Identifying the Characteristics of the Earliest Glass Works from Excavations

Introduction

Over recent decades there has been much debate concerning whether or not the Egyptians could make their own glass from its raw materials or whether they were dependent upon their Near Eastern neighbours for raw glass which they then worked into objects (e.g. Newton and Davison 1989: p.62; Stern and Schlick-Nolte 1994: p.26; Schlick-Nolte 2012: p.108ff).

Recent archaeological evidence and scientific investigation has now demonstrated that there is good evidence for the manufacture of glass from its raw materials in Egypt as well as in the Near East from around 1500 B.C. (Moorey 1994: p.189ff; Nicholson 2007; Pusch and Rehren 2007; Jackson 2005; Nicholson and Jackson 2012). Whilst the earliest glass may have originated in the Syrian-Mesopotamian region or elsewhere the most compelling physical evidence for glass-making workshops is so far confined to a few sites in Egypt.

At a meeting of archaeologists and archaeological scientists at the Japanese Institute of Anatolian Archaeology in Kaman, in 2014, the nature and identification of workshops was actively discussed and it was apparent that the full nature of the production evidence from Egypt was not widely known outside Egyptological circles. This paper therefore presents a tentative summary of those features which seem to the authors to be representative of some of the earliest primary glassworkshops in Egypt and which might therefore provide a basis for identifying such workshops in Anatolia and elsewhere.

The Egyptian Evidence

There are a number of possible workshop sites in Egypt which show some features in common. However, not all of these are currently well investigated and as a result reliance cannot always be placed on the evidence for all of them.

Although scientific analysis of glass from Egypt strongly suggests that its manufacture there had begun as early as the reign of Thutmose III (1479-1425 B.C.) (Nicholson and Jackson 2012, 2015), there is as yet no physical evidence of primary production sites of such early date. The earliest site to yield evidence of a glass workshop of some kind may be the so-called ‘palace-city’ of Amenhotep III (1390-1352 B.C.) at Malkata on the West Bank of the Nile at Thebes.

Malkata

This site has been the subject of archaeological investigation on several occasions. Work by Newbury and Tytus in 1900 (Tytus 1903) in the so-called South Village was never fully published though they do refer to ‘glass slag’ and other evidence. However, most of the industrial evidence seems to have come from the work of the Metropolitan Museum of Art between 1910 and 1921 (Keller 1983: p.20) which examined an industrial area in the ‘main palace’ complex. Keller (ibid.) cites a letter from Ambrose Lansing (1891-1959) dated November 8th, 1917 noting a “glass factory” containing “broken beads, bits of scalloped glass, fragments of glass rods and crucibles”. Not all of this material can currently be located in the Metropolitan Museum (ibid.: p.21) which precludes a full examination of the nature of the industry based on these finds.

The site has subsequently been investigated by Kemp and O’Connor in the late 1970s, by a team from Waseda University in the 1970s and in the early 2000s by an American Expedition including the Metropolitan Museum of Art (iMalqata). These missions have concentrated on

a variety of areas within the site and have not been specifically targeted toward industrial remains.

Although the evidence for glass making and glass working at Malkata is currently limited, it is clear that this was an industry that did not take place in isolation; there is clear evidence for the manufacture of faience objects at the site. This relationship between faience production and the making/working of glass in Egypt is one which is repeated at all glass production sites currently identified from Egypt[i]. This association of two related vitreous materials industries makes the separation of evidence associated with each difficult and in fact some aspects of the technology, and quite possibly some craftsmen, were probably shared between the two industries.

This sharing of technologies is most clearly demonstrated at the most fully investigated production site, that of Tell el-Amarna.

Tell el-Amarna

Amarna, the ancient city of *Akhetaten*, is located on the east bank of the Nile in Middle Egypt. It was the short-lived capital of the so-called 'heretic' pharaoh Akhenaten (1352-1336 B.C.) and did not long survive the end of his reign (see Kemp 2012).

Following the discovery by local people of an archive of cuneiform correspondence now known as the *Amarna Letters* in 1887 Flinders Petrie (1853-1942) undertook work at the site in 1891-2. As well as seeking further cuneiform tablets Petrie was specifically drawn to Amarna for its examples of "glaze work" (Petrie Journal MS 13–21 November 1891). His interest in this was amply satisfied by his discovery of what he termed as "three or four glass factories, and two large glazing works" (1894: p.25). It is clear, therefore, that as at Malkata the making of faience and the production or working of glass were taking place in close proximity.

However, the extent of the proximity of the vitreous materials industries is uncertain. This is because of Petrie's practice of collecting together finds which he believed were related and ordering them into a technological sequence without reference to their original context. As a result, material from several of these glass and glazing works, at least one of which was "grubbed in" by the local children rather than actually excavated by Petrie was amalgamated together (Petrie MS 3-9 January 1892 – Nicholson 2009: p.303). This makes it difficult for modern researchers to differentiate between workshops producing faience and those producing glass and indeed between primary and secondary workshops – assuming that these were indeed separated.

Petrie's excavations yielded no trace of furnaces for the manufacture of glass (Petrie 1894: p.26). This has been as source of some confusion since in his publication (1894) he provides a reconstruction of the glassmaking process which some have assumed meant that he had discovered such furnaces (Vandiver, Swann and Cranmer 1991). His finds included numerous (but unquantified) pebbles of white quartz some of them with drips of glaze adhered to their surface. These Petrie (1894: p.26) believed to have formed the floor of the furnace.

In his reconstruction Petrie (1894: Plate XIII: p.62) does not actually show the pebbles, but only the vessels which he thought stood upon them in the furnace. These vessels comprised a series of cylindrical pots which he thought stood rim down and served as supports for open

bowls in which the raw materials of glass production were heated together in a process known as fritting and which might have served a similar purpose during glass melting. His finds included a large lump of vesicular blue frit which preserved the form of one of the open bowls (now Petrie Museum accession number UC36457).

As well as the pebbles and pottery vessels Petrie also found numerous glass rods or canes and pincered pieces of glass (1894: p.26) as well as some lumps of raw glass. He used these finds to reconstruct glass making at Amarna which he interprets as a two stage process. The first stage involved the heating together of the constituents of glass – namely silica, from crushed quartz pebbles or sand, alkali and lime with a colourant. This initial heating stage, known as fritting, allows the materials to react together and the gases evolved during the reaction to escape. The result is a semi-fused, often vesicular, mass like that which he identified.

The second stage of the process he describes would be the crushing of the frit into a powder and its melting to form the finished glass from which objects would be manufactured. Objects such as glass vessels might be formed from or decorated with rods and canes of glass such as those which Petrie recovered.

A difficulty with Petrie's reconstruction is that it brings together finds from disparate findspots so that it is now impossible to know whether the frit, the raw glass and the glass rods – for example – came from the same workshop or from several. As a result it is not possible to differentiate primary and secondary workshops if they existed. The picture is further complicated by Petrie's separation of evidence that he considered to be for faience working from that which he considered to be for glass.

Although Petrie's plate showing the reconstruction of the glassmaking process (1894: XIII: p.62) was widely reproduced right into the 1990s (Newton and Davison 1989: p.108) doubt was increasingly cast on his evidence for the reconstruction. This was compounded by an increased emphasis on Egyptian requests for glass in the *Amarna Letters* (see Moran 1992) as well as the *Annals of Thutmose III* which many took to imply that the Egyptians could not make their own glass (e.g. Newton and Davison 1989: p.107; Schlicke-Nolte and Lierke 2002: p.20-21) but were dependent upon imports. As a result of this trend the finds from the Uluburun shipwreck were initially thought to prove the import of raw glass to Egypt (Bass 1987).

Although many of Petrie's finds survive in museums, not least in the Petrie Museum at University College London, their lack of specific contexts within Amarna has meant that they cannot be reinterpreted without additional evidence. With this in mind new excavations were carried out at Amarna in the 1990s in an area believed to be near to or uniform with one of Petrie's excavation sites. This is the area of Amarna known by its grid reference code as O45.1.

Work at this site, which proved not to have been previously excavated, yielded several kilns and furnaces as well as finds similar to those made by Petrie. However, these finds are fully contexted and so can be used to throw light on those made by him.

Two large circular brick-built structures were identified as furnaces of some kind. One of them preserves a large quantity of black, shiny vitrified material resulting from the melting of the render on the interior of the structure and from the melting of the bricks themselves (Nicholson 2007: p.36ff). It is likely that this is the kind of material, along with fuel-ash slag,

often referred to as 'glass slag' by early excavators. In fact this material can be indicative of any high-temperature process involving mud-brick structures and silica-rich plant fuels. Quantities of such 'slag' were found distributed across the excavation and are known from various parts of Amarna. The walls of these structures show an inward curve indicating that they were originally domed. They are also built with a thick and complicated brickwork pattern clearly designed to withstand thermal stress as well as to maximise insulation. They are unlike any other kiln or furnace so far known from ancient Egypt – for example pottery kilns or metallurgical furnaces. Their design also seems to make them impractical as limekilns. These furnaces appear to be intended for the making of raw glass. Other kilns/furnaces nearby are apparently associated with pottery production and probably faience making. There is ample evidence for both faience production and pottery manufacture at O45.1 suggesting that the site may have formed part of a complex of pyrotechnical industries.

Whilst Petrie (1894: p.26) found no furnaces he did find fragments of the cylindrical vessels which he thought were stands. The new excavations also recovered similar fragments. However, examination of these and pieces from the Palace Dumps make it clear that the vessels are not in fact stands but were used as containers for glass. They are lined with a calcareous slip and some examples still contain traces of the original glass. The size and shape of these vessels would yield a slightly tapering cylinder of glass which would preserve evidence of the original vessel. Such glass cylinders, in the form of a series of glass ingots were recovered from the Uluburun shipwreck (Bass 1987). Metrical analyses of the Uluburun pieces (Nicholson *et al.* 1997) shows that they have the same shape and dimensions as the interior of these Amarna vessels suggesting that far from the ingots being imported into Egypt they could have come from these Egyptian pots. Chemical analyses have similarly indicated an Egyptian origin for the ingots (Jackson and Nicholson 2010).

Fragments of frit were also recovered from the excavation and have compositionally been matched to Amarna glasses. Whether the frit was a deliberate product as part of a two stage process or was the result of an incompletely heated glass is debateable (Jackson and Nicholson 2007: p.109). Work on the frit found by Petrie has suggested that it may not have been intended as a raw glass but as a colourant for glass or faience (Shortland *et al.* 2007: p.183-184).

A number of chips of finished glass were also found and may have come from ingots. There are also pieces which show pincer marks and a small number of glass rods. The low number of such rods is probably significant in that site O45.1 appears to be a site for the primary production of glass rather than its working. The fact that Petrie's finds included many such rods may well be because his evidence came from multiple sites some of which were for primary production and others secondary workshops where vessels and other objects were made. This distinction is an important one and the presence of rods at Amarna has frequently been misinterpreted as demonstrating that the site was mainly connected with glass working rather than making (Shortland 2010: p.96). In our view this misunderstanding is entirely the result of Petrie's conflating of evidence from several find spots.

Work on the Petrie Collection at UCL undertaken by Smirniou and Rehren (2011) has identified a white bubbly vitreous material which they attribute to primary glass production. Along with the evidence already published by Jackson and Nicholson (2007; p.109 e.g. TA22, p.115) it is clear that Petrie's original view that glass was indeed made at the site is correct although the details of his reconstruction are not.

Some of these categories of evidence are repeated at the later site of Qantir.

Qantir

The site of Qantir is located in the eastern Nile Delta and is to be identified with the site of Pi-Ramesse, capital of Ramesses II (1279-1213 B.C.). The site has been known for its production of faience for many years (Hamza 1930) and yielded a complete ingot of red glass, now discoloured to green.

More recently the site has been subject to intensive excavations under the direction of Edgar Pusch of the Hildesheim Museum. Although these new excavations have not so far produced any actual furnaces (Pusch and Rehren 2007: p.156) it is clear that they were present. Most of the glass produced at Qantir seems to have been red in colour, a specialised process involving the use of copper heated in a reducing atmosphere as a colourant.

Rehren and Pusch (2005) see the production of glass at Qantir as a two stage operation. In the first stage the raw materials of production are reacted together often in a domestic-type ovoid jar, a variant of the beer jar form. The product of this reaction is then crushed and transferred to a cylindrical vessel for melting and colouring. These cylindrical vessels are closely similar to those from Amarna though their proportions differ somewhat. They are very well represented at Qantir which Rehren (Pusch and Rehren 2007: p.131) as representative of the production of "many hundreds of kilograms of glass" although the exact time over which the workshop produced is unclear. Since the Qantir site is later than that at Amarna and belongs to a more developed phase in glass production such a scale should perhaps not be unexpected.

As well as the ovoid jars and cylindrical vessels a number of fragments of ceramic funnel were discovered. These seem to have been used for adding additional raw materials into the cylindrical vessels. It is almost certain that these also existed at Amarna where fragments of a similar clay fabric adhere to some of the vessel rims and where badly eroded fragments, probably of these, were located though cannot be proven with certainty.

In short the Qantir evidence suggests a very large scale production of glass, predominantly red in colour, taking place alongside other industries – notably the production of Egyptian Blue, faience and copper. In fact the relationship of all these industries to copper is an important factor here.

Other Possible Centres

Alongside Malkata, Amarna and Qantir there are a number of other possible centres for the production of glass although evidence from these is often patchy. Kom Medinet Ghurab (also known as Gurob) was thought by Petrie and others to be a production site for glass and has produced a number of finished items. The cemeteries at Gurob date from the late Predynastic through to the Roman period, but the main settlement area (including the likely palace) dates from at least as early as the reign of Thutmose III until the late 20th Dynasty. As a royal centre it has features in common with Malkata and Amarna. It would not be surprising to find that glass production was located in such a place, however, firm evidence is currently lacking despite recent investigations at the site (Ian Shaw pers. comm.).

The site of Lisht on the east bank of the Nile between Dahshur and Meidum is in the area which has been identified as the likely 12th Dynasty capital of *Itj-tawy* although occupation at the site continues for longer and Keller (1983: p.24) dates a possible workshop on the north

side of the pyramid of Amenemhat I as late New Kingdom. The excavations carried out by the Metropolitan Museum of Art between 1906 and 1934 were of variable quality and have not been fully published making assessment of the finds problematic. However, so-called fritting pans, glass rods or canes and pieces described as cullet have been located at the site (Kozloff 1992: p.378). Much of the glass is said to be chemically uniform with that of Malkata and Amarna suggesting a typical Egyptian production (Kozloff 1992: p.378, Lilyquist and Brill 1993), although Smirniou (2012) noted some differences in the few samples of glass from the site she analysed, which she interprets as differences in the plant ashes used. According to Rehren (Pusch and Rehren 2007: p.144) the glass is of two distinct qualities – the first entirely comparable to that from Amarna and Malkata the second more bubbly and of poor quality. Kozloff (1992: p.378) suggests that this poorer glass is scavenged by the Ramesside workers from the18th Dynasty tombs but this is by no means certain.

According to Rehren (Rehren and Pusch 2007: p.144) "The evidence from Lisht thus mirrors to some extent the range of remains known from Amarna, including glass-working waste as well as crucible fragments, though on a much smaller scale, and possibly inferior quality of workmanship". However, this again reflects the likelihood that the finds may come from a number of distinct workshops but have been treated as a single entity as they were at Amarna.

A further site in Upper Egypt should also be mentioned. This is Menshiyeh near Abydos which was suggested to Newberry as the findspot of a number of glass vessels which were on sale in dealers shops in Luxor around 1911 (Keller 1983: p.20). Keller is sceptical of this site, suggesting that it may have provided a fake provenance for the vessels. However, Newberry did visit it personally and found glass rods and pieces of there (Newberry 1920: p.156 note 11) which suggests that glass working, at the very least, was taking place. The site has not subsequently been reinvestigated.

Finally, the ancient capital of Memphis may be considered as a possible production site. As an important centre throughout most of Egyptian history it is almost certain that such production took place here and there are sporadic verbal reports of cylindrical vessels being found but as yet no convincing or firm factory evidence.

Discussion – What features might constitute a factory?

The archaeological recognition of a glass manufacturing site is problematic and should not be expected to be entirely uniform. Work on such sites in Egypt is in its infancy and has not until recently been a research priority. However, it is already clear from the work at Amarna and Qantir that there are likely to be differences between workshops according to their date and to their particular production speciality. Thus one might expect evidence from Malkata and Amarna which belong to the earlier development of glass in Egypt to be on a smaller scale and perhaps to have more in common with faience making than the later industry at Qantir which is highly specialised and is centred at a site specialising in the production of copper.

The type of evidence will also vary according to whether the production is the primary manufacture of glass from its raw materials or whether it is the secondary working of glass into artefacts. This is a crucial distinction and one which has not been fully appreciated by many scholars. For example both Rehren (Rehren and Pusch 2005; Pusch and Rehren 2007) and Shortland (2010) have assumed that the Amarna evidence is essentially uniform when in fact the material was collected from several distinct workshops and arranged into a sequence

by Petrie. It is not at all clear that each workshop yielded the full range of finds. The more recent excavations have shown that some sites are apparently associated with primary production whilst others were probably for secondary. Thus site O45.1 at Amarna has very few glass rods or canes but preserves evidence of what are probably glass making furnaces along with raw glass. Similarly the balance of evidence at Qantir is toward primary production rather than the manufacture of objects.

There have been several recent attempts to characterise the features of a manufacturing site. Rehren (Pusch and Rehren 2007: p.144-145) along with Shortland (2010: p.96) mistakenly assume that the Amarna evidence is uniform and so are unable to clearly separate glassmaking from glassworking as they are misled by the view that "rods, beads and spills dominate" (ibid). This may be true of Petrie's *amalgamated* finds but is not true of the recent work. Rehren's view also implies that a workshop of the time of Akhenaten will be essentially comparable to one of the reign of Ramesses II. This assumption cannot be proven and should not be expected given the difference in time and the potentially rapid development of a nascent technology in Egypt. The fact that the production at Qantir is so highly specialised only serves to highlight the differences which have emerged over time.

Shortland (2010: p.126) is correct in saying that from the Near East we currently have no good evidence for glass production sites and their features. As a result predictions regarding the finds likely to be made on such sites have to be based on the Egyptian evidence. It should be stressed however, that just as there are chronological differences in the manner of production within Egypt one might expect there to be similar chronological and technological differences when examining sites in the Near East, particularly those relating to the very earliest production of glass.

What then, might be expected as the features of a glass manufacturing site? We suggest the following, which should be divided into two types: primary and secondary.

Primary Workshops
By a primary workshop is meant one where glass is produced from its raw materials. Such a site may or may not be involved in the making of actual objects. Its features are likely to include at least *some* of the following.

1. Raw materials. The identification of raw materials at a glassmaking site is fraught with difficulty. The quartz pebbles identified by Petrie may, for example, be intended as a raw material for glass but might similarly be intended for faience or Egyptian blue/green production. If sand were being used as the silica source then its identification is even more problematic. Similarly the alkali material, such as plant ashes, is likely to disappear in solution, as a result of wind action or be hidden and become incorporated in other environmental remains. At least in Egypt it seems that lime was not deliberately added but was present in the other raw materials (see Jackson *et al.* 1998) and so perhaps should not be expected.

2. Grindstones for the preparation of raw materials. These too are problematic in that they can be associated with the crushing of silica and other materials for the production of faience, frit or indeed cereals. Rehren (Pusch and Rehren 2007: p.147) has noted this same difficulty in determining the function of such artefacts.

3. Furnaces. These represent a particularly contentious class of evidence. This is because at present so few have been identified from Egypt so that there is no consensus as to what the earliest glass furnace should look like. The two large furnaces from Amarna O45.1 have been attributed to glassmaking by Nicholson and Jackson (2007) having discounted other possible uses as they did not conform to standardised designs known from other industrial processes and on the basis of associated finds and experimental archaeology. Such experiments cannot *prove* that the furnaces are for glass production but help to support that view. It might be expected that furnaces at Qantir when they are eventually discovered might be of a somewhat different design given their later date and more specialised nature of production. For the moment excavators can only be guided by the novel nature of particular furnaces and/or their apparent association with other evidence for glassmaking.

4. 'Slag'. This too is a problematic material as the glass production process itself does not produce a true slag. Most of the material which has been described as slag by excavators derives from fuel ash or the vitrification of mudbrick or mudplaster. The latter is the *khorfush* material recognised at Amarna (ibid.: p.86). Whilst its presence indicates a high temperature industry it is not specific to glass manufacture.

5. Crucibles. The evidence from Egypt so far suggests that these are typically cylindrical in form. They are known from Amarna, Qantir and other sites in Egypt though their proportions vary between sites. They are typically lined with a white calcareous slip which serves as a parting agent and they may also show traces of glass inside and/or on the rim or exterior. Traces of coarse ceramic may also adhere to the rim (Rehren and Pusch 2005).

6. Funnels. From Qantir there are numerous fragments of coarse clay funnels which seem to have been used to add additional raw materials to the glass batch. They also seem to have been present at Amarna to judge from the coarse clay on the rims of some vessels and from some amorphous fragments of similar fabric, though their use cannot yet be established there.

7. Reaction vessels. At Qantir ovoid jars were used to react raw materials together before final melting in crucibles (Rehren and Pusch 2005). Such vessels have yet to be identified elsewhere and may represent a later development in the history of glass production in Egypt. Their presence suggests a two stage process in glassmaking – namely 'fritting' followed by melting.

8. Frit. In terms of glass production frit is the partially reacted raw materials of manufacture such as that described by Rehren (2007) from the Qantir reaction vessels. However, material which is visually identical can be a product in its own right and intended for the manufacture of 'frit' objects or to be ground up as a pigment such as Egyptian blue or Egyptian green. The presence of frit at a site does not necessarily mean that glass was produced there; analytical work to determine its composition is necessary before drawing such a conclusion. It is also worth noting that glass can be made in a single stage operation as has been demonstrated experimentally at Amarna (Nicholson and Jackson 1998).

9. Tools. The recognition of tools used for glassmaking is, at the present time, very uncertain. This is because most tools identified could be for a variety of uses in much the same way as the grindstones, and it is presently unknown which tools might have been used

in glass production. It is safe to say that a glassmaking workshop cannot be defined on the basis of the presence of tools alone.

In order to claim that a site is for glass production the authors feel that it is necessary for it to include a range of these categories of evidence. Similarly some categories of evidence are more conclusive than others as indicated above and the possibility that finds relate to similar industries such as faience or frit production should be borne in mind. This is particularly true in Egypt where such vitreous materials industries seem to be clustered together.

Secondary Workshops

Secondary workshops are those which take fully formed glass either as ingots or cullet and re-melt it in order to work it into objects. This process may show some features similar to those of primary production.

1. Glass ingots/cullet. Because objects are worked from pre-prepared glass one might expect to find partial or complete glass ingots along with lumps of glass which may have come from ingots or from the melting of cullet. There may also be broken or misshapen objects intended for re-melting though the interpretation of these, especially if found individually, is problematic.

2. Furnaces or hearths. These need not be of the same form as glassmaking furnaces. They might well be smaller, particularly if the workshops producing objects were themselves small. Bead production, for example, might not require a furnace but simply a hearth. Vessel production would require a furnace but this too might be quite small. At present no furnaces for the working of glass have been securely identified from ancient Egypt. It is worth noting that they may be similar to or identical with faience/pottery kilns although this has not been established.

3. Slag. As noted above any high temperature process can produce the kind of fuel ash or vitrification slag frequently found on sites.

4. Crucibles. Although the cylindrical vessels known from Amarna, Qantir and elsewhere have come to be associated with primary glass production it is not unlikely that similar vessels were sometimes used in secondary glass melting although other ceramic vessels could also be used. In passing one should note that frit apparently intended as pigment is sometimes associated with these vessels but whether this is a secondary re-use of them is harder to determine.

5. Tools. The tools for glass working are also hard to identify although metal rods for making swags or chevrons in glass cane or for collecting gathers of glass for bead manufacture might be identifiable.

6. Rods or canes. These are particularly characteristic of secondary glass production since they are used to make decorative swags or chevrons on the glass or to add features such as rims or stand rings to vessels. A distinguishing feature of secondary working is likely to be the quantity of rods from a given site. Whilst small numbers may also occur on primary production sites – perhaps resulting from glass testing or limited additional secondary production – they are present in significantly greater numbers in secondary workshops and often in a wide variety of colours.

7. Fragments of finished/semi-finished objects. The presence of fragments of finished objects is, of course, typical of any site and must be used with caution. It may well be that the presence of glass objects at Ghurab has led to the supposition that it is a production site when in fact it may not be. However, the presence of semi-finished objects together with trails and pulls of glass might be a better indication of glass working. Again it is the number of finished/semi-finished objects in a concentrated area which might be indicative of a secondary workshop.

Having summarised what seem to be the main features characteristic of glass workshops it is worth noting that one should not necessarily expect to find large quantities of glass be it raw glass or fragments of finished objects. This is likely to be especially true for the earliest production of glass since the material was a new technology difficult to master and one whose products were precious. Accordingly, it is likely that any waste or surplus glass would be re-melted and thus recycled.

Conclusion

Whilst it is not, at present, possible to define all the features of an early glassworks in Egypt – and potentially by extension in the Near East – it is possible to suggest a number of characteristics which might be predicted for such an establishment. Whilst some features are more characteristic than others it is the accumulation of a selection of significant features which is most informative in attempting to identify a glass manufactory.

The distinction between primary and secondary workshops is also a crucial one and this means taking into account the context of the material which may be difficult when reviewing evidence from early excavations. It must also be borne in mind that the distinction between primary and secondary production may not be completely clear cut and that a single workshop may be involved in both processes. Thus, for example, whilst Qantir is largely concerned with primary production there are also a number of glass objects produced there notably in the form of "thin plates of red glass…which may have served in the production of inlays or plaques" (Rehren and Pusch 1999: p.173). Glass vessel fragments are also known from the site though not in large numbers.

It is hoped that future work in Egypt and the Near East will allow the construction of a more nuanced and detailed picture of glass production sites such that it is possible to predict what might be expected of the earliest and latest factories in a given area. Whilst there are bound to be some features in common, as demanded by the material itself, it is equally certain that there will be geographical and chronological variations on the technologies employed. It would be particularly helpful and informative to know more about the earliest production sites in the Near East from where it is believed that glass manufacture spread.

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[i] It is worth noting that the terms 'faience' and 'glaze' are often used interchangeably. Although stone glazing has a long history in Egypt it appears to be faience manufacture which is most commonly associated with glass production sites.