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– ARTICLE –

Procurement and Cultural Distribution of Obsidian in Northern New Zealand

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ABSTRACT

This paper provides new insights into the prehistoric exploitation of obsidian in northern New Zealand. Most of the obsidian recovered from archaeological sites in this region originated from six or seven preferred sources (out of a total of 19). Cultural distributions can be delimited for the majority of these, and indicate that the primary use of raw material from some sources, where the local obsidian constitutes >30–50 per cent of artefact assemblages, was restricted to relatively small areas. A significant proportion of the obsidian in these areas could have been procured by direct access, which may be reflected in a high percentage of artefacts with remnant cortex. Exploitation appears to have changed over time, from an early reliance on Mayor Island obsidian to greater use of alternative sources in the later period, pointing to the development of more complex distribution networks.

Keywords: Obsidian, sources, cultural distribution, procurement, New Zealand

INTRODUCTION

It is 50 years since Green (1962, 1964) recognised the potential for using obsidian artefacts in the identification of trading networks in New Zealand. A considerable amount of research has been undertaken since the 1960s with this goal in mind (e.g. Seelenfreund & Bollong 1989; see also review by Sheppard 2004), but progress has been hampered in particular by: (1) continuing uncertainty over the number of obsidian sources, and inadequate information on their physical and chemical characteristics, and (2) unavailability of a reliable, inexpensive, and non-destructive method of chemical analysis. In addition, although many useful analyses of artefact assemblages have been published, few have contributed directly to our understanding of exchange networks. However there has been some attempt to address these issues, in part through a detailed re-evaluation of the sources (Moore 2011b, in press a, b), and documentation of the cultural distribution of obsidian within particular areas (Moore 2005, 2011a, Moore & Coster in prep). Other studies have assessed the use of GIS in determining potential transportation routes (Scott 2007), and considered the spatial analysis of sourced artefact assemblages (McCoy *et al*. 2010). This research has been encouraged, to some extent, by the recent introduction of portable energy-dispersive X-ray spectroscopy (PXRF or EDXRF, Sheppard *et al*. 2010).

This article examines the pre-European exploitation of obsidian in the northern half of the North Island, a region containing all of the known sources in New Zealand. It considers some of the factors that may have influenced the use of those sources, their cultural distributions, broad changes over time, and the means of procurement. The paper is based mainly on the analysis (visual sourcing) of obsidian artefact collections held by Auckland Museum, supplemented by additional information from the published literature, unpublished reports and other data acquired by the author. The artefacts come from a variety of site types (e.g. middens, defensive pa, undefended settlements), and were obtained through either excavation or surface collecting.

OBSIDIAN SOURCES

Natural deposits of obsidian are restricted to areas of Late Miocene to Quaternary rhyolitic volcanism in the northern half of the North Island, within three main regions: Northland, the Coromandel Volcanic Zone (Great Barrier Island and Coromandel Peninsula), and Taupo Volcanic Zone, in addition to Mayor Island in the Bay of Plenty (Figure 1). Collectively these constitute what could be termed a 'source province'. The southern limit of this province is somewhat arbitrary but can be taken as a line between Whakatane and Lake Taupo and across to about Awakino on the northern Taranaki coast (Figure 2). No part of this area is more than 120 km from any obsidian source, with the exception of the Three Kings Islands off the northern tip of the North Island.

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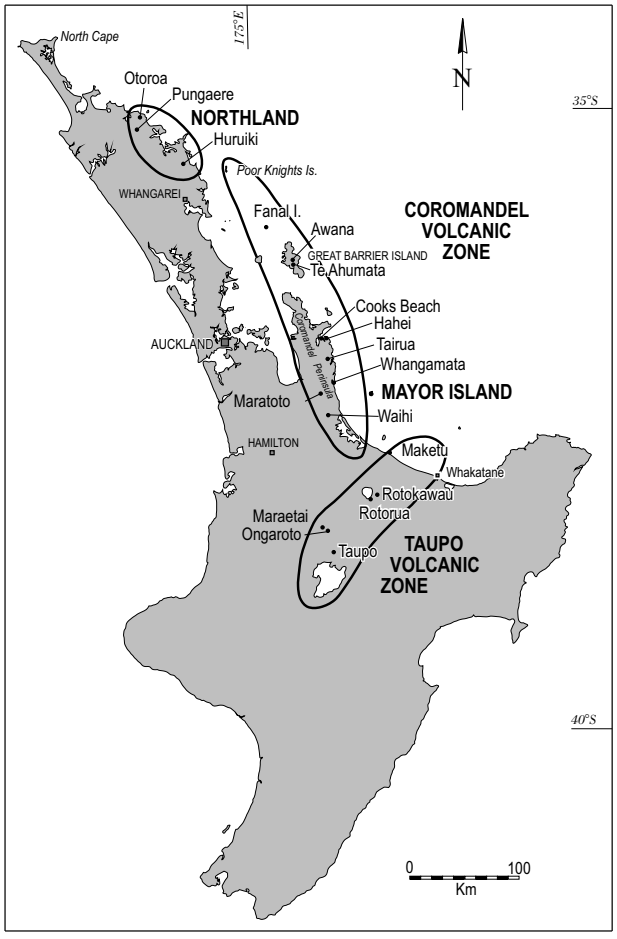

Figure 1. North Island of New Zealand, showing obsidian sources and source regions.

There has been, and still is, a degree of uncertainty over the exact number of obsidian sources in New Zealand. As many as 27 have been reported (Sheppard 2004), but this includes some occurrences of very poor quality material which was largely if not entirely unsuitable for the manufacture of flake tools. Some confusion has also been caused by the grouping of potential sources, as at Rotorua (Ward 1973). Recent studies indicate there are probably about 19 valid sources (Moore in press a, b, in prep), and on present evidence perhaps just 11 or 12 of those were actually exploited. However, chemical analyses of artefact assemblages have also revealed the existence of some obsidian with unusual composition, which suggests that all sources may not have been identified, though any additional ones are likely to be of limited extent.

FACTORS INFLUENCING EXPLOITATION

Previous studies have given little consideration as to why certain obsidian sources were widely exploited and others were largely if not completely ignored. Some of the factors that are likely to have influenced their use are quality, quantity, location or accessibility, and the physical nature of the resource (Table 1). Territoriality and the dynamic of distribution networks may also have played a role.

The ability of the obsidian to yield useable flakes was obviously a critical factor in determining whether it was utilised or not, and there is no evidence that sources consisting of poor quality material with a sub-conchoidal fracture were exploited to any extent (e.g. Otoroa, Awana). However the Fanal Island obsidian, which is only of moderate quality, was used extensively on the island itself (Moore 1986) and quite widely distributed elsewhere.

The amount of obsidian available for extraction at the known sources is highly variable, and ranges from hundreds of tonnes (e.g. Mayor Island, Taupo) to a few tens of kilograms (e.g. Maketu). Yet some sources containing relatively large quantities of flake-quality obsidian were either completely ignored or exploited on a very limited scale (Tairua, Maraetai, Ongaroto). The physical nature of the resource may also have been important. Although there are natural outcrops of obsidian in many places, except on Mayor Island and at Taupo (and possibly the Whakamaru area) the amount of material that could be readily obtained from such exposures in pre-European

Figure 2. Archaeological sites referred to in this paper. Solid dots = analysed artefact assemblages; open circles = other sites or places mentioned in the text.

Table 1. *Setting and physical nature of New Zealand obsidian sources. More significant sources indicated by **

Source	Location	Access	Nature	Quantity	Quality	Reference
Northland						
Pungaere*	inland	land/river	colluvial/detrital	moderate	good	Moore in press b
Otoroa	inland	land	colluvial/detrital	small	poor	Moore in press b
Huruiki*	near coast/ inland	land/sea	colluvial/detrital	small	good	Moore 1982, in press b
Coromandel Volcanic Zone						
Fanal Island	island	sea	in situ/colluvial	moderate	moderate	Moore 1986, 2004b, in press a
Awana	near coast	land/sea	detrital	small	poor	Moore in press a
Te Ahumata*	near coast/ coast	land/sea	colluvial/detrital	moderate	very good	Moore in press a
Cooks Beach*	coastal	sea	colluvial/detrital	moderate	good	Moore 1983, in press a
Hahei*	coastal	sea	colluvial/detrital	moderate	good	Moore 1983, in press a
Tairua	near coast	river/sea	colluvial/detrital	moderate	good	Moore & Coster 1984, Moore in press a
Whangamata*	coastal	sea	colluvial/detrital	moderate	good	Moore 1999, in press a
Maratoto	inland	land/river	detrital	small	very good	Moore 2004b, in press a
Waihi*	inland	land/river	detrital	moderate	good	Moore & Coster 1989
Taupo Volcanic Zone						
Maketu	coastal	sea	detrital	very small	good	Moore in prep
Rotokawau	inland	land/lake	detrital	moderate	moderate	Moore in prep
Rotorua	inland	land/lake	in situ?	small?	poor	Moore in prep
Maraetai	inland	land/river	in situ/colluvial	moderate	moderate	Moore in prep
Ongaroto	inland	land/river	in situ/colluvial	moderate	moderate	Moore in prep
Taupo*	inland	land/lake	in situ/coll./detrital	large	very good	Moore 2011b
Mayor Island*						
	island	sea	in situ/coll./detrital	very large	very good	Seelenfreund-Hirsch 1985

times was probably quite limited. At most locations the bulk of the obsidian is colluvial or detrital in nature and found scattered across hillsides, or along rivers, streams and shorelines, where it ranges from pebble to boulder size.

Observations on the type of cortex preserved on obsidian artefacts suggest that much of the raw material was procured from colluvial and detrital deposits, rather than being extracted from outcrops. At Lake Taupo for example, a significant proportion of the obsidian (up to 28 per cent) recovered from sites close to the source has remnants of water-worn cortex (Moore 2011b). Even on Mayor Island, where there would appear to be evidence of quarrying (Seelenfreund-Hirsh 1985, cf. Sheppard 2004), at least some of the obsidian was obtained from beach deposits. From the curvature of the cortex and size of cores it is evident that a considerable amount of the obsidian utilised was in the form of large pebbles and cobbles, and occasionally boulders. This makes good sense in terms of transportation, as the handling of rounded colluvial or water-worn cobbles would have been easier and safer than sharp angular blocks, particularly on overland journeys. The amount of waste cortex does not appear to have been an issue.

Many of the sources were directly accessible from the sea, and not surprisingly all of those in this category were exploited (Table 1). Others are located close to the coast and required only a short excursion up a navigable river (e.g. Tairua, Pungaere) or overland (e.g. Huruiki) to reach them. The few sources situated well inland, at Taupo and in the Whakamaru and Rotorua areas, were obviously more difficult to access from the coast, but within easy reach of people living in the central North Island. Accessibility, therefore, was not necessarily a constraining factor.

EXTENT OF EXPLOITATION

How much material was procured from the various sources is very difficult to assess, given the relatively few artefact assemblages that have been fully analysed and reported in detail. There is no doubt, however, that the obsidian from many sources was utilised extensively in the immediate area (e.g. Fanal, Whangamata, Taupo). Obsidian from a few sources (e.g. Mayor Island, Pungaere) occurs in significant amounts at distant sites, and it is evident that substantial quantities were being transported over considerable distances. At Houhora, for example, a total of almost

40 kg was collected, 16 kg of that from an excavated area of about 250 m² of which at least 50 per cent originated from Mayor Island (Furey 2002). And at the late site of Raupa about 20 kg was recovered from an excavated area of 385 m², representing only two per cent of the site (Prickett 1992). Approximately 95 per cent of this obsidian was from Mayor Island.

ANALYSIS OF ARTEFACT ASSEMBLAGES

Methodology

The artefact assemblages considered in this study were analysed mainly by the visual characterisation method (Moore 1988). In general this involves the initial separation of artefacts into Mayor Island and 'other' types on the basis of colour in transmitted light, followed by further division of the 'other' category into different groups using a range of criteria, including degree of translucency, presence/absence of spherulites and phenocrysts, flow banding and type of cortex. These attributes are then compared with the known characteristics of obsidian from each source to provide a definite or tentative source allocation. In some cases selected pieces may be subjected to chemical analysis to confirm the visual sourcing results.

This procedure has been successfully employed by the author (e.g. Moore 2004a, 2011a), as well as by others (Neve *et al*. 1994, Furey 2002, Cruickshank 2011). It has proved particularly useful in dealing with large numbers of flakes which can be sorted relatively quickly, and in most cases both Mayor Island and Pungaere obsidian are able to be readily distinguished from all other material, often with >90 per cent certainty. While 'grey' obsidian (grey in transmitted light) is more difficult to source, usually some can be confidently assigned to sources and options indicated for the remainder.

For this study more than 8600 artefacts were examined, from at least 75 different sites. About 2200 of these are from various sites on the Aupouri Peninsula in the Far North, which will be reported on in detail elsewhere (Moore & Coster in prep). Some information from a number of other, small assemblages was also used to improve the coverage in places. Although some data are taken from earlier studies, where possible the collections concerned were re-examined to ensure the reliability of the results. The total database consists of >19,700 flakes, pieces and cores of obsidian (Table 2).

Over 50 EDXRF analyses have also been obtained by the author, in addition to >370 by other archaeologists for sites at Auckland (Cruickshank 2011, Davidson 2011) and

Table 2. *Analyses of artefact assemblages from the northern North Island. See Figure 2 for locations of sites.*

Location	Site no.	Period	N	Mayor	Grey	Pungaere	Reference
Northland							
Waikuku Beach	N/A	Early-Mid	102	56	15	31	Moore 1988, new data
Aupouri North #	9 sites	Mid	205	171	4	62	Moore & Coster (in prep)
Aupouri South #	6 sites	Mid	2004	272	387	1345	Moore & Coster (in prep)
Kowhai Beach	6 sites	Early-Mid	169	66	28	75	this study
Houhora (1)	N03/59	Early	873?	55%	10%	35%	Furey 2002
Mitimiti	N/A	Early-Mid	124	8	5	111	this study
Motutoa	O06/307-8	Mid-Late	102			102	Frederickson 1990, new data
Mawe pa	P05/191	Late	127	6		118	this study
Pouerua*	6 sites	Mid	123	24	15	84	Brassey & Seelenfreund 1984
Urquharts Bay	Q07/571	Mid	72	12	60		Phillips 2010
Pouto	16 sites	?	116	48	41	27	this study
Okahukura	Q09/113	?	81	72	5		this study
Great Barrier Island							
Harataonga	T08/3	Mid	168	37	131		Law 1972
Harataonga	T08/5	Early	114	102	12		Law 1972, new data
Whangaparapara	S09/18	Mid-Late?	298		298		Atwell 1973
Auckland							
Matatuahu	Q11/344	Early	653	535	118		Prickett 1987, new data
Maioro	R13/1	Mid?	961	>387	461		Moore 2011a
Elletts Mt.	R11/31	Mid?	>164	>73	>91		this study
Westfield	R11/898	Mid	228	72	155		Furey 1986, new data
Hamlin's Hill	R11/142	Mid-Late	58	20	38		Walton 1979, new data
Taylor's Hill	R11/96	Mid	98	13	83		this study
Motutapu Island	R10/38	Late?	73	25	48		Ward 1974, new data
Ponui Island	R11/20	Early	488	340	148		this study

Table 2 *continued.*

Location	Site no.	Period	N	Mayor	Grey	Pungaere	Reference
Coromandel Peninsula							
Port Jackson	S09/53	Early	179	26	153		this study
Owera	T11/644	Mid-Late	106	39	67		Crosby *et al*. 1987, new data
Skippers Ridge 2	T10/226	Late	128	92	36		Bellwood 1969, new data
Whitianga	T11/914	Mid	329	4	325		this study
Hahei (2)	T11/376	Early	593	*c*.317	*c*.276		Harsant 1985
Hot Water Beach	T11/115	Early	907	313	594		Leahy 1974, new data
Tairua	T11/62	Early	49	48	1		Smart & Green 1962
Slipper Island	U12/5	Early?	269	252	17		Rowland 1975, new data
Onemana (Whitipirorua)	T12/16	Early	142	19	123		Furey 1990
Te Ananui	T12/26	Early	185	27	158		this study
Whiritoa	T12/500	Early?	601	544	57		this study
Hauraki							
Raupa	T13/13	Late	3586	3436	150		Prickett 1990, 1992
Waiwhau	T13/756	Late	591	511	80		Phillips 1988, Phillips & Green 1991
Opita	T13/788–9	Late	168	97	71		Neve *et al*. 2004
Bay Of Plenty							
Waihi Beach	T13/829	Mid	100	63	37		this study
Anatere pa (3)	U13/46	Mid	244	164	79		Phillips & Allen 1996, Moore 2005
Mt. Maunganui	U14/363	Early	322	313	9		Hooker 2009, new data
Waikite	U14/3611	Mid	110	110	0		Moore 2009
Maketu	V14/187	Early	125	122	3		Moore 2008
Kawerau*	V16/238	Mid	954	105	849		Furey 1983
Central North Island							
Tokoroa*	T16/1	Early	510	479	31		Law 1972
Whakamoenga	U18/4	Early-Late	980		980		Leahy 1976, Moore 2011b
West Coast							
Waikorea	R14/256	Early	475	454	17		Ritchie *et al*. 2009, Moore 2011a
Taharoa	R16/10	?	590	377	213		this study
Tirua Point	R17/66	Early?	170	100	70		Moore 2011a

\# Informal names
* Assemblages not available for re-examination
(1) Proportions are weight %, based on visual ID of pieces from selected excavation squares. Numerical data not available.
(2) Estimated figures based on EDXRF analysis of 397 flakes (see also Seelenfreund & Bollong 1989).
(3) Only percentages are given in Phillips & Allen (1996). My re-assessment of their original source allocations indicates at least 74 flakes were from Waihi and 5 from other 'grey' sources.

Owera, on Coromandel Peninsula (L. Furey pers comm.). In some previous studies sources have been confirmed by use of conventional wavelength-dispersive XRF (e.g. Moore 2004a) and PIXE (Neve *et al*. 1994). These analyses were used to support the source identifications made on the basis of visual attributes.

Results

Numerical data on the proportions of Mayor Island, Pungaere and 'grey' obsidian from individual sites, and some site clusters, are presented in Table 2, and specific sources for the 'grey' obsidian from selected sites are indicated in Table 3. The locations of sites listed in these tables are shown on Figure 2. Although weight may provide a more reliable measure of quantities, determination of proportions by both number and weight has generally revealed minimal difference between them (e.g. Moore 2011a).

It is evident that the majority of assemblages are composed of both Mayor Island and 'grey' obsidian, and that very few consist of material from just a single source. Pungaere obsidian is restricted to the more northern sites. Available analyses of the 'grey' obsidian suggest the bulk of it was procured from only three main sources, Te Ahumata, Hahei and Taupo (Table 3), with that from Hahei being particularly widely dispersed.

CULTURAL DISTRIBUTION

There have been few attempts to establish the cultural

Table 3.. *Sources of 'grey' obsidian for selected sites and site clusters.*

Site/Source*	HU	TM	CB	HA	WM	WI	TP	Method#	Reference
Waikuku Beach	×		×	×				EDXRF (5)	unpubl. data
Aupouri North				×				EDXRF (2)	Moore & Coster (in prep)
Aupouri South	×	×		×				EDXRF (21)	Moore & Coster (in prep)
Urquharts Bay	×	×		×				EDXRF (6)	Phillips 2010
Port Jackson		?	×	×				V	pers obs.
Owera		×	×	×				EDXRF (106)	L. Furey (unpubl. data)
Ponui Island		×		?		×		V	pers obs.
Westfield		×						XRF (7)	Ruddock 1988
R11/859	×	×		×	×	×		EDXRF (108)	Cruickshank 2011
Maioro		×		×				EDXRF (8)	Moore 2011a
Waikorea				×			×	XRF (3)	Ritchie *et al*. 2009
Tirua Point							×	EDXRF (3)	Moore 2011a
Opita			×		×	×		PIXE (76)	Neve *et al*. 1984
Mt. Maunganui		×		×			×	EDXRF (3)	Hooker 2009
Kohika[1]							×	XRF (10)	Moore 2004a

* Source codes: HU = Huruiki, TM = Te Ahumata, CB = Cooks Beach, HA = Hahei, WM = Whangamata, WI = Waihi, TP = Taupo
# V = visual ID, PIXE = proton induced X-ray emission. Number of analyses in brackets.
1 Maketu also identified.

distribution of obsidian from specific sources in New Zealand, apart from that found on Mayor Island which is known to have been dispersed throughout the entire country and as far afield as Chatham Island and the Kermadec Islands (Walter *et al*. 2010). In contrast, the Waihi obsidian appears to be restricted to a relatively small area (Moore 2005).

Ideally we would like to be able to define both the area where obsidian from a particular source was used in significant quantities (e.g. the 'supply zone' of Renfrew 1975), as well as the outer limits of its distribution where that source may be represented by just one or two flakes. McCoy *et al*. (2010) have recently suggested that the 'supply zone' can be divided into a *primary source supply zone*, where >50 per cent of an artefact assemblage comes from a specific source, and a *secondary source supply zone* where a single source accounts for 0–50 per cent of assemblages. While this seems quite reasonable in theory, their use of the term 'supply zone' (Renfrew 1975, Renfrew & Bahn 1991) implies that all of the obsidian found within that area, no matter how large, may have been procured by direct access. It also eliminates the 'contact zone' (Renfrew 1975), and thus any suggestion of exchange, altogether. Moreover, using an arbitrary figure of 50 per cent as the cut-off point ignores the fact that in some cases the 'primary' or local source may only constitute up to 30–40 per cent of assemblages (e.g. Waihi). Only one site has so far been identified with a proportion of Waihi obsidian greater than this (60 per cent, Moore 2005).

For these reasons the term 'supply zone' (of McCoy *et al*. 2010) is here replaced with 'distribution area'. This can be divided into a *primary distribution area* (PDA), where a significant proportion (>30–50 per cent) of an assemblage is from a specific source, and a *secondary distribution area* (SDA) where that source contributes from <1 per cent up to 30–50 per cent of an assemblage. These are partially equivalent to but do not replace the 'supply' and 'contact' zones of Renfrew (1975), which may be identifiable in cases where there are sufficient data. What is important is to retain some flexibility, and to distinguish distribution areas or zones that may have some significance in terms of the procurement and dispersal of material. Though much of the obsidian within PDAs *might* have been obtained by direct access to the source, it is likely that a proportion would be procured through some form of exchange. Conversely, SDAs will almost certainly include some obsidian that was obtained directly.

The approximate cultural distribution areas for some of the more significant sources are shown in Figures 3 and 4. These are based primarily on the data in Table 2, with information on the sources of 'grey' obsidian from visual identifications backed up by limited chemical analyses (Table 3). Some additional data are included from other sites. The limits of these areas are somewhat tentative, and take no account of differences in the age of sites and temporal changes in distributions. At this stage PDA's can be realistically determined for only about six of the sources, excluding Mayor Island.

Pungaere (Figure 3A)

The Pungaere obsidian is quite distinctive and readily identified among artefact collections on the basis of visual characteristics alone (Moore 1988, Furey 2002). It also has a unique chemistry (Moore in press b). Consequently its cultural distribution can be established with a consider-

able degree of confidence. The obsidian has been identified from many sites in the Far North, where it constitutes up to 80–90 per cent of some assemblages. At two late sites (Mawe pa, Motutoa) within 50 km of the source it forms 90–100 per cent of the total. In southern Northland, south of Whangarei, its distribution appears to be more restricted, and although Pungaere obsidian has been recorded from at least five different sites at Pouto, none was positively identified in collections from eight sites on the Okahukura Peninsula, a short distance to the east. It is not represented in a small collection from Urquharts Bay at Whangarei Heads (Phillips 2010).

Present information indicates the Pungaere obsidian is virtually confined to Northland, and may not have been utilised much south of the Kaipara Harbour (Pouto). So far it has been tentatively identified at only one site in the Auckland area, R11/859 (Cruickshank 2011). The outer limit of its cultural distribution is probably >140 km from source (cf. McCoy *et al.* 2010).

Huruiki (Figure 3B)

The obsidian from this source is quite similar in terms of its visual characteristics and composition to Cooks Beach-Hahei material, making it difficult to establish its distribution with any certainty. Nevertheless it has been positively identified (by EDXRF) from Urquharts Bay (Phillips 2010), the Bay of Islands (McCoy *et al.* 2010), North Cape, at sev-

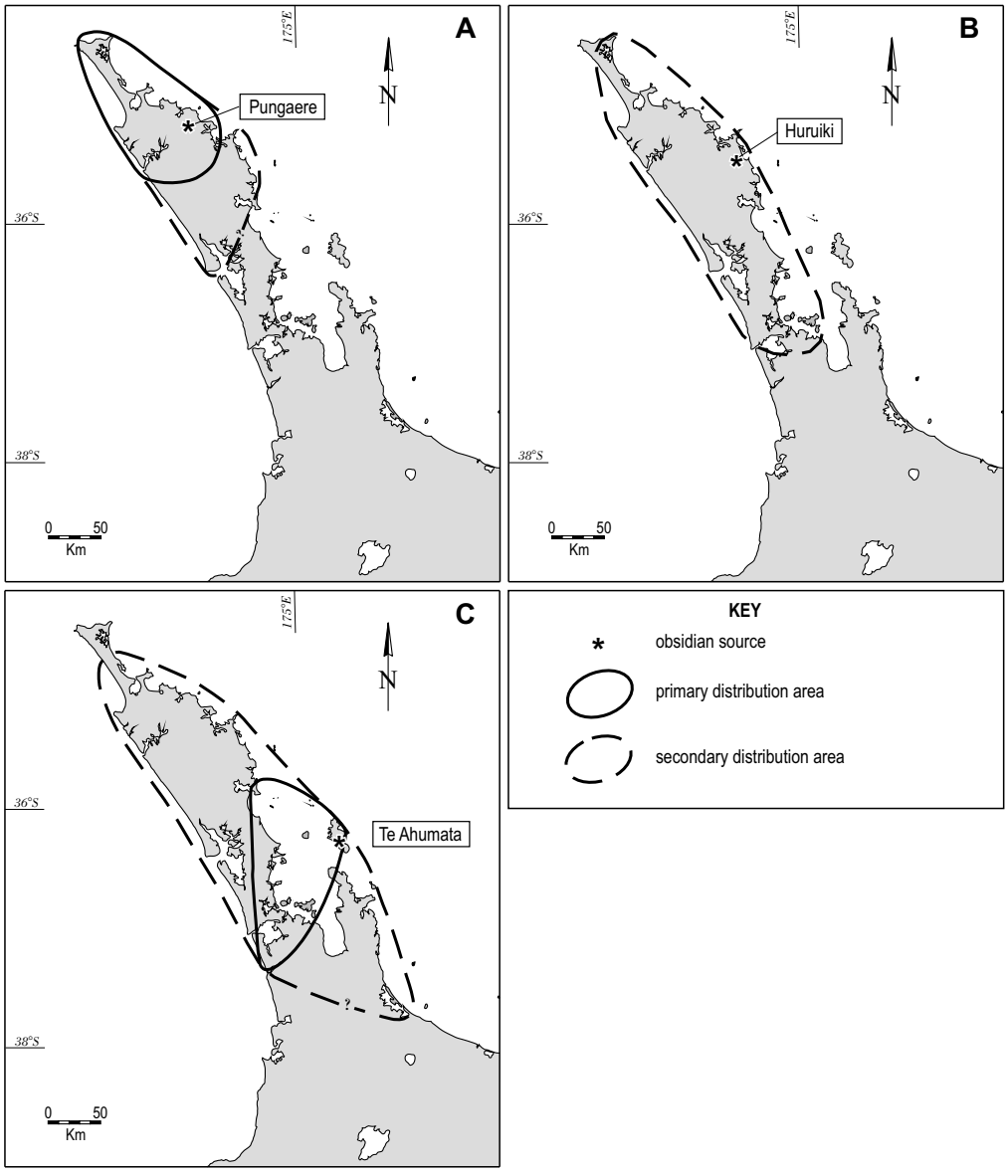

Figure 3. Cultural distributions for obsidian from the Pungaere (A), Huruiki (B) and Te Ahumata (C) sources. Primary distribution areas (PDAs) indicate high relative abundances (>30–50%) of obsidian from a particular source.

eral sites on the Aupouri Peninsula (Moore & Coster in prep), and at one site in Auckland (R11/859, Cruickshank 2011). Huruiki obsidian has also been tentatively identified from sites at Mitimiti, Pouto and Port Jackson (pers obs), as well as on Motutapu Island (Ward 1974). Thus its distribution area probably extends at least as far south as Auckland – a straight line distance of about 180 km from source.

Te Ahumata (Figure 3C)

Great Barrier Island (Te Ahumata) has long been recognised as an important source of obsidian for sites in the Auckland area (e.g. Ward 1974, Furey 1986), where it constitutes 70–80 per cent of some assemblages. At Taylor's Hill for example it forms an estimated 85 per cent of the obsidian collected, and approximately 70 per cent at Mt Roskill. On the west coast at Maioro it made up about 40 per cent of the total, but so far it has not been recorded from any sites further south (Moore 2011a). The Te Ahumata obsidian is also locally common in southern Northland, forming 45 per cent of the assemblage from Urquharts Bay (Phillips 2010). Elsewhere, small quantities have been identified, on the basis of visual characteristics and EDXRF analyses, at several sites on Aupouri Peninsula (Moore & Coster in prep), and at Mt Maunganui in the Bay of Plenty (Hooker 2009).

Cooks Beach-Hahei (Figure 4A)

These sources are located only one to two kilometres from one another, and likely to have been regarded as part of the same resource area in prehistoric times. The visual characteristics of the obsidian are fairly similar, and although the two sources can be distinguished geochemically it seems more appropriate to combine them, at least in considering broad distributions.

Obsidian from Cooks Beach and Hahei was used extensively at sites in the local area. At the Whitianga site T11/914 almost all of the artefacts are likely to originate from one or both of these sources, and at Owera EDXRF analyses indicate that about 60 per cent of the pieces are from Cooks Beach and Hahei. The obsidian also has a wide distribution, with small quantities being recorded from North Cape, Aupouri Peninsula, the Bay of Islands (McCoy *et al*. 2010), and Urquharts Bay in Northland; at several sites in Auckland (e.g. R11/859); on the west coast at least as far south as Tirua Point (Moore 2011a), and in the western Bay of Plenty (unpubl. data).

Taupo (Figure 4B)

This is undoubtedly the dominant source within the Taupo Volcanic Zone (Moore in prep). The obsidian is of very high quality and was used almost exclusively at nearby sites (Moore 2011b). It was also widely distributed along the west coast where it forms up to 50 per cent of some assemblages (e.g. Tirua Point), though there is a marked decline in the proportion of Taupo obsidian northwards (Moore 2011a) and only a few pieces have been recorded at sites in the Auckland area (e.g. Matatuahu, pers obs). In the Bay of Plenty small quantities have been identified at Mt. Maunganui (Hooker 2009) and Kohika (Moore 2004a). At the inland Tokoroa site it probably constituted less than six per cent of the total (Law 1973).

Other sources

Available data indicate that obsidian from Fanal Island was quite widely dispersed. A few pieces have been positively identified (by visual examination and EDXRF) from sites on the Aupouri Peninsula, Poor Knights Islands, Chicken Islands, and less certainly from two sites in Auckland, Matatuahu (pers obs) and R11/859 (Cruickshank 2011). It has also been suggested, based on early EDXRF analysis, that almost 10 per cent of the obsidian from the Hahei site T11/376 originated from Fanal (Harsant 1985), but this is extremely unlikely. The PDA for this source may be restricted to the Mokohinau Island group.

Although the Whangamata obsidian is known to have been used extensively at sites in the local area (Moore 1999), at present there is very limited information on its overall distribution. It has been recorded from the Opita site near Paeroa (Neve *et al*. 1994), at several locations in the western Bay of Plenty (unpubl. data), and from at least one site in the Auckland area (R11/859, Cruickshank 2011). Unfortunately EDXRF analyses have not necessarily provided a close match with the source, and until this problem is resolved it will be difficult to establish the full extent of the distribution area.

Previous research indicated the Waihi obsidian has a very restricted distribution area of perhaps <30 km radius (Moore 2005), which is largely confirmed by subsequent work. However recent analyses of assemblages from Auckland have revealed the presence of a few flakes of Waihi material in collections from Ponui Island (pers obs) and possibly R11/859 (Cruickshank 2011). Thus the outer limit of its distribution is more likely to be around 100 km (cf. McCoy *et al*. 2010).

Currently there is no evidence that sources in the central North Island were exploited to any extent, apart from Taupo (Moore 2011b). Use of Maketu obsidian has so far been recorded at only one site, the swamp pa of Kohika, about 35 km from the source (Moore 2004a). Recent EDXRF analysis of artefacts from Maungarei in Auckland indicated that six of the 121 flakes analysed originated from 'Rotorua' (Davidson 2011), but considering the limited availability and relatively poor quality of the obsidian at the presumed source (a modern quarry), this must be regarded as doubtful. As yet no artefacts have been attributed to the Rotokawau source near Rotorua, or with any certainty to sources in the Whakamaru area (Maraetai, Ongaroto).

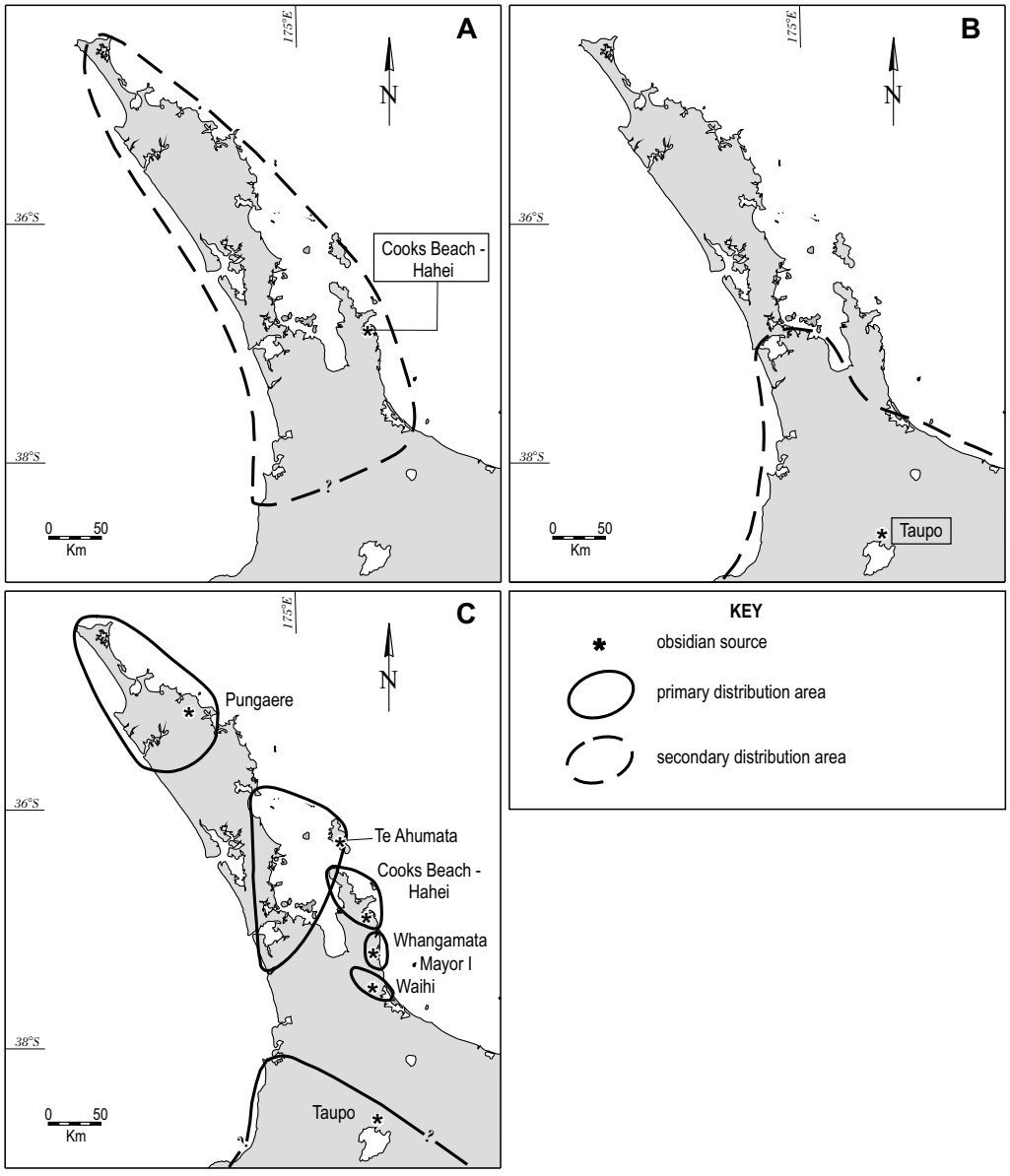

Figure 4. Cultural distributions for obsidian from the Cooks Beach-Hahei (A) and Taupo (B) sources, and primary distribution areas (PDAs) for the six main sources (C).

Figure 4C shows the PDA's for some of the more significant sources (excluding Mayor Island). Interestingly, there is virtually no overlap between these areas, even using a relative proportion of only 30 per cent as their outer limit. This map also illustrates the very clear separation of the PDAs for the three main sources – Pungaere in the Far North, Te Ahumata in the Auckland-Hauraki region, and Taupo in the central North Island, although there is some overlap in their total distributions.

SIZE OF DISTRIBUTION AREAS

McCoy *et al.* (2010:174) have suggested that 'mainland obsidian supply zones were likely small, perhaps within 30–50 km of a source', a view based upon the known distribution of Waihi obsidian (about 30 km, Moore 2005), and predicted limits of 52 km and 36 km for the 'Kaeo' (Pungaere) and Huruiki sources respectively. This is partly contradicted, however, by the fact that four (10 per cent) of the flakes analysed by them from the Bay of Islands were attributed to the Cooks Beach and Hahei sources on Coromandel Peninsula, some 230 km to the south.

The approximate sizes of distribution areas established in the present study are indicated in Table 4. It must be stressed that these are minimum figures, which in many cases are likely to increase (possibly substantially) as more data become available. In order to test the McCoy *et al.* (2010) model in relation to the Pungaere/Kaeo obsidian

Table 4. *Approximate limits of primary and secondary distribution for some mainland (M) and island sources.*

Source	Limit of primary distribution	Limit of total distribution
Pungaere (M)	120 km	>135 km
Huruiki (M)	?	160–180 km
Fanal Island	<7 km?	240 km
Te Ahumata	100 km	270 km
Cooks Beach-Hahei (M)	c.60 km	370 km
Whangamata (M)	<20 km?	>100 km?
Waihi (M)	<20 km	100 km?
Mayor Island	>400 km?	2000 km[1]
Taupo (M)	>100 km?	>200 km?

1 Figure from Walter *et al*. (2010)

specifically I have plotted relative abundance versus the straight-line distance from source (Figure 5). This clearly shows there are many sites within about 120 km of the source containing >50 per cent Pungaere obsidian. Thus the 'primary source supply zone' (= PDA) is about five times the size predicted by McCoy *et al*. (26 km). However this figure is somewhat misleading because the distribution is distinctly asymmetric, and in fact the limits of the PDA vary from around 30 km to 120 km (Figure 3A).

The small size of PDAs for the Coromandel sources of Cooks Beach-Hahei (combined), Whangamata, and Waihi is not readily explained, though it could reflect their proximity to one another and/or to the more dominant sources of Mayor Island and Te Ahumata. The higher quality, quantity and availability of obsidian from these two sources may have restricted *extensive* use of Coromandel material essentially to the local area.

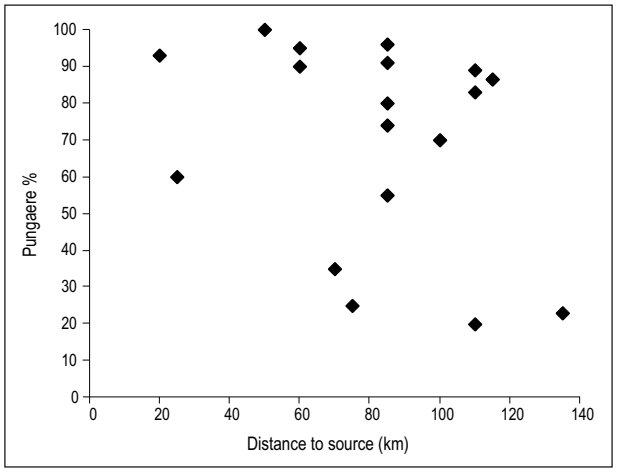

Figure 5. Proportion of Pungaere obsidian versus distance from source. Data mainly from Table 2 and Moore & Coster (in prep).

In the case of Mayor Island obsidian Walter *et al*. (2010) have suggested that the 'supply zone' (as defined by Renfrew) had a radius of about 500 km, a distance which encompasses the entire North Island. This is beyond the limit of the present study (450 km), but it is pertinent to consider if 500 km is a reasonable figure, and whether the distribution of Mayor Island obsidian within the northern North Island displays the characteristics of a typical 'supply zone' (see later).

TEMPORAL CHANGES

The relative proportions of Mayor Island, Pungaere and 'grey' obsidian for various sites (and some site clusters) are illustrated in Figure 6, based on the data in Table 2. Sites are arranged according to their known or probable age, and within each period they are ordered roughly from north to south and decreasing distance from Mayor Island. For convenience I have elected to divide the prehistoric era into three parts. The early or Archaic Period is generally regarded as spanning the late 13th to 15th centuries (Walter *et al*. 2010), while that from about 1500 AD up to European contact (1769) has often been referred to as the Classic Maori Period (Davidson 1984). Walter *et al*. (2010) refer to it as the late period, while others have informally divided it into middle and late (e.g. Seelenfreund & Bollong 1989). I suggest the middle period extends from about 1500 to 1700 AD, and the late period from 1700 to 1800 AD.

It is evident that many early period sites contain a relatively high percentage of Mayor Island obsidian, as established in previous studies (e.g. Green 1964), though there is considerable variation and no obvious overall decline in abundance with distance from source. In fact, for sites within about 150 km of Mayor there would appear to be an increase with distance. Those early sites with a relatively high percentage of non-Mayor Island obsidian tend to be situated close to alternative sources (e.g. Onemana, Hot Water Beach), but this is not always the case (e.g. Port Jackson).

For the middle period there is a distinct reduction in the proportion of Mayor Island obsidian, except at sites close to the source (e.g. Waikite), and 'grey' obsidian from various sources generally predominates. In Northland the Pungaere obsidian was widely utilised. Although there are only minimal data for late sites, it is sufficient to show that those situated relatively close to Mayor Island continued to depend mainly on this source, whereas in Northland access to Mayor Island obsidian appears to have become more restricted, resulting in greater reliance on the Pungaere source.

Changes in the use of Mayor Island obsidian are also illustrated in Figure 7, in which relative abundances are plotted against the straight line distance from source for the three main periods. Unfortunately there are limited data between 150 km and 350 km due to an apparent scarcity of early sites along the east coast between Auckland

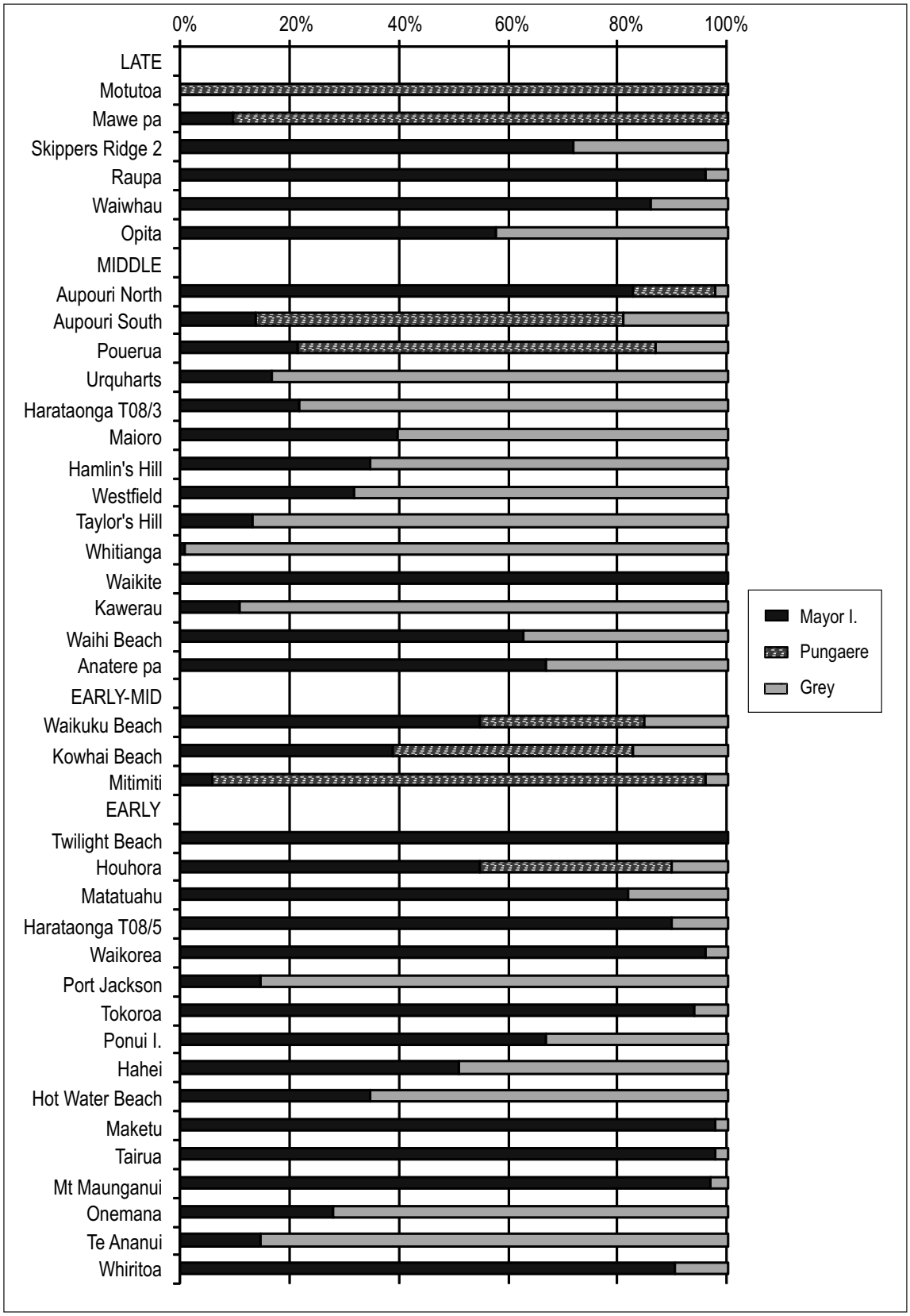

Figure 6. Relative proportions of Mayor Island, Pungaere and 'grey' obsidian at sites in the northern North Island, based on data from Table 2 (except for Twilight Beach). Sites are arranged according to approximate age, and broadly from north (top) to south.

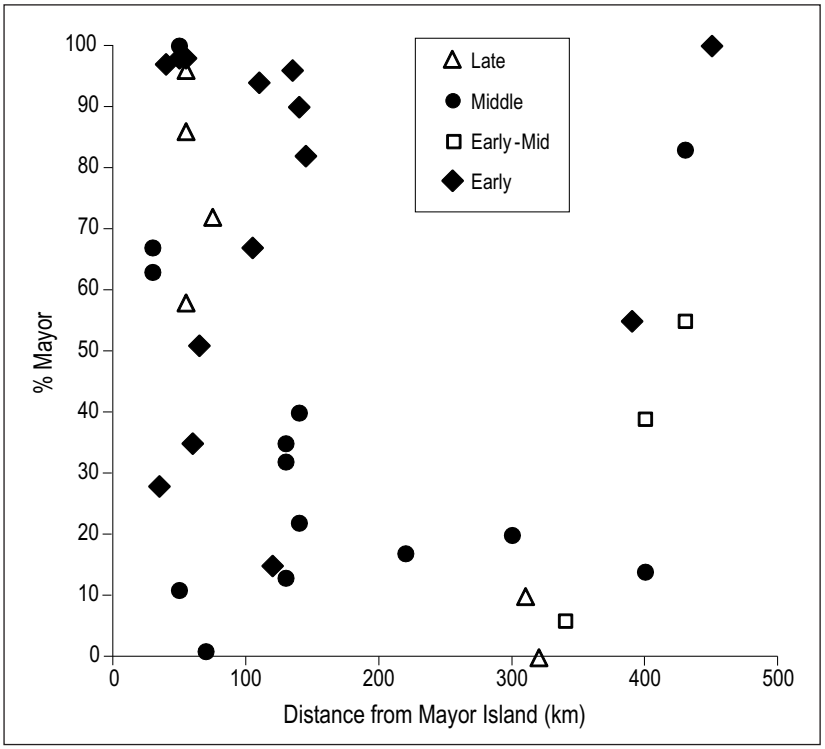

Figure 7. Proportion of Mayor Island obsidian versus distance from source, according to age of sites.

and the Far North, sometimes referred to as the 'Archaic gap' (Davidson 1982). Nevertheless, there is evidence of a general decline in the quantity of Mayor Island obsidian being utilised within 150 km of the source between the early and middle periods. The situation in the Far North, beyond 300 km from source, is unclear at present, but it does not appear to differ markedly from that for sites closer to Mayor Island, except in the late period.

PROCUREMENT: DIRECT ACCESS OR EXCHANGE?

There are two main ways in which obsidian could be obtained by the people who used it: by (1) direct access, and (2) trade/exchange, including gifting. Small quantities may also have been procured as a result of warfare and scavenging of abandoned sites. There is no obvious means of establishing with any certainty which strategy operated in any particular case, or to what degree, but it is likely that most obsidian was acquired by a combination of (1) and (2). However, for sites situated in close proximity to significant sources it seems reasonable to assume that obsidian was procured directly, and since the raw material was presumably more readily available from detrital and colluvial deposits it would be expected that such sites should be characterised by assemblages containing a high proportion of artefacts with remnant cortex.

There has been no overall study of cortex on obsidian artefacts in New Zealand. Information on this aspect has not always been recorded in the analysis of assemblages, but sufficient data are available from the published literature, unpublished reports, and recent studies by the author to provide some indication of cortex percentages for non-Mayor Island obsidian (Table 5, Figure 8). It is evident from these data that some sites within a few kilometres of a source do contain obsidian assemblages with a high proportion of cortex, in the order of 50–60 per cent, and in certain cases up to 90 per cent (e.g. Furey 1991). [The low figures for Whakamoenga Cave (average 18 per cent) and Waihora (28 per cent) at Lake Taupo are probably due to the fact that detrital or other material with cortex constitutes only a small part of the Taupo source (Moore 2011b)]. High proportions of cortex for obsidian at distant sites (e.g. Taylor's Hill) may, therefore, be indicative of direct access to the source.

Direct procurement may also be indicated by the presence of pieces of relatively poor quality obsidian from distant sources. For example, obsidian from Fanal Island has been found in small quantities at a number of sites in the northern North Island (as documented earlier) which are situated closer to much better quality material. It seems unlikely that the Fanal obsidian would be traded or gifted, and it may have been obtained while visiting the island for another purpose (e.g. mutton-birding), or during a brief stop-over at the Mokohinau Islands in transit from say Coromandel to Northland.

A possible example of direct procurement is illustrated by the small assemblage (N = 72) from a midden site at Urquharts Bay, Whangarei Heads (Phillips 2010). This is

Table 5. *Proportion of obsidian assemblages (flakes, cores and pieces) with cortex at selected sites.*

Location	Site no. #	N	Source	Cortex %	Reference
Tom Bowling Bay	AR5340	45	Pungaere	40	pers obs
Whareana Beach	N02/57	62	Pungaere	24	pers obs
Aupouri North	N02/821	107	Pungaere	15	Moore & Coster in prep
Aupouri	N03/508	73	Pungaere	23	Moore & Coster in prep
Aupouri South	N03/519	162	Pungaere	15	Moore & Coster in prep
Aupouri South	N03/323	261	Pungaere	24	Moore & Coster in prep
Aupouri South	N03/450	238	Pungaere	20	Moore & Coster in prep
Aupouri South	N03/451	200	Pungaere	37	Moore & Coster in prep
Aupouri South	N03/455	150	Pungaere	15	Moore & Coster in prep
Motutoa	O06/307–8	102	Pungaere	25	Frederickson 1990
Mawe pa	P05/191	81	Pungaere	46	pers obs
Mitimiti	AR5327	111	Pungaere	36	pers obs
Mitimiti	AR5313	84	Pungaere	50	pers obs
Urquharts Bay	Q07/571	33	Te Ahumata	50	pers obs
Mt Roskill	R11/19	44	Te Ahumata	34	pers obs
Elletts Mt	R11/31	79	Te Ahumata	16	pers obs
Westfield	R11/898	101	Te Ahumata	33	pers obs
Hamlins Hill	R11/142	33	Te Ahumata	27	pers obs
Taylor's Hill	R11/96	83	Te Ahumata *	64	pers obs
Whangaparapara 1	S09/18	261	Te Ahumata	51	pers obs
Whitianga	T11/914	325	Cooks/Hahei	41	pers obs
Onemana 2	T12/16	123	Whangamata *	58	pers obs
Te Ananui	T12/26	158	Whangamata *	56	pers obs
Whiritoa	T12/500	57	Whangamata *	42	pers obs
Kohika	V15/80	43	Maketu	81	Moore 2004a
Kohika	V15/80	42	Taupo	25	Moore 2004a
Whakamoenga	U18/4	980	Taupo	18	Leahy 1976
Waihora	T18/22	321	Taupo	28	Moore 2011b

Auckland Museum catalogue (AR) numbers are given where site numbers are unknown.

* May include a few flakes from other 'grey' sources.

1 Atwell (1973: 165) reported an extraordinarily high figure of 89% (274 of 307 pieces) for this site. My re-examination of the assemblage indicates an average value of 51% (range 36–70% at different levels), excluding very small flakes and chips. Even if most of these had some cortex, the overall proportion is unlikely to exceed 60%.

2 Furey (1991: 21) reported a figure of 90% for grey obsidian (N = 66?) from part of this site, which may reflect the discard of waste material.

dominated by 'grey' obsidian (83 per cent) from two main sources – Te Ahumata on Great Barrier Island, and Huruiki. The Huruiki source is situated only 50 km along the coast to the north, while the straight line distance to Te Ahumata is about 100 km. It is notable therefore that of the artefacts attributed to Te Ahumata approximately 50 per cent have remnants of cortex, in contrast to roughly 20 per cent of those from Huruiki. This may be indicative of easier (direct) access to the obsidian on Great Barrier than Huruiki, despite the greater distance involved.

The use of relative proportions, as in the distribution model of Renfrew and colleagues (e.g. Renfrew 1975, Renfrew & Bahn 1991), is a well-established means of assessing whether obsidian may have been obtained by direct access or through some form of exchange. In this model the proximal 'supply zones' are characterised by high proportions of obsidian (typically >80 per cent) from a particular source and show only a gradual decline in value with increasing distance, whereas more distal 'contact zones' are characterised by a distinct fall-off trend. The former situation is clearly illustrated in Figure 5, which shows only a slight decline in the higher proportions (>80 per cent) of Pungaere obsidian up to a distance of about 120 km from the source. This is also matched by a similar reduction in the percentage of cortex (Figure 8). Hence significant quantities of Pungaere obsidian may have been procured by direct access to the source.

Interpretation of the data for Mayor Island obsidian is complicated by the existence of the 'Archaic gap' (which may also extend to the middle period), but there is some indication of a change in the means of procurement (Figure 7). The trend for the early (Archaic) period is somewhat similar to that shown by the Pungaere obsidian, with a number of sites containing proportions of >80 per cent,

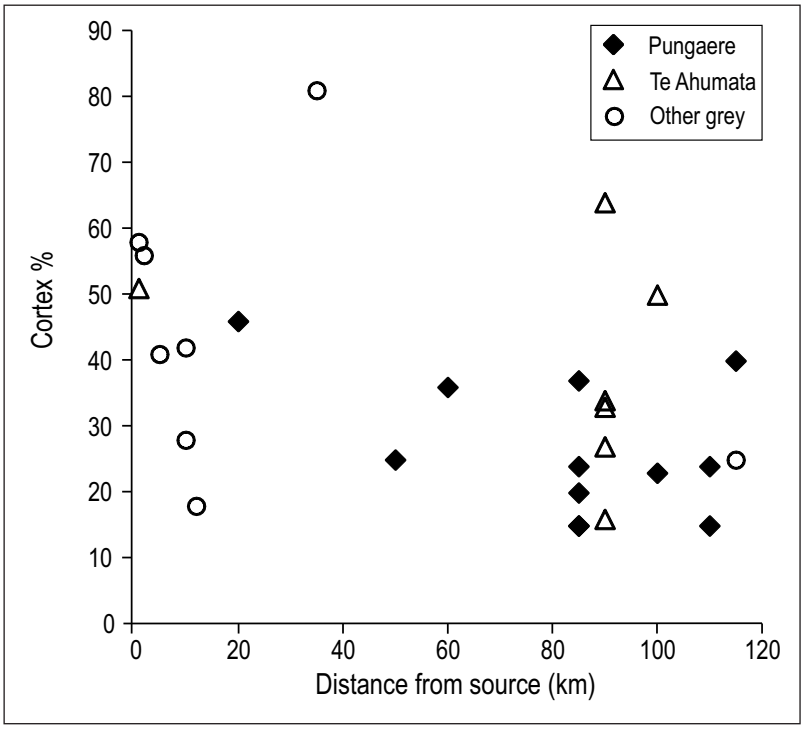

Figure 8. Proportion of artefacts with cortex in analysed assemblages. See Table 5 for details.

suggesting that much of the obsidian within about 150 km of the source could have been obtained by direct access. In the Far North, analysis of the artefact assemblage from Twilight Beach indicated that all of the obsidian was probably from Mayor Island (Taylor 1984). If so, it could be argued that this site constitutes part of the 'supply zone', which would therefore extend >400 km, in reasonably good agreement with Walter *et al.* (2010).

In contrast, data for the middle and late periods show an exponential fall-off in abundance, at least up to 350 km from source, which is more indicative of down-the-line exchange (Renfrew 1975). Further north, the high proportion of Mayor Island obsidian at Aupouri North (Figure 6) might be attributable to the existence of a redistribution centre in that area in the 16th century. During the middle and late periods there are signs of a significant contraction in the supply zone, and in the late period in particular direct access to the source may have become even more restricted.

Overall, the evidence seems to suggest that a significant proportion of the obsidian found in northern New Zealand sites was procured by direct access to the sources, at least during the early period and within certain areas (e.g. Coromandel Peninsula). Yet there is also an indication that exchange networks existed at a local level (e.g. Waikato coast, Moore 2011a), and possibly involved a greater number of sources during the middle period of prehistory.

DISCUSSION

It is evident from this study that the identification of exchange networks for obsidian, at least in the northern North Island, is likely to prove far more difficult than envisioned by Green (1962, 1964). Perhaps this could have been predicted, since the relative abundance of the raw material and accessibility of sources meant there was probably little necessity for exchange of obsidian within this region. Indeed, a review of the ethnographic literature by Seelenfreund-Hirsch (1985) indicated that although gift exchange of various goods was widely practiced in the prehistoric and proto-historic periods it apparently did not involve obsidian. However obsidian may have been considered such an every-day material that it did not require special mention.

Archaeologists have placed considerable emphasis on the importance of Mayor Island obsidian in New Zealand prehistory (Davidson 1984, Sheppard 2004, Walter *et al.* 2010), but it may not have been so highly regarded by pre-European Maori in the northern North Island as in other parts of the country. Walter *et al.* (2010) have suggested there was a major contraction of the Mayor Island distribution network prior to 1500 AD, but that access to the obsidian remained relatively stable within 500 km of the source over the entire prehistoric period. This is not the impression gained from the data presented in this study, which shows that although Mayor Island obsidian continued to be widely exploited there was a significant decline

in its use after about 1500 AD, even at sites <150 km from the source, with increasing reliance on alternative sources during the middle and late periods. This may reflect the development of more complex distribution networks.

Further research is clearly required in regard to defining distribution areas and documenting changes in those over time. We also have little idea at present how they may relate to tribal territories or political boundaries in the past, and whether the extent of primary distribution areas reflects some form of control over the resource. Such questions might only be answered by more detailed analyses of artefact assemblages within and close to the limits of these areas, involving a wider range of lithic materials.

Acknowledgements

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