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Late antique glass distribution and consumption in Cyprus: a chemical study

Andrea Ceglia [a, b, c, *], Peter Cosyns [c], Karin Nys [c], Herman Terryn [a], Hugo Thienpont [b], Wendy Meulebroeck [b]

[a] Department of Electrochemical and Surface Engineering, SURF Research Group, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium
[b] Department of Applied Physics and Photonics, Brussels Photonics Team B-PHOT, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium
[c] Department of Art Sciences and Archaeology, MARI Research Group, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium

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ABSTRACT

This paper discusses the composition of the vessel and window glass from three Late Antique Cypriot sites: Yeroskipou, Maroni-Petrera and Kalavasos-Kopetra. Over 170 glass fragments were sampled for quantitative chemical analysis through EPMA measurements. The aim of this work is to establish new insights on the chemical compositions of the glass from Late Antique Cypriot sites to observe the distribution of glass on the island. Furthermore, we compare our dataset with published data of contemporary materials from other regions. Four compositional groups were recognized and correlated to known chemical compositions: Levantine 1, Egypt 1, two types of HIMT glass, HIMTa and HIMTb, while a new group, High Lime Iron Manganese Titanium (HLIMT) has been defined. Glass was supplied to Cypriot glassmakers by both Egyptian and Syro-Palestinian primary producers. Nevertheless, we have observed a specific distribution pattern on the island. In the west, there is about 50:50 ratio between Levantine and Egyptian suppliers. On the contrary, in the central south coast the amount of Egyptian glass drops consistently, in particular in Kalavasos, leaving space to Levantine glass.

1. Introduction

During the first millennium AD, glass production was organized in a hierarchical structure (Freestone et al., 2002b). Primary workshops in the Levant and in Egypt were large production facilities with a capacity of 8–20 tons of glass per batch (Nenna et al., 2000; Freestone et al., 2002b; Thirion-Merle et al., 2003). This glass was then broken into rough blocks and shipped across the entire Empire to supply secondary workshops where it was remelted and shaped into commodities for the consumers' market (Freestone et al., 2002b). Secondary workshops were also responsible for the colouring of the naturally and decolourized glass (Van Der Linden et al., 2009).

This model of glass production assumes that the composition of the glass objects within the entire Roman Empire is related to the primary factory in either the southern Levant or northern Egypt. Characterizing the major and trace elements of glass not only contributes to defining the provenance of the applied raw glass. It also enables to recognize idiosyncratic distribution networks and, consequently, to reconstruct trade routes. At the current state of research, scholars have identified five major compositional groups distributed over the Empire between the 4th and the 7th century AD: Levantine 1, Levantine 2 (Freestone and Hughes, 2000), Egypt 1, Egypt 2 (Gratuze, 1988; Gratuze and Barradon, 1990) and HIMT (i.e. High Iron Manganese Titanium) (Mirti et al., 1993; Freestone, 1994). They are all soda-lime-silica glass, but they have different ratios of major and minor oxides related to the impurity level of the sand and flux exploited.

Although the archaeological evidence points to primary production exclusively in the Near Eastern Mediterranean, we cannot exclude the existence of primary factories in the West. First of all, because the Roman historian Pliny the Elder in his *Naturalis Historia* (c. 70 AD) mentions the existence of primary glass production in Italy, Spain and France. In addition, recent work on Nd isotopic signatures of ancient glasses suggests that Western sand deposits could have been used for certain glasses (Degryse and Schneider, 2008; Ganio et al., 2012; Degryse, 2014).

* Corresponding author. Department of Electrochemical and Surface Engineering, SURF research group, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium.
E-mail addresses: aceglia@vub.ac.be, ceglia@gmail.com (A. Ceglia).

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In Roman and post-Roman times Cyprus was a hub of the trade and commercial routes between the East Mediterranean regions, such as the Levant and Egypt and the rest of the Empire. Research on pottery shows that East Cyprus is connected to the Syro-Palestinian coast, while West Cyprus is more oriented towards the Aegean areas and Egypt (Winther Jacobsen, 2004).

From the glass perspective, this may imply a distinct distribution on the island of raw glass. Still, archaeometrical research on Cypriot glass material has rarely been applied. The only data so far available are the analysis results of 19 glass fragments from vessels and lamps coming from the basilica of Maroni Petrera (Freestone et al., 2002b). The authors determined 13 objects of the Levantine 1 group and four of HIMT glass, while two fragments are of uncertain attribution.

The aim of this paper is to establish new insights on the chemical compositions of the glass from Late Antique Cypriot sites to observe the distribution of glass on the island. Furthermore, we will compare our dataset with published data of contemporary materials from other regions.

In order to verify the existence of a regionally differentiated consumption pattern of raw glass, we compare the major and minor elemental quantification of the glass material from three early Christian basilicas in Cyprus: Agioi Pente at Yeroskipou on the West coast and those at Maroni-Petrera and Kalavasos-Kopetra on the central South coast line.

2. The archaeological sites

The Christian basilica of Agioi Pente in Yeroskipou is located on the West coast in very close proximity to the ancient capital Paphos. The site came to light during road works (Michaelides, 2005) but got heavily damaged by bulldozing and early tomb robbing as well as ploughing. Structures of an early Christian basilica and courtyard with burial area have been discovered. The site is dated between the 5th and the mid 7th century AD and much of the excavated glass can be attributed to lamp and window fragments.

The site of Maroni-Petrera is located at about 3 km from the sea. The excavation yielded a large basilica (≈60 m long) (Manning, 2002). The church was poorly preserved without any evidence of elaborate architectural decoration such as wall paintings and mosaics. On the basis of the coins found on the site, it is estimated that construction took place around the end of the 5th century AD and abandonment in the middle of the 7th century, reportedly a consequence of Arab raids (Manning, 2002).

Kalavasos-Kopetra is situated in proximity to the Vasilikos river and to the small port of Zygi-Petrini, which is at about 4 km. The site underwent a major expansion in the 6th century and it flourished until the mid 7th century. Its economy was based on mining and agriculture. Besides housing complexes, two basilicas and a monastery were found. Built during the 6th century, these structures went through small repair works and renovations until the early 7th century. Around 650 AD fires and collapses are recorded due to the Arab raid (Rautman, 2003).

3. Methodology

Based on the *in situ* optical analysis of about 400 fragments from the three sites we established a link between optical spectra and chemical composition that can be exploited to guide sampling (Ceglia et al., Submitted for publication). For the EPMA chemical analysis we selected 69 glass fragments from the basilica of Yeroskipou, 57 glass fragments from the site of Maroni-Petrera and 53 from Kalavasos-Kopetra, The total of 179 glass samples are believed to be well representative of the chemical groups present at the sites.

The archaeological excavation of Yeroskipou is still unpublished, therefore the description of the contexts is not available and the glass material is not typologically studied. On the contrary, the excavations of Maroni and Kalavasos are detailed in two associated publications which also list a large part of the glass findings. For sake of compatibility, we kept the same labels used in the respective publications, that is SF (small finds) for Maroni-Petrera and KK for Kalavasos-Kopetra. Both references contain all information about dating, contexts and drawings (Manning, 2002; Rautman, 2003).

However, since some of the selected material included unpublished glass fragments stored at the Larnaca District Museum, we had to create new labels for those pieces. For the Maroni material we used the label NSF, standing for new small finds, while for the Kalavasos material only one piece was not published, a bracelet number KK314 (Rautman, 2003, pp. 217–234).

In Supplementary Tables S1 and S2, we report the description and the contexts of the samples selected from Maroni Petrera and Kalavasos Kopetra as published in (Manning, 2002) and (Rautman, 2003).

4. Analysis

For quantitative analysis we used an Electron Probe Micro Analyser (EPMA) CAMECA SX-FIVE equipped with a LaB_6 gun, 5 WDS spectrometer and an EDS Brüker. Quantitative measurements were acquired employing a two-run procedure where we changed current and counting times, while acceleration voltage and beam diameter were kept at 15 kV and 40 μm respectively. For Si, Na, K, Al, Mn, Cl, Mg, Ca, Fe and S, beam current was set to 20 nA and counting times were 10 s both on the sample and the background (except for Na, Si and K for which we measured for 3 s on the peak to avoid alkalis displacement). For minor elements (Cu, Sb, Co, Pb, Zn, P, Ti and Ba) the beam current was set to 300 nA and counting time was 30 s on the peak (60 s for Zn and Cu) and 10 s on the background. We used several mineral and metallic standards: albite (Na, Al, Si), pyroxene (Mg, Ca), pyrite (S), scapolite (Cl), orthoclase (K), haematite (Fe), pyrophanite (Mn,Ti), apatite (P), cobalt (Co), copper (Cu), zinc sulphide (Zn), stibnite (Sb), barium sulphate (Ba) and galena (Pb).

For each sample 10 points were measured and averaged. When the sum was lower than 98% or higher than 102%, the data point was discarded. To test the accuracy of the method, Corning

Table 1
Average values (μ) and standard deviations (σ) of EPMA analysis on reference Corning glasses. The number of measurement on each standard is reported in parenthesis.

	CorA	μ (9)	σ	CorB	μ (10)	σ	CorD	μ (8)	σ
SiO_2	66.56	66.51	0.26	61.55	61.77	0.58	55.24	55.10	0.23
Al_2O_3	1.00	0.97	0.02	4.36	4.35	0.05	5.30	5.30	0.05
Fe_2O_3	1.09	1.05	0.03	0.34	0.34	0.04	0.52	0.47	0.03
TiO_2	0.79	0.70	<0.01	0.09	0.09	<0.01	0.38	0.31	<0.01
MnO	1.00	1.00	0.04	0.25	0.26	0.03	0.55	0.54	0.03
Na_2O	14.30	14.19	0.12	17.00	17.13	0.14	1.20	1.44	0.06
K_2O	2.87	2.80	0.15	1.00	0.99	0.05	11.30	11.02	0.25
MgO	2.66	2.54	0.02	1.03	0.98	0.02	3.94	3.76	0.03
CaO	5.03	5.00	0.10	8.56	8.63	0.07	14.80	14.59	0.17
Cl	0.09	0.11	0.01	0.16	0.16	0.02	0.16	0.17	<0.01
SO_3	0.13	0.16	0.03	0.45	0.51	0.04	0.19	0.20	0.02
P_2O_5	0.13	0.12	<0.01	0.82	0.90	0.03	3.93	4.04	0.01
CoO	0.17	0.19	<0.01	0.04	0.05	<0.01	0.02	0.02	<0.01
CuO	1.20	1.09	0.01	2.66	2.48	0.02	0.36	0.16	<0.01
BaO	0.47	0.51	<0.01	0.09	0.07	0.01	0.30	0.29	<0.01
Sb_2O_5	1.75	1.71	0.02	0.46	0.44	<0.01	0.84	0.82	0.01
PbO	0.10	0.07	<0.01	0.50	0.51	0.01	0.25	0.23	0.01
ZnO	0.05	0.04	<0.01	0.19	0.18	<0.01	0.14	0.17	<0.01
Total	99.39	98.76		99.55	99.84		99.42	98.62	