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SAYING SO DOESN'T MAKE IT SO

PAPERS IN HONOUR OF B. FOSS LEACH

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Douglas G. Sutton

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The Sourcing of New Zealand Archaeological Obsidian Artefacts using Energy Dispersive XRF Spectroscopy

Andrea Seelenfreund

Casilla 760, Santiago, Chile

and

Charles Bollong

Anthropology Department, Southern Methodist University, Dallas, Texas

INTRODUCTION

Obsidian artefacts from 58 archaeological sites were analysed to determine their origin using energy dispersive x-ray fluorescence (XRF) spectroscopy. This study was part of a larger research project, oriented towards the analysis of the distribution and usage of Mayor Island obsidian in prehistoric New Zealand.

Five obsidian source areas can be distinguished in New Zealand. They are all located in the North Island (Figure 1).

Obsidian was frequently used in prehistoric New Zealand, and its importance to the prehistoric population has been discussed by several authors. Green (1964) recognized that Mayor Island obsidian could easily be distinguished from all other New Zealand sources by its green translucent colour under transmitted light. Initial inspection of obsidian flakes recovered from archaeological sites using that technique showed an apparent dominance of Mayor Island obsidian in the early New Zealand sites. Green (1964) suggested that Mayor Island obsidian flows were the first to be discovered by the Polynesian settlers and that the other sources were discovered later and started to replace Mayor Island obsidian in archaeological sites. He also noted that the presence of

> obsidian in sites indicated an imbricated system of regional and inter-regional trading networks which are seemingly possible of definition given a sufficient amount of quantitative information. (Green 1964: 137)

Source characterization studies have not been regularly applied in New Zealand, mainly because of the complexity of some techniques and the costs involved. The development of a non-destructive obsidian sourcing laboratory by one of the authors [Bollong], made it possible to source large numbers of obsidian assemblages. The sourcing facility permits

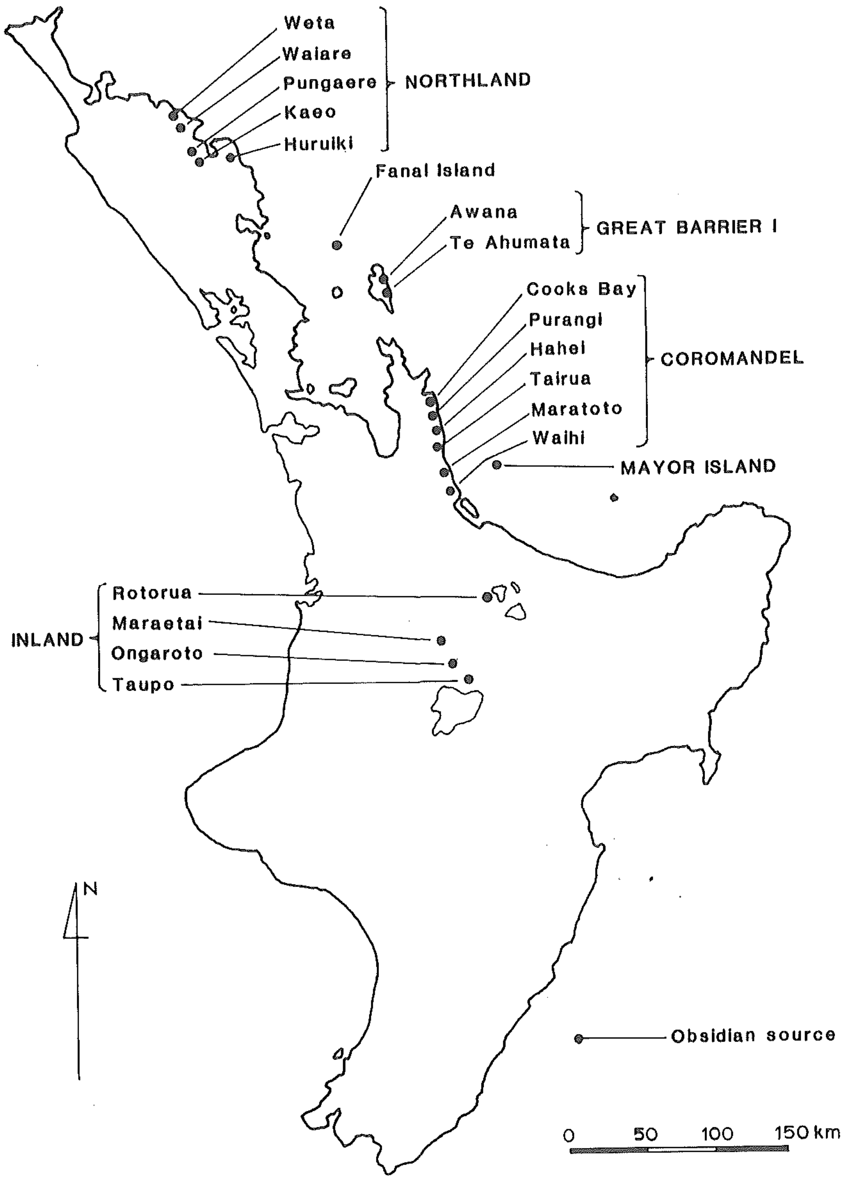

Figure 1: Locations of obsidian sources and source locations.

discrimination 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 successful (Bollong 1983: 156–7). The Mayor Island and Northland sources can be clearly separated on the basis of relative element concentrations. However, problems due to source sampling were encountered (see Brassey 1985; Brassey and Seelenfreund 1984). The system is therefore best suited to discriminate accurately between Mayor Island obsidian and all other New Zealand sources.

MATERIALS AND METHODS

The obsidian assemblages analysed came from 58 sites from the North and South Islands of New Zealand. They came mostly from contexts which were dated, either directly by radiocarbon dates or through comparison of the site's diagnostic artefacts with other dated sites in the area. The location of the sites is shown in Figure 2. Assemblage sizes varied from about 20 to 500 flakes.

The smaller assemblages of obsidian were analysed, as far as possible, in their totality. Specimens smaller than approximately 15 mm in diameter could not be analysed, since the sample holders were designed to be used with the 'average obsidian flake' that might be encountered in an archaeological context. Also, very thin samples (less than 2 mm) had to be discarded. Sample thickness affects the fluorescence response (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. Only two specimens were too large to fit the sample holders. However, the number of pieces discarded because of their size and/or thickness was up to 50 percent in some sites: Harataonga (N30/4), Mangakaware, Long Beach, Station Bay (N38/30), Station Bay (N38/37), Whakamoenga, Clarence, Pounawea and Avoca. This is a problem in the smaller assemblages. In contrast, although only 26 per cent of the Tahunanui assemblage was sourced, this represents quite a large number of flakes. For the larger 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 have introduced observer bias.

Several of the obsidian assemblages contained over 1000 pieces. Given the present efficiency of the equipment it would have taken months to analyse all of them. Therefore, all assemblages containing over 400 pieces of obsidian were sampled. An equation was used to calculate the sample size needed to represent each obsidian assemblage with a 95% margin of confidence. A margin of error of 7% obtained with samples of 200 satisfied the confidence limits, since they were higher than in most cases where the whole assemblage was analysed. A sample size of 200 was also convenient in that it could be adequately run by the isoprobe facility in a reasonable amount of time.

The pieces to be analysed were selected using random number tables. The method of selecting random numbers varied somewhat from site to site depending on their cataloguing system (see Seelenfreund 1985: 179). Some of the assemblages studied are extremely small. This, and the under-representation of the sites in inland areas of the North Island, has to be kept in mind when evaluating the sourcing results.

Nearly all the sites from which obsidian was analysed are located near the coast and not all the sites have the same functional status. Some are large settlement sites, while others represent small transitory camps, possibly occupied seasonally. The absence of inland sites analysed in the South Island, except for Hawksburn, is due to the lack of obsidian material in these sites; which is a significant fact in itself.

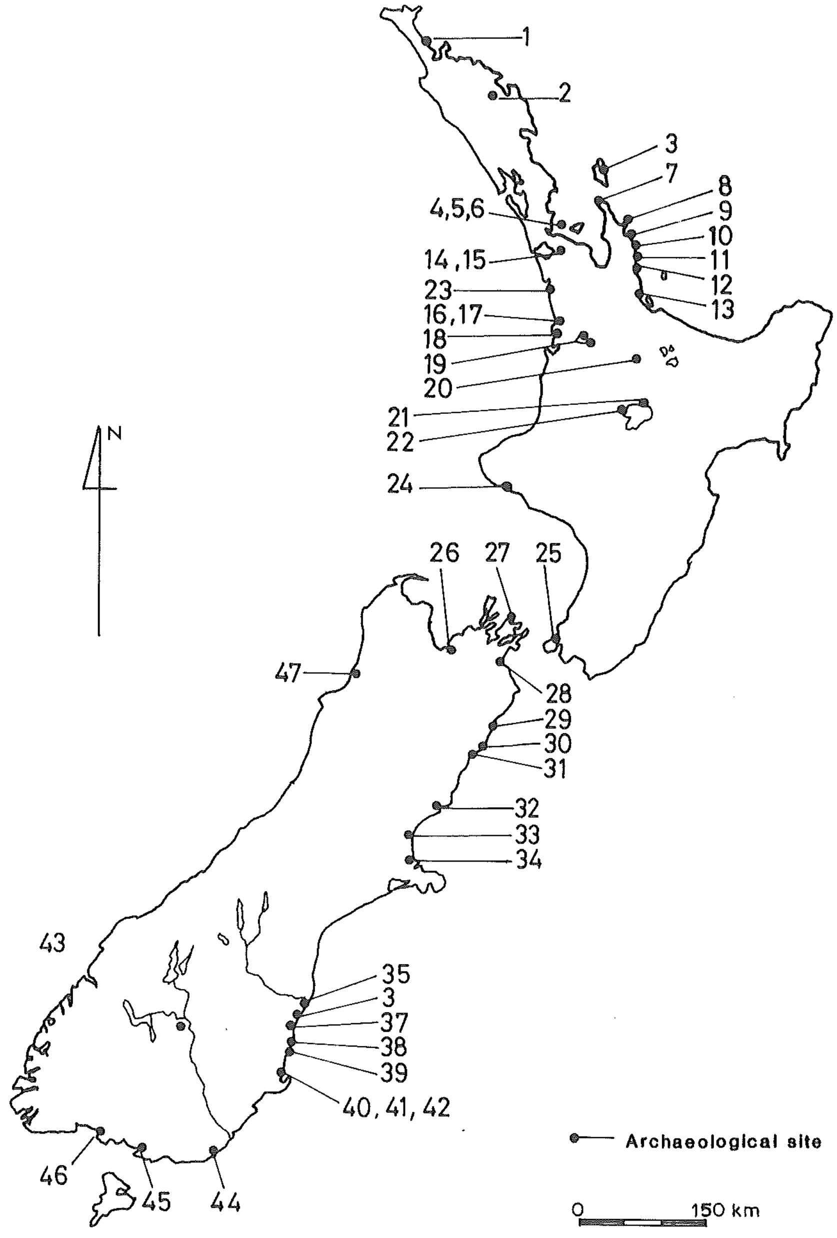

Figure 2: Locations of archaeological sites sampled for the present study (see KEY).

KEY to site numbers in figure 2

North Island

1. Houhora (N6/4); 2. Pouerua (N15/236, 237, 277, 501, 505, 507); 3. Harataonga Middens (N30/3, 4, 5); 4. Station Bay (N38/30); 5. Station Bay (N38/37); 6. Sunde (N38/24); 7. Port Jackson (N35/88); 8. Skippers Ridge I and II (N40/7, 73); 9. Hahei (N44/97); 10. Hot Water Beach (N44/69); 11. Tairua (N44/2);

12. Whangamata Wharf (N49/2); 13. Kauri Point Swamp (N53–54/55); 14. Ellett's Mountain (N42/23); 15. Hamlin's Hill (N42/137); 16. Raglan Archaic (N64/16); 17. Raglan (N64/18); 18. Aotea; Horeromaiwaho (N64/25, 8); 19. Mangakaware; Ngaroto (N65/35, 18); 20. Tokoroa (N75/1); 21. Whakamoenga Cave (N94/7); 22. Waihora (N93/5); 23. Maioro (N51/5); 24. Hingaimotu (N128/20); 25. Paremata (N160/50).

South Island

26. Tahunanui (S20/2); 27. Titirangi Pits and Sandhills (S16/93, 83); 28. Wairau Bar (S29/7); 30. Avoca (S49/46); 31. Peketa (S49/23, 48); 32. Timpendean (S61/4); 33. Houhoupounamu (S76/7); 34. Redcliffs (S84/76); 35. Waitaki River Mouth (S128/1); 36. Tai Rua (S136/1); 37. Waimataitai (S146/2); 38. Shag River Mouth (S155/5); 39. Shag Point (S146/5); 40. Purakanui (S164/8); 41. Long Beach (S164/20); 42. Murdering Beach (S164/16); 43. Hawksburn (S143/2); 44. Pounawea (S184/1); 45. Tiwai Point (S181-2/16); 46. Paihia; 47. Heaphy River Mouth (S7/1).

CHRONOLOGICAL FRAMEWORK

The archaeological assemblages 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. This is a necessary step if changes over time in exchange systems are to be detected. Assemblages were grouped 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, broad changes over time should be revealed if any such changes exist. The chronological divisions used are:

- Group 1 (early period): older than 630 BP
- Group 2 (middle period): 630 BP to 350 BP
- Group 3 (late period): 350 BP to present.

Figures 3 and 4 show the dates plotted for all analysed sites.

New Zealand archaeological radiocarbon dates 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% confidence. Some charcoal samples seem to produce dates of 200 or more years older than samples taken on bone collagen or marine shell from the same sites. Trotter and McCulloch (1975: 13) advise ignoring the charcoal samples and relying mainly on other materials, if possible. The inconsistencies seem to be greater for the earlier dates, while dates around 500 BP seem to be in more 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. Owing 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, either a mean date has been calculated, or a date is used 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.

The chronological divisions used here 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 BP. The second group includes sites in the range of 350 to 630 years BP, while the third group contains all sites younger than 350 years BP. The divisions are made allowing for certain

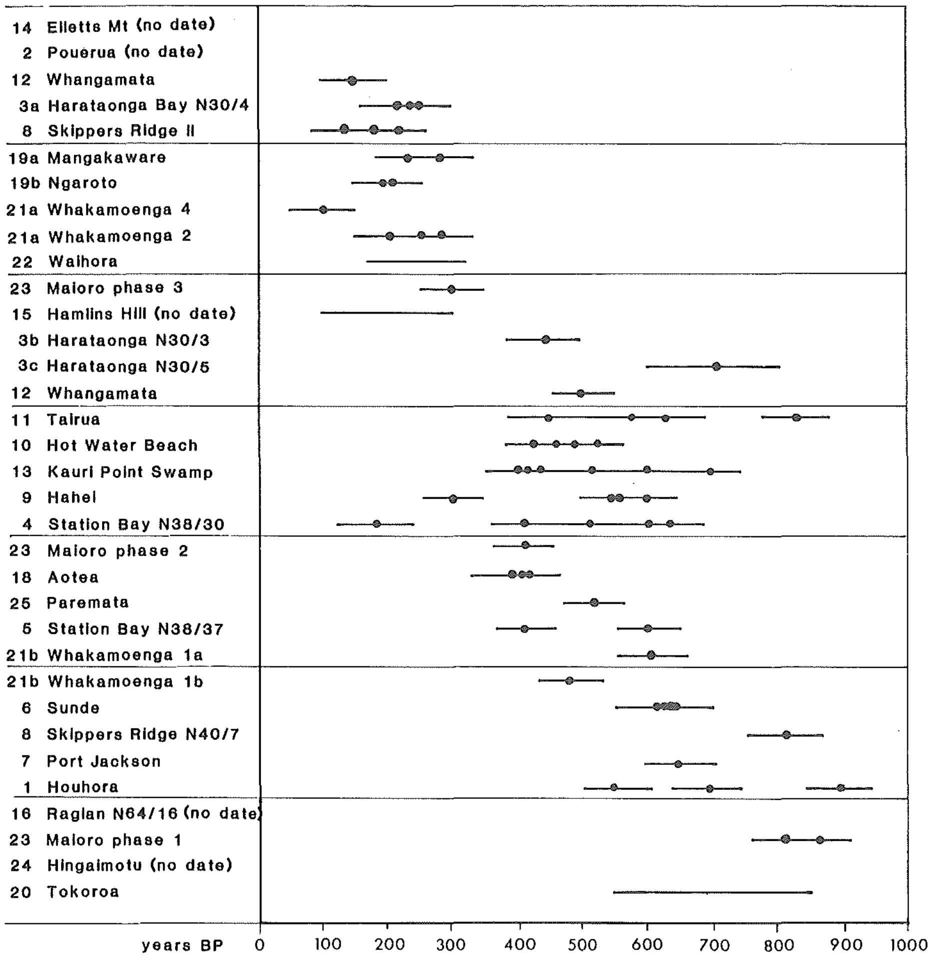

Figure 3: Radiocarbon dates (in years BP) for North Island sites mentioned in the text.

variations. For example, some sites such as Waitaki River Mouth and Pounawea have been placed in the 630 years BP and older group, because of their material culture and accepted dates, although some of their radiocarbon dates fall outside that division.

The period of 630 BP and older coincides with the settlement of the first sites in the South Island, and the hunting of moa as a basic subsistence activity. For the South Island, Anderson (1983: 47, 1984: 734) argues for a peak in moa hunting between 900 and 600 BP, which continued on the coast as opportunistic hunting until approximately 500 BP. On these grounds, as well as on evidence from the North Island sites, a division at about 630 BP is justified.

The separation of the early North Island sites is based on different criteria. The first division contains the early settlement sites of 700 years BP and older. It groups what are probably the first Polynesian settlement sites in the North Island.

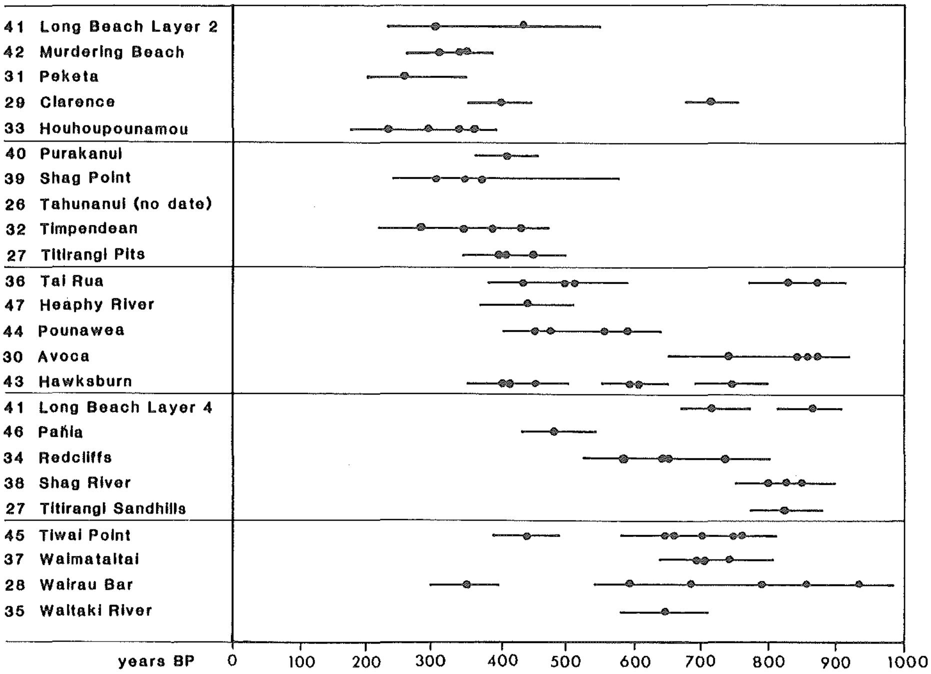

Figure 4: Radiocarbon dates (in years BP) for South Island sites mentioned in the text.

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

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

The last group, 350 years BP to the present, covers what is usually 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 BP, defended settlements 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 samples were analysed using energy dispersive x-ray fluorescence spectroscopy, following the procedure detailed by Bollong (1983). They were mounted whole on perspex (cast acrylic) holders which, in turn, were mounted on a stainless steel rack using plastic magnetic strip. Samples are brought into the irradiation position by advancement of the rack. This was controlled manually and by an MDL microcomputer run under a CP/M operating system connected to the sample changer facility.

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 7113-061750-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 by 100 and 1 µsec shaping time. The amplifier setting had to be adjusted during the course of the research because of 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 (cf. Bollong 1983: 64).

Obsidian samples were analysed for Rb, Sr, Y, Zr, Ba, La, and Ce (Figure 5). 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 usable elements (Fe, Zr and Ba) occurs at zero level in one or more particular source groups. The nett 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: 108–10).

Samples were analysed 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 on to the microcomputer link. Information is stored on 8 inch 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 (1983: 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 numbers 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

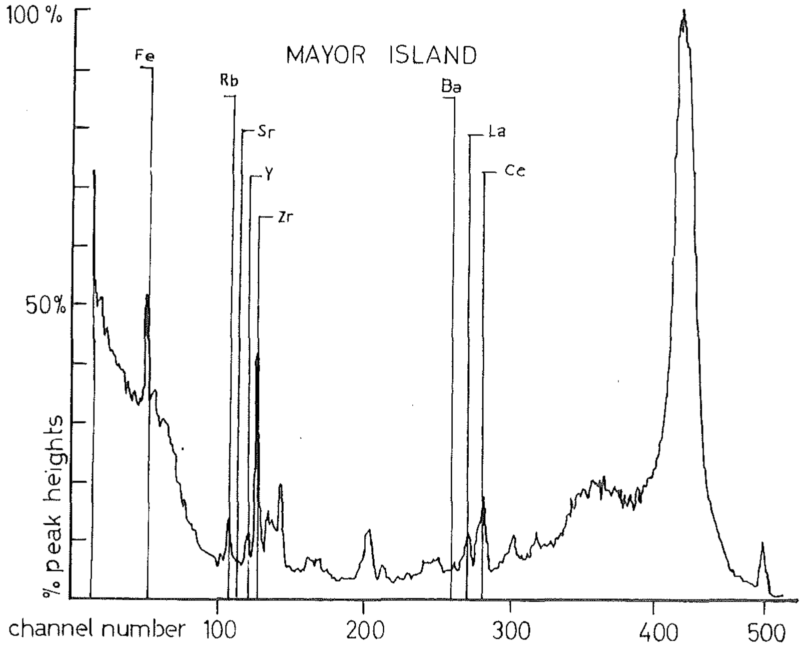

Figure 5: A typical Mayor Island spectrum.

disk. AUTOMCA incorporates into one program features of the separate programs MCA, NIGHT and CHANGER (cf. Bollong 1983).

The spectra recorded on disk can be analysed using one of the following FORTRAN programs: AMSPEC as described by Bollong (1983: 83), which allows graphing of the spectrum, determination of the energy of a region or peak, integrating window areas and producing 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 (1983: 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 of these sources in the reference matrix. To reduce the sampling error, which resulted in incorrect allocations (see Brassey 1985; Brassey and Seelenfreund 1984), 30 additional source samples were analysed. They were obtained from the Otago University Archaeometry Laboratory and Auckland University Anthropology Department comparative collections. New values were 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 resampling of the Northland sources. It is therefore unlikely that the full range of intra-source variability is represented in the new sample (Brassey and Seelenfreund 1984: 40). It is probable that allocations to the Northland sources are still slightly high. This is of particular importance only for the sites in the Northland area and will be discussed further 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 percent or 95 percent 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 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 because of 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 (1983: 89–94). As a result, 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 source.

THE SOURCE UTILIZATION PATTERN

The results of the sourcing procedures are presented in Tables 1 to 3.

Some comment on the sample size is necessary here before interpreting the sourcing results. The small sample sizes of some of the sourced assemblages can pose a problem. The margin of error for the relative proportion of the sources used at sites containing less than twenty pieces of obsidian can be as high as $\pm$ 16%. In these cases, 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 analysed sites by half. They have therefore been used but must be interpreted with caution and have been marked with an asterisk in Figures 6 to 8 and Tables 1 to 3.

For comparative purposes the results have been standardised in all cases to represent a sample size of $n = 20$. The standardisation procedure does not in itself change the proportions of the sourcing results when they are expressed as percentages. Figures 6 to 8 graphically represent the percentages of each source of obsidian in the total obsidian analysed for each site.

TEMPORAL VARIABILITY

There is 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 percent. Inspection of the sourcing results shows that at most sites material from more than one obsidian source was used.

TABLE 1
SOURCING RESULTS FROM GROUP 3, 350 BP TO PRESENT (EXPRESSED IN NUMBERS OF PIECES)

Sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14
North Island														
Elletts Mt.	19 (6.2)		7 (2.3)				32 (10.5)				3 (0.9)		61	132
Hamlins Hill	8 (5.7)		4 (2.8)	3 (2.1)			10 (7.1)				1 (0.7)	2 (1.4)	28	14
N30/4*	2 (1.0)					1 (5.0)					1 (5.0)		4	13
Mangakaware*	2 (3.3)	1 (1.7)	1 (1.7)						7 (11.7)			1 (1.7)	12	27
Ngaroto*	5 (6.5)		5 (6.5)						3 (2.3)		1 (1.3)	1 (1.3)	15	27
Pouerua:														
N15/236*		4 (2.0)											4	
N15/237*		1 (3.3)	1 (3.3)	4 (13.2)									6	
N15/255*	6 (13.2)	2 (4.4)	1 (2.2)										9	117
N15/501	9 (7.5)	13 (10.8)	2 (2.4)										24	
N15/505	4 (1.6)	33 (13.5)	2 (1.2)	6 (2.5)	1 (0.4)				1 (0.4)	2 (0.8)			49	
N15/507	5 (3.2)	19 (12.3)	6 (3.9)		1 (0.6)								31	
Raglan N64/18	48 (11.9)	2 (0.5)	18 (4.4)	2 (0.5)					2 (0.5)		9 (2.2)		81	81
Skippers R. II	49 (9.3)	1 (0.2)	18 (3.4)						30 (5.7)			7 (1.3)	105	305
Waihora					20 (2.2)		64 (7.1)	23 (2.6)	57 (6.3)			16 (1.8)	180	321
Whakamoenga 2				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 4				3 (1.3)	1 (0.4)	1 (0.4)	13 (5.4)		10 (4.2)	2 (0.8)		16 (6.7)	48	237
Whangamata A	7 (3.9)		4 (2.2)	2 (1.1)	2 (1.1)	1 (0.6)	5 (2.8)	1 (0.8)	9 (5.0)	5 (2.8)			36	36
South Island														
Long Beach*				1 (5.0)			1 (5.0)		2 (10.0)				4	32
Murdering B*	3 (6.0)								7 (14.0)				10	13
Peketa*	1 (4.0)				1 (4.0)			1 (4.0)		2 (8.0)			5	8
Totals	168	76	69	27	28	8	137	26	141	15	17	61	773	

Note: Values in brackets equal standardized values to $n = 20$.
KEY: * sample less than $n = 20$. 1. Mayor Island. 2. Northland. 3. Northland or Mayor Island. 4. Fanal Island. 5. Fanal Island or Huruiki. 6. Fanal Island or Great Barrier. 7. Fanal Island, Huruiki or Great Barrier. 8. Coromandel or Inland. 9. Fanal Island, Huruiki, Great Barrier, Coromandel or Inland. 10. Huruiki, Great Barrier, Coromandel or Inland. 11. Assigned to non-New Zealand sources. 12. Unknown. 13. Total analysed. 14. Total assemblage.

TABLE 2

SOURCING RESULTS FROM GROUP 2, 630 TO 350 BP (EXPRESSED IN NUMBERS OF PIECES)

Sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14
North Island														
Aotea	26(20.0)												26	43
Hahei	153 (7.8)	8 (0.4)	51 (2.6)	9 (0.5)			17 (0.9)	22 (7.8)	131 (6.7)		1(0.1)		392	3470
N30/3	1 (0.4)		2 (0.7)	18 (6.4)		6 (2.1)	22 (7.8)	3 (0.2)				4 (1.4)	56	171
Hot Water B.	33 (3.5)	4 (0.4)	14 (1.5)						112 (11.8)		4 (0.4)	34 (3.5)	200	1182
Kauri Pt Swamp	161 (12.9)	10 (0.8)	44 (3.5)				3 (0.2)					31 (2.5)	249	>5000
Koreromaiwaho*	4 (13.2)				2 (6.6)								6	6
Maioro 2	60 (10.3)						56 (9.6)						116	116
Paremata*	9(11.3)	1 (1.3)	2 (2.5)						1 (1.3)			3 (3.8)	16	226
N38/30*	3 (5.4)			1 (1.8)		3 (5.4)	3 (5.4)			1 (1.8)			11	26
N38/37*							2 (2.0)						2	34
Sunde*	2 (8.0)		1 (4.0)	1 (4.0)							1 (4.0)		5	6
Tairua	92 (10.6)	6 (9.2)	49 (5.7)						14 (1.6)			14 (1.6)	173	250
Whangamata*	4 (11.4)		1 (2.9)	1 (2.9)	1 (2.9)								7	82
Whakamoenga 1A				3 (1.3)			11 (4.6)	1 (0.4)	9 (3.8)	7 (2.9)		17 (7.0)	48	244
Whakamoenga 1B				7 (3.3)	4 (1.9)	2 (0.9)	11 (5.1)				1 (0.5)	16 (7.4)	43	
South Island														
Clarence*	1 (20.0)												1	5
Heaphy R.	58 (17.0)	2 (0.6)									1 (0.3)	8 (2.3)	69	77
Houhou*	1 (2.5)							1 (2.5)		5 (12.3)	1 (2.5)		8	9
Pounawea*	3 (15.0)							1 (5.0)					4	10
Purakanui	6 (5.7)			2 (1.9)	3 (2.8)	4 (3.8)	1 (0.9)		2 (1.9)			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)		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)		1 (0.1)		183	566
Tai Rua*	4 (8.0)			1 (2.0)			1 (2.0)	4 (5.0)					10	14
Timpendean*	2 (2.0)												2	11
Titirangi*	2 (2.0)												2	5
Totals	733	38	180	102	25	30	145	36	2798	13	12	136	1728	

Notes: key is the same as for Table 1.
Values in brackets equal standardized values to $n = 20$.

TABLE 3

SOURCING RESULTS FROM GROUP 1, 630 BP AND OLDER (EXPRESSED IN NUMBERS OF PIECES)

sites	1	2	3	4	5	6	7	8	9	10	11	12	13	14
North Island														
N30/5	48 (14.3)	4 (1.2)	8 (2.4)						6 (1.8)			1 (0.3)	67	113
Hingaimotu	9 (3.9)	1 (0.4)	11 (4.7)						21 (9.1)		1 (0.4)	3 (1.3)	46	99
Houhora	191 (12.7)	53 (3.5)	45 (3.0)						11 (0.7)				300	>3000
Maioro 1	336 (8.4)	2 (0.1)							459 (11.5)				795	795
Pt Jackson*	4 (8.0)								4 (8.0)			2 (4.0)	10	15
Raglan N64/16*	3 (15.0)	1 (5.0)											4	16
Skippers R.L.2*	4 (6.7)		4 (6.7)			1 (1.7)	2 (3.4)			1 (1.7)			12	17
Skippers R.L3*	2 (10.0)		1 (5.0)									1 (5.0)	4	4
Tokoroa	156 (11.6)	10 (0.7)	76 (5.6)						14 (1.0)			14 (1.0)	270	510
South Island														
Avoca*	2 (20.0)												2	20
Hakwsburn	25 (20.0)												25	40
Long Beach 4*	1 (6.7)								1 (6.7)			1 (6.7)	3	4
Long Beach misc.*	5 (9.1)	1 (1.8)	1 (1.8)						3 (5.4)			1 (1.8)	11	-
Pahia*	2 (13.3)									1 (6.7)			3	3
Redcliffs	68 (15.8)	1 (0.2)	5 (1.2)	3 (0.7)					7 (1.6)			2 (0.5)	86	99
Shag River	14 (5.6)	1 (0.4)	6 (2.4)		1 (0.4)		1 (0.4)	2 (0.8)	7 (2.8)			3 (1.2)	35	-
Titirangi S.*	2 (8.0)			1 (4.0)				1 (4.0)	1 (4.0)				5	26
Tiwai Point	69 (15.9)	7 (1.6)	5 (1.1)	1 (0.2)								5 (1.1)	87	148
Waimataitai*	1 (20.0)												1	2
Wairau Bar*	8 (14.5)	2 (3.6)			1 (1.8)								11	11
Waitaki R.	21 (16.8)	2 (1.6)	1 (0.8)									1 (0.8)	25	25
Totals	971	85	163	5	2	1	3	3	534	2	1	34	1802	

Note: Values in brackets equal standardized values to $n = 20$.
Key as in Table 1.

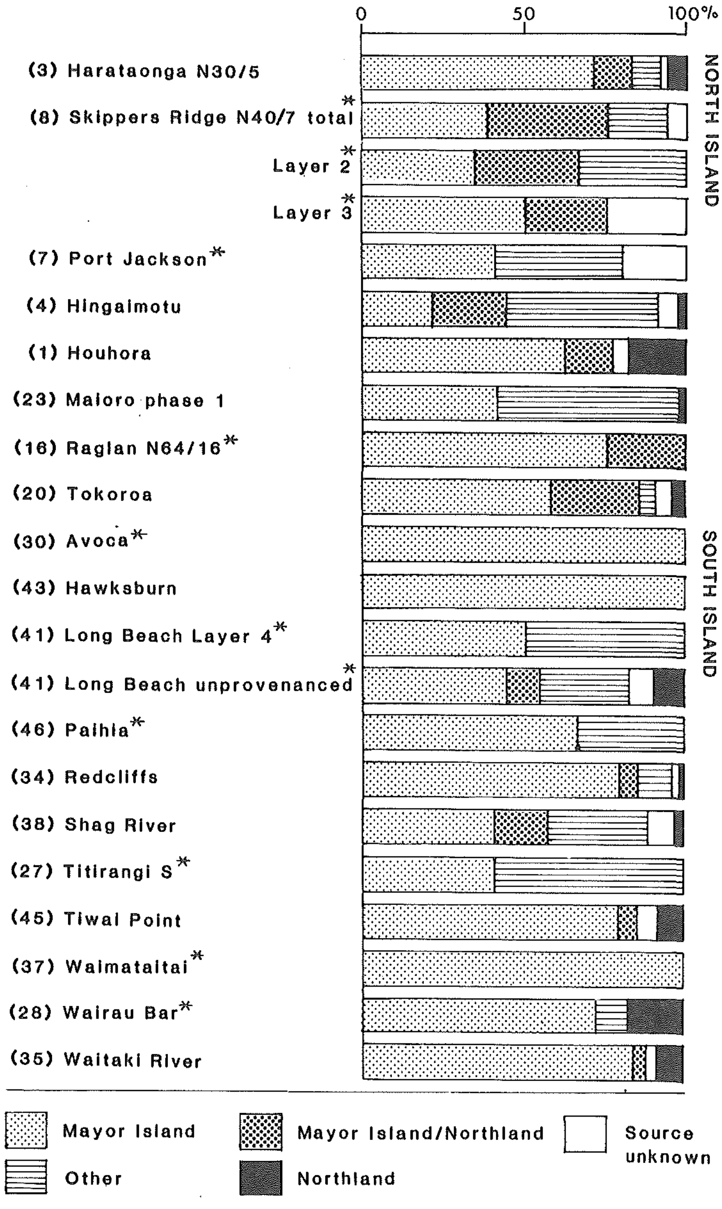

Figure 6: Sourcing results in percentages for all sites analysed, Group 1: 630 BP and older.

Group 1

The source utilization patterns from sites earlier than 630 BP show that, for the most part, Mayor Island obsidian was used. The proportions from various sources in the assemblages range from 20 to 100 percent. 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 percent)

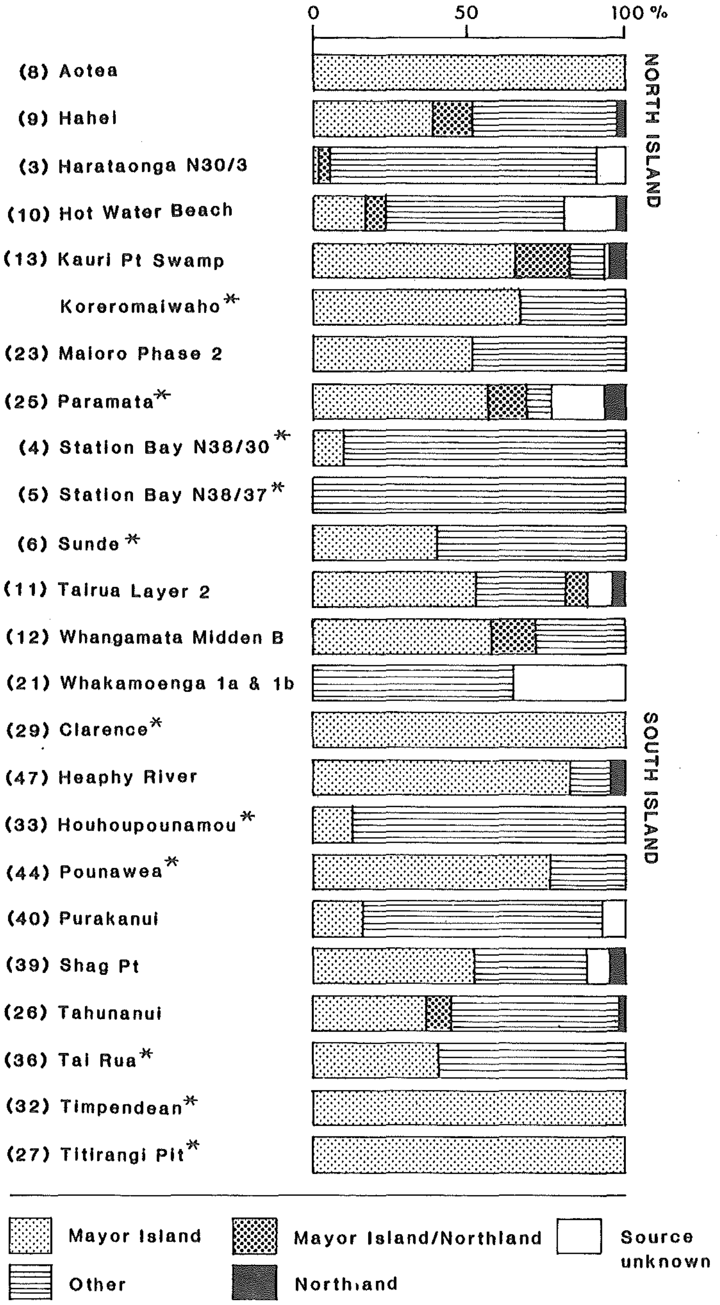

Figure 7: Sourcing results in percentages for all sites analysed, Group 2: 630 BP to 350 BP.

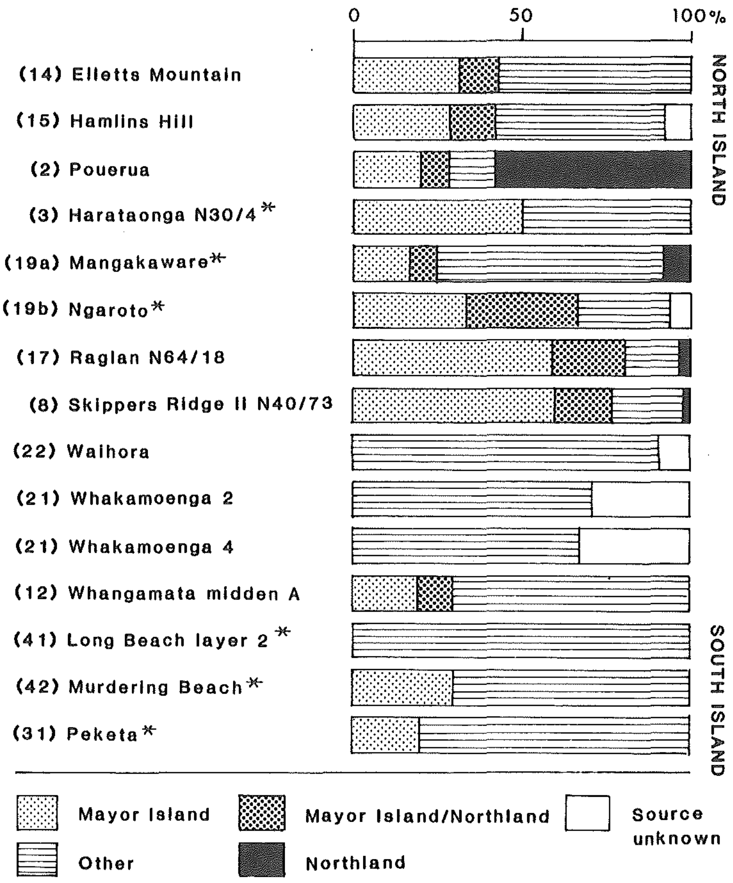

Figure 8: Sourcing results in percentages for all sites analysed, Group 3: 350 BP to present.

it is present in 58 percent and 20 percent of the middle and late period sites respectively. The proportions of Northland obsidian identified 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), although the latter site is only a few kilometres from the source.

Group 2

The proportion of material from sources other than Mayor Island, in Group 2 sites (630 to 350 BP), 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 amount of Mayor Island obsidian in the total obsidian assemblage from North Island sites decreases in general to about 70 percent 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 percent in some sites, although this result may be affected by small sample sizes. Overall, the introduction of alternative sources becomes quite marked in this time group. Sources other than Mayor Island and Northland comprise up to 85 percent 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 BP to the present). The pattern of source utilisation becomes increasingly varied and Mayor Island obsidian only represents at most 67 percent of the total obsidian sourced. In most cases it is limited to about 30 percent or even less of the pieces present. The presence of alternative sources is particularly striking in the South Island sites, where obsidian from other sources 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: 134–5). As Brassey has proposed, it is therefore possible that other sources would have been preferred to the Northland sources outside their immediate area.

SOURCE UTILISATION AND SITE FUNCTION

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. These are:

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 because they were often used for multiple purposes. For the present purpose, evidence from published reports was used to assign each site to a category. At some sites, several activity areas have been isolated, and therefore the present classification may be subject to discussion by other researchers. Categorisation of the site types is summarised in Table 4. The proportions of different types of obsidian used are affected by site function.

In Group 1 (630 BP 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 to 100 percent with a mean value of 80 percent, compared to a range of 20 to 100 percent with a mean of 58.4 percent in open settlements). By weight, the percentage of Mayor Island obsidian in the

TABLE 4
CLASSIFICATION OF SITES BY FUNCTION

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

temporary camps is also higher (mean = 66.4%) whereas it is lower at more permanent open settlements (mean = 58.7%) (Table 5).

The two lithic workshops represented in Group 1 sites (Titirangi and Tiwai Point) have very different proportions of obsidian sources. Only two source groups are represented at Titirangi. They are Mayor Island and Fanal/Huruiki/Great Barrier Island, whereas Northland, Mayor Island and Fanal Island/Huruiki obsidians are represented at Tiwai Point.

In terms of total weight of material, obsidian is found in large quantities only at Houhora and Tokoroa (Table 5). These sites have the overall highest quantities by weight of obsidian regardless of source provenance. The first is an undefended settlement while Tokoroa is a temporary moa hunter camp. The quantity of Mayor Island obsidian, for example, is only

TABLE 5
TOTAL WEIGHT (G) OF OBSIDIAN FROM ANALYSED SITES

SITE	ALL OBSIDIAN	MAYOR ISLAND
Group 3 Ellett's Mountain	275	54
Hamlin's Hill	102	24
Harataonga 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 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	-
Group 1 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 N40/7	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 Sandhills	20	4
Tiwai Point	441	325
Waimataitai	0.4	0.4
Wairau Bar	48	40
Waitaki River Mouth	270	21

substantial at Houhora (about 1.5 kg of material in the analysed sample, representing an approximate volume of 600 cc). The material from 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 at both Tiwai Point ($n = 148$) and Titirangi ($n = 24$) are extremely small, especially as it is considered that both are specialised sites primarily for the manufacture of lithic artefacts. The quantity of Mayor Island obsidian at Tiwai Point is only 440 g, which represents one or two small sized cores with 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.

The sites of Group 2 (630 to 350 BP) include open settlements, workshops and one special purpose site associated with a defended settlement. This last, which is 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 varies. No real pattern can be observed. Although, for example, temporary hunting camps 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, because of 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. 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 found.

Group 3 (350 BP 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 both utilise the local materials in preference to stone from further afield. The two sites (Waihora and Whakamoenga Cave) were occupied temporarily and only obsidian from nearby local sources is found at each.

SUMMARY AND CONCLUSIONS

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 utilisation.

From the source utilisation pattern it is clear that although Mayor Island obsidian was the most popular obsidian used in the early sites all over New Zealand, other sources were also exploited during this time. The sourcing evidence indicates that the earliest settlers in New Zealand soon learned of most of the available sources. However, some of these sources appear to have been utilised only occasionally, although their location was known. 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 utilisation patterns from Group 2 sites (630 to 350 BP) and Group 3 sites (350 BP to the present). The use of those sources seems to increase when they are close at hand and of good quality. The changes in the source utilisation pattern may reflect increasing difficulty in obtaining materials from Mayor Island, particularly within 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, although Davidson (1984: 197) argues that people did not know where their raw material came from. These north-south ties appear to have been maintained through to the middle period. The increased use of other sources by South Island people began only during the late period. In the middle period, people of the North Island used less Mayor Island obsidian, but South Island Maori maintained the dominant use of Mayor Island obsidian until later in the sequence, although local differences can be observed. For example, at sites such as Maioro, the use of Mayor Island obsidian increases in proportion through time. A similar 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 utilisation pattern differs according to the function of the sites. The pattern found indicates that at temporary hunting camps a small number of sources was used. In general, only one source is represented at those 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 BP to present) no real pattern of differential source utilisation between defended and undefended settlements can be distinguished.

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