THE ORIGIN OF PREHISTORIC OBSIDIAN ARTEFACTS FROM THE CHATHAM AND KERMADEC ISLANDS*

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ABSTRACT

It has recently been thought that two-way navigated voyaging by Polynesians in the East Pacific was confined to a land fall arc of about 574 km, and that systematic prehistoric contact beyond this range was rare and accidental in nature. Analyses of obsidian artefacts from the Chatham and Kermadec Islands challenge this view. Vestiges of "Archaic" East Polynesian Culture are found on both these islands, together with obsidian artefacts deriving from New Zealand. Somewhat greater seafaring ability might therefore be proposed for Polynesians living in the East Pacific region.

Source identification of artefacts was accomplished with the PIXE-PIGME analysis system at Lucas Heights in Australia. Multi-element analysis was undertaken, and a variety of both parametric and non-parametric statistical procedures performed on source and artefact information. The five "nearest neighbour" sources to each artefact were found along with associated probabilities of wrong classification.

Keywords: OBSIDIAN, SOURCING, PIXE-PIGME, CHATHAMS, KERMADECS, NAVIGATION.

INTRODUCTION

Over the years, quite a number of obsidian artefacts have been recovered from the Chatham Islands, and as far as is known, there is no local source of obsidian. However, there is an often quoted suggestion in the literature that there might be a source on the island. This can be traced to a comment by Haast as follows:

> The Morioris also used flint 'mataa', which they split into thin, irregular, wedge-like shapes, as knives, there being no volcanic glass ('tuhua') obtainable in any quantity, although a reef of it is known to exist under water at the south-east corner of the island at Manukau. (Haast 1885: 26)

This comment has not been substantiated by any field observation. Skinner, for example, who carried out considerable fieldwork on the island, merely referred to Haast on the subject (Skinner 1923: 98), and noted that the information probably came from Shand who had lived on the island for many years. During more recent archaeological research on the island no evidence was found of this supposed source. Geological research has

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indicated glassy intrusions in pillow lava flows at Owenga, near Manukau (Hay *et al.* 1970: 58), and this possibly could have been confused with obsidian by Shand. There is nothing in the geological character of the Chatham Islands which would preclude a local obsidian source (D. S. Coombs pers. comm. 1973), but it has to be concluded that the lack of any find since this comment was made in the late nineteenth century argues against a local source.

A study of two of these artefacts some years ago by Leach (1973) suggested that a New Zealand source was more likely. However, with improvements in our knowledge of obsidian sources together with refinements in methods of element analyses and statistical treatment of data, these identifications, and others for New Zealand archaeological sites, have been questioned (Leach and Warren 1981: 159, 162; Leach and Manly 1982: 106).

In the case of the Kermadecs, local obsidian is present on both Raoul and MacCauley islands; and not surprisingly, obsidian artefacts were recovered during archaeological fieldwork on Raoul (Anderson 1979, 1980). The obsidian source material on Raoul and MacCauley Islands is not of especially good quality for conchoidal fracture, but some of the artefacts recovered were of high quality green vitreous material suggesting a foreign origin. The known obsidian sources in the vicinity of New Zealand and these outlying islands are shown in Figure 1.

TECHNOLOGY

The assemblages examined in this study consist of 81 artefacts from the Chathams, and 11 from the Kermadecs. The Kermadec artefacts are from an excavation at the Low Flat site for which there may have been two phases of occupation at ages of 620 B.P. and 1030 B.P. (Anderson 1980: 140). The Chatham Island artefacts derive from several places. The bulk is from surface collections made on Pitt Island at a number of locations, and collected over a long period of time. A small number of pieces are from the excavations at the Waihora village, dating to the sixteenth century A.D. (Sutton 1982a: 168), the CHB site, nearby, and both the Moreroa and Owenga areas of the main island (for further details see Table 2). The two assemblages are fairly similar to each other, and like most obsidian tools in the Pacific area, not especially distinctive in form. In this respect, it would be difficult to argue on grounds of tool morphology or technology that these flake tools were more similar to those from one part of the Pacific rather than to those from another. Two particular items stand out from the others, however, and deserve special mention.

The first is a small core from Raoul which has been used to remove successive small regular flakes. It could be described as a poor example of the nucleus from prismatic blade manufacture. The interpretation is strengthened by the presence of large blade-like flakes made of basalt in the Raoul archaeological assemblage. In East Polynesia, this type of technology was most developed in the southern half of the South Island of New Zealand, apparently from the time of first settlement (about A.D. 1000) to about A.D. 1500. Here, very large prismatic blades (up to 30 cm in length) were made from silcrete, a cemented silicified sandstone, by a percussion technique (Leach 1969). Blade technology is not in evidence in the North Island at any period, and in neither island did early communities practise this art on obsidian. There have been occasional reports to the contrary—for example, some blade-like flakes have recently been recovered at Manukau heads near Auckland; however, in the view of one of us (Leach) who has examined these, they are fortuitous "blades", and should not be interpreted as evidence of deliberate prepared-core blade technology. The same is true of a large blade-like flake found some years ago at

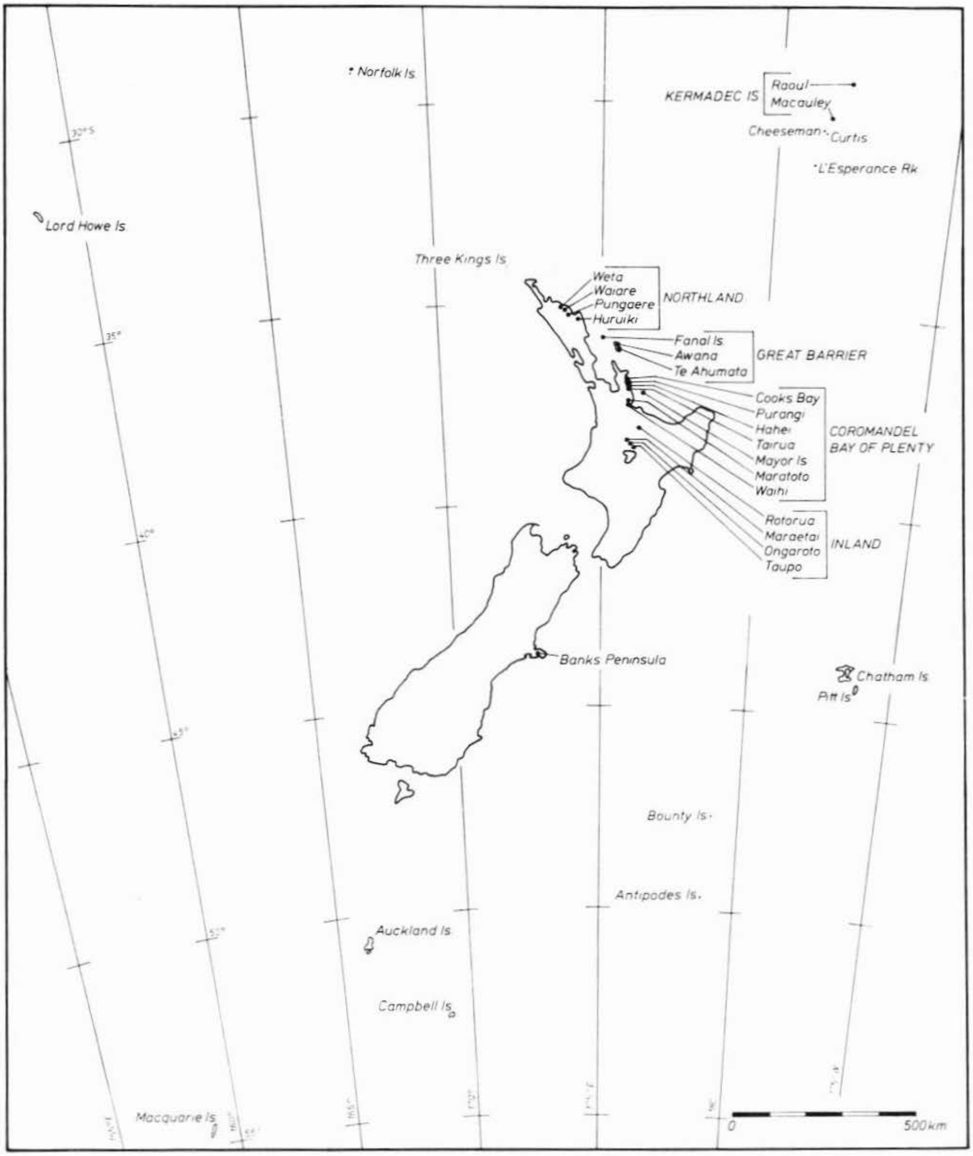

Figure 1: Map of obsidian sources in the vicinity of New Zealand, the Kermadecs, and the Chatham Islands.

Opotiki in the Bay of Plenty (Scott 1969). Elsewhere in the eastern half of the Pacific, poorly developed blade technology is present on Easter Island (McCoy 1976), Pitcairn (Knight 1965: 233 ff.), the Marquesas (Leach and Leach 1980: 128), the Society Islands, especially Raiatea basalt (A. Lavondes pers. comm. 1981), and Hawaii (Kirch 1975: 43).

In the western Pacific, good quality blade tools were made, again in very large size by a percussion method, from obsidian in the Admiralty Islands and at Talasea in New Britain (personal observations by Leach of specimens in the Australian Museum), and from a variety of rock types in Bougainville (Nash and Mitchell 1973; O'Reilly 1948).

On the whole, this type of technology could be described as advanced in the cases of the West Pacific and southern New Zealand; and present but rudimentary amongst some communities in the east Pacific. This single core from the Kermadecs is clearly in the latter category rather than the former. It is interesting to note that the core is quite small, something which McCoy noticed on Rapanui too, where the size was out of character with the few blades found, suggesting they were discarded nuclei (McCoy 1976: 334–335). This is paralleled by some specimens in New Zealand (Leach 1969: Plate 19), and also in Hawaii. At the Halawa Dune Site, for example, Kirch found that many of the 30 small cores recovered were of polyhedral shape, caused by the successive removal of elongated flakes or blades (Kirch 1975: 43). However, it was also noted that the flakes in the assemblage were unlike blades, being rather squat in appearance. The date for the earliest part of this site could have been as late as A.D. 800 (ibid.: 52).

The second item, from the Chatham Islands, is an example of one of the few recognised formal flake tool artefact forms in the east Pacific, known as *mataa* (see Jones 1981). Tools of this form were commonly made from obsidian in Easter Island (Heyerdahl 1961: 398–401) and in the Talasea area of New Britain (personal observations by Leach of specimens in the Australian Museum), from a variety of rocks in Bougainville (personal observations by Leach of the Nash and Mitchell collection), and from chert and obsidian in the Chatham Islands. It has to be admitted that this formal category is somewhat imprecise, but there are specimens from New Zealand which may be *mataa* (for example, see #1383 from Wairau Bar in Jones 1981: 94). Given the wide geographic range of this distribution, the culture-historical significance of this formal tool category in the Pacific is debatable; nevertheless, its presence on Easter Island, Pitcairn, the Chathams and possibly New Zealand, may well reflect early contact of some form or another in the eastern Pacific.

One other aspect of the technology of these artefacts is the general size of them. The vitreous green artefacts from the Kermadecs have a mean weight of 2.3 ± 1.0 g (standard deviation = 2.3 ± 0.7); this is fairly small. The Chatham Islands artefacts, on the other hand, are considerably larger. A size-frequency histogram is given in Figure 2. Some dispersion statistics for this are: Mean = 6.03 ± 1.29 g, standard deviation = 11.64 ± 0.91 g, G1/W1 = 3.24/6.86, G2/W2 = 14.04/22.39. The total weight of the Chathams assemblage is 515.76 g. The largest piece is just over 67 g, and there are six pieces over 30 g. Unfortunately, no comparable figures have been published for New Zealand or Pacific island assemblages, but these Chathams figures do indicate reasonable sized fragments—perhaps larger than might be expected for a group of people so far from a source of supply.

BACKGROUND TO THIS STUDY

Two obsidian tools from the Chatham Islands were studied by energy dispersive XRF analysis some years ago in an attempt to define their source of origin (Leach 1973). The Mayor Island source in New Zealand was proposed. This artefact study, and others which followed (for example Ward 1974c; Reeves and Ward 1976; Leach and Anderson 1978) applied the source characterisation method developed by Ward (1972, 1974a, 1974b). It is now known, however, that there were serious deficiencies in this technique (see Leach and Manly 1982), and this casts doubt not only on the results for the Chatham Islands, but on others for New Zealand too. The problem lies not in the choice of elements, nor their small number; on the contrary, it has been shown that the information base of this

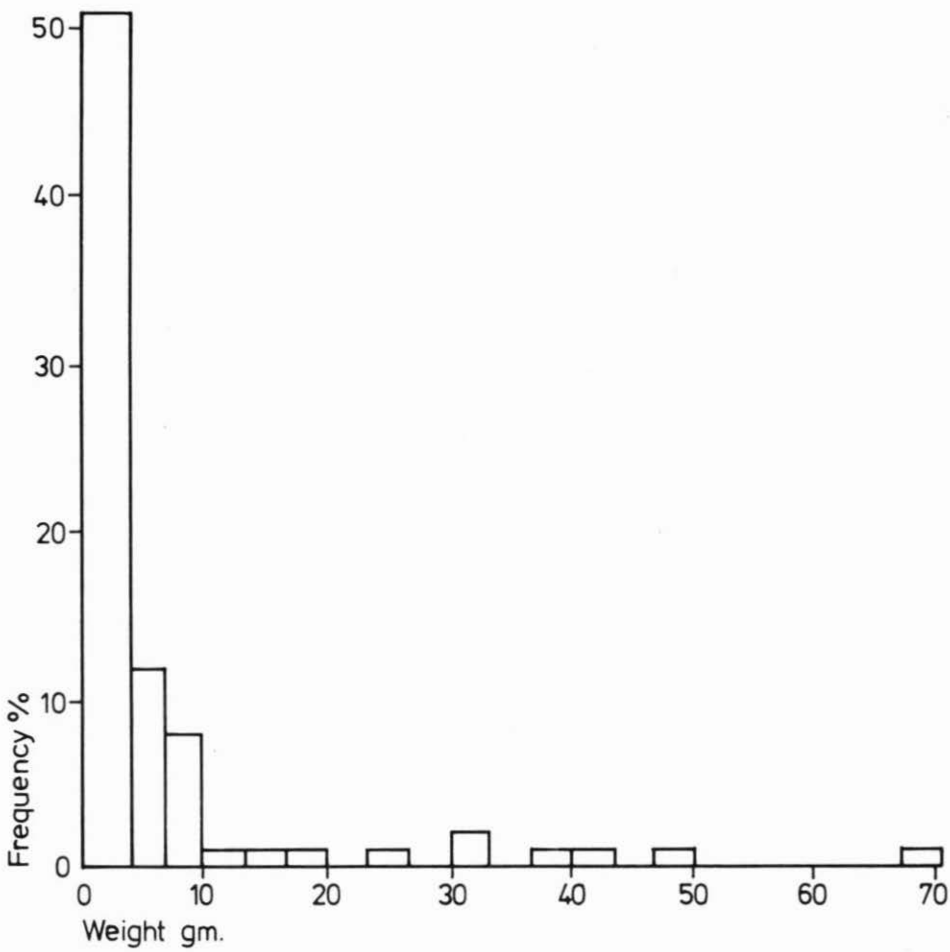

Figure 2: Size-frequency histogram for the Chatham Islands obsidian artefacts.

study provides the basis for excellent discrimination (Leach and Manly 1982: 105–106). The deficiency concerns the mathematical methods adopted for evaluating the sources of artefacts using this information base.

A second study of a larger number of Chatham Islands obsidian tools was undertaken by neutron activation analysis (NAA) by Leach and Warren (1981). This showed a surprisingly close chemical similarity between the source obsidian from Mayor Island and that from Easter Island. Again, the source of Mayor Island seemed more likely for the Chathams obsidian tools, although these identifications could only be advanced with caution. It seemed possible that a third unknown source could be involved.

This unsatisfactory situation led to the development of a more sophisticated and more conservative mathematical algorithm for identifying the sources of obsidian tools from elemental characterisation (Leach and Manly 1982). The obsidian tools from the Chatham and Kermadec Islands have been studied yet again using the newly developed non-destructive PIXE-PIGME method (Bird *et al.* 1978, 1981; Clayton 1982a; Duerden *et al.* 1979; 1980), to determine their element composition, together with source material for 66 sources around the Pacific (see Fig. 3 and Table 1). This was followed by rigorous mathematical examination of the data using several new sourcing algorithms (Leach and Manly 1982; Clayton 1982b). Full details of the analysis and data treatment are not relevant to this paper, although some brief comments on the sourcing algorithm are given below. It must be pointed out that chemical overlap between one obsidian source and another (amongst other reasons) makes it impossible to be certain of the origin of all obsidian implements. It can be said that artefacts have not come from this or that source, but never that they definitely derive from a particular source. It is the old story—no amount of statistical testing could ever prove the null hypothesis to be true (see Leach and Manly 1982: 92)! In practice, some sources overlap such a lot with others that artefacts from them cannot be sourced unambiguously. In the case of artefacts from the Chatham and Kermadec Islands, source overlaps between Mayor Island, Rapanui, and those in the East Fergusson Islands are especially troublesome. This will be discussed in detail below.

SOURCING ALGORITHS

There are basically two kinds of mathematical approaches which can be taken towards examination of element data to try and allocate artefacts to their geological sources. One of these is to devise statistical tests which are non-parametric in character, that is they do not assume that element concentrations for any one source will be normally distributed. This is a considerable advantage in the exploratory stages of sourcing studies, because data sometimes do appear to be non-normal in character. However, it has yet to be demonstrated for a large number of pieces from one obsidian flow that element concentrations are indeed non-normal. Typically, analyses of sources rely on results for only a few samples (five or less), because it is so difficult to obtain source material which represents the quality range used by prehistoric people. It is also known that a significant amount of the observed variation is due to the vagaries of instrument analysis, such as amplifier drift; and for this reason, element ratios are frequently used in sourcing algorithms. This procedure does not entirely free the data of such instrument variation; Moreover, other undesirable features are introduced (see Leach and Manly 1982: 81). In this climate of uncertainties, non-parametric methods possess a clear advantage. However, a significant disadvantage is that tests which do not assume normality have greatly reduced power to reject the null hypothesis, and this leads to a false sense of security in the results. One is therefore left trading a desirable feature for an undesirable one. Parametric methods trade the opposite way—they have considerable power to reject incorrect answers, but they have the undesirable feature of having to assume normality. Until much more is known of the genuine distributional features of element concentrations for obsidian quarries (probably from analyses of artefacts themselves rather than the geological material), it is probably wise to use both parametric and non-parametric methods in tandem, and address problems which arise by closer examination of individual artefacts. This is the approach taken in this paper.

One further distinction between parametric and non-parametric statistical treatment deserves mention. This concerns the evaluation of an artefact distance from a source—is it significant or not? With non-parametric statistics the approach normally taken is to calculate the simple Euclidean distance from the artefact to each source centroid, and allocate

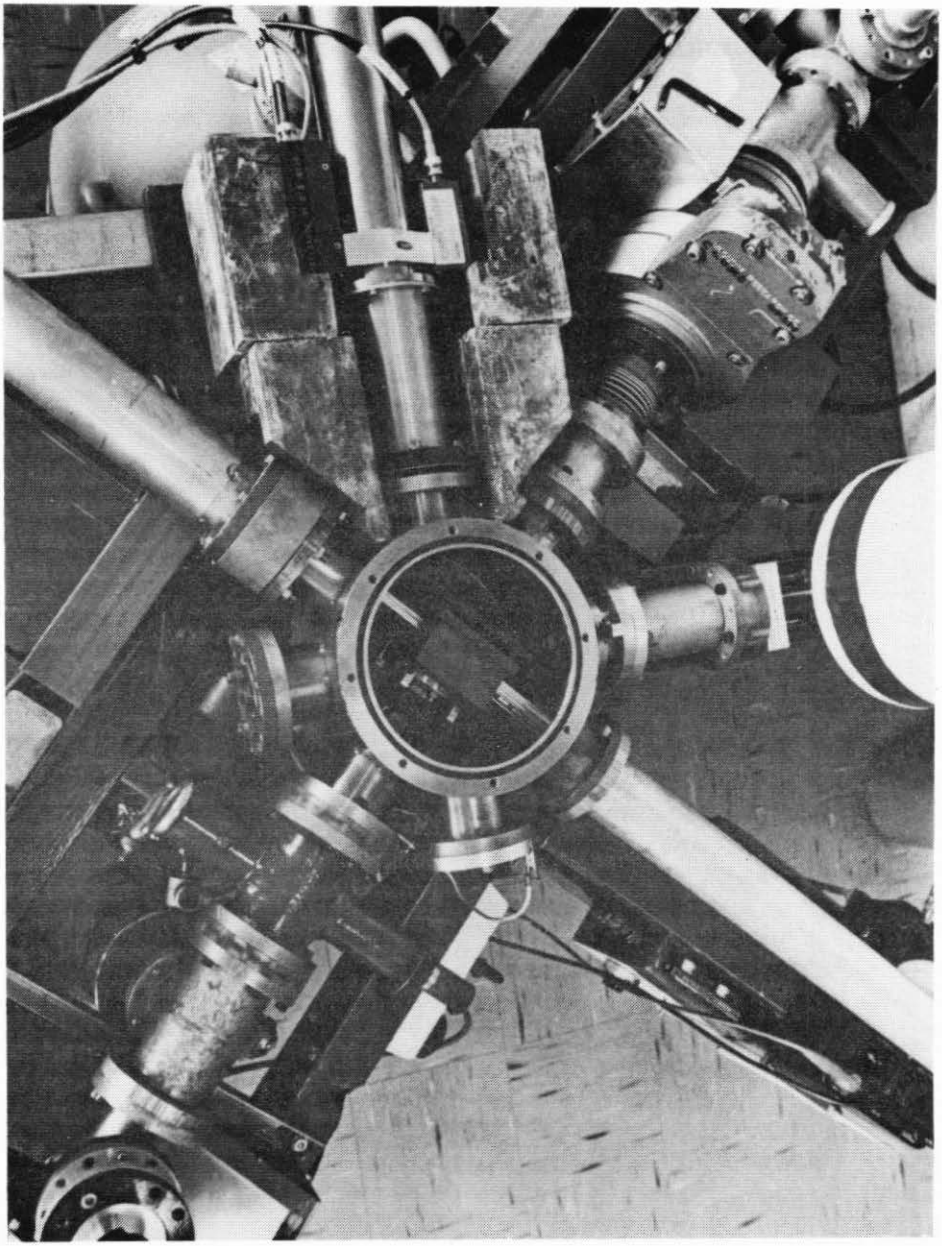

Figure 3: The sample chamber for the PIXE-PIGME analysis of obsidian artefacts. Gamma ray and X-ray spectra which are collected are automatically dumped into a computer. Batches of spectra are later reduced interactively on a computer with the aid of graphics. With use of suitable standards, absolute concentrations are determined, though for sourcing purposes raw window data can be just as effective.

TABLE 1

OBSIDIAN SOURCES USED FOR COMPARING ARTEFACTS FROM THE KERMADEC AND CHATHAM ISLANDS

Those marked with an asterisk require confirmation as separate geochemical sources; their geographic label does not necessarily denote the location of the source, if it is eventually confirmed.

Source Number	Source Name
1	Indonesia — Leles
2	Indonesia — Gunung Kiamis
3	Australia — Grampians
4	Admiralty Islands — Lalosol
5	Admiralty Islands — Baun
6	Admiralty Islands — Pam
7	Admiralty Islands — Umrei
8	Admiralty Islands — Lakou
9	Admiralty Islands — Tuluman
10	New Britain — Pilu, Voganaki
11	New Britain — Dire,Talasea,Mt Bao,Bitokara
12	New Britain — Garua
13	New Britain — Waisisi
14	West Fergusson — Igwageta, Iaopolo
15	West Fergusson — Fagalulu
16	East Fergusson — Sanaroa
17	East Fergusson — Lamonai,Numanuma Sth, Dobu
18	East Fergusson — 'Smith'
19	East Fergusson — 'Old'
20	East Fergusson — Numanuma Nth
21	* Solomon Islands — Santa Cruz
22	* Solomon Islands — Tikopia
23	* Solomon Islands — Mbo Lava
24	Vanuatu — Vanua Lava A
25	Vanuatu — Gaua
26	* Vanuatu — Vanua Lava B
27	Vanuatu — Tanna
28	Vanuatu — Losa Bay
29	New Zealand — Weta
30	New Zealand — Waiare
31	New Zealand — Pungaere
32	New Zealand — Huruiki
33	New Zealand — Fanal Island
34	New Zealand — Burgess Island
35	New Zealand — Awana
36	New Zealand — Te Ahumata
37	New Zealand — Cooks Bay
38	New Zealand — Purangi
39	New Zealand — Hahei
40	New Zealand — Tairua
41	New Zealand — Maratoto
42	New Zealand — Waihi Red
43	New Zealand — Waihi Black
44	New Zealand — Mayor Island Green
45	New Zealand — Mayor Island Yellow
46	New Zealand — Mayor Island Honey
47	New Zealand — Rotorua Red
48	New Zealand — Rotorua Black
49	New Zealand — Maraetai Red
50	New Zealand — Maraetai Black
51	New Zealand — Ongaroto
52	New Zealand — Taupo

53		New Zealand — Banks Peninsula
54		New Zealand — Otago
55		New Zealand — Arid Island
56		Tonga — Tafahi
57		Kermadecs — Raoul Island
58	*	Samoa — Fagaloa
59		Marquesas Islands — Tamaka
60		Pitcairn
61		Rapanui — Maunga Orito
62		Rapanui — Motu Iti
63	*	Rapanui — Te Manavai
64		Rapanui — Rano Kau
65		Hawaii — Mauna Kea
66		Hawaii — Pu'u Wa'a Wa'a

the artefact to the nearest neighbour. Outliers can be detected by comparing this nearest neighbour distance with the average distance observed for source material to the centroid for that source. Alternatively, the distance could be compared with the standard deviation, or even two standard deviations to be more conservative. However, it must not be forgotten that this simple Euclidean distance does not take into account correlation between element concentrations. These correlations are known to be strong for many element pairs in the case of obsidian. The simple Euclidean distance, therefore, tends to show more discrimination between sources than there really is. For this reason, non- parametric tests may appear to have greater power to reject the null hypothesis than the comparable parametric test. This power, however, is illusory.

NON-PARAMETRIC ALGORITHM

A suite of computer programs have been assembled for this purpose by Clayton (1982b). These are associated with a series of alternative and complementary ways of displaying graphs and dendrograms which illustrate the dispersion of sources and assemblages of artefacts. One approach is to carry out principal components analysis or linear mapping and produce a two or three dimensional plot which shows the artefacts with nearby sources. Alternatively, non-linear mapping can be performed which again seeks to preserve the structure of the distribution pattern, while reducing the number of dimensions for display. Finally, cluster analysis can be performed, which presents the relationships in dendrogram form.

Displaying the dispersion of sources along with artefact assemblages graphically is a most useful aid to making decisions about the source of artefacts because one can quickly "see" the relative proximity of artefacts and sources. However, one must also have some test of the likelihood of correct or incorrect allocations. This is a much more difficult objective for non- parametic methods. As was explained above, the approach taken here is to calculate the simple Euclidean distance from the artefact to each source centroid, and allocate the artefact to the nearest neighbour. Outliers are detected by comparing this nearest neighbour distance with the average distance observed for source material to the centroid for that source.

In the results presented below, scaled concentrations of Na, Al, F, K, Ca, Ti, Mn, Fe, Sr, and Zr were used. The artefacts are normally examined in batches of about 20 so that the non-linear plots do not become too complex (see Table 2).

PARAMETRIC ALGORITHM

Another suite of programs (POPPERS/RAZOR) have been assembled by Leach and Manly (1982) which complement those described above. The analysis is done at three levels. Firstly, the source information is examined to find an optimum transformation statistic which stabilises variation between sources of within-group variance. This is necessary because element variance has been found to be quite variable from one obsidian source to another. This stabilisation procedure permits the use of pooled dispersion statistics during subsequent multivariate analysis. Secondly, a modified Mahalanobis distance statistic is calculated from each source sample and artefact to each source centroid available (taking into account element correlation), together with a significance level, to test the allocation of artefacts to sources. The robustness of the element information to carry out sourcing, that is the degree of source discrimination, is assessed by calculating the degree of multivariate overlap of each source with all others. This is achieved by observing the number of wrong classifications which would occur if 10,000 artefacts were randomly drawn from each geological source. Finally, for the source information, missing data are estimated and principal components analysis performed to yield a graphical picture of source discrimination in a reduced vector space.

To stabilise variations during analysis, element ratios were calculated for the following: Al and F with respect to Na, and Si, K, Ca, Ti, Mn, Zn, Ga, As, Pb, Rb, Sr, Y, Zr and Nb with respect to Fe. The sources used in this study are listed in Table 1.

Assessment of the sourcing method (PIXE-PIGME analysis) and the sourcing algorithm have been published elsewhere (Leach and Manly 1982). Both have been given a reasonably clean bill of health, but are not perfect by any means (see Leach 1985).

SOURCING RESULTS FOR THE ARTEFACTS

A: NON-PARAMETRIC ALGORITHM

(i): Kermadecs artefacts

Artefacts RA04, RA06, RA07, RA08, RA015—these form a loose group that is reasonably well associated with the geological source on Raoul Island.

Artefacts RA05, RA010, RA011, RA012, RA013—these are clearly most similar to the geological material from Mayor Island in New Zealand.

Artefact RA014—This is similar in most element concentrations to Mayor Island, but its values for K (5.94%, cf. Mayor Island 3.2–4.2, average = 3.5%), and Na (2.93%, cf. Mayor Island 3.6–4.2, average = 4.0%) are significantly different. The problem of this artefact was most evident in the cluster analysis procedure, where the artefact grouped with the sources from both Mayor Island and Rapanui with more or less equal certainty. It must therefore be considered an outlier.

(ii): Chatham Island artefacts

These artefacts were analysed in batches, and the reference number for each of these is indicated in Table 2.

Batch 1—with the exception of two artefacts, all are associated with the Mayor Island source, and no overlap is evident with the geological material from Rapanui. The two outliers are: Artefact AD508 has high K (5.1%, cf. Mayor Island 3.2–4.2, average = 3.5%). Artefact AD514 showed low gamma counts for all elements, but the ratios appear satisfactory. It is probable that use of ratio data would place this outlier with the Mayor Island source.

Batch 2—all artefacts again appear to be associated with the Mayor Island source, although there is one outlier: Artefact AD532 did not have X-ray data recorded, and this makes its classification difficult. The gamma data appear similar to Mayor Island. Reanalysis would have to be performed for a satisfactory result.

Batch 3—all are well matched by Mayor Island obsidian.

Batch 4—With the exception of three outliers, all appear to be Mayor Island in origin. The outliers are: Artefact AE258. This shows good agreement with the Tairua source. Artefact AA526 produced gamma results which were all a little low, and it is assumed that there was a normalisation problem. The X-ray data show good agreement with the Mayor Island source. Artefact AA528 produced a low Na result (2.2%, cf. Mayor Island 3.6–4.2, average = 4.0%), and a high value for K (7.1%, cf. Mayor Island 3.2–4.2, average = 3.5%). No source can be suggested, though it is notable that the cluster analysis gave the closest distance to Mayor Island (0.621 units), with Rapanui a close second (0.624 units).

B: PARAMETRIC ALGORITHM

(i): Kermadecs artefacts

The distances to the nearest five sources and their significances are given in Table 2. This shows that artefacts RA04, RA06, RA07, RA08, and RA015, may be assigned to the source on Raoul island without ambiguity. However, in the case of the remainder, unequivocal matching is not possible. This is due to the inherent weaknesses of the sourcing method (element analysis), because there are multivariate overlaps in the results from one source to another, even with the superior discriminatory power gained by the large number of elements analysed. The fact that the non-parametric analysis (above) did not show the same degree of ambiguity merely highlights the unsatisfactory power of non-parametric statistics in general—something which leads to a false sense of security in interpretation.

At this point one must put on an archaeologist's "hat", and bring different information to bear on the problem. It will be observed, for example, in Table 2 that sources in the East Fergusson islands cannot be rejected for some artefacts, even though they have a closer multivariate distance to the Mayor Island source. It may be possible to reject one source with additional information, but not with the element data alone. It is important to recognise precisely what assumptions are being made at this point—the element data and the sourcing algorithm cannot reject two sources—the archaeologist may reject one or the other on the basis of information which has nothing to do with element concentrations. The East Fergusson source can be ruled out on a number of archaeological grounds—there is no known culture-historical evidence which would link the Kermadecs, or the Chatham Islands for that matter, to this area of the western Pacific. Another artefact, RA012, presents a somewhat different problem though, because it cannot be rejected from a Rapanui source. It is possible, but perhaps only remotely so, that contact did occur between the Kermadecs and Rapanui, although this contact may have been indirect. This question is returned to below under "troublesome artefacts". At this point it is sufficient to note that some artefacts appear to be clearly Raoul Island in origin, others clearly of Mayor Island origin, and that one artefact is more difficult to be certain about.

(ii): Chatham Island artefacts

The distances to the nearest five sources and their significances are given in Table 2. Again, this reveals the general weaknesses of the sourcing scheme to differentiate fully between all the sources available—unequivocal sourcing is possible in only rare cases. Once more archaeological information must be brought to bear on the problem. An East Fergusson source frequently occurs as a possible origin, and can again be ruled out on culture-historical grounds. This leaves numerous artefacts which could be confused with either Mayor Island or Rapanui.

In this situation it is best to examine more closely those artefacts which are especially troublesome, and work backwards from these. If an artefact is geochemically closer to Rapanui than to Mayor Island, and closer examination sustains this interpretation, this would be grounds for suspecting that some artefacts ascribed to both Mayor Island and Rapanui (in that order of distance) should remain questionable too.

C: TROUBLESOME ARTEFACTS

Artefact RA014. Whatever difficulties there were in the non- parametric algorithm in sourcing this artefact were not evident in the parametric test, where it was fairly clearly ascribed to Mayor Island. Part of the reason for this may be due to the use of more extensive element data, and the use of element ratios, which would tend to extract any variation in machine conditions.

Artefact RA012. The first test allocated this artefact to Mayor Island, while the second could not clearly distinguish between this origin and that of Rapanui. It has been observed that one element distinguishes these two sources very clearly, notably Barium (see Leach 1977). Unfortunately the PIXE method cannot clearly distinguish the Ba L transition peak from the nearby Ti K alpha transition peak. However, isotope induced XRF does not present this difficulty, since the Ba K alpha peak which can be observed is not subject to interference from other elements in obsidian.

Artefact AD508. This could not be allocated to any source by the first test, but the second test gave a clear allocation to Mayor Island. Once again, this may be put down to the use of more extensive data and use of element ratios.

Artefacts AD514, AA526. In the first test it was noted that the gamma ray results were rather low and that use of ratio data might solve the problem. This does seem to have occurred in the second test where Mayor Island is confirmed.

Artefact AD519. This was ascribed to Mayor Island by the first test, and unambiguously to Rapanui in the second. This is hardly satisfactory.

Artefact AD532. An unsatisfactory result was noted in the first test because of the absence of X-ray data. The second test found that gamma data were most similar to those from the Awana source, closely followed by Mayor Island. Only a repeat PIXE analysis could solve this problem.

Artefact AE258. In the first test this was ascribed to the Tairua source, and in the second to Tairua, Taupo, Waihi, and Ongaroto, in that order of likelihood. It is believed that this latter result fairly reflects the multivariate overlap between these central North Island sources.

Artefact AA528. In the first test no allocation could be made, although the two closest sources were Mayor Island and Rapanui. In the second test, an origin of Rapanui was indicated without ambiguity. This difference may again be attributed to more extended data and use of ratios.

TABLE 2

CLOSEST 5 SOURCES TO THE ARTEFACTS USING POPPERS/RAZOR ALGORITHM

The modified Mahalanobis distances are given in the Table.These may be thought of as units of standard deviations from the source centroid. An asterisk (*) indicates that the distance is significant, that is the source has been rejected. A number in brackets beside an artefact, for example AD532(1), indicates that other sources are also close to this artefact, and further information appears at the base of the Table. The artefacts were divided into batches for the non-parametric analysis, and these are also indicated in the Table. Of the Chatham Island artefacts, D24.148 is from Moreroa; AE256, AE257, AA518, AA520, AA522, and AA523 are from the Waihora excavations; and AE258 is from the CHB site. All remaining Chatham Island artefacts are from surface collections on Pitt Island. There are only two other pieces known from the Chatham Islands, but these have not been analysed by the PIXE-PIGME method: AE255 (from the Waihora site, but too small) and the *mataa* AE365 from Owenga (too large for this analysis—see Leach, 1973). The Kermadec pieces are all from the Low Flat excavation.

Artefact	Mayor Island	Rapanui	East Fergusson
Chatham Island artefacts			
Batch 1			
AD507	0.3,0.5,0.9	0.8,0.9	
AD508	1.0,2.0,2.1		4.0*,4.7*
AD509	0.5,1.0,1.3	2.5*	2.5
AD510	0.7,2.3	2.5*,2.6*,2.8*	
AD511	0.5,0.9,1.5	2.0	2.6
AD512	0.6,1.1,1.1		2.5,4.1*
AD513	0.4,0.8	0.7,0.7,0.7	
AD514	0.2,0.9,1.4		2.6,3.9
AD515	0.6,0.9,1.2		2.3,3.6*
AD516	0.2,0.4,0.8	1.4,1.4	
AD517	0.2,1.1,2.0	3.5*	2.5
AD518	0.3,1.4,2.5*	3.2*	2.9
AD519	2.3*	1.4,1.7,1.8,1.8	
AD520	0.6,1.6,2.1	2.8,4.0*	
AD521	0.8,2.9*	2.3,2.9*,2.9*	
AD522	0.3,1.1,1.2	3.4	3.4
AD523	0.6,1.4,2.9*	2.3,2.8*	
AD524	0.5,0.9,1.6	1.6,3.1*	
AD525	0.6,0.7,0.9		2.7,3.8*
AD526	0.5,1.4,1.6	3.6*	3.2
Batch 2			
AD527	0.3,0.7	0.7,0.9,1.0	
AD528	0.5,0.5,1.1	1.1,1.1	
AD529	0.4,1.0,1.6	2.6*	2.6
AD530	1.8,2.8*	3.5*,4.0*	2.9
AD531	0.3,0.3,0.7	0.7,0.7	
AD532(1)	3.2,5.9*,8.4*		7.0*
AD533	0.4,0.4	0.7,0.8,0.8	
AD534	0.6,1.3,2.2	1.8,2.3*	
AD535	1.8	1.8,1.9,2.2,2.4	
AD536	0.8,0.9,2.3*	2.1,2.7*	
AD537	0.3,1.0,1.2		2.6,3.6*
AD538	0.4,0.5,0.7	0.8,0.9	
AD539	0.3,1.2,2.1	1.5,2.3	
AD540	0.6,0.6,1.3	3.4*	2.5
AD541	0.3,0.4,0.7	0.7,0.8	
AD542	0.5,0.9,1.1	3.3	2.8
AD543	0.5,1.2,1.5	2.5*	2.6
AD544	0.4,0.6	0.7,0.7,0.8	
AD545	0.5,0.6,0.6		2.2,3.9*
AD546	0.7,0.8,0.9	3.7*	2.9

Batch 3			
AD547	0.6,0.6,1.2	3.4	2.8
AD548	0.5,1.0,2.1	2.1,2.5	
AD549	0.4,0.8,1.4	3.1	2.9
AD550	0.9,2.9*	1.0,1.5,1.5	
AD551	0.3,1.0,1.4	2.6*	2.4
AD552	0.5,0.7,1.2	3.2*	2.8
AD553	0.3,1.2,1.9	2.3,2.7*	
AD554	0.6,1.1,1.1	3.0	2.2
AD555	0.3,0.7,1.3	3.4	3.4
AD556	0.4,0.6,0.8	0.8,0.9	
AD557	1.0,1.6,3.4*		5.6*,6.2*
AD558	0.5,1.4,1.5		2.5,4.0*
AD559	0.7,1.2,1.9		3.1,4.4*
AD560	0.4,0.5,1.2	3.2*	2.7
AD561	0.3,0.9,1.2		2.6,3.5
AD562	0.4,2.0,2.1	2.1	2.5
AD563	0.9,1.0,2.1	2.2,2.6	
AD564	0.8,0.8,1.0		2.9,4.2*
AD565	0.5,0.9,1.3	2.9*	1.9
AD566	0.3,0.9,1.0	3.2	3.1
Batch 4			
AD567	0.8,2.7*,2.8*	3.0	5.3*
AD568	0.4,0.8,1.0	4.1*	2.8
AD569	0.4,0.6	0.8,0.9,0.9	
AD570	2.1,2.5,5.8*		6.9*,7.2*
AD571	0.4,0.9,1.1,2.4	3.1*	
AA524	0.5,0.6	1.4,1.5,1.5	
AA525	0.3,0.4,0.7	0.7,0.8	
AA526	1.2,1.6,2.3*		3.6*,4.8*
AA527	0.3,0.8,1.4	1.7	2.5
AA528	2.8*	0.8,1.4,1.7,2.3	
AA529	0.9,0.9,1.4	4.4*	3.9*
AA530	1.2,1.4,3.3*	2.1,3.5*	
AA531	0.6,0.8,1.5	1.3,1.4	
D24.148	0.5,1.0,1.4	4.0*	3.0
AE256	0.3,1.8	1.6,1.9,2.0	
AE257	0.6,1.0,1.8	2.4	3.0
AE258(1)			
AA518	0.5,0.5	0.6,0.6,0.7	
AA520	0.2,0.5,0.8	0.9,0.9	
AA522	0.3,0.4,0.8,0.8	0.9	
AA523	1.3	0.7,1.5,1.9,3.0*	
Kermadec Island artefacts			
Batch 5			
RA04(1)			
RA05	0.3,0.6,1.2		1.7,2.7*
RA06(1) RA07(1)			
RA08(1)		12.7*	
RA010	0.2,0.6,1.8		2.7,3.3*
RA011	1.8,2.9*		6.1*,6.2*,6.3*
RA012	0.3,0.3,0.9	1.0,1.4	
RA013	0.4,1.3,1.6		1.8,3.0*
RA014	0.9,1.0,1.2		2.8,3.2
RA015(1)			

Further information on specific artefacts

Chatham Island artefacts

Artefact	Awana	Tairua	Taupo	Waihi	Ongaroto
AD532	0.0				
AE258		0.2	0.5	1.5,1.7	1.7

Kermadec Island artefacts

Artefact	Raoul	Vanuatu	Tonga	Banks Peninsula
RA04	1.4	6.0*,10.6*,11.7*	12.8*	
RA06	1.7	5.1*,8.7*,9.8*		10.5*
RA07	2.7	7.0*,11.6*,12.8*	14.6*	
RA08	1.7	5.0*,11.7*	11.2*	12.7*
RA015	1.7	5.6*,9.6*,10.6*	12.1*	

Artefact AA523. The first test allocated this to Mayor Island and the second gave non-significant distances to Rapanui (closest) and Mayor Island (more distant).

Remaining difficult artefacts. There remains in the second test a large number of artefacts which have non-significant distances to both Mayor Island and Rapanui. These are:

AD563	AD566(2)	AD567	AD569	AA524	AA525	AA527
AA530	AA531	AE256	AE257	AA518	AA520	AA552
AD507	AD511	AD513	AD516	AD520	AD521	AD522
AD523	AD524	AD527	AD528	AD531	AD533	AD534
AD535(1)	AD536	AD538	AD 53	AD541	AD542(2)	AD544
AD547(2)	AD548	AD549(2)	AD550	AD553	AD554(2)	AD555
AD556	AD562					

NB: 1 = equal distances to Mayor Island and Rapanui
2 = Rapanui third closest
Remainder are closer to Mayor Island than Rapanui

DIFFERENTIATIATION OF MAYOR ISLAND AND RAPANUI OBSIDIAN FROM BARIUM CONTENT

A study of New Zealand obsidians by Leach (1977) using isotope induced XRF showed that Mayor Island obsidian was very low in Barium content, and might form the basis of a simple screening technique. This was followed by a detailed analysis of concentrations of both New Zealand and Pacific obsidian using NAA (Leach and Warren 1981). This confirmed that Mayor Island material was indeed low in Barium, and readily distinguishable from Rapanui obsidian on this element alone. The relevant information is given in Table 3.

More recently, Bollong has carried out extensive qualitative analysis of Barium and other elements for New Zealand and Pacific obsidians (Bollong 1983), using isotope induced XRF. He confirmed the distinctiveness of Mayor Island from Rapanui obsidian using Barium. However, he also found that Northland obsidian had a similarly low level of Barium to that of Mayor Island, and this finding conflicted with the earlier NAA findings. The reason for this was eventually traced to poor resolution of the Barium isotope peak with NAA due to nearby interfering isotopes. This is reflected in a coefficient of variation of about 25% for this element. The results from the isoprobe research are considered far more reliable. While this updating of results has the unfortunate effect of making it more difficult to screen Mayor Island obsidian from Northland sources, it confirms a clear difference between Mayor Island and Rapanui.

TABLE 3

BARIUM CONTENT (ppm) IN MAYOR ISLAND AND RAPANUI OBSIDIANS

Source	Mean	Standard Deviation
Mayor Island		
44	54	34
45	53	–
46	39	26
Rapanui		
61	495	118
62	459	88
63	509	106
64	466	–

It was considered worthwhile to examine all the Kermadecs and Chatham Islands artefacts on the Otago isoprobe for evaluation of Barium content. Unfortunately, at this stage of development, the method is essentially qualitative—however, the distinction between high and low Barium content is quite effective. This was done on the artefacts, and they all clearly belong to a low Barium group, which helps to reject the Rapanui source, if the artefacts are considered as a group representing one source. Why then should there be difficulty in assigning the artefacts to Mayor Island? There are a number of possibilities. One is that they come from an undiscovered source which is similar to both Mayor Island and Rapanui; another is that the artefact obsidian comes from a small number of unusual pieces of obsidian from Mayor Island which are not close to the source centroid.

To examine these possibilities, it was decided to assess the range of variation of element concentrations for sources and the artefacts using 95% equi-probability ellipses (Jackson 1956). This is a method whereby the confidence region surrounding a source may be identified. If artefacts lie outside this region, then they are unlikely to come from the source in question. There are several advantages which this technique has over multivariate methods. One is that individual pairs of powerful element discriminators may be chosen, another is that it is not necessary to obtain a pooled estimate of the covariance matrix; and finally, it is not necessary to carry out principal component analysis, with its attendant problems of distortion, in order to present the relevant information visually.

For this procedure, the Chatham Islands artefacts (with the exception of AD532 and AE258 which are quite unlike either Rapanui or Mayor Island) were treated as if they were a sample from a separate source. Three plots are given in Figure 4. This shows that the artefacts from the Chatham Islands as a group do indeed overlap with both Rapanui and Mayor Island, but more significantly, a major part of the distribution lies in a different place from both these sources. In Figure 4A, for example (Tb against Yb), the artefact distribution lies inside the 95% confidence limits for Rapanui, but about half the artefacts are outside the boundary for Mayor Island. Unless there is a serious problem in the analyses, this single plot may be sufficient grounds for outright rejection of Mayor Island as the source. In Figure 4B (Tb against Zr) the artefacts lie in a region between the two sources. In Figure 4C (Cs against Sc) the artefacts lie in a very small region where the two sources overlap. One final point—the range of elemental variation of the Chathams obsidian is quite consistent with that of the two similar sources considered (see Figure 4A and 4B especially). It has earlier been suggested that one of the reasons why there has been difficulty in ascribing the Chatham Islands artefacts to their source is that a single atypical lump of obsidian may have found its way to the island (Leach and Manly 1982: 104). The observed range of variation would seem to rule this out.

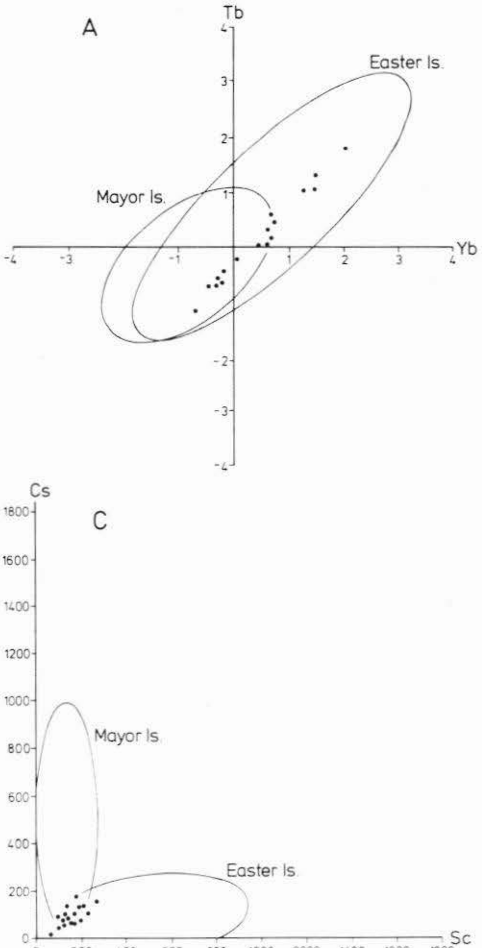

Figure 4: A selection of two dimensional 95% equi-probability ellipses for Mayor Island and Rapanui obsidian, together with the Chatham Island artefacts, for select element pairs from the neutron activation analysis. In A (Tb against Yb) the distribution of the artefacts accords more closely with the Rapanui obsidian than with that from Mayor Island. In B (Tb against Zr) the artefacts appear to lie in between the two sources. In C (Cs against Sc) the artefacts plot out in a small area of the region of overlap between the two sources. These plots suggest that at least some of the Chatham Island artefacts may be from an unknown source. The solid circles show the Chatham Island artefacts.

These results suggest that as a group these artefacts are similar to but distinguishable from both sources, and therefore an unknown source has to be seriously considered. It is not possible at this time to say more than that. As further artefact analyses are made and compared with increased samples of material from these two known sources, it is hoped the matter will be clarified. In the meantime, it would be wise to ascribe artefacts to these two sources with a certain amount of caution.

With this reservation in mind, the multivariate methods have allocated (albeit with difficulty) most of the non-Raoul artefacts to Mayor Island. The exceptions are artefacts AD519 and AA528. These have been shown to be most similar to the Rapanui obsidian, and are here designated as cf. Rapanui. This special designation should be interpreted thus: "these artefacts are most similar to this source, but do not necessarily belong to it". This form of identification is sometimes made in osteological work, where a bone looks identical or near identical to some taxa, but for some reason (on distributional grounds for example) positive identification to this taxa is uncertain.

SIMULATED DRIFT VOYAGING EXPERIMENTS

In the simulated drift voyaging experiments of Levison *et al.* (1973), it was found that of the "several thousand simulated drifts performed from islands along the southern margins of tropical Polynesia, none reached New Zealand" (ibid.: 55); this suggests that the archaeologically documented contact is more likely to have been a result of deliberate navigated trips (ibid.:56). On the other hand, drift voyages are reasonably likely from New Zealand to the Kermadecs, and further out into the East Pacific, but drifts from the Kermadecs to New Zealand are rare (ibid.: 55). They conclude that "two-stage drift voyages to New Zealand [with the Kermadecs as a staging post] are just possible, though very unlikely" (ibid.: 56). Because of the possible role of the Kermadecs in this debate, it was decided to examine these experiments more closely. In addition, some further simulations were carried out, targeted specifically on the Chatham Islands.

SIMULATED DRIFT VOYAGES FROM THE CHATHAM ISLANDS

Two sets of experiments were carried out. In the first of these, forward drift voyages were simulated for 12 months from a starting point just off the coast of the Chatham Islands, to see where craft might end up. In the second series, reverse voyages were carried out, again over a 12 month period, to see where successful landings may have come from.

In the case of forward voyages, these showed that drifts away from the Chatham Islands had about a 50:50 chance of a successful landing somewhere in the Pacific, most of these being back to the Chatham Islands itself (73.6%). This is a surprisingly high success rate, and shows that despite the remote location of the Chathams, people lost at sea would have had a reasonably high chance of survival. Apart from return drifts back to the Chathams, the most likely landfall is New Zealand, followed by the Australs group to the north-east. Remaining potential landfalls are scattered widely over the Pacific, and include the Kermadecs. Some details are given in Table 4.

In the case of reverse voyaging, two sets of experiments were carried out, one when the landing was actually on Chatham Island itself, the other off the coast a little. These gave similar results, and as one might expect, landfalls frequently came from the Chathams group itself, especially from Pitt Island (Table 5).

The points of departure are clearly dominated by successful trips from New Zealand (ignoring those originating in the Chathams), with Bounty Island and the Antipodes figuring

TABLE 4

SIMULATED DRIFT VOYAGES FROM THE CHATHAM ISLANDS

Successful landings	344
Crew expired	242
Out of bounds	47
Lost in gales	99
Total drift voyages	732

Successful landings

Back to the Chatham Islands	253
New Zealand	38
Austral Islands	10
New Caledonia	8
Tonga	6
Fiji	6
Cook Islands	4
Kermadecs	3
Niue	3
Vanuatu	3
Society Islands	2
Bounty Island	2
Antipodes	2
Norfolk Island	1
East Uvea	1
Anuta	1
Great Barrier Reef area	1
Total	344

next in prominence. These latter two islands were uninhabited at European contact. The only other possible landfalls are from the Kermadecs (6 trips of 518 made from outside the Chathams), and one from Australia! The distribution of the New Zealand trips from different parts of the country is uneven, and clearly dominated by the southern North Island area, with notably low probabilities from the far north, the far south, and the south Canterbury area (Table 6).

These voyaging experiments show that even with drift voyaging (not necessarily the most likely form of contact), there was a good chance of prehistoric contact between the Chatham Islands and New Zealand in both directions, and also that there was a significant chance of contact from the Chathams to the southern margins of Eastern and Western Polynesia, and Fiji. The Austral Islands figure prominently. The possibility of direct contact between the Kermadecs and the Chatham islands exists, but is remote.

SIMULATED DRIFT VOYAGES FROM THE KERMADEC ISLANDS

Three forward voyaging experiments were carried out from the Kermadecs. Experiment 70 and 100 were from Raoul, and experiment 150 was started some distance from Raoul, notably from Curtis Island, to avoid a proportion of immediate returns to the main island. Experiment 70 was carried out over the single month of February, Experiment 100 was over a 12 month period with the wind pattern shifted five degrees to the south, and Experiment 150 was over a 12 month period. The final simulation (Experiment 121) was a reverse voyaging one from Raoul over a 12 month period. It has been suggested that climatic

TABLE 5

SIMULATED REVERSE DRIFT VOYAGES TO THE CHATHAM ISLANDS

Landfalls on the Coast

Successful landings	621
Crew dead on arrival	19
Out of bounds	54
Lost in gales	38
Total voyages	732

Points of departure

Chatham Islands	395
New Zealand	185
Bounty Island	30
Antipodes	10
Kermadec Islands	1
Total voyages	621

Landfalls off the coast

Successful landings	551
Crew dead on arrival	26
Out of bounds	76
Lost in gales	79
Total voyages	732

Points of departure

Chatham Islands	259
New Zealand	241
Bounty Islands	32
Antipodes	13
Kermadec Islands	5
Australia	1
Total voyages	551

fluctuations in the last two or three thousand years might make a substantial difference to the results of these simulations—this was the reason for the wind shift experiment (ibid.: 14–16). A summary of the results is given in Table 7.

The forward voyaging experiments from the Kermadecs clearly show that the major area of drift contact from this group would have been to the northwest. In particular, contact with New Caledonia dominates the pattern with Vanuatu second in importance. Of the successful landings which are not back to the Kermadecs, these two archipelagos account for 76% (Experiment 70), 79% (Experiment 100), and 42% (Experiment 150) of landfalls in the forward experiments. The latitude windshift does not seem to make any significant difference to this pattern. In these forward simulations, drift contact to New Zealand is obviously very difficult. This does not mean that prehistoric contact did not take place—indeed, it may have been reasonably common, but this would have been by deliberate navigation. Another point to note is that the northwest drifting pattern is nowhere near as

TABLE 6
ORIGIN WITHIN NEW ZEALAND OF SIMULATED DRIFT VOYAGES TO THE CHATHAM ISLANDS

Latitude South	Number of landings from	Percentage
34 degrees	2	0.5
35	12	2.8
36	13	3.1
37	54	12.7
38	52	12.2
39	35	8.2
40	91	21.4
41	44	10.3
42	20	4.7
43	36	8.5
44	1	0.2
45	42	9.9
46	21	4.9
47	3	0.7
Totals	426	100.1

strong in the case of departures from Curtis Island, to the south of Raoul. In fact, New Zealand contact rises to 8% of those landfalls not arriving back in the Kermadecs.

The reverse experiment shows that 82% of drifts which started from outside the Kermadecs and end up in Raoul come from New Zealand, and the only other regions of significance are the Australs (5.5%) and the Chatham Islands (5.0%).

It is easy to see how prehistoric people in New Zealand may have learned of the existence of the Kermadec Islands. In addition, it would be understandable if accidental arrivers in the Kermadecs, perhaps in fishing canoes without sails, refurbished their craft with sails and provisions, and sailed against wind and tide back to New Zealand. New Zealand represents a major landing arc for deliberate travellers from this small group to the north. In short, two-way contact between New Zealand and the Kermadecs could have been established by such a scenario; however, this is conjecture.

CONCLUSIONS AND IMPLICATIONS

Prehistoric obsidian artefacts from the Chatham and Kermadec Islands have been shown to have been manufactured from foreign material deriving from New Zealand. The individual identifications for artefacts are not always certain, and this fairly reflects the current status of obsidian sourcing methodology. It has been shown that the elemental composition of these obsidian artefacts is sufficiently variable to indicate that the material was reasonably representative of the geological source of origin. The two most similar sources are Mayor Island and Rapanui, and it has been shown that there are systematic differences between both these sources and the artefacts from the Chathams taken as a group. Although an origin from Mayor Island is the most likely interpretation on archaeological grounds, the results could also be interpreted as indicating a third unknown source. This possibility is not ruled out in this study, but merely set aside as implausible. It is hoped that further analyses of both source material and artefacts in the future will help to change the implausible to the downright impossible. Two Chatham Islands artefacts must be designated as "cf. Rapanui" at this stage. This does not rule out the possibility that they derive from

TABLE 7

SIMULATED DRIFT VOYAGES TO AND FROM THE KERMADECS

Experiment 70: Forward voyages from Raoul in February.

Summary

Successful Landings	658
Crew expired	32
Out of bounds	22
Lost in gales	8
Total drift voyages	720

Successful Landings

Back to the Kermadecs	270
New Caledonia area	237
Vanuatu	59
Australia	33
Tonga area	21
Fiji area	12
Papua New Guinea	10
New Zealand	7
Norfolk Island	5
Lord Howe area	4
Total	658

Experiment 100: Forward Voyaging from Raoul over 12 Months, with wind pattern shifted 5 degrees to the south.

Summary

Successful Landings	620
Crews Expired	67
Out of Bounds	24
Lost in Gales	21
Total Drift Voyages	732

Successful Landings

New Caledonia	284
Back to the Kermadecs	152
Vanuatu	85
Australia	20
Papua New Guinea	14
Fiji	13
Norfolk	11
Tonga	8
Lord Howe Area	4
New Zealand	3
Santa Cruz area	2
Chatham islands	1
Australs area	1
Anuta area	1
Rennell	1
Miscellaneous	20
Total	620

Experiment 121: Reverse Voyaging from Raoul over 12 months.

Summary

Successful Landings	455
Crews Expired	202
Out of Bounds	17
Lost in Gales	58
Total Drift Voyages	732

Successful Landings

Kermadecs	253	
New Zealand	166	(Including 6 from Mayor Island !)
Australs area	11	
Chatham Islands	10	
Tonga	4	
Antipodes	3	
Fiji	2	
Bounty	1	
Australia	1	
Norfolk Island	1	
Mangareva	1	
Cook Islands	1	
New Caledonia	1	
Total	455	

Experiment 150: Forward voyaging from Curtis Island over 12 months.

Summary

Successful Landings	622
Crew Expired	52
Out of Bounds	27
Lost in Gales	31
Total Drift Voyages	732

Successful Landings

Back to the Kermadecs	412
New Caledonia	61
Tonga	44
Vanuatu	27
New Zealand	16
Norfolk	16
Fiji	15
Australia	6
East Futuna	3
Chatham	2
Australs area	3
Papua New Guinea	3
Cook Islands	2
American Samoa	2
Lord Howe area	1
Tikopia	1
Tuvalu	1
Miscellaneous	7
Total	622

TABLE 8
PROBABLE SOURCES OF OBSIDIAN ARTEFACTS FROM THE KERMADEC AND CHATHAM ISLANDS

KERMADEC ISLAND ARTEFACTS		
Mayor Island		6
Raoul Island		5
	Total	11
CHATHAM ISLANDS ARTEFACTS		
Mayor Island (NZ)		77
Central North Island (NZ)	AE258	1
cf. Rapanui AD519, AD528		2
Awana (NZ) AD532		1
	Total	81

Mayor Island. However, it has been shown that Mayor Island can be rejected more easily than Rapanui can be. A summary of the results is given in Table 8. It should be noted that the assemblage from the Chathams is all the known obsidian from the island, but that from Raoul is only a partial assemblage. There are many more obsidian artefacts from Raoul which are quite clearly of local material, and were not subjected to analysis.

The fact that the bulk of this foreign obsidian is Mayor Island in origin, rather than from a variety of sources in New Zealand, is not very surprising. This is typical of many archaeological assemblages within New Zealand, both early and late (see Leach and de Souza 1979). The fact that some artefacts are not of Mayor Island material though, may well show that the geographical source of these artefacts was from a community who lived some distance from Mayor Island, and who had obtained their obsidian in the first place by an exchange process. Of course the contact may have occurred many times rather than just once, and this might increase the chance of more than one obsidian type being in the Chathams.

We can assume therefore that there was prehistoric contact from New Zealand to these islands. In the case of both the Kermadecs and Chathams, this must have been before about A.D.1400, since the earliest radiocarbon dates for both islands are of this age (see Sutton 1980, 1982a, 1982b, 1983; Anderson 1979, 1980). An important point is whether there was similar contact from these islands to New Zealand—in other words, was the contact involved accidental one-way, or was it navigated two-way voyaging? It is difficult to be sure on this point. Two-way voyaging would be more convincing if Kermadecs obsidian or Chatham Islands chert were found in some New Zealand archaeological sites, but this has yet to be demonstrated.

Whichever type of voyaging was involved, the contact which has been documented between these islands (Table 9) is well beyond the proposed limits of two-way navigated voyaging of about 574 km (310 nautical miles). This particular distance has been chosen for several reasons. Firstly, it has been noted by Lewis (1972: 20–21) that it is possible to sail to almost all of the inhabited islands in the Pacific without crossing any patch of open sea beyond this distance. Sharp also notes historically recorded two-way voyaging of distances up to 579 km (1963: 24–32). Secondly, this figure fits well with reconstructions

TABLE 9

DISTANCES BETWEEN THE CHATHAM AND KERMADEC ISLANDS AND NEW ZEALAND

Chatham Island/Mayor Island	939 km
Kermadec Islands/Mayor Island	1037 km
Chatham Island/Kermadec Islands	1638 km
Chatham Island/closest point in NZ	681 km
Kermadec Islands/closest point in NZ	755 km

of maintained contact between Lapita site clusters by Green (1978), and also with findings of geographical clusters of languages in the Pacific, following principles of linguistic differentiation (Pawley and Green 1975: 38–40).

The greater circle distances (closest arcs) involved in these finds of obsidian were worked out. The Kermadec distances were assessed from L'Esperance Rock (the closest point to New Zealand). It was found with some surprise that the equi-distance arc from this location made a broad sweep from East Cape (755 km) to Cape Brett in Northland (798 km). In the case of the Chathams, the equi-distance arc runs along the east coast of the North Island from Cape Palliser to Cape Turnagain (681 km).

These are well beyond the supposed upper limits for two-way navigated voyaging (574 km). It has been shown above that drift voyages from New Zealand to both the Kermadec and Chatham Islands are quite feasible, but that only drifts from the Chathams are likely to have ended up in New Zealand. If we assume that navigated two-way voyaging was not involved in the contact documented by these obsidian finds, then we are left with a drift explanation. It has been shown by McArthur *et al.* (1976), and reinforced by Black (1980), that successful long term colonisation of new islands could not be guaranteed even with a founding group as high as 50 people (unlikely for a drift voyage), which might survive for several hundred years and then become extinct. Although there is no absolute number in a founding group which can be termed a "critical minimum", these two studies suggest that successful colonisation demanded more people than would have been involved in accidental drift voyages. In this respect, it is notable that the Kermadec Islands were uninhabited at European contact, but the Chatham Islands possessed a flourishing population. If this is not a function of the considerable difference in island size, it might lend support to the notion that contact between New Zealand and the Kermadecs was rather less regular than between New Zealand and the Chathams.

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