Obsidian Sourcing at Ulilang Bundok Site and its Implications for Mobility, Exchange, and Social Contexts in the Philippine Metal Age

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INTRODUCTION

What is commonly known as the "Metal Age" of the Philippines and throughout Island Southeast Asia is viewed as a critical period of transition between small-scale Neolithic farming communities of the third millennium to early first millennium B.C. and the historically recorded emergence of centralized polities with archaeological evidence for social complexity and trade networks involving exotic goods stretching into mainland Asia and beyond by the late first millennium A.D. (Andrews and Glover 1986; Bronson 1992; Bulbeck 2007; Bulbeck and Prasetyo 2000; Lloyd-Smith and Cole 2010). Much of the archaeological work on this time period in the Philippines has focused on burial sites, including often spectacularly artistic jar burials (often with anthropomorphic features) and inhumation burials with regional stylistic embellishments (Dizon 1979; Dizon and Santiago 1996; Dizon et al. 2011; Fox and Evangelista 1957; Kurjack et al. 1971; Tenazas 1974). These varying types of elaborate burials are typically accompanied by elaborately embellished rare or exotic goods such as nephrite or jade ornaments, bronze ornaments and implements, and glass beads (almost certainly traded from outside the archipelago), as well as highly decorated earthenware forms, gold-leaf ornaments, iron objects, rare shells, polished stone adzes, and obsidian (which could have been either extracted and modified within the Philippine archipelago or obtained from long-distance sources). Thus far, archaeological work in the Philippines has provided little evidence to suggest that these mortuary rites were exclusive to privileged individuals or groups within the community rather than being a collective display of community membership and identity.

Since habitation sites have been relatively neglected, although a few excavated sites dated to this period may represent settlements as well as burial grounds, there is also

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little evidence of settlement hierarchies anchored to large moated sites that might be interpreted in terms of developing political centrality and social hierarchy.[1] The utility of cultural evolutionary models of sociopolitical development in Southeast Asia that emphasize increasingly "hierarchical" models of complexity, but fail to include more diversely structured forms of status and power, has thus come under debate (O'Reilly 2003; White 1995). This suggests that patterns of "exotic" good procurement and use, and the social networks such goods represent, should be examined in more depth and with the greater accuracy afforded through chemically based materials sourcing.

Conducting chemical analyses to source the raw materials used to make objects associated with trade and exchange at the local and regional levels has increasingly supplied archaeologists with methodological answers to problems raised by purely impressionistic studies of artifact features. Chemical analysis allows us to trace the movement of materials through human mobility and social contact in various periods of the prehistory of Island Southeast Asia. However, it is only beginning to be used to examine artifacts such as earthenware ceramics, glass beads, metal objects, various types of stone tools and ornaments, and raw materials to establish their provenance and reconstruct Metal Age trade networks, as well as explore the implications of long-distance exchange in exotic goods for social organization in the period.

This article focuses on tracing the source of obsidian artifacts excavated from the Ulilang Bundok site in the province of Batangas, Philippines, which have been dated radiometrically to the Metal Age. In order to source the raw material used to create the obsidian implements, samples of obsidian were collected from two known geological sources in the Philippines: Nagcarlan, Laguna, and Pagudpod, Ilocos Norte. These samples were compared chemically to the manufactured obsidian objects. Chemical analyses of the obsidian artifacts and source samples were carried out on a scanning electron microscope using the energy dispersive X-ray spectrometer at the University of Science Malaysia, Penang, and the electron microprobe at the University of Malaya, Kuala Lumpur. Multi-elemental analysis and statistical procedures performed on elemental data obtained from the obsidian artifacts and source samples provided strong indications that the obsidian artifacts from Ulilang Bundok were made using obsidian obtained from the Nagcarlan source.

The chemical sourcing results suggest that obsidian was a limited commodity and a valued raw material that was likely mined and traded through expanding social exchange networks. This has implications for understanding how the complexity and spatial extent of trade reflect emerging forms of social complexity in the Philippine Metal Age. While the present study is limited to the single Metal Age site of Ulilang Bundok in Batangas, the methodology of chemical sourcing can be expanded to include additional Metal Age burial and settlement sites in the Philippines and a wider number of obsidian sources both within and outside the archipelago.

OBSIDIAN ARTIFACTS AND OBSIDIAN SOURCES IN THE PHILIPPINES

Because past peoples recognized obsidian for its superior flaking and cutting qualities, it became a preferred material for making tools. That prehistoric people made tools from obsidian sources is evidenced by the obsidian artifacts found in numerous sites in the Philippines.[2] These artifacts are amorphous, consisting of mostly flakes and debitage (Neri 2007).

Although the islands of the Philippines consist of volcanic island arcs associated with explosive volcanism, they have produced limited obsidian sources (Neri 2003, 2007). At present, only two obsidian sources, both associated with quaternary volcanic deposits, are known in the Philippines. One is located in the village of Caunayan, Municipality of Pagudpod, Ilocos Norte Province and the other in the village of Manaol, Municipality of Nagcarlan, Laguna Province, referred to henceforth as the Pagudpod source and the Nagcarlan source, respectively (Neri 2003, 2007; PBM 2000: 2) (Fig. 1).[3] Obsidian in the Philippines has been classified today as a semiprecious stone because of its market value and relative rarity (PBM 2000), and therefore we would expect that in the prehistoric past it would also have been a highly prized commodity of considerable social value as it moved through exchange networks.

Obsidian from Philippine sources is usually black in color and appears in the form of pebble or conglomeratic deposits. Obsidian from the Pagudpod source appears in angular fragments 3–10 cm in diameter. The local term for this glass is "Berdadero," which means a high-class type of green stone. The source occurs as a conglomeratic deposit probably of colluvial or alluvial origin; it is found in the Caunayan forest with coordinates of 18°37′35″N,120°49′51″E.[4] By contrast, obsidian from the Nagcarlan source has higher opacity and appears as a dark colored glass containing elongated or rounded bubbles. The local term for this obsidian, "Batong Dalig," refers to the name of a place where it is abundant, located at coordinates 14°10′41″N,121°21′52″E.[5] The Nagcarlan source appeared as cobble- to boulder-sized floats exposed along the lower ridges of volcanic plugs; obsidian can be found scattered along the surfaces of the slopes and on top of the mountain. According to the Philippine Bureau of Mines (PBM 2000: 6), this gemstone material can be found within approximately 1 percent of the 1000 m^2 area. The obsidian found in this area has the following characteristics: the fracture is conchoidal and luster is vitreous; it is opaque to transparent and isotropic with a refractive index of 1.48–1.52; its hardness ranges from 5 to 5.5 on the Moh's scale; and it has a specific gravity that varies from 2.33 to 2.50, depending on the abundance of vesicles (Bureau of Mines 1968: 309). It consists mainly of glass with some minute inclusions of crystallites and amygdules of quartz and zeolites.

ARCHAEOLOGICAL RESEARCH AT ULILANG BUNDOK

Briefly, the first recorded archaeological exploration of prehistoric sites in the Batangas region, where Ulilang Bundok is located, was conducted from 1932 to 1941. It covered an area of just over 310 km^2, which included practically the total area encompassed by the present municipalities of Cuenca, Alitagtag, Taal, San Luis, Bauan, and bordering areas of Batangas, San Jose, and Lipa (Beyer 1948: 243; Evangelista 1962: 20). In 1940, Professor Olov T. Janse, a Swedish archaeologist working at Harvard University, excavated nearly 60 graves in three different burial sites in the Calatagan area, including Pinagpatayan, Pulong Bakaw, and Kay Tomas. A large collection of Early Ming porcelains, both Chinese and Thai (Sawankhalok), was obtained, as well as jewelry, weapons, utensils, and spindle whorls (Beyer 1948: 245; Evangelista 1962: 20; Fox 1959: 335; Janse 1944).

The most extensive excavations at Calatagan, Batangas were conducted from 1958 through 1961 by the National Museum of the Philippines. These excavations resulted

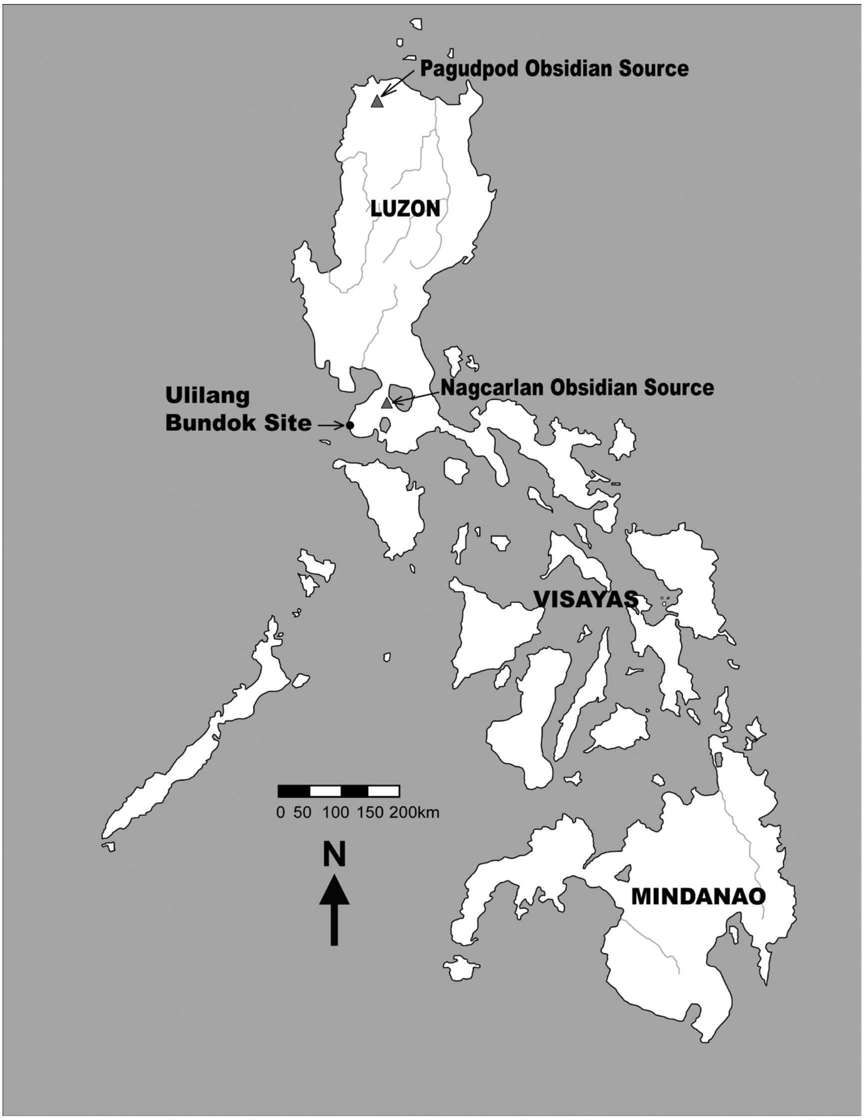

Fig. 1. Location of obsidian sources at Nagcarlan and Pagudpod and the excavated site of Ulilang Bundok in the Philippines.

in the identification of 11 distinct burial sites dated on the basis of ceramics to the fourteenth–fifteenth centuries (Fox 1959). Most of the sites excavated in Batangas in the mid-twentieth century were reported as burial sites since these were the most prominent finds, but some of the features described by these early archaeological teams were clearly indicative of settlement at some of the locales. The sheer density of artifactual remains in the region indicates that there was a densely populated community in the Batangas region.

From 1994 to 1996, archaeologists from the National Museum of the Philippines joined Hidefumi Ogawa from the Tokyo University of Foreign Studies to reinvestigate sites in the municipalities of Lian and Calatagan. The site inspection and archaeological excavations at the east coast of the Calatagan peninsula, specifically at Sitio Dayap, village of Tanagan, resulted in the recovery of artifacts, ecofacts, and features that provided information on early habitation sites (Bautista 1995*a*, 1995*b*; Ronquillo and Ogawa 1996).

The site of Ulilang Bundok, investigated by the National Museum of the Philippines in 1995, is located in Sitio Dayap, one of the progressive sitios of the village of Tanagan located southeast of the main town of the Municipality of Calatagan, Batangas Province. The residents referred to the hill as "Ulilang Bundok," translated as an abandoned, lone, or orphaned hill and referring to its prominence in the landscape. Before the area was altered by people, the hill was surrounded by mangrove forests (Bautista 1995*d*). Today, the Ulilang Bundok is bounded on the north and south by mangrove forests, on the east and northeast by Pagapas Bay with its marine resources, and on the west and northwest by a fishpond and rice paddies. It is situated approximately 32 m above sea level; the flat top of this prominent hill was formerly planted with upland rice (*Oryza sativa Linn. Var.*), but currently supports an edible wild root crop locally known as "pakit" (Dioscorea sp.). This diverse landscape and eclectic resource base surrounding the site today and in the relatively recent past may be indicative of its appeal to Metal Age populations who may have chosen a raised settlement locale that was in proximity of both good farming land and a diverse range of both terrestrial and aquatic resources. Ulilang Bundok is one of the eight sites recorded in 1995 in Catalagan, Batangas Province (Bautista 1995*a*) (Fig. 1). Test excavations done at this site resulted in the recovery of archaeological materials such as plain and decorated earthenware, stoneware, lithic flakes (including obsidian), and edible species of marine shellfish such as Tridacna sp., Osteridae sp., Voluta sp., and Trochus sp. At least four seasons of systematic archaeological excavations were later conducted at the Ulilang Bundok between April 1995 and June 1996 (Bautista 1995*b*, 1995*c*; De la Torre 1995*a*, 1995*b*, 1995*c*, 1996, 1997*a*, 1997*b*, 2002).

The site of Ulilang Bundok has a total area of about 1136 m^2, which includes about 71 mapped and designated units (each measuring 4 m × 4 m) that could be systematically excavated. However, only 20 percent of the total site area was excavated, comprising 17 trenches or 272 m^2. The archaeological excavations at Ulilang Bundok uncovered a total of 66 secondary burial earthenware vessels found associated with disarticulated, fragmented, and fragile human skeletal remains comprising mostly limb bones (De la Torre 1995*a*, 1995*b*, 1995*c*, 1996, 1997*a*, 1997*b*, 2002). Based on the number of human teeth and bones present in the vessels, it is estimated that more than one individual was placed in each vessel, suggesting multiple burial practice.

The human skeletal remains were associated with obsidian cores and chips, polished stone and nephrite adzes, beads made from stone, glass, jade, shell, and clay, as well as edible marine and brackish shells. The burial vessels were found along the carved holes or crevices of the limestone boulders. Coral stones were found underneath the bottom of the earthenware vessels, which were probably used as wedges to prevent the vessel from rolling over. Obsidian found in the jar-burial excavations, in conjunction with other precious and in some cases exotic objects such as jade objects and glass beads serving as burial goods, suggested that obsidian was one of a number of socially valued items used by the prehistoric inhabitants to mark particular aspects of social identity in the burials. Jar burials in earthenware vessels or vessels carved of

Table 1. Results of Radiocarbon Dating, with Accession Numbers, Provenience, and Dating Laboratory Sample Information

ACCESSION NO.	GRID SQUARE	BURIAL VESSEL	^{14}C DATE (YEAR B.P.)	CALIBRATED DATE (B.P.)	SAMPLE # LABORATORY
IV-95-Y-12389	N4W2	Human bones Vessel #31	1010 +/− 40	1090 +/− 40	Beta −142386 Laboratory of Material Information Kyushu Univ.
IV-95-Y-12726	N4W2	Human bones Vessel #33	360 +/− 40	380 +/− 40	Beta −142387 Laboratory of Material Information Kyushu Univ.
IV-95-Y-10992	N4W2	Human bones Vessel #28	1210 +/− 40	1290 +/− 40	Beta −142388 Laboratory of Material Information Kyushu Univ.
IV-95-Y-12172	N4W2	Human bones Vessel #34	420 +/− 40	440 +/− 40	Beta −142390 Laboratory of Material Information Kyushu Univ.

soft stone, ranging widely in burial container size, morphology, and decorative design, and containing a significant variety of both local and exotic burial accompaniments (e.g., elaborate earthenware funerary vessels, precious stone objects using such materials as obsidian and jade/nephrite, shell, metal objects, glass beads, etc.) have been recorded at numerous archaeological sites in the Philippines and are generally assigned to the Metal Age (or less often to the late Neolithic) (e.g., Dizon 1979; Dizon and Santiago 1996; Dizon et al. 2011; Fox and Evangelista 1957; Kurjack et al. 1971; Tenazas 1974). Because many of these sites lack radiometric dating, particularly the large number of sites recorded a half century or more ago and not yet reassessed with more recent archaeological work, it was essential to establish a well-dated sequence for the archaeological stratigraphy at the Ulilang Bundok.

Samples of human bones and organic materials on the pottery vessels excavated from Ulilang Bundok were selected and subjected to radiocarbon dating and accelerator mass spectrometry (AMS) dating analyses. Tables 1 and 2 present the calibrated dates produced by the samples. While there are two dates that fall within the more recent historic period, the majority of the dates are consistent with the archaeological materials discussed above that identify the burial remains as belonging to the later Philippine Metal Age spanning from the late first millennium B.C. to the early to mid–first millennium A.D.

The results of the radiocarbon analyses suggested that the practice of secondary jar burials began at the site during the Late Metal Age (500 B.C.–A.D. 850), although the site was clearly used over a significant period of time after the jar-burial phase, as evidenced in an upper cultural layer and surface finds with stoneware fragments and other more recent artifactual remains from two later historic periods. While the analysis here primarily focuses on the Late Metal Age jar burials that yielded the

TABLE 2. RESULTS OF ACCELERATOR MASS SPECTROMETRY (AMS) DATING, WITH ACCESSION NUMBERS, PROVENIENCE, AND DATING LABORATORY SAMPLE INFORMATION

ACCESSION NO.	GRID SQUARE	BURIAL VESSEL	^{14}C AGE (YEAR B.P.)	LABORATORY #	SAMPLE # LABORATORY
IV-95-Y-3640	N4W1 SW Quad	Organic material Vessel #12	1695 +/− 20	OOHM09	NUTA 2 –905 Nagoya Univ.
IV-95-Y-6282	N4W2	Organic material Vessel #18	2045 +/− 20	OOHM10	NUTA 2 –908 Nagoya Univ.
IV-95-Y-12164	N4W2	Organic material Vessel #34	1910 +/− 25	OOHM05	NUTA 2 –902 Nagoya Univ.
IV-95-Y-2805	N4W1 SW Quad	Ash adhering on pottery ring base	2820 +/− 40	GX-25684	GEOCHRON Laboratories

obsidian artifacts, the stratigraphy and diagnostic cultural materials of the main soil layers at Ulilang Bundok can be summarized as follows:

1. Surface: The surface layer was overgrown with cogon and other weeds, with rice husks and grain strewn all over the surface, confirming the comments of local informants that this area was previously planted with upland rice (*Oryza sativa Linn. Var.*). Not surprisingly, modern land use resulted in recovery of artifacts such as earthenware potsherds, stoneware potsherds, glass beads, and shells from multiple periods on the surface.
2. Layer 1: This is a dark brown (10YR3/3) silty clay loam layer with massive decomposition of organic materials. Ash and charcoal were observed, which could be attributed to the practice of "kaingin" or the slash-and-burn method, although the presence of ash could also be due to the recent massive eruption of Mount Pinatubo and the continuous eruptions of the Taal volcano. Averaging about 25–30 cm in thickness, this layer yielded earthenware potsherds, stoneware potsherds, and shell, and appeared to represent at least some later occupation at the site in the early historic period of porcelain and stoneware trade.
3. Layer 2: This is a clayey layer with approximately 1 percent silt, predominantly mixed with weathered limestone. The weathered limestone contains forams (tiny shells), which could explain the color of the soil ranging between 10YR/4/3 (brown) and 10YR/4/4 (dark yellowish brown). This cultural layer is about 18 to 20 cm thick and contains archaeological materials such as earthenware potsherds (both plain and decorated), shells, obsidian flakes and core, glass beads, stone and shell beads, metal fragments, associated with jar-burial vessels. Tree roots were still present at this level, which probably caused the breakage of the earthenware vessels and other materials. The apparent practice at this site of placing jar burials exposed on the ground at the time of site use (as suggested by the stratigraphy), coupled with likely introduced contamination by tree roots and later human activities in this markedly compressed site, may explain the two exceptionally late radiocarbon dates in Table 1 (IV-95-Y-12726 and IV-95-Y-12172) that are completely nonconforming to what is known about jar-burial chronologies in the Philippines, and two dates that are on the terminal end of what would be considered the Late Metal Age in the archipelago (IV-95-Y-10992 and IV-95-Y-12389). The AMS dates on organic material within jar-burial vessels (Table 2) were not tightly

clustered, but did largely fall within the range of what is generally viewed as the Late Metal Age (although IV-95-Y-2805 falls at the very beginning of this range).

4. Layer 3: This sterile layer is composed of coralline and weathered limestone. The bedrock or sterile layer ranges from 124 cm (DP) to 225 cm (DP) or 137 cm to 238 cm from the present soil surface. No cultural materials were found in this layer.

METHODS OF COMPOSITIONAL ANALYSIS ON OBSIDIAN

The obsidian samples used in this sourcing study were collected from two main sources: the obsidian artifacts found during excavations by one of the authors (Amalia De la Torre) at the Ulilang Bundok, Batangas; and two known obsidian sources in Nagcarlan, Laguna, and in Pagudpod, Ilocos Norte. The obsidian samples were subjected to chemical analyses with the aim of identifying the provenance of the archaeological materials to specific obsidian geological sources currently known within the Philippine archipelago. The elemental signatures of the obsidian artifacts and obsidian sources were compared for compositional correspondence by creating binary diagrams or plots of major chemical elements, with ellipses encompassing the samples from the archaeological context at Ulilang Bundok and the two Philippine obsidian sources, to create simpler visual distinctions that show the overlap in chemical composition patterns of these three groups. While some visible features of the obsidian (e.g., color and opacity) provide some preliminary clues to raw material origins, the chemical analyses and bivariate plotting allow us to precisely measure compositional similarities and differences between obsidian objects and possible sources. This methodology allows us to differentiate between highly local, somewhat distant (i.e., within the archipelago), and significantly long-distance (extra-archipelago) procurement of obsidian, which in turn provides some insights into the degree to which Metal Age populations were willing to travel distances and/or engage in geographically extensive trade networks to acquire valued raw materials for socially significant purposes such as marking community or kin group identity, status, or ability to control larger social networks relative to other groups.

The Obsidian Samples

A total of 15 obsidian samples were randomly selected for chemical analysis from the National Museum site collections that had been processed and curated by Amalia De la Torre (Table 3). These samples consist of eleven obsidian artifacts recovered during excavations at the Ulilang Bundok site in Batangas Province; two obsidian samples from a known obsidian source in Nagcarlan, Laguna Province; and two obsidian samples from a known obsidian source in Pagudpod, Ilocos Norte, which was previously studied by Neri (2003, 2007). The 11 Ulilang Bundok obsidian artifacts came from the stratified layers associated with the jar burials excavated by Amalia De la Torre and her colleagues from the National Museum of the Philippines since 1995 (De la Torre 1995*a*, 1995*b*, 1995*c*, 1996, 1997*a*, 1997*b*, 2002). As noted in the discussion of dating, the stratigraphy was complicated by the probability that the jars had been largely placed on the surface or minimally set into the ground, and there was distinct disturbance by post–Metal Age use of the site. Even so, the obsidian samples were fairly securely associated with the burial jars and contents. A number of the

Table 3. List of Obsidian Samples in the Analysis

SAMPLE	LOCATION	DESCRIPTION
1	Pagupod, Ilocos Norte	Obsidian source
2	Pagudpod, Ilocos Norte	Obsidian source
3	Nagcarlan, Batangas	Obsidian source
4	Nagcarlan, Batangas	Obsidian source
5	Ulilang Bundok	Obsidian artifact (LDP 62.5–73 cm)
6	Ulilang Bundok	Obsidian artifact (LDP 62)
7	Ulilang Bundok	Obsidian artifact (LDP 62)
8	Ulilang Bundok	Obsidian artifact (LDP 54.5)
9	Ulilang Bundok	Obsidian artifact (LDP 55)
10	Ulilang Bundok	Obsidian artifact (LDP 72.5)
11	Ulilang Bundok	Obsidian artifact (LDP 53)
12	Ulilang Bundok	Obsidian artifact (LDP 49–53)
13	Ulilang Bundok	Obsidian artifact (LDP 54)
14	Ulilang Bundok	Obsidian artifact (LDP 69.5–95)
15	Ulilang Bundok	Obsidian artifact (LDP 69)

selected obsidian samples were found in vessel numbers 18, 31, and 34, with the objects directly associated with the organic remains used in the dating of the vessels to the Late Metal Age (samples IV-95-Y-12164, IV-95-Y-12389, and IV-95-Y-6282 in Tables 1 and 2). This ensured that obsidian objects were not inadvertently included in the sample from later periods of site use that might skew our understanding of Late Metal Age patterns of obsidian procurement.

Methods of Analysis

All of the obsidian samples were cleaned in a distilled water sonic bath for 15 minutes as part of a standardized procedure to ensure against contamination by material adhering to the obsidian. Samples of obsidian chips, each measuring 1–2 mm, were then mounted in a 23 mm diameter epoxy disc and polished flat using a succession of finer grit grinding wheels and diamond pastes (the finest being 1 micron). The samples were sputter-coated with carbon to prevent electrical charging prior to analysis.

The majority of the samples were analyzed using a Scanning Electron Microscope (SEM) (Model JEOL JSM-6460LV) equipped with Oxford INCA Energy 200 Energy Dispersive X-ray Spectrometer located in the School of Physics at Universiti Sains Malaysia, Penang. Some of the samples were analyzed using the Cameca MBX Electron Microprobe equipped with wavelength dispersive spectrometers at the University of Malaya, Kuala Lumpur. Two or three different points on each sample were analyzed to account for potential heterogeneity in the microlite inclusions in the samples, since some nonuniformity in composition is common within lithic material, while chemical analysis attempts to capture overall compositional variability between samples. A single measure of variability in each element is then calculated by averaging the results for each sample and normalizing to 100 percent. Both SEM and Electron Microprobe methods were chosen among a variety of chemical characterization techniques that can be used on obsidian[6] because they are minimally destructive (only 1–2 mm size sample is needed), and they are relatively fast and accurate methods for determining the selected range of elements within the required detection limits of

0.01 to 0.1 weight percent, depending upon the element and composition of the sample. The range of elements that were detectable and were selected for comparison between the samples included Si, Al, Fe, Ca, K, Na, and O. These are among some of the most common elements that have been identified through various chemical techniques in known obsidian sources in Southeast Asia and the Pacific (Bellwood and Koon 1989; Chia 2003; Chia et al. 2010; Green and Bird 1989; Tykot and Chia 1997), and were deemed the most useful for both the present analysis and future comparative compositional studies that expand our analysis beyond the Philippine archipelago to consider extra-archipelago sources for Metal Age obsidian.

RESULTS OF THE ELEMENTAL ANALYSIS

Multi-elemental analysis was undertaken using SEM technology, average densities of specific chemicals were calculated (Table 4), and using several of the more prominent elements in the three sample groups (i.e., the two obsidian sources and the archaeological site of the Ulilang Bundok), the groups were compared for degree of overlap through bivariate plots. The bivariate plots (Figs. 2 and 3) comparing relative amounts of Al (aluminum) versus Na (sodium) and Si (silicon) versus Al (aluminum) demonstrate that the obsidian sources of Nagcarlan and Pagudpod have very distinct chemical signatures, indicating that the two sources, separated by nearly 400 km on the island of Luzon, have quite different geological origins and can be easily differentiated in compositional studies.

Turning to the question of whether the Late Metal Age community who engaged in jar-burial ritual practices at Ulilang Bundok obtained obsidian from the Nagcarlan source relatively close to the site (at a distance of 60–70 km to the northeast) or obtained "exotic" obsidian (likely through exchange) from the distant Pagudpod source

TABLE 4. ELEMENTAL DATA FOR OBSIDIAN SAMPLES FROM TWO PHILIPPINE OBSIDIAN SOURCES AND THE LATE METAL AGE SITE OF ULILANG BUNDOK

SAMPLE NO.	LOCATION	O	Na	Al	Si	Cl	K	Ca	Fe
1	Pagupod source	49.27	3.35	7.19	33.67	0.41	4.46	0.51	1.16
2	Pagupod source	47.67	3.35	7.46	35.01	0.28	4.57	0.63	1.18
3	Nagcarlan source	48.96	3.13	6.77	36.03	0.31	3.62	0.52	0.84
4	Nagcarlan source	44.66	3.07	7.08	39.64	3.82	4.01	0.66	0.99
5	Ulilang Bundok	48.81	2.98	6.44	34.31	0.00	3.49	0.66	0.98
6	Ulilang Bundok	49.55	3.00	6.71	35.79	0.00	3.63	0.52	0.80
7	Ulilang Bundok	47.42	2.94	7.01	37.49	0.00	3.84	0.61	0.72
8	Ulilang Bundok	45.51	2.98	7.06	38.55	0.00	3.95	0.66	1.13
9	Ulilang Bundok	45.86	3.12	6.92	38.50	0.31	3.98	0.59	0.88
10	Ulilang Bundok	48.53	3.07	6.73	36.40	0.27	3.76	0.53	0.85
11	Ulilang Bundok	48.65	2.95	6.66	36.20	0.28	3.74	0.63	0.92
12	Ulilang Bundok	46.84	2.94	6.85	37.88	0.00	3.74	0.63	1.13
13	Ulilang Bundok	42.59	2.80	7.09	41.67	0.34	4.32	0.52	0.85
14	Ulilang Bundok	42.20	3.07	7.45	41.18	0.00	4.39	0.70	1.04
15	Ulilang Bundok	45.79	2.93	6.86	38.85	0.00	3.93	0.72	0.94

The numbers represent the mean LOG10 parts per million for each element, with the *mean* representing the average of several chemical readings taken on the same obsidian artifact or obsidian source material to allow for slight variations in chemical composition over a single obsidian piece.

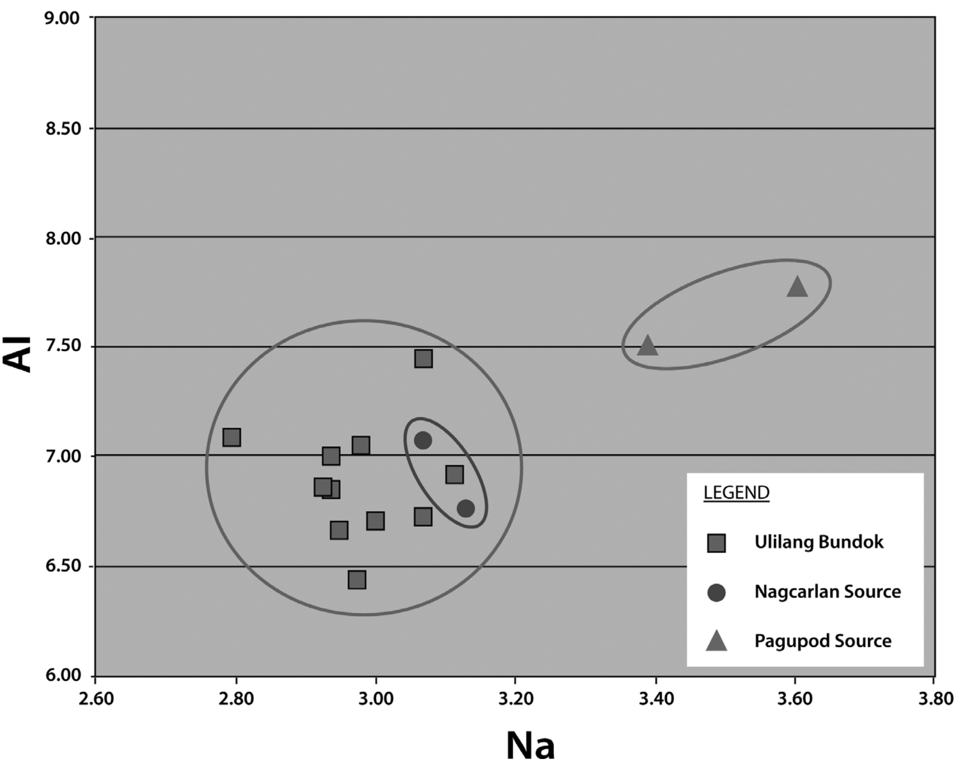

Fig. 2. Bivariate plot of Al (aluminum) versus Na (sodium). Scales are in terms of LOG10 ppm (parts per million) of the elements.

(at least 400 km to the north), the results of the analysis showed what can be interpreted as an exclusive focus on the nearest obsidian source and no evidence for use of the significantly remote source of Pagudpod obsidian. The bivariate plots clearly show that the chemical composition of the samples from the Ulilang Bundok site are similar to samples from the Nagcarlan source as indicated by the almost perfect intersection of the 90th percentile ellipses for the obsidian nodules from Nagcarlan and the obsidian objects associated with the Late Metal Age jar burials at the Ulilang Bundok site on the two-dimensional scatterplots (Figs. 2 and 3). This current work using SEM technology is supported by earlier studies by Neri (2007) and Neri and De la Torre (2007) involving geochemical analysis of the obsidian artifacts recovered from a wider variety of archaeological sites in the Philippines using EDXRF (X-ray fluorescence), again comparing their chemistry to the two known obsidian sources in the Philippines. Neri analyzed a total of 282 obsidian fragments from the Ulilang Bundok site in the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR). Trace element concentrations of Zn, Pb, Rb, Sr, Y, Zr, Nb, Ti, Mn, and Ba were identified by the peaks in Compton scatters, then converted to parts per million (ppm). The results were highly consistent with those of our current SEM-based study, indicating a similar pattern of overlap in elemental composition of obsidian from the Nagcarlan source and the Ulilang Bundok site (Fig. 4). Even with this larger sample

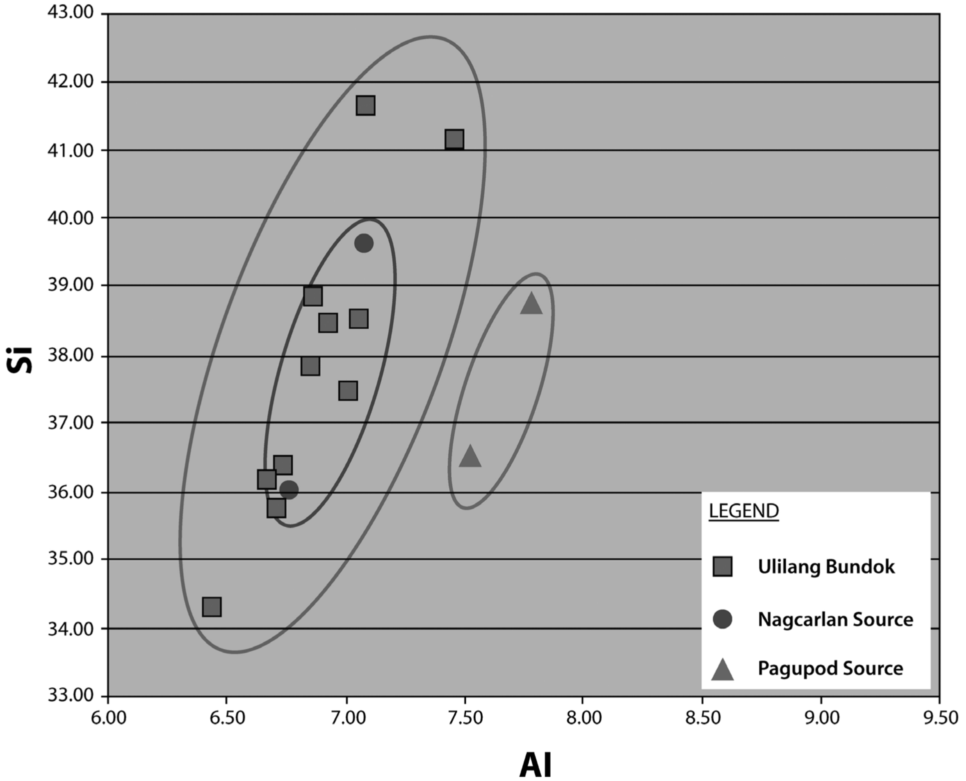

Fig. 3. Bivariate plot Si (silicon) versus Al (aluminum). Scales are in terms of LOG10 ppm (parts per million) of the elements.

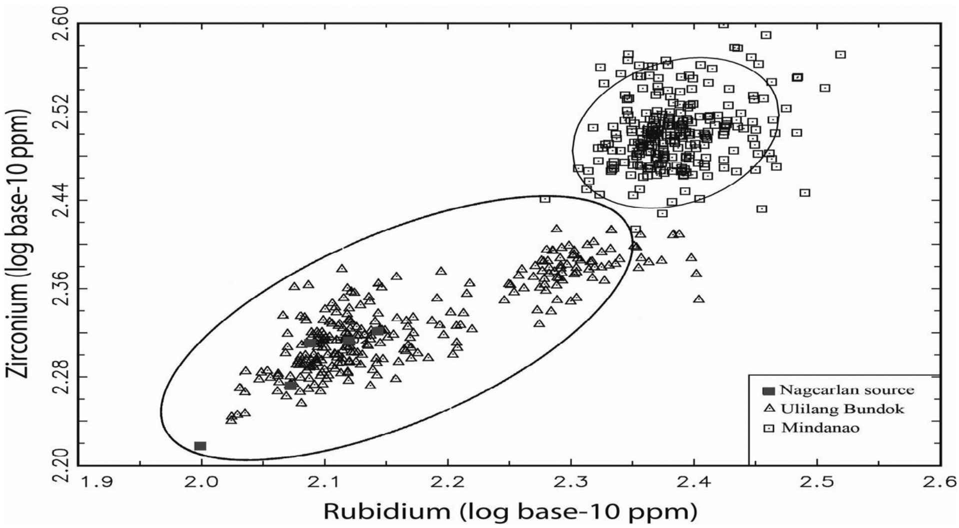

Fig. 4. Binary plot of Zr (zirconium) versus Rb (rubidium). Scales are in terms of LOG10 ppm (parts per million) of the elements (adapted from Neri et al. 2009).

and using a different method of chemical characterization, the pattern of exclusive extraction from the Nagcarlan source holds true.

The methods we have employed are therefore viable and cost-effective techniques for obsidian sourcing study. They also indicated that the obsidian artifacts can be chemically traced to the Nagcarlan source using major elements (instead of using trace elements) as well. More importantly, our study has shown that a much smaller sample size can be used to produce similar results in obsidian sourcing, and that initial sample selection based on physical characteristics is needed to avoid analyzing too many redundant samples from a single core or source. In terms of physical characteristics, there is also a strong match between the Ulilang Bundok obsidian artifacts and the obsidian raw material at the Nagcarlan source. The Ulilang Bundok obsidian objects have high opacity and some of the samples exhibit elongated or rounded bubbles, characteristics that are consistent with obsidian material from the Nagcarlan source, which has visible vesicles or oval cavities produced by the presence of bubbles of gas or vapor in volcanic rocks. Therefore, all of the current chemical and physical analyses suggest that the Late Metal Age community at Ulilang Bundok obtained its obsidian from this known locale of obsidian extraction.

However, it is important to raise the methodological issue of whether the "known" obsidian deposits currently recorded through geological surveys in the Philippines actually represent all of the intra-archipelago sources available to ancient populations. This is a question raised in Neri's (2007) earlier study, in which he not only chemically compared Ulilang Bundok obsidian to the two obsidian sources on Luzon, but also chemically examined with XRF technology obsidian artifacts from a second site, Huluga in Cagayan de Oro on the northern coast of Mindanao. The results indicated no matches with either the two known Philippine obsidian sources or with volcanic rock samples from several volcanoes in Mindanao (which might reasonably be viewed as having geochemistry similar to presently unknown sources of obsidian in the region) (Neri 2007:159), resulting in speculation that the obsidian artifacts at Huluga might have been obtained from yet unknown extra-archipelago sources. These observations point out the problems associated with the thus far highly limited work on chemical sourcing of obsidian in the Philippines from archaeological sites of all periods. As pointed out by Neri (2007:161), few obsidian assemblages recorded at archaeological sites on Luzon, Mindanao, Palawan, and in the Central Philippines, ranging from Palaeolithic to early historic and even recent in age, have been analyzed using these various compositional analysis techniques. Neri also suggests that there are likely currently unmapped obsidian sources to be discovered in island locales with active volcanic landscapes such as Mindanao, and he points out that searches for obsidian trade routes into the Philippines necessitate more collaboration with archaeologists doing chemical characterization studies in other regions of Island Southeast Asia and beyond (Chia et al. 2010; Reepmeyer et al. 2011; Spriggs et al. 2011).

IMPLICATIONS FOR UNDERSTANDING MOBILITY AND THE SOCIAL CONTEXTS OF OBSIDIAN EXCHANGE IN THE PHILIPPINE METAL AGE

While obsidian appears to have been used, in its rough nodule or flake form or as finely made implements, at Philippine sites since the Palaeolithic period, in the Late Metal Age it is often associated with burials (most often secondary jar burials) and is one of a number of local or exotic goods—including unusual shells, bronze and iron implements, gold ornamentation, elaborately decorated earthenware ceramic forms, and glass beads—that are associated with mortuary rites. These jar burials generally occur in clusters (whether in caves/rockshelters or in open sites). They are often associated with prominent landscape features such as hilltop ridges or caves with commanding views of the region, and although there have been relatively few excavations of settlement sites of this period, a number of archaeologists have noted evidence for habitation nearby.

Unlike the emphasis on individual identity and possible elite aggrandizement that seems to characterize what may be referred to as early historic inhumation burials after about A.D. 800 and up to Spanish contact, Late Metal Age burials like those of Ulilang Bundok appear to represent a more collective ethos of community identity and belonging. Socially valued goods, identified as such due to their scarcity, exoticness, and nonutilitarian function—glass beads sourced to outside the archipelago; rare and exceptionally beautiful forms of marine shell; earthenware with elaborate incised, appliqued, and punctate decoration, and even anthropomorphic forms; bronze socketed axes; nephrite jewelry; and glossy obsidian fragments—were manufactured locally from either exotic or local materials, extracted from limited sources, or obtained in long-distance and even extra-archipelago trade. While the local stylistic components of jar burial in different regions are quite distinct, the general social template for burial practices appears to be shared between island communities, indicating that Late Metal Age communities were not isolated but instead were highly mobile in terms of frequent social interaction and likely material exchanges between islands.

Given this likely complicated social landscape of frequent contact and mobility, it is difficult to trace these social networks across islands, between islands, and beyond the archipelago, but our work with obsidian sourcing is an initial step in this direction. The chemical analysis of the Ulilang Bundok site obsidian and the two Luzon island obsidian sources showed that the Late Metal Age community inhabiting Ulilang Bundok traveled about 60–70 km northeast of the site to obtain this valued commodity, important in burial ritual and possibly social exchange. As noted earlier, the landscape in the vicinity of Ulilang Bundok supported a diverse and eclectic resource base with easy access to shoreline, riverine, and maritime resources, as well as varied raw material resources, potential agricultural lands, and forest resources at distinct elevation zones. Another attraction for the Metal Age population of this region might have been relatively close proximity to the resources of the extensive Laguna Lake and the presence of the Nagcarlan obsidian as a geographically limited source within the archipelago. It is not presently possible to determine whether the Ulilang Bundok population traveled to the Nagcarlan source and extracted obsidian directly and exerted some control over this resource, or acquired it through down-the-line exchange as a means of expanding their social networks of interregional trade, which brought them in return other types of exotics for mortuary ritual and other social practices.

It is necessary to expand sourcing studies like the present one to enhance our understanding of what Late Metal Age societies were like in the Philippines and elsewhere in Island Southeast Asia prior to the rise of social stratification and political centralization in the region. Documenting networks of social interaction and exchange, as well as the archaeological contexts in which they operate (e.g., households, larger settlement systems, and ritual/mortuary sites), through compositional analysis and raw material sourcing of obsidian and other exotic artifacts is important to this endeavor.

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NOTES

1. As is found in later Bronze Age sites in Mainland Southeast Asia (Higham 1996; Higham et al. 2011; Stark 2006).
2. The majority of these obsidian artifacts were recovered during archaeological surveys or excavations such as those from the Novaliches-Marilao District and the Lake District in Rizal Province, Tagaytay, and the nearby Indang region in Cavite Province, the Pugad-Baboy and Maysan areas in Bulacan Province, San Juan River valley and Pasig-Tagig subdistricts in Batangas and Ilocos Norte (Beyer 1947); Lemery in Batangas Province (Paterno 1981); Calatagan and Lian in Batangas Province (Bautista 1995*c*; De la Torre 1997*b*, 2002; Ronquillo and Ogawa 1996); Pintu rockshelter in Nueva Vizcaya (Peterson 1974); Pila and Talim Island in Batangas Province (Fernandez and Rogel 1968); Bulacan Province down to the Bicol region (Scott 1968); Ille limestone tower in the valley of Dewil, New Ibajay in the municipality of El Nido, Palawan Province (Paz and Ronquillo 2004); Tinokod Cave in the Luyang Baga Cave complex in Mindoro Occidental Province, Mindoro Island (Mijares 1996); the municipality of Carcar, Cebu Province (Tenazas 1985); the municipality of Tigbauan, province of Iloilo on Panay Island in the western Visayas (Beyer 1947); the Bungiao rockshelter, located in the village of Bungiao, Manicahan Municipality, Zamboanga Province (Coutts and Wesson 1980 : 256; Spoehr 1973); Balobok rockshelter in Sanga Sanga Island, Tawi-Tawi Province, southwest from Zamboanga (Coutts and Wesson 1980 : 256; Spoehr 1973); and in the northern part of the island of Mindanao, such as Huluga open site in Cagayan de Oro City (ASP 2009; Neri 2003, 2005; Neri et al. 2005), Daayata open site in the municipality of Opol (Neri 2011; ASP 2009), Ilihan na Gamay in the municipality of Initao (Neri 2011; Neri et al. 2009); and recently Calumat site in the municipality of Alubijid (Neri et al. 2014).
3. According to the Philippine Bureau of Mines (PBM 2000 : 2), obsidian has been recorded in association with quaternary volcanic deposits in Mabitac, Laguna, and in Pagudpod, Ilocos Norte.
4. According to Mr. Artemio Lurenzo, Chief Village Patrol, this glassy material has been quarried by the locals and is sold at 20 peso per kg to people from the Cagayan valley in northern Luzon.
5. One of the authors (Leee Neri) was led to the Nagcarlan obsidian source by Mr. Larry Bisbe, Village Chairman in Manaol.
6. One of these other techniques, X-ray fluorescence (XRF), particularly popular because of relatively recent portable equipment (pXRF), has now revolutionized the ability for scholars to record chemical composition in the field, although archaeologists are still debating the limitations on accuracy and handling large numbers of chemicals for pXRF in particular (Nazaroff et al. 2010; Neri 2007; Sheppard 2010). An increasingly attractive alternative is Laser-Ablation Inductively Coupled Mass Spectrometry because it requires only extremely small samples (Golitko and Terrell 2012).

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ABSTRACT

This article discusses the results of chemical analysis to trace the source of the obsidian artifacts from the site of Ulilang Bundok in Batangas, Philippines. The obsidian artifacts used in this study were excavated from the site of Ulilang Bundok while samples of obsidian were also collected from known obsidian sources in Nagcarlan, Batangas, and Pagudpod, Ilocos Norte, for comparative purposes. Chemical analyses of the obsidian artifacts and source samples were carried out on a scanning electron microscope using the energy dispersive X-ray spectrometer at the University of Science Malaysia, Penang and the electron microprobe at the University of Malaya, Kuala Lumpur. Multielemental analysis and statistical procedures performed on elemental data obtained from the obsidian artifacts and sources provided strong indications that the obsidian artifacts from Ulilang Bundok were made using obsidian obtained from the Nagcarlan source. The chemical sourcing results are significant in that they suggest that obsidian was a limited and valued raw material that was likely mined and traded through expanding social exchange networks. This has further implications for understanding how the complexity and spatial extent of trade reflects emerging social complexity in the Philippines Metal Age. Keywords: obsidian, sourcing, compositional analysis, Philippines, Metal Age, trade, social organization.