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A multi-analytical approach for the archaeometric identification of a Roman period glass furnace in the central Nile delta

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ABSTRACT

A circular structure was excavated in a suspected industrial area of ancient Thmuis (Tell Timai), and due to heavy vitrification and discolouration of the inside walls, was suspected to be a glass furnace. The excavated furnace provides a unique example to further understand the mechanisms of primary and secondary glass manufacture in Roman Egypt. Samples were subjected to a number of archaeometric investigations in order to characterise the furnace, and identify its purpose. Following attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy and scanning electron microscope energy dispersive spectroscopy (SEM-EDS), we conclude that the furnace was used for glass. We propose that it is most likely that the furnace represents a small-scale, secondary glassmaking centre, shaping glass manufactured at Wadi el-Natrun, and recycling glass objects from the local area.

1. Introduction

There is limited archaeological evidence for glass-making in Egypt during the Roman period (Nenna et al., 2000), in particular, to the authors' knowledge, no excavations of secondary glass furnaces or workshops in Graeco-Roman Egypt have been published.

A number of primary glass production centres dating to the 4th to 8th centuries have been identified in Syro-Palestine and Egypt (Brill, 1988, 1999; Nenna et al., 2000; Foy and Nenna, 2001; Foy et al., 2000; Freestone et al., 2002, 2000; Picon and Vichy, 2003). Seventeen 8th century rectangular glass furnaces were excavated at Bet Eli'ezer in Israel (Freestone et al., 2000, 2002; Gorin-Rosen, 2000). Four 6th–7th century glass furnaces were also excavated in Israel, at the site of Apollonia (Freestone et al., 2008; Gorin-Rosen, 1995, 2000; Tal et al., 2004). 1st to 2nd century primary production glass furnaces have been excavated at Wadi el Natrun in Egypt (Nenna, 2003, 2007; Nenna et al., 2000, 2005). Later primary glass production furnaces dating from the Imperial period to the 8th century have been excavated near Alexandria, Egypt, at Lake Maryut (Nenna et al., 2000).

Secondary production workshops have been excavated at Sagalassos, Turkey, dating from Imperial to early Byzantine times (Degryse et al., 2006). Glass chunks, slag and kiln fragments were used as evidence to identify the site as a glass workshop. Fragments of a secondary glass furnace (Fig. 1), and evidence for primary glass production have been excavated near Bet Eli'ezer, at the site of Horbat Biz'a (Gorin-Rosen, 2012).

There are many examples of secondary glass production workshops in the western part of the Roman Empire (Foster and Jackson, 2010), but far fewer documented in the eastern part of the Empire (Stern, 2002).

1.1. Egyptian glass during the Roman Empire

In terms of glass manufacture and distribution, it appears that a number of sites around the Roman Empire were primary production centres, distributing glass products or ingots to more prolific secondary production centres for further shaping into finished products. It has been posited that primary production centres, supplying glass to secondary production centres around the empire, were located in the Levant in Israel, based on the discovery of glass furnaces at Bet Eli'ezer and Apolonia (Gorin-Rosen, 2000) and at Alexandria in Egypt (Lucas, 1962).

The archaeological evidence and compositional evidence of glass artefacts and artefacts associated with glass production support this model, based on the uniformity in both form and composition of these artefacts (Freestone et al., 2005; Scott and Degryse, 2014).

Primary glass production sites in Egypt have been identified at Malkata (Keller, 1983), Gurob (Tatton-Brown and Andrews, 1991), Qantir (Rehren and Pusch, 1997), Akhmim (Newberry, 1920), Lisht

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Fig. 1. Fragments of a Roman glass furnace excavated at Horbat Biz'a, Israel (Gorin-Rosen, 2012).

(Keller, 1983), Lake Maryut near Alexandria (Nenna et al., 2000) and Wadi el-Natrun (Nenna et al., 2000).

Secondary production sites would have focussed on creating finished products from ingots produced at primary production sites, as well as recycling glass items from the surrounding areas. As such, secondary production centres were smaller, required lower temperatures for softening glass, and are less frequently associated with other high temperature industries such as metal working and faience, as primary production centres were.

It has been established that, during the Roman Empire, glass from across the Mediterranean, despite being spatially and temporally widely distributed, has a relatively uniform elemental composition (Freestone, 2006; Wedepohl et al., 2011). However in the past ten to 15 years, it has been demonstrated that while the major elemental composition of glasses in the Mediterranean area are relatively uniform, trace elemental composition can be indicative of provenance within the Mediterranean area (Rehren, 2014; Shortland et al., 2007b). Roman glass consisted principally of silica sand ($\approx$75%), natron ($\approx$15%) in order to lower the melting point of the sand, and lime or magnesia ($\approx$10%) to stabilise the naturally soluble glass (Fleming, 1999; Mirti et al., 1993). During Roman times, lime as a stabiliser was found in a large enough quantity in beach sand, due to naturally occurring calcareous materials, to not always require the addition of a stabiliser as a separate ingredient (Freestone, 2006). A number of minerals could be added to the finished glass in order to colour or decolour the final product (Fleming, 1999; Nicholson and Henderson, 2000).

In terms of compositional characterisation of glass from Roman Egypt, very limited work has been produced, and this only recently (Degryse and Schneider, 2008; Rosenow and Rehren, 2014). In their study of Roman and Late Antique glass from Bubastis in northern Egypt, Rehren and Rosenow produce four compositionally distinct groups of glasses from the 87 samples analysed. From the data generated, they conclude that Bubastis, and likewise other glass production centres in Egypt, were integrated into a network of primary and secondary glass production centres throughout the Roman world, but with a preference for locally produced glass. However it is suggested that despite Bubastis' close proximity to Wadi el-Natrun, the glass at Bubastis is not consistent with glass originating at Wadi el-Natrun (Rosenow and Rehren, 2014).

With very little direct evidence of Roman glass production centres, (i.e., identifiable glass furnaces), interpretation on the method of glass production and distribution throughout the Roman Empire is based on surrogate archaeological evidence such as volume of glass artefacts found. Interpretation of a site as a glass production centre can therefore be somewhat problematic. We propose that the structure excavated at Tell Timai has been successfully identified as a Roman period glass furnace for secondary glass production, and as such, is one of very few examples of definitive evidence for a glass production centre in Graeco-Roman Egypt.

1.2. Archaeological context

Tell Timai is the ruins of the Graeco-Roman city of Thmuis in the eastern Nile delta. It is located on the extinct Mendesian branch of the Nile, where it had been established as a port, replacing the nearby port city of Mendes (Tell el-Ruba) when the Mendesian branch of the Nile shifted. The city flourished, reaching its peak in the second century CE, but was abandoned during the Arab period in the 10th century CE (Littman and Silverstein, 2008; Blouin, 2014). Today, Tell Timai survives as a rare example of a relatively well preserved Graeco-Roman city covering an area of approximately 90 ha in the central Nile delta. Survey and excavation have been conducted at the site by the Egyptian Minister of State for Antiquities (formerly the Supreme Council of Antiquities), the University of Hawaii since 2007 and also the Canadian Mission to Thmuis since 2013.

During the 2012 excavation season, a partially subterranean cylindrical brick structure was found in an area tentatively identified as a manufacturing area in the urban core during the 2007 site survey (Littman and Silverstein, 2008), and interpreted as a furnace (Fig. 1). The furnace has a diameter of 115 cm and a depth of 94 cm, cutting through an earlier plaster floor of a domestic structure (Fig. 2). In terms of its size and shape, the structure is consistent with glass furnaces excavated at Tell el-Amarna, which, while they represent glass