ANALYSIS OF EGYPTIAN FAIENCE VESSEL FRAGMENTS EXCAVATED IN SIDON IN 2005

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Plate 1. This photograph shows the faience vessel fragments from the 2005 Sidon excavations. The sample container in the upper left of the photograph is 4 cm top to bottom which gives an indication of scale.

Introduction

During the 2005 excavations at the College site in Sidon, a number of faience vessel fragments were discovered in association with pieces of baked clay and pottery [1]. Some of the faience vessel fragments have been examined by non-destructive variable pressure scanning electron microscopy and associated energy dispersive X-ray spectrometry (SEM-EDS). The first aim of these analyses was to improve understanding of the materials and techniques used to make the faience vessel or vessels. A secondary purpose was to seek to establish whether the fragments were likely all to be part of one vessel or whether the fragments were more likely to represent several vessels.

Some of the faience fragments (those in the lower part of Plate 1) bear hieroglyphic inscriptions. Marée has examined photographs of these and discusses the inscriptions in this volume [2], noting that they identify the originator as Queen Tawosret in her brief period of independent rule as pharoh at the end of the Nineteen Dynasty around 1190 BC, The inscriptions are of considerable importance as they identify the originator as Queen Tawosret in her brief period of independent rule as pharaoh at the end of the Nineteenth Dynasty around 1190 BC, a time of significant disruption and discontinuity in the Eastern Mediterranean. The date and origin of the vessel also give it considerable significance in the history of pyrotechnology, not least because technological changes may often be associated with social, economic and political changes. The inscribed vessel provides rare and well dated evidence of the manufacturing techniques and materials used in the production of Egyptian faience vessels at the time.

The nature of Egyptian faience

The term "faience" in the present context is used to indicate man-made ceramic objects that have a body composed primarily of crushed quartz coated in a glaze. This form of faience is often referred to as Egyptian faience, not to indicate its geographical origin (for it is also made elsewhere), but to distinguish the quartz-based faience objects from the tin-opacified glazed clay ceramic (also called faience but often now called majolica) made in mediaeval Faenze in Italy and elsewhere [3].

Egyptian faience objects generally have a body composed almost entirely of finely crushed quartz or sometimes naturally occurring sand. Small amounts of lime and alkali (from natron evaporite deposits or plant ash) are usually present in the body. They may improve dry strength after forming and prior to firing [4] and give some rigidity to the fired body by promoting sintering and by giving rise to a small amount of interstitial glass. Often, however, as in the case of the faience vessel(s) from Sidon, the body itself is very friable. The main strength of the object as a whole is often dependent on the glaze in which the body is coated.

Knowledge of the rheological properties of wet faience body mixtures and their strength when dry is at present limited. The extent to which these properties may or may not have been improved by the addition of organic binders (such as cereal flour paste) also remains a matter of speculation. It is of course quite possible that organic binders were used in some places and at some times. It may be that the presence of small amounts of lime and alkali improve cohesion and/or impart sufficient dry strength to obviate the need of any organic binder [4].

Vandiver reported chemical analyses of bodies as covering the ranges 92-99% silica, 1-5% lime and 0.5-3% soda with minor amounts of other constituents. She reported the glazes as generally being a soda-lime-silica composition with copper, manganese and/or iron as colorants [5].

The Sidon faience vessel fragments: style and form

The faience vessel fragments from the Sidon 2005 excavations are shown in Plate 1. Photographs of the bottom row of fragments have been examined by Marée [2]. He notes that parts of the lotus petal design and the upper band of inscription were originally coloured blue. He considers that the inscribed fragments originally formed part of the lower body of a 'drop vase' with a broad, rounded base and an elongated, cylindrical body narrowing slightly towards the top [2].
A close parallel to the Sidon Tawosret vase occurs in the form of a faience drop vase from a temple at Tell Deir Alla in the Jordan Valley. This vase also bears the name of Tawosret [2 & 6]. The Deir Alla vase is illustrated by Franken in a photograph [7] and by two drawings [8]. The Deir Alla vase is 24 cm high. The rim is a simple horizontal cut across the wall of the vase without any decorative form. The vase is decorated with a lower geometric band of repeating motifs possibly representing stylized lotus petals, a deep central band or block bearing inscriptions and an upper decorative band below the rim. The upper band is composed of repeating motifs perhaps representing leaves or petals and seems more delicately executed than the bolder more rectilinear lower band.

It may been seen from Plate 1 that the different Sidon fragments bear distinctly different styles of decoration, albeit with some common ground in the more or less stylized depiction of foliage. By parallel with the Tell Deir Alla vessel, differences of style in the Sidon fragments do not of themselves require that the different stylistic groups into which the fabrics are grouped in Plate 1 necessarily come from different vessels. It may be that the recovery of further fragments from future excavation will clarify the interrelationship between the fragments in Plate 1 and the question of whether they derive from one or several vessels.

Vessel structure

Visual examination of the fragments including the inscribed pieces in the lower row and the fragments in the middle row of Plate 1 shows some remar-kably straight breaks. These flat breaks are in conside-rable contrast to the other more ragged breaks. One might at first glance be tempted to think that the straight breaks could be rims. The flat breaks do not, however, bear glaze. In the case of the inscribed fragments at least there is a stronger argument against the straight breaks being rims: the flat break can hardly represent the rim because the break cuts two thirds of the way through the upper inscribed band.

Plate 2. A view of a section through the outer surface of one of the fragments with a dark red outer surface. (This fragment is shown in the top right of Plate 1). The section shows a distinct more compact subsurface layer overlying the bulk of the body.

It thus seems far more likely that at least some of the flat breaks represent planes of weakness in the structure of the body of the vessel. These lines of weakness are probably indicative of the methods used in the original construction. During construction, it may have been necessary to allow one part to dry in order to gain sufficient mechanical strength to bear the weight or the forming stresses of the application of the next section of the vessel. Construction in stages may also have been preferred because of the shape of the vessel and the limited length of the maker's fingers. The construction of large clay–based ceramic vessels provides a parallel in that it is often necessary to allow drying of the lower parts of the vessel before adding the weight of further wet clay above. The appearance of the flat breaks on the faience fragments seems consistent with some slurry having been used to join parts together but at present it is not clear whether sections of the vessel were made separately and then joined or whether one part was made first and then a further wet section formed onto it after it had dried a little. Either situation might lead to weakness and preferential breakage along the join. This topic is worthy of closer investigation as it may be possible to illuminate further the details of the production process.

Body microstructure

The bodies of the fragments are uniformly white. A finer-grained sub-surface layer may be present on some of the fragments such as the fragments with a dark red surface in the top right of Plate 1. The cross-section of the outer surface of one of the dark red pieces is shown in Plate 2. The evidence for a surface layer was less clear on other pieces examined. This is partly because it is difficult to distinguish a separate layer of body from the effects of glaze applied to the surface and also because of the obscuring effects of surface dirt and irregular fracture. The inscribed fragments in the bottom row of Plate 1 may also have a separate surface layer but here the visual evidence is slightly less clear.

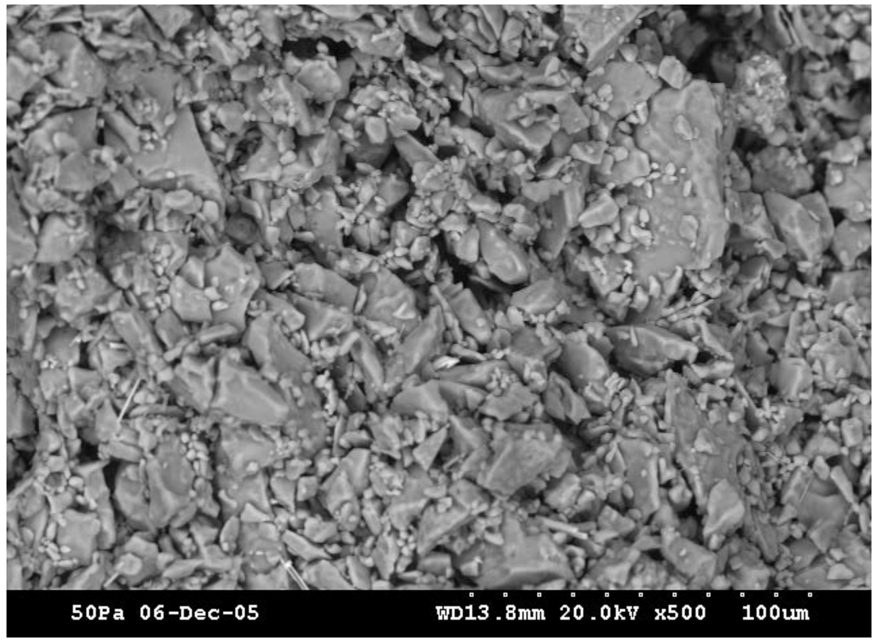


Plate 3. Side view of a fragment showing the microstructure of the body comprising angular quartz fragment ranging from about 60 micrometres down to about 2 micrometers (0.06-0.002mm) in diameter. The field of view is about 250 micrometres (0.25mm) across.

Plate 4 Fracture section across the outer surface of a fragment showing the interior of what was an air bubble included in the body of the faience. The bubble is in the centre of the field of view and is about 120 micrometres (0.12mm) in diameter. This bubble is near the outer surface but similar features are seen in the interior of the body. (See also the bubbles in a lower magnification view of another fragment in Plate 2.)

A number of fragments of the body of the vessel or vessels have been examined non-destructively by scanning electron microscopy. The main components of the microstructure are highly angular fragments of quartz [9] with a wide size distribution ranging from around 60 down to about 2 micrometres in diameter (0.06-0.002 mm). A typical electron micrograph of the body is shown in Plate 3. This microstructure is consistent with the body having been made from artificially crushed quartz, the grains being neither rounded nor sorted into a narrower size distribution as might be found in many natural sand deposits. Naturally occurring sands may have been used for other faience objects but the Sidon vessels seem to have been made from crushed quartz.

It is apparent that the body was quite wet when formed as air bubbles are seen to have been trapped in the body. One such bubble (about 0.12mm in diameter) is shown in Plate 4. Other bubbles are seen at lower magnification in Plate 2.

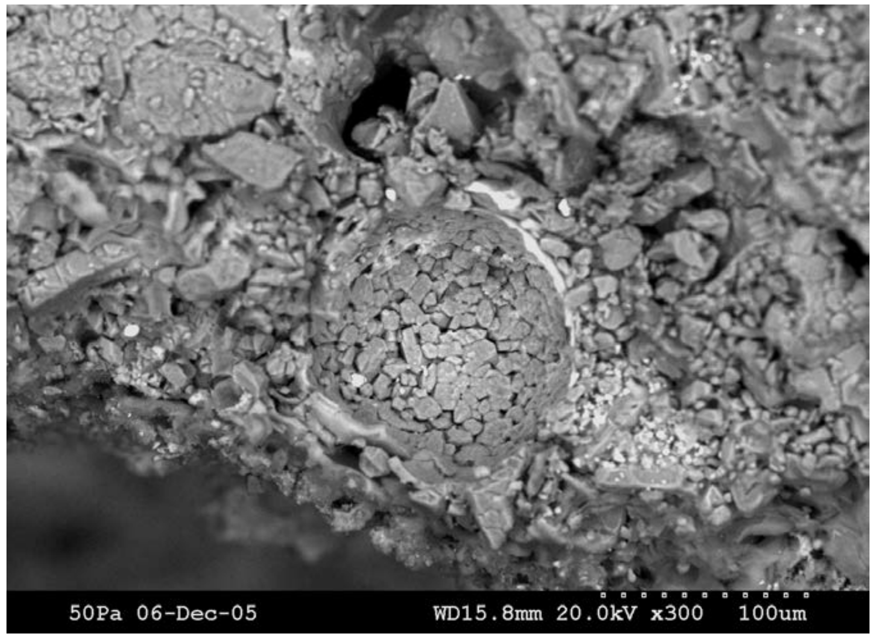
Elemental composition of body and glazes

The present analyses of the fragments were conducted non-destructively without any form of sample preparation by observing existing fractures and surfaces using scanning electron microscopy with associated energy dispersive X-ray microanalysis (SEM-EDS). Small amounts of air were introduced into the specimen chamber as necessary to avoid the accumulation of charge on insulating samples under the electron beam.

The results are reported quantitatively in this paper because of the possibilities of surface contamination from the burial environment, the inhomogeneity of the samples, the irregular surface topography of the samples, the possibilities of surface composition changes during burial and the

variable amounts of air introduced into the chamber atmosphere. Nevertheless, some broad semi-quantitative inferences are made. The observations on composition presented below are based on well over a hundred analyses.

The compositions of the bodies of the fragments analysed are primarily silica with a small proportion of lime and occasionally a trace of magnesium. Some analyses show the presence of other elements present locally within the bodies but the possibility of these being contaminants from the glazed surfaces or from the burial environment cannot be ruled out as in the initial work reported here the fractures were examined without any surface preparation beyond the careful removal of loosely adhering soil.



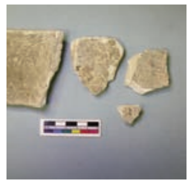


Plate 5. This plate shows the inner surfaces of the inscribed fragments which are shown in the bottom row of fragments in Plate 1.

Examination of both the inner an outer glazed surfaces using backscattered electron imaging showed them to be rather inhomogeneous in their compositions, with localized areas having higher concentrations of fluxes and colorants. Elemental contrast makes areas of higher mean atomic weight appear brighter. The uneven distribution of fluxes also causes the areas of marked surface melting to be unevenly distributed.

All the fragments have a dark brown to black glaze on their inner surface. This glaze has a fairly rough surface, perhaps in part reflecting the relatively rough internal surface of the faience beneath and perhaps in part reflecting the application of the glaze to a relatively closed vessel by brush or swab. The inner surface of the inscribed fragments (the bottom row of fragments in Plate 1) is shown in Plate 5.

The composition of the inner dark brown glaze on all the pieces analysed shows a broadly similar composition despite the variation in composition they show when analysed on a smaller scale. Compared to the body the inner dark brown glaze generally shows raised levels of magnesium, aluminium, phosphorus, lead, potassium, calcium, titanium, manganese and iron. Some of the apparent concentrations of these elements may contain contributions from soil contamination but visually cleaner areas were selected for analysis and the presence of these elements in the inner glazes is for the most part consistent. Markedly raised levels of calcium and the presence of manganese and iron appear to be particularly consistent features. Manganese is the dominant colorant in many areas and often occurs at a higher concentration than iron but again its distribution is not even and some areas are higher in iron. Lead is often present but it also is distributed unevenly and is low or not detected in some areas.

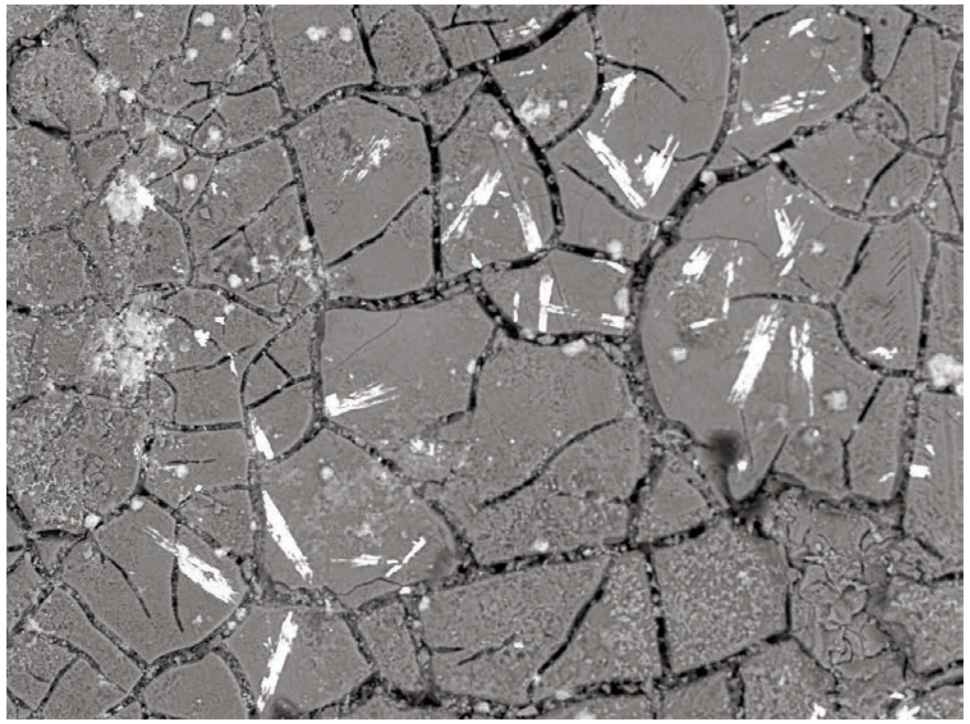


Plate 6 A backscattered electron micrograph of part of the crazed outer glaze surface of the small inscribed fragment from the upper band of inscription. The fragment is shown at the right hand end of the bottom row in Plate 1. The field of view in this micrograph is about 50 micrometres (0.05 mm) wide. The white needle-like crystals in this plate are rich in lead and van.

Inhomogeneity and contamination also needs to be considered in interpreting the results of the analysis of the outer glazed surfaces of the fragments. Analyses of the outer glazes of a number of fragments generally showed similar compositions to those of the interior glaze (sometimes with the additional presence of sodium) with the exception that manganese and higher levels of iron were only found in the areas of the dark brown or black lines on the outer glazes. The off-white areas of the outer glaze often showed a low level of iron but no manganese. A raised level of calcium was a consistent feature of the outer glazes and the raised levels of the same elements seen in the interior glaze was also common, excepting the caveat that manganese was usually only found in the dark brown decorative lines. Analysis of areas of more marked melting on the outer glaze usually revealed the presence of lead, a powerful flux. Such areas were also highlighted by their lighter colour under backscattered electron imaging.

The inhomogeneity of the glazes in terms of lead, manganese and iron concentrations, together with the presence of raised levels of aluminium and calcium in the glazed surfaces, would appear to be consistent with the glazes having been applied as a suspension of relatively coarsely ground lead, manganese and iron minerals suspended in a calcareous clay and water slip. The glaze for the inner surfaces and for the painted

lines on the outer surfaces would contain added manganese and iron colorants whereas the glaze for the outer off-white areas would be low in iron and have no manganese. The rough and sometimes streaky appearance of the inner glaze, the different base colours on the inner surfaces and the outer, and the painted decoration on the outer glaze are also consistent with the glaze being applied to the surface as a suspension. For the present this remains a hypothesis to be investigated further in the future.

Analysis of the dark red outer coating of two of the fragments in the top right corner of Plate 1 showed similar components to those found in the other glazes analysed, with iron in most areas and lead, manganese and copper in some. The presence of copper distinguishes the red surface from most others (but see below). These elements may well contribute to the colour of the dark red surface but their state of chemical combination is as yet uncertain.

Both the inner and outer glazes of a small inscribed fragment (shown in Plate 5 and deriving from the upper right hand end of the upper bluish band of inscription shown in Plate 1) also showed traces of copper but only in localized grains. The outer glaze of this inscribed fragment contained a low level of cobalt not detected in other samples analysed. The cobalt might well be the origin of the blue background colour of the upper band of inscription.

The outer surfaces of the small inscribed piece containing cobalt in the outer glaze and the dark red fragment from the upper right corner of Plate 1 share an interesting but surprising feature in common. Both have small needle-like crystals of a lead-vanadium or lead vanadium-chromium compound on the outer surface (see Plate 6). These crystals appear for the most part to be resting on the surface of the glaze but in other cases needles appear to have partially melted into areas the surface of the glaze. This implies that at least some of the needles were present when the vessel was hot, perhaps in the furnace during manufacture. In other cases the lead–vanadium or lead-vanadium-chromium deposit is more distributed, although still generally restricted to small areas. The vanadium or vanadium and chromium peaks in the SEM-EDS spectra are quite distinct but it should be noted that these elements are generally very localized so their overall concentration in the glaze as determined by an area analysis would be very low. Hedges and Kaczmarkzyk note the presence of low levels of vanadium and chromium in some of their X-ray fluorescence analyses of Egyptian faience glazes [10].

The significance of the lead-vanadium or lead-vanadium-chromium deposits is not yet clear beyond the fact that they indicate a close link in the history of the two fragments in question, both possibly being part of the same vessel but perhaps being parts of two vessels manufactured together in the same furnace or under very similar circumstances. The origin of the lead-vanadium and chromium is at present obscure but one may speculate that it might be related to some exploratory or experimental work on the part of the faience makers or others with whom they were working. A common post manufacturing event using heat might be an alternative source of the similar deposits.

Conclusions and future work

This paper represents the findings of an initial non-destructive analytical study of this very important vessel. It has given an indication of several aspects of the raw materials used, the techniques employed in forming and glazing the vessel(s), and the compositions of the body and the glazes.

On the basis of the non-destructive observations and analyses conducted, it is hypothesised that the vessel or vessels were made in sections using artificially crushed quartz. It is further hypothesized that they were glazed by the application of a calcareous clay-water slip in which lead flux and (where appropriate) colorant grains were suspended. These hypotheses remain to be tested further in future work.

It is clear that the fragments share in common many aspects of their material composition, microstructure, design and technology. Although the styles of decoration on the fragments are varied they could all be fragments of the same vessel or perhaps fragments of two or three broadly similar vessels. It is hoped that future excavation of further fragments may elucidate this.

The needle-like crystals and vanadium-containing deposits on the surfaces of at least two of the fragments suggest an even closer link or commonality of history between them. The fragments may have been part of the same vessel. Alternatively they may have been parts of two vessels that shared some very similar aspect of the pyrotechnology of their production or subsequent use. The presence of the vanadium may provide an indicator of some aspect of the history of pyrotechnology that still remains to be discovered. As is often the case, the attempt to elucidate some questions leads on to new ones.

Although the work presented here has been effected entirely non-destructively, it is intended that tiny fragments will be mounted in resin, polished and analysed by electron probe microanalysis. This will provide more precise analytical information on composition and microstructure with lower detection limits and free of some of the problems of surface contamination. This should lead to a more detailed understanding of the use of materials and the manufacturing techniques.

NOTES

1 C. Doumet-Serhal, 2004, “Sixth and Seventh Seasons of Excavation at Sidon, Preliminary Report”, *BAAL*.

2 M. Marée, 2006, (this volume) p.121.

3 P. T. Nicholson with E. Peltenberg, 2000, “Egyptian Faience”, p. 177.

4 P. T. Nicholson with E. Peltenberg, 2000, “Egyptian Faience”, p. 187.

5 P. Vandiver, 1982, “Technological change in Egyptian Faience”, p. 167.

6 J. Yoyotte, 1962, p. 464; H. J. Franken, 1992, p. 30.

7 H. J. Franken, 1961, Plate 5 between p. 368 and p. 369.

8 H. J. Franken, 1961, Plate 4 between p. 368 and p. 369; H. J. Franken, 1992, p. 31, fig. 3-9 (5).

9 The inference of the grains being quartz is based on silicon being identified by energy dispersive analysis of secondary X-rays from the grains. Strictly speaking the evidence we have observed from the samples does not preclude the presence of other silica phases.

10 A. Kaczmarczyk and R. E. M. Hedges, 1983, *Ancient Egyptian Faience,* p. 25-29.

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