Journal of Anthropological Archaeology 42 (2016) 105–121

Contents lists available at ScienceDirect

Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

Occupation duration and mobility in New Zealand prehistory: Insights from geochemical and technological analyses of an early Māori stone artefact assemblage

Rebecca S. Phillipps *, Andrew J. McAlister, Melinda S. Allen

Anthropology, School of Social Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand

ARTICLE INFO

Article history:
Received 26 June 2015
Revision received 4 April 2016
Accepted 5 April 2016

Keywords:
Stone artefacts
Stone sourcing
Reduction strategies
Use intensity
Occupation duration
Mobility
New Zealand Māori

ABSTRACT

Defining settlement–subsistence configurations, their long-term dynamics, and related mobility strategies is an on-going archaeological challenge. We undertake technological analyses of stone artefacts from a ~late 14th century Māori occupation at Tauroa Point, Northland, New Zealand. From the results we infer artefact production strategies, occupation duration, and population movements to and from this locale. Our analysis identified more than 13 stone types, with varied functional properties, and from sources up to 300 km away. The most abundant were obsidian, chert, silicified tuff, and fine-grained volcanics, including materials from the important source of Mayor Island and Tahanga. Use of exotic raw materials, especially when local equivalents were available, indicates population mobility and/or interaction with social groups residing elsewhere. The technological analysis considered tool production, use, and discard patterns as indicated by core and flake size, form, and cortex patterns; flake scar properties; and core-flake ratios. The results inform on differences in the nature and intensity of raw material use, patterns of artefact movement to and from the site, and occupation duration. Notably, preferential and intensive use of non-local obsidian suggests a social component to its procurement and use. Local obsidian, chert and silicified tuff were used less intensively, and possibly for different functions. Overall, an extended but not necessarily permanent occupation involving a variety of activities is indicated. The Tauroa Point site was clearly one component of a larger regional settlement system that involved significant mobility, with connections to other localities within the region, and quite possibly beyond.

1. Background to research

Understanding the spatio-temporal dynamics of human mobility and settlement is one of the most challenging arenas of archaeological study, with a long history of theoretical and analytical efforts.

Pioneering works (e.g., Sahlins, 1958; Service, 1962; Trigger, 1967; Willey, 1953) introduced useful conceptual frameworks that often were focused on understanding major cultural transitions, such as the development of agriculture or socio-political state formation, and found utility in assigning behaviours to dichotomous or categorical types (e.g., sedentary – nomadic; forager – herder – farmer). The reality, however, is often more complex, with a diversity of settlement–subsistence behaviours indicated across time and space, and within and across human populations. Additionally, there is increasing interest in tracking different forms of mobility at multiple social and demographic scales (Barnard and Wendrich, 2008; Holdaway and Douglass, 2012; Holdaway et al., 2010; Kelly, 1992). Historically, archaeologists have focused on the ability of populations to move, or interpreted mobility using ethnographic scale observations. Problematically, however, these approaches are not commensurate with the time-averaged nature of the archaeological record (see Bailey, 2007; Close, 2000; Holdaway et al., 2008; Murray, 1999) and human movement can rarely be distinguished as single events or the activity of single individuals. The challenge thus is to develop archaeological methods that are independent of ethnographic analogy and which explicitly consider the time-averaged nature of archaeology's material records (e.g., Close, 2000; Douglass et al., 2008; Turq et al., 2013). To this end, Close (2000) usefully distinguishes between the 'hard evidence' of *movement* as recovered from the material record versus *mobility*, which she argues is a conceptual inference derived from multiple measures of movement. In this paper, we integrate geochemical and technological approaches to inform on dimensions of artefact movement and, by extension,

* Corresponding author.
E-mail address: rphi025@aucklanduni.ac.nz (R.S. Phillipps).

http://dx.doi.org/10.1016/j.jaa.2016.04.004
0278-4165/

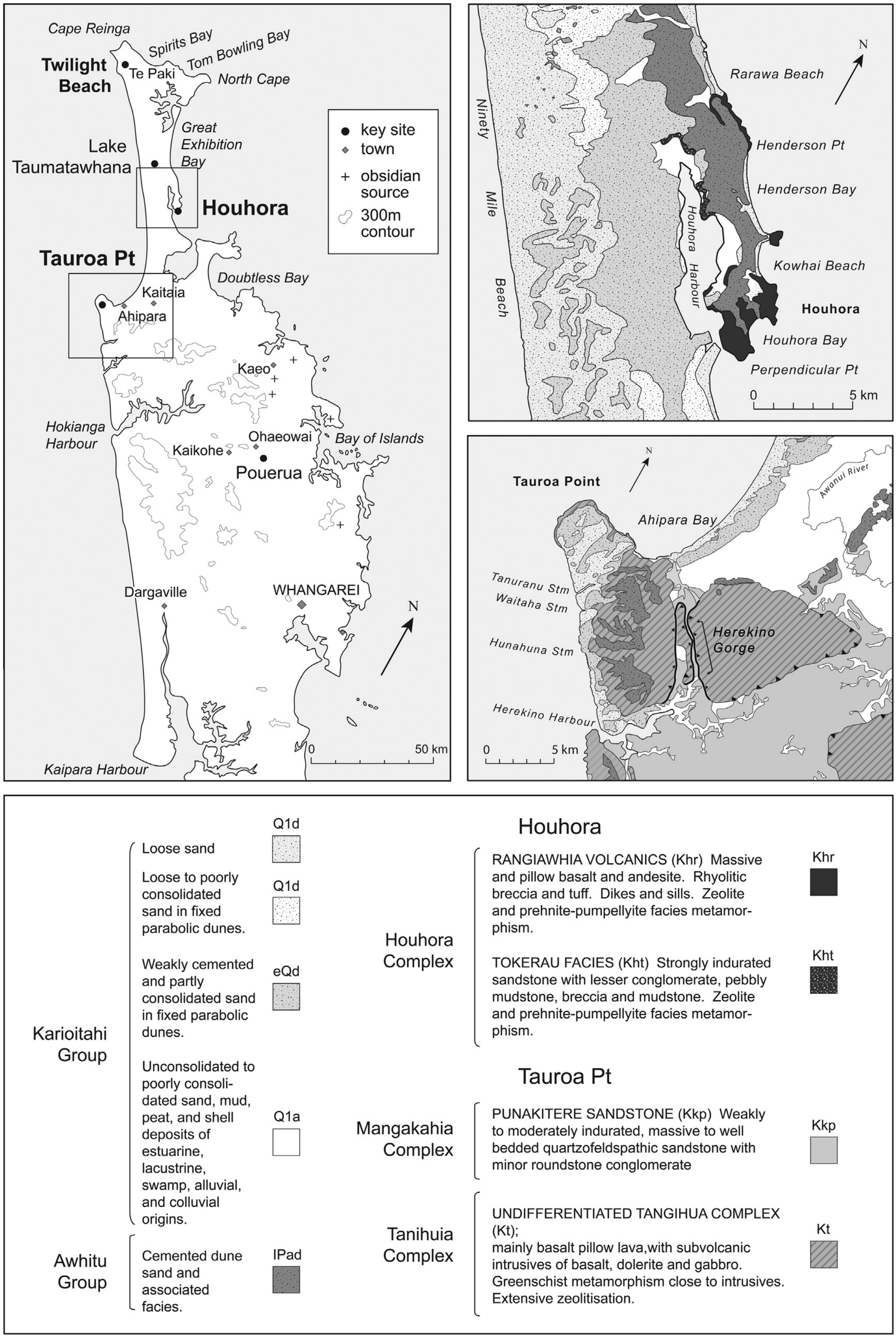

Fig. 1. Geological map of Northland, New Zealand showing rock sources and archaeological sites discussed in the text (after Isaac, 1996).

population mobility in a tribal Polynesian society that engaged in both foraging and agriculture, the New Zealand Māori (Fig. 1).

Early 20th century ethnographer Raymond Firth (1929), and other scholars since (e.g., Allen, 1996; Phillips, 2000; Walter et al., 2006), describe Māori socio-settlement systems at western contact as complex and dynamic. Māori social groups varied considerably in size and composition, and underwent frequent fusion and fission in response to agricultural cycles, seasonal foraging needs, social activities, and intertribal conflicts. Moreover, individual and group mobility was not necessarily constrained by formally recognised socio-political boundaries, as Māori periodically drew on bilateral kin connections in their efforts to acquire food, maintain social relationships and garner political support (Allen, 1996). The historical development of this ethnographic endpoint, however, is not well understood.

Drawing on archaeological records, Anderson and Smith (1996) outlined one component of early prehistoric Māori settlements, which was prominent along the eastern seaboard of the South Island, semi-permanent or "transient" villages. One of the best known examples is the 14th-century settlement of Shag River Mouth where detailed analyses indicate an initial focus on abundant but vulnerable faunal resources, followed by resource depression, prey-switching, and eventually site abandonment (Anderson et al., 1996; Nagaoka, 2002a, 2002b). Relocation to new, unexploited coastal settings followed, and over time resulted in a pattern of serially-occupied settlements which were relatively permanent (i.e., continuous occupation over multiple annual cycles by some portion of the population) but short-lived (i.e., a few decades) (Anderson and Smith, 1996). As the authors discuss, the village was effectively the hub of a "system of largely localised [population] mobility" (Anderson and Smith, 1996: 369); associated short-term settlement components included butchery camps, plant processing sites, and stone extraction areas. Over time, unexploited territories became increasingly rare on the South Island, and key faunal resources went extinct (i.e., species of the flightless Dinornithiformes or moa) (Anderson, 1989) or were considerably reduced (e.g., New Zealand fur seals) (Smith, 1985). By late prehistory, South Island settlement mobility was geographically reduced, with communities being sustained by population mobility, combined with long-distance exchange of favoured resources (Anderson and Smith, 1996: 369).

In the warmer north, Māori settlement–subsistence patterns may have been more variable, structured by differences in the composition and distribution of wild resources, as well as climate conditions that were conducive to agriculture (Allen, 2012; Irwin, 2013). Archaeologically, large population aggregations (i.e., "villages") are sometimes indicated, and sometimes of a permanent (i.e., not seasonal) nature, as for example the early 14th century site of Houhora (Furey, 2002: 35) and the late 17th century settlement of Kohika (Irwin, 2004). But more generally, considerable variation is suggested on the North Island in terms of settlement size, duration, and focus. Records from Harataonga Beach, Great Barrier Island, for example, suggest this early 14th century occupation was a small, permanent but short-lived hamlet (i.e., comprised of a few households) and associated with a diverse set of subsistence activities, including both foraging and agriculture (Allen, 2012). By late prehistory, however, this configuration had been replaced by multiple, short-lived, probably seasonal occupations centred on extraction of marine resources, possibly in association with more permanent settlements at other nearby localities. As the foregoing evidence indicates, a diversity of settlement components, mobility patterns and settlement relationships are suggested for prehistoric New Zealand.

Stone artefacts, being both portable and durable, are an important tool for investigating the nature of different settlement components, interactions between them, and variability in human movement across New Zealand landscapes over time. In Polynesia generally, there has been considerable success in the use of petrographic and geochemical analyses of stone artefacts to identify major stone sources and patterns of interaction and mobility (e.g., Allen and Johnson, 1997; Best et al., 1992; Irwin and Holdaway, 1996; McAlister, 2011; Mills et al., 2008; Prickett, 1979; Sheppard et al., 2011; Weisler, 1997, 1998, 2008). Technological studies of stone tools other than adzes, however, have been more limited (e.g., Brassey, 1985; Holdaway, 2004; Jones, 1984; Shawcross, 1964; Turner, 2000) and use of technological attributes to understand patterns of mobility is largely unexplored (but see McCoy and Carpenter, 2014). New Zealand provides an especially interesting context in which to apply and integrate these two analytic approaches. Foremost, against the backdrop of complexity suggested by historical and ethnographic observations of Māori, two additional factors provide some analytical control. First, New Zealand was settled in the 13th century AD by closely related peoples from central East Polynesia (Davidson, 1987; Walter et al., 2010), constraining variation in stone artefact technological and production traditions. Also, given the difficulty of voyaging between New Zealand and the central East Polynesia region, post-settlement contact with groups elsewhere was most likely minimal. Second, the large geographic scale and complex continental geology of New Zealand exceeds that of all other Polynesian islands, therein facilitating considerations of mobility through stone artefact sourcing. Several raw materials have quite limited geographic distributions (Davidson, 1981, 1987), as for example obsidian, which has been well studied (e.g., Jones, 2000; McCoy et al., 2010; Moore, 2012; Sheppard, 2004; Walter et al., 2010), while others are widely dispersed and more ambiguous with respect to origin, such as chert.

In this analysis, we focus on an early (~late 14th century AD) occupation at Tauroa Point, Northland (Fig. 1) (Allen, 2006a, 2006b). We consider human *movement* through: (1) the production, use and transport of stone artefacts to and from other locations; and (2) evidence for occupation duration. Initially, raw materials are evaluated in terms of their geological sources, taking into account that distance to source might affect the costs and use of a given raw material. To this end, we categorise artefact raw materials as 'regional' (Northland; roughly within 200 km) versus 'extra regional' (beyond Northland or >200 km) (see Fig. 1). Notably this approach recently has been critiqued in the New Zealand literature because direct access is inferred but cannot be demonstrated (e.g., McCoy and Carpenter, 2014; Moore, 2012; Moore and Coster, 2015). Nonetheless, the distinction is heuristically useful in considering how the distance of utilised geological sources co-varies with archaeological abundance, and variation in cultural treatments, specifically stone reduction, use and discard. Differential use of raw materials can then be used to model different forms of access to specific sources (e.g., direct access or through exchange) and alternatives assessed against other lines of evidence. In the present case, the geochemical results are complemented by a technological assessment of assemblage completeness, which also helps identify stone artefact transport patterns and occupation duration. While the Tauroa Point occupation is admittedly only one node in a complex and dynamic settlement system, analysis of the patterns of stone artefact production, use and discard at this location enables us to model activities which took place elsewhere, either before or after the Tauroa occupation. In this respect, Tauroa Point offers insights into aspects of *mobility* of the wider settlement system. In applying this combination of analytical methods that are rarely integrated in Pacific stone artefact studies our aim is to contribute towards more robust and nuanced understandings of spatio-temporal variability (or homogeneity, *sensu* Walter et al., 2010) in Māori mobility patterns and settlement dynamics.

2. Background to Tauroa Point assemblage

Tauroa Point is located on the northwest coast of the North Island, south of Ahipara Beach (Fig. 1). The area is distinguished by an extensive intertidal rock platform which is rich in traditional Māori food resources, including several species of fish, shellfish, and in the past a variety of sea mammals. The assemblage considered here derives from Site N05/302, where a 42 m^2 excavation by Department of Conservation staff in 1992 exposed two strata with a number of large and small fire features, post holes, pits, stone artefacts and faunal remains (Allen, 2006a). This large excavation was augmented by additional tests and systematic collection of eroding surface materials made in 2003 (Allen, 2006b). Excavations show that the stone artefacts derive from the initial occupation, dated to ~late 14th century AD, as discussed in Allen, 2006b (see also Allen, 2006a). This early occupation involved a variety of activities, including gathering of marine resources, food processing (e.g., cooking and possibly meat drying), production of fishhooks, and stone-working. Processing and consumption of seal, bird, and small whale took place, while remains of domesticated dog suggested its use as a food as well (Allen, 2006b). The stone artefact collection analysed here consists of materials from both the 1992 ($n = 1210$) and 2003 ($n = 254$) studies.

3. Methods

3.1. Stone sourcing

Geochemical analysis of the Tauroa Point obsidian and fine-grained volcanic (FGV) specimens was carried out at the Anthropology Department, University of Auckland, using a Bruker Tracer III SD portable X-ray Fluorescence analyser (pXRF). The instrument employs an X-ray tube with a Rh target and a 10 mm^2 silicon drift detector (SDD) with a typical resolution of 145 eV at 100,000 cps. The Tracer III SD is supplied with an in-built obsidian calibration based on 40 samples, mostly from North American sources (see Glascock and Ferguson, 2012; Speakman, 2012). Although in-built pXRF calibrations often perform well and have been used for previous obsidian studies in New Zealand (McCoy and Carpenter, 2014; McCoy et al., 2014; Sheppard et al., 2011), several New Zealand sources possess trace element concentrations that exceed the range of Bruker's in-built calibration. For example, the Kaeo source in Northland typically contains around 2000 ppm of Zr and 650 ppm of Rb, both of which are approximately twice the upper limits of the Bruker calibration range. For this reason, an empirical calibration using Bruker's S1CalProcess software was used for this study.

Eight samples were included in the obsidian calibration, one international standard (NIST SRM 278) and seven New Zealand obsidian specimens that were previously analysed using Wavelength Dispersive X-ray Fluorescence (WDXRF) by John Wilmshurst at the University of Auckland Geology Department. All samples were analysed in an air path through a filter composed of 12 mil (304.8 μm) Al and 1 mil (25.4 μm) Ti (Bruker's "yellow" filter), with an X-ray tube setting of 40 keV at 30 μA. Calibration samples were analysed five times each for 200 s, while reference specimens and artefacts were analysed twice, each for 100 s per analysis to check for consistency, and the results averaged. A total of 12 elements were calculated as parts-per-million (ppm) concentrations (K, Ca, Mn, Fe, Zn, Pb, Th, Rb, Sr, Y, Zr, Nb). The NIST SRM 278 obsidian standard was run at the beginning and end of each analysis session to monitor instrument precision; Table 1 provides both the given and calculated values for this standard. Similar methods were used for analysing the archaeological FGV specimens. The instrument was calibrated using a set of 24 international and University of Auckland Anthropology lab "in-house" FGV standards, including BHVO-1, GSP-2, JA-1, JA-2, JA-3, JB-1a, JB-2, and JB-3. In this case, a total of 17 elements were quantified and the major element concentrations were calculated as oxide percentages (SiO_2, K_2O, CaO, TiO_2, MnO, Fe_2O_3, Ni, Cu, Zn, Ga, Pb, Th, Rb, Sr, Y, Zr, Nb).

Table 1
Comparison of the given and calculated values for 10 analysis of the NIST SRM 278 standard. All values are reported as parts-per-million (ppm).

Element	Given value[a]	Calculated value		
		Mean	SD	%RSD
K	34,534	34,470	150	0.44
Ca	7025	6908	94	1.36
Mn	403	402	2.6	0.65
Fe	14,269	14,552	27	0.19
Zn	55	48	1.0	2.08
Pb	16.4	16	0.9	5.63
Th	12.4	14	0.5	3.57
Rb	127.5	128	0.9	0.70
Sr	63.5	65	0.5	0.77
Y	39	39	0.9	2.31
Zr	290	286	1.3	0.45
Nb	18	18	0.9	5.00

[a] Data from Govindaraju (1994).

3.2. Technological analysis

The technological analysis focused on the four common raw material types, chert, silicified tuff, obsidian and fine-grained volcanics, and was aimed at understanding: (1) raw material reduction; (2) variation in artefact use and discard. Artefacts were classified as cores, flakes (including chips), or tools (modified flakes and cores) and a variety of attributes measured following Holdaway (2004) and Holdaway and Stern (2004). Shatter, flakes, and flake fragments less than 15 mm in length were classified as chips. Measurements were taken on all artefacts to the nearest millimetre using digital callipers, with direct entry into a database using E4 software, initially developed by McPherron and Holdaway (1996) for stone artefacts. The proportion of cortex, if present, also was recorded for all artefacts types. Proportions of cortex were recorded as follows: none, less than 50% coverage of dorsal surface, more than 50% coverage of dorsal surface, or complete coverage of dorsal surface.

Cores were classified by the direction of worked faces (following Holdaway, 2004). Uni-directional cores are defined as artefacts worked from one platform, while bi-directional cores are those where flakes were removed from two platforms. Multi-directional cores are worked from three or more faces and radial cores are those worked from multiple platforms at right angles to one another; these two core categories indicate intensive use. Tranchet cores are flakes which have functioned as cores, specifically those where flaking was perpendicular to the long axis and produced a truncated flake. Test cores are defined as those with only one flake removed, which may indicate the testing of raw material for further use. Volume was determined using the equation for the calculation of the volume of a sphere ($4/3\pi r^2$) (Dibble et al., 2005; Douglass et al., 2008; Phillipps, 2012). Both core platform attributes and the direction of dorsal (exterior surface) flake removal was recorded. This allowed cores to be categorised with respect to degree of use and rotation. Attributes recorded for flakes included size and direction of dorsal scars. Tools were recognised by degree and type of retouch.

Tool use-life potentially informs on the duration of an occupation, as well as the nature of on-site activities. Tools with ground bevels, such as adzes, often have undergone multiple episodes of re-sharpening and may be used and curated over very long periods of time. Flake tools typically have shorter use-lives but may remain in use long enough to be re-sharpened before being discarded. As a general principle, the longer an artefact's potential use-life, the less likely it is to be discarded. Consequently, the diversity and proportions of artefacts in an assemblage with long use-lives are often taken as indicators of the degree of settlement permanence (Shott, 1989). Artefact diversity also suggests a greater range of on-site activities, which in turn suggests a relatively extended occupation (Bamforth and Becker, 2000; Binford, 1978; Kuhn, 1990, 2004; Thomas, 1989). We take as a working hypothesis that a greater abundance of long use-life artefacts (i.e., tools) equates with a comparatively longer period of site occupation.

4. Raw material sourcing results

At least 13 different kinds of rock were identified at Tauroa Point (Table 2). The array of metamorphic, sedimentary and volcanic rock types found in the Tauroa Point site would have provided the early occupants with raw materials suitable for a wide range of functions, including percussion, chipping, grinding and smoothing, cutting, and drilling. Seven of the rock types are attributable to specific geological sources, which vary considerably with respect to distance from the site. A number of the sources are extra regional and these include Coromandel Peninsula obsidian ($n = 2$), Coromandel basalt ($n = 40$), and Mayor Island obsidian ($n = 147$) (Table 12). The majority of the assemblage is, however, derived from sources that are likely located within the Northland region. These include chert, andesite/dacite and basalt specimens, all which occur in exposures at Herekino Gorge and other areas of the Tangihua Complex (Fig. 1). As suggested above, Tauroa Māori also imported these stone types from the wider region. The four most frequent raw material types, each comprising >5% of the assemblage by count or weight, were obsidian, chert, fine-grained basalt and silicified tuff. These materials are considered in more detail below in terms of their likely places of origin and abundances.

4.1. Obsidian artefacts

A number of obsidian sources have been identified in New Zealand, with Sheppard et al. (2011) listing 27. However, several of these sources are of a very poor quality for artefact manufacture (Moore, 2012). Additionally, some sources are geographically close and compositionally similar, making it difficult to confidently separate them by geochemical analysis. These include five sources near Lake Taupo (Ben Lomond, Maraetai, Ongaroto, Whangamata Fault and Whakamaru) only the last of which is geochemically distinct. Also, several sources around Lake Rotorua (Ngongotaha, Hemo Gorge, Tarawera, Lake Rotokawau, and Lake Okataina) also are too similar to separate geochemically. The nearby Lake Rotoiti source is, however, distinct. For this analysis, 18 obsidian geochemical source groups were considered, and 192 reference samples used to characterise these sources (Fig. 2).

Table 2
Frequency of raw material types: Total number of artefacts and weight for each stone type.

Material	*N*	%	Weight (g)	%
Andesite/Dacite	14	0.96	3.12	0.03
Basalt	234	15.98	1140.12	9.26
Chert	731	49.93	7978.33	64.78
Diorite	1	0.07	138.19	1.12
Gabbro	2	0.14	210.34	1.71
Greywacke	4	0.27	41.5	0.34
Obsidian	192	13.11	373.05	3.03
Pwood	3	0.20	8.9	0.07
Quartz	26	1.78	89.97	0.73
Sandstone	5	0.34	24.96	0.20
Shale	1	0.07	1.38	0.01
Tuff	233	15.92	2082.8	16.91
Unidentified	18	1.23	224.04	2.18
Total	1464	100	12316.7	100

Obsidian is the fourth most common raw material type ($n = 192$) at 13.1% based on count (weight = 3.0%) (Table 2). To assign the archaeological specimens to a source, two methods were used; a simple graphical analysis using bivariate scatterplots, and multivariate Linear Discriminant Function Analysis (LDA). Because of the large number of potential obsidian sources, it is difficult to show their separation clearly on a single scatterplot. A more effective solution is to use a recursive approach and divide the analysis into several stages (see Baxter, 1994; Hancock et al., 2008). A plot of Log_{10} (Rb/Sr) against Log_{10} (Zr/Sr) separates the reference specimens into six groups (Fig. 3). Four sources, Mayor Island, Kaeo, Weta and Waihi, are easily distinguished, while the remainder cluster into two overlapping groups (Groups 1 and 2). The majority of the archaeological specimens are associated with two of the distinct sources; 149 specimens plot with the Mayor Island reference samples and a further 43 with the Kaeo (Northland) reference samples. Of the three remaining artefacts, two are associated with the Group 1 reference samples and one clusters with the sources in Group 2.

The sources that comprised Group 1 in the previous plot can be discriminated using different ratios of the same three elements: a plot of (Sr/Zr) against (Rb/Zr) separates most of the sources but one specimen from Maketu plots near the Taupo Zone samples. This, however, has little bearing on the present analysis, which indicates that the two artefacts in this group (#2239 and #2259) are associated with the Hahei reference samples (Fig. 4a). Analysing the sources in Group 2 requires using additional elements. A plot of Log_{10} (Zr/Y) against Log_{10} (Rb/Pb) separates all six sources in this group, although the two Great Barrier Island sources (Awana and Te Ahumata) plot very close to one another. Again, this does not affect the present analysis, as the single artefact in this group (#2231) plots with the clearly-separated Huruiki reference samples (Fig. 4b).

Linear Discriminant Function Analysis (LDA) was carried out using IBM SPSS (ver. 20) software. Seven elements were used (Pb, Th, Rb, Sr, Y, Zr and Nb), all of which were Log_{10}-transformed to help equalise group variances. The results of the analysis are shown in Table 3. In total, 99% of the reference specimens were classified correctly. One of the two misclassified samples was a specimen from the Great Barrier Island source of Te Ahumata, but was assigned to Awana, a second source on that island. One of the Maketu samples was assigned to the Taupo Zone group. These results concur with the graphical analysis, suggesting that one Maketu reference specimen is an outlier and that the two Great Barrier Island sources are compositionally very similar. All archaeological specimens (100%) were assigned to the same sources as in the previous analysis: 149 to Mayor Island, 43 to Kaeo, two to Hahei and one to Huruiki.

For the 18 sources used in this study, the LDA produced a total of 12 discriminant functions, making it impossible to graphically display the separation of all sources on a single scatterplot. A plot of the first two functions shows clear separation of the same four sources as in the first stage of the previous analysis (i.e., Mayor Island, Kaeo, Weta and Waihi), but clusters the remaining sources together (Fig. 5). To obtain a better graphical representation of these sources, a second LDA was run after removing those four distinct sources and their associated artefacts. This produced the same results as before, along with the same two misclassifications, but shows the separation of the included sources more clearly (Fig. 6, Table 4).

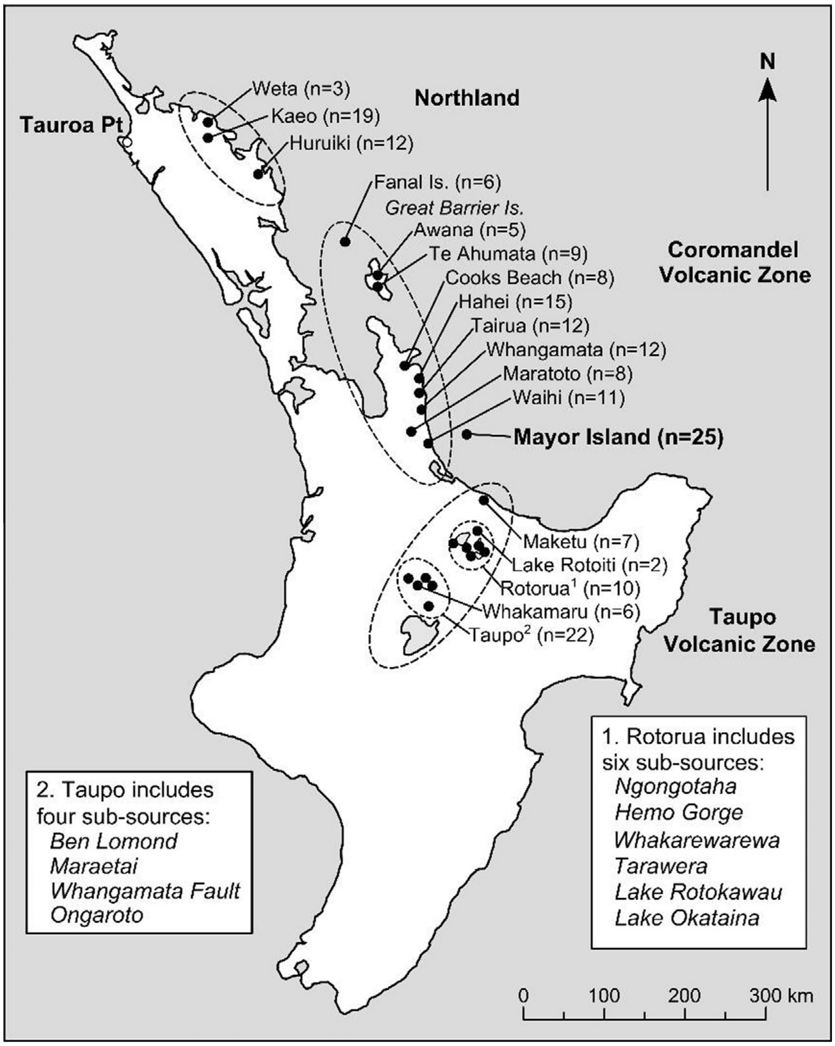

Fig. 2. Location of the Tauroa Point archaeological site and geological exposures of obsidian on the North Island.

4.2. Fine-grained volcanic (FGV) stone artefacts

Fine-grained volcanic stone, including basalt, greywacke, and andesite/dacite, was the second most common material in the Tauroa assemblage, numerically comprising 16.9% by count (weight = 9.3%). There are two likely sources for the recovered specimens. Basalt is locally available within the Northland Tangihua complex, which extends to Tauroa Point (Fig. 1). Tahanga is a second source of basalt, some 300 km distant on the Coromandel Peninsula; it was regularly used by early prehistoric Māori settlers in the production of flaked adzes and other tools, and widely distributed throughout much of the North Island (Davidson, 1981; Turner, 2000; Walter et al., 2010). It also is well represented at the nearby east coast settlement site of Houhora, on the slopes of Mount Camel (Furey, 2002).

In comparison to obsidians, geochemical information on fine-grained volcanic (FGV) tool stone is limited and the Tahanga Basalt Quarry at Opito Bay in the Coromandel Peninsular being the only source that has been investigated in detail (Felgate, 1993). Despite lacking reference data, geochemical analyses of FGV assemblages can provide useful information about the potential range of resources present. For the present study, a sample of 68 of the 252 FVG artefacts from the Tauroa assemblage was selected and analysed with the aim of representing the range of physical variation in the assemblage (Tables 5 and 6).

Calibration procedures at the University of Auckland have shown that the five heaviest of the 10 major oxides commonly analysed in volcanic stone (i.e., K_2O, CaO, TiO_2, MnO, Fe_2O_3) can be quantified to within approximately 0.2% (0.4% for Fe_2O_3) of certified values using PXRF on the flaked or polished surfaces of FGV artefacts, provided that those surfaces are reasonably uniform and not heavily weathered (see Allen and McAlister, 2013; Charleux et al., 2014). Although the five lightest major oxides (i.e., Na_2O, MgO, Al_2O_3, P_2O_5, SiO_2) often can be detected using PXRF, a combination of air-path attenuation, irregular surface geometry and weathering generally precludes their accurate quantification (see Lundblad et al., 2008). For SiO_2, the main constituent of most volcanic stone, our research indicates that non-destructive analyses of uniform artefact surfaces can consistently obtain results within approximately 3.5% of WDXRF values. While this degree of accuracy is not useful for discriminating among specific sources, SiO_2 values can provide a convenient, albeit somewhat coarse, indication of potential stone types (and exclude others), particularly for samples that cannot readily be distinguished in hand specimen. For example, basic and ultrabasic rocks (e.g., basalts and basanites) contain less than 52% SiO_2, acid rocks (e.g., dacites and rhyolites) contain over 63% SiO_2 and intermediate rocks (e.g., andesites) fall in between these values (see Le Maitre et al., 2002). Because of the paucity of compositional information for fine-grained volcanic sources of archaeological tool-stone in

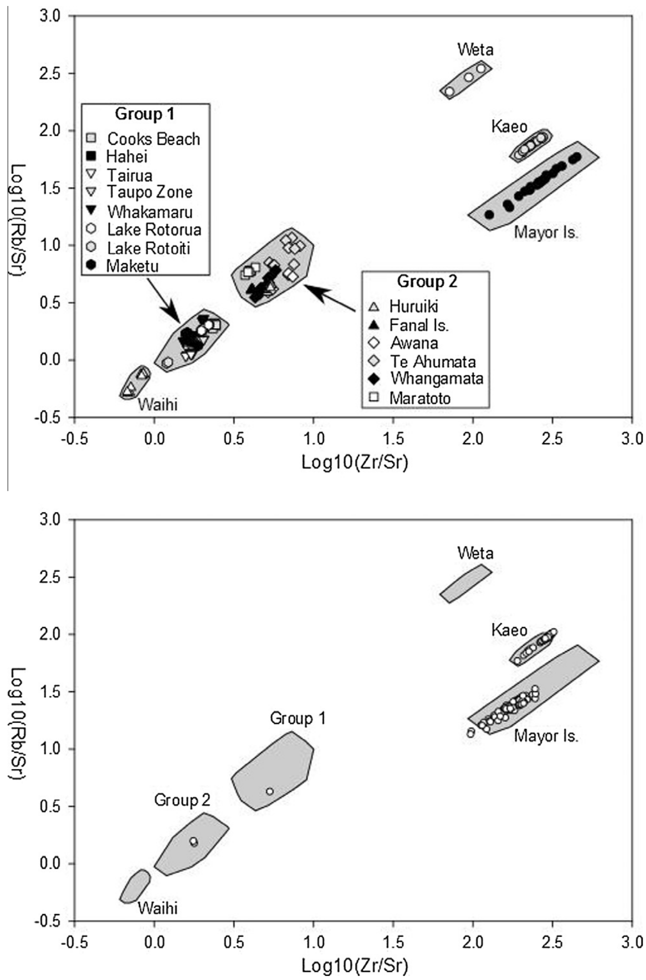

Fig. 3. Scatterplot of Log_{10} (Zr/Sr) against Log_{10} (Rb/Sr). The upper figure shows the reference specimens and the lower figure the artefacts. Groups are separated by convex hulls.

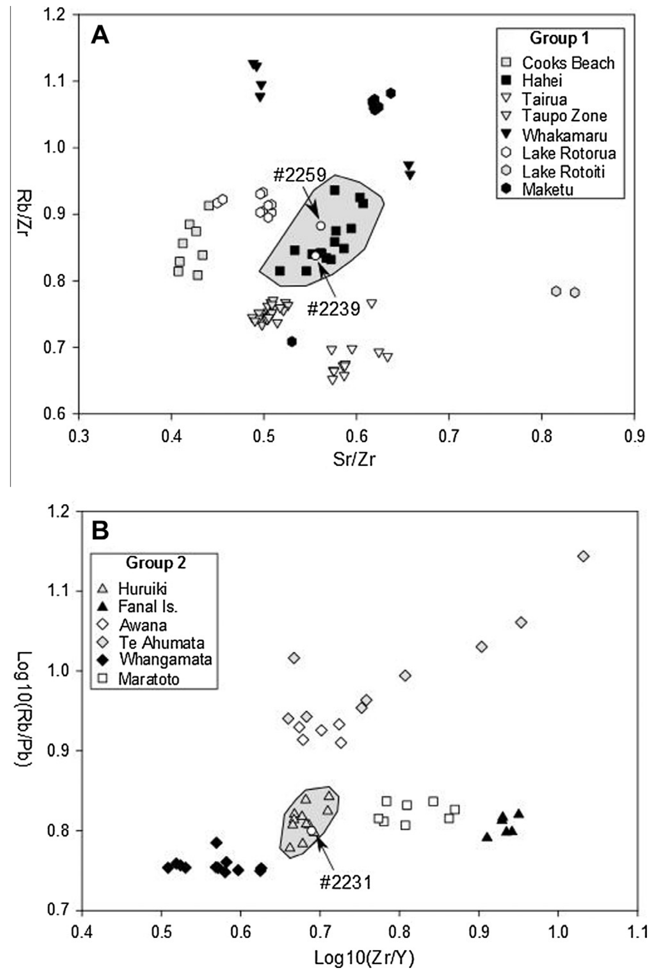

Fig. 4. Scatterplots of specimens included in Group 1 (upper) and Group 2 (lower) in Fig. 3. Artefacts are shown as open circles and their sample numbers indicated. The Huruiki and Hahei sources are enclosed in convex hulls.

New Zealand, it is useful to examine the chemical data using several exploratory methods. Pairwise plots of major elements (Fig. 7a) and trace elements (Fig. 7b) indicate that the specimens cluster into at least three chemically-distinct groups (Groups 1, 2, and 3), two of which potentially contain multiple sources (Groups 1 and 3). To further assess these initial source attributions, two multivariate techniques were employed; Principal Component Analysis (PCA) was carried out using log_{10}-transformed and standardised data for 11 major and trace elements (K_2O, CaO, TiO_2, Fe_2O_3, Ni, Zn, Rb, Sr, Y, Zr, Nb). The six remaining elements (SiO_2, MnO, Cu, Ga, Pb, Th) were excluded because they were considered either too inaccurate or too close to the detection limits of the PXRF instrument to contribute meaningful information. A plot of the first two (un-rotated) principal components produced a pattern similar to the bivariate plots (Fig. 7c). Several permutations of Hierarchical Clustering (HCL) analysis also were examined, most of which produced similar results. A representative analysis, employing the same dataset as in the PCA analysis and using Ward's Method on Euclidean distances, is shown here (Fig. 7d). The IBM SPSS (ver. 20) statistics package was used for the PCA and HCL analyses.

The Group 1 and Group 2 specimens in this study produced SiO_2 values between 46% and 56%, which is within the range obtained for comparable PXRF analyses of basalt reference samples. Compositional data from the Tahanga Quarry generated for this study and taken from Felgate's (1993) previous work are consistent with the Group 1a sample, indicating that these artefacts likely derive from this source (Table 5). Groups 1b and 1c possess similar compositions to Group 1a for most elements but have concentrations of Sr and Zr beyond the ranges of the Tahanga reference specimens, suggesting either that they derive from a Tahanga subsource not represented in the reference data or were sourced from elsewhere. The specimens identified as Group 2 share a relatively homogenous geochemistry and all four analyses demonstrate that they form a distinct group. The major element compositions are in the ranges that would be expected for basaltic rock but, without reference data for archaeological basalt sources other than Tahanga, it is not possible to identify their geographical location.

The origin of the Group 3 artefacts also is inconclusive. These specimens possess SiO_2 concentrations ranging from 55% to 66% and comparatively low amounts of the better-quantified oxides Fe_2O_3 and CaO, suggesting that they are not basalts but rather a highly silicic stone, such as andesite or dacite. Although andesites and dacites are typically lighter in colour than basalts, some deposits are similar enough to basalts to be indistinguishable in hand specimens (P. Sheppard, pers comm. 2014). Shackley (2011), for example, has recently identified several dacite sources of tool stone in New Mexico using geochemical analysis that were previously misidentified as basalts based on in-hand specimen. While the Group 3 specimens share a similar major element composition, there is considerable variation in their trace element concentrations.

Table 3
Results of the LDA.

Actual group	Predicted group																	
	Weta	Kaeo	Huruiki	Mayor Is.	Fanal Is.	Awana	Te Ahumata	Cooks Beach	Hahei	Tairua	Whangamata	Maratoto	Waihi	Taupo Zone	Whakamaru	Lake Rotorua	Lake Rotoiti	Maketu	Total
Weta	3																		3
Kaeo		19																	19
Huruiki			12																12
Mayor Is.				25															25
Fanal Is.					6														6
Awana						5													5
Te Ahumata						1	8												9
Cooks Beach								8											8
Hahei									15										15
Tairua										12									12
Whangamata											12								12
Maratoto												8							8
Waihi													11						11
Taupo Zone														22					22
Whakamaru															6				6
Lake Rotorua																10			10
Lake Rotoiti																	2		2
Maketu														1				6	7
Artefacts		43	1	149					2										195

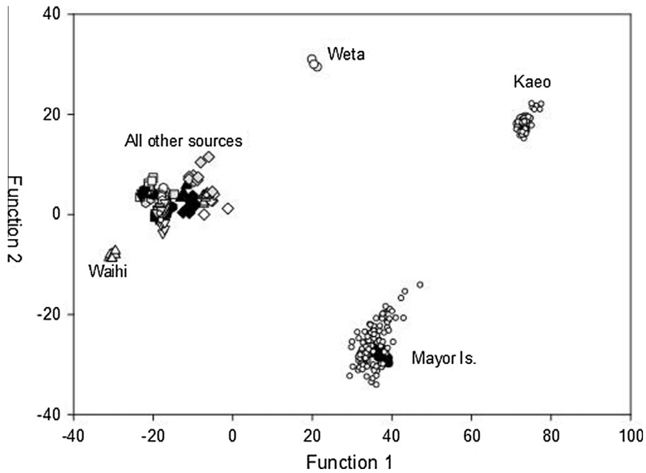

Fig. 5. Scatterplot of the first two LDA functions for all specimens. Artefacts are shown as open circles.

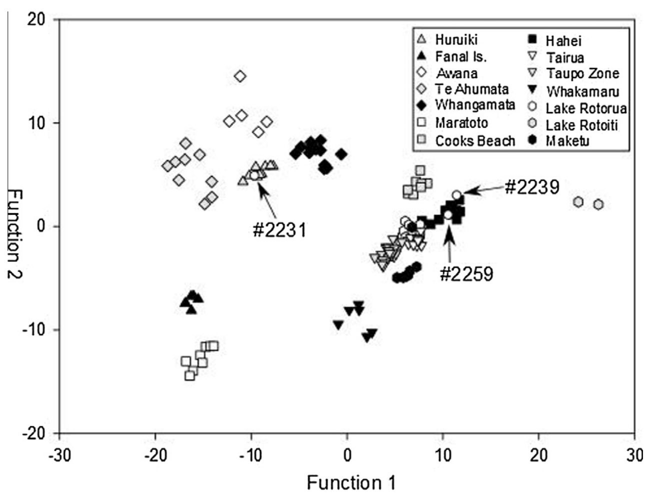

Fig. 6. Scatterplot of the first two LDA functions, with the Mayor Island, Kaeo, Weta and Waihi specimens omitted.

Table 4
Frequency of sourced obsidian.

Source	*N*	%	Weight (g)	%
Hahei	2	1.04	0.24	0.06
Huruiki	1	0.52	6.92	1.85
Kaeo	42	21.88	113.77	30.50
Mayor Island	147	76.56	252.12	67.58
Total	192	100	373.05	100.00

Although our analysis of the FGV stone artefacts is limited by a dearth of reference materials, we can conclude that at least three sources, and possibly as many as seven, are represented in the Tauroa lithic assemblage. Group 1a is physically and geochemically consistent with Tahanga basalt, a source on the east coast of the North Island and approximately 300 km south of Tauroa. It is, however, not possible to identify the locations of the other groups at present. Geological studies indicate that a variety of volcanic materials, including basalts, dacites, rhyolites and andesites, occur in the Northland area, but none of the geochemical data from these studies provide a close match to the groups in our sample (e.g., Booden, 2011; Smith et al., 1993).

4.3. Chert artefacts

Chert was the most common lithic material at the site, representing 49.8% of the assemblage by specimen count and 64.5% by weight (Fig. 8). Water-deposited chert cobbles are present in the vicinity of the site and other nearby sources include Herekino Gorge exposures, about 10 km to the south. The Houhora Complex, some 45 km distant, is another relatively nearby locality and one where greywacke and argillite also occur (see Fig. 1). Cherts are difficult to source precisely, being widely distributed and geochemically indistinct (see Sheppard, 2004). However, based on physical characteristics (i.e., colour, grain and inclusions), the Tauroa chert artefacts were sorted into three groups and attributed to source locations (Table 7).

The first group ($n = 629$) is consistent with chert which occurs near the site as water-deposited cobbles (Table 7); however, additional possible source locations include the Houhora Complex. The second group consists of 22 artefacts which have a fabric distinct from other known Northland cherts. When thin-sectioned, one example contained a radiolarian. While not unusual for cherts in general, this attribute makes it distinct from the other two chert sources. The source locality might be exposures in Herekino Gorge where the Ahipara massif is visible (Murray Gregory, pers. comm. 2003). The third group of 80 artefacts matches a distinctive chert reference material collected from the Waiere Steam near Kaeo as part of a Northland chert reference collection housed in at the University of Auckland, approximately 70 km from Tauroa Point.

4.4. Tuff artefacts

At 15.92% (weight = 16.91%), silicified volcanic tuff was the third most common raw material type. Based on similarities in colour and texture, all of the artefacts most likely derive from the same deposit. The location of the silicified volcanic tuff source is not known, but when examined in thin-section, the material proved to be sandstone quartz, with quartz grain lithic inclusions and a small amount of feldspar. The Houhora Complex displays geological sediments that would allow for the development of silicified sandstone, as there is quartz-feldspar sandstone, interbedded with an argillite mudstone that is closely fractured and quartz-veined (Fig. 1).

5. Technological results

Technological studies inform on tool production, use, discard, and transport into and out of sites (*sensu* Holdaway and Douglass, 2012), offering a more robust picture of how prehistoric social groups utilised resources and moved across landscapes. A consideration of production strategies across different raw materials, especially measures of the intensity of raw material usage, complements the foregoing geochemical analyses and may inform on raw material accessibility. Technological analyses also help distinguish local production and discard from use of imported finished or nearly finished tools. Removal of local products for use and discard elsewhere also may be discerned, providing preliminary insights into activities elsewhere in the region. Finally, information on tool diversity, abundance and use-lives informs on the nature and duration of on-site activities. The technological study which follows was primarily aimed at understanding stone artefact use at Tauroa Point as it relates to mobility.

5.1. Raw material use and artefact movement

The size and type of discarded cores can be compared to the number and size of recovered flakes to ascertain if all of the flake

Table 5
Summary data (means and standard deviations) for fine-grained volcanic stone Tauroa artefacts separated by geochemical group. Data from the Tahanga basalt quarry are also included for comparison with our Group 1a.

Group *Count*		Tahanga basalt[a] *27* $\mu \pm 1\sigma$	1a *40* $\mu \pm 1\sigma$	1b *5* $\mu \pm 1\sigma$	1c *1* Value	2 *12* $\mu \pm 1\sigma$	3a *12* $\mu \pm 1\sigma$	3b *2* $\mu \pm 1\sigma$	3c *1* Value
SiO_2[b]	%	53 ± 1.6	51 ± 2.4	52 ± 3.5	54	53 ± 2.5	62 ± 3.5	59 ± 0.2	63
K_2O	%	0.7 ± 0.3	0.7 ± 0.2	0.6 ± 0.2	0.2	3.0 ± 0.3	3.0 ± 0.2	3.3 ± 0.0	3.4
CaO	%	8.9 ± 0.6	9.1 ± 0.8	10.0 ± 0.5	11.8	7.3 ± 0.6	3.6 ± 0.4	2.0 ± 0.0	3.3
TiO_2	%	1.1 ± 0.1	1.2 ± 0.1	1.0 ± 0.2	1.3	1.3 ± 0.0	0.6 ± 0.1	0.6 ± 0.0	0.6
MnO	%	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.3	0.2 ± 0.0	0.1 ± 0.0	0.2 ± 0.1	0.1
Fe_2O_3	%	10.2 ± 0.6	10.3 ± 0.6	10.5 ± 0.9	10.1	12.0 ± 0.6	5.9 ± 0.6	4.8 ± 0.7	5.7
Ni	ppm	10 ± 3	55 ± 31	42 ± 18	46	19 ± 2	11 ± 4	26 ± 16	14
Cu	ppm	27 ± 6	25 ± 7	19 ± 2	21	48 ± 7	8 ± 4	26 ± 30	11
Zn	ppm	91 ± 6	100 ± 14	82 ± 19	83	101 ± 12	76 ± 17	92 ± 36	79
Ga	ppm	22 ± 1	20 ± 1	19 ± 2	18	23 ± 0	20 ± 1	20 ± 1	21
Pb	ppm	10 ± 4	21 ± 14	2 ± 1	15	11 ± 2	16 ± 9	5 ± 1	5
Th	ppm	3 ± 3	4 ± 1	3 ± 0	3	16 ± 1	9 ± 1	15 ± 1	13
Rb	ppm	17 ± 3	15 ± 3	11 ± 1	17	93 ± 7	79 ± 8	120 ± 3	109
Sr	ppm	311 ± 48	299 ± 38	138 ± 17	509	690 ± 20	369 ± 58	157 ± 1	494
Y	ppm	27 ± 7	30 ± 5	23 ± 2	31	36 ± 4	30 ± 5	17 ± 5	28
Zr	ppm	98 ± 10	94 ± 7	61 ± 5	89	134 ± 5	203 ± 17	123 ± 1	155
Nb	ppm	5 ± 1	3 ± 1	1 ± 1	3	16 ± 1	9 ± 2	17 ± 2	10

[a] Tahanga basalt summary data are from Felgate (1993) (n = 23) and PXRF analyses conducted for this study (n = 4).
[b] PXRF values for SiO_2 are semi-quantitative with an estimated error of ca. ±3.5%.

Table 6
Summary of fine-grained volcanic stone sources.

Source group	*N*	%	Weight	%
1a (basalt Tahanga)	38	55.88	389.09	43.48
1b (basalt)	3	4.41	4.43	0.50
1c (basalt)	1	1.47	0.87	0.10
2 (basalt)	12	17.65	472.51	52.81
3a (andesite/dacite)	11	16.18	24	2.68
3b (andesite/dacite)	2	2.94	1.1	0.12
3c (andesite/dacite)	1	1.47	2.8	0.31
Total sourced	68	100	894.8	100

material produced was discarded at the location of occupation, or if artefacts were removed for use elsewhere, thus reflecting human mobility. Core reduction attributes reflect a combination of original raw material size, shape and form (e.g., corticated nodules versus tabular blanks) and intensity of use. At Tauroa, multi-directional cores were the most frequent (53.7%), followed by uni-directional cores (24.4%) (Table 8). Differences were observed across raw material types, with multi-directional cores being most common in the obsidian assemblage. Chert and tuff cores, in contrast, were nearly equally represented by uni- and multi-directional forms.

The size of expended cores also can reveal patterns that relate to differential treatment of raw materials and core use-life, but must be considered against raw material properties. At Tauroa, obsidian cores were smaller than those of chert or tuff, suggesting heavier reduction. Core size and type are similar for both Northland and extra-regional obsidians, and may suggest a similar overall strategy of obsidian reduction (see also Holdaway, 2004). On average, obsidian cores are the smallest and there is little variability in core size across the different core types (Table 9). Chert cores are the next smallest in size, followed by those of tuff, where there is considerably more variability in mean core volume across different core types, even when only the more common forms are considered. These findings suggest that for obsidian there was a minimum core size, after which flaking became inefficient. For chert and tuff cores, in contrast, discard apparently related to some feature other than size.

In sum, the evidence suggests that cores were typically worked from more than one platform and often intensively reduced prior to being discarded. Obsidian cores were more intensively worked, and discarded at small sizes, relative to those of chert or tuff, a pattern that held for both regional and extra-regional obsidians. Given the heavy reduction of obsidian cores, large numbers of flakes should have been present, including small flakes which might reflect core rotation.

Following Holdaway (2004), flakes were classified according to the direction of their dorsal scars, with four dorsal scar patterns recognised (Table 10): uni-directional, bi-directional, sub-radial (3 directions) and radial (4 or more directions). The number of scar directions relates directly to core rotation and higher values reflect more frequent rotation and usually more intensive use of a given raw material. The use of a particular reduction strategy also could relate to raw material properties, including original form. The Tauroa Point flake dorsal scar data suggest frequent core rotation, although perhaps not as intensive as the core data discussed above in the case of obsidian artefacts.

Average flake size in relation to dorsal scar type also is instructive (Table 10). In the present analysis, complete flake size was larger for flakes from more heavily rotated cores (i.e., those with multi-directional dorsal scars). This suggests that larger cores were rotated before being discarded, whereas smaller cores were not. However, when core volume is considered (Table 9), it appears this may only be true of obsidian.

The large obsidian flakes have evidence of frequent rotation, while the dorsal scar patterns of small flakes as a whole point to less rotation. These results suggest that large obsidian cores were initially frequently rotated to produce large flakes, while small obsidian cores were less frequently rotated. This is not true in the case of chert and tuff cores, which were rotated more frequently as they became smaller. Comparing the size and evidence for rotation between flakes and cores suggests elements of the assemblage are missing, likely removed to other locations for use. In particular, there are too few large cores and flakes in the assemblage to account for the smaller or reduced artefacts. Examination of flake-to-core ratios across raw materials further supports this proposition. The flake-to-core ratio compares the number of flakes produced for every core. For this assemblage

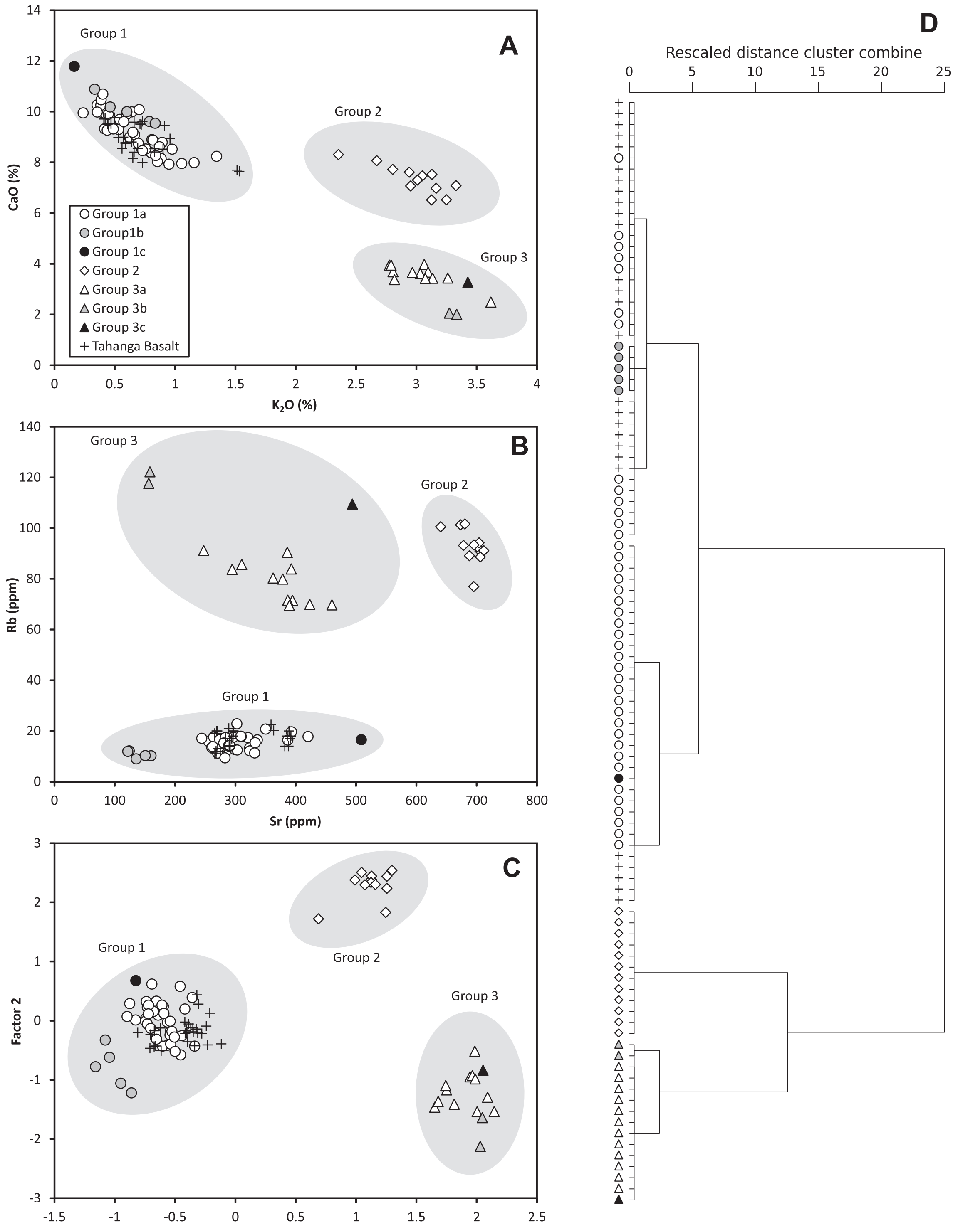

Fig. 7. Geochemical analyses of the fine-grained volcanic stone artefacts: (a) scatterplot of the major elements K_2O against CaO; (b) scatterplot of the trace elements Sr against Rb; (c) scatterplot of the first two principal component factors; (d) results of hierarchical cluster analysis. Groups 1a–3c are archaeological specimens; reference specimens from the Tahanga Basalt Quarry are represented with cross symbols (+). The ellipses are indicative only; see text for additional details.

the calculated values are 50 for tuff, 5.6 for obsidian, and 7.3 for chert. If all the components of reduction were present in the assemblage, this would indicate that far more flakes were produced per tuff core than obsidian or chert. However, the results discussed above suggest obsidian cores were reduced more intensively than tuff cores. This could arise if obsidian cores were brought into the Tauroa Point area in a partly reduced state, or some of the flakes produced at Tauroa Point were removed for use at other locations. As such, these results have implications for the movement of stone artefacts and people.

Fig. 8. Examples of chert artefacts from Tauroa assemblage, drill points (left and centre) and flake (right).

Table 7
Chert source locations.

Source location	Artefact (*n*)	Artefact (%)	Weight (g)	Weight (%)
Unsourced[a]	629	86.05	7512.3	94.16
Waiere Stream	80	10.94	305.37	3.83
Herekino	22	3.01	160.66	2.01
Total chert	731	100	7978.33	100

[a] Likely either Tauroa Point, the Tangihua range, or Houhora complex.

Table 8
Core types by raw material.

Core type	Chert (*n*)	Chert (%)	Obsidian (*n*)	Obsidian (%)	Tuff (*n*)	Tuff (%)
Test	2	15.38	0	0	0	0
Uni-directional	4	30.77	0	0	4	40
Bi-directional	3	23.08	1	9.09	1	10
Multi-directional	4	30.77	9	81.82	4	40
Radial	0	0	1	9.09	0	0
Tranchet	0	0	0	0	1	10
Total	13	100	11	100	10	100

Table 9
Average volume by core type and raw material.

Core type	Chert			Obsidian			Tuff		
	Mean	SD	% RSD	Mean	SD	% RSD	Mean	SD	% RSD
All core types	31.16	23.2	74	12.74	8.8	69	89.11	136.5	153
Test	57.98	5.1	9						
Unifacial	24.66	27.6	112				52.65	52.2	99
Bifacial	46.85	27.4	58	11.49			36.09		
Multiple	22.34	12.1	54	13.33	9.8	74	45.3	34.9	77
Radial				9.2					
Tranchet							463.3		

5.2. Tool types, use and discard, and occupation duration

The diversity of tools gives insights into the range of tasks undertaken at a site, the use of different raw materials and, to a degree, the intensity of tool usage. A total of 118 tools were identified, including both complete and broken artefacts. Altogether seven tool types were identified in the Tauroa assemblage. These include adzes, denticulates (flake tools with two or more notches), drill points, notches (artefacts where one or more flake scars have left a concave shape on the artefact edge), scrapers (one or more edges of steep unifacial retouch), and utilised flakes (those with one or more edges of re-sharpening, excluding edge damage from use or post-depositional processes). Drill points were the most common tool type, mostly made from chert, but also from basalt (3), obsidian (2), and tuff (1) (Table 11). These were most likely used in the manufacture of bone and shell fishhooks which have been recovered from the site (see Allen, 2006b: 51). All of the recovered adzes are basalt, with the exception of one greywacke specimen, which was not geochemically analysed because reference data for New Zealand greywacke sources are currently lacking.

Although some chert and obsidian flakes were modified to produce tools, very few chert flakes were re-sharpened after use. Most likely they were discarded once blunt in favour of a fresh flake. Obsidian flakes, however, were sometimes re-sharpened with 23 such obsidian flakes being recovered. Although very few tuff retouched tools were identified, one drill point, three notches and three utilised flakes were present. Given the frequency of tool forms of other raw materials, tuff, which is relatively coarse-grained, apparently was not favoured for tool production and when used did not undergo edge re-sharpening.

The presence of polished basalt flakes ($n = 35$, 14%) from finished tools (adzes and chisels) suggests some local use and maintenance of these larger artefacts. At the same time, evidence is lacking for adze production (e.g., preforms are absent and there is a low frequency of unpolished basalt flakes); these findings suggest that adze manufacture took place elsewhere. Further, the limited number of finished tools suggests adzes and chisels were typically curated and transported after use at the Tauroa site.

For other tool types local production is indicated, along with probable local use and frequent local discard. Drill points were made from locally-sourced cherts and manufactured on-site, as evidenced by flake debitage. However, several drill points also were made from types of chert or quartz for which there are no corresponding flakes or cores, that is, the specific source is only represented by complete tools. It seems likely that this reflects the transport of finished tools from elsewhere for anticipated use at Tauroa. Flake tools also were common, rendered in tuff, obsidian and chert. These were probably used in cutting and scraping activities. Only a small number were re-sharpened, probably reflecting some combination of the ready availability of raw materials (tuff, chert) and the ineffectiveness of re-sharpening in comparison to new flake production (obsidian, tuff).

The scarcity of artefacts with long use-lives (e.g., adzes) suggests Tauroa Point was not occupied long enough for these objects to be discarded. However, they were used at Tauroa Point, as evidenced by small polished flakes. As noted above a relationship between artefact use-life, discard, and occupation duration can be suggested. The number of drill points in the assemblage suggests tool manufacture, use, and discard did occur, although this

Table 10
Average flake size based on dorsal scar direction groups.

Scar direction	All material			Basalt			Chert			Obsidian			Tuff		
	N	Max. length mean (mm)	St. dev.	*N*	Max. length mean (mm)	St. dev.	*N*	Max. length mean (mm)	St. dev.	*N*	Max. length mean (mm)	St. dev.	*N*	Max. length mean (mm)	St. dev.
Unidirectional	337	28.05	14.1	50	31.58	16.7	182	25.31	12.4	31	24.03	8.9	63	33.44	14.4
Bi-directional	89	28.97	13.9	11	34.73	9.7	49	27.71	16.5	21	26.05	6.2	6	38.17	13.7
Sub-radial	8	35.25	23.6	0	n/a	n/a	3	42.67	41.0	4	27.50	3.9	1	44	n/a
Radial	3	52.33	18.8	1	69.00	n/a	0	n/a	n/a	2	44.00	17.0	0	n/a	n/a
Total	437	28.54	14.4	62	32.74	16.2	234	26.04	14.0	58	25.69	8.6	70	34.00	14.2

is not necessarily indicative of a long duration occupation, based on Shott's (1989) notion of discard, use-life, and occupation (see also Bamforth and Becker, 2000; Binford, 1978; Kuhn, 1990, 2004; Thomas, 1989). In sum, the Tauroa Point lithic evidence indicates an occupation that was long enough to carry out a range of activities, but was unlikely to have been permanent, that is extended over multiple annual cycles.

6. Discussion

6.1. Stone sources and indications of movement

The sourcing results provide a first approximation of the geographic scale of human movement but there are several provisos to consider before inferring mobility (*sensu* Close, 2000). Foremost, direct access was not the only way that non-local materials might have been obtained by the Tauroa Point peoples (see also McCoy and Carpenter, 2014; Moore, 2012). Exotic materials could have been acquired indirectly, through some permutation of down-the-line exchange. Further, in considering related transport costs, there is the possibility that the procurement of one material was embedded within the acquisition of another. For example, the three most distant sources identified in the Tauroa assemblage, Mayor Island and Hahei obsidians, and Tahanga basalt, are all situated on the Coromandel Peninsula and materials from all three locations could have been collected in a single round-trip. Lithic procurement also may have occurred in conjunction with social activities or the acquisition of other types of resources. Nonetheless, we agree with Walter et al. (2010) that the acquisition of distant materials required more complex sets of behaviours, relative to the collection of those from more proximate sources. Our technological analysis augments the geochemical study by giving insights into such behaviours. With these caveats in mind we review the sourcing evidence and suggest how these findings may (or may not) reflect movement into or out of the Tauroa Point site.

The Tauroa Point lithic assemblage is notable for the diversity of rock sources recovered. Altogether a minimum of 13 different kinds of stone were recorded, useful for a variety of purposes, with some types represented by multiple source locations (Table 12). The stone sources are located at variable distances from Tauroa Point, ranging from the immediate site area to 300 km away. The variety of Northland sources (roughly those within 200 km of the site) in particular points to an intimate knowledge of the region's geological landscape and suggests Māori experimentation with different rock types (see also Prickett, 1979).

The most common rock type was obsidian. There are three known obsidian sources in the Northland region (Jones, 2000; Moore, 2012; Sheppard, 2004), two of which are present at Tauroa, the Kaeo and Huruiki sources. Despite the regional availability of obsidian, Māori occupying Tauroa Point apparently preferred to use Mayor Island materials, a source some 300 km to the southeast and on an offshore island. The Tauroa obsidian findings (Table 4) can be compared with those from the large site of Houhora on the east Northland coast (see Fig. 1). The Houhora obsidian assemblage also is dominated by Mayor Island material (56% by weight, 66% by count) but Northland obsidian sources were important as well (35% by weight, 28% by count) (Furey, 2002: 108–109). This finding is not altogether surprising, as Mayor Island obsidian is widely represented in other early Māori sites, and has been identified further afield in the Kermadec, Chatham, Auckland, and Norfolk Islands (Anderson, 2000; Anderson and McFadgen, 1990; Anderson and O'Regan, 2000; Anderson et al., 1997; Furey et al., 2015; Leach et al., 1986). This widespread use may relate to specific flaking properties of Mayor Island obsidian or, as Walter et al. (2010:510) suggest, the procurement of distant resources may have been part of maintaining social networks. Although outside the scope of this paper, these findings as whole suggest the importance of understanding variation in the raw material form, flaking attributes, and/or performance of New Zealand obsidians. In the case of the large Mayor Island source the possibility that use was intertwined with social factors also warrants consideration. Importantly, our technological study across raw material types provides new insights into how regional and non-regional materials were used (see below).

Also of interest are artefacts fashioned from fine-grained volcanic stone, a material that was widely used by early Māori for flaked adzes. A sample of 68 of the 252 artefacts from the Tauroa assemblage was geochemically analysed and found to have derived from at least three sources (Table 6). Two of the groups, one a basalt (Group 2) and the other a dacite or andesite (Group 3), are from undetermined sources, but may be derived from somewhere within Northland, given the widespread geological occurrence of basalts, dacites and andesites in the region (Booden, 2011; Smith et al., 1993). The other group (Group 1) is sourced to the Tahanga Basalt Quarry, a large source located on the Coromandel Peninsula some 300 km distant. The acquisition of such materials presumably arose in the context of movements outside of the Northland region, and/or interaction between different social groups, as suggested for Houhora by Turner and Bonica (1994).

Four conclusions can be drawn from the sourcing analysis. First, a variety of local rock types was utilised to varying degrees. Second, there was a decided preference for some raw materials over others. In particular Mayor Island obsidian and Tahanga basalt were apparently preferred even though regional equivalents were available. Third, in some cases specific raw materials appear to have been preferred for specific tool forms, such as chert and silicified tuff for flake tools and drill points, presumably because of their physical properties (e.g., toughness). Fourth, the presence of materials from geographically distant sources minimally suggests that the early Māori of Tauroa Point were well-connected with other groups and to some extent linked into long-distance exchange networks. Alternatively, individuals from Tauroa could have travelled to Tahanga and Mayor Island and acquired materials directly.

Prior research offers some perspective on the Tauroa Point results. McCoy and Carpenter (2014) report obsidian assemblages

Table 11
Tool types by raw material.

Tool type	All raw material (*n*)		All raw material (%)	Basalt (*n*)	Basalt (%)	Chert (*n*)	Chert (%)	Greywacke (*n*)	Greywacke (%)	Obsidian (*n*)	Obsidian (%)	Quartz (*n*)	Quartz (%)	Sandstone (*n*)	Sandstone (%)	Tuff (*n*)	Tuff (%)
Adze	8	Adze	6.78	7	63.64	0	0	1	100	0	0	0	0	0	0	0	0
Denticulate	3	Denticulates	2.54	0	0	1	1.56	0	0	2	8.70	0	0	0	0	0	0
Drill Point	67	Drill point	56.78	3	27.27	54	84.38	0	0	2	8.70	5	83.33	1	25	1	14.29
File	3	?	2.54	0	0	0	0	0	0	0	0	0	0	3	75	0	0
Notch	9	Notch	7.63	1	9.09	1	1.56	0	0	4	17.39	0	0	0	0	3	42.86
Scraper	8	Scraper	6.78	0	0	4	6.25	0	0	2	8.70	1	16.67	0	0	0	0
Utilised	20	Utilised flake	16.95	0	0	4	6.25	0	0	13	56.52	0	0	0	0	3	42.86
Total	118		100	11	100	64	100	1	100	23	100	6	100	4	100	7	100

from several late prehistoric (AD 1500–1769) North Island sites with features indicative of direct access (e.g., high frequency of cortex, comparatively large artefact size) (see also McCoy et al., 2011 on Hawaiian trachyte use). Similarly, Walter et al. (2010) also argue for direct procurement, and by association long-distance population mobility, on the basis of exotic obsidian distributions and associated patterns of reduction and use (or lack thereof). More specifically the authors suggest that mobility was important for maintaining social connections and ensuring 'social reproduction', especially during the early phase of New Zealand settlement, effectively connecting "scattered communities" with wider social networks. Supporting evidence comes from the 13th century site of Wairau Bar, South Island where bone chemistry studies also suggest high population mobility (Kinaston et al., 2013). Moore (2012:18), however, highlights the complexity of such determinations, observing that quality, quantity, location, accessibility, and the physical nature of the resource were all factors in prehistoric patterns of stone use with the potential to confound interpretations of access patterns. These variables need to be controlled for by examining the geological contexts or source areas in detail, as well as properties of the raw materials themselves.

Detailed technological analyses like those undertaken here offer one way to clarify the signatures of different types of raw material access. We found that nodules and partly reduced cores were transported to Tauroa Point, where they provided raw materials for tool manufacture and subsequent use. The "missing" obsidian flake and core types discussed above suggest onward transport of artefacts also occurred, presumably with sufficient utility remaining for further use. The limited number of finished tools, such as adzes, suggests that these also were carried away for use at other locations. Holdaway and Douglass (2012) argue that the transport of such finished tools can inform on the type of mobility practiced by people and their stone transport technologies, while researchers in other parts of the world have developed effective methods for both quantifying artefact movement (e.g. Phillipps and Holdaway, in press) and assigning statistical confidence to such measures (e.g. Barrett, 2014; Lin et al., 2015). Comparable studies for New Zealand raw materials are needed to more fully understand the stone artefact assemblages of Tauroa Point and other New Zealand sites.

6.2. Occupation duration

The intensity of raw material use, along with artefact diversity, and the occurrence and frequency of long use-life artefacts, all contribute to our understanding of the duration of the Tauroa Point occupation. Several of the attributes discussed above allow for assessment of the intensity of raw material use in relation to source location versus material size and shape (Table 13). We have

Table 12
Distribution of sources.

All material source distribution	Source	Artefact (*n*)	Weight (g)
Unsourced other	Regional*	74	742.4
Unsourced tuff	Regional*	233	2082.8
Unsourced basalt	Regional*	196	751.03
Unsourced Chert	Regional*	629	7512.3
Herekino Chert	Regional	22	160.66
Waiere chert	Regional	80	305.37
Kaeo obsidian	Regional	42	113.77
Huruiki obsidian	Regional	1	6.92
Tahanga basalt	Extra-regional	38	389.09
Coromadel (Hahei)	Extra-regional	2	0.24
Mayor Island obsidian	Extra-regional	147	252.12
Total		1464	12316.7

* Sources likely to be regional.

Table 13
Measures of production and use intensity.

Measure	Table	Basalt	Chert	Obsidian	Tuff	Overall
Multiple cores	9	100.00%	30.00%	80.00%	40.00%	53.66%
Mean core volume (cm)	11	57.02 cm^3	31.16 cm^3	12.74 cm^3	89.11 cm^3	41.85 cm^3
Uni-directional dorsal scars	10	80.65%	77.78%	53.45%	90.00%	77.12%
Utilised flakes	12	N/A	6.25%	56.52%	42.86%	16.95%

argued that more intensive stone use is an indicator of extended occupation, as is discard of longer use-life artefacts, which we suggest should include cores.

Looking first at the use intensity, "multiple" type cores (which suggest frequent rotation and high intensity use), were recovered and are especially well represented in obsidian. On its own, this finding might suggest an extended occupation. However, much of the Tauroa Point obsidian is from the distant Mayor Island source and may have been intensively used at Tauroa because of the relatively high costs of acquisition. The shape and size of the original nodule forms also could have affected obsidian core rotation patterns. In this respect, Moore (2012:19) notes that many New Zealand obsidian sources provide largely corticated nodules from colluvial and detrital deposits. Mayor Island obsidian in particular occurs in varied forms at the source, including both water-worn and colluvial boulders and cobbles, as well as in thick seams that can provide blocks which lack cortex (Moore, 2012; Sheppard, 2004). Obsidian cores at Tauroa also could have been introduced in an already partly expended state. Contrasting with the obsidian, the proportion of multiple cores in the Tauroa chert and tuff assemblages, materials acquired within the region, is much lower. This is despite chert occurring locally as large-pebble to small-cobble sized corticated nodules. The less intensively utilised chert and tuff artefacts could indicate that Tauroa Point was not occupied for an extended period of time. Closer examination of raw material variability at different source locations is required to better understand how raw material shape and size co-varied with technological attributes and usage in prehistoric New Zealand contexts.

Some clarity is gained by comparing the Tauroa assemblage with that from Houhora, a larger site thought to be permanently occupied (Fig. 1; Furey, 2002). Although the types of stone tools found at Tauroa Point are similar to those of Houhora, they are much less frequent at Tauroa Point. Most notably, there are far fewer adzes at Tauroa, suggesting a shorter term occupation relative to Houhora. Further, the Houhora artefact assemblage in general is more diverse, including a variety of ornaments and gaming artefacts (*teka* darts), as well as architectural features that are consistent with an extended occupation (Furey, 2002). Overall, our analysis suggests that the early occupation at Tauroa Point site was of a shorter duration that than at Houhora.

7. Conclusions

The results reported herein both complement and extend earlier analyses of the ~late 14th century community at Tauroa Point (Allen, 2006b). The stone artefact evidence suggests that the site occupants were a regionally well-connected population, and quite possibly one with ties of considerable geographic extent. The sourcing and technological analyses further allow us to posit that the occupation was smaller in scale and duration, relative to the larger permanent "village" of Houhora (Furey, 2002). Further, a range of on-site activities are indicated at Tauroa, but with the occupants primarily focused on food gathering and processing, and the production and maintenance of tools needed for these activities. Finally, the Tauroa Point stone artefacts point to other early Mā ori sites elsewhere in the region, places which might account for certain characteristics of the Tauroa assemblage, including sites where adze production, drill point manufacture, and the initial reduction of obsidian cores took place. Refining this initial assessment of the early Tauroa Point occupation, and placing it within its larger social context, will necessarily require undertaking similar studies at other archaeological localities. Further study of both North and South Island sites, and from a range of depositional contexts and functional contexts, are likely to offer new insights into spatial and temporal variability in prehistoric Māori mobility and settlement strategies.

More generally, our analytical approach, combining lithic sourcing and detailed technological analyses, is aimed at developing proxies for prehistoric patterns of human movement and mobility strategies. With its naturally varied continental geology, and the considerable knowledge and use of the country's many rock sources by prehistoric Māori peoples, New Zealand is an ideal setting for studies of this kind. Moreover, the geographic scale of New Zealand, the country's abundant and highly varied faunal resources, and the agricultural traditions of the original Polynesian settlers, potentially set the stage for the development of multiple mobility strategies. Ultimately, understanding early New Zealand Māori mobility, resource use and settlement configurations, and patterns of interaction also sheds light on how Polynesians generally adapted to the novel environmental, economic, and social opportunities (e.g., Kinaston et al., 2013; Walter et al., 2006, 2010). While New Zealand is unique in the diversity of stone types, these conditions provide rich opportunities for investigation of spatio-temporal dynamics of processes that are globally significant, including the intersection of resource use and settlement strategies, multi-scalar interaction patterns, and socio-political change, including the emergence of competition.

Acknowledgments

Many people have assisted in this research over a number of years. We would like to thank the people of Te Rawara, including Roma Marae, Tauroa Point Community Group, Wainui Marae, and Korou Kore Marae for their support during the 2003 field season at Tauroa Point. We thank Cathryn Barr for access to the material collected during the 1992 DOC excavation. Phillipa Black, Murray Gregory, Martin Jones, Kath Prickett, Peter Sheppard, and John Wilmshurst provided very useful advice on geology and sourcing. Thanks to Louise Furey for advice on Northland archaeology and links to Houhora. Thank you to Simon Holdaway for helpful comments on this manuscript. We appreciate the help of Briar Sefton in preparing the figures and the assistance of Bruce Kaiser and the staff at Bruker Elemental in support of the pXRF instrument. Finally, we thank Charlotte Phillipps for assistance in the lab. This research was funded by grants to Allen from the Roger Green Foundation for Polynesian Research, University of Auckland Research Committee, and the Department of Anthropology PBRF fund.

References

Allen, H., 1996. Horde and Hapu: the reification of kinship and residence in prehistoric aboriginal and Maori settlement organisation. In: Davidson, J., Irwin, G., Leach, F., Pawley, A., Brown, D. (Eds.), Oceanic Culture History: Essays in Honour of Roger Green, New Zealand J. Archaeol. Spec. Publ., pp 657–674.

Allen, M.S., 2006a. Blowing in the wind: rescue excavations at site N05/302, Tauroa Point, Ahipara, Northland. Archaeol. New Zealand 49 (2), 105–119.
Allen, M.S., 2006b. Periodicity, duration, and function of occupation at Tauroa Point, Northland, New Zealand. New Zealand J. Archaeol. 27, 19–62.
Allen, M.S., 2012. Molluscan foraging efficiency and patterns of mobility amongst foraging agriculturalists: a case study from northern New Zealand. J. Archaeol. Sci. 39, 295–307.
Allen, M.S., Johnson, K., 1997. Tracking ancient patterns of interaction: recent geochemical studies in the southern Cook Islands. In: Weisler, M.I. (Ed.), Prehistoric Long-distance Interaction in Oceania: An Interdisciplinary Approach, vol. Monograph 21. New Zealand Archaeological Association, Auckland, pp. 111–133.
Allen, M.S., McAlister, A., 2013. Early Marquesan settlement and patterns of interaction: new insights from Hatiheu Valley, Nuku Hiva Island. J. Pacific Archaeol. 4 (1), 90–109.
Anderson, A., 1989. Prodigious Birds: Moas and Moa-hunting in Prehistoric New Zealand. Cambridge University Press, Cambridge.
Anderson, A., 2000. Implications of prehistoric obsidian transfer in south Polynesia. Indo-Pacific Prehistory Assoc. Bull. 20, 117–123.
Anderson, A., McFadgen, B., 1990. Prehistoric two-way voyaging between New Zealand and East Polynesia: Mayor Island obsidian on Raoul Island, and possible Raoul Island obsidian in New Zealand. Archaeol. New Zealand 25, 37–42.
Anderson, A., O'Regan, G., 2000. To the final shore: prehistoric colonisation of the subantarctic island in south Polynesia. In: Anderson, A., Murray, T. (Eds.), Australian Archaeologist: Collected Papers in Honour of Jim Allen. Combes Academic Publishing, Canberra, pp. 440–454.
Anderson, A., Smith, I., 1996. The transient village in southern New Zealand. World Archaeol. 27 (3), 359–371.
Anderson, A., Allingham, B.J., Smith, I.G.W. (Eds.), 1996. Shag River Mouth: The Archaeology of an Early Southern Maori Village. Research Papers in Archaeology and Natural History 27. ANH Publications, RSPAS. Australian National University, Canberra.
Anderson, A., Ambrose, W., Leach, F., Weisler, M.I., 1997. Material sources of basalt and obsidian artefacts from a prehistoric site on Norfolk Island, South Pacific. Archaeol. Oceania 32, 39–46.
Bailey, G., 2007. Time perspectives, palimpsests and the archaeology of time. J. Anthropol. Archaeol. 26, 198–223.
Bamforth, D.B., Becker, M.S., 2000. Core/biface ratios: mobility, refitting, and artifact use-lives: a Paleoindian example. Plains Anthropol. 45 (173), 273–290.
Barnard, H., Wendrich, W. (Eds.), 2008. The Archaeology of Mobility: Old World and New World Nomadism (Cotsen Advanced Seminars). Cotsen Institute of Archaeology, Los Angeles.
Barrett, M., 2014. Flake to Core Ratios and Human Mobility: An Investigation in Stone Artefact Assemblages from Egypt and Australia Unpublished MA Thesis. The University of Auckland, Auckland.
Baxter, M.J., 1994. Exploratory Multivariate Analysis in Archaeology. Edinburgh University Press, Edinburgh.
Best, S.B., Sheppard, P.J., Green, R.C., Parker, R.J., 1992. Necromancing the stone: archaeologists and adzes in Samoa. J. Polynesian Soc. 101, 45–85.
Binford, L.R., 1978. Dimensional analysis of behavior and site structure: learning from an Eskimo hunting stand. Am. Antiq. 43 (3), 330–361.
Booden, M.A., 2011. Geochemical Development of the Late Cenozoic Arc Volcanism in Northland and the Coromandel, and Implications for Geochemical Exploration in the Hauraki Goldfield Unpublished PhD Thesis. The University of Auckland, Auckland.
Brassey, R.J.N., 1985. Analysis of Some Lithic Artefact Assemblages from Pouerua, Northland Unpublished MA Thesis, Anthropology. University of Auckland, Auckland.
Charleux, M., McAlister, A., Mills, P.R., Lundblad, S., 2014. Non-destructive XRF analyses of fine-grained basalts from Eiao, Marquesas Island. J. Pacific Archaeol. 5 (1), 75–89.
Close, A., 2000. Reconstructing movement in prehistory. J. Archaeol. Method Theory 7 (1), 49–77.
Davidson, J., 1981. The prehistoric exploitation of stone resources in northern New Zealand. In: Leach, F., Davidson, J. (Eds.), Archaeological Studies of Pacific Stone Sources. B.A.R. International Series, Oxford, pp. 107–119.
Davidson, J., 1987. The Prehistory of New Zealand Auckland. Longman Paul Ltd.
Dibble, H.L., Schurmans, U.A., Iovita, R.P., McLaughlin, M.V., 2005. The measurement and interpretation of cortex in lithic assemblages. Am. Antiq. 70 (3), 545–560.
Douglass, M.J., Holdaway, S.J., Fanning, P.C., Shiner, J.I., 2008. An assessment and archaeological application of cortex measurement in lithic assemblages. Am. Antiq. 73 (3), 513–526.
Felgate, M.W., 1993. Geochemical Characteristics of the Tahanga Archaeological Quarry Complex Unpublished MA Thesis. The University of Auckland, Auckland.
Firth, R., 1929. Primitive Economics of New Zealand Maori. Routledge, London.
Furey, L., 2002. Houhora: A Fourteenth Century Maori Village in Northland. Bulletin of the Auckland Museum 19, Auckland.
Furey, L., Ross-Sheppard, C., Prickett, K.E., 2015. Obsidian from Macauley Island: a New Zealand connection. Bull. Auckland Museum 20, 511–518.
Glascock, M.D., Ferguson, J.R., 2012. Report on the Analysis of Obsidian Source Samples by Multiple Analytical Methods. University of Missouri Research Reactor, Columbia.
Govindaraju, K., 1994. 1994 compilation of working values and sample description for 383 geostandards. Geostandard. Newslett. 18 (S1), 1–158.
Hancock, R.G.V., Hancock, K.E., Hancock, J.K., 2008. Thoughts on the utility of a bivariate-splitting approach to Olmec ceramic data interpretation. Archaeometry 50 (4), 710–726.
Holdaway, S., 2004. The Kohika obsidian artefacts: technology and distribution. In: Irwin, G. (Ed.), The Archaeology of a Late Maori Lake Village in the Ngati Awa Rohe, Bay of Plenty, New Zealand. University of Auckland Press, Auckland, pp. 177–197.
Holdaway, S., Douglass, M.J., 2012. A Twenty-first century archaeology of stone artifacts. J. Archaeol. Method Theory 19 (1), 101–131.
Holdaway, S., Fanning, P., Rhodes, E., 2008. Assemblage accumulation as a time-dependent process in the arid zone of Western New South Wales, Australia. In: Holdaway, S., Wandsnider, L. (Eds.), Time in Archaeology: Time Perspectivism Revisited. The University of Utah Press, Salt Lake City, pp. 110–133.
Holdaway, S., Stern, N., 2004. A Record in Stone: The Study of Australia's Flaked Stone Artefacts. Museum Victoria, Melbourne.
Holdaway, S., Wendrich, W., Phillipps, R., 2010. Indentifying low-level food producers: detecting mobility from lithics. Antiquity 84, 185–194.
Irwin, G. (Ed.), 2004. Kohika: The Archaeology of a Late Maori Lake Village in the Ngati Awa Rohe, Bay of Plenty, New Zealand. Auckland University Press, Auckland.
Irwin, G., 2013. Wetland archaeology and the study of late Maori settlement patterns and social organisation in northern New Zealand. J. Polynesian Soc. 122 (4), 311–332.
Irwin, G., Holdaway, S., 1996. Colonisation, trade and exchange: from Papua to Lapita. In: Davidson, J., Irwin, G., Leach, F., Pawley, A., Brown, D. (Eds.), Oceanic Culture History: Essays in Honour of Roger Green, New Zealand J. Archaeol. Otago, pp. 225–235.
Isaac, M.F., 1996. Geology of the Kaitaia Area. Institute of Geological and Nuclear Sciences.
Jones, K.L., 1984. Polynesian quarrying and flaking practices at the Samson Bay and Falls Creek argillite quarries, Tasman Bay, New Zealand. World Archaeol. 16 (2), 248–266.
Jones, M., 2000. A Brief Prehistory of Time Unpublished PhD Thesis. University of Auckland, Auckland.
Kelly, R.L., 1992. Mobility/sedentism: concepts, archaeological measures, and effects. Annu. Rev. Anthropol. 21, 43–66.
Kinaston, R.L., Walter, R.K., Jacomb, C., Brooks, E., Tayles, N., Halcrow, S.E., Stirling, C., Reid, M., Gray, A.R., Spinks, J., Shaw, B., Fyfe, R., Buckley, H.R., 2013. The first New Zealanders: patterns of diet and mobility revealed through isotope analysis. PLoS ONE 8 (5), e64580.
Kuhn, S.L., 1990. A geometric index of reduction for unifacial stone tools. J. Archaeol. Sci. 17, 593.
Kuhn, S.L., 2004. Upper Palaeolithic raw material economies at Ucagizli cave, Turkey. J. Anthropol. Archaeol. 23, 431–448.
Le Maitre, R.W., Streckeisen, A., Zanettin, B., Le Bas, M.J., Bonin, B., Bateman, P., Bellieni, G., Dudek, A., Efremova, S., Keller, J., Lamere, J., Sabine, P.A., Schmid, R., Sorensen, H., Woolley, A.R., 2002. Igneous Rocks: A Classification and Glossary of Terms, Recommendations of the International Union of Geological Sciences, Subcommission of the Systematics of Igneous Rocks. Cambridge University Press, Cambridge.
Leach, F., Anderson, A., Sutton, D.G., Bird, R., Duerden, P., Clayton, E., 1986. Origin of prehistoric obsidian artefacts from the Chatham and Kermadec Islands. New Zealand J. Archaeol. 8, 143–170.
Lin, S.C., McPherron, S.P., Dibble, H.L., 2015. Establishing statistical confidence in cortex ratios within and among lithic assemblages: a case study of the middle paleolithic of southwestern France. J. Archaeol. Sci.
Lundblad, S., Mills, P.R., Hon, K., 2008. Analyzing archaeological basalt using non-destructive energy dispersive X-ray fluorescence (EDXRF): effects of post-depositional chemical weathering and sample size on analytical precision. Archaeometry 50 (1), 1–11.
McAlister, A., 2011. Methodological Issues in the Geochemical Characterisation and Morphological Analysis of Stone Tools: A Case Study from Nuku Hiva, Marquesas Islands, East Polynesia. University of Auckland, Auckland.
McCoy, M.D., Carpenter, J., 2014. Strategies for obtaining obsidian in pre-European contact era New Zealand. PLoS ONE 9 (1), e84302.
McCoy, M.D., Ladefoged, T.N., Blanshard, A., Jorgensen, A., 2010. Reconstructing lithic supply zones and procurement areas: an example from the Bay of Islands, Northland, New Zealand. J. Pacific Archaeol. 1 (2), 174–183.
McCoy, M.D., Mills, P.R., Lundblad, S., Rieth, T., Kahn, J.G., Gard, R., 2011. A cost surface model of volcanic glass quarrying and exchange in Hawai'i. J. Archaeol. Sci. 38, 2547–2560.
McCoy, M.D., Ladefoged, T.N., Codlin, M., Sutton, D.G., 2014. Does Carneiro's circumscription theory help us understand Maori history? An analysis of the obsidian assemblage from Pouerua Pa, New Zealand (Aotearoa). J. Archaeol. Sci. 42, 467–475.
McPherron, S.P., Holdaway, S., 1996. E4. Data Entry Software.
Mills, P.R., Lundblad, S., Smith, J.G., Smith, J.G., McCoy, P.C., Naleimaile, S.P., 2008. Science and sensitivity: a geochemical characterization of the Mauna Kea Adze Quarry complex, Hawai'i Island, Hawai'i. Am. Antiq. 73 (4), 743–758.
Moore, P.R., 2012. Procurement and cultural distribution of obsidian in northern New Zealand. J. Pacific Archaeol. 3, 17–32.
Moore, P.R., Coster, J., 2015. Evidence of a well-developed obsidian distribution network in the far north of New Zealand: new data from the Aupouri Peninsula. J. Pacific Archaeol. 6 (1), 1–17.
Murray, T., 1999. A return to the "Pompeii premise". In: Murray, T. (Ed.), Time and Archaeology. Routledge, London, pp. 8–17.

Nagaoka, L., 2002a. The effects of resource depression on foraging efficiency, diet breadth, and patch use in southern New Zealand. J. Anthropol. Archaeol. 21, 419–442.
Nagaoka, L., 2002b. Explaining subsistence change in southern New Zealand using foraging theory models. World Archaeol. 34, 84–102.
Phillipps, R., 2012. Documenting Socio-economic Variability in the Egyptian Neolithic through Stone Artefact Analysis Unpublished PhD Thesis. University of Auckland, Auckland.
Phillipps, R., Holdaway, S., 2016. Estimating core number in assemblages: core movement and mobility during the holocene of the Fayum, Egypt. J. Archaeol. Method Theory (in press). http://dx.doi.org/10.1007/s10816-015-9250-2.
Phillips, C., 2000. Waihou Journeys: The Archaeology of 400 years of Māori Settlement. Auckland University Press, Auckland.
Prickett, K., 1979. The stone resources of early communities in Palliser Bay. In: Leach, F., Leach, H. (Eds.), Prehistoric Man in Palliser Bay. Bulletin of the National Museum of New Zealand Number 21, Wellington, pp. 163–184.
Sahlins, M.D., 1958. Social Stratification in Polynesia. University of Washington Press, Seattle.
Service, E.T., 1962. Primitive Social Organization. Random House, New York.
Shackley, M.S., 2011. Sources of archaeological dacite in northern New Mexico. J. Archaeol. Sci. 38, 1001–1007.
Shawcross, W., 1964. Stone flake industries in New Zealand. J. Polynesian Soc. 73 (1), 7–25.
Sheppard, P.J., 2004. Moving stones: comments on the archaeology of spatial interaction in New Zealand. In: Furey, L., Holdaway, S. (Eds.), Change Through Time: 50 Years of New Zealand Archaeology. New Zealand Archaeological Association Monograph 26, Auckland, pp. 147–168.
Sheppard, P.J., Irwin, G., Lin, S.C., McCaffrey, C.P., 2011. Characterization of New Zealand obsidian using PXRF. J. Archaeol. Sci. 38, 45–56.
Shott, M., 1989. On tool-class use lives and the formation of archaeological assemblages. Am. Antiq. 54 (1), 9–30.
Smith, I., 1985. Sea Mammal Hunting and Prehistoric Subsistence in New Zealand. University of Otago, Dunedin.
Smith, I.E.M., Okada, T., Itaya, T., Black, P.M., 1993. Age relationships and tectonic implications of late Cenozoic basaltic volcanism in Northland, New Zealand. New Zealand J. Geol. Geophys. 36, 385–393.
Speakman, R.J., 2012. Evaluation of Bruker's Tracer Family Factory Obsidian Calibration for Handheld Portable XRF Studies of Obsidian. Report Prepared for Bruker AXS, Kennewick, WA.
Thomas, D.H., 1989. Diversity in hunter–gatherer cultural geography. In: Leonard, R., Jones, R. (Eds.), Quantifying Diversity in Archaeology. Cambridge University Press, Cambridge, pp. 85–91.
Trigger, B., 1967. Settlement archaeology – its goals and promise. Am. Antiq. 32, 149–160.
Turner, M., 2000. The Function, Design and Distribution of New Zealand Adzes Unpublished PhD Thesis. University of Auckland, Auckland.
Turner, M., Bonica, D., 1994. Following the flake trail: adze production on the Coromandel East Coast, New Zealand. New Zealand J. Archaeol. 16, 5–32.
Turq, A.W., Bourguignon, L., Faivre, J., 2013. The fragmented character of Middle Palaeolithic stone tool technology. J. Hum. Evol. 65 (5), 641–655.
Walter, R., Jacomb, C., Bowron-Muth, S., 2010. Colonisation, mobility and exchange in New Zealand prehistory. Antiquity 84, 497–513.
Walter, R., Smith, I., Jacomb, C., 2006. Sedentism, subsistence and socio-political organization in prehistoric New Zealand. World Archaeol. 38 (2), 274–290.
Weisler, M.I., 1997. Prehistoric long-distance interaction at the margins of Oceania. In: Weisler, M.I. (Ed.), Prehistoric Long-distance Interaction in Oceania: An Interdisciplinary Approach. New Zealand Archaeological Association, Monograph 21, Auckland, pp. 149–172.
Weisler, M.I., 1998. Hard evidence for prehistoric interaction in Polynesia. Curr. Anthropol. 39, 521–532.
Weisler, M.I., 2008. Tracking ancient routes across Polynesian seascapes with basalt artifact geochemistry. In: David, B., Thomas, J. (Eds.), Handbook of Landscape Archaeology. Left Coast Press, Walnut Creek, pp. 536–543.
Willey, G.R., 1953. Prehistoric Settlement Patterns in the Virù Valley, Peru (Bureau of American Ethnology Bulletin 155). Smithsonian Institution, Washington.