NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

# ARCHAEOLOGY IN NEW ZEALAND

# EARLY EXPLOITATION OF BASALT AND ANDESITE IN THE HAURAKI GULF – BAY OF PLENTY REGION

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## Introduction

Basalt was virtually the only rock type used for adzes in eastern Polynesia, and the first Polynesian settlers of New Zealand probably would have had an initial preference for this material, where available. The Tahanga basalt at Opito was certainly discovered at a very early stage, probably by 1300 AD (Moore 1976), and it subsequently became the focus of a major adze manufacturing industry which spread along the eastern Coromandel and western Bay of Plenty coasts (Turner & Bonica 1994). However Tahanga basalt was not the only fine grained volcanic rock exploited in the north eastern North Island. Small 'quarries' or working areas of similar rocks have also been recorded on Great Barrier Island (Spring-Rice 1962) and at Maketu (Moore 1981), along with minor use of andesite at Orokawa Bay (Moore 2001) (Figure 1).

Adzes of Tahanga basalt were widely distributed in the northern half of the North Island (Moore 1975, Best 1975, Turner 2000, 2005). Many were also reworked, and there has perhaps been a tendency to assume that all flakes of fine-grained volcanic rock found in sites in this region are composed of Tahanga basalt. As noted by Furey (2002: 97) "...the focus on Tahanga basalt has tended to distort the overall picture of geological exploration and use of stone in a regional setting". In some cases, therefore, other sources of similar rocks may have been completely overlooked.

This paper presents some new information on known and potential sources of basaltic-andesitic rocks in the Hauraki Gulf-Bay of Plenty region, and examines whether energy-dispersive XRF (EDXRF) analysis could be a reliable means of distinguishing between them.

## Geological distribution

Volcanic rocks are widely distributed in the Hauraki Gulf-Bay of Plenty region, and they form a large part of Coromandel Peninsula and Great Barrier Island (Edbrooke 2001). The main rock types are andesite, dacite, rhyolite and ignimbrite, while basalts are relatively rare. The more significant coastal occurrences of basaltic rocks are in the Cape Rodney-Mangawhai area north of Auckland (Ti Point Group), on Waiheke Island (Ti Point Group), and on the Mercury Islands and adjacent mainland in eastern Coromandel Peninsula (Mercury Basalts). Isolated lava flows or intrusions have also been recorded on Rakitu, off Great Barrier Island, near Tairua on Coromandel Peninsula, and at Ratahi on Matakana Island in the western Bay of Plenty (Briggs *et al*. 1996, Edbrooke 2001). The basaltic rocks of the geologically younger Auckland Volcanic Field are generally too coarse grained or vesicular for adzes.

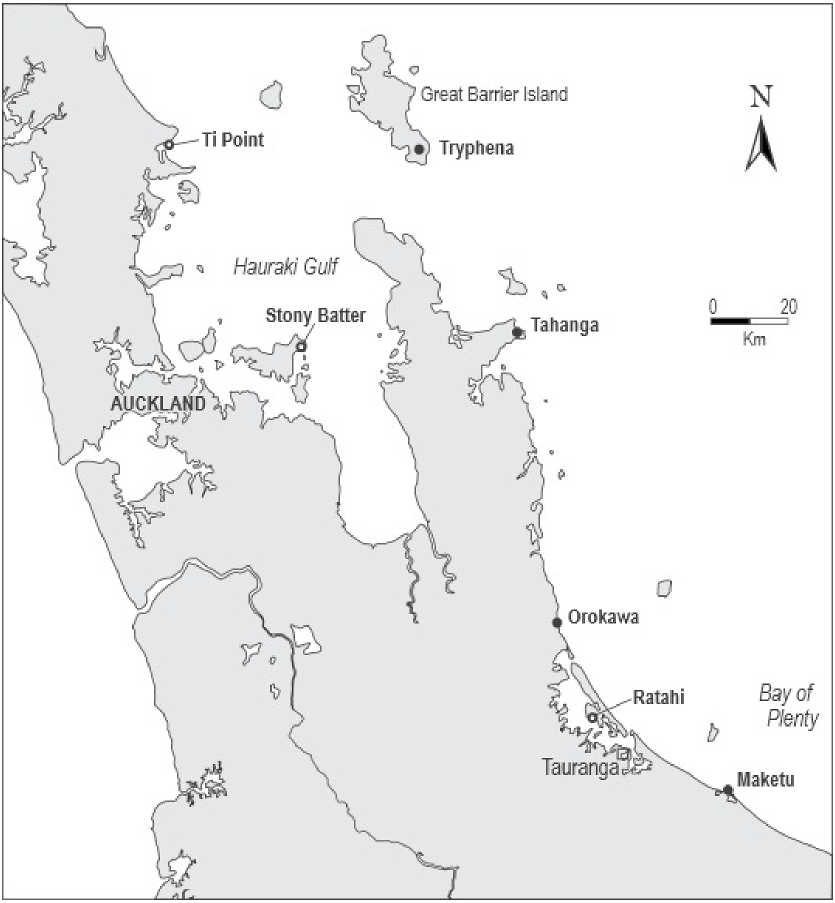


*Figure 1: Map of the Hauraki Gulf - Bay of Plenty region showing the location of exploited sources of basalt and andesite (solid dots) and other occurrences (open circles).*

## Known and potential sources

*Ti Point*

Remnants of basalt lava flows outcrop on the southern side of Ti Point, near Leigh, and there are abundant boulders and cobbles along the shoreline. Although no evidence of working of the basalt has been reported, the rock is fine grained and of flake quality (pers obs.) and potentially could have been exploited. There are other minor occurrences of basalt in the Leigh area, and further north near Mangawhai (Heming 1980).

*Stony Batter (Waiheke Island)*

At the north-eastern end of Waiheke Island large residual boulders of basaltic andesite are scattered over the dome-like hill of Stony Batter. Site surveys of this area (Rickard 1981) have given no indication they were worked, but that cannot be entirely ruled out. Chemical analyses of the andesite are provided by Black *et al*. (1992).

*Great Barrier Island*

A small 'quarry' (N35/4, T09/131) was recorded on the southern part of the island in 1962 by Wynne Spring-Rice (1962), beside a stream about 1.5 km from Tryphena Harbour. Spring-Rice described it as a small flat containing "numerous flakes and roughouts lying in deep manuka humus" and noted (p. 94) that "there was no evidence at the quarry that the roughouts were worked beyond the flaking stage". Of the two preforms collected by Spring-Rice only one (AU1073) has been relocated. It is 13 cm in length with a sub-triangular section, and could probably be classed as a Type 3 adze.

The site was relocated by the author and Brenda Sewell in April 2001. It consists of a small flat area about 8 m x 8 m in size with scattered boulders of andesite (up to 50 cm diameter), many of which show evidence of working. Only four definite preforms were found, and very few flakes, but it is likely that most flakes were concealed by the deep leaf litter covering the ground. Two of the preforms had sub-triangular cross-sections and were 32 cm and 18 cm in length. One had a sub-rectangular cross-section and was 24 cm long, and another was 19 cm in length with an irregular section. In addition, a broken preform with sub-rectangular section was found in the nearby stream. Most of these preforms had remnants of weathered cortex.

Spring-Rice (1962: 94) also reported the existence of another quarry site "on a ridge to the seaward side of Windy Hill", about 4 km to the northeast, but did not visit it. A search of this area was conducted in 1999, but no quarry located. Nevertheless there is a possibility that other outcrops or boulder fields of andesite on the southern part of Great Barrier could have been worked.

*Tahanga*

The quarry complex at Tahanga has been thoroughly investigated over the past 40 years, resulting in detailed information on the nature and extent of the quarries and working areas (Moore 1982, Turner 1992), technological aspects (Turner 1992), and composition of the basalt (Best 1975, Felgate *et al.* 2001). Its cultural distribution is also relatively well known (Moore 1975, Turner & Bonica 1994, Turner 2000). Although flakes and adzes of Tahanga basalt have been recorded at many other sites along the Coromandel-Bay of Plenty coast in recent years, to my knowledge this has not resulted in any significant new information on the use of this rock type.

*Orokawa Bay*

The exploitation of fine grained andesite cobbles at Orokawa Bay near Waihi Beach was reported by Moore (2001). At the time the only evidence of this consisted of cores and/or flakes found on some of the pā in the area. However in 2003 part of a preform with triangular cross-section was discovered at the rear of the beach at Orokawa Bay, thus demonstrating that the andesite had also been used in the manufacture of adzes, probably at an early period. The use of Orakawa andesite for this preform has been confirmed by EDXRF analysis (see below).

In 2007 two small pieces of andesite were found during the excavation of a midden (U13/1343) at Waihi Beach. The larger of these was obviously worked and had a remnant of smooth cortex, indicating it was derived from a water-worn cobble. EDXRF analysis confirmed that this piece is composed of Orokawa andesite. One flake and a broken cobble of the same andesite have also been recovered from a nearby site (T13/829), along with several flakes of Tahanga basalt. At Bowentown, a flake from the Archaic site U13/875, originally thought to be Tahanga basalt, was subjected to EDXRF analysis which indicates it is composed of Orokawa andesite. The large collection of basalt flakes from Bowentown analysed by Turner & Bonica (1994) also includes some of andesite (pers obs.). In addition, a worked piece of basalt from site U13/1339 at Waihi Beach was analysed by EDXRF to establish whether it originated from Tahanga or not. It has a very similar composition to Tahanga source samples.

*Ratahi (Matakana Island)*

Ratahi is an islet situated off the western side of Matakana Island, Tauranga Harbour. It is composed of basalt (Matakana Basalt, Briggs *et al.*

1996), and was included in this study because of its coastal location. The basalt is hard, fresh, but relatively coarse grained and thus probably unsuitable for the manufacture of adzes. Certainly there is no sign it has been worked, and no artefacts of this material have been reported from sites on Matakana Island. However the basalt does appear to have been utilised locally for oven stones.

*Maketu*

Exploitation of basalt boulders at Maketu was first reported in 1976 (Moore 1981). Although these boulders (up to 1 m in diameter) are found all along the rocky coastline on both sides of the Maketu peninsula, there are two main concentrations of worked boulders, flakes, and water-worn performs – one just north of Newdicks Beach, on the eastern side, and another on the western side of the peninsula. Both were originally recorded as a single site (N68/117, V14/15), but in recognition of the two distinct areas the Newdicks Beach locality should be referred to as V14/15 East. The preforms found at V14/15 East include one of side-hafted form (Type 5), and another resembling a 2B type (Moore 1981). Part of a polished adze, probably a 1A, has also been collected from this site.

In 2007 a previously unrecorded Archaic site (V14/187) containing moa, dog and sea mammal bone, and abundant basalt flakes, was discovered at Maketu township during the installation of a new water main (Moore 2008, Moore et al. 2009). Some of the basalt flakes were large with remnants of smooth, water-worn cortex, indicating they were struck from large cobbles or boulders (Figure 2). At least one flake had been shaped into a small preform adze or chisel, and there were one or two other flakes which appeared to have come from polished adzes. One flake was subjected to petrographic study as well as XRF and EDXRF analysis, which confirmed that it was composed of Maketu basalt.

Significantly, about 13 flakes of Tahanga basalt were also recovered from this site, along with one piece from a polished quadrangular-sectioned adze (Figure 2) and another possibly from a broken preform adze or chisel, all from the same stratigraphic level. Two of the flakes were from polished adzes. Hence there is good evidence for the contemporary manufacture of adzes and/or chisels from local basalt, and of the production or reworking of Tahanga basalt adzes, at this site.

## Physical attributes

With the exception of the Ti Point basalt (dark grey), fresh samples of the other rock types are all very dark grey (Munsell Soil Colour Chart). However the Tahanga basalt has a slight but distinct bluish tinge and initially weathers to a bluish grey colour (5PB 4/1), which helps distinguish it from the others. In

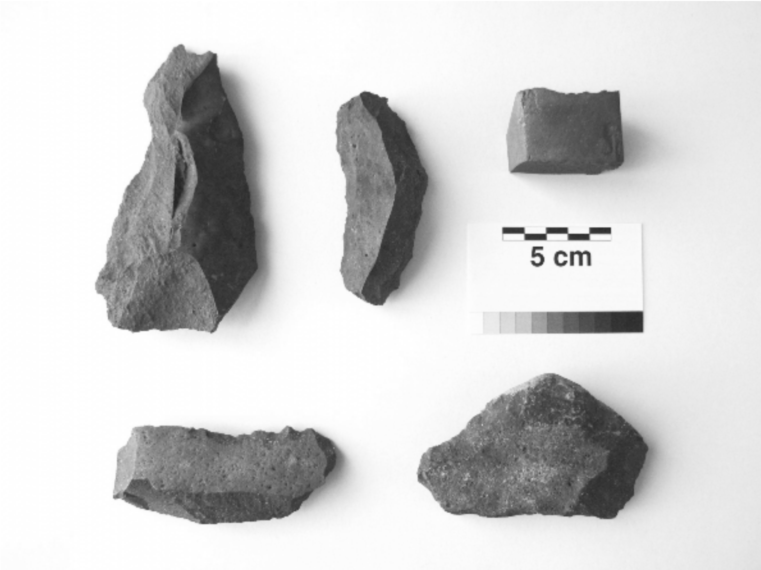


*Figure 2: Basalt artefacts from site V14/187, Maketu. All composed of local basalt except for the piece of polished quadrangular-section adze at upper right (Tahanga basalt).*

terms of texture the Tryphena, Tahanga and Orokawa rocks are all fine grained with few obvious phenocrysts, while the Ti Point and Maketu basalts are noticeably coarser and contain common to abundant small phenocrysts. The Maketu basalt also shows obvious pitting on weathered surfaces, along with vague blotches or coarse banding on some pieces, features which are similarly seen in some Tahanga material. All of the rocks have a sub-conchoidal fracture.

Trying to distinguish between these rock types on colour and texture alone would be difficult without comparison with reference samples, especially where the artefacts are weathered, stained or dirty. Nevertheless Tahanga basalt may be distinguished in most cases by its even grain size and slightly bluish grey colour. The Orokawa andesite is similar to that from Tryphena but glassier.

In her adze studies Marianne Turner made extensive use of a magnet to distinguish Tahanga basalt from metasomatised argillite, sedimentary rock types, and other basalts (Turner 2000, 2005). However, my own test of this method revealed the Maketu basalt is also strongly magnetic (probably due to the presence of the mineral magnetite), while the Ti Point basalt and Tryphena and Orokawa andesites are less so. Thus magnetism is not a reliable means of distinguishing between one basalt (or andesite) and another.

## Geochemistry

Source samples were analysed by both conventional wavelength-dispersive X-ray fluorescence (here referred to simply as XRF) and non destructive, energy-dispersive XRF (EDXRF). The reason for employing two different analytical methods was to establish whether EDXRF alone would be a reliable means of distinguishing between Tahanga basalt and similar rock types within the same region.

| **Source** | **Tryphena** | **Orokawa** | **Maketu** | |
|---|---|---|---|---|
| **Sample** | **TRY-1** | **ORK-1** | **MAK-1** | **M41** |
| (wt%) | | | | |
| SiO2 | 55.28 | 59.23 | 52.79 | 52.74 |
| TiO2 | 0.94 | 0.89 | 0.88 | 0.88 |
| Al2O3 | 18.31 | 15.65 | 17.4 | 17.44 |
| Fe2O3 | 8.83 | 10.78 | 9.39 | 9.31 |
| MnO | 0.15 | 0.19 | 0.16 | 0.16 |
| MgO | 4.07 | 1.28 | 5.34 | 5.39 |
| CaO | 8.22 | 5.29 | 9.72 | 9.84 |
| Na2O | 3.1 | 3.84 | 2.95 | 2.89 |
| K2O | 0.86 | 2.04 | 0.86 | 0.86 |
| P2O5 | 0.12 | 0.45 | 0.16 | 0.17 |
| (ppm) | | | | |
| Sc | 32 | 24 | 33 | 31 |
| V | 240 | 18 | 226 | 226 |
| Cr | 13 | 6 | 16 | 13 |
| Ni | 4 | 4 | 11 | 0 |
| Cu | 34 | 0 | 17 | 27 |
| Zn | 77 | 113 | 69 | 66 |
| Rb | 35 | 69 | 27 | 22 |
| Sr | 193 | 294 | 343 | 344 |
| Y | 30 | 36 | 20 | 21 |
| Zr | 90 | 177 | 85 | 85 |
| Nb | 5 | 9 | 7 | 5 |
| Ba | 200 | 448 | 291 | 291 |
| Pb | 7 | 15 | 4 | 4 |
| Sr/Rb | 5.5 | 4.26 | 12.7 | 15.6 |
| Zr/Rb | 2.6 | 2.6 | 3.15 | 3.9 |

*Table 1. Chemical (XRF) analyses of volcanic rocks (anhydrous). Analyses by J. Wilmshurst, University of Auckland.*

New XRF analyses of source samples from Tryphena, Orokawa and Maketu are presented in Table 1. These were run on the same machine as those analysed by Felgate *et al.* (2001). Based on its $Al_2O_3$ content the sample from Maketu is classified as a high-alumina basalt. On silica content the Tryphena sample is classified as a basaltic andesite, and the Orokawa sample is an andesite. Previously published analyses and petrographic descriptions indicate the Ti Point rocks are all basalts (Heming 1980), and those at Stony Batter are basaltic andesites (Black *et al.* 1992).

EDXRF analyses of both source samples and artefacts were undertaken using a portable Innov-X Alpha spectrometer at the Anthropology Department, University of Auckland. Some of the source samples were the same as those analysed by XRF, allowing direct comparison of values obtained by the two methods. The most useful elements for comparative purposes are Rubidium (Rb), Strontium (Sr) and Zirconium (Zr), which can be measured with good precision (Table 2).

| **Sample** | **Rb** | **Sr** | **Zr** | **Sr/Rb** | **Zr/Rb** |
|---|---|---|---|---|---|
| Tryphena | | | | | |
| TRY-1 # | 26 | 186 | 73 | 7.2 | 2.8 |
| TRY-2 | 26 | 198 | 79 | 7.6 | 3.0 |
| Tahanga | | | | | |
| TAH-1 | 7 | 276 | 75 | 39.4 | 10.7 |
| TAH-2 | 13 | 310 | 93 | 23.8 | 7.2 |
| AU17 | 8 | 297 | 84 | 37.1 | 10.5 |
| U13/1339* | 9 | 291 | 70 | 32.3 | 7.8 |
| Orokawa | | | | | |
| ORK-1 # | 59 | 309 | 167 | 5.2 | 2.8 |
| ORK-2 | 66 | 305 | 163 | 4.6 | 2.5 |
| Adze preform* | 59 | 307 | 160 | 5.2 | 2.7 |
| U13/1343* | 63 | 326 | 174 | 5.2 | 2.8 |
| U13/875* | 58 | 309 | 159 | 5.3 | 2.7 |
| Maketu | | | | | |
| MAK-1 # | 19 | 331 | 75 | 17.4 | 3.9 |
| MAK-2 | 17 | 344 | 72 | 20.2 | 4.2 |
| MAK-3 | 22 | 356 | 73 | 16.2 | 3.3 |
| M41 (V14/187)*# | 23 | 361 | 76 | 15.7 | 3.3 |

*Table 2. EDXRF analyses of selected trace elements (in ppm) for source and archaeological (*) samples. Those also analysed by XRF indicated by # (see Table 1).*

*Results*

Bivariate plots of Sr-Rb, and Zr versus the Sr/Rb ratio for both source and archaeological samples are illustrated in Figures 3 and 4. Analyses from the Tahanga quarry complex and Tryphena source previously published by Felgate *et al*. (2001) have also been included in these plots for comparative purposes, although for Tahanga, only samples that were collected from recorded sites or showed evidence of working and/or were generally fine grained, were included. This was intended to ensure that the values selected were representative of the *main type* of material exploited. The XRF analyses for Stony Batter are from Black *et al*. (1992), and an additional analysis of the Maketu basalt is taken from Werhmann (2000).

The Sr-Rb and Zr-Sr/Rb diagrams show a clear distinction between the Orokawa andesite and Tahanga basalt, and good separation of the Tryphena and Tahanga fields (Figures 3, 4). There is however a degree of overlap of the Maketu and Tahanga fields, particularly in terms of Zr concentrations. On the Sr-Rb diagram the majority of samples from the Tahanga complex form a relatively tight cluster, but there are two outliers with significantly higher Sr values (Figure 3). Both of these samples (T25a, T30b) came from isolated outcrops of the basalt north of the main hill, which have a slightly different composition (Felgate *et al*. 2001). Notably, all 5 artefact samples from Houhora analysed by Felgate *et al*. (2001) plot near the middle of the main Tahanga field (not shown), and the 4 samples analysed by EDXRF in this study also plot close to this field.

The Tryphena samples analysed by XRF plot very close together, despite the fact that the two (GB1, GB2) analysed by Felgate *et al*. (2001) were collected from the stream bed *near* the actual 'quarry', not the site itself. This suggests that the Tryphena basaltic andesite is quite homogeneous. Although there are insufficient analyses of the Orokawa andesite to establish its range in composition, considering the degree of separation between the Orokawa field and those of all other rocks, this is not a problem. Importantly, the two source samples analysed by EDXRF both have similar Zr and Sr values to the XRF sample, and element ratios are very consistent (Table 2). There are also insufficient analyses of the Maketu basalt to define its variation in composition, though the two source samples plot relatively close together, as do the three EDXRF samples. Notably the artefact (M41) from site V14/187 analysed by both XRF and EDXRF plots within the field defined by the 5 XRF and EDXRF samples. Clearly the Stony Batter andesite (if utilised) may be difficult to differentiate from Tahanga basalt, and perhaps also Maketu basalt, on the basis of Rb, Sr and Zr concentrations alone. Therefore other elements would need to be considered.

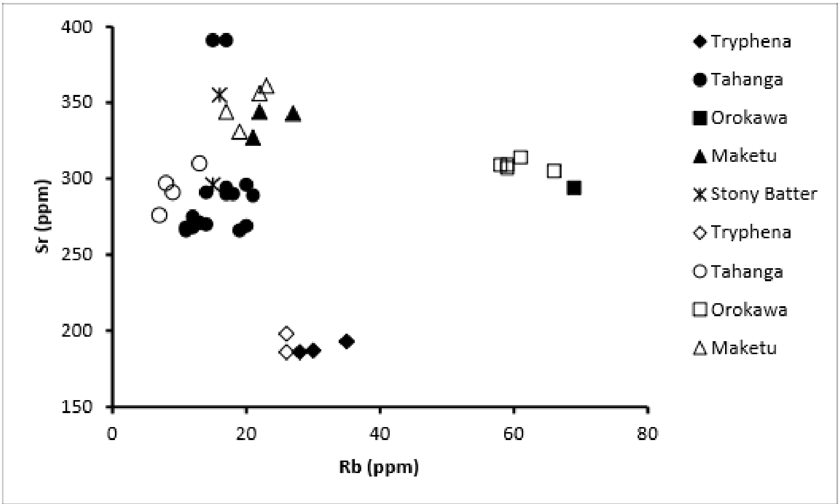


*Figure 3: Bivariate plot of strontium versus rubidium for Hauraki – Bay of Plenty basalts and andesites. Solid symbols (+ Stony Batter) = XRF, open symbols = EDXRF analyses. Data from Tables 1 & 2, with additional values from Felgate et al. 2001 (Tahanga and Tryphena), Black et al. 1992 (Stony Batter), and Werhmann 2000 (Maketu).*

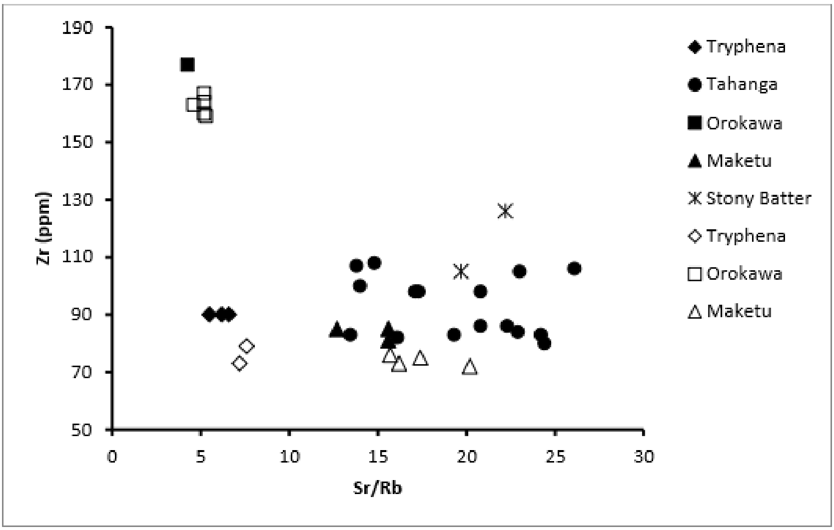


*Figure 4: Bivariate plot of zirconium versus Sr/Rb ratio for Hauraki – Bay of Plenty basalts and andesites. Symbols and data sources as for Figure 3.*

It is evident from the two plots that the EDXRF values for Rb and Zr (but not Sr) are generally lower than those obtained by XRF, even for the same samples. Average differences for the four samples analysed here by both methods are about 18% for Rb, 4% for Sr and 12% for Zr. This is not unexpected when using different methods of analysis. The slightly lower or higher values obtained by EDXRF can probably be largely attributed to surface irregularities or weathering, and accuracy could almost certainly be improved by better sample preparation (none was undertaken for this study), duplicate analyses, and use of more appropriate standards.

## Period of exploitation

Though it is by no means certain that Tahanga was the first basalt source discovered and exploited in the North Island, it is likely that adzes of this basalt were in wide use by about 1300 AD (Moore 1976). This view was initially based on a limited number of un-calibrated radiocarbon dates and an assumed age of circa 1300 AD for the Loisels Pumice. In the intervening years more reliable radiocarbon dates have been obtained, the first arrival of Polynesians is now believed to have occurred around 1280 AD (Wilmshurst *et al*. 2008), and the Loisels Pumice is thought to date to between about 1305 and 1345 AD (McFadgen 2007).

The age of some important sites is particularly relevant. At the Cross Creek site near Opito (T10/399), new data indicates the oldest layer containing Tahanga basalt flakes (Layer 7) dates to 1295-1390 AD (at 68% probability), and initial occupation probably occurred prior to eruption of the Kaharoa Tephra circa 1315 AD (Furey *et al*. 2008). The Houhora site in the Far North was occupied in the early 14$^{th}$ century, and contains many reworked Tahanga basalt adzes (Furey 2002). The oldest reliable date, on shell (Wk 5035), is 1281-1327 AD (at 95% confidence), thus raising the possibility that initial occupation could have occurred prior to 1300 AD. Hence there is some indication that the Tahanga source was discovered in the late 13$^{th}$ century.

So far, andesite from the Tryphena source has not been identified at any excavated site on Great Barrier (or elsewhere apparently), and at present it is not entirely clear when it was exploited. The triangular cross-sections of most preforms suggest the 'quarry' is probably relatively early, but it is possible the source was also being used at a later date.

Initial indications were that the Orokawa andesite had been exploited only in the late prehistoric period, post 1500 AD, because of the occurrence of flakes and cores of this material on local pa (Moore 2001). This is supported by dates from two excavated sites at Waihi Beach (T13/829, U13/1343), which confirm minor use of the andesite in the late 16$^{th}$-early 17$^{th}$ century and 17$^{th}$ or 18$^{th}$ century respectively. However, discovery of the triangular-sectioned preform at Orokawa Bay, and identification of the single flake at Bowentown (U13/875), now suggest there was some attempt to manufacture adzes from this material at a much earlier stage, probably in the $14^{th}$-$15^{th}$ century.

Both early and late exploitation of the Maketu basalt was suggested by Moore (1981) on the basis of water-worn preforms found at Newdicks Beach. Its early use is confirmed by discovery of the basalt artefacts at site V14/187, where a date on moa bone (Wk 23623) provided age ranges (at 68% probability) of 1320-1345 AD and 1385-1415 AD (Moore 2008). Since the main cultural layer directly overlies Kaharoa Tephra with no intervening soil horizon, the earlier age is certainly acceptable and suggests the Maketu basalt could have been exploited around 1320-1340 AD.

## Discussion

One of the aims of this paper was to highlight the fact that, despite the existence of a major quarry complex at Tahanga, attempts were made to manufacture adzes from other fine grained volcanic rocks within the same region, also at an early stage. It seems unlikely this could be attributed to difficulty in obtaining material from Tahanga, either as roughly shaped blocks or preforms, since Archaic sites situated relatively close to these other stone sources (e.g. Harataonga, Bowentown, Mt Maunganui) contain abundant flakes of Tahanga basalt (Turner & Bonica 1994). Hence experimentation with local rock types was not a matter of necessity but presumably reflects a desire by those inhabiting the area to determine whether these rocks were suitable for adzes or not. If not then their attempts were abandoned, although there is clear evidence at Waihi Beach that Orokawa andesite continued to be utilised on a small scale into the $17^{th}$ or $18^{th}$ century, not for adzes but perhaps as a substitute for chert (Moore 2001).

There is obviously a need to undertake similar studies elsewhere, particularly in Northland and along the Waikato coast, where significant numbers of early adze forms (Types 1, 3, 4) were apparently made from local basalts (Turner 2000 table 5.4). Identifying the sources, however, may not be a simple matter because, as in the Bay of Plenty, some are likely to be located on beaches or at stream mouths where coastal erosion and flooding may have removed much of the evidence of adze manufacture. It will therefore require a more detailed examination of both recently excavated assemblages and museum collections, and the use of geochemical analysis.

## Acknowledgements

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