Faience: the ceramic technology of ancient Egypt

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The term "faience" is commonly referred to a glazed earthenware, the use of which spread in Europe during the Renaissance from France and Italy [1]. The term was derived from Faenza, the town in Italy, where the glazed earthenware was mainly produced. The other name often used for this earthenware is "majolica". Majolica itself had a long tradition in the North African and Near East Islamic production of ceramic. In the 19th century, European archaeologists used the misleading name of "Egyptian faience" to designate the siliceous ceramics produced in the ancient Egypt. The ancient faience was a completely different material created to imitate the gloss and colour of gems and precious stones. This material started to be used in jewellery in Egypt and the Near East, about the fourth millennium BC [2], that is, during the predynastic age.

Probably invented in Egypt, this material was traded during the Bronze Age, as demonstrated by the faience objects that have been found throughout the Bronze Age Mediterranean archaeological sites. Together with glass ingots, faiences have been recovered from the Uluburun shipwreck of 1300 BC, off the Turkish coast [3]. Ref.3 presents the results of elemental analyses of some deep blue and turquoise glass ingots from this shipwreck, showing that their composition is consistent with an Egyptian origin.

It seems that the production of faience was older than that of glass, with which has in common the same raw material. Ancient faience was made by grinding quartz or sand crystals and mixing them with various percentages of sodium, potassium, calcium, magnesium and, sometimes, copper oxides. Adding water creates a faience paste; this paste is then shaped by hand in small objects, or poured into a mould. The objects were exposed to heat. During the heating, the faiences created their own glaze, a thin hard layer of various glossy colours, depending on the particular recipe used for preparing the paste.

Several researches who studied the Egyptian faience technology indicate that its recipe changed over time and from place to place. Some of the changes involved the use of soda-rich ashes derived from halophytic plants as flux additives (flux helps the materials to fuse at a lower temperature). Around the beginning of the first millennium BC, the ashes were replaced by the natural evaporite, natron, which was the flux used in the glass production. Besides the changes of composition, also the techniques used in the production changed [4−6].

As previously told, the mixture of the faience could have copper oxides. The addition of copper produced the turquoise colours of faience. The addition of manganese gives the black or purple colour. Around the beginning of glass production, during the second millennium BC, other colours were created [7]. Using cobalt the Egyptian obtained the blue colour, and with the addition of lead antimonite, the yellow. When glazed with blue-green hues, the faience was considered as substitute for blue-green precious materials such as the turquoise from the Sinai peninsula, and the lapis lazuli from Afghanistan. It seems from a funerary papyrus, that its owner Quennou, had the title of director of faience-making, and that for "faience" was used the word which strictly means lapis lazuli [8,9]. Usually, an ancient Egyptian knew the faience as "tjehnet" which meant "brilliant" or "dazzling", that is, shining with light. The symbolism embedded in blue glazing could recall both the Nile and the

waters of heavens, whereas green could possibly evoke images of vegetation, that is of regeneration and rebirth.
The objects created with faience were amulets, beads, rings, scarabs, even beautiful bowls, and the funerary figurines known as shabtis (see some examples in Fig.1-5).
Sometimes faience is considered as one of the earliest forms of glass making, and archaeologists suppose that faience, frit and glass were all made in the same workshop complexes. This was deduced from the marked similarity of the composition of faience and contemporary glasses. However, the technology of producing glass and faience is quite different. Let us briefly discuss the working of this ceramic, which is defined as the first human "high-tech" product [9]. Faience, in fact, is an artificial medium as our contemporary ceramic materials. It is better to remark once more that it is a non-clay based mixture, composed of crushed quartz and small amounts of calcite, lime and alkalis. The faience mixture is thixotropic as the clay, but it is a difficult material to hold a shape. If pressed too vigorously, this material cracks, due to a limited plastic deformation. Therefore, to help the wet working performance, the use of some binding agents have been proposed, for instance clay, egg white, Arabic gum or resin. However, modern experiments to reproduce the faience, seems to indicate just the use of alkalis as binders, in the form of natron or plant ash [6]. Moreover, pulverized glass or sintered material of similar composition could enhance the fired strength of faience bodies.
Three methods have been hypothesized to shape the body of faience objects: modelling, moulding and abrasion. The last method was used in conjunction with the first two. Modelling was probably the first technique used, as we can see from the predynastic bead manufacture, which is closer to the stone working than to the glass production. In these manufactures, the faience is modelled, probably by hand, and then holes are drilled to create beads [10]. Moulding is the process of manufacturing by shaping the faience paste using a rigid frame.
Quite interesting are the glazing technologies employed to obtain the lustre. The glazing of a siliceous body employs various methods. Among them, the main three methods are application, efflorescence and cementation. Application glazing has been the most common glazing method in ceramic technology. The procedure is the following: a mixture of small particles of silica, lime and alkalis are mixed in water to form a slurry [10,11]. This slurry is brushed on the object to glaze, or the object is dipped in it. A coating of fine powders is then created on it [12]. The use of this technique is evidenced by the presence of brush markers, drips and glaze running lines [13]. Of course, painting is the method used ot have the decoration of the faience object. The second glazing technique is the efflorescence. This is an interesting self-glazing process: the glazing materials, which are water-soluble alkali salts, are mixed with the particles of quartz of the core object [5]. Water evaporates and then the salts migrate from the body to the surface of the object. On surface, the salts crystallize, creating a thin superficial layer that glazes upon firing [8].
As discussed in [13], the cementation method is another self-glazing technique. After the object has been formed and dried, it is buried in a glazing mixture (the cement) consisting of alkalis, copper compounds, calcium oxide or hydroxide, and/or quartz. Upon firing, at about 1000 °C, a glaze layer is formed on the faience surface, and, around the object, a capsule. In this method, the alkalis and copper vaporisation are crucial to the glaze formation. After firing, the cementation mixture can be crumbled away from the object, which is now coated with glaze (Fig.6, and see also Figure 2 of Ref.13). Cementation glazing was appropriate for small objects such as beads.

Reference 13 is proposing a detailed discussion of some mechanisms of glazing. One is the Interface Glazing Mechanism (IGM). IGM involves the diffusion and migration of alkalis from the glazing powder to the siliceous faience body. There is therefore the production of a glass phase covering the object and a penetration into the bulk, which produces the buffer layer and some glass between the grains of quartz of the bulk (see Fig.7). This mechanism depends on the direct contact between the glazing powder and the surfaces of siliceous objects. Moreover, it operates exclusively at the interfaces, as its name indicates. To characterize this mechanism, Ref.13 uses three major parameters: the object appearance, the microstructure and the glass phase composition. For what concerns the object appearance, the glaze coatings on the objects glazed are typically white or whitish blue. The microstructure of the glaze has a thickness, which is moderately thin. The glass phase compositions have essentially a high concentration of alkalis and a low concentration of copper. A comparison between the glaze, the buffer layer – that is the region between the glaze and the bulk - and the interparticle glasses reveals a decrease in copper content from the glaze layer to the bulk.
There is another technique, to produce the glaze and it is the vapour glazing, based on the vaporization of salts. That is, the salts are transported as vapours through the enveloping powder to the quartz body. Ref.13 calls it the Chlorides Glazing Mechanism (CGM), based on the vaporisation of alkali chlorides. This mechanism plays a leading role in giving the faience objects with copper green-blue hues. As compared to objects glazed by the IGM-mechanism, the mechanical strength of objects glazed by CGM is considerably lower, and therefore they break easily. The microstructure of the body shows minimal interparticle glass. For what concerns the glass phase composition, in contrast to the objects glazed by the IGM-mechanism, the glass phases present in the glazes produced by the CGM mechanism are of the low alkalis-high copper type [13].
As discussed in Ref.13, the macro-photography or the use of a microscope can tell some markers of the employed glazing technology. The use of Scanning Electron Microscope (SEM) is able to distinguish the glass phase from the texture of the grains, having therefore information on the thickness of the glaze and of the buffer layer. Of course, we need some cross-sections of the material, turning this analysis in a destructive analysis. A non-invasive quite interesting analysis can be performed using the Raman spectroscopy, where a laser light interacts with molecular vibrations, reticular and other excitations of the material. This interaction shifts the energy of the laser photons. Therefore, the Raman spectroscopy, as the Infrared spectroscopy, provides information on the vibrational modes in the material.
In the Raman analysis, a sample is illuminated with a laser beam. Scattered light from the laser spot is collected and the wavelengths close to the laser line removed to analyse only the light with shifted energy. Among the first results on faiences obtained using the Raman data, we have those proposed in Ref.14. The researchers studied the coloured glazed Egyptian faiences to evaluate the effectiveness of Raman microscopy as a tool for archaeometric analysis. They concluded that Raman microscopy was extremely effective for the analysis of red and yellow faience, but no so good for the analysis of green-blue faience.
After these first analyses, FT-Raman spectroscopy and visible Raman microscopy turned out to be important non-destructive tools to investigate pigments. For instance, the specimens excavated from Tell el Amarna by Flinders Petrie in the 1890s, have been studies by Raman techniques, providing information about the chemical composition of the materials used by XVIIIth Dynasty artists at the time of King Akhenaten [15]. Moreover, as discussed in [16] where the Raman spectroscopy is used for the Roman Age mosaic glass tesserae, in the case of glasses the Raman technique is useful to study the surface weathering. It is remarkable that

the researchers were able to determine if a sample were original or a modern restoration [16]. As a conclusion, we can tell that the Raman spectroscopy, besides being important for pigments identification, can have a relevant role in the determination of fake faiences too.

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Figures

Fig.1: Amulets representing the Eye of Horus, Egyptian Museum, Turin.

Fig.2: Faience bowls blue-glazed and decorated. One of the bowl, besides the decoration with lotus flowers and blossoms has two symmetric faces of the goddess Hathor. The decoration is therefore a symbol of rebirth. Unknown origin. New Kingdom, dynasty XVIII-XX (1350-1070 B.C.). Egyptian Museum, Turin.

Fig.3: Faience bowl decorated with lotus flowers and blossoms from the Kha's Tomb. Egyptian Museum, Turin.

Fig.4: Magnificent bowl of blue faience, unknown origin, decorated with lotus flowers and fishes. First period of XVIII, Dynasty (XV century BC), Berlin, Aegyptisches Museum und Papyrussammling.

Fig.5: Funerary figurines known as shabtis of Sety I, from the Valley of the Kings, XIX Dynasty, Egyptian Museum, Turin.

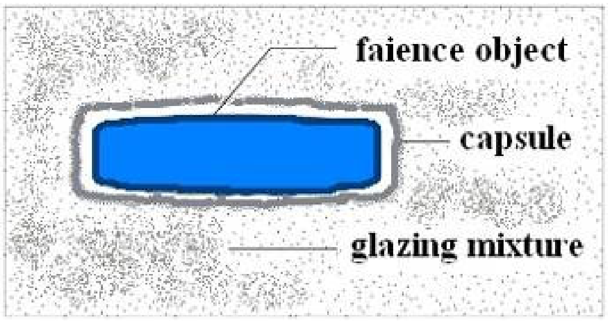

Fig.6: In the cementation method, the object is formed and dried. Then, it is buried in a glazing mixture (the cement) consisting of alkalis, copper compounds, calcium oxide or hydroxide, and/or quartz [13]. Upon firing, at about 1000 °C, a glaze layer is formed on the faience surface, and, around the object, a capsule. After firing, the cementation mixture can be crumbled away from the object, which is now coated with glaze.

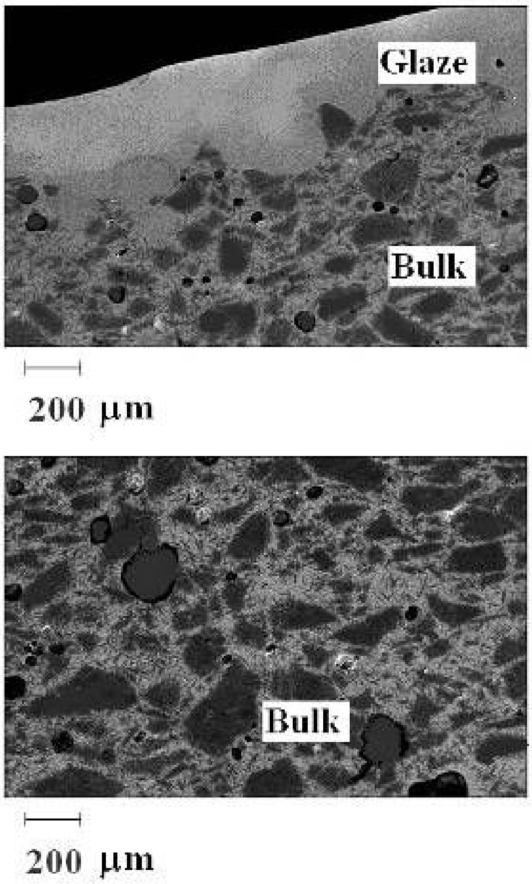

Fig.7: Two qualitative examples of how could appear some cross-sections, near the surface and in the bulk, of faience as observed by means of a Scanning Electron Microscope. The surface is covered by the glaze, which is glass (grey). In the bulk, we can see the grains of quartz (dark grey) and, among them the glass gluing together these particles. To see real SEM images, please look at Ref.13.