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INAA CHARACTERIZATION OF COLONIAL POTTERY FROM OLD HAVANA COLLECTIONS.*

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ABSTRACT

Since 1990, the Archaeology in Cuba has relied on a very limited analytic capacity, mainly for lacking in resources and of technical basis. The works performed to study ceramic artifacts related with different archaeological contexts have been carried out basically by their morphology, style features, techniques of elaboration, texture or other properties. The aim of the Research Project CUB9397/RB consisted on the application of the Instrumental Neutron Activation Analysis (INAA), as the more frequently used analytic technique for the study of chemical composition in ceramic objects during the last years, in some of the Archaeological researches that are presently in course in Cuba. Some of the commonly found colonial pottery types were analyzed by INAA in order to establish compositional models. Two major types of ceramic ware conformed the main research interests during the first stage of the research on Colonial pottery: the first, samples classified as belonging to several Majolica styles of Spanish and Mexican provenance; and the second type included samples of ordinary pottery that indicated an the presence in Havana of a starting local manufacture trying to follow Spanish traditions.

I INTRODUCTION:

Since the XVI century, and due to its geographical location, Havana became an important cross path for most of the ships travelling between the Old and New Worlds. From the XVII century the Havana port, with its safe-closed bay was selected as a meeting point for the ships that waited the caravan departure to Spain. Therefore, Havana was an important trade and cultural center in Central America. The Cuban museums keep important collections of Pottery from the colonial period. The large quantity of archaeological researches conducted since 1968 in the historic center of Havana (Old Havana) have revealed a marked presence of Majolica pottery in the excavations performed in the colonial contexts.
Majolica is a distinctively Hispanic category of glazed, wheel-thrown ceramics, distinguished by its soft earthenware paste covered by an opaque vitreous enamel or glaze. The addition of tin oxide to the glaze produces an opacity, whish is found also on the technically related French faience and English and Dutch delftware.

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The findings of Majolica pottery have been stated in sites covering practically all the period of Spanish presence in the isle *[1]*, even in those corresponding to the earlier XVI century *[2, 3]*. Different researchers have identified ceramic artifacts in Havana *[1]* and other major Cuban cities *[4, 5]* with the distinctive features described for the Majolica types found in America and the Caribbean basin *[6 ,7]*, such as *Isabela Polícromo, Santo Domingo Azul sobre Blanco, Columbia Simple (*Fig. 1*), Yayal Azul sobre Blanco (*Fig. 2*), Abó Polícromo, San Juan Polícromo, Caparra Azul, Ichtuknee Blue on White, Catalana Azul sobre Blanco (*Fig. 3*), Puebla Polícromo (*Fig. 4*), Puebla Azul sobre Blanco (*Fig. 5*)* among others.

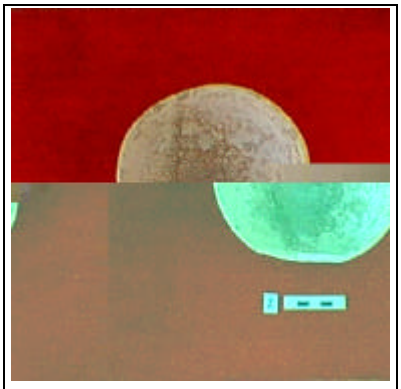

Fig. 1 Columbia simple

Fig. 2 Yayal Azul S/ Blanco

Fig. 3 Catalana Azul S/ Blanco

Fig. 4 Puebla polícromo

STUDY OF SANTOVENIA MAJOLICA.

A group of ceramic artifacts that seemed to belong to a non described yet Majolica type was found during the archaeological excavations performed in the house of the Counts of Santovenia. The typological features and a preliminary description of this ceramic were reported in the VI Havana Symposium of Culture *[8]*. Further, similar fragments and artifacts were found in other Havana sites, and a more exhaustive study was carried out with the aim to characterize these artifacts as belonging to a new (non-described) typology *[9]*. *A pale cream paste distinguishes* ***Santovenia Polícromo type,*** *with its variety* ***Santovenia Azul sobre Blanco***, with very light variations in its color tone. The paste is covered with a very homogeneous, white-bone thin tin-lead glaze. The most common identified shapes are the deep and semi-deep dishes, plates, cups and chamber bacins. The colors used in the decoration motives of the *Santovenia Polícromo* are the blue, the orange, the violet and the yellow. Some specimens show a very light green associated to the previous mentioned colors. The combination of the colors in the designs are variable, being the most frequent the appearance of blue with orange, although more complex designs include blue,

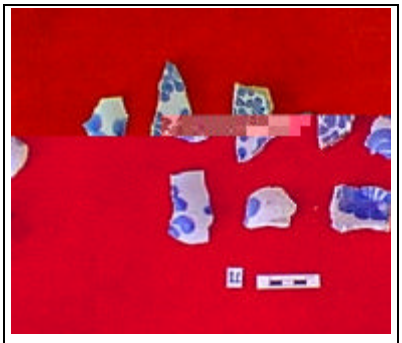

Fig. 5 Puebla Azul S/ Blanco

Fig. 6 Santovenia Polícromo

orange, violet and yellow in a single piece. The typical decoration consists of circular simple lines, sinus circles, bands, chains of stylized leafs, floral motives, concentric circles, spirals, guirnalds and semi-circles, sponge ovals and asps among others. In the variety Santovenia Azul sobre Blanco all the described typological features are present, with the distinction of the use only of the blue color on white.

Fig. 7 Santovenia Azul S/ Blanco

This Majolica is found mainly in association with other types described for the late XVIII and early XIX centuries. Our typological classification points to a Spanish origin, probably from Sevilla or Catalunya master workshops. The intention of our research is to corroborate this hypothesis by the establishment of a specific compositional model that would enrich its characterization and help in finding a correlation with other compositional patterns that could indicate possible area(s) of provenance. The well known and described Sevillan *Columbia simple*, *Santo Domingo Azul sobre Blanco* and *Yayal Azul sobre Blanco,* as well as the *Catalana Azul sobre Blanco* seems to be the more probable related Majolica types.

STUDY OF PUEBLA MAJOLICA:

Since the second half of the XVI century Spanish immigrants established the manufacturing of Majolica pottery in Puebla, Mexico [***6, 7***]. The Puebla workshops developed and reached its higher splendor in 1580 with the establishment of the foundation of the Gremios de Loceros. Initially, the pottery was manufactured trying to imitate the Chinese porcelain, and is decorated mostly with phito-zoomorphous and Chinese motives performed in blue on white (see Fig. 5). Although blue on white was the more common used combination of colors, the guild ordinances allowed the use of other tones of orange, yellow, green and black (Fig. 4). A direct influence by the potters and ceramics of Talavera de la Reina has been posted as the main cause of the appearance of the black, lace-like designs found in Puebla Polícromo type.

Even when the masters did not allow the participation of native ceramists in the Spanish production or the assimilation of local motives and costumes, they were ought to use the local raw material sources. Puebla Majolica is distinguished by a creamy white to pale peach in color paste, a result of the use of a mixture of two colors of clay (red and white) available in the vicinity of Puebla. The background enamel is usually a glossy white or cream color, and it has been suggested that a final clear lead glaze was sometimes added in a separate firing.

Puebla Majolica is one of the most frequently found Majolica potteries in Havana sites, and a study of the composition of micro and trace elements was included in our research objectives.

SAN FRANCISCO POTTERY.

Large quantities of fragments of ordinary pottery are found in the Old Havana churches and convents, where these fragments were used as light materials to fill the space over the arcades. Some archive records mention the presence of local workshops in locations surrounding the city, but there are no evidences of their existence. The ceramic fragments found in the arcades (specially over the chorus) seem to belong to a workshop established in Havana, since we found glaze (finished) and non glaze specimens of similar typology, as if the last were discarded after the first firing (see Fig. 8). The decoration is very simple, basically geometrical, with concentric circle design on the bottoms and the marl. More complex designs include phytomorphic themes, with a central medallion in the bottom. The more frequent colors are the blue, the green and the

black. The motifs appearing in most of the cases is not clearly defined, as a testimony of failures in the preparation of the pigments or in the firing process.
This ceramic ware is the first reported evidence of a local glaze pottery that tried to follow the Spanish styles in Havana, and is under typological classification now. A group of samples was analyzed by INAA in order to start its chemical compositional characterization.

Fig. 8 Ordinary pottery

II MATERIALS AND METHODS:

The INAA has proved to be a powerful tool in achieving the needed information to establish compositional models that contributed to solve many archaeological questions, such as provenance, ownership or not to determined cultures, cultural exchange between population groups and trans-culturation processes among others [***10***, ***11***, ***12***].
Despite of the lack of research nuclear reactor facilities in Cuba, the INAA has been applied in researches involving several fields, such as medicine [***13***], agriculture [***14***, ***15***, ***16***, ***17***, ***18***], industry, environmental care and others [***19***], but it had not been employed until 1995 in Archaeology studies. The access to nuclear reactor facilities and NAA laboratories has been granted as part of co-operation programs with several Institutions of Latin America, as the Instituto de Investigaciones Nucleares (México), the Centro Ezeiza and the Centro Atómico de Bariloche (Argentina) among others.
The supporting and collaborative efforts of many colleagues working on NAA and related facilities have been a real figure of merit. The work in different laboratories brings up an additional source of bias, and therefore the precision and the accuracy of the results have been checked by the analysis of Certified Reference

Element	Z	Reaction	T1/2	Analytical lines (keV)
Sc	21	45Sc(n,γ)46Sc	83.8 d	1120.52, 889.26
Cr	24	50Cr(n,γ)51Cr	27.7 d	320.08
Fe	26	58Fe(n,γ)59Fe	44.5 d	1099.25, 1291.6
Co	27	59Co(n,γ)60Co	5.27 a	1173.2, 1332.6
Zn	30	64Zn(n,γ)65Zn	244 d	1115.55
As	33	75As(n,γ)76As	1.1 d	657.2
Rb	37	85Rb(n,γ)86Rb	18.7 d	1076.6
Ba	56	130Ba(n,γ)131Ba	11.8 d	496
La	57	139La(n,γ)140La	1.68 d	328.8, 487.0, 815, 1596.4
Ce	58	140Ce(n,γ)141Ce	32.5 d	145.4
Nd	60	146Nd(n,γ)147Nd	11.0 d	91.1
Sm	62	152Sm(n,γ)153Sm	1.9 d	103.2
Eu	63	151Eu(n,γ)152Eu	5.25 a	1408.01
Lu	71	176Lu(n,γ)177Lu	6.71 d	113.0, 208.4
Th	90	232Th(n,γ)233Pa	27 d	300.1, 311.9
U	92	238U(n,γ)239Np	2.35 d	277.6

Table 1 Isotopes and lines used for quantification

Materials and by the inclusion of blind (control) samples in each analyzed group of samples.
76 samples of colonial pottery [24 Santovenia (Spanish), 26 Puebla (Mexico) and 26 of local origin] were irradiated for 5 hours in the TRIGA MARK III nuclear reactor facilities at ININ, to determine the concentrations of Na, K, Sc, Cr, Fe, Co, Zn, As, Rb, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Th and U.
The surface of the studied ceramic fragments was firstly removed to ensure the absence of contamination, and then the inner paste material was drilled in order to collect around 200 mg of powder sample for the analysis.
The analysis was carried out using the isotopes and reactions related in table 1, commonly accepted in INAA practices. Samples were irradiated for 4 hours at a neutron flux of 10^{12} n/cm^2/s. A first measurement ($T_{meas.}$ = 2000 sec.) was performed after a cooling period of 7 days, and a second measurement ($T_{meas.}$ = 2000 sec.) was carried out after a cooling time of two months.
The obtained results were evaluated by two statistical treatments: Hierarchical Cluster Analysis and Principal Component Analysis.

III RESULTS:

For the archaeological interpretation of the results, several element concentrations were discarded, due to several reasons. First of all, the concentration of the alkali metals (Na, K, Rb) as well as the results for Ba and Br, were not considered as relevant, due to the possible contamination of the samples after possible leaching or enrichment processes. The values of concentration obtained for of Co has been found in the past to be altered by contamination when using tungsten drills for sample collection [***20***].

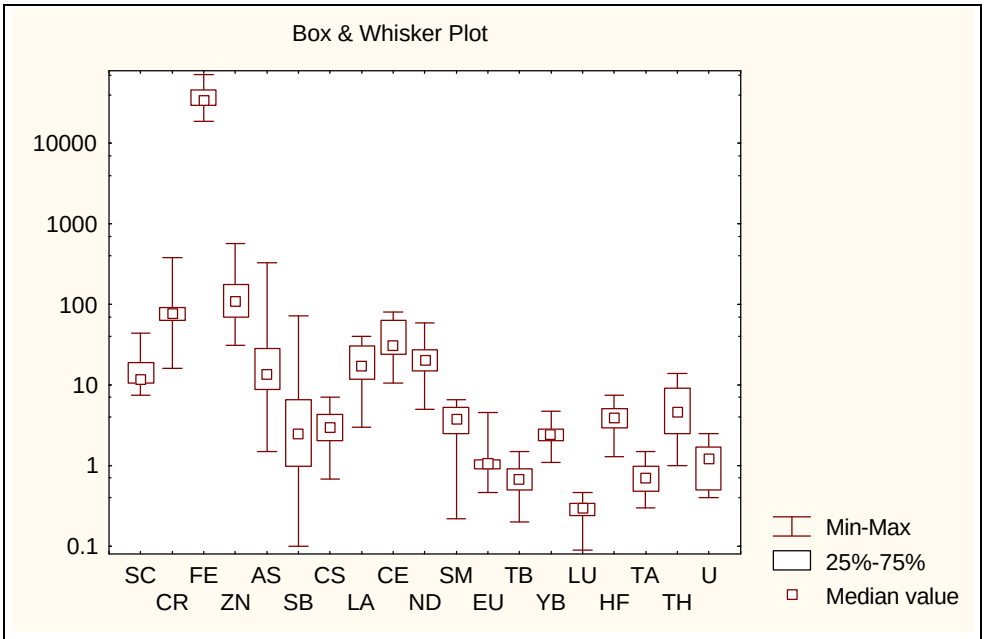

Fig. 9 Variability in the obtained concentration values.

The variability of the obtained concentrations is shown in Fig. 9.
The largest differences are observed in the values for Sc, Cr, Zn, As, Sb, Cs and the rare earth elements (REE).

RESULTS OF CLUSTER ANALYSIS.

The samples were classified in to groups using a hierarchical cluster analysis procedure. Concentration values were transformed using the Log approach [***12***], in order to avoid the uneven influence of absolute concentration ranges in the squared Euclidean distance, which was used as

measure of similarity. A very well marked differentiation in composition between *Santovenia* and *Puebla* Majolica results was revealed by Hierarchical cluster analysis, using for amalgamation the Ward's method (see Fig. 10). With the exception of some samples, which were probably wrongly classified, the rest of the samples fall in to very well isolated groups.

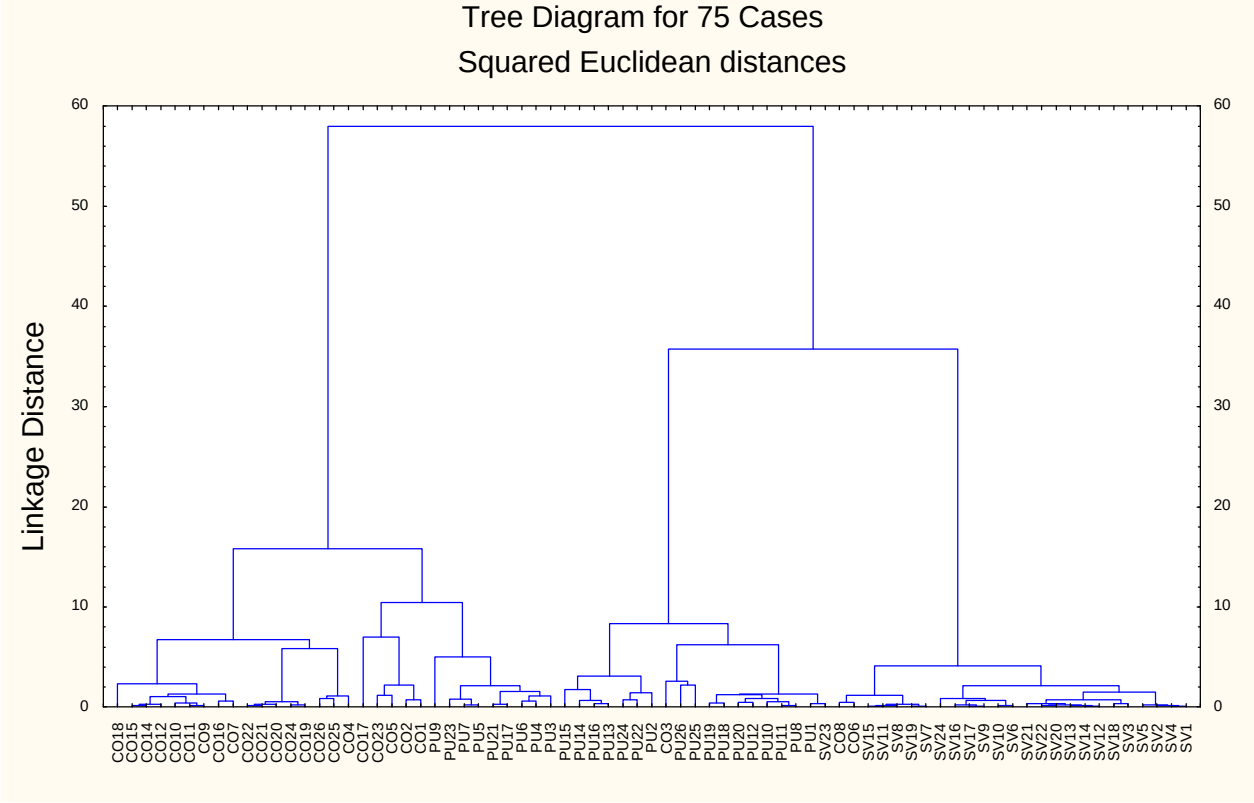

Fig. 10 Results of Hierarchical Custer Analysis

All of the samples of the *Santovenia* Majolica (SV in the Fig. 10) show a very close similarity in composition. The samples analyzed of Majolica *Puebla* type (PU in the Fig. 10) showed more spread concentration values, as expected by the use of two kinds of clay during their manufacture [*7*]. The samples corresponding to the suspected local production revealed very large variations in their composition.

RESULTS OF PRINCIPAL COMPONENT ANALYSIS.

The results of a further factor analysis procedure confirmed the observed differences in compositional patterns. Data reduction of the Log(concentration) values was performed using the extraction of the principal components analyzing the covariance matrix.

The analysis of Majolica samples showed a very good differentiation between Santovenia and Puebla samples. Table 2 and Fig. 11 relate the contribution of each of the variables to the rotated extracted factors (Varimax with Kaiser Normalization). The figure Fig. 12 show the factor scores of all the analyzed Majolica samples. A very well defined group is again observed for Santovenia samples, clearly differentiated for the Puebla type.

	Rescaled Component			
	1	2	3	4
LOG_AS	.002	-.149	**-.936**	.318
LOG_CE	.485	**.775**	.192	-.081
LOG_CR	.091	-.020	-.272	.431
LOG_CS	.427	**.656**	.112	.048
LOG_FE	**.719**	.234	-.068	-.054
LOG_EU	.444	.095	-.111	-.035
LOG_LA	**.591**	**.664**	.232	-.065
LOG_HF	**.584**	.408	.266	.016
LOG_ND	**.528**	.322	-.026	-.058
LOG_LU	**.572**	.463	.347	.140
LOG_SB	-.203	-.026	-.047	**.977**
LOG_SC	**.755**	.362	-.065	-.033
LOG_SM	**.936**	.090	.288	-.015
LOG_TB	-.018	**.781**	-.037	-.013
LOG_TH	.444	**.700**	.054	-.224
LOG_YB	.392	.525	.080	.071

Table 2 Rotated Component Matrix
(all Majolica samples)

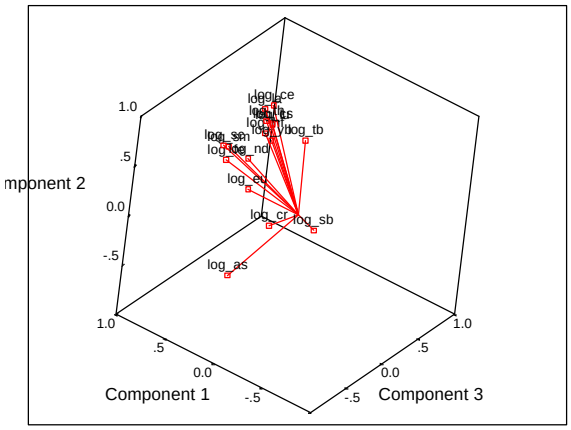

Fig. 11 Factor loadings in rotated space
(all Majolica samples)

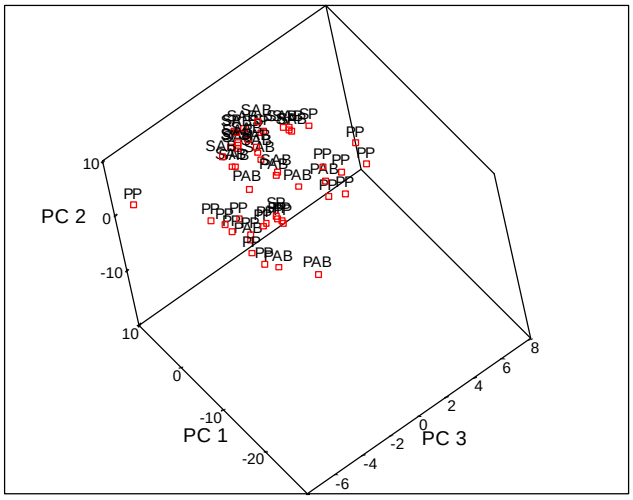

Fig. 12 Factor scores (all Majolica samples.

The Table 3 comprises the concentration values for the Santovenia, and the variations of ranges are shown in figures 13 - 15.

	Min. Val.	Max. Val.	Mean	Std. Dev.
FE	28747	42098	33373	2919
NA	1104	12942	7402	2597
K	5000	19433	11638	4818
CR	63	99	78	9.3
ZN	56	114	80	17.5
BA	199	727	384	132
AS	7.0	48.3	19.6	9.6
BR	3.0	7.0	4.8	1.0
CE	30	77	66	9.2
CS	2.0	6.87	4.4	1.1
EU	.93	4.54	1.2	0.71
HF	3.8	6.4	5.1	0.54
LA	16	40	32	4.2
LU	0.19	0.44	0.32	0.05
ND	10.4	59.5	29.6	12.5
RB	43	126	74.3	19.3
SB	1.29	13.8	4.92	3.8
SC	10.1	13.7	11.5	0.81
SM	3.7	6.6	5.5	0.54
TA	0.53	1.43	1.06	0.20
TB	0.40	1.5	0.89	0.30
TH	5.0	11.9	9.2	2.3
YB	1.6	3.1	2.57	0.37

Table 3 Descriptive Statistics for Santovenia type

The typological classification of *Santovenia* type points to a Spanish origin, probably from Sevilla or Catalunya master workshops. The research will continue on to the analysis of several well knowns and described types of Spanish Majolica (*Sevilla azul sobre blanco and Catalana Azul sobre Blanco*) which seems to be the more probable related to Santovenia Majolica types. Around 70 samples from these types are now under analysis.

The analysis of the results obtained for Puebla Majolica showed some differences in the paste composition, mainly conditioned by the found concentration values of the REE, Sc (PC1), Fe and Th (PC2), Cr and Cs (PC3), and in a less extent by difference in Sb and As contents (see Table 4 and Fig. 16)

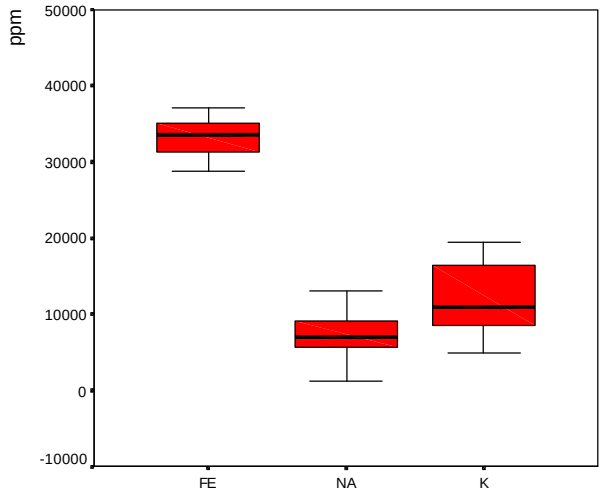

Fig. 13 Major elements in Santovenia Majolica

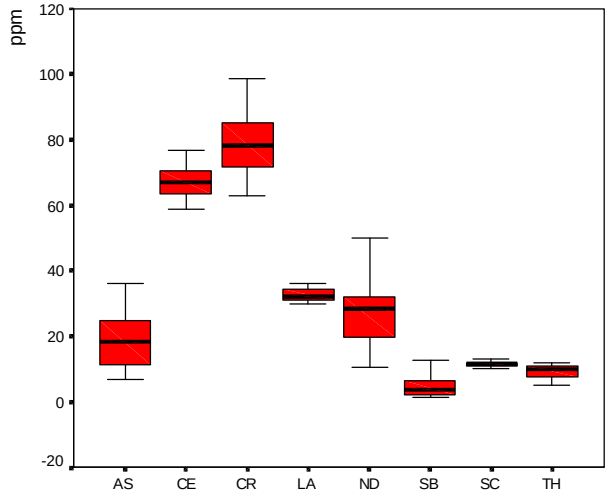

Fig. 14 Microelements in Santovenia Majolica

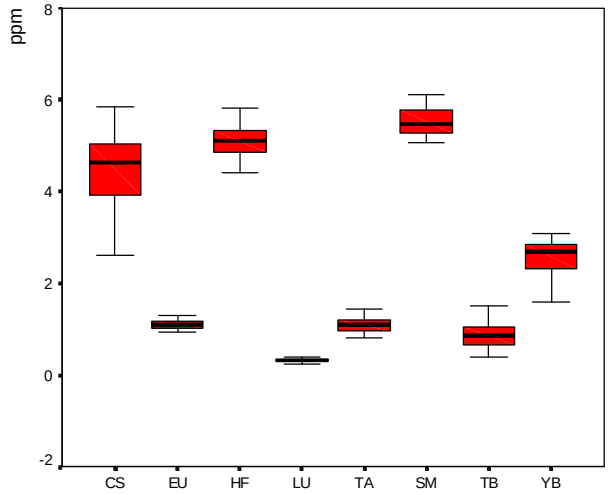

Fig. 15 Trace elements in Santovenia Majolica

	Component			
	1	2	3	4
LOG_AS	-.234	.405	.131	**.601**
LOG_CE	.333	.298	.265	.505
LOG_CR	.047	.150	**.789**	.382
LOG_CS	-.031	.321	**.655**	.095
LOG_EU	.286	**.772**	.297	-.0436
LOG_FE	.200	**.736**	.308	-.0956
LOG_HF	.418	.061	.602	-.228
LOG_LA	**.848**	.143	-.037	.098
LOG_LU	**.918**	-.018	.064	.133
LOG_ND	**.616**	.174	.536	-.066
LOG_SB	.082	-.394	.463	**.601**
LOG_SC	.374	**.798**	.291	.062
LOG_SM	**.611**	.477	.247	-.343
LOG_TB	.257	-.156	-.108	**.687**
LOG_TH	-.158	**.730**	-.119	.105
LOG_YB	**.642**	.081	.158	.370

Table 4 Rotated Component Matrix

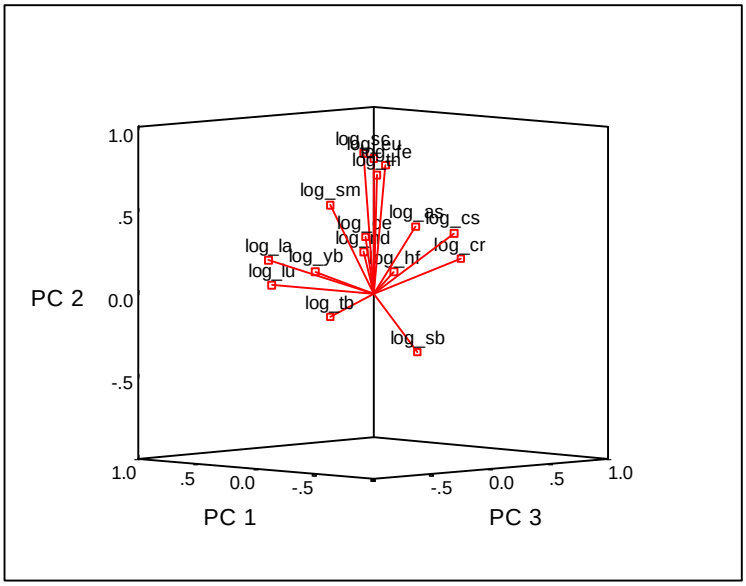

Fig. 16 Factor loadings in the rotated space

The analyzed sample group results not big enough to perform a detailed characterization of the diverse Puebla Majolica production. A larger quantity of samples shall be analyzed to define a more accurate sub-classification of Puebla Majolica.

The analysis of the concentration values obtained for ordinary pottery revealed a marked differentiation between two groups of samples, conditioned mainly by differences in the probably used clays (REE) and tempering materials (Cr, Fe, Sc) [see Table 5 and Fig. 17]. Two major workshops seem to have existed during the XVI – XVII centuries in colonial Havana, producing quite different ceramic paste (Fig. 18)

	Rescaled Component			
	1	2	3	4
LOG_AS	.178	-.340	**-.886**	.133
LOG_CE	**.968**	.068	-.038	.038
LOG_CR	.280	**.938**	-.103	.085
LOG_CS	**.913**	.030	.030	-.058
LOG_EU	**.869**	.152	.101	-.035
LOG_FE	.155	**.629**	.090	-.200
LOG_HF	**.803**	.362	.033	.086
LOG_LA	**.872**	.028	.243	.255
LOG_LU	**.563**	.242	.350	.290
LOG_ND	**.863**	-.132	.104	.092
LOG_SB	-.061	-.251	.017	**.960**
LOG_SC	-.202	**.700**	.161	-.083
LOG_SM	.378	-.174	**.644**	.207
LOG_TB	**.576**	.411	.092	.465
LOG_TH	**.852**	-.104	-.157	.027
LOG_YB	**.848**	.165	.036	-.138

Table 5 Rotated Component Matrix

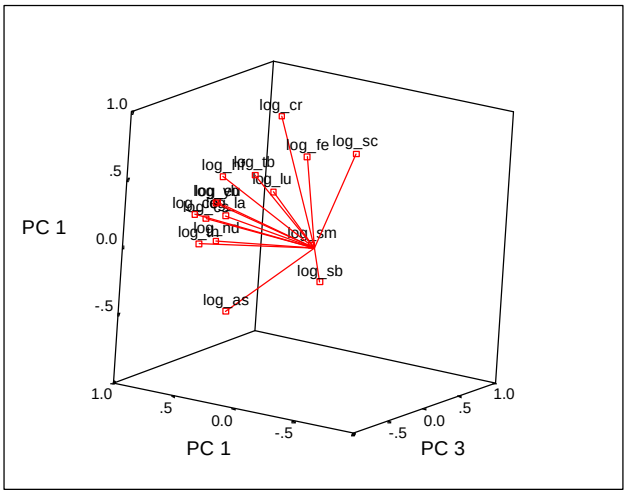

Fig. 17 Factor loadings

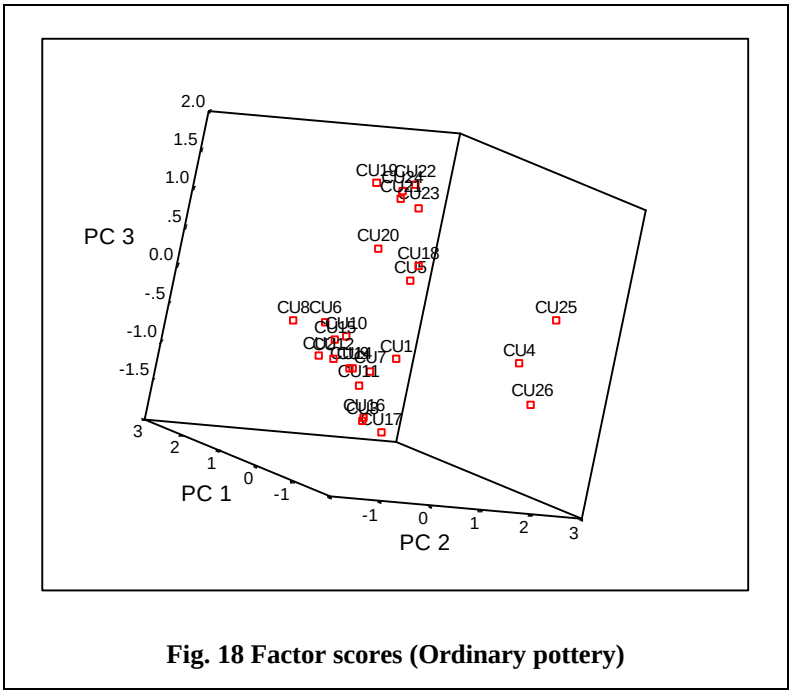

Fig. 18 Factor scores (Ordinary pottery)

IV CONCLUSIONS:

After the first year of work, several conclusions can be sustained:

- The typological classification of *Santovenia* Majolica, distinctive of the late XVIII and early XIX centuries Havana collections, was enhanced with data allowing establishing its chemical compositional model. The research will continue with the study of a group of samples comprising two Spanish Majolica types (*Sevilla azul sobre blanco and Catalana Azul sobre Blanco*) that that would enrich its characterization and help in finding a correlation with other compositional patterns that could indicate possible area(s) of provenance.
- Valuable information was obtained on the compositional variations of the Mexican Puebla Majolica.
- The production of pottery in Havana for common use during the XVII-XIX centuries employed different raw materials, probably from several procurement areas surrounding the city. A complementary analysis of clays from these areas could allow classifying the frequency and proportions of its use by Havana masters.

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