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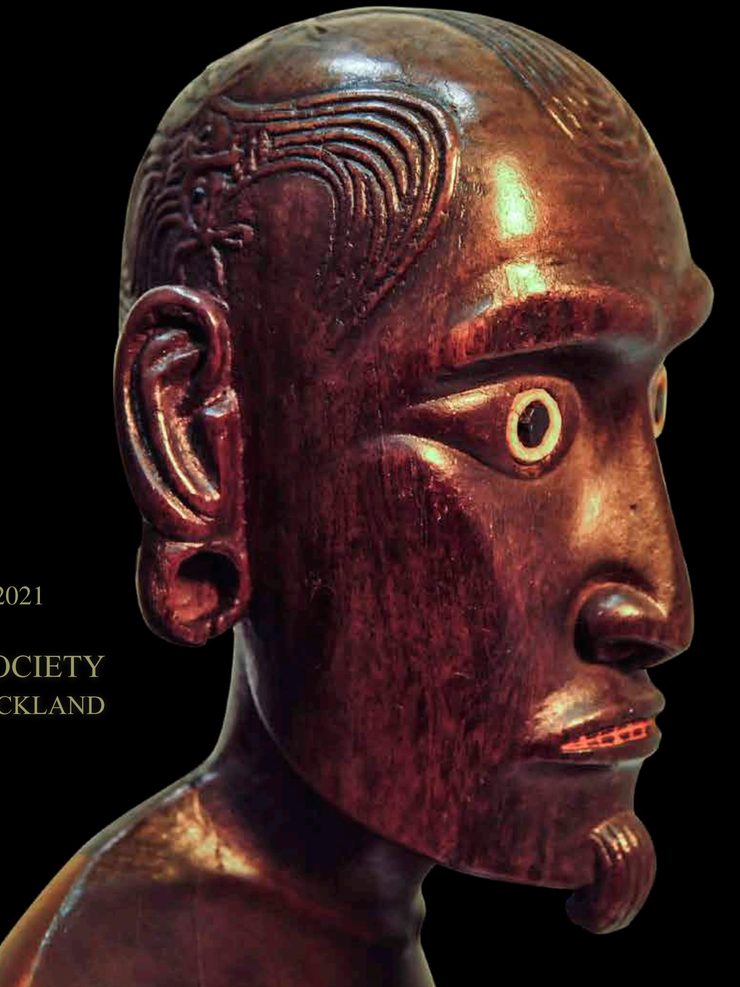

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REGIONAL VARIATIONS AND TEMPORAL CHANGES IN THE PREHISTORIC USE OF OBSIDIAN AND CHERT IN THE NORTH ISLAND OF NEW ZEALAND

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ABSTRACT: Analysis of existing quantitative data on chert and obsidian artefact assemblages from 46 archaeological sites in the North Island of New Zealand/ Aotearoa shows there was a significant overall decline in the use of chert during the Early (Archaic) cultural period, between about AD 1250 and AD 1500. This was accompanied by a similar reduction in high-quality Mayor Island obsidian in most regions, but a corresponding increase in the procurement of obsidian from other sources. Such changes can be largely attributed to the development of regionally based exchange networks. There is evidence of further change in the use of obsidian and chert more or less coinciding with the construction of defensive pā 'fortified sites' and inferred outbreak of warfare about the end of the Early period ca. AD 1500, although this affected some regions more than others. In Northland and the southern North Island high proportions of chert used at some pā and undefended villages (kainga) were mainly associated with houses. In other regions, use of chert remained at low levels throughout the Late (Classic Māori) period, up until European contact in the late eighteenth century. The data support a gradual and non-synchronous transition from Archaic to Classic Māori culture in the North Island, with greater response to change in some regions than others.

Keywords: obsidian, chert, regional variations, temporal changes, North Island, New Zealand

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The significant cultural change in New Zealand prehistory from an Early or Archaic phase (with distinct East Polynesian affinities) to a Late or Classic Māori phase (Golson 1959) resulted in major differences in adze styles and technology, fish hook design, ornamentation and adaptations to new lithic materials. The changes in material culture relating to these two phases or periods have been well documented (e.g., Davidson 1984; Duff 1956), but it remains uncertain whether the transition from Archaic to Classic culture occurred in a gradual and non-synchronous fashion (Davidson 1984) or was relatively abrupt and triggered by a major event such as the outbreak of warfare (Schmidt 1996) or destruction of coastal settlements by large tsunami (McFadgen 2007). This transition is generally considered to have occurred around AD 1500 (Walter *et al.* 2010; cf. Anderson 2016).

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Obsidian and chert are typically the most common lithic materials found in pre-European North Island archaeological sites. Although both were widely employed for cutting and scraping purposes, chert was also used for drill points, and in some cases for adzes/chisels, particularly during the Early period. Only limited study has so far been undertaken into the use of chert in New Zealand (e.g., Brassey 1985; H. Leach 1979; Phillipps *et al*. 2016). By comparison, there has been considerable research on obsidian artefact assemblages, aimed mainly at identification of their geological sources and the nature and extent of exchange networks, and primarily focused on Mayor Island obsidian (see review by Sheppard 2004). In recent years, much of this work has relied upon analysis of the obsidian by portable XRF (e.g., Ladefoged *et al*. 2019; McAlister 2019; Sheppard *et al.* 2011).

This paper demonstrates that there were some significant regional differences and temporal changes in the use of both obsidian and chert during the prehistoric period, and considers possible causes for them. The study is largely based upon data obtained from published and unpublished reports on excavations conducted at various sites in the North Island since the 1960s (Fig. 1). Although these excavations have provided important stratigraphic information, as well as details on the context and spatial distribution of artefacts, many sites remain poorly dated. Consequently, some information has also been included from surface collections in order to increase the dataset. The northern half of the island contains all of the known geological sources of obsidian in New Zealand (McAlister 2019; Moore 2012a; Sheppard 2004), along with numerous deposits of chert (Moore 1977).

In the southern half of the North Island there have been few fully reported excavations, apart from those undertaken at Palliser Bay in the 1970s (Leach and Leach 1979). These southern sites are remote from any obsidian sources but situated relatively close to occurrences of chert in eastern parts of the region (Moore 1977). No relevant information is available for sites in the central and southwestern North Island.

RELIABILITY OF DATA

Data on the amounts of obsidian and chert recovered from 46 selected North Island sites are presented in Table 1. Sites are arranged according to type, and within these categories, broadly from north to south, by region. A number of other sites, particularly middens, were excluded because they contained insufficient artefacts or obsidian only, or lacked radiocarbon dates. Relative proportions of obsidian (O) and chert (C) are conveniently expressed by the O/C ratio.

There are several potential sources of error in the dataset. Firstly, it is not always certain what the original analyst has identified as chert: in some cases it has been included in the lump term "siliceous material" (e.g., Leahy

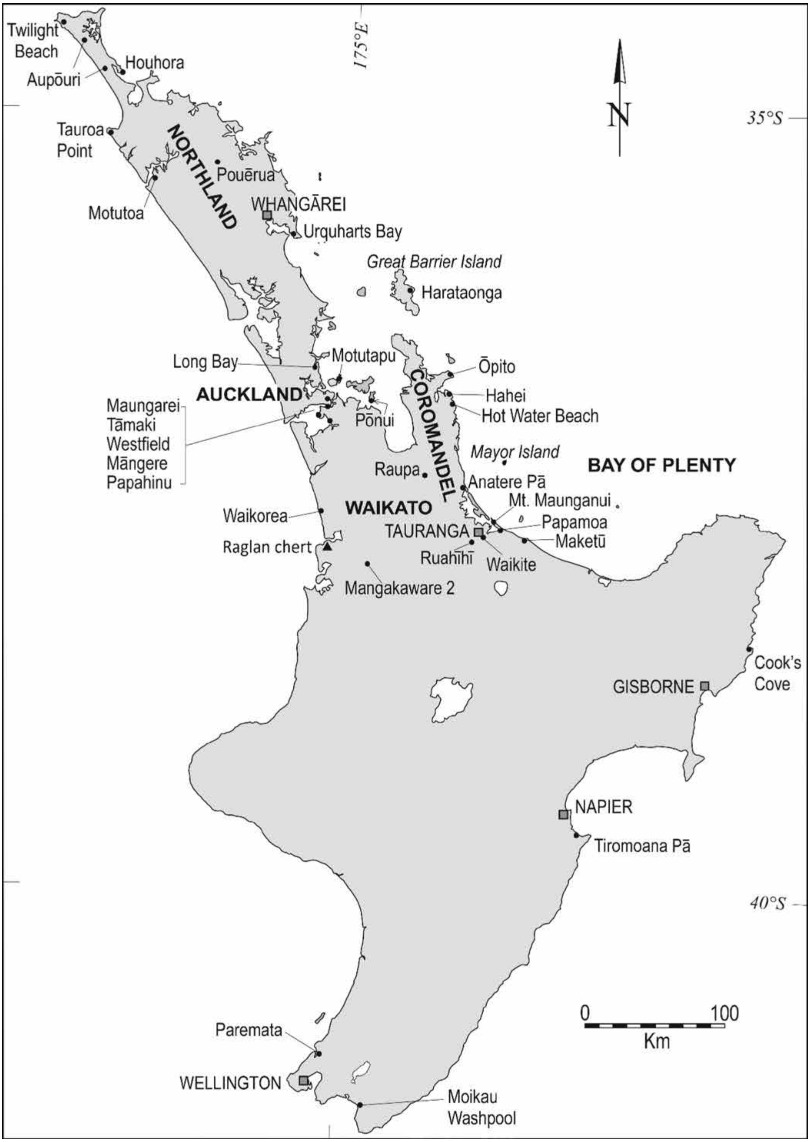

Figure 1. Map of the North Island, New Zealand, showing the location of archaeological sites with analysed obsidian and chert assemblages.

Table 1. Quantitative data on obsidian and chert, and Mayor Island obsidian, for 46 sites in the North Island (see Fig. 1). Sites arranged according to type, and approximately from north to south.

* Site numbers are those of the NZ Archaeological Association site recording scheme, www.archsite.org.nz
† Regions indicated by abbreviations: NLD = Northland, AUK = Auckland, CBP = Coromandel–Bay of Plenty, WAI = Waikato, SNI = Southern North Island.
‡ Median dates (rounded), from CALIB v8.2 (Stuiver *et al.* 2021). See Table SI-1 for date ranges.
§ Weights (g) in italics.

Site	Site no.*	Region†	Age ‡ (AD)	Obsidian § N, wt	Obsidian § %	Mayor %	Chert N, wt	Chert %	O/C	Reference
MIDDEN/WORKSHOP (n = 22)										
Twilight Beach	M02/162	NLD	1375	> 197	52%		183	48%	1.1	Taylor 1984
Aupōuri	N02/821	NLD	1570	124	86%	10%	20	14%	6.2	Coster (pers. comm.)
Aupōuri	N03/519	NLD	1620	214	90%	8%	25	10%	8.6	Coster (pers. comm.)
Aupōuri	N03/323	NLD	1490	992	98%	24%	21	2%	47	Coster (pers. comm.)
Houhora	N03/59	NLD	1340	*13,904*	57%	57%	*10,394*	43%	1.3	Furey 2002
Tauroa Point	N05/302	NLD	1300	192	21%	77%	731	79%	0.3	Allen 2006; Phillipps *et al.* 2016
Urquharts Bay	Q07/571	NLD	1610	72	83%	17%	15	17%	4.8	Phillips 2010; Moore 2012a
Long Bay	R10/1374	AUK	1490	239	94%	45%	15	6%	15.9	Campbell *et al.* 2019
NRD, Māngere	R11/859	AUK	1700	6,523	96%	31%	270	4%	24.6	Cruickshank 2011

Site	Site no.*	Region†	Age ‡ (AD)	Obsidian § N, wt	Obsidian § %	Mayor %	Chert N, wt	Chert %	O/C	Reference
Pōnui Is.	S11/20	AUK	1480	326	56%	49%	251	44%	1.3	Nicholls 1964
Harataonga	T08/5	CBP	1350	114	34%	89%	223	66%	0.5	Law 1972; Allen 2014
Ōpito	T10/161	CBP	1340	86	11%	99%	710	89%	0.1	Boileau 1980
Hahei	T11/376	CBP	1390	3,470	31%		7,809	69%	0.4	Harsant 1985
Hot Water Beach	T11/115	CBP	1520	1,183	74%	38%	426	27%	3.4	Leahy 1974
Mt. Maunganui	U14/363	CBP	1475	322	91%	97%	13	9%	25	Hooker 2009
Papamoa	U14/2912	CBP	1630	31	94%	100%	2	6%	15.5	Gumbley 2010
Maketū	V14/187	CBP	1390	125	77%	98%	38	23%	3.3	Moore 2008
Waikorea	R14/256A	WAI	1420	475	85%	96%	84	15%	5.7	Ritchie *et al.* 2009
Cooks Cove	Z17/311	SNI	1490	60	48%	100%	65	52%	0.9	Walter *et al.* 2011
Washpool	S28/47	SNI	1530	237	55%		194	45%	1.2	H. Leach 1979; K. Prickett 1979
Washpool	S28/49	SNI	1300	3,525	50%	70%	3,504	50%	1	B.F. Leach 1979; K. Prickett 1979
Paremata	R26/122	SNI	1340, 1600	110	62.5%	92%	66	37.5%	1.7	Davidson 1978; Moore and Challis 1980

Site	Site no.*	Region†	Age ‡ (AD)	Obsidian § N, wt	Obsidian § %	Mayor %	Chert N, wt	Chert %	O/C	Reference
KAINGA/HOUSE (n = 11)										
Pouērua	P05/402	NLD	1560	*106*	1%		*10,121*	99%	0.01	Brassey 1985
Pouērua	P05/857	NLD	1490	119	8%	8%	1,409	92%	0.08	Brassey 1985; Marshall 1994
Pouērua	P05/858	NLD	1610	*365*	44%	16%	*466*	56%	0.78	Brassey 1985
Motutoa	Q06/307	NLD	1770	102	42%		142	58%	0.72	Frederickson 1990
Tāmaki	R11/887	AUK	1600	187	98%		3	2%	62.3	Foster and Sewell 1988
Tāmaki	R11/899	AUK	1600	68	96%		3	4%	23	Foster and Sewell 1988
Tāmaki	R11/1201	AUK	1640	206	99%	40%	3	2%	68.7	Foster and Sewell 1993
Westfield	R11/898	AUK	1670	626	88%	32%	68	12%	7.1	Furey 1983, 1986
Papahinu	R11/229	AUK	1700	71	97%	77%	2	3%	35.5	Foster and Sewell 1995
Moikau	S28/9	SNI	1280	133	15%	70%	789	85%	0.17	N. Prickett 1979
Washpool	S58/26	SNI	1530	1	1%		84	99%	0.01	B.F. Leach 1979

Site	Site no.*	Region†	Age ‡ (AD)	Obsidian § N, wt	Obsidian § %	Mayor %	Chert N, wt	Chert %	O/C	Reference
PĀ (n = 11)										
Pouērua pā	P05/195	NLD	1680	631	19%		2,677	81%	0.24	Sutton *et al.* 2003
Pouērua	P05/371	NLD	1740	67	24%		215	76%	0.3	Sutton 1993
Pouērua	P05/408	NLD	1540	435	19%		1,885	81%	0.23	Sutton 1993
Maungarei	R11/12	AUK	1650	189	99%	12%	2	1%	94.5	Davidson 2011
Tāmaki	R11/1506	AUK	1625	130	74%	41%	45	26%	2.9	Foster and Sewell 1993
Harataonga	T08/3	CBP	1500	168	90%	22%	18	10%	9.3	Law 1972
Raupa	T13/13	CBP	1770	3,547	74%	96%	1,219	26%	2.9	N. Prickett 1990, 1992
Anatere	U13/46	CBP	1640	243	100%	70%	0		100	Phillips and Allen 1996
Ruahīhī	U14/38	CBP	1595	> 142	> 98%	100%	2	< 1.5	71	McFadgen and Sheppard 1984
Mangakaware 2	S15/18	WAI	1660	32	97%		1	3%	32	Bellwood 1978
Tiromoana	W21/1	SNI	1490	13	5%		237	95%	0.05	Fox 1978
PIT/TERRACE (n = 2)										
Motutapu I.	R10/38	AUK	1780	132	84%	21%	25	16%	5.3	Davidson 1970b
Waikite	U14/1611	CBP	1,525	110	99%	100%	1	1%	110	Moore 2009

1974); in other reports it is differentiated from sinter, silicified tuff and jasper. Secondly, it is not necessarily clear whether the figures for chert include or exclude drill points, cores and debitage, and few reports provide information on weights of materials, which would be a more useful way of determining proportions. In addition, lack of sieving may mean that small flakes were not collected, thus introducing sample bias. The classification of sites also poses some problems. Some, and perhaps many, defensive *pā* 'fortified sites', for example, were originally undefended villages or hamlets (*kainga*) that were subsequently fortified, or later functioned as undefended settlements. Therefore the artefacts recovered from such sites may relate to both defended and undefended phases of occupation, which together could have spanned > 100 years. It also needs to be borne in mind that many of the excavated areas represent only a small proportion of the total extent of sites, in some cases < 1 percent.

Since the introduction of pXRF analysis there has been an increasing tendency to report only on the numbers of analysed obsidian artefacts rather than the total obsidian assemblage (e.g., Ladefoged *et al*. 2019; McCoy *et al*. 2014; Sheppard *et al*. 2011). In some studies only 50–60 percent of artefacts were analysed, leaving doubts over the provenance of the remainder, although Mayor Island obsidian can generally be reliably identified on the basis of visual attributes alone (Moore 2012b). Different sample size criteria for pXRF analysis have also been applied, ranging from a minimum of 3.5 mm (McCoy *et al*. 2014) to 20 mm (Ladefoged *et al*. 2019), or a weight of > 1 g (Sheppard *et al*. 2011). For some assemblages, therefore, the true percentage of obsidian could be somewhat higher, so where possible data used in this study have been taken from earlier papers or original excavation reports.

Establishing reliable ages for sites is also a problem, since many radiocarbon dates obtained prior to the 1980s were based on unidentified wood or charcoal which may have had a significant inbuilt age, and cannot necessarily be relied upon (Anderson 1991). Also, the interval of particular interest, from about AD 1450 to 1600, happens to coincide with relatively flat portions of both the terrestrial and marine calibration curves, resulting in calibrated dates with large errors. For these reasons, as well as consistency, all dates have been recalibrated using the latest calibration curves SHCal20 for terrestrial samples and global Marine20 (with regional reservoir offset Delta R of -154 ± 38 ^{14}C years, http://calib.org; Stuiver *et al*. 2021) for shell samples, following Anderson and Petchey (2020); details are provided in the Appendix.

EARLY SITES

The identification of any significant changes in the use of obsidian and chert during the prehistoric period requires a reference point, and therefore we need to first look at the data from some of the more important early sites, occupied during the first 100–200 years after initial settlement. Unfortunately, there are relatively few well-stratified early sites in the North Island that have been adequately investigated or dated and are able to provide reliable data on the proportions of obsidian and chert (Table 2, Fig. 2). The five sites considered here are all coastal middens and/or working areas dating securely to the Early period. The date of initial settlement is taken as ca. AD 1250 (Anderson 1991), and almost certainly lies between ca. AD 1230 and AD 1280 (Wilmshurst *et al*. 2011), while the division between Early and Late periods at about AD 1500 follows Walter *et al*. (2010). Some have also argued for the existence of a transitional "Middle Period" from AD 1450 to 1650 (Anderson 2016; McCoy and Ladefoged 2019).

Houhora, in the Far North, is unquestionably one of the more significant early sites in New Zealand (Fig. 1). It has yielded an outstanding assemblage of Archaic artefacts (Furey 2002), though the large collection of obsidian has been only partially analysed and there is limited information on the chert component. Five main cultural layers (2a–d, 3) are recognised, all except the upper one (2a) apparently dating to the fourteenth century. The basal Layer 3 probably dates to the early 1300s, while Layer 2b was most likely deposited around AD 1350 (see Appendix). Recalibration of the single ^{14}C date from Layer 2a (NZA2391) suggests it was formed after about AD 1640 and probably in the eighteenth century; obsidian hydration readings indicate an age closer to AD 1700.

The available data (Furey 2002, tables 4, 17) suggest that, despite a significant reduction in the proportion of chert in the intermediate layer (2c), there was minimal change in the use of obsidian or chert over the period represented by the more important Layers 2b and 3 (Table 2). The lower obsidian percentage in Layer 2a should be treated with caution. Furey (2002: 20–22) noted that this layer was difficult to distinguish from the underlying Layer 2b, and consequently some artefacts may have been wrongly assigned; also there was a certain degree of reworking from older layers. Thus Layer 2a probably contains material from two or more separate events.

Site S11/20 (formerly N43/1) on Pōnui Island, near Auckland, was originally excavated between 1956 and 1962, and three main cultural levels were recognised (Nicholls 1964). Although there are indications of a decline in use of chert at this site (Fig. 2), the upper part of the sequence was considerably disturbed and contained some intermixed European

Table 2. Data on obsidian and chert from five early sites. See also Fig. 2.

Site	Layer	Age	Obsidian		Mayor Is.		Chert		O/C
		(AD)*	N/wt	%	N	%	N/wt	%	
Houhora	2a	> 1500?	2,983 g	37		50	5,031 g	63	0.6
	2b	1345	4,919 g	47		53	5,599 g	53	0.9
	2c	n.d.	4,701 g	80		61	1,143 g	20	4.1
	3	1330	4,284 g	54		44	3,652 g	46	1.17
Pōnui Island	Level 1	n.d.	179	67	100	56	88	33	2.03
	Level 2	1480	110	52	78	71	100	48	1.1
	Level 3	1480	37	37	26	70	63	63	0.6
Cooks Cove	Layer 3	n.d.	0	0	0	0	12	100	0
	Layer 5a	1555	38	44		100	49	56	0.78
	Layer 5b	1350–1510	22	58		100	16	42	1.38
Washpool S28/49	Level 3	ca. 1540	83	36	68	82	148	64	0.56
	Level 2	1340	1,975	50	1,411	71	1,964	50	1.0
	Level 1	1270	1,467	51	1,016	69	1,392	49	1.05
Paremata	Layer 2C	1660	51	59	46	90	36	41	1.4
	Layer 3	1340	55	65	51	93	30	35	1.8

* Median dates (rounded) from CALIB 8.2 (Stuiver *et al.* 2021).

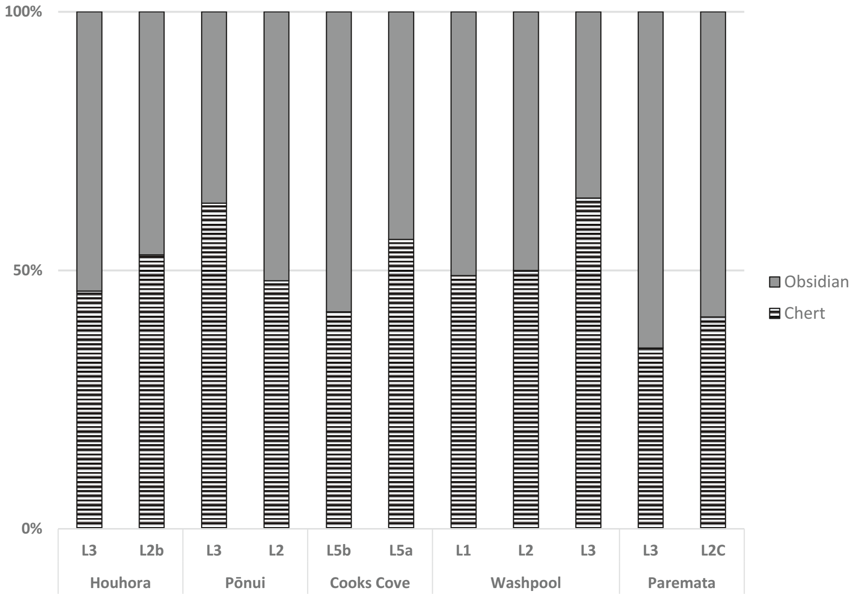

Figure 2. Proportions of obsidian and chert at early coastal sites, at different stratigraphic levels. Data from Furey (2002); Nicholls (1964); Walter *et al.* (2011); K. Prickett (1979); and Moore and Challis (1980). See Table 2 for details.

material, and therefore the data for Level 1 should probably be disregarded. Radiocarbon dates presented by Sheppard *et al*. (2011) and Irwin (2020) indicate the main cultural horizon at this site (apparently equivalent to Layers 2 and 3) was formed in the fifteenth century.

On the East Coast, the Cooks Cove site includes an early cultural layer divisible into two parts (Layers 5a, 5b) which were possibly formed 50–100 years apart (Walter *et al*. 2011). New calibrations of dates indicate the earlier Layer 5b was deposited between AD 1430 and 1580, and Layer 5a between AD 1520 and 1650 at 65% probability (Anderson and Petchey 2020). There is a suggestion of a slight increase in the proportion of chert in Layer 5a, but the numbers of flakes are too few to make a reliable judgement. All of the obsidian was apparently from Mayor Island.

Arguably the best information comes from the Washpool midden site S28/49 (formerly N168/22) at Palliser Bay (B.F. Leach 1979; K. Prickett

1979). Here three main cultural levels were recognised, the lowest (Level 1) originally considered to date to ca. AD 1180, but in view of subsequent reassessments of the time of initial settlement of Aotearoa (Anderson 1991; Wilmshurst *et al*. 2011) probably more likely ca. AD 1250 or later. The proportions of obsidian and chert in this and the intermediate level (Level 2, ca. AD 1340) are remarkably similar, and indicative of considerable stability over the first century of occupation. The uppermost Level 3, which is only indirectly dated to ca. AD 1540, shows some indication of a decline in the use of obsidian, but not of Mayor Island material. This is not evident at the nearby Washpool garden site (S28/47), which contained a similar proportion of obsidian to that of Levels 1 and 2 at the Washpool midden and is reliably dated to AD 1450–1680 (Anderson and Petchey 2020), or ca. AD 1530 (H. Leach 1979; Table 1).

Consistent proportions of obsidian and chert have also been recorded from the Paremata site near Wellington (Davidson 1978; Moore and Challis 1980). Most of the artefacts came from the lower Layers 3 and 2C, and assuming that dating of these layers can be relied upon (L3 = AD 1285–1400, L2C = 1440–1780 at 95% probability, see Appendix), it appears there was virtually no change in the use of obsidian or chert (or Mayor Island obsidian) over a period of perhaps 100 years or more.

As illustrated in Figure 2, the relative proportions of obsidian and chert at the five sites are remarkably similar. Although there are indications of a slight intra-site increase in the use of chert over time (except at Pōnui), the changes are small and could be influenced by size of the excavated areas and variability in the spatial distribution of artefacts. The percentage of Mayor Island obsidian at each site is also reasonably consistent (Table 2). The data from these particular sites do not, therefore, point to any widespread change in the use of obsidian and chert. However, as shown in Figure 3, there was in fact a significant overall increase in the O/C ratio during the Early period, by approximately a hundredfold over a period of 200 years (or 5% per decade). This represents either a major increase in the use of obsidian or a decline in the use of chert.

REGIONAL VARIATIONS AND TEMPORAL CHANGES

To identify any significant geographic and temporal differences in the use of obsidian and chert over the entire North Island, all data from Table 1 are plotted in Figure 4. This reveals that the overall increase in the O/C ratio during the Early period (Fig. 3) gradually reduces or levels off in the Auckland and Coromandel–Bay of Plenty (BOP) regions. The situation in Northland is more complex, while the limited data from southern North Island (SNI) sites show even greater variability. There is a clear indication here, though, that the main changes occurred around AD 1450–1500.

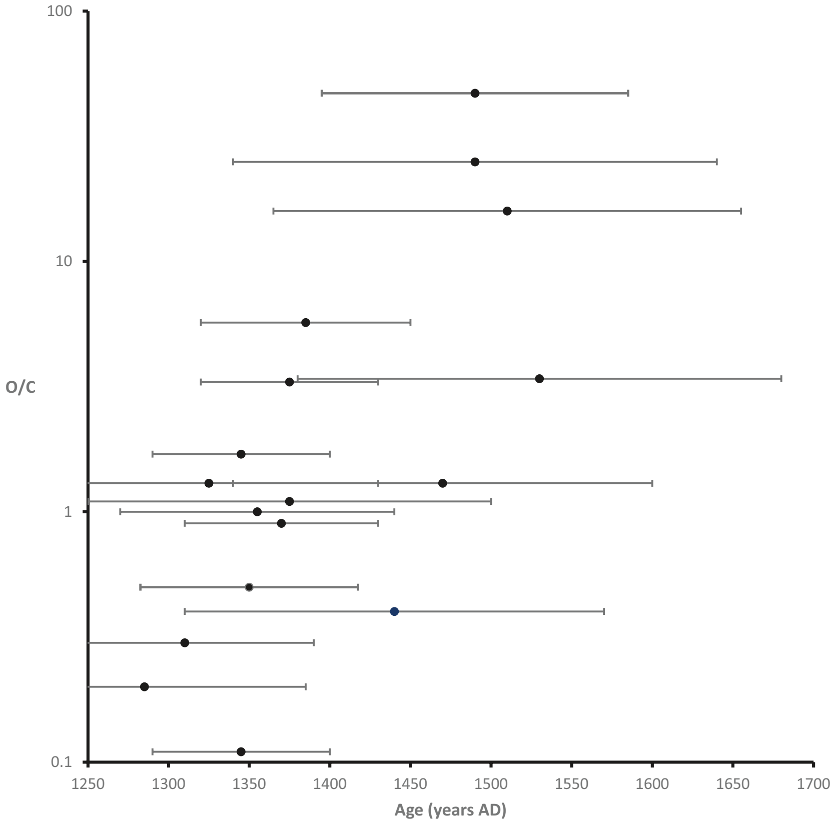

Figure 3. Trend in the O/C ratio for early sites. 95% probability age ranges from Table SI-1.

Chert

The relative proportions of chert at most North Island sites are plotted in Figure 5, according to region. Contrary to indications of minimal or no change at the five early sites (Fig. 2), it shows there was a general decline in the use of this lithic material (relative to obsidian) during the Early period, especially in the Auckland and Coromandel–BOP regions. The situation in the sixteenth–seventeenth century is more complex, with chert forming up to 100 percent of assemblages at some sites in Northland (e.g., Pouērua) but less than 20 percent in the Auckland and Coromandel–BOP regions. After about AD 1600 the use of chert at Late period sites in Auckland and

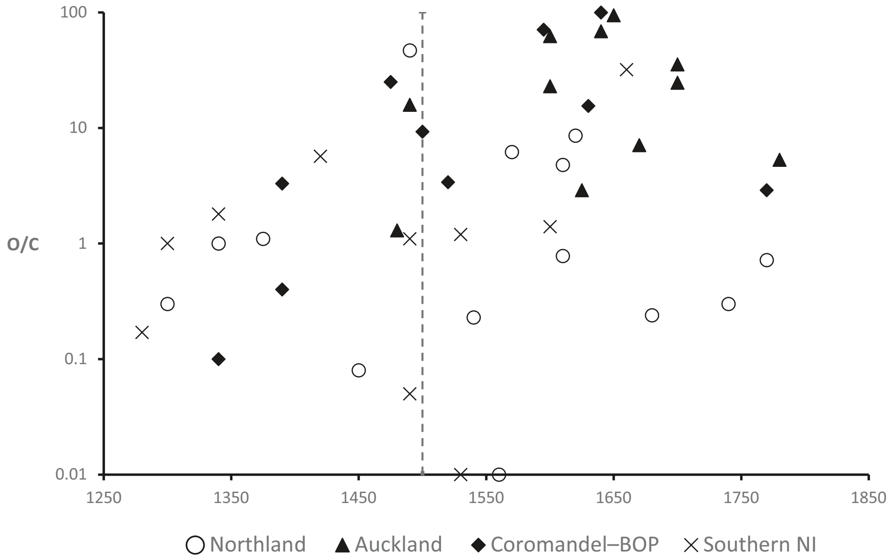

Figure 4. The O/C ratio for all sites, according to region. Based on data from Table 1 (with Waikato included in Southern North Island). Vertical dashed line marks the approximate commencement of pā construction (from Schmidt 1996).

the Coromandel–BOP region remained at low levels, but this was clearly not the case in Northland.

Although few detailed studies of chert assemblages have been undertaken, there is little evidence of any long-distance transport of artefacts or raw material in the North Island, apart from the distinctive Raglan chert on the Waikato coast (Moore and Wilkes 2005; Fig. 1). While it has been claimed that much of the chert (sinter?) found at the Houhora site in the Far North came from Coromandel Peninsula (Best and Merchant 1976), this remains equivocal (Furey 2002: 110). Notably, at the nearby and similar-aged site of Tauroa Point all the chert appears to be from local sources less than 70 km away (Phillipps *et al*. 2016), and at Pouērua most of the chert was probably also obtained locally (Brassey 1985). In the Auckland area at least some of the higher-quality material found at Early sites (e.g., Matatūahu, N. Prickett 1987) may have originated from Coromandel, whereas the chert recovered from later sites seems to be predominantly from local sources, and is described as being of relatively poor quality (e.g., Cruickshank 2011). The overall

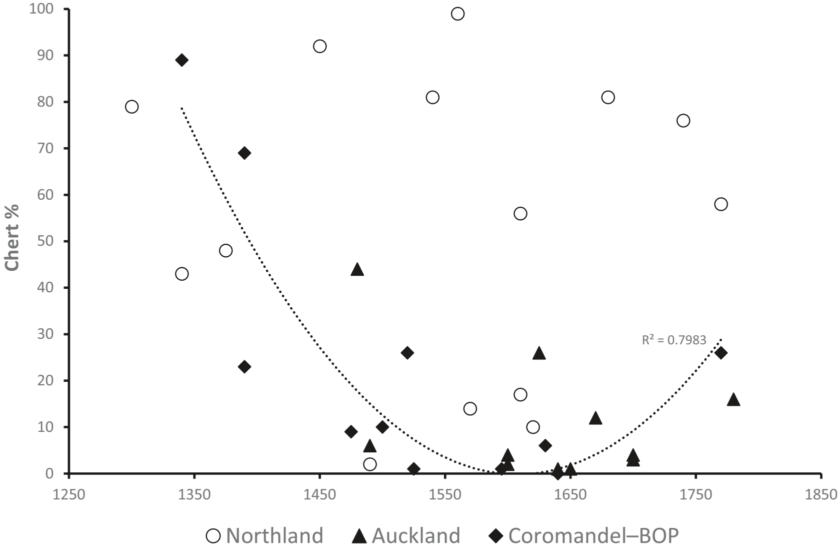

Figure 5. Proportion of chert at northern sites, and trendline for the Coromandel–BOP region.

decline in use of chert in Auckland, therefore, may have been partly due to increasingly restricted access to high-quality material, forcing a shift towards the utilisation of poorer-quality chert obtained mainly if not exclusively from local sources. But this does not explain the similar trend for Coromandel, where chert occurrences are relatively abundant (Moore 1977). Clearly, more research into the types of chert used in particular regions is required, particularly from sites dating to around the fifteenth–sixteenth century.

Mayor Island Obsidian

Obsidian from Mayor Island (MI) in the Bay of Plenty was dispersed throughout New Zealand (Walter *et al*. 2010), and there are few early sites in the North Island which do not contain any material from this source. Previous studies have established that there was a general decline in use of this high-quality obsidian over the prehistoric period (Green 1964; Leach and de Souza 1979; Moore 2012a; Seelenfreund and Bollong 1989), though details of this trend remain sketchy. In the South Island a major contraction in the distribution of MI obsidian had occurred prior to AD 1500 (Walter *et al*. 2010).

The proportion of MI obsidian relative to the total obsidian recovered from individual sites is illustrated in Figure 6 (see also Table 1). Only sites in Northland, Auckland and Coromandel–BOP are plotted since these regions provide the best data. This shows a steady decline in the use of MI obsidian in the Northland and Auckland regions during the prehistoric period, but a consistently high percentage for most Coromandel–BOP sites. The only significant outliers are the Hot Water Beach site on Coromandel Peninsula and the pā at Harataonga (T08/3) on Great Barrier Island, both of which are located close to alternative sources (Hahei/Cooks Beach and Te Ahumata respectively). Houhora in the Far North contains a surprisingly low proportion (40–60 percent) of MI obsidian for an early site (Furey 2002).

As seen for the chert (Fig. 5), regional differences in use of MI obsidian became more pronounced after about AD 1450–1500. Although a number of Late period sites still contain a high proportion, these are all located in the Coromandel–BOP region close to the source. In contrast, sites in the Auckland and Northland regions are characterised by low MI percentages, with many Northland sites containing < 20 percent. This regional differentiation is supported by data from other sites (Moore 2012a).

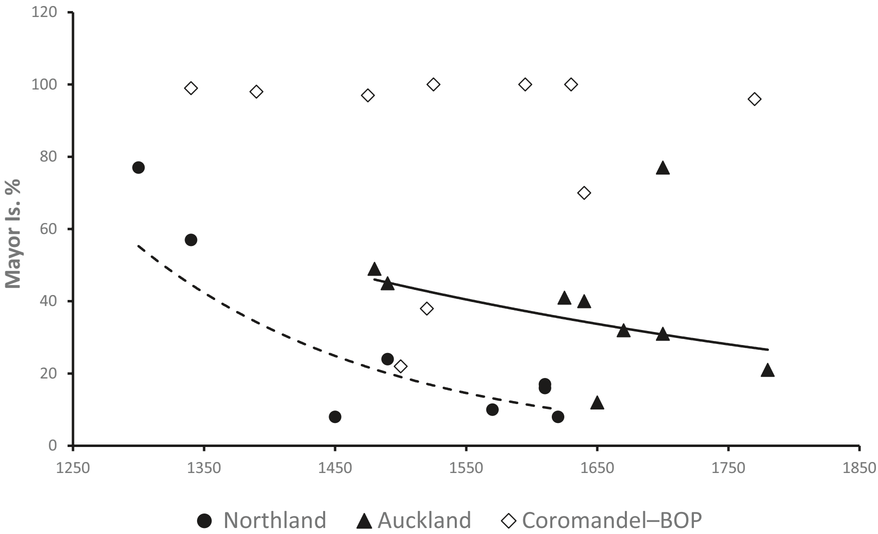

Figure 6. Proportion of Mayor Island obsidian at sites in the three northern regions, showing a decline in Auckland (solid trendline) and Northland (dashed trendline).

Other Obsidian
Despite the decline in use of MI obsidian in Northland and Auckland, O/C ratios for flake assemblages from Auckland sites remained high (Fig. 4), indicating that the reduction in MI obsidian was compensated for by the procurement of material from alternative sources. Until fairly recently the identification of these sources had been largely based upon visual attributes (see Sheppard 2004), but the introduction of pXRF analysis has now provided greater certainty. Nevertheless, there are still only limited data for sites in these regions.

The relative proportions of obsidian from different sources for three sites in Northland and three in Auckland are shown in Figures 7 and 8 respectively. These sites were selected on the basis that their obsidian assemblages had been at least partly analysed by pXRF, four of them solely by this method, while those from Aupōuri and the NRD site at Māngere were analysed by a combination of visual attributes and pXRF. The Aupōuri site chosen (N03/450) is reasonably representative of those in that area (Moore and Coster 2015). In each figure, sites are ordered by decreasing age from left to right.

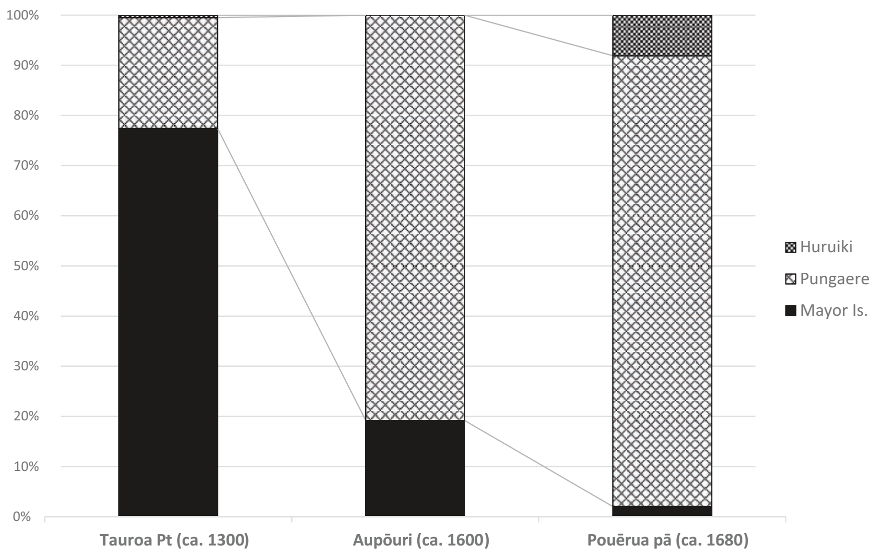

Figure 7. Temporal changes in the provenance of obsidian in Northland. Data from Phillipps *et al*. (2016, Tauroa Point), Moore and Coster (2015, Aupōuri) and McCoy *et al*. (2014, Pouērua pā).

The Northland sites range in age from the early fourteenth century (Tauroa Point, ca. AD 1300) to the seventeenth century (Pouērua pā, ca. AD 1680), and clearly illustrate the decline in use of MI obsidian in this region (Fig. 7). It was primarily replaced by inferior-quality obsidian from the main local source of Pungaere (Kāeo), which at Pouērua pā made up almost 90 percent of the total assemblage (McCoy *et al*. 2014). "Grey" obsidian (grey in transmitted light) from the distant Coromandel sources was only a minor component (< 1 percent), while material from the other local source, Huruiki, was significant only at Pouērua pā. Although these sites adequately illustrate the broad trend in obsidian procurement in Northland, the situation is considerably more complex. A recent study of artefact assemblages from 53 sites on the Aupōuri Peninsula, for example, showed that the proportion of MI obsidian utilised there remained relatively constant during the late fifteenth to seventeenth century, and apparently increased in the eighteenth century (Moore and Coster 2015). In contrast, the proportion of "grey" obsidian was highly variable and came from multiple sources, mainly Coromandel (Cooks Beach, Hahei), Great Barrier Island (Te Ahumata) and Huruiki. In

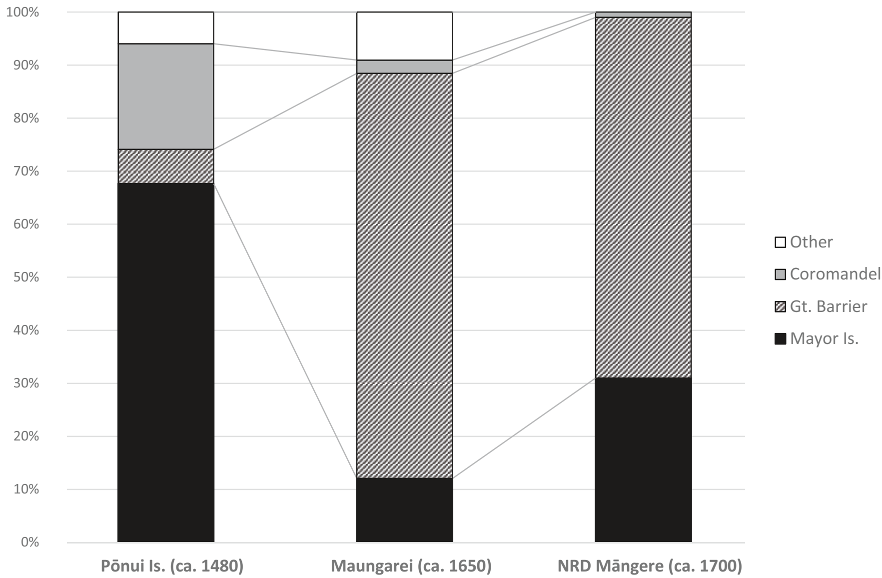

Figure 8. Temporal changes in obsidian provenance in the Auckland region. Data from Sheppard *et al*. (2011, Pōnui Island), McCoy and Carpenter (2014, Maungarei) and Cruickshank (2011, NRD Mangere).

southern Northland, analysis of a small assemblage (n = 72) from Urquharts Bay near Whangārei indicated that 45 percent of the obsidian was obtained from Great Barrier (Moore 2012a).

The situation in Auckland was similar to Northland, except that the main alternative source of obsidian was Te Ahumata, on Great Barrier Island, about 90 km offshore to the northeast (Figs 1 and 8). The use of material from this source seems to have increased significantly over time, from only 6 percent in the late fifteenth century (Pōnui) to 50–70 percent in the seventeenth to eighteenth century. On the other hand the importation of obsidian from Coromandel sources appears to have declined markedly, and little or no obsidian was obtained from Northland. This trend has recently been confirmed by pXRF analysis of an obsidian assemblage (n = 239) from a fifteenth-century site at Long Bay, north of Auckland City (Campbell *et al*. 2019).

It is evident from Figures 7 and 8 that the shift towards a greater reliance on alternative sources had already begun by the early fourteenth century in northern Northland (in good agreement with the evidence from Houhora) and by the fifteenth century in Auckland. In both cases this apparently pre-dates construction of the first defensive pā (Schmidt 1996).

SITE TYPES

While archaeological sites are usually classified according to their dominant feature (e.g., midden), in reality many were multifunctional and used for any combination of living, cooking, food storage, food processing and manufacture of tools. Thus the sites referred to here as "midden/workshops" could, in some cases, also be regarded as kainga (e.g., Houhora). Similarly, few pā were constantly defended, and at times they functioned as open settlements or kainga (e.g., Maungarei/Mt Wellington, Davidson 2011). There is, therefore, considerable overlap between site types, and in situations where there is some doubt as to how they should be classified I have simply used my own judgement.

It is evident from Table 1 that there is considerable variation in the O/C ratio among some site types (from 0.01 to 100), which is clearly illustrated in Figure 9. The early sites are almost exclusively midden/workshops, and overall these show a relatively consistent increase in the O/C ratio, at least until the sixteenth century (Fig. 3). Although this trend appears to have levelled off after about AD 1500 (cf. Fig. 3), as mentioned earlier many later middens (not included in this study) tend to contain very few artefacts, often of obsidian only, resulting in high O/C ratios. Nevertheless, the continuity of this trend, as shown in Figure 9, would seem to suggest that whatever purpose the obsidian and chert were used for during the Early period remained much the same in the Late period.

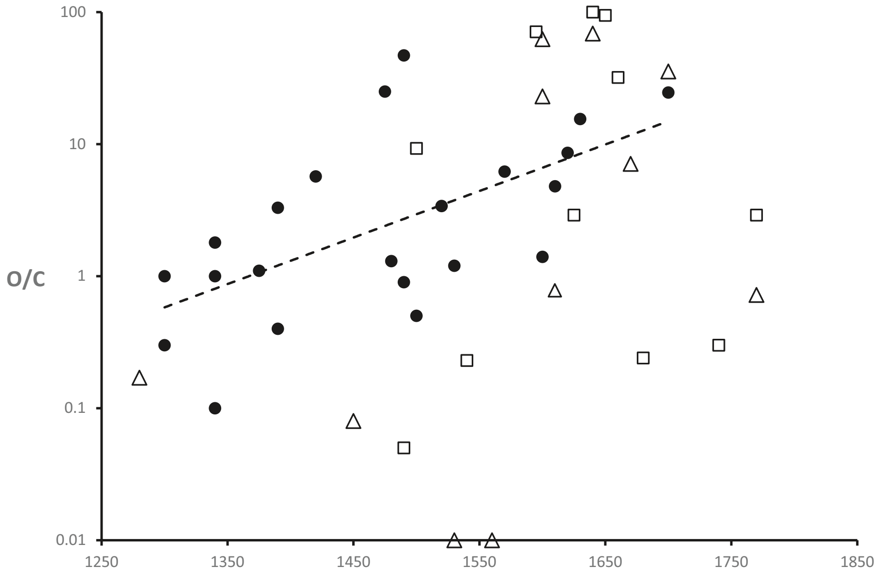

Figure 9. The O/C ratio for different site types, and trendline for midden/workshops.

Many of the excavated sites dating to the Late period are kainga and pā which, in contrast to the middens, show a much wider variation in the O/C ratio (Fig. 9). A number of kainga and pā have low O/C ratios, and most of these are situated in Northland (e.g., Pouērua) and the southern North Island (Fig. 4, Table 1). By comparison, many of the kainga and pā in the Auckland and Coromandel–BOP regions are characterised by high O/C ratios. Such marked differences in the relative proportions of obsidian and chert among these site types may be at least partly attributable to regional cultural differences.

Midden/Workshops

Early midden/workshops were exclusively coastal, and are generally interpreted as seasonal or semi-permanent camps or hamlets primarily focused on fishing and/or exploitation of larger fauna, particularly moa. Initially, as illustrated in Figure 2, a significant quantity of chert was being used at some sites (typically around 50 percent), but by the sixteenth century it had fallen, particularly in Auckland and Coromandel–BOP, to < 30 percent (Fig. 5). There is no indication, however, of an abrupt change in the use of obsidian or chert at these early coastal sites that might be attributable to some catastrophic natural event, such as the impact of large tsunami (McFadgen 2007).

Kainga and Houses

Figure 9 shows that the proportion of chert being used at some kainga was particularly high (O/C < 0.1), and excavation reports for these sites in many cases indicate it is related to a close association with houses. The Moikau house S28/9 at Palliser Bay, which is dated to AD 1185–1390 (see Appendix), is the earliest dwelling site that has been excavated in New Zealand (N. Prickett 1979). A large number of chert and obsidian flakes were found on the floor of this house, with a particular concentration on the left side (looking in) and rear of the building suggesting, by reference to ethnographic accounts, that the flakes were primarily used by junior members of the household, and most likely women. Surprisingly, a very high proportion of the chert (92 percent) consisted of waste material, indicating that flakes were actually being produced inside the house. Nigel Prickett (1979) speculated that the used flakes were employed in making clothing or other objects from flax and perhaps skins. At the nearby sixteenth-century Mākōtukutuku house S28/56, most chert flakes (all very small) were found in the porch area (H. Leach 1979).

This association between houses and high chert/low obsidian usage is also particularly well illustrated at Pouērua, where five separate kainga were excavated (Sutton 1994). Unfortunately, only one of these (P05/402) is securely dated, to the fifteenth–seventeenth century (ca. AD 1560?), but dates for two other sites (P05/857, 858) suggest they were occupied around AD 1450–1550. What is most notable is the consistent proportions of obsidian and chert (and thus O/C ratio) at these sites, with the exception of P05/858 (Table 1). This is suggestive of a close relationship between the inhabitants of the kainga, for perhaps 50–100 years or more.

The best data are from the kainga P05/857, where the remains of five houses were discovered and the amounts of obsidian and chert associated with each house were recorded separately (Marshall 1994). The interpreted sequence of house construction, as indicated in Table 3, would suggest a gradual increase in the use of obsidian at this site (Fig. 10). Houses H1 and H3 were considered to be contemporary, and this is supported by the similar O/C ratios. This apparent increase in obsidian at P05/857 is not evident at nearby P05/402, where the later of the two houses identified contained only chert (Brassey 1985).

Evidence of numerous houses was also uncovered during extensive and meticulous excavations on the impressive volcanic cone of Pouērua (P05/195) in 1984–1985 (Sutton *et al*. 2003). On this large pā, early house sites, pre-dating the construction of defences, contained few if any stone flakes, and the bulk of the obsidian and chert was associated with later houses within the uppermost cultural layers (Layers 1 and 2), mainly post-dating the defensive phase which is inferred to have begun around AD 1600. Dates for Layers 1 and 2 suggest most of these later houses were constructed after

Table 3. Proportions of obsidian and chert associated with houses at Pouērua. Data from Sutton (1993, 1994); Sutton *et al*. (2003); and Table SI-1. See Fig. 10.

Site/feature	Age (AD)	Obsidian (N, %)		Chert (N, %)		O/C
Pouērua Pā P05/195 (1450–1810) ca. 1680						
Area I (house?)	ca. 1730	58	17%	274	83%	0.21
Area II total	1450–1640	180	20%	741	80%	0.24
Quad B (2 houses)	ca. 1700?	115	21%	441	79%	0.26
Quad D house	ca. 1700?	16	9%	171	91%	0.09
Area III south terrace	ca. 1750	26	12%	187	88%	0.14
Area IV (house)	1750–1800	293	24%	934	76%	0.31
Area V	ca. 1600?	4	20%	16	80%	0.25
Area VII (house)	ca. 1750?	3	5%	54	95%	0.06
Peripheral pā P05/371 (1510–1890)						
Area 2 house	ca. 1740	67	24%	215	76%	0.31
Peripheral pā P05/408 (1440–1640)						
Area 1 house	ca. 1540	62	8%	669	92%	0.09
Kainga P05/857 (1330–1620) ca. 1490						
House H2 (Area III)	Latest?	18	19%	76	81%	0.24
House H1 (Area I)	Same as H3	37	7%	474	93%	0.08
House H3 (Area IV)	Same as H1	54	9%	537	91%	0.1
House H4 (Area V)	Second	2	2%	101	98%	0.02
House H5 (Area VI)	Earliest	1	1%	80	99%	0.01

about AD 1700. Though not all of the stone flakes recovered from the various excavation areas were associated with houses, the O/C ratio is remarkably similar throughout (Table 3, Fig. 10). The highest ratio is for the largest and possibly latest house, in Area IV. For the most part the ratios are also slightly higher than for the nearby kainga, suggesting greater use of obsidian on the pā. House sites excavated on two smaller peripheral pā P05/371 and P05/408 (Sutton 1993) have similar O/C ratios (Table 3).

Interestingly, the association of chert with houses at Pouērua and in the southern North Island is not evident in the Auckland area among sites of similar age. Foster and Sewell (1988: 49), for example, found no spatial relationship between house structures and the occurrence of obsidian and other stone flakes at site R11/899, Tāmaki. This was also true at the nearby pā R11/1506 (Foster and Sewell 1993), at Hamlins Hill (Davidson 1970a) and on Motutapu Island (Leahy 1970), although one house on Motutapu contained abundant obsidian on the floor (Ladefoged and Wallace 2010). At Papahinu, none of the 14 separate houses identified were associated with

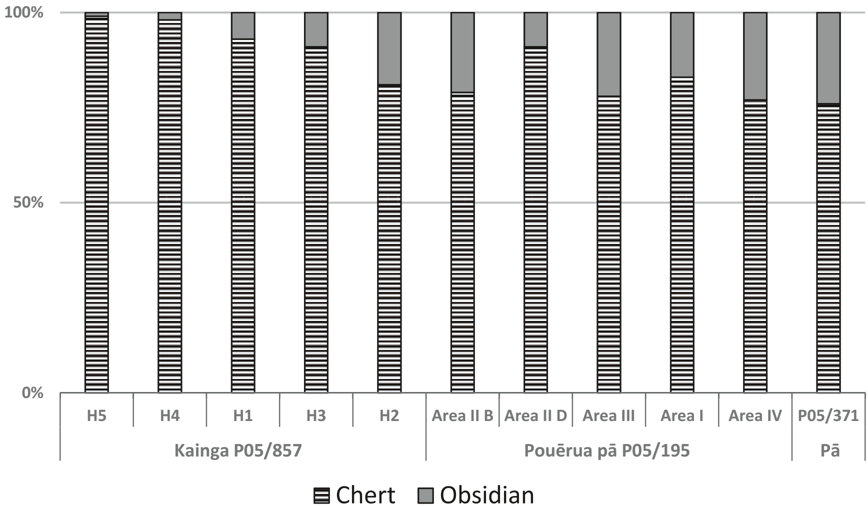

Figure 10. Proportions of chert and obsidian associated with house sites at kainga and pā at Pouērua, arranged from older (left) to younger for each site. This sequence potentially spans a period of up to 250 years (ca. AD 1500–1750). Data from Table 3.

concentrations of chert flakes (Foster and Sewell 1995). It is reasonable to assume, therefore, that whatever the chert was being used for at Pouērua was undertaken by other lithic materials, or at other places within sites, in the Auckland area.

Defensive Pā

Radiocarbon dates indicate that the construction of pā, and by implication the initiation of warfare (or at least the threat of conflict), commenced around AD 1500 (Schmidt 1996), at or close to what is conventionally accepted as the end of the Early (Archaic) period. Notably, a typical range of Early period artefacts and faunal material was recently recovered from a small pā (Te Ahua) on the west coast of Auckland which appears to date to the mid-to-late fifteenth century (Turner *et al*. 2010). Recalibration of the two dates (Wk27056, 27057) indicates this pā was probably occupied around AD 1490 (AD 1420–1560 at 68% probability). Therefore, pā construction may have begun somewhat earlier in some areas, perhaps around AD 1450.

The wide variation in the O/C ratio among pā sites (Table 1, Fig. 9) would seem to suggest that while there was limited effect on the supply of obsidian in the Coromandel–BOP area as a result of increasing conflict (Figs 4, 6), there was a more significant impact in parts of Northland and the southern North Island. However, this is difficult to confirm because although obsidian assemblages from many pā have been analysed, few can be confidently attributed to pre-defensive or defensive phases. It is therefore worth taking a closer look at the data from Pouērua, especially since obsidian from the main pā P05/195 has been recently analysed by McCoy *et al*. (2014). Their analysis suggests there were significant changes in not only where the obsidian was procured from but how. Specifically, they argue that there was a change from unrestricted access to local obsidian sources during the earlier undefended period to "extreme restriction" in direct access coinciding with construction of the first fortifications on Pouērua Pā around AD 1600.

The data presented by McCoy *et al*. (2014) indicate the main changes in obsidian assemblages occurred during the defended period in Areas I and III of the pā (Fig. 10). They do not state which stratigraphic level their obsidian artefacts were from, but 85 percent of those in Area III (n = 50) were found in the uppermost Layers 1 and 2 (Sutton *et al*. 2003, table 5.5 and p. 39). Layer 2 was interpreted as pre-dating the second defences in that area and dates to < 250 BP. Most of the obsidian in Area I also apparently came from Layers 1 and 2, which date to ca. AD 1730 and are considered to post-date the defences. Thus although some of the obsidian from Area III may relate to the defended period, both in this area and Area I most was associated with features dating to after about AD 1750. Therefore the "extreme restriction" in access to local obsidian did not coincide with the first fortifications, as might be expected (McCoy *et al*. 2014), but with late defences and post-defensive occupation perhaps > 100 years later. As shown in Figure 10 there is no indication of a dramatic change in the proportions of obsidian and chert being used at Pouērua relating to late occupation of the main pā (Areas I, II and IV). No information is available on the nature or likely sources of the chert.

Dating Pouērua. The data from Pouērua are of particular importance because the consistently high use of chert in this area (Fig. 10) is suggestive of considerable stability over a period of > 200 years, despite the construction of defensive pā and inferred restrictions in obsidian supply (McCoy *et al*. 2014). Notably, similar-aged sites in Northland, on the Aupōuri Peninsula and at Urquharts Bay, do not contain an unusually high proportion of chert (Table 1). Although more reliable dating of the kainga and peripheral pā at Pouērua is required to establish when this high use of chert began, for the time being we are limited to the few dates obtained by the original investigators. The three main sites of interest are the peripheral pā P05/408 and kainga P05/402 and P05/857. Previously reported dates, which were all based on identified charcoal, suggest these sites were occupied between about AD 1450 and 1600.

In order to gain greater certainty about the age of these sites the available ^{14}C dates were recalibrated (Table 4). This indicates that the "Cattleyards" pā P05/408 and kainga P05/402 are of similar age and probably date to between AD 1440 and 1640 (95% probability), or ca. AD 1540. The single date obtained for the kainga P05/857 is attributed to clearance of the original vegetation (Marshall 1994), and provides only a maximum age (AD 1390 at 85% probability) for occupation of the site. Moreover, the dated sample consisted mainly of charcoal from larger tree species (rewarewa, kohekohe) and could have an inbuilt age of at least 50 years. Allowing for these factors I have estimated a likely age for the kainga of about AD 1490 (AD 1420–1630 at 95% probability).

The reassessment of these dates means that initial occupation of the Pouērua area, exceptionally high use of chert and gradual increase in obsidian (Fig. 10) probably began sometime between AD 1450 and 1550, well before construction of defences on the main pā at around AD 1600. Also, it is possible that some of the kainga and peripheral pā were contemporary, and therefore that the settlement as a whole was not necessarily undefended and may already have been under some degree of threat prior to AD 1500 (cf. McCoy *et al*. 2014). However, the consistently low O/C ratios across all sites at Pouērua would suggest that the unusually high use of chert was not related to conflict but to some cultural factor that has not yet been identified.

Table 4. Recalculated ^{14}C dates for Pouērua. Dates calibrated using SHCal20 and rounded to nearest 5–10 years.

Site	Lab no. *	Material †	CRA (BP)	Calibrated age (95% probability)
P05/402 (kainga)	NZ7309	Charcoal	400 ± 55	AD 1450–1640
P05/408 ("Cattleyards"pā)	NZ7330	Charcoal	407 ± 60	AD 1440–1640
P05/857 (kainga)	NZ7308	Charcoal	495 ± 55	AD 1390–1510 (85%), AD 1575–1620 (11%)

* All dates by Institute of Nuclear Science (now GNS Science).

† Details of charcoal composition are given in Sutton (1994, Appendix 1) and Sutton (1993, "Cattleyards" pā).

DISCUSSION

There are clear indications, from changes in the use of obsidian and chert, that regional differentiation had already begun in the North Island in the fourteenth century. This is well illustrated, for example, by the high proportion of local Pungaere/Kāeo obsidian at Houhora and other early sites in the Far North (Moore 2012a; Phillipps *et al*. 2016), despite an apparently strong connection (in the case of Houhora) with the Coromandel area (Furey 2002). Either it was proving difficult to procure superior-quality obsidian from Mayor Island in the fourteenth century, or it was simply considered more expedient to make use of poorer-quality local material. However, the lack of any significant differences between or changes in the proportions of chert and Mayor Island obsidian at individual Early sites, both in northern and southern parts of the North Island, is at odds with the overall decline in use of these materials. It is indicative of considerable stability at these particular settlements over periods of perhaps 50–100 years and of the maintenance of long-distance communication networks regardless of increasing regionalisation.

The rapid decline in use of chert appears to have ended, or at least slowed, following the introduction of fortified pā around AD 1500 (Schmidt 1996), but it is by no means certain that the outbreak of warfare was entirely responsible. Warfare presumably resulted in increased territoriality, the breakdown or disruption of existing long-distance distribution networks, and greater dependence on local lithic resources, at least initially. It would seem to be the most likely explanation for the reduced use of Mayor Island obsidian in Northland and the Auckland area from the fifteenth century. But the procurement of lithic materials was not necessarily consistent within regions. In the Far North, sites on the Aupōuri Peninsula dating to the sixteenth century contain a much higher percentage of obsidian than the kainga and pā of similar age at Pouērua (Moore and Coster 2015). Yet many of the Aupōuri sites also have a low MI obsidian content, in common with Late period sites in other parts of Northland (e.g, Urquharts Bay, Motutoa).

To some extent, the proportions of lithic materials also appear to be dependent upon site function. It is notable, for example, that the main differences post-AD 1500 were in relation to pā and kainga, and that the proportions of chert and obsidian being used at midden/workshops remained more similar to those in the Early period. Since these were exclusively coastal then we can probably assume that much of the obsidian and chert was being utilised in the manufacture of items related to fishing and associated activities (e.g., fish hooks, nets). On the other hand, many of the kainga appear to be closely associated with gardening. In regards to pā, it seems there was a preference for using obsidian rather than chert in the Auckland and Coromandel regions, while the reverse was the case in Northland, at least at Pouērua. This would seem to point to the existence of regional cultural differences.

The idea that conflict may have caused restrictions in access to obsidian sources, as promoted by McCoy *et al*. (2014) (see also McCoy and Ladefoged 2019), certainly warrants further examination. Evidence from Pouērua in particular would suggest there was little or no disruption to the supply of obsidian around the time that warfare is inferred to have broken out, and that if existing exchange networks were affected then it was only a relatively short time before they were re-established or entirely new supply chains formed. Clearly the situation during the Late period was complex, and further research will be required to understand it.

* * *

This paper has demonstrated the value of using relative proportions of the two most common lithic materials found at archaeological sites in the North Island, obsidian and chert, in identifying both regional variations and temporal changes in New Zealand prehistory. The O/C ratio also provides an additional means of determining similarities or differences between sites and site types in any particular area. Available data show there was a significant overall decline in the use of chert, and a corresponding increase in obsidian, in all regions during the Early (Archaic) period, up until about

AD 1450–1500, although the use of high-quality Mayor Island obsidian also declined. Data from individual coastal sites, however, suggests that long-distance communication networks were largely maintained.

During the Late (Classic Māori) period there is evidence of increasing regionalism, with higher use of chert at sites in Northland and the southern North Island and of Mayor Island obsidian in the Coromandel–Bay of Plenty region. Changes in the use of obsidian and chert more or less coincided with commencement of the construction of defensive pā (and by inference the outbreak of warfare) ca. AD 1500. Conflict likely caused a breakdown in existing communication networks, at least temporarily, resulting in greater reliance on local lithic resources in some regions.

The evidence presented here lends support to the notion of a gradual and non-synchronous transition from the Early/Archaic period to Late/Classic Māori period of New Zealand prehistory.

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APPENDIX

Radiocarbon dates for archaeological sites mentioned in text. Dates calibrated using SHCal20 for terrestrial samples and global Marine20 with Delta R of –154 +/– ^{14}C years for marine shell (see Anderson and Petchey 2020). Calibrations using OxCal version 4.4 and CALIB version 8.2. Note that most dates have been rounded to the nearest 5–10 years, following recommendation by Stuiver *et al.* (2021). Not all available dates are listed.

* Lab prefixes: NZ = Rafter Radiocarbon Laboratory, GNS Science; Wk = Waikato University Radiocarbon Dating Laboratory
† Median age from CALIB v8.2
‡ Estimated age

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
MIDDEN/WORKSHOP							
Twilight Beach	M02/162	NZ6579	shell	1005 +/– 33	1250–1500	1375	Coster 1989; McFadgen 2007
Aupōuri	N02/821	NZ7066	shell	766 +/– 36	1430–1720	1570	Coster 1989; McFadgen 2007
Aupōuri	N03/519	NZ7069	shell	713 +/– 48	1460–1810	1620	Coster 1989; McFadgen 2007
Aupōuri	N03/323	NZ6581	charcoal	430 +/– 32	1440–1625	1490	Coster 1989; McFadgen 2007
Houhora Layer 3	N03/59	NZA2438	charcoal	727 +/– 86	1190–1420	1310	Furey 2002
Houhora Layer 3	N03/59	Wk5485	charcoal	640 +/– 40	1295–1415	1350	Furey 2002
Houhora Layer 2b	N03/59	NZA2436	charcoal	632 +/– 86	1270–1460	1360	Furey 2002
Houhora Layer 2b	N03/59	NZA2437	charcoal	774 +/– 87	1150–1410	1280	Furey 2002
Houhora Layer 2b	N03/59	Wk5034	shell	960 +/– 40	1280–1550	1410	Furey 2002
Houhora Layer 2b	N03/59	Wk5035	shell	1060 +/– 45	1185–1470	1330	Furey 2002
Tauroa Point	N05/302	Wk13534	charcoal	746 +/–39	1230–1390	1300	Allen 2006

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Urquharts Bay	Q07/571	Wk26035	shell	719 +/– 35	1470–1790	1610	Phillips & Druskovich 2009
Long Bay Phase 4	R10/1374	Wk45302	shell	869 +/– 19	1350–1635	1480	Campbell *et al.* 2019
Long Bay Phase 7	R10/1374	Wk45304	shell	845 +/– 19	1390–1660	1505	Campbell *et al.* 2019
NRD Māngere Area A	R11/859	Wk27371	shell	709 +/– 36	1470–1800	1630	Campbell & Hudson 2011
NRD Māngere Area B	R11/859	Wk27372	shell	523 +/– 35	1680–1950	1810	Campbell & Hudson 2011
Pōnui Island	S11/20	NZ7764	charcoal	535 +/– 48	1320–1480	1430	Sheppard *et al.* 2011; Irwin 2020
Pōnui Island	S11/20	NZ7765	shell	957 +/– 39	1280–1550	1410	Sheppard *et al.* 2011; Irwin 2020
Pōnui Island	S11/20	Wk3578	shell	840 +/– 40	1380–1670	1510	Sheppard *et al.* 2011; Irwin 2020
Pōnui island	S11/20	Wk3579	shell	850 +/– 40	1370–1660	1500	Sheppard *et al.* 2011; Irwin 2020
Pōnui Island	S11/20	Wk3580	shell	860 +/– 40	1350–1650	1490	Sheppard *et al.* 2011; Irwin 2020
Pōnui Island	S11/20	Wk3581	shell	820 +/– 40	1400–1680	1530	Sheppard *et al.* 2011; Irwin 2020
Ōpito	T10/161	NZ354	charcoal	689 +/– 40	1290–1400	1340	Anderson 1991
Hahei	T11/376	NZ4951	charcoal	556 +/– 61	1300–1500	1415	Harsant 1985; Anderson & Petchey 2020

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Hahei	T11/376	NZ4952	charcoal	548 +/– 59	1315–1500	1420	Harsant 1985; Anderson & Petchey 2020
Hahei	T11/376	NZ4953	charcoal	700 +/– 59	1270–1400	1340	Harsant 1985; Anderson & Petchey 2020
Hot Water Beach Layer 4	T11/115	NZ1297	shell	832 +/– 44	1380–1680	1520	Leahy 1974; McFadgen 2007
Mt. Maunganui	U14/363	Wk26693	shell	852 +/– 36	1370–1660	1500	Hooker 2009
Mt. Maunganui	U14/363	Wk26694	shell	906 +/– 36	1315–1610	1450	Hooker 2009
Papamoa	U14/2912	Wk22622	shell	675 +/– 30	1490–1830	1655	Gumbley 2010
Papamoa	U14/2912	Wk23092	shell	713 +/– 33	1470–1795	1620	Gumbley 2010
Papamoa	U14/2912	Wk23093	shell	678 +/– 34	1490–1830	1650	Gumbley 2010
Papamoa	U14/2912	Wk23094	shell	740 +/– 34	1450–1760	1590	Gumbley 2010
Maketū	V14/187	Wk23623	bone	609 +/– 30	1320–1430	1390	Moore 2008
Waikorea	R14/256A	Wk1899	charcoal	560 +/– 40	1320–1450	1420	Ritchie *et al.* 2009
Cooks Cove Layer 5a	Z17/311	Wk24846	charcoal	361 +/– 35	1460–1640	1560	Walter *et al.* 2011; Anderson & Petchey 2020
Cooks Cove Layer 5a	Z17/311	Wk24847	charcoal	389 +/– 36	1460–1630	1550	Walter *et al.* 2011; Anderson & Petchey 2020

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Cooks Cove Layer 5b	Z17/311	Wk23489	shell	844 +/– 33	1380–1670	1510	Walter *et al*. 2011; Anderson & Petchey 2020
Cooks Cove Layer 5b	Z17/311	Wk23490	bone	624 +/– 30	1310–1430	1350	Walter *et al*. 2011; Anderson & Petchey 2020
Washpool garden	S28/47	NZ1512	charcoal	390 +/– 87	1410–1800	1555	H. Leach 1979; Anderson & Petchey 2020
Washpool garden	S28/47	NZ1513	charcoal	344 +/– 86	1430–1940	1580	H. Leach 1979; Anderson & Petchey 2020
Washpool garden	S28/47	NZ1514	charcoal	514 +/– 87	1300–1630	1450	H. Leach 1979; Anderson & Petchey 2020
Washpool midden Level 1	S28/49	NZ1505	charcoal	767 +/– 45	1220–1390	1280	Anderson 1991
Level 1	S28/49	NZ1511	charcoal	797 +/– 45	1190–1380	1260	Anderson 1991
Level 2	S28/49	NZ1507	charcoal	665 +/– 44	1290–1405	1345	Leach 1979; Anderson 1991
Level 2	S28/49	NZ1508	charcoal	683 +/– 88	1225–1440	1340	Leach 1979; Anderson 1991
Level 2	S28/49	NZ1510	charcoal	670 +/– 44	1290–1400	1345	Leach 1979; Anderson 1991
Paremata Layer 3	R26/122	NZ8542	bone	680 +/– 45	1285–1400	1340	Davidson 1978; McFadgen 2007
Paremata Layer 2C	R26/122	NZ8543	shell	740 +/– 50	1440–1780	1600	Davidson 1978; McFadgen 2007

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
KAINGA/HOUSE							
Pouērua	P05/402	NZ7309	charcoal	400 +/– 55	1450–1640	1540	Sutton 1994
Pouērua	P05/402	NZ7250	charcoal	330 +/– 60	1460–1800	1580	Sutton 1994
Pouērua	P05/402	NZ7651	charcoal	391 +/– 59	1450–1650	1550	Sutton 1994
Pouērua	P05/857	NZ7308	charcoal	495 +/– 55	1330–1620	1450	Sutton 1994
Pouērua	P05/858	NZ7303	charcoal	360 +/– 55	1455–1660	1560	Sutton 1994
Pouērua	P05/858	NZ7304	charcoal	280 +/– 55	1485–1810	1660	Sutton 1994
Motutoa	Q06/307-8	NZ528	shell	609 +/– 87	1535–1950	1730	Frederickson 1990
Motutoa	Q06/307-8	NZ789	shell	511 +/– 71	1650–1950	1810	Frederickson 1990
Tāmaki	R11/887	NZ7064	shell	726 +/– 30	1460–1770	1600	Foster & Sewell 1988; Bulmer 1994
Tāmaki	R11/899	NZ7048	shell	741 +/– 25	1450–1750	1590	Foster & Sewell 1988; Bulmer 1994
Tāmaki	R11/899	NZ7065	shell	716 +/– 30	1470–1790	1610	Foster & Sewell 1988; Bulmer 1994
Tāmaki	R11/1201	Wk1946	shell	690 +/– 35	1480–1820	1640	Foster & Sewell 1993
Westfield	R11/898	NZ6163	shell	660 +/– 55	1490–1880	1670	Bulmer 1994
Westfield	R11/898	NZ6164	shell	746 +/– 55	1440–1780	1590	Bulmer 1994

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Westfield	R11/898	NZ6165	shell	637 +/– 52	1510–1900	1700	Bulmer 1994
Westfield	R11/898	Wk1720	shell	630 +/– 45	1520–1900	1710	Bulmer 1994
Westfield	R11/898	Wk1721	shell	540 +/– 45	1655–1950	1800	Bulmer 1994
Westfield	R11/898	Wk2030	charcoal	340 +/– 45	1460–1660	1565	Bulmer 1994
Papahinu Layer 4	R11/229	Wk3316	shell	750 +/– 50	1435–1770	1590	Foster & Sewell 1995
Papahinu Layers 2 + 3	R11/229	Wk3315	shell	490 +/– 50	1690–1950	1835	Foster & Sewell 1995
Papahinu Layers 2 + 3	R11/229	Wk3317	shell	520 +/– 50	1670–1950	1810	Foster & Sewell 1995
Moikau	S28/9	NZ1644	wood	775 +/– 59	1185–1390	1280	N. Prickett 1979; Anderson 1991
Moikau	S28/9	NZ1645	wood	777 +/– 59	1185–1390	1280	N. Prickett 1979; Anderson 1991
Washpool cross-site	S28/56	NZ1642	wood	340 +/– 84	1440–1810	1585	Leach 1979
Washpool cross-site	S28/56	NZ1643	wood	492 +/– 85	1390–1640 (90%)	1470	Leach 1979
PĀ							
Pouērua pā Area VII	P05/195	NZ6869	charcoal	<250		1750 ‡	Sutton *et al.* 2003
Pouērua pā Area II	P05/195	NZ7310	charcoal	300 +/– 55	1460–1810	1630	Sutton *et al.* 2003
Pouērua pā Area I	P05/195	NZ7312	charcoal	260 +/– 55	1505–1810	1730	Sutton *et al.* 2003
Pouērua pā Area II	P05/195	NZ7322	charcoal	390 +/– 55	1450–1640	1550	Sutton *et al.* 2003

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Pouērua pā Area III	P05/195	NZ7341	charcoal	<250		1750 ‡	Sutton *et al.* 2003
Pouērua (Stone-walled pā)	P05/371	NZ7311	charcoal	250 +/– 50	1510–1890	1740	Sutton 1993; Schmidt 1996
Pouērua (Cattleyards pā)	P05/408	NZ7330	charcoal	407 +/– 60	1440–1640	1540	Sutton 1993; Schmidt 1996
Maungarei	R11/12	NZ7749	shell	655 +/– 50	1500–1880	1680	Davidson 2011
Maungarei	R11/12	NZ7750	shell	685 +/– 50	1470–1840	1650	Davidson 2011
Maungarei	R11/12	NZ7751	shell	674 +/– 50	1480–1850	1660	Davidson 2011
Maungarei	R11/12	NZ7752	shell	732 +/– 50	1450–1680	1600	Davidson 2011
Tāmaki River pā	R11/1506	Wk1940	shell	730 +/– 35	1460–1775	1600	Foster & Sewell 1993
Tāmaki River pā	R11/1506	Wk1941	shell	720 +/– 35	1465–1790	1610	Foster & Sewell 1993
Tāmaki River pā	R11/1506	Wk1942	shell	670 +/– 45	1490–1850	1660	Foster & Sewell 1993
Tamaki River pa	R11/1506	Wk1943	shell	750 +/– 45	1440–1760	1590	Foster & Sewell 1993
Tāmaki River pā	R11/1506	Wk1944	shell	680 +/– 50	1480–1845	1650	Foster & Sewell 1993
Tāmaki River pā	R11/1506	Wk1945	shell	690 +/– 50	1470–1830	1640	Foster & Sewell 1993
Harataonga	T08/3	R4543/3	charcoal	443 +/– 58	1440–1640	1500	Schmidt 1996
Raupa Level I	T13/13	Wk2039	shell	510 +/– 50	1680–1950	1820	N. Prickett 1992
Raupa Level I	T13/13	WK2040	shell	620 +/– 50	1530–1910	1720	N. Prickett 1992

Site	Site no.	Lab no. *	Material	CRA (BP)	Calibrated age (95% probability)	Median age †	Reference
Anatere	U13/46	Wk3751	shell	660 +/– 51	1490–1870	1670	Phillips & Allen 1996
Anatere	U13/46	Wk3755	shell	720 +/– 50	1460–1800	1610	Phillips & Allen 1996
Anatere	U13/46	Wk4659	shell	670 +/– 50	1485–1860	1660	Phillips & Allen 1996
Anatere	U13/46	WK4661	shell	700 +/– 50	1465–1710	1630	Phillips & Allen 1996
Ruahīhī	U14/38	NZ4602	shell	711 +/– 40	1470–1800	1620	McFadgen & Sheppard 1984
Ruahīhī	U14/38	NZ4603	shell	714 +/– 32	1470–1790	1615	Schmidt 1996
Ruahīhī	U14/38	NZ4604	shell	796 +/– 33	1420–1690	1550	Schmidt 1996
Mangakaware 2	S15/18	NZ1125	charcoal	286 +/– 83	1460–1815 (86%)	1660	Bellwood 1978; Schmidt 1996
Tiromoana	W21/1	NZ1915	charcoal	413 +/– 57	1440–1640	1530	Fox 1978; Schmidt 1996
Tiromoana	W21/1	NZ1916	charcoal	488 +/– 57	1400–1625	1455	Fox 1978; Schmidt 1996
PIT/TERRACE							
Motutapu Is.	R10/38	NZ1168	charcoal	188 +/– 86	1625–1950 (93%)	1780	Davidson 1970b; Bulmer 1994
Waikite	U14/1611	Wk24665	shell	821 +/– 31	1400–1670	1530	Moore 2009
Waikite	U14/1611	Wk24666	shell	838 +/– 32	1390–1670	1510	Moore 2009
Waikite	U14/1611	Wk24667	shell	854 +/– 32	1370–1660	1500	Moore 2009
Waikite	U14/1611	Wk24668	shell	780 +/– 32	1430–1700	1560	Moore 2009