The demise of a monopoly: Implications of geochemical characterisation of a stemmed obsidian tool from the Bishop Museum collections

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ABSTRACT

Geochemical analysis using portable X-ray fluorescence (pXRF) shows that a large stemmed tool in the Bishop Museum, thought at one time to be a mata’a from Rapa Nui, is composed of obsidian from the Mopir outcrops on New Britain, Papua New Guinea. As the first large, ceremonial stemmed tool from this quarry, it challenges the hypothesis that production was limited to one region, therefore suggesting that a more complex set of social networks operated in the period prior to 3000 BP in the Bismarck Archipelago.

Keywords: obsidian, geochemical sourcing, portable X-ray fluorescence, Melanesia, Rapa Nui (Easter Island), Oceania

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AN ANOMALY?

Most prominent among the obsidian mata’a showcased in the Museo Antropológico Padre Sebastián Englert [Father Sebastián Englert Anthropological Museum] on Rapa Nui (Easter Island) is the cast of a large tool, the original of which is housed in the Bishop Museum’s Ethnology Collections (Accession Number B.2195) (Figures 1 and 2 and Table 1). Since the artefact was made on a kombewa, or double-bulbed flake, the blade has smooth ventral flake surfaces on both sides that meet to form a rounded shape, with a strong, sharp edge that does not require further retouch (cf. descriptions in Araho et al. 2002). The side notches that create the crescent and separate a long, central stem were formed by marginal, bifacial retouch, which has been overlain by further small overlapping retouch scars that give it a serrated appearance. The stem of the artefact, which has a recent break at the distal end, was also bifacially retouched using percussion techniques, but some flakes have also been struck from a central ridge across the surface. Finally, overlapping scars have formed a series of notches along the edges of the stem.

Although many mata’a from Rapa Nui were also made on kombewa flakes and have a similar rounded outline of the blade, the very large size, the deep notches that form the crescent shape and the systematic bifacial working of the stem are unique. Over the years, a number of scholars have commented that this tool is unusual, but generally it has been accepted as part of Rapa Nui material culture. The purpose of this report is to use portable X-ray fluorescence (pXRF) to test whether the tool was actually made from Rapa Nui obsidian. The results produced a surprise that has significant implications for understanding obsidian manufacture and exchange in Melanesia.

A MISATTRIBUTION?

According to the accession documents and correspondence curated by the Cultural Collections Department at the Bishop Museum, obsidian implement B.2195 was collected between 1902 and 1920 by Rev. William H. Cox. His collection was acquired by the Bishop Museum in 1920, and included 341 ethnographic objects from Melanesia, including objects from New Britain, New Ireland, Buka, the Admiralty Islands and the Duke of York Islands. During this same year, the Bishop Museum acquired a large collection of ethnographic objects that the private collector J.L. Young had collected on Rapa Nui, including 232 obsidian mata’a. At some point thereafter, the stemmed obsidian tool from Cox’s collection was attributed to Rapa Nui and began to shape views about obsidian use on the island. In Ethnology of Easter Island, originally published in 1940, Métraux (1971) referred to the obsidian artefact as an “implement of unknown use”, but other than illustrating it, he did not remark that it was unusual:

In the Bishop Museum collection is what looks like an enlarged obsidian spear head but the tang is of such a length and thickness that it forms an effective hand grasp.

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Geochemical characterisation of a stemmed obsidian tool

Figure 1. A stemmed obsidian tool (Accession Number B.2195) from the Bishop Museum’s Ethnology Collections (Jesse W. Stephen, copyright Bishop Museum).

... It is much heavier than the spear heads and its long curved edge renders it suitable as a cutting implement. It could have been used as a hand weapon or as an implement for cutting up large fish or human flesh. (Métraux 1971: 281)

Heyerdahl later described the artefact in his 1962 report on surface artefacts from Rapa Nui:

A large and aberrant obsidian instrument from Easter Island, that could almost seem to be an elaborate prototype of the crescent-shaped variety, is in the Bishop Museum collection ... Although of unknown use, this sharp-edged, carefully chipped and modelled specimen is sufficiently reminiscent of a Peruvian tumi to be suggestive of similar use as a surgical or cutting instrument. (Heyerdahl 1962: 399)

In 1992, Van Tilburg noted that the implement would be “of great significance in understanding Easter Island iconography” (1992: 17) and drew parallels between its crescent shape and crescent shapes on other types of Rapa Nui material culture, including stone statues and wooden artefacts. She also remarked that in his discussion of Lapita influences on Oceanic art forms, Newton (1988: 23) “believes that the tanged, crescentic blade is the ‘mental template’ of Roti, Lapita, and successive blade forms” (Van Tilburg 1992: 17), stating that “an Easter Island mata’a, or spearpoint, would fit perfectly into the crescentic outlines of prehistoric blades provided by Newton”. Later, however, Van Tilburg noted that there was a problem with this particular tool’s supposed Rapa Nui provenance:

... [B.2195] was acquired in 1920 as part of the Rev. William H. Cox collection. Rev. Cox apparently lived some 18 years in Melanesia, and his collection is dominated by Melanesian objects, casting some doubt on the origin of this piece. Metraux accepted its Rapa Nui provenance. Appropriate testing of the obsidian is the only method of confirming that this axe is, indeed, from Rapa Nui. (Van Tilburg 1994: 171)

The possible attribution to Melanesia proposed by Van Tilburg makes a great deal of sense, and not only because

Table 1. The maximum dimensions of stemmed tool B.2195 compared to selected morphometric data from mata’a in the collections of the Bishop Museum (n = 302) (mata’a data from Mulrooney et al. 2014). All measurements are in mm except for the weight (g).

<table>
<thead>
<tr>
<th></th>
<th>Stemmed tool B.2195</th>
<th>Rapa Nui mata’a mean</th>
<th>Rapa Nui mata’a S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>585</td>
<td>110.7</td>
<td>78.4</td>
</tr>
<tr>
<td>Length</td>
<td>173.5</td>
<td>95</td>
<td>24.6</td>
</tr>
<tr>
<td>Blade width</td>
<td>222.3</td>
<td>86</td>
<td>22.9</td>
</tr>
<tr>
<td>Blade thickness</td>
<td>35.2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Stem length</td>
<td>106.1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Stem width</td>
<td>32.9</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Stem thickness</td>
<td>30.9</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

crescent shape and crescent shapes on other types of Rapa Nui material culture, including stone statues and wooden artefacts. She also remarked that in his discussion of Lapita influences on Oceanic art forms, Newton (1988: 23)

Figure 2. A line drawing of B.2195 with maximum measurement locations shown (after Métraux 1971 [1940]: 282, fig. 50).
### Table 2. A summary of the calibrated results for multiple analyses of the obsidian standard NIST SRM 278 from the Bruker Tracer III pXRF analysers at the Bishop Museum and the University of Auckland. All concentration values are reported as ppm.

<table>
<thead>
<tr>
<th>Given Value</th>
<th>Bishop Museum</th>
<th>University of Auckland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
</tr>
<tr>
<td>Mn</td>
<td>403</td>
<td>336</td>
</tr>
<tr>
<td>Fe</td>
<td>14269</td>
<td>13618</td>
</tr>
<tr>
<td>Zn</td>
<td>55</td>
<td>36</td>
</tr>
<tr>
<td>Ga</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Th</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Rb</td>
<td>128</td>
<td>119</td>
</tr>
<tr>
<td>Sr</td>
<td>64</td>
<td>58</td>
</tr>
<tr>
<td>Y</td>
<td>39</td>
<td>38</td>
</tr>
<tr>
<td>Zr</td>
<td>290</td>
<td>257</td>
</tr>
<tr>
<td>Nb</td>
<td>18</td>
<td>16</td>
</tr>
</tbody>
</table>

†Data from Govindaraju (1994).

Cox was resident in New Britain as the chairman of the Methodist Mission for 33 years (Sydney Morning Herald 1934). In addition, large, carefully flaked stemmed tools made on kombewa flakes have been found in many parts of Papua New Guinea, and recent geochemical studies using a range of techniques have determined that these were made at the obsidian sources on New Britain and Lou Island (Manus). Stemmed tools of a similar size and with deep side notches, creating a crescent-shaped blade, have been sourced to both the Kutau-Bao outcrops on New Britain and to the Umleang source on Lou Island (Torrence et al. 2009, 2013), but none of the artefacts have notches along the stem as in the Bishop Museum example. It is therefore possible that it is derived from another location.

### pXRF ANALYSIS

To test whether the stemmed artefact is made of obsidian from Rapa Nui or Melanesia, we measured the chemical composition of the tool and compared it with published data on Rapa Nui source material (Mulrooney et al. 2014) and 54 source samples from Melanesia. The analysis was done using a pair of Bruker Tracer III SD pXRF instruments, one of which is housed in the Bishop Museum’s Anthropology Laboratory and the other of which is in the Anthropology Laboratory in the School of Social Sciences, University of Auckland. These instruments were set up to measure the same nine elements: Mn, Fe, Zn, Th, Rb, Sr, Y, Zr and Nb. In total, 54 Melanesian source samples from four regions were included in the reference set. This included 44 at the Auckland Anthropology Laboratory and a further ten at the Bishop Museum to assist comparison (Supplementary Table 1).

The Bishop Museum instrument was equipped with a filter consisting of 6 mil copper (Cu), 1 mil titanium (Ti) and 12 mil aluminium (Al), and it was operated at 40 keV and 20 μA for 180 s in an air path. Measurements were taken from three areas of the artefact and on ten source samples, and the results were averaged. Elemental concentrations were calculated with Bruker software using the calibration coefficient provided by Bruker that is based on the analysis of 40 well-characterised source obsidian samples (see Speakman 2012).

To increase the sample size, the second instrument was used to analyse 44 additional Melanesian source samples at the University of Auckland. The X-ray tube was operated with a setting of 40 keV at 12 μA, through a window composed of 12 mil Al and 1 mil Ti filters. Each specimen was analysed in an air path for 60 s twice on different portions of its surface and the results were averaged. Tests at the University of Auckland have shown that precision and accuracy for analysis times between ~45 and 300 s are statistically indistinguishable (see also Hall et al. 2014). The mid-z elements (Rb to Nb), in particular, settle to within a few parts per million (ppm) of their final values after analysis times of 30 s or more. Concentrations were calculated as ppm using Bruker’s SICalProcess (ver. 2.2.33) software, with a calibration coefficient derived from the analysis of 29 reference samples, including 22 international standards (GA, GSP-2, JA-2, JF-1, JG-1a, JG-2, JP-1, JR-1, MAG-1, NIM-S, NIM-G, OU-1, Pacs-2, QLO-1, RGM-1, SCO-1, SDC-1, STM-1, SY2, SY3, YG-1 A and YG-1 B) and seven “in-house” obsidian standards (ANU 2000 (Wekwok), AU-17.59, AU-29.16, AU-32.1, AU-7.21, AU-9.3 and AU-9.5) analysed at the University of Auckland, School of the Environment Geology Laboratory by wavelength-dispersive X-ray fluorescence. The obsidian standard NIST SRM-278 was regularly analysed at both the Bishop Museum and University of Auckland laboratories to check calibration and monitor instrument drift. Results from recent analyses summarised in Table 2 show that both instruments provide levels of accuracy and precision similar to those obtained by other researchers (e.g., Glascock & Ferguson 2012; Shackley 2005, 2012; Speakman 2012).
The Melanesian obsidian sources can be divided into four major regions: Admiralty Islands, Fergusson Islands, Banks Islands (Vanuatu) and New Britain (Sheppard et al. 2010; Summerhayes 2009) (Figure 3). The four chemical groups recognised for New Britain include Mopir, Baki, Kutau-Bao and Gulu (for full descriptions and previous pXRF results, see Ambrose et al. 1981; Fullagar et al. 1991; Sheppard et al. 2010; Torrence et al. 1992, 2013). Data for the chemical composition of the Rapa Nui sources are solely derived from the previous pXRF study conducted by Mulrooney et al. (2014: Table 1).

**RAPA NUI DISCOUNTED**

For the first stage of our analysis, the artefact was compared to our reference set described above. A scatterplot of Y against Nb completely separates the obsidian sources from Melanesia and Rapa Nui and shows that the artefact is clearly associated only with the Melanesian specimens (Figure 4a). A comparison of all other measured elements further indicates that the artefact is not derived from a Rapa Nui obsidian source (Figure 5). With the sole exception of Mn, none of the elemental concentrations of the artefact overlap with the ranges of Rapa Nui sources. In contrast, the artefact is within the ranges of the Melanesian source specimens for all elements.

**FINDING THE BISMARCK ARCHIPELAGO SOURCE**

The next task was to test whether the tool was made with obsidian from New Britain as predicted, or if it is derived from elsewhere in Melanesia. This step is important because three stemmed tools with the deep side notches that create the crescent shape have been sourced to the Umleang obsidian source on Lou Island in Manus Province (Admiralty Islands) (Torrence et al. 2009: fig. 2; Torrence et al. 2013: Table 1 and figs. 3 and 6). Four additional stemmed tools with crescent-shaped blades were assigned to the Kutau-Bao source by Torrence et al. (2013: Table 1), but several others have also been found at the Kutau-Bao obsidian quarries (Torrence, unpublished field notes). A tool from the FABN site (reported in Torrence 2004a: 3; see also Araho et al. 2002) is perhaps the closest in overall configuration, because it also has the very substantial notches that create long pointed ends on the crescent shape, but reasonable side notches are also found on other less well-worked examples from site FABN (Torrence 2004a: 3).
Figure 4. Scatterplots showing stemmed tool B.2195 in relation to probable obsidian sources: (a) Rapa Nui versus Melanesian sources; (b) sources within Melanesia; (c) sources within New Britain. The artefact is indicated with a black star.

Figure 5. A comparison of the ranges and means of all measured elements common to both pXRF analysers for obsidian reference specimens from Melanesia and Rapa Nui. The relative position of artefact B.2195 is indicated with a black star. All concentration values are reported as ppm.

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Because there are a large number of obsidian sources in Melanesia, it is difficult to show their separation in a single scatterplot. A more satisfactory approach is to determine from which of the four Melanesian source regions the artefact is most probably derived, and then examine that region in more detail (e.g., Torrence et al. 2013: fig. 13). A plot of Nb against Rb separates these regions and places the artefact among the New Britain sources (Figure 4b). A further scatterplot of the trace element ratios Sr/Zr against Rb/Y is used to discriminate within the New Britain sources (Figure 4c), and this indicates that the artefact is associated only with the Mopir source reference specimens. Comparing data for each element shows that the artefact possesses a very similar chemical signature to the Mopir source; all measured elements fall inside the range of this source and the mid-z trace elements (Rb to Nb) are within 2 ppm of the source average (Table 3). On this basis, we can now assign the stemmed artefact to the Mopir source with a high degree of confidence.

DISCUSSION AND CONCLUSION

The finding of a carefully made crescent-shaped stemmed tool from the Mopir obsidian source is highly significant, since all the others with this form from New Britain were derived from the Kutau-Bao outcrops. Stemmed tools have previously been reported from the Mopir quarries by Fullagar et al. (1991), but the artefacts that they collected are very thick, bulky and have irregular shapes, unlike the thin, finely worked ceremonial tools. Kononenko et al.
Figure 6. Three stemmed tools from West New Britain, two of which have a crescent-shaped body that resembles B.2195: (a) from site FABN; (b) from site FCR; and (c) PR 1884.19.31.6, which was sourced to the Mopir source (photo copyright Pitt Rivers Museum, University of Oxford). Scale bar is 1 cm.
of sources that were being exploited for contemporary utilitarian artefacts. The elaborate notching on the stem that sets this tool apart from all others also suggests that each stemmed tool may have been designed to be unique and physically distinctive because it was connected to its owner, to a specific story, to an event or to some other meaning. Finally, we are left wondering how many other stemmed tools from Papua New Guinea are hidden away in museum collections and, because they have been so poorly known until recently, have been misattributed to Rapa Nui or other parts of the world.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Bishop Museum, the Australian Research Council and the University of Auckland. We thank Betty Lou Kam, Kamalu du Preez, Lissa Gendreau and Marques Marzan for facilitating access to the Ethnology Collections at the Bishop Museum. We offer thanks to Peter Sheppard for providing geological samples and to Katherine McKellar for assisting with the XRF analysis for the Auckland part of the study. We thank Richard Cox for his generous donation, which supported the purchase of the Bruker pXRF instrument at the Bishop Museum. Bruce Kaiser, at Bruker Elemental, Kennewick, Washington, is thanked for providing ongoing advice and support for the pXRF instruments. We are grateful to the reviewers for pointing out areas where the paper could be improved.

REFERENCES


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**SUPPORTING INFORMATION**

Additional Supporting Information may be found in the online version of this paper at the publisher’s website:

Table S1