Journal of Archaeological Science: Reports 11 (2017) 647–657

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Mosaic tesserae from Italy and the production of Mediterranean coloured glass (4th century BCE–4th century CE). Part II: Isotopic provenance

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ARTICLE INFO

Article history:
Received 1 August 2016
Received in revised form 23 December 2016
Accepted 23 December 2016
Available online xxxx

Keywords:
Roman glass tesserae
Punic glass
Neodymium isotopes
Strontium isotopes
Roman glass provenance
Roman glass compositional types

ABSTRACT

We have investigated the provenance of highly coloured Roman glass from Italy by determining strontium and neodymium isotope signatures. The results suggest that the main production area was the Levantine coast and that other potential areas are the central-western Mediterranean and possibly Egypt. The Levantine isotopic values are variable, possibly attesting to the existence of sub-zones; they overlap with values from Apulia and Basilicata in Italy. Mosaic tesserae and raw glasses have been compared with other isotope values and this suggests that colorant-rich raw materials were added at or near primary production sites. The isotopic signature of one glass cake from a 4th–early 3rd century BCE Sardinian wreck suggests that western Roman production might be rooted in the Phoenicio-Punic tradition. We have observed a mis-match between the five chemical types of later natron glass and the isotopic provenance signatures.

1. Introduction

The suggested systems of production and trade of late Hellenistic and early Roman glass are supported by scarce archaeological evidence and the location of the workshops devoted to the primary production of raw glass is largely unknown for this period (Henderson, 2013, 214–223). Early examples of glassmaking furnaces, dating back to the 1st century BCE–1st CE, have been excavated in the Lebanon (Kowatli et al., 2006), while later examples have been found in Egypt, in the 1st––4th century CE (Nenna et al., 2000) and Israel, in the 4th–8th CE (Gorin-Rosen, 2000). The dominant role of the eastern Mediterranean in the primary production of natron glass is noted, during the 1st century CE, by the Latin author Pliny the Elder (Plin., NH, 36. 193–194). However, he mentions the existence of a primary glass industry also in Italy, in the Gulf of Naples, in Spain and Gaul, but without specifying the exact locations. This has never been demonstrated archaeologically, but strontium and neodymium isotope results of colourless Roman glasses has apparently identified the existence of glass-making activity in the western Mediterranean (Degryse and Schneider, 2008; Ganio et al., 2012; Degryse, 2015). Even though we have a few examples of primary glass making furnaces, the locations for the production centres for highly coloured Roman glass is completely unknown.

Studies which determinine neodymium and strontium radiogenic isotopes signatures have demonstrated that this methodology is useful for determining the provenance of archaeological glasses, enabling researchers to trace the geological provenance of silicates (Banner, 2004) and carbonates (Wedepohl and Baumann, 2000) respectively. Recently, published results have started to demonstrate that some glasses which fall into the same chemical group are characterized by different isotopic signatures (Degryse and Schneider, 2008, Ganio et al., 2012), suggesting a different origin from that indicated by the chemical groups. Consequently, isotopic characterization is making an important contribution to our understanding of the dynamics of the ancient glass industry and trade (Degryse and Schneider, 2008; Degryse et al., 2009; Henderson et al., 2010; Ganio et al., 2012; Henderson, 2013, 326–335; Devulder et al., 2014; Degryse, 2015; Blomme et al., 2016).

In this paper, we present strontium and neodymium isotope values for Roman highly coloured glasses, for the first time, in any quantity. We discuss the provenance of coloured glass from Roman Italy, focusing on mosaic tesserae. This gives us the opportunity to consider the isotopic results for different glass colours, whether different colours were made in different areas and the isotopic relationship between coloured mosaic tesserae and raw glass.

Data discussed in part I (Boschetti et al., 2016a) allowed us to identify the colouring and opacifying technologies used for the samples analysed: white glasses are all opacified by calcium antimonate, while yellow and yellow-green glasses by lead antimonate, with the exception of one sample (BS 29), where lead antimonate and lead stannate crystals are used together. Red glasses can be divided in two groups: dull

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http://dx.doi.org/10.1016/j.jasrep.2016.12.032
2352-409X/

red samples, opacified by nanometric particles of cuprous oxide and sealing-wax red samples, opacified by dendritic crystals of cuprous oxide. Translucent glasses are coloured by cobalt, copper, manganese and iron ions, while decolorisation was obtained by introducing manganese oxide. As summarized in Table 2, the majority of the samples are natron glasses, but plant ash glasses and samples with an unusual composition, possibly denoting the addition of plant ashes to a natron raw glass are also attested. This addition of plant ashes could have been functional leading to a lowering of the viscosity and extending the working range of the glass (the literature on this subject is summarized elsewhere: Duckworth et al., 2016, 155).

The processes of colouring and, eventually, recycling must both be considered as potential factors contaminating the primary raw materials or, in the case of adding colourants to a raw glass, the raw glass itself. A discussion on the possible process adopted in antiquity for colouring the glass is helpful in evaluating the possible contamination affecting the composition and the isotopic signature of glass.

The interaction between the ceramic crucibles and natron glass, in relation to the firing temperature is a phenomenon scarcely studied. Presently, the most comprehensive literature is for plant ash Late Bronze Age glasses from Qantir, Egypt (13th century BCE). Here, the practice of adding colourants to a partially formed glass, in ceramic crucibles internally coated by a layer of lime is discussed extensively (Turner, 1954; Pusch and Rehren, 2007, 132–139; Smirniou and Rehren, 2016). This layer is intended as a parting layer, useful to facilitate the extraction of the glass cake from the crucible and also to minimize the interaction between the ceramic and the glass, during thermal treatment. Experimental and analytical works have estimated that glass production at Qantir was organised in two steps (Pusch and Rehren, 2007: p. 149–150): a first firing, at temperatures below 1000 °C, resulting in the partial melting of the batch and a second firing, adding colourants to the partially vitrified glass. This second step occurred at higher temperatures, of between 1000 and 1150 °C. During the first step, the interactions with both the crucible and the parting layer appear very limited. In the second phase, the contamination of the glass can sometimes be observed, as the parting layer partially or completely dissolves in the glass and the internal surface of the ceramic vessel shows signs of interaction.

Despite the lack of archaeological evidence, during the Roman period, the good compositional match between coloured and colourless glass suggests a model, where colourants were added to raw glass. Starting from this assumption, we can estimate a temperature range for this process and, following the results obtained by Rehren and coauthors (Smirniou and Rehren, 2016; Pusch and Rehren, 2007), we can make some hypothesis on the impact of contamination, during colouring. A viscosity test performed on the raw glass BASE (sample B, in Montanari et al., 2014), isotopically analysed here, has shown that this glass reaches the flow point at 962 °C and has an interval of workability comprised between the 685 and 862 °C. According to these data, colouring could have occurred at a relatively low temperature, below 962 °C. For yellow glasses, the temperature of decomposition of lead antimonate crystals in a natron glass matrix would have been needed when the glass is still very viscous, which means, within the interval of workability of the glass (Verità et al., 2013, 33–34).

We can therefore estimate that colouring glass for mosaic tesserae could have occurred at low temperature, resulting in a minimum interaction with the crucible and, if present, with the parting layer. In any case the crucibles used in this period for this process are likely to have been significantly larger. This low temperature accords with the "fabric" of Roman mosaic tesserae, frequently rich in air bubbles and colour streaks. According to these technological observations, we can assume that the impact of contamination, during the colouring process, was likely very limited.

The other factor possibly affecting the composition of coloured glass is the interaction with stone tools used for grinding the raw materials. However, according to what is estimated in literature (Degryse et al., 2015), this contamination is very limited and would not change significantly both the composition and the isotopic signature of the glass.

Finally, as discussed in part I of this paper (Boschetti et al., 2016a), the impact of recycling before, at least, the middle of the 1st century CE, was likely to have been very limited: this was probably a consequence of the relatively small volume of glass circulating before the full establishment of glass-blowing, which occurred around the 50 CE (Boschetti, 2011). Presently, the earliest evidence from Italy of glass cullet in a context of trade is from the wreck Iulia Felix and dates back to the end of the first half of the 3nd century CE (Dell'Amico, 2001). Starting from the 4th century CE, the archaeological evidence shows that glass tesserae were recycled when added as colourants to colourless glass cullet (Boschetti et al., 2016b). The results of chemical analysis performed on our samples (Boschetti et al., 2016a) did not provide evidence for the characteristics of recycling. These factors include increased amounts of alumina or potassium oxide (compared to the values of a typical Roman natron glass composition) and the presence of elements like copper, lead or antimony, in glasses where these elements are not introduced intentionally as colourants and opacifiers (Paynter, 2008).

In this paper, we focus on a variety of research questions:

1. How do our results contribute to ideas about the provenance of Roman glass in general;
2. How do our results contribute to the provenance of natron and plant ash glasses and to any differences in provenance between them;
3. Is there a difference in the provenance between raw and coloured tesserae and vessel glasses;
4. How do isotopic signatures of our natron samples compare to the chemical compositional groups of later glasses (4th–8th century CE) defined in literature as Levantine I and II, HIMT, Egyptian I and Wadi el Natrun (Nenna et al., 1997; Freestone et al., 2000; Freestone et al., 2002) and to published results for Roman colourless glass (Ganio et al., 2012);
5. By comparing the Roman results with a Punic cake of glass, dating to the late 4th–early 3rd century BCE, we address what links, if any, there are between Roman glass making and the earlier Mediterranean tradition.

2. Materials and methods

2.1. Description of the tesserae, un-worked glass and vessel samples

We selected 31 glass samples from well dated archaeological contexts, for isotopic characterization (see Table 1). These had been chemically and microstructurally analysed (Boschetti et al., 2016a, 2016b).

The reason for focusing our research on the Italian peninsula, with Sardinia and Sicily, is so as to trace changes and continuities in the technology and provenance of glass, looking at the centre of the Roman Empire. The lapse of time considered allows us to trace eventual changes across the whole development of the Roman age, starting immediately before Romanisation (in the late 4th–early 3rd century BCE) extending through to the Roman Republic (2nd century–30 BCE) to Late Antiquity (4th century CE), before the collapse of the Roman Empire.

Our earliest sample is a fragment of glass cake from a late 4th–early 3rd BCE Punic wreck which sunk in the Gulf of Oristano, Sardinia, presently the only evidence of unworked glass in a context of trade, in this period. It was included to initiate a comparison between Roman glass-making and the earlier Mediterranean natron glass tradition (the sampling criteria are described extensively in Boschetti et al., 2016a).

Most of the samples are mosaic tesserae (late 2nd BCE–4th CE), including some of the earliest glass tesserae from Sicily and the Italian peninsula (dated to the middle and late 2nd century BCE in the south and to the late 1st BCE in the north), but we also analysed fragments of an opaque red glass cup, an opaque white twisted stirring rod, two chunks of raw glass from Pompeii and Aquileia, a lump of colourless