The Elemental Analysis of Glass Beads

Walder, Heather, Dussubieux, Laure

Published by Leuven University Press

Walder, Heather and Laure Dussubieux.

For additional information about this book
https://muse.jhu.edu/book/103372

For content related to this chapter
https://muse.jhu.edu/related_content?type=book&id=3271389
Chapter 11

Inland from the sea: Rethinking the value of mineral soda alumina drawn glass beads from medieval North India

Mudit Trivedi\(^1\) and Laure Dussubieux\(^2\)

1. Introduction

Small drawn glass beads, specifically those previously termed ‘Trade-wind’ or ‘Indo-Pacific’ beads, have long been the lingua franca of Indian Ocean archaeological networks. As mass-produced, lightweight, readily transported items, they have been understood as the premier premodern commodity. Researchers have focused upon their distribution networks attempting to disentangle the patterns of their exchange and their social significance across different contexts of their production and consumption (Van der Sleen 1956; Francis 1990, 2002). Over the last two decades, elemental analysis, especially the use of trace element concentrations, has been critical to advances in their study.

Indian Ocean drawn glass bead assemblages in most regions include artifacts fashioned from a range of glasses including potash, plant ash and mineral soda-high alumina South Asian glass (Dussubieux et al. 2010; Lankton and Dussubieux 2008; Lankton et al. 2006; Carter 2016; Wood 2016). This compositional diversity has significantly circumscribed the presumed centrality of Indian craftsmen in the histories of the origin and diffusion of this technique. Instead, it is clear that in every phase of the Indian Ocean trade, drawn glass beads produced in South Asia entered into complex bead markets and found their way into assemblages where they were one kind of bead used amongst many others.

The greatest advance in the study of these networks and the role of beads made in South Asia has come through using trace element chemistry to establish definite compositional groups within each of these glass recipes. These compositional groups are understood as spatially and temporally discrete instances of these recipes, differentiated by structured variation in trace elements and major oxides related to flux and silica source. In the case of South Asian mineral soda-high

\(^1\) Stanford University, USA
\(^2\) Field Museum, Chicago, USA
alumina (m-Na-Al) glass, this approach led to the delineation of five major compositional groups (Dussubieux et al. 2010; Dussubieux and Wood 2021, see Annex B). Distinct in terms of their hypothesized area of origin within South Asia, and in terms of their patterned phases of exchange to sites in mainland and island South-East Asia, Eastern and Southern Africa and beyond, the m-Na-Al compositional groups have parsed the Indian Ocean South Asian bead trade into determinate patterns between regions.

Yet, the specific patterns of the production of these drawn glass beads within South Asia are poorly understood, especially for the period after the 5th century CE, ironically exactly when we know most about the export trade. The dearth of glass bead assemblage quantification, seriation and single-locus excavations within South Asia means we know little about the shifting geography of craft centers, communities of practice, their distinctive repertoires, and the specific innovations and developments in drawn glass bead technologies across the South Asian early medieval (600-1200 CE) and medieval periods (1200-1700 CE).

This paper presents the first analysis of a major second millennium CE glass assemblage, from Indor, Northern India. Of 6000 glass artifacts comprising bangles, beads, vessels, and glass processing debris, 218 samples were analyzed (see Table 11.1). The Indor results have significantly advanced our understanding of South Asian and m-Na-Al glass, providing evidence of 6 hitherto undetected new compositional groups of m-Na-Al glass, designated groups 7 through 12. A discussion of the significance, distinctive chemistry and insights into shifting patterns of glass supply and use at Indor is forthcoming in Trivedi and Dussubieux (in preparation).

<table>
<thead>
<tr>
<th>Artifact type</th>
<th>Number of artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass beads</td>
<td>211</td>
</tr>
<tr>
<td>Glass bangles</td>
<td>3960</td>
</tr>
<tr>
<td>Vessel fragments</td>
<td>637+</td>
</tr>
<tr>
<td>Fragments of Glass Processing debris (various types)</td>
<td>~475</td>
</tr>
</tbody>
</table>

Table 11.1: Vitreous artifact counts from the Indor Project

From this wider analysis, this paper contributes to this volume by focusing upon the 12 drawn beads that were sampled from Indor. It reveals hitherto unprecedented variation in drawn beads by compositional group. Through this first case-study of medieval South Asian drawn glass beads, this paper presents arguments about the complexities of drawn glass bead production and exchange within medieval
South Asia. It contrasts the evidence at hand for the long-distance trade of such beads within and beyond South Asia. From this it reflects on the opportunities such situated studies provide for understanding the use and rethinking the value of these distinctive beads. To do so, it comparatively situates the Indor drawn beads within m-Na-Al datasets and builds arguments, bringing together observations from their morphometric specificities, colorant chemistry and patterned forms of bead-use.

2. Drawn bead exchange networks and mineral soda alumina glass

Drawn glass beads in South Asia have attracted three kinds of scholarly attention: 1) syntheses of archaeological finds and comments on their distributions (Abraham 2016, 2013), 2) ethnoarchaeological study of one of the last surviving centers of drawn bead production at Papanaidupet (Stern 1987; Francis 1990, 2002; Kanungo 2016) and 3) elemental analyses of selected beads (Brill 1987, 1999; Varshneya et al. 1988; Basa 1994). As discussed above, in the past two decades the third approach has provided the most robust means of historicizing the production, exchange and use of these beads in the region.

Annex B provides an analytical summary of m-Na-Al compositional groups and an account of the distributions of groups 1 through 4 and 6 in detail. Here, three aspects are stressed. First, the analyses in this volume from Indor, Nepal, Kish and Mayotte (Aldenderfer and Dussubieux, this volume; Larson and Dussubieux, this volume; Wood et al., this volume) collectively provide evidence for drawn bead production in all of the new groups of m-Na-Al glass (7 through 12). This leads to the question of how we model and understand this heterogeneous nature of m-Na-Al drawn bead production. Earlier interpretations of m-Na-Al compositional groups have been culture-historical, i.e., that particular glass groups relate to specific production regions, bounded time-periods and exchange-networks. This picture was based largely on the analysis of the widely traded drawn beads and not to the same degree on the different social and technical scales at which bangle, wound bead, and later vessel production occurred in South Asian societies. The emerging picture of m-Na-Al glass now suggests the temporal, spatial and social overlap of compositional groups, suggesting complex networks of raw glass exchange between distinct communities of practice, taste and consumption (Trivedi 2020; Trivedi and Dussubieux, in preparation). In this context, this chapter provides the first analysis of drawn beads within South Asia in the period when their trade to destinations outside South Asia was at its peak.

Accumulating research has detailed how Group 1 glasses, known to originate from South India and Sri Lanka, and which circulated in the Bay of Bengal in the
Early historic period (400 BCE to 500 CE) were also traded much further and produced into later periods. Group 1 drawn beads, c. 500-700 CE were exchanged across long distances to sites in Zanzibar, Quseir al Qadim and Merovingian Europe (Pion and Gratuz 2016; Then-Obluska and Dussubieux 2016; Wood et al. 2017). As reported in this volume, new evidence suggests that Group 1 beads also circulated in small numbers in the Middle East and the Levant, identified at the site of Kish in Iraq and Quseir, Egypt (Dussubieux, this volume; Then-Obluska and Dussubieux 2016). Group 3 is understood to be Early historic and associated with the site of Kopia and the Ganga plains. Group 3 drawn bead circulation is less well understood but also appears to have been centered on the Bay of Bengal, and Group 3 beads have been prominently recovered at Khao Sam Kaeo and other sites on the Siamo-Malay peninsula (Dussubieux et al. 2010; Dussubieux and Kanungo 2013; Dussubieux and Bellina 2017).

In contrast, m-Na-Al Groups 2 and 4 provide concrete evidence for second millennium CE trade networks. Group 2 was hypothesized to be related to the western Indian site of Chaul, or its immediate region, and was widely traded to the Swahili coast as well as to Island South East Asia (Dussubieux et al. 2009, 2010; Dussubieux and Wood 2021) m-Na-Al Group 4 beads have been recovered in Southeast Asian glass assemblages and rarely in Swahili contexts (Carter and Beavan 2014; Carter et al. 2016, 2019). Forthcoming analysis from the Swahili coast, where both groups 2 and 4 had already been extensively documented, has revealed the existence of a previously unknown, m-Na-Al Group 6 (Dussubieux and Wood 2021).

In contrast, we have little evidence from South Asia for the second millennium CE. Groups 2 and 4 are both poorly understood in terms of their area of origin, raw glass trading networks (if any), artifact repertoires and geographies of production and use within South Asia. As a first data point on the early medieval period, Aldenderfer and Dussubieux (this volume) report Group 6 beads from early medieval (6th-7th centuries CE) Nepal. It is evident that there is extensive, regionally diverse drawn and wound glass bead production across the early medieval and medieval periods of South Asian history, with a geography likely distinct from that in prior epochs. The accumulated published data, despite its limits, allows for the recognition of discernable shifts in the distributions of glass beads over these periods. Kanungo’s synthesis of the early medieval and medieval data indicates a clear concentration in North India, in the Yamuna plains and hills near Delhi, a region from which glass assemblages have hitherto been neither systematically described nor analyzed (Kanungo 2014:177-178). This article presents analysis of a small sample from one such site.
3. **Indor: Historical and archaeological context**

The valley of Indor is located a short distance south-west of Delhi in the region of Mewat in North India (Figure 11.1). Mewat is unique in North Indian medieval history, stereotyped as an enduring site of rebellion and intransigence towards the empires based at the capital cities successively raised at Delhi. In this context, the fortified city of Indor was built in the region of Mewat in the 14th century CE. Since 2015, Trivedi has directed, in collaboration with the Rajasthan Department of Archaeology and Museums, an archaeological survey and excavation project centered upon the valley and medieval city of Indor.

![Fig. 11.1: Indor amongst major m-Na-Al drawn bead sites.](image)

A 20 Ha fort, a monumental graveyard, and a series of occupied mounds in the valley comprise the hinterland of Indor, where a phase of urbanization is closely associated with the conversion of the lineage of the Khanzada of Mewat to Islam. Trivedi's research has established a settlement-history of the Indor valley over the last 1000 years, detailing successive phases of rapid urbanization and increase in settlement followed by fission and ruralization alongside later episodes of urban renewal. The wider survey has yielded vestiges of agrarian and military
infrastructures and traces of a range of craft-production activity, especially associated with the foundation of the city of Indor and Khanzada efforts at forging a regional polity in the 15th century. This includes clear evidence for extensive use and production of glass ornaments, especially bangles. Targeted excavations on the Lower Town A mound (Site IAS002) at Indor have allowed for the detailed seriation of medieval assemblages based on 36 radiocarbon dates. The excavated sample ranges between CE 1350-1960 and provides the first detailed window into medieval glass assemblages in North India excavated under controlled single-locus methods (Trivedi and RDAM 2015, 2016a, 2016b; Trivedi 2020). The Unit A excavated assemblage is divided into two phases here. Phase 1, CE 1350-1500, is a period of urban growth linked to the foundation of the Fort, when the Khanzada strive for ascendancy over Mewat, during which despite repeated sieges, the city of Indor flourished. Phase 2, CE 1500-1800, is a mixed period, moving between urban disrepair, incorporation into the Mughal empire and by the 18th century a new kind of urban formation (see Trivedi 2021 for an extended discussion).

The earliest occupation identified at Indor, dated to the 12th/13th century CE, included probable faience beads recovered as associated surface finds. Glass, including beads, is subsequently present from c. 1350 onwards and is available from every cultural phase at Indor after the conversion of the Khanzada and the construction of the city. Glass vessels and glass beads are less common than bangles at Indor. Table 11.1 above provides counts for different classes of vitreous finds from the Indor survey and excavations. Samples from each of these artifact categories (drawn and wound beads, blown glass vessels, glass bangles, glass working debris and crucible fragments) were selected for elemental analysis conducted at the Elemental Analysis Facility, Field Museum in 2019 (for protocols see Annex A). The results have yielded significant insights into cultural changes in medieval glass assemblages, shifts between recipes, and the growing intimacy of glass-working at North Indian small towns like Indor from the 15th through 18th centuries (Trivedi 2020; Trivedi and Dussubieux, in preparation).

3.1. The Indor glass bead assemblage

The Indor glass bead assemblage comprises 211 beads of which 152 were recovered from the controlled and targeted Unit A excavations on the Lower Town A Mound (Excavation details in Trivedi and RDAM 2016b). The remainder were recovered from surface collections made within the Fort of Indor and at other sites documented in the Indor Valley.
Drawn beads (n=146) dominate the glass bead assemblage, comprising 92% of the total. A small but valuable corpus of molded (n=6) and wound (n=10) beads were also recovered but are not discussed here. Of the 146 drawn glass beads excavated at Indor, all but four can be securely phased to the two periods outlined above.

**Fig. 11.2:** Colors of drawn beads at Indor by phase.
Of these 142 beads, more than half date to the 15th century occupation. A few clear trends are apparent at the assemblage level. 62% of all drawn beads are black, a noteworthy trend, and in both periods, black beads are at least 40% of the assemblage. The next most common colors are a range of greens, in greater proportion after 1500. Blues occur in small but regular quantities; cobalt blue is readily distinguished from a lighter hue. Markedly, yellows (n=7) and reds (n=3) are particularly rare (Figure 11.2). These trends contrast sharply with the varying relative abundance of mineral soda alumina bead assemblages especially as traded to the East African coast. Comparable medieval South Asian drawn glass bead assemblages have not been published fully nor quantified.

Most of the Indor drawn glass beads are oblates or irregular cylinders, resulting from their bulk rounding by documented reheating and polishing processes (Kanungo 2016). Barrel shaped beads consistently occur at a low frequency, seemingly restricted to black and yellow glass. White and colorless beads are infrequent finds. Tubular drawn beads are very rare at Indor and only two were recovered.

These distinctive patterns of shape and color indicate a clear preference for black, green and blue annular, often irregular beads. They present the first trends of the exchange, use and consumption of drawn beads in medieval South Asia. We can expect these patterns to look very different for another site in North India with differences likely to be evidenced even at Indor in future excavation units in other elite neighborhoods. From this assemblage, 12 drawn glass beads were selected judgmentally (Table 11.2, Figure S11.1) to include samples from across stratigraphic and chronological divisions and distinct colors.
Rethinking the value of mineral soda alumina drawn glass beads from medieval North India

<table>
<thead>
<tr>
<th>S. no</th>
<th>Sample name</th>
<th>Color</th>
<th>Diaphaneity</th>
<th>Period</th>
<th>Size</th>
<th>Shape</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GD001</td>
<td>Green</td>
<td>Translucent</td>
<td>1350-1500</td>
<td>very small</td>
<td>oblate</td>
<td>m-Na-Al-4</td>
</tr>
<tr>
<td>2</td>
<td>GD002</td>
<td>Blue</td>
<td>Translucent</td>
<td>1350-1500</td>
<td>very small</td>
<td>cylinder</td>
<td>m-Na-Al-4</td>
</tr>
<tr>
<td>3</td>
<td>GD010</td>
<td>Black</td>
<td>Opaque</td>
<td>1350-1500</td>
<td>small</td>
<td>barrel</td>
<td>m-Na-Al-10</td>
</tr>
<tr>
<td>4</td>
<td>GD015</td>
<td>Red</td>
<td>Opaque</td>
<td>1350-1500</td>
<td>small</td>
<td>barrel</td>
<td>m-Na-Al-4</td>
</tr>
<tr>
<td>5</td>
<td>GD031</td>
<td>Blue</td>
<td>Translucent</td>
<td>1350-1500</td>
<td>very small</td>
<td>broken cylinder</td>
<td>m-Na-Al-4</td>
</tr>
<tr>
<td>6</td>
<td>GD076</td>
<td>White</td>
<td>Translucent, Opaque</td>
<td>1350-1500</td>
<td>small</td>
<td>oblate</td>
<td>m-Na-Al-4</td>
</tr>
<tr>
<td>7</td>
<td>GD077</td>
<td>Yellow</td>
<td>Opaque</td>
<td>1350-1500</td>
<td>small</td>
<td>lenticular</td>
<td>m-Na-Al-2</td>
</tr>
<tr>
<td>8</td>
<td>GD84</td>
<td>Black</td>
<td>Opaque</td>
<td>1350-1500</td>
<td>medium</td>
<td>barrel</td>
<td>m-Na-Al-7</td>
</tr>
<tr>
<td>9</td>
<td>GD118</td>
<td>Colorless</td>
<td>Translucent</td>
<td>1500-1800</td>
<td>small</td>
<td>oblate</td>
<td>m-Na-Al-8</td>
</tr>
<tr>
<td>10</td>
<td>GD144</td>
<td>Green</td>
<td>Translucent</td>
<td>1500-1800</td>
<td>medium</td>
<td>oblate</td>
<td>m-Na-Al-3</td>
</tr>
<tr>
<td>11</td>
<td>GD146</td>
<td>Blue</td>
<td>Translucent</td>
<td>1500-1800</td>
<td>small</td>
<td>cylinder</td>
<td>m-Na-Al-4*</td>
</tr>
<tr>
<td>12a</td>
<td>GD165Gr</td>
<td>Green</td>
<td>Translucent</td>
<td>1350-1500</td>
<td>large</td>
<td>tube</td>
<td>m-Na-Al-9</td>
</tr>
<tr>
<td>12b</td>
<td>GD165Y</td>
<td>Yellow</td>
<td>Opaque</td>
<td>1350-1500</td>
<td>large</td>
<td>tube</td>
<td>m-Na-Al-9</td>
</tr>
</tbody>
</table>

Table 11.2: Description of analyzed drawn beads (GD146 is discussed below).

4. Results

The beads were analyzed at the EAF in 2019 (see Annex A for more details about instrumentation and protocol). All 12 drawn glass beads sampled from Indor are m-Na-Al glasses. However, in contrast to all prior studied assemblages of drawn glass beads in South Asia, and m-Na-Al drawn glass beads traded outside South Asia, this small sample of 12 drawn glass beads was unprecedentedly heterogeneous. Figure 11.3 presents a graphical summary of the 3D-Principal Component Analysis (PCA) used to classify m-Na-Al beads (as defined in Dussubieux et al. 2010; Trivedi and Dussubieux, in preparation, Annex B). The 12 Indor glass beads were classified to 7 different groups of m-Na-Al glass, namely Groups 2, 3, 4 and 7 through 10. These definite trends of compositional variation are summarized period-wise in Table 11.3. Group 6 drawn beads are notably absent, but bangles of these glasses do occur at Indor (Trivedi and Dussubieux, in preparation). The results are discussed in terms of the shift between periods, and the morphology and typology of the beads and the colorant chemistry.
4.1. Compositional diversity and shift in m-Na-Al groups between periods

From Indor’s Phase 1, 1350-1500 CE, 9 drawn beads were sampled. Of these 5 are m-Na-Al group 4 and the other are single examples from Groups 2, 7, 9 and 10. Both the preponderance of Group 4 and the heterogeneity are notable in the context of the color preference towards black that structures the Indor drawn bead assemblage. Group 4 appears to contribute a range of colors (green, blue-green, white, cobalt blue and red) but black beads sampled were produced from Groups 7 and 10 glasses.

The evidence from Phase 2, CE 1500-1800 CE, indicates a shift with Group 3, 4 and 8 compositions, yet the small sample (n=3) precludes any generalization. These three beads are also distinguished by their rich and distinct colors in the Indor assemblage in bright green, colorless, and cobalt blue glass. These three groups are strongly associated in their trace and REE compositions and possibly
indicate different North India glass production signatures (Trivedi and Dussubieux, in preparation).

<table>
<thead>
<tr>
<th></th>
<th>1350-1500</th>
<th>1500-1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outlier to 4</td>
<td></td>
<td>1*</td>
</tr>
</tbody>
</table>

Table 11.3: Group-wise summary of Indor results by m-Na-Al group. (Greens indicate preponderance, gray shading conspicuous absence)

A note is needed on the Group 3 bead, as m-Na-Al Group 3 glasses have hitherto been understood as limited to the period c. 400 BCE to CE 500. The wider Indor analysis has demonstrated that Group 3 glasses continue into the second millennium CE. Trivedi and Dussubieux (in preparation) demonstrate that trace element trends appear to separate chronologically distinct eras of production within the PCA group. Group 4 and 8 are similar in composition, but Group 8 has consistently higher uranium levels. The sole Group 4 bead from Phase 2 (GD146) bears anomalously high uranium for Group 4 glasses, and this is discussed further below.

Within the limits of the sample size, it appears that Indor’s Phase 1 witnessed bead supply from a wide range of producers working different m-Na-Al glasses beyond Group 4. As discussed below, this supply appears to be structured by color and intended use. Two provisional trends may be hazarded about Phase 2 from the small sample analyzed: (a) networks supplying beads to Indor may have contracted, a hypothesis we will test in further analysis and (b) shifts in use and preference are indicated in changed techniques and goals of bead color production.

4.2. Bead morphology and typology

The Group 4 beads from Phase 1 present a range of morphological characteristics providing insights into their production and likely patterns of use. GD001, a dull green bead, is distinguished by its irregular annular shape, indicative of indifferent bulk reheating at the polishing stage (see Figure S11.1). GD002 bears striations of lighter and darker aqua shades, likely indicative of a melt where colorant was not completely homogeneously mixed in. GD015, an opaque red barrel-shaped
bead, bears the distinctive darker colored striations, a known artifact of the drawing process. GD031 is a small dark (cobalt) blue barrel-shaped bead that was irregularly cut and then heat-treated, and used despite its markedly irregular shape. GD076, a rare white bead, was also heat rounded to an irregular shape. Across all colors, the morphological evidence suggests that Group 4 bead producers operated on a mass scale of production, and their products were likely incorporated into a range of beaded products where individual symmetry and appearance were not of concern.

In contrast, the sole Group 2 bead, GD77, a modified lenticular disc, displays prominent flat sides, possible signs of having been segmented with a tool, a trend evidenced in published Group 2 examples (Dussubieux et al. 2008). GD010 (Group 10) and GD084 (Group 7) are visually similar shaped black barrel beads notably produced from distinct m-Na-Al glasses. The three richly colored beads analyzed from the Phase 2 are also broadly more symmetrical. Bead roundness and asymmetry have been recorded to understand production processes and organize bead-series (Francis 1990; Wood 2016). These observations suggest that bead morphology may also indicate patterned forms of use: asymmetrical types were likely produced for incorporation into a range of beaded fabrics, clothes, and furnishings with more carefully finished specimens, and shapes like barrels were likely intended for other uses, where they would be more visible, in personal ornaments such as necklaces, or as beaded into higher-value fabrics.

GD165 is a distinctive bicolor drawn tubular bead. It is one amongst a series of types known to combine a yellow core over which a green or blue exterior is drawn. These types have a long history in South Asian assemblages. Similar in color, but not always also in form, these beads have been recovered from Early Historic through Medieval periods from sites in the Deccan (Nevasa, Navdatoli and Brahmapuri-Kolhapur where it was known from 15th century contexts). Specimens are also known from Mantai, Sri Lanka, and the type was traded to Thailand (Rodcharoen 2014), Sungai Mas, Malaysia (Davison 1972:170-171), and the Philippines (Dussubieux pers. comm.). East African finds include those in Group 6 glasses from Tanzania (Dussubieux and Wood 2021) and Mayotte (Wood et al., this volume). Both of GD165 yellow and green glasses are m-Na-Al Group 9. The uniqueness of GD165 in composition amongst sampled beads and its typological singularity amidst the Indor bead assemblage suggest indices of its value. This result helps provide another chronological and compositional anchor for the type and the cultural preference and value it indexes; the lack of compositional analyses of its cognates from other sites limits what can be asserted about how GD165 relates to this family of beads, and Group 9 glasses to their production.
4.3. Colorant chemistry

While the small sample analyzed precludes generalizations from these 12 beads to the structure of the Indor drawn bead assemblage in terms of m-Na-Al compositional groups, the colorant chemistry of the 12 beads from Indor discussed here allows for key observations about colorant knowledge and techniques in m-Na-Al glass-working traditions.

![Fig. 11.4: Biplots (all scales log) for (a) Group 3 Cu (ppm) by Pb (ppm) and (b) Cu (ppm) by Fe$_2$O$_3$ (wt %). In these two plots circles are Kopia reference data from Dussubieux and Kanungo 2013, all colors represent bead colors, pink is colorless (c) Group 4 Fe$_2$O$_3$ (wt %) by CuO (wt %) (d) Fe$_2$O$_3$ (wt %) by Co (ppm), Reference data from Dussubieux et al. (2010). (e) Group 2 Fe$_2$O$_3$ (wt %) by PbO (wt %). Reference data from Dussubieux et al. (2008) (circles) and Dussubieux (this volume) (diamonds), Indor (square) (f) Fe$_2$O$_3$ (wt %) by CuO+MnO (wt %) for all black glasses analyzed from Indor (data from Trivedi and Dussubieux, in preparation).
Beyond the morphological traits observed above, Group 4 beads are known for a range of variation in both form and composition. In the 15th-17th century CE contexts of the Cardamom Mountain Jar Burials (CMJB) sites in Cambodia, Group 4 irregular oblates have been noted as bearing ‘skewed striations’ (Carter and Beavan 2014; Carter et al. 2016). In addition to this morphological irregularity, variability in Group 4 compositions has been noted: Dussubieux et al. (2008) and Carter et al. (2016) define a high-Mg m-Na-Al glass co-occurring with Group 4 beads. The Indor Group 4 beads do not cluster in this way, instead demonstrating irregular spread away from Group mean in most trace elements, with only GD076 displaying significant difference in major oxide levels with lower lime levels (see Table 11.4).

A shift within Group 4 colorant strategies is evidenced across the wide color spectrum of these beads at Indor. As discussed previously by Dussubieux et al. (2010; 2011), varying levels of iron and copper create desired black, green and red hues. Figures 11.4c and 11.4d indicate how the Group 4 red, green and light blue (GD001,2,15) beads recovered from Indor were produced through the addition of 1% CuO and between 1.7-2.7% Fe₂O₃. In contrast, GD031 and GD146 are high cobalt blues. Figure 11.4d makes clear that these are distinct from known Group 4 cobalt blues by an order of magnitude in Co concentrations (respectively 1394 and 2116 ppm). Such high levels of cobalt are striking, suggesting a deliberate shift towards ensuring richly colored blues. A further observation is necessary: Table 11.4 indicates GD146 and GD031 are themselves differentiated on account of GD146’s anomalous U levels (304 ppm). This uranium elevation may result from the use of cobalt derived from a cobaltite-ore co-mineralized with uranium, as is known in regions adjacent to Indor (Baidya 2018; Singh 2012). Alternatively, as discussed at length in Trivedi and Dussubieux (in preparation) this may be a result of distinct South Asian silica sources with very high uranium. The latter trend distinguishes Indor Group 8 from Group 4 glasses. For these reasons GD146 is labeled here as an outlier to Group 4.
Rethinking the value of mineral soda alumina drawn glass beads from medieval North India

Table 11.4: Colorant corrected compositional data for the major oxides (wt%) and the trace elements (ppm) used in the PCA for discriminating between m-Na-Al groups.

<table>
<thead>
<tr>
<th>Sample name</th>
<th>GD001</th>
<th>GD002</th>
<th>GD010</th>
<th>GD015</th>
<th>GD031</th>
<th>GD076</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SiO$_2$cc</td>
<td>61.32</td>
<td>62.05</td>
<td>59.82</td>
<td>59.46</td>
<td>62.03</td>
<td>65.47</td>
</tr>
<tr>
<td>Na$_2$Occ</td>
<td>20.76</td>
<td>22.09</td>
<td>20.74</td>
<td>20.35</td>
<td>22.04</td>
<td>18.58</td>
</tr>
<tr>
<td>MgOcc</td>
<td>1.26</td>
<td>1.10</td>
<td>1.25</td>
<td>1.76</td>
<td>1.00</td>
<td>0.95</td>
</tr>
<tr>
<td>Al$_2$O$_3$cc</td>
<td>9.29</td>
<td>8.00</td>
<td>10.00</td>
<td>10.05</td>
<td>8.24</td>
<td>8.44</td>
</tr>
<tr>
<td>K$_2$Occ</td>
<td>3.64</td>
<td>3.63</td>
<td>3.51</td>
<td>3.72</td>
<td>3.22</td>
<td>3.92</td>
</tr>
<tr>
<td>CaOcc</td>
<td>1.39</td>
<td>1.31</td>
<td>2.20</td>
<td>1.90</td>
<td>1.35</td>
<td>0.75</td>
</tr>
<tr>
<td>Fe$_2$O$_3$cc</td>
<td>2.34</td>
<td>1.81</td>
<td>2.48</td>
<td>2.75</td>
<td>2.12</td>
<td>1.89</td>
</tr>
<tr>
<td>Sr</td>
<td>76.92</td>
<td>65.39</td>
<td>201.25</td>
<td>71.48</td>
<td>73.56</td>
<td>63.88</td>
</tr>
<tr>
<td>Zr</td>
<td>175.96</td>
<td>173.02</td>
<td>142.43</td>
<td>131.49</td>
<td>187.10</td>
<td>74.08</td>
</tr>
<tr>
<td>Cs</td>
<td>5.04</td>
<td>3.97</td>
<td>3.38</td>
<td>6.06</td>
<td>3.74</td>
<td>4.19</td>
</tr>
<tr>
<td>Ba</td>
<td>384.21</td>
<td>350.98</td>
<td>377.21</td>
<td>367.20</td>
<td>295.42</td>
<td>504.68</td>
</tr>
<tr>
<td>U</td>
<td>66.40</td>
<td>50.09</td>
<td>347.69</td>
<td>54.22</td>
<td>56.55</td>
<td>122.80</td>
</tr>
</tbody>
</table>

Analyzed Early Historic Group 3 glasses include an “unusual transparent emerald green” (Dussubieux 2010:1651). This distinctive green glass was produced by modifications that included additions of significant amounts of copper (~2000 ppm) in combination with c. 2% lead (Dussubieux and Kanungo 2013:363). Figures
11.4a and 11.4b indicate that the visually similar GD144 is distant from the other Group 3 glasses not just in time but also colorant modification of base glass. GD 144 has only trace Pb (31 ppm). The ‘emerald’ hue results instead from the highest Cu (>11000 ppm) and Fe$_2$O$_3$ (2.55%) levels known in Group 3 glasses.

The sole Group 2 yellow bead, GD077, was noted above as sharing morphometric characteristics with contemporary Group 2 yellow beads traded outside of South Asia. Figure 11.4e demonstrates that chemically it clusters well with specimens analyzed from Chaul in western India and traded to Eastern Africa (Dussubieux et al. 2008). Interestingly, the two black beads, GD084 (Group 7) and GD010 (Group 10) fit two different compositional groups. Yet, both were colored by the same method involving the addition of only 2 to 2.5% Fe$_2$O$_3$ without any copper or manganese, which are other common additions involved in producing black in the Indor glasses (see Figure 11.4f).

5. Discussion

The results presented above demonstrate for the first time a wide range of m-Na-Al glasses concurrently in use and circulation within South Asia. The wider Indor results establish determinate shifts in glass bangle typology and raw glass use (Trivedi 2020; Trivedi and Dussubieux, in preparation) and in the groups used by m-Na-Al blown glass vessel producers. As drawn glass beads in South Asia have not been parsed into typologically or morphologically determinate series as is the case for second millennium East Africa (Wood 2016), within the subcontinent, regional scale geographic differentiation of drawn bead production, circulation and patterns of use is not yet possible.

Despite the limited sample size, the following trends are important: Drawn bead producers accessed a wide range of m-Na-Al glasses. Morphometric patterns in bead-finishing and within-compositional-group modifications of base glass for particular colors (Group 4 cobalt blues and Group 2 yellows) indicate patterns and shifts in production. In some cases, these trends reveal how production shifted towards more symmetrical richly colored beads likely responding to preferences and demands for particular uses. The discussion below considers the implications of the Indor drawn bead compositions in terms of how drawn bead production, exchange and value have been studied posing questions of interest to future studies.

5.1. Drawn bead production in South Asia: beyond the Papanaiidupet model

The wide range of m-Na-Al compositional groups identified in Indor’s drawn beads poses several questions about our models of their production. While Groups 2, 4 and 6 drawn beads appear to index enduring major drawn bead mass-production
centres with evidence for possibly divergent assemblages produced for export, we cannot assert much without further analyses of South Asian assemblages for the new Groups 7, 8, 9 and 10, or even for Group 3 drawn bead production in the second millennium CE.

The ethnoarchaeological observations made by Francis (Francis 1990) at Papanaidupet have led to the notion that the lada-technique based, proto-industrial scale production of drawn beads model underlies archaeological appraisals of all drawn bead production in South Asia. As extensively documented by Kanungo (2016), this model involves an entire small town / village community organized around the processing of beads after they have been drawn at a specially constructed furnace and workshop. Yet, Francis himself also documented much smaller scale production, sans special infrastructure, of drawn tubes and beads from them, skillfully manipulated out of a melt intended for producing many other items (Francis 1982:14). When we consider the evidence of Groups 7 through 10 we might do well to keep in mind other smaller-scale and mixed-modes in which drawn bead production may have been organized.

5.2. Compositional-group heterogeneity, drawn bead makers and m-Na-Al raw glass supply

The morphometric trends distinguishing Group 4 and 2 above likely indicate these come from distinct workshops/ craft-traditions where regular patterns of colorant chemistry, drawn bead processing, and investments in finishing beads appear tied to working a particular compositional group of m-Na-Al glass. Until direct evidence from an excavated workshop is analyzed, it is not possible to further specify whether single workshops were connected to multiple m-Na-Al raw glass producers or largely tied to one compositional group. As suggested above, one way of addressing these issues is by distinguishing who is producing which drawn beads from which m-Na-Al glass. Another is to use the data at hand and comparatively attend to the specific colorant-related modifications effected both within-groups over time and between-groups by artifact type within m-Na-Al glass to historicize and track techniques developed to modify glass to meet changing preferences.

The heterogeneity currently evidenced precludes any easy generalization from the 12 analyzed samples to the drawn bead assemblage (n=146). Yet, the absence of black beads from Group 4, and their contribution to the ‘new’ compositional groups 10 and 7 give pause. In the context of the preference for black and green drawn beads in the Indor assemblage, this may indicate that producers of the new compositional groups, Groups 7 through 12, preferentially supplied raw glass/ beads in colors distinct from known Group 4 and 2 repertoires. These observations,
currently qualitative, are supported by the recovery of black drawn beads in Groups 7 and 10 at both Indor and Mayotte (Wood, this volume) and colorless drawn beads in Group 8 from Indor and at Mayotte in Groups 9 and 11, i.e., not in Groups 2, 4 and 6. As more South Asian bead assemblages are quantified and analyzed, such associations between compositional group, color and method of producing color will need to be tested.

5.3. Inland and overseas: differential networks, different tastes?

The diversity of m-Na-Al compositional groups reported here is mirrored in the new analyses presented in this volume from Kish, Tel Anafa and Mayotte (Dussubieux, this volume; Larson and Dussubieux, this volume; Wood et al., this volume), where beads recovered span previously defined Groups 2 and 6 and newly defined Groups 7, 9, 10 and 11. There is no temporal overlap between these sites and the samples discussed in this paper from well-dated contexts between 1350-1800 CE at Indor. How then are we to understand the longevity of such bead-production in relation to the no doubt historically and socially specific patterns of their exchange and use? As argued here, archeometric and contextual data must be brought together to understand these specificities.

An overlapping complex set of networks has likely existed in every period structuring South Asian bead production and exchange. These networks can be schematized at three broad tiers of operation, joining raw glass supply from primary glass producers to bead-producers (likely mostly distinct), and then finished beads from bead-producers to beaders, and finally both finished beaded items and bulk-strung-beads to the differential Indian Ocean and intra-South Asian exchange networks. Within South Asia, bulk-beads and finished beaded products were likely exchanged across different distances and to distinct destinations, with the bulk-strung beads likely travelling shorter distances to beading communities and the latter more widely to consumers near and far. The archaeological contexts where the beads discussed in this paper were recovered, as part elite assemblages at Indor, suggest the latter trajectory.

At the Indor Unit A excavations, in domestic inter-floor fill contexts, where accumulation was rapid between series of mud-plastered floors, we have slight traces of indexing patterns of use. In one such loci (L34), an entire string of blue oblates likely broke and went to ground where the person stood; 30 drawn beads were recovered from less than 5 litres of sediment. To emphasize the importance of context: these 30 beads constitute 19.7% of the entire excavated assemblage. The adjacent loci, L35, contributed another 9%, n=14 from another such episode. None of these were included in the analyzed sample discussed here, but they resemble Group 4 beads in their morphometric irregularity. Their context and nature of
recovery suggests their use as strands either worn directly or beaded as strands into attire. Other beads, such as the Group 2 yellow GD076, or black barrel beads were usually recovered as solitary finds in particular loci, accidental singular inclusions in the archaeological record, a pattern suggesting their having been beaded singly, or stitched in serial form (not as a strand with only a stop-bead) into attire.

These context-of-recovery observations can be situated within the larger trends structuring the Indor drawn bead assemblage where demand for green and black is stable throughout, and annular beads of these colors are recovered at low frequencies across loci. As provisional hypotheses to be tested, the Indor results suggest that irregular and indifferently shaped beads may have been incorporated into quotidian uses, their value differentiated only by their relative availability in terms of abundance of colors at site – indicated by the rarity of blue overall and the recovery of so many blue beads in one loci (L34). More regularly finished, richly colored beads, and barrels (as opposed to annular) may in contrast have been produced by distinct workshops, answering specific demands for a different class of beads incorporated differently into attire, furnishings and life in ways that lead to different patterns of recovery from the first set. As a hypothesis, a hierarchy that joins bead morphology, use-value, and preference might explain the nature of production across workshops. Do differences of compositional group relate to who was producing which kind and color of drawn bead for which kind of use? Are irregular-shaped, mass-produced, broader-use drawn beads traded more widely and produced in particular m-Na-Al glasses against more symmetrical specially-shaped drawn beads originating from workshops operating at different scales of production, producing goods for targeted uses? Given these provisional hypotheses, it is particularly notable that m-Na-Al drawn beads traded to East Africa demonstrate very different frequencies of yellows, reds, different blues, greens and blacks in contemporary periods of the second millennium CE (Wood 2016) as compared to Indor. Anthropological insights into how preference and taste structure not just demand but production, linking communities of taste to communities of practice, may aid the interpretation of the complexities of m-Na-Al drawn bead production (Stahl 2002).

6. Conclusion: Reconsidering value in the archaeometry of beads

Hitherto, the archeometric evaluation of m-Na-Al bead exchange has been structured by the archaeological concepts of bead series and compositional group. This paper has suggested that attention to context, and residual evidence for patterns of use (elicited through bead morphology, provenience and nature of
recovery) alongside colorant preference and alteration in colorants can indicate ways to situate archaeometric data towards investigating not just exchange, but questions of temporally shifting preferences and socially specific taste. Arguably, from the scale of the loci to drawn bead assemblages compared across oceans, the use of beads structures trends just as significantly as the culture-historical accounts given of successive periods of bead-exchange. Cultural shifts, such as the embrace of Islam, as at Indor, likely shifted bead-preference in profound ways, but this first analysis of second millennium CE beads awaits comparative data from other South Asian contexts for such assessments.

In this context, recent arguments by Wynne-Jones (2020) to reorient the study of Indian Ocean networks away from long-distance exchange to ‘standing still’ are salient. Wynne-Jones exhorts archaeologists to attend less to exchange-value than to the archaeological emergent patterns of use-value in these diverse contexts joined by the networks such as the drawn bead trade. Far inland from the sea and as demonstrated above not unconnected to oceanic exchange, this reorientation of questions applies as much to Indor as to m-Na-Al assemblages outside of South Asia. The analytical challenge is to understand not just how these beads were made and traded, but as much how their value was emergent in their use. Drawn-bead archaeometry and its unique insights have particular contributions to make to this reorientation, especially when archaeometric data are used dialectically, integrated with contextual, morphometric and assemblage-level data.

Acknowledgments

MT thanks the Department of Archaeology and Museums, Government of Rajasthan for their long-term collaboration and support of the Indor Project. The Archaeological Survey of India are thanked for granting permission for the analysis of the samples discussed in this paper. He also thanks the editors of the volume for their detailed review and comments and LD for her guidance and discussion throughout the Indor analysis. The LA-ICP-MS analysis was funded in part by NSF grant BCS 1628026 to the Elemental Analysis Facility.

References


