

RESEARCH UPDATE

Pattern in Glass Use in the Roman and Byzantine Worlds: A Report on Current Research at the Institute of Archaeology and UCL Qatar

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Introduction

Glass is a solid substance unlike most others. It has no defined crystal structure, that is to say it has no orderly repetition of the same arrangement of atoms over and over again regardless where in the crystal you look. Instead, it has a more variable random distribution of its constituent atoms, giving it a liquid-like structure even though it is mechanically solid. In the ancient world, the main components were broadly the same, namely silica, soda and lime, but in glass made in each particular region they were arranged slightly differently. The same, it could be said, holds true for the way glass production and use was organised throughout most of the first millennium AD. A small number of major glass types may be identified in each archaeological assemblage, termed Roman blue/green, Levantine I, HIMT and so on, but their relative proportions and relationships to each other differ from region to region, from site to site, just as the main components in glass differ in their arrangement wherever you look.

This, however, is as far as the comparison goes, at least for now. The main constituents of the glass material are extremely well defined metal oxides; their origin and individual physical and chemical properties are well understood, as is their effect on the properties of the glass. The main glass production groups, in contrast, are only very approximately defined in their composition, origin and chronological currency. Different scholars use different names for what appear to be identical, at least very similar glass groups, while similar names are being used for seemingly unrelated compositions. The location of production is known for only a very few glass groups, and nearly nothing is known about the distribution processes that ensured a more-or-less steady supply of glass across the Roman and Byzantine Empires, from what appears to be a restricted production region along the eastern Mediterranean coastline. It is as if we know that, yes, most cars are being made somewhere in Japan, Korea, and maybe Indonesia, but for half the cars we don't know where exactly they were made, we have no idea who owns and runs the factories, how they are being supplied with their raw materials, how their product is being marketed and shipped around the globe, and what determines the ebb and flow of individual brands over time. For a commodity as important as glass, in a region

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covering most of the Old World and a period as recent as the first millennium AD this is clearly a less than satisfactory state of affairs.

Current Research at UCL

For the last five years or so, the Institute of Archaeology has played a very active role in advancing research into Roman and Byzantine glass compositions. Much of the formative work of our understanding of the Byzantine glass industry was carried out by Ian Freestone and co-workers (summarised in Freestone 2006, Freestone *et al.* 2009), and the Institute's current *Early Glass Technology Research Network* including members from both the Institute and UCL Qatar tackles the issue head-on. This report aims to give a summary of the latest findings and current developments as they emerge, placing our research into the context of work done elsewhere.

Defining glass groups

Chemically characterising glass groups is fundamental to recognising glass from the same source, and differentiating it from glass from other sources. This ability in turn is essential to any attempt to understand how each glass group contributes to the larger picture. Our working hypothesis for first millennium AD glass-making states that there were a small number of major glass-making centres, all using mineral natron from the Wadi Natrun in northern Egypt and fusing it with their own individual local beach or desert sand. The furnaces employed for this were capable of producing in a single firing slabs of glass weighing up to twenty tons (Nenna, in press), sufficient to produce in the order of 50,000 to 200,000 glass vessels at a time. Vessel production, however, took place elsewhere. The huge slabs of glass were broken up into chunks the size of a head and shipped to countless secondary kiln sites scattered across the Empire, where the glass was re-molten and blown into vessels serving local or sometimes regional markets (Fig. 1). In addition to the shipment of raw glass, individual artefacts or sets of vessels



Fig. 1: Glass chunks ready for re-melting and blowing into vessels, stored in a pottery vessel in the 6th-7th century workshop at Beth Shean, Israel. (reconstruction displayed in the Israel Museum, Jerusalem; photo Ian Freestone).

also moved long-distance, for instance as gifts, as containers, as souvenirs or specialist trade items. Finally, there was a lively market for recycled glass, as evidenced from the cargo of shipwrecks (Silvestri *et al.* 2008) as well as from historical sources.

The key to distinguishing the primary glass groups lies in the slightly different range of minor minerals of the different sand sources used by each primary producer – not consciously of course, but simply reflecting their local sand composition. We do not know how many individual firings each primary producer undertook per year, but it is reasonable to assume that each batch of four to sixteen tons of sand (the balance to the final weight being the natron added as flux) was slightly different in its mineralogy, and hence minor oxides, from the previous one, within a certain range of composition for each region. Thus, each of the major glass groups will have a certain spread in composition, in stark contrast to the typically very tight compositional ranges for the natural glass, obsidian. So far, none of these major glass groups has been formally defined in terms of ‘necessary’ and ‘acceptable’ compositions. Most case studies develop their own compositional groupings specific for their particular assemblage, sometimes linking them to groups identified

in earlier studies. The graphs developed by Freestone (2002a, 2006) based on CaO vs Al_2O_3 and Fe_2O_3 vs Al_2O_3 , and the associated tables have proved particularly popular for this comparison of glass compositions, and represent at present the 'quasi-reference' groups for much work in the Anglo-Saxon literature, while similar tables published by Foy *et al.* (e.g. 2003) play a similar role in the French literature. Most recently, Gliozzo *et al.* (2013) have correlated numerous glass groups from the literature identifying five major groups as well as several smaller ones, providing an important first step to harmonise group terminology. Similar work is currently done by members of the Institute's *Early Glass Technology Research Network*. Among the most pressing tasks right now is to properly define which compositions are consistent with one of the main glass groups of the mid-first millennium AD, called HIMT, on account of its **H**igh **I**ron **M**anganese and **T**itanium concentrations (Freestone *et al.* 2005; Rehren and Cholakova 2010).

Glass consumption pattern

The glassmaking region along the eastern Mediterranean is traditionally divided into two major 'provinces' – the Syro-Palestine coastline covering modern-day Israel and Lebanon, and the Egyptian region from the western Nile Delta to the northern coast of the Sinai. It is remarkable, but not surprising how glass consumption in these two provinces appears to be restricted to the regionally-produced glass. Across the Levant and as far south as Petra in Jordan there is a dominance of Levantine glass compositions (Schibille *et al.* 2008; Rehren *et al.* 2010), linked to production in sites in modern-day Israel, while in Egypt other glass compositions dominate, most likely linked to local glass-making there (Gratuzé and Baradon 1990; Rosenow and Rehren 2014). Unsurprisingly, settlements on the west coast of the Sinai have a mixture of glass from both provinces (Kato *et al.* 2008). A much more varied supply picture, however, is seen further afield, both in the Mediterranean and the Roman provinces (Freestone *et al.*

2002b, 2008; Rehren and Cholakova 2010, 2014; Schibille and Freestone 2013). Very unexpected, and of major importance for our understanding of the Late Roman glass industry, was the recent study of an assemblage from Pergamon undertaken by members of the Research Network. There, a totally new glass composition emerged sometime before the middle of the first millennium AD. These glasses can be linked to the local salt deposits to the east of the city which are rich in boron, among other light elements; accordingly, these glasses are characterised by much higher boron concentrations than all other known glasses from the eastern Mediterranean (Schibille 2011; Rehren *et al.* 2014). In contrast, very few of the dominant glass groups known from elsewhere in this period are represented in Pergamon. Economically, the emergence of this regional industry has to be seen as part of the regionalisation of the Byzantine Empire in the second half of the millennium. In terms of research history it goes to show that even major discoveries are still to be made even in a subject seemingly as well studied as Roman and Byzantine glass.

The next steps

Work is in progress to put the chemical glass group definitions on a stronger footing, and should result in a step change in research. Matt Phelps is undertaking a detailed study of the chronological development of well-dated vessel glass in Byzantine and early Islamic Palestine, funded by an AHRC studentship. Analysis of raw glass chunks from shipwrecks off the eastern Mediterranean coast is allowing us to refine our understanding of the primary glass products before they were subjected to extensive recycling and mixing processes. In November 2014, an international conference on glass will take place at the Institute organised as part of Daniela Rosenow's Marie Curie fellowship. At around the same time we expect to start a new three-year project, recently awarded to UCL Qatar, to push ahead with a synthesis of glass compositions and a 'mapping exercise' across the Byzantine and early Islamic Empires. One of

the aims is to see which compositional glass groups were used when and where, and in combination with which others, in order to gain insight into the agents determining the large-scale flow of glass. The emphasis here is on the consumption side of the glass industry, with particular focus on important regions of the Byzantine world traditionally less well covered by existing case studies, such as Asia Minor and the Balkans. Of interest also is the transition in these regions to the 'Islamic' glass compositions that emerge from the 8th and 9th century AD in the Levant, which are often linked to a collapse of mineral natron supply from Egypt. In the Levant, this manifests itself through a re-emergence of plant-ash based glass making, possibly based on a continuing glass-making tradition in the Sasanian Empire that can be traced back to the Late Bronze Age. A major focus of the new work will be to trace the boron-rich glass across space and time in order to see how it relates to the economy of the Byzantine Empire; after all, Pergamon was a major city not far away from Byzantium, and it is unlikely that it developed its glass economy in splendid isolation. Early indications, based on literature data, show that this glass probably reached Bulgaria to the west and Syria to the east, and we hope to be able to include glass from Byzantium itself in our study.

Very clearly, none of this can be done in isolation, and we are cooperating with several international partners in our research. Through this, we are confident that the strength of the Institute with its global outlook, cross-disciplinary approach and unrivalled research capacity will ensure that progress in first millennium AD glass studies remain intimately linked to work undertaken at UCL, and led by UCL staff and students.

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