Analysis and Comparison of Glass Beads from Ban Non Wat and Noen U-Loke. By Alison Carter and James Lankton

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IX ANALYSIS AND COMPARISON OF GLASS BEADS FROM BAN NON WAT AND NOEN U-LOKE

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Glass beads and ornaments are ubiquitous at Iron Age period sites across Southeast Asia and recent research has highlighted the diversity of glass types found in both South and Southeast Asia during this period (e.g. Dussubieux *et al.* 2010; Lankton and Dussubieux 2006; Lankton *et al.* 2008). Chemical compositional analysis can assist in identifying the different types of glass found at a site, which in turn allows archaeologists to understand how trade networks may have been changing over time or how people at particular sites may have been interacting with one another. This process is analogous to identifying geological sources for stone artifacts, although variables such as the possible use of similar glass recipes in multiple locations, as well as the persistence of particular recipes over hundreds of years, can make the identification of glass source areas more complex.

This report presents the results of compositional analysis of glass beads and artifacts from the sites of Ban Non Wat (BNW) and Noen U-Loke (NUL) using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). In this report we will address the different types of glass found at BNW and NUL. We will then explore several research questions. First, how do the glass types at BNW and NUL compare to one another? Second, how do the glass types at each site change over time? Lastly, do the different glass compositional types shed any light on relationships with other sites in Southeast Asia or participation in specific trade networks? The results show that similar types of glass were found at both sites, although in different quantities. They also indicate a change in glass types over time, reflecting changing trade and interaction networks.

EARLY GLASS IN SOUTH AND SOUTHEAST ASIA

Ancient glasses were made from three important components: silica, fluxing agents, and stabilizing agents. The primary component of glass is silica (SiO_2), the source of which was generally sand or quartz pebbles (Henderson 2000). Because silica has a high melting point, fluxing agents were added in order to facilitate the melting process. The two principal fluxing agents were potassium oxide (potash, K_2O) or sodium oxide (soda, Na_2O). These fluxing agents were often derived from plant sources, including such high-soda desert plants as *Salicornia* or *Sasola*; however soda from mineral deposits was also used (Henderson 2000). The magnesia (MgO) levels in a sample are useful for determining if the glass was made using a mineral vs. plant ash flux. Glass made with a mineral alkali flux generally has below 1.5 weight percent (wt%) MgO, while glasses made with a plant ash flux have MgO levels above 1.5 wt% (Sayre and Smith 1961; 1967). The last important component of glass was the stabilizer, which prevented the glass from dissolving in water; the most common stabilizers were lime (calcium oxide, CaO) and alumina (aluminum oxide, Al_2O_3) (Turner 1956). Other elements found in glass include intentionally added opacifiers or colouring agents, such as antimony, tin, cobalt, copper, lead and iron, along with naturally occurring impurities. Glass recipes can vary depending on the different types and amounts of silica, fluxing agents, and stabilizers used.

THE GLASS ARTIFACTS FROM BAN NON WAT

Over 800 glass artifacts, primarily beads, have been identified in seven seasons of excavation at the site of BNW. Glass artifacts were selected for analysis on two separate occasions. The first group of 14 artifacts from the 2005-2006 field season was analyzed in 2008. A second group of 15 glass artifacts from multiple excavation seasons was analyzed in 2010. The samples were selected to represent the range of glass artifacts recovered from the site and several were from burial contexts. Radiocarbon dates from the extensive excavations at this site allow many of these artifacts to be put into an absolute chronology (Table 9:1) (Higham and Higham 2009). The burials and layers at both BNW and NUL represent the entire Iron Age period in the upper Mun Valley. Higham has divided each site into cultural phases and mortuary phases (MP) that roughly correspond to one another (Higham and Higham 2009; Higham and Kijngam 2009; Higham 2011).

The majority of the glass artifacts studied were small, drawn, monochromatic beads called Indo-Pacific beads, the most common bead types found in Southeast Asia (see Francis 1990, 2002). Indo-Pacific beads were made by drawing glass into long, hollow tubes and then cutting them to make individual beads. When viewed closely, these beads often show longitudinal striations from the tube-drawing process. After the beads have been cut, they are often heated to round the edges, and as a result, Indo-Pacific beads can be found in many shapes from tubular to oblate (Francis 2002). In addition to these beads, several other bead types were identified at BNW, including a flattened bicone (20009), two coiled beads (19501 and 24505), earring or bangle fragments (n=9), a fragment of vessel glass (18014), and one other unidentified blue glass fragment (5090). From the group selected, five earring and bangle fragments were too weathered to produce confident results (18066, 19773, 19780, 3073, and 8253). Compositional analysis from the remaining 24 artifacts will be discussed in further detail below.

METHODOLOGY

The glass beads and artifacts were analyzed by Carter in the LA-ICP-MS laboratory at the Field Museum in Chicago, Illinois, managed by Dr. Laure Dussubieux (for additional details on this technique and its performance see Dussubieux *et al.* 2009). LA-ICP-MS is an ideal technique for analyzing archaeological artifacts because it requires no sample preparation and is virtually non-destructive, leaving only a small trace invisible to the naked eye. The equipment used is a Varian ICP-MS connected to a New Wave UP213 laser. LA-ICP-MS is composed of three major components. The first is the laser sampling system. Samples were placed in a quartz chamber with continuous argon gas flow-through and a laser beam measuring 55 microns in diameter was focused on the glass sample. About ten percent of the minute glass particles released are picked up by the argon gas and transported to the second component, an argon plasma torch. The 8000 °C plasma rapidly dissociates the glass particles into constituent ions, and these ions pass through the third major component of the system, a quadrupole mass spectrometer. The quadrupole flight path through the spectrometer separates the ions by mass and charge before they are measured in the ion detector. Detection limits for most elements range from 10 parts per billion (ppb) to 1 part per million (ppm), with an accuracy of 5-10% depending on the elements and their concentrations. A total of 54 elements were recorded in the final results. The analytical protocol and calculation methods used were adapted from Gratuze (1999).

RESULTS AND DISCUSSION

Full chemical compositional results for all samples are presented in Appendix 1, with major and minor elements reported as weight percent (wt%) for oxides, and trace elements as parts per million. In the current study, seven different glass types were identified. We first consider the glass artifacts from BNW and then continue with the glass artifacts from NUL. Lastly, questions raised in the introduction are addressed.

Potash glass

Four artifacts were identified as being made from potash glass. Potash glass is fairly common in Southeast Asia, as potash glass artifacts in the form of rings, earrings, bangles, and beads have been found at multiple sites across the region. Although no primary production sites for potash glass have been identified, the presence of at least three different sub-types suggests that multiple manufacturing centres were involved (Lankton and Dussubieux 2006). The three sub-types vary in the amounts of CaO and Al_2O_3, and include: potash glass with moderate amounts of CaO and Al_2O_3 (m-K-Ca-Al), potash glass with low calcium oxide (m-K-Al), and potash glass with low alumina (m-Ka-Ca).

All potash glass artifacts from BNW were classified as belonging to the m-K-Ca-Al potash sub-group; they included three earring fragments (17673, 17671, and 19013) and one unidentified fragment of glass (5090). All objects were blue or blue-green in colour. Two of the samples (17673 and 17671) were found in a burial context dated to the Iron Age 1 period (400-200 BC) while the third sample (19013) was dated to the later Late Iron Age period (AD 200-400). The unidentified glass object is from square X, layer 2:10.

Similar glass earring or bangle fragments have been identified at other sites in Cambodia and Thailand. For example, blue glass ring, earring, or bangle fragments made from m-K-Ca-Al glass have been found at the sites of Phum Snay and Prohear in Cambodia (Carter, in press). A comparable blue earring fragment was also recorded at the Lopburi province site of Promtin Tai, although the sample was too weathered to determine its composition accurately (Lertcharnrit and Carter 2010). Potash glass beads are also common at the Cambodian sites of Prohear, Village 10.8, and Bit Meas (Carter, in press). No potash glass beads have yet been excavated at BNW, however they have been identified at NUL (discussed further below). It is likely that the five weathered earring and bangle fragments also belong in this category, although their corrosion makes this difficult to confirm.

Although primary glass workshops, where glass was melted from its raw materials, have not been identified, scholars have suggested various locations that may have produced potash glass. For example, the large quantity of potash glass with moderate CaO and Al_2O_3, along with evidence for glassworking, at the site of Arikamedu, India, points toward this location as a possible primary manufacturing centre (Lankton and Dussubieux 2006). Potash glass is also fairly common at the peninsular Thai site of Khao Sam Kaeo, where there is evidence for secondary glassworking in the form of bracelet manufacture using potash glass (Lankton and Dussubieux, in press). The low-alumina potash glass type remains poorly understood, but most likely dates to the 4th to 2nd c. BC, with most examples found in Thailand at the site of Ban Don Ta Phet Lastly, large numbers of the low-CaO glass artifacts been found in many areas of Southeast Asia, with dates ranging from the 4th to 2nd c. BC into the 2nd century AD (Lankton and Dussubieux 2006). Important variations in trace element concentrations within this group, and indeed for m-K-Ca-Al glass as well, suggest the presence of multiple primary production sites, possibly including northern Viet Nam or southern China. Until glass production workshops are identified archaeologically, the exact manufacturing location(s) for potash glass, with its various sub-types, remains unknown.

High-alumina mineral soda glass (m-Na-Al Type 1)
Ten glass beads were classified as high-alumina mineral soda glass (m-Na-Al). This compositional group is the most common type of glass found in Southeast Asia. Dussubieux *et al.* (2010) have identified five different subtypes of mineral soda alumina glass, of which m-Na-Al Type 1, identified by its relatively low uranium and high barium content, is the most prevalent during the Iron Age of Southeast Asia. The m-Na-Al Type 1 glass is often found in a wide variety of colours including opaque red, orange, yellow, green, light blue, black and translucent light blue, although not medium or dark purplish blue coloured with cobalt. The m-Na-Al Type 1 glass is believed to have been manufactured in Sri Lanka and South India (Dussubieux 2001; Dussubieux *in press* 2010; Dussubieux and Gratuze, in press). Lankton and Dussubieux (in press) have noted a regional shift from potash glass to high-alumina soda glass at sites across Southeast Asia around the turn of millennium BC/AD. The reasons and meaning for this shift are still under debate (discussed below).

All the m-Na-Al Type 1 glass beads at BNW were found in layer 3 to layer 1 (approx. 200 BC- AD 600). Seven of the glass beads (15506) were from burial 266, an infant jar burial dated to the late Iron Age, approximately AD 400-600 (Higham and Kijngam 2009:73). The burial contained 112 glass beads, the majority of which were yellow (n=55), as well as light blue (n=14), dark blue (n=26), red (n=9), orange (n=6), white (n=1) and a single black glass bead. One dark blue bead from this burial appears to be another type, m-Na-Ca-Al (discussed below). In addition to the glass beads the burial also included bronze bangles and an agate pendant. Three other glass beads from non-burial contexts were also placed in the m-Na-Al Type 1 category. All three beads were from Layer 2 and have been dated to approximately 200-400 AD. They included a yellow bead (20002), a greenish-blue bead (20523), and an orange bead (20519). The orange bead has higher levels of MgO than the other m-Na-Al Type 1 beads, typical of many opaque orange glass beads found in Asia.

Based on similarities in colour and form, it is believed that approximately 232 additional beads in burial and non-burial contexts may also be classified as high-alumina mineral soda glass (Fig. 9:1). These include Indo-Pacific beads in red, orange, yellow, green, turquoise blue, black, and white colours. The majority of these Indo-Pacific beads were found in Layer 2. Orange, yellow, and light blue beads were the most common glass colour types found at BNW. It is possible that some of the yellow beads are actually lead glass (see below) and not high-alumina mineral soda glass, but this cannot be confirmed without additional compositional analysis.

Lead glass beads
Four beads from BNW had high levels of PbO (30-50 wt%), classifying them as lead glass. The lead glass beads include two coiled light blue beads (19501 and 24505), an opaque blue flattened bi-cone bead (20009), and a yellow oblate bead (20512). All four samples date to the Late Iron Age period (200-400 AD). During initial analysis, one bead (19501) was described as a possible collared bead, however, during later excavations additional similar beads were found that appear to have been wound or coiled, and this classification was reassessed. In this method, the beads are produced by winding or coiling glass around a metal rod. An additional bead from a group of 16 was analyzed in the current study (24505). These beads look remarkably similar to Chinese coil beads described by Francis (2002, colour plate 16). However, Francis argues that the earli-

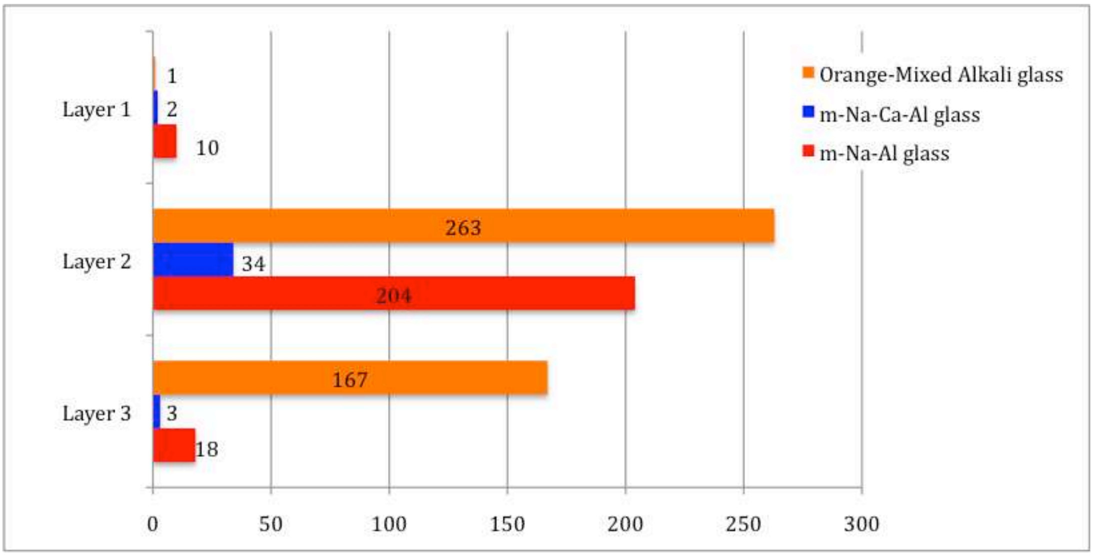

Fig. 9:1. An estimate of the quantity of the mixed alkali, m-Na-Ca-Al, and m-Na Al glass types over time at Ban Non Wat. These numbers are estimates and with additional compositional analysis it may be found that quantities of each type could vary.

est Chinese coil beads date to the eighth century AD and that these beads were not common until the decline of Indo-Pacific beads during the 12th century AD (Francis 2002:76). These beads may represent early examples of this bead type that become common during a later period.

Lead beads are rare at Southeast Asian archaeological sites. Dussubieux (2001) only identified six: three from the site of Angkor Borei, Cambodia (2nd century BC-2nd century AD) and three from the later 9th century AD site of Sarawak in Indonesia. Recent research indicates that there are also lead glass beads at the Sa Huynh site of Lai Nghi in Vietnam (Karsten Brabender, pers. comm.). A yellow lead glass bead was also discovered at the site of Prohear (Carter, in press). It is possible that with continued study lead glass beads could be found to be more common.

There also appears to be considerable variability within the lead glass type. The lead glass beads at Angkor Borei were notable for their high barium content, a characteristic usually thought to indicate a Chinese origin (Stark and Dussubieux 2002). In contrast, the lead glass beads from BNW do not have high barium content. Of the four lead glass beads at BNW, cat. 20512 has extremely low levels of CaO and high levels of SnO_2 in comparison to the other samples, and cats. 20009 and 24505 have much higher levels of Na_2O. It is possible that these beads belong to the early period high-lead glasses without barium, which are characterized as containing higher levels of arsenic (Brill in press 1991). The BNW samples do contain elevated levels of arsenic in comparison to the other beads studied; especially cat. 20512 that contained 3876 ppm arsenic. It is clear that further research is needed to better understand these beads and the lead glass type. Lead isotope analyses may assist in better understanding when and where these beads were manufactured (e.g. Henderson *et al.* 2005).

Mineral soda glass with variable amounts of alumina and lime (m-Na-Ca-Al)

Thus far, only one bead has been identified as mineral soda glass with variable amounts of alumina and lime, although there are probably additional beads that fall into this category. This bead was one of a group of seven similar beads found amongst a larger group of high-alumina mineral soda glass beads in burial 266 (discussed above). The beads are unusual in that they are tubular with sharp, not rounded, edges and coloured with cobalt. This type of glass is sometimes difficult to identify due to the wide variability in its composition, and especially its similarity to high-alumina soda glass (Dussubieux and Gratuze 2010). However, m-Na-Al Type 1 beads were not coloured with cobalt (Dussubieux *et al.* 2010), allowing us to more confidently place this artifact in the m-Na-Ca-Al category. Figure 9:1 presents an estimate of the additional m-Na-Ca-Al glass beads found at BNW based solely on their dark cobalt blue colour. As with the high-alumina mineral soda glass, most of the dark blue cobalt glass beads were found in Layer 2 (approx AD 300-500). This type of glass can also be found in other colours, and previous studies have also identified potash glass beads in a dark cobalt blue colour.

The m-Na-Ca-Al glass type has been found at locations across south India, Sri Lanka, and Southeast Asia (Carter, In Press; Dussubieux and Gratuze 2010; Lankton and Dussubieux, in press), and the variations in major and trace elements make it likely that there is more than one 'm-Na-Ca-Al' glass, with different types having different archaeological meanings. The manufacturing locations may include Arikamedu, India, where the glass previously identified as 'Arika' has an m-Na-Ca-Al composition (Dussubieux and Gratuze, in press). Similar m-Na-Ca-Al glass has been found at the site of Phu Khao Thong, Thailand (Dussubieux and Gratuze 2010), although it remains rare at other, seemingly contemporaneous, peninsular sites. A different m-Na-Ca-Al glass, often cobalt blue, was probably produced at Khuan Lukpat on the west coast of the Thai/Malay Peninsula (Lankton and Dussubieux, in press).

Soda-lime glass with plant-ash alkali source (v-Na-Ca)

Two artifacts were classified as soda-lime glass with a plant-ash alkali source (v-Na-Ca). The first is a fragment of a glass vessel (18014) that dates to the Late Iron Age period (AD 200-400). The other is a light blue glass fragment (18), which may come from an earring or bangle. The glass fragment was found in square Y layer 2, which dates to the later Iron Age based on the presence of Phimai black pottery (Higham and Kijngam 2009: 137). Soda-lime glass with a plant-ash alkali source was the earliest glass produced, dating to the mid-2nd millennium BC in western Asia and Egypt, and most likely continued to be produced in Mesopotamia even while glassmakers in the Roman world changed to a mineral soda (trona or natron) flux. The v-Na-Ca composition of the vessel glass from BNW is quite similar to that of a group of high magnesia (HMG type 1) glass fragments from the Sasanian-controlled site of Veh Ardasir (3rd-6th centuries AD) in Central Iraq (Mirti *et al.* 2008), and its presence in Southeast Asia may be interpreted in the context of increased control of Indian Ocean trade by the Sasanians during the 4th- 6th centuries CE (Lankton and Dussubieux 2006).

Mixed-alkali glass

An orange disc bead (cat. 20514) is the only sample to be classified as mixed-alkali glass, however there are numerous additional beads that may also fall in this category. In contrast to the ubiquitous Indo-Pacific glass beads that were drawn from long tubes, many mixed-alkali opaque orange disc beads appear to have been wrapped (Saitowitz and Reid 2001). In this proposed method, a flat glass sheet is wrapped around a metal rod to form a long tube from which the glass disc beads were sliced. Large numbers of these beads have been found at sites in Northeast

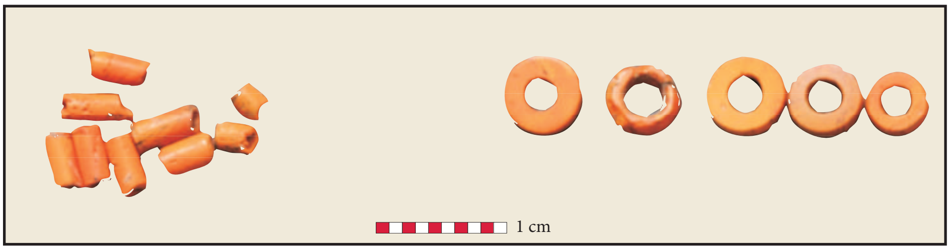

Figure 9:2 Examples of orange mixed alkali glass beads from Noen U-Loke. Both types of beads are believed to have been wrapped, not drawn as with Indo-Pacific beads. The disc shaped beads (NUL-030) are on the right; the tube shaped beads (NUL-028) are on the left.

Thailand, including NUL. Based on compositional work on beads from NUL, a second form of mixed-alkali glass bead has been identified: a small, short tubular bead that also appears to have been wrapped (Fig. 9:2). Figure 9:1 illustrates the estimated quantity of orange opaque mixed-alkali beads found at BNW in burial and non-burial contexts. A few stray orange wrapped beads were identified in Layer 4, however the majority of the beads appear in Layers 3 and 2 (approx 200 BC-AD 400). Based on typology alone, these beads were the most abundant bead type found at the site, with nearly twice as many found as the high-alumina mineral soda glass. However, previous studies have found that disc beads have also been made from potash and m-Na-Al glass, so this assumption would have to be tested with further compositional analysis.

The high number of orange opaque disc beads at both BNW and NUL is unusual when compared to other sites in Southeast Asia (see Lankton and Dussubieux, in press). Mixed-alkali glass is present, although rare, at the peninsular Thai site of Khao Sam Kaeo (Lankton and Dussubieux, in press). Additional orange wrapped beads have been found near Ban Non Wat at the sites of Non Muang Kao (Saitowitz and Reid 2001) and possibly Ban Bon Noen (Pilditch 1992). No beads of this type have yet been found in Cambodia. Similar orange and red opaque disc beads have also been reported at sites in southern India and Sri Lanka, where they may have been manufactured, as well as Chombeung, Thailand, Giong Ca Vo, Vietnam (Dussubieux 2001; Lankton and Dussubieux 2006), Ban Chiang (White 1982), and the peninsular Thai site of Ta Chana (Pongpanich 2009:51). However, Francis notes that many orange and red disc beads were not wrapped, but in-

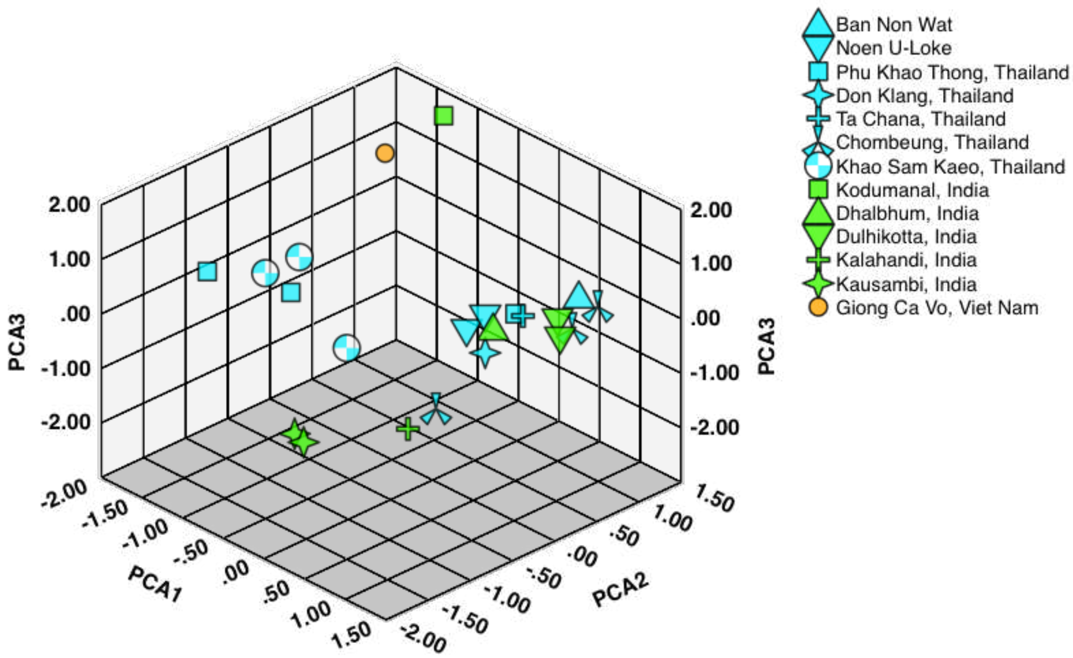

Figure 9:3. A 3D PCA scatterplot of the compositions of opaque orange mixed alkali beads from various sites in South and Southeast Asia. The scatterplot indicates there may be several different types of mixed alkali glass in circulation. Beads from sites in Thailand are blue, beads from sites in India are green, and a bead from a site in Viet Nam is orange. Data for the scatterplot taken from Dussubieux 2001 and from unpublished data courtesy of Laure Dussubieux and Bernard Gratuze.

stead made from solid canes of glass that were sliced into discs and then perforated by drilling (Francis 2002: 136-7). While these disc beads appear to share a similar glass type and bead shape as the objects found at Ban Non Wat, their manufacturing method would appear to distinguish them from the wrapped beads found in Northeast Thailand.

In order better to understand where the BNW bead falls within the spectrum of mixed-alkali glass, the composition of this bead was compared to orange mixed-alkali glass beads from several other sites in South and Southeast Asia. The compositions were evaluated using principal component analysis (PCA). PCA is an ideal exploratory method for reducing and simplifying a large number of linked variables, such as the elements produced in LA-ICP-MS analysis, into components (see Baxter 1994). Figure 9:3 shows the first three principal components, which account for 69.5% of the variance, graphed as a scatterplot. The scatterplot shows multiple possible groups of mixed-alkali glass beads, with those from the peninsular Thai sites of Khao Sam Kaeo and Phu Khao Thong being distinct from the mixed-alkali glass found at other sites in India and Southeast Asia. However, the BNW and NUL mixed-alkali glass may share a compositional similarity with beads found at the peninsular Thai site of Ta Chana, the central Thai site of Chombeung, and the northeast Thai site of Don Klang, as well as two sites in India: Dhalbhum and Dulhikotta. It should be noted that these groupings are only preliminary and cannot yet tell us where or when the beads were manufactured. Additional research on both the composition and manufacturing method of mixed-alkali beads is needed before confidently distinguishing between these clusters. Indeed, future research may find that the distinctions between the groups will change. However, this preliminary analysis does indicate the presence of several types of mixed-alkali glass in circulation during the Iron Age period.

Unknown glass type

Two beads found in layer 1 were of an unusual potash-lime glass type, with a plant-ash flux. One glass bead, colourless, was about 10mm in diameter and was found in square Y, while the other, transparent greenish-blue bead and approximately 8mm in diameter, was found in square A4. Both beads appear to have been wound. The beads have high levels of MgO (approximately 5 wt%) and CaO (13-15 wt%), as well as 6-10 wt% K2O and 5 wt% Al_2O_3. The beads are similar in composition to wound beads found in burials of members of the Ma, K'Ho, and Ru tribes in Viet Nam, dating from the 16th-18th centuries AD (Brill 1999). These beads fall well outside the Iron Age period, the focus of this report, and therefore will not be explored in depth.

GLASS BEADS FROM NOEN U-LOKE

Over 800 glass beads and artifacts have been uncovered at BNW, however the over 7000 glass beads uncovered in burials at the nearby site of Noen U-Loke (NUL) dwarf this number (Talbot 2007). This difference is especially striking when we consider that over 900 m^2 have been excavated at BNW during the 2002-2007 field seasons, while only 220 m^2 were excavated at NUL over two seasons. Approximately 50 glass beads, as well as an object described as glassy slag found on a piece of black ceramic were previously analyzed by Saitowitz and Reid (2001), who used electron probe microanalysis (EPMA) to measure the major elements and LA-ICP-MS to analyze trace elements. Most of the beads analyzed were Indo-Pacific trade beads, however they also identified several orange wrapped beads discussed above, and a group of bi-colour beads with a red core and orange outer layer. Of the beads they analyzed, Saitowitz and Reid found that the majority (n=37) were high-alumina mineral soda glass (m-Na-Al Type 1); five beads were mixed-alkali; four were described as low-alumina potash glass (m-K-Ca); three were soda-lime glass with plant-ash alkali (v-Na-Ca); and two were high-lime mineral soda glass (m-Na-Ca-Al).

Although their report was admirable, Saitowitz and Reid did not provide a context for the beads they analyzed, making it difficult to determine if there was a change over time in the quantity or type of glass at the site. In order to better understand the complete NUL glass bead assemblage, glass bead artifacts from Noen U-Loke were examined and recorded by Carter at the Phimai National Museum in 2010. Unfortunately, not all of the beads could be recorded as some did not have their associated context information and others were not available for study. Nevertheless, this analysis provides a more comprehensive understanding of the entire glass bead collection from NUL than previously discussed.

Additionally, LA-ICP-MS analysis has greatly expanded since Saitowitz and Reid's original report. Therefore, an additional 29 beads from NUL were analyzed as part of the current study (Table 9:2). The same methodology and procedure were followed as described above. It should be noted that two of the 29 beads will not be included in the current discussion. The first, NUL-011, was too corroded to provide confident results. The other, NUL-017, is an unusual polychrome bead that lacks adequate provenance information. The results from the remaining 27 artifacts will be briefly summarized and compared to the broader collection of NUL glass beads recorded at the Phimai museum as well as those noted in the NUL excavation report (Higham *et al.* 2007).

2009 analysis of Noen U-Loke glass beads

Four beads were classified as potash glass beads. Although three of these (NUL-006, NUL-010, and NUL-029) have relatively low levels of CaO, they should probably be classified as m-K-Ca-Al glass, since they lack the high rubidium and high rubidium/strontium ratios that characterize the m-K-Al potash glass subtype. NUL-016, a dark blue-purple bead, was classified as m-K-Ca-Al glass as well, the same glass subtype as that found at Ban Non Wat. Three of these beads were found in a MP5 context (AD 400-600), however one bead (NUL-029) was found in burial 37 (MP3A: 100 BC- AD 200). This wide spread in composition and date confirms our earlier suggestion that more than one primary production centre should account for the m-K-Ca-Al glass found in Southeast and South Asia. Seventeen of the glass beads sampled fell into the high-alumina mineral soda glass compositional type (m-Na-Al Type 1). These Indo-Pacific beads came in a variety of colours including black, blue, blue-green, grey, turquoise, white and yellow. Nine of the m-Na-Al beads were from MP5 (400-600 AD) burial 8, the burial of a young adult also containing pottery vessels and an iron knife and sickle (Higham and Thosarat 2007: 137). Other glass beads were from MP4A (AD 200-400), including one from burial 105, a rich burial of an adult male, which contained 494 glass beads in a variety of colours as well as bronze jewelry, an iron point, and a silver bracelet (Higham et al. 2007)

Also found in burial 8 were bi-colour glass beads, also classified as m-Na-Al Type 1. These Indo-Pacific beads have a core of red glass and an outer layer of orange glass. Although they are uncommon, similar bi-colour beads have also been found at sites in South India and Sri Lanka (Dussubieux and Gratuze, in press), as well as Phum Snay (Carter, in press) and Angkor Borei, Cambodia (Dussubieux 2001), Khlong Thom and Takua Pa in peninsular Thailand, Sungai Mas, Malaysia (Francis 2002), and Ban Non Noen in Central Thailand (Pilditch 1992).Four beads were classified as m-Na-Ca-Al glass: NUL-003, NUL-005, NUL-007 and NUL-015. As with the m-Na-Ca-Al glass found at BNW, their compositions were similar in many respects to high-alumina mineral soda glass, but all four were coloured with cobalt. Two of the beads were broken, but all appear to be tubular beads with sharp edges, similar to the BNW bead discussed above. These beads were found in contexts associated with MP4A and 5 (approximately AD 200-600). Two orange opaque beads from NUL were identified as being mixed-alkali beads: NUL-028 a tubular bead and NUL-030 a disc bead. Both appear to have been wrapped, as discussed above (Fig. 9:2). The beads were from burial 37, an adult female from MP3A (100 BC- AD 200) and found with over 200 similar beads, as well as agate beads, bronze finger rings, and a pig offering (Higham and Thosarat 2007:156).

ARCHAEOLOGICAL QUESTIONS

How do the glass beads at BNW and NUL compare to one another?

Returning to the questions asked during the introduction, we must first ask how the glass artifacts at BNW and NUL compare one with the other. The sites are just 1.8 km apart and so it is unsurprising that they have similar types of glass. Glass types found at both sites include: m-Na-Al Type 1, potash glass, mixed-alkali glass, m-Na-Ca-Al, and v-Na-Ca glasses. However, there are a few notable differences between the two sites. A small group of lead glass beads has been identified at BNW, but no similar beads have been identified at NUL. Potash glass earring and bangle fragments have been identified at BNW, but no potash glass beads like those found at NUL have been uncovered. Perhaps the most obvious difference is the much larger quantity of beads and artifacts found in burials at NUL. Only thirteen Iron Age burials at BNW had glass artifacts, and of these only four had more than 50 beads. Conversely, the number of glass beads in burials is much higher at NUL, with 53 burials containing glass beads, and at least 12 burials having more than 50 beads. While the earliest glass artifacts appear at BNW during the Iron Age 1 period (420-100 BC), glass does not appear at NUL until MP3 (100 BC-AD 200), with a peak in the quantity of glass beads during MP3 and MP4 (AD 200-400) (Talbot 2007). Part of the discrepancy in the quantity of beads could be related to the dates of occupation at both sites. The majority of burials at BNW date to the earlier Iron Age 1 period, whereas the later Iron Age period and its accompanying increase in mortuary wealth is better represented at NUL (Higham and Higham 2009). Nevertheless, when we look at both sites together, we are able to see a broad shift in glass types over time.

How do glass types change over time at BNW and NUL?

The earliest glass artifacts are not beads, but blue glass earrings found at BNW (Higham and Kinjgam 2009). These objects were found in occupation contexts as well as burials (357, 235, 237, and 101) dating to the Iron Age 1 period (420-200 BC). Based on the current LA-ICP-MS study, we know that these earrings were made from potash glass. Lankton and Dussubieux (in press) have noted a regional shift from potash glass to high-alumina mineral soda glass at sites across Southeast Asia around the 2nd century BC- 2nd century AD. However, Carter (in press) has also identified roughly contemporary sites in Cambodia, falling within the 200 BC- AD 200 timeframe, that have distinctly different and non-overlapping distributions of glass. For example, no high-alumina mineral soda glass has been identified at the site of Prohear, which is dominated by potash glass beads. In contrast, the site of Angkor Borei has large quantities of high-alumina mineral soda glass but no potash glass (see also Dussubieux 2001). Although the precision of radiocarbon dates for this period may be questioned, if we accept the current dating for the graves at Prohear and Angkor Borei, this raises the question that the difference in glass-type distribution is related not only to a temporal shift in the availability of glass, but also to the presence of two distinct glass bead

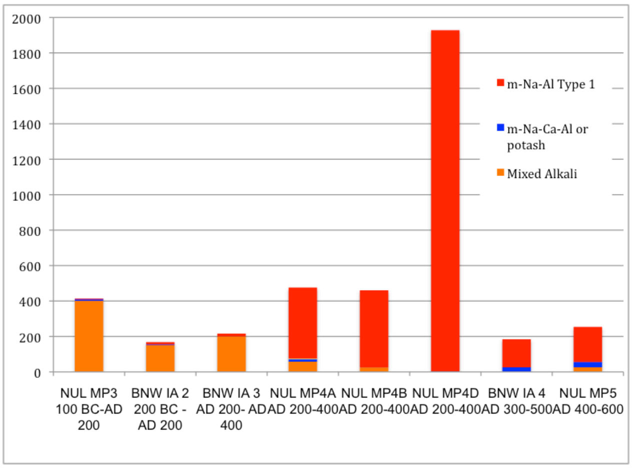

Fig. 9:4. An estimate of the quantity of different glass types at Ban Non Wat and Noen U-Loke over time.

trading networks.

The potash glass artifacts from BNW (n=4) and NUL (n= 8) are instructive in this regard. While potash glass is rare at most Southeast Asian sites after the 1st century AD, four of the NUL potash glass beads identified in the current study were from mortuary phase 5, dated from AD 400-600. This observation is consistent with potash glass beads, often cobalt blue, found at Arikamedu, Phu Khao Thong, and in Eastern Han tombs in northern Vietnam (Dussubieux 2001). In addition, potash glass beads are relatively common in Korean graves into the 5th century AD (Lankton and Lee 2006).

The dominance of opaque orange mixed-alkali glass seems to be characteristic of BNW and NUL and perhaps other sites in the Northeast Thailand. These beads are first seen in Iron Age 2 burials at BNW (200 BC- AD 200) and mortuary phase 3 burials at NUL (100 BC- AD 200). However, they began to decline around AD 200 when they were replaced by high-alumina mineral soda glass in multiple colours. Figure 9:4 demonstrates the change in the quantities of three types of glass found at NUL and BNW over time. The figure is not representative of all the glass beads uncovered at both sites, as not all of the beads were available to be recorded. For example, exact numbers of the glass beads found at NUL MP4C are unavailable, as are specifics regarding over 700 beads found in a burial during MP3B. Nevertheless, it does allow one to see the general distribution of glass types over time and space. We still do not know where these beads were made, although their limited circulation and compositional similarity to other beads found in Thailand may point toward a nearby manufacturing centre.

The introduction of high-alumina mineral soda glass brought higher quantities of beads in a variety of different and new colours. This is best reflected at Noen U-Loke, which has a more extensive late Iron Age period component. Mortuary rituals were also changing during this period, as larger quantities of glass beads were being placed in subadult burials (Talbot 2007:338). The large number of glass beads found in certain burials, such as the over 1719 light blue glass beads from burial 13, also hint at the large numbers of beads that were available through exchange networks during this period and may have been brought to the site in a single exchange event. Nevertheless, the number of glass beads at the site declined by MP5, with only 500 found in burials, and NUL appears to have been abandoned shortly after this phase.

What do the glass artifacts tell us about the relationship between Ban Non Wat and Noen U-Loke, and their participation in trade networks with other sites in South and Southeast Asia?

Compositional analysis of glass beads from BNW and NUL allows us to identify changing glass types over time, which in turn may be related to changing trade and exchange networks. While we still do not know where potash glass artifacts were being made, potash glass beads and artifacts have been found in high quantities at Dong Son, Sa Huynh, and sites in peninsular Thailand which were participating in South China Sea exchange networks. The relatively low number of potash glass artifacts and beads indicate that BNW and NUL were perhaps only peripherally involved in these early glass trade networks, which may have been focused on coastal sites.

By 100 BC, orange mixed-alkali glass beads were present at sites in Northeast Thailand. As discussed above, the unique distribution of this artifact at sites in Northeast Thailand is notable, however this is not the only artifact with a fairly restricted distribution at sites in Northeast Thailand. Theunissen (2007) has also highlighted the limited distribution of notched agate pendants at sites in this region. This pattern could be related to personal preference for specific types of beads or could be related to their relative isolation from maritime exchange networks (Theunissen 2007:373). Similar reasons could be considered for the distribution of mixed-alkali glass beads. While both artifacts may have originated in a distant location, their restricted distribution suggests the importance of these prestige objects within the Northeast Thailand interaction sphere.

In fact, it does not appear that people at BNW and NUL were participating in broader exchange networks until the appearance of high-alumina mineral soda glass beads, which were believed to have been imported from manufacturing sites in South Asia and possibly peninsular Thailand. We do not know if these beads, made from a different type of glass and found in new colours, were considered to be exotic or different from the earlier glass beads found at these sites. However, when these beads appear in Southeast Asia, they are traded widely across the landscape. The m-Na-Al Type 1 beads appear at NUL during MP4 (AD 200-400) and at BNW during Iron Age 4 (AD 400-600). It was during MP4 at NUL that we also see an increase in the quantity of grave goods with certain individuals, evidence for additional stress within the

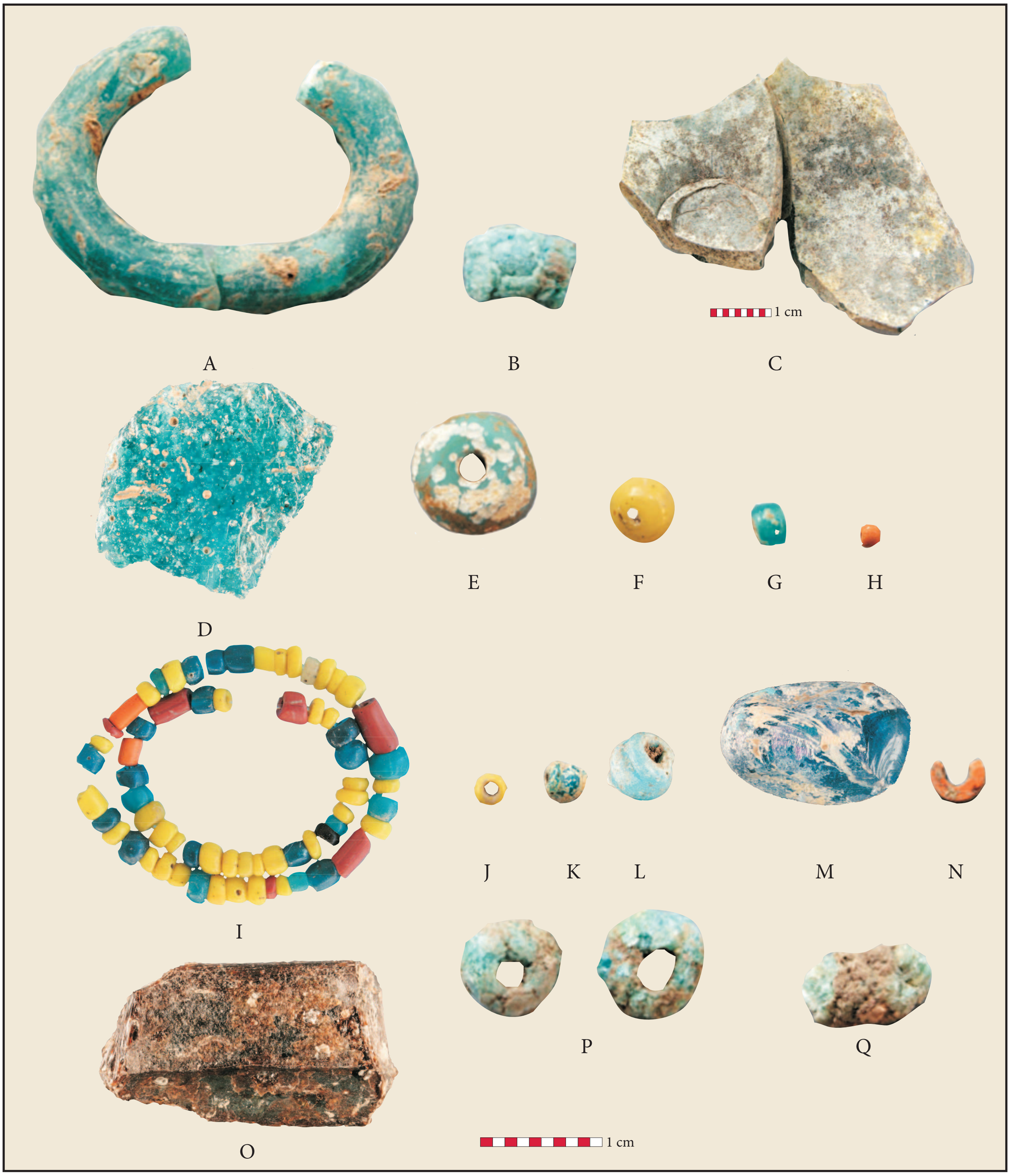

Fig. 9:5 The analysed glass from Ban Non Wat. A. cat. 17673 burial 235, B. cat. 17671 burial 235, C. cat. 18014 E7 2:7, (actual size), D. cat. 5090 X1 2:10, E. cat. 20009 G2 2:2, F. cat. 20002 G5 2:2, G. cat. 20523 G6 2:7, H. cat 20519 G6 2:5 I. cat. 15506 burial 266 actual size, J. cat. 20512 G6 2:5, K. cat. 19501 F7 2:1, L. cat. 24505 E4 2:5/6, M. cat. 18 Y1 2:5, N. cat. 20514 G6 2:5, O. cat. 3073 B3 4:6, P. cat. 18066 burial 377 Q. cat. 19870 burial 377

community, and perhaps for changing social organization (Higham 2007; Talbot 2007). MP4 also coincides with a broader trend of increasing interaction between sites in Southeast Asia and more intense contact with South Asia (Bellina and Glover 2004). These changes were part of the beginning of the long-term processes that culminated in the development of early states and ultimately the Kingdom of Angkor.

Table 9:1 *Glass artifacts from Ban Non Wat analyzed by LA-ICP-MS*

Cat. No	Artifact	Colour	Context Information	Period	Date	Compositional Group
17673	Earring fragment	Light blue	Burial 235	Iron Age I	400-200 BC	m-K-CA-Al
17671	Earring fragment	Light blue	Burial 235	Iron Age I	400-200 BC	m-K-CA-Al
19013	Earring fragment	Light blue	F6 2:6	Late Iron Age	AD 200-400	m-K-CA-Al
5090	Glass fragment	Blue	X1 2:10	Iron Age	100 BC- AD 400	m-K-Ca-Al
20002	Oblate bead	Yellow	G5 2:2	Late Iron Age	AD 200-400	m-Na-Al Type 1
20523	Oblate bead	Greenish blue	G6 2:7	Late Iron Age	AD 200-400	m-Na-Al Type 1
20519	Oblate bead	Orange	G6 2:5	Late Iron Age	AD 200-400	m-Na-Al Type 1
15506-orange	Oblate bead	Orange	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
15506-yellow	Oblate bead	Yellow	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
15506-turquoise	Oblate bead	Turquoise	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
15506-dark blue 1	Oblate bead	Dark Blue	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
15506-black	Oblate bead	Black	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
15506-white	Oblate bead	White	Burial 266	Late Iron Age	AD 300-500	m-Na-Al Type 1
20512	Oblate bead	Yellow	G6 2:5	Late Iron Age	AD 200-400	Lead
20009	Flattened bicone bead	Light blue	G5 2:2	Late Iron Age	AD 200-400	Lead
19501	Coiled bead	Light blue	F7 2:1	Late Iron Age	AD 200-400	Lead
24505	Coiled glass	Blue	E4 2:5/6	Late Iron Age	AD 200-400	Lead
15506-dark blue 2	Oblate bead	Dark Blue	Burial 266	Late Iron Age	AD 300-500	m-Na-Ca-Al
18	Bangle fragment?	Blue	Y1 2:5	Later Iron Age	200 BC-AD 200?	v-Na-Ca
	Vessel	Transparent blue-green	E7 2:7	Late Iron Age	AD 200-400	v-Na-Ca
20514	Wrapped disc bead	Orange	G6 2:5	Late Iron Age	AD 200-400	Mixed alkali
393	Large oblate bead	Greenish-blue	A4 1:2	Historic	16th-18th century AD?	Unknown-
4	Large oblate bead	Clear	Y1 1:5	Historic	16th-18th century AD?	Unknown
3073	Bangle fragment	Greenish-brown	B3 4:6	Unknown	Unknown	Weathered
burial	Bangle fragment	Blue	A3 1:5	Unknown	Unknown	Weathered
18066	Oblate bead	Greenish blue	Burial 259	Iron Age I	400-200 BC	Weathered
19773	Earring?	Greenish blue	Burial 357	Iron Age I	400-200 BC	Weathered
19780	Earring fragment	Greenish blue	Burial 357	Iron Age I	400-200 BC	Weathered

CONCLUSION

Glass beads, as well as agate and carnelian artifacts, have often been considered indicators of contact with India. However, Theunissen (2007; Theunissen *et al.* 2000) has criticized the long-held belief that the presence of artifacts of an Indian origin at a site was equivalent to Indian influence, especially at inland sites. Recent research on glass

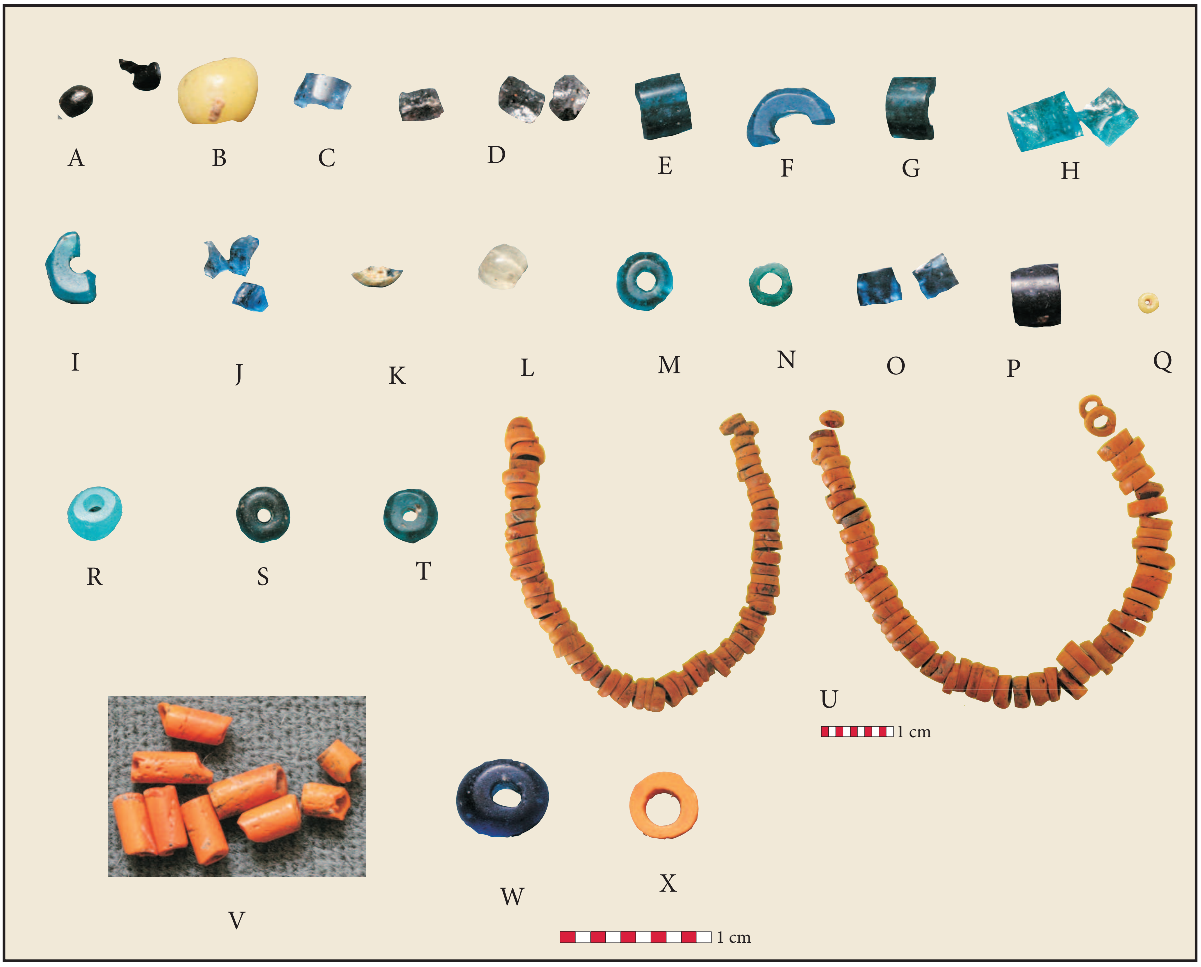

Fig. 9:6 The analysed glass beads from Noen U-Loke. A cat. 1465, B, cat. 141, C. cat.1457, D. 1417, E. cat. 1414 F. cat. 1414, G. cat. 1457 H. cat. 1457, I. cat. 1457, J. cat. 207K. cat. 1417, L. cat. 1501, M. cat. 1417, N. cat. 1417, O. cat. 1414, P. cat. 1414, Q. cat. 207, R. cat. 207, S. cat. 207, T. cat. 207, U. cat. 207, V. burial 37, W. burial 37, X. burial 37

confirms this argument, as it appears that many early glass artifacts may actually have been produced in Southeast Asia (e.g. Lankton and Dussubieux, in press; Lankton *et al.* 2008). The presence of glass artifacts whose manufacturing locations are unknown adds to the complexity of these exchange networks. Early Iron Age people in Northeast Thailand appear to have had an important but localized interaction sphere in which blue potash-glass earrings, mixed-alkali glass beads, and notched agate pendants were important prestige objects. These artifacts may have originated in exotic locations, but their controlled distribution highlights the importance of these local interaction networks for Iron Age people, especially as related to increasing socio-political complexity (Higham 2011). With compositional analysis of glass beads and artifacts we are better able to see and understand these important trade and interaction networks and their changes over time.

Acknowledgements

We wish to thank Drs. Charles Higham, Rachanie Thosarat, and Nigel Chang for allowing access to the glass artifacts from BNW and for allowing our participation on the project. We also wish to thank the Phimai National Museum for providing access to the objects from Noen U-Loke. We are also grateful to the National Research Council of Thailand and the Fine Arts Department of Thailand for granting permission to examine these beads and to Dr. Amphan Kijngam for his assistance in getting permission to bring the beads to the United States. Karsten Brabaender shared information from his research on glass in Viet Nam. Bernard Gratuze also shared compositional data from his analysis of mixed-alkali glass. Lastly, we wish to acknowledge Dr. Laure Dussubieux at the Field Museum in Chicago; without her help this project would not have been possible.

TABLE 9:2 Glass beads from Noen U-Loke analyzed by LA-ICP-MS

Sample ID for analysis	Cat. No	Artifact	Color	Context Information	Period	Date	Compositional Group
NUL-001	1465	Broken oblate bead	Black translucent	X1 3:13	MP4A	AD 200-400	m-Na-Al
NUL-002	141	Broken oblate bead	Yellow opaque	3:6 Feature 1	N/A	AD 250-650	m-Na-Al
NUL-003	1457	Broken short cylinder	Blue translucent	T9B3	MP4A	AD 200-400	m-Na-Ca-Al
NUL-004	1417	Broken oblate bead	Grey translucent	T9B9	N/A	Unknown	m-Na-Al
NUL-005	1414	Broken short cylinder	Dark blue translucent	T9B2	MP5	AD 400-600	m-Na-Ca-Al
NUL-006	1414	Broken oblate bead	Dark Blue Trans broken	T9B1	MP5	AD 400-600	m-K-Al, Low CaO or m-K-Ca-Al
NUL-007	1457	Broken short cylinder	Dark Blue Trans Broken	T9B8	MP4A	AD 200-400	m-Na-Ca-Al
NUL-008	1457	Broken oblate bead	Dark turquoise translucent	T9B4	MP4A	AD 200-400	m-Na-Al
NUL-009	1457	Broken oblate bead	Dark blue turquoise	T9 B7	MP4A	AD 200-400	m-Na-Al
NUL-010	207	Broken oblate bead	Bright blue translucent	Burial 8	MP5	AD 400-600	m-K-Al, Low CaO or m-K-Ca-Al
NUL-011	1417	Broken oblate bead	Corroded	3:9 Feature 1 T9 B10	MP3A	100 BC- AD 200	v-Na-Ca
NUL-012	1502	Broken oblate bead	White translucent	Burial 105	MP4A	AD 200-400	m-Na-Al
NUL-013	1417	Oblate bead	Dark turquoise translucent	3:9 Feature 1	N/A	AD 250-650	m-Na-Al
NUL-014	1417	Broken short cylinder	Blue-green translucent	3:9 Feature 1	N/A	AD 250-650	m-Na-Al
NUL-015	1414	Broken oblate bead	Dark Blue Trans Broken	T8B8	MP5	AD 400-600	m-Na-Ca-Al
NUL-016	1414	Broken short cylinder	Dark blue/ purple translucent	T8B8	MP5	AD 400-600	m-K-Ca-Al
NUL-017	N/A	Broken barrel bead	Red, white, blue, yellow opaque mixed glass	Unknown	N/A	Unknown	v-Na-Ca
NUL-019	207	Oblate seed bead	Yellow opaque	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-020	207	Oblate bead	Turquoise translucent	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-021	207	Oblate bead	Dark blue translucent	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-022	207	Oblate bead	Dark blue translucent	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-023	207	Oblate seed bead	Red core with orange coating	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-024	207	Oblate seed bead	Red core with orange coating	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-025	207	Oblate seed bead	Red core with orange coating	Burial 8	MP5	AD 400-600	m-Na-Al

TABLE 9:2 *Glass beads from Noen U-Loke analyzed by LA-ICP-MS* (cont.)

Sample ID for analysis	Cat. No	Artifact	Color	Context Information	Period	Date	Compositional Group
NUL-026	207	Oblate seed bead	Red core with orange coating	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-027	207	Oblate seed bead	Red core with orange coating	Burial 8	MP5	AD 400-600	m-Na-Al
NUL-028	492	Short tube	Orange opaque	Burial 37	MP3A	100 BC- AD 200	Mixed-Alkali
NUL-029	492	Oblate bead	Bright blue translucent	Burial 37	MP3A	100 BC- AD 200	m-K-Al, Low CaO or m-K-Ca-Al
NUL-030	492	Wound disc bead	Orange opaque	Burial 37	MP3A	100 BC- AD 200	Mixed-Alkali

TABLE 9:3 *The percentage composition of the glass samples from Ban Non Wat*

Cat.	Description	Glass Type	SiO2	Na2O	MgO	Al_2O_3	P_2O_3	K2O	CaO	MnO	Fe_2O_3	CuO	SnO_2	PbO_2
5090	Blue glass fragment	m-K-Ca-Al	75.2	1.4	0.5	1.4	0.3	14.2	4.2%	0.0	0.7	1.6	0.0	0.1
17673	Blue earring fragment	m-K-Ca-Al	82.2	0.6	0.3	1.6	0.2	11.8	1.7%	0.0	0.5	0.8	0.0	0.0
17671	Blue earring fragment	m-K-Ca-Al	89.2	0.1	0.5	1.9	0.2	0.8	5.4%	0.0	0.5	1.1	0.0	0.0
19013	Blue earring fragment	m-K-Ca-Al	77.2	0.8	0.3	3.4	0.2	13.5	3.0%	0.0	0.3	0.8	0.0	0.0
15506	red bead	m-Na-Al Type 1	67.1	13.0	0.4	9.3	0.1	2.1	2.8%	0.1	1.8	2.2	0.2	0.4
15506	orange bead	m-Na-Al Type 1	55.9	12.6	0.8	12.6	0.2	1.9	3.2%	0.1	2.7	7.8	0.3	1.7
15506	yellow bead	m-Na-Al Type 1	65.3	13.9	0.3	8.6	0.0	2.3	1.7%	0.0	1.2	0.1	1.2	4.6
15506	turquoise bead	m-Na-Al Type 1	68.6	14.1	0.4	9.2	0.0	2.0	2.8	0.1	1.5	0.6	0.0	0.1
15506	dark blue bead	m-Na-Al Type 1	67.8	14.3	0.3	9.7	0.0	2.4	1.8	0.0	0.9	1.6	0.2	0.3
15506	black bead	m-Na-Al Type 1	74.8	12.0	0.4	6.8	0.0	1.7	1.4	0.1	2.1	0.0	0.0	0.0
15506	white bead	m-Na-Al Type 1	67.1	14.6	0.7	9.6	0.0	1.8	4.4	0.1	1.3	0.0	0.0	0.0
20002	yellow bead	m-Na-Al Type 1	63.6	18.5	0.3	7.1	0.0	1.5	2.7	0.1	2.6	0.1	0.3	2.3
20523	Blue bead	m-Na-Al Type 1	66.9	18.1	0.3	8.4	0.0	2.2	1.8	0.0	1.1	0.5	0.0	0.1
20519	orange bead	m-Na-Al Type 1	56.3	14.2	1.1	13.4	0.2	2.1	4.5	0.1	3.8	3.7	0.0	0.0
19501	blue coiled bead	lead glass	54.8	0.1	0.1	0.6	0.2	3.6	4.4	0.0	0.6	1.0	0.1	33.9
20009	blue flattened bicone bead	lead glass	45.7	1.9	0.1	0.2	0.0	9.6	4.8	0.0	0.2	0.9	0.1	35.9
20512	yellow bead	lead glass	36.6	0.2	0.1	0.6	0.0	8.6	0.2	0.0	0.3	0.1	3.5	49.5
24505	blue coiled bead	lead glass	40.0	2.0	0.2	0.2	0.0	9.8	4.2	0.0	0.2	0.8	0.0	42.1
15506	cobalt blue bead	m-Na-Ca-Al	72.3	13.2	0.4	5.4	0.1	1.0	4.1	1.3	1.4	0.0	0.0	0.0
18	blue bangle fragment?	v-Na-Ca	67.0	16.9	2.7	1.4	0.2	1.8	8.4	0.2	0.5	0.1	0.0	0.1
18014	transparent blue-green vessel glass	v-Na-Ca	61.1	16.8	3.5	2.3	0.4	2.8	8.8	3.0	0.8	0.0	0.0	0.0
20514	orange disc bead	mixed alkali	56.0	6.5	1.9	6.4	1.5	8.6	2.9	0.4	4.7	10.3	0.1	0.1
393	large green glass bead	unknown	57.7	3.5	5.3	5.8	0.1	9.7	15.9	0.0	0.6	0.7	0.1	0.1
4	large clear glass bead	unknown	58.5	3.9	5.8	5.3	0.0	6.0	19.1	0.0	0.4	0.0	0.0	0.0

TABLE 9:4 *The composition of the glass samples from Ban Non Wat expressed as parts per million*

Cat. no.	Description	Glass Type	Li	Be	B	Sc	Ti	V	Cr	Ni	Co	Zn	As	Rb
5090	Blue glass fragment	m-K-Ca-Al	5	7	57	3	478	14	12	50	54	26	98	117
17673	Blue earring fragment	m-K-Ca-Al	3	0.3	78	2	447	11	7	53	66	15	172	131
17671	Blue earring fragment	m-K-Ca-Al	2	1	97	2	378	16	5	31	24	19	47	19
19013	Blue earring fragment	m-K-Ca-Al	7	1	55	2	361	10	4	22	11	14	35	121
15506	red bead	m-Na-Al Type 1	8	5	18	4	2709	69	25	62	19	58	53	46
15506	orange bead	m-Na-Al Type 1	9	3	28	7	2454	97	52	103	25	161	190	46
15506	yellow bead	m-Na-Al Type 1	12	5	27	4	2438	63	21	10	5	17	23	40
15506	turquoise bead	m-Na-Al Type 1	8	6	21	5	2644	61	25	29	8	23	14	44
15506	dark blue bead	m-Na-Al Type 1	9	5	21	3	2083	70	20	38	12	31	33	43
15506	black bead	m-Na-Al Type 1	9	7	25	5	8277	65	44	10	8	32	4	36
15506	white bead	m-Na-Al Type 1	7	6	27	5	2532	79	21	8	4	15	13	37
20002	yellow bead	m-Na-Al Type 1	9	1	35	7	1715	73	35	9	6	18	172	47
20523	Blue bead	m-Na-Al Type 1	12	1	34	3	2023	85	28	16	6	36	5	55
20519	orange bead	m-Na-Al Type 1	14	1	46	9	2505	145	64	57	31	53	8	71
19501	blue coiled bead	lead glass	4	0.3	5	1	126	13	7	34	2	88	476	10
20009	blue flattened bicone bead	lead glass	6	0.2	2	1	46	2	1	16	1	82	306	6
20512	yellow bead	lead glass	27	0.5	2	0.4	34	4	1	10	1	50	3876	20
24505	blue coiled bead	lead glass	5	4	2	1	51	3	5	22	1	392	223	8
15506cob	cobalt blue bead	m-Na-Ca-Al	13	13	75	6	1250	102	14	82	595	48	14	20
18	blue bangle fragment?	v-Na-Ca	12	8	99	3	308	10	28	29	129	25	4	13
18014	transparent blue-green vessel glass	v-Na-Ca	12	1	96	3	797	23	75	20	186	508	15	11
20514	orange disc bead	mixed alkali	24	1	38	6	1213	43	25	213	149	874	318	142
393	large green glass bead	unknown	23	7	18	3	1140	17	16	16	7	66	26	17
4	large clear glass bead	unknown	15	7	14	3	1206	23	12	7	1	17	0.0	12

TABLE 9:4 *The composition of the glass samples from Ban Non Wat expressed as parts per million* (cont.)

Cat. no.	Description	Glass Type	Sr	Zr	Nb	Ag	Sb	Cs	Ba	La	Ce	Pr
5090	Blue glass fragment	m-K-Ca-Al	156	72	2	1	2	1	255	9	20	2
17673	Blue earring fragment	m-K-Ca-Al	34	103	2	1	1	1	140	10	19	2
17671	Blue earring fragment	m-K-Ca-Al	98	67	1	1	1	1	105	10	21	2
19013	Blue earring fragment	m-K-Ca-Al	88	72	2	1	1	1	227	10	18	2
15506	red bead	m-Na-Al Type 1	330	415	7	17	15	1	604	21	39	4
15506	orange bead	m-Na-Al Type 1	426	287	7	59	71	0.4	513	24	49	6
15506	yellow bead	m-Na-Al Type 1	298	566	8	3	2	0.3	1080	30	48	5
15506	turquoise bead	m-Na-Al Type 1	294	547	7	3	3	0.5	681	22	38	5
15506	dark blue bead	m-Na-Al Type 1	360	521	7	22	14	0.3	1348	31	49	5
15506	black bead	m-Na-Al Type 1	180	949	23	0	1	0.2	443	42	79	9
15506	white bead	m-Na-Al Type 1	429	229	7	1	1	0.4	699	23	36	5
20002	yellow bead	m-Na-Al Type 1	281	305	5	2	40	0.5	378	19	34	4
20523	Blue bead	m-Na-Al Type 1	339	559	7	5	1	1	1295	30	50	5
20519	orange bead	m-Na-Al Type 1	525	193	7	1	6	1	664	34	60	8
19501	blue coiled bead	lead glass	35	10	1	42	667	0.5	30	3	5	1
20009	blue flattened bicone bead	lead glass	31	4	0.2	37	309	0.2	17	1	3	0.3
20512	yellow bead	lead glass	13	2	0.5	94	1076	0.2	25	2	6	0.3
24505	blue coiled bead	lead glass	27	4	0.3	24	504	0.1	17	2	3	0.4
15506cob	cobalt blue bead	m-Na-Ca-Al	319	186	3	1	1	0.2	1602	13	131	4
18	blue bangle fragment?	v-Na-Ca	458	39	1	1	16	0.2	155	5	9	1
18014	transparent blue-green vessel glass	v-Na-Ca	568	106	3	0.2	1	0.2	293	8	18	2
20514	orange disc bead	mixed alkali	94	54	7	13	14	6	357	16	32	4
393	large green glass bead	unknown	319	121	5	3	17	0.2	158	7	20	3
4	large clear glass bead	unknown	269	263	7	0.4	1	0.2	125	5	10	2

TABLE 9:4 *The composition of the glass samples from Ban Non Wat expressed as parts per million* (cont.)

Cat. no.	Description	Glass Type	Ta	Au	Y	Bi	U	W	Mo	Nd	Sm	Eu
5090	Blue glass fragment	m-K-Ca-Al	0.3	1	6	2	1	1	40	8	2	0.3
17673	Blue earring fragment	m-K-Ca-Al	0.2	0.1	7	1	1	1	34	8	2	0.3
17671	Blue earring fragment	m-K-Ca-Al	0.2	0.2	7	1	1	1	47	8	2	0.3
19013	Blue earring fragment	m-K-Ca-Al	0.2	0.1	8	1	1	2	74	8	2	0.3
15506	red bead	m-Na-Al Type 1	0.4	0.3	13	3	7	0.4	1	15	3	1
15506	orange bead	m-Na-Al Type 1	0.5	0.2	11	12	5	0.3	5	19	3	1
15506	yellow bead	m-Na-Al Type 1	1	0.0	10	0.2	4	0.4	2	19	3	1
15506	turquoise bead	m-Na-Al Type 1	1	0.4	15	0.4	11	1	1	17	3	1
15506	dark blue bead	m-Na-Al Type 1	1	1	9	3	5	0.4	1	18	3	1
15506	black bead	m-Na-Al Type 1	1	0.4	12	0.2	9	1	2	31	5	1
15506	white bead	m-Na-Al Type 1	0.4	0.4	18	0.1	3	1	1	19	3	1
20002	yellow bead	m-Na-Al Type 1	0.4	0.1	15	7	19	0.3	1	16	3	1
20523	Blue bead	m-Na-Al Type 1	0.4	0.2	8	1	7	0.2	1	17	3	1
20519	orange bead	m-Na-Al Type 1	0.5	1	15	0.3	5	0.3	2	27	5	1
19501	blue coiled bead	lead glass	0.1	0.4	3	12	0.4	0.2	1	2	0.5	0.1
20009	blue flattened bicone bead	lead glass	0.0	0.1	2	2	0.1	0.1	0.2	1	0.2	0.0
20512	yellow bead	lead glass	0.1	0.1	1	319	0.1	0.4	1	1	0.2	0.0
24505	blue coiled bead	lead glass	0.1	0.5	2	2	0.2	0.2	1	1	0.4	0.1
15506cob	cobalt blue bead	m-Na-Ca-Al	0.4	0.5	11	1	21	1	3	13	3	1
18	blue bangle fragment?	v-Na-Ca	0.2	1	4	0	1	1	2	3	1	0.3
18014	transparent blue-green vessel glass	v-Na-Ca	0.2	0.0	6	0	1	1	10	7	2	0.3
20514	orange disc bead	mixed alkali	1	0.2	13	20	14	4	13	13	3	0.5
393	large green glass bead	unknown	0.4	0.0	10	3	1	1	1	10	2	1
4	large clear glass bead	unknown	1	1	5	0.5	2	1	1	4	2	0.4

TABLE 9:4 *The composition of the glass samples from Ban Non Wat expressed as parts per million* (cont.)

Cat. no.	Description	Glass Type	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
5090	Blue glass fragment	m-K-Ca-Al	1	0.3	2	0.2	1	0.2	1	0.2	2	3
17673	Blue earring fragment	m-K-Ca-Al	1	0.2	1	0.2	1	0.1	1	0.1	3	5
17671	Blue earring fragment	m-K-Ca-Al	1	0.2	1	0.3	1	0.1	1	0.1	2	4
19013	Blue earring fragment	m-K-Ca-Al	1	0.2	1	0.3	1	0.1	1	0.1	2	4
15506	red bead	m-Na-Al Type 1	3	0.4	2	0.4	1	0.2	2	0.3	10	5
15506	orange bead	m-Na-Al Type 1	2	0.4	2	0.4	1	0.2	1	0.2	8	6
15506	yellow bead	m-Na-Al Type 1	2	0.3	2	0.4	1	0.2	1	0.2	14	14
15506	turquoise bead	m-Na-Al Type 1	2	0.4	2	1	2	0.2	2	0.3	14	6
15506	dark blue bead	m-Na-Al Type 1	2	0.3	2	0.3	1	0.2	1	0.2	13	14
15506	black bead	m-Na-Al Type 1	4	0.5	3	0.4	2	0.2	2	0.3	25	20
15506	white bead	m-Na-Al Type 1	2	0.5	3	1	2	0.3	2	0.4	5	5
20002	yellow bead	m-Na-Al Type 1	3	0.4	3	1	2	0.2	2	0.2	9	8
20523	Blue bead	m-Na-Al Type 1	2	0.3	1	0.3	1	0.1	1	0.2	16	14
20519	orange bead	m-Na-Al Type 1	4	0.5	3	1	1	0.2	1	0.2	5	7
19501	blue coiled bead	lead glass	0.4	0.1	0.5	0.1	0.3	0.03	0.2	0.0	0.3	1
20009	blue flattened bicone bead	lead glass	0.3	0.0	0.3	0.1	0.2	0.02	0.1	0.0	0.1	0.3
20512	yellow bead	lead glass	0.2	0.0	0.1	0.0	0.1	0.01	0.1	0.0	0.1	1
24505	blue coiled bead	lead glass	0.4	0.1	0.4	0.1	0.4	0.1	1	0.1	0.4	0.3
15506cob	cobalt blue bead	m-Na-Ca-Al	3	0.5	3	0.4	2	0.3	2	0.4	4	4
18	blue bangle fragment?	v-Na-Ca	1	0.2	1	0.2	1	0.3	1	0.2	2	1
18014	transparent blue-green vessel glass	v-Na-Ca	1	0.2	1	0.2	1	0.1	1	0.2	3	2
20514	orange disc bead	mixed alkali	2	0.4	2	0.5	1	0.2	1	0.2	2	8
393	large green glass bead	unknown	2	0.4	2	0.4	1	0.2	1	0.2	3	4
4	large clear glass bead	unknown	2	0.2	1	0.4	1	0.3	1	0.4	6	5

TABLE 9:5 *The percentage composition of the glass samples from Noen U-Loke*

ID	Description	Glass Type	SiO_2	Na_2O	MgO	Al_2O_3	P_2O3	K_2O
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	75.2	0.9	0.4	4.4	0.1	14.6
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	79.4	0.5	0.2	3.3	0.1	13.3
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	78.3	0.8	0.3	2.8	0.1	13.9
016	Dark blue-purple broken bead	m-K-Ca-Al	75.4	1.4	0.5	1.9	0.3	13.8
001	Brown/Black transparent broken bead	m-Na-Al Type 1	65.6	14.5	0.8	9.6	0.2	2.0
002	Yellow opaque broken bead	m-Na-Al Type 1	63.6	13.5	0.5	9.9	0.1	1.9
004	Transparent grey broken bead	m-Na-Al Type 1	63.5	18.2	0.3	9.5	0.0	2.4
008	Turquoise broken bead	m-Na-Al Type 1	68.1	16.8	0.3	6.8	0.0	1.7
009	Dark blue broken bead	m-Na-Al Type 1	60.5	19.8	0.3	10.2	0.1	1.9
012	White trans broken	m-Na-Al Type 1	70.0	14.2	0.5	8.5	0.0	2.1
013	Turquoise bead	m-Na-Al Type 1	67.9	16.3	0.4	7.2	0.0	2.4
014	Transparent blue-green bead	m-Na-Al Type 1	66.5	17.3	0.3	7.0	0.1	2.0
019	Opaque yellow bead	m-Na-Al Type 1	60.4	15.0	0.5	11.3	0.0	2.0
020	Turquoise bead	m-Na-Al Type 1	66.3	15.2	0.3	10.3	0.0	3.4
021	Turquoise bead	m-Na-Al Type 1	67.0	18.3	0.3	7.1	0.0	1.7
022	Turquoise bead	m-Na-Al Type 1	72.5	15.3	0.3	6.3	0.0	1.3
023	red/orange bead: orange glass	m-Na-Al Type 1	57.3	12.5	1.0	12.6	0.2	1.9
023	red/orange bead: red glass	m-Na-Al Type 1	64.7	12.8	0.9	12.2	0.1	1.9
024	red/orange bead: orange glass	m-Na-Al Type 1	56.8	12.9	1.0	13.0	0.2	1.7
024	red/orange bead: red glass	m-Na-Al Type 1	69.0	11.8	0.8	9.1	0.1	1.9
025	red/orange bead: orange glass	m-Na-Al Type 1	57.6	12.3	1.0	11.8	0.2	1.9
025	red/orange bead: red glass	m-Na-Al Type 1	64.1	12.3	0.9	12.3	0.1	2.1
026	red/orange bead: orange glass	m-Na-Al Type 1	57.8	12.7	0.9	12.1	0.2	1.7
026	red/orange bead: red glass	m-Na-Al Type 1	65.7	11.9	0.8	10.9	0.1	1.8
027	red/orange bead: orange glass	m-Na-Al Type 1	57.3	11.9	1.0	12.1	0.2	2.0
027	red/orange bead: red glass	m-Na-Al Type 1	63.0	12.1	0.9	12.8	0.1	2.2
003	Blue trans broken	m-Na-Ca-Al	73.1	14.6	0.3	3.9	0.1	0.8
015	dark Blue Trans Broken	m-Na-Ca-Al	71.6	11.7	0.6	5.0	0.1	1.3
005	dark Blue Trans Broken	m-Na-Ca-Al	66.5	15.9	0.3	6.5	0.0	1.4
007	dark Blue Trans Broken	m-Na-Ca-Al	65.7	18.5	0.3	7.3	0.0	1.9
028	opaque orange tubular bead	mixed alkali	61.7	5.9	2.2	6.8	1.6	7.7
030	opaque orange disc bead	mixed alkali	59.4	8.2	2.0	6.7	1.6	7.1

TABLE 9:5 *The percentage composition of the glass samples from Noen U-Loke* (cont.)

ID	Description	Glass Type	CaO	MnO	Fe_2O_3	CuO	SnO_2	PbO_2
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	1.0	1.4	1.3	0.1	0.0	0.2
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	0.6	1.1	1.3	0.1	0.0	0.0
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	0.8	1.3	1.2	0.2	0.0	0.1
016	Dark blue-purple broken bead	m-K-Ca-Al	2.1	2.6	1.6	0.0	0.0	0.0
001	Brown/Black transparent broken bead	m-Na-Al Type 1	4.3	0.1	1.9	0.1	0.0	0.1
002	Yellow opaque broken bead	m-Na-Al Type 1	3.5	0.1	1.6	0.0	0.6	4.1
004	Transparent grey broken bead	m-Na-Al Type 1	2.4	0.3	1.5	0.7	0.0	0.2
008	Turquoise broken bead	m-Na-Al Type 1	2.1	0.1	1.1	1.9	0.2	0.5
009	Dark blue broken bead	m-Na-Al Type 1	2.4	0.1	1.1	1.6	0.3	0.6
012	White trans broken	m-Na-Al Type 1	2.2	0.1	1.8	0.0	0.0	0.0
013	Turquoise bead	m-Na-Al Type 1	2.7	0.2	1.4	0.9	0.1	0.1
014	Transparent blue-green bead	m-Na-Al Type 1	2.3	0.1	1.3	2.1	0.3	0.5
019	Opaque yellow bead	m-Na-Al Type 1	3.0	0.0	1.1	0.0	1.3	4.9
020	Turquoise bead	m-Na-Al Type 1	1.9	0.0	0.8	0.9	0.1	0.1
021	Turquoise bead	m-Na-Al Type 1	2.5	0.2	1.3	0.9	0.1	0.1
022	Turquoise bead	m-Na-Al Type 1	1.4	0.3	1.0	1.0	0.0	0.0
023	red/orange bead: orange glass	m-Na-Al Type 1	3.9	0.1	2.8	4.6	0.5	2.3
023	red/orange bead: red glass	m-Na-Al Type 1	3.5	0.1	2.4	0.8	0.0	0.2
024	red/orange bead: orange glass	m-Na-Al Type 1	4.0	0.1	2.9	4.4	0.7	1.9
024	red/orange bead: red glass	m-Na-Al Type 1	2.7	0.1	2.2	1.3	0.1	0.4
025	red/orange bead: orange glass	m-Na-Al Type 1	4.0	0.1	2.8	5.0	0.5	2.4
025	red/orange bead: red glass	m-Na-Al Type 1	3.4	0.1	2.6	1.6	0.1	0.2
026	red/orange bead: orange glass	m-Na-Al Type 1	3.8	0.1	2.7	4.7	0.7	2.3
026	red/orange bead: red glass	m-Na-Al Type 1	3.9	0.1	2.5	1.6	0.1	0.2
027	red/orange bead: orange glass	m-Na-Al Type 1	4.1	0.1	2.7	5.0	0.6	2.5
027	red/orange bead: red glass	m-Na-Al Type 1	3.6	0.1	2.8	1.7	0.1	0.2
003	Blue trans broken	m-Na-Ca-Al	5.2	0.4	0.5	0.0	0.0	0.0
015	Dark Blue Trans Broken	m-Na-Ca-Al	5.9	1.4	1.2	0.1	0.0	0.0
005	Dark Blue Trans Broken	m-Na-Ca-Al	2.3	0.5	1.2	0.9	0.7	3.3
007	Dark Blue Trans Broken	m-Na-Ca-Al	2.5	0.7	1.2	0.8	0.2	0.5
028	opaue orange tubular bead	mixed alkali	2.5	0.4	3.5	7.2	0.2	0.1
030	opaque orange disc bead	mixed alkali	2.8	0.5	3.7	7.2	0.2	0.1

TABLE 9:5 *The composition of the glass samples from Noen U-Loke expressed as parts per million*

ID	Description	Glass Type	Li	Be	B	Sc	Ti	V	Cr	Ni	Co	Zn
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	24	1	95	5	1059	45	15	47	275	14
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	17	2	99	4	795	55	9	47	406	3
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	20	1	86	4	742	51	2	66	410	5
016	Dark blue-purple broken bead	m-K-Ca-Al	13	4	128	9	714	80	14	108	642	3
001	Brown/Black transparent broken bead	m-Na-Al Type 1	8	1	30	4	3058	67	31	13	6	4
002	Yellow opaque broken bead	m-Na-Al Type 1	11	2	17	4	3027	63	24	8	5	6
004	Transparent grey broken bead	m-Na-Al Type 1	11	1	22	3	3543	58	27	18	9	13
008	Turquoise broken bead	m-Na-Al Type 1	9	1	23	3	2493	63	19	10	6	41
009	Dark blue broken bead	m-Na-Al Type 1	18	2	51	3	2650	77	13	21	11	13
012	White trans broken	m-Na-Al Type 1	9	1	21	4	6024	64	47	9	7	5
013	Turquoise bead	m-Na-Al Type 1	12	3	23	5	2627	66	27	17	7	9
014	Transparent blue-green bead	m-Na-Al Type 1	9	2	18	4	2733	67	22	22	8	104
019	Opaque yellow bead	m-Na-Al Type 1	10	1	24	4	1544	90	12	8	3	3
020	Turquoise bead	m-Na-Al Type 1	19	2	28	2	2004	68	11	11	4	8
021	Turquoise bead	m-Na-Al Type 1	10	1	23	3	2449	62	13	16	6	7
022	Turquoise bead	m-Na-Al Type 1	15	1	110	3	2482	45	25	11	5	34
023	red/orange bead: orange glass	m-Na-Al Type 1	11	1	44	7	2535	100	50	126	23	328
023	red/orange bead: red glass	m-Na-Al Type 1	12	1	54	7	2630	90	46	20	9	16
024	red/orange bead: orange glass	m-Na-Al Type 1	13	1	45	8	2613	102	47	107	25	250
024	red/orange bead: red glass	m-Na-Al Type 1	13	1	94	5	3269	81	46	38	13	31
025	red/orange bead: orange glass	m-Na-Al Type 1	12	1	43	7	2475	96	46	132	27	295
025	red/orange bead: red glass	m-Na-Al Type 1	12	1	51	7	2614	97	48	39	11	13
026	red/orange bead: orange glass	m-Na-Al Type 1	12	1	36	7	2702	103	49	99	31	227
026	red/orange bead: red glass	m-Na-Al Type 1	11	1	46	7	2831	121	52	40	11	22
027	red/orange bead: orange glass	m-Na-Al Type 1	12	1	42	7	2547	97	48	132	26	282
027	red/orange bead: red glass	m-Na-Al Type 1	12	1	51	8	2794	101	50	40	12	14
003	Blue trans broken	m-Na-Ca-Al	11	1	82	2	725	53	7	51	267	20
015	dark Blue Trans Broken	m-Na-Ca-Al	26	3	75	6	1670	55	12	112	677	7
005	dark Blue Trans Broken	m-Na-Ca-Al	12	1	16	3	2618	64	18	30	234	23
007	dark Blue Trans Broken	m-Na-Ca-Al	13	1	22	3	2604	69	18	24	157	22
028	opaque orange tubular bead	mixed alkali	29	2	44	6	1371	43	16	183	87	251
030	opaque orange disc bead	mixed alkali	27	2	50	6	1410	44	18	157	85	238

TABLE 9:5 *The composition of the glass samples from Noen U-Loke expressed as parts per million* (cont.)

ID	Description	Glass Type	As	Rb	Sr	Zr	Nb	Ag	Sb	Cs	Ba	La
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	384	51	155	5	1	0.1	1	4	1840	16
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	318	34	107	4	1	0.1	2	1	799	11
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	310	38	108	3	1	0.1	1	2	889	13
016	Dark blue-purple broken bead	m-K-Ca-Al	114	127	31	3	3	4	4	4	3314	12
001	Brown/Black transparent broken bead	m-Na-Al Type 1	52	415	519	7	2	0.1	0.3	1	723	25
002	Yellow opaque broken bead	m-Na-Al Type 1	50	447	474	7	7	0.1	0.5	0.5	785	29
004	Transparent grey broken bead	m-Na-Al Type 1	60	431	730	11	14	0.1	5	0.5	1719	48
008	Turquoise broken bead	m-Na-Al Type 1	30	258	350	6	16	0.3	9	0.4	443	16
009	Dark blue broken bead	m-Na-Al Type 1	30	497	478	8	28	0.3	5	0.3	867	20
012	White trans broken	m-Na-Al Type 1	54	308	685	15	0.4	0.1	0.3	0.4	650	34
013	Turquoise bead	m-Na-Al Type 1	59	284	556	9	8	1	6	1	726	23
014	Transparent blue-green bead	m-Na-Al Type 1	40	263	627	8	18	1	73	1	483	25
019	Opaque yellow bead	m-Na-Al Type 1	35	569	278	4	2	2	0.2	0.4	1033	23
020	Turquoise bead	m-Na-Al Type 1	78	382	392	6	4	0.1	1	0.3	1629	36
021	Turquoise bead	m-Na-Al Type 1	38	257	488	6	10	0.1	5	0.4	712	21
022	Turquoise bead	m-Na-Al Type 1	28	178	574	7	2	0.1	1	0.4	481	31
023	red/orange bead: orange glass	m-Na-Al Type 1	49	473	333	7	33	0.1	94	1	635	31
023	red/orange bead: red glass	m-Na-Al Type 1	47	438	392	7	31	0.1	5	1	596	28
024	red/orange bead: orange glass	m-Na-Al Type 1	40	515	371	7	41	0.2	184	1	683	34
024	red/orange bead: red glass	m-Na-Al Type 1	38	361	555	8	61	0.1	15	1	607	29
025	red/orange bead: orange glass	m-Na-Al Type 1	54	489	343	7	43	1	124	1	637	30
025	red/orange bead: red glass	m-Na-Al Type 1	48	455	387	7	68	0.1	8	1	636	30
026	red/orange bead: orange glass	m-Na-Al Type 1	41	477	416	7	64	2	94	1	661	33
026	red/orange bead: red glass	m-Na-Al Type 1	42	418	421	7	80	0.1	8	1	589	29
027	red/orange bead: orange glass	m-Na-Al Type 1	61	508	371	7	39	0.2	131	1	680	33
027	red/orange bead: red glass	m-Na-Al Type 1	59	484	420	7	66	0.1	8	1	684	33
003	Blue trans broken	m-Na-Ca-Al	11	381	147	2	0.2	0.1	0.3	0.2	839	8
015	dark Blue Trans Broken	m-Na-Ca-Al	21	443	287	7	1	1	2	1	1564	19
005	dark Blue Trans Broken	m-Na-Ca-Al	29	268	521	6	31	0.5	8	0.3	834	19
007	dark Blue Trans Broken	m-Na-Ca-Al	44	318	462	6	49	0.3	9	1	1018	20
028	opaque orange tubular bead	mixed alkali	163	76	46	7	13	1	16	7	396	15
030	opaque orange disc bead	mixed alkali	157	90	58	8	13	1	12	7	408	17

TABLE 9:5 *The composition of the glass samples from Noen U-Loke expressed as parts per million* (cont.)

ID	Description	Glass Type	Ce	Pr	Ta	Au	Y	Bi	U	W	Mo	Nd	Sm
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	67	4	0.3	0.2	12	0.2	1	0.4	4	12	3
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	75	3	0.2	0.4	10	0.1	1	0.3	1	10	3
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	93	4	0.3	0.2	11	1	1	0.5	1	14	3
016	Dark blue-purple broken bead	m-K-Ca-Al	152	4	1	1	10	1	2	1	43	13	5
001	Brown/Black transparent broken bead	m-Na-Al Type 1	45	5	1	0.3	17	0.1	11	0.3	1	18	4
002	Yellow opaque broken bead	m-Na-Al Type 1	49	6	0.4	0.2	15	0.1	8	0.2	0.4	20	4
004	Transparent grey broken bead	m-Na-Al Type 1	74	7	1	0.4	9	1	6	0.4	1	22	3
008	Turquoise broken bead	m-Na-Al Type 1	30	3	0.4	0.2	11	2	22	0.2	1	12	2
009	Dark blue broken bead	m-Na-Al Type 1	45	4	1	1	9	1	14	0.1	1	15	3
012	White trans broken	m-Na-Al Type 1	61	7	1	0.2	11	0.1	6	0.4	0.5	26	5
013	Turquoise bead	m-Na-Al Type 1	39	6	2	1	18	6	8	2	2	18	5
014	Transparent blue-green bead	m-Na-Al Type 1	46	6	1	0.5	13	15	7	1	2	17	4
019	Opaque yellow bead	m-Na-Al Type 1	37	5	1	0.1	9	0.2	10	0.4	0.4	19	3
020	Turquoise bead	m-Na-Al Type 1	59	6	0.4	0.3	9	0.4	6	0.1	1	20	3
021	Turquoise bead	m-Na-Al Type 1	35	4	0.4	0.3	16	6	6	0.3	1	16	3
022	Turquoise bead	m-Na-Al Type 1	51	6	0.4	0.4	10	1	10	0.3	1	18	3
023	red/orange bead: orange glass	m-Na-Al Type 1	60	7	0.5	0.3	13	17	6	0.4	3	25	5
023	red/orange bead: red glass	m-Na-Al Type 1	51	6	0.5	0.0	13	0.5	7	0.3	2	22	4
024	red/orange bead: orange glass	m-Na-Al Type 1	65	8	0.5	0.3	14	11	10	0.3	4	28	5
024	red/orange bead: red glass	m-Na-Al Type 1	50	7	1	0.4	15	1	6	0.4	2	23	4
025	red/orange bead: orange glass	m-Na-Al Type 1	57	7	0.4	0.2	13	16	7	0.3	3	25	5
025	red/orange bead: red glass	m-Na-Al Type 1	55	7	0.5	0.2	13	1	6	0.3	2	25	5
026	red/orange bead: orange glass	m-Na-Al Type 1	64	8	0.5	0.2	14	21	7	0.4	3	27	5
026	red/orange bead: red glass	m-Na-Al Type 1	52	6	0.4	0.1	14	1	6	0.3	2	23	4
027	red/orange bead: orange glass	m-Na-Al Type 1	61	8	0.5	1	14	17	7	0.4	2	27	5
027	red/orange bead: red glass	m-Na-Al Type 1	61	7	0.5	0.2	15	1	8	0.4	3	26	5
003	Blue trans broken	m-Na-Ca-Al	65	2	0.3	0.3	8	0.1	25	0.4	2	8	2
015	dark Blue Trans Broken	m-Na-Ca-Al	140	5	1	0.1	15	1	13	1	4	17	5
005	dark Blue Trans Broken	m-Na-Ca-Al	59	4	0.5	1	13	4	7	0.4	1	14	3
007	dark Blue Trans Broken	m-Na-Ca-Al	66	5	0.4	2	11	3	6	0.3	1	16	3
028	opaue orange tubular bead	mixed alkali	31	4	1	0.2	13	22	17	4	10	13	3
030	opaque orange disc bead	mixed alkali	38	4	1	0.4	15	16	21	4	10	15	3

TABLE 9:5 *The composition of the glass samples from Noen U-Loke expressed as parts per million* (cont.)

ID	Description	Glass Type	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Hf	Th
006	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	1	2	0.4	2	1	1	0.2	2	0.3	4	4
010	Dark blue broken bead	m-K-Al, low CaO or m-K-Ca-Al	1	2	0.4	2	0.4	1	0.2	1	0.2	2	3
029	Dark blue bead	m-K-Al, low CaO or m-K-Ca-Al	1	3	0.4	3	1	2	0.2	1	0.2	3	3
016	Dark blue-purple broken bead	m-K-Ca-Al	2	3	2	4	2	3	1	3	1	2	3
001	Brown/Black transparent broken bead	m-Na-Al Type 1	1	3	1	3	1	2	0.3	2	0.3	13	7
002	Yellow opaque broken bead	m-Na-Al Type 1	1	3	0.5	2	1	2	0.2	2	0.3	13	7
004	Transparent grey broken bead	m-Na-Al Type 1	1	2	0.3	1	0.3	1	0.1	1	0.2	19	19
008	Turquoise broken bead	m-Na-Al Type 1	1	2	0.3	2	0.4	1	0.2	1	0.3	9	7
009	Dark blue broken bead	m-Na-Al Type 1	1	2	0.3	2	0.4	1	0.2	1	0.2	12	9
012	White trans broken	m-Na-Al Type 1	1	3	0.4	2	0.4	1	0.2	1	0.2	17	16
013	Turquoise bead	m-Na-Al Type 1	2	4	2	4	2	3	2	4	2	17	9
014	Transparent blue-green bead	m-Na-Al Type 1	1	3	1	3	1	2	1	2	1	17	14
019	Opaque yellow bead	m-Na-Al Type 1	1	3	0.4	2	0.4	1	0.2	1	0.1	9	8
020	Turquoise bead	m-Na-Al Type 1	1	2	0.3	2	0.3	1	0.1	1	0.1	11	20
021	Turquoise bead	m-Na-Al Type 1	1	3	0.4	3	1	2	0.2	2	0.2	13	7
022	Turquoise bead	m-Na-Al Type 1	1	2	0.3	2	0.4	1	0.2	1	0.2	14	18
023	red/orange bead: orange glass	m-Na-Al Type 1	1	4	0.5	3	1	2	0.2	1	0.2	10	9
023	red/orange bead: red glass	m-Na-Al Type 1	1	3	0.4	2	0.4	1	0.2	1	0.2	11	9
024	red/orange bead: orange glass	m-Na-Al Type 1	1	4	1	3	1	2	0.3	2	0.2	11	9
024	red/orange bead: red glass	m-Na-Al Type 1	1	3	0.5	3	1	2	0.3	2	0.2	16	9
025	red/orange bead: orange glass	m-Na-Al Type 1	1	3	0.5	3	1	2	0.2	2	0.2	10	10
025	red/orange bead: red glass	m-Na-Al Type 1	1	3	0.4	3	1	2	0.2	1	0.2	11	9
026	red/orange bead: orange glass	m-Na-Al Type 1	1	3	0.5	3	1	2	0.2	2	0.3	12	10
026	red/orange bead: red glass	m-Na-Al Type 1	1	3	0.5	3	1	1	0.2	1	0.2	11	10
027	red/orange bead: orange glass	m-Na-Al Type 1	1	3	0.5	3	1	1	0.3	2	0.2	11	10
027	red/orange bead: red glass	m-Na-Al Type 1	1	4	1	3	1	2	0.3	2	0.3	13	10
003	Blue trans broken	m-Na-Ca-Al	1	2	0.3	2	0.4	1	0.2	1	0.2	4	4
015	dark Blue Trans Broken	m-Na-Ca-Al	2	4	1	4	1	3	1	3	1	8	6
005	dark Blue Trans Broken	m-Na-Ca-Al	1	2	0.4	2	1	1	0.3	2	0.3	13	6
007	dark Blue Trans Broken	m-Na-Ca-Al	1	3	0.4	2	1	2	0.3	2	0.5	12	7
028	opaue orange tubular bead	mixed alkali	0.4	2	0.3	2	0.4	1	0.2	1	0.2	2	9
030	opaque orange disc bead	mixed alkali	1	3	0.4	3	1	2	0.3	2	0.3	7	9