intra-group exchanges were not common, and usually affected certain craft specialists, like carvers and tattooers. These would exchange their services for other products. Transactions carried out extracommunally were commonly carried out. The main items exchanged included foodstuffs, and lithic resources, but cloaks, ornaments, feathers and other products were also involved. The ramification and variety of goods exchanged in the protohistoric and early historic exchange networks are described by Colenso (1868), Mair (1972), Shortland (1844) and others.

Food was an important item of exchange. Along the eastern coast of the South Island, for example, people exchanged preserved muttonbirds, and dried fish from the south for *kauru* (prepared root of the *ti* (*Cordyline* sp.)), for *kumara* from the North Island, and mats (Beattie 1920:67; Stack 1898:24). According to Stack (ibid.) at a village he visited in inland Canterbury, the inhabitants devoted time to planting of kumara and preparation of *kauru* for the express purpose of exchanging them for other goods they required.

On a trip from Dunedin to Christchurch, Shortland (1851) observed that some canoes hauled up on a beach were packed full with casks of preserved muttonbirds - *poha-titi* - many ornamented with feathers, destined as presents to relatives further north on Banks peninsula. A lot of these, he states, also would be sent north of Cook Strait (ibid.:224).

Shortland (ibid.) also observed on the North Island that certain villages of the interior obtained some foods from the coast in exchange for inland products. Preserved eels, forest birds, rats and other items were sent to the coastal settlements who in return supplied fish and seaweeds.

Colenso (1868) also recorded the exchange of food products between groups living on the coast and the interior parts of the North Island.

> Dried sea-fish, or dried edible sea-weed, or shark oil, or *karaka* berries, would be given by natives living on the sea-coast to friendly natives dwelling inland; who would afterwards repay with potted birds, or eels, or *hinau* cakes, or mats, or rouge [red ochre], or birds' feathers and skins (ibid.:17).

Some groups had exploitation rights in different ecological areas. Mair (1972:210) for example, mentions that in the Wairarapa area, groups had rights to exploit land over a widely scattered area. Some of them, for example, had the right of exploitation over certain areas where red ochre existed, which they prepared and made available to other groups. Gifts were sometimes sent to places at considerable distances; the Wairarapa Maori for example, would send presents to places as far away as Napier (ibid:210).

On occasions, special inter-tribal meetings were called at which a number of items were exchanged. Servant (1973) was able to observe such a meeting at Hokianga, Northland, between 1839 and 1842.

> During these kind of meetings, a pyramid is sometimes built, on a 20 square foot base, rising to 80 feet high, with a large number of poles, firmely fixed, forming several 'storeys', on the outside of which are hung edible provisions, baskets of potatoes, dried fish, *kumaras* and other commodities of this kind... Each portion is marked for each tribe and each tribe, in its turn, makes a *hakari* in the following years. (Servant 1973:23).

Besides foods, garments, ornaments and lithic materials were part of the exchange networks. Servant (ibid.:7), also observed that a number of special cloaks, mainly of dog-skin were obtained from the South, as they were not made in the North. Feathers were also an important item of exchange. The preparation and transactions of white feathers for exchange by the Bay of Island Maori were observed by Nicholas (1817:398-99). He states that they were

> prepared exclusively in the Bay of Islands, whence they are carried into other districts, and form a staple article of trade. These feathers are neatly dressed, and each of them has a small piece of wood tied round the quill end, which serves to stick in the hair... (ibid.:398).

The ethnographic information of gift exchanges and the items employed in these transactions clearly show that a number of very different goods were exchanged for each other. One of the least recorded items of exchange, and, at the same time, one of the most conspicuous in the archaeological record, are lithic materials. With the exception of greenstone, which was probably the item which took the most attention from the European ethnographers, very little information is to be obtained from the ethnographic and ethnohistorical sources on the transfer of lithic raw materials or lithic artefacts. The appearance of greenstone at places far removed from its source was recorded by the earliest visitors (De Surville 1982; Labbe 1982, Forster J.G. 1777; Forster J.R. 1778, 1982; Cook 1961; Crozet 1891). Overland east-west patterns of movement of goods developed on the South Island as a result of the localization of greenstone sources on the West Coast, as well as North-South sea based movements to the North Island. Beattie (1912:143) affirms that no regular trade in greenstone ever developed. West Coast natives, when visiting the East Coast of the South Island would bring pieces of greenstone as gifts to their hosts. According to Skinner (1912:149), foodstuffs, fine mats and perfumes (*taramea*), made from the sap of grasses were among the items that they received in exchange.

References to obsidian exchange are absent. Best (1974:53) only quotes that cores of obsidian were often carried by travellers, who could then flake off a piece whenever needed.

ARCHAEOLOGICAL EVIDENCE OF MOVEMENT OF GOODS

The exploration of the New Zealand ethnographic and ethnohistorical sources shows a picture in which a wide variety of goods changed hands by diverse means. Nevertheless, the information is scanty in regard to the exchange of lithic resources. Contrary to ethnographic source data, the archaeological record provides a wealth of information on the variety of stone resources exploited and exchanged in prehistoric New Zealand.

Interest in the sources of stone materials found in archaeological sites was perhaps first expressed by von Haast in 1871. Von Haast thought that a number of stones found at a site on the Rakaia River (South Island) originated as far away as the Dun Mountains in Nelson, and others came probably from the neighbourhood of Banks Peninsula (von Haast 1871:83-96). Foreign stones were also identified by von Haast at the "Otokai kitchen midden" (1879:151-152). Travers (1875) also remarked on the large quantities of foreign stones at a number of sites he found on the South Island. Travers was probably one of the first to speculate on the nature of the communication routes along different regions of the South Island and between the North and South Islands. For example he noted

> in the ovens on the coast, besides flakes and rough knives of chert and flint, are found flake knives of obsidian, a rock which only occurs in the Volcanic District of the North Island (ibid.:69).

He also remarked on a number of other lithic resources found at sites in Central Otago, which were foreign to the area. For instance, he found chert pieces in the Otago coastal middens which he assumed came from "the same chert which occurs *in situ* in the interior" (ibid.). He also observed at a site in Central Otago a "hornstone cleaver [that] must have been brought from a very great distance" (ibid.:68).

Archaeological research in New Zealand carried out in the last 20 years or more has shown a remarkable interest in the identification of stone materials employed by the prehistoric Polynesian inhabitants. Identification of foreign stone resources at archaeological sites has been coupled with the investigation and exploration of native stone quarries. Lockerbie (1955, 1959) examined the geological sources of stone materials of the sites he excavated in the south of the South Island, and suggested possible points of origin for the materials he encountered. Much earlier Skinner (1914) initiated the recording of argillite quarries exploited for the manufacture of stone adzes. Duff (1946) recorded further argillite quarries in the Nelson-Marlborough area.

More extensive studies on the range of stone resources employed began in the mid 1960's by Green (1964), Trotter (1967b), and Wilkes and Scarlett (1967). Trotter, for example, studied the range of lithic materials employed at the Katiki Point site (Canterbury) and computed the abundance of each type as its percentage in the total stone tool assemblage (Trotter 1967b:240-45). Similarly, Wilkes and Scarlett at the Heaphy River Mouth site in southwest Nelson, identified the different types of rocks employed by the inhabitants of the site. No other sourcing techniques were employed at the time than hand specimen identification. Nonetheless, the authors went one step further and suggested several possible sources from where the materials might have been obtained. Although the authors did not make any further inferences on the results of their examinations of the stone assemblage, this study was probably the first to show the great potential in New Zealand of examining the rock sources of the abundant stone assemblages from archaeological sites.

In later years, Millar (1971) analyzed the stone assemblage from the Tahunanui site near Nelson. He attempted to identify the sources of several of the different rock types recorded, by visual examination and using these results he proposed that the pattern of rock exploitation, particularly that of metamorphosed argillite had changed throughout the occupational history of the site (Millar 1971:163-72).

The attention given to the identification of rock types at archaeological sites is a direct result of the increasing attempts by New Zealand archaeologists to find suitable sourcing techniques. One of the most important attempts in this respect was the initiation by Green (1964) of an obsidian sourcing programme in which a number of techniques were developed. Research on the sourcing of lithic materials has not just been restricted to obsidian studies. More recent work by Brassey (1985), Prickett (1975), Leach (1978), Leach and Anderson (1978), and Ritchie (1976), have focused their attention on a wide variety of rock types. As Davidson (1984) has pointed out, it has become increasingly clear that lithic resources including obsidians, nephrite, argillites, quarzites, etc. were transported over huge distances during the prehistoric period.

The initiation of an intensive research programme at Palliser Bay in 1972 (Leach 1976, Prickett 1975) provided the material for the most extensive source identification study so far undertaken. More recently the study of the rock resources used at Pouerua, Northland has provided the same type of information for another part of the country (Brassey 1985). Prickett (1975) has argued that lithic material from sources up to 800 km to the north and 700 km to the south of Palliser Bay was exploited and that at least 32 different lithotypes were being used (ibid.:203), of which half were imported. Nevertheless, Prickett argues, the imported stones constituted about 82 per cent of the assemblages. The most important rocks in terms of their abundance in the separate assemblages were cherts (36 per cent) and obsidian (19.5 per cent), followed by argillites and greywackes. Prickett's work is the first study to speculate on the importance of the presence of foreign lithic material in archaeological sites. The evidence from the analysis of the Palliser Bay stone assemblages showed that relationships extended to areas at considerable distances. Argillites, nephrites and schists were obtained from the Nelson-Marlborough area. It is argued by the author, that most articles arrived as finished pieces. The relationships with areas to the south changed over time and in later periods the variety of stones obtained from the south seemed to have been less. Exchange relationships to the north were strong also, and the materials obtained included obsidian, cherts and limestones (ibid.:217-18).

The difficulty of relating the archaeological evidence of traded materials with the ethnographic records on exchange is fully understood by Prickett. The ethnohistoric evidence on trade/exchange is hard to relate to the archaeological evidence, and Prickett only goes as far as to suggest the possible items which might have been given in exchange for the lithic materials received. No attempt is made by the author to relate the archaeological evidence to the possible exchange mechanisms in operation at the time. B.F. Leach (1978) has also noted the practical difficulties in relating the ethnohistoric evidence to the archaeological picture. Based on the analysis of the Washpool sites at Palliser Bay, B.F. Leach (ibid.) concludes also that the large range of foreign materials present at the sites were obtained by some type of exchange. Changes in the proportions of stone flakes are interpreted as shifts in the networks of communications which linked the Palliser Bay area with other parts of New Zealand. Leach (1978:392) does not believe that the actual social circumstances responsible for the presence of foreign goods, can be actually discerned from the archaeological data.

Further analysis by S. Best (1975, 1977) and Davidson (1972) on sites on the North Island, particularly on adze material and to some extend obsidian has shown that a large number of the raw material was obtained from the Coromandel-Bay of Plenty area.

The analysis of obsidian distribution in New Zealand has suffered from the same problems as the sourcing studies of other lithic materials. Although numerous studies have been carried out, in which the sources of obsidian used at particular sites have been studied, no real advances have been made towards explaining the exchange mechanisms involved. The wide distribution of obsidian was noted for a long time, but more serious studies commenced with Green's obsidian dating and sourcing program in 1964. More widespread use of obsidian sourcing followed. Davidson's (1972) study of Motutapu Island showed that at least four obsidian sources were exploited at a single time. These included Huruiki (Northland), Great Barrier, Mayor Island, and Whitianga. On the basis of the obsidian data, Davidson concluded that the different sources were discovered and exploited in succesive stages, as Green (1964) had already suggested. However, these initial obsidian sourcing results have to be treated with caution, as the source allocations have been questioned (Leach and Manly 1982:106).

The study of another large assemblage from Houhora (Mt Camel) in Northland showed also a number of foreign materials at the site (Best 1975:23-25, 1977:318; Best and Merchant 1976). Best believes that close ties existed between the Northland group and the Coromandel area. No further comments are made by the author on the possible type of these relationships. Almost 90 per cent of the obsidian was assigned by Best to Mayor Island, on the basis of colour and density. A re-analyis of the obsidian performed by Bollong (1983:148) using energy dispersive XRF spectroscopy, showed that a significantly higher proportion of obsidian had been obtained from local sources. Leach (cited by Bollong 1983:137-138; see also Gillies 1978), however, has questioned Best's allocations, and believes that the proportions of Northland obsidians was as high as 30 per cent. Bollong's (1983) re-analysis showed, though, that the assemblage contained only 17.4 per cent obsidian from the Northland sources. This is still significantly higher than Best's results. Brassey (1985) has questioned the accuracy of these results on the basis of source allocation problems encountered with the Pouerua site assemblage (Brassey 1985; Brassey and Seelenfreund 1984). He believes that the proportion of Northland obsidian in the Houhora assemblage could actually be as high as 30 per cent, as Leach has suggested (Brassey 1985:147).

By 1976 nearly 500 pieces of obsidian from about 16 different sites in New Zealand had been submitted to diverse sourcing procedures (Reeves and Ward 1976:276). The widespread distribution of Mayor Island obsidian was again noted, but also the distribution of obsidian from the Huruiki sources. Reeves and Ward (ibid.) summarized the information on obsidian usage for different areas of the country. Thus, they concluded for example, that for the Auckland and Coromandel area, Mayor Island and Huruiki obsidians were exploited in the early phases, while later on a greater variety of sources was exploited including obsidians from Taupo and Great Barrier Islands (ibid.:279-281). In general, the authors noted that, following initial settlement by the Polynesian settlers, a significant number of lithic sources were exploited. Subsequently, "great territoriality developed" (ibid.:285) which inhibited the use of widespread sources and, therefore, general use of local resources was made. The authors argued that, during the period of consolidation, mainly local resources were exploited, but exchange networks with adjacent groups developed, involving the movement of goods in favor of the earlier movements of groups of people (ibid.). Reeves and Ward's study does not suggest in any way, how obsidian exchange could have been carried out. The study examines mainly the evidence of obsidian use through time in the different areas of New Zealand.

Brassey (1985) studied the lithic assemblages recovered from six archaeological sites in the Pouerua area, Bay of Islands, in Northland. Identification of lithic sources was attempted, and Brassey found that some of the materials at the sites came from as far as the Nelson and D'Urville Island area. Foreign lithic materials included obsidians, argillites and nephrites, but these stones did not represent a large proportion of the lithic assemblage. Most of the materials used, which included different types of rocks, were probably obtained within close range from the site. It was found by the author that rocks, such as cherts, sandstones, basalts, petrified wood and obsidian came in large proportion from the Northland area (ibid.:31-67). The small range of non-local stone artefacts attributed to sources at quite considerable distances is common to a number of New Zealand archaeological sites.

Brassey (ibid.:133-144) attempted in his study to explain the reason behind the acquisition and use of the lithic materials. He proposed several alternative explanations for the patterns of lithic usage found at the Pouerua sites. Source allocations showed , for example, that obsidians were obtained mainly from the local sources, but Mayor Island and other sources of 'grey' obsidian such as Fanal Island, Great Barrier and/or Huruiki were also represented. Aproximately 74 per cent was obtained from the local sources and only 17 per cent from Mayor Island (ibid. 49-50, and Table 6). Some of the materials, he argued were obtained because of the function they were intended for, while others were obtained because of the better quality of the materials. He argued, that in those cases where non-local stones were used in preference to local materials, this was mainly due the suitability of the different rocks for the tasks they were intended to be used for.

In summary, the archaeological evidence points in general towards a wide movement of goods over considerable distances. Although some authors have interpreted the presence of foreign goods as evidence of direct communications or close relationships between the different areas (Best 1975), there is no evidence at present to sustain an argument of what form these were. As Davidson (1982:19, 1984:201) has pointed out, a constant link of interactions connected different areas of the country and the inhabitants had all special links with people in their surrounding areas, as well as with groups further away.

SUMMARY AND CONCLUSIONS

Ethnographic and ethnohistoric records have shown that a variety of goods were exchanged in pre-european Maori society. The ethnographic evidence suggests several ways in which these materials could be transfered - gift exchange being probably the most important one. Other ways of obtaining desired goods are also recorded. The range of goods as described from the ethnographic sources is expanded with the archaeological evidence. Archaeological research carried out in New Zealand has shown that besides the perishable foodstuffs a range of lithic materials was obtained from areas as far away as 800 km. Foreign rocks recorded at sites included nephrites, basalts, obsidians, argillites and, to a lesser extent other types of rocks such as cherts. So far, the analysis of the range of utilized rock resources at New Zealand archaeological sites has stopped short of identifying the exchange mechanisms involved in its acquisition. Most studies have limited themselves to identifying the occurrence of foreign lithic materials and their probable sources, and suggesting that some sort of communication links existed between the different areas of the country. Brassey's study (1985) which proposes to explain the reasons behind the presence of foreign lithics at Pouerua, marks an important step away from the initial sourcing studies in New Zealand. As Brassey himself points out (ibid.:133) the significance of the pattern of the range of sources used and how the materials were obtained are not entirely separable.

In the following chapter a review of the procedures and theoretical issues involved in identifying exchange mechanisms from the archaeological record will be discussed, in order to be able to interpret the obsidian source utilization pattern on a New Zealand wide basis.

CHAPTER III

THE STUDY OF PREHISTORIC EXCHANGE: METHODOLOGICAL AND THEORETICAL PROBLEMS

INTRODUCTION

One of the most interesting aspects in the study of prehistoric people is the communication networks which existed in the past. Increasing numbers of studies in recent years have dealt with systems of exchange in which material goods changed hands as part of wider networks of trade or exchange. A number of techniques have been developed to locate the geographic sources of raw materials, and models have been proposed to explain the processes involved in such exchanges.

One of the problems faced in this, and other previous work, concerns the means of archaeologically identifying the mechanisms by which the goods in question were exchanged. Increasing numbers of studies of prehistoric exchange have used highly variable methods to distinguish archaeologically between many types of exchange mechanisms. In this chapter the theoretical background and analytical techniques employed in previous studies of prehistoric obsidian exchange will be evaluated. This will be followed by a brief appraisal of these approaches in terms of which ones could most profitably be employed for the study of obsidian exchange in New Zealand.

Studies of obsidian exchange have been carried out from two different perspectives - regional and site oriented. When adopting a regional perspective, archaeologists have studied the distribution of obsidian or other resources over a large area. The spatial distribution is then interpreted using a number of models of prehistoric exchange. Site oriented studies, on the other hand, have focused on the study of imported goods in a single site, and used the information on the location, provenance, abundance, etc. of the goods to reconstruct the mechanisms by which these objects arrived at the site. Both types of studies offer a variety of possibilities for the investigation of the prehistoric obsidian distribution in New Zealand, and are reviewed in the present chapter.

THE ARCHAEOLOGICAL IDENTIFICATION OF EXCHANGE SYSTEMS

Anthropologists have described numerous ways in which transactions are carried out in modern societies. Several authors have tried to classify the patterns by which goods change hands in different societies (Polanyi 1957, Sahlins 1972). The identification in the archaeological record of the different ways in which goods change hands is a difficult task. Some archaeologists (Renfrew 1965, 1977a; Renfrew *et al.* 1966; Hodder 1974; Hodder and Orton 1976:98-124; Clark 1978, 1979; Pires-Ferreira 1975; Pires-Ferreira and Flannery 1976) have tried to link different exchange mechanisms to ethnographically described economic institutions such as reciprocity, redistribution, market exchange and others, in an initial series of hypothetical models, which they later tried to prove using archaeological data. One of the main problems in trying to correlate exchange mechanisms with economic institutions is that there are no clear cut boundaries between the different types of the latter categories; indeed they are not mutually exclusive as has been shown both ethnographically and ethnohistorically by a number of authors (Buechler 1983; Earl 1977; Earl and Ericson 1977; Murra 1956, 1972). The distribution of exchanged goods within a community, or outside it, may well have been produced by different types of exchange.

Sillitoe (1978:265-275) has shown, for example, in his study of the Wola of the Highlands of Papua New Guinea that the presence of goods in the community can be ascribed to numerous types of transactions, which are all individually distinguished in the Wola language.

Some authors have tried with moderate success to find archaeological indicators that would help in the definition of the economic institutions under which the transactions were carried out. Pires-Ferreira (1975:6) argues, for example, that one way of identifying reciprocal exchange from the archaeological record is by the identification of a large range of variability of goods between households. She argues that for Mesoamerica, where individual households negotiated for their own goods in this case obsidian, a great variability in the sources present could be expected.

A similar argument has been employed to define archaeologically a redistributive economy, in which a central authority collects goods for payments and the financing of its projects and expenses. For example, Earle and D'Altroy (1982) have argued that reciprocal exchange could be inferred through the absence of large storage facilities since, as they believe, their presence reflects some sort of redistribution of products within the community. While this may be true for certain cases; in general, the absence of large storage facilities cannot be taken as an indication of absence of redistribution. A large range of goods that might be redistributed within a community may not need large and elaborate storage facilities. Pires-Ferreira (1975) has further argued that redistribution could be identified, in the case of Mesoamerican obsidian exchange, by the uniform distribution among households of local goods. The situation, she argues, might reflect a centralized collection and pooling point and later redistribution of goods among community mem⁄bers.

The apparent uniformity of distribution in an archaeological site, for example the obsidian distribution in the Valley of Oaxaca may, however, be produced by other effects. The seeming uniformity might be nothing more than the result of many years of subsequent occupation where the same sources were supplying the one area for a long period of time. As Zeitlin (1979:133) argues, the archaeological remains would approximate the average of various individual acquisitions, and each household would show a similar mix of sources even if obsidian were obtained independently. When possible, other lines of evidence should be used to support the distributional evidence.

Attempts to identify other specialized trading institutions, such as administered trade or market trade, from the archaeological record have not proved very successful. For example, attempts have been made to prove, archaeologically the existance of markets and market trade, by the presence of an all purpose money

(Bohannan and Dalton 1971:153-154) or permanent market place. Market exchange does not necessarily have to take place in permanent market places. For this reason the archaeological absence or presence of a permanent market place site is not enough evidence to suggest the non existence or existence of market trade. "Periodic Trade Fairs" took place in parts of tropical lowland South America,where the participants travelled long distances, through usually non-friendly territory, to obtain certain products (Lathrop 1973:173). Even if these trading places could be identified archaeologically, how do we know that a market type of exchange took place ? Meillasoux (1971:82-83) observes that market exchange or markets often occur at the border of complementary economic zones. He further argues that the presence of currency or an all purpose money is an indicator that the trade dealt with might have been market exchange. The presence of money facilitates market transactions by providing a universal medium of exchange with a standard value against which all goods can be measured. Adams (1974) does not discount the possible existence of market exchange by the absence of an all purpose money, as he illustrates in his re-analysis of Assyrian trade. The presence of all purpose money is certainly a helpful indicator of market exchange, but where the currency has not survived, or cannot be identified archaeologically, other indicators must be found.

Certain types of 'money' such as, for example, 'red-feather' and shell and stone money' are frequently found in Western Pacific archaeological sites and have been well documented (Bellwood 1978a; Davenport 1962). The presence of this type of money in an archaeological site does not imply, in this case, the existence of market type exchanges as suggested by Adams (1974).

From the above brief review, it can be seen that archaeology still lacks a way of unequivocally identifying the ways in which transactions took place between individuals, groups or larger communities. Nonetheless, if these 'economic institutions of exchange' cannot be identified, as yet, through the archaeological record, archaeologists have explored other ways in which the exchange mechanisms can be identified archaeologically.

THE STUDY OF THE MECHANISMS OF EXCHANGE

The economic institutions under which exchange can be carried out in different societies are linked to the different 'mechanisms' or 'modes' of exchange. Renfrew and others, as mentioned above, pioneered mathematical models in which they explored the relationships between the two, and these will be discussed later in this chapter. Although Renfrew (1975:41) has defined at least ten different 'modes of exchange', basically four mechanisms by which people or communities can acquire non-local goods can be isolated :

1)direct access, also defined sometimes as unilateral conveyance (Zeitlin 1979:142).

2)bilateral reciprocal trade.

3)long distance trade, carried out by professional traders or organized expeditions.

4) down-the-line exchange.

A brief examination of how each of these is expressed ethnographically and archaeologically follows. The correlation between modes of exchange and the institutions of exchange will be described in order to help in the prediction of the archaeologically observed patterns when the New Zealand data are examined.

DIRECT ACCESS

By definition this is not a type of exchange as it does not involve a transaction between two groups or individuals. It usually takes the form of a group travelling to the source of the desired goods and acquiring them under peaceful conditions. This type of acquisition described ethnographically among certain groups of Australian aborigines (Berndt and Berndt 1964:111) and the Pomo Indians in California (Vayda 1966:495) is characteristic of low populated areas commonly of egalitarian groups of people, where it may represent the only way of obtaining certain necessary materials.

BILATERAL RECIPROCAL TRADE

As defined by Zeitlin (1979:144) this can occur when two separate and independent communities meet on special occasions (ceremonial, social or economic) on which goods are exchanged. It has been described ethnographically by Berndt and Berndt (1964:122) for Western Australian aborigines and for the Siassi Islanders in Northeast Papua New Guinea. (Harding 1967). Renfrew has defined this mode of exchange as "boundary reciprocity" (1975:41). It is not necessarily restricted to non complex societies, as it can also be found in more complex societies, occuring at certain transitory fairs or markets.

LONG DISTANCE TRADE

This is also known as Freelance Trading (Renfrew 1975:44), or Expeditionary Conveyance (Zeitlin 1979:146), and is carried out by professional traders. Goods are obtained by a trader at a distance in exchange for goods or currency and then traded to one or more communities which are permanently home-based. Trade expeditions of this kind, organized either by a single person or a group, are recorded, for example, among the Siassi and Trobriand Islanders of Melanesia (Harding 1967; Malinowski 1932). Such trading expeditions have also been described in other areas of the Western Pacific, such as the islands of Yap and Santa Cruz. Special long-distance trips of this kind were made in a more-or-less regular basis from the outer islands to Yap in order to pay tributes and fulfil other social and political obligations. The fleets that travelled to Yap left from Ulithi atoll and totalled 22 canoes representing each of the major islands in the atoll (Lessa 1950:42). Green (1982:16) believes that long-distance voyaging of this kind might be the clue to the presence of imported goods in a large range of the prehistoric Lapita sites in the Western Pacific. Other such expeditions are recorded outside the Pacific area, for example, among the Aztecs in Mesoamerica (Sahagun 1959:14-19).

DOWN-THE-LINE EXCHANGE

The term was used first by Renfrew (1972, 1975) to describe a distribution pattern of goods over long distances, when goods are passed from one point or community to another through a number of intermediate links. Zeitlin (1979:148) classifies it as "pass-along conveyance', and sees it as a "reduplicated bilateral or expeditionary conveyance" (ibid.). Renfrew (1975) and others (Webb 1974; Beale 1973) have associated down-the-line exchange with balanced reciprocity.

The literature review presented in the foregoing chapter, in which the ethnographic evidence for trade in New Zealand was explored, does not allow an *a priori* election of any of the above mentioned 'modes of exchange' to best describe the prehistoric New Zealand situation. However, certain institutions can be ruled out as they are traditionally associated with complex societies and have never been recorded in New Zealand (for example Market trade and Administrative trade). A decision on which type of exchange was in operation can only be made by testing a number of theories and models based on the study of actual archaeological data. The following part of this chapter will be devoted to the analysis of techniques used to identify modes of distribution of exchanged goods. An evaluation of these models and techniques will be followed by an appraisal of which would be most profitable when applied to the New Zealand archaeological data.

ANALYTICAL PERSPECTIVES IN THE STUDY OF TRADE

In the studies of archaeological exchange which have become more and more popular in the last 10 to 15 years, a big concern has been to find analytical techniques which would allow the identification of particular types of distribution.

Most analytical techniques have been introduced from studies of human geography and the most widely applied methods include regression analysis (Renfrew 1977a, 1977b; Sidrys 1977; Clark 1979) and gravity models (Hodder 1974; Hallam, Warren and Renfrew 1976). Most of these studies have approached the archaeological evidence from one of two perspectives, either regional or site oriented. Many regional studies using mathematical models have attempted to identify regional trends in the distribution of obsidian or other resources, using a small scatter of sites over a very large area. By contrast, Ammerman (1979) has shown that analyses over large areas can be misleading, and that a detailed analysis of one region can produce results contradicting large scale analysis.

B.F. Leach (1976, 1978) reached a similar conclusion in his study of the proportions of Mayor Island obsidian in New Zealand. The limitations of the mathematical models have been discussed by Hodder (1982), and they have been criticized on the grounds of two interlinked problems which concern the lack of equivalence between prediction and explanations. The best fit regression curve is not an explanation of the reasons for certain distributions. Hodder argues that, whilst the methods are adequate for describing the distributions, the social processes that produced them cannot be differentiated by the application of mathematical equations.

Archaeological site oriented research carried out in the last few years has concentrated on one site, and studied the trends through time within that site. Spatial intra-site analysis has also been a fruitful enterprise for the understanding of prehistoric exchange. In the following sections regional and site oriented research are discussed. The chapter is concluded with an evaluation of how some of these studies can be incorporated in the study of obsidian exchange in New Zealand.

REGIONAL ANALYSES

Distance Fall-off Studies

Pioneering studies using distance decay analysis have been carried out by Renfrew, Dixon and Cann (1968), and Dixon *et al.* (1968). In these two articles the authors note that beyond a 'supply zone', immediately surrounding the geological source in Anatolia, the proportion of obsidian within the total chipped stone assemblage of sites declined in an exponential way, in direct proportion to distance from the source. Renfrew and other scholars noted that the shape of the line describing the relationship between distance and quantity is almost flat up to a radius of approximately 300 km from the obsidian source and after this point it drops off steeply. The differences between the two areas, named the 'supply zone' and 'contact zone' (Renfrew *et al.* 1968:329; Dixon *et al.* 1968:45; Renfrew 1969a:157, 1975:46-47, 1977a:84), were interpreted as being caused by two different exchange mechanisms operating in the areas. Within the supply zone communities acquired their own material from the source, while in the contact zone they obtained the required obsidian through exchange with their neighbours. The analysis of the fall off curves led Renfrew to postulate his down-the-line model of exchange (Renfrew *et al.* 1968; Renfrew 1969a, 1972, 1975).

In these studies Renfrew tried to correlate possible institutions of exchange with the archaeologically recoverable data. In later works he tried further to link exchange mechanisms to different shaped fall off curves, which led to the formulation of a fundamental hypothesis that underlies all his previous models. The 'Law of Monotonic Decrement" postulated by Renfrew (1977a:72), argues that "in circumstances of uniform loss or deposition and in the absence of highly organized directional (i.e. preferential non homogenous) exchange, the curve of frequency or abundance of occurance of an exchanged commodity against effective distance from a localized source will be a monotonic decreasing one". One of the problems affecting Renfrew's Law of Monotonic Decrement is the small number of variables it considers. Other variables which affect the distribution, but which are not taken into consideration by Renfrew's Law, can seriously modify the observed fall off curves. Nevertheless, Renfrew's model serves as a guideline for comparing different exchange mechanisms. Deviations from his law can be used to determine new factors involved in prehistoric exchange. Directional trade, for example, as defined by Renfrew (1977a:85-87, 1975:48-51) does not conform to his law, but its deviation can as well be specified . A number of scholars have applied fall off studies to the study of prehistoric obsidian exchange in different regions of the world, as well as to other types of goods (McBryde 1978, McBryde and Harrison 1981; Fry 1980; Earle and D'Altroy 1982; Hodder and Lane 1982). The studies on prehistoric obsidian exchange showed a number of deviations from Renfrew's proposed law.

Ericson (1977a, 1981) in his study of Californian obsidian exchange demonstrated that, from a regional viewpoint, the quantity of obsidian decreased with distance from the source. When he used population density as a variable he found that, distance was not the only variable affecting the obsidian distribution. He found that for 70 per cent of the systems examined, 44 to 88 per cent of the variability of the exchange could be explained using a multiple linear regression model in which the percentage of the obsidian from one source represented the dependent variable while population density, distance from the source, and distance to the next closest source were the independent variables. He found that although distance was the best predictor variable, the effect of the population density, or some equivalent measure, should not be ignored. The distance to the second nearest obsidian source did not have a significant impact on the distribution (Ericson 1981:53). The methodology employed by Ericson to study the distribution was three dimensional synagraphic mapping since, as he argues, in a two-dimensional model only the magnitude of an observation and its distance from a source is considered, but the spatial position of the observation is not considered in its local context. This simplification often masks significant variability in the data (ibid.:104).

The value in Ericson's study lies in his identification of the importance of factors other than quantities and their role in the interpretation of his fall off data. This type of analysis requires a large quantity of archaeological and ethnohistoric data to be successful, and might not be possible to undertake. It nevertheless is of importance in pointing out the influences of various factors which should be considered in the final interpretation of archaeological data.

Wright (1969) suggested other variables which influenced the fall off patterns of exchange, when his data did not quite fit the pattern predicted by Renfrew. In his analysis of obsidian distribution in the Zagros-Tauros area from the Near East he suggested that the weight of the material was a more appropriate measure than its proportion in the lithic assemblage, since the material was transported by humans without the aid of pack animals. Other problems identified by Wright which influenced the general pattern, were temporal variations in the amounts of obsidian reaching the site, the availability of alternative resources (flint) in certain areas, and the change in the mode of transport of the obsidian through time. He also argued that only sites with the same function should be compared at any one time (Wright 1969:47-52, 1974:38).

The importance of site function has also been discussed by Sidrys (1977), in his study of Maya obsidian trade. When he plotted obsidian density against linear distance from the source, his data showed a poor fit (low Pearson-r values). A re-examination of the sites showed a large range of different sites, from agricultural hamlets to large nucleated centres. Regression analysis performed on sites divided into major and minor centres showed highly significant Pearson-r values and that the bigger centres were able to import up to six times more obsidian than the smaller centres (1977:97). In order to compare economically dissimilar sites, Sidrys (ibid.:98) established a Trade Index (defined as obsidian density multiplied by the distance from site to source). The regression analysis also showed that the major centres had a higher Trade Index than the smaller centres (ibid. :98-99). As a further result of the diachronic study of Mayan obsidian distribution, Sidrys observed distinct changes between the Classic and Postclassic Periods. This was discovered using an alternative trade measure: the ratio of obsidian to pottery sherds. The fall off pattern using the obsidian to sherd index on one axis and distance on the other again showed a differentiation of sites below and above the least square regression line (ibid.:100-102). To explain this, the author proposed that the shift was due to changes in the transport routes, with transport becoming more efficient as it shifted from overland routes to primarily riverine and sea coast routes (ibid.:103). The increased transport efficiency, he concluded, decreased the value of the foreign obsidian making it more accessible and permitting its regular utilitarian use (ibid.:104). Sea transport has also been seen as easing the difficulties of overland cargo transport . Ammerman (1979; Ammerman *et al.* 1978) has pointed out that in Neolithic Calabria the sea did not represent a barrier to exchange as had previously been assumed by, for example, Hallam *et al.* (1976:100).

The work carried out in the Calabria region in Southern Italy by Ammerman (1979) on obsidian exchange networks raised some basic questions about the adequacy of the down-the-line model and the Law of Monotonic Decrement postulated by Renfrew. Systematic surface collections of lithic material from sites in Calabria contained a high percentage (90 per cent) of obsidian while, in contrast, assemblages from sites on the east coast had less than 40 percent. The fall off with distance from the source is far more pronounced on the sites on the east coast of Calabria. Sites located at more or less the same distance from the obsidian source showed very different values in the proportion of obsidian (ibid.:100-101). Ammerman offers two possible explanations for the deviations from Renfrew's down-the-line model, the availabity of local chert resources, and the position of the site in the exchange network. However, he does not exclude the possibility of a range of other factors.

In an earlier study Ammerman *et al.*(1978; Ammerman and Feldman 1974) discussed some other problems apparent in Renfrew's studies (also discussed by Wright (1969, 1970, 1974) which might be responsible for distortions in the fall-off patterns. He found that the effects of time were the most important factor which eluded Renfrew's model. The authors set up a simulated exchange system, in which an exchange process operated over a large number of time steps. They concluded that down-the-line exchange is a "dynamic time dependent process" (Ammerman *et al.* 1978:182) since they could show that with the increase in time the proportion of obsidian in sites distant from the source increased, as did the area covered by the supply zone. They applied this insight to the data sets used by Renfrew *et al.*(1968:328) from Armenian and Cappodocian obsidian sources, and showed that the possible differences in size of the supply zones of both sources could be due to variations in the operation of the systems. They also included two additional parameters - a dropping rate and passing rate - which were developed by Ammerman and Feldman (1974) and concluded that once a state of equilibrium was reached within the exchange system "the slope of the fall off line is essentially the same as the ratio of the dropping rate to the passing rate " (1978:186). Another point they discussed was the potential influence of geographic factors, such as location of the obsidian source, and natural communication lines. Finally Ammerman *et al.* (1978) suggest certain lines of inquiry to follow in obsidian trade studies. They point out the importance of recording the form in which trade is carried out (finished tools, prepared cores, blocks), and of the examination of the site types and their function within the region under examination, if one wishes to carry out comparative regional studies (ibid.:192).

In a study of obsidian distribution at Owens Valley, California, Bettinger (1982) observed an overlap between supply zone and territorial boundaries. Although the observed pattern resembled Renfrew, Dixon and Cann's (1968) model, where a resource shows a supply area where obsidian is abundant and a fall off area further removed from the source where it competes with alternative resources, the distribution along the fall off line showed sharply differentiated zones of supply and consumption. Due to the absence of alternative obsidian resources within the study area, it was argued that the break observed along the fall off line corresponded to boundary lines of aboriginal territory (Bettinger 1982:121-123). Bettinger's argument is based on the underlying assumption that if obsidian distribution is affected by territorial ownership a high frequency should be expected within the territory where procurement would be by direct access. Secondly, low frequencies of obsidian should be expected in neighbouring territories. Thirdly the boundary between the two areas would be marked by a sharp cut in the observed frequencies (ibid.:112).

Findlow and Bolognese (1980a, 1980b, 1982) have analyzed obsidian distributions in New Mexico and noted the importance of political organization in the fall off patterns observed. They stress the importance of incorporating this and a number of other factors, such as topography, site function and demography into the analysis. In order to achieve the integration of these factors into the regression analysis, improvements in the measurement of cost factors are suggested by the authors. In an earlier paper (1980a) the authors proposed a distance/work coefficient which was calculated

> "by first finding the line between the site and the source that at once minimized distance and topographic relief. The cost of using the path to and from the source was then measured as the integral under the line, the lower bounds of the area being set by the lowest elevation along the line" (1980a:239).

This was replaced in a later paper by a measurement of movement cost, calculated using factor analysis. The effects of topographic relief were standardized, using factor analysis, in order to estimate the transport costs involved in the movement of obsidian from the source (1982:71). The improved measurement would allow one to take into consideration "the subtle effects of topography within a particular region", ignored by the previous method (ibid.). In their research the authors have tried to differentiate exchange systems by applying a number of regression techniques. They applied four different regression models to their data on obsidian abundance: linear, hyperbolic, exponential, and power function models. For every individual source, each best fit regression line represents a different exchange mechanism (ibid.:72). Different regression models were found to best describe obsidian distribution data for different periods. For example, a linear model best fitted the Antelope Wells obsidian distribution during the Archaic Period,while an exponential model best fitted the distribution from Basketmaker II to Pueblo II Periods. Further the Pueblo III and IV Periods were best represented by a hyperbolic model (ibid.:76). Since each of these models has been associated with a specific type of exchange, the best fit model allowed the identification of temporal and regional differences in the exchange systems.

The most important conclusion to come out their study was that sociopolitical factors are causative in the formation of complex down-the-line exchange systems. Social movements, (i.e. increasing or decreasing sociopolitical complexity) "would seem to promote concomitant movement either towards or away from direct access " (ibid.:80). A further implication of their study is that mathematical models will not be accurate and successful, unless the appropriate factors and variables influencing the system are accounted for. The combined use of regression analysis with qualitative inspection of the data will yield the best approach, as neither can operate successfully alone (1980a:247).

The different approaches used to study regional exchange described above have all started from the initial exploratory hypothesis proposed by Renfrew, and have shown the power and usefulness of fall off curves, regression analysis and other techniques in the evaluation of prehistoric exchange types. However, as has been shown above, they can also be used to evaluate the effect of other factors on obsidian distributions (transport methods, technology, influence of alternative resources). In the following two sections an evaluation of two further models for use on a regional basis will be made before concluding with an appraisal of the relevance of these models to the study of obsidian exchange in New Zealand.

The Gravity Model

The gravity model, borrowed from studies in geography (Hagget 1965) has also recently been applied to the study of obsidian distributions (Hallam *et al.*1976; Hodder 1974, 1978; Renfrew 1977a). The gravity model, which was designed to measure cultural interaction (Crumbley 1979), is expressed by the following formula:

$$I_{ij} = \frac{P_i \quad P_j}{D^b_{ij}}$$

where I_{ij} is the predicted interaction between two places (i and j), P_i and P_j represent the population of the two places, D_{ij} the distance between the two, and b an exponent of a chosen value (Hagget 1965:35; Olsson 1970:227; Crumbley 1979:146).

The model has been applied by Hallam *et al.* (1976) to study obsidan distribution in the Mediterranean. To suit the data, the size of the two centres was replaced by a variable measuring the 'attractiveness' of the obsidian source. The quantified 'attractiveness' of the source was used to predict the proportion of obsidian from each source to be found at each site (ibid.:102). Two equations for measuring the 'attractiveness' were devised. The first

$$Q = \frac{-A}{D}$$

where A is the measure of atractivness, Q is the quality of obsidian found at the site , and D the distance between two places. This equation poses a problem in that in order to obtain the measure of 'attractiveness' (A), the value of Q (quality of the obsidian found at the site), must be known. The second equation is

$$r = \frac{k\ d}{1 - K^2}$$

where K^2 is the "ratio of the 'attractiveness' of the source (assumed constant), d is the distance between the two sources, and r the radius of the circle dividing the areas where the proportion of obsidian found at sites are not equal" (1976:101). This equation poses a problem in that one already has to know the location of the sites which contain equal quantities of obsidian. As the authors postulate, the 'attractiveness' can be measured, and the proportions of obsidian to be found at the site be predicted, if the source boundaries are known.

These equations are used to examine the spatial distribution of sites containing equal quantities of obsidian from two known sources. When the attractiveness is made a constant factor, the sites are predicted to fall on a curved line midway between the two sources, but when attractiveness is not the same for the two sources, the sites will fall within two circles separating the two sources.

The model in general presents practical problems when applied to archaeological data. Firstly, to solve the population equation, artefacts sensitive to economic indicators have to be found, and secondly, to solve the measure of distance, historical or other evidence of interaction between a known and an unknown centre has to be found. To resolve these basic problems, well dated contemporaneous sites distributed over a large areá have to be used. The problem of distance measures has been discussed by several authors and will be referred to in Chapter VI.

Finally it has to be stressed that the gravity model, when applied to archaeological problems, is primarily designed to record spatial distributions, rather than to document or explore exchange mechanisms.

Because the present research concentrates mainly on the reconstruction of prehistoric exchange mechanisms and not on a description of the spatial distribution, the use of the gravity model is not called for. Moreover, some of the variables which have to be incorporated into the gravity model include factors, such as population composition, which are not purely economic (Crumbley 1979). They are cumbersome or impossible to record from the archaeological data and there is no assurance that they can actually help in the reconstruction of prehistoric exchange.

Other Models: Technological Model and Trade Routes

There are two further approaches to the study of obsidian distribution. The first was applied by Sheets (1980a) to the study of obsidian trade in the Valley of Zapotitan in El Salvador. A technological approach was used to study the economic organization of obsidian manufacture and usage. The aim of the study - to record the position of each archaeological site within the trade network and to describe the lithic industry - was accomplished by recording a number of descriptive variables for each site. The variables selected to record technological aspects of the lithic material are the proportion of artefact types, mean weight per piece, the ratio of the cutting edge of prismatic blades to their weight and the number of hinge fractures on each piece. These data, recorded for the total obsidian assemblage, were used to reconstruct the mechanisms of obsidian exchange and the process of obsidian manufacture in the area.

The technological study allowed Sheets to observe that the obsidian was entering the sites in different ways, and was related to the position of the site in a settlement hierarchy. He observed seven levels in the settlement hierarchy of the valley and noted that obsidian entered the valley at the top level sites and was redistributed from these to the lower level settlements and villages. The obsidian found at the sites from the top two levels showed a high incidence of flakes with cortex in the assemblages, higher mean weight values and lower ratio values for cutting edge blades versus blade weight in relation to the other sites. The specialization of the industry at the top of the hierarchy was also indicated by the small number of hinge fractures, which are directly related to the skill of the knapper, and contrasted sharply with the obsidian production at the smaller villages, where obsidian production was carried out at the level of a "small cottage industry" (1980a:12). Further down in the settlement hierarchy obsidian was obtained from itinerant craft specialists and was harder to acquire, as was indicated by the high cutting edge to weight ratio of the blades (ibid.).

Sheets' study is important in that it demonstrates the possibilities of the analysis of obsidian technology, and its role in understanding the relationship between sites and quarries and between specialized sites and distance from the source.

Technological measures have also been employed by Renfrew (1969, 1977b; Sidrys 1976b) to study exchange. The main argument used by Renfrew in his study was that sites distant from the source will have access to less raw material and this should be reflected in the obsidian assemblage at the sites. If it is a scarce and valued resource, more efficient use of it will probably have been made and one could expect a smaller size of flakes and debitage at the site. This kind of behaviour has been documented by Sidrys (1976a) for the Mayan area, and Renfrew (1977b:295) also argues for a reduction of size of the waste material and re-use of artefacts. Other authors recording such decrease in size are Evett (1973) on Italian Neolithic greenstone axes, McBryde and Harrison (1981) in Australia for ground stone axes, and ethnographically Hughes (1977) and Strathern (1969) have observed a similar situation for ground stone axes in New Guinea.

A similar approach to Sheets (1980a), has been used by Ammerman (1979) in the analysis of obsidian production in Calabria. Ammerman recognizes the importance of the technological variables, but his analysis was not as sophisticated as Sheets' study.

Finally Hammond's (1976) attempt to trace the trade routes by which the obsidian travelled in Mesoamerica, should be mentioned. Hammond suggests that the differential distribution of material from two different sources was related to their respective trade routes. Obsidian from one source was supposed to have travelled overland, while obsidian from the other source was supposed to have been transported to the coast and then distributed both along it and inland through the coastal ports. Characterisation studies carried out at a later date have given support to this hypothesis (Hammond 1972, 1976).

Implications of the Regional studies for New Zealand prehistoric exchange

Distance fall off studies, even if they present some problems, seem to offer a number of possibilities for the study of prehistoric exchange in New Zealand. One of the main problems faced by the archaeologist when interpreting the fall off pattern has been mentioned by Hodder (1974; Hodder and Orton 1976) and involves the similarity of the fall off curves produced by two different processes - random walk and down-the-line exchange. Renfrew (1977a) suggests the use of additional data to solve the problem, and also notes that, even so, direct access can be distinguished from reciprocal exchange (ibid.:86).

Other problems faced by researchers investigating distance decay arise from the variable quality of the raw data. To construct plots which measure the abundance of obsidian in relation to distance from the source, it is necessary to choose an appropriate abundance measure. In this respect the New Zealand data share a problem with other places in the world, notably the lack of information for a number of sites on the quantities of other lithic materials recovered. The absence of sufficient or adequate data on either the absolute or relative abundance of obsidian at a number of sites where obsidian has been found makes the use of distance fall-off curves difficult. It is possible to find different indices which can be collected from the available assemblages. Wright has suggested the use of mean weights (1969, 1970, 1974) as an index of abundance, in the lithic assemblage rather than percentages. Ammerman (1978:193, 1979:103) has warned against this measure, because the statistical means can be skewed towards the smaller pieces. He suggests the use of cumulative frequencies. The problem of mean weights can be overcome by classifying the data into different categories, such as cores, flakes, and waste flakes and then comparing the relationship of each of these separate variables with distance from the source. In this way the mean weight values will not be skewed towards the smaller pieces. In the present study the obsidian cores, flakes, blades and debitage for the selected sites on both the North and South Island of New Zealand are investigated for the relationship of the variables of size and weight with distance from the source.

The other methods reviewed appear to be of little practical value for the present study. The gravity model focuses mainly on the description of spatial distributions instead of exchange mechanisms. Trade routes can be of help in identifying relationships in spatial patterns but do not in themselves help in the clarification of prehistoric exchange mechanisms. For these reasons neither model is used in the present research.

SINGLE SITE ANALYSIS

All the above mentioned studies have a common approach in their regional outlook on the study of obsidian distribution. A number of other studies, though few in number, have focused on the analysis of obsidian distribution within one single site, and attempted to explain the methods by which foreign goods found at a site were acquired. Information such as source of obsidian and its location within the site in a spatial and temporal context has in some instances been used to reconstruct the mechanisms of exchange. Relatively few studies have been carried out using this approach to elucidate the exchange mechanisms in terms of actual trade or exchange theory.

Some of the techniques do not vary significantly from those commonly employed in the analysis of archaeological assemblages. Time trend analysis, spatial variability in the quantities of different kinds of obsidian found at a single site, variability of source composition and, lastly, the formal analysis of obsidian have been applied to the problem by different researchers. The most relevant of these studies are briefly summarized below.

Quantitative Studies

In this type of study a basic measure of abundance must be found in order to monitor quantitative changes through time. A number of methods to measure the abundance of obsidian or its relative proportion in a site have been developed. These record the changes through time in the importation to, and use of, the raw material in the archaeological site in comparison with other commonly occuring artefacts.

Renfrew, Dixon and Cann (1968) in their analysis of Near East trade used the counts of flaked obsidian relative to flaked flint. The value obtained as a percentage was interpreted as a reflection of the proportion of imported obsidian in the total lithic assemblage.

Wright (1969:48-50) criticized the use of raw numerical counts, because, he argued, it overlooked weight differences between artefact types. No consideration was given to the fact that a small quantity of large cores might represent considerably more material in terms of volume and transport cost than a large number of small flakes. Wright therefore calculated an obsidian to flint percentage based on weight. His use of data from other excavations was obstructed by the poor and inconsistent recovery techniques of many earlier projects. In the absence of data on sample weight, Wright estimated the weights on the basis of counts, having to ignore functional and temporal variations within his samples.

Renfrew (1969b; 1977b) calculated values for several variables which could measure the variation in the obsidian supply for an area. Values for each phase of occupancy in the Deh Luran plains were calculated for the following variables :

1) Total number of pieces,

2) percentage of obsidian in the total chipped stone assemblage,

3) number of pieces of obsidian per cubic meter of excavated material, and

4) mean weight of obsidian pieces.

He noted some problems with measuring some of the above variables. The number of pieces of obsidian per cubic metre of excavated material is susceptible to the excavator's bias, due to selective sieving, size of sieve mesh and selective recovery of material from different areas of the site, as well as the nature of the fill of the archaeological site (1969b:432). Renfrew believed that the mean weight measure was a more useful means of comparing the abundance of material with the ratio of the same material in other sites. Nevertheless this can be influenced by functional and stylistic factors (1969b:432, 1977b:296). The quantity of obsidian at the site can also be affected by differential activities or functions within the site.

In another study Cobean *et al.* (1971) utilized several indices to quantify the obsidian found at San Lorenzo Tenochtitlan in Mexico. The total number of obsidian pieces (separated into flakes, blades and waste material) were plotted for their abundance in the site. This was then compared to the numbers of grinding implements (manos and metates) in the site. Each mano/metate unit was assumed to represent one household. The two figures were then compared and plotted against each other and the ratio of obsidian to mano/metate units would represent the actual consumption of obsidian of each household. The authors found the amount of obsidian in the site increased through time and hypothesized that this represented a "rise in prosperity or 'buying power' of the individuals" (Cobean *et al.* 1971:666).

Zeitlin (1978; 1979) in his study of obsidian procurement and the long distance exchange links at the Isthmus of Tehuantepec, used the total weight of obsidian against the total count of pottery in the site. This ratio was an index to measure abundance of obsidian at the site through time. He notes changes in the use of obsidian, and these are interpreted as shifts towards a more intensive utilization of it (1978:202). Pottery was used, since it was uniformly abundant in the site and could be assumed to have a relatively constant per capita consumption rate over time. Changes were seen as alterations in the intensity of use. Intra-site variation was smoothed out by sampling areas of the site that represented all its different occupational phases.

Alternatively, Sidrys (1976b:450) used obsidian count per unit volume of excavated fill, while another method of measuring abundance has been employed by Moholy-Nagy (1975) at the Maya site of Tikal, Guatemala. The ratio of obsidian flake-blades to flint flake-blades was calculated for all obsidian found in a non-ceremonial context. The gradual increase in the value of the ratio from the Middle Period to the Late Classic Period was interpreted as showing that obsidian was available to all members of the population due to an efficient procurement and distribution system. The late drop after the Postclassic Period in the values of the ratios, was seen as a drop in the accessibility of the obsidian to the lower social groups of the population, making obsidian an 'elite' item. It also suggested difficulties in the importation of the obsidian into the area (ibid.:517).

A different approach was employed by Torrence (1981). In order to control for differences in site function or in the contexts of the sampled deposits, the mean weight measures were calculated separately for each artefact type, but again, for intra-site comparisons the total weight per unit volume of excavated material was calculated (ibid.:281). This measure was used to analyse the output of the obsidian workshops at Phylakopi in the Aegean.

Irwin (1977a, 1977b) quantified the obsidian found in his excavations on Mailu Island, Melanesia, calculating the percentage (counts) of obsidian versus chert artefacts. Irwin's study stands out in that it is one of the few to attempt to predict the nature of local and long distance trade through the duration of the site's occupational history by quantifying the obsidian data (1977b:22-23). Variations in the relative proportions of chert and obsidian are interpreted as a reflection of changes in the supply network, rather than of consumer preferences (ibid.:23). Irwin found that obsidian was abundant during the Early Period of Mailu prehistory but later decreased in importance, being almost totally replaced by local chert (1977a:308-311). In the later Mayri Period, chert is abundant in the early Period but is steadily replaced by obsidian, and then again looses importance during the succeeding Mailu Period (1977a: 308-311, 1977b:23-25). In spite of the observed pattern, Irwin concluded that the documentation of long distance movement of material did not help to clarify or explain any of the exchange mechanisms by which the materials changed hands (1977b:26). Nevertheless, despite Irwin's pessimistic conclusion, the combined use of techniques such as fall-off studies, variability in the abundance and technological analysis might lead to an understanding of the exchange mechanisms involved.

Finally, Prickett (1975) in her study of stone resources at Palliser Bay in New Zealand, used relative percentages of different types of stones to record the changing patterns of utilization within the area. The importance of the non-local rocks in the area was noted by Prickett (ibid.) and Leach (1976), leading to the interpretation that the predominance of imported rocks, including obsidian, was due to the build up of stronger and more reliable exchange networks (Leach 1976:169). Nevertheless, no further attempt was made to identify exchange mechanisms, although Leach (ibid.:175) points out the possibility of two different exchange networks operating simultaneously.

Research in New Zealand could take advantage of some of the methods described above. It certainly would be profitable to monitor the changes in obsidian supply through time, in order to test hypotheses on the changes in the system of exchange. It would be possible, for example, to argue that a change in the quantities of obsidian supplied to one site (or to an area) over a period of time was due to different systems of acquisition which might be directly related to a shift in the exchange mechanisms. Renfrew, Moholy-Nagy and Irwin have made some important theoretical propositions linking the abundance of obsidian to the development of systems of exchange.

TABLE 3.1

Measures of abundance which have been used in the study of obsidian exchange (after Torrence 1981)

Measures based on quantity or relative proportion :

Percentage of obsidian in the total lithic assemblage	Renfrew *et al.* 1968; Renfrew 1969b, 1977b; Ericson 1977a; 1977b; Findlow and Bolognese 1980a, 1980b; Prickett 1975; Leach 1976; Irwin 1977a, 1977b.
Ratio of obsidian blades to flint blades	Moholy-Nagy 1975.
Total number of obsidian flakes	Cobean *et al.* 1971.
Total number of obsidian blades	Cobean *et al.* 1971.
Total quantity of obsidian	Cobean *et al.* 1971; Renfrew 1969b; 1977b.
Total weight of obsidian per unit volume of excavated earth	Sidrys 1976a, 1976b, 1979; Renfrew 1969b, 1977b.
Ratio of obsidian artefacts to grinding equipment.	Cobean *et al.* 1971.
Total weight of obsidian to total count of pottery sherds.	Zeitlin 1978, 1979.

Measures based on Technological differences:

Distribution of artefact weights	Ammerman 1979.
Relative percentage of debitage types	Sheets 1980a, 1980b; Torrence 1981.
Relative percentage of cortical flakes	Sheets 1980a; 1980b.
Number of hinge fractures	Sheets 1980a; 1980b.
Mean blade width and thickness	Sidrys 1976a; Torrence 1981.
Mean ratio of blades cutting length to weight	Sidrys 1976a; Sheets 1978.
Mean weight of artefacts	Renfrew 1969b; 1977b; Torrence 1981.

Spatial Variability

The analysis of spatial variations in the archaeological context has been widely carried out in Mesoamerican sites. For example, during the Teotihuacan mapping project, large areas scattered with obsidian artefacts were noted and sampled, as well as the location of workshops. The history of obsidian production at the site was reconstructed, based on source composition and artefact types encountered (Millon 1967, 1970). Another study was performed by Sheets (1978) on the workshops at Chalchuapa, El Salvador. At the site of Loma Torremonte in Mexico, variations in the quantity and quality of the obsidian assemblage were used to link specialized and differential acquisition of raw material.

Lastly, in another study by Pires-Ferreira (1975; Winter and Pires-Ferreira 1976; Winter 1972), spatial variations of the obsidian sources within one site were analyzed. The authors explored the obsidian distribution at the two villages of Tierras Largas and San Jose Mogote, assuming that a large variation between households both in sources used and the proportions used from each source would be a reflection of a reciprocal economy (1976:306). On the other hand, uniformity in obsidian distribution between households was assumed to be the result of redistribution (ibid.).

The analysis of the obsidian assemblages from the Tierras Largas and San Jose Mogote household clusters showed large intra-site variations in the sources employed during the early Formative Period at Tierras Largas but became more uniform during the Middle Formative. Comparatively, the utilization at San Jose Mogote was very uniform throughout its occupation. On this basis, Winter and Pires-Ferreira concluded that at the large early Formative villages, obsidian was obtained from several sources, pooled by the elite and later redistributed to the rest of the population. In contrast, at the smaller sites, households obtained their supplies directly through reciprocal exchange. During the Middle Formative Period this was replaced by pooling and redistribution (ibid.:309-310).

Winter and Pires Ferreira's study is particularly important in that it is the first one to integrate data on source composition and intra-site variability into the study of exchange mechanisms.

Archaeological research at San Lorenzo Tenochtitlan indicated that with each occupational phase increasing numbers of obsidian sources were used. Cobean *et al.* (1971:670) concluded that trade played an important role in the expansion of sources employed and that this was due mainly to certain major changes that occurred in the magnitude or the structure, or both, of the Olmec culture sphere (ibid.).

Renfrew (1977b:308) also notes the variation in the relative abundance of two different kinds of obsidian in the Deh Luran plains. Green obsidian is more abundant during the Early Period and reached its highest level of consumption very early in the occupational history of the area. Consumption was then stable throughout several phases and dropped in the last phases. Grey obsidian reached its maximum consumption at a later stage but its use declined at the same time and rate as that of the green obsidian. These changes in quantities and relative proportions of obsidian consumption are interpreted as being caused by differences in the effectivness of the down-the-line trade network, or difficulties in access to the trade networks for the two sources (ibid.:309). The author is more inclined to accept the latter view - a change in supply due to transport or political factors.

The analysis of intra-site variability performed at Palliser Bay, New Zealand by Prickett (1975) and Leach (1976) showed that at least seven sources were utilized at one point in time . The trend observed earlier by Green (1964:139), where obsidian from one source (Mayor Island) was dominant in the Early Periods in North Island sites and declined in popularity at later sites further removed from the source, was not confirmed by Prickett (1975) and Leach (1976). Considerable variation from this trend was observed by Leach (ibid.:171). Green (1964) did not attempt to use his information to analyze exchange mechanisms, but rather as a relative dating technique. Leach concluded from his analysis that, as a dating device, the proportion of Mayor Island obsidian in a site would only be applicable at a very general level. Leach does consider the shifts in the proportions of obsidian and other local and imported rock sources found in the study area. However, none of the authors goes beyond noting the existence of communication networks and suggesting possible routes of communication.

Reduced potential for consumer variation due to a limited number of sources makes it difficult to interpret changes in compositional variability in terms of exchange. One of the main problems faced in the study of source variability is that the household units must be clearly recognizable. The unavailability of these data for a number of New Zealand sites has hampered some of the possible analyses making it difficult to incorporate this approach in the present study.

Formal Analysis

Finally, Winter and Pires-Ferreira (1976) have noted that it is important to record the form in which a piece enters the site, since it might be related to the type of exchange. The authors suggest a general relationship between exchange mechanisms and the form of objects, based on the observation of the association of three different variables : 1) the proportion of obsidian from two sources of high quality material, 2) the quantity of prismatic blades and 3) the degree to which pooling and redistribution might have taken place. It is thought that the blades are alien to the site and that their exchange was controlled by an elite group (ibid.:310). This relationship between the form of the object (for example prismatic blades) and the exchange mechanism has been pursued to some degree by Ammerman *et al.*(1978). The consideration is that the more valuable an item, the more likely it is that its exchange will be controlled by a special group. Ammerman also argues that the differences in obsidian use at a site reflect specialization. He has tried to apply this line of argument to his research in southern Italy, by recording the differences in weight of obsidian debitage at the sites. Wright (1969) has also proposed a specialized exchange for obsidian blades in the Near East.

Implications of single-site analyses to the New Zealand study of prehistoric exchange

Most of the single-site analyses described above could in some way be performed in New Zealand. However, the nature of the sites in New Zealand does not compare with the huge workshops in the Aegean or large settlements of Mesoamerica, which were used over a number of centuries. The sites in this study have all been used for a short length of time, although some have been used repeatedly. Nevertheless, time-trend analysis on the variation in quantities of obsidian at a single site would be of little use in explaining exchange mechanisms for the whole country.

The differences in source utilization are meaningful in sites like the villages of San Jose Mogote or Teotihuacan in Mesoamerica. It is extremely hard to record these differences for family groups in temporary settlements or hunting camps such as those used for this study. It might be rewarding to attempt such a line of research in the future on some of the larger permanent villages on the North Island, but at present this approach cannot be used here.

For the present purpose, the form of the obsidian seems to be the most useful of the four techniques outlined above. This aspect has been given attention in some studies, such as Leahy's (1976) study at Whakamoenga Cave in the North Island, and it seems worthwhile to pursue it in particular for the analysis of lithic workshops.

In this category one might include the lithic quarries and mines which represent the centre of production. Quarry analyses are relatively new but have proven an extremely fruitful line of inquiry. They have been performed by a number of scholars all over the world (Leach 1984; Gramly 1984; Torrence 1981, 1984; Purdy 1984; Gibson 1984; Luedtke 1984; McCoy 1977; Stevenson *et al.* 1984, Bosch 1979; and others). Some of the most exciting research relevant to this study has been carried out by Torrence (1981, 1984) on the Sta Nychia and Demenegaki quarries on Melos in the Aegean. Torrence was able to show that consumers obtained their obsidian by direct access (1981:425). Singer and Ericson (1977) have stressed the possibilites of quarry analysis for studies of prehistoric exchange.

It was believed that the present study would profit considerably by an analysis of the obsidian sources, quarries, and workshops on Mayor Island. A site survey was carried out in May 1982 with this purpose in mind. Several areas where the obsidian flows were mined were found and these are described in the following chapter. Further research on the quarries, workshops, and mines was sadly hampered by factors beyond control and cannot therefore be included in the present study. It is hoped that in the future it will be possible to carry out a more detailed examination of the obsidian quarries, mines and other archaeological sites on Mayor Island.

SUMMARY AND CONCLUSION

The present chapter has discussed a range of different approaches to the study of obsidian exchange in different areas of the world. The applicability of a number of regional and site oriented research approaches employed in the study of prehistoric exchange were discussed in order to investigate which ones could profitably be applied to the study of New Zealand obsidian exchange. A far larger range of research has concentrated on regional aspects, focusing on the relationship between abundance or size of obsidian artefacts and distance from the source of obsidian. Site oriented research has mainly been carried out in Mesoamerica, but lately quarry research has been carried out in a number of places. From the foregoing review it is clear that a number of methods can be employed, but due to a number of restrictions in the New Zealand data it seems that the most profitable approach for the present study is to integrate aspects of several of the techniques reviewed.

The main points concluded in the present chapter may be summarized as follows:

1) Although attempts to identify archaeologically economic institutions such as reciprocity, redistribution and others observed in present day societies have been made, these have not been conclusive. There are at present no ways of establishing unequivocally which of these was responsible for the distribution of goods as found in prehistoric sites.

2) The prospects of using regionally oriented research in New Zealand seem encouraging. Fall-off studies have been shown to be of use, even if there are still problems in how to interpret specific patterns. There is every chance that this type of analysis will be profitable in New Zealand.

3) The technological approach employed by Sheets (1980a, 1980b) shows the important role of understanding the technology of obsidian production in relation to distance from the source and with respect to the degree of craft specialization. This approach can be applied in New Zealand and sufficient data seems to be available to attempt it.

4) The gravity model employed by some authors, does not seem of any use for the present study.

5) A number of aspects of single site analyses could be of use in the present study. Firstly the formal analysis of the obsidian assemblages provides some interesting results and has already been employed in New Zealand. Of special importance is the analysis of quarries and related workshops that can provide information on the patterns of exploitation of a resource and its subsequent transformation for consumption.

The approach employed in the present study draws on the methodology of other researchers. The main focus of the thesis is on regional analysis. It was believed that the study could also profit from the analysis of certain sites on Mayor Island where the main obsidian flows are located, and that fieldwork at the quarries there could provide a number of answers about prehistoric obsidian exploitation in New Zealand. In the following chapter the results of the site survey carried out on Mayor Island are discussed. The data used here for the regional analysis were collected from excavated assemblages stored in New Zealand museums and universities. The regional study deals with the analysis of the fall off patterns of a number of variables. This research is described in Chapters V and VI.

CHAPTER IV

QUARRY EXPLOITATION: THEORETICAL ISSUES AND THE OBSIDIAN EXPLOITATION ON MAYOR ISLAND

INTRODUCTION

When discussing the prospects of site oriented analyses in Chapter III for the study of prehistoric obsidian exchange in New Zealand it was found that this type of analysis offers a number of possibilities. As discussed in the previous chapter the study of the sites of procurement - the quarries - can be of assistance in providing answers to specific questions relating to prehistoric obsidian exchange. In particular the behaviour observed at the quarry sites can be expected to reflect skills, production rate, and methods of procurement of the people making and using the final products, be it at the quarry itself or at places far removed.

Four major questions arise when discussing the exploitation of specific resources and will be discussed in this section . If access to the source of the raw material were controlled, certain behavioural patterns might be expected to be present at the sites. How was the material obtained, who controlled access to the resource areas, how was it enforced ? How is this expressed in the archaeological record ? These are the main questions which will be discussed in this section.

The following chapter will discuss how the above points would be expressed archaeologically. Firstly, a number of ethnographically documented examples of quarry exploitation in different places of the world and at different time periods will be described. Secondly, a number of archaeological studies of prehistoric quarries will be examined in order to see if any of the studies can be of use in predicting a particular type of behaviour at the quarry sites. It is hoped that some of these examples will provide insight into the pattern of exploitation observed at Mayor Island.

The second part of the present chapter is devoted to the description of Mayor Island, its geology and the archaeological fieldwork carried out there. The archaeological remains found on Mayor Island are discussed in relation to the theoretical discussion of quarry exploitation and production which follows.

CONTROL OVER ACCESS AND PRODUCTION AT LITHIC QUARRIES: THEORETICAL DISCUSSION

The concept of ownership of a quarry is of paramount importance when discussing control over access. In certain cases the exploitation of a quarry will be open to all those who need it. In others it may be controlled by local residents or a particular kin group. If ownership does exist then the owners may or may not maintain their rights on the quarry. Several options are open for this. They may have territorial boundaries which could be marked in some way. In other cases they may need to assert ownership by force so that some sort of fortifications or defenses would be needed. In other instances the location of the resource may be kept a secret. It can be expected that if ownership rights are exerted, the owners will derive some sort of privileges or profits from their control. This in turn may imply that the owners have a monopoly over the resource and that other groups must be willing to pay for this resource. In order to maintain control it is frequently necessary for people to reside permanently near the source, or maintain a constant watch over the territory surrounding the prized resource . Spence and Parsons (1972:28) believe that this might have been the case at Teotihuacan, where large quantities of obsidian were used at the city. They believe that due to the size of the industry and in order to maintain a high output it was necessary for Teotihuacan to have had "control or undisputed access" to both the local sources of grey obsidian and the green obsidian from Hidalgo. Restricted access to a quarry and tight control directly imply that the resource exploited is considered to be a valuable asset.

The behaviour observed at quarry sites has to be seen as part of the larger economic system in which it is embedded. Clearly the existence of any sort of control over access is linked to the basic economic background under which exploitation is taking place. As Torrence (1981, 1984) has observed, monopoly exercised over a resource is strongly linked to the later commercialization of the extracted produce and that the monopoly over a resource is a prerequisite for the creation of profits (Jacobs 1972: 27-29, Torrence 1981:178). Commercialization of a product in a competitive market economy implies that it is of some importance or has an inherent value. Nevertheless, the output of a product is not necessarily always correlated to 'market' factors, that is, with supply, demand and price conditions. Output may be related to other non-market factors, which are cultural, ecological or other, as has been shown for example by Nash (1961) and Cook (1970). Nash, in a study of pottery manufacture and output in Chiapas, Mexico, reached the conclusion that "production is maximised not at the time of highest prices on the market, but rather in time with the rhythm of sacred and secular celebrations which require cash outlay and provide opportunities for disposal without storage problems" (Nash 1961:187). Cook's study of the metatero industry in Oaxaca, Mexico, showed that the output of metates (stone grinders) fluctuates regularly in accord with the agricultural calendar as well as with market factors (1970:788-789).

Archaeologists have proposed a number of ways by which the type of exchanges in operation in a cultural system could be predicted from the distribution of traded goods (see Chapter III). In the same way predictions concerning the economic structure could be made by studying the behaviour at the points of origin of the product. A number of archaeological indicators can be expected to be found at quarry sites which are distinctive for identifying control over access or ownership.

The evidence of control over access to a quarry could be expected to be found not only at the site itself but also in the surrounding area. Possible evidence could include territorial markers, defensive constructions in the vicinity protecting access routes, or domestic structures of people living on a full time basis at the quarries.

Controlled access to the quarries suggests that they may be exploited by a single group of people, consequently the labour force specializing in the extraction of the raw material and its subsequent stages of modification could be expected to be highly skilled in their work. It is also likely that once the raw material was extracted by workmen it was roughly worked for easier transport and then finished somewhere else. Archaeologically, the remains left at a quarry by specialized workers, employed only on the extraction of the raw material, might be different to those left by a periodic visitor collecting some material on an occasional expedition to it, when the quarry is open to everybody's use.

Torrence (1981) has shown that some form of limited access to resources exists in commercial style industries. The author examined a number of commercialized and non-commercialized stone working industries (English and French gunflint industries, Mexican metateros, New Guinea axe quarries, and others) and found that if production for exchange is the primary reason for the exploitation, access to the raw material and/or the skills of manufacture will be restricted, regardless of the type of economy in which the objects are produced (Torrence 1981:241-244). She argues, moreover, that the degree of restriction will vary according to the nature of the products dependence on the goods received in exchange. Torrence says, further, that if the final product is mainly going to be used locally, there are no reasons for restricting access to the resources; only if the material is quarried to produce goods for export is access to the quarries restricted (ibid.) As an example, she cites the quarries exploited for the production of ceremonial axes in New Guinea, where access is restricted. In contrast, in the quarries which are worked to extract stone for the production of utilitarian axes, for local use only, access is open to all groups. The author concludes that if production at a quarry is chiefly for the export market, the resource will be controlled and one can expect full time specialist craftsmen, with a monopoloy in the necessary skills, working at the extraction sites. Torrence (ibid.) was not able to find any archaeological indicators that would clearly establish rights of ownership from any of the ethnographic examples she studied. Nonetheless, the identification of one of these aspects, such as the existence of specialized craftsmen, may show that there was control over access or that the quarry was exploited for export. These observations, based on the study of a number of ethnographic test cases, do help in establishing ways of measuring these aspects in archaeological terms.

Craft specialization as indicated above is another factor present when exploitation is specialized and oriented towards a specific goal. This can be identified in the archaeological record as Sheets (1980) has demonstrated. The number of knapping errors such as hinge fractures observable on flakes are an indication of the skill of the craftsmen working. The presence/absence of a specialized workshops at or near the quarry sites can also be taken an an indicator of the degree to which the raw material was modified for local consumption or for export.

In summary, boundary markers, fortifications, location of settlements, skill of craftsmen and the presence of a specialized workforce may be able to be identified archaeologically and could indicate the degree to which a quarry was controled. This in turn, could indicate for what final purpose the products were produced, whether for local use or for export.

In the following section a number of ethnographic and archaeological case studies will be examined in order to see if any additional indicators can be found in the field. Ethnographic information on quarry exploitation is extremely scarce, neither are archaeological studies of prehistoric quarries abundant, although they have increased considerably in the last few years.

ETHNOGRAPHIC EXAMPLES OF QUARRY EXPLOITATION

Gould's numerous studies (1968, 1978, 1980, Gold, Koster and Sontz 1971) on the hunter/gatherer's use and manufacture of stone tools provide the most detailed information on quarry exploitation in the Australian Central and Western Deserts. Gould observed that material was extracted either from surface quarries or mined for extraction of unweathered cherts. Behaviour at quarries, where material was extracted from surface rock outcrops, consisted of reducing cores by applying rock-to-rock percussion (to boulders, nodules or outcrops), using the natural angles as striking platforms. Wastage is high at such sites and there is little spatial patterning of the waste material (Gould 1980:124). Gould notes that, in contrast, at quarries where the raw material has to be laboriously mined out of the ground a more efficient method of core reduction is employed - direct percussion with a hammerstone and careful preparation of striking platforms. This system was extremely economical in terms of the production of waste material (ibid.:126). Small cores were carried away from quarries that were never more than 32 km distant from the habitation site (1980:124-126). Expeditions to known quarries sometimes involved deliberate detours and, at other times, special expeditions to the quarries were organized. Cores removed from the quarries were usually fairly small in size, so that they could be carried more conveniently back to the camp.

At the Western Desert quarries, Gould (1978:819) was able to distinguish between two activity areas on the basis of the size of waste flakes. At the larger quarries separate chipping stations consisting of small circular or oval shaped patches cleared from rocks with occasional hammerstones found nearby (1978:819, 1980:123). At small quarries small sized waste flakes are characteristic of percussion flaking, and appear where the block-to-block percussion technique was employed for core reduction.

It can be extracted from Gould's findings that archaeologically activity areas can be differentiated mainly due to the nature of the waste flakes. No permanent habitation sites exist close to the quarrying areas. The high percentage of waste material at the quarries is due to on site preliminary core reductions to reduce weight of the material to be taken away. Gould does not mention any limitations or restrictions of access to the quarries he studied. From his description it seems that each group visited the quarries within their own territory and no access restrictions seem to have been observed.

By contrast, McBryde's study of the Mt William Axe Quarry in Southeast Australia has shown that some restrictions were enforced (McBryde 1978, 1979, Binns and McBryde 1972, McBryde and Watchman 1976, McBryde and Harrison 1981). Axes produced at the Mt William Quarry were exclusively for exchange, and McBryde and Harrison (1981:191) argue that the quarry itself acquired characteristics of a sacred-ceremonial place. Access to Mt William was strictly limited, as reported by Howitt (1904:72, 311-312) and its resources could only be worked by specialists who possessed the necessary status and kin associations. A similar situation was reported by McBryde and Harrison for the quartzite blade quarries in Arnhem Land (McBryde and Harrison 1981).

The behaviour at the Mt William quarries was initially recorded by Howitt (1904) and Fison (1890) and is also described in McBryde and Watchman (1976:164). The quarry was owned by a group of the Wurundjeri of the Yarra Valley and the quarrying was the responsibility of one man, Billi-billari. Any request for axe stones had to go through him; nobody was allowed to work the outcrops by themselves. Requirements had to be made known to Billi-billari, and payments were also negotiated through him. He worked by himself at the quarry, although on occasion other members of the group with ownership rights were also allowed to work on it during his absence. Apart from this, there are no descriptions of the actual work at the quarry. Archaeological research carried out by McBryde (1978) at the quarry has identified separate working areas, including flaking areas, separate from the extraction sites. As most work at the quarry was carried out at one time by only one man, in the opinion of McBryde (ibid.) selection of activity areas is most likely to reflect the preference of this craftman. However, if these flaking floors were in use before his time, they might reflect spatial separation of activities of different craftsmen within the site.

Summarizing the information obtained from these two examples, it is found that access restrictions do not necessarily leave any distinct archaeological traces. In both cases where access was restricted, as at the Mt William Axe Quarry, and where there was no restriction, as in the Central and Western Desert, no habitation areas and physical remains of boundary markers have been found to be associated with the quarries. The working floors seem to provide the best areas to identify differerential working patterns. Although in both the examples, discrete working floors were found, the nature of the waste material can be of paramount importance in the identification of the patterns of exploitation.

The absence of boundary markers to mark restricted access to the site may be due to the fact that restrictions were enforced by other means or simply that they were either not noticed by the early recorders or have not survived. On the other hand, the fact remains that they might not be a necessary feature of a quarry site, even if access were restricted, since it might have been enforced by other means which leave no physical trace.

New Guinea Axe Quarries

The working of most quarries in the New Guinea Highlands is open to everybody, whether the stone is to be used locally or for exchange. Each local group seems to work for their own needs, and no specialization of tasks seems to exist. A similar situation has been recorded for the New Guinea axe quarries. Torrence (1981:232-236) in her analysis has already noted that here, also, access is restricted to quarries where axes for exchange were produced, and also that no boundary markers are to be found. Stone working quarries have been studied by Vial (1940), Chapell (1966), Strathern (1965), Hughes (1977), but few of these descriptions refer to the actual quarrying process.

Vial (1940) notes though that certain quarries can be worked by specific groups. This is the case for the Dom quarry, from where special stone for bride-axes were extracted, "only Dom Gondigu could work it" (ibid.:161) while other quarries could be visited by a number of villages (ibid.:159). The Dom quarry was worked by workmen living at the quarry in huts besides the shafts for long periods of time (5 months as observed by Vial), while their families stayed in the nearby villages and brought food daily. Vial observed the actual working at the quarries where axe blades were obtained. Stone preforms were flaked out at the quarry and then taken home for polishing. Stones at this quarry were mined from a deep shaft and stored until the end of the mining process. A number of them were flaked out simultaneously and taken back to the home camp to polish. They were later taken to the village and distributed among the Dom and neighbouring tribes (ibid.)

In the New Guinea quarries when access was restricted to a group or group of tribes or when it was open to any group, working patterns did not seem to differ in essence. In both examples, (as reported by Vial (1940) and also by Chapell (1966)), workers either mined the flows, excavating deep shafts or 'drives', using sometimes only sharpened sticks, baskets and other wooden implements, or the rock was simply broken out of the outcrop using wooden poles. In all cases the stones were worked to the required preform at the quarry and then polished somewhere else, close to a source of water and sand (Vial 1940:159).

Wise (1981) has shown that manufacturing styles can be isolated between different axe quarries in New Guinea. Differences in manufacture were shown to reflect the type of production taking place at the quarries. Manufacturing styles at quarries with restricted access, and where axes were produced for exchange, showed little variation in style. In contrast, axes coming from quarries where material was obtained by direct access by the consumers, showed a higher variability in manufacturing styles. In this case, as many styles of production as quarries exploited were observed (ibid.:230-237).

In these cases, as well as in the case of the Mt William axe quarry in Southeastern Australia, it seems to have been 'common knowledge' when access to the quarry was restricted, and no physical boundary markers were necessary or present near the quarries. As there does not seem to be any differential approach to the extraction work, or the reduction methods, identification of these cannot necessarily bring us closer to establishing restrictions of ownership of access.

Obsidian Quarrying and Usage by Ethiopian Hide Workers

As a final ethnographic example from outside New Zealand, the obsidian quarrying process of Ethiopian hide workers will be examined.

In Central Ethiopia people belonging to three separate ethnic groups - the Gurage, the Arussi-Galle and the Sidama - are at present still engaged in the preparation of hides using obsidian scrapers. One of these groups was studied by Gallagher (1977a, 1977b). The obsidian is extracted by them from a quarry a half-day's walk away from the village. Trips are made approximately once a fortnight to once every two to three months, and the quarry is not owned or controlled by a particular group. The quarry resembles an undifferentiated mass of obsidian debris which Gallagher (1977a:263) says is "heaped almost knee deep". Work at the quarry does not seem to follow a systematic pattern. The obsidian is quarried from the ground using long digging sticks with iron tips on them. Large blocks are extracted in this way. Then using a hammerstone, which is always left at the quarry site, flakes are detached to test the quality of the obsidian block. If the block is of good flaking quality, the desired number of flakes are detached and are further reduced to the required size at the quarry, because of the need to minimize carrying weight. The final manufacture of the hide scrapers is performed at the village (Gallagher 1977b:407-410). The flaking and retouching of the scrapers, as well as the resharpening of these is performed carefully over a container, either a basket or hide. The waste material is, in this way, carefully collected and later dumped in a pit or dump away from the living area (1977b:411). Obsidian flakes are occasionally traded to groups that live more distant from the quarry.

The raw material quarried in this case is used directly as a tool, and is in general not used in itself for any transactions. There does not seem to be much value attached to it outside the hide-working community, which is formed by a small group of skilled endogamous craftsmen. The skill has been protected and is only performed by men of certain ethnic groups.

Extraction activities at the Ethiopian quarries and the nature of the resulting debris left behind there do not seem to differ much from the specialized axe manufacturing quarry at Mt William, where access was restricted.

New Zealand Greenstone Exploitation

Although no systematic study of greenstone quarrying and working has yet been done in New Zealand, ethnohistoric sources provide a picture of how this rock used to be worked. Greenstone (nephrite and bowenite) is found at a number of locations on the West Coast of the South Island of New Zealand, from Milford Sound north to as far as Nelson/Marlborough (Ritchie 1976). Greenstone was used for the manufacture of ornaments and certain tools, adzes and weapons, and was traded widely over New Zealand. The first published scientific description of Maori greenstone sources by Hector (1863:460) mentions that it was obtained from boulders lying on the beach. On his visit to Anita Bay (Milford Sound) he wrote :

> I landed to examine the beach from which the Maori procured the jade or greenstone for the manufacture of their ornaments and weapons. It is from among the shingle that this stone is obtained, occurring in rounded pebbles along with fragments of hornblendic gneiss and felstone... (Hector 1863:460).

Information on the possible sources exploited by the Maori and on the greenstone trade is firstly given by von Hochstetter (1864:467). He writes,

> even now almost every year parties come from the Northern Island with money, coverings, clothing and so on to the Buller, Grey and Arahura to barter with the Maoris settled at the mouths of these rivers for partly worked and partly raw nephrite. Little is yet known concerning its occurrence *in situ*. As far as can be ascertained from the natives and others, there are three main places where nephrite is known to occur thus...it was said to be so hard and firm, that they could not break it, and because of lack of

> suitable tools, had to be content with the pieces they found in the river and on the beach.

There is a large number of ethnohistorical references indicating the knowledge of the Maori population concerning the greenstone sources. References to the working of greenstone are provided by Heaphy (1959:241) on a trip to the West Coast where he observed a group of people at a pa on the mouth of the Teremakau River engaged in the working of the stone.

> The inmates of each house were busily engaged making mere pounamu and ear pendants of that material for trade and presents to the northward. They saw the slab with a piece of mica slate, wet and afterwards polish it with a fine sandy limestone which they obtain in the vicinity. The hole is drilled with a stick, pointed with a piece of Pahutani flint. The natives here are principally of the Ngaitau or southern tribe, and located themselves at the Araura after being dispersed into the interior. On reaching the west coast they located themselves at this place, where they imagined they would be safe from molestation and could work the greenstone, which is brought down the Araura river and in its bed after floods.

Other references to settlements engaged in the exploitation of greenstone are given by Beattie (1920:45). He describes the place names of some Maori settlements used as a base to extract greenstone.

From the ethnohistoric records it can be concluded that the nephrite and bowenite sources were exploited by a number of groups. Since they were not obtained from specific quarries, but, rather, picked up at certain spots along rivers and beaches, it can be concluded that there was no apparent restriction on who could exploit these sources. Groups from the North Island made occasional trips to acquire it by themselves or to trade for it. Captain Cook (1967:72-73) specifically mentions meeting greenstone traders on their way south. The presence of a specialized village or settlement on the West Coast where everybody was engaged in greenstone manufacturing seems to be more of an exception. Most of the exploitation seems to have been carried out mainly by groups using base camps from where special periodic expeditions to the source areas were made. Archaeologically, greenstone exploitation would not leave many remains. No quarries are to be found, since the material is picked up from beaches and rivers, and the later manufacturing carried out somewhere else. Although the material was mainly exploited for trade, no restrictions such as the ones observed in New Guinea are apparent.

When comparing the above case studies it is not possible to find substantial differences between quarries to which access was restricted and those to which access was open to everybody. Torrence (1981) has suggested that restrictions of access are enforced when the material exploited is to be used for trade. The exploitation of greenstone in New Zealand does not agree with this observation, although the absence of restrictions in New Zealand may be due to the nature of the sources of raw material. In summary, it is found that quarries with restricted access (Mt William and certain axe quarrries in New Guinea) do not show evidence of:

1)protection of the skill

2)boundary markers

3)permanent settlements

4)fortifications or defensive structures

5)secrecy of the quarry location

Discrete working areas are found at the Mt William axe quarry. Quarries with no access restrictions share the following factors with restricted access quarries :

1)absence of boundary markers

2)absence of fortifications

3)quarry location is not secret

In some cases discrete working areas are found, such as at the central and western desert quarries in Australia. Permanent settlements are not present, with the exception of the New Zealand example, where it is not known how common such a practice was. Only one group chose to protect the skill (Ethiopian hide workers), mainly due to the fact that the resource in itself was used to manufacture a more valuable product.

Before examining the situation of the Mayor Island quarries, a number of archaeological case studies will be described. In these studies there has been mostly a concentration on the technological aspects of stone working rather then on establishing the social and economic contexts of lithic exploitation. Nevertheless, within these examples it might be possible to find some evidence which can be used to support socio-economic interpretations. The examples chosen are a rhyolite quarry in New England, and one obsidian quarry on Easter Island as well as a number of non-obsidian quarries from the Pacific area - the Mauna Kea adze quarry in Hawaii, and two quarries from New Zealand.

ARCHAEOLOGICAL CASE STUDIES

Prehistoric Rhyolite quarrying at Mount Jasper, New Hampshire

Archaeological research at the Mt Jasper rhyolite source in northern New England was undertaken by Gramly (1984, Gramly and Cox 1976). Research at this source area showed that it had been exploited over a period of more than 7000 years and all extraction work was carried out directly by the consumers. The best quality rhyolite appears on outcrops on the mountain, on top of high, steep cliffs and also as lower grade material on the lower slopes of the mountain.

Two prehistoric working and extracting areas were identified. The older of these is located on the top of the mountain, where a rather poor quality dike was exploited, leaving large amounts of waste products behind (Gramly 1984:12). Working was apparently later extended to an area further down the slope where better quality material was obtained. A 10 metre deep mine shaft was located here, from which approximately 63 cubic metres of raw material had been extracted (ibid.). More recent workshops, dating to the Late Ceramic Period (approximately 1500 B.P.) were located at the base of the mountain. These had been used by parties travelling up the valley by the river (ibid.:13).

Excavations at the Hill Workshop on the top of the mountain, showed no pattern of artefact distribution or clustering. Three distinct classes of stone tools were found both at this workshop and at the later workshop at the bottom of the hill. Tool classes recognized include debitage and preforms (class I), hammerstones, adzes and large scrapers (class II), and lastly class III artefacts featured a wide range of tools some heavily used, which had all been employed in tasks unrelated to the manufacture of stone tools. Most of these were made of foreign materials. (Gramly 1984:16). The analysis of the Hill workshop showed that the deposition of artefacts was the result of a repeated number of small operations that could not be isolated from each other. The evidence suggests to Gramly (ibid.) that during the Archaic period the source had been visited by small groups in order to replenish their toolkits (ibid.:20).

Excavations carried out at the Dead River workshop belonging to the Late Ceramic Period showed, in contrast to the early workshop discrete concentrations of debitage. Different classes of artefacts were also found in the working areas. Three separate working areas were distinguished. At the first area (Alpha 1) a strong clustering of class II artefacts was found with a high concentration of debitage. The author believes that this area might have been the result of a party of miners employed in the processing of stones and mining implements (ibid.:19). A similar situation was observed at Alpha 2. In the third area (Beta), class I artefacts were smaller and large concentration of class III artefacts were found. A larger amount of bifacial tools was also produced at this spot. The different tools manufactured at this last cluster was thought to be the result of a group of people arriving at the site and replenishing a large quantity of their toolkit (ibid.).

The availability of boat transport by this late ceramic group meant, in the author's opinion (ibid.:20), that

> with their canoes, Ceramic Period hunters were not tied down to a few lithic resources. They could range widely amd remain away from quarries for longer periods. On the other hand, by staying on the hunt for extended periods, more stone had to be extracted for toolmaking when they camped at a lithic workshop. Their entire toolkit and not just a few elements of it, needed replacing.

The archaeological research carried out at the Mt Jasper quarry has shown that a number of factors can influence prehistoric quarry exploitation. One important factor in this case was the transport available to the miners. With the use of canoes the miners were able to extract more material during one single visit, and therefore return less often to the quarries. Supply of stones was by direct access, the consumers working the outcrops themselves and producing the finished tools at the site. This is reflected in the lack of differentiation of activities within a working area. Archaeologically, this is reflected in the lithic debitage left at the quarry site and the associated workshops. The presence of a wide range of artefacts, but especially of class III tools (artefacts manufactured of exotic materials) was of use for establishing the pattern of exploitation of the prehistoric quarry site. In addition, an estimate of the total quarried material was made over the timespan of exploitation of the quarry. This amounted to only 39 kg of stone per year (Gramly 1984:12) over a life span of approximately 7000 years. Such a low rate of extraction can only be expected if the quarry was exploited merely once or twice a year by small parties. The estimation of the volume of stone extracted by mining and quarrying over the time span of its occupation may yield an impression of the magnitude of the extraction industry and the magnitude of material extracted at any one time. In this light the role of the quarry in an exchange network, if any, might be assessed.

Mauna Kea Adze Quarry, Hawaii

This impressive quarry situated on the slopes of Mauna Kea volcano on the Island of Hawaii, was studied by McCoy (1977, McCoy and Gould 1977) and Cleghorn (1982). The quarried area extends from about 2800 metres to 4300 metres above sea level (McCoy 1977:223). It consists of a number of areas where extracting activities and flaking-reduction activities were carried out. Chipping stations are sometimes clustered together in large areas, while others are small and isolated. During the course of the site survey, workshops, overhangs, rockshelters , open air shelters and ceremonial shrines were recognized as distinctive features at the quarry. Examination of the site remains led to the conclusion that the Mauna Kea adze quarry was a specialized adze manufacturing site. Specific tasks were carried out at different parts of the main quarry. Some areas contained mainly large core blanks, while others such as the rockshelters, had small adze preforms and small finishing flakes (ibid.:241). At the same time a number of smaller working floors were found dispersed over a fairly large area where a concentration of waste flakes and used cores indicate isolated activity areas (ibid.:239). Although identification of the specialized task areas was made, the observed pattern of areal clustering of certain types of materials at extraction sites and rockshelters was believed to be due to the need of working in a more sheltered location of the exposed quarrying areas (McCoy and Gould 1977:238). McCoy does not believe that specialized skilled craftsmen were at work at the quarry, each performing a separate task (1977:241).

Cleghorn's (1982) analysis on the Mauna Kea adze manufacturing technology showed, in contrast, that adze production was the result of the presence of skilled craftsmen working usually in groups of two (ibid.:344). The technological analysis of mainly two types of adzes (rectangular and trapezoidal) showed that the craftsmen often used poor quality materials, because the raw material appeared in its natural stage in a tabular form that facilitated the production of these adzes. The author believes that they were mainly produced for trade or exchange. Adze production was highly standardized, following a set sequence in the reduction work. Standardization was also extended to size and forms of the adze preforms. (ibid.:343).

Small stone structures have been interpreted as religious shrines. These are mainly located on top of rock outcrops overlooking the more important working areas.

The extraction work at the quarry was performed using wedges and wooden levers to extract the basalt slabs from the ground. Large slabs were broken up, taking advantage of the natural cracks in the rock produced by thermal action. Preliminary flaking of adze preforms was done using different sized hammerstones (McCoy and Gould 1977:238).

In addition to the basalt for adze manufacture, a low quality glassy lava was quarried, which was probably employed for a number of domestic tasks. The source of this glassy basalt is close to the main waste flake concentration area of the whole quarry. This glassy rock was extracted and flaked on the spot (ibid.:241). The archaeological evidence does not supply many clues on possible access restrictions to the site. Complete reduction of preforms was carried out at the site, while no evidence exists that the final polishing was done there. The location of this quarry is on the very inhospitable slopes of a high mountain, and there is no ethnographic information on the use of the quarry. Although the adze manufacturing was carried out by highly skilled craftsmen, there is no evidence that they worked permanently at the quarry. The only possible evidence present to supply clues on acccess restrictions might be obtained from the presence of craftsmen at the site. The presence of full time specialists is postulated by Cleghorn (ibid.) on the basis of a measure of flaking skill established as the ratio between flake length to striking platform thickness. If this factor does indeed measure the skill of the workmen at the site, as postulated by Cleghorn, some sort of access restrictions to other groups can be postulated. It is probable that sizeable expeditions to obtain the raw material were planned in advance. The finished adzes were traded to other islands of the Hawaiian archipelago.

The Maunga Orito Obsidian Quarry on Easter Island

The Orito obsidian quarry on Easter Island is located on the slopes of a low volcanic cone on the southwestern side of the Island. The quarry was examined by Stevenson *et al.* (1984). Preliminary research on the quarry established that the material was mined out of shallow pits from the hillside. The obsidian in its natural state appears in blocks and slabs the largest of which are only about 30 cm in length and about 10 cm thick.

Two distinct types of artefacts were manufactured. The first class of tools made was the *mataa*, a stemmed obsidian flake used as a spearhead. These were manufactured from large unifacially worked block cores (Stevenson *et al.* 1984:121). A large number of these finished tools was recovered at the quarry from surface and excavation contexts. The authors argue that these were produced and finished at the site, and they propose that it would be preferable to produce this type of tool at the quarry site, since it reduced transport weight. One or two *mataa* could be produced out of a single block (ibid.:122).

The other class of tools made of obsidian are slightly modified flakes with one useable edge. A large number of flakes have been utilized without any edge modification. These flakes were struck from block cores and slab cores which were prepared at the quarry site. Core preparation consisted of the removal of primary and secondary flakes to remove all traces of natural cortex and weathering from the rock (ibid.:121). Again, no structural indications are present that indicate restricted access to the quarries. It is notable that no habitation or food preparation sites were found in the immediate vicinity of the quarry, which could directly be associated with it.

The examination of the values of consumption of obsidian in a residential context showed a pattern of increasing consumption between about 1700 and 1800 A.D.. Since this period coincides with a politically and socially unstable time, the authors hypothesize that the trend might be due to a change in access to the source produced by the unstable socio-political scene. This

> may have resulted in the inability of a specific group to control access to resources, such as obsidian, within its own territory. Thus greater access to the obsidian quarries may have promoted its use now that costs associated with acquiring the material had been reduced (ibid.:124).

This final statement by the authors is extremely important for the possible similarities we might encounter with the Mayor Island quarries. The analysis of lithic production, types of flakes, their size and abundance, both at the quarry and at domestic sites seems to show a way of isolating events that affect quarry exploitation. The archaeological correlation we might obtain from this case study comprise

1) large number of prepared cores at the quarry,

2) large proportion of decortication flakes at the quarry,

3) low frequency of cortex flakes at habitation sites,

4) high frequency of small 'tertiary flakes' and,

5) presence of exhausted cores at the domestic sites.

This topic is discussed again later in Chapter VI.

Prehistoric Quarry Exploitation in New Zealand

A number of lithic quarries in New Zealand have been described and studied. A wide range of stone resources were exploited by the prehistoric inhabitants of New Zealand for the manufacture of a variety of artefacts including ornaments, adzes and other tools. Adze manufacturers exploited a number of different types of rocks, including basalt which is found for example at Tahanga on the Coromandel Peninsula on the North Island and near Brighton Island on the South Island. In addition, metasomatised argillite sources were often exploited for adze manufacture. The most important quarries are located along the Nelson Mineral Belt and at Bluff harbour and Riverton . In addition, Central Otago orthoquartzite (silcrete) blade quarries have been exploited (Leach 1984). Two examples of quarry exploitation in New Zealand will be described below.

Oturehua Silcrete-Blade Quarry

This prehistoric silcrete blade quarry located in the Ida Valley in Central Otago was studied by Leach (1984). Associated workshops were also found nearby. The raw material appears in well weathered boulders which litter the surface of the hillside. To obtain better quality stone the raw material was extracted from pits up to 8.5 by 2.5 metres in size, but mainly only three by two metres in size. Most were about 20 to 25 cm deep beneath the surface. Spatial analysis of the workshop areas was carried out in order to study the spread of material during work and also the movements of the knappers on the working floor.

The extracted blocks were split in situ to determine the quality. The selected blocks were then transported to the workshops, which were located just below the main quarry area (Leach 1984:108-110). Decortication, platform preparation and the production of the blades was carried out at the workshops. These were then taken away to be used later on. Discarded cores and waste flakes were left behind. Blades were struck by direct percussion using a hammerstone. Only three were found at the site, suggesting they were carried away by the workers after the task was completed (ibid.:111).

The blade production techniques observed at Oturehua show quite considerable variations. Leach (ibid.) describes the production approach as 'opportunistic'. Most cores show that blades were struck from one prepared platform but some cores show that blades were extracted from up to seven different faces of the core. Previous blade scars were sometimes used as fresh platforms.

The Oturehua quarry is seen as a specialized site used almost exclusively for extracting and manufacturing purposes, and was only occupied in the author's opinion for a few days at a time (ibid.:117). The later distribution of the blades in almost all coastal habitation sites and also the blade manufacturing technology adapted from the adze making technology favour, in Leach's (ibid.) opinion, the hypothesis that these quarries were not worked by full time knappers or were exploited exclusively by a single group of people. The presence of habitation sites close to the quarry can be taken as possible evidence for the more permanent exploitation of the quarries. The variations in core reduction and preparation can be taken as an indication that a number of workers, each with a slightly different approach worked at the site.

There is no evidence whether access was restricted to particular groups of people or not.

Argillite Adze Quarries

A large number of argillite adze quarries in the Nelson-D'Urville Island area have been reported by Skinner (1914), Duff (1946), Jones (1972) and, Walls (1974). Forty quarry sites have been recorded, while a further argillite adze quarry has been reported and studied by Leach and Leach (1980, H. Leach 1984) at Riverton, Foveaux Strait. The argillite exploited ranges from black to black-veined pale grey in colour.

Argillite in the Nelson Mineral Belt appears in a strip of land about two miles wide, reaching from D'Urville Island in the north to the Matakitaki Valley in the south (Walls 1974:38). The outcrops take the form of clusters of large boulders. Occassionally pits were excavated to obtain less weathered material. A preliminary analysis of a number of quarries in this area showed that the boulders were broken up using large hammerstones of altered granodiorite carried in from the Nelson Boulder Bank, or alternatively using indurated sandstone hammerstones (ibid.:38). Not all quarries were worked to the same degree. Walls (ibid.:35) recognizes five separate groups of quarries:

1)Highly utilized quarries with a high proportion of flaking activities and stone resources,

2) quarries with moderate resources but well exploited,

3) quarries with limited resources intensively exploited,

4) insignificant quarries with resources not fully exploited and

5) worked boulders from a river or small hillside source. Adze manufacturing, including decortication and initial flaking to produce the desired preforms was carried out mainly close to the quarry site. According to Walls (ibid.:39) the adzes were manufactured for trading, and an important feature of these quarries is the absence of any occupation sites.

The Riverton adze quarry examined by Groube (1964) and by Leach and Leach (1980, H. Leach 1984) shows some close similarities to the Nelson quarries. This site was an archaic adze manufacturing quarry and workshop, where a variety of adzes was manufactured including side hafted, triangular and reverse triangular, large quadrangular sectioned and many small trapezoidal and lenticular sectioned adzes (Leach and Leach 1980). The adze manufacturers used a more or less standarized procedure involving several steps which "to some extent was 'formalized', set by custom and thus transmitted by generations" (H. Leach

1984:117). Quarrying, involving mainly the breaking up of large naturally fractured boulders obtained from the intertidal zone of the headland, beach cobbles and from areas higher up behind the beach (H. Leach 1984:113), was followed by transportation to the working area. Two ways of reducing cores were employed. If large quadrilateral and trilateral adzes were to be manufactured cores were reduced to the required size and shape. Many preforms were the result of the final stages of reduction of the main cores, but more often preforms were recognizable large flakes struck from the parent core (ibid.:114). Following core decortication and ridge preparation, triangular blades were removed from the corners. At a later stage the edge overhang was reduced (Leach and Leach 1980:117-137, Leach 1984:114-117).

Associated features found during the excavation of the site included some midden material, faunal remains and ovens, all indicative of subsistence activities carried out during the course of the work at the quarry (Leach and Leach 1980:107-110, 139).

The Riverton site and also the quarries at Nelson were occupied primarily for the manufacture of adzes from the local argillites and knappers showed a high degree of skill in their work, employing a range of techniques (ibid.:139). It appears that the final working stages - hammering and polishing - were not carried out at the sites. There is no information or apparent evidence that the quarries were worked by a group of permanently 'employed' craftsmen. On the contrary, it seems likely that the quarries were visited by groups of men skilled in stone working whenever they required adze material.

Summarizing the archaeological case studies we find that the identification of working areas is crucial for the isolation of craft specialization which in turn might lead to the identification of ownership and patterns of exploitation of a quarry. The analysis of lithic debitage from a quarry and associated workshops seems to provide the best way of identifying this. The presence/absence of specialized tools, discrete working areas and other associated archaeological materials, such as midden refuse, are useful for the identification of prehistoric patterns of quarry exploitation. Lastly, the attempt by Gramly (1984) to establish the amount of material extracted from a quarry, shows a way of measuring the magnitude of the quarrying effort performed.

The foregoing examples of quarrying in New Zealand all show that, although a high degree of skill was employed by the knappers, no permanent groups seem to have been employed in the manufacture of adzes or other lithic materials. It is more likely that the stone working techniques were taught and acquired by a restricted number of individuals in each group, who when required made special trips to the quarries to make the desired tools. None of the case studies examined shows any evidence of restricted access, but as seen above this is very difficult to identify.

The identification of restricted access and specialization of the workforce in the archaeological record can possibly be done best with a detailed analysis of the flaked stone industry. This data is most easily acquired from the workshops, therefore the identification of this particular type of specialized camps is of great importance.

As seen from the above examples the measurement of control over access to resources using archaeological data is not easy to obtain. In light of the evidence of the preceding case studies the obsidian quarries of Mayor Island will be examined in the next section of this chapter. The research reported below is devoted to the description of the quarries and other sites recorded on Mayor Island during the fieldwork period, and which could be associated in any way to the exploitation of the obsidian resources.

TUHUA OR MAYOR ISLAND

Mayor Island, is a volcanic island situated 28 km east-northeast of the Tauranga Harbour in the Bay of Plenty. The first general studies were carried out by the surveyor, Gold-Smith, who visited the island in 1884 while people were still living there. He noted the volcanic nature of the island, but erroneously called the rocks basalt, and also studied its flora and fauna. He made the first records on the historic background of Mayor Island, describing a number of sites, pa and living areas, some of which could easily be identified when visiting the island in 1982. A detailed study of its flora and fauna was later carried out by Sladden (1926), Atkinson and Percy (1956) and lastly by Bayly *et al.* (1956).

MAYOR ISLAND PHYSIOGRAPHY AND GEOLOGY

Mayor Island is the upper part of a volcanic cone, more or less circular in plan at sea level, with an average diameter of 5 km. The geology of the island has been studied by several people: Von Wolfe (1904) recognized the peralkaline composition of the lava rocks; later studies by Thomson (1926), Bartum (1926), Marshall (1932, 1935, 1936a, 1936b, 1937) expanded on the geologic knowledge of Mayor Island, with analyses of rock forms and structure, and chemical analysis. Cotton (1941,1944) described Mayor Island landforms, with particular reference to its volcanic history. Later studies describing the volcanic history, petrography of the lavas and detailed chemical analyses of the lava rocks and their mineral constituents have been performed by Brothers (1957), Ewart (1965), Ewart *et al.* (1968), Nicholls and Carmichael (1969), Baily and MacDonald (1976), Rutherford (1976) and, finally Buck (1978, Buck *et al.* 1981).

Mayor Island comprises a main cone which forms the main slopes of the island. The highest points of the island are found here and are known as Opuahau (354 m) and Tuataretare (320m). Steep cliffs characterize the seaward side of the main cone, while on the inland side vertical cliffs form the roughly circular caldera walls. The outward side of this cone has been deeply eroded, especially on the northern coast, by radiating water courses forming features like Ruawaipiro Pass (Buck 1978:9). The interior of the caldera has an approximate diameter of 4.5 km and the walls surrounding it reach at its maximum point a height of 200 metres and only 20 metres at the lowest elevation at Te Rangiora Bay.

The main cone is traversed on its western side by a fault line running northwest to southwest, which is marked by a scarp crossing the caldera. Within the caldera, another three, or possibly five, fault lines cross its floor in a north to northeast line. The most impressive and largest feature within the caldera is a central dome, known as the 'Young Dome', 251 metres in height. The dome is a built up of a series of viscous lava flows and its slope, though moderate, is covered with huge lava blocks and crevasses. To the east, two deep hollows have formed two lakes, which are joined by a narrow swampy area. Both lakes are about three metres above sea level (Buck 1978).

On the northern side of the island, lies a narrow fan-shaped area, known as Te Ananui Flat, between the two northern extents of the caldera wall. On the northern side steep cliffs fall 10 to 20 metres down to the sea.

Another fault area, known as Panui Flat, lies on the Otutuaroa Peninsula on the Southwest side of the island. This narrow neck of flat land connects a small parasitic cone, Te Panui, to the flanks of the main volcanic cone. High cliffs also surround this small peninsula on the seaward side.

No streams are present on Mayor Island; except for a few small natural springs no other fresh water sources are found outside the two lakes inside the caldera.

The extremely dense vegetation on Mayor Island, is composed largely of *Leptospermum scoparium* and *Leptospermium ericoides*, *Metrosideros tormentosa*, *Entelea arborescens* and *Aristotelia serrata* (Allan and Dalrymple 1926) which mask the rock cover of the island. Nevertheless, Buck (1978, Buck *et al.* 1981) has been able to identify a succession of separate peralkaline ryholite lava flows and interbedded pyroclastic deposits which built up the main cone of the island. The pyroclastic deposits originated, according to Buck (ibid.), both from flow pyroclastic eruptions and pyroclastic airflows. They occur as thick deposits on the slopes of the main cone or as thinner sequences interbedded between the peralkaline lavas of the cone.

Six main types of pyroclastic fragments are identified by Buck: crystalline and glassy pantellerites, obsidian (totally glassy pantellerite with conchoidal fracture), glass shards, pumice, accretionary lapilli and free crystals.

1) Pantellerite fragments : These exhibit a large range of texture, colour and structural variation. Being mainly black, grey, green, red pink, or white, they vary from vesicular to amigdaloid holocrystalline to hypocrystalline (Buck *et al.* 1981:455).

2) Obsidian : Many deposits of obsidian are found. The obsidian ranges from green, black-green, grey-brown to grey. A few obsidian fragments contain vesicles, but mainly contain abundant crystallites and some microlites. Occasionally it is also microphenocrystic with anorthoclase, aegirine and aenigmatite microphenocrysts (Buck 1978:124, Buck *et al.* 1981:455). The obsidian on Mayor Island is most probably derived from the outer margins of the magma chamber (ibid.)

3) Glass Shards: Glass shards occurring on Mayor Island assume three different types. 1. curved fragments composed of glass which originally enclosed globular bubbles, 2. Flat glass plates - platy fragments- formed by fragmentation of the walls which enclose flattened lens shaped vesicles , and 3. Pumiceous fragments which are glass containing fine pumice fragments (Buck 1978:126).

4)Pumice : it occurs in angular to subround fragments varying in colour from grey to white.

5) Accretitionary lapilli have probably formed by the agglutination of ash in a moist ash cloud and are generally spherical (Buck *et al.* 1981:456).

VOLCANIC HISTORY

Mayor Island has a complex volcanic history. Buck (1978) recognizes 10 separate events which are responsible for the present features of the island. This differs substantially from what Brothers (1957) found in his study. The main sequence involves the following events: A main eruption 42000 years or more ago, which formed the main cone with thick lava flows. Subsequently a period of quiescence occurred during which the cone was extensively eroded. 42000 to 8000 years ago renewed lava flows covered parts of the eroded main cone. At least three separate events are recognized during this period. Firstly, airfall tephras and lava and pyroclastic flows, followed by ignimbrite base surges and glowing pumice avalanches, and finally renewed airfall tephras, pumice flows and escape from vents formed on a developing ring fracture. These periods are all separated by intermittent periods of quiescence and soil formation. Between 8000 and 1000 years ago voluminous plinian type eruptions took place. This caused the collapse of the caldera around 6340 years ago. The last of these events erupted through a caldera lake, which had formed after the collapse of the caldera. This series of eruptions expelled, in Buck's (1978, Buck *et al.* 1981) opinion, large quantities of water from the lake over the crater rim, flooding down radial gullies of the main cone. As a result, thick alluvial deposits were formed on the western and eastern coastline. Lowering of the caldera lake level followed. A number of phreatic and phreatomagmatic eruptions formed the youngest sequence of pyroclastic deposits recognized on Mayor Island, which consist of a series of thin base surge deposits.

The final phase of the volcanic history of Mayor Island was the eruption less than 1000 years ago of the rhyolite dome, known as the 'Young Dome', from a central vent in the caldera floor. Soil formation on the dome is very poor (McCraw and Whitton 1971). The formation of the dome probably emptied the remaining craterlake. Nevertheless its surface drainage has formed two lakes in the hollows between the lavas of the dome and caldera wall. At present Mayor Island is going through a period of quiescence and according to Buck (1978, Buck *et al.* 1983) this volcano may be regarded only as dormant with active volcanic eruptions still likely to happen.

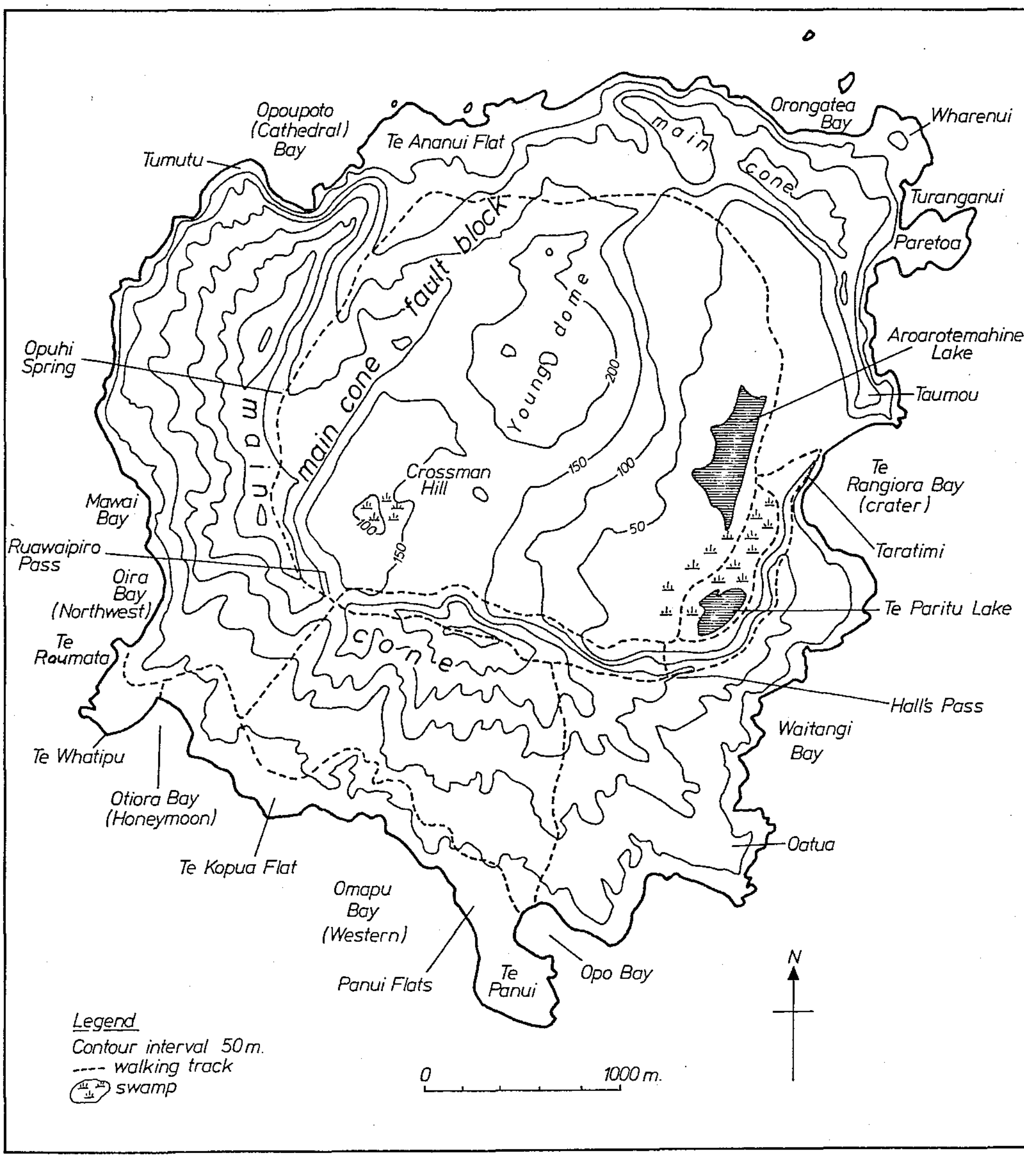


Figure 4.1. : Physical Map of Mayor Island

TRADITIONAL HISTORY OF MAYOR ISLAND

Mayor Island has been the territory of the Whanau a Tauwhao, a hapu of Ngaiterangi of the Mataatua waka. Whanau a Tauwhao people claim not only land on Mayor Island, but also on Motiti Island, Rangiwaea and Otawhiwhi (modern Bowentown) in the Tauranga District, and some areas of the Aldermen Islands. The traditional history of Mayor Island, or Tuhua, is therefore closely interlinked with that of the mainland areas in the Tauranga district. A detailed study of the history of Whanau a Tauwhao, not only of Tuhua, but from Motiti and the mainland areas has been compiled by Stokes (1980) and Matheson (1971). Much of the information presented here is based on Stokes (1980).

Whanau a Tauwhao trace their history back to the Ngaiterangi who landed at Whakatane. After a struggle with the local Arawa people, Ngaiterangi people settled at Maketu. Ngaiterangi people at a later date conquered Maunganui in the Tauranga district, and later consolidated this conquest by intermarriage with Ngati Ranginui people of Tauranga.

Whanau a Tauwhao also trace their ancestry to the Tangata Whenua before the arrival of the canoes Mataatua, Te Arawa and Tainui.

Wilson (1906:30-31) comments on the conquest of the pa at Maunganui and the relationship between Whanau a Tauwhao and Ngaiterangi,

> Thus about one hundred and fifty years ago [c. A.D. 1700] Ngaiterangi obtained possession of Tauranga, and drove the remnant of its former people, Ngatipekekiore away into the hills, to the sources of the Wairoa and Te Puna rivers; where although now related to the conquerors they still live. Another hapu of Tauranga's ancient people are Te Whanau a Ngai Tauwhao, also called Whitikiore. They hold Tuhua - Mayor Island - and in 1835 numbered about 170 people. Their chief was Tangiteruru but now Tupaia (Hori Tupaea), chief of Ngaiterangi proper, is also chief of both these tribes.

At a Land Court hearing in 1867 Hori Tupaea established his claim to Motiti, in order to refute the Arawa claim based on residence at Matarehua by Ngatoroirangi, tohunga of Te Arawa (Stokes 1980:5). Hori Tuapea stated:

> I belong to the Whanau a Tauwhao. I belong also to Ngatiraukawa and also Ngaiterangi. The Ngaiterangi are on shore and the Whanau a Tauwhao are on two islands, Motiti and Tuhua, 12 generations we have been here. My ancestors are buried at Motiti. I have also children born and died on Motiti. Te Ipu and Te Ninihi are living, they are my nephews. I have two children of my own born there, Akuhata and Hamiora. Tauwhao is the claimant to Motiti but the Ngatiawa are mixed... I trace my claim from Hikutu (son of Tauwhao and Tamaoho) then Tahakura, then Kiriwhero, then Hinetehoro (mother) and then myself. (quoted by

Matheson 1971:85).

At the same hearing a similar claim was expressed by Te Patu:

> The Ngaiterangi live on land and the Tauwhao live on two islands, Motiti and Tuhua. Ngaiterangi have nothing at all to do with Motiti. All the tribes know this. (Matheson 1971:85).

As Stokes (1980:5) explains, Hori Tupaea does not actually refute his relationship with Ngaiterangi, as he was a paramount chief of Ngaiterangi. It was important at that hearing to establish his prior claims to Motiti Island. At present Whanau a Tauwhao regard themselves as a mixture of Tangata Whenua tribes, Ngaiterangi and Ngati Awa.

A number of traditions relate the story of the origin of the obsidian or tuhua. Most of these relate a struggle between the tuhua (obsidian) and pounamu (greenstone) and tell how it came that the greenstone is only found in the South Island. Different versions are given by Hovell (1967), Best (1912), Colenso (quoted in Best 1912), White (1897-90) and Grey (1956). Colenso's version gives also some background to the volcanic history of Mayor Island:

> This island appears to be of volcanic origin and abounds in pumice, obsidian, slag lava, pitchstone and other vitreous and volcanic substances. I use the word 'appears' in consequence

> of a curious relation which some years ago I received from an old priest residing at Tauranga, in the Bay of Plenty. I had been inquiring of him the place where and the manner how, they in former days obtained the green jade or axe stone for ornaments and weapons of war. In answer to my inquiry he asserted that this stone was both a fish and a god (atua, demon or supernatural thing); that it formerly lived at the Island of Tuhua, whither the skilled men of all the neighbouring tribes went to obtain it, which was done by diving, accompanied with several superstitious ceremonies in order to appease its wrath, and to enable them to seize it without injury to themselves; but that suddenly it made the whole island and surrounding sea its cloaca maxima, covering every place thickly with excrementitious substances, which still remain, and swam away to the Middle Island (South Island) of New Zealand, where it has ever since resided, and whence they have been obliged to obtain it (Colenso 1845, quoted in Best 1912:203).

Some of the local traditions refer also to old inhabitants of Tuhua. Stokes (1980) collected a number of different versions of these traditions. They tell of a group of people Tangata Whenua, called Te Ananui, that lived on the island. When people from Hawaiki invaded the island they moved to the northern flats on the coast - Te Ananui Flats - where they continued to live and grow their kumara. Years later a group decided to return to Hawaiki, and a group left under Akakura, leaving the chief Te Whitikiore behind (Stokes 1980:12).

THE HISTORIC PERIOD

In 1864 Mayor Island was included in the Tauranga confiscation act, but was later returned to the ownership of Whanau a Tauwhao. In 1888 a Crown Grant was issued, under which the island was divided under 95 share owners. Subsequently the Crown purchased some of the shares (AJHR G10 1886:3 and Apendix 1). At the time that Wilson visited the island in 1835 only 170 people resided there permanently. In 1862 an epidemic killed about 60 people and by 1864 only 23 adult males were living on the island (AJHR E2, 1864). Tribal battles between Whanau a Tauwhao and the Arawa and the Ngapuhi from the North in 1820 and later in 1830 were also partly responsible for the population decline. A number of the former residents left the island to live on the mainland. Most settled around Katikati. In 1884 Gold-Smith visited the island. He reports that only nine people, three men, four women, and two girls were living on the pa at Te Panui (Gold-Smith 1884).

Since 1913 Tuhua has been a sanctuary declared under the Animals Protection Act 1908 (New Zealand Gazette 1913:1883). A further declaration in the Gazette in 1919 (New Zealand Gazette 1919:1252) set Mayor Island apart as a sanctuary and reserve for the preservation of imported and native game. Under the Wildlife Act of 1953 the island became a Wildlife

Refuge.

In the early 1940s the island was vested in a Trust Board re~~s~~presenting the Maori landowners and the Crown. In 1949 the Maori Land Court appointed a group of 11 trustees (8 Maori representatives and 3 Crown, representing the Departments of Maori Affairs and Lands and Survey). These trustees have the authority to administer the reserve as if it were a National Park.

THE MAYOR ISLAND OBSIDIAN DEPOSITS

At a number of localities on Mayor Island, obsidian suitable for artefact manufacture is available. The quality of the different flows is quite distinct. At several points high quality flaking obsidian with a minimum of microlites and phenocrystaline inclusions is found. Each obsidian variety , distinguished on the basis of its colour has, traditionally, a separate maori name. *Mata* is the common name for obsidian. It is also known as *tuhua*, hence the maori name for Mayor Island. Traditionally four types of obsidian are thus distinguished. *Tuhua* is the black variety, *Waiapu* a light honey coloured obsidian, *Paretoa* a greenish-black obsidian, and *Kahurangi* reddish-brown obsidian (Best 1912:197).

Sladden (1926) and Thomson (1926) were the first to properly survey Mayor Island. They noted "the black glassy substance known as obsidian, with which the island abounds, and which is a product of its one time volcanic activity ..." (Sladden 1926:195). Sladden noted obsidian flows

> on the northwestern side of the island, where the cliffs rise up sheer to a height of over 300 ft. or more ... here are to be seen at intervals one above the other, several strata of a red crumbly substance resembling burnt earth "(ibid.:196).

Sladden also noted at the northern headland of Omapu Bay the impressive archway "composed partly of obsidian, its flat top being crowned with a straggling growth of pohutukawa" (ibid.:197).

Thomson, who visited the island during the same year, mentioned in a separate report the sources from which high quality flaking obsidian could have been extracted in former days. At Orongatea Bay he noted that "sea-cliffs appear to be entirely composed of the tuffs of more than one series, but the stacks known as the Pinnacles are composed of dykes with vertical obsidian selvages" (Thomson 1926:211). He also observed the large variability in the colour of the obsidians, "although black obsidian is the commonest, a great variety of colours can be collected, grading down to pale salmon-pink and glasses resembling beeswax in colour and lustre" (ibid.:212). He also mentioned that the obsidian selvages at Orongatea Bay for the most part contained fairly numerous phenocrysts of quartz and feldspar. Other deposits described by Thomson are the ones at Opo Bay on the north side of the bay and also those on the east side of the island from Opo Bay to Te Rangiora Head, where the obsidian flows are 20 to 30 feet in thickness (ibid.:212-213).

Marshall (1937) notes that all around the island, except at Taratimi Bay, two separate obsidian selvages are to be found, the formations have an upper and lower selvage of obsidian. Lastly Brothers' (1957) main interest when surveying the island was to establish its volcanic history. He nonetheless noted a number of the distinct flows of the main volcanic cone, observing that "individual flows have no great vertical thickness and rarely exceed 100 feet, but laterally they sometimes extend for many hundreds of yards" (ibid.:338). Obsidian selvages on both upper and lower surfaces are a consistent feature of the flows. The upper surface invariably is extensively ruptured and penetrated by less glassy lava which has welled up from within the flows so that the top selvage rarely forms a continuous sheet. On the other hand, the lower selvage is usually of uniform thickness and is laterally continuous. Lower selvages vary from several feet to 9 feet in thickness. Upper selvages are generally thicker, even were unbroken, or where flow brecciation of the upper selvage has caused mixing of obsidian blocks with stoney lava. This top zone may be up to 20 feet thick.

Brothers recognized a number of thin obsidian selvages along the northern and western side of the island following a ring shaped fault line. Brothers (1957) believed these obsidian selvages and the fault line, indicated the location of an "old dome" which filled the present crater valley. Buck (1978, Buck *et al.* 1981) has shown that this feature never existed, but that the materials of the old dome, which were "massive rhyolite flows, with numerous glassy phases, bearing thin selvages of obsidian " (Brothers 1957:553), escaped through a number of secondary vents during the period of caldera collapse, between 8000 and 7000 years B.P. (Buck 1978:193, 197-198). True obsidian is not found on the slopes of the "young dome" in the caldera, "for the glassy rocks invariably contained 30 per cent or more of phenocrystic material " (Brothers 1957:556).

Pos, in 1965 collected obsidian samples from three localities on Mayor Island which he named 'sources'. The three localities sampled had high quality glassy obsidian, one located near Paretoa Pa (N54/16), and one on the north side of Oira Bay. The third locality sampled was an old prehistoric quarry site on the crater wall, known at present as the 'Staircase' (Pos 1965:108). None of the localities can be truly called 'individual sources', since, as already mentioned by Brothers (1957), Thomson (1926) and others, the obsidian appears in more or less continuous flows all along the walls of the main crater.

Ward (1971) for his obsidian characterization study used obsidian collected from eight separate localities around the island (Ward 1971:Apendix 1). These are described individually and are included in Table 4.1. below.

A number of other localities were found during the 1982 survey where high quality glassy obsidian could be extracted with relative ease. At the bottom of the cliffs on the south side of Te Rangiora Bay the lower obsidian seam was sampled. Obsidian here is of high quality. High quality obsidian from the upper selvage was also exposed on the crater rim behind Taumou Pa. Obsidian with a high percentage of phenocrysts can be picked up at a number of places on the interior slope of the main cone, especially around Hall's Pass, and Rauwaipiro Pass. Along the ring fault line on the western side of the island large semi-glassy lava flows can be observed, some of which contain sections of low quality flaking obsidian, and some good quality obsidian boulders.

TABLE 4.1.

Description of sampled obsidian deposits on Mayor Island

Locality Name	Location	Obsidian Description	Quality
Te Raumata	South end of Oira Bay	banded flows, vitreous lustrous	high
Oira Bay	North End of Oira Bay	flows range in colour from black to honey, lustrous	high
Taratimi	Above the 'Staircase' and from the old quarry	black vitreous	high
Opo Bay	North end of Bay upper and lower selvages	black banded	good
-	Between Wai-tangi and Te Horo Bay	honey coloured vitreous lustre	good
Okawa	South tip of Okawa Point	black vitreous	good
Rangiora	South side of Te Rangiora Bay from lower selvage	black to black-green vitreous,	high
Taumou	On crater rim behind Taumou Pa	black lustrous and vitreous	high
Halls Pass	obsidian from the upper selvage, on the inside of the crater wall	black with phenocryst inclusions	poor
Opuhi Spring	500 m North of the spring	boulders on valley floor, green-black and black banded stratified flow	good to poor

ARCHAEOLOGICAL FIELDWORK ON MAYOR ISLAND

Mayor Island was first surveyed by the Government surveyor Gold-Smith in 1884. Many of the places visited by him can no longer be identified, since they are now overgrown by dense bush. The population at that time was living at Te Panui pa, which Gold-Smith described as occupying

> a very strong position; from the seaward side it is only accessible by climbing up perpendicular cliffs of basalt, pumice and obsidian. The natives make use of a rough ladder, by which they descend to the foot of the cliffs, where hauled up on the beach they keep their canoes. The pa is situated about 100 feet above sea level (Gold-Smith 1884:420).

South of the pa on a flat area, occupying about 25 acres, Gold-Smith observed cultivations of potatoes, kumara, corn and tobacco, strawberries and raspberries (ibid.)

He also visited two further pa located on the same bay - Okotore and Tikitikinahoa, both occupying strong positions. Gold-Smith also mentions garden areas in the inside of the crater on the south side of the lakes (ibid.:422). He further mentioned a number of other pa, some of which he visited. Taumou pa on the north end of Te Rangiora Bay was in his opinion the strongest on the island. On a 500 feet high crag "with precipitous slopes on three sides, and with only a very narrow steep approach to it up a ridge of obsidian which the pa commands. There are large quantities of obsidian about the pa, in blocks of from a few pounds weight up to many tons " (ibid.:423). A small spring surfaces at the top of this pa. Tarawakaura, on the top of the 'Young Dome' was not visited by him.

Gold-Smith observed a number of old gardens and cultivated spots around the island. Extensive areas had been cultivated at Wharenui Point, Te Ananui Flats, and especially on the flat land around Oira Bay reaching to Opo Bay. The land from Otiora Bay to Opo Bay "has all been cultivated and the ruins of old whares are still to be found. Ruins of old houses are to be found in every favourable spot..." (ibid.:426). Another small pa at Oira Bay took the attention of Gold-Smith. Located at the south end of the bay, Te Raumata pa holds " a very strong position. The ditch which cuts it off from the main island is very deep ... This point is highly 'tapu' " (ibid.).

Surprisingly, Gold-Smith does not mention any places were obsidian was actively quarried. His only reference to obsidian usage is when referring to the siege of Taumou pa by Ngapuhi warriors in the 19th century, "... hurling the blocks of obsidian down on their heads as they rushed to the attack..." (ibid:423). Most probably boulders of rhyolite lava were used and not obsidian.

The island was later visited by Pos (1961, 1965) who recorded a number of archaeological sites, ranging from pa, middens, and pits to a few stone structures. Pos recorded a total of 16 fortified sites on the island, of which three were recorded as more permanent living areas. These were Te Panui, Paretoa and Whatepu. He also recorded a number of pits or rua associated to the pa sites. Most importantly for the present study, Pos recorded one obsidian quarry, although he noted two other sources of high quality obsidian. He describes the quarry, (site number N54/5) as

> a true quarry, where flake quality obsidian has been obtained by tunnelling into the obsidian seam for a distance of about six feet. The site is on the wall of the crater hundreds of feet above sea level. Many chips of obsidian are lying about the site" (1965:108).

The two other areas where high quality obsidian was found by Pos are located below Paretoa pa and on the north side of Oira Bay.

Fieldwork for the present study was carried out in May 1982. At this stage an intensive site survey was carried out, both to locate sites and to get an insight into the range of sites to be found on the island. Further fieldwork was planned for the summer of 1982-83 but, since this work could not be carried out, the interpretation that follows has to rely on the information collected during the initial fieldwork season.

Several of the sites described by Gold-Smith and Pos were relocated and mapped, while others could not be found or have been destroyed in the time which has elapsed. The survey did not cover the entire island as can be seen from figure 4.2. Some areas were extensively surveyed (Te Panui and Te Kopua Flats), while others were only cursorily examined due to the difficult terrain, dense vegetation and lack of time. Areas not surveyed include parts of the Dome and Crossman Hill, even though a brief reconnaissance of these areas was made. Big lava blocks and thick vegetation on a very thin soil, covers much of this area, which in places is extremely steep. The areas between Oira Bay and Cathedral Bay on the north side as well as the northeast area of the island could not be surveyed in detail.

Description and Discussion of Sites

The sites will be discussed in terms of their type category rather than by geographical distribution. A detailed description of each site with its site record number and geographical coordinates can be found in Apendix 2. A list of site types is given in Table 4.2.

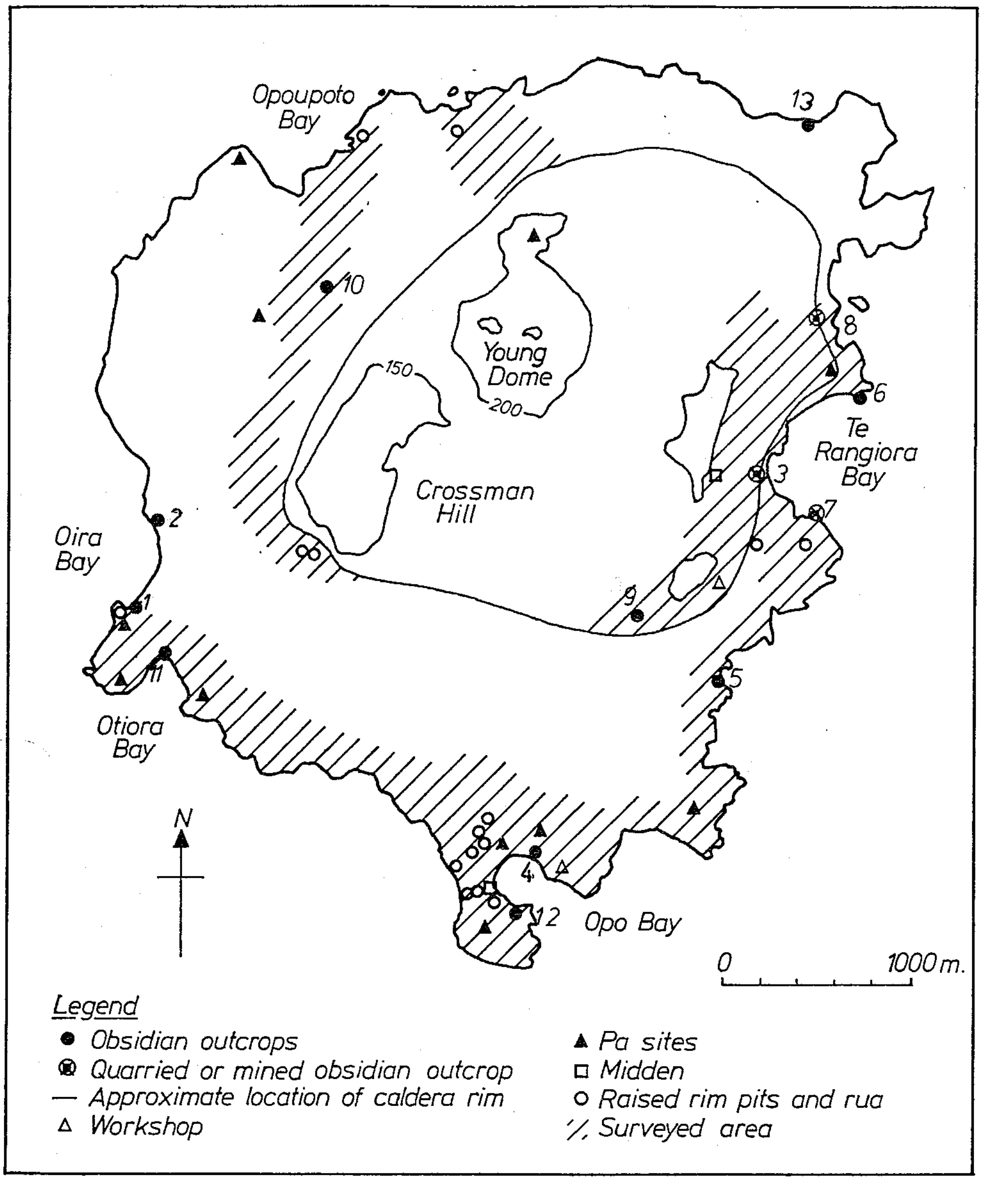


Figure 4.2: Archaeological sites recorded on Mayor Island

Key to numbers of obsidian outcrops: 1. Te Raumata 2. Oira Bay 3. Taratimi 4. Opo Bay 5. Waitangi Bay 6. Okawa 7. Rangiora 8. Taumou 9. Halls Pass 10. Opuhi Spring 11. Otiora Bay 12. Panui 13. Orongatea Bay.

TABLE 4.2.

Site types recorded on Mayor Island [1]

Site types	Number of sites
Pa	3
Pits (storage)	9
(other)	8
Quarries	3
Working Floors	1
Middens	3
Terraces	4
Pit and terrace complexes	5
Platforms	3
Ditches	3
Others	1
Total	43

[1] Note: Not all sites have a separate site record number

Pits

The predominant type of sites was pits, a number of which are associated with terraces. A total of 16 pits was found. These can be divided into two types. Of the first type (rua) nine were found. All of these are located on the slope next to the top of natural ridges formed by lava flows. These places are all well drained and suitable for food storage. They were found mostly concentrated in groups of two or more. Only in one place were they located on the top of the ridge itself (site N54/23) where they are associated with a terrace complex.

Of the second type of pits (rectangular) eight were found. These are rectangular structures, with a raised rim on at least three sides. Dimensions vary from 2 metres wide to 7 metres wide and 3.5 metres long to 10 metres in length. Three of them were found isolated from other archaeological features, while two were found together and associated with an apparently defensive ditch nearby. These two are located on top of the crater rim, while the others are on the flat areas near the coast.

Pits and Terraces

Five complexes of pits and terraces were found. The terraces have all been cut into the sides of natural ridges or the top of these have been artificially flattened. Some of the terraces are very narrow, and might support at the most two houses (N54/23). The pits are located on the sides of the ridges and not on the terrace proper, as it is the case for the isolated pits. The pits associated with these terraces are all of the first type (rua), with one exception (rectangular raised rim pit).

Terraces and Platforms

Two types of platforms were found built on natural lava ridges, or of artificially built up soil. Two platforms built by flattening the top of natural ridges were found over Parikoura Point. Gold-Smith (1884) describes a pa in this vicinity. No fortification remains are obvious on the surface, but shell fragments indicate that the area has been used as a living place. The other platform is an artificially built up earth mound, surrounded by an artificial ditch. It is possible that it supported some kind of house structure. Two small terraces cut into a low ridge were found along Te Kopua Flats . They resemble rectangular pits, but the area has been artificially levelled and the soil used to build a bank and rim around the terraces. A ditch drains the upper terrace.

Middens

Three middens close to fresh water sources were found as well as a few isolated shells in the vicinity of some of the pits and terraces. Two middens were located near the beach on the edge of a natural bank. The upper one has been exposed by erosion of the bank and the midden can be seen in the cut underneath the roots of an old pohutukawa tree. The lower midden could have been formed by dumping the refuse over the bank, or through erosion of it. Midden remains include *Nerita* sp., paua (*Haliotis iris*), limpets (*Cellana* *strigilis* and *C. radians*), Cook's turban (*Cookia sulcata*), and *Thais orbita*. Fishbones are abundant in the two coastal middens and charcoal and obsidian flakes were found in all of them. Only one midden deposit was found inside the crater at the shores of the Green Lake (*Aroarotamahine*), while some isolated shells were found at the working floor inside the crater described below.

Pa

Only three sites recorded fall into this category. Fifty per cent of the sites recorded in earlier surveys were pa, and two of the pa sites recorded and mapped in 1982 had been recorded earlier. Most of the sites recorded in previous years are almost inaccessible due to the extremely dense vegetation that has grown and obliterated many of their original features. Taumou (N54/4) has been recorded earlier. This is a fortified terraced pa built on top of the crater rim on a high peak with almost vertical walls and cliffs falling away on three sides. Only three of supposedly seven terraces could be positively identified.

The other two fortified sites include one headland pa, built on a peninsula with cliffs on three sides of it, overlooking Opo Bay (Panui). A defensive ditch has been recorded for this site but a modern tractor track has been cut along it. The other pa is built on a natural ridge with a defensive ditch on one end, and a natural scarp surrounding the remainder of the site.

Ditches

One ditch was found that cuts through the crater rim and seems to serve a defensive purpose. It is associated with two rectangular pits. One of the obsidian quarries (Staircase) is a few hundred metres further along the crater rim. Other small ditches were found crossing through small ridges near some of the storage pits. It is more likely that these served as drains, since they were very shallow, narrow and short. They cut across the top of these ridges and then disappear.

Gardening sites

No positive identification of gardening areas was made. A stone alignment enclosing the upper part of one small valley or drainage was found. It is not clear what function it might have served. Other possible stone alignments were found in the flat areas behind Te Panui, which according to Gold-Smith had been cultivated.

Quarries

Only three places were found on the island that can be classified as quarries. One of these had already been described briefly by Pos (1965). In two of the quarries the obsidian flows had been mined following the natural vein inwards, forming tunnels about one metre high and about two metres deep. The obsidian quarried at these places is invariably of very good flaking quality - very glassy with few or no phenocrystic inclusions. Present access to these quarries is rather difficult. Since a boat was not available, it was not possible to investigate other areas around the coastline where other similar quarries might have been found.

Staircase quarry : Located at Taratimi Bay this quarry overlooks Te Rangiora Bay (Crater Bay). It was first described by Pos in 1965 and assigned a site number (N54/5). The quarry is located on the ridge of the main volcanic cone at a point where it is not more than five metres wide. It is also the lowest point of the crater ridge. Access to it can be by following the crater rim north after climbing up from Opo Bay. Or alternatively in former times it should have been possible to climb directly up from Te Rangiora bay below the quarry. This steep slope is continuously eroding away. The natural obsidian flow is exposed here at the crater rim both on the inside and the outside of the crater. A tunnel approximately one metre wide and 1.5 metres deep has been mined into the obsidian selvage on the outer wall of the outcrop. On the inside overlooking the caldera some pecking has also been carried out. The ground around the outcrop and in front of the 'shaft' is covered with small waste flakes and irregular pieces of obsidian, not bigger than 15 cm in length. The waste flakes do not cover the ground thickly and are probably the result of the mining activities. There is no evidence that the blocks obtained were further worked at this site, and no hammerstones or worked cores were found. The material obtained from this selvage is of high quality and since its surfaces are fresh, no decortication of the cores would be necessary. (figure 4.3).

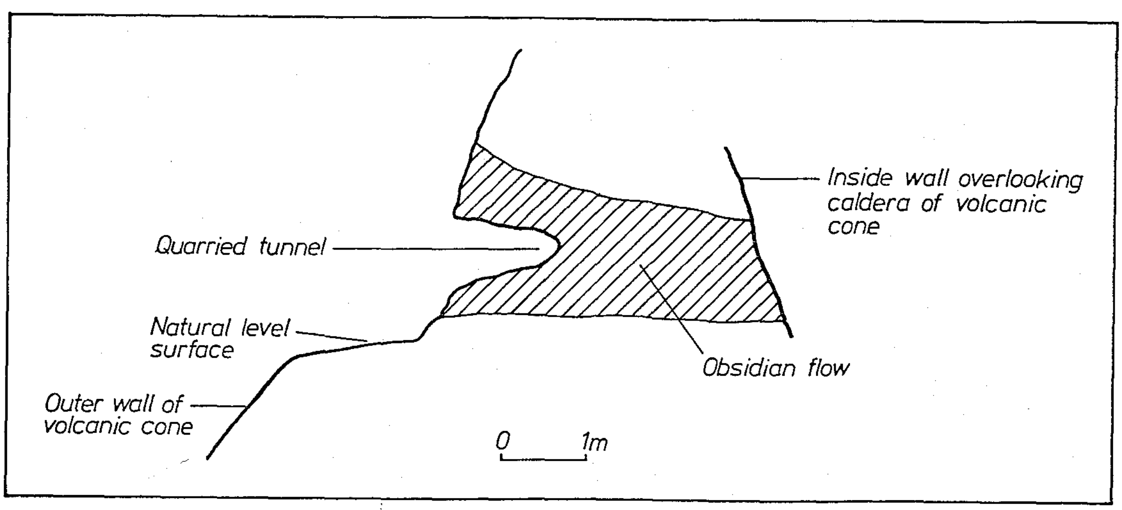
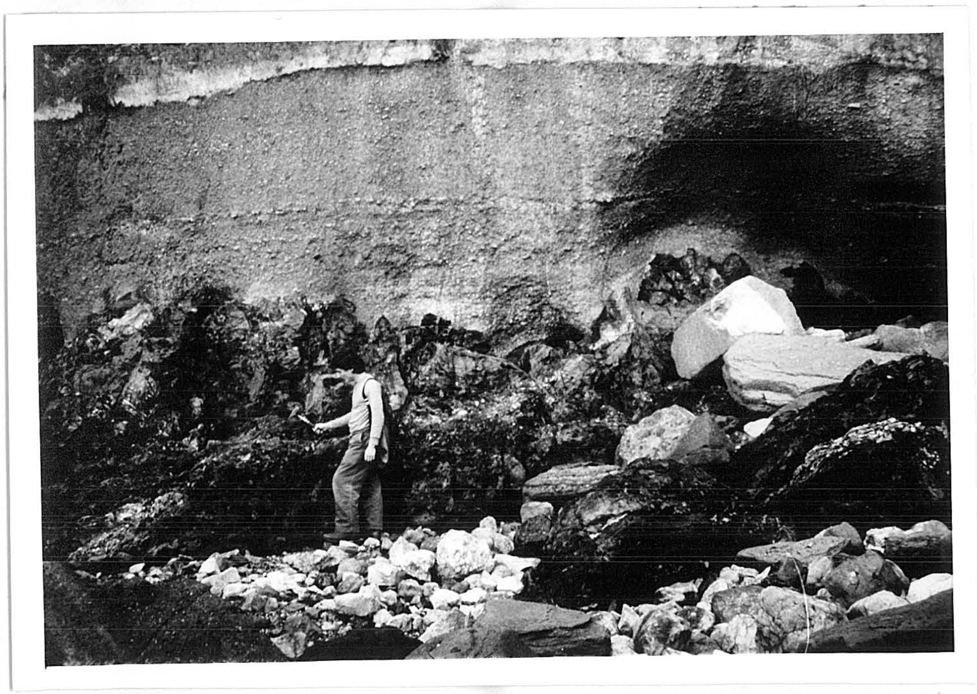


Figure 4.3 : Approximate cross-section through "Staircase" obsidian quarry

Taumou Pa Quarry : On the top of the rim of the volcanic cone just behind Taumou Pa, the upper selvage of obsidian is exposed. At this point the crater rim is less than four metres wide. The obsidian outcrop has been quarried here in several places. Blocks have been hammered out of the flow, but no tunnelling is apparent. The area around the outcrop is also covered with waste flakes (Figures 4.5a,4.5b).

Te Rangiora Bay Quarry : This quarry is located at the end of a boulder beach at the south end of the bay. Here, a mine drive has been quarried into the cliff, the lowest part of which is mainly composed of obsidian. The tunnel is about a metre wide and over a metre in depth. It cuts obliquely into the rock (plate 4.6) Small obsidian cores and waste flakes surround the mining area. Access to this quarry would have been mainly by sea.

<u>Figure 4.4a :</u> The mined shaft at the "Staircase" obsidian quarry



<u>Figure 4.4b :</u> Lower obsidian flow exposed at Te Rangiora Bay

Figure 4.5a : Upper obsidian flow at Taumou pa

Figure 4.5b : Obsidian flow at Taumou Pa with some quarrying scars

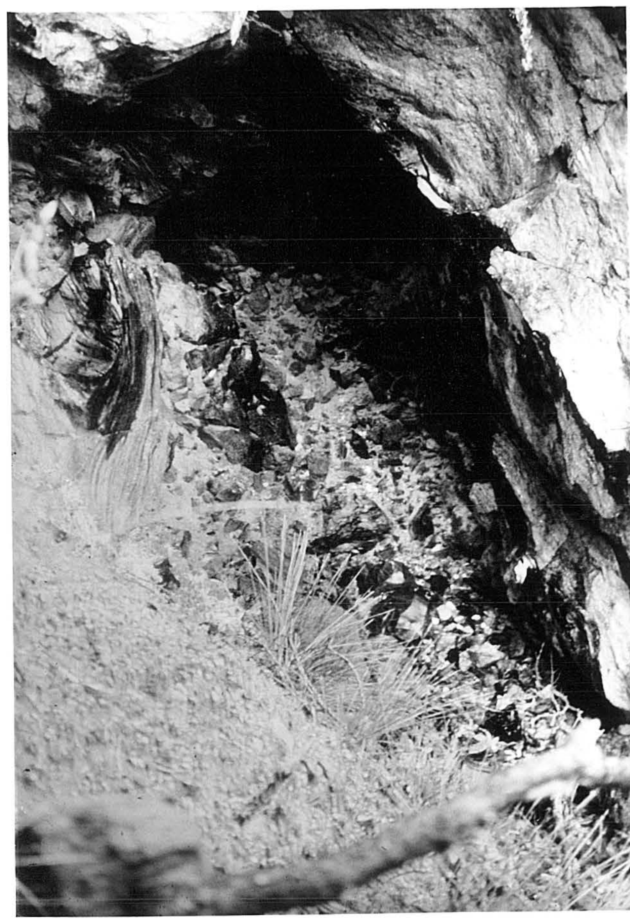


Figure 4.6. : The mined shaft at Te Rangiora Bay quarry

Working floors

Only one site during the whole survey was identified as a possible stone working floor. This is located on the inside of the caldera a few metres off the southeast shore of the Black Lake (*Te Paritu*). The area contains a high concentration of obsidian blocks cores and flakes, but since no further archaeological work was possible, the identification of this site as a true working floor remains open, as well as the type of work that was carried out there.

The occupation sites of Mayor Island do not seem to be directly related to the extraction of obsidian or the working of the quarries. Although the raw materials are of excellent quality and abundant., archaeological sites associated with the extraction work are not obvious. This is very strange in light of the apparent importance of Mayor Island obsidian in New Zealand prehistory. Further archaeological work on Mayor Island was not possible during the course of the present research since permission to carry out excavations was refused by the Mayor Island Trust Board. The archaeological potential of the quarries and settlements is, nevertheless, not as promising as could be expected from comparable archaeological sites or quarries not only in New Zealand but other places of the Pacific and further afield. For this reason, the impossibility of carrying out further studies in the area at the present stage does not seem a major setback for the interpretation of the obsidian exploitation of Mayor Island. However, if the decision by the Mayor Island Trust Board should be reversed, further archaeological fieldwork might focus particularly on the relationships between the quarries and occupational sites, as well as on the identification of lithic workshops. An important aspect of any future research on Mayor Island would be to establish the nature and location of the earlier settlements. At present the archaeological evidence for early permanent and intensive, or even for periodic occupation on Mayor Island is surprisingly poor.

DISCUSSION AND CONCLUSIONS

An unexpected result of the archaeological survey of Mayor Island was the absence of any concentrated quarrying and flaking areas. From the volume of obsidian collected in archaeological sites throughout New Zealand it is surprising to find only two or three areas where some sort of continuous quarrying of obsidian took place. Nor are these quarries extensive, especially if one considers that they were probably exploited over several hundred years. No other archaeological remains such as middens, ovens,etc. were found at the quarries, which suggests that only periodic visits were made to the two main quarry areas. Since access to the quarry at Taumou Pa is necessarily through the pa site, and the quarrying at this point is not extensive, one might assume that this outcrop was only used during the occupation of the pa; again unsystematic working of the quarry is indicated.

The technology employed by the prehistoric quarry workers in extracting the obsidian cannot be reconstructed in detail. The absence of known working floors on the island and of major working debris at the quarries, suggests that most of the material was transported in blocks or cores to the mainland from where it was distributed to other parts of the country. On the whole, the production and extraction industry of the Mayor Island obsidian quarries, as can be reconstructed from this survey, does not seem to provide any evidence to support restriction of access to the quarries. No indication of specialization, or intensive exploitation is present. This is coupled with fairly unsystematic working patterns at the quarries. Nevertheless, an important factor that cannot be ignored is the fact that 30 per cent of the recorded sites are defended settlements. It is difficult to tell without further archaeological fieldwork whether or not these belong to late Maori occupation, but traditional history suggests that the defensive structures date from the later occupation. It still remains to be found out if some of the defended settlements date back to earlier periods. But it is not known if the pa and quarrying sites are contemporary or to what extent they are related.

The behaviour represented at the quarries does not give any indication that a permanent workforce was employed in extractive tasks for an ongoing exchange system. This conclusion is also confirmed by the evidence that cores and obsidian blocks were not further worked on the island. Since the material was of such high quality, there was no need to test the stone to ensure high quality obsidian was carried away. At the same time, due to the nature of the material, it is reasonable to argue that it was carried away in whole cores from which flakes could be struck as needed, instead of transporting already struck flakes. Travel by canoe also facilitates transport in the sense that bigger loads could be carried.

It seems likely that exploitation of the raw material was made for a number of different consumers, such as, in the first instance, Mayor Island residents themselves, their relatives on the mainland, and for other groups more distantly related. Traditional history shows that the people of Mayor Island had close links with the mainland tribes, and it is therefore probable that much of the quarrying and extraction work was also performed to supply these groups with raw material.

Special purpose visits could have been also performed by groups from further afield. Maning (1875:103) mentions that the Ngapuhi from Northland went to Mayor Island from where they obtained their obsidian. Adams (1971:32) says that Mayor Island was the subject of many raids by other tribes, Ngapuhi and Rarawa from the north and Ngatimaru from the west, Te Arawa from the south and Ngatiwa from the east, all at various times, either in search of utu , or "just for the devil of it" (ibid.). From this last statement it appears quite possible that a number of these raids could in actual fact have been carried out in order to obtain obsidian.

When comparing the exploitation of obsidian with that of other lithic resources in New Zealand one finds some substantial differences. Most important is the absence of large working floors and flaking debris close to the quarries. It is hypothesized here that most of the obsidian from Mayor Island was quarried during periodic visits to the island for the specific purpose of obtaining obsidian. Further research, such as survey and excavation work on Mayor Island is needed to fully confirm this.

In the next chapter the results of the sourcing analysis of the obsidian assemblages found in archaeological sites both in the North and South Islands are given. The regional analysis should help in the confirmation or refutation of this conclusion.

CHAPTER V

THE SOURCING OF NEW ZEALAND OBSIDIAN: THE ARCHAEOLOGICAL SAMPLE

INTRODUCTION

The obsidian artefacts analyzed for the purpose of this study came from 58 archaeological sites; most of these come from dated contexts, either directly by C14 dates, or through comparison of the site's diagnostic artefacts with other dated sites in the area. Thirty-seven of the sites are in the North Island, and the remaining 21 are located in the South Island. The size of the obsidian assemblages varied from about 20 to over 5000 flakes in a single assemblage. The assemblages were selected as far as possible to represent all different geographical areas within New Zealand. The location of the sites is shown in Figure 5.1.

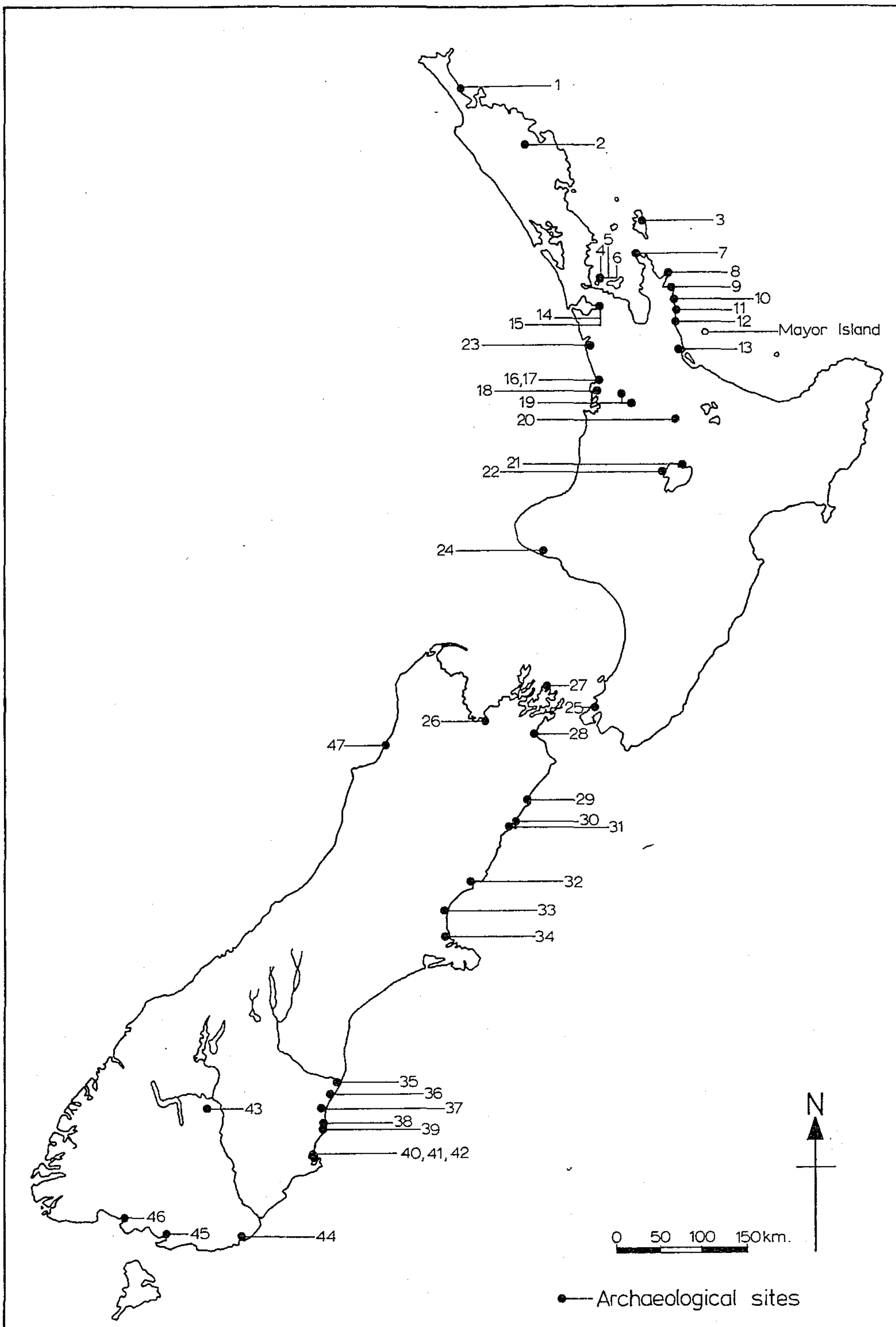


Figure 5.1 : Map of New Zealand showing location of archaeological sites sampled for the present study (key to numbers on following page).

Key to site numbers in Figure 5.1.

NORTH ISLAND

1. Houhora
2. Pouerua
3. Harataonga Middens (N30/3, N30/4, N30/5)
4. Station Bay N38/30
5. Station Bay N38/37
6. Sunde
7. Port Jackson
8. Skippers Ridge I and II
9. Hahei
10. Hot Water Beach
11. Tairua
12. Whangamata
13. Kauri Point Swamp
14. Ellett's Mountain
15. Hamlin's Hill
16. Raglan N64/16
17. Raglan N64/18
18. Aotea; Koreromaiwaho
19. Mangakaware; Ngaroto
20. Tokoroa
21. Whakamoenga Cave
22. Waihora
23. Maioro
24. Hingaimotu
25. Paremata

SOUTH ISLAND

26. Tahunanui
27. Titirangi Pits and Sandhills
28. Wairau Bar
29. Clarence River
30. Avoca
31. Peketa
32. Timpendean
33. Houhoupounamou
34. Redcliffs
35. Waitaki River Mouth
36. Tai Rua
37. Waimataitai
38. Shag River Mouth
39. Shag Point
40. Purakanui
41. Long Beach
42. Murdering Beach
43. Hawksburn
44. Pounawea
45. Tiwai Point
46. Pahia
47. Heaphy River Mouth

The smaller assemblages of obsidian were analyzed as far as possible in their totality. Specimens smaller than approximately 15 mm in diameter could not be analyzed, since the sample holders were designed to be used with the 'average obsidian flake' as might be encountered in an archaeological context. Since there is a broad range of flake sizes possible an area of 15 to 20 mm was designed to allow enough latitude to mount both large cores and small flakes. Also very thin samples (less than 2 mm) had to be discarded. Sample thickness affects the fluorescence response as shown by Bollong (1983:95). With reduced thickness there is an apparent increased response of the low-Z elements and a decrease in the proportional response of the high-Z elements. Samples too large to fit the sample holders were only encountered twice. The number of pieces discarded due to their size and/or thickness amounted to up to fifty percent in some sites. Interpretation of the results has therefore to be made cautiously for the following sites: Harataonga (N30/4), Mangakaware, Long Beach, Station Bay (N38/30), Station Bay (N38/37), Whakamoenga, Clarence, Pounawea and Avoca) This represents a problem only in the smaller assemblages where the sourcing results might be afffected by this. For the larger assemblages, such as Tahunanui for example, where only 26 per cent of the assemblage was sourced, the situation is not so problematic since this percentage represents quite a large number of flakes. For the large assemblages a sampling strategy was adopted which is described below. No attempt was made to select samples visually according to colour variations in the obsidian, as this would introduce observer bias.

MATERIALS AND METHODS

SAMPLING STRATEGY

Several of the obsidian assemblages contained over 1000 obsidian pieces. It would take months with the present efficiency of the equipment to analyze all of them. It was therefore decided to take a sample of all assemblages of over 400 pieces of obsidian. To determine the sample size an equation was used which would allow the calculation of a sample size to represent the obsidian population with an acceptable margin of confidence (95 per cent). As a preliminary step, the margin of error of the results of the non-sampled obsidian assemblages already sourced was calculated. It was found that at 95 per cent confidence the margin of error obtained varied between ±4 per cent and as much as ± 16 per cent. To calculate approximate 95 per cent confidence limits of the results obtained by the isoprobe analyses the following equation was used :

$$\hat{p} \pm 1.96\sqrt{\frac{\hat{p}\ (1 - \hat{p})}{n}}$$

(Steel and Torrie, 1980:479)

where

$\hat{p}$ = the estimate of the proportion of one trait, 1.96 = the standard normal value for approximately 95 per cent confidence, and n = the total size of the sample.

$\hat{P}$ was calculated as the proportion of Mayor Island obsidian in the total assemblage of the site. To estimate the size of n, it was assumed that the proportion of Mayor Island obsidian in a site was 1:2. This makes the error limits a maximum and represents the worst possible case. Using the above equation

$$\hat{p} = \frac{1}{2}$$

$$\hat{p} \pm 1.96\sqrt{\frac{\frac{1}{2}(\frac{1}{2})}{n}}$$

$$\hat{p} \pm \frac{1}{\sqrt{n}}$$

if,

n = 100 $\hat{p} \pm 100 = \hat{p} \pm 0.1$ or 50 per cent ± 10 per cent

n = 200 $\hat{p} \pm 200 = \hat{p} \pm 0.7$ or 50 per cent ± 7 per cent

The margin of error of ± 7 per cent obtained with a sample of 200, satisfies the confidence limits, since they are higher than in most cases where the whole of the assemblage available was used. A sample size of 200 is also a convenient number that can be adequately run by the isoprobe facility in a reasonable time.

The pieces were then selected using random number tables. The method of selecting random numbers varied between sites, depending on the cataloguing and bagging system employed for each site. The sampling strategy employed for each site sampled is discussed below. The sites which were sampled in this manner were : Hot Water Beach, Kauri Point Swamp, Whakamoenga Cave and Houhora.

Hot Water Beach

All obsidian flakes had individual accession numbers. Random number tables were used to determine which flake was to be sampled. From five digit numbers the last three digits determined the sample chosen.

Houhora

The material from Houhora was analyzed by Bollong (1983) when testing the setting up of the Otago University isoprobe facility. The Houhora material contains over 3000 flakes; a sample of 400 flakes was taken by Bollong (ibid.:137). The results of his analysis were checked against the modified program SELECT, which allocates the individual pieces to a reference source (see Brassey and Seelenfreund, 1984).

Kauri Point Swamp

The site contained over 10,000 flakes. The obsidian pieces did not have individual accession numbers which could be used for random selection, so individually bagged specimens of about 200 at a time were laid out in a line and every 20th bag chosen until the desired sample size was reached. This procedure was not strictly random, but there was no obvious source for observer bias in the selection.

Whakamoenga Cave

Flakes for this site were selected using random number tables. The flakes were all in separate numbered bags representing separate excavation squares and levels. The first two digits of the random number determined the number of the bag to be sampled. and the last digit determined the number of flakes taken from each bag. These were then taken as a grab sample.

Some of the assemblages studied are extremely small. This fact, and the under-representation of the sites in the inland areas of the North Island, has to be kept in mind when evaluating the results of the fall-off studies.

Nearly all the sites in the North and South Islands are located very near or on the coast, and not all the sites had the same functional status. Some are large settlement sites, while others represent small transitory camps, possibly occupied seasonally. The absence of inland sites analyzed in the South Island, except for Hawksburn, is due to the lack of obsidian material in these sites, a significant fact in itself.

A short description of the archaeological sites from which obsidian was analyzed is contained, in alphabetical order in Appendix 1. The number of pieces of obsidian made available, and the number sourced, is noted.

CHRONOLOGICAL FRAMEWORK

For the purpose of all subsequent analysis, the archaeological assemblages used in this study were separated into groups of approximately contemporaneous sites, to allow for a comparison of the sites on a regional as well as on a local basis. The sample is large enough to be subdivided on the basis of chronology. This is a necessary step if changes in the exchange system occurring during different times are to be detected. It is highly desirable to group assemblages into time periods for purposes of time-trend analysis in exchange patterns. There is little agreement amongst New Zealand archaeologists on more than two general periods of prehistory, and even less agreement on more than two phases of cultural change for New Zealand as a whole.

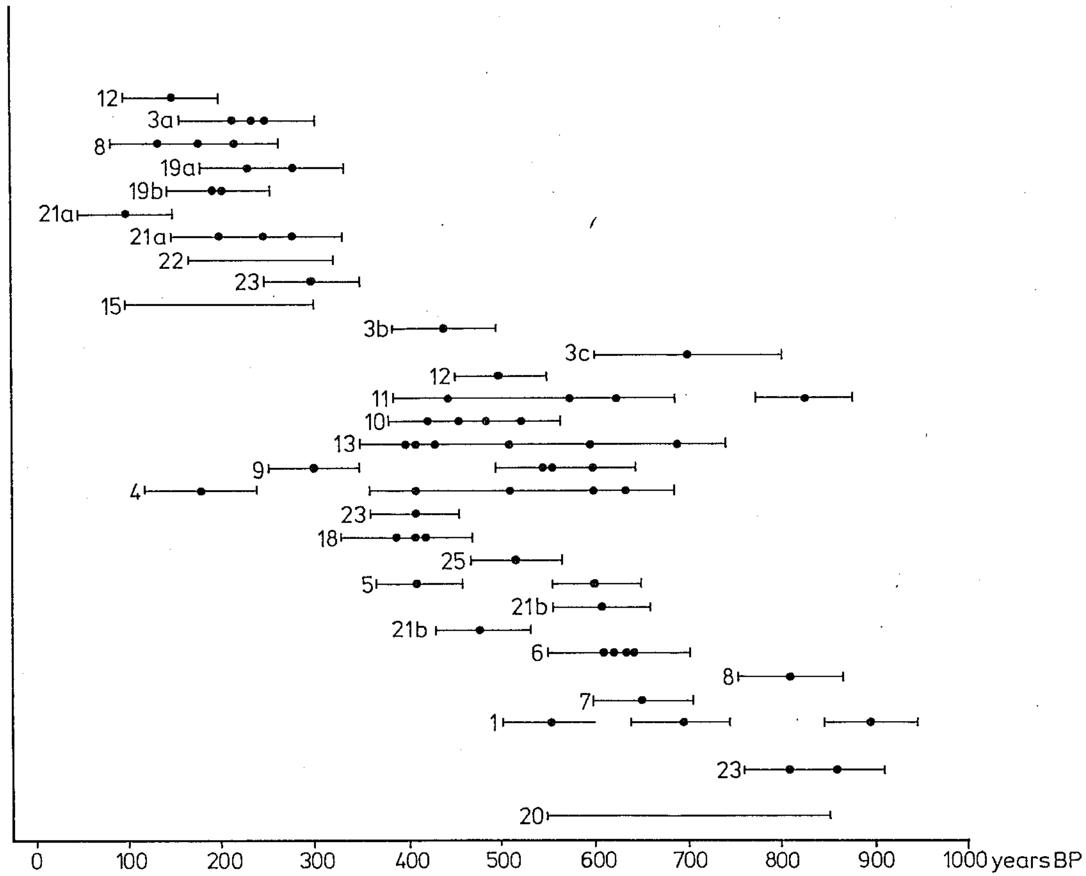
In the circumstances it was decided to attempt to group assemblages into three chronological divisions, based whenever possible on radiocarbon dates, and where otherwise, on rather less secure grounds of economy and material culture. It is accepted that individual archaeologists may find some points of disagreement as to the ascription of some assemblages into some chronological groups; however, even if some of them are indeed in error, the broad changes through time should still be revealed in this study if any such changes exist. The individual reasons for the assemblage groupings are to be found in Appendix 1. The periods chosen for grouping are the same for the North and South Islands :

Group 1 (early period) : older than 630 B.P.;
Group 2 (middle period): 630 B.P. to 350 B.P.;
Group 3 (late period) : 350 B.P. to Present.

Figures 5.2 and 5.3 show the dates plotted for all the analyzed sites. The radiocarbon dates for New Zealand are difficult to interpret as McFadgen (1982),Trotter and McCulloch (1975) and Anderson (1982, 1984) note. Since New Zealand prehistory covers less than 1000 years, errors in radiocarbon dating are proportionally large, e.g. errors of ± 150 years at 95 per cent confidence. Some charcoal samples seem to produce dates 200 or more years older than samples taken on bone collagen or marine shell from the same sites. Trotter and McCulloch (ibid.:13) advise ignoring the charcoal samples and relying mainly on other dates, if available. The inconsistencies seem to be greater for the earlier dates, while for dates around 800 B.P. , the dates seem to be more in general agreement. As McFadgen (1982:390) discusses, the time elapsed between the date of death of the sample and the date of an event are an important source of error. Due to calibration curve errors and counting errors samples less than 200 radiocarbon years apart cannot be distinguished on either wood, charcoal or bone collagen samples. For the purposes of this study, a mean date has been calculated, or a date used for the site which has been accepted by the excavators and is in general agreement with the archaeological evidence from the site, or the layer within the site.

Figure 5.2 : Radiocarbon dates (in years B.P.) for North Island sites mentioned in the text.

14	Ellett's Mt. (no date)
2	Pouerua (no date)
12	Whangamata
3a	Harataonga Bay N30/4
8	Skipper's Ridge II
19a	Mangakaware
19b	Ngaroto
21a	Whakamoenga (occupation 4)
21a	Whakamoenga (occupation 2)
22	Waihora
23	Maioro phase 3
15	Hamlin's Hill (no date)
3b	Harataonga N30/3
3c	Harataonga N30/5
12	Whangamata
11	Tairua
10	Hot Water Beach
13	Kauri Point Swamp
9	Hahei
4	Station Bay N38/30
23	Maioro phase 2
18	Aotea
25	Paremata
5	Station Bay N38/37
21b	Whakamoenga (occupation 1a)
21b	Whakamoenga (occupation 1b)
6	Sunde
8	Skipper's Ridge N40/7
7	Port Jackson
1	Houhora
16	Raglan N64/16 (no date)
23	Maioro phase 1
24	Hingaimotu (no date)
20	Tokoroa



41 Long Beach Layer 2
42 Murdering Beach
31 Peketa
29 Clarence
33 Houhoupounamou
40 Purakanui
39 Shag Point
26 Tahunanui (no date)
32 Timpendean
27 Titirangi Pits
36 Tai Rua
47 Heaphy River
44 Pounawea
30 Avoca
43 Hawksburn
41 Long Beach Layer 4
46 Pahia
34 Redcliffs
38 Shag River
27 Titirangi Sandhills
45 Tiwai Point
37 Waimataitai
28 Wairau Bar
35 Waitaki River

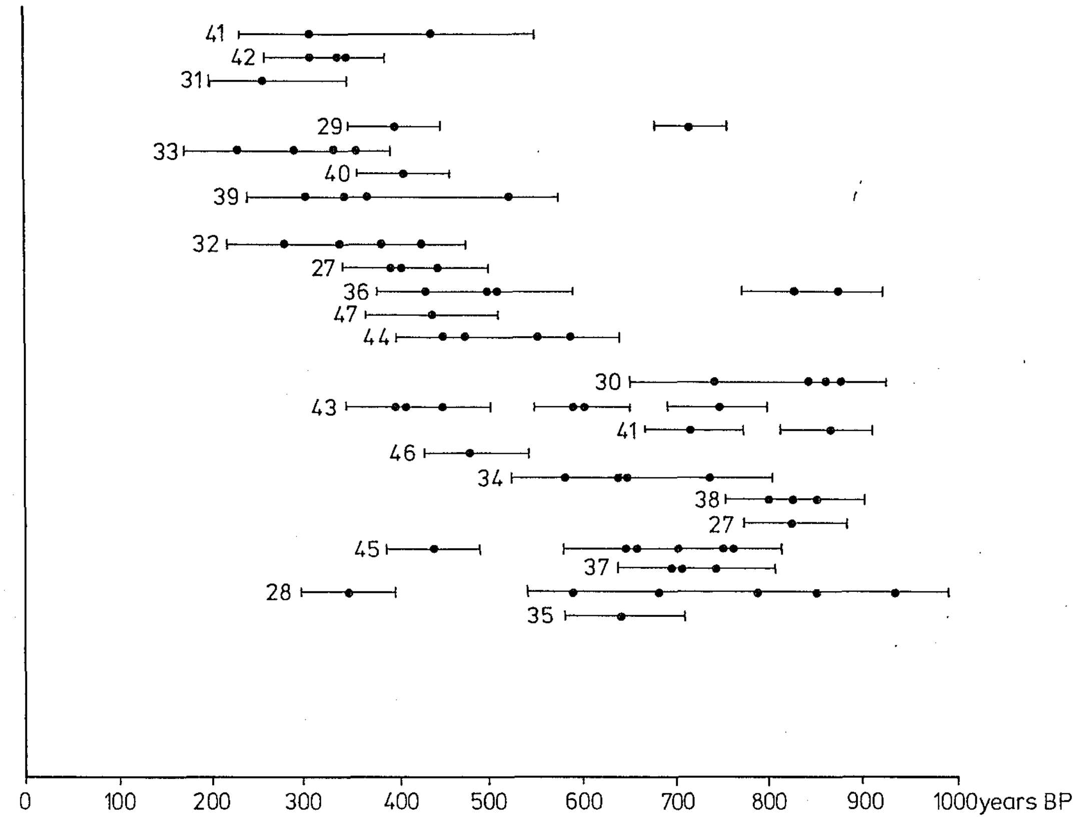


Figure 5.3 : Radiocarbon dates (in years B.P.) for South Island sites mentioned in the text.

These time divisions are not entirely arbitrary, and some arguments can be advanced that they may correspond with significant cultural and/or economic changes in New Zealand prehistory. However, this subject is beyond the scope of this thesis, and is avoided whenever possible.

The divisions used here for separating the sites are based on broad changes within the subsistence strategies of both the North Island and South Island Maori.

The first subdivision groups South Island sites which are older than 630 years B.P.. The second group includes sites in the range of 350 years B.P. to 630 years B.P., while the third group contains all sites younger than 350 years B.P. The divisions are made allowing for certain variations, some sites for example have been grouped in the 630 years B.P and older group, on account of their material culture and accepted dates, even if some of their radiocarbon dates fall outside the range given. Examples of this situation are the Waitaki River Mouth and Pounawea sites.

The period of 630 B.P. and older coincides with the settlement of the first sites on the South Island, and the hunting of moas as a basic and important subsistence activity. For the South Island, Anderson (1983:47, 1984:734) argues for a peak in moa hunting between 900 to 600 B.P., extending on the coast to around 500 B.P. in the form of opportunistic hunting. On these grounds, as well as on evidence from the North Islands sites, a division around 630 B.P. seems reasonable.

The separation of the early North Island sites is based on somewhat different criteria. The first division contains the very early settlement sites of 630 years B.P. and older, grouping what probably constitutes the first Polynesian settlement sites in the North Island.

From 630 years B.P. to 350 years B.P. only a few sites are represented. This division is taken to mark a transition to the Classic Maori Phase. A trend can be identified in subsistence pattern changes, midden content, and increased number of storage pits. The changing economic situation is also reflected in the material culture in a decline in stone flakes size, certain types of fishhooks, and a general shift in the material culture.

The second group of North Island sites, 630 years B.P. to 350 B.P., involves all sites with an Archaic East Polynesian cultural assemblage. At the same time, this classification keeps the sites on the Coromandel Peninsula as one unit. As Law (1982:6) notes that the Coromandel Peninsula sites are closely related in their material culture and settlement layout these sites show a fairly uniform cultural development and material cultural and should be treated as a contemporaneous unit.

The last group , 350 years B.P. to the present, covers what usually is termed the 'Classic Maori occupation'. A fairly marked gap can be identified between the dates of Classic Maori occupation and the earlier sites in the South Island. By 350 B.P. defended settlements on the North Island are widespread, marking a change in subsistence patterns and in the general cultural assemblages.

THE SOURCING PROCEDURE

INSTRUMENTATION AND PROCEDURE OF ENERGY DISPERSIVE XRF SPECTROSCOPY

The archaeological samples were analyzed using energy dispersive X-ray fluorescence spectroscopy, following the procedure detailed by Bollong (1983). The obsidian samples were mounted whole on perspex (cast acrylic) holders, which, in turn, are mounted on a stainless steel rack using plastic magnetic strip. Samples are brought into the irradiation position by advancement of the rack. This can be controlled by a MDL microcomputer run under a CP/M operating system connected to the sample changer facility, as well as manually.

Sample preparation included surface washing and brushing with acetone, technical grade ethanol, and distilled water to remove, where necessary, labels and surface contaminants.

Energy dispersive X-ray fluorescence analysis of the obsidian was carried out with an ORTEC model 7113-06175-S Si(Li) detector (effective diameter of 0.6 mm). Sensitivity is to a depth of 0.5 mm. Other components of the system are a 0.05 mm beryllium window that separates the detector diode from the atmosphere, ORTEC 729-A liquid nitrogen level monitor, ORTEC 117-B pre-amplifier, and an ORTEC 572 amplifier connected to a NORLAND INO-TECH 5300 MCA. The amplifier gain setting is of 0.61 x 100 and 1 u sec shaping time. The amplifier setting had to be adjusted during the course of the research due to minor changes in the element peak positions. The analysis range is 0 - 60 KeV.

The radioisotope used for the analysis is a 50 mCi americium-oxide (isotope 241) source ceramic with an active diameter of 6.4 mm. This gives a standard activity of 1554 mCi/cm squared. The radioactive source is housed within a lead collimation container. The collimation inserts are made from aluminium alloy and capped with a 4 mm lead shielding to prevent the transmission of uncollimated 59.57 KeV gamma radiation (c.f. Bollong, 1983:64).

Obsidian samples were analyzed for Rb, Sr, Y, Zr, Ba, La, and Ce. To determine the analytical value for the specified elements in the spectra, ratio measures taken over the Compton/Rayleigh peaks were employed, since these are within the spectrum and independent of the trace element concentration. Element ratios were not used since each of the possible useable elements (Fe, Zr, and Ba) occur at zero level in one or more particular source groups. The net element peaks were taken as ratios against the net mid-Compton value and the ratio assigned as a measure of the proportionate element presence (Bollong, 1983:108-110).

Samples were analyzed for 4000 seconds each and assigned to sources using a special computer program. FORTRAN program AUTOMCA developed at the University of Otago Archaeometry Laboratory controls the operation of the automated sample changer facility and the transfer of the collected spectra onto the microcomputer link. Information is stored on 8" floppy disks and in printout form. A separate program is used for discriminating the spectra and matching them up with the geological reference group. An outline of the computer software employed follows; the two main programs, AUTOMCA and SELECT are modified versions of the software developed by Bollong (ibid.:80).

FORTRAN program AUTOMCA records initially the position of the samples on the stainless steel sled by reference to a mounted scale. It records as well literal information on the artefacts and run number assigned by the operator. The program cross-checks against possible duplication of existing run numbers already present on the destination disk, as well as the distances between samples as entered by the operator. This information on the samples is kept on a separate data file (SAMPLES.DAT).

Following this initial step the program automates and runs the sample changer facility and transfers the collected spectrum from the MCA to the MDL. The program dumps the spectrum into the random access memory (RAM) of the MDL and converts the 1024 channels into 512 by channel pair adding. This sub-program incorporates the prepared data file (SAMPLES.DAT). As the spectrum is transferred via the MCA/MDL link, it is displayed on the graphics monitor. The spectrum information is then written onto floppy disk. AUTOMCA incorporates into one program features of the separate programs MCA, NIGHT and CHANGER (c.f. Bollong, 1983).

The spectra recorded on disk can be analyzed using one of the following FORTRAN programs : AMSPEC as described by Bollong (ibid.:83), which allows graphing of the spectrum, determination of the energy of a region or peak, integrate window areas and produce counts per channel printouts of the spectrum displayed.

The sourcing of the obsidian is performed by program SELECT, which is a modified version of SCREEN as developed and described by Bollong (ibid.:83,119). The sourcing parameters are the same as in program SCREEN. The modification resides in the reference group file, where the mean and standard deviation values for the Northland sources (Waiare, Pungaere, Weta) were modified to reduce sampling error produced through the inadequate representation in the reference matrix of the Northland sources. To reduce the sampling error, which resulted in incorrect allocations (see Brassey 1985, Brassey & Seelenfreund, 1984), thirty additional source samples were analyzed (samples were obtained from the Otago University Archaeometry Laboratory and Auckland University Anthropology Department comparative collections), and new values calculated for the reference source matrix. The ability of the system to discriminate between the Mayor Island and Northland sources improved. Nonetheless the new set of source material was not obtained by systematic re-sampling of the Northland sources; it is therefore unlikely that the full range of intra source variability is represented in the new sample (ibid.:40). It is probable that source allocations to the Northland sources are still slightly higher. This is only of particular importance for the sites in the Northland area and will be discussed further below when the sourcing results are described. The sourcing program attempts to reject the unknown spectrum as having come from one of the sources in the reference group file against the two and three standard deviation dispersion values for that element in a given source. If the value does not fall within the two or three standard deviation dispersion range for that element it is rejected at a 99 per cent or 95 per cent confidence level.

An additional set of ratios between elements is used to increase the system's power to reject inappropriate sources. Two sets of ratio tests were used, one for the Mayor Island and Northland sources, and one for all other sources. Since both the Mayor Island and Northland sources recorded had low to zero Ba levels, this element could not be used to discriminate between these two sources. Ratios in this case were taken to the Zr peak. All other ratios are taken to the Ba peak. During the actual running of the program for the selection or screening process, each element window value generated is compared element by element with the reference source matrix, first at the 2 sigma dispersion level and then again at the 3 sigma level. If any value beyond the standard range is encountered the source is rejected. It then proceeds to compare the ratio values for those sources which have not been rejected on previous grounds.

The only problem encountered with this method was that due to the variability in surface texture of the obsidian artefacts, the mid-Compton and Rayleigh peaks varied sometimes in range far beyond the mean values expected, as recorded by Bollong (ibid.:89-94).

As a result of this, these spectra were rejected as not belonging to any of the known obsidian sources in the reference group. To overcome this problem, the spectra were examined visually and the proportional peak heights of the different element concentrations were compared. On the basis of this examination they could usually be assigned to a given source.

THE SOURCE UTILIZATION PATTERN

The results of the sourcing procedures are presented in Tables 5.1 to 5.3. Some comment on the sample size is necessary here before interpreting the sourcing results. The small sample size of some of the sourced assemblages can pose a problem. The interpretation of the sourcing results of the sites with a sample size of fewer than 20 pieces is to be taken cautiously. The margin of error for the relative proportion of the sources used at these sites can be as high as ±16 per cent (in the worst cases). In these sites a variation of one or two pieces may change the proportion of sources used quite drastically. Ideally any sample size of fewer than, say, 20 pieces would be discarded for reasons of statistical significance, but this would reduce the number of sites by half; they have therefore to be used with caution. These sites are marked with an asterix in Figures 5.4 to 5.6 and Tables 5.1 to 5.3. For this reason and for comparative purposes the results have been standardized to represent in all cases a sample size of n=20. The standardization procedure does not in itself change the proportions of the sourcing results when they are expressed as percentages. Figures 5.4 to 5.6 graphically represent the percentages of each source of obsidian in the total obsidian analyzed for each site.

TABLE 5.1
SOURCING RESULTS FROM GROUP 3, 350 B.P. TO PRESENT, (EXPRESSED IN NUMBERS OF PIECES)
(Note: Values in brackets equal standarized values to n=20)

SITES	MAY	NOR	N/M	FAN	FAN HUR	FAN GBA	FAN HGB	COR INL	F/H/G C/I	H/G C/I	OTH	UNK	TOT	TOTAL OBSIDIAN
North Island:														
ELLETTS MT.	19 (6.2)	0	7 (2.3)	0	0	0	32 (10.5)	0	0	0	3 (0.9)	0	61	132
HAMLIN'S H.	8 (5.7)	0	4 (2.8)	3 (2.1)	0	0	10 (7.1)	0	0	0	1 (0.7)	2 (1.4)	28	14
HARATAONGA N30/4 *	2 (1.0)	0	0	0	0	1 (5.0)	0	0	0	0	1 (5.0)	0	4	13
MANGAKAWE*	2 (3.3)	1 (1.7)	1 (1.7)	0	0	0	0	0	7 (11.7)	0	0	1 (1.7)	12	27
NGAROTO *	5 (6.5)	0	5 (6.5)	0	0	0	0	0	3 (2.3)	0	1 (1.3)	1 (1.3)	15	27
POUERUA:														
N15/236 *	0	4 (2.0)	0	0	0	0	0	0	0	0	0	0	4	
N15/237 *	0	1 (3.3)	1 (3.3)	4 (13.2)	0	0	0	0	0	0	0	0	6	
N15/255 *	6 (13.2)	2 (4.4)	1 (2.2)	0	0	0	0	0	0	0	0	0	9	117
N15/501	9 (7.5)	13 (10.8)	2 (2.4)	0	0	0	0	0	0	0	0	0	24	
N15/505	4 (1.6)	33 (13.5)	2 (1.2)	6 (2.5)	1 (0.4)	0	0	0	1 (0.4)	2 (0.8)	0	0	49	
N15/507	5 (3.2)	19 (12.3)	6 (3.9)	0	1	0	0	0	0	0	0	0	31	
RAGLAN N64/18	48 (11.9)	2 (0.5)	18 (4.4)	2 (0.5)	0	0	0	0	2 (0.5)	0	9 (2.2)	0	81	81
SKIPPER'S RIDGE II	49 (9.3)	1 (0.2)	18 (3.4)	0	0	0	0	0	30 (5.7)	0	0	7 (1.3)	105	305
WAIHORA	0	0	0	0	20 (2.2)	0	64 (7.1)	23 (2.6)	57 (6.3)	0	0	16 (1.8)	180	321
WHAKAMOENGA LEVEL 2	0	0	0	6 (2.0)	2 (0.6)	5 (1.6)	12 (3.9)	1 (0.3)	13 (4.2)	4 (1.3)	2 (0.6)	18 (5.9)	61	433
WHAKAMOENGA LEVEL 4	0	0	0	3 (1.3)	1 (0.4)	1 (0.4)	13 (5.4)	0	10 (4.2)	2 (0.8)	0	16 (6.7)	48	237
WHANGAMATA MIDDEN A	7 (3.9)	0	4 (2.2)	2 (1.1)	2 (1.1)	1 (0.6)	5 (2.8)	1 (0.8)	9 (5.0)	5 (2.8)	0	0	36	36
South Island:														
LONG BEA *	0	0	0	1 (5.0)	0	0	1 (5.0)	0	2 (10.0)	0	0	0	4	32
MURDERIN *	3 (6.0)	0	0	0	0	0	0	0	7 (14.0)	0	0	0	10	13
PEKETA *	1 (4.0)	0	0	0	1 (4.6)	0	0	1 (4.0)	0	2 (8.0)	0	0	5	8
TOTALS	168	76	69	27	28	8	137	26	141	15	17	61	773	

TABLE 5.2
SOURCING RESULTS FROM GROUP 2, 630 B.P. TO 350 B.P. (EXPRESSED IN NUMBERS OF PIECES)
(Note: Values in brackets equal standarized values to n=20)

SITES	MAY	NOR	N/M	FAN	FAN HUR	FAN GBA	FAN HGB	COR INL	F/H/G C/I	H/G C/I	OTH	UNK	TOT	TOTAL OBSIDIAN
North Island:														
AOTEA	26 (20.0)	0	0	0	0	0	0	0	0	0	0	0	26	43
HAHEI	153 (7.8)	8 (0.4)	51 (2.6)	9 (0.5)	0	0	17 (0.9)	22 (7.8)	131 (6.7)	0	1 (0.1)	0	392	3470
HARATAONGA N30/3	1 (0.4)	0	2 (0.7)	18 (6.4)	0	6 (2.1)	22 (7.8)	3 (0.2)	0	0	0	4 (1.4)	56	171
HOT WATER	33 (3.5)	4 (0.4)	14 (1.5)	0	0	0	0	0	112 (11.8)	0	4 (0.4)	34 (3.5)	200	1182
KAURI POINT SWAMP	161 (12.9)	10 (0.8)	44 (3.5)	0	0	0	3 (0.2)	0	0	0	0	31 (2.5)	249	>5000
KOREROMAI-WAHO *	4 (13.2)	0	0	0	2 (6.6)	0	0	0	0	0	0	0	6	6
MAIORO 2	60 (10.3)	0	0	0	0	0	56 (9.6)	0	0	0	0	0	116	116
PAREMATA *	9 (11.3)	1 (1.3)	2 (2.5)	0	0	0	0	0	1 (1.3)	0	0	3 (3.8)	16	226
STATION BAY N38/30 *	3 (5.4)	0	0	1 (1.8)	0	3 (5.4)	3 (5.4)	0	0	1 (1.8)	0	0	11	26
STATION BAY N38/37 *	0	0	0	0	0	0	2 (2.0)	0	0	0	0	0	2	34
SUNDE *	2 (8.0)	0	1 (4.0)	1 (4.0)	0	0	0	0	0	0	1 (4.0)	0	5	6
TAIRUA	92 (10.6)	6 (9.2)	49 (5.7)	0	0	0	0	0	14 (1.6)	0	0	14 (1.6)	173	250
WHANGAMATA MIDDEN B *	4 (11.4)	0	1 (2.9)	1 (2.9)	1 (2.9)	0	0	0	0	0	0	0	7	82
WHAKAMOENGA LEVEL 1A	0	0	0	3 (1.3)	0	0	11 (4.6)	1 (0.4)	9 (3.8)	7 (2.9)	0	17 (7.0)	48	244
WHAKAMOENGA LEVEL 1B	0	0	0	7 (3.3)	4 (1.9)	2 (0.9)	11 (5.1)	0	0	0	1 (0.5)	16 (7.4)	43	
South Island:														
CLARENCE *	1 (20.0)	0	0	0	0	0	0	0	0	0	0	0	1	5
HEAPHY RIV	58 (17.0)	2 (0.6)	0	0	0	0	0	0	0	0	1 (0.3)	8 (2.3)	69	77
HOUHOUPOU *	1 (2.5)	0	0	0	0	0	0	1 (2.5)	0	5 (12.3)	1 (2.5)	0	8	9
POUNAWEA *	3 (15.0)	0	0	0	0	0	0	1 (5.0)	0	0	0	0	4	10
PURAKANUI	6 (5.7)	0	0	2 (1.9)	3 (2.8)	4 (3.8)	1 (0.2)	0	2 (1.9)	0	0	3 (2.8)	21	38
SHAG POINT	41 (10.5)	4 (1.0)	1 (0.3)	10 (2.6)	5 (1.3)	1 (0.3)	4 (1.0)	1 (0.3)	3 (0.8)	0	2 (0.5)	6 (1.5)	78	78
TAHUNANUI	67 (7.3)	3 (0.3)	15 (1.6)	49 (5.4)	10 (1.1)	14 (1.5)	14 (1.5)	3 (0.3)	7 (0.8)	0	1 (0.1)	0	183	566
TAI RUA *	4 (8.0)	0	0	1 (2.0)	0	0	1 (2.0)	4 (5.0)	0	0	0	0	10	14
TIMPENDEA *	2 (2.0)	0	0	0	0	0	0	0	0	0	0	0	2	11
TITIRANGI *	2 (2.0)	0	0	0 (0.0)	0	0	0	0 (0.0)	0 (0.0)	0	0	0	2	5
TOTALS	733	38	180	102	25	30	145	36	2798	13	12	136	1728	

TABLE 5.3
SOURCING RESULTS FROM GROUP 1, 630 B.P. AND OLDER (EXPRESSED IN NUMBERS OF PIECES)
(Note: Values in brackets equal standarized values to n=20)

SITES	MAY	NOR	N/M	FAN HUR	FAN GBA	FAN HGB	FAN INL	COR C/I	F/H/G C/I	H/G	OTH	UNK	TOT	TOTAL OBSIDIAN
North Island:														
HARATAONGA N30/5	48 (14.3)	4 (1.2)	8 (2.4)	0	0	0	0	0	6 (1.8)	0	0	1 (0.3)	67	113
HINGAIMOTU	9 (3.9)	1 (0.4)	11 (4.7)	0	0	0	0	0	21 (9.1)	0	1 (0.4)	3 (1.3)	46	99
HOUHORA	191 (12.7)	53 (3.5)	45 (3.0)	0	0	0	0	0	11 (0.7)	0	0	0	300	>3000
MAIORO 1	336 (8.4)	2 (0.1)	0	0	0	0	0	0	459 (11.5)	0	0	0	795	795
PORT JACKSON	* 4 (8.0)	0	0	0	0	0	0	0	4 (8.0)	0	0	2 (4.0)	10	15
RAGLAN N64/16	* 3 (15.0)	1 (5.0)	0	0	0	0	0	0	0	0	0	0	4	16
SK.LAYER 2+	* 4 (6.7)	0	4 (6.7)	0	0	1 (1.7)	2 (3.4)	0	0	1 (1.7)	0	0	12	17
SK.LAYER 3+	* 2 (10.0)	0	1 (5.0)	0	0	0	0	0	0	0	0	1 (5.0)	4	4
TOKOROA	156 (11.6)	10 (0.7)	76 (5.6)	0	0	0	0	0	14 (1.0)	0	0	14 (1.0)	270	510
South Island:														
AVOCA	* 2 (20.0)	0	0	0	0	0	0	0	0	0	0	0	2	20
HAWKSBURN	25 (20.0)	0	0	0	0	0	0	0	0	0	0	0	25	40
LONG BEA.+	* 1 (6.7)	0	0	0	0	0	0	0	1 (6.7)	0	0	1 (6.7)	3	4
LONG BEA.++	* 5 (9.1)	1 (1.8)	1 (1.8)	0	0	0	0	0	3 (5.4)	0	0	1 (1.8)	11	-
PAHIA	* 2 (13.3)	0	0	0	0	0	0	0	0	1 (6.7)	0	0	3	2
REDCLIFF	68 (15.8)	1 (0.2)	5 (1.2)	3 (0.7)	0	0	0	0	7 (1.6)	0	0	2 (0.5)	86	99
SHAG RIVER	14 (5.6)	1 (0.4)	6 (2.4)	0	1 (0.4)	0	1 (0.4)	2 (0.8)	7 (2.8)	0	0	3 (1.2)	35	19
TITIRANGI S	* 2 (8.0)	0	0	1 (4.0)	0	0	0	1 (4.0)	1 (4.0)	0	0	0	5	26
TIWAI POINT	69 (15.9)	7 (1.6)	5 (1.1)	1 (0.2)	0	0	0	0	0	0	0	5 (1.1)	87	148
WAIMATAITAI	* 1 (20.0)	0	0	0	0	0	0	0	0	0	0	0	1	2
WAIRAU BAR	* 8 (14.5)	2 (3.6)	0	0	1	0	0	0	0	0	0	0	11	11
WAITAKI RIV	21 (16.8)	2 (1.6)	1 (0.8)	0	0	0	0	0	0	0	0	1 (0.8)	25	25
TOTALS :	971	85	163	5	2	1	3	3	534	2	1	34	1802	

Note:
+ SKIPPERS RIDGE (OPITO) N40/7
+ LONG BEACH LAYER 4
++LONG BEACH UNPROVENANCED

Key to abbreviations in Tables 5.1. to 5.3.

*	= sample size less than n=20
May	= Mayor Island sources
Nor	= Northland sources
N/M	= Northland or Mayor Island sources
FAN	= Fanal Island
FAN/HU	= Fanal Island or Huruiki sourced
FAN/GBA	= Fanal Island or Great Barrier sources
FAN/HU/GBA	= Fanal Island, Huruiki or Great Barrier Island sources
COR/INL	= Coromandel or Inland sources
F/H/G/C/I	= Fanal Island, Huruiki, Great Barrier, Coromandel or Inland sources
H/G/C/I	= Huruiki, Great Barrier, Coromandel or Inland sources
OTH	= assigned to non-New Zealand sources
UNK	= source unkown

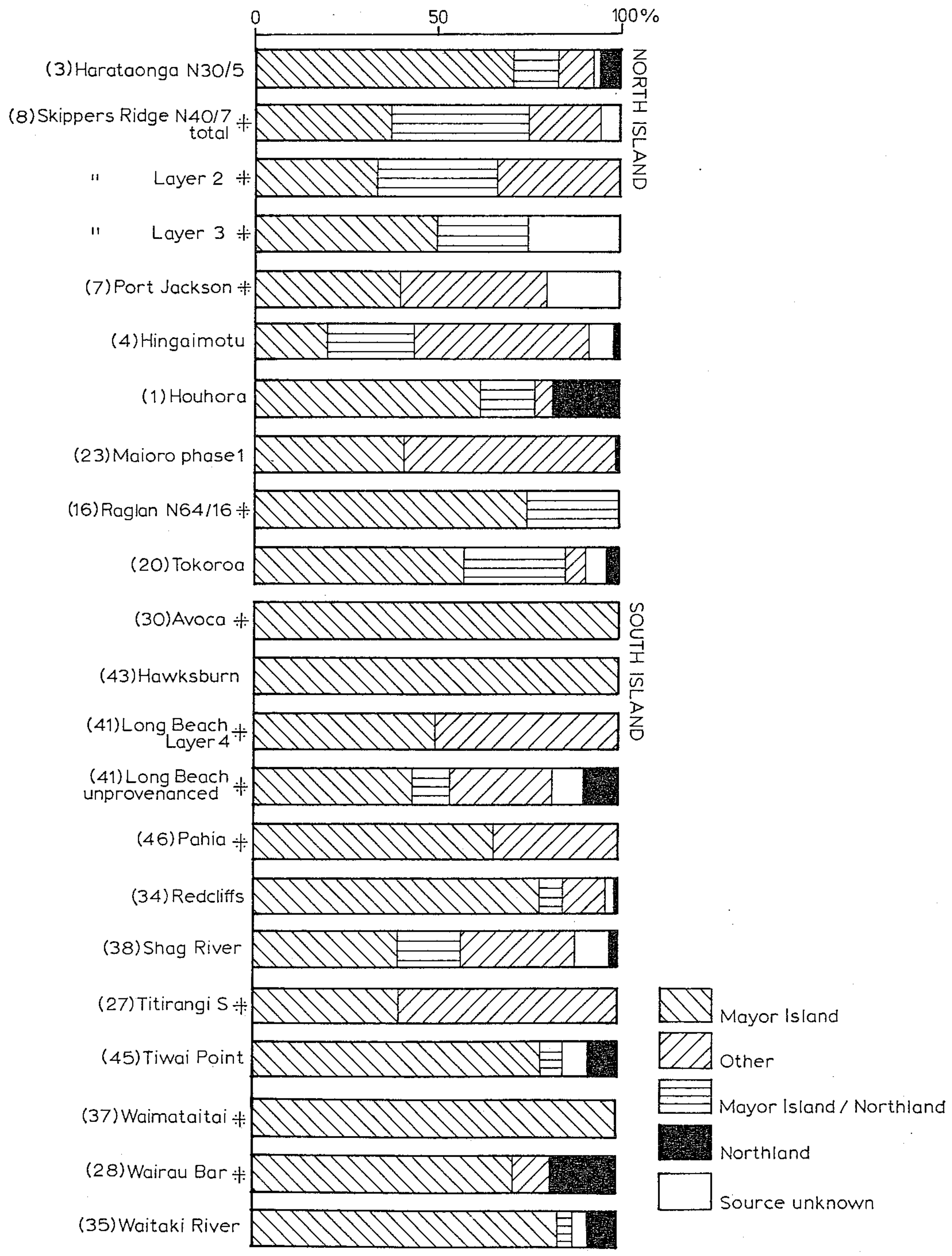


Figure 5.4.: Sourcing results in percentages for all sites analyzed, Group 1 630 B.P. and older

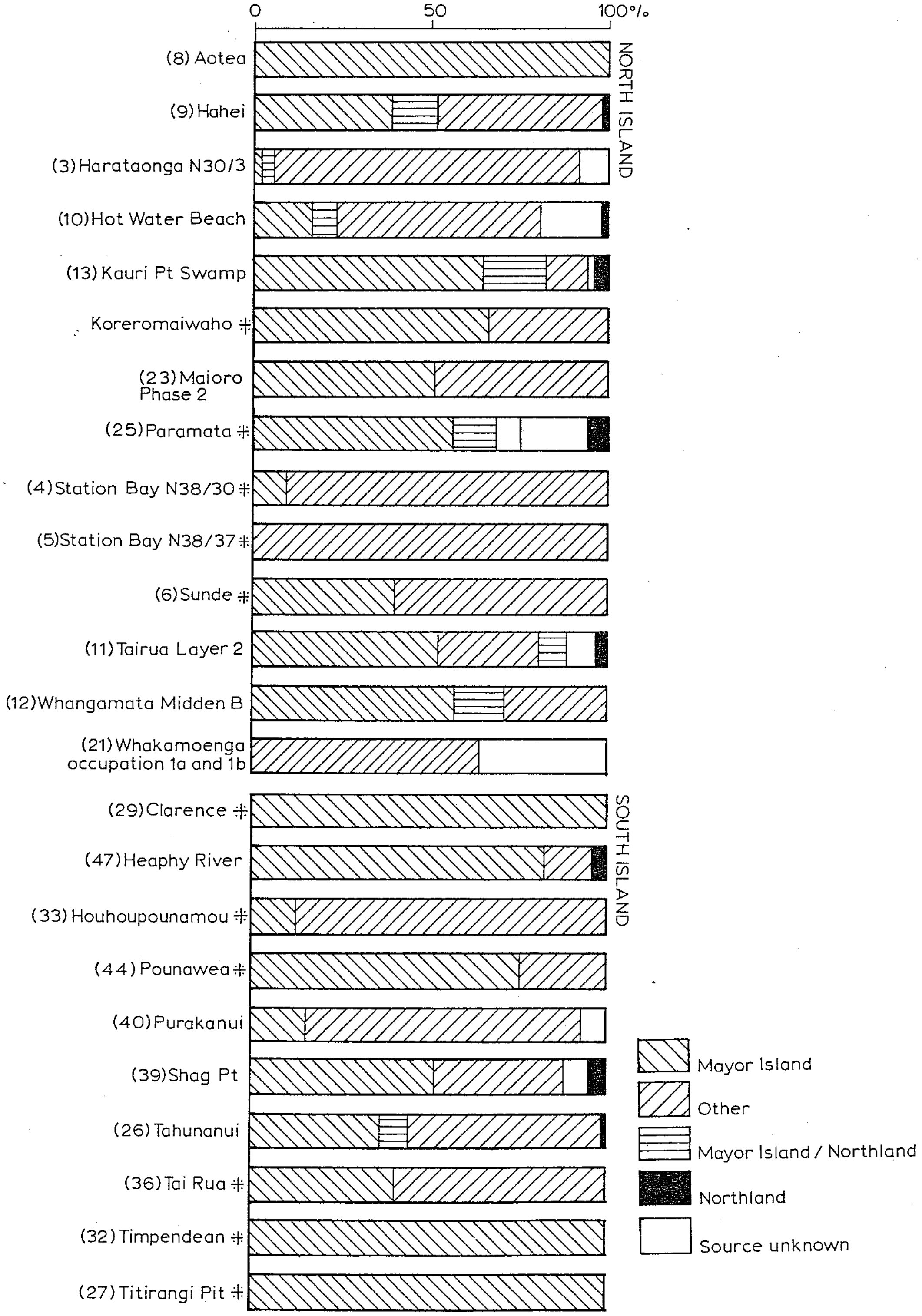


Figure 5.5.: Sourcing results in percentages for all sites analyzed, Group 2 630 B.P. to 350 B.P.

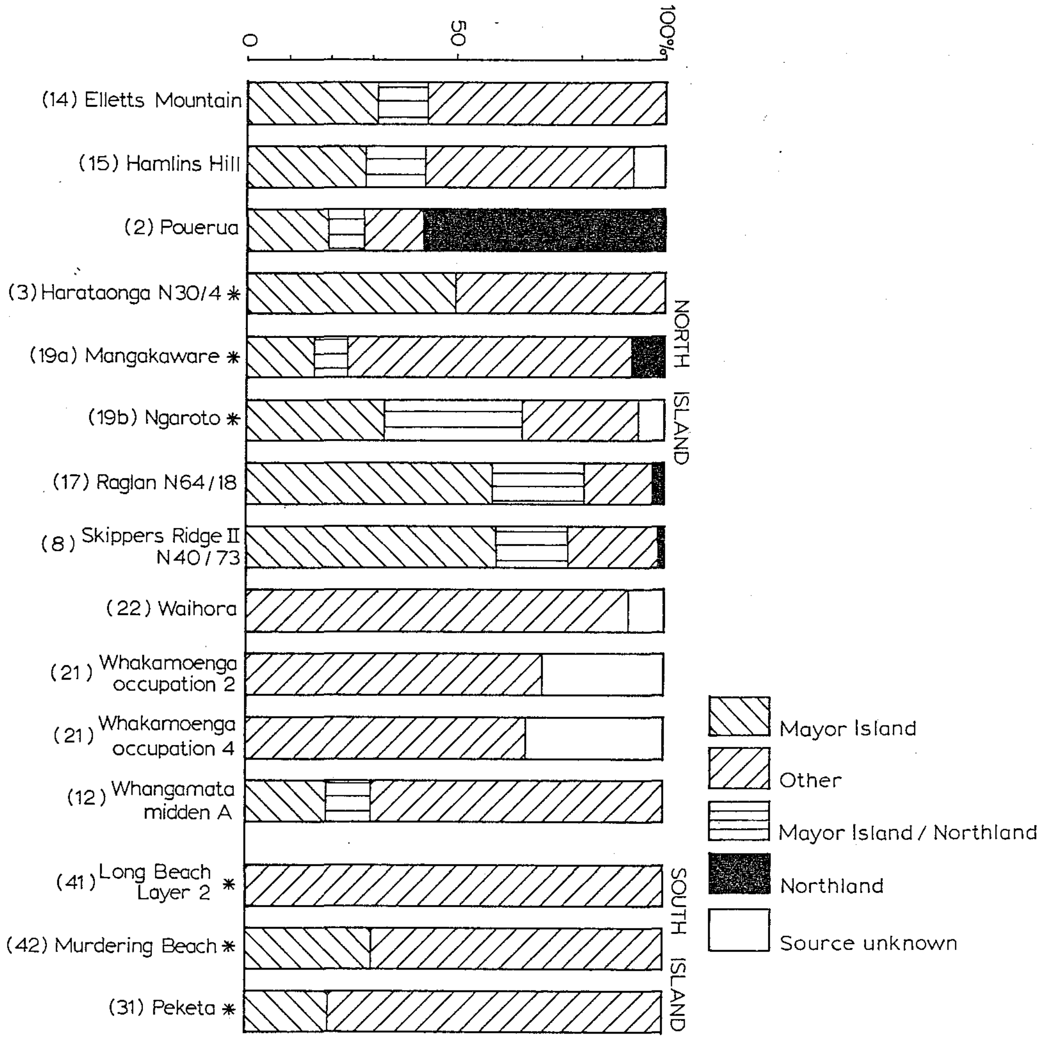


Figure 5.6.: Sourcing results in percentages for all sites analyzed, Group 3 350 B.P. to present

TEMPORAL VARIABILITY

The results of the sourcing show a large range of variability in the percentages of different sources used in the various sites. The percentage of Mayor Island obsidian in the total assemblages varies from zero to 100 per cent. Inspection of the sourcing results show that at most sites more than a single obsidian source was employed.

Group 1

The source utilization patterns from the early sites (earlier than 630 B.P.) show that for the most part Mayor Island obsidian was employed. The proportions from various sources in the assemblages range from 20 to 100 per cent. The use of sources other than Mayor Island is more common in the North Island sites. The widespread distribution of obsidian from the Northland area is of interest. Although the proportions of Northland obsidian are low (maximum 18 per cent) the obsidian is present in 58 per cent of the early sites, compared to only 33 per cent and 20 per cent of the middle and late period sites respectively. The proportion of Northland obsidian outside its area of natural occurrence, at sites as distant as Wairau Bar in the South Island, is also of interest. It is as high in this site (2 out of 11) as at Houhora (53 out of 300), which is only a few kilometres from the source.

Group 2

The proportion of material from alternative sources to Mayor Island, in Group 2 sites (630 to 350 B.P.), is quite marked in comparison to Group 1. A number of sites containing obsidian do not have any material from the Mayor Island sources. The percentage of Mayor Island obsidian in the total obsidian assemblage from North Island sites decreases in general to about 70 per cent in this period and is replaced by obsidians from the Coromandel, Auckland, Great Barrier Island and Inland sources. In the South Island, on the other hand, the proportions of Mayor Island obsidian are still as high as 100 per cent in some sites, (but see significance of proportions in small samples above) although overall the introduction of alternative sources becomes quite marked in this time group. Sources other than Mayor Island and Northland comprise up to 85 per cent of the obsidian of some assemblages.

Group 3

The predominance of Mayor Island obsidians observed in the early period sites disappears in the late sites (350 B.P. to the present). The pattern of source utilization becomes increasingly varied and Mayor Island obsidian only represents at most 67 per cent of the total obsidian sourced. In most cases though, its presence is limited to about 30 per cent or even less. The presence of other sources is particularly striking in the South Island sites, where obsidian from other sources now dominates. The increase in the proportions of stone from sources other than Mayor Island is probably due to the proximity of some sites to alternative obsidian sources. For instance, the Pouerua sites contain a high proportion of stone from the nearby Kaeo sources, and the Waihora and Wahakamoenga Cave sites contain exclusively obsidian from the nearby Taupo sources. Mayor Island obsidian seems to have been preferred over obsidian from other sources, except when an alternative source was noticeably closer than Mayor Island. This is the case for sites such as Ellett's Mountain, Whangamata, and Harataonga. The proportions of Northland sources (Kaeo, Waiare, Weta) remains consistently low or absent outside the immediate area of origin. The obsidian from the Northland sources contains a relatively high occurrence of phenocrystic inclusions and its flaking quality is not as high as that of Mayor Island obsidian or some of the other sources (Brassey 1985:134-135). As Brassey (ibid.) has proposed, it is therefore possible that other sources would have been preferred to the Northland sources outside their immediate area.

SOURCE UTILIZATION AND SITE FUNCTION

Since the sites used in this study are functionally variable, it may be useful to investigate the source use pattern in relation to site function. The sites studied here represent at least five different functional categories:

1)open undefended sites
2)temporary hunting camps
3)defended sites
4)lithic workshops
5)special purpose sites

The ascription of sites to certain types can be ambiguous, as archaeological sites were often used for multiple purposes. The interpretation as to what the main activities carried out at each site were can be debatable. For the present classification, the evidence from the published reports was used to define the specific assignation of each site to any of the categories. At some sites several differential activity areas have been isolated, and therefore the present classification may be subject to discussion by other researchers. Categorization of the site types is summarized in Table 5.4. Examination of the source utilization pattern shows that the proportions of different types of obsidian are affected by the different function of the site.

TABLE 5.4.

Classification of sites by site function

OPEN SETTLEMENTS	TEMPORARY CAMPS	DEFENDED SETTLEMENTS	WORKSHOPS	SPECIAL SITES	
Hamlin's H.	Waihora	Ellett's Mt.			
Murdering B.	Whakamoenga	Mangakaware			G
Harataonga-		Peketa			R
N30/4		Ngaroto			O
Skippers R.		Raglan N64/18			U
Pouerua					P
Whangamata					
Long Beach					1
Aotea	Whakamoenga	Koreromaiwaho	Tahunanui	Kauri Pt	
Hahei	Timpendean	Maioro		Swamp	G
Hot Water B.	Tai Rua	Harataonga-			R
Paremata	Houhoupou-	N30/3			O
Station Bay	namou				U
N38/30					P
Station Bay					
N38/37					2
Sunde					
Tai Rua					
Whangamata					
Clarence					
Purakanui					
Shag Point					
Pounawea					
Heaphy R.					
Titirangi S.					
N30/5	Raglan		Titirangi		
Hingaimotu	N64/16		Tiwai Pt		G
Houhora	Tokoroa				R
Maioro	Hawksburn				O
Port Jackson	Pahia				U
Skippers Rid	Waimataitai				P
N40/7					
Redcliffs					3
Avoca					
Shag River M					
Long Beach					
Waitaki R.					
Wairau Bar					

In Group 1 (630 B.P. and older), open settlements, temporary camps and workshops are represented. Temporary camps show an overall higher proportion of Mayor Island obsidian than, for example, the more permanent open settlements (a range of 58 per cent to 100 per cent with a mean value of 80 per cent, compared to a range of 20 per cent to 100 per cent with a mean percentage of 58.4 per cent in open settlements). By weight the percentage of Mayor Island obsidian in the temporary camps is also higher (mean=66.4 per cent) while at the more permanent open settlements the percentage expressed by weight is lower (mean=58.7 per cent) (Table 5.5). The two lithic workshops represented in Group 1 sites (Titirangi and Tiwai Point) have very different proportions of obsidian sources. While only two source groups are represented at Titirangi (Mayor Island and Fanal/Huruiki/ Great Barrier obsidian), at Tiwai Point, Northland and Fanal Island/ Huruiki sources are represented, in addition to the Mayor Island source material.

In terms of total weight of material, obsidian is found only in large quantities at Houhora, Harataonga (N30/5) and at Tokoroa (Table 5.5). These three sites have the overall highest quantities by weight of obsidian regardless of source provenance. The first two sites represent undefended settlements while Tokoroa is a temporary moa hunter camp. The quantity of Mayor Island obsidian, for example, in itself is only substantial at Houhora (about 1.5 kg of material in the analyzed sample, representing an approximate volume of 600 cc). The material from both Harataonga (N30/5) and Tokoroa could represent, at the most, obsidian struck from three or four average sized cores. The total weight of the obsidian from the remaining sites ranges from a few grams to about 200 to 300 grams. The quantities of obsidian found both at Tiwai Point (n=148) and Titirangi (n=24) are extremely small especially as it is considered that both sites are specialized sites primarily dedicated to the manufacture of lithic artefacts. The quantity of Mayor Island obsidian, for example, while dominant at Tiwai Point, is only 440 grams, which represents one or two small sized cores of an approximate volume of 177 cc.

Quantities of obsidian from sources other than Mayor Island are small at temporary hunting camps. At these sites one, or at most, two sources are represented. It is probable that the obsidian recorded from these sites can be traced to two or three cores. Northland obsidian is found only at Tokoroa and only in small quantities in this class of sites. Northland material is not represented at all in hunting sites of the South Island.

TABLE 5.5

Total weight (g) of obsidian from analyzed sites

SITE	TOTAL WEIGHT OF ALL OBSIDIAN (g)	TOTAL WEIGHT MAYOR ISLAND OBSIDIAN (g)
GROUP 3 (350 B.P. to present)		
Ellett's Mt	275	54
Hamlin's H.	102	24
N30/4	14	9
Mangakaware	102	19
Ngaroto	152	16
Raglan N64/18	292	287
Skipper's Ridge I	796	-
Waihora	3235	-
Whakamoenga Cave	758	159
Whangamata	720	-
Long Beach	9	8
Murdering Beach	6	1
Peketa	14	-
GROUP 2 (630 B.P. to 350 B.P.)		
Aotea	126	112
Hahei	1495	574
Harataonga N30/3	311	11
Hot Water Beach	2903	247
Kauri Point Swamp	2187	1146
Koreromaiwaho	14	14
Maioro	123	72
Paremata	700	39
Station Bay N38/30	47	10
Station Bay N38/37	10	-
Sunde	29	8
Tairua	870	407
Whakamoenga Cave	391	-
Whangamata	39	28
Clarence	6	3
Heaphy	703	580
Houhoupounamu	23	6
Pounawea	14	7
Purakanui	41	2
Shag Point	260	126
Tahunanui	662	214
Tai Rua	93	27
Timpendean	8	8
Titirangi Pits	6	-

(Table 5.5. continued)

SITE	TOTAL WEIGHT OF ALL OBSIDIAN (g)	TOTAL WEIGHT MAYOR ISLAND OBSIDIAN (g)
GROUP 1 (630 B.P. and older)		
Harataonga N30/5	345	307
Hingaimotu	217	93
Houhora	2292	1476
Maioro 1	604	215
Port Jackson	28	5
Raglan Archaic	67	13
Skipper's Ridge II	84	19
Tokoroa	2402	1167
Avoca	9	6
Hawksburn	29	28
Long Beach	6	3
Pahia	8	6
Redcliffs	534	394
Shag River Mouth	233	133
Titirangi	20	4
Tiwai Point	441	325
Waimataitai	0.4	0.4
Wairau Bar	48	40
Waitaki River Mouth	270	21

The sites of Group 2 (630 B.P. - 350 B.P.) include open settlements, temporary hunting camps, defended settlements, workshops and one special purpose site associated with a defended settlement. This last one, represented by the Kauri Point Swamp assemblage, has been interpreted as having a special ceremonial character (Shawcross 1964, 1976). The proportions of Mayor Island obsidian in the different site types is varied; no real pattern can be observed. Although, for example, temporary hunting camps seem to have a slightly higher percentage of Mayor Island obsidian, the variation is large within the sites and too few sites are represented in the sample to draw definite conclusions. The mean percentage, by weight, of Mayor Island obsidian in temporary camps is 54.7, compared to 29.83 in open settlement sites and 53.8 for the defended settlements. The defended sites use a smaller range of obsidian sources, although again, due to small sample size some of these patterns may be misleading. For example, less obsidian is found at smaller hunting camps, therefore it is not surprising that fewer obsidian sources are represented. From the observed pattern, it does appear that a larger range of obsidian sources was employed at open settlements than at the hunting camps. It is possible to assume that a hunting party might carry one or two cores of obsidian to strike flakes as needed and therefore a smaller variety of sources would be represented at these sites, compared to the more permanent ones (both defended and undefended), where the full range of sources available to a certain group might be expected to be found.

Group 3 (350 B.P. to present) sites include open settlements, temporary camp sites and defended settlements. The defended settlements show a very uneven distribution of sources. No general pattern of differential obsidian use between open settlements and defended settlements can be observed in this group of sites. On the other hand, the two temporary hunting camps represented in the sample both utilize the local materials in favour of stone from further afield. The two sites (Waihora and Whakamoenga Cave) were occupied temporarily and only obsidian from nearby local sources is found at these sites.

SUMMARY AND CONCLUSIONS

In summary, obsidian from 58 archaeological sites was sourced. The sites included hunting camps, workshops, undefended and defended sites, and special purpose sites. In order to carry out time trend analysis, the sites were divided into three chronological groups. Sourcing results showed that temporal variations existed in source utilization.

From the source utilization pattern it can be noted that although Mayor Island obsidian was the most popular obsidian to be used in the early sites all over New Zealand, other sources were also exploited, to a lesser degree, during this time. The sourcing evidence indicates that the earliest settlers in New Zealand soon learned of most of the available sources present in the country, and that, although their location was known, some of these sources appear only to have been utilized occasionally. Mayor Island obsidian appears to have been the preferred material; this may well be explained in terms of its excellent flaking quality, although central location may have been a factor.

The increase in the use of other sources in later periods is apparent from the examination of the source utilization patterns from Group 2 sites (630 to 350 B.P.) and Group 3 sites (350 B.P. to the present), (see Figures 5.4 to 5.6). The use of sources other than Mayor Island seems to increase when the other sources are close at hand and are of good quality. The changes in the source utilization pattern may reflect increasing difficulty in obtaining materials from Mayor Island, particularly in the North Island.

Some ties between people of the South Island and North Island seem to have existed in early times, particularly as reflected by the presence of Northland materials in the South Island (for example at Wairau Bar and Tiwai Point), although Davidson (1984:197) argues that people did not know where their raw material came from. These seem to have been maintained through to the middle period. The increased use of other sources in the South Island appear only during the late period. In the middle period, (Group 2), people of the North Island used less Mayor Island obsidian, but in the South Island maintained the dominant use of Mayor Island obsidian until later in the sequence, although local differences are observed. For example, at sites such as Maioro in the North Island, the use of Mayor Island obsidian increases in proportion through time. A similiar situation was observed by Leach (1976) at the Washpool sites in Palliser Bay.

As suggested by other authors (Prickett 1975) the increase in warfare and territoriality during the later period probably made it more difficult to obtain materials from areas previously exploited. Possible restrictions on travel through certain territories might have encouraged the use of different or non-traditional sources.

The source utilization pattern differs according to the function of the sites. The pattern found indicates that at temporary hunting camps a small number of sources was employed. In general, only one source is represented at these sites. This pattern is observed in all three groups of sites from the early to late periods. The use of Mayor Island obsidian appears also more frequent at temporary hunting sites, particularly during the early period. These patterns tend to fade out during later times. Particularly in the late sites (350 B.P. to the present) no real pattern of differential source utilization between defended and undefended settlements can be distinguished.

The following Chapter will look in more detail at the use and geographical distribution of Mayor Island obsidian in a regional perspective.

CHAPTER VI

A REGIONAL ANALYSIS OF NEW ZEALAND OBSIDIAN

INTRODUCTION

The present chapter has three main objectives: to describe the prehistoric distribution of obsidian in New Zealand; to analyse the procurement strategies in light of the available data; to integrate these data with the available theoretical body on mechanisms of exchange and procurement of raw materials.

The study is focused on a regional perspective and through the quantitative analysis of the data collected, it should be possible to analyze prehistoric obsidian use in New Zealand prehistory. With the analysis of artefact distribution and the relationship between abundance and distance from the source, the different variables which affect regional exchange networks will be evaluated and tested. The quantitative analysis of the obsidian data is used to isolate patterns that could provide an understanding of the mechanisms of exchange involved.

MATHEMATICAL MODELLING OF REGIONAL EXCHANGE

Mathematical models have been applied to the study of regional exchange networks in the expectation of isolating variables affecting exchange, and to provide indications towards the nature of these networks. Renfrew discussed the hypothetical relationship between exchange types and the abundance of a given item in a series of articles (1975; 1977a). In his most recent detailed article on the subject, Renfrew proposed a number of models to predict classes of archaeologically identifiable trading mechanisms: down-the-line, reciprocal exchange, directional trade or central place distribution, prestige chain trade and free lance trade. His proposition that each of these types of exchange could be described and identified by a characteristic and specific type of curve was shown by Hodder (1978) to be ambiguous, as several different types of exchange could be described by the same fall-off curve.

Renfrew proposed four fall-off patterns (Figure 6.1) which ideally could each identify a different type of exchange. By plotting distance on one axis and abundance on the other axis, the resulting patterns could be compared with his proposed curves and the type of exchange involved could be identified. The shape and steepness of the fall-off curves would be characteristic of a certain exchange process. Down the line exchange. for example, would be described by an exponential fall off, where the area around the source - the supply area - would show a small slope, followed by a steep sloped fall-off, which is described as the "contact zone ". Renfrew found that this pattern best described the obsidian distribution of Anatolian obsidian in the Near East (Renfrew, Cann, and Dixon 1968:44-45; Renfrew 1972:465). The exponential fall-off observed, which was related to distance, was interpreted as a reflection of down-the-line exchange, where the consumer obtains its supplies of the commodities from another community somewhat closer to the source, which in turn obtained it from another neighbour closer to the source. The proportion passed on was estimated at 1/2 to 2/3 of the goods acquired.

This process was described mathematically by Renfrew using the exponential formula of

$$Y=K^{x/1}\cdot N$$

where 1 is the distance between villages and Y is the percentage of the traded item received at the distance x outside the supply zone; N, is the proportion at the edge of the supply zone, and K the proportion of the goods which is passed on to the next community (1975:47).

In directional trade, graphically described by Renfrew as in Figure 6.1(d), the fall-off curve is distorted by sudden peaks representing centres of secondary distribution. Central place market exchange would essentially produce the same picture. In a prestige chain exchange system the drop-off in the contact zone is attenuated. This slope would be expected if the exchanged good were a very valuable item, though exchanged under conditions of reciprocity. In contrast to the above, free lance trading is described by Renfrew (1972:468-470; 1975:48-51) by a gradual slope within the sphere of operation of the traders, and a steep and sudden fall-off outside their area of operation (Figure 6.1.(c)).

Hodder conducted a series of simulations to determine which regression model best described the proposed fall-off curves. He simulated a system in which a series of random walks were taken away from a fixed source. He was able to generate a number of fall-off curves which resembled closely Renfrew's down the line predicted fall-off curve (1978:158-164; Hodder and Orton 1976:127-154). By changing the number and length of the randomly taken steps away from the source he concluded that very similar curves could be produced by simulating different conditions in the random walk processes. The simulation study provided also

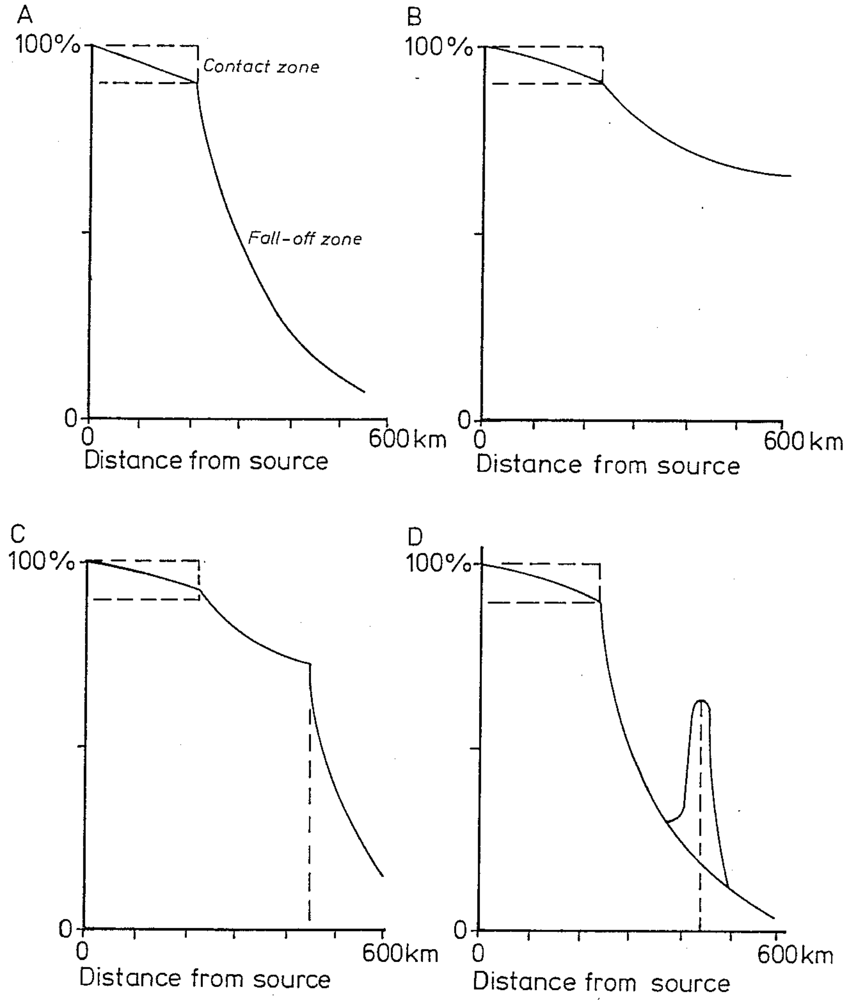


__Figure 6.1.:__ Predicted Fall-off curves for different types of exchange (after Renfrew 1972).

interesting information in relation to the shape of the fall-off curve. Hodder notes that there was a positive relationship between convexity of the fall-off curve and length of the steps taken, and a very concave curve was associated to a small number of very short steps in the random walk (Hodder 1978:159; Hodder and Orton 1976:142,145).

Hodder also found that the value of exponent alpha in the equation

$$\text{Log } Y = a - b^{\alpha} + c$$

used to describe the fall-off pattern produced by each of the random walks, was the most sensitive index when step lengths and number of steps were modified. High alpha values were associated with convex curves. In a previous study Hodder had calculated a regression model that best fits certain classes of archaeological goods by finding the standard error associated with all exponential equations in which the alpha values varied from 0.1 to 2.5. The equation with the lowest standard error was defined as the best fit model. The analysis of archaeological case studies showed that goods with low associated values, bulky objects or those whose dispersal range away from the source was small were best described by equations where the alpha values varied between 0.1 and 0.6. On the other hand, alpha values between 0.9 and 2.5 best fitted objects exchanged over long distances and which were highly valued goods (Hodder 1974:179-183; 1978:164; Hodder and Orton 1976:113). From Hodder's work it is possible to link the shape of a curve to a type of exchange.

From the trends identified by Hodder's study it should be possible to link the shape of the fall-off curve with exchange types and commodity exchanged. The random walk model though is appropriate for all types of exchange excluding direct access, since it does not involve transactions between two communities and therefore in terms of Hodder's model, the number of steps are necessarily small. A steep curve resembling Renfrew's down-the-line exchange was related to a large number of short steps, while a flattened fall-off curve, associated with prestige exchange was associated with an equation with high alpha values created by a small number of large steps (Hodder 1978:159; Hodder and Orton 1976:138-145). It should therefore be possible in an empirical case to predict to a certain point exchange type by the best fit alpha values of the regression equation.

Findlow and Bolognese (1980a;1982) have added another set of predictions for the analysis of distance related fall-off curves. While their analysis is based on Hodder's (1974; Hodder and Orton 1976) work and on Renfrew's (1977a) discussion, their predictions vary. In the first instance they predict that a linear regression model can be used to identify "direct access", whereas the other authors have employed an exponential model where alpha = 0. Findlow and Bolognese (1980a:235; 1982:72-73) recognize that this model is almost equivalent to the linear model, though in cases when it does not fit, the pattern might indicate a different situation with an exponential fall-off from an exceptionally large supply area (1982:74). The prediction that direct access would be best described by a linear model can be justified, since the expected effect of distance on the abundance in the absence of exchange can be expected not to be magnified as distance increases, as it would be if an exponential model were used.

Finally the hyperbolic model proposed by the authors, depicts an exchange system intermediate between a simple linear and an exponential system. In the hyperbolic model the fall-off beyond the supply zone is much more attenuated. This model has not been found to fit most empirical data (Findlow and Bolognese 1980a; 1982).

The use of regression analysis can be useful for identifying prehistoric exchange mechanisms, though the results cannot be taken as final. The biggest problem is that similar curves can be produced by different trading systems. As Hodder has pointed out there is a definite relationship between length of steps, the number of steps from the source of production and the site of consumption with the value of the goods exchanged in the shape of the fall-off curve. However, Hodder suggests the use of other types of analysis, such as surface trend analysis and the detection of spatial autocorrelation (1978:162; Hodder and Orton 1976), instead of more detailed analysis of the fall-off curves in terms of exchange mechanisms, as these can be extremely ambiguous.

Renfrew (1977a) has also pointed out that different trading mechanisms can be present in several types of commercial and non-commercial exchange systems. For example, directional trade can be present both in a redistributive exchange system and market exchange. Other overlap could possibly be found in the free lance trading system, where the fall-off curve could be duplicated either by a commercial system with middlemen transporting the goods or a system of balanced reciprocity. Hodder's solution to this uses more sophisticated methods of analysis which cannot be applied in the New Zealand case, since the data are not available for the sites.

In addition to these problems, Clark (1979) argues that there are a number of other factors, besides the type of exchange, which can modify the alpha exponent, mainly "distributional boundaries associated to special social or economic cultural meanings attached to goods, patterns generated by economic competition between goods, and the size of the supply zone" (1979:186). If regression analysis is to be used to explain and measure prehistoric exchange, Clark argues, the factors causing the variations in alpha have to be controlled either by exploring curves not generated by alpha or alternatively explore situations where the social value and the "nature of economic competition" of the goods is known (ibid.:187). A reexamination of Renfrew's (1977a) hypothesis concerning the predicted alpha values for different kinds of exchange systems, showed that they were not valid when applied to specific examples. Clark (1979:184) argues that additional variables are masking the predicted values. But, because we must first assume that the exchange mechanism is known before testing the ocurrence of the predicted alpha values, his results are not conclusive. It becomes clear from Clark's study that a good deal more study needs to be done to test the validity of either Renfrew's (1977a) or Hodder's (1978; Hodder and Orton, 1976) models.

The use of regression analysis for the New Zealand data can be useful for identifying certain trends in the prehistoric behaviour, and for making an initial set of predictions on aspects of regional exchange, even though it cannot be conclusive. For example, in the absence of any distinct decrease in the quantities of obsidian with distance and low correlation values, directional trade could be invoked. Direct access to the source should be detectable by the shape of the curve where a simple linear model best fits the data. On the other hand, a down-the-line exchange should be more difficult to differentiate from other types, such as free lance trading, though the shape of the curve in the supply zone could be indicative. The quantitative analysis of the New Zealand data in conjunction with the study of the fall-off curves and regression analysis should provide a basis for deducing possible exchange types in operation in prehistoric New Zealand. The use of regression analysis requires a measurement of the abundance of any given goods and a measure of effective distance from the site of production or source of raw material to the place of consumption. The following sections will discuss these aspects, and will be followed by a quantitative analysis of the archaeological data used for this study.

TABLE 6.1.

Test models employed for predicting different modes of exchange.

Model	Mode of Exchange	Reference
Linear Exponential alpha=0	Direct Access Reciprocity	Ericson 1977a;Hudson 1978; Renfrew 1975; Hodder 1978; Hodder & Orton 1976; Findlow & Bolognese 1980a,1980b,1982
Exponential alpha=1 or 2	Down the line	Hodder 1974; Renfrew, Dixon & Cann 1968; Sidrys 1977; Torrence 1981
Exponential alpha=2	Free lance trade (middlemen) Simultaneous exchange systems	Hogg 1971; Renfrew 1977a
Hyperbolic	Development towards complex directional exchange	De Atley & Findlow 1979; Findlow & Bolognese 1982

MEASURE OF DISTANCE

The choice of an effective distance measure in the New Zealand scene has to take into account travel both by land and sea. Torrence's (1981:136) factor of two used to represent the extra cost involved in overland travel was taken arbitrarily. It is not possible to establish the exact routes by which the materials were transported. The ethnographic literature mentions a combination of sea, river and land travel for journeys up and down the country in protohistoric New Zealand. Best (1974:212), for example, records sea voyages from Tauranga to Hastings and Banks Peninsula. Nephrite was often obtained by parties travelling by canoe along the West Coast (Skinner 1912). Firth (1929:432) mentions also that people frequently preferred travel by canoe to overland travel. Although sea travel could be a more hazardous method of transport, it would have been more expedient if sources were to be directly exploited. Overland travel might have been easier, but possibly slower and loads could become cumbersome. Based on ethnographic information a factor can be calculated involving days of travel over a certain distance by sea and overland. This can then be used to calculate a more accurate factor to account for differences in travel costs.

Doran (1976) studied the performance of a single outrigger canoe - *wa* - of the Caroline Islands and the double outrigger canoe, *vinta*, of the Sulu Archipelago. The *wa* canoes commonly perform trips over approximately 300 km and up to approximately 900 km. The *vinta* is mainly used for fishing expeditions on distances up to approximately 1000 km. In their performance he compares them favourably with a modern day trimaran. Performance was measured in terms of speed, progress against wind and speed downwind. Though boat speed was measured, no published information from Doran's study is available.

Research in the Amphlett Islands by Lauer (1976:71-89) showed that distances up to 75 km are covered in about four days or less of sailing. The average sailing speed for the larger sailing outrigger canoes, with mast and sail, called *aidedeya*, is 2.5 knots. His data show that under ideal wind conditions 67 km can be covered in a day's voyage (nine hours) at a speed of about four knots. A distance of 25 to 30 km at a speed of 2.1 to 2.3 knots can take six to seven hours. Paddling is used if winds fail.

For comparable prehistoric European craft such as the *Sutton Hoo* and *Nydam* boats, a rowing speed of three knots (roughly five km per hour) for six hour days is estimated. This makes about 30 km a day. Under sail somewhat faster conditions are experienced. The *St Brennan* a 12 metre long open boat of celtic type - built of hides stretched over wooden frames - averaged only two to three knots crossing the Atlantic. At times it reached five to seven knots for longer periods and occasionally up to 12 knots (Anderson, pers. comm.).

The double canoe built in 1966, the *Nalehi*, a replica of a Hawaiian canoe, can make 16 km an hour sailing at its best performance. The *Hokule'a*, built mainly as a sailing canoe can reach up to 18.5 km an hour. In tradewinds of 27 to 28 km/hr the *Hokule'a* could make approximately 11 km/hr heading at about 70 degrees off the wind (Finney 1979).

Various types of river and ocean going craft were in use in New Zealand at the initial contact period in the first decades of the nineteenth century. The sea and numerous lakes and rivers facilitated movement from one area to the other. A number of types of craft of oceanic origin were used on the rivers, lakes and on the sea. Rafts, dugouts and catamarans were used on lakes and rivers, while dugouts, built-up canoes, double canoes and outriggers were used on the sea (Bathgate 1969).

Some information on the speed of Maori watercraft is available. Governor Grey (Cooper 1851:256-274) in his 1849-50 trip south across Lake Taupo took three and three quarter hours to cross 13 lake miles and three and a half hours to reach a point about 12 miles (19 km) south. This trip was faster than Bidwell's (1841) who took six hours to get from Taupo to Motuere in a dugout canoe.

From this information a speed of about five km/hour can be estimated for the average prehistoric watercraft, with the exception of the large deep sea voyaging canoes, which could probably average about 11 km/hour. A reasonably fit person is able to walk an average of five km/hour, for six hours a day. This agrees with Walter's (n.d., cited in Brassey 1985:130-131) observations on travel rates through light bush. He calculated a rate of 35 km per day. It therefore appears that land travel could almost be as fast as travel by sea, provided reasonable tracks were used, and a direct flat route chosen. However, it was possibly more economical to travel by sea, as larger loads could be carried in a boat.

On this evidence an equal coefficient for overland and sea travel will be used. Certain routes would have been easier covered by sea and vice versa. A number of prehistoric tracks followed river valleys; these would have been navigable at points.

For the purposes of the present work a 'maximum distance' was calculated in favour of a straight line 'minimum distance'. The maximum distance represents a better approximation of the real distance between two places. Most sites used in this study are located on the coast and therefore it is possible to assume that most travel in a North-South direction was carried out by sea. Distance was measured as the most direct sea route between the obsidian sources (Mayor Island) to the archaeological sites. In the case of the inland sites the distance by sea to the nearest river mouth was measured and then the direct distance inland to the site along the river course.

MEASURE OF ABUNDANCE

The techniques for measuring the abundance of obsidian through time, discussed in Chapter III have been used by Renfrew (1977b) to formulate hypotheses about the systems of exchange involved. In the study of the Deh Luran plains he suggests that the changes in the amount of obsidian present can be interpreted as changes in the exchange mechanism which supplied the area. This, he argues, involved a shift from reciprocal exchange to a redistributive economy and reflects, as well, competition between the redistributive centres (Renfrew, 1977b:310; Renfrew and Dixon, 1976:147-149). All other studies have mainly recorded the abundance to monitor the supply of obsidian into the area of study (see Chapter III, Table 3.1).

The authors seem to accept that all sites are functionally similar. However, there will most certainly be a differential supply of raw material to sites fullfilling different functions within an exchange system; supply will be channelled differentially to permanent settlements, hunting camps or religious centers. No definite reference to this problem is made by any of the authors concerned. This problem is of particular importance in New Zealand, where we are dealing with a large variety of sites, including hunting camps, permanent settlements on the coast or inland and fortified temporary and permanent villages. Even if the supply to the area was constant, one cannot expect the absolute abundance to be the same for each of the above functional categories of sites.

Not all measures of abundance used by previous authors are applicable to the New Zealand situation. Obsidian from the New Zealand sites analyzed in this study comprise from 100 per cent to less than ten per cent of the total lithic assemblage. A number of studies have used ratios of obsidian versus pottery or flint to measure the changing patterns within a site at various phases of its occupancy. Finding a measure of abundance applicable to a wide range of sites is more difficult if regional comparisons are to be attempted. Possibly a combination of measurements would be the most applicable in this case.

The recovery techniques and information available on the archaeological sites considered in this thesis vary enormously. For some sites sufficient data are available to calculate an abundance ratio of obsidian versus other flake material, while for other sites very scant and incomplete information is available. The absolute number of obsidian flakes is not a good indicator of obsidian abundance, since it might be affected as discussed earlier by differential recovery techniques and actual size of the excavations. There are two possible artefacts against which the obsidian ratio in this case could be measured: ground stone tools (adzes) and/or all other flaked stone flakes (porcellanite, silcrete, chert). The advantage of using adzes as a comparable element is that they are diagnostic artefacts in New Zealand sites. On the other hand, early site reports often do not record numbers of these artefacts. Finished adzes and adze preforms are often not differentiated, and when they are, this separation can be ambiguous. Flaked stone tools are often not well recorded either, and information on their weight and number is not complete. The scope of this dissertation research did not allow complete re-analysis of all the flake stone tools in the assemblages being studied, in addition to the obsidian. However, enough and better data were available from published excavation reports on quantities of flaked lithic materials than on adzes and adze preforms, and these were used therefore. Table 6.2. presents the data of obsidian (numbers) against the numbers of non-obsidian flakes found in the sites.

Information on the quantity of flaked stone material in the archaeological sites is fragmentary and consequently the percentages of obsidian in the total flaked lithic assemblage cannot be calculated for all sites.

Table 6.2.

Number of obsidian flakes and other lithic flakes in analyzed sites (information from published sources), with percentage of obsidian flakes in flaked stone assemblages, with distance to the nearest source.

Site	Other Flakes	Obsidian Flakes	Percentage Obsidian	Distance to nearest source
Group 3 350 B.P. to present				
Ellett's Mountain	?	132	?	
Hamlin's Hill	-	14	100	220
Harataonga N30/4	2	13	87	145
Mangakaware	?	27	?	
Ngaroto	10	27	73	130
Pouerua	5822	117	20	23
Raglan N64/18	?	74	?	
Skippers Ridge II	-	305	100	75
Waihora	-	321	100	50
Whakamoenga Occupation 2	-	433	100	50
Whakamoenga Occupation 4	-	237	100	50
Whangamata midden A	-	36	100	36
Long Beach	486	32	6	1523
Murdering Beach	?	13	?	
Peketa	?	8	?	

(Table 6.2. continued)

site	other flakes	obsidian flakes	per-centage obsidian	distance to nearest source
Group 2 630 B.P. - 350 B.P.				
Aotea	1	43	98	350
Hahei	7617	3470	31	64
Harataonga N30/3	18	171	90	10
Hot Water Beach	606	1182	69	58
Kauri Point Swamp	-	>5000	100	35
Koreromaiwaho	-	6	100	350
Maioro	-	116	100	230
Paremata	110	226	67	980
Station Bay	?	26	?	
Station Bay	?	34	?	
Sunde	-	6	100	200
Tairua	4	250	98	50
Whangamata	87	82	49	36
Whakamoenga	-	244	100	35
Clarence	?	5	?	
Heaphy River	?	77	?	
Houhoupounamou	?	9	?	
Pounawea	1183	10	1	1620
Purakanui	97	38	28	1524
Shag Point	160	78	32	1484
Tahunanui	15000	566	36	1120
Tai Rua	800	14	2	1440
Timpendean	145	11	7	995
Titirangi	?	5	?	

(Table 6.2. continued)

site	other flakes	obsidian flakes	percentage obsidian	distance to nearest source
Group 1 630 B.P. and older				
Harataonga N30/5	451	113	20	10
Hingaimotu	5	99	95	240
Houhora	494	3000	86	420
Maioro	-	795	100	100
Port Jackson	?	15	?	
Raglan N64/16	?	16	?	
Skippers Ridge	-	17	100	73
Skippers Ridge	-	4	100	73
Tokoroa	-	510	100	180
Avoca	900	20	2	1120
Hawksburn	300	40	12	1920
Long Beach	87	4	4	1524
Pahia	?	2	?	
Redcliffs	2043	99	5	1172
Shag River	?	19	?	
Titirangi	?	26	?	
Tiwai Point (working floor)	1000	148	13	1740
Waimataitai	?	2	?	
Wairau Bar	?	11	?	
Waitaki River	?	25	?	

TECHNOLOGICAL MEASURES

The variety of recovery techniques used on archaeological sites has resulted in an uneven quality in the nature of the data. The percentage of obsidian in the total lithic assemblage is not entirely satisfactory as an index to study exchange. It can be expanded by the inclusion of a technological measure reflecting differences in methods of manufacture of the artefacts. In effect, the technology of obsidian manufacture can be used to examine exchange types. If sites distant to an obsidian source have access to lesser amounts of raw material one would expect the raw material to be treated differently when it is scarce than when it is abundant. As the raw material becomes less plentiful, less wastage of the raw material could be expected and the overall size of the debitage (waste flakes) in the assemblages, could be expected to decrease (cf. Renfrew 1977b:295). Such a re-use and re-working of artefacts should occur where the raw material gets scarce. McBryde and Harrison (1981), Evett (1973), Hughes (1977) and Strathern (1969) have observed both archaeologically and ethnographically a negative relationship between artefact size and distance from the quarry.

Although a general decline in size with increasing distance can be expected for most types of artefacts, several factors can determine the shape of the distance fall-off curve. Artefact size can be determined by factors other than the availability of the raw material, such as functional and stylistic variables imposed by the consumers.

General predictions on the shape of the fall-off curves can be made. For direct access the fall-off curve should be linear, while a down-the-line exchange should cause size to decline exponentially. The use of size alone as an index to measure exchange behaviour poses some other problems. Ammerman (1979:107) has suggested that site function (measured by the form in which the obsidian enters the site) is of key importance in establishing the role of the site in an exchange network. His argument, that only cores and large flakes or blades are found at certain sites, is mainly directed towards identifying site function. He argues that sites a with greater proportion of artefacts in the early stages of manufacture were involved in direct trade with the source, or received the raw material preferentially, and then it was passed on to nearby sites. If Ammerman's hypothesis is extended to the New Zealand data, it could be argued that at permanent base settlements the greater amount of imported raw material would be found, while at temporary camps one would expect a lower number of artefacts in the early stages of manufacture, such as cores and exhausted cores.

The use of size alone as an index to measure exchange behaviour can be severely biased by selective and differential recovery techniques during the excavation of a site. Since there is no way in the present case to allow for variations in sieving and recovery techniques, the assemblages here have been used in their totality. By using the largest possible sample of obsidian it is hoped that the effect of the differences in the context of the excavation of the artefacts will be minimized. Measurements of size have been separated by their stage of manufacture in the reduction sequence. It is hoped in this way that sampling bias due to factors beyond the writer's control can be accounted for. A technological analysis was performed on the sourced Mayor Island obsidian assemblages.

Classification of flakes was based on a reduction sequence of New Zealand obsidian which was worked out on the basis of all available archaeological obsidian. The reduction sequence from raw material to finished tool is presented in Figure 6.2. The raw material in New Zealand appears naturally in basically two different forms:

a) weathered cobbles and boulders

b) natural flows or dykes

The first type is found, for example, at the obsidian deposits of Northland (Kaeo, Pungaere, Waiare), Taupo and Coromandel (Moore 1983, Moore and Coster 1984, Ward 1973). The material appears as cobbles or boulders and can be picked up in river beds, or from bomb deposits and detrital deposits (Ward 1977:183; Brassey 1985:42-43). This obsidian has usually a weathered surface and some natural cortex.

The second type of obsidian deposits is found at Mayor Island, while another obsidian dyke has been reported by Morgan (1927:72) in the vicinity of Kaitaia. Obsidian from these deposits has usually no cortex or badly weathered surfaces.

The initial stages of core preparation differ for each type of obsidian, depending on the presence or absence of cortex on the nodule available. In general, no careful core preparation was carried out before removing flakes from the cores. The flaking approach could probably best be described as 'hit or smash' in order to produce irregular flakes. Such a 'nodule smashing' technique or approach has been recorded also in Mesoamerica (Boksenbaum 1980). Obsidian flakes struck in this way, constitute the larger bulk of the artefact assemblages of the Early and Middle Preclassic. In the nodule smashing technique, two or more flakes are detached simultaneously (ibid.:12-15). The general reduction sequence involves the following steps.

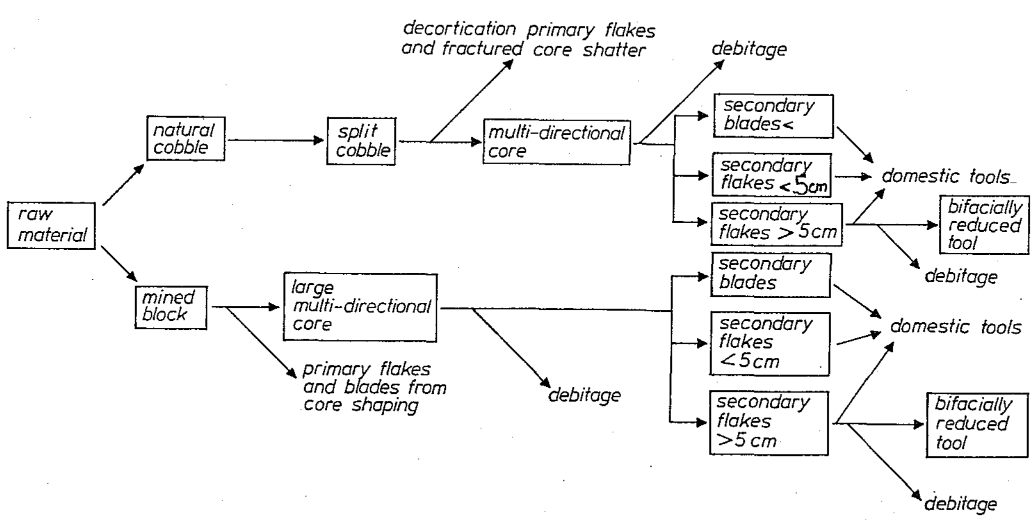


Figure 6.2. : The obsidian reduction sequence

The natural cortex covered cobbles are split to produce a flaking platform flakes may also be removed from the edges. The removal of edge flakes produces a multi-directional core from which further flakes can be struck. From the cores and core fragments it appears that flakes were struck in more than one direction.

Mined blocks do not present cortex, and preparation of these blocks for flake removal may have been minimal. Mining at the quarry site produced a block with a usable shape and possibly striking platform(s) from which the required flakes could be struck.

Flake preparation from both types of core seems to have been identical. Hard hammer percussion flakes were removed from around the core, producing mostly irregular shaped and sized flakes and an occasional parallel sided blade. The lithic artefact assemblages studied from New Zealand archaeological sites are composed mainly of flake tools. These consist primarily of flakes which were modified slightly to produce a workable edge or a flake that was used without edge modification. Eventual additional percussion flaking was applied to the larger flakes to produce more sophisticated bifacial flaked artefacts.

The archaeological obsidian was classified into cores, core fragments, primary flakes, secondary flakes, primary and secondary blades and debitage. Each of these categories is defined below:

Cores: blocks of raw material from which flakes have been struck.

Core fragments: exhausted cores or pieces of cores from which a series of flakes/ blades have been struck, and which cannot be used to produce any further flakes or blades.

Primary flakes: the first flakes removed from the core; they may have cortex on one or more surfaces. They do not show flake scars on their dorsal surface, and are the result of the decortication of the core or its preparation for flake production.

Secondary flakes show few if any remains of the original exterior surface of the core, and have flaking scars on the dorsal surface.

Primary blades (1:2w) are the product of the decortication or shaping of the core and have a portion of the exterior surface of the core. Generally they are struck along a natural straight edge or corner.

Secondary blades do not show any remains of the original outer surface of the core, and have flaking scars on the dorsal surface.

Debitage: waste flakes and chips resulting from the working of the cores at all stages from decortication to secondary flake removal, as well as waste material from flake retouch. They show flake scars on most surfaces.

THE PERCENTAGE OF OBSIDIAN IN THE TOTAL FLAKED LITHIC ASSEMBLAGE

In order to consider the relative abundance and the relationship with distance for each site studied, a separate analysis for each individual source should ideally be carried out. A separate fall-off curve, abundance and technological study should be done for each individual source exploited in prehistoric New Zealand. However, a number of problems are present which make this approach impossible at present.

1) Only Mayor Island obsidian and obsidian from the Northland area can be isolated with any degree of accuracy from the rest of the obsidian assemblages using the present sourcing facilities at Otago University.

2) All other obsidian sources exploited in prehistoric New Zealand cannot be individually identified.

Distance decay curves and other quantitative studies can therefore only be attempted for the Mayor Island and Northland assemblages. Since the proportion of Northland obsidian is so insignificant in the assemblages outside its area of natural occurrence, as discussed in Chapter V, the present analysis will be concentrated mainly on the Mayor Island obsidian component of the assemblages.

Nevertheless, the relative importance of the total obsidian assemblages in the flaked lithic material is briefly considered here. Based on Table 6.2., the percentages of obsidian in the total lithic assemblage were plotted for each of the three groups of sites, against distance from the source with the highest representation in the assemblage. When these were sources other than Mayor Island or Northland, the distance to the closest alternative obsidian source was taken.

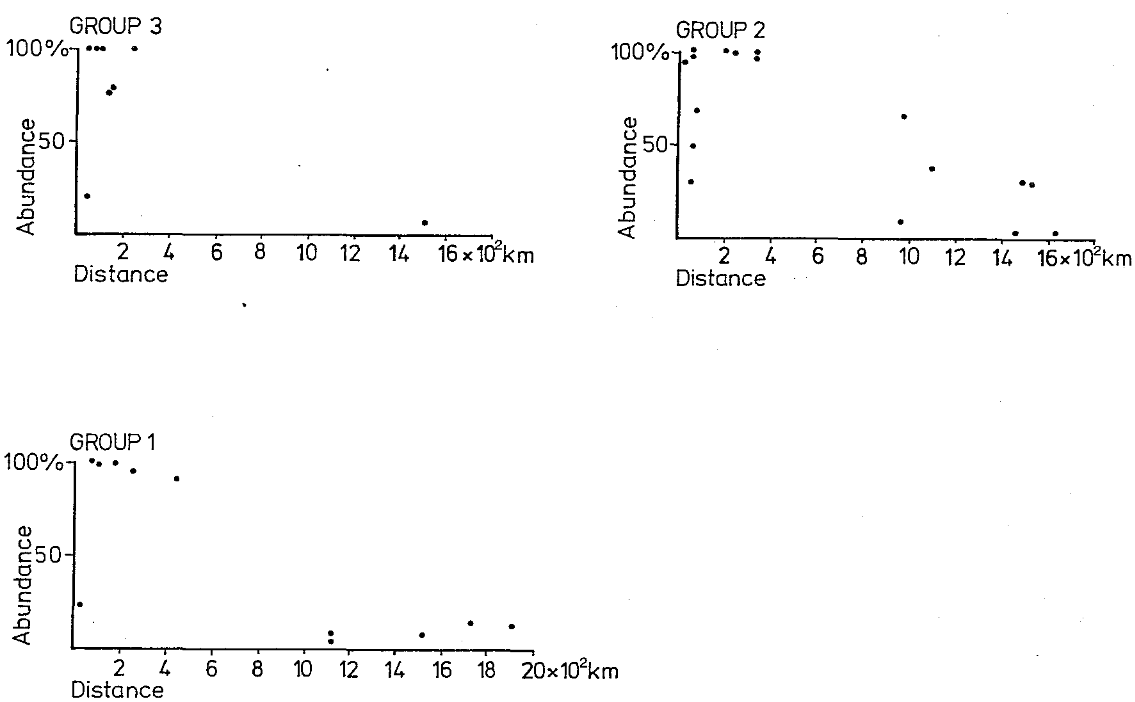


Figure 6.3.: Fall-off curves for relative abundance of obsidian in the total flaked lithic assemblage

Initial inspection of the three plots in Figure 6.3., shows a clear fall-off in the the abundance of the obsidian after approximately 300 km from any source. The fall-off pattern is different for the three groups of sites, but nonetheless, overall similarities in the pattern can be observed. The importance of obsidian in the majority of sites decreases dramatically at distances of over 1000 km from the quarries. Based on a purely qualitative inspection of the data, either free lance trading or down-the-line trading could be supported for the sites located at distances of approximately 1000 km from the sources. In all three plots a number of outlying points can be observed. Their abnormal position in the plots does not seem to be related to site function. Qualitative inspection of the three plots shows that within the approximate radius of 300 km from the sources almost no fall-off can be detected.

In Group 1 sites (630 B.P. and older), the percentage of obsidian in the total assemblage of flaked stone artefacts is minimal (not higher than 19 per cent) at South Island sites (over 1000 km form the source). In all these sites, obsidian does not play an important role numerically. Silcrete blades are the predominant lithic artefacts in these sites together with occasional chert, porcellanite and argillite flakes. Both chert and silcrete are available at sources located closer to the sites than any of the obsidian quarries. All these sites, containing small percentages of obsidian and located at over 1000 km from the sources, are in the South Island of New Zealand. In the North Island sites, obsidian plays a major role in the lithic assemblages (85 to 100 per cent) with only one exception (Harataonga N30/5).

In Group 2 sites (630 B.P. to 350 B.P.) the abundance of obsidian in the sites further away from the source increases quite substantially compared to the earlier sites. At all the South Island sites, the obsidian percentage increases to 36 per cent. In general, in the North Island sites the percentages remain as high as in the early period sites, with the exception of three sites, where the decrease in abundance seems to be more related to site function than to distance to the source. For example, at Hahei obsidian represents only 31 percent of the lithic materials. Activities at this site are mainly oriented towards the manufacture of basalt adzes and drills (Harsant 1984).

Lastly, for the final group of sites (350 B.P. to present) it is difficult to argue a definite fall-off in obsidian abundance. Within the first 300 km the obsidian percentages are as high as in all the earlier sites. Due to the lack of information on sites at increasing distances no definite conclusions can be made on the fall-off pattern. From the single site in the sample (Long Beach), it appears that the fall-off is steep and obsidian is not an abundant artefact in the tool kit.

Regression analysis performed on the data showed that the fall-off patterns were highly significant at 95 percent for the three groups of sites, as seen from Table 6.3.

TABLE 6.3.

Associated F values for abundance (percentage counts) of obsidian with distance

	F value	Degrees Freedom
Group 1	5.88	7
Group 2	20.54	15
Group 3	13.65	9

Following Findlow and Bolognese (1980a, 1980b) and Torrence (1981) the correlation coefficient was used to identify the best fit equation for the fall-off data of abundance with distance. The Pearson-r value was calculted for six regression models: one linear and five exponential (using the equation Log $Y=-bx^{\alpha}+a$, where the alpha values were varied from 0.1 to 2.0). The correlation values associated with each of the models tested are given in table 6.4., for each of the three groups of sites.

TABLE 6.4.

Pearson-r value for regression analysis of distance with abundance (percentage counts) [1]

Model	Group 1 N=9	Group 2 N=17	Group 3 N=11
Linear	-0.676	-0.760	-0.776
Exponential alpha = 0.1	-0.523	-0.998	-0.567
Exponential alpha = 0.5	-0.460	-0.606	-0.537
Exponential alpha = 1.0	-0.405	-0.591	-0.499
Exponential alpha = 1.5	-0.376	-0.561	-0.475
Exponential alpha = 2.0	-0.364	-0.533	-0.464

[1] N refers to the number of sites considered.

The analysis has produced a picture that essentially confirms the first qualitative impressions. The abundance for all groups of sites declines with distance. In two out of three cases a linear equation produced better results than an exponential model. An alpha value of 0.1 was found to best fit the data of Group 2 sites. The early and later period sites (Groups 1 and 3) were found to be best described by a linear model. The variation in the best fit model from a linear to an exponential, indicates that some changes in the distribution of the obsidian may have taken place. The low values of alpha (0.1) and the linear model both suggest that obsidian was carried to the site by a small number of short moves (c.f. Hodder 1978; Hodder and Orton 1976), suggesting that direct access might have been the mode of acquisition rather than down-the-line exchange (see also Table 6.1).

In a way, this sort of result is not completely unexpected for the North Island sites. The almost complete lack of fall-off within the first 300 km radius from Mayor Island strongly suggests that direct access was the main form of acquisition of the raw material.

THE UTILIZATION OF MAYOR ISLAND OBSIDIAN

The following section considers the geographical distribution and the technological aspects of the utilization of Mayor Island obsidian. The sourcing results presented in Chapter V indicated that the utilization of Mayor Island obsidian decreased in the later periods of New Zealand prehistory. The percentage of Mayor Island obsidian in the total obsidian assemblages and its relationship with distance from the source is considered here.

When the percentage (weight) of Mayor Island obsidian in the total obsidian assemblage is plotted against distance from Mayor Island, a significant correlation between the two variables is only found for the early sites (F=14.655 at P=0.05 with 17 DF). In the early group of sites (Group 1) a distinct increase in the proportion of Mayor Island obsidian is found with increasing distance. This relationship holds true for all site types. Although, as discussed above, the overall importance of obsidian in the total flaked lithic assemblage decreases in these sites with increasing distance from the source, Mayor Island obsidian was more popular at more distant places. Since no particular differences can be detected in relation to site function, distance and popularity of Mayor Island obsidian (see Figure 6.4), it could be argued that the increased percentage of Mayor Island obsidian is related to its higher value in areas further removed from the source.

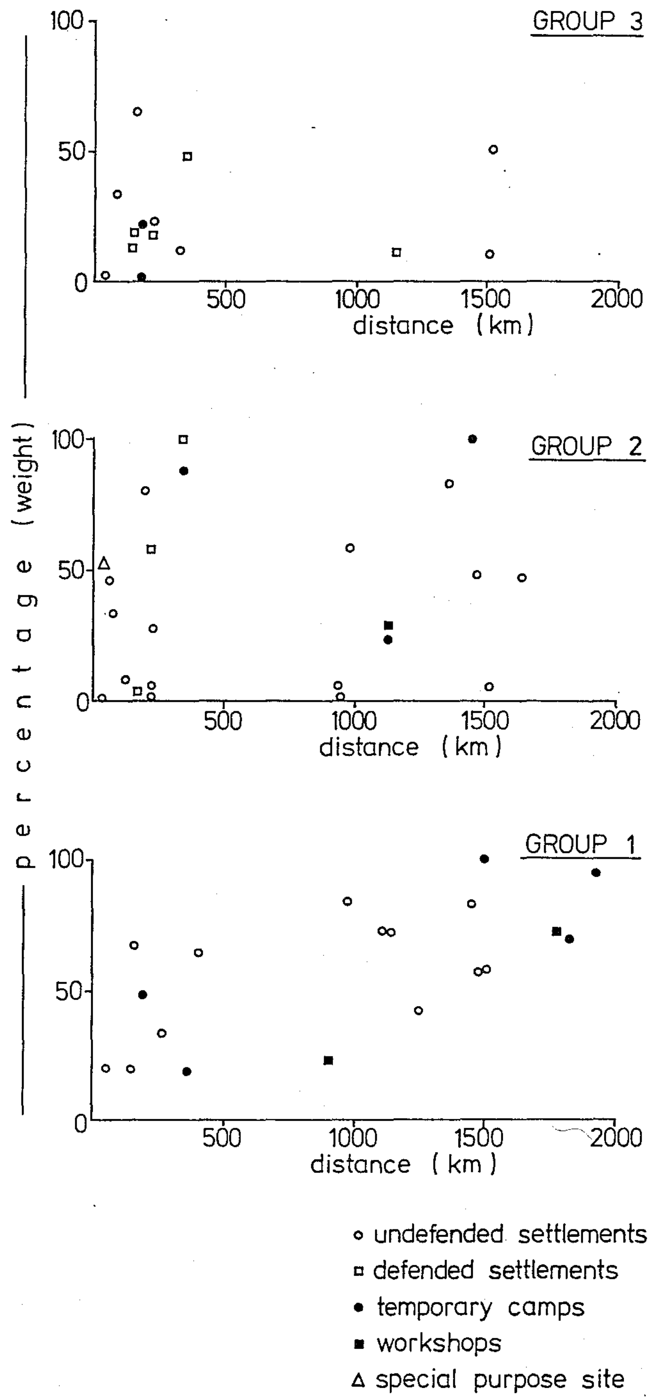


Figure 6.4. : Percentage (weight)of Mayor Island obsidian in the total obsidian assemblage.

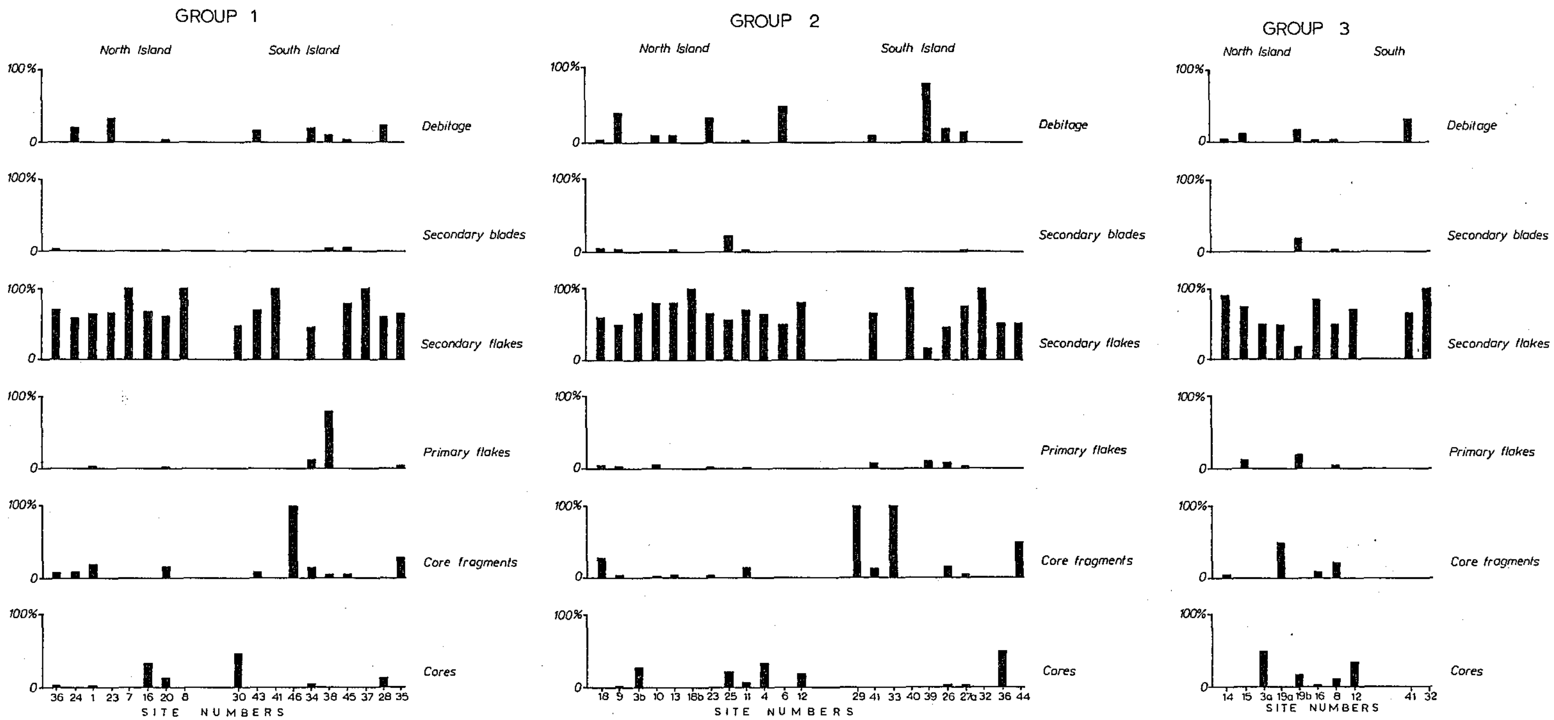


Figure 6.5. : Percentage (counts) of artefact types

In later periods (Groups 2 and 3) the relationships between distance and percentage of Mayor Island obsidian are not significant (F= 0.134 and F= 0.158 respectively). The distribution is equally random when individual site types are compared. It can be argued that this was due to the larger variety of good quality sources discovered as time went by, and their increased exploitation; the relative importance of Mayor Island obsidian decreased. Distance does not seem to be an important factor in the acquisition of Mayor Island obsidian. Two possible alternative propositions can be made to explain the observed pattern.

1) Supply was left to 'chance', and whatever obsidian that was available was used.

2) Mayor Island obsidian lost its exclusive value as more sources were made available.

The technological analysis that follows should be helpful in testing these two propositions. If technology was less wasteful in the earlier sites it could be argued that Mayor Island obsidian was a more valued item in this period than during the later periods. The proportions of the various stages of manufacture of artefacts in each site (cores, flakes, blades, debitage) of the three groups of sites are presented in Tables 6.5 to 6.7. The tables show the technological breakdown for all the Mayor Island obsidian recovered from the sites. Figure 6.5

graphically represents the percentages of the different types of artefacts recorded. Measures of distance, from all sites to Mayor Island and the values of the mean weight of artefacts for all sites studied are given in Tables 6.8 to 6.10.

The first point to establish is whether the technological data, when plotted against distance, show any evidence to support Renfrew's (1972) Law of Monotonic Decrement. An inspection of Tables 6.8 to 6.10 and the graphs in Figures 6.6 to 6.8 indicate that for the three groups of sites, the mean weight variable does not decline monotonically with distance. The relationship was investigated for only four artefact types - cores, core fragments, secondary flakes and debitage. Primary flakes, and primary and secondary blades were excluded from the analysis due to their small representation in the samples.

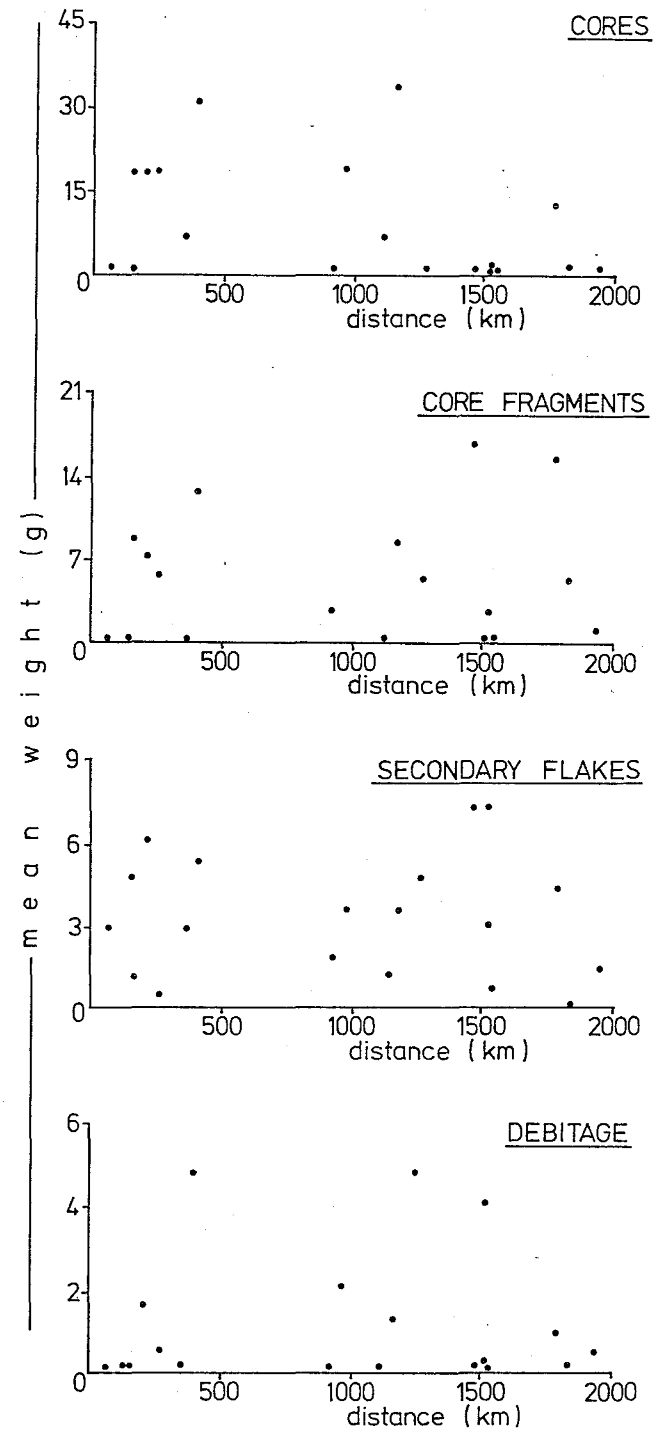


Figure 6.6. : Fall-off for mean weight of artefact type with distance from the source, Group 1 sites.

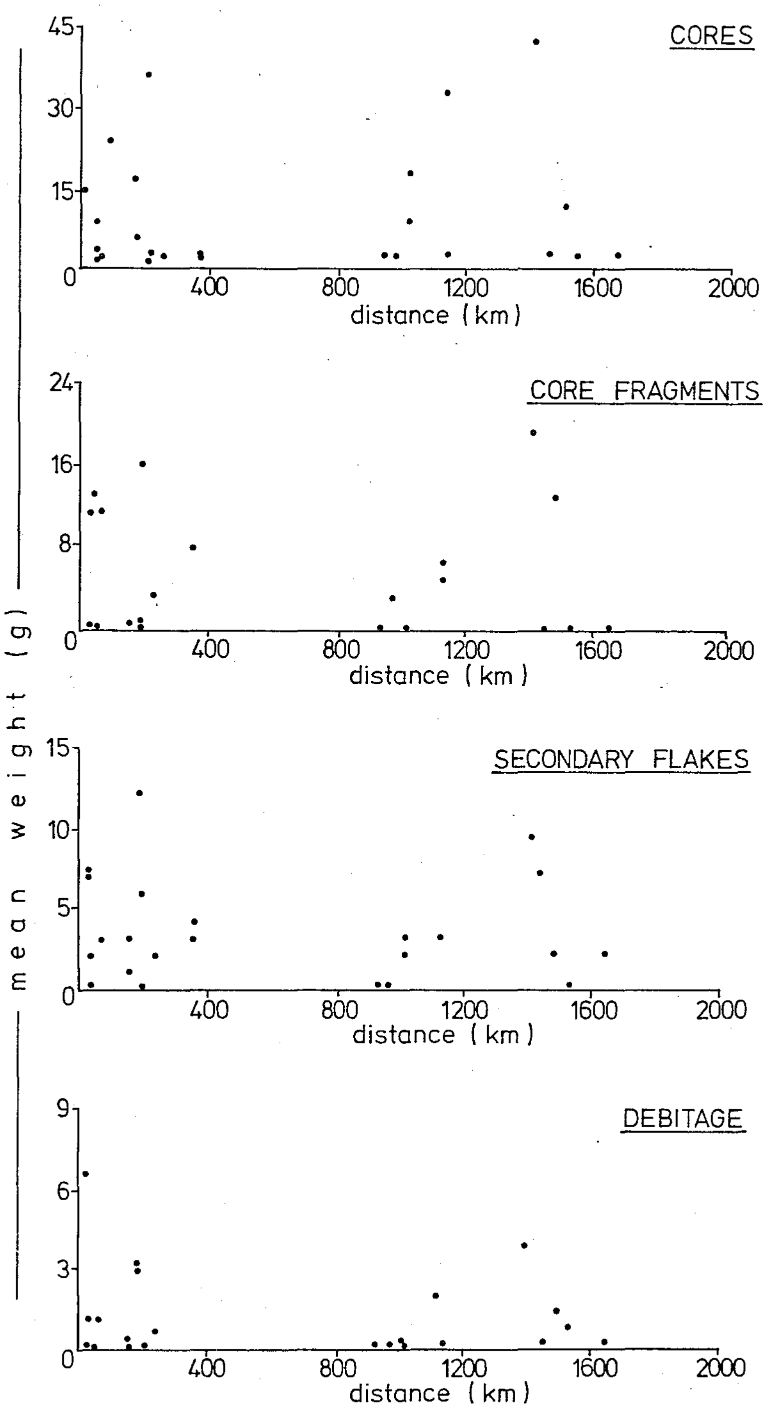


Figure 6.7. : Fall-off for mean weight of artefact type with distance from the source, Group 2 sites.

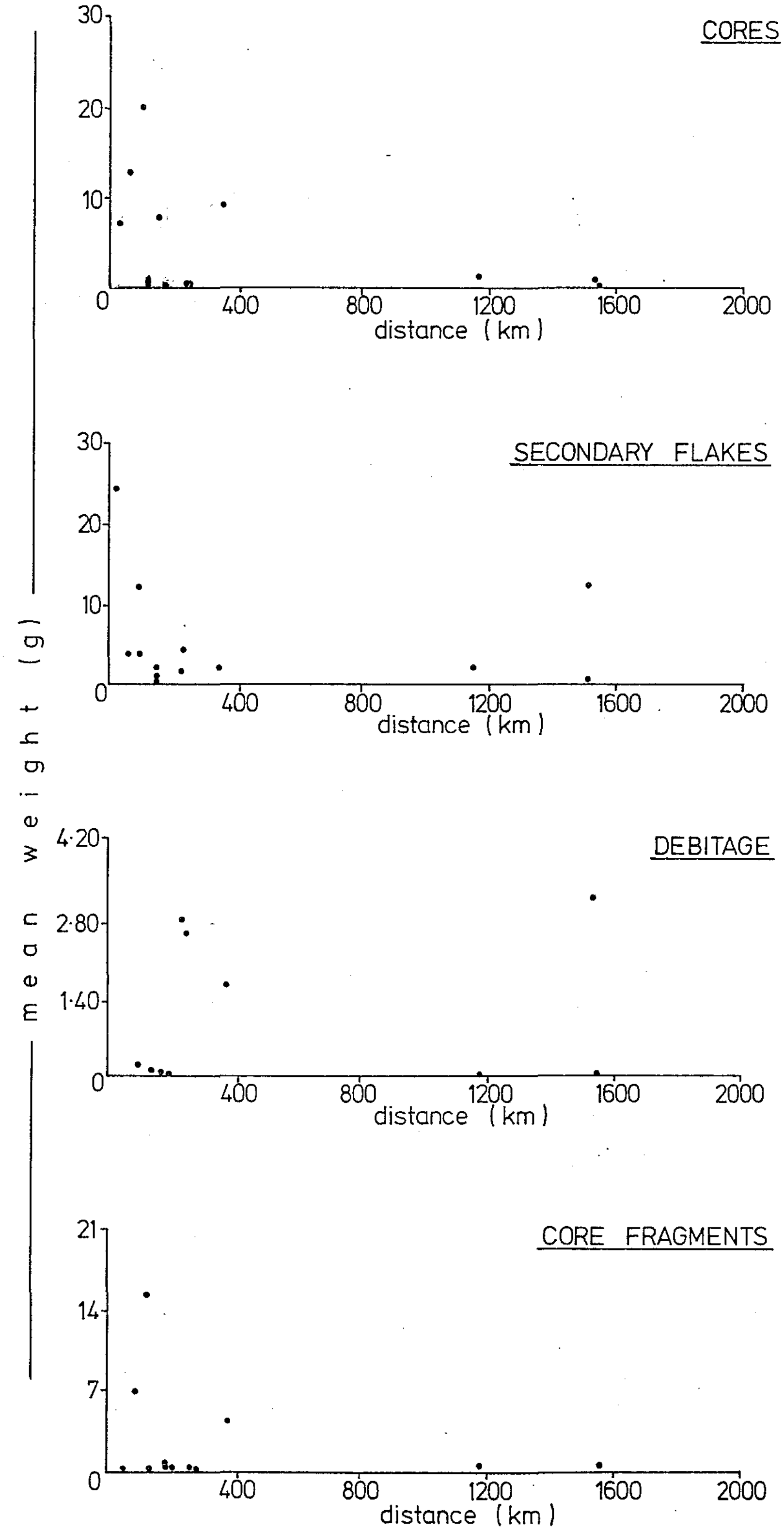


Figure 6.8. : Fall-off for mean weight of artefact type with distance from the source, Group 3 sites.

TABLE 6.5

Percentage of different artefact types, Mayor Island obsidian, 630 B.P. and older

Sites	n	cores	%	core frags.	%	primary flakes	%	secondary flakes	%	secondary blades	%	debitage	%	distance
North Island														
N30/5	48	3	6.3	5	10.4	0	0.0	38	79.2	1	2.1	0	0.0	142.0
Hingaimo	20	0	0.0	2	10.0	0	0.0	14	70.0	0	0.0	4	20.0	1240.0
Houhora	191	5	2.6	39	20.4	11	5.8	129	67.5	0	0.0	7	3.7	420.0
Maioro 1	336	1	0.3	3	0.9	0	0.0	216	64.3	0	0.0	116	34.5	230.0
Prt Jack	4	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	152.0
N64/16	3	1	33.3	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0	352.0
Skippers	6	0	0.0	0	0.0	0	0.0	6	100.0	0	0.0	0	0.0	73.0
Tokoroa	156	19	12.2	24	15.4	3	1.9	99	63.5	4	2.6	7	4.5	180.0
South Island														
Avoca	2	1	50.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0	1120.0
Hawksbu	25	0	0.0	2	8.0	0	0.0	18	72.0	0	0.0	5	20.0	1920.0
Long Be	1	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1524.0
Pahia	1	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	1804.0
Redclif	68	3	4.2	11	16.2	9	12.7	30	44.1	0	0.0	15	22.1	1172.0
Shag Ri	20	0	0.0	1	5.0	0	0.0	16	80.0	1	5.0	2	10.0	1484.0
Titiran	2	0	0.0	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	920.0
Tiwai P	69	0	0.0	3	4.3	1	1.4	55	79.7	5	7.2	4	5.8	1740.0
Waimata	1	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1492.0
Wairau	8	1	12.5	0	0.0	0	0.0	5	62.5	0	0.0	2	25.0	932.0
Waitaki	21	0	0.0	6	28.6	1	4.8	14	66.7	0	0.0	0	0.0	1464.0

TABLE 6.6

Percentage of different artefact types, Mayor Island obsidian, 630 B.P. to 350 B.P.

Sites	n	cores	%	core frags.	%	primary flakes	%	secondary flakes	%	secondary blades	%	debitage	%	distance
North Island														
Aotea	26	0	0.0	7	26.9	1	3.8	16	61.5	1	3.8	1	3.8	350.0
Hahei	204	2	1.0	9	4.6	3	1.5	102	48.5	6	3.0	82	41.4	64.0
N30/3	3	1	33.3	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0	144.5
Hot Wate	33	0	0.0	1	3.0	2	6.1	27	81.8	0	0.0	3	9.1	58.0
Kauri Pt	61	0	0.0	11	6.8	0	0.0	129	80.1	3	1.9	18	11.2	35.0
Koreroma	4	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	350.0
Maioro 2	60	0	0.0	1	1.7	1	1.7	40	66.7	0	0.0	18	30.0	230.0
Paremata	9	2	22.2	0	0.0	0	0.0	5	55.6	2	22.2	0	0.0	980.0
Tairua	92	7	7.6	15	16.3	1	1.1	67	72.8	1	1.1	1	1.1	50.0
N38/30	3	1	33.3	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0	212.0
N38/37	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	212.0
Sunde	2	0	0.0	0	0.0	0	0.0	1	50.0	0	0.0	1	50.0	212.0
Whangama	5	1	20.0	0	0.0	0	0.0	4	80.0	0	0.0	0	0.0	35.0
Whakamoe	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	163.0
South Island														
Clarence	1	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	976.0
Heaphy R	58	1	1.7	8	13.8	5	8.6	37	63.8	1	1.7	6	10.3	1380.0
Houhoupo	1	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	0	0.0	1108.0
Pounawea	3	0	0.0	0	0.0	0	0.0	3	100.0	0	0.0	0	0.0	1620.0
Purakanu	6	0	0.0	0	0.0	0	0.0	1	16.7	0	0.0	5	83.3	1524.0
Shag Poi	41	2	4.9	7	17.1	4	9.8	19	46.3	0	0.0	9	22.0	1484.0
Tahunanu	67	1	1.5	3	4.5	2	3.0	49	73.1	1	1.5	11	16.4	1120.0
Tai Rua	4	0	0.0	0	0.0	0	0.0	4	100.0	0	0.0	0	0.0	1440.0
Timpende	2	1	50.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0	995.0
Titirang	2	0	0.0	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	920.0

TABLE 6.7.
Percentage of different artefact types, Mayor Island obsidian, 350 B.P. to present

Site	n	cores	%	core frags.	%	primary flakes	%	secondary flakes	%	secondary blades	%	debitage	%	distance
North Island														
Elletts	19	0	0.0	1	5.3	0	0.0	17	89.5	0	0.0	1	5.3	220.0
Hamlin's	8	0	0.0	0	0.0	1	12.5	6	75.0	0	0.0	1	12.5	220.0
N30/4	2	1	50.0	0	0.0	0	0.0	1	50.0	0	0.0	0	0.0	145.0
Mangakaw	2	0	0.0	1	50.0	0	0.0	1	50.0	0	0.0	0	0.0	130.0
Ngaroto	5	1	20.0	0	0.0	1	20.0	1	20.0	1	0.0	1	20.0	130.0
N64/18	48	1	2.1	5	10.4	0	0.0	41	85.4	0	0.0	1	2.1	352.0
Skipp II	49	6	12.2	11	22.5	3	6.1	25	51.0	2	4.1	2	4.1	75.0
Waihora	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	164.0
Whakamoe	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	163.0
Whangama	7	2	28.6	0	0.0	0	0.0	5	71.4	0	0.0	0	0.0	36.0
South Island														
Long Bea	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1523.0
Murderin	3	0	0.0	0	0.0	0	0.0	2	66.7	0	0.0	1	33.3	1524.0
Peketa	1	0	0.0	0	0.0	0	0.0	1	100.0	0	0.0	0	0.0	1140.0

TABLE 6.8.

Mean weight Mayor Island obsidian 630 B.P. and older

Sites	N	total mean	SE	SD	core mean	SE	SD	cr fr mean	SE	SD
North Island										
N30/5	48	6.40	1.0	6.4	17.9	*	*	7.80	*	*
Hingaimo	20	4.65	0.9	4.2	0.0	0.0	0.0	5.05	*	*
Houhora	191	7.73	0.4	6.1	29.8	*	*	11.90	1.0	6.3
Maioro 1	336	0.64	0.1	1.3	18.6	*	*	5.10	*	*
Prt. Jac	4	1.35	*	*	0.0	0.0	0.0	0.00	0.0	0.0
N64/16	3	4.43	*	*	6.8	*	*	0.00	0.0	0.0
Skippers	6	3.10	*	*	0.0	0.0	0.0	0.00	0.0	0.0
Tokoroa	156	7.48	0.6	7.9	19.3	2.5	10.9	7.60	0.7	3.5
South Island										
Avoca	2	3.15	*	*	5.1	*	*	0.00	0.0	0.0
Hawksb	25	1.10	0.2	1.2	0.0	0	0	0.80	*	*
Long B	1	3.20	*	*	0.0	0	0	0.00	0.0	0.0
Pahia	1	5.70	*	*	0.0	0	0	5.70	*	*
Redcli	68	5.79	1.0	8.8	33.1	*	*	8.30	1.4	4.9
Shag R	20	6.65	1.1	4.8	0.0	0	0	3.40	*	*
Titira	2	2.20	*	*	0.0	0	0	2.40	*	*
Tiwai	69	4.71	0.7	5.3	11.7	*	*	16.00	*	*
Waimat	1	0.40	*	*	0.0	0	0	0.00	0.0	0.0
Wairau	8	4.97	2.0	5.7	17.9	*	*	0.00	0.0	0.0
Waitak	2	10.69	1.2	6.0	0.0	0	0	16.45	*	*

(Table 6.8. cont.)

Sites	pr fl mean	SE	SD	sec fl mean	SE	SD	sec bl mean	SE	SD	debit mean	SE	SD
North Island												
N30/5	0.0	0.0	0.0	4.7	0.80	4.3	4.6	*	*	0.0	0.0	0.0
Hingai	0.0	0.0	0.0	4.5	1.10	4.0	0.0	0	0	4.9	*	*
Houhor	9.6	1.7	5.5	5.6	0.20	2.7	0.0	0	0	4.7	*	*
Maioro	0.0	0.0	0.0	0.7	0.05	0.8	0.0	0	0	0.2	0.1	0.3
Pt.Jac	0.0	0.0	0.0	1.4	*	*	0.0	0	0	0.0	0.0	0.0
N64/16	0.0	0.0	0.0	3.3	*	*	0.0	0	0	0.0	0.0	0.0
Skippe	0.0	0.0	0.0	3.1	*	*	0.0	0	0	0.0	0.0	*
Tokoro	5.7	*	*	5.9	0.60	6.4	2.8	*	*	1.7	*	0.0
South Island												
Avoca	0.0	0.0	0.0	1.2	*	*	0.0	0	0	0.0	0.0	0.0
Hawksb	0.0	0.0	0.0	1.3	0.30	1.3	0.0	0	0	0.5	*	*
Long B	0.0	0.0	0.0	3.2	*	*	0.0	0	0	0.0	0.0	0.0
Pahia	0.0	0.0	0.0	0.0	0.00	0.0	0.0	0	0	0.0	0.0	0.0
Redcli	8.5	*	*	3.8	0.70	3.9	0.0	0	0	1.2	0.2	0.9
Shag R	0.0	0.0	0.0	7.1	1.40	5.2	7.9	*	*	4.0	*	*
Titira	0.0	0.0	0.0	2.0	*	*	0.0	0	0	0.0	0.0	0.0
Tiwai	9.5	*	*	4.2	0.60	4.0	4.4	*	*	0.9	*	*
Waimat	0.0	0.0	0.0	0.4	*	*	0.0	0	0	0.0	0.0	0.0
Wairau	0.0	0.0	0.0	3.7	*	*	0.0	0	0	1.8	*	*
Waitak	9.7	*	*	7.3	0.88	3.4	0.0	0	0	0.0	0.0	0.0

TABLE 6.9.

Mean weight Mayor Island obsidian 630 B.P. to 350 B.P.

Sites	N	total mean	SE	SD	cores mean	SE	SD	cr fr mean	SE	SD	pr fl mean
North Island											
Aotea	26	4.29	0.6	3.2	0.0	0	0	7.7	*	*	3.4
Hahei	198	2.90	0.3	3.8	19.5	*	*	11.7	*	*	2.7
N30/3	3	3.70	*	*	3.7	*	*	0.0	0.0	0.0	0.0
Hot Wate	33	7.49	1.1	6.5	0.0	0	0	11.5	*	*	17.6
Kauri Pt	161	7.12	0.4	4.7	0.0	0	0	12.6	0.8	2.9	0.0
Koreroma	4	3.60	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Maioro 2	60	1.20	0.2	1.9	0.0	0	0	3.9	*	*	0.4
Paremata	9	4.33	1.3	5.0	13.9	*	*	0.0	0.0	0.0	0.0
N38/30	3	3.46	*	*	6.6	*	*	0.0	0.0	0.0	0.0
N38/37	0	0.00	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Sunde	2	4.20	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Tairua	92	4.42	2.1	21.4	34.2	*	*	15.5	3.3	13.1	0.0
Whakamoe	0	0.00	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Whangama	5	5.52	*	*	15.7	*	*	0.0	0.0	0.0	0.0
South Island											
Claren	1	3.30	*	*	0.0	0	0	3.3	*	*	0.0
Heaphy	58	10.00	1.4	10.3	38.6	*	*	18.6	*	*	10.4
Houhou	1	5.70	*	*	0.0	0	0	5.7	*	*	0.0
Pounaw	3	2.23	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Puraka	6	0.30	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Shag P	41	3.06	0.5	3.2	9.4	*	*	13.4	*	*	4.5
Tahuna	67	3.20	0.5	4.4	29.8	*	*	4.1	*	*	6.3
Tai Ru	4	6.65	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Timpen	2	3.84	*	*	5.5	*	*	0.0	0.0	0.0	0.0
Titira	2	2.00	0.0	0.0	0.0	0	0	2.2	0.0	0.0	0.0

(Table 6.9. cont.)

Site	SE	SD	sec fl mean	SE	SD	sec bl mean	SE	SD	debit mean	SE	SD
North Island											
Aotea	*	*	3.2	0.6	2.6	2.6	*	*	0.1	*	*
Hahei	*	*	3.2	0.4	3.8	3.4	*	*	1.4	0.1	1.0
N30/3	0	0	0.9	*	*	0.0	0	0	0.0	0.0	0.0
Hot W	*	*	7.3	1.1	5.8	0.0	0	0	1.1	*	*
Kauri	0	0	6.7	0.5	4.8	0.0	0	0	6.5	0.7	3.2
Korer	0	0	3.6	*	*	0.0	0	0	0.0	0.0	0.0
Maior	*	*	1.5	0.3	2.2	0.0	0	0	0.4	0.2	0.8
Parem	0	0	3.4	*	*	1.4	*	*	0.0	0.0	0.0
N38/30	0	0	1.9	*	*	0.0	0	0	0.0	0.0	0.0
N38/37	0	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
Sunde	0	0	5.6	*	*	0.0	0	0	2.8	*	*
Tairu	0	0	12.4	1.8	15.2	3.4	*	*	2.9	*	*
Whaka	0	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
Whang	0	0	3.0	*	*	0.0	0	0	0.0	0.0	0.0
South Island											
Claren	0	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
Heaphy	*	*	8.5	1.4	8.5	6.3	*	*	3.5	*	*
Houhou	0	0	0.0	0.0	0.0	0.0	0	0	0.0	0.0	0.0
Pounwe	0	0	2.2	*	*	0.0	0	0	0.0	0.0	0.0
Puraka	0	0	0.1	*	*	0.0	0	0	0.4	*	*
Shag P	*	*	2.3	0.7	3.1	0.0	0	0	1.3	*	*
Tahuna	*	*	2.9	0.4	3.1	3.2	*	*	1.5	0.4	1.4
Tai Ru	0	0	6.7	*	*	0.0	0	0	0.0	0.0	0.0
Titira	0	0	1.8	0.0	0.0	0.0	0	0	0.0	0.0	0.0
Timpen	0	0	2.2	*	*	0.0	0	0	0.0	0.0	0.0

TABLE 6.10.

Mean weight Mayor Island obsidian 350 B.P. to Present.

Sites	n	total mean	SE	SD	cores mean	SE	SD	cor fr mean	SE	SD	pr fl mean
North Island											
Elletts M	19	2.85	0.50	2.1	0.0	0	0	0.3	*	*	0.0
Hamlin's	8	3.00	0.80	2.1	0.0	0	0	0.0	0.0	0.0	2.8
N30/4	2	4.50	*	*	7.3	*	*	0.0	0.0	0.0	0.0
Mangakawa	2	9.50	*	*	0.0	0	0	15.7	*	*	0.0
Ngaroto	5	3.12	*	*	19.1	*	*	0.0	0.0	0.0	1.0
N64/18	48	2.92	0.32	2.2	9.5	*	*	4.6	*	*	0.0
Skipper's	49	5.85	0.70	4.9	12.4	*	*	7.1	1.2	3.9	7.3
Waihora	0	0.00	0.00	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Whakamoen	0	0.00	0.00	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Whangamat	7	22.69	*	*	6.4	*	*	0.0	0.0	0.0	0.0
South Island											
Long Beac	0	0.00	0.00	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Murdering	3	9.47	*	*	0.0	0	0	0.0	0.0	0.0	0.0
Peketa	1	1.40	*	*	0.0	0	0	0.0	0.0	0.0	0.0

(Table 6.10 cont.)

Sites	SE	SD	sec fl mean	SE	SD	sec bl mean	SE	SD	debit mean	SE	SD
North Island											
Ellett	0	0	2.40	0.3	1.2	0.0	0	0	2.4	*	*
Hamlin	*	*	3.10	*	*	0.0	0	0	2.7	*	*
N30/4	0	0	1.80	*	*	0.0	0	0	0.0	0	0
Mangak	0	0	3.30	*	*	0.0	0	0	0.0	0	0
Ngarot	*	*	11.90	*	*	0.2	*	*	0.1	*	*
N64/18	0	0	2.58	0.3	2.0	0.0	0	0	1.8	*	*
Skippe	*	*	4.07	0.5	2.8	5.5	*	*	0.3	*	*
Waihor	0	0	0.00	0.0	0.0	0.0	0	0	0.0	0	0
Whakam	0	0	0.00	0.0	0.0	0.0	0	0	0.0	0	0
Whanga	0	0	24.94	*	*	0.0	0	0	0.0	0	0
South Island											
Long B	0	0	0.00	0.0	0.0	0.0	0	0	0.0	0	0
Murder	0	0	12.60	*	*	0.0	0	0	3.1	*	*
Peketa	0	0	1.40	*	*	0.0	0	0	0.0	0	0

No significant relationship could be found between mean weight of artefact types or mean weight of the total assemblage with distance from the source. Table 6.11. shows the F values and corresponding degrees of freedom associated with the data.

TABLE 6.11.

F-values for mean weight of artefact type with distance from the source

Group	Artefact type					DF
	cores	core frags.	second. flakes	debit.	total sample	
Group 3	2.032	0.825	0.083	1.620	0.365	17
Group 2	0.235	0.015	0.346	0.634	0.099	22
Group 1	2.794	0.295	0.135	0.024	0.004	17

However, some minor trends, statistically not significant can be observed in the data. The fall-off in the mean weight of cores observed for Groups 1 and 3, corresponds with the expected behaviour. With increasing distance, cores were used for longer before being discarded. This is also confirmed by the decrease in weight of the exhausted cores (core fragments). Secondary flakes also show a slight tendency to decrease in size with increasing distance. For some of the variables there is a tendency for a positive relationship between artefact weight and distance as opposed to the predicted trend. The mean weight of cores for Group 2, for example, increases in direct opposition to the predictions of the Law of Monotonic Decrement. The relationship between debitage mean weight and distance is also positive for both Groups 3 and 1 sites. The tendency of the debitage to show a positive relationship with distance, especially in Group 3 sites, may be due to problems in site representation in the sample, or even recovery techniques employed during site excavations at particular sites. Scarcity of the material does not seem to have affected the way in which the material was used. Although Mayor Island material might have been a more valued obsidian, no special care seems to have been taken to ensure maximum use of the material.

The absence of any definite relationship between the mean weight of artefacts and distance and the almost total absence of any distance decay pattern in all three groups of sites is significant and rather unusual. The explanation for this different and 'anomalous' pattern may be related to a high degree of mobility of the prehistoric Maori population.

In addition to the investigation of the relationship of the mean weight of artefact type with distance, the relationship between the total weight of obsidian of each artefact type with distance from Mayor Island was investigated. Again, no significant relationship between total weight of material and distance was found for most cases. The only significant relationship (F = 3.21 at P=0.01 and 17 DF) was found for the total weight of cores of Group 1 sites (Figure 6.9.). The total weight of the obsidian cores decreased with increasing distance. Although the relationship for the other groups of sites is not significant, the general pattern shows a decrease in total weight of obsidian material as the distance from the source increases. The Pearson r value using different alpha exponents was again calculated for the total weight of cores for Group 3 sites. It was found that this relationship was best described by a linear model (r= -0.399). In accordance with the predictions this would be indicative of direct access as the most likely method of procurement of the raw material.

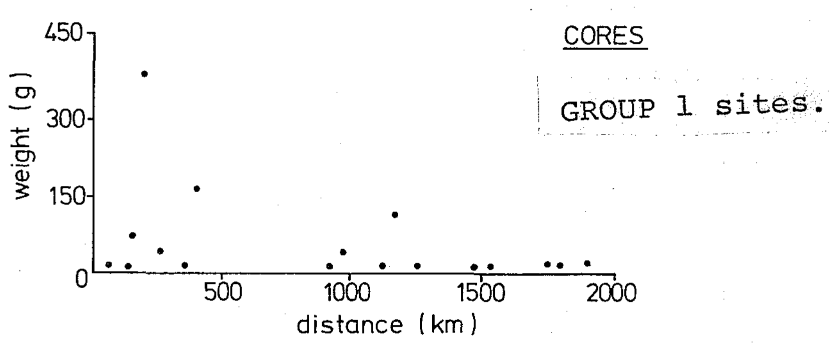


Figure 6.9. : Fall-off curve for total weight of obsidian (cores) with distance.

The low correlation between the variables confirms that the Law of Monotonic Decrement is not operating in the case of Mayor Island obsidian distribution in New Zealand. Directional trade cannot be invoked for an explanation of the pattern because individual sites are not receiving supplies preferentially. Distance does not seem to affect the technology of the artefact production, as the assemblages are all relatively similar.

The mean values for the variables considered in the study are quite similar among the sites studied. It seems that even the most distant sites, such as Hawksburn, Tiwai Point or Pahia, did not alter their technology in response to the assumed high costs of acquisition. The lack of correlation between the technological variables and distance could be due to strong stylistic/functional constraints. It appears that obsidian flakes were only used for certain tasks which did not require any careful preparation or elaboration. Especially in the South Island sites, where alternative lithic materials were used preferentially (silcrete and porcellanite), obsidian seems to have played a minor role in the tool kit. Detailed use wear analysis on newly excavated obsidian assemblages could be a useful guide in clarifying some of these points.

In general it seems that obsidian was not exchanged through any elaborate exchange system. From the different lines of evidence it seems that, for example, within the North Island and within an approximate radius of 300 km from the source on Mayor Island, most obsidian was acquired either directly from the source or from groups of people living extremely close to them who had access to a large supply of the raw material.

The fall-off experienced in the abundance of obsidian at places further than, say, 300 km from the sources on Mayor Island, makes it clear that obsidian was not of prime importance at these sites. The small quantities of it in the sites do not encourage the suggestion that special trips were made to acquire it. Rather, on the odd occasion when long trips were undertaken, obsidian was acquired together with other items and taken south. Most commonly though, it probably reached the more distant sites by way of a down-the-line system. It should be mentioned also, that a few huge blocks of obsidian have been found on occasions at places along the South Island coast, for example on the Otago Coast (Otago Museum accession numbers D75.595; D75.207), North Canterbury and Milford Sound. The North Canterbury block weighs 54 kg (Anderson n.d.), and blocks of this size could only have been transported by canoe. They were most probably obtained on a trip north, or otherwise left by a party who could acquire it from the source while on a special visit to the south. The two blocks held at the Otago Museum have been sourced by Leach and Manly (1982:100-101) to Mayor Island. The block from Milford Sound, one of the largest ever found in New Zealand was found to be of an unknown New Zealand or Pacific source (Leach, pers. comm.). Mayor Island obsidian, as mentioned before, seems to have had a higher value in the South Island sites, and could therefore have been a valued gift given in exchange for some southern items.

Although, as mentioned, flake and debitage size are not responsive to distance, the total weight and therefore quantity of cores decreases with distance. Most excavated South Island sites have few or no cores and a higher proportion of exhausted cores. Even if the size of the final products does not seem to be affected by the scarcity of the raw material, cores were used until they were exhausted.

FINAL REMARKS

Based on the regional analysis of obsidian distribution several important conclusions arise.

1) Obsidian was generally the most important raw material for the manufacture of flaked tools in the North Island sites considered. In contrast, at South Island sites, obsidian was only marginally represented and is not an essential part of the tool kit.

2) Mayor Island obsidian increasingly dominates in the obsidian assemblages as one moves away from the obsidian sources. South Island sites show a marked preference for Mayor Island obsidian, especially during the early period. The dominance of Mayor Island

obsidian disappears in general during later times, nevertheless it is still of greater importance in South Island sites. It is argued that Mayor Island obsidian was more valued at these places than obsidian from other sources. Access to other sources may have been more difficult in comparison as it involved travel through possibly hostile territories.

3) From the technological analysis performed on the obsidian assemblages it can be concluded that the manufacturing technology of flakes did not change with increasing distance from the source. The obsidian flaking was remarkably uniform all over New Zealand, as it was used apparently for the manufacture of multipurpose cutting/scraping tools. This also explains partly the lack of any correlation between artefact type and distance and the 'anomalous' fall-off pattern observed from the artefactual analysis.

The explanation of the fairly even amounts of obsidian found at North Island sites in a radius of approximately 300 km from Mayor Island may lie in the nature of the high mobility of the prehistoric population. Long trips were apparently not a rare occurrence in historic times. Numerous ethnographic references recount long trips undertaken by groups of people at which long stops for food gathering and other reasons were made (Heaphy 1959). The collection of raw materials during these voyages did not engender much extra cost. The quantity of obsidian entering the sites would therefore not be related to distance but would be a function of the degree to which trips were made, their purpose and the number of stopovers made during these trips.

4) Differences in the fall-off pattern of obsidian abundance between the North and South Islands, indicate that there were possibly two ways of acquiring the raw materials, existing side by side. Direct access, seems to have been the more common way of obtaining obsidian in the North Island, although, this does not exclude the distribution through a down-the-line system between neighbouring communities. A down-the-line system is more appropriate to explain the South Island pattern.

Finally, in the following concluding chapter (Chapter VII), the implications of these findings are discussed.

CHAPTER VII

DISCUSSION AND CONCLUSION

The principal objective of the present thesis, to understand the role of Mayor Island as the main source of obsidian in prehistoric New Zealand and identify the mechanisms of exchange responsable for its distribution, has been met, within the limitations of the archaeological data. The study of Mayor Island obsidian exchange was approached following two basic lines of research. In both cases a number of conclusions have been reached, although several theoretical and methodological problems were encountered along the way. It remains now to integrate the results of these two separate lines of inquiry, the study of the quarries on Mayor Island, and the regional distance fall-off studies, to reconstruct the picture of prehistoric obsidian exchange in New Zealand.

Most significantly, all lines of evidence pursued agreed, whether based on the regional data, or the analysis of the Mayor Island sites, that obsidian exploitation from the Mayor Island sources was not highly organized. Looking first at the data from the quarries themselves and the site survey carried out on

Mayor Island, the evidence points towards unspecialized and unintensive exploitation and extraction of obsidian from the flows. From the absence of extensive working floors and quarry debris it appears that access to the obsidian deposits was unrestricted and that obsidian was obtained by individual parties, who carried away whole blocks elsewhere.

In addition, the evidence from the Mayor Island obsidian distribution and the fall-off pattern support the findings from the site oriented study.

The results from the sourcing of New Zealand obsidian assemblages have shown a pattern of change, both in source utilization throughout New Zealand and in obsidian utilization from the early to the later periods of occupation. Initially, Mayor Island seems to have played an important role, since it provided the best quality obsidian sources. Other available sources were soon discovered and exploited to varying degrees. Nevertheless, Mayor Island obsidian was the most commonly used obsidian during the first few hundred years, although in later times, other sources were increasingly used, particularly by North Island communities.

On the basis of the various studies, an approximation of the possible exchange mechanisms in operation can be made. The identification of the 'precise' mode of exchange from among all the possible types is impossible without further testing and data collection. The final results obtained from the analysis of the Mayor Island obsidian distribution tend to favour the suggestion that a substantial number of communities located at considerable distances from the Mayor Island obsidian sources (up to approximately 300 to 400 km), obtained their raw materials through direct access throughout the temporal depth of New Zealand prehistory. The changes observed in the pattern of source exploitation have been linked to changes in political affiliation and increasing warfare placing restrictions on travel and movement through certain territories. If most communities within a 'contact area' had obtained their raw materials directly from the sources, and access to these became increasingly more difficult, alternative sources had to be exploited. The increasing proportions of Mayor Island obsidian at certain sites (Washpool, Maioro) may have been a direct result of changing political affilitations. At South Island sites, 800 km or more distant from any source, the obsidian did not play an important role; other lithic materials replaced it. The preference for Mayor Island obsidian was particularly strong at places where no other readily available obsidian existed.

Procurement for most consumers within a certain radius by direct access to the obsidian sources is supported by both the regional analysis (Chapter VI) and the research carried out at the quarries themselves

(Chapter IV). It appears that despite the apparent simplicity of this model, the procurement strategy might have been more complex. The temporal changes in source utilization observed (Chapter V) between the three groups of sites considered might be of some importance for understanding changes in the distribution pattern due to broader economic or political changes taking place at the time. The data examined in the previous chapter (VI), indicated that, for a large number of consumers, the distance from the quarries to the place of consumption was not the most relevant factor in procurement costs. One may ask what other possible reasons might be put forward to explain this pattern. The fishing grounds surrounding Mayor Island are some of the richest in New Zealand for the presence of deep sea game species, within relative calm waters. Even today Mayor Island is considered one of the prime areas in New Zealand for deep sea fishing. It is suggested, therefore, that stops on Mayor Island may have been scheduled within other activities, such as special fishing trips. Visits might therefore have been undertaken for a variety of reasons as Mayor Island may have offered several attractive prospects to the visitors, obsidian being but one of them.

The obsidian fall-off study indicates further that most obsidian at sites in the South Island probably arrived through a down-the-line exchange system. Whether it was received from some other communities through gift-exchange or some other custom cannot be established at present. Nevertheless, one can assume that mostly high quality flaking obsidian would have been given as a gift to visitors from the South Island, or left by North Island parties on special trips to the south. As increasingly more and more varied sources were exploited in the North Island, this would have been reflected to some extent in the materials reaching the South Island sites. However, during the later periods of prehistoric occupation, Mayor Island obsidian maintained its position as the dominant type in the South Island.

It is by no means certain if obsidian in the South Island was exclusively received by a down-the-line exchange mechanism. Although this type of exchange is supported by the abundance fall-off data, the technological analysis of the obsidian artefacts does not completly agree with the predicted behaviour. Strictly speaking, if down-the-line exchange was the only system responsible for the dispersion of obsidian, one would expect that, as the raw material was passed on through the system, unworked blocks would be reduced to smaller and smaller forms, or would be exchanged in ever decreasing quantities. This would mean that only the sites close to the source would have unworked blocks of obsidian, and a larger amount of cores, and worked cores and flakes would enter the more distant sites.

None of these predictions proved to be strictly correct for the New Zealand data since no significant relationship between distance from the source and the form of the raw material as it entered the sites was found. It was found that the total weight of cores was the only variable which was inversely correlated with distance, and in accordance with the theoretical predictions, direct access was again indicated by the correlation coefficient. Ethnographic information reviewed in Chapter II shows that commodities were acquired both by direct access and by exchange. Movements of people over 1000 km or more are also documented (Anderson 1980). It can be suggested that once the material had arrived in the South Island it was distributed through reciprocal exchanges between related groups.

The use of particular types of sources at specific site types is supported by the data. Differences, especially between permanent and temporary sites, are observed. It is likely that parties on special hunting journeys would select carefully the pieces they would take and, therefore, one would expect to find only few sources represented at these sites.

No technological differences in artefact manufacture between functionally different sites could be found from the examination of the data. The technology to produce obsidian artefacts was remarkably uniform throughout the region.

An important implication of the finding that obsidian was obtained by two systems is that fairly large quantities of a resource can be distributed over a large area without systematic exchange taking place. Further implications are that costs of acquisition may not necessarily be reflected in the technology of artefact production, and that the distribution of a resource is not necessarily the result of a complicated exchange system.

It has also been assumed usually, that if a resource was distributed over a large area, it must have had a high value associated with it. However, the cost of acquisition of the obsidian would be considerably reduced if it was obtained by reciprocal exchange or a down-the-line system and it would reduce the procurement cost for people living further from the area of supply. Other reasons for the apparent low value of obsidian may be related to the form of transport used. Travel by canoe was probably more efficient and easy, would reduce the associated cost of overland travel and would have increased the area of the supply zone. In addition, the cost incurred in obtaining obsidian may have been reduced by the fact that it was obtained in conjunction with other activities. The examination of the relationship between transport, distance, demand and the type of exchange may shed further light on the value of a given resource.

In retrospect, limitations of the present work become evident. One of the most serious deficiencies encountered was the lack of sophisticated techniques for measuring human behaviour. The theoretical review presented in Chapter III demonstrates the state of our current inability to predict and detect accurately types of human behaviour. As Anderson (n.d.:17) has pointed out it is not only the exchange mechanisms themselves which elude archaeological demonstration but the fact that the existence of transactions requiring two way activities often cannot be demonstrated.

One of the major problems of the regional analysis utilizing the fall-off curves proposed by Renfrew (1972, 1975, 1977a) is that they cannot adequately discriminate between different classes of exchange. Probably the biggest problem in archaeological exchange studies is the lack of a theoretical background that could enable us to predict exchange types. As the theoretical review showed, the present state of exchange theory does not allow for accurate discrimination in the field of any of the exchange types described by anthropologists. Further progress in this line of inquiry requires a better theoretical basis for predicting the nature of exchange and development of the methodological techniques. These limitations are mainly reflected in the regional analyses.

However, something has been learned in this study concerning the nature of obsidian exchange in New Zealand. Although limitations in the archaeological data were encountered, as discussed in each Chapter, several significant conclusions have been made. It was found that the site oriented study - the analysis of the quarries proved extremely informative. Although no sophisticated techniques were used, or more detailed research carried out at this point, it is clear from the highly informative results obtained from the initial site survey, that quarry analysis can provide a number of answers in the detection of the functioning of prehistoric exchange systems. The relationship that emerged between the quarry sites, types of production and procurement has shown the value of the combined regional and site oriented approach. More work investigating the relationship to other obsidian source utilization is needed before the total picture of obsidian consumption in New Zealand can be fully understood. Further work investigating the relationship to other obsidian source utilization is needed. The development of an accurate sourcing procedure capable of discriminating between other New Zealand sources should be a priority.

The present study is offered as an initial attempt at solving some of the complicated aspects of prehistoric human communications. Future fieldwork and analytical work should provide the required data to confirm or, perhaps, alter the present conclusions.

The data files from the prsent research have been stored in the Otago University Archaeology Laboratory archive system, and can be consulted for research purposes, prior consultation with the author.

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ABBREVIATIONS

Am. Antiq.	American Antiquity
A.P.A.O.	Archaeology and Physical Anthropology in Oceania
B.A.R.	British Archaeological Reports
DSIR	Department of Scientific and Industrial Research
J.P.S.	Journal of the Polynesian Society
J.Arch.Sci.	Journal of Archaeological Science
J.R.S.N.Z.	Journal of the Royal Society of New Zealand.
N.Z.A.A.	New Zealand Archaeological Association
N.Z.A.A.N.	New Zealand Archaeological Association Newsletter
N.Z.J.A.	New Zealand Journal of Archaeology
N.Z.J.G.G.	New Zealand Journal of Geology and Geophysics
N.Z.J.Sci.	New Zealand Journal of Science
N.Z.J.Sci.Tech.	New Zealand Journal of Science and Technology
Rec. Auck. Inst. Mus.	Records of the Auckland Institute and Museum
Rec Cant. Mus.	Records of the Canterbury Museum
T.N.Z.I.	Transactions of the New Zealand Institute
T.P.N.Z.I.	Transactions and Proceedings of the New Zealand Institute
T.P.R.S.N.Z.	Transactions and Proceedings of the Royal Society of New Zealand
T.R.S.N.Z.	Transactions of the Royal Society of New Zealand

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APPENDIX 1

DESCRIPTION OF ARCHAEOLOGICAL SITES MENTIONED IN THE TEXT

The sites are listed in alphabetical order according to the names used in the text, followed by the official site number of the New Zealand Archaeological Association and, in brackets, the number assigned to the site on the location map (Figure 5.1). Radiocarbon dates are given in 'years before present' and are cited using as far as possible the 'old half life' of C14, uncorrected for secular variation.

Aotea N64/25 (18)

Aotea consists of a series of prehistoric terraces on a slope of a shallow valley, on the Waikato Coast near Aotea Harbour. The site corresponds to a settlement which dates to the late fifteenth or early sixteenth century A.D.. About 20 terraces are spread out over the gentle slope; they tend to occur in groups, one large one with two or three smaller ones. Four terraces were excavated and were numbered A1 to A4. Terraces A1 and A2 have not been dated. Terrace

A2 had two occupations on it. Terrace A4 featured several occupations for which C14 dates are available : 1560± 50 B.P., 1520± 50 B.P. Structural evidence on the terraces belonged to sleeping and/or cooking houses. Artefacts, besides 43 obsidian pieces, include abraders, files, polishers, drills, one adze fragment, one scraper and one greenstone flake (Fox and Cassels 1983). Twenty five pieces of obsidian from the site were analyzed.

Avoca Point S49/46 (30)

The site is a small moa-hunter settlement located at Avoca Point on the Kaikoura Peninsula, northeast coast of the South Island. Occupational remains were mainly found in one layer of black stained soil and limestone gravel. Faunal material recovered from the site included extinct birds, sea birds, seal bones, rat and dog bones, as well as several species of shellfish. The cultural assemblage recovered from the site included mainly silicious rock flakes, 900 flint flakes and 20 obsidian flakes, as well as one obsidian core and three flint cores. Besides the above artefacts, 74 basalt and argillite flakes were recovered. Historic records indicate that a burial with a moa egg and adze head was found late last century. The excavations are discussed by Trotter

(1980). The site is dated to around 866 B.P. on the basis of radiocarbon dates (840± 60 B.P.; 880± 40 B.P.; 860± 40 B.P.; 740± 90 B.P.) (ibid.:283-284). Two obsidian flakes from the site were analyzed.

Clarence S42/11 (Garden Complex sites C and D) (29)

The Clarence sites are located on the mouth of the Clarence River. Four sites were investigated by Trotter and McCulloch in 1979. On the raised beach terrace and alluvial fan deposits, lies an extensive gardening complex (site C), with pits, low walls and raised terraces. The site covers an area of about 10 ha. Site D, a small hilltop pa, consists of a group of pits and terraces, similar to site C. Both sites are described in detail by Trotter and McCulloch (1979). Trotter (pers. comm. 1984) believes that the sites are about 400 years old. Five obsidian pieces were made available; only one piece was analyzed.

Ellett's Mountain N42/23 (14)

A defended hillsite pa located on the Auckland Isthmus for which no dates are available. Salvage excavations were carried out by the New Zealand Historic Places Trust in 1982. Obsidian from this site was recovered from a Late Period context (McKinlay, pers. comm.).

Hahei N44/97 (9)

The site is a coastal dune midden located on the east coast of the Coromandel Peninsula and is typical of Archaic sand dune middens in the area. Salvage excavations were carried out on two occasions (Edson and Brown 1977; Harsant 1979, 1984). The main activities carried out at the site were the manufacture of adzes, drill points and other lithic and bone artefacts. Over 3000 flakes were recovered from the site. Siliceous flakes were more abundant, but judging from use-wear analysis, Harsant (ms) thinks that obsidian tools were more important at the site. The site has been dated to around 580 B.P. Five radiocarbon dates were obtained, 300±45 B.P., 556±64 B.P., 549±60 B.P., 700±60 B.P. Harsant (1983:60) prefers the two intermediate dates for the site on the basis of economic and artefactual evidence from the site. Four hundred and fourty nine obsidian pieces were analyzed and results were obtained for 397 pieces.

Hamlin's Hill N42/137 (15)

Hamlin's Hill is located between the Tamaki River and the upper reaches of the Manukau Harbour, south of Auckland. An extensive area of pits and terraces make up the site. Salvage excavation conducted exposed the interior of the pits, and evidence for houses and cooking areas. The site is located close to sea resources, and it is well placed for exploitation of shellfish, both in the nearby harbour and river. Few artefacts were recovered from the site: one adze fragment and a few obsidian and greywacke flakes (Davidson 1970b; Irwin 1975). Structural and economic evidence place the site into the Classic Maori Phase (Davidson 1970b:121). Twenty eight obsidian flakes were analyzed.

Hingaimotu N128/20 (24)

The site, located in the sand dunes south of Opunake, south Taranaki, was a small multi-activity habitation site occupied for only a brief period of time during the Archaic Phase. Excavations carried out by Fyfe revealed a shallow occupational surface with a hearth and an oven. No dates are available for the site. Artefacts comprised Archaic adzes, obsidian flakes, chert flakes, bone artefacts and stone artefacts (drill, files) (Fyfe n.d.). Forty six obsidian flakes were analyzed.

Harataonga Bay, Eastern Midden N30/4 (3)

The site is a midden located on the eastern side of the sandy Harataonga Bay on Great Barrier Island. It is situated on a low terrace behind the beach. Eight and a half, two metre squares were excavated. Stratigraphy on the site was simple, and was composed of a surface midden layer which overlay, in most places, a sterile layer of sand. A series of ovens at the base of the midden layer was partly filled with sand and charcoal. Five earlier cultural deposits restricted to one area of the site were found beneath the midden layer and were separated from it by a clean sand layer. Very few artefacts were recovered from the site, mainly obsidian flakes and some siliceous flakes and worked bone. The site served as a base for food preparation, primarily of shellfish, fish and birds. Radiocarbon dates for the site are 216± 55 B.P. and 247± 55 B.P. (Law 1972; Law 1982). Four obsidian flakes were analyzed.

Harataonga Bay, Western Midden N30/5 (3)

The site is located on the western side of Harataonga Bay, Great Barrier Island. The midden lies on the dunes behind the beach, and is part of a generalised occupation site where many different activities were carried out. No evidence of structures was found at the site. Part of the site was stratified into two layers (upper and lower). Artefacts from both layers are Archaic, and the faunal material from both layers is nearly identical. The artefacts are therefore treated as a single period assemblage (Law 1972). No radiocarbon dates are available for the site, but on the artefactual evidence a thirteenth century date is postulated (ibid.:100). Artefacts from the site include one-piece bone fishhooks, lure fishhooks and points, needles and a bird spear. Stone artefacts include adzes and adze preforms, basalt and siliceous flake material and obsidian flakes. Sixty seven obsidian flakes were analyzed.

Harataonga Bay Pa N30/3 (3)

This site is located on a low ridge above the beach of Harataonga Bay on Great Barrier Island. The only visible features of the pa were the pit and a ditch, both of which were investigated. Except for obsidian, artefacts were rare on the site. The site was mainly used for storage, defence, cooking and some stone working. Its small surface area could not have sustained more than three or four houses, and a storage pit (Law 1972). One radiocarbon date for the site is available of 441± 55 B.P. (Law 1982). Fifty two obsidian flakes were analyzed.

Hawksburn S143/2 (43)

The Hawksburn moa-hunting site is located in Central Otago at an altitude of 660 metres above sea level in the Carrick Mountains. The main occupation area is quite large and was covered with porcellanite and silcrete flakes. The site has one main cultural layer, (it probably represents a camp-site which was occupied several times for possibly short periods of time), which is divided into distinct activity areas: a cooking area, represented by ovens, moa-bone, stone tools and flakes, a midden area containing moa, small bird and dog bones, some freshwater mussel, shell fragments, and a row of three hut sites marked by stone kerbed scooped hearths. Artefacts recovered from the site are mainly silcrete blades, porcellanite flakes worked into scrapers and knives as well as argillite adzes. There were 40 small obsidian flakes almost entirely from around the huts (Anderson 1979:48-59).

The site is radiocarbon dated to about 650 B.P. (Anderson 1979). Twenty six obsidian flakes were analyzed.

Heaphy River Mouth S7/1 (47)

The site is located at the mouth of the Heaphy River, northwest Nelson. Excavations were carried out in 1960 to 1963 (Wilkes and Scarlett 1967). The occupational deposit was restricted to one layer of blackened sand and crushed shell. Several pavements were uncovered at the site, which were interpreted as wood and stone working areas (op. cit.:198). The site was a small settlement with distinct activity areas, including adze repair and flaking, and minnow lure manufacturing. Stone flakes recovered include obsidian and argillite (both used and waste flakes), adzes and a grindstone, and silicified sandstone flakes used as knives and scrapers. Several ovens were found at the site. Bone (seal, moa and small birds) and shell fragments were found associated with them. Faunal material found in a separate midden included mussels (*mytilus sp.*) and pipi (*paphies* sp.), but no bone remains. Artefacts recovered include bone minnow lures, bone points, ornaments, abraders, adzes and flakes. One radiocarbon date dates the site at 432± 70 B.P. (op. cit.:210). Sixty nine obsidian flakes were analyzed.

Hot Water Beach N44/69 (10)

The site is a beach midden situated on the east coast of the Coromandel Peninsula. Salvage excavations were carried out in 1969 and uncovered three occupational layers (layers 3b, 4 and 5). Adze finishing was an important activity carried out at this coastal site. All adze material came from the nearby Tahanga basalt quarry. It was also a fishing camp mainly confined to inshore fishing. No general changes in the subsistence and exploitation pattern between Layers 4 and 5 were found. Layer 3b, a later occupation, suggests a more restricted exploitation of resources. Bone working tools (drills) and other stone flakes are few in number. Radiocarbon dates for the site are all from Layer 4 and are 421± 40, 484± 79, 453± 40, 325± 78 B.P. The site was probably occupied between A.D. 1350 and A.D. 1540 (Leahy 1974). One hundred and ninety obsidian pieces were analyzed.

Houhora N6/4 (1)

The site is located on a low coastal platform at the mouth of the Houhora Harbour, and at the foot of Mt. Camel, by which name it is also known. The excavation and the site have been discussed by Shawcross and Roe (1966) and Roe (1967). The lithic material from the site was analyzed by Best (1975,1977). Two radiocarbon dates from the lower occupation are 796±56 B.P. and 690±40 B.P.(Shawcross 1972:603-605). Shawcross suggests that the site represents the first settlement of a 'virgin region' (1972:611). Davidson (1984:169), in contrast, argues that the site is probably a typical early Polynesian settlement in the far north, a summer hunting and fishing camp, and probably far from unique in the Northland area. Over 3000 obsidian flakes were recovered from the site as part of the lithic assemblage. Other diagnostic artefacts recovered from the site include bi-perforate lure points and broad tattooing chisels, fishhooks, bone artefacts and adzes. Four hundred obsidian flakes were selected for analysis.

Houhoupounamu S76/7 (33)

The site is located in North Canterbury on the inland side of dried up lagoon or swamp, about two kilometres from the beach. The bottom layer is formed by a shell midden. The site was occupied twice between 250 B.P and 350 B.P. and around 500 B.P. (Trotter 1982:90). Nine obsidian flakes were analyzed.

Kauri Point Swamp N53/54-55 (13)

The obsidian assemblage analyzed for this study comes from a swamp deposit adjacent to Kauri Point Pa, located on the Katikati Peninsula in the Western Bay of Plenty. The pa was first excavated by Golson and the Auckland Archaeological Society in 1961. Golson's report (1961) outlines three occupation periods for the pa. Ambrose (1962) in later excavations established five periods of occupation. Shawcross in 1962 and 1963 searched the adjacent swamp for cultural deposits. It yielded a large number of wooden artefacts, including 334 fragments of wooden combs, wooden figures, horticultural tools, gourds, flutes, wooden vessels, textiles and about 14,000 obsidian flakes. The material recovered has been reported by Shawcross (1964) and the excavation by Shawcross (1976). Seven radiocarbon dates were initially obtained for the site.

Problems in dating the sequence led to two additional samples being analyzed. On the basis of these additional samples Shawcross (op. cit.:296) concluded that the initial deposits of the swamp dated to the sixteenth century and that it was used until the eighteenth century. Green (1978) re-assessed the dates discarded by Shawcross and concluded that the probable beginning of the sequence at the swamp is more likely to have been around the end of the fifteenth century A.D. He further argued that the upper limit of the sequence is likely to have been before A.D. 1770 and probably before A.D. 1650. Correlating the sequence with the construction of terraces of the pa (dated at A.D. 1350 to 1570) allowed Green to conclude "that the swamp deposit ... is not of long duration, at least in relation to the entire pa which carries on into the eighteenth century A.D." (Green, 1978:37). The sequence for the site can be summarized as follows. The swamp and pa were used for gardening, and terraces were constructed on the headland. These activities took place around A.D. 1500. The deposit of combs and other objects in the swamp began probably shortly afterwards and continued for about 200 years. At the same time a ditch and palisade and pit were constructed on the pa and a midden deposit formed. Later a new defensive system was constructed on the pa, which was used until the eighteenth century. Shawcross (1964, 1976) suggests that the swamp site represents a *wai* *tapu,* a dump for sacred objects rendered *tapu* by their associations. Two hundred and forty nine obsidian flakes from the swamp were analyzed.

Koreromaiwaho Pa N64/8 (18)

This site is adjacent to the Aotea site. It is a small headland pa located on the crest of the sand dunes. Surface finds recorded included patches of shell midden and a scatter of artefacts. Some pits and a ditch were visible. Some surface artefacts were collected (Fox and Cassels 1983:93-94), and include some obsidian flakes. Six pieces of obsidian were analyzed.

Long Beach S164/20 (41)

The Long Beach midden site is located at the back of the sanddunes on the open bay of Long Beach, Otago. It has two cultural layers separated by a sterile sand layer. The earlier one (layer 4), dated to the late Archaic by two radiocarbon dates, 490± 58 B.P. and 733± 59 B.P., produced a typical Archaic artefact assemblage (bait and lure hooks, worked whale bone, silcrete blades, adze fragments and four obsidian flakes), as well as a transition barracouta point. The middle layer which separated the Archaic layer from the later one, had some intrusive artefacts, including six obsidian flakes, which with few exceptions could not be assigned with certainty to one or other of the adjacent layers. The upper layer (layer 2) contained several Classic Maori artefacts (bone pendants, bone comb teeth, trolling lures, composite bait hooks, chalcedony, 32 obsidian and other stone flakes). There is a general continuity in style in the site from the late Archaic layer to the ca. 200 years later Classic Maori layer (Leach and Hamel 1981). Seven flakes were analyzed from a dated context , and 11 flakes were unprovenanced.

Maioro N51/5 (23)

The site is a defended settlement on a knoll near the west coast of the North Island and close to the Waikato River and the Manukau Harbour. Excavations uncovered four phases of occupation, shown by successive storage pits. The site began as an undefended settlement in the thirteenth century, which is known from a series of filled storage pits which underlie later defences. The second phase saw the beginning of a palisaded enclosure; the earlier pits were filled in, the natural slopes of the knoll were steepened, and a working floor was uncovered. In the third phase in the sixteenth century, the defences were strengthened and reconditioned. Shortly thereafter, the defences fell into disuse and the site became an open settlement again. Large storage pits were dug. Radiocarbon dates corrected for secular effects using the new half life for Phase 1 are 873± 55 B.P. and 821± 47 B.P.. Green (1983), believes that the younger range of these dates is a better estimate for the age of Phase 1 occupation. Three dates for Phase 2 are available (420± 52 B.P., 345± 51 B.P., and 293± 56 B.P.) of which the latter one is considered to be too young (ibid.). Phase 3 is supposed to have been around 1510 to 1630 A.D., while the latest occupation, Phase 4, took place in the sixteenth to seventeenth century (Green, 1983; Fox and Green, 1982). The obsidian from the site had been previously analyzed by McFadgen (Fox and Green 1982). The results were checked against the Otago University sourcing results and seemed to be in agreement, with a few exceptions, therefore the results used here do not precisely coincide with the ones in Fox and Green (ibid.). Results were obtained for 931 obsidian pieces. In those cases were the flakes could not be analyzed by the Otago University facilities (due to size), the results from McFadgen's analysis were used.

Mangakaware II N65/35 (19)

The site is a prehistoric swamp fortification in the Central Waikato on the edge of Lake Mangakaware. It comprised a palisaded enclosure which contained houses and cooking areas built on sand lenses built up over the original peat surface. It is dated mainly within the sixteenth and seventeenth centuries A.D. The settlement was defended by its palisades and its location in the swamp. Eight to ten houses were concentrated on one side of the site, close to the lake. The population of the site exploited marine resources which were carried to the site by canoe. Shellfish and fish remains were found. The site was occupied throughout the year. Artefacts recovered from the site belong to the 'Classic Maori Phase' (Golson 1959). These included stone adzes (type 2b), pounders and grinders, wooden beaters, bone pendants, and other bone and wooden artefacts. Thirty two obsidian pieces were found originally at the site; some were subsequently lost (Bellwood 1978b:40). The artefact assemblage dates probably to between A.D. 1500 to A.D.1700 (ibid.). Radiocarbon dates on wood fragments place the initial occupation of the site at around A.D. 1450 to 1500 (424± 74 B.P. and 389± 54 B.P.) and the two dates of 280± 76 B.P. and 232± 38 B.P. may define the latest limit of the occupation. Bellwood (op. cit.:71) believes that the site was occupied for probably less than 300 years and most probably between the sixteenth and seventeenth centuries. Twelve flakes from the site were analyzed.

Murdering Beach S164/16 (42)

The site is located on a small beach near Dunedin. It is a late prehistoric settlement set in the foredunes; earlier material was found inland. The site was investigated by Lockerbie (1959) after it had been fossicked for some time. Radiocarbon dates suggest occupation about 300 years B.P.

Ngaroto N65/18 (19)

Ngaroto is a swamp pa located on the edge of Lake Ngaroto in the Waikato area. Excavations were carried out by the Waikato Archaeological Group and later by W. Shawcross (Shawcross 1968). The site is a defended settlement with a number of platforms with houses, and a palisaded enclosure. The site was continuously occupied for several hundred years. Artefacts recovered belong to a Classic Maori assemblage (Golson 1959), and include stone clubs, *patu*, greenstone ornaments, pounders, pumice pots, adzes and stone flakes. The site was occupied between

A.D. 1500 and A.D. 1860 and was similar to, though larger than, the Lake Mangakaware swamp pa. Fifteen flakes of obsidian were analyzed.

Paremata N160/5 (25)

The site lies at the entrance to Porirua Harbour on the west cost of Wellington on extensive low sand dunes. The site rescue excavations were described by Davidson (1978a:203-236). The site had been badly disturbed, and extensive mixing of its three layers occurred. Nevertheless, three Maori occupations could be identified: a moa-hunting occupation, a later prehistoric one and a Maori-European occupation - Paremata Pa - in the nineteenth century (op. cit.:227). Because of the disturbance, the lithic material was initially analyzed as a single assemblage by Moore and Challis (1980:325-329). Green obsidian dominates over all rock types, forming about 45% of the total lithic assemblage. Other lithic material includes chert (25%), metasomatised argillite (15%), greywacke, basalt and other rocks. Obsidian was evenly distributed among the layers. Thirty one flakes appear to be late occupation, and 63 appear to be associated with Layer 3 (moa-hunting period) (Davidson 1978a:224). Other artefacts recovered include a number of bone ornaments and tools. A radiocarbon date of 514± 80

B.P. obtained at a later date, can not be related to any of the excavated layers (op. cit.:214).

Peketa S49/23 and S49/48 (31)

The site is a Kati Mamoe pa, dated at about 240 years B.P. (280± 50 B.P. and 340± 50 B.P.) (Trotter 1982:98). Seven flakes were analyzed, six from S49/23 and one from S49/48.

Port Jackson N35/88 (7)

Located on the north end of the Coromandel Peninsula, the site was first excavated by Davidson. An oven with associated burnt moa and *Nestor meridionalis septentrionalis* (kaka) bones was excavated. In 1981 further excavations were carried out. An Archaic occupation was recorded and a later Maori occupation in another area of the site. the Archaic midden contained about 80% *Nestor meridioanlis septentrionalis* (kaka) bones, and some seal and moa bones. The later occupation contained exclusively shells and no bone remains. A radiocarbon date on moa bone collagen collected at the site gave a result of 650 B.P. The site has been described by Foster (1982), and as he has commented (ibid.:13-19, 168-69), the site has been heavily deflated over the last years and artefact representation (mainly surface collected) may be affected. Obsidian analyzed was recovered from the Archaic context of the site, (areas B and C), a pebble floor, and surface collected; they have to be treated as a single sample (ibid.:89). Fifteen flakes were analyzed.

Pouerua sites: N15/236, N15/237, N15/277, N15/501, N15/505, N15/507,
(2)

These archaeological sites, located in the Pouerua area, in the inland Bay of Islands, are all open settlement sites surrounding the Pouerua cone *pa*. The sites were investigated as part of the Pouerua project (Sutton 1982, 1983, 1984; Brassey 1985). No absolute dates for the site are available as yet, but the sites date to the late prehistoric or possibly early historic period (Brassey ibid.:13).

Pounawea S184/1 (44)

The site, located at Manuka Point - Pounawea - in southeast Otago, has been described by Lockerbie (1959:75-110) and Hamel (n.d.). Initial radiocarbon dates for the site were published by Fergusson and Rafter (1957:732-749). The site is a deep stratified midden, now interpreted as belonging to a single cultural tradition with little or no change in its subsistence activities or material culture. Radiocarbon dates from the site range from 500 to 800 years B.P. Artefacts recovered from the site reflect the subsistence activities carried out at the site, and include fishhooks, lures, harpoons, stone adzes, and a wide range of stone flakes and blades. Only three obsidian flakes from the site were available for analysis from the ten flakes excavated in 1979 (Hamel n.d.:31).

Purakanui S164/8 (40)

This site, located on the western shore of Purakanui Inlet, northwest of the Otago Heads, is dated to the late fourteenth century A.D. The site, a large midden, had three occupational layers, all believed to have been deposited within the space of a few years. The site was excavated in 1979 and the excavation and artefacts are discussed by Anderson (1981:201-221). The main function of the site was open-sea fishing, mainly red cod and barracouta. Other faunal material identified included some seal, dog, shellfish, and a variety of fish. Artefactual material included a large range of stone flakes and blades mainly of silcrete and chert. Thirty eight obsidian flakes were recovered, of which 17 were analyzed. Shell and bone implements included fishhooks and awls. Of the five radiocarbon dates, two are regarded as secure, 562± 30 B.P. and 571± 34 B.P. (op. cit.:205).

Raglan Archaic Dune Site N64/16 (16)

Archaic site located on the northern edge of the modern Raglan Golfcourse at G.R. N64/374446. A large amount of basalt flakes and adze blade tools were recovered from this site as well as some chert and bone artefacts. The obsidian assemblage was surface collected (Edson, pers. comm.).

Raglan N64/18 (17)

This site is likewise a surface collection made from a dune site on the northern side of Raglan Harbour. Artefacts recovered include sandstone grinding tools, sinkers and bone fishhooks (Edson, pers. comm.).

Redcliffs S84/76 (34)

Redcliffs comprises several archaeological sites on flat ground adjacent to cliffs alongside the estuary of the Heathcote and Avon Rivers, just north of Christchurch. The material analyzed comes from a site lying on old sand dunes which have accumulated along the base of the cliffs. Evidence points to a single occupation scattered over about 4 ha., with a smaller later occupation represented by a few artefacts. Cooking activities and the disposal of food remains appear to have been carried out throughout the site, with artefact manufacture restricted to some areas. Prehistoric Archaic middens along the area had been uncovered since 1851 (Torlesse, 1851:7; Trotter 1967a:251).

Part of the analyzed material (57 flakes) came from a sewer trench dug in 1969. Bones of four species of moa, extinct birds, rat, dogs and seals were found. Artefacts present were cores and flakes of basalt produced from adze manufacture. All these were recovered from a single occupational deposit. Radiocarbon dates on moa bone collected gave ages of 615± 40 B.P. and 581± 40 B.P. (Trotter 1975b:199). Further controlled excavations were carried out at the Redcliffs School section, where under a disturbed layer, a black deposit containing artefacts, midden shells, stones and bones was found. The main structure found was a pit used as an oven. Artefacts indicated food preparation, manufacturing and other activities (Trotter 1975b). Eighty two obsidian flakes were analyzed.

Shag Point S146/5 (39)

Shag Point is a mid-sixteenth century A.D. site located on the tip of the Shag Point Peninsula, North Otago. It lies about half a mile north of the Archaic site at Shag River Mouth. The site was excavated by Trotter in 1969. Artefacts recovered are typologically similar and represent one single occupational layer. A radiocarbon date on shell places the site at 434± 50 B.P. Artefacts recovered from the site were mainly stone flakes of chalcedony, obsidian and orthoquartzite. Moa bone was used for manufacturing fishhooks and lures. Activities carried out at the settlement included fishhook manufacture, though the main activity at the site was food gathering and preparation, as evidenced from the extensive midden material. a number of stone abraders were manufactured at the site, apparently for use elsewhere (Trotter 1970). Seventy eight obsidian flakes were analyzed.

Shag River Mouth S155/5 (39)

Located on the south side of the Shag River mouth beside some small fsand hills, the site produced a substantial quantity of artefacts and moa bone remains. Sporadic excavations have been carried out at the site since 1872 (Teviotdale 1924; Skinner 1924). The site had, like the Waitaki River Mouth site, remains of groups of houses containing stone-edged hearths. A considerable number of stone artefacts (about 200 adzes) and bone tools (fishhooks, awls, etc.) were recovered from the site. It was probably a settlement which was repeatedly occupied for long periods of time (Anderson 1982b). The site represents one of the earliest settlements in the South Island, with two radiocarbon dates of 823±55 B.P. and 802±55 B.P. Thirty five obsidian pieces from different excavations (by Teviotdale and Trotter) were analyzed.

Skippers Ridge I (Opito) N40/7 (8)

The site is located on a ridge top behind the beach and coastal flat at Opito Bay, east Coast of the Coromandel Peninsula. The site consists of an extensive settlement with storage and cooking areas. A total of four occupations was recorded at the site. Radiocarbon dates from the first occupation date it to 807± 57 B.P. The first three occupations were probably continuous and probably little time elapsed between them. The main changes from occupation 1 to 3 involve the building and rebuilding of storage structures. Occupation 4 belongs possibly to a period before A.D. 1300. The settlement apparently was an adze working site, as shown by the large number of basalt flakes and chips at the site, and a complete absence of bone artefacts including fishing gear and siliceous stone flakes. The portable material culture could not generally be associated with any of the structures or confidently associated with a particular occupation. It was therefore regarded as a single assemblage, broadly contemporary with the use of the pits. The material from Layer 2 (occupation 4) represents probably a separate assemblage and is probably associated with only one occupation (Davidson 1974, 1975; Bellwood 1969). Fifteen flakes of obsidian were analyzed.

Skippers Ridge II N40/73 (8)

The site is located on a small ridge behind the foredunes of Opito Bay, Coromandel Peninsula. Excavations at the site were carried out by Bellwood in 1967 (Bellwood 1969), and are located about 200 metres from a site excavated by Parker in 1959-60 (Parker 1959, 1960) called Skippers Ridge I. The site was composed of a series of pits and ditches. The pits were both rectangular and circular in shape and served a variety of purposes. Some were connected by drainage ditches (for a description and discussion see Bellwood 1969:199-204). Artefactual material recovered from the site comprised 139 worked basalt flakes, 305 worked obsidian pieces, 26 chert flakes, five basalt adze roughouts and two finished adzes, as well as one basalt polisher and some kauri gum. The artefacts from the site seem to have been used for cutting and scraping of fibres and wood, and the site as a whole seems to have been used for food storage, stone tool manufacture and the working of wood; fibre dressing might have taken place as well. The site was dated to < 132 B.P. and < 213 B.P. [sic] (ibid.). It is close enough in age to the prehistoric period for no European artefacts to be found and for stone adzes and flakes still to have been made and used. It was contemporaneous with the neighbouring site, Skippers Ridge I. One hundred and five obsidian flakes were analyzed.

Station Bay, N38/30 (4)

The site, located on Motutapu Island, is an undefended settlement with pits, terraces, house floors and midden material, all set on a sloping ridge overlooking the bay. One burial was also found. One radiocarbon date on bone collagen of 600±50 B.P. from the burial is interpreted as being too old (Leahy 1972). Twenty six obsidian flakes were analyzed.

Station Bay, N38/37 (5)

The site is an undefended settlement, located on Motutapu Island. It comprises a settlement area with pits, terraces and middens. The site was excavated by Davidson (1970a). Six radiocarbon dates were obtained. Davidson estimates the most likely occupation at 185±71 B.P. (1984:250). Thirty four obsidian pieces were analyzed.

Sunde Site, Motutapu Island N38/24 (6)

The Sunde site is a midden at Northwest Bay, Motutapu Island, which was occupied before, between and after the Rangitoto ash falls. The site was occupied on at least three successive occasions by people with an Archaic material culture as evidenced by adzes, mostly in the process of manufacture, and some items of fishing gear. The first occupation before the ash fall period was abandoned apparently at the onset of the eruption (A.D. 1350± 50), but the site was probably resettled shortly thereafter. Two cultural layers above the ash continue in the same tradition as the pre-eruption occupation. During the last occupation the site was only occupied for cooking. It lacks the earlier artefacts and probably belonged to a separate occupation phase.

The earliest C14 date is from below the ash layer and dates the ocupation around 640± 60 B.P. A second date from above the ash layer dates at 630± 60 B.P. (Scott 1979; Davidson 1974; Law 1975b; Nichol 1981). Five flakes were analyzed.

Tahunanui S20/2 (26)

This is an archaic site, located on the north coast of the South Island, close to Tahunanui Beach, Nelson. The site has only one cultural layer which was deposited over a prolonged period of time, mainly as a stone tool manufacturing place. An extremely high density of flake material (argillite and obsidian mainly) covered the site. Artefacts manufactured at the site included adzes and fishing gear, which was mainly made from moa bone (Millar, 1964). The site has been dated to 589± 70 B.P. The dates come from an oven sample, which possibly predates the main occupation (flaking activities) (Millar, 1967). One hundred and seventy seven obsidian flakes were analyzed.

Tairua N44/2 (11)

Tairua is a littoral stratified midden located on the dune at Tairua, Coromandel Peninsula. The cultural layers at the site represent two temporarily separate layers. There is also a clear differentiation of activities at the site. The earlier layer at the site (layer 2) contains a large range of artefacts and faunal material attributed to the Archaic Cultural Phase (Golson, 1959). The material at the site is consistent with artefactual evidence from other Archaic sites in the North Island. Green (1970) originally believed that the earliest layer belonged to the initial period of occupation of the Coromandel Peninsula. The later occupation (layer 1) is different from the one below. It is a midden composed mainly of mudflat shellfish species.

Radiocarbon dates at the site are restricted to three dates for layer 2, of which one is contaminated (879± 49 B.P.). A further date of 443± 40 B.P. seems questionable, and the last one, 570± 60 B.P. is taken on shell. A date no later then the fourteenth century A.D. is accepted for the site (Green 1962; Jones 1973; Rowland 1977; Smith 1978). One hundred and seventy three flakes were analyzed.

Tai Rua S136/1 (36)

The site is situated behind the modern beach of the Waimakarua River in North Otago. The site was excavated by Trotter and Gathercole and several reports have been published (Trotter 1959, 1965a, 1965b, 1966, 1970; Gathercole 1961; Hjarno 1967). A total of seven layers was uncovered , ranging from modern occupation to early Archaic. The site was an undefended settlement where a series of activities such as butchering of moa, cooking, tool manufacturing, etc. took place. Stone tools comprised mainly siliceous and greywake flakes, a few adzes, hammers, and sinkers. Bone artefacts included a variety of fishhooks. Trotter (1979) believes that settlement was less permanent than at Wairau Bar. Radiocarbon dates place the site at 500 B.P.. Nine dates were obtained from moa bone collagen, marine shell, and charcoal (Trotter 1979:227). Eight pieces of obsidian from the site were analyzed.

Timpendean S61/4 (32)

The site is also known as the Weka Pass Shelter. It is a rockshelter located in a limestone outcrop, with a panel of rockdrawings on the inner face. The shelter was excavated first by Haast in 1876 and later again by Trotter (1972). Trotter's excavations revealed three periods of occupation, the main occupation containing shells. moa bone, other bird bones, stone artefacts (obsidian, siliceous flakes, argillite, and adze pieces) and bone artefacts. A high percentage of marine shells found suggests to the authors direct contact with the coast. Radiocarbon dates of this layer taken on marine and freshwater shell are respectively 436±53 B.P. and 704±41 B.P.. A date of 450 B.P. is accepted by the authors for the site (Trotter 1972:49). Two obsidian flakes from the site were analyzed.

Titirangi Sandhill S16/83 (27)

This site, located at the head of Titirangi Bay, Marlborough Sounds, was occupied at least three times. The main activities carried out during the first occupation of the site were moa-hunting and adze manufacture. This earliest occupation is dated to 830 B.P. Nineteen obsidian pieces were found.

A second occupation dated to 440 B.P., used the site for adze manufacture. No big bird hunting was recorded. Two obsidian pieces were recovered from this context.

The last occupation was shortly after European contact. European claypipes were recorded, but otherwise the artefacts were manufactured of bone, wood and stone (Trotter 1977b). Five obsidian pieces from the site were analyzed.

Titirangi Pit S16/93 (27)

This site is part of a series of pits, probably used as dwellings, located on ridges overlooking Titirangi Bay, Marlborough Sounds. The pit investigated is adjacent to a small pa site (Trotter 1977b:10) Five obsidian pieces were found, two of which were analyzed.

Tiwai Point S181-2/16 (45)

The Tiwai Point site is located on a low gravel and sand peninsula opposite Bluff, between Awarua Bay and Foveaux Strait. The site was an extensive stone working area. Excavations were carried out in 1967-1968 in two separate areas. The first area was an argillite and other stone material working floor. The second area was also an extensive flaking floor which was associated with a midden containing fish and bird bones, including moa bones, as well as shellfish and mammal bones. Both areas belong to a single occupation. Finished artefacts recovered included adzes, some chisels, lure shanks, fishhooks and some dentalium beads (Park 1969; Sutton and Marshall 1980, Huffadine 1978). The site has been dated by C14 to the thirteenth century A.D. (770±80 B.P., 770±60 B.P., 700±40 B.P., 640±40 B.P. and 442±53 B.P. which is considered too late for the site) (Park 1979). Seventy seven obsidian flakes were analyzed.

Tokoroa N75/1 (20)

This is an Archaic moa-hunting site from the inland North Island. Green (1970) assigned it into the Settlement Phase of the area. The site is located on a streambed. It was only occupied for a short time by people in transit. At the time of the initial occupation of the site, forest grew in the area which supplied food resources, berries, birds and fungi. The exploitation of the resources was however not very significant, only two to three moa are represented at the site. Artefacts recovered were 510 pieces of obsidian and a few adze flakes. Morwood (1974) on the basis of obsidian use-wear analysis believes that the site was a base camp, but that not all activities carried out there were represented in the excavations. He argues further that the tools used were not manufactured at the site, or at least in the area excavated. Two hundred fifty four flakes were analyzed.

Waihora Rockshelter N93/5 (22)

The site is located on the western bay of Lake Taupo. Excavations in 1956 established four occupational layers in a total of eight layers of deposition. The first five upper layers, except layer two had cultural material. The three deeper layers were all sterile and contained natural deposits. Layer 5 represents the most recent occupation on the site. Artefacts included broken combs, woven material, lake and marine shells, pumice artefacts, obsidian and other stone flakes, and bone toggles. Layer 4 had obsidian charcoal, gourd remains and stone flakes associated, as well as one adze and adze roughout. Faunal remains included shells and dog, rat and bird bones. Layer 3 did not have any specific artefacts associated. Bird and rat bones were also found. Layer 2 was sterile and layer 1 contained only one adze.

All these occupations seem to have been temporary; but during the last period the shelter might have been used for the exposure of bodies and deposition of personal artefacts (Hoskins and Leahy 1982). Besides the above artefacts, 32 obsidian flakes covered with red ochre, *kokowai* and two adzes, all unprovenanced, were recovered from the site. The site is dated by comparison of its artefactual material to Whakamoenga Cave with the seventeenth to late eighteenth century A.D. (ibid.). One hundred and eighty flakes of obsidian were analyzed.

Waimataitai S146/2 (37)

Located at the mouth of the Waimataitai River, Katiki, Otago; it was a moa-hunter camp site. The site was excavated and described by Trotter (1955:295-303; 1967b:137-142). Moa bone fishhook manufacturing debris was present in some quantity. About half of the bone artefact assemblage is made of moa bone. Lithic material included silcrete blades. Two radiocarbon dates on shell gave a date of 626±30 B.P. and 701±47 B.P. One obsidian piece was analyzed.

Wairau Bar S29/7 (28)

Located on the shingle bar at the Wairau River, Marlborough, it was described by Duff (1956) and Bell (1957) and later by Trotter (1977a). Being one of the richest South Island moa-hunter sites it has been considered a 'site-type' within this period of New Zealand Prehistory (op. cit.:75). Some 39 burials with associated gravegoods were uncovered at the site (Houghton 1975:231-246), separate from a habitation area featuring postholes and ovens. Radiocarbon dates place the site between 600 B.P. and 700 B.P. A large assemblage of sophisticated adzes, artefacts and ornaments, whale tooth pendants, and a large assemblage of fishhooks and minnow lures. The obsidian analyzed from the site was recovered during Trotters's excavations. A total of eleven pieces was analyzed.

Waitaki River Mouth S128/1 (35)

Located on the sea coast just south of the Waitaki River mouth, the site lies on two river terraces. The site represented in Teviotdale's view an early moa-hunter site (Teviotdale 1939), and was excavated on several occasions from 1931 to 1937 by Skinner, Teviotdale and others (Teviotdale 1939). Structural remains found at the site, suggest to Anderson (1983) that the site was a frequently occupied camp. The midden produced remains of not less than 68 moas, and probably many more. The site represents one of the earliest settlements of the South Island (600±80 B.P.). The obsidian flakes from the site are all unprovenanced. Twenty five flakes were analyzed.

Whakamoenga Cave N94/7 (21)

Whakamoenga Cave is located on the north shore of Lake Taupo. The stratified deposits inside the cave date from the Archaic to European times. Eleven layers were found at the site which were grouped into three occupations on the basis of a rockfall, a renewed occupation and the appearance of European material. Occupation 1 is dated to the fourteenth to fifteenth century A.D. by two radiocarbon dates: 605±55 B.P. and 479±55 B.P. This occupation was divided into two periods, separated only by a short time break. Moa bone and other bush bird bones were recovered from this layer; an obsidian working area was uncovered at the back of the cave. Occupation 2 was dated by radiocarbon to 279±55 B.P. and 249±59 B.P. Fewer bushbird bones were found and numerous obsidian flakes were prepared at the site. The material was probably brought to the site by canoe from Whangamata Bay (Leahy 1976) to be worked and then removed. This activitiy was carried on from the earlier occupation. Used shells were abundant at this level.

The latest occupation (4) is dated to the ninteenth century A.D. It contained European material mixed with obsidian flakes (Hoskins 1962; Leahy 1976). One hundred and thirty nine obsidian flakes were analyzed. Eighty three of these are from late contexts, and the remaining 56 from Archaic contexts.

Whangamata Wharf N49/2 (12)

The site is located on the east coast of the Coromandel Peninsula on a sandspit between a large estuary and an ocean beach. The site was excavated in 1969, and two main occupation layers were uncovered. The top layer was a thick deposit of shell midden (midden A), and beneath, separated by about one metre of sterile sand, a second layer of midden (midden B) was found. The composition of midden A was mainly shells (bivalves), while midden B contained a higher percentage of bones over shell. A large number of dog bones were found in midden B, as well as large quantities of obsidian flakes. Only two adzes were found and relatively few basalt flakes; the function of the site is believed to have been habitation rather than as workshop.

Midden B is an Archaic occupation, while the later midden belongs to late prehistoric Classic occupation (Allo 1972). Forty three obsidian flakes were analyzed, thirty six from midden A, and seven from midden B.

APPENDIX 2

LIST OF SITES RECORDED ON MAYOR ISLAND

(Grid references are given for the NZMS map 260, Map No. U13, (1979))

Site number and Grid Reference	Site description
N54/1 E:279900 N:642740	Panui Pa. Headland pa with some terraces and pits.
N54/2 E:279895 N:642790	Ridge Pa defended on the northwest side by a ditch and a scarp on the other three faces. It has one platform somewhat elevated on the top and one terrace on the scarp, that overlooks the beach on South East Bay.
N54/4 E:280055 N:643035	Taumou Pa. Hilltop terraced pa naturally fortified, with artificial terraces, now almost completely obliterated.
N54/5 E:280030 N:642975	Quarry. Tunnel mined into an obsidian flow on top of the crater rim. Flakes are scattered on the ground.
N54/8 E:279895 N:642760	Midden exposed by erosion of the natural terrace above South-East Bay. Midden material consists of *Cellana* sp., *Nerita* sp., *Haliotis* sp., a few cockles, *Cookia sulcata*, one mammal bone, charcoal and obsidian flakes, as well as a few fishbones. It is probably the same midden as site N54/8 recorded by H. Pos (1965).
N54/23 E:279780 N:642937	Two pits with associated terraces. The pits have been described by P. Moore (N54/23). A third pit is on the scarp on the inside wall of the crater. Several terraces on the scarp

of the crater wall, both inside and outside were found. A ditch (N54/24) delimitates clearly this site to the northwest.

N54/32 E:279820 N:643160	Sub-rectangular pit, without raised rim. (dimensions: 3m by 4m).
N54/33 E:280020 N:642940	Two rectangular pits with raised rim, along the crater rim. Pit A: 6.5 x 5.0 m by 0.70 m deep; Pit B: 10.0 x 7.0 m by 0.50 m deep.
N54/34 E:280020 N:642940	Ditch cutting across the crater rim. About 5 metres of the pits of site N54/33.
N54/35 E:280065 N:642940	Two platforms on a natural ridge, separated by a ditch. One shell was found on the side of the platform (*Cookia sulcata*).
N54/36 E:280050 N:642940	Series of three terraces on a natural ridge. One rectangular pits with raised rim on the lowest one. Two storage pits were found on the scarp of the uppermost terrace. Pit dimensions are: 1.0 x 1.5 m by 0.50 m deep.
N54/37 E:280007 N:642960	Rectangular pit with raised rim. Pit dimensions: 2.0 x 3.5 to 4.0 m long.
N54/38 E:280017 N:642980	Midden on a low mound near the shore of the Green Lake. Midden material includes *Nerita* sp., *Haliotis* sp., *Cellana* sp., *Thais orbita*, and *Cookia sulcata*, obsidian and charcoal.
N54/39 E:280029 N:642900	Working floor. Obsidian flakes, cores and boulders are lying scattered on the ground. A few shell fragments were also seen.
N54/40 E:280025 N:643050	Cave. A small, low natural cave with an artificial rock wall covering the low entrance. The cave is located on the lower slopes of the 'Dome'.
N54/41 E:279895 N:642760	Midden exposed underneath a natural bank or terrace on South-East Bay. Midden material seems to have been

dumped from the top of the terrace on to the beach. Material consists of *Haliotis* sp., *Nerita* sp., *Cellana* sp., *Cookia sulcata*, charcoal, fishbones and obsidian flakes.

N54/42 E:279890 N:642770	Raised platform, oval shaped, with a surrounding ditch, 2.0 m wide and 1.0 m deep. The platform is 1.5 m high and 20 m long and about 15 m wide.
N54/43 E:279880 N:642760	Rectangular pit with raised rim on three sides.
N54/44 E:279880 N:642775	Storage pit (rua) with a round opening in the bottom of a small valley.
N54/45 E:279895 N:642755	Rectangular pit with a raised rim on three sides. It is open to the north, and facing a small man-made terrace. Could be part of Panui Pa.
N54/46 E:279890 N:642790	Two pits or rua with a round opening, located on a scarp.
N54/47 E:279895 N:642785	Sub rectangular pit (rua), about 1.0 m deep. Caved in.
N54/48 E:279880 N:642795	Two deep pits on a ridge top. Pit dimensions: Pit A: 1.20 m x 1.20 m by 1.0 m deep; Pit B: 0.60 m X 0.60 m by 1.0 to 1.2 m deep.
N54/49 E:279895 N:642795	Two pits or rua located on the top of a ridge. Both pits are caved in. Pit dimensions are: 0.85 m x 1.30 m and 1.60 by 1.30 m .
N54/50 E:279895 N:642795	Ditch cutting transversally across the above ridge (site N54/49) where the pits are. It could have been a drainage ditch. Another ditch on the ridge immediately to the west of the above, apparently serving the same purpose, was found.
N54/51 E:279895 N:642795	Three storage pits (rua), two on top of a ridge and the third on the side of it. The three pits are located to the northwest of N54/49.

N54/52 E:279895 N:642795	Stone alignement, encircling the upper end of a small gully. The stones are rough lava blocks, standing about 50 cm tall.
N54/53 E:279730 N:642865	Two adjoining terraces with a raised rim and a drainage ditch coming out of the upper one, and running around the lower terrace.
N54/54 E:280050 N:642965	Quarry. Tunnel mined into an obsidian flow at the outer base of the crater wall, on Te Bay.
N54/55 E:280060 N:643055	Quarry. Obsidian flow on the crater rim, behind Taumou Pa. Flakes scattered on the ground, but there is no tunnelling.
N54/56 E:279920 N:643160	Complex of three rectangular pits. Two are open on one end. They do not have a raised raim. The pits are between 2 m and 4 m long.
N54/57 E:279700 N:642900	Storage pit, semi-circular in shape, located on the peninsula on the south end of Northwest Bay.
N54/58 E:279700 N:642900	On the same peninsula where the above site is located, a flat stone in an upright position was found. It could be marking a burial place, since traditionally this area has been used for burials. It was therefore not further investigated.