Research Report

Long-term obsidian use at the Jerimalai rock shelter in East Timor

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Abstract

We report new evidence from East Timor for the long-term prehistoric use of a single high-silicate obsidian source. Ten artefacts from Jerimalai shelter in East Timor analysed with SEM/EDXA and LA-ICPMS demonstrate the exploitation of this source began in the Pleistocene by 42,000 cal. BP, and continued to be used periodically into the mid to late Holocene. The data supports previous results suggesting that a high-silicate obsidian of unknown location has been transported over considerable distance to rock shelter sites in the east of Timor.

Archaeological investigations of caves and shelters in the eastern part of East Timor have produced evidence of an early occupation of the island by modern humans by 42,000 cal. BP; currently the earliest evidence for modern human presence in Island Southeast Asia east of the Sunda shelf (O'Connor 2007; O'Connor *et al.* 2010). Previously reported finds of obsidian artefacts in the East Timor rock shelters Matja Kuru 1 and 2 (MK1 and 2) and obsidian and pitchstone artefacts from the rock shelters Bui Ceri Uato (BCU) and Bui Ceri Uato Mane (BCUM) on the Baucau Plateau of East Timor (Figure 1) indicated that use of these raw materials began at least 13,000 years ago, and continued episodically into the mid to late Holocene (Ambrose *et al.* 2009:608).

The discovery of small numbers of obsidian artefacts in East Timor sites raised the possibility of long distance movement of this raw material within Island Southeast Asia such as evidenced by the occurrence of obsidian artefacts in Bukit Tengkorak, Sabah, successfully provenanced to the Kutau/Bao source in West New Britain, Papua New Guinea (Bellwood 1989; Tykot and Chia 1997). The East Timor obsidian artefacts comprised a very small proportion (less than 1%) of the total lithic assemblage at all sites from which they were recovered, were uniformly of small size ($\bar{x}$ -length 11.7mm SD 5.7; $\bar{x}$ -weight 0.56g, SD 1.11) with a general lack of cortex (only one artefact showed rounded cortex on the dorsal surface), suggesting they may have been reduced from highly curated cores. The six cores from

Bui Ceri Uato analysed in the previous study supported this assumption, being of exceptionally small size. Additionally, the high-silicate obsidian flakes analysed by Ambrose *et al.* (2009) showed no evidence of retouch such as would be consistent with re-use/curation of a highly prized exotic material (Binford 1979). Glover (1986:56) similarly reported that in his assemblages obsidian “flakes larger than 1 cm were exceptional, and none show any signs of secondary working or even of extensive utilisation”. Additionally, obsidian artefacts were not found in two uphill rock shelter sites in the central part of the island, Uai Bobo 1 and 2 (Glover 1986:132–133).

Ambrose *et al.*'s (2009) study into the Timor artefacts therefore attempted to ascertain whether or not the East Timor artefacts derived from one or more source localities and whether the sources were likely to be local or external to East Timor. This study found that the pitchstone artefacts were confined to the Baucau plateau sites and could be matched with a local source in the same region. The high-silicate obsidian artefacts occurred at all four widely spaced sites but no source could be identified. The authors proposed that the long-term use of a single source of obsidian indicates the occurrence of an as yet unknown local source in East Timor, rather than import of obsidian from a non-Timor source (Ambrose *et al.* 2009:614).

In this report we present additional evidence for the long-term utilisation, associated with the initial inhabitation of the island by modern humans, of the same high-silicate obsidian source as previously reported with the analysis of ten obsidian flakes from Jerimalai shelter.

Background

The Jerimalai shelter is located in a limestone terrace near the far eastern coast of East Timor (Figure 1). Its maximum dimensions are c. 28m north-south and c. 10m in depth. Site aspect is east, facing the sea (O'Connor 2007:528, Figure 2). Although radiocarbon assays on material from the upper part of the deposit indicated the site was last occupied intensively in the late Holocene c. 2500 years ago, contemporary use was evident in recent hearths and wooden structures on the surface, particularly at the southern end of the shelter.

Two 1m² test pits were excavated in July 2005 in the southern section of the shelter, respectively 2m (TP A) and 5m (TP B) behind the drip line. Excavation was carried out in 2–5cm spits and all removals were wet-screened through fine mesh of <2mm. The excavation resulted in a stratigraphic sequence of more than 150cm depth (O'Connor 2007:529, Figure 3). To date, 15 radiocarbon dates have been obtained from Pits A and B, mainly on marine shell as charcoal did not occur in the lower levels of the test pits (Table 1). The radiocarbon dates suggest an initial occupation of the shelter at around 42,000 cal. BP with some occupation until the late Holocene. The excavated rich cultural material included large numbers of unmodified and modified chert artefacts and large quantities

of shellfish, fish and turtle bone. Ceramics occurred only in the upper part of the stratigraphy (O'Connor 2007). The ten obsidian flakes analysed in this study were found throughout the sequence without a noticeable concentration of artefacts in upper or lower levels (Table 1).

Obsidian is a natural volcanic glass that emerges when rhyolitic lava (usually with a SiO₂ content of >70%) cools very quickly during a volcanic eruption. The shock cooling limits the development of crystals in the matrix of the material and results in a homogeneous amorphous rock, which is very brittle and can easily be flaked producing very sharp edges. Geochemical research in the past was able to provenance obsidian artefacts from a series of archaeological sites successfully. Unfortunately, previous archaeological research in Island Southeast Asia only intermittently focused on the identification of obsidian sources or the provenancing of obsidian artefacts, so that the knowledge about possible raw material sources in this area is limited.

The geology of East Timor itself is a complex system of arc-continent collisions at the intersection of the Indo-Australian, Eurasian and Pacific tectonic plates (Hall 2002;

Hamson 2004; Wheller *et al.* 1987). East Timor is tectonically part of the southern arm of the Outer Banda Arc. The petrology of Timor originates from the subduction of the Australian plate under the Eurasian plate, so that rocks of Permian to post-orogenic Upper-Miocene and recent age are exposed at the surface. Since three million years ago, Timor has progressively emerged from north to south with southern Timor becoming fully exposed in the late Pleistocene (Johnston and Bowin 1981). Although located in one of the most active tectonic zones on Earth, East Timor has been volcanically inactive during the last three million years, deriving from the accretion of the Outer Banda Arc to the Australian continent (Elburg *et al.* 2005). Moving northward at the same rate as the Australian plate, the uplift of East Timor might therefore originate from the folding processes of a continental plate rather than active volcanism (Richardson and Blundell 1996). Even though Pleistocene volcanism did not occur on East Timor, volcanic outcrops of Pliocene age can be found. Ambrose *et al.* (2009) reported a source of pitchstone in Baucau, central north East Timor (Figure 1), and could successfully provenance several artefacts from the BCU and BCUM rock shelters to this source.

Level	Number	Material	Age BP	ΔR	AGE CAL BP 95% (2σ) CAL BP range	Sample No.
Square A						
Spit 1						ANU9487
Spit 3	Wk-19224	charcoal	2570±34	0	2143-2326	
Spit 5	Wk-19225	charcoal	3245±39	0	2940-3203	
Spit 6	Wk-18154	marine shell (Turbo)	5341±41	-400	5126-5430	
Spit 21	Wk-19226	marine shell (Turbo)	5909±40	-400	5760-5984	
Spit 26	Wk-18156	marine shell (Haliotis sp.)	10110±79	-400	10370-10815	
Spit 29						ANU9495
Spit 30						ANU9494
Spit 31						ANU9493
Spit 32						ANU9492
Spit 38	Wk-19227	marine shell (Turbo)	13658±91	-400	14915-16119	
Spit 40						ANU9489
Spit 46	Wk-17831	marine shell (Trochus)	38255±590	-400	41327-42996	
Square B						
Spit 3	Wk-19228	charcoal	124±32		0-273	
Spit 9	Wk-18157	marine shell (Trochus)	4580±42	-400	4136-4399	
Spit 12						ANU9456
Spit 14						ANU9459
Spit 21	Wk-18159	marine shell (Trochus)	5595±43	-400	5457-5643	
Spit 28						ANU9460
Spit 34	Wk-19231	marine shell bead (Nautilus)	6118±41	-400	5999-6244	
Spit 40	Wk-18160	marine shell (Trochus)	8879±78	-400	8917-9353	
Spit 49	Wk-19232	marine shell (Haliotis sp.)	14007±140	-400	15241-16691	
Spit 56	Wk-17833	marine shell (Turbo)	35387±534	-400	38523-41019	
Spit 61						ANU9461
Spit 66	Wk-17833	marine shell (Trochus)	37267±453	-400	40728-42219	

Table 1. Allocation of radiocarbon dates and artefacts to Spit Numbers in Jerimalai. Radiocarbon dates have been calibrated with CALIB 6.01 (Stuiver *et al.* 2011), calibration using IntCal09 and Marine09 data (Reimer *et al.* 2009).

Results

The obsidian flakes from Jerimalai (Table 1) were examined with a JEOL JSM6400 Scanning Electron Microscope equipped with an Oxford ISIS energy-dispersive X-ray analyser (SEM-EDXA, Oxford instruments Link ISIS 3.3 software) for eight major elements (Na, Mg, Al, Si, Ca, K, Ti, Mn and Fe) at the Research School of Biological Sciences, ANU. Laser ablation – ICPMS (LA-ICPMS) analysis was conducted in the Research School of Earth Science at the ANU (Falkner *et al.* 1995; Longerich *et al.* 1996; for detailed experimental set-up and methods used, Reepmeyer 2008). Counts for 31 isotopes (^{31}P , ^{45}Sc , ^{49}Ti , ^{51}V , ^{55}Mn , ^{63}Cu , ^{85}Rb , ^{88}Sr , ^{89}Y , ^{90}Zr , ^{93}Nb , ^{95}Mo , ^{118}Sn , ^{133}Cs , ^{138}Ba , ^{139}La , ^{140}Ce , ^{144}Nd , ^{147}Sm , ^{153}Eu , ^{158}Gd , ^{162}Dy , ^{166}Er , ^{174}Yb , ^{175}Lu , ^{181}Ta , ^{186}W , ^{206}Pb , ^{207}Pb , ^{208}Pb , ^{232}Th and ^{238}U) were determined by calculating the mean counts for each isotope from three analysis runs per sample. For multivariate statistical analysis, the C2 package was employed (Juggins 2005). Absolute parts per million (ppm) counts of 31 isotopes were log (lg) transformed and examined with Principal Component Analysis (Baxter 2006).

Ten obsidian flakes were included in the multi-element analysis. The geochemical composition of the artefacts was compared in two separate analyses first with 13 obsidian sources from Papua New Guinea, and second with seven obsidian source from Indonesia and the Philippines (Figure

1). Additionally, the recently reported geochemical composition of the high-silicate obsidian artefacts from two East Timor rock shelter sites, MK and BCU (Ambrose *et al.* 2009), were included in the second analysis. The low silicate pitchstone source of Baucau, East Timor showed a clear separation in the silicate-oxide weight percent (74.12 wt% for the analysed artefacts compared with <54 wt% SiO_2 for the pitchstone source) and was excluded from the analysis. Table 2 presents the results of the LA-ICPMS analysis. The very low standard deviation in the elemental composition of the ten artefacts from Jerimalai suggests that all artefacts originate from the same obsidian outcrop.

The 39 element concentrations measured with SEM-EDXA and LA-ICPMS were tested for their quality to separate sources from each other. Principal Component Regression on the first and second score ranked the measurements of Potassium oxide (K_2O) and the elements of ^{85}Rb , ^{133}Cs , ^{186}W , ^{208}Pb , ^{232}Th and ^{238}U highest. These oxides and elements were explored with the unsupervised discrimination method of Principal Component Analysis (PCA).

The first analysis included the dataset of 13 obsidian sources from Papua New Guinea (Figure 2). The source samples derive from the obsidian collection of the Archaeology and Natural History department of the Australian National University and have been previously analysed using LA-ICPMS (Ambrose *et al.* 2009; Reepmeyer 2009). The PCA on the material (the first

Figure 1: Location of the Jerimalai shelter and selected obsidian sources in Island Southeast Asia and Papua New Guinea.

- ▲ location of the Jerimalai shelter and the Matja Kuru and Buri Ceri Uato cave sites,
- location of selected obsidian sources.

Jerimalai, East Timor					
<i>n=10</i>					
	(%)	SD		(ppm)	SD
SiO ₂	74.12	0.26	Zr	157.10	5.63
TiO ₂	0.17	0.03	Nb	17.84	0.45
Al ₂ O ₃	13.28	0.19	Mo	1.89	0.04
MgO	0.09	0.03	Sn	3.69	0.08
MnO	0.05	0.06	Cs	7.89	0.06
FeO	1.58	0.18	Ba	1155.58	11.32
Na ₂ O	3.86	0.06	La	57.86	1.92
K ₂ O	4.53	0.13	Ce	112.74	1.55
CaO	1.18	0.03	Nd	39.94	1.16
Total	98.99	0.40	Sm	8.24	0.29
			Eu	1.17	0.05
	(ppm)	SD	Gd	7.11	0.25
P	80.95	1.84	Dy	6.55	0.25
Sc	8.62	0.71	Er	3.83	0.14
Ti	842.62	23.07	Yb	3.85	0.17
V	0.21	0.01	Lu	0.57	0.03
Cr	0.28	0.03	Ta	1.34	0.04
Mn	493.81	16.35	W	2.20	0.03
Co	0.18	0.02	²⁰⁶ Pb	38.67	0.60
Cu	2.04	0.23	²⁰⁷ Pb	35.26	0.47
Rb	184.56	1.67	²⁰⁸ Pb	37.02	0.65
Sr	161.38	3.28	Th	24.98	1.31
Y	35.80	1.25	U	4.66	0.15

Table 2: Summary statistics, weight percent of major element oxides measured with EDXA and absolute counts in parts per million of trace elements analysed with LA-ICPMS.

Figure 2: Principal Component Analysis on artefacts and PNG sources. 1 Kutau/Bao, WNB; 2 Baki, WNB; 3 Mopir, WNB; 4 Lou, AD; 5 Manus, Southwest; 6 Manus, Lepong; 7 Igaweta, West Fergusson; 8 Fagalulu, West Fergusson; 9 Dobu Island, East Fergusson; 10 Sanaroa, East Fergusson.

Figure 3: Principal Component Analysis on artefacts and Indonesian and Philippines sources. 1 NagrekA, Java; 2 NagrekB, Java; 3 Leles, Java; 4 Tapus, Sumatra; 5 Nagcarlan, Luzon; 6 Tondano, West Sulawesi; 7 Tidore, Halmahera; 8 BCU artefacts, East Timor.

eigenvector representing 81.3% of the variance and the second 15.2%) showed a clear separation of all obsidian sources from each other. The discrete distribution of the ten analysed artefacts suggests that none of the artefacts found in Jerimalai matches any of the Papua New Guinea sources.

Unfortunately, the comparison dataset on Indonesian and Philippine obsidian sources is very limited. In this study LA-ICPMS data from seven obsidian sources (Figure 1: Leles, Nagrek A and Nagrek B, three source locations from the Bandung area [West Java], data from three sources on Tidore [Halmahera], Tondano [North Sulawesi] and Tapus [South Sumatra], and one source from Nagcarlan [Central Luzon], Ambrose *et al.* 2009) and the geochemical data of seven artefacts from BCU were included in the PCA. The PCA (the first eigenvector representing 68.7% of the variance and the second 27.8%) shows a discrete distribution of all Indonesian and Philippine obsidian sources and the Jerimalai artefacts (Figure 3). There is, however, a compositional match with the artefacts from the MK 1/2, BCU and BCUM rock shelters which suggests that the same high-silicate obsidian source reported as the provenance for these artefacts was also exploited for the production of the Jerimalai artefacts. Unfortunately, the location of this obsidian outcrop is not known at this stage.

Discussion and conclusion

The geochemical analysis of the ten Jerimalai obsidian artefacts provides evidence for the episodic exploitation of a single high-silicate obsidian source throughout the site's

occupation history. Despite the limited knowledge of possible obsidian sources in Island Southeast Asia the geochemical analysis of the Jerimalai artefacts demonstrates convincingly that they are from the same source as the obsidian artefacts from the MK1/2, and BCU and BCUM sites, previously described by Ambrose *et al.* (2009). Artefacts from a pitchstone source in the Baucau outcrop which were identified in the earlier study as present in the Baucau sites, BCU and BCUM, were not found in the Jerimalai assemblage. Based on the radiocarbon dates and distribution of obsidian down the profile the previous study concluded that obsidian use began only c. 13,000 years ago. The distribution of obsidian artefacts in Jerimalai extends the use of this material back to earliest beginnings of human occupation of East Timor commencing at 42,000 cal. BP.

In the earlier study it was stated that the artefacts made on high-silicate obsidian most likely derived from a local source as “longevity in access to a homogeneous obsidian supply would be difficult to sustain if it required an external voyage to some distant island, especially when there are no prospective islands within easy canoe range of the northeast Timor coast” (Ambrose *et al.* 2009:614). Although we are no closer to identifying the source, it is assumed, for the high-silicate content and homogeneous matrix of the obsidian, that the primary source of the material is more likely to be a localised rhyolitic dome or lava flow, which rarely extends more than 10km² (Hughes and Smith 1993). This assumption is important as the fact that artefacts made of the same quality obsidian are found from the Baucau Plateau region to the extreme eastern end of the island, a distance of c. 90km (Figure 1), indicates that it was considered valuable enough to merit land transport over substantial distance. The minimum distance to the source, combined with small size, low number, low $\bar{x}$ -weight and general lack of cortex on the flakes, however, indicates that direct access to the source is unlikely. Additionally, its equally sparse occurrence in all five Timor assemblages may indicate that the source location is some distance from both the regions investigated to date. The distribution of obsidian artefacts in archaeological sites only in coastal locations (Glover 1986:133), however, to some extent diminishes possibilities for obsidian outcrops in the eastern upland areas.

Until further research is conducted on obsidian sources on the Sunda-Banda Arc and in other areas of Island Southeast Asia, the detailed provenance of the artefacts remains unresolved. Long-term use of an obsidian source in a large area over several tens of thousands of years has been reported from the Kutau/Bao region in West New Britain (Figure 1, Torrence *et al.* 2004). The Jerimalai artefacts are of a high-silicate obsidian predicted to have been a valued lithic resource (Torrence 2005). The small-scale use of this material is therefore puzzling. Small size and low numbers suggest long distance transportation of the material (Renfrew 1975), but the complete lack of any artefacts made from obsidian in sites in hinterland locations refutes a hypothesis of a widespread exchange system of this raw material, such as seen in the Bismarck Archipelago.

Migration, exchange and the timing and phasing of cultural transmissions between islands have been dominant and controversial themes in the archaeology of Island Southeast Asia (Bellwood 1997; Bulbeck 2008; Szabó and O'Connor 2004). It is therefore somewhat surprising that a raw material which has the proven potential to identify detailed exchange and/or migration routes has been somewhat neglected. Without further fieldwork identifying obsidian outcrops in Island Southeast Asia crucial data for understanding social interaction and cultural transmission across this vast island network will continue to be missing. It is therefore suggested that future archaeological research in this area should prioritise the study of obsidian sources to elucidate its use and transportation in prehistory.

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Reviews

Polynesians in America: Pre-Columbian Contacts with the New World

Edited by Terry L. Jones, Alice A. Storey, Elizabeth A. Matisoo-Smith, and José Miguel Ramírez-Aliaga.

AltaMira Press, 2011. ISBN 978-0-7591-2004-4. Pp. xx + 359. US\$85 (hbk).

It has been years since I last read a book like this one. *Polynesians in America* is pugnacious and opinionated. The mental firewall the editors have build around their collective enterprise of 14 chapters written singly or in combinations by a total of 12 authors is so visible that I know in advance absolutely nothing I say about it in any way critical or negative will be able to get through to be taken seriously by those responsible. This is a pity, because we do not live in a black-and-white world. This book has its good points as well as its unfortunate ones. For example, those who have been following the debate about pre-Columbian chickens in the New World will definitely want to check out Chapter 8 by Alice Storey, Daniel Quiróz, and Lisa Matisoo-Smith in which they address criticisms of their ancient Chilean chicken results. And Geoff Irwin, as usual, gives a masterful summary of ancient voyaging in the Pacific in Chapter 13.

On the negative side of the ledger, however, this is a book that likes to use words and phrases like 'remarkable', 'legitimate', 'wild-eyed', 'startling', 'dangerous', 'strong resistance', 'ill-informed', 'most up-to-date', 'the other lonely, rational voice', 'massive backlash', 'serious archaeologists', 'multimedia onslaught', 'huge paradigm shift', 'lingering ethnocentrism', 'convoluted arguments', and my own favourite out of the whole lot of these needless rhetorical flourishes: 'almost unequivocally'.

This is also a book that has good guys and bad guys, sometimes named but often just treated impersonally as despicable intellectual trends – for example, that now popular whipping boy called processual archaeology.

The editors clearly think they are on to a good thing, even if the rest of the world has been neglecting the issue of pre-Columbian contacts between Polynesians and the Americas for an unforgivably long time. Terry Jones in Chapter 1 presents the case for caring deeply about whether such contacts did or didn't happen. Chapter 2 by Alice Storey and Jones coyly subtitled "The Good, the Bad, and the Ugly" tries to be a history of diffusionist thought in 20th century