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CHEMICAL COMPOSITION PATTERNS OF CERAMIC WARES FROM FUSTĀT EGYPT *†

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1. INTRODUCTION

Pottery has been studied and classified by archaeologists in an effort to understand its stylistic development and learn something about the techniques of manufacture as practiced in various cultures at different points in time. As these wares are exported to various centers of commerce and trade one might expect to find local styles and techniques changing to reflect the influence of the imported ware. In this respect the discovery of kilns and kiln dumps with wasters and misfired pots are of great importance in establishing the provenience of pottery styles in a particular time period.

The art historian and archaeologist now has available a relatively new technique which can remove a number of uncertainties in determining whether pots are imported or local imitations of a foreign style. This technique involves the quantitative analysis of about 30 different chemical elements in the body fabric of the sherd by neutron activation. In short, a small sample (100 mgm) of the interior fabric is powdered, pressed into a uniform sized pellet and irradiated with neutrons along with appropriate standards in a reactor. The now radioactive samples are analyzed using a germanium gamma-ray spectrometer at five different times selected to achieve the best data from nuclides with a variety of half-lives, from a few minutes to several years long.

It has been shown in previous work, (Perlman 1969) that clays formed in

a particular geological setting have a chemical composition pattern, or fingerprint, which one can use to distinguish one geological area, or general clay source, from another. These fingerprints may have been altered by the techniques used in making a particular style of pottery. For example, the addition of frit, temper, or limestone to the clay and variations in firing temperature can modify the basic clay fingerprint.

The general procedure for analyzing the chemical fingerprints has been described previously (Perlman 1969, Widemann 1974) and will be mentioned only briefly here.

Pottery which is known by stylistic or other criteria to be locally made and which is homogeneous chemically serves as a reference group for local material. For each element the mean value of the abundance and the root-mean-square deviation (σ) from this value is determined for all of the pots in the reference group.

If the average value of the root-mean-square deviation for approximately 20 elements is 10 % or less, the group is considered to be a "good" reference group suitable for classification purposes. For a pot of unknown provenience to be a member of this group, and thus to have the same provenience, the abundance of most of its elements should agree with the corresponding value in the reference group within one σ and very few elements should disagree by more than two σ.

2. DISCUSSION OF PROBLEM

Fustāt, the old city of Cairo, was of both commercial and industrial importance in the Islamic period. George T. Scanlon in cooperation with the American Research Center in Egypt directed the excavation of Fustāt in 1964, 1965, 1966, and 1967, (Scanlon 1966 and 1967) and has generously provided the samples from Fustāt. These excavations yielded at least seven broad

classifications of pottery, (Scanlon 1971). Among these are the luster wares.

It was with the hope of establishing the provenience of this luster ware, in particular, that we undertook the neutron activation analysis of several types of pottery excavated in Fustāt. In the twenty-eight pieces analyzed, seven are luster ware, three are "Fustāt Fatimid Sgraffiato" ware, three are Monochrome glazed sgraffiato ware, five sherds are 13-14th Century Iranian style Underglaze Painted faïence ware, and the remainder are single sherds of different types.

The sherds divided into two vastly different types of fabric; clay-bodied and a faïence-bodied material which is 80-90% SiO_2 (quartz).

3. CLAY BODIED WARE

The luster ware was found in both body types. The clay-bodied pottery will be discussed first.

The first distinct chemical group includes one piece of polychrome luster and three pieces of monochrome luster on a white opaque glaze.

The second group of clay bodied sherds contains three pieces of glazed "Monochrome Sgraffiato" ware whose design is "carved" through a light colored slip applied to the red or dark brown body fabric. The style is similar to Eastern Mediterranean ware.

The third group consists of only two pots. One is "Polished Red ware" and the other is a waster of "Early Lead ware".

The chemical composition of these three groups of pottery excavated in Fustāt are shown in Table I. The entries at the top of each column are the number of pots in the group and the average standard deviation (σ) for 20 elements. Below are listed the average chemical composition and the standard deviation in parts-per-million (or % if so indicated) for each element.

The four luster ware sherds form a good chemical group whose average

standard deviation is .7%. This chemical fingerprint matches very closely that of two previously analyzed types of sherds from David Whitehouse's excavation at Sīrāf; "Samarra" ware and "Early Turquoise" ware. Table II shows the chemical composition of these two reference groups and the luster ware.

In addition, Table II shows the chemical composition of two types of pottery from three cemetaries in upper Egypt. One is a calcareous buff decorated ware from Ballas and the other is described as "Nile Mud" (Perlman 1969).

The chemical fingerprint of the luster ware matches both types of the Mesopotamian ware within one standard deviation for each element, however, it is a slightly better fit to the "Samarra" ware reference group. The average standard deviation 8.4%, for twenty elements is indicative of a good chemical group. The luster ware composition is not like either of the two Egyptian groups. Thus, it appears that the lustered clay-bodied pottery was imported to Egypt from somewhere in the Mesopotamian area.

At present, we can not say as much about the provenience of the other two groups of pottery excavated in Fustāt.

The composition of the Monochrome Sgraffiato group shown in Table I is somewhat like a sherd of Cypriot base ring ware and three pieces of Polished Red ware from Ras Shamra previously analyzed. It is not like either of the two Egyptian reference groups. Another single sherd stylistically similar but technically inferior has a still different chemical fingerprint. It may be that further investigation could establish the provenience of these two monochrome sgraffiato types of pottery.

The two pots in the third group shown in Table I match the composition of previously analyzed a single sherd that was excavated at Abkah in Egypt. Once again further investigation is necessary to establish provenience. We can only note that at present the fingerprint does not match any reference group.

4. FAÏENCE-BODIED WARE

Thirteen of the Fustāt sherds had chemical compositions very different from those normally found in clay. They had unusually low abundances of iron, aluminum, and a number of trace elements, a normal or slightly higher abundance of sodium and a very high abundance of silica (SiO_2). This composition is roughly similar to that reported by Lucas (1962) for ancient Egyptian faïence so we will refer to these as faïence-bodied wares. The majority of these sherds are members of two distinctive groups, whose abundances are tabulated in Table III. Three of the four sherds in the first group in Table III are wasters; two of "Fustāt Fatimid Sgraffiato" and one of "Monochrome Celadon". Scanlon notes (1971) that abundant wasters of "Imitation Celadon" are found at Fustāt. As seen in Table III, the above sherds, three of which are known to be locally made at Fustāt, form a chemical group which has an average standard deviation of 20% for twenty elements.

Two sherds of faïence-bodied luster ware had chemical compositions very similar to that of the faïence -bodied local ware from Fustāt. The agreement between the abundances of the luster ware and the local ware suggest that the luster ware may also be local to Fustāt although more extensive measurements would be necessary to make a definitive assignment of provenience.

The second group of five faïence sherds is "Underglaze Painted" in the style of 13-14 Century A.D. Iran. The fingerprint of this ware is entirely different from that of the locally made first group. Allan et al. (1973), in a recent paper, reported the emission spectroscopy analyses of fourteen tiles and bowls dating stylistically to the period around 1300 A. D. and belonging to groups of ceramic objects generally agreed to have been manufactured in the north or northwest part of Iran. In Table III are shown the average abundances and root-mean-square deviations for eleven of the sherds which were most alike in chemical composition. The compositions of these Iranian sherds

are variable but seem to be distinctly different than those of Fustāt local faïence bodied wares. There are more similarities between the Iranian sherds and the Underglazed Painted Ware but there are also some differences (e.g. Ca and Na). In view of the problems encountered because of non-uniformity of the faïence-bodied wares, the small number of samples analyzed and the lack of precise trace element data on faïences, no provenience assignment can be made for the Underglaze Painted Ware.

In general the faïence-bodied material is chemically not as uniform as clay. As quoted by Allan (1973) it can be made by mixing ~8% frit (50% quartz and 50% soda) with ~8% clay and ~84% quartz (Lucas 1962). Impurities in the other ingredients can modify or mask the trace element compositions in the small clay fraction. Further analysis of these components may enable us to unmask the clay and to pinpoint its provenience.

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FOOTNOTES AND REFERENCES

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Allan, J. W., Llewellyn, L. R., and Schweizer, F., 1973, Part 2, "The Story of So-Called Egyptian Faïence in Islamic Persia: Investigations Into Abū'l-Qasim's Treatise," Archaeometry 15, 165.

Lucas, A., 1962, Ancient Egyptian Materials and Industry (Edward Arnold Ltd.).

Perlman, I. and Asaro, F., 1969, "Pottery Analysis by Neutron Activation", Archaeometry II, 21.

Scanlon, George T., 1966, "Fustāt Expedition - 1965", Part 1, Journal American Research Center in Egypt, 5, 83.

Scanlon, George T., 1967, "Fustāt Expedition-1965", Part 2, Journal American Research Center in Egypt, 6, 65.

Scanlon, George T., 1971, "The Fustāt Mounds - A Sherd Count" Archeometry, 24, 220.

Widemann, F., Picon, M., Asaro, F., Michel, H. V., and Perlman, I., 1974, LBL-1964, submitted to Archaeometry.

APPENDIX

DESCRIPTION OF POTTERY AND GLAZES

Clay-bodied luster ware

Fustāt No.

8 Polychrome luster, red brown transparent overglaze and metallic luster with olive green undertone on a thick lead tin-opacified glaze. Fabric very fine pale yellow earthenware.

27 Metallic luster with olive green undertone on a lead tin-opacified white glaze. Fabric very fine pale yellow earthenware.

28 Metallic luster with yellow-green-olive undertone on the interior, reddish brown undertone on the exterior on a lead tin-opacified white glaze. Fabric very fine white earthenware.

29 Metallic luster with olive undertone and many brown spots, 0.5 - 1.0 mm in diameter, on a lead tin-opacified white glaze. The exterior is somewhat deteriorated and discolored. Fabric very fine pale yellow earthenware.

30 Metallic luster with olive undertone shading to yellow orange at the edges of the luster painting on a thick lead tin-opacified white glaze. Fabric light brownish gray, very fine earthenware.

Faience-bodied luster ware

9 Poor metallic luster, light olive with very thin light red areolae at the edges of the luster painting on a lead tin-opacified creamy glaze. Fabric coarse, white faïence.

31 Slightly metallic brown luster kufic letters on slightly tin-opacified turquoise lead glaze. Fabric coarse, gray faïence.

"Fustāt Fatimid Sgraffiato

3 Parts of two pots fused together and overfired. Coarse, irregular crazing. Fabric fine, very pale brown.

A. Transparent light olive green. Rim sherd.

B. Brown black, opaque where thick, Body sherd.

10 Transparent light olive green glaze, coarse even crazing. Overfired waster. Fabric very fine almost vitrified, white faïence.

15 Transparent very light greenish lead glaze with a splash of very light copper blue. Some light brown discoloration and some areas of deterioration. Fabric fine, white faïence.

17 Metallic brown luster over transparent colorless glaze with cobalt blue underglaze. Fabric white, fine faïence.

4 Slightly opacified monochrome celadon gray green on both surfaces. Two rim sherds fused together with no evidence of overfiring. Fabric white, coarse porous vitreous faïence.

Monochrome sgraffiato

21 Transparent caramel glaze on white slip. Sgraffiato ornamented. Crude workmanship in contrast to FUST-23, 24, 25. Fabric reddish brown coarse earthenware with much ungraded temper.

23 Transparent caramel brown glaze on white slip. Sgraffiato ornamented. Fabric light red, medium coarse earthenware with a small amount of coarse temper.

24 Transparent light olive glaze on white slip. Sgraffiato ornamented. Fabric brown, fine earthenware.

25 Transparent light caramel glaze on white slip. Sgraffiato ornamented. Glaze has adhered poorly to the slip which is not fused to the body

and the glaze has flaked off wherever it is not directly on the bare body. Fabric light red, very fine earthenware.

Underglaze painted faïence

12 Transparent colorless glaze with underglaze painting in copper and cobalt blue and black which is greenish gray where it is thin. Fabric white, medium texture faïence.

13 Transparent colorless glaze with underglaze painting in cobalt blue, greenish black and greenish gray. Raised ornament produced by an impasto of milky white underglaze 1.0 mm thick. This sherd imitates FUST-14 without using molded decoration. Fabric white, medium texture faïence.

14 Transparent colorless glaze with underglaze painting in brownish black. Molded ornament on both surfaces. Mold made. Medium crazing on the exterior. Fabric white, medium texture faïence.

19 Transparent colorless arsenic glaze containing bubbles, underglaze painting in opaque black over transparent cobalt blue, underglaze opaque red brown over the black underglaze. Fabric white, fine-texture faïence.

20 Transparent colorless glaze containing strontium, arsenic and calcium on both surfaces, underglaze painting in opaque red brown and cobalt blue outlines with a fine black line on the interior. Slight surface deterioration with small areas turned milky white. Fabric white medium-texture faïence.

Miscellaneous earthenware

1 Red polished (psuedo Samian). Somewhat vitreous dark brownish, pink slip on both surfaces. Fabric pink, medium texture heavily tempered earthenware.

6 Early lead. Transparent colorless glaze with underglaze painting in olive green and brown, very fine crazing. Fabric pink, medium texture earthenware with much coarse temper.

5 Early painted. Moderately deteriorated opaque white tin glaze with opacified light antimony yellow between dark brown outlines of a diamond shaped design with an ochre diamond in the center on the exterior: opaque ochre interior. Fabric pink, medium texture earthenware with much coarse temper.

7 Fayyumi ware. Transparent colorless glaze on both surfaces with bands of transparent turquoise blue on the interior. A poor glaze with many bubbles and inclusions. Some slight surface deterioration. Fabric very pale brown earthenware, medium coarse temper with much coarse ungraded temper.

22 al-Mina ware. Thin transparent, faintly yellowish glaze covering the interior and approximately 10 mm. of the exterior rim over a white slip, underglaze washes of caramel and green. Sgraffiato design cut with a square sectioned tool 1 mm. wide. Fabric reddish yellow medium texture earthenware.

26 Hof Sid (Hafsid) earthenware. Milky translucent white lead glaze decorated with overglaze painting in copper with a little blue and manganese purple. Appears to be part of a tile. Fabric very

pale brown, very coarse texture with much medium temper.

Miscellaneous faïence

16 Transparent, brilliant, turquoise blue on both surfaces. Crazed, some deterioration and iridescence. Fabric white, very, very fine almost vitrified faïence.

TABLE I

Chemical Composition of Clay-Bodied Wares Excavated in Fustāt, Egypt

	Fustāt Pottery		
	Luster ware and Polychrome luster	Monochrome Sgraffiato ware	Early Lead and Polished Red ware
No. of pieces in group	4:(Fust-8,27,28,29)	3:(Fust-23,24,25)	2:(Fust-1,6)
σ	7%	4.2%	5.3%
Element			
Al%	6.07±.12[1]	9.33±.24[1]	12.2±.5[2]
Ca%	13.9±.3	7.9±1.6	.98±.45
Mn	950±50	679±34	365±31
Na(%)	1.41±.16	.92±.14	.51±.09
K(%)	.92±.33	2.76±.32	1.48±.22
U	1.96±.05	3.16±.16	3.38±.11
Ba	172±14	339±28	200±7
Sm	4.04±.11	6.57±.07	8.90±.03
La	21.7±1.0	41.2±1.1	55.0±.4
Ti%	.372±.038	.460±.010	1.036±.004
Lu	.316±.017	.423±.012	.515±.022
Co	26.9±1.9	19.2±.9	15.2±.4
Sc	19.16±.56	18.08±.54	27.00±1.24
Fe%	5.01±.12	4.99±.12	3.93±.51
Cs	3.2±1.1	8.73±.30	3.60±.42
Cr	260±13	115±5	152±2
Th	7.125±.031	14.05±.41	14.02±.95
Eu	1.019±.025	1.399±.017	2.167±.007
Ce	46.4±1.1	84.8±.3	116.3±1.4
Hf	3.34±.06	4.85±.17	7.42±.10
Ta	.814±.018	1.252±.020	1.73±.07

[1] The values in this column are the average abundance in parts-per-million (or % if so indicated) and the standard deviation of the abundances.

[2] The values in this column are the average abundances in parts-per-million (or % if so indicated) and the range of the abundances. σ for this column is the average value of these ranges.

TABLE II

Chemical Composition of Clay-Bodied Luster Ware Excavated in Fustāt and Reference Groups

	Lustre Ware and polychrome luster	Sīrāf "Early Turquoise" ware	Sīrāf "Samarra" Ware	Egyptian Ballas[1] Buff Ware	Egyptian "Nile Mud"[1]
No. of pieces in group	4	13	12	20	32
σ	7%	8.6%	8.4%	7.3%	8%
Element					
Al%	6.07±.12[2]	6.50±.28[2]	6.36±.30[2]	—	—
Ca%	13.9±.3	13.1±1.0	13.2±1.0	8.26±1.13[2]	2.58±.84[2]
Mn	950±50	904±45	899±40	391±42	1204±68
Na%	1.41±.16	1.70±.21	1.65±.11	.671±.168	1.355±.215
K%	.92±.33	.87±.30	.87±.48	—	—
U	1.96±.05	1.76±.21	2.11±.15	4.57±.44	2.26±.41
Ba	172±14	231±64	182±47	405±82	493±74
Sm	4.04±.11	4.13±.15	4.05±.12	—	—
La	21.7±1.0	22.6±1.5	22.6±.7	39.3±1.2	32.8±1.2
Ti%	.40±.03	.40±.03	.43±.04	.468±.046	.996±.049
Lu	.316±.017	.311±.017	.313±.02	.367±.024	.512±.027
Co	26.9±1.9	28.5±1.0	26.9±1.5	17.66±.88	34.96±1.60
Sc	19.16±.56	19.13±.55	18.72±.52	17.41±.60	23.11±.96
Fe%	5.01±.12	4.92±.15	4.91±.19	4.63±.15	6.82±.24
Cs	3.2±1.1	2.3±.90	3.5±1.2	3.01±.25	1.39±.21
Cr	260±13	308±49	257±22	190±9	181±16
Th	7.125±.031	7.16±.22	7.15±.11	9.90±.35	6.94±.49
Eu	1.019±.025	1.043±.043	1.007±.030	—	—
Ce	46.4±1.1	47.2±1.6	46.2±1.2	—	—
Hf	3.34±.06	3.44±.17	3.26±.16	5.52±.54	8.67±.75
Ta	.814±.018	.788±.038	.799±.035	1.077±.072	1.445±.106

[1] Data taken from I. Perlman and F. Asaro, Archaeometry 11, 21 (1969).

[2] The values in this column are the average abundances in parts-per-million (or % if so indicated) and the standard deviation of the abundances.

Table III

Chemical Composition of Faïence-Bodied Ware Excavated in Fustāt, Egypt and Reference Groups

	"Fustāt Fatimid Sgraffiato" & Monochrome Celadon ware	Luster Ware	Ancient Egyptian Faïence Lucas[1]	"Underglaze "Painted" faïence	Iranian Allan et al.[2]
No. of pots in group	4:(Fust-3,4,10,15)	2:(Fust-9,31)		5:(Fust-12,13,14,19,20)	11
σ	20%(20 elements)			25%(20 elements)	31%(8 elements)
SiO_2%	[87][3]	[87][3]	88	[89][3]	92.1±1.3
Al%	2.24±.41[1]	2.15±.15[5]	3	.61±12	.45±.09
Mg%	<1.	<4.		< 1.8	.32±.08
Ca%	2.82±1.05	2.19±.15	2.4	4.8±1.6	.90±.40
Mn	158±73	126±44		420±180	350±130
Na%	1.98±.28	2.20±.23	<2	1.08±.26	2.4±.7
K%	.73±.16	.89±.08		.51±.10	.83±.16
U	.95±.15	1.28±.13		1.15±.17	
Ba	81±15	136±60		116±20	
Sm	2.04±.23	1.82±.22		1.06±.18	
La	12.2±1.1	12.4±1.6		7.0±1.6	
Ti%	.212±.044	.144±.042		.049±.020	.04±.02
Lu	.133±.011	.109±.03		.079±.014	
Co	4.5±2.5	4.26±.48		6.5±3.0	
Sc	4.79±.71	4.50±.08		1.91±.56	
Fe%	.92±.20	1.12±.01		.39±.10	.26±.06
Cs	.55±.17	.60±.14		.34±.13	
Cr	32.9±2.0	33.3±4.4		138±91	trace
Th	2.92±.46	2.94±.30		1.44±.29	
Eu	.473±.041	.409±.01		.239±.037	
Ce	24.7±2.8	22.8±2.5		12.1±2.3	
Hf	2.15±.56	2.42±.72		2.57±.53	
Ta	.43±.04	.56±.05		.16±.02	

[1]A. Lucas, "Ancient Egyptian Materials and Industries", 1962, revised by J. R. Harris, 4th ed., Edward Arnold, Ltd., London, p. 474.

[2]J. W. Allan, L. R. Llewellyn, and F. Schweizer, "The History of So-Called Egyptian Faïence in Islamic Persia", 1973, Archaeometry 15, No. 2, p. 165-173.

[3]The SiO_2 content was determined by difference to 100%.

[4]The values in this column are the average abundances in parts-per-million (or % if so indicated) and the standard deviation of the abundances.

[5]The entries in this column are the average composition of the 2 sherds and the range for each element. σ for this column is the average value of these ranges.

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