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GLASS PRODUCTION

صناعة الزجاج

Andrew Shortland

Glasproduktion
Production de verre

Glass production starts in the second half of the sixteenth century BCE. Glass was produced from the combination of quartzite pebbles with a plant ash flux, usually with the addition of copper, cobalt, antimony or manganese colorants, and opacifiers. The earliest surviving glassmaking workshop is a subject of debate since archaeological evidence for glass production is rare and often equivocal. No glassmaking factories have yet been found in Mesopotamia or Northern Syria, but several candidates are known from ancient Egypt, including the sites of Malqata, Amarna, and Qantir. This is still very much a topic of current research, both through archaeological investigation and scientific analysis.

بدأت صناعة الزجاج بالنصف الثاني من القرن السادس عشر قبل الميلاد، وصنع الزجاج من مزيج من حصى الكوارتز ورماد النبات مع إضافة النحاس، الكوبالت، الأنتيمون، ملونات المنجانيز، ومواد لتعتيم اللون. إن أول مثال باقٍ لورشة صناعة زجاج مجال للجدل لأن البقايا الأثرية لصناعة الزجاج نادرة وغالباً تكون مبهمّة. لم يعثر على أية ورش لصناعة الزجاج ببلاد ما بين النهرين أو شمال سوريا، ولكن يوجد عدة أماكن محتملة لذلك بمصر القديمة، مثل منطقة الملقطة أو العمارنة أو قنطير. هذا الموضوع مازال موضع نقاش، والأبحاث الأثرية والعلمية مازالت جارية.

Objects of glass first appear in the archaeological record of Egypt in the reign of Thutmose III (Lilyquist and Brill 1993; Nicholson 1993; Peltenburg 1987). The origin of the invention of glass is not clear, with both Egypt and Mesopotamia being proposed. However, the earliest datable glass and hence glass production seems to come from Mesopotamia in the last half of the sixteenth century BCE. It seems to be imported into Egypt for the first time in quantity as tribute following the successful campaigns of Thutmose III in the early years of his reign (Beck 1934; Nicholson 1993, 2006; Shortland 2001). Evidence for the production of glass is rare in the archaeological record of any period, but especially of the earliest eras. There may be

several reasons for this rarity—perhaps there were initially a very small number of factories and perhaps of limited extent. However, one of the major reasons for their rarity has probably to do with the difficulty of identifying such facilities. The production of glass objects can be divided into two clear stages: glassmaking and glassworking. “Glassmaking” is the production of glass from the raw materials, whereas “glassworking” is the transformation of raw glass into finished objects. Theoretically, these could both be done in the same place, but in practice, in the ancient world, they seem to have often been split into two different sites (Freestone et al. 2002). Long range trade in raw glass is supported by the late fourteenth century BCE Uluburun shipwreck. Its cargo

included at least 175 glass ingots; judging from their chemical composition, many, but not all, of them were manufactured in Egypt (Pulak 2005; Rehren 2005). To date, no glassmaking factory has been found in Mesopotamia at all, but there are several proposed in Egypt, as discussed below.

Raw Materials

The main raw material for glass production is silica, thought to be in the form of quartzite pebbles in the case of Egyptian glasses (Shortland 2000a; Turner 1956). These pebbles have a very high melting temperature, around 1700°C. In order to produce a glass from them, a plant ash flux is added. This lowers the temperature for the production of glass to around 1100°C, which was achievable in an ancient furnace (Turner 1954). Almost all of the glass in Egypt was colored and frequently opacified. Light and mid-blue glasses were produced from copper in the form of bronze or copper scale, which was added to the melt. Lead isotopic analysis suggests that the copper colorant has the same source as the copper used in Egyptian tools and weapons (Lilyquist and Brill 1993; Shortland et al. 2000). Darker blue glasses were often made with a cobalt colorant; this colorant has a particular pattern of trace element impurities (high alumina, manganese, nickel, and zinc), which has enabled the cobalt colorant to be sourced to cobalt bearing alums of the Western Oases of Egypt (Kaczmarczyk 1986). The blues are the most common colors in the glasses and frequently form the body glass for the core formed vessels. The opacifier calcium antimonate occurs in white glasses, which is formed by adding antimony to the glass melt and allowing it to cool. The source of the antimony is unknown, but it is a rare element, and it is possible that the source might be as far away as the Caucasus (Shortland 2002). The lead antimonate opacifier has been identified in yellow glasses (Lilyquist and Brill 1993). Once again, the Caucasus may be the source of the antimony, but it is likely that the lead comes from local Egyptian mines, most notably Gebel Zeit on the Red Sea coast, which was exploited in the

New Kingdom for the lead sulphide galena for use in eye pigments or kohl (Shortland et al. 2000). Mixing blue glasses and these opacifiers gives opaque blue and green colors, respectively. The final colors in glass are pink, purple, and black—all colored with manganese of unknown source—and red, which again uses copper (Shortland and Eremin 2006).

Production Technologies

Little is known about the way glass was produced. It is not a subject that was written about in Egyptian texts and, unusually, does not seem to be depicted in any of the fairly common tomb scenes, which show metal, pottery, or stone production. However, there is evidence in the form of texts from the Library of Ashurbanipal at Nineveh, the information of which is thought to date to the second millennium BCE (Oppenheim et al. 1970). These detail recipes and furnace conditions; however, many of the words used are difficult to translate and some have strong magical and religious elements, which makes interpretation of the texts difficult (Shortland 2008). The best evidence therefore comes from analysis of the glass itself and rare archaeological finds of glassworking or glassmaking factories.

Factories

Analysis of the glass has shown that there were at least two different factory sites operating in the fourteenth century BCE, at least one in Egypt and one in Mesopotamia or Northern Syria (Shortland et al. 2006). Early glassmaking or glassworking factories have been identified at the sites of Malqata, Amarna, el-Lisht, and Qantir.

Malqata

The site of Malqata on the west bank of the Nile at Thebes was excavated by the Metropolitan Museum of Art's Egyptian Expedition between 1910 and 1921 (Keller 1983). Here, within the workmen's quarter of an extensive palace complex built by

Amenhotep III, the earliest evidence for a glassmaking or glassworking site in the world was found. The excavators record finding crucible and glass slag, but the objects themselves were not retained by the museum and are thus not available for modern study. Glassworking debris, such as rods, drips, and trails, was abundant (Keller 1983).

Amarna

Petrie (1894: 25) stated that he had found “the sites of three or four glass factories, and two large glazing works... though the actual workrooms had almost vanished” at the site of Amarna in Middle Egypt in the late nineteenth century. Regrettably, he does not state where these workshops were, but later work (Borchardt and Ricke 1980; Shortland 2000b) has shown that they lay within the southern end of the city, amongst the poorer quality housing. An Egypt Exploration Society expedition led by Paul Nicholson was working on one of these factories, O45.1, through the 1990s (Nicholson 1995, 2007). Two kilns 2 m in diameter were uncovered; they were described as thick walled and highly vitrified, with a sacrificial, regularly replaced lining, and associated with a large amount of *keborfush*, the local word for black ‘slag’ (in this case, the melted clay lining of the furnace, which has solidified on cooling). A third smaller kiln was found apparently associated with the other two and of a type recognized by Nicholson to be a pottery kiln. Associated with the site were frit, melted glass, glass rods, and fragments of cylindrical vessels. All of this strongly suggests that this site designated O45.1 was used for the manufacture of vitreous materials (Nicholson 1995, 2007) although not necessarily glassmaking.

El-Lisht

The Metropolitan Museum of Art’s Egyptian Expedition also excavated the site of glass production at el-Lisht. This site was situated in a technological complex dated to 1295 - 1070 BCE, on the northern and eastern sides of the much earlier 12th Dynasty pyramid of Amenemhat I (Keller 1983). Working

between 1906 and the mid 1930s, they uncovered glass crucibles and slags, glass working debris in the form of rods, drips, and wasters, and a single large glass ‘ingot’. The factory seemed to be producing glass beads, rings, pendants, and inlays. Once again, significant amounts of the finds were not retained, making it difficult to interpret the function of the site (Keller 1983).

Qantir

A series of glass workshops have been hypothesized at Qantir-Pi-Ramesse in the eastern Nile Delta dating to 1250 - 1200 BCE (Rehren and Pusch 1997, 2005, 2007; Rehren et al. 2001). This site is different to the others described above in that it has relatively little glassworking debris. Instead, it has a large number of cylindrical vessels or glass-coloring crucibles for which no domestic parallel is known. So far, about 1100 fragments have been recovered, representing a minimum of 250 to 300 vessels (Rehren and Pusch 2005). One of these crucibles, 00/0344, inventory number 3108, is filled with a heavily corroded block of raw glass, which seems to represent a glassmaking charge that was abandoned before the batch material had fused completely—in effect, preserving much of the original raw material (Rehren and Pusch 2005, 2007). The site seems to have specialized in the production of red glass, a color that is very rare at the other glass sites above.

Two further sites, Menshiyeh (Keller 1983) and Kom Medinet Ghurab (Kozloff and Bryan 1992), have been suggested as areas of glass production. However, there is considerable doubt as to the dating and function of the sites, and they “cannot feature significantly in discussions of New Kingdom glass production” (Nicholson 2007: 21).

The Earliest Glass Factory?

As discussed above, there is a distinction to be drawn between glassmaking factories and glassworking areas. Malqata, Amarna, and el-Lisht all contain significant amounts of glassworking debris, so this is what was obviously going on here. However, the

presence of glassmaking is much harder to derive. It has been claimed that Qantir represents the earliest surviving glassmaking factory on the basis of the crucible described above, the only example of a glass batch preserved as a charge before being fully vitrified in the furnace. However, others have claimed that the Amarna workshop of O45.1

is a glassmaking facility on the basis of the presence of high temperature kilns and frits that appear to be colorants. Too many of the finds from el-Lisht and Malqata have been lost to enable them to be considered. This is still the subject of much research, and only further excavation and analysis is likely to resolve the issue for certain.

Bibliographic Notes

The subject divides into two groups of works: archaeological excavation of the sites and scientific examination of the glass objects themselves. The most important sites are Amarna and Qantir, each of which was fully documented in 2007 (Nicholson 2007; Rehren and Pusch 2007). The scientific work is usually published in the journals *Archaeometry* and *Journal of Archaeological Science*, both of which have seen a great increase in the work on glass—particularly this early glass—over the first few years of the twenty-first century. General works on the subject include Lilyquist and Brill (1993), Nicholson (1993), Shortland (2000a), and the introductions to both works described above.

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