LATE-PLEISTOCENE AND HOLOCENE OBSIDIAN TRANSFER IN THE BISMARCK ARCHIPELAGO, PAPUA NEW GUINEA

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Obsidian analysis allows for archaeologists to investigate notions of trade and exchange over vast areas of land and sea. Here we report the results of Particle Induced X-ray Emission–Particle Induced Gamma-Ray Emission analysis undertaken on obsidian excavated from Buang Merabak, a Pleistocene cave site in central New Ireland, Papua New Guinea. Although the dataset is relatively small, it provides new information reflecting cultural connectivity as early as 20,000 (uncalib) bp. Also, it provides a valuable opportunity to re-evaluate some pre-existing models of trade and exchange. The data support the notion that there may have been more than one trade/exchange network in operation during the Pleistocene and, also, broadly supports the Summerhayes spatio-temporal model for the mid- to late-Holocene.

THE DISTRIBUTION OF OBSIDIAN is particularly useful in modelling prehistoric trade/exchange networks. In the Bismarck Archipelago, much pioneering research was undertaken by Wal Ambrose and, subsequently, has been picked up by Summerhayes, Specht, Fullagar, White, Torrence, and others. Here we present and describe new data from obsidian artefacts recovered from stratified deposits at Buang Merabak, central New Ireland. Although the dataset is small, it provides additional information to that already published reflecting obsidian distribution patterns in the Bismarck Archipelago.

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Background

Obsidian is used widely by Pacific archaeologists to describe trade and exchange networks because it is relatively easy to identify its origin through chemical analysis. Here we compare obsidian artefacts excavated from central New Ireland with other artefacts recorded from across the Bismarck Archipelago. In this region, there are four identified obsidian source areas each containing a number of geochemically distinct obsidian deposits (Summerhayes 2003).

There are two models of obsidian distribution currently being discussed in the literature: one identified as occurring during the late-Pleistocene and the other during the mid-Holocene. Results of chemical analysis of the obsidian transferred during the Pleistocene from west New Britain into New Ireland is proposed to reflect two distinct obsidian distribution networks (Allen 2000, 152; Leavesley and Allen 1998: 71–73). The mid-Holocene distribution model, proposed by Summerhayes (2003), is specific to Lapita sites and suggests different sources of obsidian were used over time.

The combination of carbon dating and stratigraphy recorded from Matenbek and Buang Merabak, indicate that the first movement of west New Britain obsidian into New Ireland occurred at or immediately prior to the height of the Last Glacial Maximum (Summerhayes and Allen 1993; Rosenfeld 1997). To determine transfer routes, Summerhayes and Allen (1993) chemically analyzed a sample of the Matenbek obsidian assemblage using the Particle Induced X-ray Emission–Particle Induced Gamma-Ray Emission (PIXE–PIGME) technique. The results show obsidian deposited in the late-Pleistocene was sourced predominantly from Mopir but with some samples coming from Talasea sources.

Density analysis of fifteen of the sixteen obsidian artefacts previously excavated from Buang Merabak, SQ2B (see Table 1), suggests the majority of the artefacts came from Talasea (12), whereas a small number came

TABLE 1. **Summary of Obsidian Data From SQ2B (Rosenfeld 1997, 221).**

Period	Sample and source
Late-Holocene	3443, Talasea; 3444, Talasea; 3445, Talasea; 3446, Admiralty.
Early-Holocene	3447, Talasea; 3448, Unsourced; 3449, Talasea; 3450, Mopir; 3451, Talasea; 3452, Mopir; 3453, Talasea.
Pleistocene	3454, Talasea; 3455, Talasea; 3456, Talasea; 3457, Talasea; 3458, Talasea.

from the Mopir (2) and the Admiralty Islands (1) (Rosenfeld 1997, 221). Although the sample size from this low yielding excavation is small, the source trend is inconsistent with the Summerhayes and Allen (1993) Matenbek results. The proximity of the excavation sites (120 km distant), the relatively contemporaneous nature of the deposits (late-Pleistocene), and the distance between the obsidian sources (55 km apart) (Leavesley and Allen 1998; Allen 2000), suggest that there could be two different exchange networks reflected. Subsequently, Allen (2000, 154) has suggested that, if this pattern can be substantiated, then it might indicate "more direct" transfer possibly including direct voyaging from Talasea to central New Ireland.

The mid- to late-Holocene obsidian distribution model described by Summerhayes (2003) is summarized in Table 2. This model presents two spheres of obsidian distribution occurring over time. The first is a southern network out of west New Britain, and the second is a northern west to east network out of the Admiralty Islands. Although obsidian from both areas occurs throughout the sequence, Summerhayes demonstrates through chemical analysis that obsidian from the west New Britain dominates the early-Lapita assemblages, whereas the latter are dominated by the Admiralty Islands sources.

Buang Merabak Samples

The 18 obsidian artefacts described here were excavated from TPIA and TPIB during the years 2000 and 2001. All are small and highly reduced. They have an average length of 13.4 mm (range 9.5–15.25 mm) and weight of 0.656 gm (range 0.2–1.8 gm) as per Tables 3 and 4.

TABLE 2. **Summary of Obsidian Source and Distributions Following Summerhayes (2003).**

Period	Years BP	Distribution
Early-Lapita	3300/3000 – 2900	WNB sources dominate across the entire BA.
Middle-Lapita	2900 – 2700/2600	Admiralty sources dominate the eastern BA (NI & ENB) and WNB sources dominate in WNB.
Late-Lapita	2700/2600 – 2200	Admiralty sources continue to dominate NI but WNB sources expand into ENB.
Post-Lapita transition	2200 – 1600	Admiralty sources continue to dominate in NI while WNB sources increase their dominance in ENB.

Abbreviations: WNB, west New Britain; BA, Bismarck Archipelago; NI, New Ireland; ENB, east New Britain.

TABLE 3. **Metric Data Obsidian Artefacts From TPIA and TPIB, Buang Merabak.**

Artefact #	TP	Spit	L	W	Th	Plat L	Plat W	Wt
BM#1	TPIB	6	9.5	15.75	2.75	1.1	1.9	0.3
BM#2	TPIA	8	12.6	16.7	5.5	3.85	12.8	0.9
BM#3	TPIB	12	11.4	18.3	4.5	2.7	2.5	0.9
BM#4	TPIB	12	11.5	15.3	2.7	0.01	0.01	0.3
BM#5	TPIB	4	14.8	10.7	3.4	1.55	5.05	0.4
BM#6	TPIB	14	20.7	17.05	6.65	7.8	6.6	1.5
BM#7	TPIB	18	11.95	15.95	13.05	detached	detached	1.8
BM#8	TPIB	28	10.2	6.15	2.85	0.05	1.0	0.1
BM#9	TPIA	13	12.2	14.4	2.3	3.5	5.5	0.5
BM#10	TPIB	10	15.2	14.2	5.1	4.05	10.55	1.2
BM#11	TPIB	9	15.05	11.1	3.55	1.95	5.1	0.5
BM#12	TPIA	15	16.15	14.95	3.5	2.45	7.25	0.8
BM#13	TPIB	16	16.25	7.95	1.85	1.7	4.2	0.3
BM#14	TPIB	16	10.45	7.3	2.27	0.995	2.35	0.2
BM#15	TPIB	15	10.4	13.4	2.25	2.2	6.45	0.2
BM#16	TPIB	15	13.45	6.2	5.1	N/A	N/A	0.3
BM#17	TPIB	15	13.40	4.2	5.05	4.15	1.85	0.2
BM#18	TPIB	21	15.25	11.15	5.65	1.65	1.2	1.4

Measurements are in millimeters or grams. Abbreviations: TP, test pit; L, percussion length; W, width at right angle at midlength; Th, thickness at midlength; Plat L, platform length; Plat W, platform width; Wt, weight; BM, Buang Merabak.

The Buang Merabak obsidian samples appear in stratigraphic contexts consistent with what is known from other sites in New Ireland (see Table 5). However, one sample (BM#8) appears to deviate from this having been excavated from unit 4. Elsewhere in the region, obsidian has never been recovered from 27,000+ bp levels. The occurrence of BM#8 in Unit 4 could reflect post-depositional downward movement given the lack of obsidian from layers of a similar age from other New Ireland sites and its location in the very top spit of Unit 4. Only a few millimeters of downward movement within the sediment column would be required to move this sample from Unit 3 to Unit 4. Given this, for the purposes of this study, sample BM#8 is considered to be from Unit 3 and, therefore, is considered to have been deposited with the other artefacts around 20,000 (uncalib) bp.

Chemical Analysis

Obsidian is a volcanic glass that forms during eruptive activity. The chemical composition of obsidian can range from "basaltic" to "rhyolitic," although

TABLE 4. **Morphological Features of the BM Obsidian Artefacts (TPIA and IB).**

Artefact #	Artefact designation	# dorsal scars	# ventral scars	# dorsal ridges	Termination
BM#1	ORF	6	0	1	Feather
BM#2	Flake	2	0	1	Feather
BM#3	Flake	4	0	4	Step
BM#4	Flake	7	0	3	Feather
BM#5	Flake	13	0	1	Feather
BM#6	Flake	9	1	2	Step
BM#7	Trapezoid	2	0	1	Snap
BM#8	Bipolar flake	4	0	2	Bipolar
BM#9	Flake	5	0	2	Step(?)
BM#10	Bifacial flake	12	15	4	Feather
BM#11	Flake	4	0	2	Feather
BM#12	Flake	6	0	4	Hinge
BM#13	Flake	2	0	2	Snap
BM#14	Flake	2	0	1	Snap
BM#15	Flake	2	0	1	Hinge
BM#16	AF	N/A	N/A	N/A	N/A
BM#17	Flake	3	0	1	Feather
BM#18	Flake	14	5	3	Step

Abbreviations: BM, Buang Merabak; ORF, Overhang removal flake; AF, Angular fragment.

predominantly it forms in more silicious (rhyolitic) volcanic events. This is because rhyolitic events are more explosive enabling the formation of pyroclastic glass. The chemical composition of obsidian reflects the composition of the molten magma from which it is formed and is typically consistent throughout individual flows, providing a chemical signature.

The very fine grainsize and homogenous nature of obsidian means the composition of the surface provides a representative approximation of the entire sample. This means nondestructive irradiation of the surface of artefacts and rock fragments is adequate to identify the chemical compositions and, thus, provides an effective means of tracing source characteristics of artefacts.

Melanesian obsidian artefacts have been successfully sourced to their original flows using PIXE–PIGME analysis (as discussed in Bird et al. 1997). Element ratio plots and principle component analyses have been used to compare artefact compositions with source compositions to identify source area characteristics.

Several identifying characteristics of Melanesian obsidian sources have been determined using PIGME analysis (www.ansto.gov.au/ansto/environment/iba/projects/archaeology.htm) including (1) Admiralty Islands

TABLE 5. **Samples Per Spit and Unit for Those Artefacts Subjected to PIXE–PIGME Analysis.**

Sample code	Spit	Unit spits	Unit	Unit age (Uncalib bp)	Unit age (BP)
BM #5	4	1–8	1	1,800–3,500	1,300–3,300
BM #2	8				
BM #3	12	9–17	2	7–12k	8,200–13,150
BM #4	12				
BM #6	14				
BM #7	18	18–27	3	17–20k	19,650–23,050
BM #18	21				
BM #8	28	28–40	4	27–39.5k	N/A

The Unit Designation and Ages are Discussed in Leavesley (2004). Abbreviation: BM, Buang Merabak.

obsidian has high fluorine content; (2) New Britain obsidian has low sodium and fluorine content; and (3) Vanuatu obsidian has high aluminium and low fluorine content. PIXE–PIGME analyses of the Buang Merabak artefacts were conducted at the Australian Nuclear and Science Technology Organisation (ANSTO) laboratory in Lucas Heights. PIXE was used to identify and quantify individual elements ranging from Al to U in the obsidian and artefacts. The artefacts were not damaged during this process. The artefacts were irradiated by 2–3MeV protons produced by 3Van de Graaff and 10 MV tandem accelerators. X-ray detection was done with energy dispersive semiconductor detectors. The elemental composition was calculated by DOIBA. PIGME is used to identify and quantify the elements with low Z-activities (light elements in the periodic table) including F and Na. The artefacts were analyzed using large volume Ge detectors that calibrated emitted gamma-rays produced by nuclear reaction of the sample following irradiation. The results are presented in Table 6.

Buang Merabak Obsidian PIXE–PIGME Results

Eight obsidian artefacts from Buang Merabak were analyzed using the PIXE–PIGME technique for chemical characterization. Figure 1 presents a bivariate plot of Strontium (Sr) and Flourine (F) compositions from the Buang Merabak artefacts and representative samples from seven known obsidian sources in Melanesia. Sr and F are known to be characteristic of source locations within Melanesia. The eight obsidian artefacts appear to plot in four ratio groups. Two clusters containing three artefacts with similar Sr : F ratios and two single outliers. The comparative source data presented on the graph are taken from Bird et al. (1997) and indicate that

TABLE 6. **PIXE–PIGME concentrations of 21 elements for obsidian artefacts from Buang Merabak (BM).**

			F	Na	Al	Si	K	Ca	Ti	Mn	Fe	Rb	Sr
Run	Sample	Spit	ppm	%	%	%	%	%	ppm	ppm	%	ppm	ppm
6	BM#5	4	1301.2	3.30	6.71	32.70	6.15	4.25	3907	797	2.52	149	93
2	BM#2	8	560.3	2.60	6.47	37.09	5.46	1.56	2679	670	1.18	56	221
5	BM#3	12	550.0	2.54	6.35	37.14	5.69	2.38	2739	714	1.22	58	218
4	BM#4	12	552.4	2.58	6.41	34.46	5.10	2.49	2530	669	1.18	54	220
11	BM#6	14	565.7	2.14	6.03	35.61	6.66	1.32	2428	493	1.09	64	168
8	BM#7	18	542.8	2.34	5.92	34.11	5.54	2.95	2454	513	1.11	61	162
9	BM#18	21	562.0	2.35	6.05	29.73	4.35	1.22	1964	439	0.96	64	163
7	BM#8	28	486.2	2.99	6.07	36.54	3.04	1.73	2145	846	1.21	36	206

Sample	Y	Zr	V	Cr	S	Cl	Co	Zn	Ga	Ba	Pbl	Source
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	
BM#5	49	454	62	310	181	7770	63	98	35	543	23	Admiralty
BM#2	21	163	53	268	256	3174	35	52	21	295	15	Kutau
BM#3	19	165	39	289	283	3387	31	56	18	370	13	Kutau
BM#4	20	161	50	369	214	3007	33	58	20	285	18	Kutau
BM#6	20	159	26	172	225	4211	35	40	21	350	13	Gulu
BM#7	20	162	48	248	185	4125	35	51	18	403	15	Gulu
BM#18	25	150	26	350	133	2005	30	36	13	485	14	Gulu
BM#8	27	155	33	288	161	2494	28	69	17	162	20	Mopir

Results from files 09jan01Xa.csv & 09jan01Gc.csv. Presented in weight percentages and parts per million (ppm).

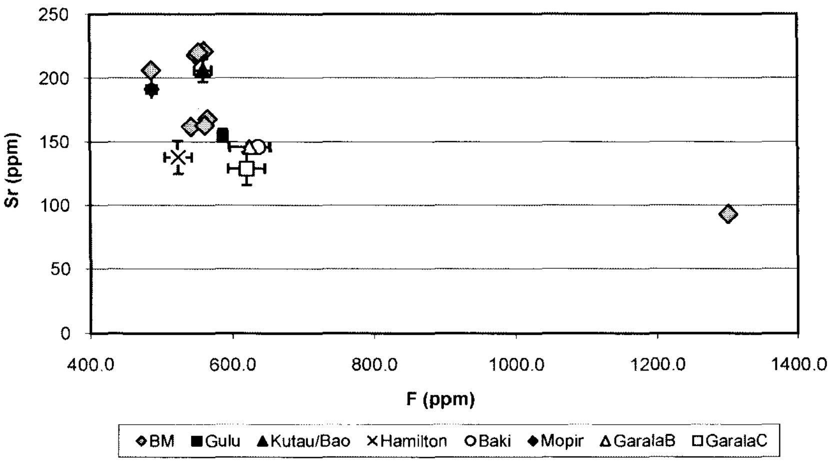

FIGURE 1. **A bivariate element plot of Fl and Sr for the obsidian artefacts collected at Buang Merabak (BM). Representative New Britain obsidian source data are also presented with error bars (data from Bird et al, 1997).**

three of the groups are likely to have been sourced from New Britain. Specifically the sources appear to be, Kutau and Gulu areas on Willaumez Peninsula and Mopir, all in west New Britain (locations shown in Bird et al. 1997: 63, fig. 2). The remaining sample (BM#5 from spit 4), has a Sr : F ratio inconsistent with the New Britain source samples. The high fluorine content is more typical of the Admiralty Islands obsidian; however, we have no data for comparison.

Previously Ambrose used density analysis to characterize and source the obsidian derived from Buang Merabak, SQ2B. This method, although indicative does not always have the capacity to differentiate between sources with similar geochemical characteristics. The analysis, undertaken using the PIXE–PIGME method, confirms what Ambrose proposed as the dominance of the Willaumez Peninsula sources during the Pleistocene in central New Ireland (Rosenfeld 1997). Also, the results are consistent with the overall pattern of transportation of obsidian indicated by Ambrose's density analysis results.

Discussion

The transportation of obsidian to New Ireland as early as ~20,000 (uncalib) bp was initially identified by members of the Lapita Homeland Project

(Allen, Gosden, and White 1989; Gosden and Robertson 1991, 42). Obsidian analyses carried out by Summerhayes and Allen (1993) indicates that Mopir was the dominant supplier of obsidian to the southern New Ireland sites at this time. This new data from the small sample collected from Buang Merabak, suggest that Willaumez Peninsula sources predominantly supplied central New Ireland. A possible consequence of this is that there may have been two separate linkages between New Ireland and New Britain. This is not to say that there was no overlap, because all three sites (including Matenkupkum) contain obsidian from both source areas.

It has been argued that obsidian made its way to southern New Ireland by way of "down-the-line" exchange via the Gazelle Peninsula and across the St. George's Channel. This is explained as the extraction of obsidian from the nearest available source (Summerhayes and Allen 1993, 147; Summerhayes 2009, 114). The different geochemical character of central and southern New Ireland assemblages allow for a number of possibilities to be considered about the processes of obsidian transfer to New Ireland. First, perhaps both sources were transferred by down-the-line exchange to New Ireland, and for some reason, perhaps social, the occupants of southern New Ireland preferred Mopir obsidian, whereas the central New Ireland occupants preferred the Willaumez Peninsula material. For this to be the case, the recipients may have been either very familiar with obsidian or exchange networks did not overlap in any major way. Given that these two sources are virtually inseparable to the naked eye, it is not immediately obvious how the consumers might have differentiated between sources. Alternatively, Allen (2000, 154) suggested a more direct transfer of obsidian to central New Ireland that bypassed southern New Ireland. Transfer by way of voyaging canoe directly from the Willaumez Peninsula to the central west coast of New Ireland, a sea crossing of ~300 km, requires greater technology than the land route but is consistent with Summerhayes and Allen (1993) and Summerhayes (2009) in that it reflects "extraction of obsidian from the closest available source" (Summerhayes and Allen 1993, 147). A sea crossing of this nature is entirely possible given the broadly comparable sea crossings required for the colonization of Manus by at least 26,000 (uncalib) bp (Minol 2000, 25).

Given the small sample size from central New Ireland, it is entirely possible that the current difference between the obsidian from central and southern New Ireland will narrow with a larger dataset. This can easily be tested as further central New Ireland data from stratified sites comes to light.

Moving to the mid- to late-Holocene, the spatio-temporal distribution of obsidian reported here is consistent with the obsidian distribution model presented by Summerhayes (2003, 2009). Although the west New Britain sources are dominant during the early-Lapita, the Admiralty sources are also present in relatively lower quantities. The single fragment of Admiralty's obsidian from Buang Merabak is derived from a layer expected to include contributions from both west New Britain and Admiralty source areas.

Given the chemical composition of BM#8 and its precarious location in the stratigraphy of the site, further work is suggested to determine whether this holds any significance.

Conclusion

Although admittedly small, this dataset supports the accuracy of the initial density analyses undertaken by Ambrose in the mid-1980s. The data indicate that, unlike the southern New Ireland Pleistocene sites, a majority of obsidian excavated from Buang Merabak, located in central New Ireland, is from the Willaumez Peninsula sources. The Leavesley and Allen (1998; also see Allen 2000) hypothesis that two quite different source distributions might imply different linkages between New Britain and New Ireland remains a distinct possibility. Also, this might imply a more direct transfer of obsidian from the Willaumez Peninsula to central New Ireland that perhaps included a significant sea crossing (Allen 2000, 541). Given the potential significance of these results, further work is suggested to collect and analyze more obsidian from the central New Ireland sites to build up a statistically relevant sample.

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