Analytical Study of Some Unfinished Obelisk Quarry Pottery Vessels in Aswan, Egypt, Case Study

Walid Kamel Ali Elghareb
Conservation Department
Faculty of Archaeology
Aswan University
Aswan, Egypt

Abstract

Study of components of excavated archaeological pottery from the Eastern Quarry in Aswan by various examination and analysis methods such as Polarized Microscope, Scanning Electron Microscope with Energy Dispersive of X-Ray Unit "SEM- EDX" and X-ray diffraction analysis have played an important role in the identification of pottery technology and its deterioration. The research has revealed a nature of the technological process for the pottery manufacture in unfinished obelisk quarry in the eastern Aswan, Proving that the used clay was Nile clay; Tempers are grog, sand, calcite, and granite powder. Surface treatment was slip layer, while the firing atmosphere was different mix of oxidizing and reducing atmosphere. The type of archaeological pottery fabric was fine to coarse fabric, proving that there is a difference of the manufacturing technology in this site. It also highlighted the difference in the craftsmanship and skill of the manufacturer in selecting the clay, purification, shaping , surface treatment, and firing, Which confirmed that there was no pottery workshop in this archaeological site, but the artifacts came from different places with the residents or pioneers of the eastern quarry in Aswan for cutting granite from the old kingdom to the roman period, or the pottery was brought from different workshops from other sites in Aswan as the western Aswan" Elephantine island". The research also proved deterioration of the pottery fragments as firing atmosphere, salts crystallization such as halite and gypsum, spread of gaps, poor physical structure, and surface deformation by sandy clay soil deposits. The research recommends that it should be selection of appropriate materials and methods in treatment of the pottery in this site such as the cleaning, extraction of salts, consolidation, museum display and storage based on the mineral composition and chemical, mechanical and thermal properties identified by the researcher. It also recommends conducting new excavations to uncover the sites of pottery firing kilns in western Aswan where the residential areas, and its relation to pottery of the unfinished obelisk Quarry.

***Keywords**:* (Pottery, Manufacture, Slip layer, Kiln, Deterioration)

1. Introduction

Aswan comprised a number of islands, most notably Elephantine island, a rockygranite island known in ancient Egyptian texts as yipo meaning "the elephant teeth or elephant hills"[1], and then became In Greece the Elephantine, a reference to the commercial center for the trade of ivory and the elephant teeth. Since prehistoricperiods it was Settled, the island has become commercially, militarily and religiously importance in the first dynasty. Many objects have found from the old kingdom, a temple of the goddess Satet was built, throughout the middle and new kingdom, the island retained its commercial importance. The kings of new kingdom had interested in Elephantine, the temples were built for the gods Khenom, Satat and Anakat," Holy Elephantine Trinity" by Hatshepsut and Thutmose III., Elephantine continued playing an important role throughout the late period. 26dynasty kings took great interest in the island and established a scale for the Nile. The island was patronized by the kings of thirty dynasty, then the Ptolemaic and Romans kings who registered their names on the walls of the temples. The island contains foundations and ruins of a church dating back to 6 th century AD, as well as many quarries such as a quarry of Suhail island and the eastern quarry" unfinished obelisk quarry[2], as well as many workshops of various crafts[3].Elephantine was the first Territory, it was a land of the goddess satet "goddess of Elephantine island", which was one of the most important ancient centers exactly like the eastern quarry.

Aswan anciently had been called yipo, the city was known in ancient times as Sweenet in Greece [4] and then Swan, which means the old market, then Aswan for the Arabs, the cut granite rocks were called syenite in Greece, such as granite of the eastern quarry " unfinished obelisk quarry"[5], in some times, it was also known as Tasty [6], the eastern quarry was one of the most important granite quarries in the eastern Aswan as in fig. (1).

Figure1 represents the unfinished obelisk quarry in eastern Aswan.

Hundreds of rock inscriptions and king cartridges were carved by quarries missions in the eastern Aswan "unfinished obelisk quarry"[7].The pottery fragments discovered in the eastern quarry indicated various administrative organizations. The excavations revealed thousands of pottery vessels in some ruins of Elephantine island, proving presence of pottery workshops in Elephantine [8], as in fig. (2).

Figure 2 represents the ruins of the island of Elephantine

The analysis process is considered one of the most important processes in examination of the archaeological material[9], it has been branched out and developed its fields[10], through which we can identify the pottery manufacture in this site, its classification, the nature of pottery fabric, additives" Tempers"[11], the mineral components of the used clay in manufacture, clay classification[12], determination of the firing temperature[13], firing atmosphere[14] and kind of the kilns[15],This also indicates trade relations and pottery function uses [16]. The examination and analysis play an important role in diagnosis of causes and the deterioration phenomena to the pottery heritage, establishing a scientific methodology for its treatment and conservation consistent with nature of the pottery damage. This study is one of the first studies in the field of pottery examination and analysis in the eastern quarry in Aswan, which reveals the nature of pottery manufacture technology and its deterioration in this site, having a historical and civilization importance being one of the most important quarries sites in Aswan throughout the historical ages.

2. Materials and Methods

2.1. Study materials

Four pottery samples of various shapes and colors were selected in the eastern quarry "unfinished obelisk quarry" in Aswan and were used in the process of examination and analysis carried out in the research as in fig. (3).

Figure3the pottery samples used in the examination and analysis

2.2. Methodology Study

2.2.1. Visual Examination

The method of visual examination is the first stage of the examination process. It is preferable to use some different lenses [17] evaluating the state of archaeological material, technological process, pottery functional use and a nature of the deterioration [18].

2.2.2.Examination by Polarizing Microscope

It plays an important role to identify the petrographic structure of the mineral components of the archaeological pottery [19], the pottery samples were obtained from the eastern quarry in eastern Aswan. Thin sections of pottery samples were made by a specialist. The petrographic examination was carried out using Nikon Eclipse LV100pol with digital camera under magnification 2 X up to 80X; Thin sections were prepared and conducted in the polarized microscope laboratory at the Geology Department, The Faculty of Science, Cairo University.

2.2.3. Scanning Electron Microscope with Energy Dispersive of X-Ray unit "SEM- EDX".

The Scanning Electron Microscope with Energy Dispersive of X-Ray Unit "SEM- EDX" plays an important role in identifying morphology of the pottery, its mineral composition and its nature of deterioration [20]. The pottery samples were examined without prior preparation using the JEOL JSM-840 and ESEM Quanta 250 FEG, XTE 325 / D8395, Operating conditions "20 kV and 1×10^{-9}A", equipped with the Energy Dispersive of X-Ray Unit, This examination was conducted at Scanning Electron Microscope Unit at the National Research Center in Cairo.

2.2.4 X-Ray Diffraction Analysis

It plays an important role in designation the mineral components of the archaeological pottery, which helps in identifying the type of clay used in manufacture, additives, as well as effect of firing and effect of burial environment on the burial pottery in the soil.[21]. Four pottery samples were prepared for powder XRD analysis, the used device is X'Pert Graphics and 'Identify' by Philips, the pattern of diffraction between "4:70 2θ" ,operating conditions: Cu-Kα radiation, 45 kV and 40 mA. This analysis was performed at the Center of micro Analyzes at the Institute of Metals in Helwan. .

3. Results

3.1. Visual Examination

It has been shown by the visual examination that the pottery fragments is different in their colors and firing temperature degree, sharing in presence of a high proportion of sandy clay soil deposits, it also showed existence of calcification and crystallization of the salts, it also proved that the pottery fragments were shaped by different forming techniques such as wheel or coiling method, showing that it was manufactured at several different pottery workshops.

3.2. Polarizing Microscope Examination

The examination of the first pottery sample showed fine fabric Pottery from round or sub-round quartz grains to angular quartz grains , rutile, as well as presence of grog in an iron oxide-rich matrix as shown in fig.(4) .

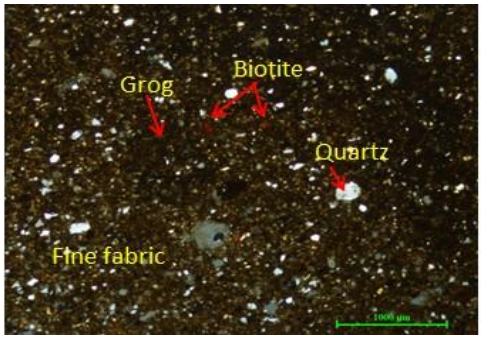


Figure.4 Petrography micrograph of the first sample shows existence of quartz grains, grog, rutile, and biotite (10X-CN).

While the second sample showed existence of coarse fabric of quartz granules in various shapes and sizes, whether round or sub-round grains, mostly angular coarse grains, as well as calcite, muscovite and pyroxene in an iron oxide-rich matrix, as in fig. (5 A).And fig. (5B) represents an enlargement of part of the sample in the eastern quarry showing the presence of pyroxene, quartz and calcite.

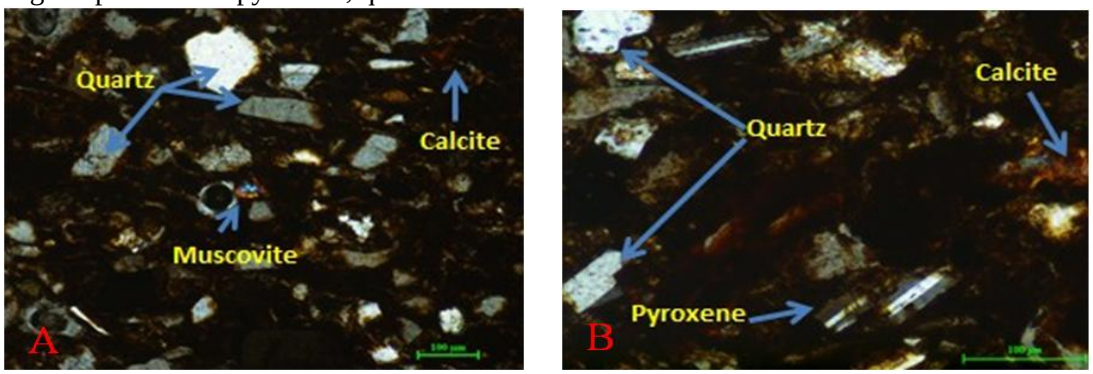


Figure5 Petrography micrograph of the second pottery sample, A: quartz, calcite and muscovite (10X-CN), B: quartz, calcite and pyroxene (40X-CN).

While the third pottery sample showed existence of medium fabric of round or sub-round quartz grains to angular quartz grains, as well as calcite and olivine in an iron oxide-rich matrix, as shown in fig.(6).

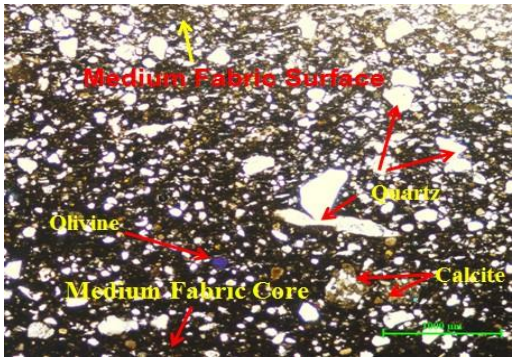


Figure 6Petrography micrograph of the third pottery sample showing quartz, calcite and olivine in an iron oxide-rich matrix (10X-CN).

While the examination of the fourth pottery sample in the eastern quarry in Aswan showed presence of fine to medium pottery fabric of round or sub-round to angular quartz grains, as well as calcite, olivine, biotite and grog, as in fig.(7).

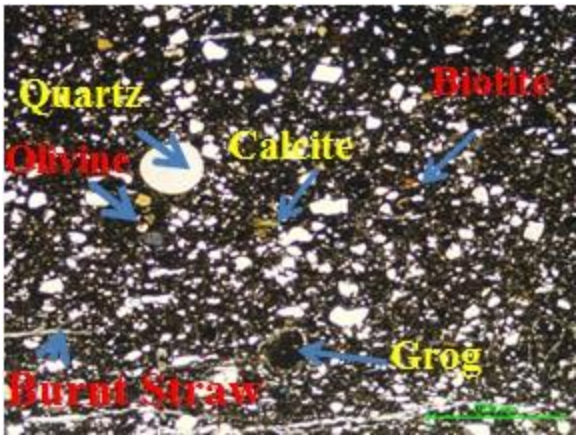


Figure 7 Petrography micrograph of the fourth pottery sample showing quartz, calcite, olivine, grog and biotite (10X-CN).

3.3. **Examination and Analysis by Scanning Electron Microscope coupled with the Energy Dispersive of X-Ray Unit "SEM-EDX".**

Four archeological pottery samples in the eastern quarry in Aswan were examined by SEM-EDX, which deals with the samples without any prior preparation.

3.3.1. Examination by Scanning Electron Microscope

The examination by SEM- EDX for the first pottery sample showed fine pottery fabric, in addition to presence of homogeneous quartz grains. It also showed surface treatment using the slip layer, showing existence of some gaps and exfoliations due to effect of burial environment, as in fig. (8).

Figure 8SEM photomicrograph of the first pottery sample.

While The examination by SEM- EDX for the second pottery sample in the eastern quarry showed presence of coarse pottery fabric of added coarse quartz grains, which confirms the manufacturer's failure in choosing the clay's type, purification of impurities or the surface treatment, as well as presence of some salts and heterogeneous granules, as shown in fig.(9).

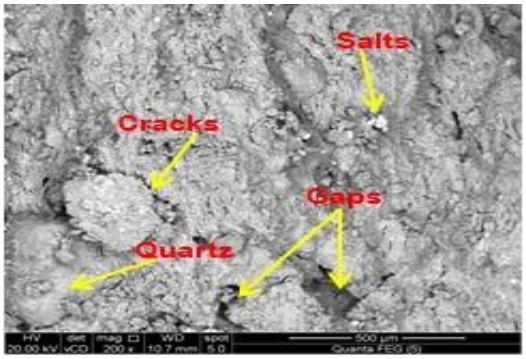


Figure 9.SEM photomicrograph of the second pottery sample.

While the third pottery sample showed presence of medium pottery fabric of added medium quartz grain, as well as salts crystallization and peeling of the slip layer, as shown in fig. (10).

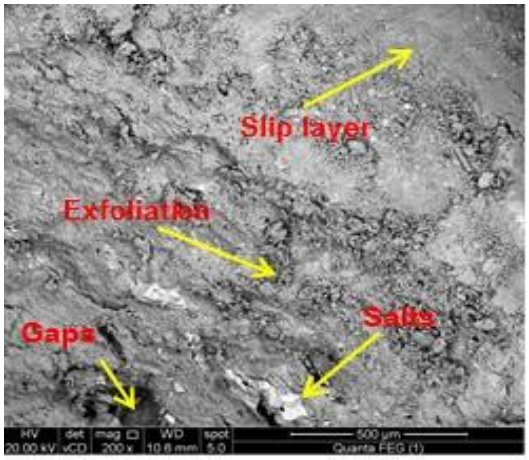


Figure10 SEM photomicrograph of the third pottery sample.

The examination of the fourth pottery sample showed presence of medium to coarse pottery fabric of the added quartz grains "additive materials", as well as presence of some salts and gaps as shown in fig. (11).

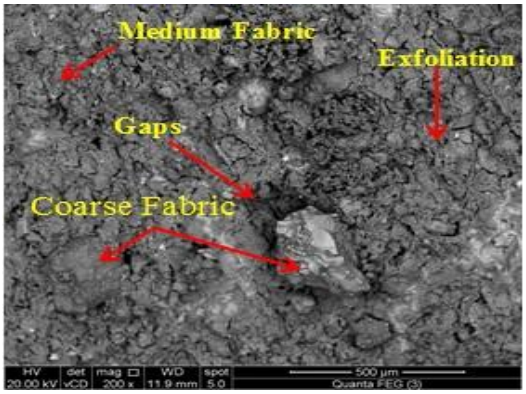
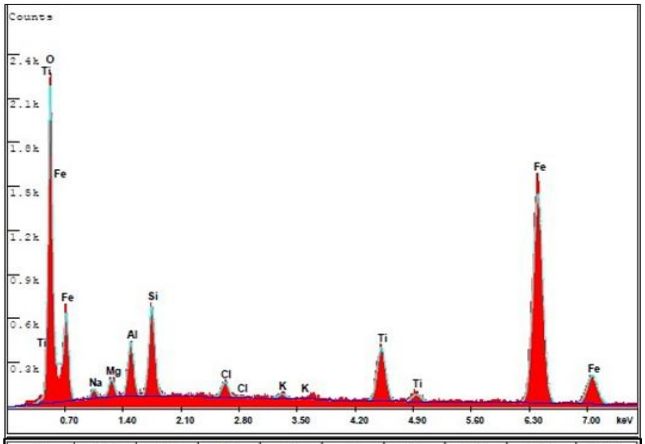


Figure11. SEM photomicrograph of the fourth pottery sample.

3.3.2. Analysis of the Scanning Electron Microscopy with EDX.

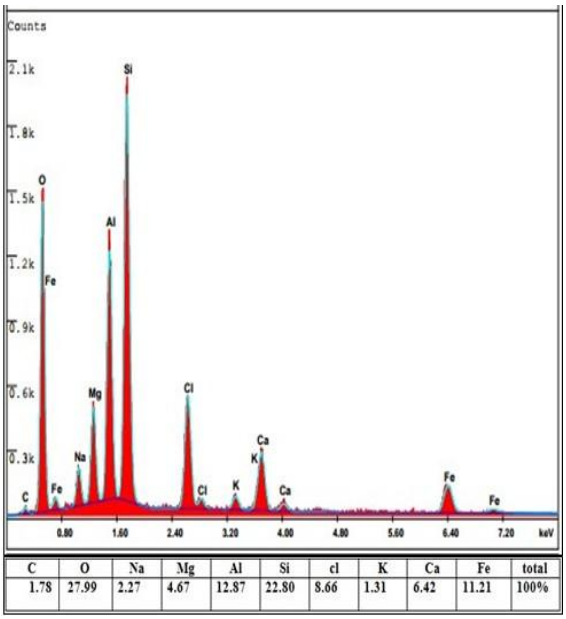
The results of the analysis of the first pottery sample showed presence of Sodium, Magnesium, Aluminum, Silica, Chlorine, Potassium, Titanium and iron,as shown in fig.(12).



O	Na	Mg	Al	Si	cl	K	Ti	Fe	total
16.94	0.77	1.14	2.98	4.53	0.91	0.36	6.61	65.76	100%

Figure 12 EDX pattern of the first pottery sample.

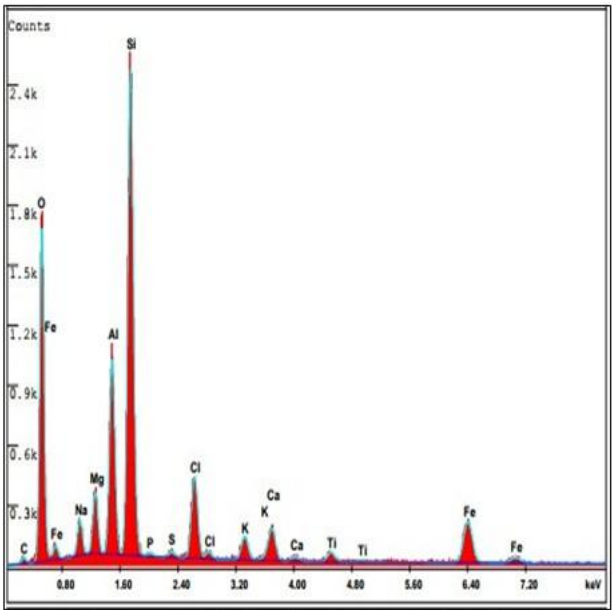
The results of the analysis of the second pottery sample showed presence of Carbon, Sodium, Magnesium, Aluminum, Silica, Chlorine, Potassium, Calcium, and iron,as shown in fig. (13).



C	O	Na	Mg	Al	Si	cl	K	Ca	Fe	total
1.78	27.99	2.27	4.67	12.87	22.80	8.66	1.31	6.42	11.21	100%

Figure 13 EDX pattern of the second pottery sample.

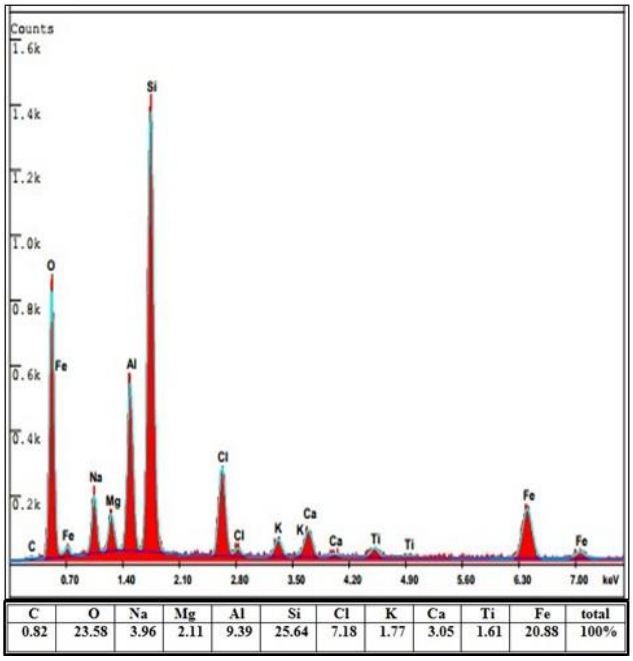
The results of analysis of the third pottery sample in the eastern quarry in Aswan showed presence of Carbon, Sodium, Magnesium, Aluminum, Silica, Phosphorus, Sulfur, Chlorine, Potassium, Calcium, Titanium and iron as in fig. (14).



C	O	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	total
1.66	27. 59	2.17	3.04	9.87	25.85	0.22	0.39	6.09	2.23	3.39	1.52	15.97	100%

Figure14EDX pattern of the third pottery sample.

The results of analysis of the fourth pottery sample showed presence of Carbon, Sodium, Magnesium, Aluminum, Silica, Chlorine, Potassium, Calcium, Titanium and iron, as in fig. (15).



C	O	Na	Mg	Al	Si	Cl	K	Ca	Ti	Fe	total
0.82	23.58	3.96	2.11	9.39	25.64	7.18	1.77	3.05	1.61	20.88	100%

Figure 15EDX pattern of the fourth pottery sample.

3.4. X-Ray Diffraction Analysis

The first pottery sample in the eastern quarry in Aswan was analyzed by X-ray diffraction, The pattern of XRD contains quartz (SiO_2), hematite (Fe_2O_3), mulite ($Al_2O_3.2SiO_2$) and Albite ($NaAlSi_3O_{10}$) as in fig. (16). It is clear of the results of the pattern of X-ray diffraction that the sample is good firing being contains hematite and the mulite which appears above 950 ċ. .

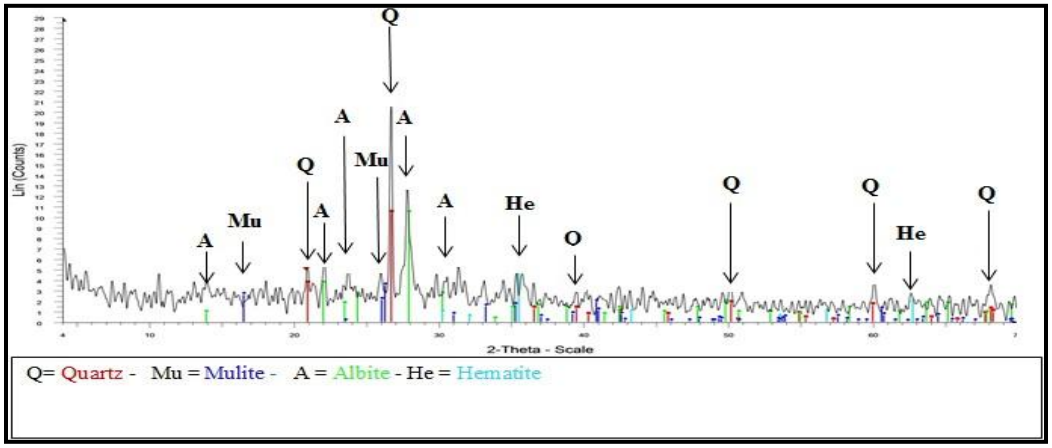


Figure 16 XRD pattern of the first pottery sample in the eastern quarry in Aswan.

The second pottery sample was analyzed by XRD, where the pattern contains Quartz (SiO_2) ,Magnetite (Fe_3O_4), Albite ($NaAlSi_3O_{10}$), Halite(NaCl), Microcline ($KAlSi_3O_8$) and Calcite ($CaCo_3$). The results of XRD pattern shows that the sample is not good firing because it contains magnetite, as shown in fig. (17).

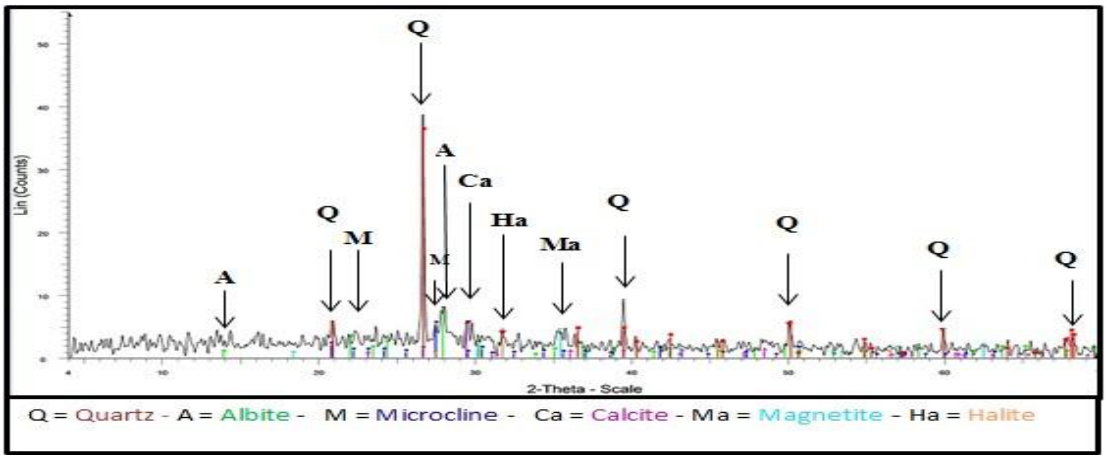


Figure17 XRD pattern of the second pottery sample in the eastern quarry in Aswan.

The third pottery sample was analyzed by XRD, The pattern contains Quartz (SiO_2), Magnetite(Fe_3O_4), Hematite(Fe_2O_3), Albite ($NaAlSi_3O_{10}$),Halite(NaCl) , and anhydrite ($CaSo_4$) .The results of XRD pattern shows that the sample is medium firing and suffers from the crystallization of salts from the burial in the soil[22] and climate changes asdaily and annual temperature and moisture variation[23], as shown in fig.(18).

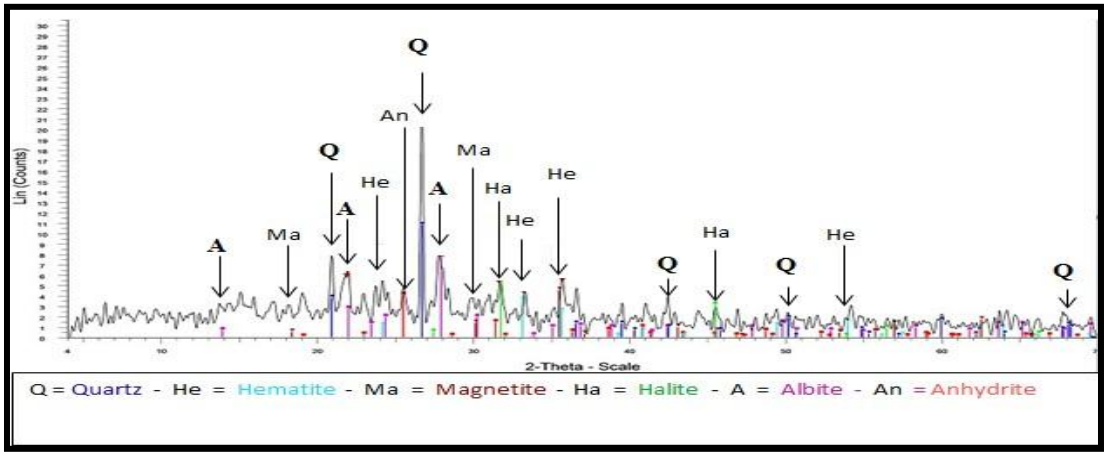


Figure18 XRD pattern of the third pottery sample in the eastern quarry in Aswan.

The fourth sample in the eastern quarry was analyzed by X-ray diffraction, The XRD pattern contains Quartz (SiO_2), Hematite(Fe_2O_3) , Albite ($NaAlSi_3O_{10}$) , Halite(NaCl), Microcline ($KAlSi_3O_8$), it is clear of the results of XRD pattern that the sample is good firing being contains hematite, as in fig. (19).

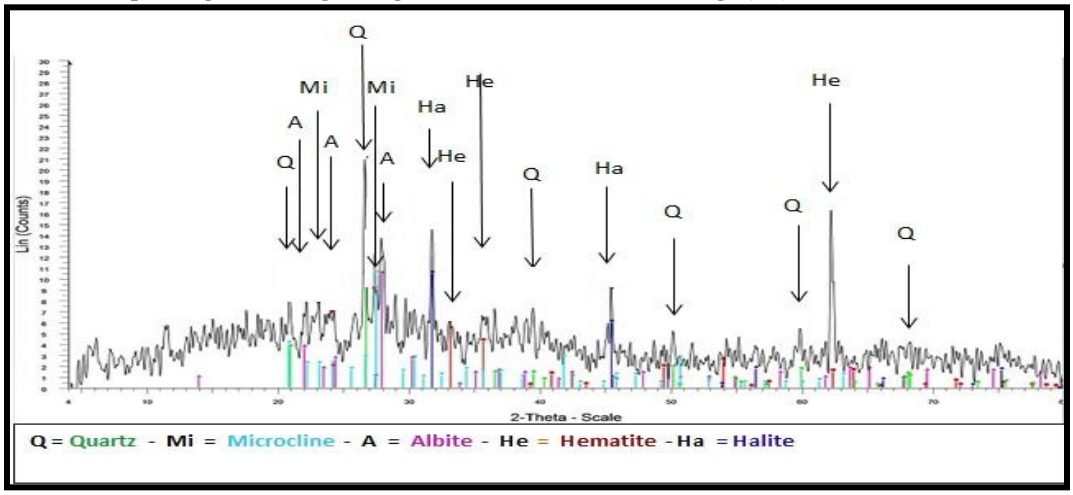


Figure 18 XRD pattern of the fourth pottery sample in the eastern quarry in Aswan.

4. Discussion of Results:

The results of the research show that the visual examination proved that pottery fragments were formed by hand shaping or the potter wheel, the surface treatment was slip layer or red wash, some of them were high polished and others were unpolished. The examination also revealed a high percentage of additives materials such as quartz, soiling, calcification, crystallization of salts and mechanical damage of the soil, where most of the objects suffered from breaking. The polarized microscope examination showed that the used clay in the manufacture in unfinished obelisk quarry pottery in Aswan is Nile clay because of existence of biotite, muscovite, pyroxene, rutile and olivine.

The polarized microscope examination also proved presence of additives materials such as sand, grog, calcite (common additives used in the pottery starting from the old kingdom to late period) and granite powder for the presence of olivine, being one of products of decomposition of granite by physicochemical weathering, it is characteristic of the Pottery Manufacturing in Aswan as one of the local additives, Whether in archaeological or modern pottery.The polarized microscope examination showed the difference of the ancient manufacturer's skill in shaping and surface treatment of clay bodies by applying a slip layer, which was high polished as in the first sample. The second pottery sample was untreated and unpolished, but the third and fourth pottery samples were medium degree in their manufactural technology whether in selection of the clay or surface treatment of the clay bodies.

The polarized microscope examination proved that firing atmosphere of the first sample was oxidized atmosphere, mulite and hematite confirmed that. Where the firing atmosphere of the second pottery sample was reduced atmosphere. But the firing atmosphere of the third pottery sample was mix of reduced and oxidized atmosphere, Confirmed by existence of magnetite and hematite at the same time. The examination of the fourth sample showed that the firing atmosphere was oxidized, but the firing temperature degree is medium, Confirmed by presence of only hematite and absence of any high-temperature minerals such as mulite.

The polarized microscope examination showed fine fabric in the first pottery sample, coarse fabric in the second sample, medium fabric in the third sample, and fine to medium fabric in the fourth sample, indicating a difference in technique of pottery manufacturing in this archaeological site, confirming that there is no pottery workshop in this archaeological site, but the artifacts came from different places with the residents or pioneers of the eastern quarry, or the pottery was brought from different workshops in Aswan, where Variation of firing temperature degree, fabric and type of the clay in all pottery samples.The examination and analysis of SEM- EDX confirmed that the used clay in the manufacturing is Nile clay because of existence some oxides such as sodium, potassium, calcium, iron, and titanium in the mineral composition of the pottery.

The examination and analysis of SEM- EDX showed high or low of the firing degree of the pottery samples on basis of increase or lack of carbon ratio. Its percentage in the first pottery sample was very poor, the second sample was 1.78%, the third sample was 1.66% and the fourth sample was 0.82%.The examination and analysis of SEM- EDX also showed fine fabric in the first pottery sample, coarse fabric in the second pottery sample, medium fabric in the third pottery sample, and fine to medium fabric in the fourth pottery sample.The examination and analysis of SEM- EDX has also confirmed presence of some salts such as halite, sulphates and phosphates in archaeological pottery samples.

X-ray diffraction analysis has shown that the used clay in the pottery manufacture in the unfinished obelisk quarry in Aswan is Nile clay being containing muscovite, biotite, pyroxene and calcite; this confirms the previous results of examinations and analysis. The analysis has also shown that firing atmosphere of the first sample was oxidized atmosphere, mulite and hematite confirmed that. Where the firing atmosphere of the second sample was reduced atmosphere. The firing atmosphere of the third sample was a combination of reduced and oxidized atmosphere, confirmed by presence of magnetite and hematite at the same time. The examination of the fourth sample showed that the firing atmosphere was oxidized, but the firing temperature degree is medium, confirmed by presence of only hematite and absence of any high-temperature minerals such as mulite.

The analysis proved the presence of some salts such as chlorides "halite" sulphates "gypsum", due to the burial in the soil, giving a great indication of impact of the saline soil or as a result of climate changes such as daily and annual temperature or moisture variations in the unfinished obelisk quarry in Aswan.

Most of the examinations and analysis highlighted a difference of the craftsmanship and skill of manufacturer in selecting the clays , purification of Impurities and shaping by hand or potter wheel, as well as difference of his ability to treat the surface using the slip layer or red wash, in addition to the difference in his ability to high control in firing atmosphere that was different among an oxidized or reduced atmosphere, and some others were mixture of oxidized and reduced atmosphere, which proves the difference in pottery manufacture in unfinished obelisk quarry in Aswan. indicating that the pottery is not from one site or workshop for difference of type of the clay,additives, shaping, treatments and the firing atmosphere, proving that there is no pottery workshop in that archaeological site, but the artifacts came from different places with the residents or pioneers of the eastern quarry in east Aswan from the old kingdom to the roman period, or the pottery was brought from different workshops from other sites in Aswan as in the western Aswan.

5. Conclusion

The research has revealed a nature of the technological process for the pottery manufacture in unfinished obelisk quarry in the east Aswan, proving that the used clay was Nile clay; Tempers are grog, sand, calcite, and granite powder. Surface treatment was slip layer, while the firing atmosphere was different mix of oxidizing and reducing atmosphere. The type of archaeological pottery fabric was fine to coarse fabric, proving that there is a difference of the manufacturing technology in the site. The research also highlighted the difference in the craftsmanship and skill of the manufacturer in selecting the clay, purification of clay, shaping and surface treatment, Which confirms that there is no pottery workshop in this archaeological site, but the artifacts came from different places with the residents or pioneers of the eastern quarry in Aswan from the old kingdom to the roman period, or the pottery vessels was brought from different workshops from other sites in Aswan as in the western Aswan" Elephantine island". The research also proved the deterioration of pottery fragments as low firing temperature degree, crystallization of salts such as halite and gypsum, spread of gaps, poor physical structure, and surface deformation by sandy clay soil deposits. It recommends that it should be selection of appropriate materials and methods in treatment of the pottery in this site such as the cleaning, extraction of salts, consolidation, display and storage based on the mineral composition and chemical, mechanical and thermal properties identified by the researcher. The research also recommends conducting new excavations to uncover the sites of pottery firing kilns in western Aswan" Elephantine island where the residential areas, and its relation to the pottery in the unfinished obelisk quarry.

Acknowledgment

I extend my sincere thanks and appreciation to Prof. Dr. Ezzat Abdel Rahman, Professor of Minerals at the Faculty of Science at Aswan University for his encouragement and practical support. I also extend my deep thanks and gratitude to Mr. Mohammed Saadallah, Restorer of Aswan and Nubia Monuments at the Ministry of Antiquities for his help and cooperation in the archaeological site.

References

Manal E. Fawzi, Region of Elephantine, Master Thesis,, Faculty of Arts, Zagazig University,2008, p.14.

Noureddine,A., Sites of Ancient Egyptian Antiquities from the Ancient Ages until the End of the Ancient Egyptian Periods, Dar Al-qsa Press, Cairo,20008, pp. 300-301.

Selected Researchers, Elephantine Archaeological City, German Institute in Cairo, 2016, p.10.

Hassan,M.K., Historical and Civilizational Importance of Aswan in ancient history, Journal of The Faculty of Arts, Aswan University,2002, pp. 9-17.

Noureddine, A., Ancient Egyptian Antiquities Sites in Aswan, Journal of Faculty of Arts, Aswan University,2002, pp. 42-46.

Hawass, Z., Nubia through the ages, Supreme Council of Antiquities, 2008, p. 17.

Christian DiroucheNoblkour, The Secrets of the Nubian Temples, Translation Fatima Abdulla, The Supreme Council of Antiquities Press, Cairo,2006, p.16.

Abdul Majid, M.B., Religion of South Hamiya Yab, Journal of The Faculty of Arts, University of Aswan, 2002, p.42.

Abdel-Ghani, M, and N., S., Abdel-Rahim, (analytical study of ottoman Egyptian ceramic tiles from Abdel Baqi ElShorbagy mosque, Alexandria, in journal of The Unknown Face of The Art work, Istanbul Kultur University, Turkey,2012, pp.69-71

Bersani,D.,Lottici,P., Virgenti,S., Sodo,A.,Malvestuto,G.,Botti,A., SevilleMariani,E., Tribaudino,M., Ospitalie,F, Catarsif,M.,Multi Techniques investigation of archaeological pottery from Parma, Italy, in journal of Raman Spectroscopy, Vol.41,N.11, 2010,pp.1556-1561.

Schleicher,L.,Miller,J.,WatkinsKenney,S.,CarnesMcNaughton,L.,andWildeRamsing,M.,Non-destructive chemical characterization of Ceramic shards from Shipwreck 31CR314 and Brunswick Town, North Carolina, in journal of archaeological science,Vol.35,N.10,2008, pp.2824-2838.

Pankaj Singh, and Sukanya Sharma,Thermal and spectroscopic characterization of archeological pottery from Ambari, Assam, in journal of Archaeological Science, Amsterdam, Netherlands, 2016, pp.556-563.

Schiffer, M. B., behavioral archaeology, Academic Press, New York, 1976, pp.5-21.

Maniatis, Y., Simopoulos, A., Perdikatsis, V., and Kostikas, A., The effect of reducing atmosphere on minerals and iron oxides developed in fired clays , Journal of the American Ceramic Society,Vol. 66,U.S.A,1983 ,pp.773-781.

Murat Bayazit, Iskender Işık, Ali Issi, ElifGenç, Spectroscopic and thermal techniques for the characterization of the first millennium AD potteries from Kuriki-Turkey, Ceramics International, Vol. 40, Amsterdam, Netherlands,2014, pp.14769-779.

Kamel,W.A. , Scientific Evaluation of the Effect of Techniques of the pottery manufacture on the Rate of deterioration in Some Archeological Sites, with the Study of the Most Important Methods of Treatment and conservation of Selected Pottery Models, Ph.D. Thesis, Department of Restoration, Cairo University,2007, p.69.

Nagwa,S.,A.,analytical study and conservation of archaeological terra sigillata ware from roman period,Tripoli,liyba,in journal of Applied Science and Technology,Vol.2,N.2,2016, p.22.

Sayre , E.V.,Application of Compositional Analysis to the study of Materials Objects of Art and Archaeology , in Material Issues in Art and Archaeology , edited by Sayre , E.V., Druzik , J., and Stevenson , C., Pennsylvania ,1988, pp. 41-49. .

Hamdan, M. A. Martinez, S. M. Garcia Valles, M. T. Nogues, J. M. Hassan, , F. A. Flower, R. J., Aly, M. H., Senussi A. and Ibrahim, E. S., Ancient Egyptian Pottery From The Subsurface Flood Plain of The Saqqara–Memphis Area: Its Mineralogical and Geochemical Implications ,Archaeometry, Vol. 56, N. 6, John Wiley & Sons Ltd., U.k,2014, pp.987-1008.

Badawi, M.Ismail, The Impact of Environmental Conditions on The Roman Tomes in Alexandria City, in Bulletin of The Faculty of Arts, Qena, Vol.10, 2000, pp.67-69.

Alaimo,R.,Bultrini,G.,Fragala,L.,Giarrusso,R.,andMontana,G.,Microchemicaland Microstructure Characterization of Medival and Post Medival Ceramic Glaze Coatings, in Journal of Applied Physics,Vol.79, 2004,pp.263-272.

El-Gohary, M., Analytical investigation of disintegrated granite surface from the un-finished obelisk in Aswan, international journal of Archaeological Science, Vol.35, 2011, pp.29-39.

Abdeltawab,N., and Askalany,M., (2011), study of durability of alabaster used in the temple of Luxor and Karnak and laboratory evaluation of consolidation treatment, in Egyptian Journal of Archaeological and Restoration Studies,Vol.1,issue 2,p.18.