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Short Citation:
Nicholson, 2009, Faience Technology. *UEE*.

Full Citation:
Nicholson, Paul T., 2009, Faience Technology. In Willeke Wendrich (ed.), *UCLA Encyclopedia of Egyptology*, Los Angeles. http://digital2.library.ucla.edu/viewItem.do?ark=21198/zz0017jtts

1082 Version 1, March 2009
http://digital2.library.ucla.edu/viewItem.do?ark=21198/zz0017jtts

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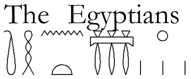
Fayence
faïence

Faience has been described as "the first high-tech ceramic," which aptly describes its artificial nature. Unlike conventional, clay-based ceramics, the raw material of faience is a mixture of silica, soda, and lime reacted together during firing to make a new medium, quite different in nature to its constituents. The Egyptians referred to the material as tjehenet ("that which is brilliant or scintillating"), because of its reflective qualities, which they associated with the shiny surfaces of semi-precious stones.

وصِف الفايينس كأول نوع من الخزف يصنع بإستخدام تقنية عالية فبعكس الخزف المصنوع من الطين، يتكون الفايينس الخام من مزيج من السليكا والقلويات والجير وهي مواد تتفاعل سوياً أثناء الحرق لتكوين مادة جديدة تختلف كثيراً عن مكوناتها. أشار المصريون القدماء إلى الفاينس بإستخدام كلمة << *tjehenet* >> التي تعني الامع أو المتلألئ بسبب طبيعته التي تعكس الضوء والتي ربطوها بلمعة الأحجار النصف كريمة.

Faience has been described as "the first high-tech ceramic" (Vandiver and Kingery 1987b), which aptly describes its artificial nature. Unlike conventional, clay-based ceramics, the raw material of faience is a mixture of silica (quartz), alkali (soda), and lime reacted together during firing to make a new medium, quite different in nature to its constituents. The Egyptians referred to the material as  *ṯḥnt* (*tjehenet*) "that which is brilliant, scintillating, or dazzling," in view of its reflective qualities, which they associated with the shiny surfaces of semiprecious stones.

Nomenclature

Faience derives its modern name from its bright colors, which reminded early travelers to Egypt of "Fayence," a colorful tin-glazed pottery that they knew from late medieval times and that took its name from the town of Faenza in northern Italy (confusingly, this pottery is itself now usually called majolica). The color most associated with the material is blue or blue-green and was probably produced in imitation of semiprecious stones such as turquoise and green feldspar, as well as lapis lazuli. The Egyptian name for the material was *ṯḥnt* (*tjehenet*), meaning "brilliant" or "dazzling" in reference to its brilliant shine, like that of the stones it was imitating (Friedman 1998: 15).

The origin of faience is probably to be sought in the Egyptian desire for semiprecious stones, not least those with the reflective blue color of the sky. It may have been the wish to replicate these that led to the glazing of steatite (soapstone, which hardens to become enstatite on firing) and quartz. The glazing of these stones developed as early as Predynastic times, when a soda-lime-silicate glaze was applied over the carved stones.

Peltenburg (1987: 20) has made the point that faience glazing was an essentially "cold working" technology, unlike glass, which was "hot worked." By this is meant that the faience worker prepared his object and glazing materials cold, the firing of the object being done at a later stage. This technique also applies to the glazing of stone and indicates a clear link between craftsmen in semiprecious stones and glazing in the earliest phase of the production of glazed materials.

It is not clear how the transition from objects carved from stone to objects made from what is essentially a reconstituted and modified stone (comprising crushed quartz or sand and alkali) was made, but it happened during the Predynastic Period and was already well established by Early Dynastic times. It may have been driven by the desire to achieve more detailed "carvings" than could readily be produced from solid quartz and yet preserve a greater brilliance than normally found on glazed steatite. The steps in this discovery are not known, but the result is essentially a reconstituted stone to which the name "Egyptian faience" has been given.

It is worth noting that Egyptian faience, more frequently referred to simply as "faience," is not exclusive to Egypt but is well known elsewhere in the Near East and the Aegean, and is found in smaller quantities in Europe where it was produced, and probably developed, independently (for summaries see Beck and Stone 1936; Newton 1980; Stone and Thomas 1956).

Raw Materials

As with all ancient materials the resources necessary for faience production had to be sourced from within the landscape. In the case of faience these materials would comprise silica (quartz, either in the form of pebbles, which could be crushed, or quartz sand) and an alkali (soda in the form of natron from the Wadi Natrun or other lesser sources, or from the ash of burnt plants). To these would be added lime (intentionally or not), either naturally present in the sand or from crushed or calcined (heated) limestone. Color was normally achieved by the addition of metal compounds, most notably copper.

Traditional craftsmen did not work to the kinds of precise formulas now employed in industrial manufacturing. As a result, variations in faience composition are to be expected and numerous faience recipes are known. Vandiver states that a fairly typical bulk composition is:

Silica	(SiO_2)	92 – 99%
Lime	(CaO)	1 – 5%
"Soda"	(Na_2O)	0 – 5%

To this mixture may be added small quantities of copper oxide (CuO), magnesium oxide (MgO), and potassium oxide (K_2O), along with quantities of aluminum oxide (Al_2O_3) and traces of other elements (Vandiver 1983: A18). It should be noted that the form in which these substances (which show as oxides in analyses) were added is not known with certainty.

The silica makes up the body of the material. However, unlike the components of glass manufacture, the soda and lime are not present in sufficient quantity to melt the silica completely at the production temperatures; rather, they serve to react with the silica to form a small amount of glass that binds the silica grains (Kaczmarczyk and Hedges 1983; Nicholson and Peltenburg 2000; Tite et al. 1983; Vandiver and Kingery 1987b; fig. 1).

Forming of Objects

In order to form an object a faience paste first had to be produced. This would involve the collection and crushing of quartz pebbles, probably using pounders and quernstones, or the collection of quartz sand. The sand itself would normally have required some crushing or grinding to render it into a flour-like powder to which crushed natron (or plant ash) and lime would be added. These ingredients too would need processing. The lime might come from crushed limestone, or from limestone that had been calcined and then reduced to powder (it might also be naturally present among the quartz sand and

so be crushed and added unintentionally with the sand itself). Where plant ash soda was used the coarse material from the ashing of the plants would have to be picked or sieved out before crushing the remainder. The materials would then be mixed together in approximately the ratio presented above. The paste produced was thixotropic—that is, subject to changes in viscosity that would make it difficult to shape and prone to losing detail.

Figure 1. Cross section through a faience inlay from Tell el-Amarna. The upper surface, a thin layer of greenish glaze, tops a layer of very fine faience and a coarse layer beneath. This piece was probably glazed by efflorescence.

A wide range of techniques was used for the shaping of the faience body material. An object might be roughly modeled in the soft paste, allowed to dry and then abraded to its final shape using sharp tools. This abrasion technique seems to have been widely used to make the small animal figures popular in Early Dynastic times.

Where numerous identical pieces were required—for example, inlays for furniture or buildings, or amulets—then molding could be used. A pad of clay was impressed with the shape of the desired object, using an existing object or a metal or wooden former, or perhaps by carving out the clay to the desired shape. The mold was then fired and could subsequently be used to produce multiple copies of the object in faience paste. Since the object was not fired in the mold but rather tipped out of it to dry, the mold could be used many times in quick succession. Eventually the mold, which was porous, would itself soak up some of the paste materials; when efflorescent pastes were being used, the mold would eventually gain an effloresced surface and become useless. At this point it seems that the mold would be discarded and a new one made. It is likely that the glazed tiles used in the Step Pyramid complex of Djoser were made by molding and may thus serve as an early example of mass production. These tiles are believed to have been glazed using the efflorescence process (described below under *Glazing*), which was typical of the Old Kingdom (Vandiver 1998: 122).

Because the faience paste is thixotropic, even molded pieces are rarely truly identical, since the material often loses detail, such as impressed hieroglyphs, as it dries (fig. 2). Molded pieces may therefore require some re-touching, essentially re-carving of detail, after they are removed from the mold. This has been a source of difficulty in modern replication experiments. It is worth noting, however, that modern experimenters (e.g., Eccleston 2008; Griffin 2002; Lavenex Vergès 1992; Tite et al. 2007) necessarily start their work with no experience of faience production and so lack the years of expertise of the ancient practitioners. As a result, some of the difficulties inherent in the process are more obvious than they would have been in ancient times.

Larger items, such as vessels, might be formed around a core of straw or other plant materials (as with some of the "hedgehog" figures from the Middle Kingdom), or modeled or molded in sections that were joined together (such as some of the chalices of the New Kingdom and later). There is debate about whether the potter's wheel was used to make vessels, although Vandiver (1983: A123 - A125) believes that it was employed from the New Kingdom onwards. In her study, Vandiver found no evidence for clay being added to the body of the vessel to increase its plasticity (1983: A124), but has subsequently stated that 5 - 25% clay was added (Vandiver 1998: 123), and that 10% is

sufficient to facilitate throwing. Wheel throwing has been argued for the Ptolemaic and Roman periods in particular, when clay may have been included in the faience body, but there has been no agreement about whether the wheel was actually used.

Figure 2. Clay mold (left) for making a faience ring bezel (right). Note that the hieroglyphs are less clear on the bezel than in the mold. This is a common problem in faience manufacture.

While faience was mostly used for the production of small items, it was also sometimes used in the production of larger pieces. One of the largest of these is a scepter (Victoria and Albert Museum 437-1895) inscribed for Amenhotep II found by Petrie at Naqada in 1894. The piece measures 2.158 m in length, but is made by joining shorter sections together with faience paste. Also made for Amenhotep II is a large sphinx, 250 mm long and 140 mm high, now in the Metropolitan Museum of Art (MMA1972.125). The same collection includes a faience lion (MMA 35.1.23; from Qantir, dating to the reign of Ramesses II) holding a captive chief of Kush. Its height (0.70 m) and bulk make it among the largest pieces known. The site of Qantir has yielded a great deal of evidence for faience production and some particularly fine pieces (Hamza 1930).

These large pieces are well known because they are exceptional in scale. However, there is an extensive size-range of objects between these and the smallest faience items, such as rings, beads, and amulets. Perhaps most common in this middle category are tiles. From Amarna and other New Kingdom sites we have many tiles probably intended for inlaying (e.g., into furniture or as decorative architectural elements). Some of these are the elaborate polychrome tiles — yet to be satisfactorily replicated — representing naturalistic subjects from the Amarna Period, as well as tiles representing the "Nine Bows" from Ramesside times. Other tiles are polychrome by virtue of deliberate and obvious inlay; these include the well-known "daisy tiles," in which white and yellow flowers are set into circular voids in the green background, good examples of which are to be found in the Metropolitan and Petrie museums.

A less obvious form of "tile" is the hieroglyph inlay, or sculptured piece. These can be quite large and represent individual hieroglyphic signs, or parts of the human body (hands and heads, for example), which would be used to make up composite figures for inlay into walls or furniture. A number of such pieces have survived from the vitreous-materials workshop recently excavated at Amarna (Nicholson 2007).

Glazing

There are three known methods of faience production (see Tite and Bimson 1986). However, as Vandiver (1998: 121) has pointed out, the tendency of scholars to concentrate on the glazing method has sometimes obscured our view of change in the faience production process. Nonetheless, it is important that the three basic glazing methods are understood. They are as follows:

1. Application. This is the method by which Petrie (1894, 1909, 1911) assumed all faience was made. He derived most of his information for this view from the examination of surface material at Memphis and, later, from actual excavation there. His reconstruction of the process was aided by what he knew of the manufacture of glazed ceramics in his own time. In the application

method an object made of faience body material is coated with a slurry (a suspension of glazing ingredients) or a powdered glaze, usually before firing. This coating material contains (or is itself) the colorant, which might be copper or Egyptian blue. It is allowed to dry on the object, and once the object is fired, the coating becomes fused to give a shiny glaze. The overall coating also serves to strengthen the object and, in the case of containers intended for liquids, to make it waterproof.

The application method of glazing was particularly common in Ptolemaic and Roman times. At the Roman-Period site of Kom Helul at Memphis, Petrie found the remains of cylindrical containers known as "saggars," in which stacks of vessels were placed during firing (Petrie 1909, 1911; cf. Nicholson 2006). The vessels were placed one inside the other, separated by small cones of clay (each cone's point rested on the inside of the vessel beneath, while the cone's broad end was attached to the stand ring of the vessel; fig. 3). After firing, the stack of vessels would be removed from the saggar by breaking away the cones. The cone-point would leave only a pin-prick mark in the glaze, while the breaking away of the broad end of the cone would leave a scar on the vessel's stand ring, where it would not normally be visible (see Shortland and Tite 2005). The saggars themselves became glazed over time and it is common to find examples whose interior is coated in, for example, dark blue glaze, but whose underside is light blue. This is a consequence of the fact that the saggars were stacked one above the other, as a result of which the underside of a saggar would reflect the glaze color of the saggar beneath it, while the saggar's interior walls bore the color of the vessels stacked inside.

The marks left on the glazed objects by the cones are a clear indication that glazing was carried out by application, as are brush marks, drips and runs of glaze, and occasional finger marks left on the objects as the glaze slurry dried. If too much glaze was used, or the firing was at too high a temperature, or for too long a time, glaze sometimes became too liquid and so pooled in the bottom of vessels, leaving a thick layer.

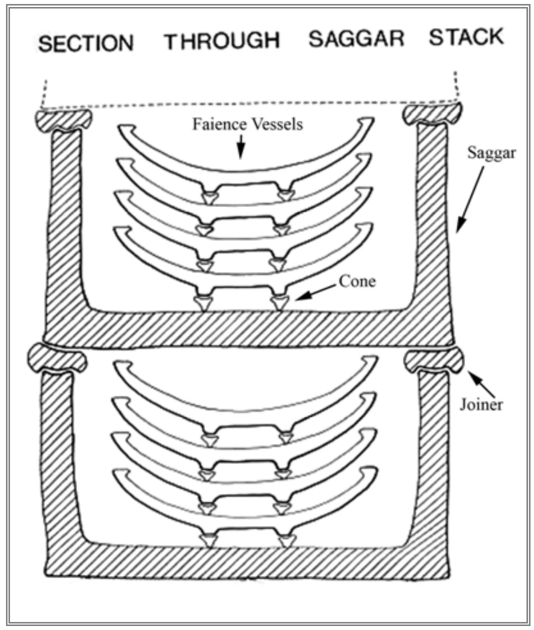


Figure 3. Reconstruction of a Roman-Period saggar stack from Memphis. The faience vessels are separated from one another by small clay cones. The base of one saggar serves as the lid of the one beneath and is joined to it by a ring of clay.

It can be very difficult for the archaeologist to determine glazing methods—even where it is possible to examine a cross section, as in a sherd, and the problem is compounded when examining complete objects, although application leaves the clearest macroscopically detectable indications. The scanning electron microscope (SEM) is the most reliable method for determining glazing technique (Kaczmarczyk and Hedges 1983; Tite and Bimson 1986; Tite and Shortland 2008; Tite et al. 1983) and, in the case of application glazing, shows, in the cross section, a clear layer of glaze upon the faience body (Tite et al. 1983).

2. Efflorescence. This seems to have been the most common method of producing a glaze during the Pharaonic Period and is especially prevalent from at least the New Kingdom onward. In this method the

materials of the faience body (paste) are mixed with the coloring material (frequently copper). The mix is prepared wet and can thus be shaped into an object, often by being pressed into a mold. As the object dries, an effloresced "scum" layer develops on the surface of the object.

After firing in the kiln, this effloresced coating forms the colored glaze. Because the ingredients are mixed throughout the body material, rather than simply added to the surface of an already-made object, the heating causes them to fuse together and create a substantial glassy phase. (It will be recalled that faience is essentially the same as glass in its composition, and so contains materials that develop a glassy phase.) The alkali acts as a flux in faience pastes, allowing the silica to fuse at lower temperatures than would otherwise be possible. The greater amount of fluxing materials in effloresced paste—as compared to that in the other two methods of glazing faience pastes—helps to create interparticle glass (rather than interstitial glass: see Vandiver 1998: 124), which helps to bind the silica together and so produce a stronger object. By this method it became possible to produce finger rings of sufficient strength to be worn. Vandiver (1998: 132) states: "Faience bodies are the complex process of glassmaking stopped in the middle as described by a narrow range of variables. Glazes on faience bodies are the glass forming reactions carried to completion."

The efflorescence technique is well attested at Amarna (where there are molds covered in effloresced paste), but was not recognised by Petrie, who thought that all faience was made using application. The technique was not generally noted until the 1960s, when Kühne (1969) produced a paper on this "self-glazing" technique. Since no glaze is actually added to the finished object, there are no brush marks or finger marks present from this technique, nor are there usually stand marks from kiln furniture (such as cones). However, some pieces do seem to have stood on undulating surfaces in the kiln; as a result, some marks may be found even on effloresced pieces. A clearer indication of the technique is that the glaze will be thinnest on those parts of the object where air was least able to circulate during drying. This is usually the underside, where the piece was set to dry on a board or other surface where the air could not easily circulate to produce an effloresced surface. As a result, the glaze on the underside of an inlay or vessel is often very poor and erratic; since it would not normally have been seen, it was likely unimportant to the makers (Tite and Bimson 1986; Tite et al. 1983).

When examined under a SEM, it is obvious that there is a great deal of interparticle glass between the silica grains and that this extends to the surface, where it forms the glaze. Although this glassy phase is usually most extensive at the surface, it is present throughout (Tite and Bimson 1986).

3. Cementation. This method of glazing only became known to archaeologists in the 1960s, when Wulff, Wulff, and Koch (1968) discovered it being practiced in the (contemporary) town of Qom in Iran, the site after which it takes its alternative name, the "Qom Technique." In this method the silica making up the faience body material, along with alkali, is shaped to produce the object. Once dry, the object is placed in a container tightly packed with a powdered mixture—the glazing material—comprising lime, ash, silica, charcoal, and a colorant. A range of mixtures of these ingredients has been shown to yield a glaze. Once again this is a soda-lime-silica glaze, but its method of transfer to the object is markedly different in that it glazes by reaction with the object's silica core, rather than by being directly applied to it. After the object has been buried in the glazing powder, the container is then placed in the kiln and fired. During the firing process there is a reaction between the surface of the object and the powder around it, whereby the object becomes glazed. Interestingly, the glazing powder not in direct contact with the silica does not become fused into a glaze, but remains as powder and can be crumbled away from the object after firing (see Brandt 1999).

Faience objects glazed by cementation have, of course, no brush marks, drip marks, or stand marks, and the technique is therefore extremely difficult to determine with confidence on a fragmentary hand specimen. Under a SEM the glaze can be seen to penetrate a little way into the silica body, which is otherwise unaffected, in marked contrast to the thick layer of what is essentially pure glaze on applied pieces, or the interparticle glass of effloresced examples.

The cementation technique is thought to have occurred in Egypt from at least as early as the Middle Kingdom but is not well attested, perhaps because relatively few pieces have been scientifically examined and because it is difficult to detect with certainty.

It should be borne in mind that glazing techniques might sometimes be combined (cf. Vandiver and Kingery 1987a) and individual objects might thus exhibit a confusing mixture of methods. For example, because faience paste is thixotropic and often loses detail (such as impressed hieroglyphs; fig. 2) as it dries, faience workers were sometimes able to restore definition by abrasion, thereby removing part of the effloresced surface. Such surface damage could be retouched using a thin solution of the efflorescent body material, i.e., a solution of the body material that contains the glazing constituents. Accordingly brush marks or secondary efflorescence layers might be introduced.

Coloring

The earliest faience is invariably blue or green, exhibiting the full range of shades between these two colors. The coloring material was usually copper. From the New Kingdom onward, however, the color palette was extended, probably following the introduction of glass into Egypt. Kühne (1969: 25) believed that ground glass might have been added to the faience body, thereby increasing the range of colors as well as increasing the strength of the material. Vandiver (1983: A108) later took the same view. More recent work by Shortland (2000: 58), particularly on the material called by Lucas (1962: 163 - 164) "Variant D," has shown that the composition does not match that of glass, and that its addition is therefore unlikely. It is possible that the glassy phase may result from the addition of colored frit to the faience mixture. (Frit is a mixture of the ingredients of glass that have been incompletely reacted together; it is a material in its own right and can be used as a pigment or for making objects.) It is certainly true, however, that glass may have been used as an ingredient in applied glazes, especially for yellows and lime greens (Vandiver 1998: 122). Other colors were produced using transition metals such as red iron oxide. Cobalt could be used for dark blues.

Whatever the main glaze color, black manganese was commonly used to add detail, such as the hieroglyphs and decorative patterns frequently seen on otherwise plain objects.

Firing

It has generally been assumed that faience was fired at temperatures of 800 – 1000°C (Vandiver 1998: 124). This is likely to be true for many pieces, whether they were prepared in a kiln or fired in the open. Unlike unglazed pottery, faience pieces tend to stick together if they come into contact with each other during firing. This can leave pieces adhered to one another in such a way that they are difficult to separate. As a result, it has usually been assumed that they were fired on trays or in saggar vessels. It is known that saggars were used in the Roman production at Memphis (Petrie 1909, 1911; Nicholson 2006), and it is possible that they were also employed in the firing of some New Kingdom material. The cylindrical vessels believed to have been used for the production of glass ingots at Amarna may also have been used as small saggars for the firing of faience objects (Nicholson 2007: 130). However, the faience objects could not be set directly upon the ceramic surface during firing or they would also stick to that. It is likely that lime or possibly quartz pebbles (Eccleston 2008: 33; Petrie 1894: 26) were used as a separating layer.

It may be that scholars are sometimes overly focused on the scale and temperature of faience production; indeed the work of Eccleston (2008) has shown that it would be possible to manufacture faience in a simple bread-oven. Although he fired at temperatures of 800 – 900°C it is possible that a longer firing at a lower temperature might have yielded similar results, and we should be aware that small-scale production in particular might require the minimum use of materials. Although much more research needs to be done on the firing temperatures of faience, Vandiver (1998: 129 - 136) has made some progress in this direction, noting that specimens fired at higher temperatures generally have smooth glaze, rounded bubbles, and greater penetration of glaze into the body.

Firing structures for faience are not well known. The surviving evidence is summarized in Nicholson and Peltenburg (2000). A series of pits, some lined with broken bricks, at Abydos, dating from the mid-Old Kingdom into the Middle Kingdom, forms the earliest known evidence for purpose-built firing structures. These pits may have operated at temperatures below those normally quoted, but this remains speculative.

For the Middle Kingdom there is production evidence from Kerma in Nubia (Lacovara 1998) and from Lisht, although there is uncertainty as to whether a structure found at Lisht is a Middle Kingdom kiln or a later (intrusive) silo. Evidence for kilns is better for the New Kingdom and several possible candidates are known from Amarna site O45.1. However, it must be stressed that these latter could simply be pottery kilns. It is quite possible that faience firings took place in these, or indeed in the structures identified as possible glass kilns, since several craft-working facilities are located in close proximity (see Nicholson 2007). The best evidence comes from the massive Roman-Period furnaces excavated by Petrie (1909, 1911) at Memphis. These seem to have been square or rectangular in form, unlike the smaller ovoid kilns of the New Kingdom, and would have held large quantities of material in saggars. Based on inclusions in the slaggy waste material, Petrie stated that they were fired using straw; this evidence is currently being reviewed. The scale of these kilns or furnaces is such that they may have been fired at high temperatures for prolonged periods, but we should be cautious in applying existing evidence to earlier periods and to smaller scales of production.

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As with many Egyptian crafts, the standard account of faience production can be traced back to the work of Sir Flinders Petrie at Tell el-Amarna (1891 - 1892, published as Petrie 1894) and Memphis (1908 and 1910, published as Petrie 1909, 1911). However, many of the details given by Petrie have been shown by recent work to be only partly correct, and some modification is needed. Alfred Lucas examined faience along with other materials during the 1920s (see Lucas 1962 for the latest edition of his findings). Binns, Klem, and Mott (1932) were the first to note that self-glazing of faience was possible. Ethnographic work by Wulff, Wulff, and Koch (1968) showed that faience could be glazed by cementation as well as by application and efflorescence. The following year Kühne (1969) published his important study of faience of the second millennium BCE, and in 1971 Kiefer and Allibert (1971) attempted to develop the work undertaken by Binns on self glazing (or efflorescence). These works eventually led to renewed interest in determining how the main faience-making techniques could be detected. Important pioneering analyses seeking to determine faience-making techniques were published by Tite, Freestone, and Bimson (1983) and by Tite and Bimson (1986). Tite's work established the background from which subsequent work developed, and he has recently edited and co-written a summary of analytical work on faience (Tite and Shortland 2008). Other important early work was

undertaken by Kaczmarczyk and Hedges (1983), Vandiver (1983), and Vandiver and Kingery (1987b). The work by Kaczmarczyk and Hedges (1983) with its significant technological appendix by Vandiver remains the most exhaustive analytical study of faience. More recently Shortland (2000) has carried out work on faience from Amarna and, in collaboration with Tite (Shortland and Tite 2005), from Memphis. This latter may require some reinterpretation in light of the ongoing work at that site. Recent excavations by Nicholson at Amarna have investigated the making of faience and glass there (Nicholson 2007), putting some of Petrie's finds into a more secure context. An attempt to update the work of Lucas (1962) and summarize more recent work on the subject has been made by Nicholson and Peltenburg (2000). A very useful summary of the production of faience and of the range of objects it was used to produce has been provided by Friedman (1998).

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Figure 1. Cross section through a faience inlay from Tell el-Amarna. The upper surface, a thin layer of greenish glaze, tops a layer of very fine faience and a coarse layer beneath. This piece was probably glazed by efflorescence. Photo by Gwil Owen. Reproduced courtesy of the Egypt Exploration Society.

Figure 2. Clay mold (left) for making a faience ring bezel (right). Note that the hieroglyphs are less clear on the bezel than in the mold. This is a common problem in faience manufacture. Photo by Gwil Owen. Reproduced courtesy of the Egypt Exploration Society.

Figure 3. Reconstruction of a Roman-Period saggar stack from Memphis. The faience vessels are separated from one another by small clay cones. The base of one saggar serves as the lid of the one beneath and is joined to it by a ring of clay. Drawn by Joanne Hodges.