Egyptian faience: ancient making methods and consideration of technical challenges in sculptural practice

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Ancient Making Methods and Consideration of Technical Challenges in Sculptural Practice

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DECLARATION

This thesis is submitted to the Centre for Research and Education in Art and Media CREAM at the School of Media, Arts & Design, University of Westminster, in partial fulfilment for the degree of Doctor of Philosophy. It is entirely the author's own work, except where noted, and has not been previously submitted for this or any other awards.

Abstract

This practice-based research deals with an archaeological material known today as ‘‘Egyptian faience”; it was described as “the first high-tech ceramic” (Vandiver and Kingerey, 1987). Faience has long been overlooked and yet it played a significant role in the development of the art and science of both ceramics and glass. Faience objects were made mainly from the early fourth millennium BC until the late Roman period in the 7th century AD, though a few rare faience workshops survive today. The friable nature and the poor plasticity of the faience paste presented major challenges to craftsmen in terms of their ability to produce successful faience artefacts. Nevertheless, ancient craftsmen managed to overcome these problems and created fabulous objects of art by using and developing various making methods, that they adapted to the material. This study attempts to shed light on these manufacturing techniques, particularly through close examination of archaeological artefacts from a sculptor/ceramicist's perspective. It also considers issues of the raw materials, their preparation and their processing, as well as the technological choices and challenges faced by the faience-makers. The project combines fundamental and structured experimental work with analytical studies of the faience samples. The cross sections of the samples were studied under a scanning electron microscope, which supplied the research with significant information on the microstructure of the material and the chemistry of its glaze formation. The artwork created for this research project was informed by the research findings and was designed to explore the characteristic elements of the faience material and to investigate its potentials and its limitations in contemporary ceramic practice. The ethno-archaeological study of a surviving faience workshop in Iran, which was carried out during this research, provided a rare opportunity to explore and document the cementation method of faience production within the context of a traditional workshop. This was especially valuable in the light of our new understanding of faience technology.

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I dedicate this thesis to my parents and to my wife and sons who have endured this long journey with grace and patience.

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1 Chapter 1: Introduction

1.1 Chronology

The information in this list based on the chronology from the 'Atlas of Ancient Egypt' (Baines & Malek, 1980). The list was modified to include only relevant dates and names.

Predynastic	**5500–2920 BC**		
		5500–4000	Badarian
		4000–3500	Amratian (Naqada I)
		3500–3100	Gerzean (Naqada II)
		3100–2920	Late Predynastic (Naqada III)
Early Dynastic Period	**2920–2649 BC**		
		2920–2770	1st Dynasty
		2770–2649	2nd Dynasty
Old Kingdom	**2649–2134 BC**		
		2649–2575	3rd Dynasty
		2630–2611	*Djoser (Netjerykhet)*
		2575–2465	4th Dynasty
		2465–2323	5th Dynasty
		2419–2416	*Raneferef*
		2323–2150	6th Dynasty
		2150–2134	7th/8th Dynasty
First Intermediate Period	**2134–2040 BC**		
		2134–2040	9th/10th Dynasties
		2134–2040	11th Dynasty (Theban)
Middle Kingdom	**2040–1640 BC**		
		2040–1991	11th Dynasty
		1991–1783	12th Dynasty
		1783–1640	13th/14thDynasty
Second Intermediate Period	**1640–1532 BC**		
			15th/16th Dynasty (Hyksos)
		1640–1550	17th Dynasty (Theban)
New Kingdom	**1550–1070 BC**		
		1550–1307	18th Dynasty
		1479–1425	*Thutmose III*
		1473–1458	*Hatshepsut*
		1427–1401	*Amenhotep II*
		1401–1391	*Thutmose IV*
		1391–1353	*Amenhotep III*
		1353–1335	*Akehenaten*
		1335–1333	*Smenkhare*
		1333–1323	*Tutankhamun*
		1323–1319	*Ay*

		1319–1307	*Horemheb*
		1307–1196	19th Dynasty
		1307–1306	*Ramesses I*
		1306–1290	*Seti I*
		1290–1224	*Ramesses II*
		1224–1214	*Merneptah*
		1196–1070	20th Dynasty
		1194–1163	*Ramesses III*
Third Intermediate Period	**1070–712 BC**		
		1075–945	21st Dynasty
		978–959	*Siamun*
		945–712	22nd Dynasty
		945–924	*Shoshenq I*
		909–883	*Shoshenq II*
		835–783	*Shoshenq III*
		828–712	23rd Dynasty
		731–720	*Iuput II*
		724–712	24th Dynasty
		770–712	25th Dynasty (Nubia + Theban)
Late Period	**712–332 BC**		
		712–657	25th Dynasty (Nubia + all Egypt)
		664–525	26th Dynasty
		664–610	*Psametik I*
		589–570	*Apries*
		570–526	*Amasis*
		525–404	27th Dynasty (Persian)
		404–399	28th Dynasty
		399–380	29th Dynasty
		380–343	30th Dynasty
Second Persian Period	**343–332 BC**		
Graeco–Roman Period	**332 BC–AD395**		
			Ptolemaic Period
		304–284	*Ptolemy I*
		30BC–AD395	Roman period
Meroitic Kingdom	**300 BC–AD350**		

1.2 Introduction to the research

'Egyptian faience' has been described as "the first high-tech ceramic" (Vandiver, 1987). It is, in a broad definition, made of fused siliceous material coated with alkaline glaze, and the material is virtually clay-free. Whilst, as the name indicates, it was widespread in Egypt, it was also found and manufactured in the rest of Mesopotamia[1], Persia, the Indus Valley and the Mediterranean region. Faience objects were very common in Ancient Egypt and Mesopotamia from the early fourth millennium BC until the late Roman period in the 7th century AD. Faience as a material was used to produce a wide range of artefacts from beads and small objects to vessels, tiles and architectural elements. The use of the material gradually declined and the production techniques were lost.

1.3 Research question

Archaeologists identified Egyptian faience in the late nineteenth-century and ever since it has been the subject of many studies by researchers, especially in terms of its composition and glazing methods (see Chapter 2). The friable nature and the poor plasticity of the faience paste presented major challenges to craftsmen in terms of their ability to form faience artefacts. Ancient craftsmen managed to overcome this problem and created fabulous objects of art by using and developing various making methods. Several experiments, attempting replication, were conducted to support the theoretical and analytical studies of faience (Kiefer & Allibert, 1971; Noble, 1969; Shortland, 2000; Tite, 1987; Vandiver, 1983), although in only a few of these did anyone consider the workability of the faience paste (Eccleston, 2008; Griffin, 2002; Leveque, 1998; Lucas & Harris, 1962). Generally these experiments were lacking in structure and subtlety. No experimental studies so far have explored the formation methods of large and complex faience objects, or faience vessels, or considered in detail the practical challenges that faced the ancient faience makers.

1.4 Aim and scope

The aim of this study is to provide an overview of the history of the faience material and investigate the technological processes involved in its production. The emphasis in this study is on the methods used to make and shape faience objects from a

[1] Mesopotamia is a term from ancient Greek that is used in archaeological and historical context to refer to land encompassing the Euphrates and Tigris river systems. This corresponds to the modern-day countries of Kuwait, Iraq, Syria and southeast of Turkey.

sculptor/ceramic maker's perspective and to produce practical evidence on how to overcome the difficulties in shaping the faience paste. The project combines fundamental and structured experimental work with the creation of a body of art works, designed to explore the characteristic elements of the material and to investigate its potentials and its limitations in a contemporary ceramic practice.

1.5 Research methods

The choice of methods used in this research was determined by its nature. First the research dips into a few archaeological collections to study the faience artefacts and establish some guidelines to the practical work. Then it applies experimental and scientific approaches to suggest solutions to the problems at hand.

The methods used to achieve the aims of the research are:

1. Collection and study of Archaeological Evidence: A general study and visual examination of hundreds of faience artefacts and fragments was undertaken, using a hand-held magnifying glass (10x) as well as an optical microscope (10-40x). The relevant artefacts were measured and photographed and notes were taken on the technological evidence and of any related features. The artefacts examined are part of the archaeological collections of Egyptian faience in selected museums, including the collections of the British Museum, Petrie Museum and the Victoria and Albert Museum in London, the Ashmolean Museum in Oxford and the Fitzwilliam Museum in Cambridge. The study of the collection of the Petrie Museum of Egyptian Archaeology in University College London was particularly valuable, and my previous work and connection to the Institute of Archaeology facilitated good access to the Petrie collection. The study of this collection became more intensive and frequently renewed in the last two years. This has complemented and informed the practical experiments as they have evolved. Every time new results have emerged they have helped me to see the Petrie material with new eyes. This ongoing interdependence of observation of historical material with experimental results has helped to drive the research, and often suggested new pathways to explore. The advantage of Petrie's collection beside its

accessibility was the nature of the materials it houses. The collection is important not only because of its secure provenance and its wide materials typologies, but also because of Flinders Petrie's (1853–1942) interest in technology and everyday objects. In addition, his important finds of glass and faience workshops in Egypt at sites like Amarna and Memphis provide a unique insight into the life and industries of ancient Egypt.

2. Ethnographical study of a surviving faience workshop in Iran was started in October 2011 with a field-trip to Qom[2]. This study concentrates on one of the less understood methods of faience-making, namely 'cementation'. In this method the quartz-rich objects are buried in a glazing powder, which during firing reacts with the objects and forms a glaze coat on them. This visit provided a rare opportunity to explore and document this method of production within the context of a traditional workshop, and was especially valuable in the light of our new understanding of faience technology. Some samples were collected at the site and later were analyzed using an energy dispersive spectrometer (EDS[3]) attached to scanning electron microscope (SEM[4]); this analysis helped the research to establish the roles of the various raw materials used at Qom, and to understand better the nature of this enigmatic technique.

3. A series of extensive practical experiments was carried out to produce faience samples. These experiments were designed to explore the role of the various raw materials used in faience production. By systematically changing the ratio of one ingredient and fixing the others, I could establish its effect on the physical and visual qualities of the faience samples created. In addition I experimented with different binders and changed their ratios in the faience samples to study their effects on the plasticity of the paste. Other experiments explored the effect of variation in the silica

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[2] Qom is a holy city in central Iran.

[3] Energy Dispersive Spectrometer (EDS), a detector attached to SEM that uses the generated X-ray peaks from the interacted electrons with the specimen to identify the chemical elements in the examined region.

[4] Scanning electron microscope (SEM) is a microscope that uses a beam of energetic electrons rather than light to examine objects and generate images on a very high scale of magnification.

particle-size on the workability of the faience paste. The influence of firing temperature on the faience material was also tested in this work.

4. Analytical work was carried out on the experimental faience samples – first by an optical microscope in order to examine the physical properties of the samples and their cross sections, then through the examination of samples using backscatter electron imaging (BSE[5]) on the SEM-EDS (scanning electron microscope with energy dispersive spectroscopy detector). By these means the structures of the sampled materials were revealed. The images showed clearly the different phases in the samples; they also helped to explore and characterise the different areas in the samples: i.e. surface glaze, interaction zone and core area. Also I used secondary electron imaging (SE[6]) to distinguish various particles in the phases and an EDS detector to determine the chemical composition of several parts of the samples. The elemental analyses associated with SEM study revealed information on the composition, the microstructure and on raw materials distribution within the samples, while secondary minerals were also identified by this work.

5. Sculptural Practice: In the artwork designed for this research project, I was able to adapt the use of Egyptian faience in my own sculptural work and explore further its physical properties during the repetition of the processes involved in the making of my numerous Figures and figurines. This practical approach also enabled me to suggest answers on how the ancient Egyptian craftsmen managed to make large and complex objects.

[5] Backscattered Electron Imaging (BSE), utilises the collided electrons in the SEM with the different atoms of the specimen to create an image related to the atomic number of the elements (lighter tones signify heavier elements).

[6] Secondary Electron Imaging (SE), is utilising the secondary electrons produced in the SEM to create topographic images of a specimen's surface that displays its texture and the relation of its features to the material's properties.

1.6 Overview of thesis structure

The research in this work consists of two parts. First is the study of the material by using a multi-faceted approach: theoretical, experimental, analytical and ethnographical researches. And the second part is the application of the research findings in my sculptural practice for the creation of a body of artwork for the research exhibition.

This account is divided into seven chapters. The first chapter provides the aim of this research and describes the methods applied to achieve the goals of the research. In addition to the necessary definitions and introduction to the material. The historical background for the use of Egyptian faience is also covered in this chapter followed by a review of the relevant literature that deals with the material. The second chapter covers the evidence in the archaeological records and discusses the raw materials and the manufacturing processes. Then it discusses the data collected for this research and provides a summary of the examination and study of hundreds of faience artefacts in five major museums in the United Kingdom: the Ashmolean Museum in Oxford, the British Museum in London, the Fitzwilliam Museum in Cambridge, and the Petrie Museum and the Victoria & Albert Museum both in London. The third chapter deals with the analytical work, its procedure and its interpretations. It covers the experimental research and the microscopic analyses of the samples and discusses the results. The fourth chapter provides an ethnographical study of a traditional faience workshop surviving in Iran and discusses the analyses of the collected samples. The fifth chapter introduces the concept and the historical background for the idea behind the artwork designed for the final exhibition, followed by demonstration of the technical procedures for creating the faience figures and objects for the exhibition and discusses their relation to the core archaeological research of this study. The sixth chapter discusses the development of the conceptual work and the aim of the exhibition, followed by the details of the scale planned and of the display itself. The dissemination of the research in the final exhibition is also described in this chapter. The final chapter draws together the conclusions of the research work and discusses the advantages and limitations of using experimental work as a tool to study ancient crafts, in addition to the role of this research in informing and inspiring the resulting contemporary artwork.

1.7 Definitions and nature of the material

Faience or more correctly 'Egyptian Faience' is by definition a vitreous material, a kind of ceramic that contains a body of sintered crushed quartz and with an alkaline glaze on the surface; the material is virtually clay-free (Griffin, 2002; Nicholson, 2007; Tite & Shortland, 2008). Although faience is a material created from common ingredients, the archaeological end product was regarded in the ancient world as a luxury item used as an alternative to lapis lazuli or turquoise and ranked by the elite next to gold and semi precious stones. To the ancient Egyptian, faience was known as *'tjehnet', which* meant "brilliant" or "dazzling" and it was thought to shine with light as the symbol of life, rebirth and immortality (Friedman, 1998). Another word was '*khesbedj'*, which meant blue and was also used to mean lapis lazuli; it was later used in the New Kingdom for faience (Nicholson & Shaw, 2000). Nicholson in a recent study discusses the terms '*jnr nwḏh* ' and '*t wḏht'* that were commonly used for glass and meant "stone of the kind that flows" to suggest that: "the stone workers may have been the originators of faience and that the material was regarded as an artificial stone" (Nicholson, 2012). In archaeological studies, other terms commonly applied to faience include sintered quartz, and glazed frit. This variety of terms is understandable considering the fact that many ancient faience pieces retain little or no trace of their original glaze and are therefore mistaken for another material (Moorey, 1994). The term faience has been described as "…a long-standing misnomer for a composite material consisting of a sintered quartz body and a glaze" (Moorey, 1994, p167). The term 'faience' originally derives from the medieval tin-glazed ceramics –also known as Majolica– produced in the city of Faenza in Italy. To begin with the archaeological finds of Egyptian faience were compared to the Italian medieval product because they shared the same white body and the vibrant glaze (Noble, 1969). The term 'faience' is probably not the most suitable name for the material but it is now so imbedded in the archaeological literature that it is unlikely to be replaced (Nicholson & Shaw, 2000). The term 'Egyptian Paste' is also used for faience in the ceramic field, but in this study the term ‘faience paste’ is used to describe the unfired material and ‘faience’ for the finished fired material.

1.8 Historical background and chronology

Glazed stones predate faience finds; they are commonly stones such as steatite or serpentine coated with an alkaline glaze. Sometime towards the end of the 5th Millennium BC, faience was first produced in the Near East, and then Egypt, progressively taking over from glazed stones. The first faience beads date to the Ubaid[7] period (5400–4300 BC), whereas early examples of faience in Egypt date to Naqada I[8] phase in the middle Predynastic period (4000–3500 BC) (Moorey, 1994). By contrast in the Indus valley, faience was only produced for a short period from the beginning of the 3rd Millennium BC, and even during this period, glazed steatite remained dominant (Tite & Shortland, 2008). From Egypt and the Near East, faience spread westwards and northwards, initially to Crete, Cyprus and Rhodes, central Europe and Italy, and ultimately to France and Britain by the Roman Period. A useful time-line showing the chronological relationship in the ancient world was created by Tite & Shortland (2008) (Table 1).

The majority of studies on ancient faience concern the Egyptian faience industry because of the relatively unified territory of Egypt and the well-preserved material culture, whereas the ancient Near East had a complex regional diversity and variations in the material culture associated with each region chronologically and culturally. Another problem facing any close study of faience from the Near East is their poor preservation due to their severe weathering. The study of Vandiver (1983) shows that faience technology evolved after complex experimentations during the early ages, from applying glaze on carved steatite Figures to the exploration and manipulation of quartz paste.

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[7] Ubaid period (ca. 5400–4300 BC) is a prehistoric period of Mesopotamia (present day Iraq and Syria)
[8] Naqada I was cultural period in Predynastic Upper Egypt.

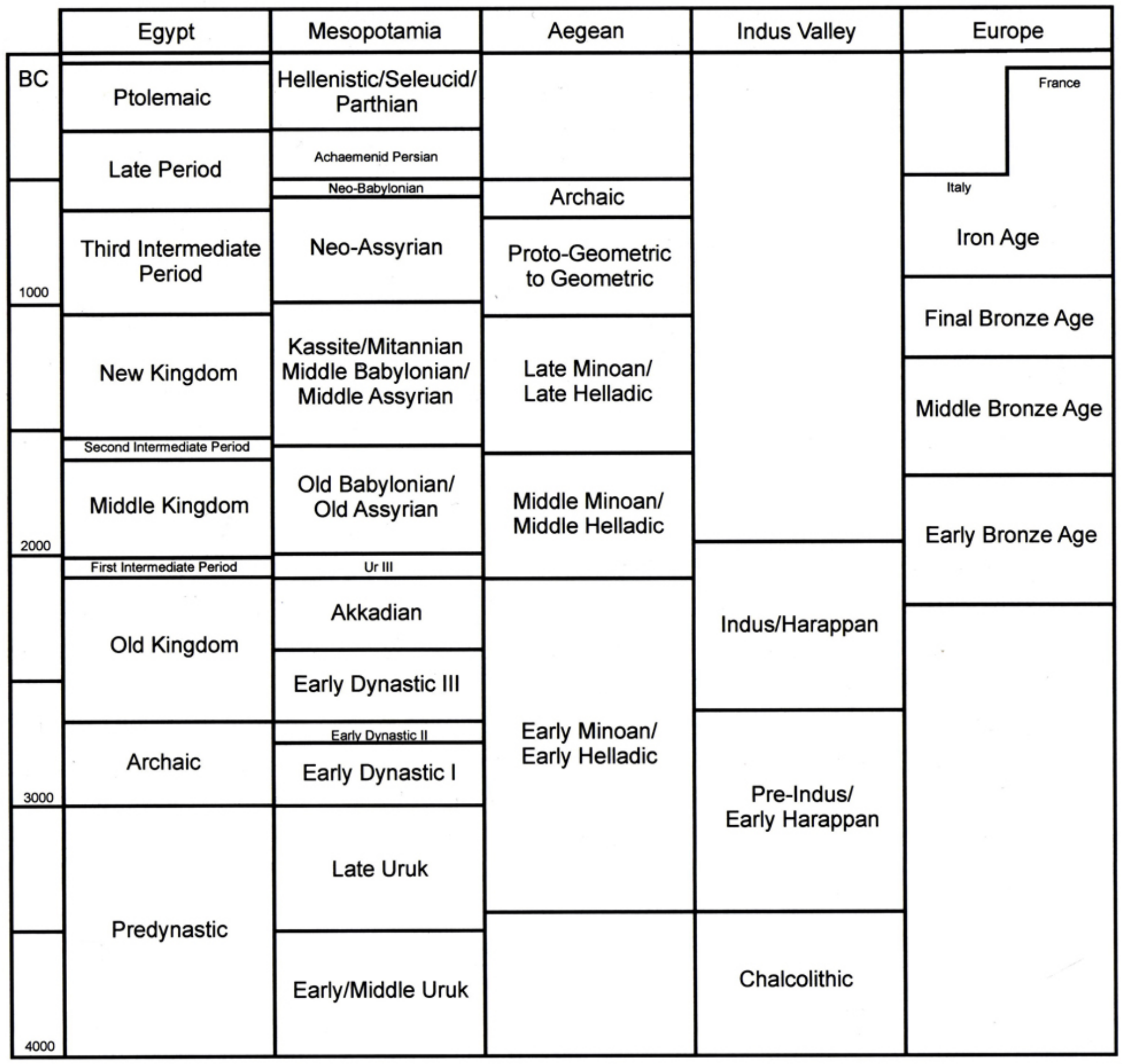

Table 1: Time-line chronological relationship between Egypt, Mesopotamia, Indus Valley and Europe (based mainly on Italy) (after Tite and Shortland, 2008)

The early faience was probably a by-product from the stone carving industry and was shaped using stone working methods to make beads, amulets and small objects. Efflorescence as a self-glazing method was adopted in addition to the older method of application, and became possible with the adoption of bodies prepared from crushed rock (Vandiver, 1983; Nicholson, 2012).

During the Middle Kingdom period (2040–1782 BC), the cementation method of glazing was developed and used; the forming techniques remained simple – for example modelling and moulding on a form or core. Faience production flourished in the New

Kingdom (1570–1070 BC) when a greater diversity of shapes and techniques were introduced that resulted from the advance of glass technology. The body of faience was improved by mixing it with frit and powdered glass and this improvement, coupled with the introduction of new designs and ideas, led to enhanced materials, colours and shapes. Additionally, Egyptian faience makers in this period began to imitate foreign ceramics such as Mycenaean stirrup jars (Friedman, 1998). Generally many of the finest faience objects were produced in this period. The increase in the quantity and quality of faience objects in the New Kingdom, especially moulded amulets production, suggests increased organization in the industry and possible state control (Shortland, 2000). Also an expansion of faience production is seen in the middle of the second millennium BC in Mesopotamia. In the Mittanian[9] phase (1550–1350 BC), the expansion of faience production is reflected in the large number of prestige goods found during this period primarily in association with temples and palaces (Moorey, 1994). During the Middle Assyrian phase (1350–1200 BC), production became more standard and widely spread, and the material began appearing frequently amid grave goods (Moorey, 1994).

Faience manufacture declined in quality during the Third Intermediate Period in Egypt, but the Late Period witnessed a revival in faience production, and a new range of excellent objects and glazing appeared. By the Graeco-Roman Period we have evidence of close relations between faience production and the pottery industry, which includes faience vessels thrown on the potter’s wheel and application of glaze as a slurry. The faience link to pottery in the Roman period probably caused a shift towards glazed pottery production and gradually led to the decline of faience—especially after the discovery of lead glazes, which paved the way for glazed pottery.

1.9 Literature review

Egyptian archaeological contexts are rich with faience artefacts and since its identification in the late nineteenth-century the material has become the subject of

[9] Mittani was a state in northern Mesopotamia ca. (1550–1350 BC).

many studies. The literature devoted to Egyptian faience can be divided into three main categories:

Material science and technology: these works concentrate on compositional analyses and the glazing methods, with less emphasis given to the making and shaping of faience objects. Petrie (1909) and Lucas & Harris (1962) described the material as a glazed ware and the latter classified faience by a number of variants depending on its visual properties. (Binns et al., 1932) identified the efflorescence glazing method, which is later discussed by Noble (1969). The cementation glazing method was identified in the 1960s (Wulff et al., 1968; Kiefer & Allibert, 1971). A major technical study by Kaczmarczyk & Hedges (1983) analyzed hundreds of faience samples, with a valuable contribution by Pamela Vandiver in identifying production and glazing method (Vandiver, 1983) and since the publication of this study, faience technology has become a matter of continued debate, especially with the advance of material science and the use of scanning electron microscopes (SEM). Many papers and studies have discussed faience in that context, such as Tite et al. (1983), Tite & Bimson (1986), Nicholson (1993), Nicholson & Peltenburg (2000), Shortland (2000), Tite & Shortland (2003), Nicholson (2007), Rehren (2008), Tanimoto & Rehren (2008), and finally a valuable overview of the faience technology in the ancient world by Tite and Shortland (eds.) (2008), which included papers by Vandiver, and others. In this category a recent paper by Matin & Matin (2012) examined the cementation glazing method through experimental work. These studies cover various areas of faience technology from the chronological developments to the chemistry and compositions, the shaping and glazing technologies, and the application of different analytical techniques. However, these works concentrate on compositional analyses and the glazing methods while less emphasis has been given to the making and shaping of faience objects: an area that remains understudied. Noble (1969), Kieffer (1971) and Vandiver (1997) and recently Griffin (2002), Eccleston (2008), Tite and Shortland (2008) and Matin and Matin (2012), all attempted some experimental reconstruction of the material but again approached it from a material science perspective with a focus on glazing methods. A valuable study by Vandiver and Kingery (1986) did examine the complicated manufacturing technology of a faience chalice from the New Kingdom using Xero-radiography to explore the forming technique.

Curatorial literature: these works are devoted to artefacts and museum studies detailing collections and exhibitions; Riefstahl (1986) catalogued the faience collection in the Brooklyn museum; the volume on the exhibition ‘Gift of the Nile’, edited by Friedman (1998) which included essays on social, artistic and technological aspects made a valuable contribution to faience studies; Spurr, Reevs and Quirke (1999) studied and recorded the Mayers collection at Eton college.

Archaeological reports: these include papers and reports on excavated materials, and also discuss different aspects of the production of faience. Of particular importance is the work of Boyce and Nicholson in the Amarna excavation reports (Kemp, 1984-1995), and Nicholson’s major volume on the vitreous materials at the site 45:1 in Amarna in (2007).

2 Chapter 2: Data Collection

2.1 Evidence of faience manufacture in the archaeological record

From the first dynasty faience workshops existed in urban centres. We have evidence of a few workshops: from the Old Kingdom at Abydos[10], from the late Middle Kingdom at Lisht, from the New Kingdom at Amarna[11], Qantir[12] and Malkata[13] and from the Late Period and Roman Period at Buto[14], Memphis[15] and Naucratis[16]. A possible workshop from the Middle Kingdom was also found in Kerma[17] in the Sudan (Nicholson & Peltenburg, 2000). Another faience bead factory from the Late Bronze Age was excavated at Tyre, in modern-day Lebanon (Bikai, 1978).

Iconographically, only one scene (Figure 1) from the twenty-sixth Dynasty tomb of *Ibi* (*Aba*) at Thebes[18] is believed to represent faience working (Davies, 1902). According to Davies, a wall painting in this tomb depicts one man preparing the faience paste in a dish while a second man fashions a lotus-shape ornament, presumably also of faience. Although such depictions were common for other industries such as pottery, sculpture, metal, masonry, etc., Friedman suggests that faience depiction was prohibited because of its inherently magical and religious significance (Friedman, 1998).

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[10] Abydos is a sacred site in Egypt, and was the centre for the cult of the god Osiris. It flourished from Predynastisc Period until the Christian times (ca. 4000 BC–641AD).
[11] Amarna is the modern name of the city of *Akhetaten* the new capital in the New Kingdom during the reign of Akhenaten ca. 1353–1336 BC.
[12] Qantir is the present site in the eastern delta in Egypt. It was the city of Pi-Ramesse, the new capital of the great pharaoh Ramasses II (1279–1213 BC) from the Nineteenth Dynasty.
[13] Malkata is a settlement and palace site opposite the modern city of Luxor in Egypt, dated to the early fourteen century BC.
[14] Buto is an ancient city in Egypt in the north-western Delta, it was occupied from the Predynastic Period until the Roman Period (ca. 3300 BC–395AD).
[15] Memphis is the ancient capital of Egypt for most of the Pharaonic time, located south of modern Cairo.
[16] Naucratis is a site of a Greek settlement in the western Delta in Egypt. It dates to ca.630 BC
[17] Kerma is in Upper Nubia, and was probably the capital of the Kushite Kingdom (ca 2686–1650 BC)
[18] Thebes surrounds the modern city of Luxor in Upper Egypt. It was the political and religious centre from the Middle Kingdom to the end of Pharonic period (ca. 2055–332 BC).

There exist two literary references to faience manufacturers in Egypt: an Old Kingdom *mastaba*[19] notes an official who was “controller of the *tjehnet* workshop”, and a Middle Kingdom stele mentions the “overseer of *tjehnet*” (Foster, 1979). In the Aegean, the term *ku-wa-no-wo-ko-i*, meaning glass paste or faience workers, appears in the Linear B tablets at the Citadel House at Mycenae[20], confirming the local manufacture of faience in association with the palace (Foster, 1979).

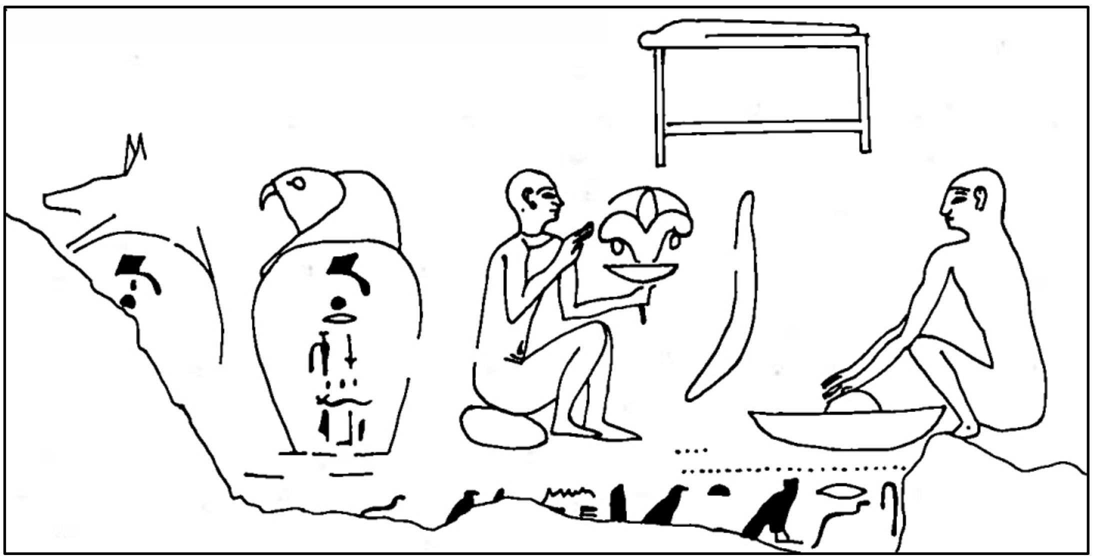


Figure 1: Faience workers depicted in the 26th-Dynasty tomb of Ibi (Aba) at Thebes. (After Davies 1902, pl. XXV)

2.2 Raw materials, sources and processing

The microstructure of a typical faience object that was obtained from analytical scanning electron microscopy shows that it has three distinctive layers, a body of a partially sintered, coarsely crushed quartz or sand coated with a glass layer, and in between an interaction zone, where the quartz grains are cemented by a glass matrix/interparticle glass (Figure 2).

[19] *mastaba* is kind of tomb used in the Early Dynasty in Egypt for both royal and private burials (ca.3100–2686 BC).

[20] Mycenae was a major centre of Greek Civilization, located in the Peloponnese southwest of Athens. The city flourished in the late Bronze Age (ca. 1600–1100 BC).

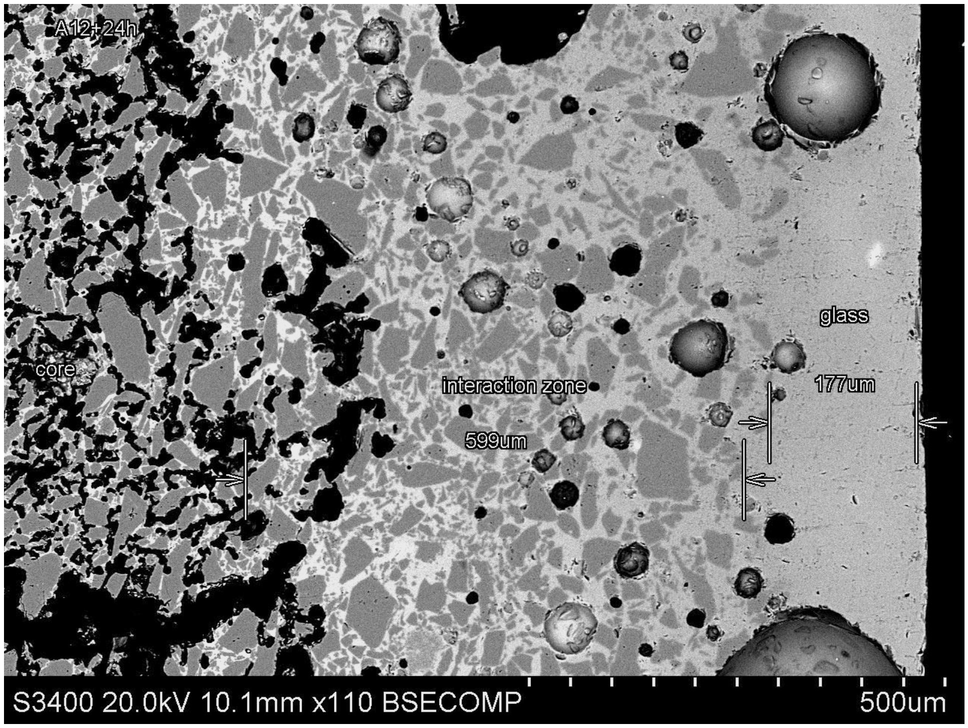


Figure 2: SEM image of typical faience microstructure

The study by Vandiver (1983) showed that the typical faience body is composed of:

92–99 per cent SiO_2 (silicon dioxide)

1–5 per cent CaO (calcium oxide)

0.5–3 per cent Na_2O (sodium oxide)

Minor quantities of CuO (cuprous oxide), Al_2O_3 (aluminium oxide), TiO_2 (Titanium dioxide), MgO (magnesium oxide) and K_2O (potassium oxide).

2.2.1 Silica

Silica is the major component of faience. The two possible sources of silica are fine sand and quartz pebbles. Both materials are freely available in nature; they can be retrieved from the seaside, riverbeds and the desert. The most likely source of the silica in faience is crushed quartz pebbles because of its white pure quality. This is supported by Petrie's finds of quartz pebbles among the debris from the faience and glass production sites in

Amarna (Petrie, 1894). Also Wulff reports that pure quartz pebbles were collected from a dry riverbed, then finely crushed for use in the traditional faience workshop in Qom in Iran(Wulff et al., 1968). Other evidence for the use of quartz pebbles as a source of silica comes from a faience reproduction workshop in Qourna[21] in Egypt (Sode & Schnell, 1998). Impurities in the sand, like lime, potash, alumina, magnesia and iron and titanium oxides, can cause discolouration of the faience bodies, as it tends to be slightly gray or brown in colour (Tite et al., 2008). Sand can still be used when purity is not essential or as a core material. To prepare the silica some grinding action is needed to obtain very fine particles. Petrie suggested that repeated heating and cooling of quartz pebbles would cause cracking and ease the crushing (Petrie, 1894). The experimental work by Eccleston proved that the firing of quartz pebbles to 800^{o}C facilitated their pulverization into fine powder (Eccleston, 2008). Crushed quartz pebbles could also contain impurities from the grinding tools (Rehren, 2008). The silica particles in faience are sharp and angular in shape but this does not exclude the use of sand as a source because the silica in faience is typically ground into very fine particles in the range of 20–70 microns (Tite et al., 2008).

2.2.2 Alkali Flux

The soda (Na_2O) comes either from desert plants' ash or from natron which is a salt rock available in Egypt at Wadi Natron and El Kab, and which was already in use by the Egyptians for medicine and mummification (Shortland, 2000). Natron can be easily crushed to add to the faience mixture. Several soda-rich plant species are confined to Egypt and the Near East, *Salsola soda*, *Salsola vermiculata* and *Halopeplis species* (Barkoudah & Henderson, 2006; Tite et al., 2006). The plant ash is obtained by burning the desert plants before they dry in the summer heat. The workers in Qom burned the desert plants in a pit to produce ash sintered into hard blocks or burned them in an open heap and then collected the dry ash. The collected ash was then melted into blocks in calcining furnaces to remove the organic impurities (Wulff et al., 1968). Finally

[21] Qourna is a village in Upper Egypt located on the west bank of the river Nile opposite the modern city of Luxor.

the ash was ground to a fine powder and added to the faience mixture. In both natron and desert plant ash, only the carbonate and bicarbonate are relevant to the fusing of the silica since the majority of chlorides and sulphates form a separate salt melt (Rehren, 2008). The only way to determine the source of soda is by chemical analysis of the material. If the amounts of potash, magnesia and lime are high, it suggests the use of plant ash as a source of alkaline flux (Tite & Shortland, 2003).

2.2.3 Lime

Lime is a loose term that embraces both calcium carbonate and calcium oxide and in faience the material would usually come from limestone or chalk, which are widely available in nature. Sands or plant ashes may contain some minor amounts of lime naturally and can therefore often account for some CaO found by analysis (Tite et al., 2008). My ethnographical study in Iran notes that faience makers at Qom added 20% hydrated lime [$Ca(OH)_2$] to the glazing powder but no lime was added to the faience body– this was also reported by Wulff (1968). Griffin (2002) states that the addition of lime by more than 2% by weight to the faience mixture improves its workability. Lime is very soft and can be easily crushed into a fine powder to add to the faience mixture; it has a slight natural plasticity.

2.2.4 Colourant oxides

The most common colourant is copper oxide (CuO). It was either obtained from grinding copper ores azurite or malachite, or corroded copper metal (Tite & Shortland, 2003). It was also suggested that copper was introduced as crushed copper/bronze scale, which resulted from the repeated heating of the metal (Kaczmarczyk & Hedges, 1983). This is supported by evidence from contemporary faience makers in Egypt (Sode & Schnell, 1998), and in Iran (my ethnographical study and Wulff et al, 1968). The copper oxide, in glass solution, is responsible for the blue and green colour of the faience, whereas white faience is produced using a transparent glaze over a white quartz core or slip layer (Tite et al., 2008). The advance of the glass industry in the New Kingdom in Egypt led to the production of faience in different colours by the addition of various metal oxides to the faience body (Shortland, 2000). The transparent colours such as turquoise blue, dark blue and purple are associated with ions: turquoise blue with copper ions (Cu^{2+}), dark blue with cobalt ions (Co^{2+}), and purple with manganese ions (Mn^{3+}). While the opaque colours such as black, red and yellow are associated with oxide particles; black with either manganese oxide or reduced iron oxide, red with oxidised iron oxide particles, and yellow with lead antimonite particles (Tite et al., 2008). Also in the New Kingdom we see the innovation of "Variant D" faience, which was classified by Lucas & Harris (1962); it has a hard vitrified and coloured core. Here, the use of powdered coloured glass or frit in the faience mixture has been suggested for producing this variant. In addition, cobalt oxide was used, either alone or mixed with copper to produce a more vibrant blue colour (Shortland, 2000).

The provenance of faience artefacts in archaeology is largely based on the source of the colourant oxides, especially the identification of impurities and the use of lead isotope analysis (Tite et al., 2008). In this context, the most readily identifiable source for cobalt colourant in the New Kingdom was cobaltiferous alum from the Kharga and Dakhla Oases in the Western Desert of Egypt (Rehren, 2001). This cobalt colourant was used not only in Egypt but also in the Levant and along the Aegean cost in the Late Bronze Age (Tite et al., 2008). In general the identification of the sources of the various raw materials, especially the colouring agents, can provide a wider picture of the organization of faience production and the workshops' relationship with the regional trade system (Shortland, 2000).

2.2.5 Clay and organic binders

The addition of clay to the faience paste has been a matter of debate. The average level of alumina in faience objects is 1.2% by weight, which might have come from the addition of clay. Some scholars believe this percentage, if it comes from clay, is too small to make a difference to the plasticity of the mixture (Lucas & Harris, 1962; Noble, 1969). The experimental work by Griffin proved that minor amounts of clay 1–3% by weight gave good results. Alternatively it has been suggested that the use of organic binders

(Vandiver, 1983), such as starch, gum Arabic, and gum tragacanth could improve the workability of the faience paste. However such materials would leave no traces in the body after firing, and their use, therefore can only be hypothesized. We have no evidence from archaeology supporting the use of organic binders. Experimental work by Eccleston (2008) showed that the addition of gum facilitated modelling but affected the efflorescence process. The present faience makers at Qom in Iran used an organic gum ‘serish’ to bind the crushed quartz and facilitate the forming of the artefacts (see chapter 4 on ethnographical study in 2011). However back in the 1960s, the faience makers in Qom were using a different binder, gum tragacanth (Wulff et al., 1968). The role of clay and organic binders will be discussed later in this study.

2.2.6 Forming methods

The pulverized raw materials of silica, lime, soda, and additional colourant were then mixed with water. The resultant paste was thixotropic, meaning that the paste is stiff and behaves as solid at first, then becomes soft and flowing as it is shaped. If shaped too rapidly it cracks and splits (Vandiver, 1983). Because of its poor working properties, faience paste is difficult to shape, unlike clay which has a more plastic body composed of platelets that can slide over one another when wetted and retain their new form when making-pressure ceases. Thus faience bodies were formed by modelling and moulding using various cores and moulds. More complex objects were made from different components and then joined together using a faience slurry (Nicholson & Peltenburg, 2000). In all cases the surfaces of the objects were sculpted further with tools once they were hard, which removed any primary forming evidence, such as earlier tooling marks on the surface, and make it difficult to detect the forming method(s) used (Tite et al., 2008). Generally and due to the short nature of the faience paste, only limited forms and sizes were possible to achieve. This disadvantage caused the faience workers to explore different addition to the paste or changes in forming methods to improve the workability of the material. Forming methods will be discussed in detail in the third chapter of this study.

2.2.7 Glazing methods

Three glazing methods for faience have been identified by Vandiver (1983); efflorescence, cementation and application (Figure 3). But also a combination of these methods could be used for glazing one object (Vandiver, 1998). Each of these methods can be distinguished by its characteristic features and also by its microstructure (Tite et al., 1983; Tite & Bimson, 1986) (Figure 4).

Application is the earliest glazing technique; it involves applying the glazing material as a slurry consisting of powdered quartz, calcite, and alkali, mixed with water. This slurry is applied to the dried faience surface by dipping, pouring or brushing; the porous body absorbs the water in the slurry, leaving a layer on the surface, which melts upon firing and forms a glaze. Use of this method would leave characteristic marks on the surface, such as drips and flows.

E*fflorescence* is a self-glazing technique first identified by Binns *et al* (1932) and further investigated by Noble (1969). During the drying process the soluble alkaline salts present in the faience body migrate to the surface. At the surface, these salts effloresce as the water evaporates leaving a layer of powdery flux. Upon firing to C. 900^{O}C, the effloresced layer melts and fuses with the silica and lime at the surface to form a thin glaze layer. The characteristics of this method are variations in glaze thickness and the lack of glaze on the inside surfaces and on the bases of the objects, because there is not enough air circulation here to encourage evaporation of the soda-rich water of plasticity, and consequently achieve efflorescence in these regions.

Cementation is a self-glazing technique, which was first identified by Wulff et al (1968) at Qom in Iran. It involves embedding the faience body in glazing powder. This powder consists of soda, lime, copper oxide and charcoal. During the firing to 1000^{O}C, the glazing powder reacts with the silica on the surface of the object and forms a uniform glaze all over. This method can be recognized by the overall glaze thickness (Tite et al., 2008).

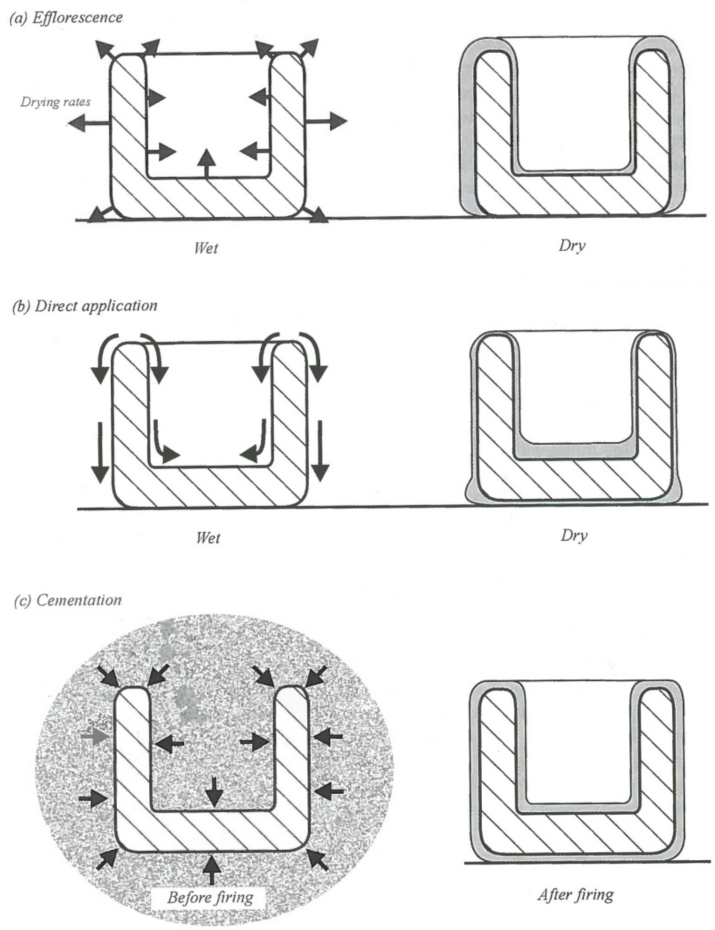
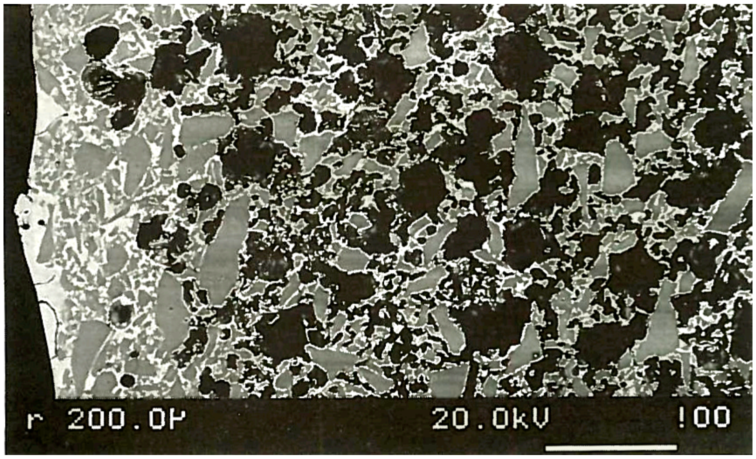
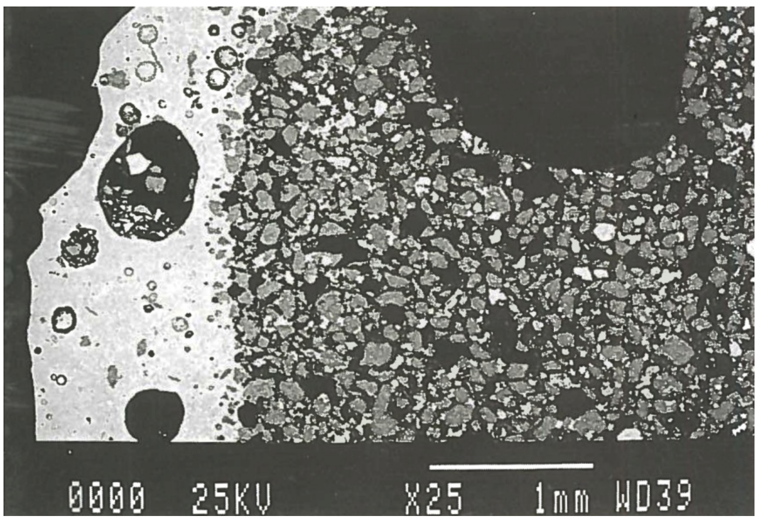


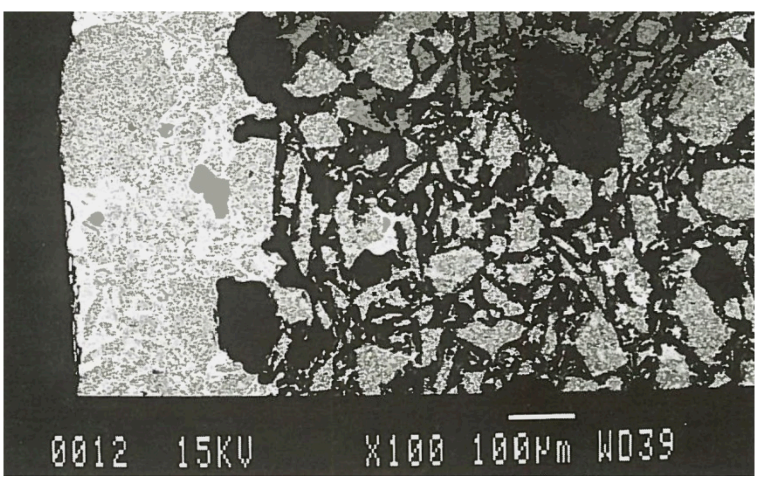
Figure 3: Schematic diagram illustrating the three methods used for glazing faience. (a) efflorescence glazing; (b) application glazing; (c) cementation glazing. After (Tite et al., 2008, p48)



(a). SEM image of faience glazed by efflorescence. A clear distinction between glaze, interaction layer and body with extensive interparticle glass in the body. From an Eighteenth Dynasty faience vessel (Courtesy of the Petrie Museum of Egyptian Archaeology, University College London, and Professor M.S. Tite. UC 30153)



(b). SEM image of faience glazed by application. From a Late Period shabti from Amarna. A clear distinction between the glaze and the body with no interaction layer. (Courtesy of the Trustees of the British Museum and Professor M.S. Tite. BMRL 16322)



(c). SEM image of faience glazed by cementation. From a Twenty-first Dynasty shabti. Thin glaze, wide interaction layer and poor interparticale glass. (Courtesy of the Trustees of the British Museum and Professor M.S. Tite. BMRL 16323)

Figure 4: Scanning electron microscope images of the microstructure of the three methods for glazing faience. The glass phase appears light gray and the silica grains are dark gray. After (Nicholson, 1993)

2.2.8 Firing and kilns

The temperature required for the firing of a faience object ranges from 850–1000˚C (Nicholson, 1998). During the firing process, the silica grains in the body become sintered and a reaction between the alkali, silica, lime and copper forms a glaze on its surface. This process is not completely understood, especially the role of lime in the mixture (Vandiver, 1983). The replication and microstructure study using the SEM (Tite et al., 1983; Tite & Bimson, 1986) distinguishes between the three glazing methods of faience by the characteristics of the three various layers in faience structure. These layers are: quartz-free (glaze layer), quartz embedded in a matrix of glass (interaction layer) and quartz partially sintered with interparticle glass (core) (Figure 4). The microstructure for Egyptian faience is discussed in detail in the third chapter of this study.

Archaeological excavations have found some limited evidence of the shape and nature of faience kilns. From more circumstantial evidence at the New Kingdom site Amarna in Egypt (Nicholson, 1995; Nicholson, 2007), we can presume that the faience kilns were of a cylindrical shape, were 50–100 cm in diameter, were probably domed and were made of mud bricks or large pottery vessels or both.

Petrie reported excavating faience kilns in Amarna, where their floors were lined with quartz pebbles (Petrie, 1894), probably to make the pebbles easier to process later, although these finds were not properly documented. Nicholson suggested that the faience objects would have been placed in lidded containers/saggars to protect them during firing from smoke and ash particles (Nicholson, 1998). With regards to the fuel, the excavations at Amarna showed that wood and domestic waste were used for the firing of vitreous materials. Charcoal and animal bone fragments were found at Amarna and are probably remains from the firing(Nicholson & Peltenburg, 2000). Experimental work by Mark Eccleston (2008) proved that the firing of faience objects was possible by using a domestic bread oven of the type common in Amarna. More kilns for producing faience were discovered at Memphis (Petrie, 1909) and (Nicholson, 2013). The excavations revealed a major production centre for faience from the Graeco-Roman Period. The kilns have a rectangular structure, with an internal dimension one by two meters and 2.4 meters in depth. They are sunk halfway into the ground with a draught or stacking hole located at the middle of the profile. The kilns appear to have had an up-draught system where the fired faience vessels sat in a stack of saggars. This allowed fuel to be thrown between them, but the saggars prevented the ashes from damaging the glazes (Shortland & Tite, 2005).

2.3 Faience Objects in museums

The Egyptian faience collections of several museums in the United Kingdom were studied for this research: the British Museum, the Petrie Museum of Egyptian Archaeology, the Victoria and Albert Museum in London, the Ashmolean Museum in Oxford and the Fitzwilliam Museum in Cambridge. The aim of this aspect of the study is to explore the different typologies of faience artefacts that were produced in ancient Egypt and to select relevant objects in order to explore the diversity of their manufacturing techniques. The emphasis here is on faience-making technology and therefore the typological assortment for faience artefacts was based mainly on the objects' categories and physical shapes rather than on their chronological order, although changes in the technical aspects of production methods over the different periods were also considered. Early faience artefacts made from glazed stones and steatite are excluded from this typology because they were simply carved from natural stones rather than fabricated from prepared 'pastes'. The typology of faience objects can be divided into the following categories:

2.3.1 Beads

The earliest faience artefacts were beads. The craftsmen used lithic technology to produce them; first, individual beads were formed and then left to dry before being shaped by scraping and grinding. The beads were then pierced using a bow-operated drill. Also faience beads were made by forming the paste on rods (metal or reed) and then during drying cutting the paste into discs and tubes. Mass production of fine tubular beads was achieved by dipping stalks of grain into faience slurry, then cutting them to certain lengths during drying (Sode & Schnell, 1998). Individual Beads were also made by shaping the faience paste on straw that acted as a perforation; this was probably used as an alternative to piercing (Nicholson, 2007). Decorative beads were also produced such as the cord-beads from Nekhen[22] from 3000 BC in the Petrie Museum. These beads were made by rolling and manipulating wet rods of faience paste (Figure 5). The most likely method for glazing beads was cementation as faience beads are often glazed all over. Faience beads were produced in all periods in ancient Egypt by the same techniques. However form, colour and quality vary from one period to another.

2.3.2 Amulets

Early amulets were made also using lithic technology, by grinding and scraping lumps of dry faience into the desired shapes. The New Kingdom saw the introduction of moulding techniques and numerous amulets were then made by using open-face moulds made of fired clay (Nicholson, 2007) (Figure 6). Combined techniques were used also to make amulets such as scarabs with seals incised on the underside. Small figurine-amulets of gods and sacred animals were moulded and then finished by scraping. Holes were either drilled into the body after drying or during drying at the leather-hard[23] stage. Suspension loops were made separately in faience and then at the leather-hard stage were attached to the amulets using faience slurry.

2.3.3 Rings

Faience signet rings were popular during the New Kingdom Period. Their bezels were incised or moulded with various designs, such as the name of a king or deity, lotus flower, glyphs, etc. They were produced either from a one piece mould and then the bezel was incised with the design, or the bezel and the shank of the ring were moulded

[22] Hieraconpolis or Nekhen was the religious and political capital of Upper Egypt from the late Predynastic Period (3200–3100 BC) and during the Early Dynastic Period (3100–2686 BC).

[23] Leather-hard is a stage during the drying of clay when it is no longer plastic and is rigid enough to handle and shape by scraping, piercing, tapping, etc.

separately and then attached using faience slurry (Figure 8) (Quirke & Tajeddin, 2010). The making of these fine rings was only possible due to the improved quality and techniques of faience production during this Period.

2.3.4 Tiles and inlays

Faience tiles were produced either by cutting various shapes into flat slabs of faience paste or by pressing the faience paste into a negative mould with a pattern or design. Early tiles from the Old Kingdom's third Dynasty (2649–2575) were found within the step pyramid at Saqqara[24], which dates to around 2650 BC (Figure 7). They show that each tile was probably shaped by cutting a moulded convex slab of faience paste during the leather-hard stage to a standardized dimension, and then grinding the underside to shape the protrusions that were used for fitting, which were drilled later. Faience tiles were generally glazed by the efflorescence method since the undersides would not be visible. The same technique was used to produce inlays for furniture and architectural decoration.

2.3.5 Statuettes

The ancient Egyptian craftsmen created fine statues made of faience, for example figures of gods, kings and animals. At the beginning they used stone carving technology and tools (Vandiver, 1983; Nicholson, 2012). Early faience statues were generally modelled from a mass of faience paste but occasionally an organic core such as straw was used. The paste was worked on while it was dry or during its leather-hard stage by scraping and grinding. Wetting with water smoothed the surface and finer details were applied by incision. Later by the time of the New Kingdom open face moulds were used to create cult and funerary statues such as *shabtis* (see chapter 5). The backs of the statues were shaped by scraping and smoothing during or after the drying stage. Two-part moulds were used in the Graeco-Roman Period to produce faience statues. Often faience statues were made by layering, which involved the use of coarse faience paste for the core body and then applying fine faience paste layer on the surface. This practice

[24] Saqqara is an ancient burial ground in Egypt.

was adopted, first to enhance to quality of the glazed surface, and second, to use sand which is a readily available source of silica as opposed to laboriously ground quartz. Also experimental work has shown that including various particle sizes of silica in the paste improves its workability. Faience Figures and statues were glazed either by application or by efflorescence methods, or both.

2.3.6 Vessels

A wide range of vessels was produced from faience in ancient Egypt during all periods, such as bowls, plates, chalices, cups, flasks, jars, kohl and cosmetic containers and inkwells. Craftsmen used various techniques in the making. The early vessels were thick and heavy and often made after prototypes in stone and alabaster, and used lithic technology. Modelling the faience paste or forming it on a core was also used to create vessels and containers. Often different parts were made separately and then joined using faience slurry. The layering technique, with its coarser substrate, was often used to give the pieces a uniform and finer finish. Moulds, both positive and negative, were used to create various shapes or sections for composite pieces. Subsequently in certain instances, handles, spouts and decorative elements were added using faience slurry. Luxury and decorative containers were shaped as sculptures or combined with sculptures (Figure 11).

2.3.1 Ritual objects

This group of artefacts includes objects such as ritual sistrum[25], *ankh*[26] (Figure 72) and royal sceptres. A combination of forming methods was used to create them but they can be considered as kind of sculpture. A unique example of a massive cult object can be

[25] Sistrum is a musical instrument of ancient Egypt consisting of a handle holding a frame with transverse metal rods that rattled when shaken.
[26] Ankh is an ancient Egyptian symbol of power, it represents the key of life and was carried by priests and kings.

Figure 5: Nekhen 'curtain' beads from the 1st Dynasty. Petrie Museum of Egyptian Archaeology UCL. (photo by Z. Tajeddin)

Figure 6: Faience collar necklace composed of amulets in the shape of leaves, flowers, fruits and lotus petals, made in open face moulds. From Amarna, New Kingdom. EA 59334.
(© - Trustee of the British Museum)

Figure 7: Tiles from the step pyramid of Saqqara from the 3rd Dynasty, Fitzwilliam Museum, Cambridge. (photo by Z. Tajeddin)

Figure 8: faience rings and their moulds. (top): One piece mould production., (bottom): Two piece mould production.
(Courtesy of Petrie Museum of Egyptian Archaeology UCL)

found in the Victoria and Albert Museum in London. This object was made in the shape of the *was*-sceptre[27] and built in sections that were joined together and then fired as one piece (Figure 90). This object will be discussed in detail in chapter 5.

2.4 Physical and microscopic examination

The selected faience artefacts and fragments were subjected to a general study using visual examination and a hand-held magnifying glass (10x) as well as an optical microscope (10–40x). Then they were measured and photographed and notes were taken on the technological evidence and any related features. A few case studies are discussed in this chapter because of their relevance to the sculptural practice for this research project.

2.4.1 Object 1: Faience hawk UC11005

This faience figurine is from the Early Dynastic Period (2920–2649 BC), found in Hierakonpolis[28], its dimensions are: height 4.0 cm, length 4.9 cm, width 2.2 cm. The figurine was modelled by hand from faience paste while it was still plastic and a wooden tool was probably used to shape the chest and the edges (Figure 9a). The peak was formed by pinching the plastic paste with two fingers leaving indentations for the eyes, which were enhanced by tooling. The underside was scraped when the paste became firm and relatively dry, to shape the tail and the feet. The Hawk was glazed by the efflorescence method, hence the thicker glaze on the edges and the absence of glaze where it was scraped at the underside (Figure 9, d & e).

[27] The *was*-sceptre is an emblem of authority carried by Egyptian deities and kings. It is also the hieroglyph for ‘domination’.
[28] Hieraconpolis, see Nekhen

a. The peak was pinched by two fingers

b. The details on the front shaped by a flat tool

c. The body formed by hand from a plastic paste

d. The chip showing the coarse sandy core and the thick glaze on the edge

e. The scraped back during drying caused lack of glaze

Figure 9: Faience Hawk, UC11005, from The Early Dynastic Period (2920–2649 BC), (photos by Z. Tajeddin)

2.4.2 Object 2: Fragment of furniture inlay UC45197

This fragment of a blue-green faience inlay tile depicting a falcon with a curved back is from the decoration of a wooden vase. It dates from the Old Kingdom's fifth Dynasty (2465–2323 BC). Its dimensions are: height 3.8 cm, length 3.0 cm width 1.3 cm. This panel was shaped from a flat slab of faience paste, which was pressed onto a curved surface (presumably of a wooden vase). The shape of the falcon was then marked and the surrounding area was carved out, leaving a low relief (Figure 10, b & d). At the bottom a frieze or rod of faience was attached to the panel by faience slurry that can be still seen at the joints (Figure 10, b & c). The design was glazed by the application method using different colourants.

a. Inlay fragment of falcon UC45197 **b. A frieze was attached to the edge using faience slurry**

c. The panel was shaped on a curved surface **d. The design was marked then the surrounding area was carved out leaving a low relief that was glazed with blue and black**

Figure 10: Fragment of faience inlay depicting a falcon UC45197 from the fifth Dynasty (2465–2323 BC), (photos by Z. Tajeddin)

2.4.3 Object 3: Part of blue-green glaze Bes[29] vessel UC45451

The fragment is from the Late Period (713–332 BC), with dimensions: height 11.2 cm, diameter 7.5 cm. The preserved part is slightly less than half of the original. The original

[29] Bes was the god of music in ancient Egypt, also the protector of children, women and households.

vessel was constructed out of eight sections; the base is in the shape of a bowl, and it was produced in a negative open-mould. The top section was formed on a positive core-mould. The two halves were attached together at the leather-hard stage using faience slurry. The joining seam and the slurry can be seen on the inside. The face of Bes was incised and carved on the surface, then the rim, the arms and the ears were attached to the body using slurry. The vessel was glazed with the application method, hence the bubbles that have formed on the surface (Figure 11).

Figure 11: Fragment of Bes vessel from the Late Period (713–332 BC), UC45451. Note evidence of tool marks on the surface, bubbles from the applied glaze, also the joining seam and slurry on the inside. (photos by Z. Tajeddin)

2.4.4 Object 4: Fragment of an alabastron UC86952

This fragment of a small alabastron[30] is from the 19th Dynasty (1293–1212 BC), its dimensions are: height 6.7 cm and diameter 2.85 cm. The small vase originally had a

[30] Albastron is a type of small narrow vessel used in the ancient world for holding oil.

green glaze that has faded away to a brownish/white, and it is broken at one side. The vase is constructed by coiling a rod of faience paste and then pressing it on to a solid core. The core probably made of combustible material such as animal dung mixed with clay. The remains of this core would have been scraped out after firing, leaving a residue on the interior surface, which can be still seen. The vase then was decorated by incising a pattern to its surface during drying, at the leather-hard stage. Small handles were attached to the body using faience slurry. The vase was glazed with the efflorescence method, hence the poor glaze that had developed on the surface after scraping it for decoration (Figure 12).

c. The body formed by hand from a plastic paste

d. The chip showing the coarse sandy core and the thick glaze on the edge

e. The scraped back during drying caused lack of glaze

Figure 12: Faience albastron, UC28695, from The 19th Dynasty (1293–1212 BC), (photos by Z. Tajeddin)

2.4.5 Object 5: Fragment of sistrum UC29145

This is a fragment of a blue faience double-sided Hathor[31] head, part of sistrum from the 18th Dynasty (1570–1293BC), and its dimensions are: height 6.8 cm, length 6.8 cm and width 2.9 cm. The core of the object is relatively coarse. The sistrum was constructed in sections. The Hathor head is made from two halves. Each was pressed into an open-mould, then joined together and the gaps were filled with faience paste. The slight difference in the quality of the faience in the body is evident at the joining seam (Figure 13, b & d). A shift of the two halves can be seen at the side. The handle was joined at the base using fine faience paste that is still in the body (Figure 13e). The sistrum was decorated with manganese oxide and glazed by the application method, hence the thicker glaze that has collected in the curves.

2.4.6 Object 6: Large hand fragment UC 45139

Fragment of blue faience relief in the form of an outstretching hand from the 18th Dynasty (1570–1293BC). Its dimensions are: height 7.0 cm, length 13.6 cm and width 2.9 cm. This unusually large piece was probably part of a life-size sculpture. Remains of the body that it was attached to are still visible. The hand was formed on a flat surface and shaped by modelling and scraping during the various stages of drying. The hand was attached to the body with fine paste that can be still seen on the back (Figure 14c). The statue was glazed by the application method.

[31] Hathor was a popular goddess in ancient Egypt; she was associated with love, joy and motherhood. Hathor was also depicted as a cow.

a. Weathered glaze showing the thicker areas, also the joining line is evident at the underside

b. Slight shift in joining the two halves

c. Black lines of manganese oxide used for decoration then glazed by the application method

d. Slight difference in the quality of faience is evident in the body at the joining seam

e. The handle was inserted into the base, remains of its fine faience paste are still evident

Figure 13: Fragment of blue faience double-sided Hathor head, part of sistrum from the 18th Dynasty (1570–1293BC), UC29145. (photos by Z. Tajeddin)

2.1 Discussion

The faience objects' typology created for this work is limited to artefacts examined in the aforementioned museums. It does not cover all typologies of faience that exist in other collections and other museums. Future studies could expand this typology to include more categories. The selected artefacts examined in this chapter were chosen for their relevance to the practical work of this project. They include examples of various forming techniques that have many parallels with traditional making techniques using ordinary pottery clays, although the frequent reworking of the nearly dry faience paste by abrading, carving and incising, seems closer to lithic working methods. Also one might suspect some parallels with contemporary glass-making in the use of long coils around a core.

a. Blue glaze applied to the surface

b. The hand shaped on a flat surface and then attached to the body

c. Fine faience slurry was used to join the hand to the original body

Figure 14: Large hand fragment from the 18th Dynasty (1570–1293BC), UC45139. (photos by Z. Tajeddin)

3 Chapter 3: Analytical and Experimental Research

3.1 Experimental research

The experimental research for this project was essentially informed by two sources; first the study of faience artefacts from several museums in the United Kingdom (see Chapter 2) and second is the literature sources that include experimental attempts at faience reproduction such as (Noble, 1969; Kiefer & Allibert, 1971; Vandiver, 1983; Griffin, 2002; Eccleston, 2008), and the results from the analytical work on Egyptian faience artefacts published in the works of scholars such as (Kaczmarczyk & Hedges, 1983; Vandiver, 1983; Shortland, 2000; Tite & Shortland, 2008). The research evolved over the period of this project and was frequently renewed in the light of the emerging practical results and the study of the ancient artefacts in the museums' collections. This ongoing interdependence of observation of historical material with experimental results has helped to drive the research, and often suggested new avenues to explore.

3.2 Criteria

A series of extensive practical experiments were carried out to produce faience samples. The main objective in this work was to establish a practical approach for creating and glazing contemporary faience objects. Thus the focus was on:

1. The faience paste's workability and how to improve it in order to make large pieces.
2. The making techniques suitable to create large objects
3. Establishing a suitable glazing method for sculptural objects.

For the glazing method, it was obvious that only the efflorescence and application methods would be considered, since the cementation glazing method is not suitable for large objects. Furthermore I decided to concentrate on exploring the efflorescence method for my experiments for the following reasons: (a). It is a self-glazing method. (b). The lack of research into the self-glazing mechanism. (c). The method produces finished objects in one firing. (d). The application glaze is widely used today in ceramic technology, while efflorescence is still an unusual technique.

Therefore the experiments were designed to explore the faience paste plasticity, the making methods and the process of efflorescence glazing.

3.2.1 Measuring plasticity

Rice (1987) in her book "*Pottery Analysis"*, discusses this property of clay and states that plasticity by definition is the deformation of clay by force. She identifies three kinds of forces causing the deformation: "One is compressive force–pressing on a wet clay, which will eventually cause it to crack. Another is tensile force–stretching or extension of the clay mass, which will also cause cracking beyond a certain limit. A third force is shear—simultaneous of opposing forces on the clay, which will cause it to crack or rupture." (Rice, 1987, p61). Plasticity can also be assessed by its "working range" or "workability" which refer to the amount of water added to a dry material to obtain a mass that can be formed satisfactory (Rice, 1987). However there is no satisfactory method to test clay plasticity, thus it is common amongst potters to assess clay plasticity through "feel" which could include squeezing the clay, biting it, pinching it or by making a loop (Rice, 1987). Faience paste has basically very poor workability – far less than clay. The amount of water added to the dry mixture is crucial; less water results in dry and crumbly paste, more water causes the paste to slump and flow. Therefore it is very important to add the water very slowly to obtain a mass that has a relative good workability. For my experiments I tested the faience paste by pinching and making coils to assess its workability. I rated the results as 'poor', 'average' and 'satisfactory', whereas, in relation to clay, a satisfactory rating for faience paste is equal to the least plastic-clay.

3.2.2 Making methods

The faience paste is thixotropic –unlike plastic clay, it cracks if exposed to pressure. Therefore, it was generally treated more like sand sculptures which are formed by modelling, layering, tapping and scraping. In this research I applied my knowledge and skills as a sculptor and ceramist to devise ways of forming the faience paste, and tested various techniques in order to manipulate the material and to create large faience objects. To these ends I tested on the improved paste bodies common clay-forming methods such as modelling, moulding, coiling, slab building, etc. and tried to adapt them for my work with faience.

3.2.3 Glazing tests

A set of tests were designed to explore the role of the various raw materials used in faience production. By systematically changing the ratio of one ingredient and fixing the others, I could establish its effect on the physical and visual qualities of the faience samples created. Then selected samples were subjected to analytical work – first by optical microscope in order to examine the physical properties of the samples and their cross sections, and then through examination of samples using a scanning electron microscope. By these means the microstructures of the sampled materials were revealed. The images showed clearly the different phases in the samples; they also helped to explore and characterise the different areas in the samples: i.e. surface glaze, interaction zone and core area. The elemental analyses associated with SEM study provided information on the chemical composition, the microstructure and on raw material distribution within the samples.

3.3 Sample preparation

The raw materials used in this project were obtained from ceramic suppliers[32] in the United Kingdom, The chemical analysis for raw materials as provided by the various suppliers can be found in Appendix I. For the main components: silica (SiO_2) I used quartz and flint (300 mesh[33]) and sand (60–90 mesh), for sodium carbonate (Na_2CO_3) I used soda ash, for sodium bicarbonate ($NaHCO_3$) I used commercial baking soda and for calcium carbonate ($CaCO_3$) I used whiting (300 mesh). For colourants I used copper

[32] Pottery Crafts (www.potterycrafts.co.uk) and Potclays Limited (www.potclays.com).
[33] Mesh scale is a system used to determine the particle size of the grains.

oxide (CuO), copper carbonate ($CuCO_3$), cobalt oxide (CoO) and red iron oxide (Fe_2O_3). In addition, for alkalis I also tested ash from a desert plant '*Eshnan*' from Syria and natron salts from Wadi Natron in Egypt, with both obtained through personal contacts in these countries. For binders I tested various types of highly plastic clay from the ceramic suppliers, such as bentonite and ball clay. Also two organic binders were tested: '*serish'*[34] from Iran and gum Arabic[35]from art-materials supplier[36]. The components were mixed dry in a bag, then water was added to the mixture. The paste lumps were tested for their plasticity and then small tiles were cut to a fixed length of 5 cm, approximately 3 cm in width and 0.5–0.7 cm thick. The tiles were left to dry to allow the alkali salts to effloresce. Different drying environments were tested to explore this critical factor for forming the glaze. The tiles were then fired in an electric test kiln. Different firing temperatures, were tested from 800°C to 1100°C, as were slow and fast firing schedules.

3.4 Results and Discussion

My first set of experiments was based on published compositions (Noble, 1969; Vandiver, 1983; Eccleston, 2008) (table 2).

The tests were tiles and moulded amulets, fired to 850°C and 900°C at 100°C per hour, the results were as follow: Noble's composition gave a satisfactory paste (good plasticity) and produced thin semi-gloss glaze with a white core. Vandiver's composition gave a poor paste and produced a matt light gray powdery surface. Eccelston's composition gave a highly plastic paste but produced a bubbly vitrified surface and the sample was inflated and cracked (Figure 15).

[34] Serish is natural gum that comes from the roots of giant asphodel; latin name: *Ermurus Aucherianus Bioss;* also known as sirish, chiresh, sarish, siris and shirias
[35] Gum Arabic is natural gum exuded from some kinds of acacia and used as glue, binder and as an incense.
[36] L. Cornelisson & son (www.cornelissen.com)

Sample	Silica SiO_2	Lime	Feldspar	Alkalis		Colour	Binder	
	Quartz	$CaCO_3$		Na CO_3	$NaHCO_2$	CuO	Gum Arabic	Ball Clay
Noble	85	2	2	3	3	1		6
Vandiver	92	3		4		1		
Eccleston	65	4		13		3	5	10

Table 2: Test samples based on published compositions

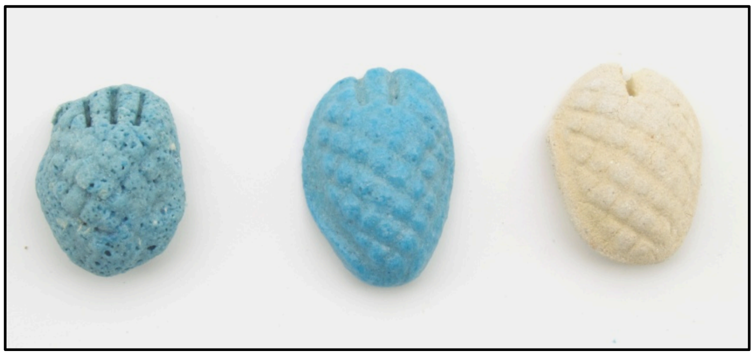


Figure 15: Samples of first set. Compositions from right to left: Vandiver, Noble and Eccleston. (photo by Z.Tajeddin)

The following series of tests were designed to explore the roles of each component by systematically changing the ratio of one ingredient and fixing the others – a strategy aimed to establish the effect of each component on the physical and visual qualities of the faience samples created. All samples were tested for different firing temperatures: 850°C, 900°C and 950°C.

3.4.1 Quartz

Firing a test tile made of 98% quartz with 2% gum Arabic (for bonding) to 900°C produced a fragile tile without any sintering (Figure 16).

3.4.2 Quartz and Lime

Firing 94% quartz with 4% lime and 2% gum Arabic to 900°C produced also a fragile sample without sintering (Figure 16).

These tests served as reference material, especially when examined by the scanning electron microscope SEM, as they helped to identify the morphology for each component in the microstructure.

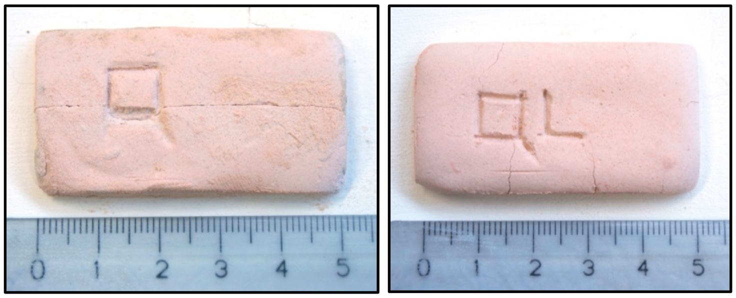


Figure 16: Fired samples of tiles made of quartz (left) and quartz and lime (right) bonded with 2% gum Arabic fired at 900°C (photo by Z. Tajeddin)

3.4.3 Quartz, lime and Alkali

For this range of tests, the lime amount was fixed at 4% and the copper oxide at 1%. Here I experimented with adding sodium carbonate from 1% to 12% in one set of tests (A), and with adding a combination of (50:50) of sodium carbonate and bicarbonate in the same percentages (from 1% to 12%) to a second set (A^{-}). The quartz amount added for each test varied to bring the total to a 100%. The quartz used was 300 mesh (Figure 17 & 18). These two sets were fired at 900°C, then further sets, using these same variations, were produced and tested at different firing temperatures: 850°C and 950°C. In addition I re-fired a set of samples at 1000°C and 1100°C (Figures 20). The result of these series demonstrated clearly the role of alkaline materials in creating the glaze and also its role in bringing out the blue colour. From these tests only results with successful glazes were taken as the basis for the next experiments (A_X and A^{-}_{XII}). These samples contained 10–12% of alkali, 4% lime, 1% copper oxide and 85%–83% quartz (300 mesh) respectively. The quality of the efflorescence and the resulting glaze was also improved by leaving the paste to mature for 24 hours before it was left out to dry and effloresce (Figures 17 & 18). Another set of tests was carried out using, separately, 12%

bicarbonate (A^{+}_{XII}), 20% Syrian desert plant ash *'eshnan'* (A_{EXX}), and a 12% mixture of sodium carbonate, bicarbonate and chloride (A_{XIICl}) (table 3). These tests were compared to the successful sample (A^{-}_{XII}) that contained combination of (50:50) of sodium carbonate and bicarbonate. The '*eshnan*' produced a poor glaze, as expected from its XRF chemical analysis, which showed low alkali levels (12.0% Na_2O, 8.0% MgO, 3.7% K_2O and 1.4% Cl). The bicarbonate sample produced a vitrified tile but no glaze, and that was also the case with 33.3% sodium chloride in the alkali (Figure 19).

Sample	Silica SiO_2	Lime $CaCO_3$	Alkalis		Salt	Syrian desert	Colour
	300 mesh		Na CO_3	$NaHCO_2$	NaCl	plant ash	CuO
A_{XII}	83	4	12				1
A^{+}_{XII}	83	4		12			1
A^{-}_{XII}	83	4	6	6			1
A_{XIICl}	83	4	4	4	4		1
A_{EXX}	75	4				20	1

Table 3: Test of samples with different alkalis

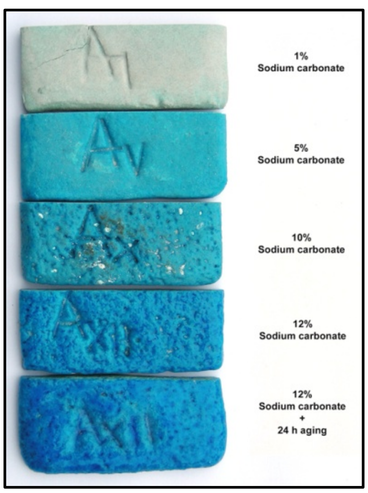


Figure 17: Sodium carbonate tests fired at 900°C

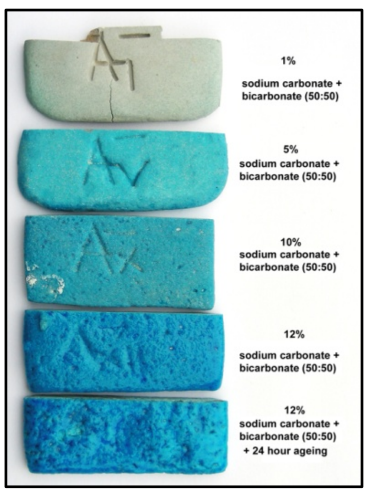


Figure 18: (50:50) sodium carbonate and bicarbonate tests fired at 900°C

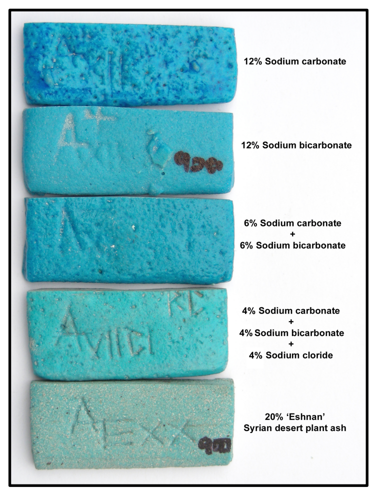


Figure 19: Tests with different alkalis fired at 900°C

Figure 20: Sets of samples with (50:50) sodium carbonate and bicarbonate (A¯), sodium carbonate (A) fired to 950°C (left), to 1000°C (middle) and 1100°C (right).

3.4.4 Gum Arabic

Gum Arabic was added by 1 to 5% (G_I – G_V) to the successful glazing result (10–12% alkali) to test its effect on the sample (Table 4). The tests were fired at 900°C. This experiment showed that adding gum improved the workability. However a higher percentage of gum had a negative effect on the body of the sample as it made it spongy and weakened the tile's structure. In addition it produced poor efflorescence, in another words it inhibited migration of the alkali salts to the surface. More tests of (G_I – G_V) were fired at 1000°C and 1100°C (Figures 21).

3.4.5 Lime

'Lime' (calcium carbonate) was added by 1 to 5% (L_I – L_V) to the successful glazing result (10–12% alkali) to test its effect on the sample (Table 4). The tests were fired at 900°C. This experiment showed that adding lime had no clear effect on the plasticity of the paste nor on the physical appearance of the test tiles, however the absence of lime produced a matt glaze. More tests of (L_I – L_V) were fired at 1000°C and 1100°C (Figure 21).

Sample	Silica SiO_2	Lime $CaCO_3$	Alkalis		Gum Arabic	Colour
	300 mesh		Na CO_3	$NaHCO_2$		CuO
G	83	4	6	6		1
G_I	82	4	6	6	1	1
G_V	78	4	6	6	5	1
L	87		6	6		1
L_I	86	1	6	6		1
L_V	82	5	6	6		1

Table 4: Test of samples with different percentages of gum Arabic and lime contents

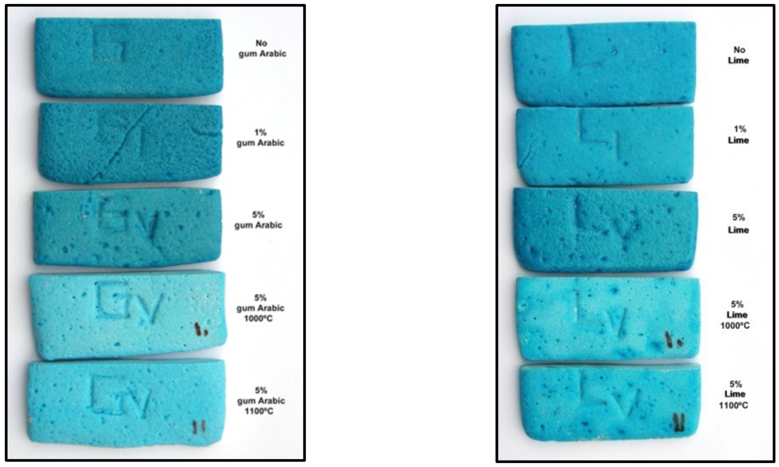


Figure 21: tests with gum Arabic (left) and with lime (right)

3.4.6 Particles size

In this set of experiments the samples contained fixed amounts of 12% of alkali, 4% lime, 1% copper oxide and here I tested silica sand with different particle sizes rather than the 300 mesh quartz used earlier. First I used 83% of 40, 80, 100 and 200 mesh as the only silica used in the tests and then each of the above mesh sizes was tested in combination with an equal amount of 300mesh quartz. These sets of tiles were tested with or without gum Arabic and also at different firing temperatures: 850°C, 900°C, 950°C and 1000°C. the results show that tiles with lower mesh-sizes produced poor pastes, and only the (50:50) mixtures with 300 mesh were sintered upon firing. No successful glaze was obtained for any of these tests, and the addition of gum Arabic improved the plasticity of the pastes (Figure 22). It became clear from these tests that finer quartz is necessary to produce the glaze, however the fine paste is more thixotropic and difficult to form objects. As a follow up, further experiments were made to obtain an ideal paste. This resulted in the combination of (60:40) 300 mesh quartz with 80–100 mesh silica sand. This gave a good workable faience paste and a satisfactory glazing result.

3.4.7 Clay

In this set of experiments I tested the addition of different kind of clays on the plasticity of the paste, namely, red clay, bentonite and ball clay, at 2% and 5%. The samples contained fixed amounts of 12% of alkali, 4% lime, 1% copper oxide and 80%–78% of quartz (300 mesh) respectively. The choice of red clay was to match the Nile silt that was commonly used in ancient Egypt for pottery making. The use of ball clay was to match the Egyptian marl clay that has a buff colour. Bentonite was used for its high plasticity (Figure 23). These tests introduced a satisfactory plasticity to the pastes. They also gave a smoother and better glaze. Using 2% of red clay did not change the colour of the core body but higher percentages caused this to become more red (Figure 24).

Figure 22: Tests of particle sizes

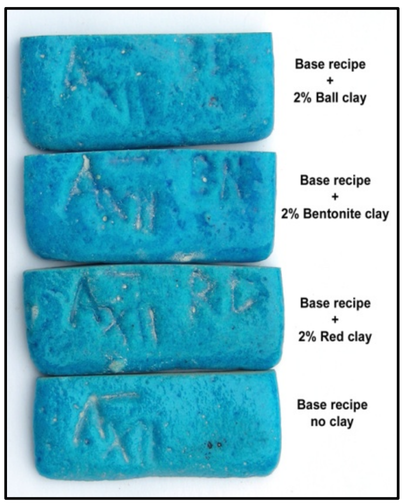


Figure 23: Tests of different clays

Figure 24: Tests of red clay

3.4.8 Colouring oxides

Different oxides were tested with the base recipe that contains 12% alkali, 4% lime and 83.5 to 74% of quartz (300 mesh). The colourant oxides were: copper oxide (CuO) 1% of which gave a turquoise colour and 2% a blue colour; cobalt oxide (CoO) at 0.5% gave dark blue; red iron oxide (Fe_2O_3) at 2% gave a beige colour and 10% gave a red/brown colour; black iron oxide (FeO) at 2% gave a light brown colour; chrome oxide (CrO) at 1% gave yellow and 2% gave lime green; manganese dioxide (MnO_2) 0.5% gave a pink colour and 2% black colour (Figure 25).

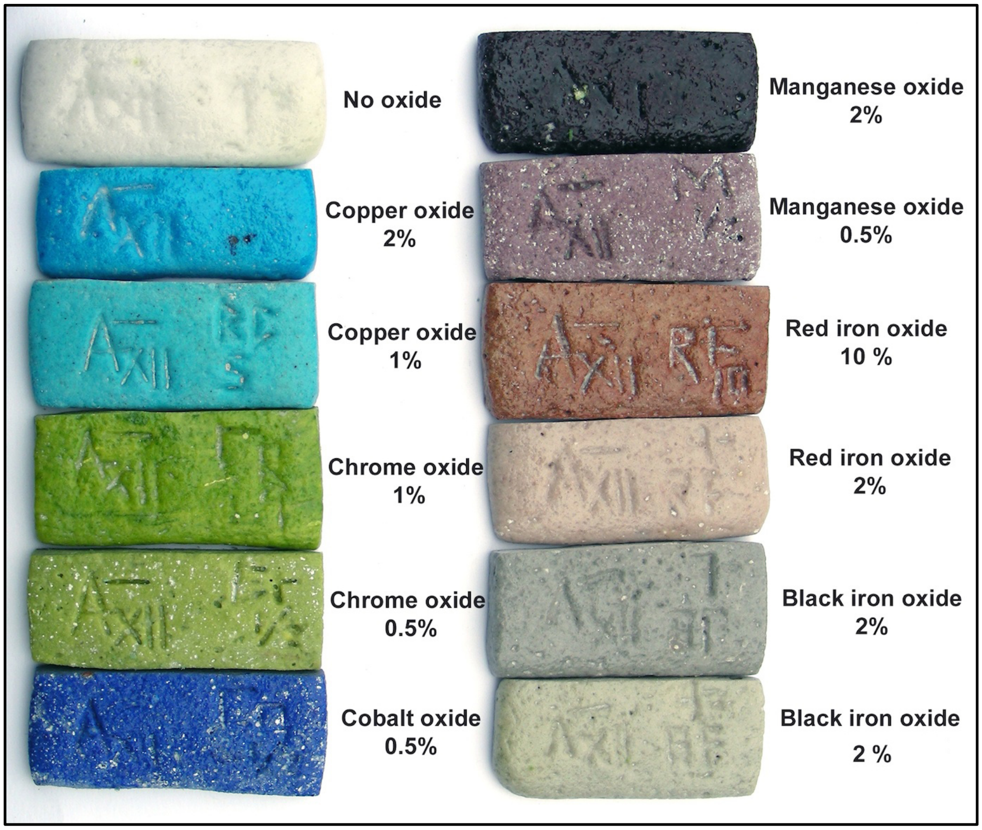


Figure 25: Tests of colouring oxides.

3.4.9 Drying factor

The above experiments were carried out indoors during the winter months in London. However, it was noticed when the summer arrived that the new tests produced better glazes. This observation led me to reconsider the effect of environmental factors on the efflorescence phenomenon. New sets of tiles were produced to test the efflorescence of alkaline salts in a drying cabinet heated to 40°C. These tests achieved a uniform and smooth glaze with a reduced percentage of 7–8% (50:50) mixture of sodium carbonate and bicarbonate.

3.4.10 Tests on making methods

Larger and thicker samples were made to test the workability of the faience paste. After the series of tests based on the above experiments and observations, the following recipe was chosen to explore some making methods, the recipe was:

- 87 % silica, which contains 60% quartz or flint and 40% silica sand (90 mesh)
- 4% soda ash (sodium carbonate)
- 4% whiting (calcium carbonate)
- 4% plastic clay
- 0.5–1% colourant oxide

The reduction of the alkaline content from 10-12%, as used in the earlier tests, down to 4% in the thick tests, was due to observing alkaline salts forming on the surface of fired tests that had used these higher alkali percentages, especially after a period of time. This was more evident if the objects were placed in a humid environment. The experiments showed that lowering the alkaline contents to 4% for the thick objects was still sufficient to produce a successful glaze. This observation can be explained as follow: Most of the paste's content of soluble alkaline salt migrates to the surface in the thick than in thin objects. Higher levels of sodium salts then 'digest' more silica on the object's surface during firing, which creates thicker glazes, and these can be troublesome in firing. In addition to this effect only a certain amounts of alkaline flux is needed to form a successful glaze. Therefore any excess amount in the paste does not react completely with the silica to produce glaze during the firing process, but remains in the faience body and continues to efflorescence after firing. By decreasing the levels of sodium salt in the pastes' original recipes both problem can be addressed.

The workability of this recipe was ideal for making figures and large objects. It was suitable for modelling and moulding while at the plastic stage, and easy to carve and sculpt when leather-hard. In addition the experiments showed that, unlike clay bodies, pieces of faience could be joined together when they are dry, before and after firing using faience paste or slurry (Figure 26). The faience objects were left to dry and effloresce in a drying cabinet heated to 40°C, then they were fired to 900°C at 100°C per hour.

Figure 26: Tests showing joined faience pieces using slurry and paste before and after firing.

3.5 Scanning Electron Microscopy

A selection of samples from the experimental work was chosen for analysis. They were examined by the scanning electron microscope (SEM) in the Wolfson Archaeological Science Laboratories at the Institute of Archaeology, University College London. A Hitachi S-3400N SEM with an Oxford instrument of energy dispersive spectroscopy EDS attached was used for this analytical work. The purpose of this analysis was first to identify and characterise the raw materials and confirm their chemical composition. Second, to study the microstructure in the faience cross section i.e. glaze, interaction zone and core. Third, try to understand the mechanism of glaze formation by comparing the samples at different stages according to the gradual increase of the active materials such as lime, soda, clay and colourants to the experimental tests.

The microstructure of the various samples was studied using secondary electron imaging (SE) to determine the properties of the various particles, the particle sizes and the particles' distribution. The backscattered electron imaging (BSE) was also used to visually distinguish between the various particles based on their compositional differences. The chemical composition of the materials was analysed using the energy dispersive spectrometer (EDS) attached to the scanning electron microscope (SEM-EDS).

3.5.1 Sample preparation

Each of the selected samples was sliced at the horizontal side to reveal its cross section. The sampled slices were cut using an electrical tile cutter. Then they were mounted in resin blocks and ground down and polished to ¼ µm. Finally a thin layer of conductive carbon coat was applied to the surface to reduce the charging of electrons during analysis. All samples were examined at working distance of 10mm and using a beam current of 20kV.

3.5.2 Analytical data and discussion

3.5.2.1 Quartz

The backscattered electron image for the 98% quartz (300 mesh) sample with 2% gum Arabic (Q), fired to 950°C, shows angular grains of silica compacted together but not bonded (Figure 27). Large voids can be seen left over from burnt gum Arabic grains with a residue of ash minerals. The silica grains appear as a smooth light gray colour within a black background, which is a void space. The grain-size ranges from less than 1 µm to 115 µm.

3.5.2.1 Quartz and lime (QL)

The backscattered electron image for a sample that contains only 94% quartz and 4% lime (QL), shows angular particles of silica grains as a smooth light gray tone with lime grains as a dark speckled gray colour. All grains are compacted together but not bonded (Figure 28). The maximum grain size for the calcium particles is 70 µm, which suggests that they were crushed and reduced in size during the paste formation.

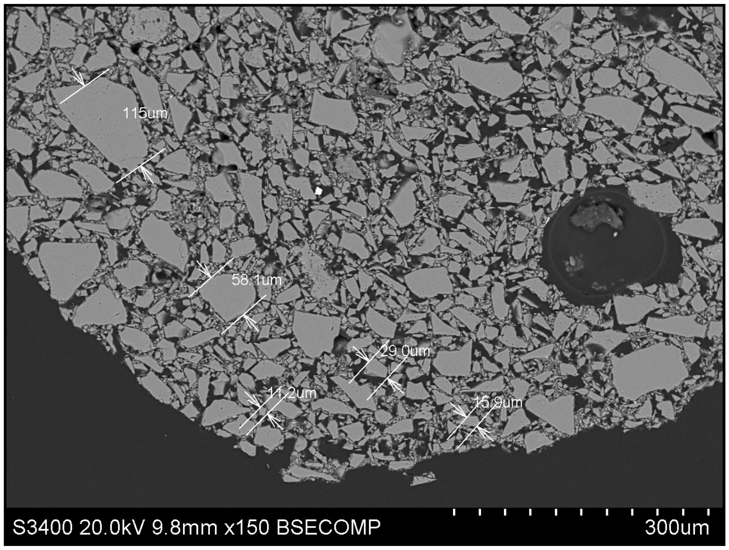


Figure 27: Backscattered electron image of a quartz sample (Q) fired to 950°C. the round void to the right from burnt gum Arabic grain that left residue of organic ash minerals

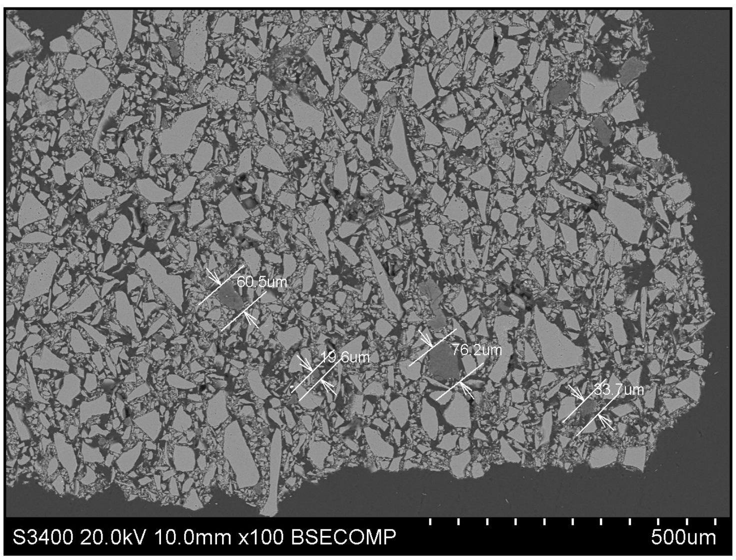


Figure 28: Backscattered electron image of a quartz and lime sample (QL) fired to 950°C.The lime grain appear in dark speckled gray

3.5.2.2 Quartz, lime and alkali

The results of the samples with sodium carbonate are discussed in this section. However, the samples with (50:50) of sodium carbonate and bicarbonate displayed a very similar pattern to those with sodium carbonate alone. First, the addition of 1% sodium carbonate to sample (A_I), which contained 94% quartz, 4% lime and 1% copper oxide, resulted in the formation of interparticale glass deposits near to the surface of the tile. The sodium contents that were migrating towards the surface during drying, did not reach the surface and formed a zone just before, which contained enough soda to react with lime at the silica-grains to form minor glass colonies (Figure 29). The sample was fragile and had a powdery surface with a light blue hue (Figure 18). Increasing the amount of sodium carbonate to 5% in the sample (A_V), which contains 4% lime, 1% copper and 90% silica, brought more soda to the surface to form an interaction zone about 500µm in width (Figure 30). This sample had a vitrified blue surface but was fragile and without glaze (Figure 18). Raising the amount of Sodium carbonate to 10% in sample (A_X), which contains 4% lime, 1% copper and 85% silica, resulted in the formation of a thicker interaction zone about 700 µm wide. This test also showed a high amount of interparticle glass in the core (Figure 31) and was firm and vitrified with a matt blue glaze (Figure 18). The addition of 12% of sodium carbonate in sample (A_{XII}), which contains 4% lime, 1% copper and 83% silica, formed a glaze layer about 100–200 µm thick and an interaction layer about 500 µm in width, in addition to an intensive presence of interparticle glass in the core (Figure 32). This sample had a glossy blue glaze and white sintered core very similar to an ancient faience sample (Figure 18). In sample (A_{XII}+24), I left the paste of (A_{XII}) sample to age for 24 hours before making the test tile. The result gave a thicker glaze of 180 µm, and a deeper interaction layer about 600 µm in width (Figure 33) and (Figure 18). The microstructure of this sample presented a classic image of a faience artefact glazed by the efflorescence method.

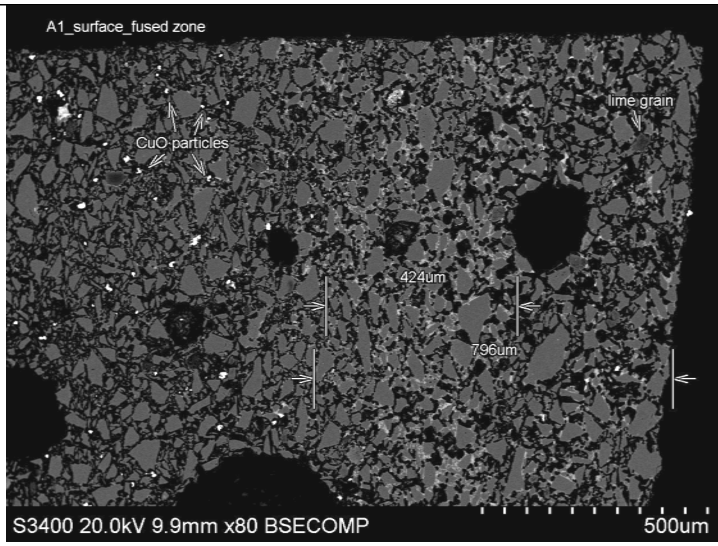


Figure 29: Sample (A_I), the addition of 1% of sodium carbonate to a body contained quartz, lime and copper oxide, resulted in formation of interparticale glass deposits near the surface of the tile. Copper particles remained dispersed in the body.

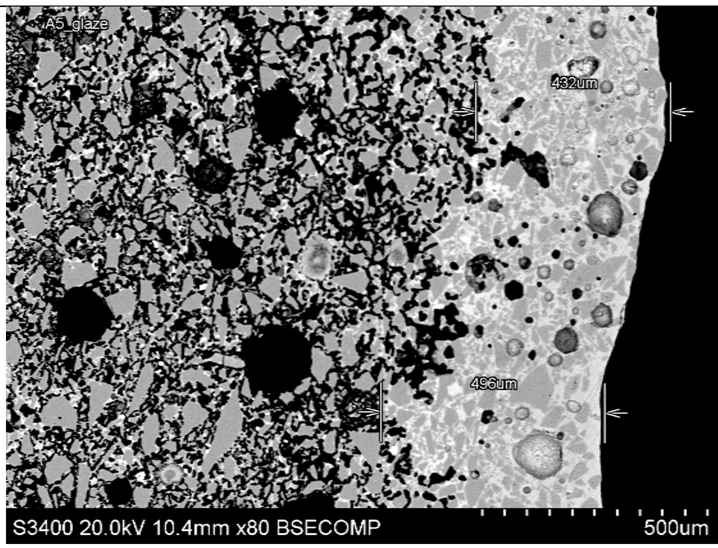


Figure 30: Sample (A_V) has 5% of sodium carbonate, it brought more soda to the surface to form an interaction zone about 500 µm in width.

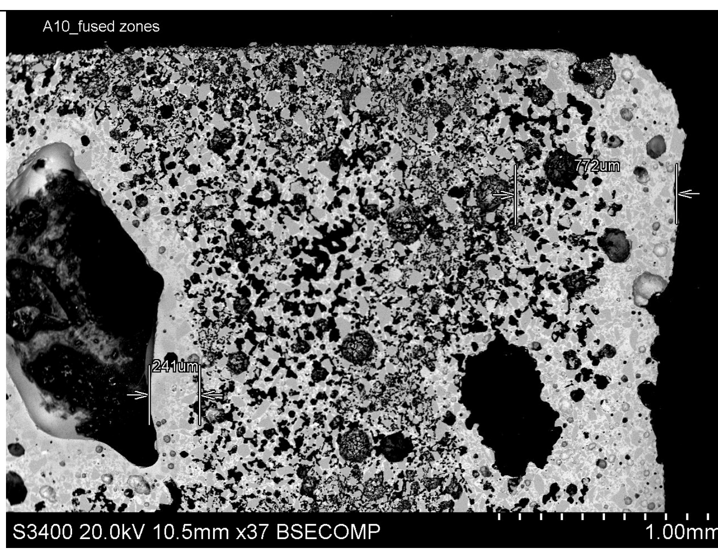


Figure 31: Sample (A_X), 10% of sodium carbonate in a sample, resulted in a formation of a thicker interaction zone about 700 µm wide and a high amount of interparticle glass in the core.

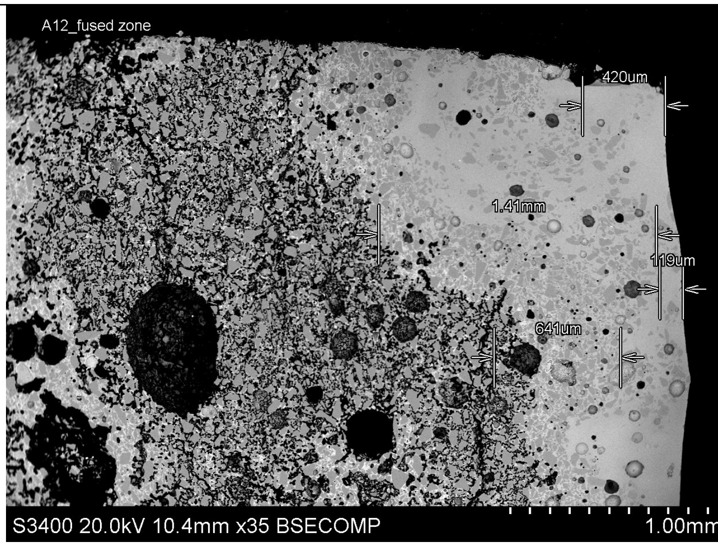


Figure 32: Sample (A_{XII}), a 12% addition of sodium carbonate in the body formed a glaze layer about 100–200 µm thick and an interaction layer about 500 µm in width, in addition to an intensive presence of interparticle glass in the core.

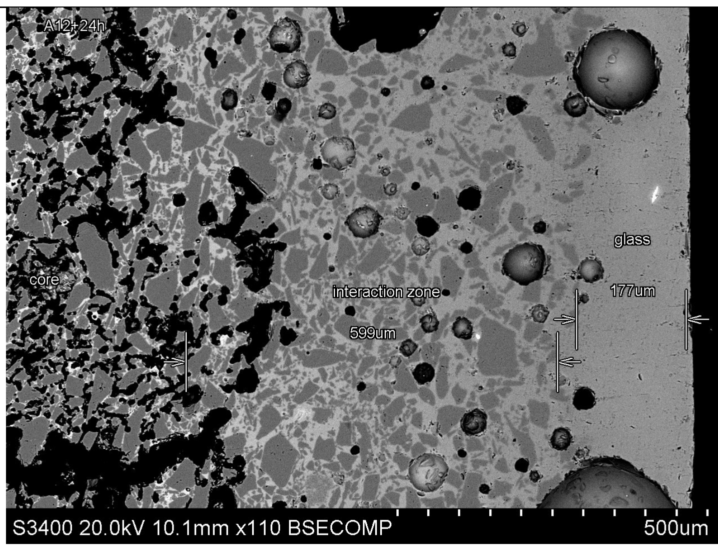
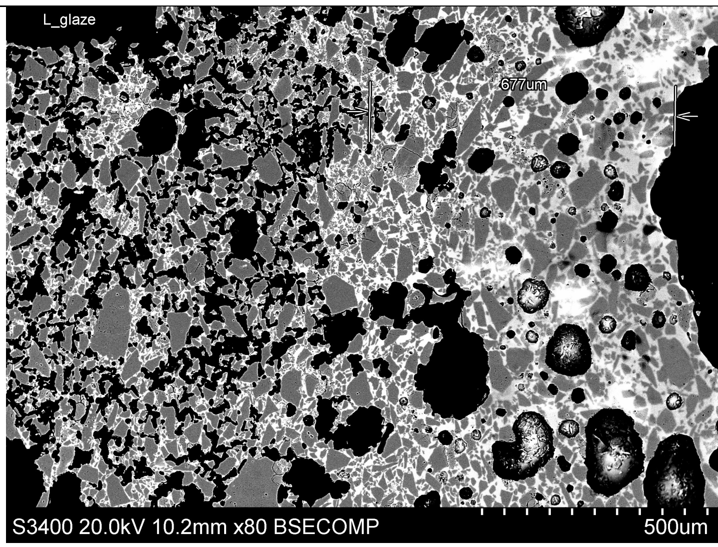
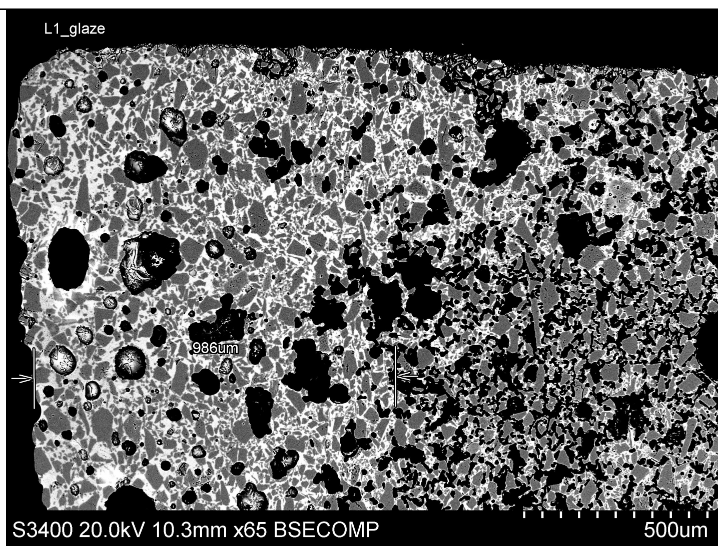


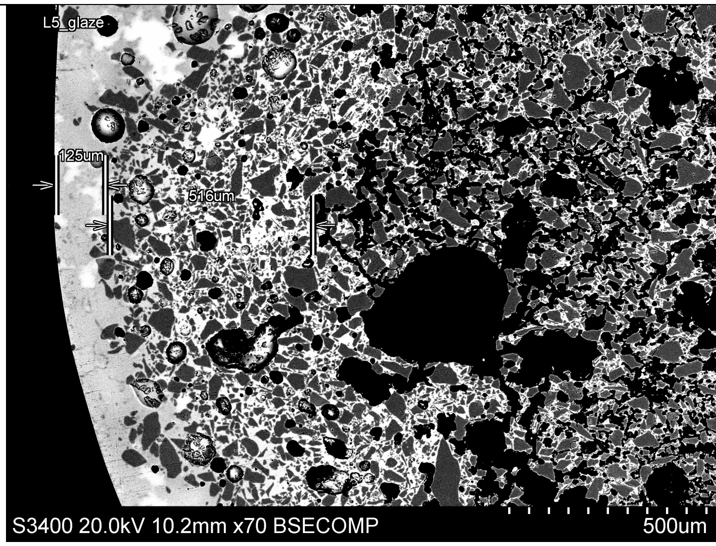
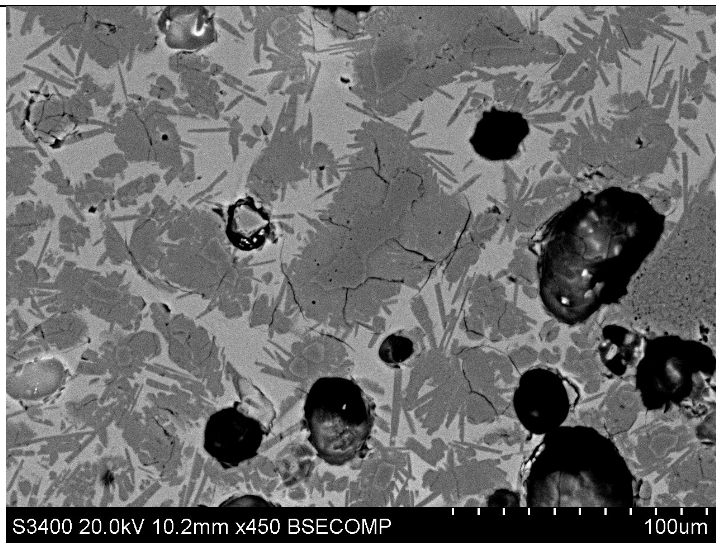
Figure 33: Sample (A_{XII}+24), the paste of (A_{XII}) sample was left to age for 24 hours before making the test tile. The result gave a thicker glaze of 180 µm, and a deeper interaction layer about 600 µm in width.

3.5.2.3 Lime

The microstructure study for the lime test tiles (Figure 21) showed that in sample (L), which has no lime but only 89% quartz, 1% copper oxide and 10% sodium carbonate, developed an interaction layer that is 680 µm wide with rich interparticle glass in the core, however there was not enough fusion to form a glass phase on the surface of the tile (Figure 34), and the resulting glaze was matt. The addition of 1% lime in sample (L_I) to the base recipe produced a wider interaction layer 980 µm but again no glass phase formed (Figure 35). In sample (L_V) that contained 5% of lime, a glaze layer 125 µm thick was developed, an interaction layer 510 µm and rich interparticle glass in the core

(Figure 36). Firing the (L_V) sample to 1100°C produced needle-shape crystals formation of cristobalite (Figure 37) measuring 15–60 µm in length in-between the quartz particles in the glass matrix. The tiles fired to a temperature above 1000°C were pale and lost their glaze.

	**Figure 34: Sample (L) formed an interaction layer that is 680 µm wide and rich interparticle glass in the core, however there was not enough fusion to form a glass phase on the surface of this tile**
	**Figure 35: Sample (L_I) formed wider interaction layer that is 980 µm, and rich interparticle glass in the core, but there was still not enough fusion to form glaze**

	**Figure 36: Sample (L_V) formed a 125 µm thick glaze, an interaction layer that is 510 µm wide and rich interparticle glass in the core.**
	**Figure 37: image of the core shows needle-shape crystal-formations of cristobalite (dark gray) 15–60 µm in length in between the quartz particles.**

3.5.2.4 Gum Arabic

The microstructure of the tests on gum Arabic (G_I and G_V) (Figure 21), which contained 4% lime, 1% copper oxide, 10% sodium carbonate and 84-80% quartz respectively, revealed that the interaction layer for the sample with 1% gum Arabic is wider than on the sample of 5% gum. On the other hand the interparticle glass in the core for the latter was greater. This pattern explain how the gum Arabic affects the migration of the alkali to the surface to form a glaze and the soda remains in the body to form more interparticle glass in the core (Figures 38 and 39).

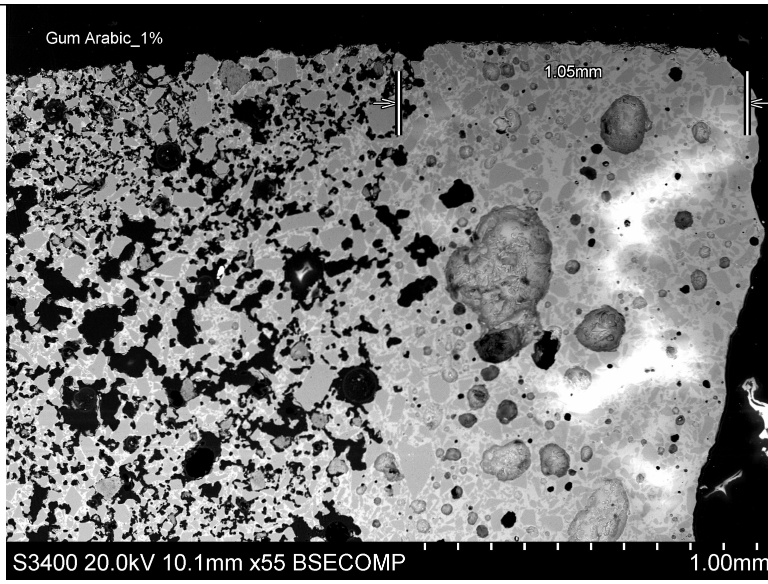


Figure 38: Sample (G_I) with 1% gum Arabic forms a 1mm wide interaction layer

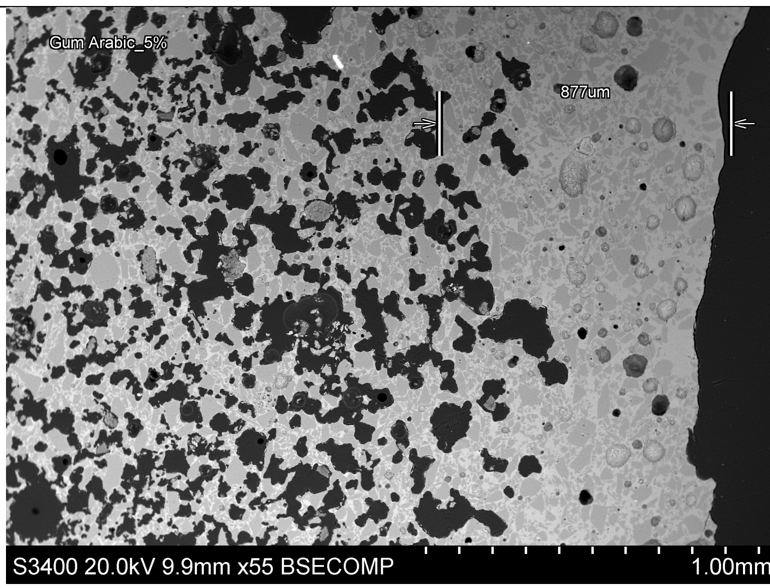


Figure 39: Sample (G_V) with 5% gum Arabic forms 870 µm wide interaction layer and therefore a poor glaze. The soda remained in the core to form more interparticle glass there.

3.5.2.1 Silica particle size

A series of samples were designed to test the role of silica particle-sizes on the faience quality and glaze. These were (A_{XII}-40), (A_{XII}-80), (A_{XII}-100), (A_{XII}-200), whereas the 883% silica in the base sample A_{XII} was replaced by a (50:50) mixture of 300 mesh quartz and silica 40 mesh sand, 80 mesh, 100 mesh, 200 mesh respectively, the other amounts were fixed at 4% lime, 1% copper oxide and 12% sodium carbonate. These samples were compared to (A_{XII}) that contains 83% of 300 mesh quartz and no sand. The microstructures of these samples revealed that in all cases a thick interaction layer was formed on the surface but the grains of the silica sand were too large to be fused

(Figures 40–44). Therefore it is important to have enough very fine silica ca 300 mesh to form the glaze.

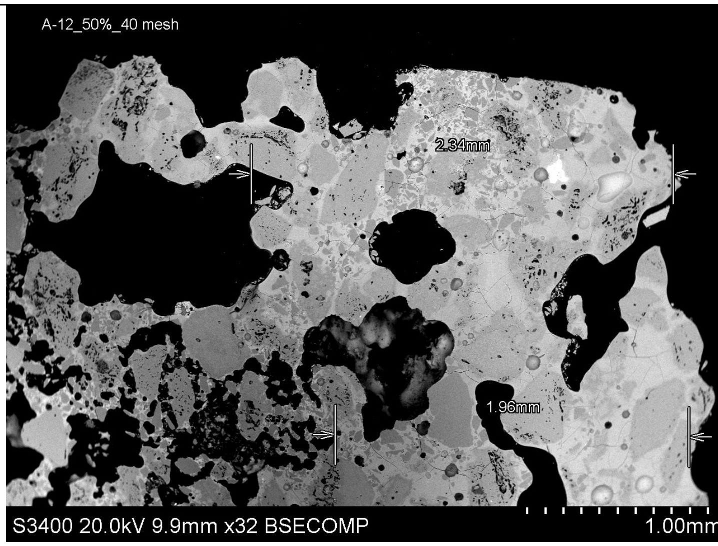


Figure 40: Sample (A_{XII}-40) has (50:50) mixture of 300 mesh quartz and 40 mesh sand. The sample was vitrified but the silica particles were too large to be fused to form a glass.

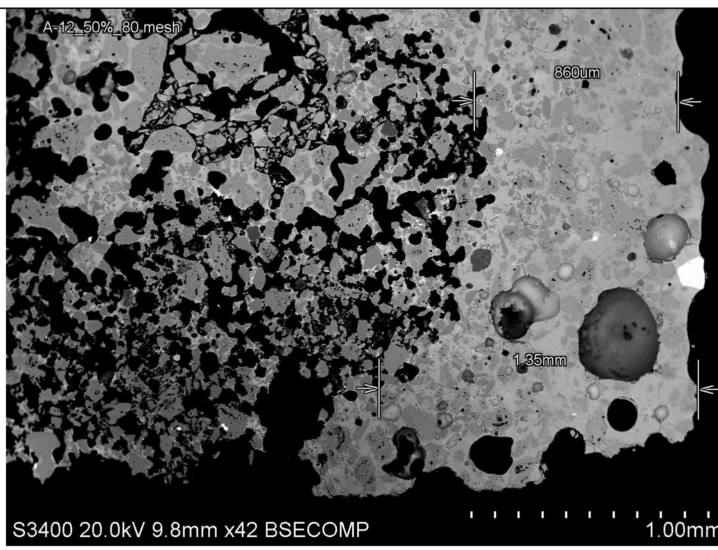


Figure 41: Sample (A_{XII}-80) has (50:50) mixture of 300 mesh quartz and 80 mesh sand. A thick interaction layer developed but no glaze.

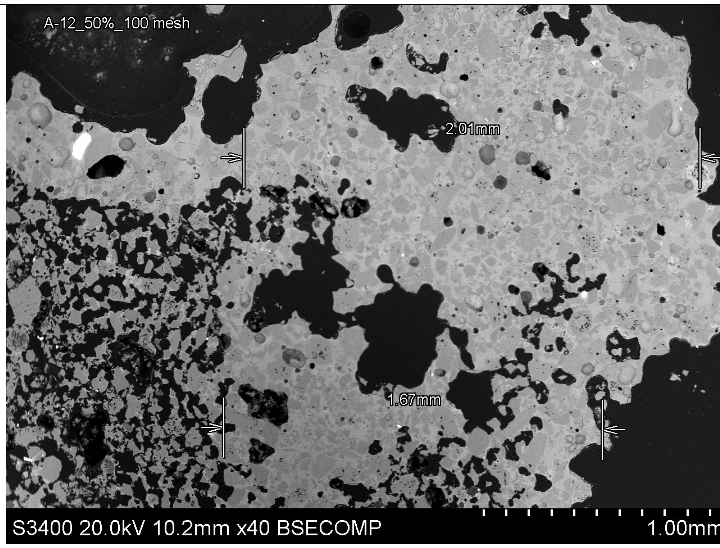


Figure 42: Sample (A_{XII}-100) has (50:50) mixture of 300 mesh quartz and 100 mesh sand. The sample was vitrified and a thick interaction layer was formed on the surface but no glaze.

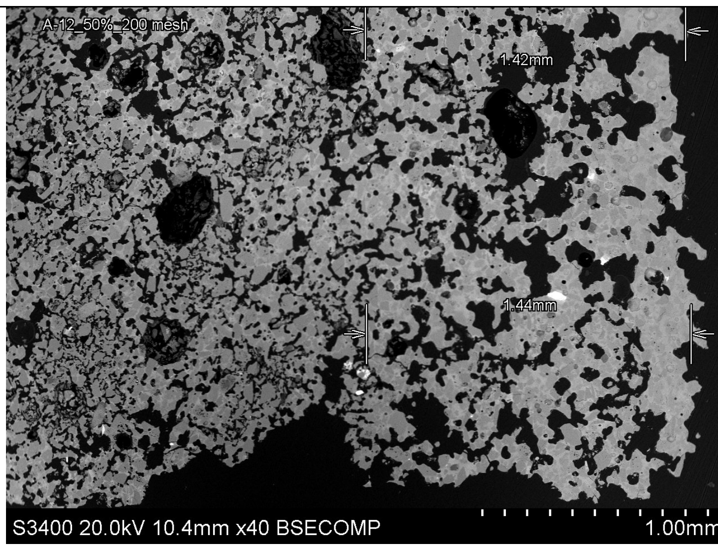


Figure 43: Sample (A_{XII}-200) has (50:50) mixture of 300 mesh quartz and 200 mesh sand. The sample was vitrified with a rich core of interparticle glass but no glaze was formed on the surface.

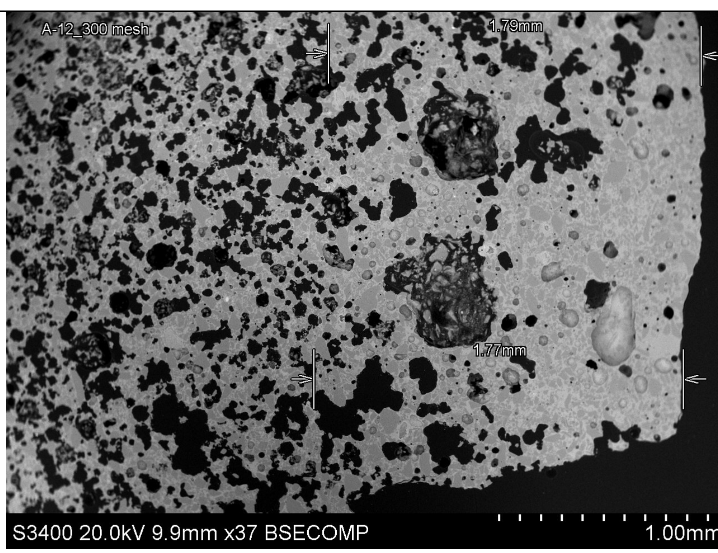


Figure 44: Sample (A_{XII}) has 300 mesh quartz and no sand. The sample produced a good glaze and a wide interaction layer and the core is rich with interparticle glass.

3.5.3 Conclusion

The experiments that were created to test the role of the various components on the faience samples was able to shed light on the faience chemistry and to provide answers to the research questions. Through this fundamental and empirical experimental approach it was possible to suggest solutions to issues related to the faience paste's plasticity and it's making methods. Also it enabled me to explore factors related to the formation of the efflorescence glaze and to obtain successful results.

By systematically changing the ratio of one ingredient and fixing the others, it was possible to establish the effect of these changes on the physical and visual qualities of the faience samples created. Furthermore the Backscattered electron images for these experiments revealed clues on the mechanisms responsible for forming glazes by efflorescence.

The parameters necessary to produce a good blue faience by the efflorescence method can be summarised as follow:

The main component in faience is silica, which can be obtained from crushed quartz pebbles, pure sand or flint stones. The particle sizes of the silica grains play a crucial role in producing a successful glaze. A minimum of 60–70% 300 mesh silica is needed to produce a sintered faience body and a fine glaze. The addition of 30–40% of 60–90 mesh silica gives the paste the strength to form large faience objects and improves the workability of the paste. The workability of the faience paste can be further improved by adding 2–4% of plastic clay, or by the addition of a minor amount of gum Arabic – to a maximum of 2% gum. However the gum Arabic has a negative effect on the efflorescence mechanism and therefore has to be used with caution. The sufficient amount of alkaline is 4–8% of sodium carbonate, or (50:50) sodium carbonate and bicarbonate. The thicker the body of the faience object, the less alkaline salt is needed in the original recipe. It was also observed that letting the paste mature for 24 hours in a sealed plastic bag before shaping and leaving to effloresce, improved the quality of the glaze upon firing. The effect of environmental factors on the efflorescence phenomenon should also be considered. The efflorescence of alkaline salts in a drying cabinet heated to 40°C produced a uniform and smooth glaze. For the rest of the components, an amount of 2-4% of lime is needed to produce a stable glaze, and a 0.5–1% of copper oxide or carbonate is sufficient to give the colour blue to the glaze. The ideal firing temperature for faience objects is 900°C at 100°C per hour.

This approach to the study of faience could be developed further to expand the testing areas and address other questions, which would in turn enrich our understanding of this archaic but rather sophisticated technology.

4 Chapter 4: Faience Workshop in Iran; an Anthropological Study

4.1 Introduction

The use of Egyptian faience was common in the ancient world until the late Roman period in the 7th century AD. Gradually the use of the material declined and the production techniques were lost. Archaeologists rediscovered Egyptian faience in the late nineteenth-century and ever since the material has been the subject of many studies. The researchers initially identified two methods of glazing for faience, namely application and efflorescence. In 1986 Hans E. Wulff proposed that bead production in Iran was a survival of ancient Egyptian faience but that these beads were made by an entirely different glazing method than was generally assumed (Wulff et al., 1968). Now it is recognized that what Wulff discovered was a third method for glazing faience, namely cementation, sometimes known as the "Qom technique" (Vandiver, 1983).

The identification of Qom production has led to the belief that faience production has never ceased in Iran, and this is supported by evidence present in the old Persian literature, for instance, in the poems of Nassir Khusrau, Sanai, and Rumi in the 11th, 12th and 13th centuries AD, respectively (Matin & Matin, 2012). Dr Wulff passed away in 1967 before the publication of his paper in 1986. Since then there has been little interest in the production in Qom. However, in 1997 there was a call for a project in Germany to preserve and support this traditional craft. The project was called: *Khar-Mohre – die antiken blauen Perlen des Iran ("* Donkey-Beads – The ancient beads of Iran") (Busz & Gercke, 1999). This project was part of a study and exhibition of faience technology and modern faience works of art, and included a paper by Jochen Brandt on the cementation glazing technique from Qom (Busz & Gercke, 1999). More recently Mehran and Mojan Matin have conducted another study on experimental study of cementation glazing (Matin & Matin, 2012). However, the research by Wulff and others still leaves many unanswered questions and so in 2011, and as a part of this study, I planned a trip to Iran in order to investigate and document the production of the Qom beads.

4.2 Hans Wulff's documentation

In the 1960s, Dr Wulff travelled around Iran to research the traditional crafts that were still in practice in the country and in 1966 he published his celebrated book *The Traditional Crafts of Persia*. Among the crafts that Wulff reported was the stone-paste[37] beads that were produced in the holy city of Qom. In his documentation of this craft, he described a dozen young workers from one bead workshop rolling small balls out of stone paste. After they dried, they were drilled by an adult worker with a bow-operated drill. The beads were later dipped in an alkaline glaze that contained copper oxide (Wulff, 1966). Wulff then describes the glazing technique according to one master: *"freshly rolled and pierced beads, about two dozen at the time, were placed into a flat dish that had the bottom sprinkled with a dry mix of frit and oxide. The beads were shaken and rolled around in the dish and became evenly coated with glaze powder. All these beads were fired to a particularly bright turquoise"* (Wulff, 1966). Wulff admitted that the bead-masters were reluctant about giving him any further details on the glazing method. He assumed that they feared competition, as this production was exclusive to Qom (Wulff, 1966). It became clear later that the bead masters misled Wulff and gave him false information. However Dr Wulff managed in 1966 to gain the trust of one bead master from Qom, who gave him access to his workshop. Wulff was able then to report on the various stages of the production from the selection and collection of the raw materials to the making and glazing methods, and finally the firing. As a result in 1968 a paper by Dr Wulff, his daughter Hildegard Wulff and Dr Leo Koch was published in the *Journal of Archaeology* (Wulff et al., 1968). In this paper the authors describe in depth the technology of bead-making in Qom. This revealed another technique for producing and glazing faience objects, which is now recognised as the cementation method or "Qom technique" (Vandiver, 1983). Wulff also collected samples from the workshop in Qom, which were later analysed by Dr. Koch in Australia.

[37] Stone-paste is a ceramic material that contains mainly quartz and some clay, frit and organic binders.

4.3 Beads workshop in Qom 2011

At the beginning of 2011, I was told by an Iranian contact that the production of faience beads in Qom was probably still in operation. Later in October that year I travelled to Iran to study and document this production as part of my research on the technology of Egyptian faience.

At first and upon arriving in Qom, I went to the old Bazaar, where the workshops were based in the 1960s (Wulff et al., 1968) but there was no sign of any bead workshops there or in the city's commercial centre. Nevertheless, the blue beads were sold everywhere in the bazaar and in the shops nearby Qom's holy shrines. After much investigation, I was told that there were two workshops for making these beads. Both were located outside of Qom. It took much negotiation to arrange a visit to one of the workshops but I could not get access to the second one. The visited workshop was in the industrial zone in the 'Qanvat' Area east of Qom. The second workshop was also located north west of Qom in 'Kuh-Sefid'. 'Qanvat' was an industrial area full of factories producing terracotta bricks. These were fired in massive clamp-kiln structures that dominated the landscape. The Bead workshop belonged to an Iraqi immigrant, Ustad Saed Mustafa Radawy. He used to work in the other workshop that has been owned and run for generations by 'Saadatman', an Iranian family, according to Ustad Radawy. He learned and practiced the making of this craft there with them, but a few years ago he became independent and started his own workshop and now had three men working with him. The workshop is located in a purpose built building that has four rooms and a courtyard. The main room was the general working area with a large kiln constructed on one side of the room. The second room was for making and drying the terracotta containers that were used to fire the beads. The two other rooms were used as storage for the raw materials and the finished beads.

4.3.1 Raw materials

The workers used for the beads-body a mixture of three kinds of fine quartz and sand and some gum powder called 'serish'[38]. The mixture consists of:

5 parts of Firuzkuh[39] sand

4 parts of Qazvin[40] quartz

3 parts of Hamadan[41] quartz and

1 part of the Natural gum 'serish'

It worth noting here that the workers use the same terracotta containers used for the glazing as a measuring unit. One worker mixed the materials at first dry and then with 25wt% water. The mixture was then wedged and kneaded to a dough consistency. The dough was then covered with cloth and left to rest before being used to make the various objects. The workers mix every morning a fresh patch of paste, which they use the same day because any leftover material, once aged, would be unworkable. It is noted in the experimental work by Matin and Matin (2012) that mixing the dry gum powder with the components and then adding the water improves the plasticity or workability of the paste and decreases the dilatancy[42].

The gum 'serish' derives from Afghanistan and can be bought in Qom's bazaar. This gum is an alternative to the gum 'tragacanth'[43] that was used back in 1960s in Qom's bead workshop. The tragacanth gum was mixed first with water then added to the crushed silica (Wulff et al., 1968). However, Wulff did report the use of gum serish in textile and bookbinding crafts in his book *The Traditional Crafts of Persia* but not in faience beads-production itself (Wulff, 1966).

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[38] serish is natural gum that comes from the roots of giant asphodel; latin name: *Ermurus Aucherianus Bioss;* also known as sirish, chiresh, sarish, siris and shirias

[39] Firuzkuh is a town and province located north-east of the capital Tehran

[40] Qazvin is a city and province north-west of Tehran

[41] Hamadan is a city and province south-west of Tehran

[42] Dilatant paste in ceramic technology refers to the suspensions of non-plastic materials such sands and quartz. The dilatant paste becomes stiff if stressed and back to mobility if the stressing force is removed. More dilatancy means less plasticity.

[43] Tragacanth is a natural gum obtained from the sap of several plants in the Middle East

Today the quartz and sand are delivered to the workshop in large 50kg bags from three different regions in Iran, Firuzkuh, Qazvin and Hamadan. Whereas back in 1960s the workers themselves sourced the quartz pebbles from the nearby dry riverbed and processed them by crushing and grinding to obtain the fine silica powder(Wulff et al., 1968).

For the glazing powder, the Master prepares a mixture that consists of:

20 parts of finely ground ash of cattle dung

16 parts of sodium carbonate

10 parts of finely crushed hydrated lime

About 3 percent of the total weight of crushed copper scale

The flux sodium carbonate is delivered to the workshop in 50 kg bags from a chemical company in Shiraz. This essential alkaline ingredient was added in the 1960s in the shape of ash from the desert plant 'oshnan'[44]. This plant was collected at that time from the open salt fields around Qom and fired to obtain an ash that is rich with alkali-carbonates, chlorides and sulphates. This ash was not only used in the beads workshops at the time but also in the glass and ceramic workshops in Iran (Wulff et al., 1968). The hydrated lime is bought from local builders merchants supply. The copper scale is still obtained from the copper-pot makers in Qom in the same way as in Wulff's time.

The dry cattle dung is delivered from local farms. To prepare the dung ash, the workers burn patches of the dry dung in an open metal container in the workshop's courtyard, then collect the ash and grind it so that it is ready to be used in the glazing powder. Wulff mentions in his paper that the bead master adds a half part of charcoal to the glazing powder (Wulff et al., 1968). The new master in Qom said that they never used charcoal in the glazing powder. It is likely that in the 1960s, the bead master did not reveal the whole truth and told Wulff that the added ash came from crushed charcoal. Wulff later doubted this information, and wrote: "Mr. G. Hammer of R. Flowler

[44] Desert plant oshnan; latin name: *salsola kali* and *salsola soda*

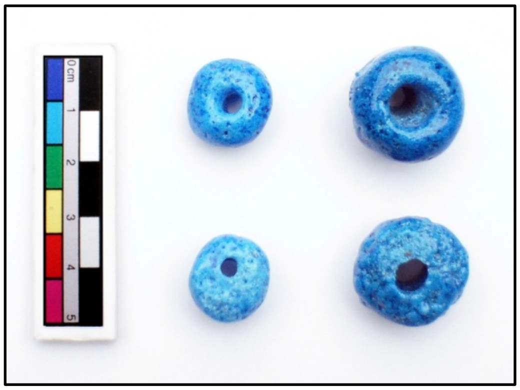
Potteries, Ltd., of Sydney who aided our analyses of the raw materials, thinks that the phosphate contained in the plant ash or perhaps added to the powder in the form of bone ash (and not revealed to us by our reluctant informants) would prevent adhesion"(Wulff et al., 1968). Furthermore, recent experimental work on the cementation technique showed that the charcoal plays no role in the glazing chemistry in this method (author's experimental work) and (Matin & Matin, 2012).

4.3.2 Making methods

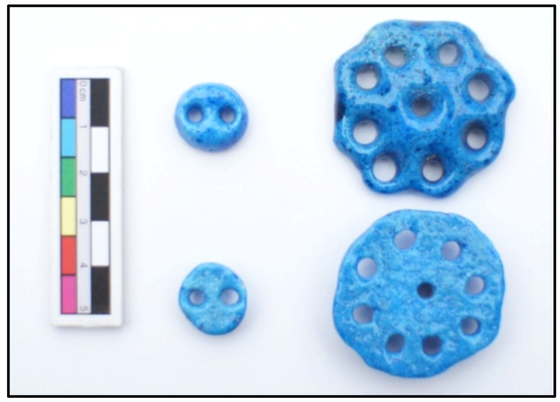
The production can be divided into three kinds: beads, buttons, amulets and ornaments.

1. Beads: The workers make two different sizes of roughly spherical beads, approximately 15 and 20mm in diameter (Figure 45a). These beads are formed with the aid of a steel device copied from a nineteenth-century German pill-making machine (Figure 46). The worker places a rod of the paste between two steel panels carved with half cylindrical grooves of the desired diameter, then moves the upper panel back and forth on the rod of faience paste to cut it into many spherical beads. The beads are then moved to a tray made of fired clay to be pierced with a steel rod to create perforations through the beads' axes. The tray has many negative spherical cups to support the beads as they are pierced (Figure 47).
2. Buttons: Two kind of buttons were produced, small ones with two holes, approximately 15mm diameter and larger buttons with nine holes in a rosette pattern, approximately 30mm diameter (Figure 45b). These buttons are made by pressing the paste into a steel pan that has 44 negative moulds of the button-form (Figure 48). The pan is then tipped over to release the buttons on to a sheet of paper (Figure 49). The pan is cleaned and brushed every time with some kind of thin gasoline oil to prevent the paste from sticking to the steel surface.
3. Flat amulets and little ornaments (Figure 45c): first the worker prepares an 8 mm thick slab by rolling the paste with a metal rolling pin between two guiding metal strips (Figure 50). Then he cuts the slab with metal frames in various designs. These metal cutters moulds are similar to those used for making cookies (Figure 51).

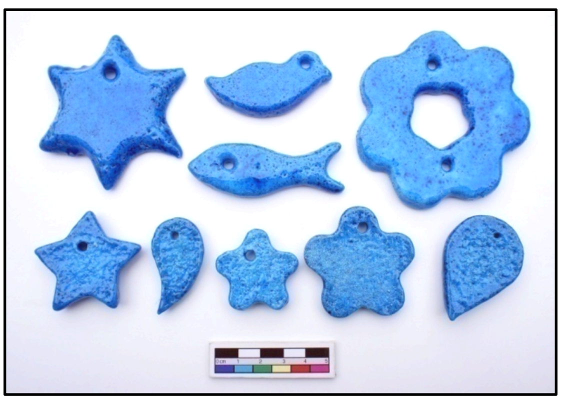
4. Small figures and salt dishes (Figure 46d): these objects are made by pressing little lump of the paste into terracotta open-face moulds (Figure 52). The paste is first rolled in sand to prevent it from sticking to the mould.



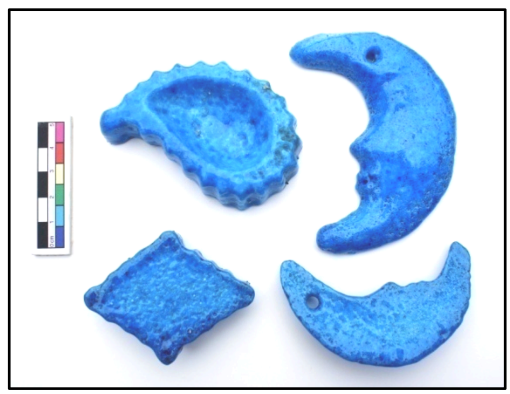
a. Spherical beads



b. Small and large buttons



c. Amulets and ornaments



d. Salt dishes and ornaments

Figure **45**:**The variety of beads and objects produced in Qom. They are glazed all over but the glaze is rougher at the bottoms, especially in the larger pieces. All pieces display darker blue dots on the glaze and some drips of thicker glaze. (photos by Z. Tajeddin)**

Figure **46: Steel device copied from a nineteen-century German pill-making machine**

Figure **47: Tray made of fired clay with negative spherical cups to support the shape of the beads while they are pierced with the metal rod (on the left)**

Figure 48: Steel pan that has 44 negative moulds for the faience buttons

Figure 49: The buttons are tipped over on sheets of paper and left to dry

Figure 50: 8 mm thick slab made by rolling the paste with a metal rolling pin between two guiding metal strips

Figure 51: Metal frame moulds in various designs

Figure 52: Terracotta open face mould and faience amulets

4.3.3 Firing and kilns

The beads and the various objects are left to dry indoors for a day or two depending on the weather. The dried beads are then buried in the glazing powder within terracotta containers. These containers are about 30 cm in diameter and 20 cm in height. They are made by pressing a layer of clay into a two-parts plaster mould (Figure 55), then left to dry and fired in the kiln to 1000°C. To fill the containers, the worker sprinkles the glazing powder first on the bottom of the container to a level of about two centimetres, then he carefully places a layer of beads or amulets next to each other leaving 1–2 cm. spaces in between them (Figure 56). He then sprinkles another layer of glazing powder on the top of the beads and compresses the surface gently with a flat wooden piece. More layers of beads and glazing powder are added in the same way until the container is filled to the top, making sure that all the beads are covered with a final layer of the powder. Each container holds between 500 to 1000 beads or buttons depending on their size. In the case of stacking amulets and ornaments, the number of objects in the containers is much fewer because of their larger size. The filled containers are then stacked in the kiln ready to be fired.

The down draft kiln is of a cylindrical shape slightly domed at the top; it is constructed within the main room in the workshop. The beads' containers are stacked on circular rows of platforms built into the kiln's walls (Figure 57). The kiln's door is then closed with fired bricks and sealed with clay. The kiln is fired with natural gas by a burner located underneath the kiln in the centre of the kiln's floor. During the firing the flame rises to the top and then turns down at the dome and finally is ejected through flue holes in the floor. These holes are connected to a series of four pipes built into the walls that leads to the rooftop. The kiln is fired first to 600° C, at rate of 100° C per hour, then to 800° C, at 50° C per hour and finally to 1000° C, at 30° C per hour. The firing last 16 hours and then the kiln is left to cool for a day. The firing schedule for faience beads and objects is given in (Figure 54). There is a large vent in the kiln's rooftop, which is sealed with a large disc of dried clay during the firing and opened gradually during the cooling period. The Kiln design is very similar to the one witnessed by Wulff in 1967. The only difference is the fuel, black oil in Wulff's time (Wulff et al., 1968).

The kiln is opened when the temperature falls to around 100° C. The workers carry the containers out of the kiln and tip them over on the workshop's floor. The block of friable glazing powder breaks and crumbles revealing the brilliant blue beads (Figure 58).

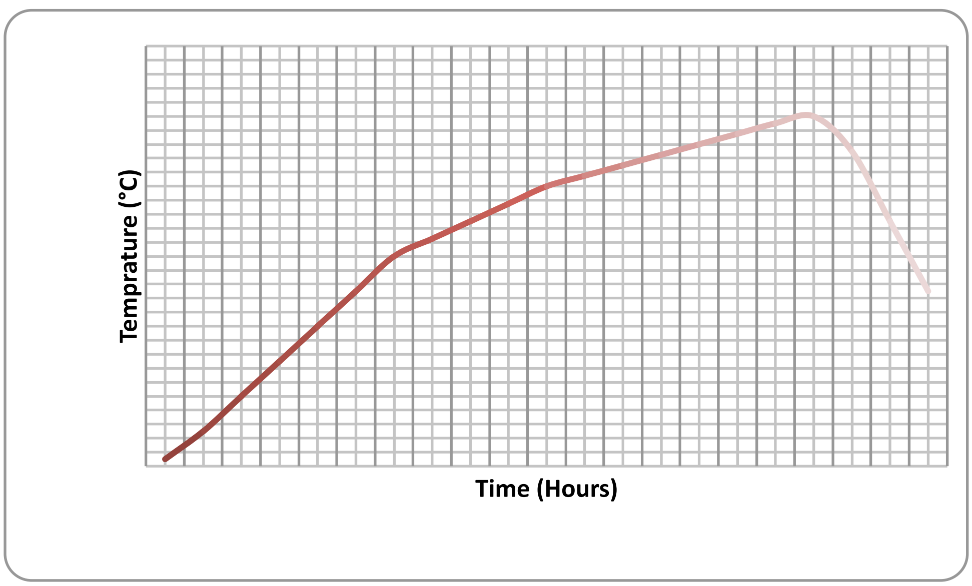


Figure 53: Firing schedule for faience beads and objects in Qom

The workers step on the block to release all the beads from the semi-vitrified capsules. The resulted heap is sieved to separate the beads and capsules from the glazing powder. The beads appear to have shrunk by about 1mm within the glazing powder forming capsules around them from the semi-vitrified glazing powder. Finally, the beads are collected and packed in bags, the fused capsules are discarded and the glazing powder recycled in the next firing, at which stage is added more of the original ingredients. The beads and object are glazed all over. The glaze is brilliant turquoise blue with dark blue speckles. It is fairly smooth and uniform but rough on the undersides of the pieces, especially the larger ones. In addition most of the beads and objects display some drips and pools of darker and sometimes thicker glaze on their vertical sides (Figure 45).

Figure 54: Glazing powder containers are made by pressing slabs of clay into two-parts plaster moulds then left to dry before firing

Figure 55: The glazing powder is sprinkled first on the bottom of the container, then alternate layers of beads and powder fill the container to the top

Figure 56: The kiln interior showing the stacked containers and the gas burner in the floor

Figure 57: Broken container revealing the beads within the glazing powder

4.4 Analysis of raw material from Qom

The raw materials used in Qom's workshop were examined by a scanning electron microscope (SEM). The purpose of this examination was to identify and characterise the raw materials and establish their chemical compositions. The microstructure of the various quartzes and sand used were studied using secondary electron imaging (SE) to determine the properties of the quartz particles, the particle sizes and the particles distribution. The backscattered electron imaging (BSE) was also used to visually distinguish between the various particles based on their compositional differences. The chemical compositions of the materials were analysed with the aid of energy dispersive spectrometer (EDS). The energy dispersive detector attached to the scanning electron microscope (SEM-EDS) was used for qualitative analysis of large areas in addition to small area's spot analysis. The samples were placed on stubs using carbon-coated double-tape disks, and then coated with conductive carbon coating to reduce the charging of the electrons. The materials were examined at a beam current of 20kV. A sample of the cattle dung ash was analysed by using X-ray diffraction[45] (XRD) and thermo gravimetric analysis[46] (TGA), both analyses were undertaken by Prof-Dr Patrick Degryse in the Centre for Archaeological Science[47] in Leuven, Belgium. These analyses helped to determine the mineralogical properties of the cattle dung ash.

4.4.1 Beads' body

The microstructure revealed that all the silica materials used in the workshop were from processed minerals (Figure 59). The silica from Firuzkuh is possibly processed from fine sand. The grains in this sample are often rounded and relatively large (maximum particle size is about 400 micron[48]). The bulk analysis of the Firuzkuh sample shows 94.4% silica and some impurities of iron oxide, alumina and lime. The silica samples from Hamadan and Qazvin contain finely crushed quartz particles, which could have been sourced from sand or pebbles (maximum particle size is about 70 and 170 microns, respectively). The bulk analysis for the Hamadan sample shows 99.2% silica with 0.8% impurity of iron oxide, whereas the sample from Qazvin has 94.5% silica and impurities of alumina and potassium, which suggests some feldspar in the material and indicates sand as a probable source. The presence of a minor percentage of iron oxide in the crushed silica may be the result of contamination from the wear of the grinding tools (Rehren & Pusch, 2007). In summary the choice of these different silica sources was made not only because of their purity (all are above 94%w of silica) but also because of the variation in particle size (40, 80 and 200 mesh[49]). The use of quartz of various particle-size[50] and the

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[45] X-ray Diffraction (XRD), is used to identify elements by their crystal structure by measuring the reflected X-ray beams to produce the atomic and molecular structure and then compare it to known patterns

[46] Thermo Gravimetric Analysis (TGA) is used to determine a material's characteristics by studying its physical and chemical properties as they change with a constant heating rate.

[47] The Centre for Archaeological Science, Celestijnenlaan 200E - b2408, BE-3001 Leuven, Belgium

(http://ees.kuleuven.be/cas)

[48] Micrometer (µm) also commonly known as micron, it is a metric unit of length measurement:(1 meter is 100000µm)

[49] Mesh scale system is used to determine the particle size of the quartz grains, for that a selection of various sizes of grains was measured by the Scanning Electron Microscope images. A percentage count for

addition of dry powder of gum serish, forms, when mixed with the required water, a workable dough that can be used to make the various beads and objects. The relative plasticity of the mixture is due to the presence of the gum and the distribution of small particles of silica among the larger ones in the paste body, which allow them to move together without breaking the paste. It should be mentioned here that the three sources of silica are about 300 km away from Qom, in three different directions – Qazvin to the north-west, Firuzkuh to the north-east and Hamadan in the west of Qom. All three sites are known for mining and for supplying a variety of raw materials[51] to ceramic and construction companies. The particle size distribution and mesh size for the used quartz and sand is giving in Table 5. Also the Chemical composition of quartz and sand is given in Table 6.

Quartz and Sand	Less than 40µm	40–70µm	70–170µm	170–400µm	Mesh size
Firuzkuh sand		10	55	35	40
Qazvin quartz	70	20	10	–	80
Hamadan quartz	85	15	–	–	200

Table 5: Particle size distribution percentage in the quartz and sand used in Qom workshop for the beads body (microns wt%)

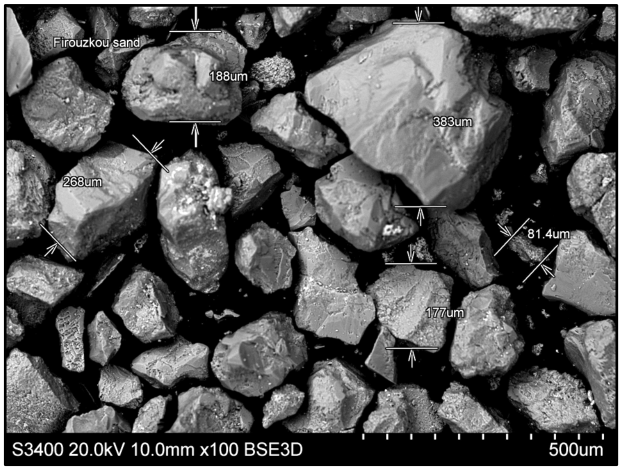
Quartz and Sand	SiO_2	Al_2O_3	CaO	K_2O	FeO	TiO_2
Firuzkuh sand	94.4	2.6	0.8		1.7	0.5
Hamadan quartz	99.1				0.9	
Qazvin quartz	94.5	4.0	0.4	1.1		

Table 6: Chemical composition of quartz and sand (normalised to 100)

various particle sizes for each material was calculated and compared to mesh chart to establish the mesh size.

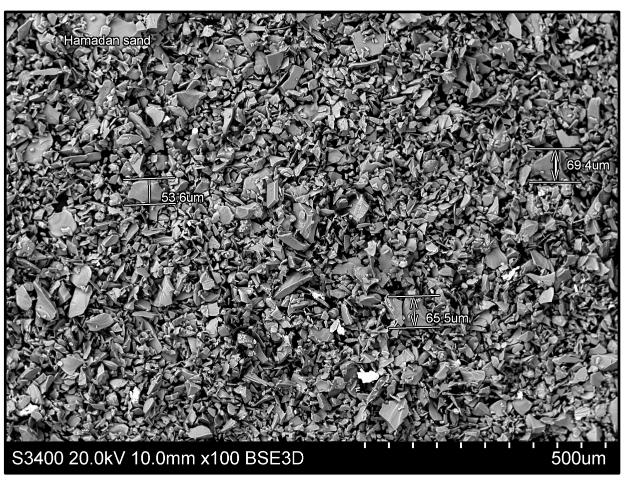
[50] The particle-size factor is discussed in the experimental research in chapter 4

[51] National Geoscience Database of Iran, http://www.ngdir.ir/MiningInfo/MineMinerals.asp



a. Backscattered SEM image of Firuzkuh sand in 100 magnification

b. Backscattered SEM image of Qazvin quartz in x100 magnification



c. Backscattered SEM image of Hamadan quartz in x100 magnification

Figure 58: SEM-Backscattered images in x100 magnifications of the three quartz raw materials used in the faience paste in Qom

4.4.2 Glazing Powder

The glazing powder consists of 20 parts in volume of ash from the cattle dung, 16 parts of sodium carbonate, 10 parts of finely crushed hydrated lime and about three percent of the weight of crushed copper scale. The mineralogy X-ray diffraction analysis (XRD) of the cattle dung ash shows it consists of mainly halite ($NaCl$) and Sylvite (KCl), minor quartz, augite, muscovite, feldspar and K/Na phosphate (Table 7). The thermo gravimetric analysis (TGA) of the ash shows virtually no weight loss when the sample is fired to 200° C, which means there is hardly any organic matter/carbon or water in the ash (Dr P. Degryse, personal communication). These results show that the dung ash provides the crucial salts for the glazing powder (sodium and potassium chlorides). The glazing powder mixture of cattle dung ash mixed with the sodium carbonate, hydrated lime and copper scale provides first the lime and alkali fluxes that are needed with the silica from the beads to form the glaze and second the chlorides that play the important role of delivering the copper ions to the beads to give the blue colour to the glaze. As mentioned above after firing, the workers reuse the fired glazing powder in a new mix after adding half the initial amounts of the dung ash, sodium carbonate, hydrated lime and copper oxide.

The chemical compositions of the glazing powder before (GP) and after firing (GP2) are given in (Table 8), the results show a major reduction in the amounts of soda, silica, alumina, potassium and chlorine. The chemical composition of the copper scale is given in (Table 9), which confirms its source; the presence of 2.8 wt% of tin oxide in the metal scale indicates the use of bronze metals.

Quartz	Low - alpha-SiO_2	15.7
Augite	Aluminian - Ca (Mg, Fe^{+3}, Al)(Si, $Al)_2O_6$	10.6
Halite	NaCl	33.0
Sylvite	KCl	23.6
Muscovite	$(K,Na)Al_2(Si,Al)_4O_{10}(OH)_2$	4.3
Aphthitalite	$K_3Na(SO_4)_2$	12.8

Table 7: Mineralogy X-ray diffraction analysis of cattle dung ash, wt% (P. Degryse, personal communication)

	SiO_2	Al_2O3	CaO	MgO	Na_2O	K_2O	CuO	Cl	FeO	SO_3	P_2O_5
CDA	28.8	2.1	16.0	6.7	8.5	11.3		11.8	1.7	8.4	4.7
GP	18.3	2.7	30.0	2.7	25.0	4.1	3.0	5.3	1.6	4.2	5.2
GP2	14.9	1.6	55.7	3.7	6.2	1.9	1.9	2.1	0.9	7.3	3.7

Table 8: The chemical compositions of the cattle dung ash, glazing powder and the fired glazing mix (normalised to 100)

	SiO_2	Al_2O_3	CaO	MgO	CuO	ZnO	FeO	SO_3	P_2O_5
Copper scale	4.6	2.2	1.9	0.7	85.1	2.8	0.5	0.7	1.4

Table 9: The chemical composition of the copper scale used in the glazing powder (normalised to 100)

4.5 Analytical data

Several samples of the beads with their capsules from the Qom workshop were studied first with a low power binocular microscope and then with the scanning electron microscope (SEM). A sample of the cattle dung was analysed by using X-ray diffraction (XRD) and thermo gravimetric analysis (TGA), Both analyses were undertaken by Prof-Dr Patrick Degryse at the Centre for Archaeological Science in Leuven, Belgium.

4.5.1 Microscopic Evidence

The glaze on the bead appears to be uniform all over its surface, however it becomes little rough and uneven at the bottom side of the beads. The binocular microscopic examination of the cross section of a Qom bead and its capsule shows partially fused quartz particles in the bead's body (white colour) surrounded by a continuous glass matrix (blue colour) and a thin blue glaze layer on the bead's surface (Figure 60). Some larger glass matrix areas are observed within the bead's body possibly due to a complete fusion of an accumulation of fine quartz particles. The capsule is relatively solid and bluish on the inside surface but it becomes more friable and brown towards the outside (Figure 61). This structure is due to the presence of a glass matrix that is blue in colour on the inside wall of the capsule but this glass phase gradually becomes patchy until it disappears completely towards the outside wall of the capsule.

Figure 59: Cross section of a Qom bead and its capsule shows partially fused quartz particles in the bead's body (white colour) surrounded by a continuous glass matrix (blue colour)

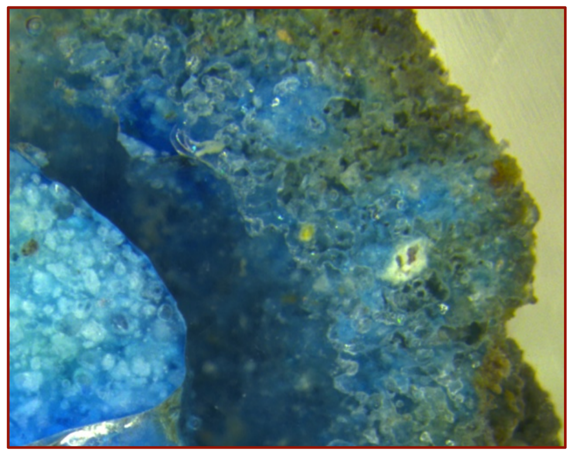


Figure 60: The capsule is relatively solid and bluish on the inside surface because of the glass matrix but it become more friable and brown towards the outside whereas the glass matrix gradually ends

4.5.2 Microstructural and compositional evidence

For the SEM analysis, a section of a faience bead with part of its capsule was mounted in a resin block, polished to ¼ µm and carbon-coated before analysis. The SEM image of the bead shows a glaze layer (light gray) that varies in thickness between 250–450 microns. There is no interaction zone between the glaze and the body (Figure 62), but there is a continuous glass matrix (light gray) that fills most of the area between the quartz particles (dark gray) in the body (Figure 63). At higher magnification, needle-shape crystals formations (dark gray) measuring 15–60 μm in length can be observed in-between the quartz particles within the glass matrix (Figure 64).

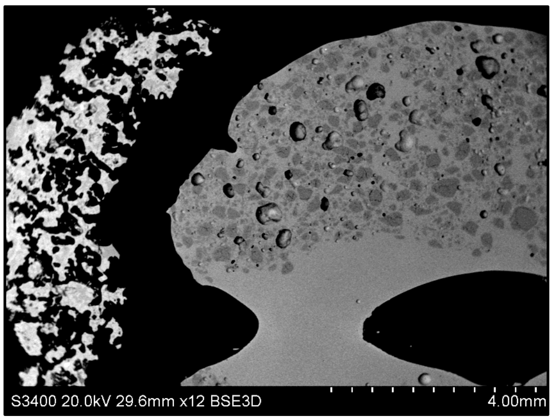


Figure 61: Backscattered image of bead and capsule shows continuous glass matrix (light gray) that fills most of the areas between the quartz particles (dark gray) in the body

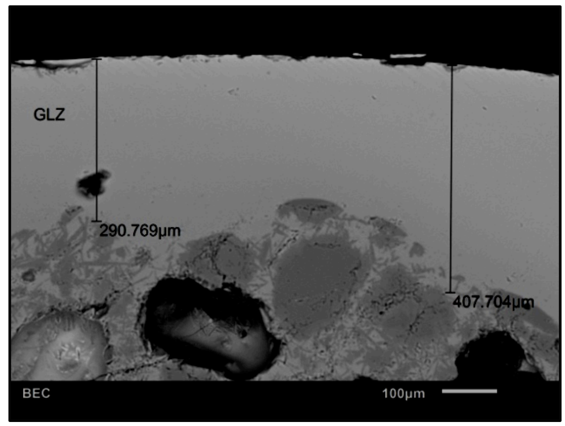


Figure 62: Backscattered image of the bead shows a glaze layer (light gray) that varies in thickness between 250–450 microns. There is no interaction zone between the glaze and the body

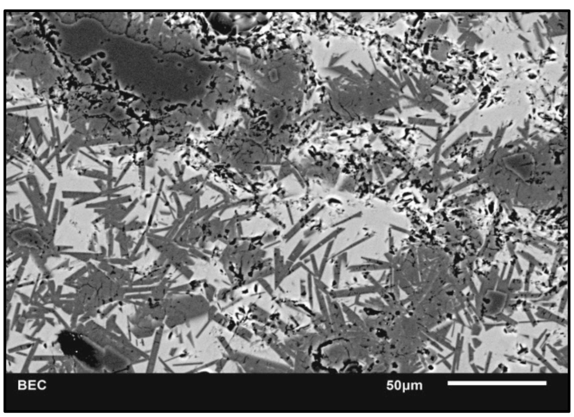


Figure 63: B**ackscattered image of the core shows needle-shape crystal formations of cristobalite (dark gray) measures 15–60 μm in length in-between the quartz particles**

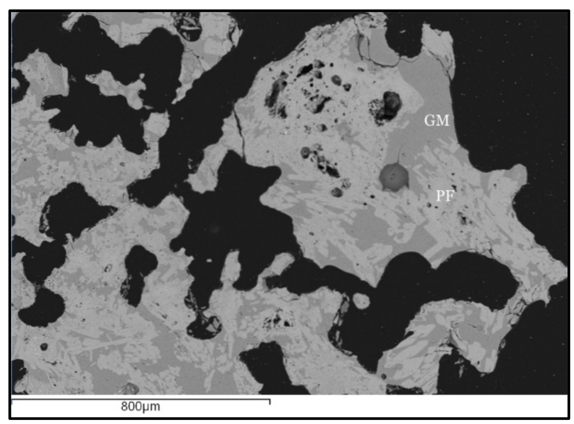


Figure 64: B**ackscattered image of the capsule shows patches of partially fused areas (PF) and patches of glassy matrix (GM)**

The capsule is between 1 and 3mm thick, and it is thicker at the bottom. The SEM imaging of the capsule shows a friable glazing mixture that contains patches of partially fused areas (bright grey) and patches of glassy matrix (light grey) (Figure 65). The results obtained from analysing the chemical composition of the glass phases at different areas in both bead and capsule using the SEM-EDS are discussed below.

The Bead: The SEM image shows the presence of a glaze layer and a continuous interparticle glass phase from the glaze to the core with no intermediary interaction layer (Figure 62 and 63). The presence or absence of the interaction layer and the interparticle glass were considered defining characteristics between the different glazing methods (Tite et al., 1983; Tite & Bimson, 1986). However, it was later proposed that these characteristics should perhaps be used with caution (Vandiver, 1998; Tite et al., 2008). This latter view is supported here in the case of Qom bead, as the interparticle class is present and continuous within the bead's body.

These beads from Qom can perhaps be described as a "Variant E", which is a glassy faience (Anon., n.d.). In this variant the faience body is more homogeneous and displays no interaction layer. However Tite and Shortland state that: "glassy faience should most probably not treated as real variants. Instead, they should be regarded as the end members of a sequence of faience objects in which increasing proportions of glazing mixture have been added, resulting an increasing amounts of interparticle glass" (Tite et al., 2008, p55). The EDS analytical data of the glass phases at the glaze and at the core is presented in (Table 10). The glass phase composition is essentially high alkali-lime-silica glass. Study of the composition profiles of the glass phase from the glaze layer through to the interparticle glass in the core indicates an increase of calcium and potash contents and a decrease of soda, chloride and copper contents from the glaze layer to the core (Table 10). The decrease in copper (surface to core) in cementation glazing was previously observed and considered to be another defining characteristic of this glazing method (Vandiver, 1998). It was also observed in the SEM examination that the interparticle glass in the bead contains needle-crystal formations of cristobalite[52]. The

[52] cristobalite is one of the four silica phases. It has the same chemical formula SiO_2 but a distinct crystal structure. It is only stable at high temperature above 1470°C but can crystallize metastably at lower temperature (http://en.wikipedia.org/wiki/Cristobalite) (accessed on 20.07.2014)

EDS for these needles is given in (Table 12), which shows these crystals to be almost pure silica.

The capsule: The chemical analysis of the capsule's different patches is given in Table 11. In the partly fused areas (PF) we have high amounts of silica and lime (48–42%) with lesser amounts of alkalis and copper oxide. In the glassy areas (GM) we have a glass phase with a high alkali presence and an increased percentage of copper oxide. (This result is discussed in the next section).

	SiO_2	Al_2O3	CaO	MgO	Na_2O	K_2O	CuO	Cl	FeO	P_2O_5
capsule (GM)	58.4	2.2	6.7	3.6	16.7	6.7	2.5	1.5	0.2	0.4
glaze	67.3		1.2		14.8	5.5	9.5	1.4	0.3	
core	73.6	1.3	4.5		10.0	6.0	2.8	0.7	0.6	

Table 10: EDS analysis of glass phase in the capsule, the glaze and the body of Qom bead (normalised to 100)

	SiO_2	Al_2O3	CaO	MgO	Na_2O	K_2O	CuO	Cl	FeO	SO_3	P_2O_5
GP2	14.9	1.6	55.7	3.7	6.2	1.8	1.9	2.1	0.9	7.5	3.7
PF	47.9	1.0	41.7	3.4	1.6	0.3	0.6		0.4	0.2	1.6
GM	58.4	2.2	6.7	3.6	16.7	6.7	2.5	1.5	0.2	0.4	

Table 11: The chemical composition of the glazing powder and the capsule (normalised to 100)

	SiO_2	Na_2O	K_2O	CuO
Core needle	99.1	0.5	0.2	0.2

Table 12: EDS analysis of quartz needle in the core of Qom bead (normalised to 100)

4.6 Discussion

4.6.1 Glazing mechanism

It was postulated by researchers that the cementation glazing mechanism of faience artefacts is a complex one in which the alkalis from the glazing powder vaporise and diffuse at a temperature near 1000°C into the silica body of the beads to form alkali-lime-silica glass. This glass wets the body and draw away by surface tension from the glazing powder (Wulff et al., 1968; Anon., n.d.; Vandiver & Kingery, 1987). However, the recent experimental work conducted by Matin and Matin (2012) demonstrated convincingly that there is a combination of two mechanisms involved in forming the blue glaze in the cementation method, namely Interface Glazing Mechanism (IGM) and Chloride Glazing Mechanism (CGM) (Matin & Matin, 2012). In the first, the silica on the surface of the beads reacts during firing with the calcium and alkaline oxides in the glazing powder to form alkali-lime-silica glass. As the firing continues, this reaction goes deeper into the bead's body. In the case of our beads from Qom, where there are potash from the cattle dung ash and soda in the glazing powder, the potash flux penetrates deeper and its percentage increases from the glaze to the core because it is more effective than the soda as flux, which decreases in value from the glaze to the core (Table 11) (Vandiver & Kingery, 1987; Tite et al., 2008; Paynter, 2009). It should be noted here that the experimental work by Matin and Matin (2012) eliminated the possibility of vaporisation of soda and potash alkali during the firing as previously suggested (Tite et al., 2008), seeing the process as direct contact between the artefacts and the glazing powder.

The second mechanism is a Chloride Glazing Mechanism (CGM). In this case, the presence of alkali chlorides and their vaporisation with copper during firing in cementation glazing is the main factor in providing the copper blue colour to the glaze (Matin & Matin, 2012). The role of salt (NaCl) in cementation glazing was already suspected in (Wulff et al., 1968), where it was proposed that "the 1% copper oxide in glazing powder reacts with the salt in the plant ash to form cupric chloride ($CuCl_2$) which decomposes to cuprous chloride (CuCl) and chlorine at 993°C." (Wulff et al., 1968). However the experimental study by Matin and Matin (2012) observed vaporisation of chlorine at a lower temperature (920°C) and thus this temperature is sufficient to create glaze in this way (Matin & Matin, 2012). Nevertheless, their experiments revealed that a 1000° C temperature is needed in cementation glazing due to the factor played by the level of the alkali carbonate and the chloride contents in the glazing powder, which has a converse linear relation with the copper vaporisation ratio (Matin & Matin, 2012). The beads from Qom were fired to 1000° C but they display a highly vitrified body and the reaction seems to be much deeper. This probably resulted from the high level of sodium carbonate (25%) in the glazing powder (Table 8), whereas the experiments by Matin and Matin (2012) shows that 5% is sufficient to form the glaze at this temperature. This high vitrification in the modern Qom samples is evident in the presence of the interparticle glass in most of the bead's body, which resulted from an intensive reaction with the glazing powder and therefore a deeper penetration of alkalis into the bead's body. Furthermore, the presence of needle-crystal formations of 'cristobalite' in the interparticle glass could have resulted from the excessive deposition of copper in the presence of alkalis and chlorides, as noted by (Wulff et al., 1968) and Matin and Matin (2012). The formation of these needles could be also the result of a high firing temperature or longer soaking[53] period during the firing. Such formation in association with a high firing temperature was also observed in the experimental work by the author (see chapter 3).

4.6.2 Capsule formation mechanism

The mechanism for forming the capsules in cementation glazing can be explained in the light of EDS analysis and the experimental work. The capsule forming is a by-product of the Interface Glazing Mechanism (IGM) that occurred at the bead's surface. During the firing the alkalis in the glazing powder react with the silica at the bead's surface forming an alkali-lime-silica glass, which causes the bead's surface to melt and withdraw.

[53] soaking is a term used in firing ceramics to indicate holding the temperature at a fixed rate during firing for a certain period of time

However, where the glazing powder has been in contact with the bead islands of glass matrix form (GM) (Figure 65). This is due to the high level of calcium oxide in the glazing powder. This glass phase is rich in silica and alkalis with small amount of lime. On the other hand the partially fused zones (PF) (Figure 65) contain a high amount of lime (41.5%) and very little alkali. If we compare the chemical composition of the capsule's areas to that of the fired glazing powder (GP2), we find a general increase of the silica in all areas of the capsule, a decrease of the lime contents in the glass matrix, and a decrease and increase of the alkalis and copper in the partly fused areas and the matrix areas, respectively (Table 11). The experimental work by Matin and Matin (2012) showed that the shrinkage in the beads is caused by some dissolution of the bead's free silica as some of the bead's surface material dissolves into the surface of the glazing powder. Surface silica from the faience beads is lost in all directions to the glazing powder, which forms capsules of sintered mixture around the beads. If the firing proceeds, the migration of silica continues but only through the underside. A very extended firing could lead to the entire bead being dissolved leaving behind an empty capsule (Matin & Matin, 2012).

4.6.3 Comparison of Analytical results

To compare the results of the analytical study of Qom beads from 2011 to traditional Qom beads, a group of old Qom beads were analysed (Figure 66). These older beads were given to me by Professor Ian Freestone from the Institute of Archaeology in London. According to him they were the property of Mavis Bimson from the British Museum and she obtained them in the 1980s from a dealer in beads. Bimson's beads were studied using the SEM and EDS to obtain information on their microstructure and their chemical composition (Figure 67). Traces of the capsule were detected on the inner surface of one bead's perforation, which were also analysed (Figure 68). The EDS analysis results are given in (Table 13). It was expected that the Qom beads from the 1980s should correspond with the micro structural criteria for cementation method as demonstrated by Wulff et al. (1968), Vandiver, (1998), Tite and Bimson (1986) and other researchers. The bead has a thin glaze and interaction layer and the quartz particles in the core are bonded by small amounts of interparticle glass (Figure 67). The composition profile of the beads obtained by the EDS analysis shows also a typical profile. The soda, chloride and copper oxide contents decrease from the glaze layer, through the interaction layer and to the core, whereas the potash, lime and magnesia contents increase from the glaze through the interaction layer and to the core. As mentioned earlier the decrease of copper oxide from the glaze to the interaction layer was considered a defining characteristic in cementation glazing (Vandiver, 1998). Also the glass matrix of these beads showed no cristobalite needle formation. The two differences between the Bimson bead and the modern sample are the absence of an interaction layer and the presence of cristobolite needles in the glass matrix in the modern beads. These differences in the modern beads of Qom appear to have resulted from a more intense firing schedule and a higher level of alkali and copper oxide used in the glazing powder. Comparison of the compositional profiles of the glass phases between the bead from 2011 and Bimson's bead from 1980s (Tables 9 and 13) shows corresponding profiles for both samples for all the contents in term of the increase and decrease of their levels from the glaze to the core. It can be seen that the amounts of the potash, chloride and copper contents are considerably higher than those in the 1980s sample. The soda content in the glaze matrix of the capsule is also higher in the modern sample; it is 16.7 versus 9.9 in the old sample, but its level in the glaze is lower (14.8 versus 17.6). On the other hand, the lime content in the capsule is higher in the older sample than it is in the modern one. These Figures confirm the unnecessarily and excessive use of soda ash in the modern workshop in Qom.

Figure 65: Faience beads from Qom, obtained in 1980s

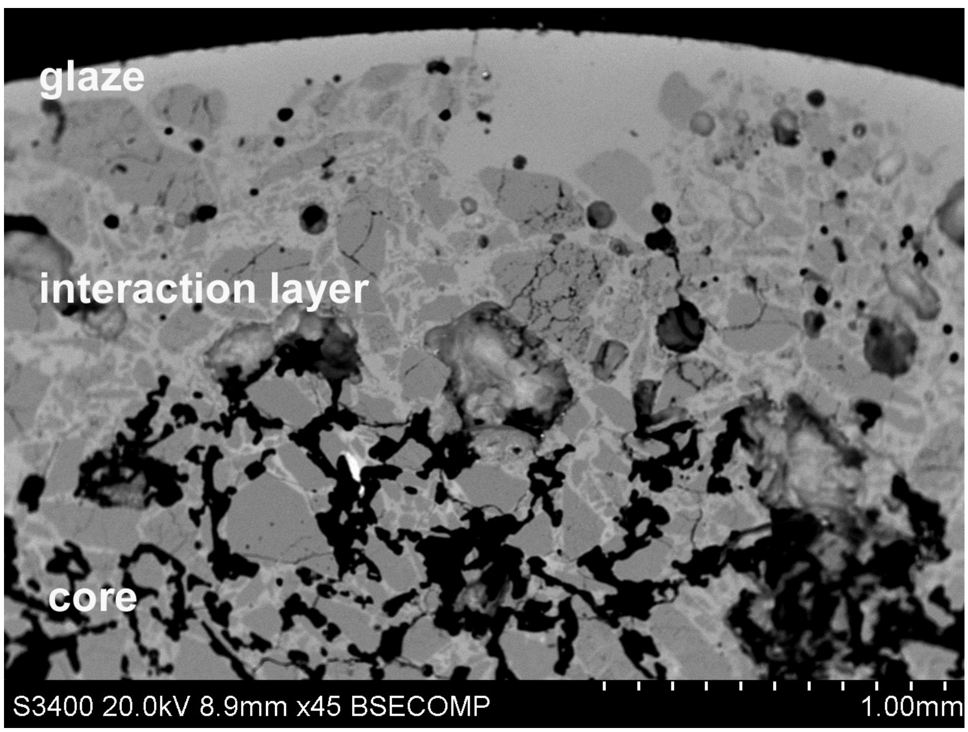


Figure 66: Backscattered image of a Qom bead from 1980s shows the glaze layer, the interaction layer and the core

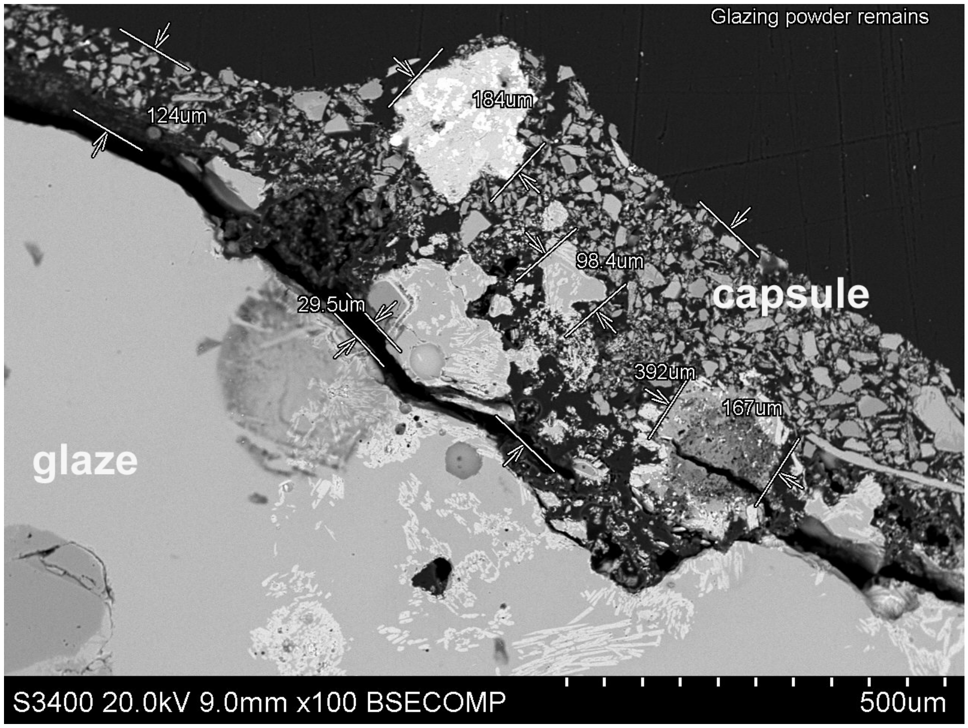


Figure 67: Backscattered image of the remains of the capsule shows patches of glassy matrix and sintered grains of lime and silica (GM)

	SiO_2	Al_2O3	CaO	MgO	Na_2O	K_2O	CuO	Cl	FeO	SO_3
capsule (GM)	63.8	3.5	12.9	2.1	9.9	3.1	1.5	0.5	1.6	0.6
glaze	70.2	0.7	1.6		17.6	2.8	5.3	0.8	0.4	0.6
interaction layer	75.3	2.5	4.8	0.8	10.9	3.2	0.7	0.4	1.0	0.3
core	73.4	2.8	4.4	1.2	8.8	3.7	0.8	0.3	4.4	0.2

Table 13: EDS analysis of the glass phases in capsule, glaze and body of a Qom bead from the 1980s (normalised to 100%)

4.7 Conclusion

Two workshops in the holy city of Qom in Iran are still producing beads along the lines of Egyptian faience. A visit to one of them was arranged in 2011, and this ethno-archaeological[54] study provided an opportunity to explore and document this method of faience production within the context of a traditional workshop. In conclusion, the

[54] ethno-archaeology is ethnographic study of people for archaeological reason

technology used to made donkey faience beads and amulets seems to have remained relatively unchanged for thousands of years. This enigmatic method of production has its roots in the early Bronze Age circa 6500 years ago. However a shift in the production technology was reported in this study. These changes must have been adopted in recent decades, since the report by Wulff in 1968 showed a production style that corresponded more closely with ancient methods. The first significant change was the introduction of alternative raw materials, which are now acquired from construction and chemical industries instead of sourcing locally and processing the raw materials in the workshop. The second change was in adopting new methods, which were introduced to speed production and reduce labour. It remains unclear when these changes were made and how those who introduced them worked out these alternatives. For instance, the substitution of Qom quartz pebbles for sands and quartz from various provinces in Iran, the shift from using the desert plant ash to the industrial soda ash and, more curiously, the use of the ash of cow dung, which probably was not revealed to Wulff back in 1960s. The use of cow dung ash is apparently well-established in these traditional ceramic workshops as it was recently discussed in a study on its role in the early glazing technology (Matin, 2013). Further research is required to understand these changes in production. The samples that were collected at the site and later analysed by SEM and EDS helped the research to establish the roles of the various raw materials used at Qom, and to understand better the nature of this archaic technology. These analyses revealed that the recent faience donkey beads from Qom could be described as a Variant E, which is a glassy faience (Lucas, 1962). These beads are made of vitrified silica and have the same desired glossy blue glaze that characterizes this traditional production of Iran. However these beads are stronger and more vitrified than the previously known faience beads of Qom, and this is due to the high amounts of alkali used in the glazing powder and a more intense firing schedule.

The bead master from Qom explained that the faience donkey beads have a strong traditional significance, especially in terms of material and the blue colour. He also told us that there is still a high demand for these beads – both locally and beyond Iran's border. These beads apparently are exported to many countries such as Iraq, Turkey and Afghanistan, and as far as Greece and Cyprus. He told us that he fears competition because there were attempts to produce similar beads made of wood or modern synthetic materials such as plastic and resin but that fortunately for him the customers were not satisfied. The workshop has had to expand the range of objects they produce to include amulets as well as other objects sought after by visitors and tourists.

5 Chapter 5: Sculptural Practice and Theoretical Framework

5.1 Aim and objectives

This research presents a significant opportunity to explore an ancient craft technology and experience some of the challenges that faced ancient craftsmen. The artwork created in response to these investigations is informed both by the ancient artefacts themselves and by contemporary history and culture. It also benefits from our accumulation of knowledge, understanding and experience in the field of ceramics and sculpture, and explores various aspects of an important ancient craft practice, namely Egyptian faience. It is hoped that the body of work created will inspire a renewed relationship with past cultures and technologies, as well as creating an interesting contemporary response to an ancient craft.

5.2 Historical background

It is necessary here to give an introduction and definition to some elements in this research, relating to the ancient Egyptian religion, mythology and funerary practices. These elements present the inspirational background to the artworks produced for this research project.

5.2.1 Afterlife

The belief in the afterlife in ancient Egyptian religion is one of the oldest known in history. The Egyptian viewed human life as a series of transformations. In common with many recurring patterns in nature; it starts with birth, growing up, old age, death and rebirth. Life for the ancient Egyptian was very short; they began producing children in their teens and were mostly dead by thirty-five years old (Taylor, 2010). The ancient Egyptians were therefore obsessed with death, burial and the afterlife. They enjoyed life and desired it to continue after death. They filled their tombs with their personal possessions, favourite objects, tools, food and drink for use in the afterlife (Quirke & Spencer, 1992). They also believed that they would carry on living with their friends and families and have their slaves and servants working for them. They were convinced that it was possible to achieve this transformation if proper preparations were made to preserve the body and sustain the soul (Wilkinson, 2005). According to ancient Egyptian myth, the deceased would be joined with Osiris[55] the king and god of the underworld after they successfully passed a final judgement. This judgement ceremony is known as 'the weighing of the heart' and takes place at the entrance to the underworld (Figure 69) (Wilkinson, 2005). In this ceremony the heart of the deceased was weighed against the feather of Maat[56]. If the heart was as light as the feather, it meant the deceased had led a righteous life and could be escorted to Osiris and welcomed into the afterlife. If the heart was heavier than the feather, the deceased would be thrown to a monster to be consumed and punished(Taylor, 2010). This ceremony is often illustrated on the papyri of the "Book of the Dead[57]".

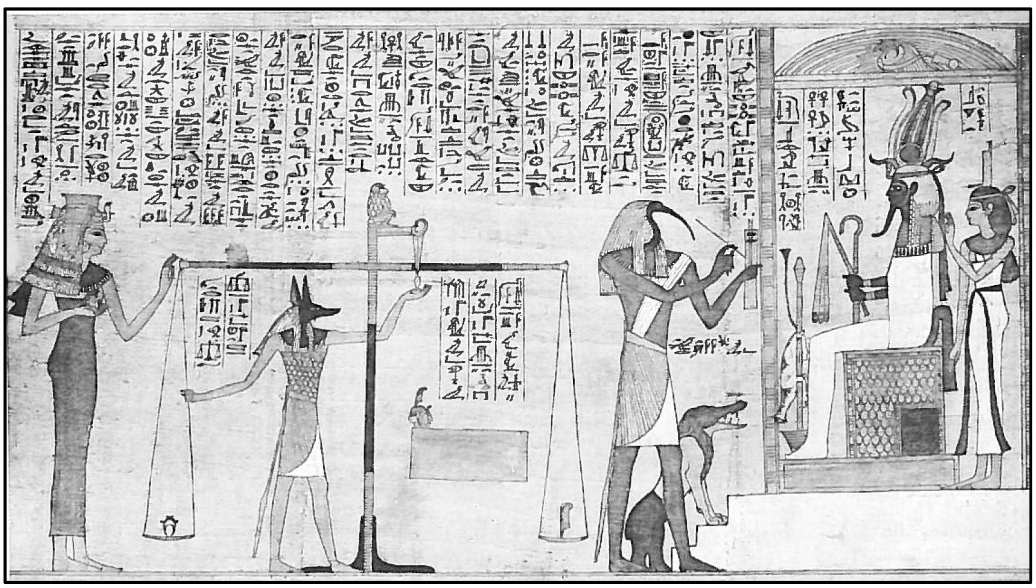


Figure 68: This judgment ceremony 'the weighing of the heart' of *Maatkara* before Osiris, Third Intermediate Period. (after: Quirke 2013, p xxvii)

[55] Osiris was in ancient Egypt the god of the underworld, death, resurrection and fertility. He also judged the dead in the afterlife. In the old myth, Osiris was murdered by his brother Seth but Osiris's widow Isis saved him and brought him back to life to be impregnated by him and conceive his child Horus, who avenged his father and claimed the kingdom from Seth (Wilkinson, 2005).

[56] Maat is the goddess and the concept of cosmic order and justice in ancient Egypt.

[57] The Book of the Dead is a collection of funerary spells usually written on papyrus roll and placed with the deceased; it was in use in ancient Egypt from the New Kingdom to the early Roman Period

5.2.2 'Shabti'

As discussed above, the ancient Egyptian believed that the next world was much like the present and they would have the company of their friends and family and enjoy the attention of their servants (Stewart, 1995). The early servant-figures were placed in the tomb of the late Old Kingdom (2686–2613 BC). These model servants were often carved in wood and represented not only agricultural workers but also various professionals such as boatmen, bakers, butchers, brewers, etc. In the Middle Kingdom (2040–1782 BC) these servant-figures began to be replaced by mummified form figures with agricultural attributes, which were known as *Shabtis* (Stewart, 1995). The word *shabti* probably derived from the word *shabat* meaning 'stick' (Quirke, 2013), hence the early Middle Kingdom *Shabti* figures were made of wooden sticks (Stewart, 1995). This practice continued throughout Egypt to the Late Period (713–332 BC). The *U-Shabti* or *Shabti* were funerary figurines, often made from faience but also from pottery, clay, wood, wax, alabaster, limestone, granite, steatite and serpentine, and more rarely glass and bronze. They were produced in large numbers in ancient Egypt to be placed in tombs (Figure 70). They were intended to act as substitutes or as servants for the deceased once they were activated in the afterlife.

Figure 69: Memphis, 500 BC – Troop of funerary servant figures *Shabtis* in the name of Neferiberheb. (Photo by Serge Ottaviani, licensed under CC BY-SA 3.0)

The term *U-Shabti* means 'answerer' and the *Shabti's* duty was to answer for the deceased during judgment by the gods, and to act as a deputy if he or she was summoned for any labour in the afterlife. There are several spells in the book of the dead that convey magical power to actual objects. These objects were the '*knot*[58]of the goddess Isis, the heart scarab[59] and the *Shabti.* They were activated in this way to protect or prepare their owners to face challenges in the afterlife. These spells were often accompanied by instructions and recommendations of their effectiveness. For example Quirke (2013) translated a spell version for activating a *shabti* from the ''Papyrus of Nu", estate manager for the treasurer from about 1400 BC (British Museum EA 10477), it reads:

> "O stick-figure here, if they summon the Osiris
>
> The estate manager for the treasurer, Nu true of voice,
>
> To do any work that is done there in the god's land,
>
> Then, see, the marks have been struck for him there
>
> As for a man for his task
>
> Their summons is on you for any moment at which it is made,
>
> To put plantations in the marshlands, to water the riverbanks,
>
> To ferry sand of the west or of the east.
>
> 'I shall do it: here I am', you should say" (Quirke, 2013, p21)

[58] The knot of Isis also is the hieroglyph *tet*, an ancient Egyptian amulet associated with the blood of the goddess Isis (Lurker, 1980)

[59] The scarab is an ancient Egyptian amulet in the shape of dung beetle. It is associated with the god Kheperi who push the sun disk across the sky every day (Wilkinson, 2005).

The *Shabti's* text (spell6) that activates the figure was written on the *Shabti*'s body (Figures 78, 79 & 81). These words are also repeated in spell 151. A *Shabti* was usually included in the diagram of the burial chamber in spell151, as part of the essential equipment of the dead person (Taylor, 2010). Early New Kingdom *Shabtis* were sometimes provided with miniature tools such as hoes, picks and baskets, and from the Third Intermediate Period (1070–712 BC) some overseer figures were provided with a whip, however later *Shabti*s had such details painted, carved or moulded on the body (Shaw & Nicholson, 1995). At the beginning of this trend the deceased were supplied with one *Shabti*, but by the New Kingdom the numbers were increased to reach 365 *Shabti*s with one *Shabti* for each day of the year, in addition to thirty-six 'overseer' figures (Figure 71). The overseers were *Shabtis* dressed in kilts and they carried whips; they were supplied in the ratio of one to ten of the ordinary *Shabtis*. Their duties were to organise the work in the afterlife. Initially early *Shabtis* were placed individually in the burials or sometimes in miniature coffins, but in the later periods where *Shabtis* were provided in large numbers, special wooden boxes were used to contain them (Figure 72) (Stewart, 1995).

Figure 70: Faience *shabti* for Ns-pr-n-nbw. Overseer with headband and projecting kilt. From the Third Intermediate Period, 21st Dynasty. Height 12.5 cm (Courtesy of Petrie Museum of Egyptian Archaeology, UCL (UC 39935)

Figure 71:Polychrome wooden *shabti* box and figures for Henutmehyt. From 19th Dynasty, New Kingdom. Height: 33.5cm, width: 19.2 cm, Length: 33.5 cm. EA 41548 (© - Trustees of the British Museum)

5.2.3 *Djed*-pillar

The *djed*-pillar in ancient Egypt is known to be a symbol of power and stability like the *ankh* or the *was*-sceptre (Figure 73), as a hieroglyph it represents stability and permanency. Its origin goes back to the Predynastic Period in Egypt and thus the meaning of this fetish symbol remains very speculative. It was suggested that it represents a stylized leafless tree or a pole with notches on it (Lurker, 1980). The most popular interpretation is that the *djed*-pillar was associated with fertility and represents a pole with grains tied up to it (Lurker, 1980; Shaw & Nicholson, 1995).

Figure 72: Faience amulet in the shape of an ankh combined with a *djed*-pillar and a *was*-sceptre, height 23.5 cm, from 26th Dynasty, c. 664–525 BC. British Museum EA 54412. (© - Trustees of the British Museum)

In another interpretation, it was seen as a column supporting the sky and guaranteeing the authority of the king (Rundle Clark, 1960). Originally the *djed*-pillar was associated with the god *Sokar*[60]/*Ptah*[61], the patron of deity in Memphis. *Ptah* was described in ancient Egypt as 'the noble pillar'(Shaw & Nicholson, 1995). This association eventually led the *djed*-pillar to become the symbol of the god Osiris, the god of the dead. The *djed*-pillar was described in chapter 155 of the 'book of the dead' as the backbone of Osiris. An ancient ritual of 'raising the pillar' took place in Memphis and spread later to all of ancient Egypt. In this ritual the king and the priests erected the *djed*-pillar in a symbolic act to establish stability to the kingdom (Shaw & Nicholson, 1995). In the New Kingdom the 'raising of the pillar' ceremony was seen as the triumph of Osiris over his brother, the god Seth[62] (Shaw & Nicholson, 1995). The association of the *djed*-pillar with the tree, the column and Osiris was rooted in the ancient Egyptian myth of creation.

[60] *Soka*r is an ancient Egyptian god of Memphite Necropolis. He began as god of earth and fertility but later became a mortuary god.
[61] *Ptah* is the Egyptian god of Memphis, god of craftsmen and the inventor of arts.
[62] *Set or Seth* is one of the earliest deities in ancient Egypt. He is god of confusion and disorder. His cult at Nagada was practiced from Predynastic times.

According to the myth, as told by Plutarch, in the "*Book of the Dead"*, the god Seth was envious of his brother Osiris so he invited him to a banquet where he killed him by tricking him into a coffin made to fit Osiris's body. Seth then threw it with its divine contents in the river Nile. The coffin was carried to the sea and washed ashore near the city of Byblos on the Syrian coast. A sacred tree grew rapidly around the coffin, enclosing it within its trunk. The king of Byblos became impressed by its growth so he ordered it to be felled and used it as a pillar in his palace. Isis, the widow of Osiris, was still searching for the body of her husband and came to know of its fate. Isis was granted a boon after she ministered to the ill child of the king of Byblos. She begged for the pillar that supported the roof, which was given to her by the queen of Byblos. Isis extracted the body of Osiris and brought it back to Egypt. Isis bound the pillar together, wrapped it with linen, strewed it with spices and flowers and gave it back to the king of Byblos. The pillar remained in Byblos, where it was worshipped as it had once contained the body of Osiris and thus became a symbol of strength. Back in Egypt the resurrected Osiris had no further role to play in the world of the living. He became the king of the dead and remained in the underworld. (Budge, 1904) and (Thomas, 1986). This myth seems to correspond with the idea of Rundle Clark of the *djed*-pillar as a column. Furthermore Vincent Brown elaborates on the idea to convincingly suggest that the *djed*-pillar was a stylized combination of four columns that held up the four corners of the sky (Brown, 2002). This theory is supported by an early representation from the first dynasty of the pillar with four papyri-form capitals (Figure 74). Brown also refers to the hieroglyph *wadj*, which is represented by a single papyrus stem and has the meaning of 'youthful', '*sceptre*', '*pillar*', 'support' and 'column' (Faulkner, 1962). In this view the bands on the *djed*-pillar could correspond with both the bands on the papyrus rolls and those on the Egyptian architectural columns. In addition Brown draws upon the ancient Egyptian idea of the sky being divided into four corners, which were supported by four staffs of four gods. These staffs are seen as a combined pillar of four pillars, one standing behind the other in typical ancient Egyptian artistic style (Figure 75).

Figure 73: Two ivory *djed*-pillars found in a First Dynasty tomb at Helwan. (Photograph taken by J. D. Degreed) , (after Brown, 2000)

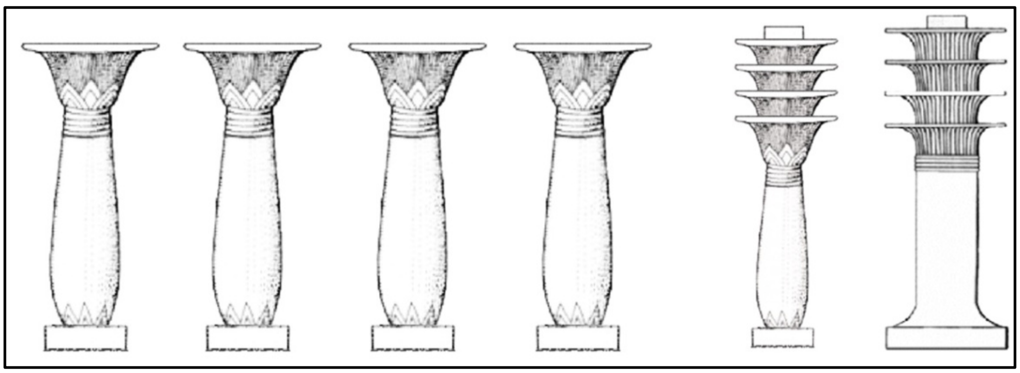


Figure 74: *Djed*-pillar seen as a stylized combination of four papyri-form columns that held up the four corners of the sky, (after Brown, 2000)

Brown finds further support to his theory with the concept that the four gods holding the four corners of the sky were the four sons of Horus. These gods were also associated with the *canopic* jars[63] that contained the organs of the deceased. The chest that was used to contain the four jars was often decorated with depictions of *djed*-pillars(Brown, 2002). Another important aspect of the *djed*-pillar is its relation to the *tet* symbol or the *knot* of Isis, which represents 'the blood of the goddess Isis'. The *djed*-pillar is often depicted next to the *knot* of Isis, especially in the decoration on temples walls, amulets

[63] Canopic jars were used in ancient Egyptian mummification ritual to contain the organs of the dead.

and sarcophagi (Figure 76). These two symbols together represent the nature of life via the unity of these two opposing forces in the world (Lurker, 1980).

Figure 75: The *djed*-pillar depicted next to the *knot* of Isis on a faience pectoral from the British Museum EA (photo by Zahed Tajeddin)

5.3 The Concept of Nu-*Shabti* in the present research

For my exhibition, I imagine that Ancient Egyptian tombs are opened in the present day and the *Shabtis* discover that there is no afterlife, no god of the underworld, no master to substitute for and no labours to perform. They are liberated and become free to do whatever they like. I call them *"Nu"Shabti*, where *"Nu"* is given the meaning of new and liberated. These *Nu-Shabtis* would wander among us in 2014 finding things to do with their lives. Some follow our lifestyle and become happy with our activities, our shopping and consumption patterns, and all our gadgets and tools. Other *Nu-Shabti*s remain restless and continue searching for freedom and liberty. The Arab Spring in 2011 brought millions of protesters to the streets of Tunisia, Egypt, Libya, Yemen, Syria, etc. The crowds called for justice and freedom from their oppressive rulers. Some of my *Nu-Shabtis* also find themselves becoming demonstrators and freedom fighters and joining us in mankind's eternal quest for freedom. In these varying responses to our modern existence they reflect us all, and also the complications and contradictions of the world in which we currently operate.

5.4 Making Faience *Nu-Shabti* figures

5.4.1 Historical Background

The great majority of ancient *Shabti* figures were made of Egyptian faience (Stewart, 1995). The early faience *Shabti*s appeared in the Middle Kingdom and became popular in the New Kingdom (1570–1070 BC) but from the Third Intermediate Period to the Late Period (713–332 BC), *Shabti*s were almost exclusively made of Egyptian faience (Stewart, 1995). It was mentioned earlier that the word for faience in ancient Egyptian is *tjehnet*, which means dazzling and scintillating. (Bianchi, 1998) proposes that the ancient Egyptians were not interested in “art for art sake” and faience was not prized simply on aesthetic grounds but it was considered for its symbolic values. The luminous quality of faience explains its association with the sun and the concepts of fertility, life and resurrection, thus also to the god of afterlife Osiris. Therefore the material was used for figures such as *Shabti*s and the “brides of Dead” (Bianchi, 1998). Furthermore, the word *tjehnet* was also used as an epithet for the sun god Re[64] (Raven, 1988). Bianchi draws attention to this complex relationship when he explains: “Papyrus on some late Period faience *Shabti* are introduced by the word *sehedj*, traditionally translated into English as “the one who causes [someone or thing] to be illuminated = the inspector.” But since the word *sehedj* is often followed immediately by that for the deceased identified as Osiris, the phrase is perhaps better translated as “the illuminated Osiris,” meaning that because the *Shabti* is made of *tjehnet*, the deceased has already become assimilated with the solar deity, Re” (Bianchi, 1998). The metaphor of the deceased who upon death, is resurrected from Osiris into Re, already existed as early as the Old Kingdom (Bianchi, 1998). This strong symbolic significance of faience was the reason for its use largely for making *Shabti* figures in ancient Egypt.

[64] Re is the sun god in ancient Egypt

The mummified figure of the *Shabti* has a complex three-dimensional shape. Therefore the ancient Egyptian faience makers used moulds to produce multiple copies of it. The mould for making *Shabti*s was an open-face one-piece mould, made of fired clay. An example from the Late Period of such a mould is now among the collection of the Petrie Museum (UC40663) (Fig. 77).

Figure 76: ***Shabti*** **mould in terracotta from the Late Period. Height 10.6 cm. (Courtesy of the Petrie Museum of Egyptian Archaeology, University College London. UC 40663)**

Figure 77: ***Shabti*** **mould in terracotta from Qantir. Height 18.5 cm. (Courtesy Excavation Qantir-Piramesse, Dr. Edgar B. Pusch, UCL Qatar)**

In another example of *Shabti* moulds from Qantir, the flat base indicates that the prototype-master *Shabti* was pressed into a lump of clay sitting on a flat surface, then the mould was cut around the prototype and the edges were shaped by hand, hence the finger marks evident on the side of the mould (Fig. 78). Generally the use of open-face terracotta moulds became widespread in the New Kingdom; it marks the beginning of mechanical reproduction of artworks (Anon., n.d.). Archaeological sites such as Amarna and Qantir from the New Kingdom yielded thousands of these terracotta moulds for the production and reproduction of faience artefacts. The prototype or the masterpiece that was used to make the mould was carefully sculptured to have no undercuts. In other words, it had no edges or corners, which would prevent the release of the positive figure from the negative mould. The prototype could have been carved in limestone or made of clay or beeswax (Quirke & Tajeddin, 2010). The faience *Shabti* was made by pressing the faience paste in the open-face mould to obtain the front detailed impression, then it was released from the mould by tipping it over on a piece of cloth, hence the impression of cloth that can be seen on some specimens. After the *Shabti* dried, the back was then modified according to the *Shabti* style. Finally and before firing, fine details and glyphs were added to the surface, either by incision with fine tools or painting with colouring oxides, see video[65] of experimental work by the author (Petrie3D, 2013). Generally we can distinguish four main styles of the *Shabti*s' backs: a, b, c and d. These styles varied depending on the period, the faience paste used, the craftsmanship and the quality.

a. Full back: in this style, the craftsman reshaped the back to a classical three-dimensional full form (Figure 79). This style was very fine and used for some early and royal *Shabti*s.
b. Stylized back: the craftsman here reshaped the back with some surface modifications resembling a full body form (Figure 80). This style was used in the New Kingdom and the Third Intermediate Period.
c. Flat back: The *Shabti* in this style is kind of a high relief, here the craftsmen did not modify the back and left it completely flat (Figure 81). This style was used in all periods for fast and mass-production.
d. Back pillar: this is a distinctive style of the Late Period, where the craftsman reshaped the back leaving a supporting structural pillar (Figure 82). Statues with back pillars were made in earlier periods, usually for a striding pose (Stewart 1995).

The *Shabti*s were glazed by all three methods: efflorescence, application and cementation, and also with combined methods.

[65] https://www.youtube.com/watch?v=C_KWXznxovQ

Figure 78: Faience *Shabti* of Seti I, From the New Kingdom, 19th Dynasty, in Chiddingstone Castle, no: EDECC 01:0308. (Courtesy of Glenn Janes)

Figure 79: Faience *Shabti* for Nes ta-neb(t)-Ischer(u). From the Third Intermediate Period, 21st Dynasty. Height 14.9 cm. (Courtesy of Glenn Janes)

Figure 80: Faience *Shabti* for Djed-khonsu-iuf-ankh. From the Third Intermediate Period, 22st Dynasty. Height 10.2 cm (Courtesy of Petrie Museum of Egyptian Archaeology, UCL (UC 29999A

Figure 81: Faience *Shabti* for Wedja-Hor from the Late Period, 26th Dynasty, c. 595–570 BC, Height 19.4 cm. (Courtesy of Glenn Janes)

5.4.2 Nu-Shabti moulds

As discussed, ancient faience *shabtis* were reproduced in ancient Egypt by the use of fired-clay moulds. The mould for making a *shabti* was an open-face one-piece mould (see Figure 77 and 78). However, for the purpose of the practical work in this research, a two-part terracotta mould was used to make the *Nu-shabtis*. First, a prototype was created in clay, then cast in plaster of Paris; experiments were also made using different materials, such as wax and casting resin[66]. In practice plaster of Paris was used for its convenience to the purpose and for its ease of production. The ancient Egyptian would

[66] casting resins are synthetic resins made of chemical polymers. They are viscous liquids to start with but are capable of hardening permanently.

perhaps have used beeswax to make the prototype for the *shabtis*. The use of beeswax was suggested as a suitable material for faience mould making in a previous experimental study by the author where it was argued that the "…'mould master piece' was wax, which can be easily modelled when soft, and finished to high definition by filing and incising when dried… The 'master piece' had to be hard enough to be pressed into soft clay, leaving its motif as a negative in the mould surface; in addition, it should not stick to the wet clay on removal" (Quirke & Tajeddin, 2010). Beeswax was readily available in Ancient Egypt; it was used in cosmetics, as an adhesive, as a sealant and also for making models for metal casting (Serpico & White, 2000).

The unconventional use of a two-part mould for faience was considered here anew in order to reduce the finishing work on the back of the *shabti*s. The design of the *Nu-shabti* is based on the traditional mummy form but a few changes were made to distinguish the new from the old *shabtis.* For example the *Nu-shabti* has no headdress and his hands are free (Figures 83 and 84). The shape of the *Nu-shabti* was carefully formed to avoid any undercuts. For that the statue is divided into two parts front and back, with the seam positioned along the side profile of the statue. The mould was made by pressing the prototype into soft clay. The mould was then fired to 1000° C after It was completely dry. For this project two identical moulds were made and used to produce the Nu-*shabti*s. It was necessary to wash the mould sections with fresh water after each use to dissolve and remove the soda that leached from the faience paste to the body. This soda would form a crust of salt deposit on the mould-surface if left to dry and effloresce.

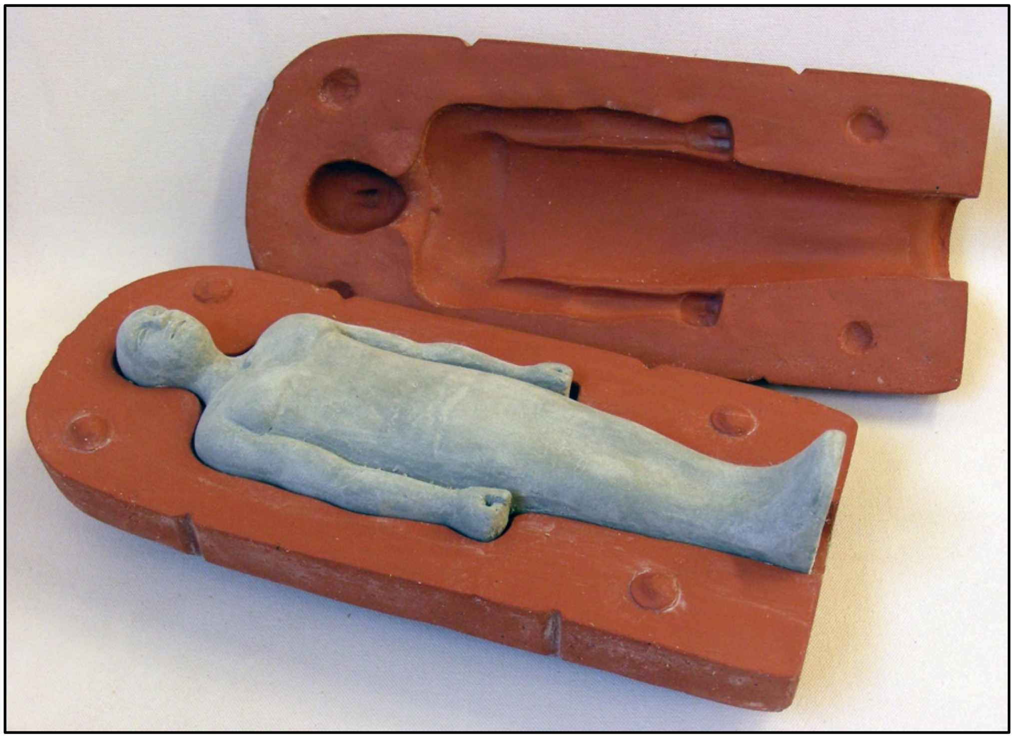


Figure 82: The two-part terracotta mould for the Nu-shabti. (photo by Zahed Tajeddin)

5.4.3 Production Method of the *Nu-Shabti* and Paste Variation

A series of experiments were carried out to establish a suitable faience paste and an effective working procedure.

The glazing method used for making the *Nu-shabtis* was the efflorescence method and therefore the chosen faience paste's components were:

- 87 % silica
- 4% soda ash (sodium carbonate)
- 4% whiting (calcium carbonate)
- 4% plastic clay
- 0.5–1% colourant oxide

This mixture was used as guidance; it was based on the experimental works carried out previously by the author (see Chapter 3). Different paste variations were formulated to explore and obtain the optimum results (Table 15). These variations are discussed later in this chapter. All materials used were purchased from pottery suppliers in the United Kingdom. The silica was added as quartz (300 mesh) or flint (300 mesh), alone or mixed with silica sand (90 mesh) or various combinations of the three types (see Table 15). The best result for a workable paste contained a 60% fine quartz or flint (300 mesh) with 40% silica sand. Different kinds of plastic clay were used to explore and improve the workability of the paste. These clays were bentonite clay, china clay, ball clay[67] (AT), (BKSL), (AK) and (HV). The chemical composition for these clays is given in Table 14. The use of these clays was also discussed in chapter 4 of this work. The dry components were mixed first, apart from the soda, which was dissolved in hot water then added to the mixture. Also a mixture of sodium carbonate and bicarbonate was used for some *Nu-shabti* Figures (see Table 15). The added water was 20–25 wt% of the total weight. The paste mixture was wedged and kneaded to a dough consistency. The faience paste was then stored in sealed buckets and used after being left for few hours to mature.

Ball clay	**SiO_2**	**Al_2O_3**	**Fe_2O_3**	**K_2O/ Na_2O**
AK	50	32	1.1	2.1
AT	55	29	2.3	3.6
BKSL	71	19	0.7	2.0
HV	62.7	24.8	0.9	2.6
Hyplas	70	20	0.8	2.3

Table 14: General chemical components for the various types of ball clay (from supplier[68])

[67] ball clay is a fine-grained highly plastic clay, predominantly containing kaolinite, mica and silica. When it is fired it has a light creamy colour due to the presence of iron oxide. It is supplied in various types depending on its components (AK, AT, BKSL, HV, Hyplas)

[68] Pottery craft (www.potterycraft.co.uk)

Shabti code	Silica SiO_2			Lime $CaCO_3$	Alkaline		Colourant		Clay						
	Quartz	Flint	S sand		Na_2Co_3	$NaHCO_3$	CuO	$CuCo_3$	BN	CC	BC (AT)	BC (HV)	BC (BKSL)	BC Hyplas	BC (AK)
2	64			4	10			2						20	
3	70			4	5	5	1							15	
4	76			4	5	5	1							10	
5	80			4	5	5	1							5	
6	77			4	4	4	1							10	
7	72			4	4	4	1						15		
8	76			4	6	2		2			10				
9	76			4	4	4		2	5						5
I	42		42	4	5		2		5						
II	42.5		42.5	4	3	3	1		4						
III	42.5		42.5	4	3	3	0.5		4						
IV	43		43	4	3	3			4						
V	43		43	4	5				5						
VI	44.5		44.5	4	4				3						
VII	58		29	4	4		1		4						
VIII	52.2		34.8	4	4		1		4						
IX	52.2		34.8	4	4		0.5								4
X	52.2		34.8	4	4		CoO = 0.5					4			
XI	52.2		34.8	4	4		0.5						4		
XII	52.2		34.8	4	4		1				4				
XIII	52.2		34.8	4	4		0.5			4					
XIV	52.2		34.8	4	4		1.5					4			
XV	52.2		34.8	4	4		CoO = 0.25				4				
XVI	52.2		34.8	4	4		CoO = 0.25					4			
XVII	52.2		34.8	4	4		MnO = 0.5								
XVIII	52.2		34.8	4	4			0.5					4		
XIX	52.2		34.8	4	4		MnO = 0.25						4		
XX	52.2		34.8	4	4		0.5								

Shabti	Silica SiO_2			Lime	Alkaline		Colourant		Clay						
code	Quartz	Flint	S sand	$CaCO_3$	Na Co_3	$NaHCO_2$	CuO	Cu Co_3	BN	CC	BC (AT)	BC (HV)	BC (BKSL)	BC Hyplas	BC (AK)
XXI	52.2		34.8	4	4		CrO = 0.5				4				
XXII	52.2		34.8	4	4			1			4				
XXIII		87.5		4	4		0.5						4		
XXIV		87		4	4		1				4				
XXV		88		4	4						4				
XXVI		88		4	4								4		
XXVII		87		4	4		1					4			
XXVIII		88		4	4							4			
XXXIX		88		4	4				4						
XXX		87		4	4		1		2		2				
31		87.5		4	4		0.5		2			2			
32		87.5		4	4		0.5		2				2		
33		87.5		4	4		0.5		2	2					
34		52.2	34.8	4	4		0.75		2			2			
35		52.2	34.8	4	4				2		2				
36		52.2	34.8	4	4		red G26 = 0.75		2			2			
37		52.2	34.8	4	4		green G53 = 0.5		2				2		
38		52.2	34.8	4	4		marbled		1	1	1	1	1		
39		69.6	17.4	4	4		1		2				2		
40		52.2	34.8	4	4		1		2			2			

S sand: silica sand 90 mesh

BN: Bentonite

CC: China clay

BC: Ball clays: Puraflo (AK), Hymond (AT), BKSL, Hyplas, (HV), see Table 62

Red G26: red ceramic stain

Green G53: green ceramic stain

Table 15: Experimental data of the *Nu-shabtis*

For making the *Nu-shabti* figures, the two parts of the mould were cleaned with fresh water and then filled in turn with the faience paste, making sure that the paste was pushed into the whole mould. A void core was left in the centre of the sections (Figure 9). The faience paste was then brushed with water to moisten the surface, and the mould sections were quickly put tightly together before they started drying. The mould was secured and then tapped on both sides to prevent sticking and facilitate the release of the figure within the mould. The mould was then placed on a flat surface and the upper section of the mould was carefully lifted away, leaving the figure supported by the lower section (Figure 83). The faience paste is thixotropic and it needs this support until it dries. Some work on the exposed half was carried out at this stage to improve or add features to the figures. For example, the changing of the arm gestures for some *shabtis* was made at this stage. After the figure became dry and was able to stand upright freely, it was lifted out of the lower mould and more work was carried out on the now-exposed back. The seam marks were also removed at this stage (Figure 84). The Nu-*shabti*s were glazed by the efflorescence glazing method. Therefore they were left to dry and effloresce for a good period of time. However, factors such as the drying environment and the flow of air played a significant role in developing a good and homogeneous effloresced crust (see Figures 85 and 86). Therefore the figures were dried in a chamber heated to 50°C to control the drying of the paste and to obtain a uniform efflorescence of the sodium salts onto the surface (Figure 86). After 24 hours the figures were ready to be fired. The *shabti*s were fired in an electric kiln at 100°C per hour to 950°C, then the kiln was switched off and left to cool down to room temperature. Generally a glaze layer was formed on the figures (Figure 87). The results varied depending on the components and the drying procedure, which are discussed below.

Figure 83: The two-part terracotta mould with a faience figure standing freely after drying. (Photo by Zahed Tajeddin)

Figure 84: crust and blooms of effloresced sodium salts formed on the surface during drying in an open room with a free flow of air. (Photo by Zahed Tajeddin)

Figure 85: crust of effloresced sodium salts formed on the surface during drying in a 50°C heated chamber. (Photo by Zahed Tajeddin)

Figure 86: a group of finished *Nu-shabtis.* (Photo by Zahed Tajeddin)

5.4.4 Results and discussions

The experimental approach to the making of the *Nu-shabtis* provided valuable information on the practical aspects of faience production. Changing and testing variations of the faience paste components led to a better understanding of the material, which in turn offered the opportunity of achieving suitable and workable pastes without changing the original formula. In addition, through repetition and the observation of practice, it became possible to devise a practical working procedure that ensured consistency and quality for the final figures. The results of this work can be summarized as follow:

The particle size of the silica has proved to be a crucial factor in facilitating the construction of medium and large faience sculptures. Although the paste made of fine flint or quartz gave a smoother glaze, it was thixotropic with very poor workability. The experiments have demonstrated that the optimum ratio of fine to coarse silica sand was 60:40 wt% (see Table 15). This ratio of silica in the paste, in addition to 4 percent of plastic clay gave a workable paste with sufficient plasticity. The resulting glaze was semi glossy, which corresponds with some ancient faience glazes.

The amount of clay added to the paste was another crucial factor. The various tests showed that using a little amount of plastic clay (between 2–4 wt%) enhanced the ability of the paste for modelling and moulding. On the other hand, adding a higher percentage of clay (more than 10wt%) gave poor results. The glaze was not smooth and had a bubbled surface. In addition the figure's volume shrank during drying and firing. The best results were achieved by using clays such as bentonite, which gave a very smooth and shiny glaze. Furthermore, a variation in glaze smoothness and quality was obtained when different kinds of highly plastic clays were combined, for example the ratio of 2:2 of bentonite with ball clay such as (AT) or (AK).

The hollow core solution was adapted after a few experiments on different procedures; it proved to be better than the solid form. This is because of the thixotropic nature of the paste. It was more practical to have a void in the centre, which gave the space for the two halves of the figure to move and settle when the mould sections were joined together and tapped, thus obtaining a good adhesion between them.

Xeroradiographs of a *Nu-shabti* were taken in the conservation laboratory in UCL-Qatar (Figure 88). These images provided additional clues to the faience body's characteristics. They enabled us to see evidence for the figure's construction method such as the joining lines and the core shape. The X-radiography also revealed numerous round or oval voids in the body about 1–2 mm in diameter. These voids are probably associated with air bubbles trapped in the body during kneading of the faience paste.

The efflorescence glazing method that is used throughout these experiments proved a very practical self-glazing technique, especially after the success achieved in controlling the efflorescence phenomenon by using heated space to give homogenous results. Other glazing methods were also tested here for the *Nu-shabtis*. The application glazing method gave good results but it involved adding more working stages for drying the figures before and after applying of the glaze (by dipping or brushing). The cementation method of glazing was not suitable for these large figures; the resulting glaze was very poor and the figures were very fragile.

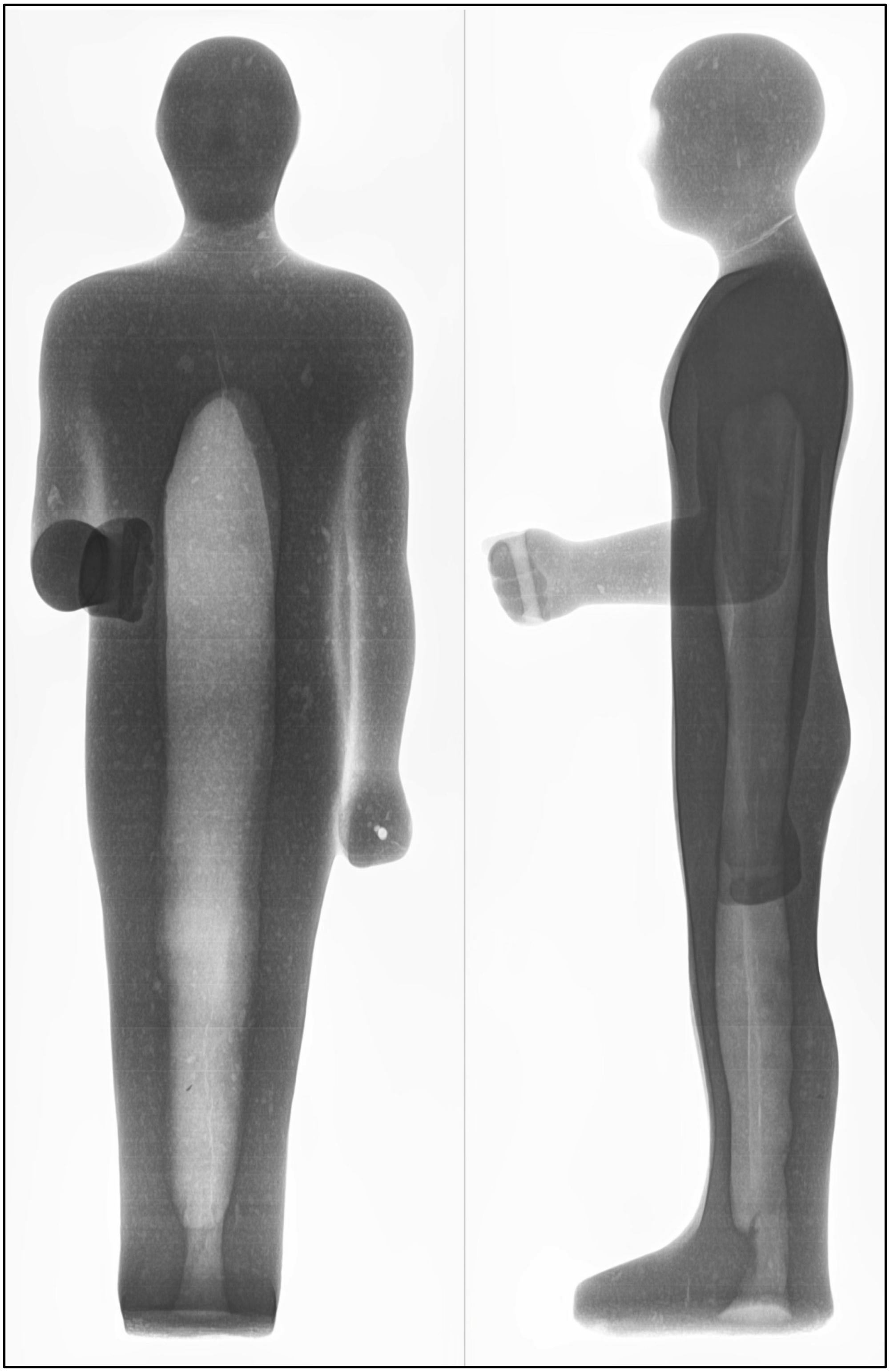


Figure 87: X-rays of a *Nu-shabti*, front and profile position, showing the core void area and the joining seam at the sides, also round and oval voids in the body from trapped air bubbles during kneading of the paste. These features match those witnessed on ancient faience artefacts. (Photo by Zahed Tajeddin)

5.5 Making the *Djed*-pillar

5.5.1 Background and Challenges

Archaeological finds and records show little evidence for large-scale faience objects. The nature of the material makes it very difficult to construct large artefacts. Faience paste contains mainly heavy sand and silica particles mixed with water and held together with minor amounts of alkali, lime and binder. The worker has to operate against the force of gravity to restrain the paste and prevent it from collapsing under its own weight; it is like building sand castles on the beach. It must have been very tempting and challenging for the ancient faience craftsmen to create larger pieces of the material. An early example of such attempts I would like to propose is a baboon statue from the First Dynasty in the dynastic period (3050–2686 BC). It was found in Abydos, and is now in The Fitzwilliam Museum in Cambridge, England (accession object number: E.23.1905). The baboon is 23 cm in height (Figure 89).

Figure 88: Faience baboon statue from the First Dynasty, found in Abydos, now in The Fitzwilliam museum in Cambridge, England (accession object number: E.23.1905). (Photo by Z. Tajeddin)

The baboon figure is relatively large when compared to other faience objects from this early period – i.e. five times larger than the average object. The faience manufacturing in this early period mainly used stone carving technologies. The faience paste would be at first roughly shaped into a lump, then left to dry before being abraded, carved, sculptured and incised with fine details using the same techniques and tools for stone-working. Unlike the other faience objects from the period, this statue is hollow. The maker formed the faience paste around a removable core-material. This not only reduced the weight but also supported the piece at the wet stage and eased its drying and firing.

The advances in the production techniques of faience objects in the New Kingdom (1570–1070 BC) led to more experimentation and attempts to create significantly larger scale pieces than before. The faience masters became more confident, and many objects such as vessels, tiles, statues and other cult objects exceeded 20cm in size to reach 30 and 40cm.

Nevertheless, the largest known faience object comes from the early New Kingdom. It is the *wa*s-sceptre[69] of Set, its dimensions are: height: 215.8 cm, width: 25 cm, depth: 48.2 cm and it weighs 65.0 kg (Figures 90 & 91), it is ten times larger than the average large faience objects yet recorded. The *sceptre* was found in 1894 by Flinders Petrie in Naqada, south of Egypt, about thirty miles north of Thebes (present Luxor). The fragmented object was uncovered from the temple of Set[70] at the ancient town of Nubt. Petrie wrote: "Within the temple, in the most N.W. chamber, were a large quantity of fragments of blue glaze. After getting these to England, we at last found them to be parts of a gigantic was sceptre, about 7 feet high." (Petrie & Quibell, 1895). Petrie declared that the sceptre was too much broken to be all restored with certainty. He described it: "It was made by the sandy core in 8 or 10 separate pieces, each made on a centering of straw twist. These were engraved with all the devices, placed in one

[69] *was*-sceptre is an emblem of authority carried by Egyptian deities and kings. It is also the hieroglyph for 'domination' (Wilkinson, 2005).

column, with the head-piece separate, covered with glaze and fired in a kiln, which was capable of baking a length of five feet upright, without letting the glaze become burnt or unequally heated. It is the greatest triumph of glazing known in ancient world." (Petrie & Quibell, 1895).

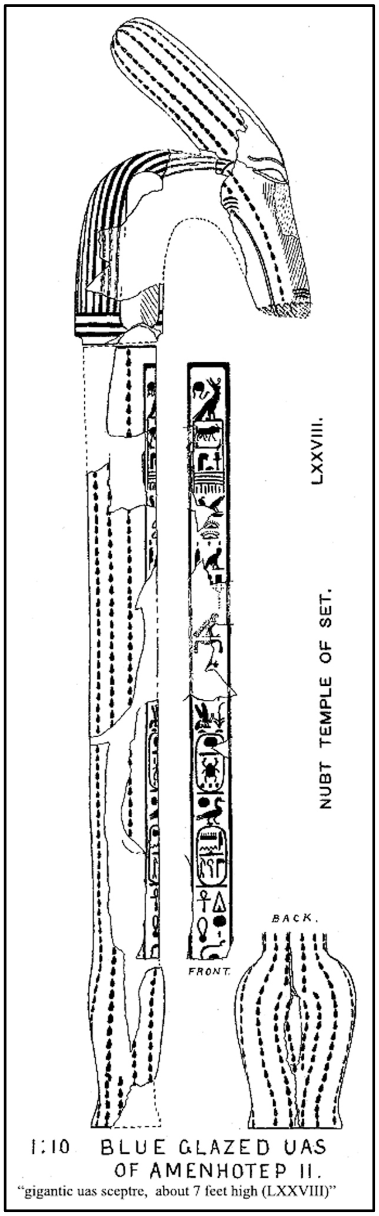


Figure 89: The *was*-sceptre of Set, the largest known faience object from the early New Kingdom (After Petrie, Naqada and Ballas, London, 1895, plate78)

Figure 90:The *was*-sceptre now on display in the Victoria and Albert Museum, London. (Photo by Zahed Tajeddin)

The sceptre was restored and then erected at the South Kensington Museum, today the Victoria and Albert Museum. It is now displayed in case 45 in room 145, the World Ceramics gallery in the section dedicated to iconic world ceramics. It has the accession object number (437–1895) (Figure 91). The *was* functioned as a ritual *sceptre* or staff, it is made of turquoise glazed faience inscribed with black coloured hieroglyphs with reference to Amenhotep II[71] (reigned 1427–1400 BC). The *sceptre* is currently displayed in a closed glass case in the museum and therefore closer examination or analysis is rather restricted.

Towards the end of the New Kingdom, we see that the faience craftsmen became much more skilled and confident with constructing and assembling faience pieces on a grand scale (Friedman et al 1998). The Palace of Ramasses II in Qantir in the eastern Delta, north of Egypt revealed a large installation of polychrome faience tiles sometimes larger than 40 cm in length. In addition to large-scale solid sculptures of faience figures, such as the lion subduing a prince of Kush[72], now on view in gallery 124 in The Metropolitan Museum of Arts in New York, United States of America, (accession number 35.1.23), (Figures 92 and 93).

[71] Amenhotep II the seventh Pharaoh of the 18th dynasty, son of Thutmose III (Wilkinson, 2005).

[72] Kush is a kingdom located in modern upper Nubia and Sudan. It was the main enemy of the Egyptian in the Middle Kingdom and the Second Intermediate Period (Wilkinson, 2005)

Figure 91: Fragmentary statue of a lion with the cartouches of Ramasses II subduing a prince of Kush, The Metropolitan Museum of Arts, New York. (Photo by M. Marrsch, CC BY NC–SA 2.0)

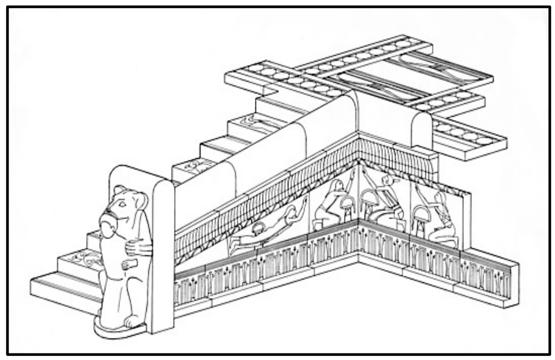


Figure 92: Reconstruction of the stairway mounting up to the platform of the throne dais at the palace of Ramasses II in Qantir. The Metropolitan Museum of Art, Purchase, Rogers Fund, Edward S. Harkness Gift and by exchange, 1922, 1929, 1935 ©(www.metmuseum.org)

Figure 93: Fragments of a faience statue of lion subduing a prince of Kush, Cairo Museum (Courtesy of Excavation Qantir-Piramesse, Dr. Edgar B. Pusch, UCL Qatar)

There were probably several of these statues that functioned as newel posts at the bottom of the staircases to the throne dais in the royal palace. Another of these statues is on display in Cairo Museum in Egypt (Figure 94). The site of Qantir is the city of Pi-Ramesse, the new capital of the great pharaoh Ramasses II. It is a huge and complex site but the archaeology is poorly preserved due to the floods and agricultural activities in this fertile area. The lion statue's dimensions are height: 70cm, width: 29cm. The Qantir's massive lion statues were probably made by constructing faience paste in a huge mass which was then carved and sculptured after drying. The lion statues and the *was*-sceptre are the largest known faience objects in history.

5.5.2 Experimental work and the making of the gigantic *djed*-pillar

The choice of making a three-dimensional *djed*-pillar was based on the significance of this amulet/symbol in ancient Egyptian mythology and its close association with the *was*-sceptre, in addition to its relation to the concept of the underworld. In an attempt to explore the challenges faced by the ancient faience masters when constructing huge faience objects, a plan was made to build a gigantic *djed*-pillar to be the centrepiece at the final exhibition of this research project. The endeavour was to create an object parallel to the largest known faience object, the *was*-sceptre of Set. To these ends a residency was arranged to complete this work at the European Ceramic Work Centre (EKWC) in 'S-Hetrogonbosch in The Netherlands. The working facilities at EKWC were ideal for such an undertaking, especially the huge gas kilns there for firing large-scale ceramic objects.

At first a series of experiments were made to establish a suitable faience paste and working procedure. The chosen faience paste's components for the pillar were:

- 89 % silica
- 4% sodium carbonate
- 4% calcium carbonate
- 2% plastic clay
- 1% copper oxide

The silica was added as 40% silver sand (60mesh) and 60% fine quartz (200mesh). The plastic clay used was "bentone RM286" (a very fine bentonite clay). It contains: 39.5% Alumina, 46.5 Silica and 14% organic binders. All materials used were purchased from pottery suppliers in The Netherlands. The components were mixed first dry apart from the soda, which was dissolved in hot water then added to the mixture. The water was 20% of the total weight. The paste was mixed in an industrial dough mixer with a 30–40 kg capacity. The faience was then stored in sealed buckets and used after having been left for 24 hours to mature. The construction of the pillar was based on the information we have from Petrie's description of the *was*-sceptre fragments (see above 1.7.1), combined with the knowledge gained through the experimental work, made by the author for this research. The decision was taken to build the pillar in four or five sections and then join them as one piece in a final firing. Each of the sections was built around a core made of a cardboard structure filled with canes of reed (Figure 98). The core was removed before the firing and after the paste was set and dry. The mould was made of layers of styrofoam. The choice of styrofoam wasn't essential but rather convenient. The EKWC has a 3d printing workshop, which allowed me to digitally draw the 3d design of the pillar and its mould using Rhino software (Figure 95). From this 3d design, a 3d print could be created either by milling the styrofoam boards or by cutting them using computerised hotwire. The mould for the pillar was cut using the hotwire system (Figures 96 and 97). A thin layer of latex applied to the surface of the styrofoam mould that prevented the faience paste from sticking to the mould, and prevented the Styrofoam from drawing-out the soluble soda through diffusion.

The first layer of the mould and the core were placed on a kiln shelf covered with alumina powder/paper to prevent the adhesion of faience to the ceramic shelf during firing. The faience paste was then shaped into coils and packed into the void in between the mould and the core structure by pushing and tapping it with a wooden stick to fill all the space. When the mould layer was filled with paste, the next mould layer was added and filled to the top with faience paste in the same way. This operation was repeated until the mould of the pillar's section was filled completely (Figure 99).

The mould then was placed in a drying chamber heated to 50°C to aid the drying of the paste within the mould. The mould was removed after 48 hours when the paste became firm enough to stand without the support of the core and the mould (Figure 99). The pillar's surface was then abraded to remove all the seams from the mould's layers. It was then sprayed with water and rendered/smoothed using a metal trowel. The reed core was then removed gently from the core of the pillar's section. The pillar's section was put back in the heated chamber to dry and to allow the soda to effloresce to the surface (Figure 100). After 48 hours it was ready to be fired.

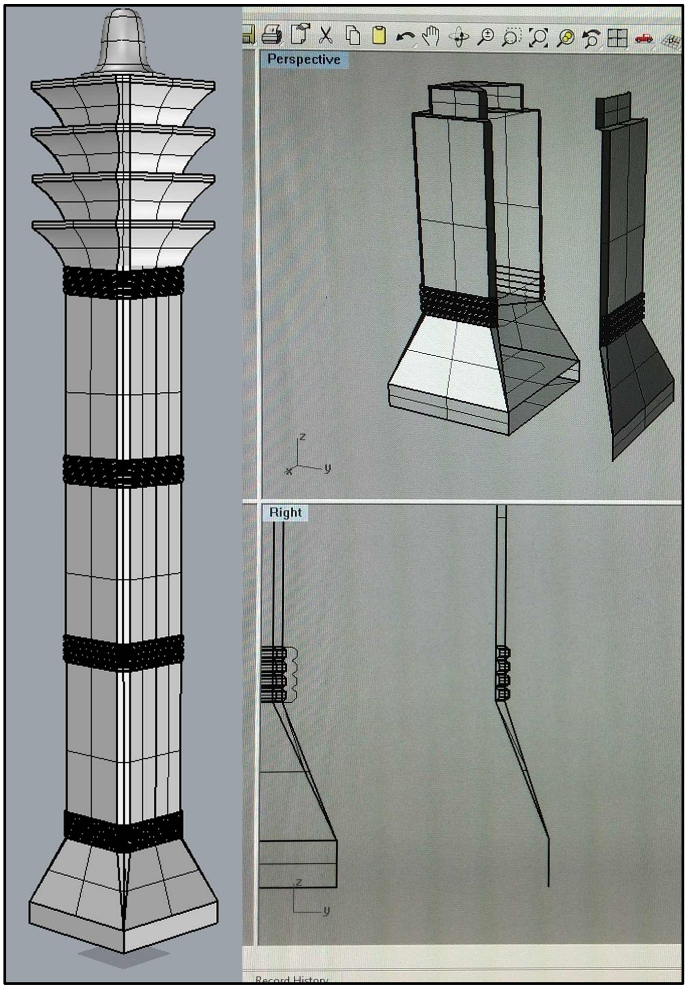


Figure 94: 3D digital drawings of the pillar using Rhino software. (Photo by Zahed Tajeddin)

Figure 95: The mould layers for the pillar were cut using the hotwire system. (Photo by Zahed Tajeddin)

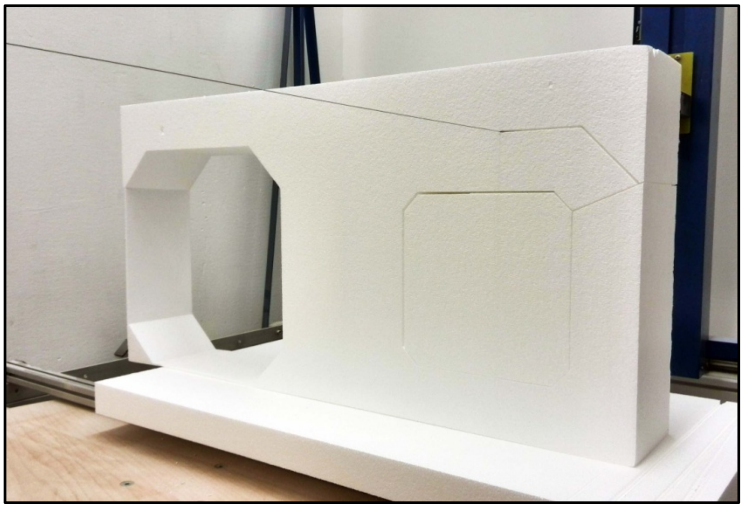


Figure 96: Cutting the styrofoam boards by using computerized hotwire. (Photo by Zahed Tajeddin)

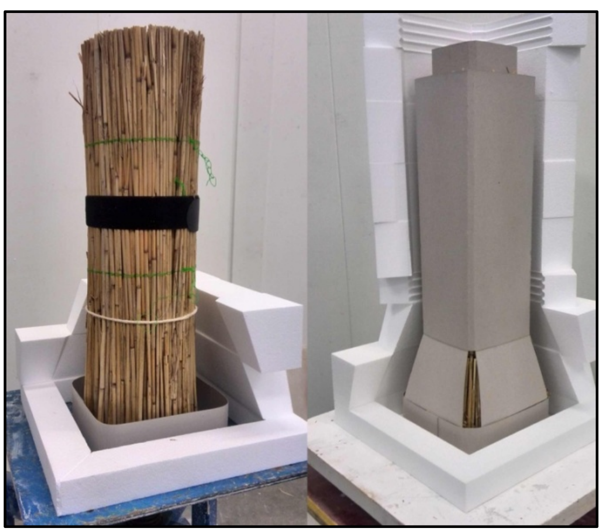


Figure 97: the pillar's sections were built around a core made of cardboard structure filled with canes of reed. (Photo by Zahed Tajeddin)

Figure 98: Forming the pillar's sections using the multi-layered mould.(Photo by Zahed Tajeddin)

The other sections of the pillar were built following the same steps. The capital section of the pillar where the leaves expand outwards was processed differently. These thicker wings were filled with reeds to avoid the excess of weight at the top of the pillar, and to ensure better and faster drying. A series of vents towards the core were made in the pillar's walls at the capital to allow the burned organic materials to escape during the firing and to prevent cracking (Figure 101).

Figure 99: The soda effloresces to the surface upon drying in heated space. (Photo by Zahed Tajeddin)

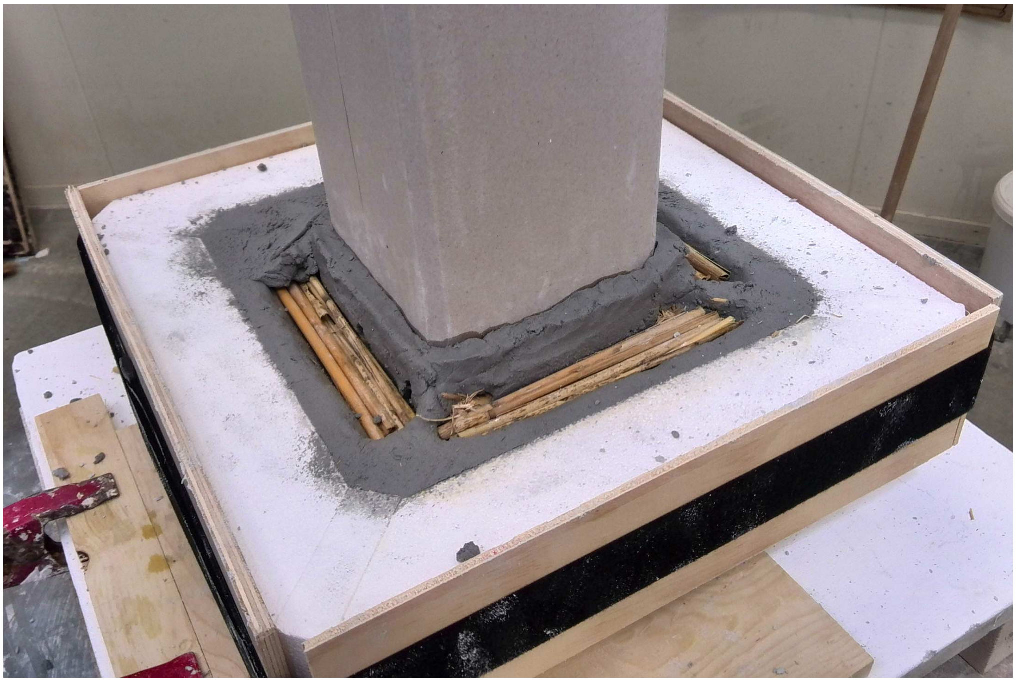


Figure 100: The thick wings of the capital were filled with reeds to avoid an excess of weight at the top of the pillar. (Photo by Zahed Tajeddin)

The top part of the pillar, which is in the shape of an inverted lotus flower, was shaped separately in an open mould and then left to dry and to effloresce in the same way as the other sections. The pillar's sections were fired separately in a gas kiln. The firing was set to a slow rate: at first 30°C per hour to 140°C, then at 40°C per hour to 400°C and at 50°C per hour to 550°C, a slower rate of 3 hours applied between 550°C and 650°C allowed for the quartz inversion[73]. The kiln then continued at 100°C per hour to 900°C, and then soaked at this temperature for 30 minutes. The kiln then cooled down at 80°C per hour to 650°C. At this point slower cooling was applied at 25°C per hour to allow again for the quartz inversion, when the temperature reached 550°C. Once past this point the kiln was left to cool down to room temperature (Figure 102).

[73] Quartz inversion is a sudden reversible change in the lattice structure of the silica from α-quartz to β-quartz. It occurs upon heating the silica at 573° C and is accompanied by a liner expansion of 0.45%, which can lead to cracks in the ceramic body.

Figure 101: firing schedule for the faience *djed*-pillar

The pillar's sections were then assembled together as one piece on a kiln shelf covered with alumina paper. The pieces were cemented together using the same faience paste. A thin layer of glaze was applied at the joints and the damaged areas. The pillar was then fired as a complete object in a large gas kiln following the same firing steps as used for the five sections. The end result was satisfactory; the sections were fused together in the firing to form one large piece of faience (Figure 103). However a network of cracks appeared on the different sections of the pillar, mainly running vertically. These cracks were probably caused by tension in the joints due to various thicknesses in these areas (Figure 104). This would have been avoided by reducing the thickness of the pillar's wall at the joints.

Figure 102: the faience *Djed*-pillar is 220 cm tall and weighs 80kg. (Photo by Zahed Tajeddin)

Figure 103: vertical cracks were probably caused by tension in the joints due to various thicknesses in these areas. (Photo by Zahed Tajeddin)

5.5.3 Result and discussion

In this practical work the endeavour was to study the technical aspects of the *was*-sceptre and adapt them to make a large parallel creation in the shape of a *djed*-pillar. By these means, one could experience the challenges that faced the ancient craftsman and establish conclusions about the technology from modern perspectives. Furthermore, different approaches were taken to making and glazing methods in order to understand the limitations of the material and to explore its potential use in a contemporary context. The outcome of this work can be summarised below.

The ancient *was*-sceptre was constructed out of ten short sections then glazed with the application method and fired as one piece. In this study, the pillar was made from four long pieces with an extra cap. The pieces were glazed with efflorescence and fired separately, then joined using faience paste, glazed with an application layer and fired again as one piece. Thus the changes to the original Egyptian making method were:

1. Making only four, but longer sections, in faience paste. This became possible by designing and creating a multi-layered mould-system that facilitated the building of taller sections in faience paste without having them collapse during production. The moulds' layers were able to support the faience paste structure during the wet stage and the drying period. The mould was made using 3D design technology and 3D printing technology, using computer-controlled cutting. One of the significant outcomes of this research was the successful use of modern materials for moulding the faience paste.
2. *Changing the joining method:* Through the experimental work, I was able to establish that the faience body has hardly any shrinking factor, in addition the thermal expansion/contraction that is a product of the alpha-beta quartz change has a minor significance. In other words, it does not change its volume significantly during drying and firing. Therefore fired faience pieces could be joined together using faience slip or paste and be fired again to become one new piece without

cracking or splitting. This result is impossible to achieve with clay bodies due to the high shrinking ratio of clay during drying and again during firing. The sections of the original Egyptian *was*-sceptre were presumably joined before firing and thus they had to be short because taller unfired sections of faience would have been very delicate and fragile to handle and stack on top of each other. In the case of the *djed*-pillar, however, it was constructed out of four main units, which was only feasible through using pre-fired sections.

3. *Changing of the glazing method*: In the making of the *djed*-pillar I used a combination of two glazing methods, namely efflorescence and application. The *was*-sceptre was glazed with the application method alone. The advantage of using the efflorescence glazing method is its self-glazing capacity, but achieving a homogeneous glaze all over the piece with this method could be difficult due to the need for ideal environmental factors, which would help to form a good efflorescence layer. My experimental work on the efflorescence glazing method and the effect of different environmental factors on the faience objects during drying, such as temperature and the flow of air, led to a better understanding of this phenomenon. As a result I arranged a chamber heated to 50°C by a flow of hot air supplied by an electrical heater. This chamber replicated the hot and dry desert environment of Egypt and facilitated the efflorescence of soda. The resulting efflorescence, and thereafter the glaze, was more homogeneous. A final thin application layer was used on the joints and the faulty surfaces to improve the quality of the glaze. However, this layer of applied glaze was too thin and thus resulted in a poor glaze at these areas.

5.6 Conclusion

The making of the *djed*-pillar has shown the complex nature of constructing such a large object in Egyptian faience. The work required tight planning, adequate timing and work-efficiency. For these processes, it was important to have a good understanding of the material and its limitations, to develop the working skill and experience to achieve the desired outcome and to have the appropriate workshop facilities to organise production and to be able to fire an object of such unusual scale. The experimental and analytical preparations were crucial elements in this project; they helped towards making choices in regards to the paste components, the mould material and form, the core's nature and structure, the building procedure, the surface finishing, the joining method, the glazing method and finally the firing strategies and schedule. Furthermore the faults and errors that occurred during the work were very informative and challenging. They contributed positively to the work process through better understanding of the limitations of the material and the way it behaves under different circumstances or at various working scales. The practical work also managed to shed light on the technological choices that faced the ancient faience craftsmen. The ancient craftsmen had to adopt new measures and techniques – different from their traditional methods to be able to achieve such a marked increase in scale, as seen in the *was*-sceptre case and the Qantir palace figures of the New Kingdom. Although the faience workers of this time used techniques that were developed during the earlier periods, they pushed their production to the limit. Generally, there was a major increase in the quality, diversity and quantity of faience objects, especially in jewellery and personal adornments. This may well have been due to the state control or supervision of the industry (Shortland, 2000; Quirke & Tajeddin, 2012). We have seen in this study that the faience work required efficiency, division and an adequate supervision of labour. In the case of the *was*-sceptre, the craftsmen explored different materials and techniques in order to overcome the difficult physical properties of the faience paste and to find a suitable method to enable them to achieve such an exceptionally large object.

However despite the success in making faience objects on such a scale, we have little evidence for the craftsmen adopting these new techniques to make more large objects. The majority of Egyptian faience objects remained small in size and the craftsmen used the traditional and risk-free methods for their production. This observation can be explained by studying the nature of faience workshops in ancient Egypt. The archaeological excavations at sites such as the ancient capital city of Amarna, distinguished between three types of crafts production centres (Kemp, 1989), which also apply to the faience production. The first type is small-size and domestic workshops "cottage industries", which were small residential houses with basic installations for production. The second type is formal constructions and institutional workshops, which were working complexes often, associated with the palace or the temple and could include a range of crafts activities. The third type is courtyard establishments, which were intermediate workshops and storage units that may have been related to private ownership or that worked under state monopoly (Kemp, 1989). From these three patterns we could conclude that the making of significant faience objects such as the *was*-sceptre or the lions from Qantir could only be produced within institutional workshops and probably as special commissions for the king or the high priests. Excavations at Qantir also confirm this view, where all elite crafts workshops were found attached together (Pusch, 1993). All known large objects were associated with the king; the *was*-sceptre with Amenhotep II and the Qantir's lions were made for the palace of Ramasses II. This kind of work was only possible with the support of the state and with the existence of skilled craftsmen capable of undertaking such advanced and challenging commissions.

6 Chapter 6: Exhibition and Research Dissemination

6.1 Introduction: conceptual significance

My work with ancient artefacts, together with an abiding interest in archaeology and mythology, has exerted considerable influence on my sculpture. I create finely balanced figures, which I subsequently finish with oxides and glazes, creating textures that are weathered and earthy in tone. The handling of ancient artefacts in my work in the field of archaeology and conservation has been an exciting experience. It reinforces the notion of artefacts being "not static embodiments of culture but rather, a medium through which identity, power and society are produced and reproduced" (Avrami et al., 2000). Ancient artefacts take me to a past that is teeming with life. It is not only the aesthetic value that is interesting, but also the people who made these objects, dealt with them and used them; it is about their thoughts, beliefs, joys and sorrows. They are what inspire me in my own art. In this present project, I am proposing to bring some of these ancient artefacts into our world, to share some of our present experiences and to create a renewed discourse between the past and present.

6.2 Contemporary Sculpture in Archaeological Museums

Arguments in favour of the collaboration between the fields of archaeology and contemporary sculpture have been made (Acheson Roberts, 2013). In contrast to the passive acceptance that is associated with traditional methods of display, it has been suggested that contemporary art can facilitate an active, more physically engaged, response from the visitors seeking to experience the human past within the environment of a museum.

It has been argued that archaeology must be made to engage with the broader public (Acheson Roberts, 2013). Since the museum is the place where society encounters the results of archaeological investigation, it is important therefore that it provides a meaningful exposure to the past. Creative approaches to exhibition design can improve the public's understanding of the archaeological artefacts and also add to their enjoyment of the exhibits.

There are a number of ways in which contemporary sculpture can help achieve this objective. With its ability to reference context, it can challenge the expectations of the detached observer and facilitate personal interpretation by the public, thereby stimulating an engagement with the construction of meaning that the exercise of archaeology represents, while at the same time reflecting the uncertainty of archaeological reality.

Modern sculpture can also facilitate the visitors' relationship to the peoples of the past and their shared humanity. This can be achieved through an expression of continuity of experience that in turn aids our comprehension of the passage of time. Contemporary sculpture and installation can also provide links to relevant archeological concepts and processes by highlighting the ways through which the objects arrive in the display room – from their discovery and analysis to their curation.

To visualise how the above could be achieved, I will analyse, by employing the above perspective, the works of a number of contemporary artists. British sculptor Rachel Whiteread's (b. 1963) work, for instance, makes enquiries into the nature of our urban environment and the way humans relate to overlooked aspects of architecture and furniture. It does so by capturing in casts the empty or negative spaces created by the objects. The human form is absent yet revealed through the traces of humanity that these 'petrified' spaces represent.

In a sense, encountering and deciphering Whiteread's sculptures is, for the viewer who experiences them in a museum context, akin to the archeologist's process of inference. They also suggest archaeology's main aim of reconstructing human experience from its remains. The unsettling transformation of the familiar into a 'fossil' that Whiteread produces evokes concepts of memory and past lives, both topics pertinent for archaeology. The work also invites viewers to reflect upon their own engagement with their constructed world and their own immediate surroundings.

Modern sculpture can encourage visitors to take part in archaeological issues and debates, for example about the limitations of technology. By linking the process of destruction of the original object in order to produce a cast (which is what Whiteread does when she produces sculptures out of negative spaces) to the inevitably destructive act of excavation, her work can be seen to point to the vulnerability of the past to contemporary human intervention.

A different example of current sculpture that brings into question matters of archaeological relevance can be found in the work of the British sculptor Anthony Gormley (b. 1950). This is manifested in his concern with human scale, the body's inhabitation of space, and the restrictions and capacities that our corporeality implies. The 'embodied' approach to archaeological sites and museum interpretation can be explored through his sculpture.

By reminding us of the role of the human body to make sense of the world and achieve understanding, while also exploring human experience in a universalised way, Gormley's sculptures offer a message of human continuity and help visitors to connect to the peoples of the past without prejudices or stereotypical ideas.

6.3 Artistic Discourse within the Museum: The Artist's Perspective for Immediacy and Materiality

Throughout the 1990s there was an increased interest in the artist as a catalyst for artistic discourse within the museum. The museum environment has been criticised for having much too rigid a structure and one that was seen as 'out of touch' with the world, most specifically, the world of experience. James Putnam cites, in '*Art and Artifact: The Museum as Medium'* (2001), as many as 145 museum-oriented art projects within the 1990s compared to 48 from the whole of the previous twenty years.

Putnam argues that artists started visualising the museum as an ideal location for site-specific practices at a point when they began to reject the 'white cube' sterility of institutional spaces. This 'institutional critique' trend was also influenced by the writings of the French philosophers Roland Barthes and Michael Foucault, and motivated artists to consider the conventional museum as a place for social and cultural debate (Putnam, 2001) and(Dorsett, 2009). He also identifies in artists an urge for the construction of meaning through working with objects, in the manner of a curator, by means of juxtaposition and context.

The effect of having a contemporary artist as a curator can be analysed through Andy Warhol's exhibition at the Rhode Island School of Design's Museum of Art in 1969. It started with the idea that a renowned artist digging through the museum's vaults could excite curiosity and attract a wealth of visitors. Contrary to expectation Warhol's artistic decisions put the museum's conventions under strain by challenging the very notions of curation, expertise and connoisseurship. One instance, he chose to exhibit the entire reserve collection of shoes in their storage cabinets, duplications and inferior pieces included.

Warhol's rejection of the calculated order of the modern museum facilitated a new perspective into the collecting of artefacts and it did so by bringing audience and museum staff alike to consider those pairs of shoes not individually but as a whole. In addition, the sheer accumulation of items brought to the exhibition a physical immediacy and a materiality that would have been very difficult to convey in an orthodox museum presentation. It seems in fact that the possibility of conveying anything other than abstracts of information in textual form is a peculiarly museological problem (Dorsett, 2009).

6.4 Exhibition Venue: The Petrie Museum of Egyptian Archaeology

Following on the previous argument, my research exhibition was conceived within the notion of the museum as a place for social and cultural debate, and also it would create an opportunity for contemporary sculpture to communicate to archaeology. The exhibition would therefore be ideally placed within an Egyptian archaeological collection, with the intention of creating a dialogue between the ancient and new.

The Petrie Museum of Egyptian Archaeology in London presented an ideal venue for this installation. The collection has a wide variety of ancient Egyptian faience artefacts. It includes beads, amulets, figures and vessels, in addition to significant materials related to the technology and the production of faience objects.

In addition, the Petrie Museum's collection has provided a fundamental reference-source for this research project. A proposal was therefore presented to the curator of the collection and the museum's management and they kindly agreed to allow the use of the museum as a venue for my exhibition. The Museum galleries will be used to display both the results of my research and the created artwork in a close proximity to ancient objects.

The significance of this choice of venue issues from the nature of the work, both conceptually and technically. It would encourage the audience to question ancient and modern perspectives in several areas of thought and behaviour, from belief and consumerism to the search for freedom.

In addition, the revival of an ancient craft technology would bring forward issues concerning creativity and innovation, while its placement, or perhaps *dis*-placement in a modern context, and its juxtaposition against its venerable parallels, would highlight questions around acquisition, discard and commodity fetishism.

6.5 *Nu-shabti* Installation and Research Dissemination

The large-scale *djed*-pillar, which was made of faience for this exhibition, as a parallel commentary on the *was*-sceptre of Amenhotep II (see Chapter 5), will form the centre-piece of the exhibition.

In addition, a large number of *Nu-Shabtis* will be displayed in selected spaces around the galleries, as groups, and also as individuals or couples, seemingly performing a variety of actions. In addition, individual *Nu-Shabtis* will be placed among the permanent displays of the museum, alongside, and in conversation with the ancient artefacts within the collection.

Regarding the dissemination of the research on Egyptian faience, I will design a number of posters, describing faience-making procedures and analytical research, and which will be put on display in the main gallery. Furthermore, the experimental test samples, moulds and other related technical materials will also be arranged in a display unit in the main gallery for the audience's appreciation.

To allow for a complete experience for the visitors, I have produced a video demonstrating the various stages of faience-making, which will be played on a permanent screen in the main gallery. This will be joined by a series of events, such as a seminar, a gallery talk, a faience-making workshop, and an opening evening reception, to create a maximum of interaction and to allow for that meaningful exposure to the human past that I have referred to above and which is the goal of the archaeological museum.

7 Conclusion

7.1 Summary of the research

This research presented a significant opportunity to explore an ancient craft technology and experience some of the challenges that faced the ancient craftsmen. Egyptian faience was very common in the ancient world from the Indus valley, in the east, through Mesopotamia and Egypt and on to the rest of the Mediterranean region to the west. Its use spanned over five thousand years from the early fifth millennium to the Late Roman Period. The advantages of using the faience material lay in its simple raw materials and its brilliant and colourful finish. However the physical properties of faience limited the craftsmen with regard to the shape and size of their objects. These limitations were also reflected in their function; that is they produced mainly beads, amulets and jewellery, small figures and vessels, tiles and inlays for architectural purposes. Therefore the focus of this study was on the working properties of the faience paste, which, unlike clay, has minimal plasticity and a tendency to slump and crack during shaping. This friable nature and the poor workability of the faience paste presented a major challenge to ancient craftsmen and we have only a few rare examples of large objects, such as the *was*-sceptre of Amenhotep II, the lion statues from Qantir and some fragments in various collections.

The research questions for this project were established at the start of the study, with the first aim being to identify the formation methods and the finishing processes related to the manufacture of faience objects throughout the different historical periods. This involved a comprehensive survey of faience objects in UK museums. Second was to examine the role of the raw materials themselves, the technological choices made in their adoption, and their influence on the fired faience products. Third was to explore the application of faience in sculptural work and to discuss the advantages and limitations of working with such an unusual ceramic material.

A multi-faceted approach was adopted to answer these research questions. This included artefacts study, experimental archaeology and archaeometry, as well as the creation of practical work that was designed to build on these investigations in order to create an ambitious and contemporary sculptural installation.

In chapter two, published evidence on the faience material and its raw materials was explored by surveying the archaeological literature. This information was reinforced by a thorough study of the Egyptian faience collections of several museums in the United Kingdom. Close examination of these surviving faience pieces provided considerable evidence for their means of manufacture. A faience artefacts typology was also created based on form and function. However, due to the limited framework of this research, this typology was not all-inclusive and focused mainly on objects related to the research question. However future studies could expand this typology to include some extra categories. A selection of artefacts studied in this research was listed here to highlight some of the range of forming methods used in faience production. Chapter three displays the results of the extensive experimental and analytical work, devised to understand the material in its finest detail. It lists the test samples in addition to the related analytical studies of their backscattered SEM images. A systematic series of Egyptian faience replica samples was created to test separately the role of each of the raw materials in Egyptian faience's common ingredients, and to understand how they influenced the body and the glaze. The samples' cross sections were studied under a scanning electron microscope. These results supply us with important information on the microstructure of the samples and the chemistry of the glaze-formation. As a result, it was possible to establish that the addition of minor amounts of clay provided a significant boost to the paste's workability without causing obvious changes to the faience's microstructure. Other experiments explored the effects of variation in silica's particle-size on the workability of the faience paste. This also proved to be successful and informative, and supported the evidence of layering of different qualities of pastes in ancient objects, which was widely practiced for the more elaborate artefacts.

The ethno-archaeological study is reported in chapter four. This concerned fieldwork in Iran that managed to observe and document one of the last traditional workshops operating in the region that is still using faience for the production of beads and small ornaments. This study provided an opportunity to explore a rare method of faience production within the context of a traditional workshop. It was noticed in this study, when compared to the descriptions provided by Wulff et. al (1968), that in recent decades a major shift in faience production has occurred. This has involved introducing alternative materials to those used traditionally and also adopting new making techniques in order to reduce costs and labour. The group of samples collected at the site were analysed using a Scanning Electron Microscope with an Energy Dispersive Spectrometer (SEM-EDS), which helped to shed light on this archaic technology. A further study could be designed to investigate this shift in technology, as a case study of factors that influence the appearance, development or disappearance of a traditional craft.

Chapter five introduces the historical background to the practical work and then brings together the results of the various studies in this research in order to disseminate the findings in an integrated way. This will take the form of a final artwork that will embody both the material discoveries and the understandings of faience-manufacture that are at the heart of this subject.

The experimental work was a significant tool in exploring the technological process of making ancient faience objects; it also puts to the test the validation of our theoretical research.

7.2 Contribution to knowledge

Egyptian faience is a well-researched subject but this project allowed me to bring the perspectives and experiences of a sculptor and ceramist to its study. The existing literature is largely art historical or microstructural, with rather less emphasis on raw materials and manufacture. Comprehensive replication experiments, as used in this research, needed a background in practical ceramic manufacture and the facilities of a ceramics workshop. The ceramics department of the University of Westminster, where I was based for this study, provided mixing, making and drying space, kilns and specialised drying environments. These dedicated facilities were also essential for the large-scale production of faience needed for the museum installation that provided the practice element of the research degree. In addition to these workshop facilities, my earlier studies at UCL, in the Department of Archaeology had given me an awareness of the potential of electron microscope studies of ceramics. A continuing association with UCL allowed me exploit these possibilities in imaging and understanding the multitude of practical tests generated throughout the project.

Because of this particular combination of professional ceramic practice and microstructural observation, it was possible to devise a series of fundamental experiments in faience raw materials that gradually constructed an image of how Egyptian faience operated as a ceramic material, and from this to devise an ideal faience body, suitable for very large scale production.

The application of the faience material to very large-scale moulding (creating the *djed*-pillar) needed even more advanced facilities than those at Harrow (University of Westminster) and these were generously provided by EKWC in the Netherlands. In particular computer generated models and cutting equipment were used here to create giant styroform moulds to a specific design. It proved practical to mould faience directly into these moulds, and to build up a single two-metre faience pillar as a centrepiece of the Petrie exhibition.

A similar combination of ceramic making experience and microstructural study also proved valuable in understanding the methods and materials used in a rare surviving faience workshop that I visited in Iran, and studied in detail for this project. It was possible to see here not only a survival of faience-making, but also evolving practices that made use of industrial raw materials and firing methods.

In brief, the contribution to knowledge has been made possible by this two-fold approach to the research questions: namely using the experiences of a trained artist and ceramist and the potentials of scientific investigation. These have allowed a fundamental study of the faience material, insights into a rare surviving faience workshop in Iran and the creation of a sculptural exhibition made from faience that has used the material on a scale unseen for many millennia.

7.3 Future scope

The accumulated data for this study of faience objects could be used to create a reference catalogue postulating the various forming and glazing techniques employed. Such a reference catalogue is absent from our libraries and could be used in both archaeological studies and ceramic practice. The survey of faience objects in the UK that helped to inform this work could also be extended to museums beyond the UK and the typologies further refined and expanded. The combination of reconstructive archaeology and microstructural study has proved a valuable approach to understanding the faience material, but the addition of a third element to this work, namely the use of an ancient technology in modern sculptural practice, has great potential in its own right. The present work has laid the foundations for such an informed use of an ancient and widespread technology that had almost disappeared from the world, as an inspirational material for the use of contemporary artists.

Appendix I

Technical Information - Materials

		TYPICAL % ANALYSIS								
PRODUCT	MATERIAL	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Others	
1273WAD	N6 Fireclay	54.20	1.25	29.30	2.10	0.27	1.06	0.09	2.94	8.53	Loss
3401	Alumina Hydrate			56.00						44.00	Loss
3402	Barium Carbonate										
3403	Basalt	48.60	1.60	14.10	11.20	7.90	10.30	2.40	6.00	0.10	MnO
3406	ESVA	50.20	1.00	32.50	1.00	0.20	0.30	0.30	2.00	12.50	Loss
3407	Hyplas 71	71.00	1.60	19.00	0.70	0.10	0.40	0.30	1.70	5.50	Loss
3408	HV	62.70	1.50	24.80	0.90	0.20	0.30	0.30	2.30	7.10	Loss
3409	Hymod AT	52.00	1.00	30.00	2.60	0.30	0.60	0.40	3.10	9.20	Loss
3412	Bone Ash										
3413	Calcium Chloride										
3416	China Clay	46.60	0.07	38.30	0.38	0.33	0.25	0.30	0.68		
3418	Colemanite	4.50		0.10	0.04	26.00	2.00			44.00	B_2O_3
34191	Potclays Stone	72.90	0.02	14.93	0.13	2.06	0.09	4.00	3.81		
3421	Cryolite										
34242	Dolomite	0.73		0.06	1.25	31.25	19.88			46.00	Loss
3426	Feldspar Potash	72.30		15.00	0.12	0.15	0.15	2.13	9.30	0.40	Loss
3427M	Feldspar Soda	69.50		18.50	0.14	0.15	0.15	8.10	2.50	0.40	Loss
3428	FFF Feldspar	66.80		19.00	0.12	0.30	0.10	5.00	8.40		
3431M	Flint	98.00									
3432	Fluorspar	2.00				2.00				93.00	CaF_2
3440	Magnesite	2.80			0.20	0.80	93.60				
3449	Nepheline Syenite	60.70		23.40	0.07	0.70	0.10	9.80	4.60		
3452	Quartz	98.00		0.80	0.07						
3454	Rutile	0.80	95.20		0.80					0.90	ZrO_2
3458	Soda Ash		0.80	0.07	0.07						
3461	Sodium Silicate										
34661	Talc	51.80	0.28	7.10	1.66	0.21	32.16				
3467	Tin Oxide										
3470	Whiting	0.20			0.03	55.60	0.14			43.70	Loss
3474	Zinc Oxide										
3476	Zircon	36.00	0.20		0.60	0.30				63.00	ZrO_2

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