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Paul T. Nicholson

Glasbearbeitung, Gebrauch und Entsorgung
Verre, utilisation et écart

Glass in ancient Egypt appeared in the New Kingdom. It was a novel and highly prized material, which quickly found favor with the elite. The first known glass sculpture in the round depicted the Egyptian ruler Amenhotep II. The purposes for which glass was used overlap with those traditionally known for objects made in faience, and both materials can be regarded as artificial versions of semiprecious stones, notably turquoise, lapis lazuli, and green feldspar. The techniques by which glass was worked in the Pharaonic period fall into two broad groups—the forming of vessels around a friable core, which was subsequently removed, and the casting of glass in molds to make solid objects. The vessels produced by core forming were almost invariably small, a matter of a few centimeters in height, and were mainly used for precious substances such as unguents. Cast items included sculpture as well as inlays and small amulets.

ظهر الزجاج في مصر القديمة في عصر الدولة الحديثة، حيث كان مادة جديدة وثمينة للغاية، والتي سرعان ما وجدت رواجاً لدى الطبقة العليا. أول المنحوتات الزجاجية المعروفة تصور الملك أمنحتب الثاني. كما استخدم الزجاج مثلما استخدم الفيانس ويمكن اعتبار كلا المادتين صناعة تقليد للأحجار شبه الكريمة خاصةً الفيروز واللازورد والفلسبار الأخضر، وتنقسم التقنيات المستخدمة في صناعة الزجاج المصري إلى مجموعتين :تشكيل الأواني حول نواة قابلة للتفتيت والتي يتم إزالتها فيما بعد، والصب في قوالب من الزجاج لصناعة القطع الصلبة ، وكانت الأواني التي تصنع باستخدام النواة عادةً ما تكون صغيرة إلى حدٍ ما – طولها بضعة سنتيمترات – والتي استخدمت بشكل أساسى للمواد الثمينة مثل المراهم ، كما شملت القطع المصنعة عن طريق الصب المنحوتات والتمائم الصغيرة.

Although there are reports of examples of glass dating before the New Kingdom, most of these are unconfirmed or uncertain (Beck 1934; Lucas 1962), and one must distinguish between glass, which was intentionally produced, and that arrived at "accidentally." To this latter category should be assigned small objects of glass, which were actually intended as faience but which have lost their silica core and so become glass (Nicholson 2007). Since the basic ingredients of glass and faience are the same (silica, lime, and soda), it is not surprising to find some blurring of the groups when particular heating conditions occur.

As a new material in Egypt, glass of the New Kingdom seems to have enjoyed a relatively high status. Indeed, some of the earliest pieces we know about bear the names of Hatshepsut (clear colorless name beads; see Reeves 1986) and of Thutmose III (vessels; see Nicholson 2006); it seems to have been

regarded as a material suitable for royal gifts, such as shabtis. Apparently glass sculpture in the round is an Egyptian innovation (Cooney 1960). It is commonly suggested that glass might have been a royal monopoly during the New Kingdom. However, this is an oversimplification, and Barry Kemp (pers. comm. 2006) has pointed out that we know of no such concept nor of sumptuary laws for Egypt at this time. Nonetheless, it does appear that the actual making of raw glass might have been under state control at least until the end of the 18th Dynasty (Nicholson 2007). That individuals of lower status gradually gained increasing access to glass should not be surprising. As the material became more common, it was used for a greater range of items and spread beyond the upper echelons of society.

The treatment of glass must be divided into two parts: the *making* of glass from its raw materials (Nicholson 2007; Rehren and Pusch 2007) and its *working* from already processed glass. Only the latter, along with the use and discard of glass, is covered here.

The introduction of glass blowing in the first century BCE and the incorporation of Egypt into the economy of the Roman state radically altered the production, distribution, and status of glass and is not considered here.

Raw Glass

Processed glass may be in the form of ingots, newly made from the raw materials (or possibly from recycled materials), or in the form of scrap glass, known as cullet. Our present knowledge of early Egyptian glass does not usually allow us to differentiate glass made from new materials from that made from cullet. However, because vessel glass was frequently polychrome, it would be difficult to recycle, unless vessels and other products were first separated by color (such as some inlays, beads, etc.). A glass ingot from Amarna, now in the collection of the Liverpool University Museum (Nicholson 2007: 24), may be the result of remelting/recycling of glass, but this is by no means certain—recycled glass is not necessarily obvious in macroscopic examination.

The earliest glass in Egypt was probably imported from elsewhere in the Near East (see Oppenheim 1973), and since much of that production was for polychrome vessels, it is unlikely that it was recycled. Similarly, the very earliest local production in Egypt would have used freshly produced glass, though we should not rule out limited recycling of single color glass, particularly since this was a precious raw material. By the time the beakers of Neskhons (wife of Pinedjem II) of the 21st Dynasty were produced, it is possible that recycled glass, albeit of a new natron-based composition, may have been in use. However, although the Neskhons pieces lack the quality of earlier vessels, analysis of their composition has not suggested recycling (Schlick-Nolte and Werthmann 2003).

Glassworking Practice

While glass itself was a new material in Egypt and as such seems to have enjoyed a high status, it was not used in the creation of innovative forms. Glass seems rather to have been regarded as an extension of faience and, perhaps by implication, of semiprecious stones such as turquoise, lapis lazuli, and green feldspar. The connection between these materials is probably through color and brilliance. Faience was regarded as a substitute for semiprecious stones, not necessarily inferior to them but of a different and artificial material. All carried connotations of the heavens and the brilliance of the skies. Since the body color of much of the earliest glass is also blue, it seems to have been regarded as yet another representation of this heavenly blue brilliance. That such was the case is probably reflected in the term "Menkheperura (i.e. Thutmose III) lapis lazuli" (Schlick-Nolte and Lierke 2002: 20) for a material believed to be glass, given in the *Annals of Thutmose III* at Karnak and sharing the color of the semiprecious stone.

It is possible that the association with precious stones might have led to the production of vessels in shapes that were

already produced in faience, itself imitating forms known in stone. In other words, artificial stones such as faience and glass were used to make traditional stone vessel shapes. However, these shapes are not ones normally found in turquoise, lapis, or feldspar, but more commonly in travertine/calcite (Egyptian "alabaster") or hard stones, and one must consider why this should be.

A possible answer may be found in the history of these materials. Once faience started to be developed, one of the means by which it could be shaped was by abrasion, essentially "carving" from a block of material, albeit often a partly shaped block. From small vessels, the kind of things which lapidaries (gemstone cutters) may have produced in semiprecious stone, to larger vessels is a relatively small step. These larger faience imitations of stone were being made in the typical blue color, so it would be logical for glass vessels, also usually in blue base glass, to follow this tradition.

Further support for the idea that glass followed the traditions established by faience makers may come from the way in which glass first arrived in Egypt. Both Petrie (1925) and Oppenheim (1973) believe that its making may have been introduced by glassmakers brought to the country as captives from the Near East. If this was so, and they were induced to establish a new industry, it is most likely that they would be integrated among Egyptian specialists who worked on material that shared some of the properties and technology of glass—the makers of the artificial precious stone: faience. The work of Petrie (1894) at Amarna makes it clear that faience and glassmaking/glassworking activities went on in close proximity to one another, a finding confirmed by the recent work by the Egypt Exploration Society (Nicholson 2007). Part of this technological link is probably the use of heat in the final stage of production.

It is interesting to note also that some of the earliest glass vessels were treated as though they were of stone in that, after casting, they were drilled to make them hollow. These pieces seem to belong to the phase in which glass was coming into Egypt perhaps in the form of ingots from the Near East, or was first being made locally at a time when its properties were still not fully understood. Thus we have an artificial, high-tech material being treated as though it were stone. This combination of working practices and the embedding of a new craft into an old established one is an area that requires further research.

Glassworking Techniques: Cold Working

However the earliest raw glass arrived in Egypt, be it as ingots or as locally made glass, the earliest stages in its manufacture into objects require heat at some stage.

In order to make useful objects, raw glass would have been reheated and cast, probably into blocks with the approximate shape of the desired object. The glass would then have been annealed, an essential process in glassworking involving the slow cooling of the glass object, be it glass block or glass vessel. This cooling process allows the stresses developed in the hot glass to be gradually reduced and released so that the cooled object will not shatter. A piece of glass, which is simply put aside to cool in the workshop, would quickly crack or explode. Annealing may take place in a chamber to the side of, or above, the main furnace or might be carried out in a separate structure. It may take several days to anneal large pieces.

The earliest glass, once it had been annealed, was worked cold. The interior of a vessel might thus have been drilled out using a bow drill, probably with a copper cylinder as the drill bit just as Stocks (2003) has demonstrated for stoneworking. This practice would have to have been carried out with great care because glass, like other siliceous materials such as flint, will fracture conchoidally (shell shaped), and glass spalls around the drill would be difficult to disguise. It is notable that the edges of rims and feet on early glass vessels including a kohl pot (BM24391), which was made in this way, are often covered in sheet gold, perhaps covering

areas where the glass was prone to chipping in use or where it had been damaged during the polishing stage of the operation.

The casting and cold working of glass was not confined to the earliest phases of Egyptian glass history. However, its use in the manufacture of hollow forms seems to have been limited to its earliest phase. In the later reign of Tutankhamen, the technique of casting and cold working was used to produce two headrests. One of these, in dark blue glass and with an incised inscription, had the edge of the upper part covered by sheet gold, while that in light blue glass was made in two parts joined by a wooden dowel, the join being covered by a band of gold foil (fig. 1). Both would have required very careful working by skilled lapidaries after the form was cast in glass.

The other main branch of the glassworking technique is to use heat in the active shaping of the object, that is to "hot work" it.

Glassworking Techniques: Hot Working

1. Gathering. At its simplest, this involved gathering a small blob of glass from the furnace and then piercing it to form a bead. This was most easily achieved simply by gathering the glass around a rod so that it was ready-pierced. The shape of the bead was manipulated with tools and by rolling it on a flat surface known as a marver. Thus beads of spherical, cylindrical, or faceted shapes could be produced.

A hot thread of molten glass could also be drawn out from the furnace, allowed to solidify, and then be gently reheated in order to be shaped. In this way the simple earrings of the New Kingdom might have been produced, along with items such as applicator rods for kohl vessels and similar straightforward/plain pieces. Like all glass objects, once shaped and, in the case of beads, removed from their rod, they would need to be annealed.

2. Core forming. A process known as core forming was the most widely used method for producing glass vessels from the New

Figure 1. Glass headrest of Tutankhamen. This is believed to have been cast and cold worked. It was made in two parts joined by a wooden dowel and covered by a gold band. Carter's number 403a.

Figure 2. A core drying before being heated and coated in glass.

Kingdom into Hellenistic times (Gudenrath 1991: 214 - 215; Nicholson and Henderson 2000; Stern and Schlick-Nolte 1994: 27 - 44). It was a more difficult and time consuming operation than simple gathering and became the common process for making glass vessels once the properties of glass were better understood and confidence in its use had been achieved.

In this method a core made from clay mixed with dung and plant fiber was shaped in the form of the vessel interior (Wosinski and Brill 1970). It was formed around a handling rod, which allowed the piece to be manipulated (fig. 2). This core was then dried and coated with glass (fig. 3). The exact means of coating has been subject to much debate, with some researchers suggesting that the core was rolled in powdered glass (Schlick-Nolte and Lierke

Figure 3. Applying glass to a dried and heated core.

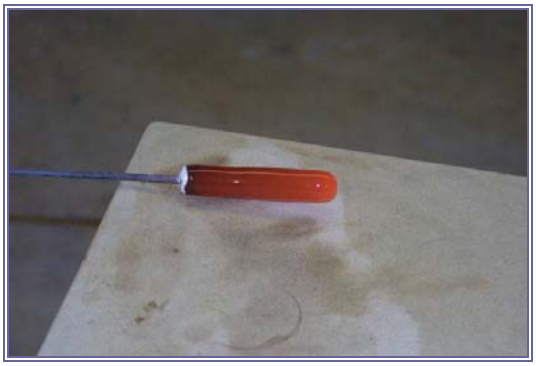

Figure 4. A core covered in glass being rolled on the marver stone. Note that the rim has been given a band of white glass.

Figure 5. Using a metal tool to draw up some of the bands of applied decoration to form them into swags or zigzags.

2002: 27 - 28) or covered by the application of chunks of softened glass. It has also been suggested the core was dipped into a pot of molten glass (cf. Harden 1968: 50) or that molten glass was trailed onto the core (Nicholson and Henderson 2000: 202 - 204). Whatever means was used, the glass was then

Figure 6. A completed replica of a kohl tube in the form of a palm. The piece has been annealed and still contains the core, which now has to be broken up to remove it.

rolled on a marver (smooth stone slab) to give it a more even thickness over the core and get the basic shape of the vessel exterior (fig. 4). This process required many reheatings of the core and the glass surrounding it and much work at the marver.

Once the core had been covered and a fairly uniform thickness of glass achieved, decorative trails might have been added to the vessel body. This was done by softening rods of glass and marvering them into the body. By using a blade to draw the trails up or down the body, it was possible to form them into chevrons or swags, common patterns on Egyptian glass vessels (fig. 5).

Rims were added to core formed pieces by using pincers to draw glass from the vessel wall or by adding rings of glass to the top of the vessel. Such rims were sometimes embellished by adding a trail of glass in a contrasting color. The same technique could be used for adding a foot to a vessel, while handles were made by adding a gather of glass to the vessel wall.

The whole object, still containing its core, would then be allowed to anneal slowly (fig. 6). This did not, of course, complete the process and some skill was still required in order to remove the core. Removal of the handling rod, probably at the point when the piece was placed in the annealing oven, left a void at the axis of the core, and this could gradually be enlarged by abrading the friable

material inside the vessel away. By careful abrasion most of the core could be broken up and tipped out through the neck of the vessel. The contact zone between the vessel and the core inevitably preserved part of the core; this can regularly be observed under the shoulders of broken vessels. While most ancient Egyptian glass is opaque or translucent rather than transparent, this lack of clarity is no doubt added to by the remains of the core.

It is possible that the need to use a core, and the knowledge that it could not be fully removed, may have encouraged the use of strongly colored body glasses rather than the development of transparent colorless glass. The name beads of Hatshepsut and Senenmut indicate that such glass could be made in the ancient world at an early date, but did not find use in vessels.

3. Molding/Slumping. In Pharaonic Egypt, molding or slumping was used to produce open form vessels, represented by the conglomerate glass pieces known from Malqata and elsewhere. Here fragments of glass of different colors were placed together and heated so that they fused together into a single continuous plane. They were perhaps first fused into a disc or oval shape and then reheated so that the fused disc slumped over a form or into a mold, forming a dish or bowl (figs. 7 and 8). Glass pieces could also be heated together in a mold, though this would be more difficult to achieve satisfactorily. A rim, in the form of a softened glass rod, was sometimes added to the vessel. This technique might be regarded as the origin of what was to become mosaic glass, a specialty of the Roman Period.

The making of inlays and occasionally of amulets was apparently achieved by using open-face molds just as in the production of faience. The molds were probably made of fired clay or, more rarely, stone and have not been discerned with certainty from those used for faience (see Cooney 1960: 13).

4. Lost wax. There remains the question of the manufacture of small items such as amulets and inlays other than those that may have been made in open-face molds. A few small pieces in the round exist and seem to have been made by the lost wax process. In this method, a wax image of the object was produced and had clay pressed around it. The object was then heated, which fired the clay and melted away the wax leaving a void in the shape of the object. The void was then filled with the intended medium for the object—in

Figure 7. A replica of a Roman ribbed bowl being slumped over a former.

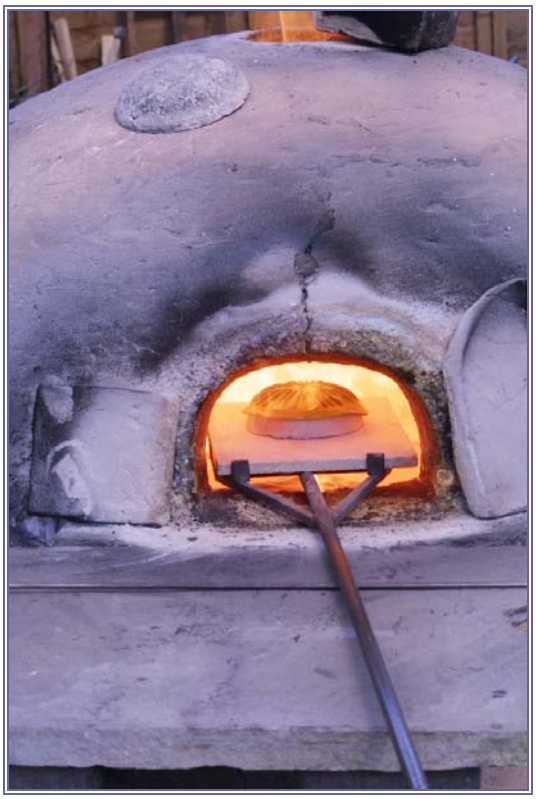

Figure 8. A replica Roman bowl slumping over its former in the furnace.

this case glass. The lost wax technique is best known for casting gold or copper alloy, where the medium is very fluid, and would not be particularly well suited to glass, where the medium is quite viscous. It may be that powdered glass was continually added to the heated mold until it was filled, in this way small items can be produced without the risk of trapping large air bubbles. Whatever means was used, the finished object would require considerable retouching.

Shabtis made in glass might have been produced by the lost wax process, but this is uncertain, and Cooney (1960: 13) states that they were extensively reworked after casting in whatever kind of mold was used.

Glass Use and Discard

The purpose of glass objects has already been touched upon, namely as items of personal adornment, inlays, and containers. For small items of adornment the use of glass was essentially identical to that of faience and even stone—serving as beads or amulets whose color and shape had particular symbolic or decorative importance. However, at least in its earliest phases, glass was a new material, apparently conjured up from unlikely raw materials, which alone shared few if any of the properties of the finished item. The seemingly miraculous quality of this rare new material may have given glass a status above that of faience, making it a prestige product destined for the use of the high elite of Egyptian society.

The only items of glass sculpture in the round, which are known from ancient Egypt, were associated with pharaoh or his highest officials. That figures of the king or shabtis for his nobles were made in the material emphasizes its importance as well as its acceptance as a substitute, though not an inferior one, for faience or stone. Glass had a status, which rendered it suitable for the afterlife as well as the earthly one. This view is further reinforced by the use of glass inlays in the gold mask of Tutankhamen rather than lapis lazuli and the manufacture of head rests for his tomb in glass. The use of materials in the ancient world cannot be judged by the value we place on them today—just as the iron in Tutankhamen's tomb was a novel, high-tech material, so glass seems to have enjoyed royal approval as a new and fascinating product.

The use of glass containers was associated with expensive contents. Vessels served to hold perfumes, oils, and unguents rather than common items. Indeed, the use of glass simply as a convenient and quickly produced container is a result of glassblowing, a technique introduced in Roman times from the first century BCE. The time taken to produce a glass vessel by the core forming technique meant that each was an individually crafted work of art, whose form and appearance may well have been as important and as valued as the contents.

The questions of glass discard and recycling have not been studied for ancient Egypt. There has been little work on the question of discard of materials in general. What is clear is that the earliest glass had a considerable value, and most of our glass finds of vessels are from funerary contexts. Multi-colored glass was difficult to recycle because the colors become merged and yield a dirty opaque glass. While the addition of a strong colorant such as cobalt might alleviate this problem, it is more likely that only monochrome glass was recycled. It might be expected that with a newly established craft, whose practitioners were few and worked in a limited number of centers, the return of broken glass to the workshops would be very limited and difficult to achieve. More likely, broken fragments might have been treasured by more low ranking individuals, pierced as beads or kept as curios. Vessels or other items, which broke at the workshops, could of course be easily recycled. Scientific examination of early glasses from Egypt is not as yet sufficiently advanced for much to be said about the occurrence or scale of recycling.

Bibliographic Notes

There is extensive literature on the history of glass, amongst which the work edited by Tait (1991) is particularly accessible. On Egyptian glass in particular, the work by Nolte (1968) remains a valuable summary of the range of vessels and gives some indication of possible working areas and the determination of dates. The range of material is accessibly covered by Cooney (1976) in his catalog of Egyptian glass in the British Museum. The technology of Egyptian glass in general and its scientific examination have been covered by Nicholson and Henderson (2000). There has been a considerable interest in many aspects of glass production, especially at Amarna (Nicholson 2007; Shortland 2000, 2009) following the work of Petrie (1894).

References

Beck, Horace C.
1934 Glass before 1500 BC. *Ancient Egypt* XIX, pp. 7 - 21.

Cooney, John
1960 Glass sculpture in ancient Egypt. *Journal of Glass Studies* 2, pp. 10 - 43.
1976 *Glass*. Catalogue of Egyptian Antiquities in the British Museum 4. London: British Museum Publications Limited.

Gudenrath, William
1991 Techniques of glassmaking and decoration. In *Five thousand years of glass*, ed. Hugh Tait, pp. 213 - 241. London: British Museum Press.

Harden, Donald
1968 Ancient glass I: Pre-Roman. *Archaeological Journal* 125, pp. 46 - 72.

Lucas, Alfred
1962 *Ancient Egyptian materials and industries*. 4th edition, revised and enlarged by John Richard Harris. London: Edward Arnold. (Originally published 1926.)

Nicholson, Paul T.
2006 Glass vessels from the reign of Tuthmosis III and a hitherto unknown glass chalice. *Journal of Glass Studies* 48, pp. 11 - 21.
2007 *Brilliant things for Akhenaten: The production of glass, vitreous materials and pottery at Amarna Site O45.1*. London: Egypt Exploration Society.

Nicholson, Paul T., and Julian Henderson
2000 Glass. In *Ancient Egyptian materials and technology*, ed. Paul T. Nicholson, and Ian Shaw, pp. 195 - 224. Cambridge: Cambridge University Press.

Nolte, Birgit
1968 *Die Glasgefäße im alten Ägypten*. Münchner Ägyptologische Studien 14. Berlin: Bruno Hessling.

Oppenheim, A. Leo
1973 Towards a history of glass in the ancient Near East. *Journal of the American Oriental Society* 93, pp. 259 - 266.

Petrie, William Matthew Flinders
1894 *Tell el-Amarna*. London: Methuen.
1925 Glass found in Egypt. *Transactions of the Newcomen Society for the Study of the History of Engineering and Technology* 5, pp. 72 - 76. (Note that this is not actually by Petrie, but an account of a lecture given by him.)

Reeves, Nicholas
1986 Two name-beads of Hatshepsut and Senenmut from the mortuary temple of queen Hatshepsut at Deir el-Bahri. *Antiquaries Journal* 66, pp. 387 - 388.

Rehren, Thilo, and Edgar Pusch
2007 *Hochtemperatur-Technologie in der Ramses-Stadt: Rubinglas für den Pharao*. Forschungen in der Ramses-Stadt: Die Grabungen des Pelizaeus-Museums Hildesheim in Qantir-Pi-Ramesse 6. ed. Edgar Pusch, and Manfred Bietak. Hildesheim: Verlag Gebrüder Gerstenberg Hildesheim.

Schlick-Nolte, Birgit, and Rosemarie Lierke
2002 From silica to glass: On the track of the ancient glass artisans. In *Reflections on ancient glass from the Borowski Collection*, ed. Robert Bianchi, pp. 11 - 40. Mainz: Philipp von Zabern.

Schlick-Nolte, Birgit, and Rainer Werthmann
2003 Glass vessels from the burial of Nesikhons. *Journal of Glass Studies* 45, pp. 1 - 34.

Shortland, Andrew J.
2000 *Vitreous materials at Amarna: The production of glass and faience in 18th Dynasty Egypt*. British Archaeological Reports International Series 827. Oxford: Archaeopress.
2009 Glass production. In *UCLA Encyclopedia of Egyptology*, ed. Willeke Wendrich. Los Angeles: University of California. (Internet resource: http://digital2.library.ucla.edu/viewItem.do?ark=21198/zz001nf67x.)

Stern, E. Marianne, and Birgit Schlick-Nolte (eds.)
1994 *Early glass of the ancient world: 1600 B.C. - A.D. 50*. Ostfildern: Gerd Hatje.

Stocks, Denys
2003 *Experiments in Egyptian archaeology: Stoneworking technology in ancient Egypt*. London and New York: Routledge.

Tait, Hugh (ed.)
1991 *Five thousand years of glass*. London: British Museum Press.

Wosinski, John, and Robert Brill
1970 A petrographic study of Egyptian and other cored vessels. In *Studies in glass history and design: Papers read to Committee B Sessions of the VIIIth International Congress on Glass, held in London, 1st - 6th July 1968*, ed. Robert Charleston, Wendy Evans, and A. E. Werner, pp. 123 - 124. Sheffield: Society for Glass Technology.

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Figure 1. Glass headrest of Tutankhamen. This is believed to have been cast and cold worked. It was made in two parts joined by a wooden dowel and covered by a gold band. Carter's number 403a. Photograph by the author.

Figure 2. A core drying before being heated and coated in glass (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 3. Applying glass to a dried and heated core (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 4. A core covered in glass being rolled on the marver stone. Note that the rim has been given a band of white glass (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 5. Using a metal tool to draw up some of the bands of applied decoration to form them into swags or zigzags (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 6. A completed replica of a kohl tube in the form of a palm. The piece has been annealed and still contains the core, which now has to be broken up to remove it (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 7. A replica of a Roman ribbed bowl being slumped over a former (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.

Figure 8. A replica Roman bowl slumping over its former in the furnace (Taylor and Hill, Roman glassworkers, Andover, Hampshire, U.K.). Photograph by the author.