PRELIMINARY ANALYSIS OF THE STONE, GLASS, AND METAL BEADS, AGUSAN RIVER VALLEY, MINDANAO, PHILIPPINES

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The Agusan River Valley in Mindanao, Philippines, has great archaeological significance, particularly for the Age of Contacts and Trade. Intensifying pothunting activities, however, complicate the systematic study of the region due to the loss of the artifacts' stratigraphic context. This article is concerned with the archaeological research potential of beads recovered from disturbed contexts by presenting results from the multi-level analysis of 200 stone, glass, and metal beads donated to the Agusan River Valley Archaeology and Heritage Project. Descriptive and typological analyses reveals a preference for certain bead shapes and colors, while preliminary compositional analysis identifies similarities with colorants used in glass beads excavated in Indonesia, Malaysia, and Singapore. These results provide insights into the cultural lives of precolonial communities along the Agusan River Valley and their participation in a wider interregional exchange network.

INTRODUCTION

The Agusan River Valley spans the provinces of Agusan del Sur and Agusan del Norte in the Caraga region of Mindanao, Philippines (Figure 1). The archaeological potential of this area is well-established, particularly for the Age of Contacts and Trade with the East from the 10th to 16th centuries (Fox 1970). Present-day Butuan City figured in the Southeast Asian maritime trade between the 10th and 13th centuries. The existence of a thriving riverine entrepôt in the region is attested to by records of tribute missions to Song-dynasty China (Bolunia 2014; Gamas 2020), toponyms and geological studies (Bolunia 2014, 2017), and a wealth of archaeological finds, including wooden lashed-lug boats discovered in Barangay Libertad that are dated between the late 7th and 10th centuries (Lacsina 2020).

Prestige goods, found in burial contexts, have also been found in the region. Wooden coffins, tradeware ceramics, porcelain figurines, iron and bronze implements, ivory, glass beads, and gold fragments and ornaments have been

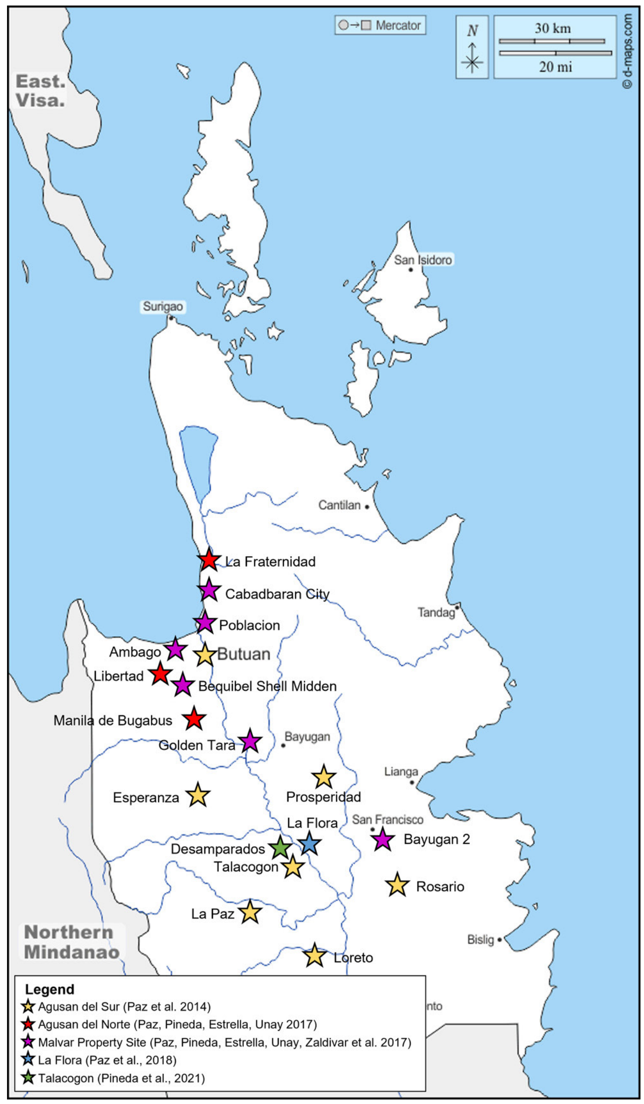

Figure 1. The location of sites surveyed and/or excavated by the Agusan River Valley Archaeology and Heritage Research Project (d-maps.com).

excavated from various archaeological sites in the valley, with dates ranging from the 10th to 19th centuries CE (Bolunia 2014, 2017; Burton 1977; Estrella 2016, 2018; Peterson 2011; Ronquillo 1987a, 1987b). The recovery of incomplete beads, crucibles, stone molds, and metal slag has raised the possibility of bead reworking and/or metal working in the valley (Paz et al. 2017; Paz et al. 2018; Ronquillo 1987a), while the abundance of worked and unworked gold materials highlights the importance of this precious metal in these precolonial communities (Bolunia 2014; Burton 1977; Estrella 2016, 2018; Gamas 2020; Paz et al. 2014).

Archaeological work in the valley, however, is complicated by the frequency of gold-panning and pothunting activities in the region. Since the 1970s, the provinces of Agusan del Norte and Agusan del Sur have been hotbeds for unsystematic excavation of precolonial burial sites. *Pag-aantik* is the local term for pothunting, with the *sonda* – a long, thin metal rod used to check for the presence of buried ceramics – as the pothunter's primary tool (Estrella 2018). Burton (1977), Paz et al. (2014), Peterson (2011), and Ronquillo (1987a, 1987b) report the destruction of potential sites that were heavily probed with *sonda*.

Pag-aantik continues to be prevalent in the valley and is done at a professional level, commissioned by financiers for antiquarian collectors (Estrella 2018; Paz et al. 2018). Unfortunately, materials recovered by pothunters lack the contextual information necessary for site interpretation (Burton 1977).

This article is concerned with the archaeological research potential of beads recovered from similar uncertain contexts. Due to their diminutive size, beads are rarely recovered from undisturbed contexts even in controlled excavations (Basilia 2011; Estrella 2016). Site disturbance due to rampant looting (Carter 2016; Francis 1991) or construction projects (Yankowski 2004) only add to this concern. But with the accessibility and availability of compositional analysis, the loss of stratigraphic context may not be as grave an issue for beads compared to other archaeological materials. Compositional data can aid in rebuilding *chaînes opératoires* for bead production (Lankton et al. 2006), identifying transition and manufacturing periods (Carter et al. 2016; Dong, Li, and Liu 2015; Dussubieux and Allen 2014; Henderson, An, and Ma 2018), tracing raw material sources (Carter and Dussubieux 2016), and understanding influences and interaction (trade) networks (Carter 2016).

Two hundred glass, stone, and metal beads randomly collected from various grave sites in the Agusan River Valley comprise the assemblage under study (Figure 2). The beads, along with a gold strip (Figure 3), were donated to the Agusan River Valley Archaeology and Heritage Research Project (ARVAHRP) in 2017 by a professional pothunter working in Agusan del Sur (Victor J. Paz 2022: pers. comm.). The ARVAHRP, which began in 2014 as the Agusan del Sur Archaeology and Heritage Project, is based at the School of Archaeology, University of the Philippines Diliman in Quezon City. The Project's scope has expanded from one province to the entire Agusan River Valley. Several surveys and excavations have been conducted by the project team in the Caraga region, with the primary objective of expanding our understanding of human/landscape relationships in the Agusan River Valley over time (Paz et al. 2014).

The randomized method of retrieval means that the bead assemblage and gold strip come from uncertain contexts. However, if we accept that the assemblage was, indeed, collected from Agusan River Valley sites, the beads and gold strip date between the 10th and 16th centuries. Previous systematic excavations in the valley recorded beads and gold ornaments in relative association with other artifacts dated to this period (Bolunia 2017; Burton 1977; Estrella 2016; Peterson 2011).

BEADS FROM PHILIPPINE ARCHAEOLOGICAL SITES

Fox and Santiago (1985) initiated the curation and development of the Philippine Bead Type Collection, with the assistance of chemist Jose B. Lugay. It is a significant resource for bead analysis: Fox and Santiago (1985) identified diagnostic bead types, assigned them to a period of Philippine prehistory (Fox 1970), and arranged them in chronological order. The collection, in essence, "established beads as chronological markers for relative dating" (Basilia 2011:14). In his analysis, Francis (2002:209) acknowledged the collection's import, as "[it] is the only countrywide data bank on beads anywhere in the world," but also noted that radiocarbon dates for Philippine sites were not well-established at the time. As such, it should be used with caution and understanding of its limitations (Basilia 2011; Francis 2002).

In assembling the collection, Fox and Santiago (1985) determined the arrangement based on when a specific bead type first appeared in the Philippine archaeological record and/or when it was manufactured in the Philippines. The earliest bead types in the collection were assigned to the Late Neolithic (ca. 1500-500 BC) and were made from shell, stone, and animal teeth.

This was followed by Metal Age types, divided into Early and Developed phases (500 BC-AD 1000), which marked the appearance of beads made of semi-precious stones (nephrite, jasper, agate, carnelian, and onyx), and

Figure 2. Select beads from the Agusan River Valley assemblage: a-b) agate/carnelian beads, c) crystal-quartz beads, d-g) opaque yellow glass beads in a variety of forms, h) translucent dark blue glass beads, i) opaque light blue glass beads, j-k) opaque dark green glass beads, l) opaque brown melon glass bead, m) opaque black bead of indeterminate material, and n-r) polychrome, translucent to opaque glass beads. The coin is 24 mm in diameter (all images by author unless otherwise indicated).

worked gold leaf, as well as Indo-Pacific glass beads, also called trade-wind beads (Francis 2002). These are small (>5 mm), usually opaque, and produced in a limited range of colors (Francis 2002). The Philippine Metal Age aligns with the production and exchange of high-alumina mineral-soda glass beads, specifically the m-Na-Al 1 and m-Na-Al 3 glass sub-groups in South Asia, Sri Lanka, and parts of Southeast Asia (Dussubieux, Gratuze, and Blet-Lemarquan 2010). Indeed, Lankton, Dussubieux, and Gratuze (2006) found compositional similarities between potash and mineral-soda

Figure 3. Worked gold strip donated with the Agusan River Valley bead assemblage; length: 157.6 mm.

beads from Metal Age deposits in the Tabon Cave complex of Palawan and glass samples from Khao Sam Kaeo in Thailand, a known manufacturing center for stone and glass ornaments. Three analytical instruments were used to obtain the compositional data presented by Lankton, Dussubieux, and Gratuze (2006): laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS), electron probe microanalysis (EPMA), and scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM-EDS).

Evidence for local Indo-Pacific bead production is absent in the Philippine archaeological record and it is assumed that all glass artifacts were acquired through trade (Basilia 2015). Ronquillo (1987a) raised the possibility of glass beadmaking and reworking in Butuan, but more confirmatory evidence is needed in the form of a workshop, debitage, and associated structures. The imported nature of these glass beads imbued them with value and prestige, becoming markers of significance and wealth as evidenced in Philippine Metal Age burials (Barretto-Tesoro 2003).

Yankowski (2004) analyzed 130 Indo-Pacific beads recovered from a disturbed burial context in Tagbilaran City, Bohol, which is tentatively dated to the Philippine Metal Age (500 BC-AD 1000). They were found in association with earthenware vessels, iron implements, and fragments of glass bracelets. The beads were predominantly monochromatic red and yellow, and manufactured using two different techniques: drawing and winding. The assemblage also included a 14-sided opaque orange glass bead, which may have been modeled after semi-precious agate/carnelian beads.

At the Napa Property site in Catanauan, Quezon province, dated to the 1st-2nd centuries (Paz et al. 2016), Indo-Pacific beads have been found in association with primary and secondary jar burials and extended burials. Luga (2013) analyzed 989 beads from Locality 1, the majority of which were glass. Yellow (n=435) and orange (n=394) glass beads were the most numerous. The former was mostly associated with primary adult jar burials and occurred with other rare artifacts, such as a shell disc pendant, metal implements, obsidian, and a deer-antler pendant. Orange glass beads, on the other hand, were more closely associated with sub-adult burials, which also contained rare bead types – a blue Chinese bead, a green barrel bead, and a black barrel bead.

Basilia (2015) analyzed 222 beads from Locality 4 of the Napa Property site. Glass beads comprised most of the assemblage, with yellow (n=128) and orange (n=55) again being the most numerous.

Even with the arrival of imported glass beads, local bead production persisted during this period. Using multiple levels of analysis and experimentation, Basilia (2011) demonstrated that the development of drilling technology and the transfer of technological knowledge allowed the production of micro-perforated cut-shell beads at Ille Cave, El Nido, Palawan. In the Quezon province, Basilia (2015) posited the possibility of local production of dolomitic-limestone beads.

The first millennium, which corresponds to the beginning of the Age of Contacts and Trade, marked the decline (but not disappearance) of Indo-Pacific beads and the arrival of Chinese-made beads (Carter 2016; Francis 2022:76-77). Fox and Santiago (1985:13) noted the appearance of "[multicolored] glass beads with complex designs," as well as coiled, melon, eye, local brass, gold, chevron, and large stone (jasper, carnelian, and quartz) beads. The coiled, melon, and eye beads are generally ascribed a Chinese origin (Adhyatman and Arifin 1996; Fox and Santiago 1985). Coiled beads, in particular, were among the most numerous and traded extensively in East and Southeast Asia, dominating the bead trade in the Philippines from ca. 1200 to 1450 (Francis 2002). Lead appears to be a common ingredient in the trade beads of this period.

In Barangay Libertad, Butuan City, glass beads were excavated in association with Song-dynasty tradeware ceramics dated to the 10th-13th centuries. This was also reported by Peterson (2011) for the Masago site in Agusan del Norte. At the Marsan Durango site 1 in Talacogon, Agusan del Sur, Pineda et al. (2021) found a fragment of a broken glass bead that appeared to be coiled.

Beads have also been found in association with archaeological materials (including clay crucibles and molds made of fired clay, stone, and lead) from the 15th-16th centuries at many archaeological sites in and around Butuan (Estrella 2016). At least two comparative compositional studies of Philippine glass beads relative to other Southeast Asian glass samples for this period have been conducted.

Carter et al. (2016) analyzed lead-potash glass beads from jar burials in the Cardamom Mountains in Cambodia, and compared them to beads from the 14th-century Fort Canning site in Singapore and a previously unpublished collection from the Philippines. These beads are from the site of Tanjay, Negros Oriental, in the Philippines (Laure Dussubieux 2022: pers. comm.). Tanjay is dated from the 15th to the beginning of the 16th century. Paste and glass beads are classified as prestige goods at this site as they occur in burials with other valued foreign and local items such as porcelain, bronze, decorated earthenware, and bone ornaments (Junker 1999; Orillaneda 2016). There are compositional similarities between the three sites, but the Cardamom Mountain beads were more similar to those from the Philippines, based on the concentrations of Li and Rb. These results indicate that both lowland (Tanjay) and upland (Cardamom Mountains) communities participated in the regional maritime exchange network. They also underscore the research potential of glass beads in demonstrating the direction and extent of trade.

Using LA-ICP-MS, Craig (2021) and Craig and Dussubieux (2022) analyzed 85 glass beads excavated from three Philippine shipwrecks of the 15th-17th centuries: Pandanan (southern Palawan), Santa Cruz (Zambales), and Royal Captain Shoal wreck 2 (west of Palawan). The results showed three broad directions of exchange and identified regional market shifts in Southeast Asia and the Indian Ocean exchange networks. The first period is associated with the Pandanan shipwreck (1460-1487) which carried drawn red and black mineral-soda beads stored in Thai jars. The Santa Cruz shipwreck (1488-1505) carried wound, blue lead-potash beads associated with Longquan celadon and black and yellow mineral-soda beads in Thai ceramic containers. The Royal Captain Shoal wreck 2 (1573-1620) carried lead-potash beads of multiple monochrome colors in association with Chinese blue-and-white ceramics. These changes in cargo reflect shifts in manufacturing regions – from Chaul, India, in the 15th century to China in the 17th century – and, in consequence, bead compositions, colors, and forms.

Cayron (2006) previously studied the Pandanan shipwreck's glass beads which were contained in Vietnamese stoneware jars. He compared 60 red and 144 black beads from Pandanan with those from Sungai Mas in Kedah, Malaysia, demonstrating similarities in style, form, and technology between the two sites. Chemical analysis was not conducted on the beads due to the cost, insufficient comparative data, and the chemical deterioration of the glass.

METHODOLOGY

The Agusan River Valley bead assemblage was analyzed using descriptive and compositional methodologies. Descriptive analysis of the entire bead assemblage was conducted using a digital caliper, 10x tabletop magnifier and lamp, and a *Munsell Bead Color Book* (Munsell Color 2012). The length and diameter of a bead, along with the diameter of the perforation, were measured in millimeters. Shape, color, diaphaneity, and ornamentation were also noted. The method of manufacture was determined by observing the direction of striations on glass and the rounding of facets on stone beads. Specimens with no visible striations or other evidence relating to manufacture were labeled "undetermined." These methods are in accordance with published guidance for archaeological bead analysis (Cayron 2006; Francis 1991, 2002).

Of the 200 beads, 18 were selected for further chemical compositional analysis using portable X-ray fluorescence (pXRF) spectrometry (Figure 4). Based on their morphological attributes, these beads were representative of the colors, shapes, and materials of the entire assemblage. The least-weathered specimens were selected for this phase to minimize the effects of post-depositional deterioration, burial, and submersion on the beads' chemical compositions (Lamb 1965; Tamura, Nakamura, and Truong 2020). Liu et al. (2012) found the major glass ingredients Na, K, Al, and Ca to be especially volatile in measuring the chemical composition of weathered glass beads. Fe and Ti were likewise unpredictable, while Mn appeared to be the least affected by weathering. These findings shall be considered in the interpretation of the results.

The 18 samples were analyzed using a Vanta handheld XRF analyzer with a silicon drift detector at the Lithics Laboratory of the School of Archaeology, University of the Philippines Diliman. The analyzer was placed on a docking station. Each sample was mounted in a shielded sample chamber where it was subjected to two beams of differing light concentrations. Beam 1 (40.0 kV) measured Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, Ba, W, Hg, Pb, Bi, Th, and U. Beam 2 (10.0 kV) measured Mg, Al, Si, P, S, K, Ca, Ti, and Mn. Light elements (LE) were excluded from measurement.

The Agusan River Valley bead assemblage was also entered into an inventory and provisionally given the accession code [unprov]-XIII-[2022]. This is in accordance with the National Museum of the Philippines's convention for accessioning archaeological sites (Peralta 1978). For this assemblage, however, the assignment of such a code is for the purpose of the inventory only. The term "unprov" and year were placed in brackets to acknowledge the lack of provenience and indicate the date of accession, not the date of recovery.

DESCRIPTIVE ANALYSIS

The Agusan River Valley assemblage is composed of glass, stone, and metal beads, with the first being the predominant material (Figure 5). Following Santiago (2003) and Cayron (2006), a typological flowchart was prepared.

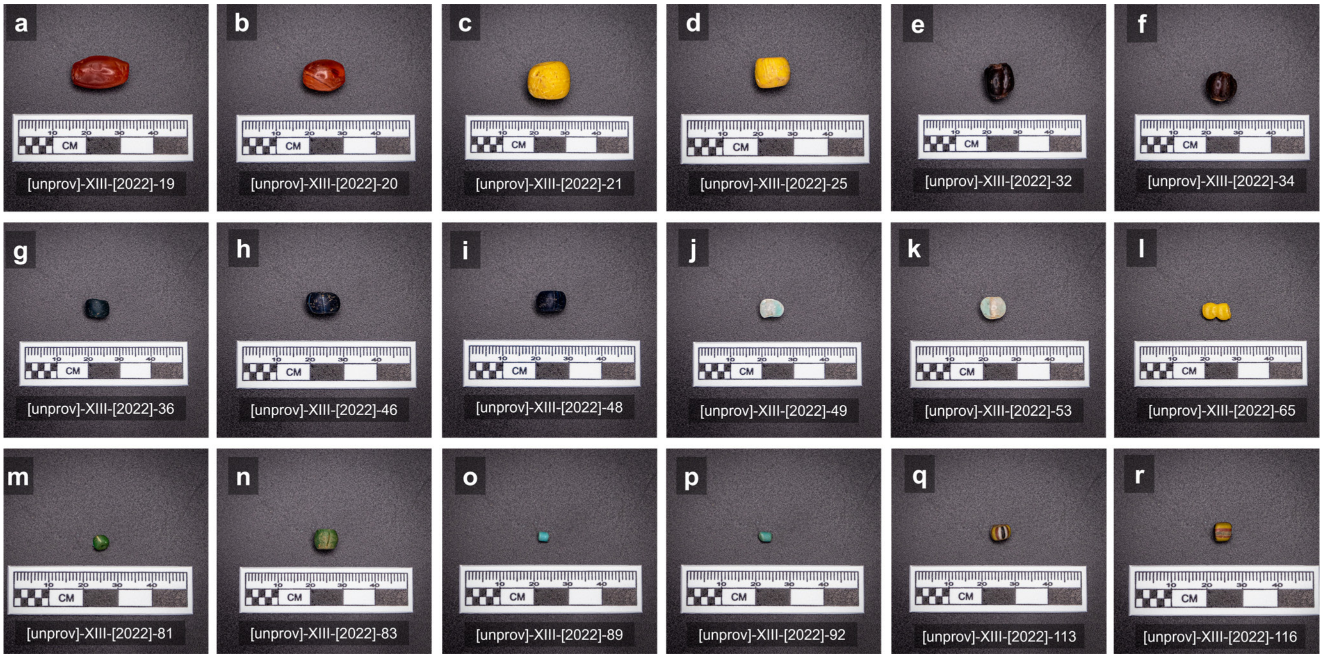

Figure 4. Stone and glass beads selected for pXRF analysis: a-b) agate/carnelian beads, c-d) opaque yellow glass beads, e-f) opaque brown melon glass beads, g) translucent dark shadow blue glass bead, h-i) translucent dark navy glass beads, j-k) crystal-quartz beads, l) opaque yellow segmented glass bead, m-n) opaque dark green glass beads, o-p) opaque light blue glass beads, and q-r) polychrome, translucent to opaque glass beads (photo: Adrian Peter Cartalaba).

The general color of the beads was noted, not their *Munsell Bead Color Book* codes. A total of 34 bead types were identified: 3 stone, 30 glass, and 1 metal (Figures 6-7).

Stone Beads

There are 27 stone beads in the assemblage, visually identified as agate/carnelian (red) and crystal quartz (white). They represent two shapes: barrel and oblate. The average length of the former is 14.5 mm, with a diameter of 9.65 mm. The oblate beads are short, averaging 5.72 mm in length and 6.72 mm in diameter.

The manufacturing method could not be identified with certainty, but all the beads appear to have been tumble-polished, as opposed to abraded, due to the rounded appearance of their facets and edges. The beads were drilled from either one (for oblates) or both (for barrels) ends, as evidenced by the extensive chipping around the perforations (Figure 8). Carnelian beads from Lovea and Sophy in Cambodia exhibit the same scarring, which is "indicative of expedient and less-careful bead production" (Carter et al. 2022) as the damage caused by drilling results in an uneven spherical shape. Drilling from both ends is visible when [unprov]-XIII-[2022]-19 and -20 beads are held to the light: the silhouettes of the perforations are angled and meet in the middle.

Glass Beads

Both monochrome and polychrome glass beads are part of the Agusan River Valley assemblage. Of the former, yellow is the predominant color, with 94 beads in total. Blue (n=32), green (n=22), brown (n=4), and black (n=1) monochrome

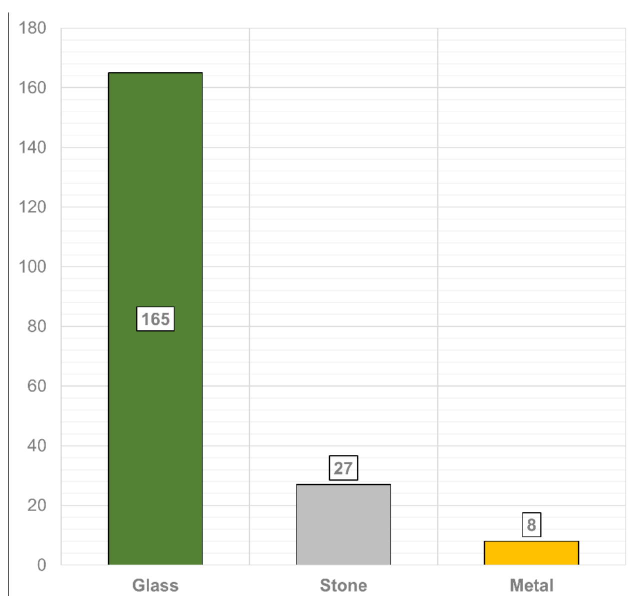

Figure 5. The Agusan River Valley bead assemblage, by material.

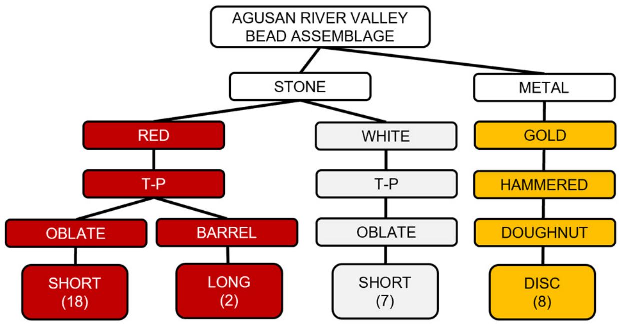

Figure 6. Typological flowchart of the stone and metal beads in the Agusan River Valley bead assemblage.

beads are also present (Figure 9). The polychrome beads have base colors of either brown (n=10) or yellow (n=2). They are decorated with yellow, blue, red, black, and white longitudinal stripes. The majority (n=137) are opaque, while 16 beads are translucent. The 12 polychrome beads exhibit different levels of opacity: their perforations are visible through the glass when held to the light, while the bodies are opaque.

Most of the beads are drawn (n=119), while 35 are labeled "undetermined" since no striations were noted on magnification. Eleven specimens may have been made by winding.

Five bead shapes are represented: barrel, doughnut, melon, segmented, and tubular. The average measurements for each shape are indicated in Table 1. The doughnut shape is the most common, with 90 beads in total occurring in yellow, light blue, green, and black. Only four could be classified as true discs (Cayron 2006). Eighty-five are classified as short, while one bead is long ([unprov]-XIII-[2022]-104). There are 49 barrel and 17 tubular beads.

The eight melon beads are of two colors, opaque yellow and translucent brown, and exhibit variations in the number of pressed lobes, e.g., the lobes of one specimen ([unprov]-XIII-[2022]-33) are not as prominent in comparison with the other melon beads. Longitudinal striations visible on the surface indicate they were made using the drawing technique, rather than winding as described by Cole (2012). The Agusan melon beads also have rounded ends, unlike the flattened ends characteristic of both the small and large Tani melon beads, and do not exhibit horseshoe-shaped marks on their surface (Cole 2012).

Melon beads have existed for thousands of years, originating in Egypt, with the earliest forms probably taking inspiration from the lotus rather than the melon fruit (Eisen 1930). In Asia, they were first associated with the Han dynasty, "probably inspired by Western imports through the Silk Road" (Adhyatman and Arifin 1996:78). Kwan (2013) noted that many melon beads were found at sites dating to the Yuan Dynasty (1271-1368). In the Philippines, melon beads were "invariably excavated in sites associated with trade potteries from Asia" (Fox and Santiago 1985:13). They date to the Age of Contacts and Trade with the East (10th-16th centuries), and contain high levels of lead, but no barium.

The melon beads in this assemblage are smaller than those described by Cole (2012) and Kwan (2013), and seem to be closer in size to the yellow melon beads loosely dated to the 17th-19th centuries from Irian Jaya (Adhyatman and Arifin 1996). These latter beads probably originated in China and share the same rounded ends as the Agusan melons, though the "cuffs" on the latter appear to be more prominent.

Only one bead ([unprov]-XIII-[2022]-65) is identified as segmented. This form originated in the Middle East and was "made by constricting a heated tube to form bulges that are cut apart as single or multiple beads" (Francis 2002:11).

Metal Beads

The eight metal beads in the assemblage are classified as doughnut-shaped discs. Their average length is 0.44 mm, with

Table 1. Average Measurements (in mm) of the Glass Beads Based on Shape.

Shape	Quantity	Bead Diameter	Perforation Length	Perforation Diameter
Doughnut	90	5.04	2.39	1.82
Barrel	49	6.10	4.28	1.91
Tubular	17	3.32	3.62	1.07
Melon	8	9.55	9.29	1.98
Segmented	1	5.10	7.60	2.50

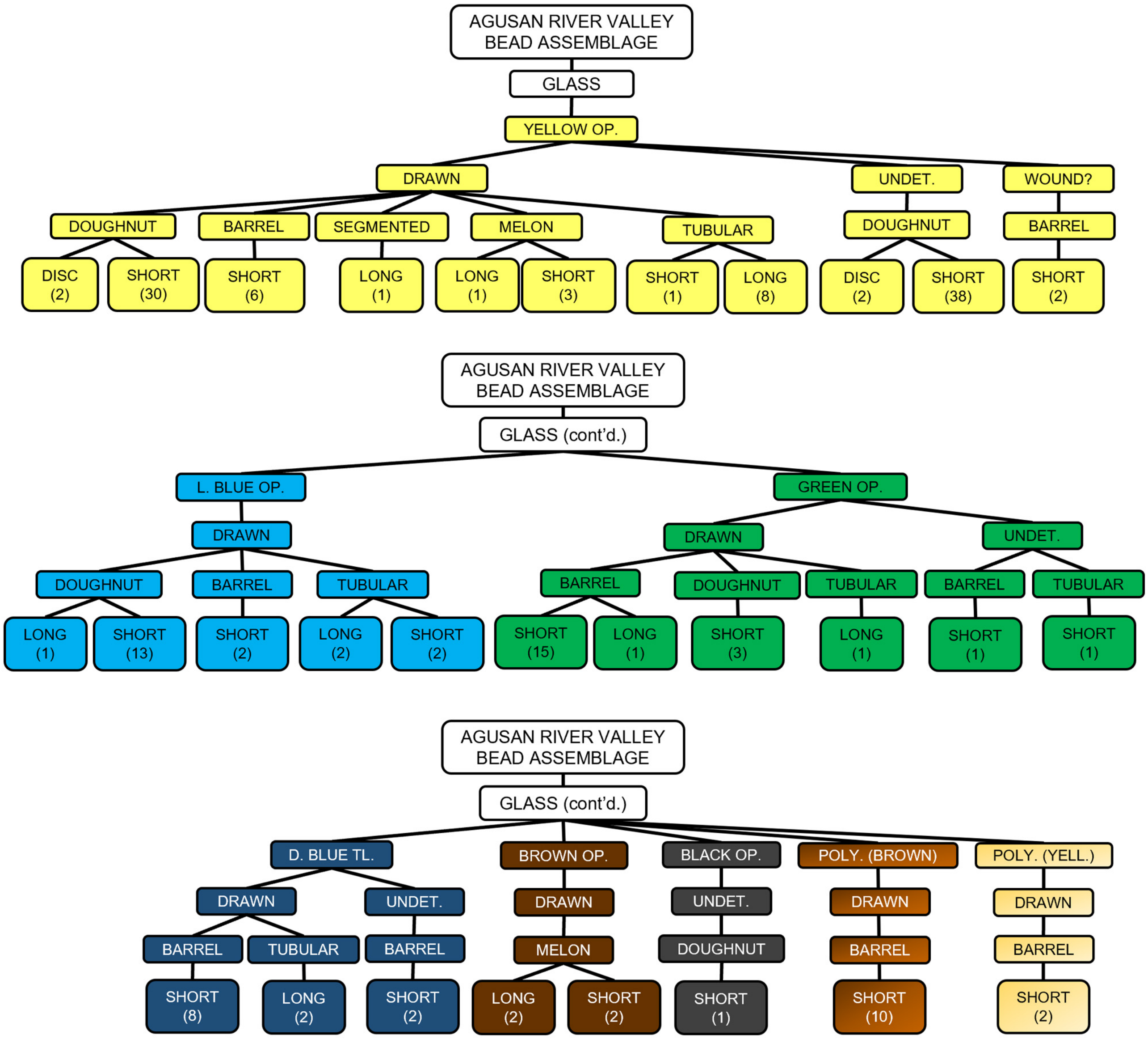

Figure 7. Typological flowchart of glass beads in the Agusan River Valley bead assemblage.

a whole-bead diameter of 4.9 mm and a perforation diameter of 4.05 mm. They appear to be made of gold. Evidence of manufacture is difficult to discern due to the size of the specimens, but they are assumed to have been fused and hammered, based on Estrella's (2016) description of similar circular beads at the National Museum Regional Branch in Butuan.

COMPOSITIONAL ANALYSIS

Four stone and 14 glass beads were selected for further compositional analysis using a pXRF spectrometer. The results are provided in Tables 2 and 3. The concentrations of the major elements are given in percent by weight (%), while minor and trace elements are in parts per million (ppm). Elements not detected are labeled "n.d."

Given the limitations of the pXRF spectrometer for provenance studies (Bonneau et al. 2014; Liu et al. 2012), the results of this analysis are preliminary and cannot be used to conclusively determine the chemical classes of the Agusan River Valley samples. Nonetheless, they present interesting insights that could be explored in future research.

Figure 8. Drilled perforations of stone beads.

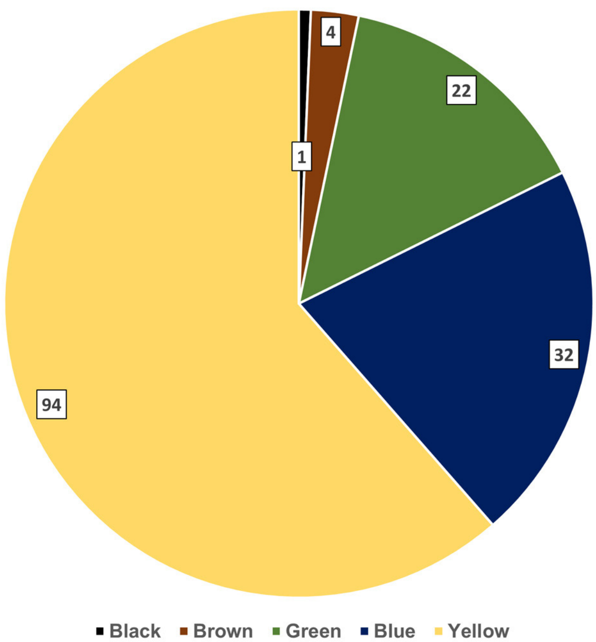

Figure 9. Glass bead colors of the Agusan River Valley assemblage (monochrome only).

Stone Beads

Two agate/carnelian and two crystal-quartz beads were selected for pXRF spectrometry. The Si content of all four is significantly lower than the values obtained by Carter and Dussubieux (2016). Whether this is an effect of surface weathering remains to be seen.

The Ni, Rb, Sr, Zr, Sb, Ba, and Y content of the beads also does not correspond to Carter and Dussubieux's (2016) published data set. These elements were identified as diagnostic for the geologic sources included in their study. In particular, the Ba concentrations in the four Agusan River Valley stone beads are elevated. These discrepancies likely stem from the limitations of pXRF spectrometry. In future research, a more sensitive technique, such as LA-ICP-MS or Instrumental Neutron Activation Analysis (INAA), should be used to improve precision so the results can be utilized for provenience studies.

Glass Beads

Fourteen glass beads were selected for compositional analysis. The major elements recorded for all specimens are Mg, Al, Si, K, and Ca. S, Mn, Fe, Sn, and Pb were present in varying amounts (i.e., wt% for some samples, ppm in others). Minor and trace elements include P, Ti, Ni, Cu, Zn, Sr, and Sb. Fourteen elements were detected in some but not all samples, namely: V, Cr, Co, As, Se, Rb, Y, Zr, Nb, Ag, Ba, W, Bi, and Th.

Cluster analysis was used to group the compositional data set into clusters using the statistical software IBM SPSS Statistics (2017). Only element concentrations present in all 14 samples were considered in the analysis, all of which are associated with colorants used during the manufacturing process. The use of certain coloring agents can be traced to particular workshops, periods of manufacture, or, at the very least, sites with glass beads colored using the same recipes.

Three groups were identified based on significant variations in S, Cu, Sn, Sb, and Pb (Figures 10-11). Mn, Ni, and Zn were also used, though their contributions to the final clusters are less significant.

Cluster 1 is composed of two opaque yellow barrel beads ([unprov]-XIII-[2022]-21, -25). This group is characterized by higher concentrations of Sn and middle-range Pb relative to the other clusters. Lead stannate ($PbSnO_3$) is a known yellow opacifier in glass beads and

Table 2. Compositional Data for Stone Beads Obtained by Portable XRF.

Accession No.	20	19	53	49
Method of Manufacture	tumble-polished	tumble-polished	tumble-polished	tumble-polished
Color	barn red	barn red	white	white
Opacity	translucent	translucent	translucent	translucent
Mg	n.d.	n.d.	n.d.	3000
Al	1480	1460	2730	n.d.
Si	56.69%	55.14%	49.56%	53.50%
P	283	205	n.d.	n.d.
K	n.d.	99	n.d.	n.d.
Ca	1019	1091	2.192%	393
Ti	320	390	n.d.	300
Mn	59	53	n.d.	123
Fe	475	316	346	75
Co	27	n.d.	52	47
Ni	25	16	29	29
Cu	5	10	35	29
Zn	9	13	12	15
As	3	n.d.	n.d.	n.d.
Se	4	3	9	7
Rb	3	3	8	7
Sr	5	4	7	5
Y	7	5	6	6
Zr	8	11	8	9
Mo	7	10	13	12
Ag	36	n.d.	n.d.	n.d.
Cd	32	14	n.d.	n.d.
Sn	42	75	73	50
Sb	35	72	115	75
Ba	830	1540	640	510
W	8	n.d.	n.d.	n.d.
Hg	n.d.	6	n.d.	9
Pb	5	9	13	11
Bi	22	49	69	57
LE	42.83%	44.32%	47.81%	46.03%

Table 3. Compositional Data for Glass Beads Obtained by Portable XRF.

Accession No.	21	25	32	34	36	46	48
Method of Manufacture	wound?	drawn	drawn	drawn	drawn	drawn	drawn
Color	mustard gold	mustard gold	dark brown	dark brown	dark shadow blue	dark navy	dark navy
Opacity	opaque	opaque	translucent	translucent	translucent	translucent	translucent
Mg	2.81%	1.51%	3.04%	2.51%	2.55%	2.12%	2.09%
Al	2.078%	3.777%	1.749%	1.794%	2.417%	2.034%	2.217%
Si	33.96%	30.34%	36.30%	35.35%	32.78%	36.40%	38.12%
P	813	3050	557	793	870	840	580
S	2.512%	2.695%	1830	1380	9230	2200	2490
K	2.622%	2.032%	2.024%	2.244%	1.968%	1.984%	1.603%
Ca	3.354%	3.061%	3.504%	3.143%	3.623%	3.617%	3.965%
Ti	990	1940	440	830	1210	1730	1460
V	n.d.	n.d.	n.d.	n.d.	97	175	n.d.
Cr	243	363	n.d.	111	131	n.d.	124
Mn	9060	5480	1.030%	1.624%	9010	1457	1805
Fe	5430	1.334%	4444	5090	8120	9720	1.169%
Co	53	n.d.	34	n.d.	277	500	490
Ni	66	96	49	45	92	84	120
Cu	82	372	29	24	1192	904	1015
Zn	82	88	20	39	140	71	50
As	2310	6180	9	5	n.d.	n.d.	n.d.
Se	34	61	5	7	n.d.	6	5
Rb	n.d.	n.d.	19	28	26	18	14
Sr	482	394	464	508	584	622	512
Y	n.d.	n.d.	9	9	n.d.	9	10
Zr	36	n.d.	68	109	87	117	104
Nb	90	287	n.d.	n.d.	6	n.d.	n.d.
Mo	36	77	17	4	19	12	15
Ag	41	59	26	n.d.	37	n.d.	20
Sn	1.455%	2.597%	101	75	4887	139	100
Sb	166	312	71	51	72	121	38
Ba	n.d.	n.d.	1750	1140	n.d.	1230	n.d.
W	62	107	19	20	n.d.	n.d.	16
Pb	6.957%	13.46%	33	14	2.305%	941	892
Bi	n.d.	n.d.	43	63	n.d.	67	36
Th	34	119	n.d.	n.d.	n.d.	n.d.	n.d.
LE	42.24%	37.29%	51.35%	52.30%	50.75%	51.76%	49.85%

Table 3. Continued.

Accession No.	65	81	83	89	92	113	116
Method of Manufacture	drawn	drawn	drawn	drawn	drawn	drawn	drawn
Color	mustard gold	dark palm green	dark palm green	light blue spruce	light blue spruce	polychrome	polychrome
Opacity	opaque	opaque	opaque	opaque	opaque	translucent to opaque	translucent to opaque
Mg	1.660%	1.19%	2.32%	2.17%	2.45%	2.63%	2.83%
Al	2.435%	2.91%	4.46%	1.931%	3.22%	1.941%	3.304%
Si	28.14%	21.37%	26.01%	26.31%	25.27%	34.37%	31.08%
P	310	540	760	320	790	763	828
S	1.193%	4.826%	6.251%	6.809%	7.326%	8740	6860
K	1.641%	1.261%	1.669%	1.545%	1.394%	2.020%	1.741%
Ca	3.415%	2.515%	2.862%	3.771%	3.409%	2.802%	2.789%
Ti	1120	2280	1850	630	1350	850	1310
V	n.d.	n.d.	n.d.	120	260	n.d.	105
Cr	273	406	429	350	265	140	n.d.
Mn	9420	677	534	327	619	9530	9090
Fe	6570	1.069%	1.060%	5010	7990	9560	7890
Co	n.d.	73	83	73	n.d.	n.d.	n.d.
Ni	63	89	96	76	78	45	46
Cu	75	8160	7230	6380	6680	3806	6951
Zn	67	1499	1473	1176	1061	1191	1222
As	765	1.456%	7290	8580	8630	1620	675
Se	14	130	n.d.	107	96	12	13
Rb	26	n.d.	n.d.	n.d.	n.d.	23	25
Sr	317	572	502	539	534	496	487
Y	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Zr	61	n.d.	n.d.	n.d.	n.d.	59	75
Nb	34	474	518	342	450	8	5
Mo	18	129	112	64	73	11	8
Ag	68	89	148	133	97	n.d.	28
Sn	6560	7850	7720	3.032%	2.929%	3143	1201
Sb	72	240	385	445	326	143	100
Ba	n.d.	1420	n.d.	n.d.	960	510	n.d.
W	n.d.	202	101	46	109	22	n.d.
Pb	3.762%	19.28%	19.28%	15.75%	18.39%	1.284%	9384
Bi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Th	n.d.	128	187	145	107	n.d.	n.d.
LE	55.17%	41.60%	33.15%	36.19%	32.56%	50.88%	53.62%

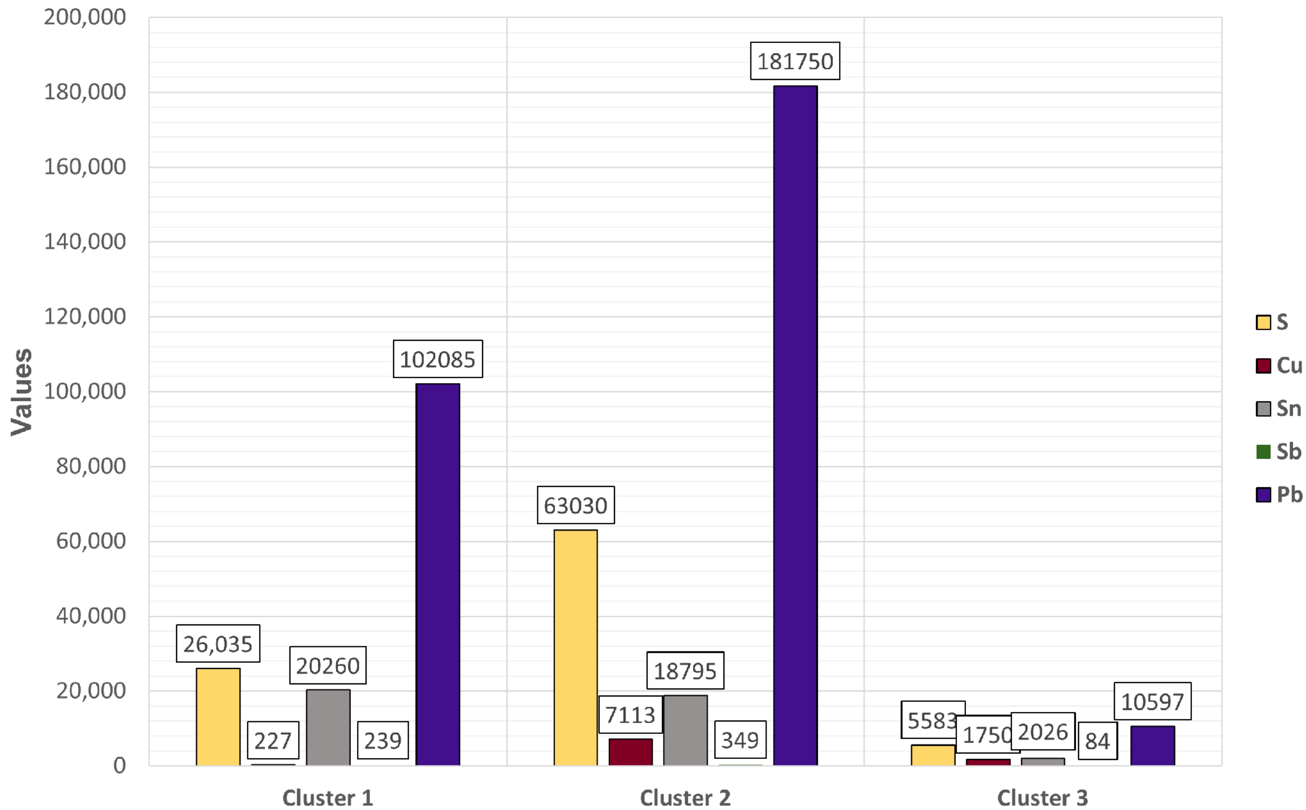

Figure 10. Clusters based on the chemical compositions of analyzed glass beads from the Agusan River Valley.

fragments from Indonesia (Dussubieux 2009), Malaysia (Dussubieux and Allen 2014), Singapore (Dussubieux 2010), and the Pandanan Island (Palawan) and Santa Cruz (Zambales) shipwrecks in the Philippines (Craig and Dussubieux 2022). The compositional results for both beads also indicate minor concentrations of Mn which may have been used to reduce the greenish tinge introduced by iron impurities in the sand used to produce the glass (Henderson 2013). These beads also contain major levels of S and As which could indicate the use of arsenic sulfide pigments as yellow colorants such as alacranite (As_8S_9) and orpiment (As_2S_3). Both pigments have been utilized in Japanese woodblock prints from the late Edo (1615-1868) and early Meiji (1868-1912) periods (Luo et al. 2016), as well as Chinese reverse glass paintings dated to the beginning of the 20th century (Steger et al. 2019).

Cluster 2 is composed of dark green and light blue beads ([unprov]-XIII-[2022]-81, -83, -89, -92). This group is characterized by significantly higher concentrations of S, Cu, Sb, and Pb and middle-range Sn relative to the other clusters. Ni and Zn are also elevated. The four beads appear to have been colored with a brass alloy, as evidenced by minor concentrations of Cu and Zn in association with Pb and Sn. The use of this combination as a colorant for blue glass has been recorded in Indonesia (Dussubieux 2009) and Malaysia (Dussubieux and Allen 2014; Ramli et al. 2017). Slight differences within the cluster can be observed: the dark green beads have higher levels of Cu and Zn compared to the light blue beads, suggesting that a slight increase in raw materials could produce a darker color (Dussubieux et al. 2010), a testament to the mastery and technical knowledge of early glassworkers.

Cluster 3 is composed of eight beads – two brown melon beads, one dark shadow blue bead, two dark navy beads, one yellow segmented bead, and two polychrome beads. This group is characterized by significantly lower concentrations of S, Sn, Sb, and Pb, as well as the highest levels of Mn, relative to the other clusters. Varying levels of Mn appear to be the primary colorant for this group.

The brown melon beads ([unprov]-XIII-[2022]-32, -34) may have been colored with MnO_2 as they are the only samples that contain major Mn levels. Ferric oxide (Fe_2O_3) has also been recorded as a brown colorant (Dong, Li, and Liu 2015), but the volatility of Fe due to surface weathering precludes a positive determination.

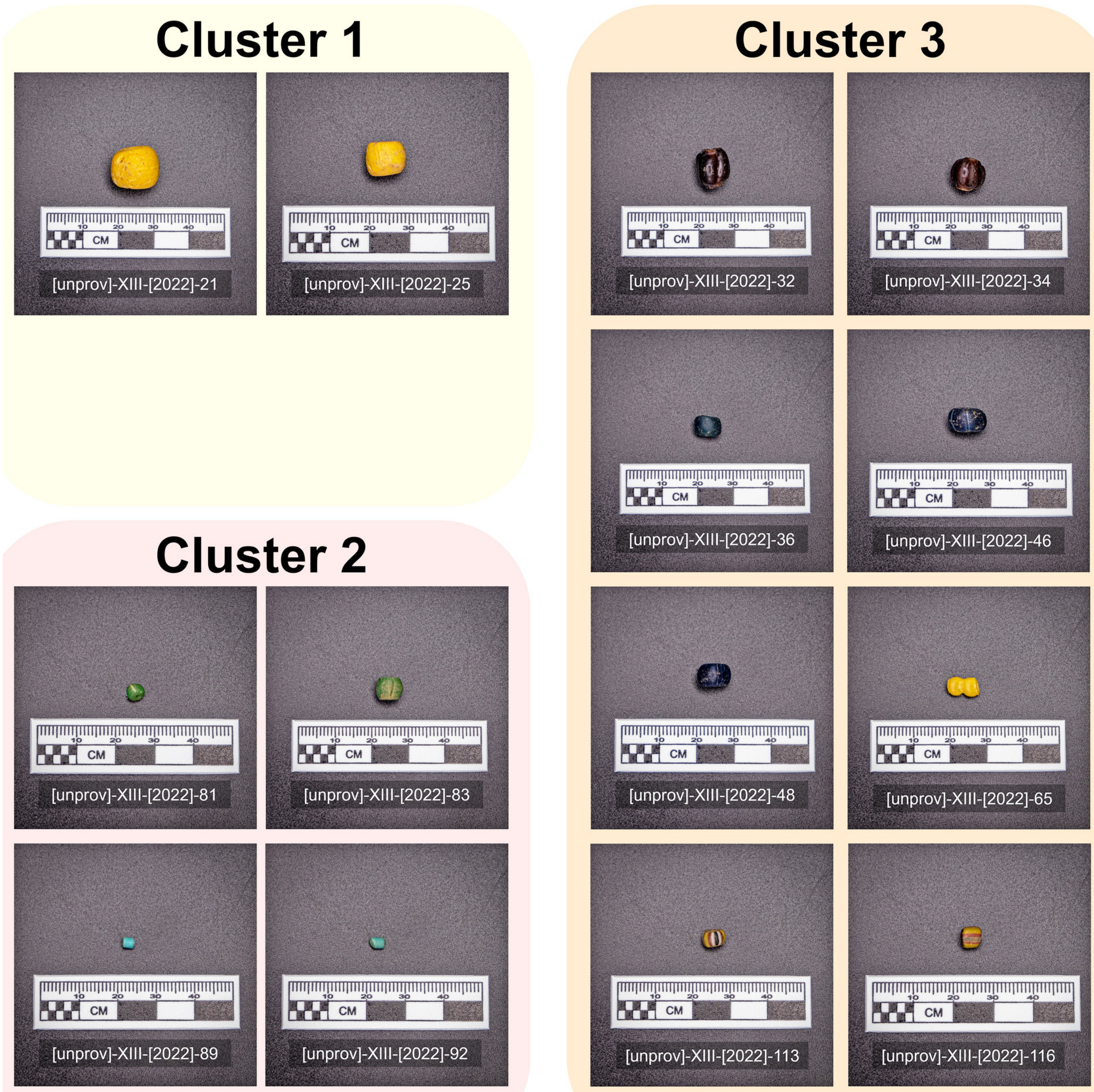

Figure 11. Summary of cluster analysis of glass beads from the Agusan River Valley.

The dark shadow blue and dark navy beads ([unprov]-XIII-[2022]-36, -46, -48) contain trace amounts of Co alongside minor Mn concentrations. These suggest a second type of blue colorant: a manganese-containing cobalt ore. Ono et al. (2018) note a Chinese origin for cobalt ores with manganese – as opposed to zinc-bearing cobalt ores (Dussubieux 2009) – which have been used as a blue colorant for potash glass. The dark shadow blue bead also contains relatively higher levels of S, Pb, and Sn, which could suggest another additive.

Though visually similar to the Cluster 1 beads, the yellow segmented bead ([unprov]-XIII-[2022]-65) was grouped in Cluster 3 due to its relatively higher Mn and lower S, Sn, Sb, and Pb levels. As content was also lower. Variations in the levels of As and Sn among the Cluster 1 samples and this segmented bead may be the contributing factor in the difference in grouping. Still, its S, Sn, and Pb concentrations are higher than the other samples in Cluster 3.

The final two beads in Cluster 3 ([unprov]-XIII-[2022]-113, -116) are polychrome with multi-colored longitudinal stripes. The base color of 113 is yellow and the glass contains slightly higher concentrations of As, Pb, and Sn compared to the other bead which has a brown body. Both contain minor amounts of Cu and Zn nearly comparable to Cluster 2 beads.

DISCUSSION

The Agusan River Valley bead assemblage is composed of 34 bead types: three stone, thirty glass, and one metal. Predominant among these are opaque yellow glass doughnut beads. Lamb (1965:113) notes that "color is an important factor in our understanding of the significance of beads." The preference for certain colors may reflect a community's values – whether these are sartorial, mercantile, or societal in nature. It is thus possible to surmise that the high percentage of yellow glass beads in this assemblage could reflect a preference for this color.

A similar preference can be seen in Localities 1 and 4 at the Napa Property Site in Catanauan, Quezon (1st-2nd centuries). At both sites, opaque yellow glass beads predominate. They accompany primary adult jar burials and occur with other prestige goods such as a shell disc pendant, metal implements, obsidian, and a deer antler pendant (Basilia 2015; Luga 2013). Whether this preference is widespread throughout early Philippine communities cannot be determined at this time.

The consistent occurrence of worked and unworked gold items in Butuan and other northeastern Mindanao sites (Bolunia 2017; Burton 1977; Gamas 2020), along with the posited precolonial gold-working tradition in that region (Estrella 2016; Ronquillo 1987a), provide evidence for the importance of gold in these communities. The predominance of yellow glass beads may have been influenced by the locals' predisposition towards this precious metal.

The substitution of one material for another in ornaments is well-documented in the literature. Basilia (2011) posits that agate, carnelian, and glass beads may have inspired the application of red and yellow colorants to micro-perforated cut-shell beads. During the Ming dynasty in China, glass was used to imitate jade and white jade, which were considered valuable materials that could only be used by palace officials and the nobility (Kwan 2013).

It is possible that the yellow beads were collected from many sites and that their predominance in this assemblage is misleading. To this end, a comparative statistical analysis of glass beads recovered from other sites within the Agusan River Valley and the rest of the region will elucidate this premise.

Preliminary compositional analysis using a pXRF spectrometer on a select number of stone and glass beads revealed interesting insights into their origin and manufacture. The four stone beads do not correspond to Carter and Dussubieux's (2016) compositional data set of potential raw material sources in India, Iran, and Thailand. In particular, the Ba level of the Agusan River Valley samples is greater than those recorded in agate and carnelian beads from Cambodia and Thailand. This could indicate a different geologic source.

The available data sets for stone beads and their geologic deposits are sparse compared to similar studies on glass materials. Investigations and identifications of outcrops and quarries with evidence of historical exploitation would be helpful in determining the extent and intensity of exchange networks for semi-precious stone beads and ornaments in the precolonial period.

For the glass beads, three compositional clusters were identified based on their coloring agents. The clusters match the colorants of beads from other sites in East and Southeast Asia, including China (Steger et al. 2019), Japan (Luo et al. 2016; Ono et al. 2018), Indonesia (Dussubieux 2009; Ono et al. 2018), Malaysia (Dussubieux and Allen 2014; Ramli et al. 2017), Singapore (Dussubieux 2010), and two shipwrecks in the Philippines (Craig and Dussubieux 2022). Most of these sites fall within the presumed chronological range for the Agusan River Valley bead assemblage (10th-16th centuries) and thus illustrate the extent and intensity of the Valley communities' participation in the maritime exchange networks during this period.

There are two exceptions, however. Alacranite and orpiment as yellow colorants were detected in Japanese woodblock prints and Chinese reverse glass paintings dated between 1615 and the early 20th century (Luo et al. 2016; Steger et al. 2019). These dates are *younger* than the presumed range for the assemblage, but orpiment has long been in use in China, where it was part of the traditional painting palette and existed in large geological deposits (Gliozzo and Burgio 2022; Steger et al. 2019). As such, its use as a coloring agent appears to have long been in practice.

On the other hand, the Aru Manara site in Northern Maluku, Indonesia, presents an *older* assemblage. Blue potash-glass beads colored with manganese-bearing cobalt ores – a potentially similar colorant as in the Cluster 2 blue beads – was excavated from layers dated to 150-50 BC (Ono et al. 2018). Beads of this type were imported to Japan during the Yayoi Period (550 BC-AD 150), but their distribution waned during the Kofun period which began in AD 250 (Ono et al. 2018). These dates are significantly older than the presumed range for the assemblage and contemporaneous with the Early to Developed Philippine Metal Ages.

There are three possibilities: 1) blue potash-glass beads were still being traded to the Philippines during the Age of Contacts and Trade, 2) they represent an heirloom bead tradition (Francis 2002), or 3) were recovered from older contexts. Bolunia (2017) noted the absence of an archaeological site linking Agusan del Sur's Neolithic and Age of Contacts and Trade periods. Additionally, one of the Tabon Cave beads mentioned in Lankton, Dussubieux, and Gratuze (2006) is a dark blue potash-glass bead dated to the 1st-3rd centuries BC.

Unfortunately, the uncertain provenience of the Agusan River Valley bead assemblage prohibits a conclusive determination on these early dates. Nonetheless, the current evidence strongly suggests a connection between sites in the Agusan River Valley, Island Southeast Asia, and East Asia during the 10th-16th centuries.

CONCLUSION

Multiple levels of analysis were employed to elicit a range of useful data from the Agusan River Valley bead assemblage, a set of glass, metal, and stone beads donated by a pothunter to the ARVAHRP. Descriptive and typological analyses, following the template of Santiago (2003) and Cayron (2006), were used to identify a preference for opaque yellow doughnut-shaped beads. The consistent occurrence of worked and unworked gold materials at Agusan River Valley sites could have influenced this preference, with yellow-colored glass mimicking the appearance of gold ornaments.

The results of preliminary compositional analysis using a pXRF spectrometer suggest the participation of precolonial communities in the Agusan River Valley within a wider exchange network in Island Southeast Asia and East Asia. The selected glass beads share compositional similarities with glass samples from Indonesia (Dussubieux 2009; Ono et al. 2018), Malaysia (Dussubieux and Allen 2014; Ramli et al. 2017), and Singapore (Dussubieux 2010). The results for agate/carnelian and quartz beads are inconclusive, as they do not correspond to the published data set (Carter and Dussubieux 2016). More research is needed in this area.

A more robust and precise characterization method is needed to confirm the above suggestions, but these preliminary results are promising. "Orphaned" collections, like the Agusan River Valley bead assemblage, can be incorporated into the official archaeological corpus, albeit at a limited and preliminary level.

More research is needed to fully appreciate the significance of different bead types in precolonial communities in the Agusan River Valley, as well as the extent and intensity of bead exchange in the region. The possibility of a bead reworking – if not beadmaking – site in the region warrants a second look, particularly since compositional analysis can identify the chemical signatures of raw materials for glassmaking.

The expansion and updating of Fox and Santiago's (1985) Bead Type Collection is also needed, such as the inclusion of precise compositional data for each illustrated bead. The resulting comprehensive record will be useful in building a better chronology for Philippine beads (Cayron 2006). It may also reveal significant differences in bead preferences and utilization on a site-by-site basis (Lamb 1965), which shall ultimately be helpful in piecing together the Philippine archaeological record.

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