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Glass bead production in Europe during the 17th century: Elemental analysis of glass material found in London and Amsterdam

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ABSTRACT

This article focuses on the elemental analysis of glass material found at the 17th c. glass bead production site at the Hammersmith Embankment in London, UK, using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). The glass beads manufactured at this site are similar to those found at some North American Native sites. In order to better understand how bead production was organized in Europe and assess the possibility of sourcing glass trade beads found in North America and perhaps Africa, data obtained for the Hammersmith Embankment site are compared to that obtained from the Kg10 site located in Amsterdam, Netherland. This site yielded very similar material also dating from the 17th c. Results, including major, minor and trace elements reveal that the glass at both sites was manufactured according to similar recipes involving soda plant ash purified to different degrees. This recipe was quite likely imported from Venice. Trace elements reveal that sand from different origins was selected. Four different sub-groups were identified in the London samples and three in the Amsterdam samples. This indicates that the glass was not manufactured on site but instead obtained from different primary glass workshops. Although it is possible to distinguish most of the beads from the Hammersmith Embankment from the beads from Kg10, a slight compositional overlap between the sites makes provenance attribution for some types of glass beads difficult.

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1. Introduction

In North America, made-man glass in the form of beads appears at Native sites with the first contacts with Europeans. Excerpts from Christopher Columbus' journal dated between October and December 1492 mention glass beads given as gifts or traded for water, gold and other goods (Brill and Hoffman, 1987; Francis, 1986:32–33). Beads were rapidly included in the repertoire of cultural artifacts favored by the different Native communities able to procure them directly from Europeans or through inter-tribal trade. The ubiquity of glass beads, the variability of the assemblages and the narrow dating of some sites created opportunities to establish chronologies that could be used for the dating of undocumented sites (e.g. Quimby, 1966:82–83; Spector, 1976). The classification system for trade beads in North America established by Kidd and Kidd (1970) later augmented by Karklins (1985a, 1983 and 2012) facilitated reliable bead description and comparison between sites; however, it became rapidly apparent that some beads could not be easily classified due to the lack of distinctiveness of their physical attributes.

Studies based on the measurement of the chemical compositions of the glass provided additional criteria for bead classification. The composition of European glass beads found at Native American sites has been extensively studied early on by means of instrumental neutron activation analysis (INAA) (e.g. Hancock et al., 1994, 2000; Kenyon, et al. 1995; Moreau et al., 2002; Sempowski et al., 2000) and more recently using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) (Burgess and Dussubieux, 2007; Walder, 2013a,b). Despite the large amount of data produced by these different studies, the trade mechanisms that moved the beads from their European production centers to North America and the organization of bead production and trade in Europe is poorly known and the rare attempts to track North American glass beads back to Europe have been limited in their success because of a lack of comparative data for contemporaneous European material.

While Venice is generally considered to have been the principal producer of glass beads for the world market during the early post-medieval period, other European countries produced them as well. A well-documented source is Holland where a number of factories manufactured drawn beads during much of the 17th c. (Baart, 1988; Hulst et al., 2012; Karklins, 1983; Karklins, 1985b). In 2001 and 2005, excavators from the Museum of London Archaeology uncovered the remains of two furnaces with associated glass beads and production wasters at the Hammersmith Embankment in West London. Attributed

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to the second quarter of the 17th c., this site provides the first concrete evidence for the production of drawn glass beads in England during the post-medieval period (Jamieson, 2006; Karklins et al., 2015). Visually, the bead styles from the Hammersmith site are very similar to those from the factory sites in Holland and those from contemporary Native American sites in eastern North America (Karklins, 2015, pers. obs.). In order to determine if there are any significant differences in the glass compositions of the beads from these different sources, LA-ICP-MS was used to identify the major, minor and trace elements of 37 objects from the Hammersmith Embankment. This report discusses the recorded compositions and compares them to those of 20 glass ornaments and wasters found at the contemporaneous site of Kg10 in Amsterdam.

2. Experimental and samples

2.1. Experimental

The analyses were carried out at The Field Museum in Chicago, USA, using an Analytik Jena inductively coupled plasma-mass spectrometer (ICP-MS) connected to a New Wave UP213 laser for direct introduction of solid samples.

For better sensitivity, helium is used as a gas carrier in the laser. We use the single point analysis mode with a laser beam diameter of 80 μm, operating at 70% of the laser energy (0.2 mJ) and at a pulse frequency of 15 Hz. The ablation is performed without any prior sample preparation. A pre-ablation time of 20 s is set in order, first, to eliminate the transient part of the signal and, second, to be sure that possible surface contamination or corrosion does not affect the results of the analysis.

For each glass sample, the average of four measurements corrected from the blank is considered for the calculation of concentrations. The isotope Si29 was used for internal standardization. Concentrations for major elements, including silica, are calculated assuming that the sum of their concentrations in weight percent in glass is equal to 100% (Gratuze, 1999). Two different series of standards are used to measure major, minor and trace elements. The first series of external standards are standard reference materials (SRM) manufactured by NIST: SRM 610 and SRM 612. Non-certified values were taken from Pearce et al. (1997). The second series of standards were manufactured by Corning. Glasses B and D are glasses that match compositions of ancient glass (Brill, 1999, vol. 2, p. 544).

The detection limits range from 10 ppb to 1 ppm for most of the elements. Accuracy ranges from 5 to 10% depending on the elements and their concentrations. A more detailed account of the performances of this technique can be found in Dussubieux et al. (2009).

2.2. Samples

The glass artifacts from London were selected by Karlis Karklins to be representative in terms of color and object type of the excavated glass assemblage. They come from the Hammersmith Embankment excavations that have not been fully published yet. A more comprehensive description of the beads assemblage from this site is provided in Karklins et al. (2015). This site was formerly the grounds of a large mansion built in the early 17th c. by Sir Nicholas Crisp (ca. 1599–1666). Crisp was a slave trader and Commissioner of the Customs. The site yielded industrial features and among them, furnaces for the production of glass beads. All the beads and bead production tubes were of drawn manufacture (Jamieson, 2006). Thirty-seven objects were analyzed. Forty-nine measurements were carried out as some artifacts were polychrome and the composition of the different colored glasses was assessed separately. The analyzed glass objects were either translucent amber, dark blue, purple, colorless, opaque red or white (Table 1, Fig. 1).

For comparative purposes, twenty glass artifacts excavated in Amsterdam at the Kg10 site, located in an area adjacent of the Keizersgracht canal, were also analyzed. The excavation yielded approximately 50,000 glass beads and other glass debris related to glass bead manufacturing along with drinking glass fragments, glass chunks of different colors and crucibles. The site relates to the Two Roses glasshouse which operated from 1621 to 1657 (Karklins et al., 2015:20). Glass material from this site was previously analyzed using INAA (Karklins et al., 2002); however the small number of elements available with this analytical technique (11) greatly limited any comparison with the LA-ICP-MS results. The glass artifacts are listed in Table 2. A few of them are shown in Fig. 2.

3. Results

Full compositions for all the samples, including 54 elements, are presented in Table 3. To determine the types of sand and flux that were mixed together, we considered the reduced compositions of the samples (only the concentrations of SiO_2, Na_2O, MgO, Al_2O_3, CaO, K_2O and Fe_2O_3), eliminating any contribution of coloring or opacifying ingredients, as suggested by Brill (1999, vol. 2, p. 9). After re-calculation, the sum of the concentrations for these constituents is 100% (Table 4).

3.1. The Hammersmith Embankment glass beads

All the glass objects from the Hammersmith Embankment site are composed of soda-lime glass, the most abundant constituents after silica being soda (Na_2O) and lime (CaO). In general, magnesia (MgO) and potash (K_2O) concentrations are higher than 1.5% suggesting the use of halophytic plant ash as a flux. Depending on the soda, lime and other constituent concentrations, four different groups were identified (Fig. 3 and Table 5).

Group 1 encompasses most of the samples. It has an average soda concentration of 13.6% and an average lime concentration of 11.1%. Group 2 is characterized by lower lime concentrations (7.8% on average) and higher soda concentrations (15.6% on average). Group 3 has the highest soda concentrations but also the lowest lime contents. It also has the lowest magnesia concentrations and highest potash concentrations. Group 4 has low soda concentrations (9% on average) but lime concentrations in this group are fairly similar to the concentrations in group 1. This group has the highest alumina concentrations (3.5% on average).

Comparison of glass types 1, 2 and 3 reveals that the soda concentrations in these glasses are higher while the concentrations of lime and magnesia are lower. This may be due to the use of different types of soda plant ash or the use of soda plant ash with different degrees of purity.

The variation of trace element concentrations for such elements as zirconium and niobium, two elements expected to be associated with the sand, exhibits different trends with a correlation for groups 4 and 1 distinct from that of groups 2 and 3 (Fig. 4). From a general point of view and independently of the considered groups, results show that zirconium always correlates positively with a large range of elements including aluminum, titanium or the rare earth elements. Niobium correlates systematically with tantalum, both elements being found in minerals of the pyrochlore type. This suggests the use of at least two types of sand containing different types of minerals.

Group 1 contains samples of all colors except purple. Group 2 includes dark blue glass and one purple bead. Group 3 includes 5 purple beads while group 4 includes one dark blue and two white specimens. Beads with fairly similar typologies are in different glass groups.

Two glass beads are amber colored. They do not contain any element in a sufficiently high concentration that could explain the color. The presence of sulfur (not measured using LA-ICP-MS) can lead to the Fe^{3+}–S_n^{2-} group that will impart an amber to dark color to the glass (Schreurs and Brill, 1984).

LON009xB appears turquoise blue, a color that usually indicates the presence of copper. Yet this sample contained only 0.05% copper. No other element in particularly high concentration (such as cobalt) is present in this glass, but it does contain significant concentrations of

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