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Original article

EFFECT OF INTERNAL STRUCTURE AND BURIAL ENVIRONMENTAL CONDITIONS ON EGYPTIAN NETTED FAIENCE BEADS DEGRADATION

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Abstract:
This study aims to identifying the faience beads that were used on archaeological mummies by identifying damage that appear on these beads, studying the surface changes and appearance of these beads, as well as identifying their chemical composition of the martial beads, used in its manufacture and the chemical changes that have occurred over time by using examination methods. also, the properties of samples of faience were examined using a Scanning Electron Microscopy (SEM) attached with EDX, USB Digital Microscope, X-Ray diffraction and Fourier Transform Infra-red (FTIR) analysis. Also, one of the objectives is to explore how the materials and techniques used in the manufacture of faience affect its deterioration. Moreover, since the cracks indicate the crystallization of soluble salts, this research is confirming the attendance of soluble salts. Also, by reviewing the FTIR spectrum it was found that they were consistent with the results of XRD and EDX examines.

1. Introduction

The use of beads to create Necklace has been prevalent since the time of ancient Egypt. In less typical instances, beads were made into netted mummy wraps, netted gowns, and decorative shrouds for clothing. Each of these objects has been found in storage boxes or on top of wrapped bodies in the tombs of royals and other high-status persons, who made up a small minority in ancient Egyptian society. Mummy wraps from the Third Intermediate, Late, and Early Ptolemaic Periods seem to have been a special element of those graves, fig. (1).

Figure (1) different kind of objects made of faience beads; **a.** Greco-Roman blue faience necklace (*Museum of the Faculty of Archeology Cairo*). This is the same type and shape as the faience beads that were used in the Netted Beads on the mummy, **b.** a wide collar of colorful faience, carefully crafted using beads that are reduced in length to form a curved shape (*Museum of Civilization -Cairo, Egypt*), **c.** string of faience beads, Lipscombe collection (*Garstang Museum*), **d.** face of faience beads - late period of ancient Egypt; Made of colorful faience beads (*Nubian Museum Aswan Egypt*).

In order to preserve the decoration faience, whether it is decorative pieces, necklaces, a net on the mummy, or its use for various purposes in ancient Egypt, it is necessary to constantly identify and study the pieces so that we can know the extent of the weakness of the material and the reasons that lead to deterioration. The ancient Egyptian Faience was referred to as "tjehnet," which translates to "brilliant" or "dazzling," and was believed to gleam with light as a representation of life and eternity. An additional term, "khesbedj," denoted blue and could potentially refer to lapis lazuli; it was subsequently used to refer to faience in the New Kingdom. Ancient Egyptian faience manufacture appears to illustrate a historical market conundrum as it defies such a dichotomy: Faience, which is composed of inexpensive and ordinary materials, is widely utilised by the wealthiest and lower classes of society nonetheless [1]. The term Egyptian faience in the present context refers to a ground-quartz body with alkaline glaze which first produced in Egypt, Early Egyptian samples of faience date to the middle Predynastic period's Naqada I era (4000–3500 BC) it was first employed in the early fourth century B.C. and is still in use today in the Near East for the manufacture of tiny items including bowls, beads, rings, bracelets, and tiny figures [2]. the beaded covering was one of the decorations with which the mummy was ornamented next wrapping it in linen wraps. It was placed on top of the mummy wrappings and was made of hollow tubular faience beads, involving of faience material knotted collected in a net pattern, fig. (2).

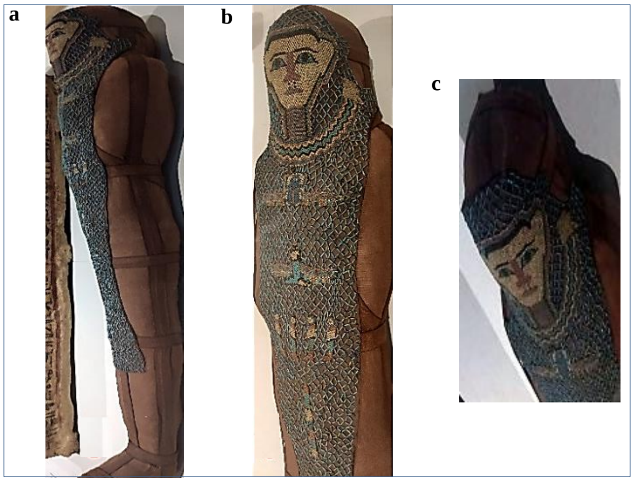

Figure (2) netted beads - late period of ancient Egyptian in Nubian Museum - Aswan, Egypt; **a.** a side of the mummy covered by the netted faience, **b.** front of the netted faience on the mummy's body, **c.** the netted faience covering the mummy's face.

During the first phase of Greek rule in Egypt, which officeially marks the beginning of the Ptolemaic period, the practice of providing the departed with a bead net persisted, fig. (3-a). Type No. 1: the body is covered with net from the shoulders to the ankles. Type No. 2: from the shoulders to the ankles, the body is covered with a net. Type No. 3: the entire body is covered with net. Amulets, beads, and shabtis (mummiform servant figures) are examples of little figurines that are mass-produced using moulds; in certain situations, these items are personalized for the departed [3]. Ancient Egyptian faience was made without purposefully adding clay, according to analysis; but, in later periods, minute amounts of clay were added to the crushed quartz matrix to make it more practical. The making process did not require complex techniques because the main component is silica, the greenish-blue color is produced by copper oxide, and the quartz grains are held together by the addition of lime and alkali flux or soda. The figure is then dried and fired in a kiln after it has been formed dried. After combining the dry ingredients with water, the mixture is shaped into the required shape. One can tell the difference between clay and faience paste as soon as the paste is wet. The body's alkaline salts rise to the top when the paste dries, forming an effloresced crust. This layer combines with the lime, copper oxide, and quartz during burning to make a glaze. Egyptian faience is composed of crushed quartz or sand, lime, and ash or natron, which is a mineral composed of hydrated sodium salts that may be found in dried marsh. The soda-lime-silica glaze that covers the quartz body is often created by adding copper oxide, giving it a vivid blue or greenish hue. One can distinguish between the object's outside glaze layer and its interior core substance, also referred to as the "body." Silica (SiO_2), which was easily attainable in the Egyptian desert, makes up to 99% of the body [4]. There are several documented faience formulas, and variations in faience composition are expected. nonetheless, the generally spoken mass composition is: Silicon dioxide (SiO_2) 92: 99 % - 1: 5 percent lime (CaO) "Soda" (Na_2O): 0.5 percent Small amounts of copper oxide (CuO), magnesium oxide (MgO), potassium oxide (K_2O), aluminum oxide (Al_2O_3), and traces of other elements may be added to this combination [5]. There are two types of the glazed layer, First, lead one: second, alkaline glaze. Silica, calcium oxide, sodium oxide, and trace amounts of copper, aluminum, titanium, and magnesium oxides were used to create the alkaline glaze. Egypt utilized this kind of glazing from the pre-dynastic era (3050 B.C.) to the Roman era (30 B.C.). On the other hand, lead oxide, silica, aluminum oxide, and minute quantities of sodium, potassium, and magnesium oxides were used to make the lead glaze [6]. It is well acknowledged that three distinct glazing procedures may be used to create faience: efflorescence, cementation, and direct application [7]. The efflorescence technique first emerged in the Late Predynastic and Early Dynastic eras (c. 3000-2686 BCE). The application method is the initial technique and emerges last, during the Second Intermediate period (c. 1650-1550 BCE). The cementation method arrives later, in the mid-Middle Kingdom (c. 1985-1650 BCE), fig. (3-b). The application process includes applying a slurry—a mixture of water, silica, and alkalis—on the quartz body before it dries and fires to a temperature of around 950°C [8]. Efflorescence is the second method; Egyptian blue is made by a special process in which quartz particles are blended with alkali salts, and the alkali move from the water's surface to its core when the water evaporates. The piece was burned to generate a crystalline network of salt and a thin coating of glaze; cementation is the third procedure. a coating of glazing powder that, when burned to around 1000°C, partly melts [9]. Following the fire process, the glazing mixture separates off the now-glazed porcelain items [10]. The beads would have been created using one of two techniques: modelling or moulding. When using the modelling method to make beads, the paste is manually rolled while the material is still wet to create the appropriate form and size [11]. If a ball bead was the intended shape, the material would next be punctured with a sharp object while it was still wet or somewhat dried [12]. If the bead had been lengthy and cylindrical or tubular, it may have been created by rolling the faience paste over a reed, which would burn out during burning and leave a flawless hole. Molding is the second bead-forming technique that gained popularity in the New Kingdom and may also be used to create pendant-style beads. After the paste was ready, it was put into a mould and allowed to cure. This technique might be used to make beads with intricate designs and forms. After that, the beads would be drilled or punctured to make the hole [13]. The chemical composition and internal components of the faience play an important role in the deterioration process, and the nature of this material, being a glazing material, is quickly affected by various environmental factors. The susceptibility of faience is related to production materials and methods, including the three different glazing methods. Properties such as the thickness of the glass layer, the nature of the boundaries among the response layer and the base material, the attendance or absence of glass between the elements in the body and the weight concentration of copper throughout the microscopic structure of the faience are studied. Cracks in the glaze, which may have formed during the manufacture process, make the fragile core weak to external influences and thus more susceptible to deterioration. The pieces contain a hard core and a thin glass layer and are therefore relatively weak. Different production procedures play a role in these variances in weak points. The knowledge increased about damage phenomena related to the production process can be relevant and significant for those dealing with faience conservation and restoration [14-17].

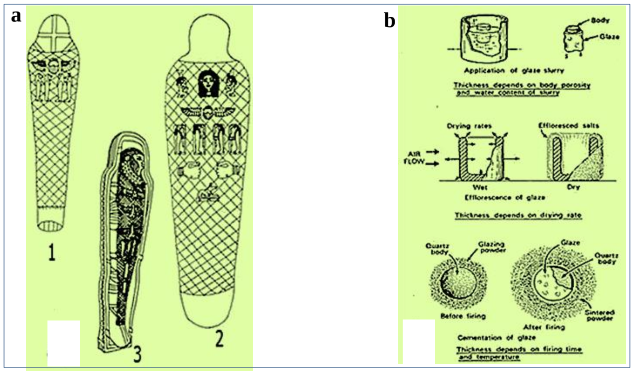

Figure (3) **a.** netted beads mummy covers types, type 1 (the body is covered with net from the shoulders to the ankles), type. 2 (from the shoulders to the ankles, the body is covered with a net) and type 3 (the entire body is covered with net), (*After: Spizzichino, 2022*), **b.** the three techniques of glazing faience that Vandiver explained (*After: Okkelberg, 2011*).

2. Materials and Methods

2.1. Samples collection

In this study some faience beads were collected which are the remains of some ancient Egyptian faience beads, were discovered at one of the archaeological sites in Egypt. These beads were used to cover mummies, and the number of these beads which used in this study is 14 beads. The beads are hollow cylinders with a length between 1.3 cm and 1.4 cm, an outside diameter is approximately 0.2 to 0.3 cm, these beads are also distinguished by their many shades of colour, which vary between light blue, greenish blue, and light green, fig. (4). To identify them, these beads were studied, examined, and analyzed.

Figure (4) photograph of a selection of Egyptian faience beads studied in this work.

Beads were made less often to create netted mummy wraps, netted gowns, and decorations on clothes or shrouds. Each of these objects has been found in storage boxes or on top of wrapped bodies in royal tombs. Quartz makes up the majority of the material used to create faience instead of clay. It was created by adding natron and water to crushed desert sand, which naturally includes some limestone, clay, and other mineral particles. The classic porous, white or greyish core of Egyptian faience was generated by firing this paste. The beads made of blue and blue green colors imitating lapis lazuli and turquoise. At other times, beads were sewn to the mummy in pattern like formations [18]. Faience is a silicate substance that is often blue-green in colour because to the presence of copper. It is made up of an alkali glaze and a body of small quartz particles [19]. The mummy wrappers are distinguished by the blue-green color of the beads and their grid arrangement. The color blue was thought to be a sign of life and renewal in the skies and seas. Likewise, green was a powerful symbol of resurrection and beaded was a representation of life. The data was gathered using the following strategies and tactics, which allowed the study to accomplish its objectives.

2.2. USB digital light microscope

A portable WIFI digital microscope model (*X001EZIICF*) with a 2.0 Megapixel image sensor and a 50-to 1000 X magnification, 1920*1080P capture resolution, and an LED illumination light source that could be adjusted with a control wheel were employed. It is simple to use and non-destructive. It offers a way to examine damage phenomena and deterioration characteristics that are not readily apparent to the unaided eye, such as micro cracks and voids, among other things.

2.3. Scanning electron microscopy (SEM) attached with EDX

A scanning electron microscope (SEM-EDX) *Model JEOL JSM 5400 LV EDX Link ISIS* – Oxford detector was used to examine ancient Egyptian faience beads. The materials were examined in high vacuum without coating at the Asyut Univ. SEM unit in Egypt.

2.4. X-ray diffraction (XRD) analysis

X-Ray diffraction analysis (XRD) was used to identify the mineralogical composition of the ancient Egyptian faience beads. XRD device with the following operation conditions was used: Diffractometer type: *Philips model pw1710*, Cu anode target, Cu Kα radiation ($\lambda = 1.5418$ Å) was used. The X-ray tube voltage is 40 K.v. and the current was 30 Ma. Using X-RAY diffraction powder materials put in holder, the sample is placed in an aluminum holder, pressed and then placed in the device. Analysis Program: Match Version 3.8.3.151.

2.5. Fourier transform infra-red (FTIR) analysis

Faience bead was characterized initially with using Fourier Transform Infrared spectrometry (FTIR). Sample powder was mixed with KBr (IR-grade) and pressed into a pellet using a press. Fourier Transform Infrared Spectrometer – Thermo Nicolet Is10 FTIR spectrometer (The resolution of the spectrometer is 0.4 cm^{-1}, and the spectral range is 4000 to 400 cm^{-1}). The samples were ground and mixed with KBr powder. Spectra were obtained in the transmission mode. This analysis was undertaken at Faculty of science, Asyut University, Egypt.

3. Results

3.1. USB digital light microscope

A digital microscope was used to observe. The pieces of faience, which aided identify the damage that is difficult to get by the naked eye. The examination of the faience beads using the portable optical light digital microscope revealed several characteristics of their deterioration, fig. (5). It showed the buildup of dirt and dust, as well as the numerous cavities, fractures, and glaze layer losses on the surface of the beads. The USB digital microscope revealed flaking and the existence of pores in certain areas of the glaze, along with other flaws like pinholes brought on by incorrect glaze layer manufacture also, surface irregularities, color changes, and manufacturing defects resulting from the silica not melting completely. The most frequent glazing layer efficiency is decreased by these pores, which are dispersed over the surface of the beads.

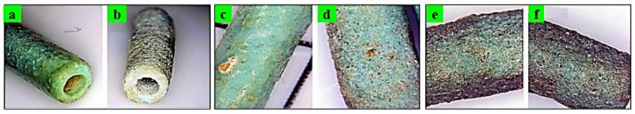

Figure (5) **a.** one of the faience tube in greenish blue colour, **b.** one of the faience tube in blue colour, c. cracks, **d.** loss of glazing layer, **e.** color changes, **f.** surface irregularities, 50-X.

3.2. *SEM-EDX*

Two samples from the faience tube surface examined and evaluated using EDX in conjunction with scanning electron microscopy. The bodily samples' SEM analysis showed a widespread distribution of holes and pores. in addition to the presence of salt crystallization which fragmented, Surface irregularities and damaged of the faience, Additionally, the SEM analysis of the faience beads revealed definite evidence of weathering, which led to the glaze's frequent disappearance and, as a result, the interaction layer's full or partial exposure. When the glazing is present, it typically exhibits a network of fissures that run parallel to the surface and show signs of severe weathering, fig. (6- a & b). The EDX analysis of the faience tube surface present in tab. (1). indicates that the faience contains three primary elements in the two EDX analysis for the first and second samples respectively are: silicon (SiO_2: 34.43%, 37.49%), sodium is (Na_2O 8.98%, 6.79% + K_2O 1.67%, 4.67%) and calcium (CaO 4.93%, 8.12%). Calcium, the primary source most likely comes from calcium carbonate, or limestone. As a result, calcium is a readily available element that can be used to make the foundation of faience. The production of faience depends on the presence of sodium. The EDX analysis indicates that the faience beads contain both K and Na. Nonetheless, the glaze's potash and soda levels were more than what was anticipated for natron. The presence amounts of copper (CuO 2.19%, 3.76%) refers to that the glazes in the faience beads are colored with copper, Turquoise, or blue colored glazes for faience, were obtained by adding metal parings or minerals containing copper, such as malachite. Many copper-colored faience objects contain a small amount of tin oxide, probably resulting from the use of oxidized bronze as a colorant [20]. Also, digital microscopic examination and EDX analysis showed that the faience beads are a single component that was made by Efflorescence. for this 'self-glazing' method, the components that form the faience body (quartz, lime and soluble alkali salts) were mixed with copper colorant compounds and water to form a paste [21]. As the faience paste was allowed to dry, the alkali salts moved to the top and created an outer layer that was efflorescent. This layer melted and combined with lime, quartz, and copper oxide during the burning process. resulting in a glazed surface. The efflorescent layer contains sodium and to a lesser degree potassium carbonates, chlorides and sulfates from the natron or plant ash.

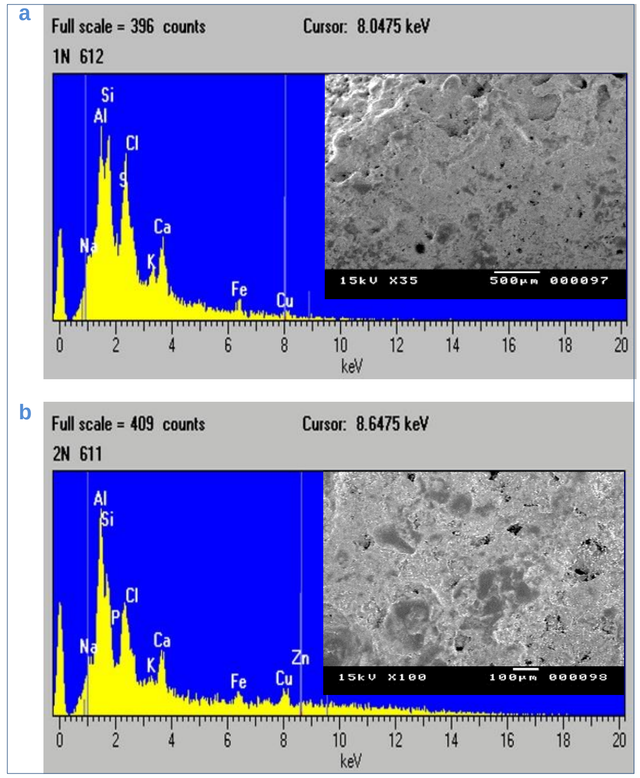

Figure (6) SEM photomicrographs & EDX patterns of the surface one of the faience beads **a.** sample 1, **b.** sample 2

Table (1) EDX composition in wt.% of the faience beads

Sample	Chemical composition (wt%) of the faience bead											
	Elements											
	SiO_2	Na_2O	CaO	K_2O	Al_2O_3	Fe_2O_3	CuO	SO_3	Cl	MgO	P_2O_5	**Total**
1	34.43	8.98	4.93	1.67	15.17	2.82	2.19	15.86	4.26	5.01	4.68	**100**
2	37.49	6.79	8.12	4.67	14.64	3.95	3.76	3.6	4.73	6.94	5.31	**100**

3.3. *XRD results*

XRD result of the sample shown in fig. (7), the faience bead consists of 30.9% quartz (SiO_2) as a major phase, 22.5% Cuprorivaite ($CaCuSi_4O_{10}$) a blue pigment, and 12.3% Calcite ($CaCO_3$), 13.1% atacamite, 0.2% paratacamite ($Cu_2Cl(OH)_3$), 20.5% Halite (NaCl) and 0.5% Calcium sulfate ($CaSO_4$), as minor phases as minor components. Egyptian sand is often rich in calcium carbonate ($CaCO_3$), which is why using it has caused the formation of a strong peak characteristic of the calcium carbonate [22].

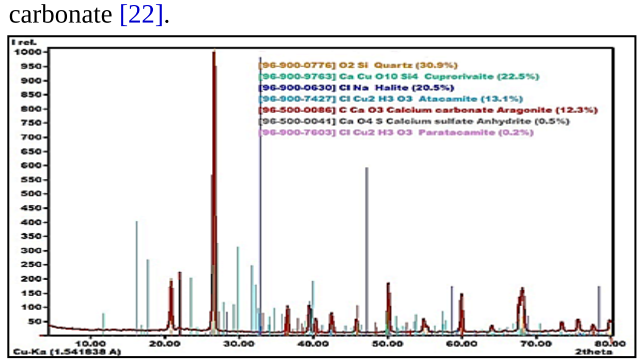

Figure (7) XRD patterns of faience bead.

3.4. *FTIR*

The faience bead was described via Fourier Transform Infrared Spectroscopy (FTIR), This allowed us to determine the main mineralogy and materials utilized in the manufacturing of beads. FTIR spectrum of the faience bead, fig. (8) shows the characteristic bands of crystalline order in the SiO_2 matrix at 1081.43 cm^{-1} (Si - O - Si stretching bands), 778.17 cm^{-1} (Si-O-Si bending bands) and at 467.19 cm^{-1} (Si - O - Si bending), Also, an inverted peak at 1081.43 cm^{-1} and 693.80 cm^{-1} corresponding to a peak at 667 cm^{-1} in the transmission spectrum for Egyptian blue (cuprorivaite) [23], while the absorption band in the area around 3439.08 cm^{-1} and 1635.41 cm^{-1} can be related to the stretching and bending vibrations of the HOH water molecule. The absorption bands in 693.80 cm^{-1} regions correspond to the typical absorption of Na-Cl. Additionally, the presence (and relative quantity) of quartz in the combination affects the bands' positions since FTIR reveals that bands for cuprorivaite and quartz overlap in these locations. The Egyptian blue transmission spectrum also shows an inverted peak at 693 cm^{-1}, along with a smaller inverted peak that is typical of quartz (778 cm^{-1}) [24].

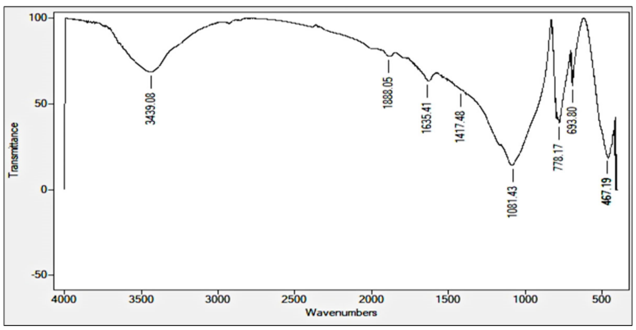

Figure (8) FTIR spectrum of the faience bead.

4. Discussion

Through the study, the USB microscope demonstrated the accumulation of dust and debris inside the tubes as well as on their outside, which caused the glazing layer to distort as a result of being buried in the earth. In addition, several cracks and a glazing layer loss were found, Also, Microscopic examination showed that the archaeological faience beads do not contain an inner core, which confirms that they were manufactured by the "efflorescence" method [25]. The efflorescence technique blends the glazing salts into the quartz body before it is moulded and fired; since the glazing salts are blended inside the core, this process produces vitrified material that is burnt and eventually becomes inter-particle glass inside the core [26]. Also, Glazes can change through two distinct processes when buried: uniform dissolving and selective leaching. First, water interacts with the glass to remove alkali components like potassium and sodium, creating a de-alkalized, silica-rich layer; second, the silicate network dissolves completely. A silica-rich gel-like layer forms as a result of selective leaching, which also encourages more glazes modification [27]. Faience objects may appear stable, Occasionally, this isn't the case. It is anticipated that variations in the microstructure brought about by the production process will affect mechanical vulnerability. The substance that makes up a bead often extremely brittle and prone to physical damage, to the point where handling the object is unsafe [28]. By studying EDX results, the results indicate that the concentration of quartz in the two samples was (SiO_2: 34.43%, 37.49%), which indicates that the maximum concentration of quartz is present in both samples. Sand is one of the primary raw materials used in the creation of faience, which helps to explain the silicon content. Given the abundance of sand in Egypt, silica is most likely the source of the high silicon content in the faience body. Additionally, quartz has been proposed as a possible source of the silicon content [29]. Presence of alumina (Al_2O_3 15.17%, 14.64%) shows the presence of aluminum silicates and quartz; the glaze's foundation suggests using quartz [30]. Additionally, the data' presence of Na and K indicates that plant ashes were frequently used in ancient Egypt in place of natron. Plant ashes high in potash are used to make faience in Egypt and the Near East. Natron is the most likely source of sodium (sodium carbonate and sodium bicarbonate compound). In Ancient Egypt, natron was a substance that was frequently utilized, most notably as an embalming salt for mummification [31]. Sodium was utilized as a flux for silica, reducing the melting point of silicon to create fluorescent materials, in the form of sodium carbonate [32]. Moreover, presence amounts of phosphates (P_2O_5 4.68%, 5.31%) is indicated using the large supply of phosphates and alkalis found in dung ash. This indicates that making faience using dung ash [33]. The two possible sources of the alkalis flux used to produce the faience glazes are the natural evaporite, natron, as well as the ashes from halophytic, salt-tolerant plants that flourish in desert, salt marsh, and coastal environments. The ratios obtained for sodium or potassium alkalis confirm the use of a mixture of both alkalis in the form of Na_2O+K_2O [34]. The Ancient Egyptians may have obtained copper from naturally occurring minerals including chrysocolla, a hydrated copper silicate, azurite, and malachite, a copper carbonate hydroxide. Moreover, it's possible that copper was extracted using cuprite (copper oxide). The EDX results and the percentages of the elements that were identified confirm that these beads date back to the Roman period in Egypt, between the time of the Roman Empire and the eighth and ninth century AD Most of the beads consist of soda-lime-silica glasses with minimal amounts of magnesia and potash. Significant concentrations of calcium oxide and alumina are further characteristics of this composition [35]. Because the faience beads are exposed to changing temperature conditions and/or contain soluble salts, the state of faience pieces is in jeopardy. Depending on the kind of salt, all soluble salts will deliquefy at a particular relative humidity level and reconstitute during drier times. Because the freshly created crystals press on the pore walls and take up more space than the salt solution, this process damages the pore walls. Salts that crystallize can damage faience by upsetting the glaze's surface. It is a primary cause of the faience colour changing phenomenon [36]. Additionally, the presence of calcium, magnesium, iron, sulphate, and sodium components suggest that water action caused the weathering process, where hydrogen ions (H^+) replaced the alkali ions (Na^+ and K^+). Moreover, hydrogen (H^+) ions eventually replace the alkali ions (Na^+ and K^+) that weather a faience surface, breaking down the glass network over time. As a result, the structure of silica glass disappears and is replaced by an amorphous layer called silica gel. Leaching out of both the colorants and the alkalis caused a change in the chemical composition of the surfaces of the faience beads. The colorants were deposited as fine amorphous or weakly crystalline compounds rather than as ions. Porous tiny beads may also degrade because soluble salts are found in the body, where they dissolve and re-crystallize. Contains the elements of chloride (Cl 4.26%, 4.73% and SO_3 15.86%, 3.6%) confirms that the alkaline compounds that leached from the faience's core to its surfaces, along with the crystallization of calcium sulphate or sodium chloride salt, were responsible for the degradation of the faience beads. During long-buried times, Chloride salts from groundwater can be absorbed by the worn regions of the glazing layer. As a result, the tested samples' chloride concentration rose. The chloride can be found as copper chloride inclusions in a variety of complex salts [37, 38]. Egyptian blue, a man-made pigment which used in the faience created by heating silica, copper alloy filings or copper ore like malachite, lime (calcium oxide), and an alkali like potash or natron $Na_2 CO_3.NaHCO_3.2H_2O$, was the main blue pigment used in ancient Egypt. The Egyptians never employed green fluorescent; rather, all green fluorescent found in Egyptian artefacts is the result of basic copper (II) chlorides being formed by the chemical breakdown of copper compounds [39]. The existence of water-soluble salts in combination with Egyptian blue is necessary for this colour change, as is the blue's capacity to discolor due to the presence of chlorides, which catalyze the decay process and cause bronze sickness. Following the elimination of copper and chlorine from the pigment layer, the blue pigments' colour changes to show precipitation from migrating solutions [40]. The hydroxide ion is replaced by the chloride ion to generate a soluble metal chloride that is hygroscopic. This process is particularly harmful when Egyptian blue cuprorivaite—a pigment material—is present, which is why the phenomena of Egyptian blue becoming green is known as "copper chloride cancer". XRD analysis verified the existence of calcium sulphate, which is produced by the chemical interaction between minerals (like calcite $CaCO_3$) and air pollutants (particularly SO_2). If salts precipitated below the surface material (a condition known as sub-florescence or crypto-florescence), it might cause serious damage [41,42]. The FTIR spectrum indicates whether the preparation contained unreacted silicates or quartz, or if there was merely cuprorivaite (Egyptian blue) and other trace amounts [43]. By studying the FTIR spectrum the typical bands of calcite have been observed at 1888 cm^{-1} (C = O stretching) and 1417 cm^{-1} (C = O stretching), as per the FTIR investigations. Based on the FTIR investigations, the bands at 467 cm^{-1} show the existence of an amorphous silicate phase originating from quartz, and there are the typical bands of calcite. The dominating bands are caused by the presence of silicates. It displays calcium sulphate bands at 1635 cm^{-1} and 3445 cm^{-1} for salts in the spectra as well [44, 45], Egyptian blue's infrared absorption spectrum is previously known from published research. It consists of two strong components at 1056 and 1008 cm^{-1}, two medium-intensity components at 664 and 484 cm^{-1}, and lesser intensity at 1230, 1160, 800, 755, 595, 521, and 420 cm^{-1}, A portion of them have been linked to Egyptian blue, but a specific proportion of quartz has also been identified with its distinctive doublet at 798 and 769 cm^{-1}; the strong band at 1100 cm^{-1} is obscured by the comparable band of the primary constituent, cuprorivaite [46,47]. These results findings agree with the results of the XRD and EDX analyses.

5. Conclusions

The faience, which the Egyptians named "tjehnet," refers to "dazzling" or "bright" and was prized for its shiny glassy surface. It is stated that its blue or green color was an affordable alternative to the mineral turquoise and lapis lazuli. Because the faience can be formed in moulds, it was widely produced. The first faience objects were small items such as amulets and beads, but gradually larger objects were manufactured. Most appear to have been produced specifically for burial use. Knowing how faience is made and its components is essential to understanding the weak aspects of faience artifacts. It is important to think about the history of faience in Egypt. Faience production developed alongside the attendance of steatite verification in Predynastic times (5500-3050 BC) but became common later. All analytical studies also confirmed that these beads were made using the efflorescence method and date back to the Roman period. The study found that the beaded shroud was one of the accessories with which the mummy was decorated after wrapping it in linen wraps. It was placed on top of the mummy wrappings and was made of hollow tubular faience beads, consisting of faience material tied together in a net pattern. Also, this study showed that faience is exposed to numerous damage conditions that lead to a deterioration in his condition. Using investigation methods and interpreting the results obtained using SEM- EDX, USB Digital light Microscope, XRD and (FTIR) to study archaeological faience and its components. The Examination of the beads revealed dirt interference, as well as cavities, cracks, and loss of the glaze. The USB digital microscope exposed peeling and the presence of pores in the glazing areas, in addition to other defects such as holes resulting from incorrect industrial of the glazing layer. The use of SEM showed holes and pores, the presence of salt crystallization and surface irregularities. In addition, the effects of damage appeared clearly. EDX analysis of the surface of the faience tube confirms that it contains mainly three elements in the EDX analyzes of the first and second samples, respectively: silicon (SiO_2: 34.43%, 37.49%), sodium (Na_2O 8.98%, 6.79%). + K_2O 1.67%, 4.67%) and calcium (CaO 4.93%, 8.12%). As for the XRD results of the faience bead itself, it turned out that it was composed of 30.9% quartz (SiO_2) as the main substance, 22.5% coprorivite ($CaCuSi_4O_{10}$) a blue pigment, 12.3% calcite ($CaCO_3$), 13.1% atacamite, and 0.2% paraacamite (Cu_2Cl).$(OH)_3$), 20.5% halite (NaCl) and 0.5% calcium sulphate ($CaSO_4$), as minor components. moreover, by reviewing the FTIR spectrum of the faience bead it was found that they were consistent with the results of XRD and EDX investigates. From this study, it was concluded that the composition and components of the faience had an influential role in damage particularly, after the beads were exposed to burial and weathering conditions.

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