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CLASSIFICATION OF THE REGIONAL ABORIGINE CERAMIC PRODUCTION AND ITS DISTRIBUTION IN THE CENTRAL REGION OF CUBA BASED ON NAA*.

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The chemical composition of ceramic fragments of Cuban Aborigine *Subtaíno* and *Archaic* settlements of the central region of Cuba (700 – 1500 AD) were analysed by Neutron Activation Analysis (NAA) and Electron Probe Microanalysis (SEM-EPMA). The classification of the analysed samples in several compositional groups served as a new evidence to the discussion of ceramic production and regional interaction between the *Subtaíno* and *Archaic* settlements.

Keywords: Subtaíno, pottery, aborigine, NAA, chemical analysis sourcing.

INTRODUCTION:

The earlier aborigine settlements in Cuba (4000 – 500 BP) have been classified as *Archaic* (or *Siboneyes* in the literature up to the 80's). These communities were mainly devoted to fishing, gathering and hunting activities, and in their latest settlements (proto-agricultores), evidences of an incipient agriculture are stated. Large collections of lithic and shell tools have been compiled from excavations through the whole island, and these communities have been classified as *Cayo Redondo* (when the presence of stone daggers or balls is predominant) or *Guayabo Blanco* (when shell tools are predominant). The study of the lithic industry in the sites of Aguas Verdes and Playitas (Kozlowski, 1975; Febles, 1991) suggested the possibility of an origin of these communities in the formative period (3000 BP), when a big migration might take place from Colombia toward the south of North-America (Mississippi valley), passing trough the Antilles arc. Samples of primitive pottery have been found in some *Archaic* sites.

For some decades, the Cuban archaeologists have accepted the generic classification in *Taínos* and *Subtaínos* (Rouse, 1942) for the study of the groups carrying agricultural and pottery traditions (Agroalfareros). The first and earliest ones (XII-XVI AD) were spread in the eastern edge of the island (Guarch, 1978) and their pottery is usually associated to the series of styles *Chicoide* (see figure 1). The Subtaínos, perhaps were as early established as since VIII AD (Tabío & Rey, 1979), and were distributed mainly at the east and the central territories of Cuba, and its earthenware is associated with the *Meillacoide* stylistic series. This pottery shows a poorer decoration and elaboration (figure 2) when compared to the *Chicoide* exponents.

Figure 1 Exponents of *Chicoide* pottery, Maisí, Oriente.

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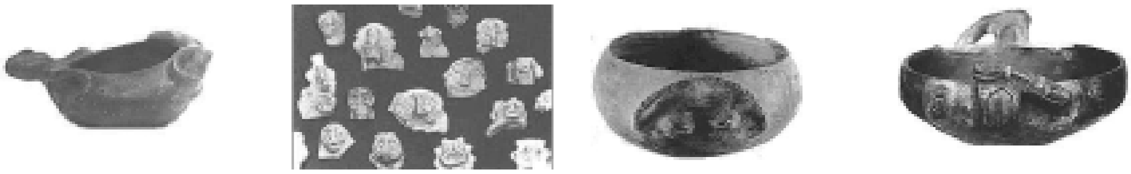


Figure 2 Exponents of *Meillacoide* pottery artefacts.

The archaeological researches in Cuba have been oriented mainly to the study of both the eastern and western territories of the island: the former province Oriente, considered as the location with the higher density of Agroalfarero communities; and the former provinces of Pinar del Río, La Habana and Matanzas, where mostly *Archaic* sites have been discovered. However, and in despite of the rich diversity and relevance of the central region of Cuba, this region has been only partially and incompletely studied.

The variety in the landscape of the central region of Cuba (ca. 200 km WE, 120 Km NS) was extremely favourable for the development of diverse social and economic structures. Located in the heart of the Cuban archipelago, the central region was the centre of the confluence of pre-hispanic cultures with uneven levels of development, ideology and social organisation. The communities arriving from the eastern territories, bearing strong agricultural and pottery traditions interacted with the *Archaic* already established centuries ago in these territories, and successive transculturation and assimilation processes should take place. Christopher Columbus in his second trip to the island of Cuba was already impressed by the magnificent Jagua bay (Colón, 1867), and the first records about the native settlements around the bay are given by Sebastián de Ocampo during his navigation around the islands, and subsequently by the friar Bartolomé de las Casas, who lived in the region for many years (Las Casas, 1967).

The technological techniques and stylistic features of the ceramic wares from this territory show certain unity with the *Meillacoide* series. The masters of the central region used the techniques of putting successive cords to build up the vessels, and the firing of the artefacts in open sky kilns. The decoration motives became simpler when compared with the *Meillacoide* exponents from the eastern edge of the island. A tendency to schematise the represented themes seems to be the result of their contact with the *Archaic* culture, as well as the use of a decoration based on incisions and applications in panels. The handles are smaller, consisting of small pieces with an elementary moulding of abstract and geometric shapes, giving up the richness in anthropomorphic and zoomorphic motives from the eastern cultures. Population groups in the Southwest, the Northeast and the Middle East of the central region show local variations that suggest the need in studying their history and social development. The classification of the aborigine pottery manufacture of the Centro region in three major stylistic variations (Jagua, Yayabo and Yaguajay) is described in details on the latest interpretations of Celaya and Godo (Celaya & Godo, 1998) on the origin and formal transformation of the themes represented in the pottery.

The chronological information about some *agroalfarero* settlements and their interactions with the existing by then *Archaic* (Pichardo, 1948, 1960), spread from the east (earlier sites) toward the centre of Cuba (late sites), has suggested the hypothesis of two migration routes following that direction (see figure 3). The process of the agroalfarero settlement in the central region seems to have started in the southern limits of the provinces of Ciego de Avila and Sancti Spíritus, with the sites of Palo Alto, Toma de Agua, Tayabacoa and Guayabalito. Some communities continued moving north to reach clear inland locations in the actual municipalities of Jatibonico (Godo et.al., 1999) and Sancti Spiritus (González, 1984). A unity in the style of the decoration is the main cause for its association to a local development, defined as *Yayabo* (see figure 4). Other settlements were established in many sites at the Southwest of the Centro region in the actual provinces of Cienfuegos and Trinidad, showing different patterns in the decoration motives (figure 5). Different aspects of the life of the communities developing the Jagua pottery have been widely described in the literature (González & Avello, 1946; Morales et. al., 1947; Herrera, 1964, Domínguez, 1991). Finally, a differently decorated pottery (figure 6) is found in the sites Playa Carbó, Júcaro II and others, located in the east of the northern coast, and that were studied by the members of the group Caguanes (Chirino J., 1992; Martínez et. al., 1994; Martínez & Falcón, 1994). The Yaguajay ware seems to have developed from the stylistic traditions found in the sites located farther to the east by the north coast, in the provinces of Ciego de Avila and Camaguey.

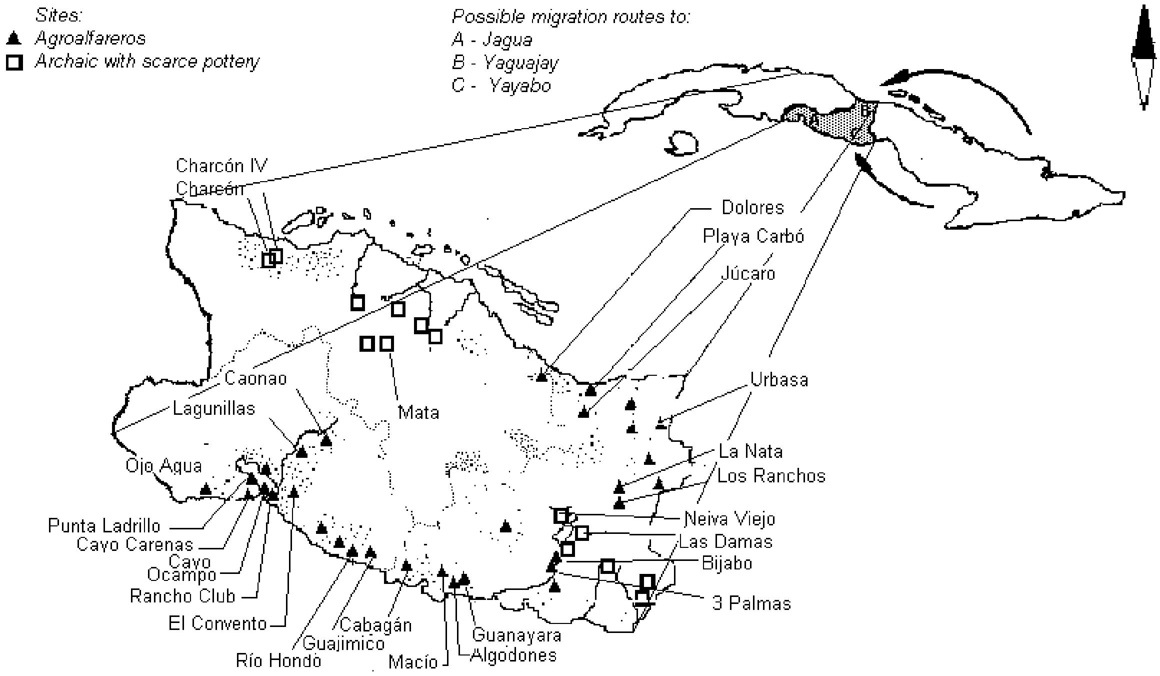
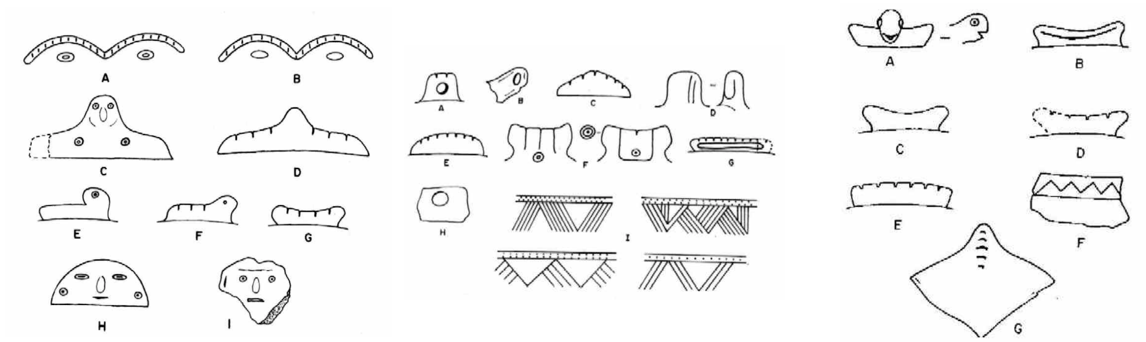


Figure 3 Settlement of Central Region by agroalfareros arriving from the east.



a) Applications (A, B), zoomor-phic and anthropomorphic moti-ves (C-I), Site “Los Ranchos”

b) Decoration in handles (A-H) and panels (I), Site “Los Ranchos”

c) Decoration in handles, Site “La Nata”

Figure 4 Stylistic features of the Yayabo pottery

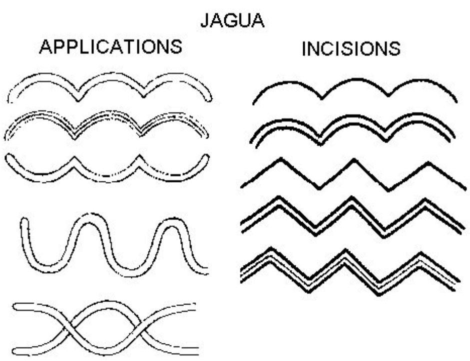
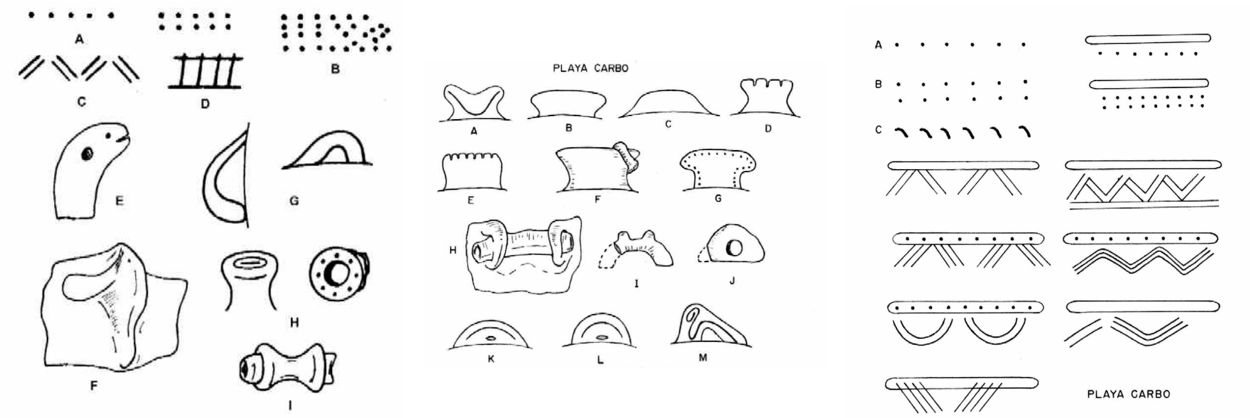


Figure 5 Decoration with applications and incisions in the pottery of Jagua



a) Decoration in the ware of "Júcaro II" b) Decoration of the handles, site "Playa Carbó" c) Decoration with incisions and applications, site "Playa Carbó"

Figure 6 Stylistic features of the Yaguajay pottery

RESEARCH PROBLEMS AND QUESTIONS

To source pottery and trace its distribution in the Centro region should contribute with new evidence to the discussion of ceramic production and regional interaction between the *Subtaíno* and *Archaic* settlements. It is possible to formulate the following research questions:

1. Are there any compositional patterns in the pottery of the region, which might reflect the existence of several production loci?

Based on the observations of stylistic features described above, it is possible to investigate whether they might be also an indicator of the existence of different production loci.

2. How many procurement areas the potters of the central region could exploit?

Although several authors have described the pottery findings when studying different sites, there have not been any conclusions about what clay deposits the communities living in the areas could use. The rich diversity of the geology of the zone, and therefore of available procurement materials for pottery manufacture, should impose a source of differences in the composition of the paste of the aborigine pottery.

3. Was pottery exchanged between the different communities living in the region?

Early historical records witness about the native settlements around the Jagua bay (Las Casas, 1967), and perhaps the work by Dominguez (Domínguez, 1991) is the more complete study published so far about the archaeology of the aborigine settlements around the Jagua bay. The hypothesis of some interrelation between these communities, as well as the description of the site "El Convento" as being of a larger magnitude, leads to the expectation of some exchange.

4. Was the ceramic presence in the Archaic settlements an indication of an incipient manufacture of pottery, or was it the result of the exchange with Subtaíno communities living in the region?

The settlement of the region by subtaíno groups should experience extremely diverse interactions with the local archaic communities. It is difficult to assess whether the scarce presence of pottery in archaic sites would evidence the transfer of knowledge and pottery manufacturing skills, or just the result of exchange or trade of goods. The analysis of composition patterns in the associated to these sites pottery might provide information for a more conclusive definition.

CERAMICS.

228 samples corresponding to 15 Agroalfarero and 12 Archaic sites from the Centro region (Table 1, figure 3) were analysed between 1997 and 1999. Samples were selected following the techniques of Ford's method from the funds of the existing in the area museum collections, trying to conform groups of fragments from each region that would be proportional to the amount of ceramic material collected in each of the three major zones. Most of the fragments came from Jagua zone, which correspond to the higher density of agricultural sites in the whole Centro region. Some Archaic sites

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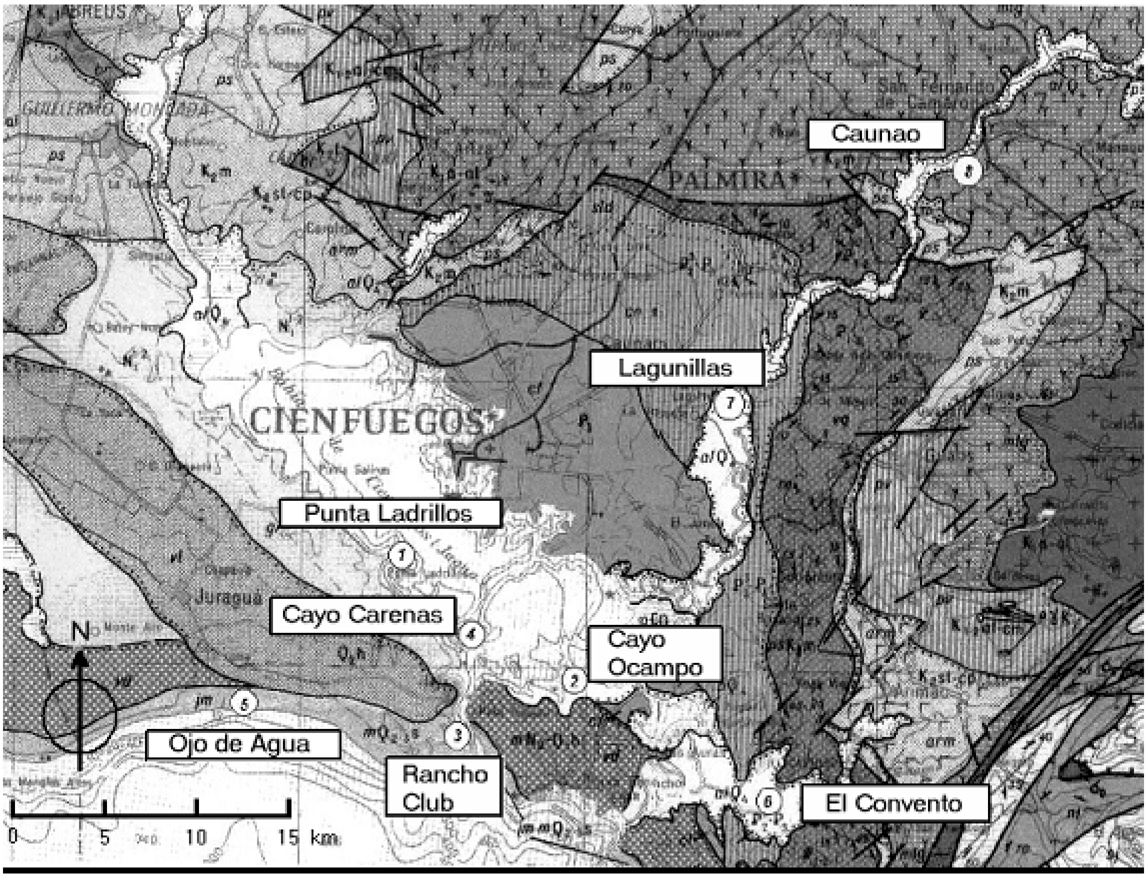
were selected among the ones closely located to any of the three supposed loci, while others were sampled far enough from them, trying to reveal the scope of the Agroalfarero influence.

Table 1 Samples analysed from the Centro Region

Agroalfarero sites			Archaic sites with ceramic findings		
Loci	Site	Analysed fragments	Site	Analysed fragments	Possible interaction with
Jagua	Ojo de Agua	25	Lagunillas	3	Jagua
	Punta de Ladrillos	14	Caunao	4	
	Rancho Club	3	Guajimico	2	
	Cayo Carenas	15	Tres Palmas	3	Yayabo
	Cayo Ocampo	32	Neiva Viejo	5	
	El Convento	30	Las Damas	3	
	Río Hondo	2	Bijabo	3	
	Cabagán	2	Urbaza	12	Yaguajay
	El Masío	1	Dolores	6	
	Guanayara	2	Mata	6	Jagua ?
	Laguna de Algodones	2	Encrucijada	1	
Yayabo	La Nata	10	Charcón	8	
	Los Ranchos	11			
Yaguajay	Júcaro II	11			
	Playa Carbó	9			

The observed technological features, such as a medium to large grain size, the absence of well elaboration of the surface, among others, suggest that the ceramic production of the zone had a not very well specialised character. The characteristics of the paste seem to have been resulting from the selection of clays showing better characteristics for the manufacture, rather than from the use of other materials for tempering purposes. Therefore, the use of the term “temper” in this text shall be interpreted as to referring to the fraction of the paste corresponding to grains larger than 0.01 mm. Therefore, we tried to emphasise on the suspected differences in the raw materials available from the surrounding areas to differentiate the chemical composition of the pottery paste.
A big constraint for the characterisation of the analysed samples, and therefore for a more consistent interpretation of the results, is the absence of dating for the findings of the region.
Clays from the region were not analysed due to two concurrent constraints. First, the intense program of water resources improvement developed in the region during the last 30 years has lead to the construction of numerous artificial lakes and reservoirs that might cover some of the original clay beds. In another hand, the number of samples that can be analysed using the analytical facilities of institutions in other countries has to be defined in advance in most of the cases, and is finite. Therefore, to carry out a research involving the searching of correlation on results between clays and ceramic samples would impose the analysis of a larger amount of samples, due to the extreme geological variability of the region. As far as to a large extent, the analysis of pottery fragments remains the more informative source, we tried to compensate the lack on information on the composition of clays performing a detailed study of the geology of the region.

GEOLOGY AND RAW MATERIALS:
The complex geology of the Centro region leads to the supposition of a consequent variation in the composition of the clays from the possible procurement alluvial deposits, which cross formations containing ultra-basic, basic, intermediate and acid rocks (Mapa Geológico de la República de Cuba, 1985).



LEGEND

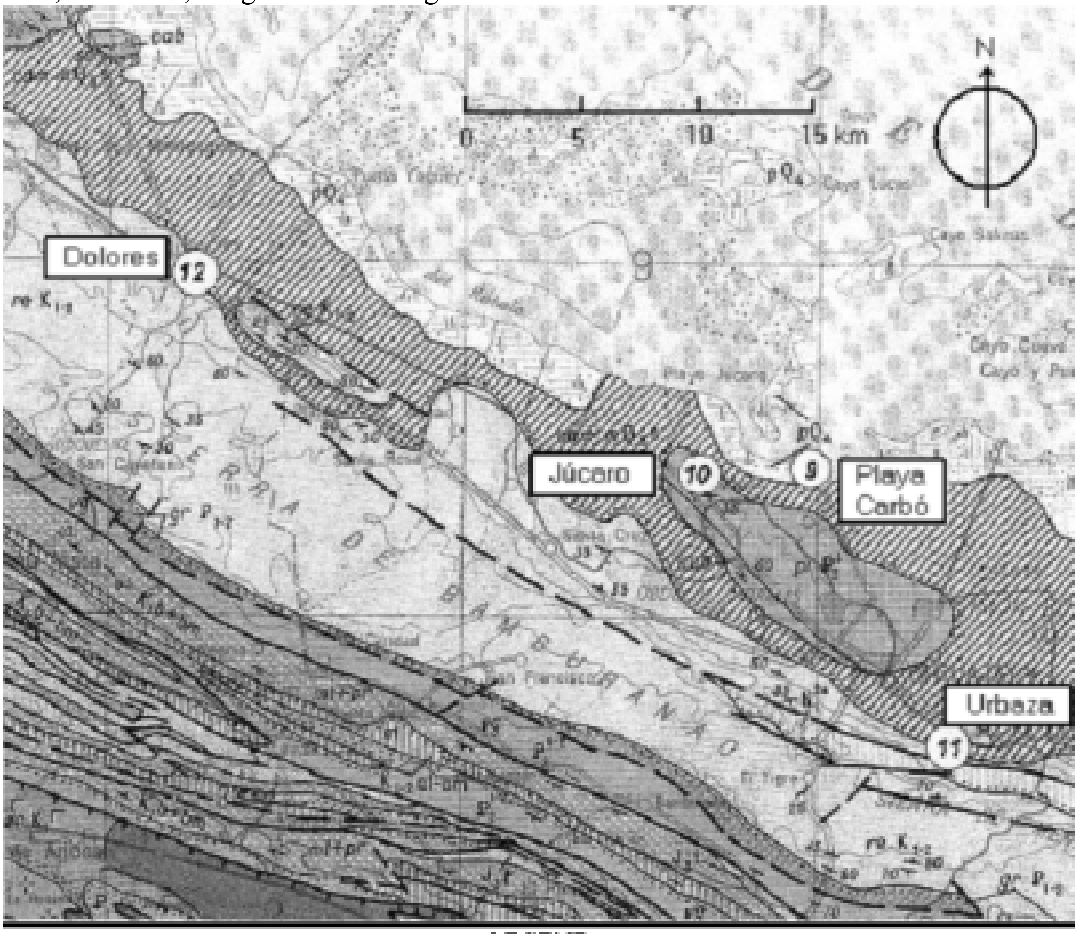
alQ_4	Alluvium: Grey and brownish-grey slimes, sandy mud and clays
$mQ_{2-3}s$	Marine: Organodetritic and organogenic limestone, brownish-grey calcareous rocks.
Q_2h	Red clays, sandy clays, sand with gravel, pebble and boulder.
mN_2Q_1h	Marine: Organodetritic and organogenic limestone, white / light grey calcareous rocks
N_1^{1-2}	Biogenic and detritic limestone, with dolomite presence.
P_3	Aleurolite, conglomerates, and sandstorm.
P_2^3 P_3	SALADITO (***sld***): Limestone; CAUNAO(***cn***): Conglomerates, sandstorm.
P_{1-2}	Limestone, marga, breach-conglomerates, tobaceous rocks.
K_2m	Conglomerates, sandstorm, aleurolite, marga, limestone, vitroclastic tobaceous rocks.
$K_2st\text{-}cp$	Basalt, reef limestone
$K_{1-2}al\text{-}cr$	Limestone, tufaceous, tobaceous, basic lava, silicite and marga.
$K_1a\text{-}al$	Tobaceous, basic to medium lava, limestone and elastic rocks, basalt, andesite – basalt

Figure 7 Geology of the Jagua region and location of the sites.

Surrounding the Jagua bay clockwise (figure 7), the first source of clays are the red clay deposits from the formation Villa Roja, that are originated from the weathering of calcareous and limestone rocks and which contain as natural non-plastic inclusions sand landslide, boulder and pebble. Next, there are the grey to brownish-grey mud beds lying around the mouth of the Damuji river at north-west of the bay, and which contain sand as natural impurity. The Damuji River originates in a formation of limestone rocks with a strong presence of andesite (Brujas, not shown in the map) and cross formations rich in conglomerates, sandstorm, aleurolite, marga, limestone and vitroclastic tobaceous rocks, among other kinds of rocks.

The last beds are found along the banks of the rivers Arimao and Caunao, which sources are located in the rocky mountains surrounding the bay from the Northeast and the east, and where basic and intermediate rocks such as lava, basalt, andesite-basalt, breach, tobaceous rocks and limestone are frequent. These rivers cross in their path to the eastern bank of the Jagua bay through formations of limestone, marga, conglomerates, tobaceous rocks and sandstorm.

The geology of the eastern territories of the Centro region is even more complex. Successive formations of ultrabasic, basic and acid rocks constitute the Sierras of of Meneses and Bamburanao on the Northeast and the Sierra of Jatibonico in the Middle East (see maps on figures 8 and 9). The Sierras of Bamburanao and Meneses consist mainly of biogenic limestone, biomicrite, calcareous rocks and dolomite. The rivers descending to the northern coast cross a formation of conglomerates, sandstorm, limestone, conglo-breech and gravelites.



LEGEND

pQ_4	MARSH DEPOSITS: Carbonated, tarragon and turba, mangrove swamps.
mQ_{3-4}	MARINE: Greenish brown/ dark/ brownish grey clays and clay sands
P_2^3	Conglomerates, sandstorm, limestone, conglo-breech, gravelites
K_{1-2}	Biogenic limestone, biomicrite, calcareous, dolomite
P_{1-2}	Breech, limestone
P_2^{1-2}	Chaotic complex, breech, conglomerates, limestone, sandstorm, marga, clays
K_1b+bm	Stratiphied limestone, biomicrites
J_3t	Stratiphied limestone, biomicrites, calcilutite, calcareous, alternations of argilite and silicate
K_{1-2}al-cm	Limestone (biomicrite and calcareous), silicite y breech conglomerates
ν	Undifferentiated gabroids, gabros, diabasas, gabro-troctolites, anortosite

Figure 8 Geology of the Yaguajay region and location of the sites.

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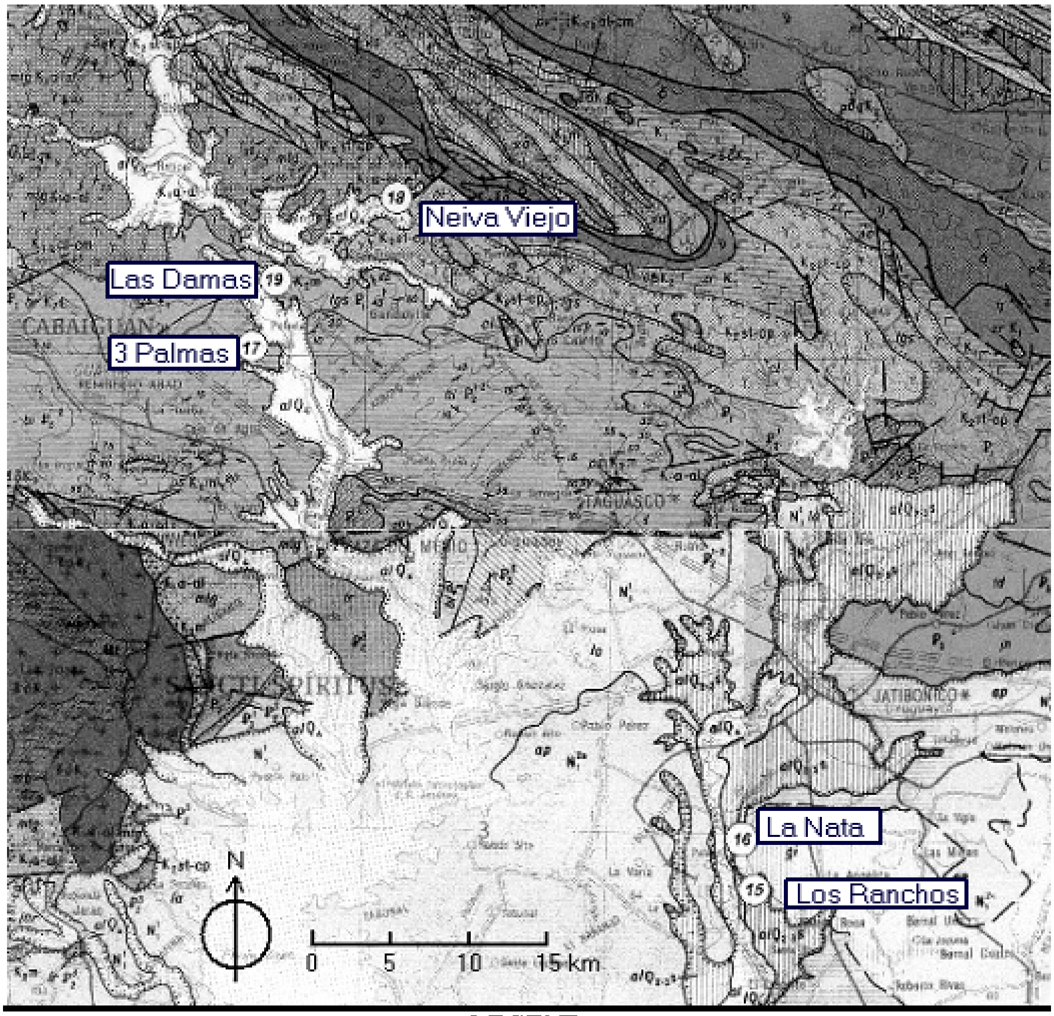


LEGEND

K_2	Complex of leucocratic granites and apliptic sienites
σ	Sepentinites, harzburguites, therzolites, wherlites, serpentinized dunites
ν	Undifferentiated Gabroids, gabros, diabasas, gabro-troctolites, anortosite
K_1	Diabasa, basalt, silicite, tobas
K_2st-cp	Tobaceous, medium-basic vulcanite, margas, clays, reef limestone
K_1a-al	Tobas, medium and basic lava, limestone and clastic rocks, basalt, andesite-basalt, breech-lava, basitic and andesite tobas, tufitas and limestone
P_1	Breech-conglomerates, conglomerates, sandstorm, aleurolites
P_2^{1-2}	Conglomerates, sandstorm and limestone
alQ_{2-3}^{s}	Alluvium: Cross-stratified sand/pebble, sandy clays, clays, mud-clays
alQ_4	Alluvium: Grey and brownish-grey mud, sandy slime and clays
P_3	Marga, sandstorm, conglomerates and limestone.
N_1^{2a}	Marga, biogenic clay limestone, sandy limestone.
N_1^1	Conglomerates, sandstorm, aleurolites, clays

Figure 9 Geology of the Yayabo region and location of the sites.

The sierra of Jatibonico is constituted by large massifs of sepentinites, harzburguites, therzolites, wherlites, serpentinized dunites as well as of gabroids, gabros, diabasas, gabro-troctolites, and anortosite rocks. To the south, two major rivers drag sediments to the coast areas: the Zaza to the Southwest and the Jatibonico to the Southeast directions. Down to the location of the sites of Neiva

Viejo and Las Damas, the river Zaza cross two consecutive formations consisting of tobas, medium and basic vulcanite, margas, clays, reef limestone, and of tobas, medium to basic lava, limestone and clastic rocks, basalt, andesite-basalt, breech-lava, basitic and andesite tobas, tufitas and limestone, respectively. Further, the Zaza flows through a formation of conglomerates, sandstorm and limestone in its way toward the location of the site 3 Palmas.
The Jatibonico crosses several formations in its way to the location of the sites La Nata and Los Ranchos, consisted of diabasa, basalt, silicite, tobas, medium-basic vulcanite, margas, reef limestone, breech-conglomerates, conglomerates, sandstorm, aleurolites, marga, sandstorm, conglomerates and limestone.

ANALYTICAL PROCEDURES AND STATISTICAL INTERPRETATION

The procedure followed for the preparation of the analytical portion, as well as NAA reactions and isotopes are described in details in the technical document summarizing the results of the IAEA-CRP (IAEA-TECDOC, 2001). The activation and measurement of the samples were carried out between 1997 and 1999 via the collaborative access granted by the NAA teams of three institutions: ININ-Mexico, CAE-Argentina and IPEN Peru. The characterisation of aborigine ceramic production was constrained to the interpretation, from all of the obtained data, of such chemical elements that were determined in all of the samples with adequate precision and accuracy. The differences in the established analytical protocols provoked that different sets of elements were determined in each analysis campaign. Since the achieved accuracy varies from element to element, only 14 elements (Na, K, Sc, Cr, Fe, Rb, Ba, La, Ce, Sm, Hf, Cs, Yb and Th) were considered to be determined with accuracy better than 10 %, and thus accepted for the statistical evaluation. The concentration values obtained for Co and Ta were disregarded due to possible contamination during the sampling procedure (Report I RCM IAEA-CRP, 1997). The results of the intercomparison run performed as part of the IAEA CRP allowed assessing the traceability of the obtained results, as well as to compensate small systematic deviations found when comparing the results obtained in each campaign/laboratory for some elements.
For SEM-EPMA analysis, cross-sections of the fragments were polished with Silicon carbide abrasive paper (up to 4000-grain density), and washed in an ultrasonic bath with deionised water. The surfaces were coated with a C layer deposited by sublimation. XRF spectra were collected from grain inclusions and X-ray maps showing the distribution of several elements were used to infer the presence of the major minerals in the paste.
The data set was thoroughly examined to exclude the cases presenting missing or wrong values. The scaling of the concentration values to log-10 values was selected as the way of compensation for the differences in concentration levels, based in the observations of log-normal distributions of the compositional data sets (Sayre, 1975; Glascock, 1992).
Principal Component Analysis (PCA) was selected to simplify the exploration and the interpretation of the results, reducing the number of dimensions of the data set of related variables to the minimal number of factors explaining the maximum variance of the related data. The extracted components were further rotated using the Varimax method, in order to provide greater agreement between axes and variable correlation, and thus easing the interpretation of the causes conditioning the observed differences. The conformation of a predictive model of group membership was established according to the hypothesis formulated in concordance with the archaeological contexts and previous interpretations, as well as to relevant information obtained from other sources, such as the interpretation of the Geology of the zones (and therefore the expected differences in the composition of the raw materials), the observation of the ceramic paste by optical and electronic microscopy and the Petrography analysis of thin sections, among others.
The canonical discriminant analysis was selected for group definition, using as input variables the component scores extracted by PCA, since these scores fulfil the requirements of orthogonality and quasi-normal distribution of the input data. A set of discriminant functions was generated, based on linear combinations of the predictor variables providing the best discrimination between the groups (Davis, 1986). The functions were generated from a sample of cases for which group membership was "known", and were further applied to the rest of the cases, with measurements for the predictor variables but unknown group membership. The prior probabilities to belong to a given group were computed from group sizes, and the Mahalanobis distance from sample to each alternative group

centroid provided the criteria for evaluating the relative probabilities of membership of the specimen to each of the conformed groups.

RESULTS AND DISCUSSION

The analysis of the obtained data was subdivided in three groups, following the stylistic classification mentioned above as well as the geographical distribution of the sites in the three respective territorial zones.

Jagua pottery:

The results obtained for 142 fragments from Jagua region had undergone a principal component analysis. The concentration of 12 elements revealed to account for most of the variability in the data set for 67 samples, and the first four components extracted accounted for the 85 % of the variability of the data. The results in Table 2 reveal that there is a complete association between the Rare Earth Elements (REEs). As far as the REEs tend to concentrate in the sediments resulting from processes involving hydrolysis, such as clay beds are, the presence of REEs in the first component also suggests that the main differences in the paste composition are conditioned by the use of clays from different composition. The Cr is the element with a high loading in the first component, and its correlation with the REEs could be an indication of its concentration in the clay fraction.

Table 2. Factor Loadings after the extraction of Principal Components for Jagua region.

	Factor loadings						
	12 elements 67 cases				10 elements 142 cases		
	PC1	PC2	PC3	PC4	PC1	PC2	PC3
LG_CE	**0.901**	0.025	0.191	-0.036	**0.807**	0.187	0.233
LG_LA	**0.883**	0.080	0.349	0.045	**0.818**	0.222	0.385
LG_SM	**0.820**	0.016	-0.003	-0.050	**0.843**	0.191	0.152
LG_CR	**0.774**	-0.101	-0.532	0.295	**0.756**	-0.066	**-0.634**
LG_YB	**0.760**	0.069	0.093	0.059	**0.732**	0.395	-0.031
LG_NA	-0.286	**0.935**	0.130	-0.039	-	-	-
LG_FE	0.126	**0.845**	0.079	0.086	0.154	**0.916**	0.070
LG_SC	0.451	**0.673**	-0.075	0.180	0.342	**0.852**	-0.173
LG_TH	0.146	-0.120	**0.745**	0.011	0.254	-0.047	**0.628**
LG_RB	0.137	0.078	**0.657**	0.171	0.038	0.074	0.402
LG_BA	-0.003	0.150	**0.521**	0.148	0.090	0.488	0.258
LG_K	0.024	0.149	0.394	**0.894**	-	-	-

The observed correlation of the transition metals Sc and Fe with Na (high loadings in the second component) leads to the hypothesis that the differences in the concentration of these elements are mainly due to the presence of several minerals, which should be naturally present in the larger grain fraction of the clays of the region. The same conclusion can be inferred from the loadings for Th, Rb, Ba (third component) and for K (fourth component).

To allow the classification of all of the 142 samples of this zone, a second analysis was performed, this time excluding the concentrations of Na and K. The results obtained did not strongly differ from the already obtained (see Table 2). The ordination of all the samples in the principal component space showed three clearly differentiated groups (figure 10). Groups of samples corresponding to each of these three groups were submitted to petrography and SEM-EPMA analysis. In general, the size of the mineral inclusions varied from 0.02 mm to 1.5 mm, suggesting that they might reflect the naturally occurring size in the clay beds. The observation of the paste texture under optical and electronic microscopy was found to be coarse in general, with cavities and fissures as large as several millimetres and tenths of millimetre wide.

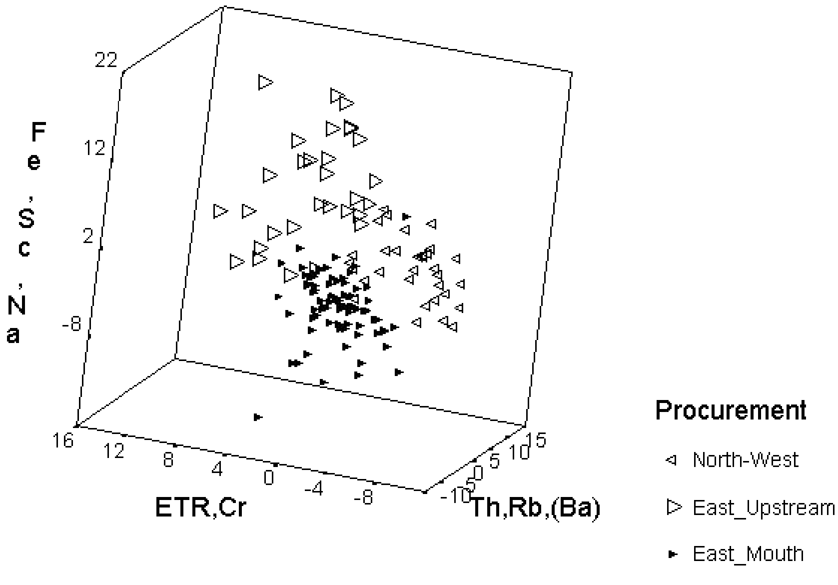


Figure 10 Ordination in the PC space of Jagua samples

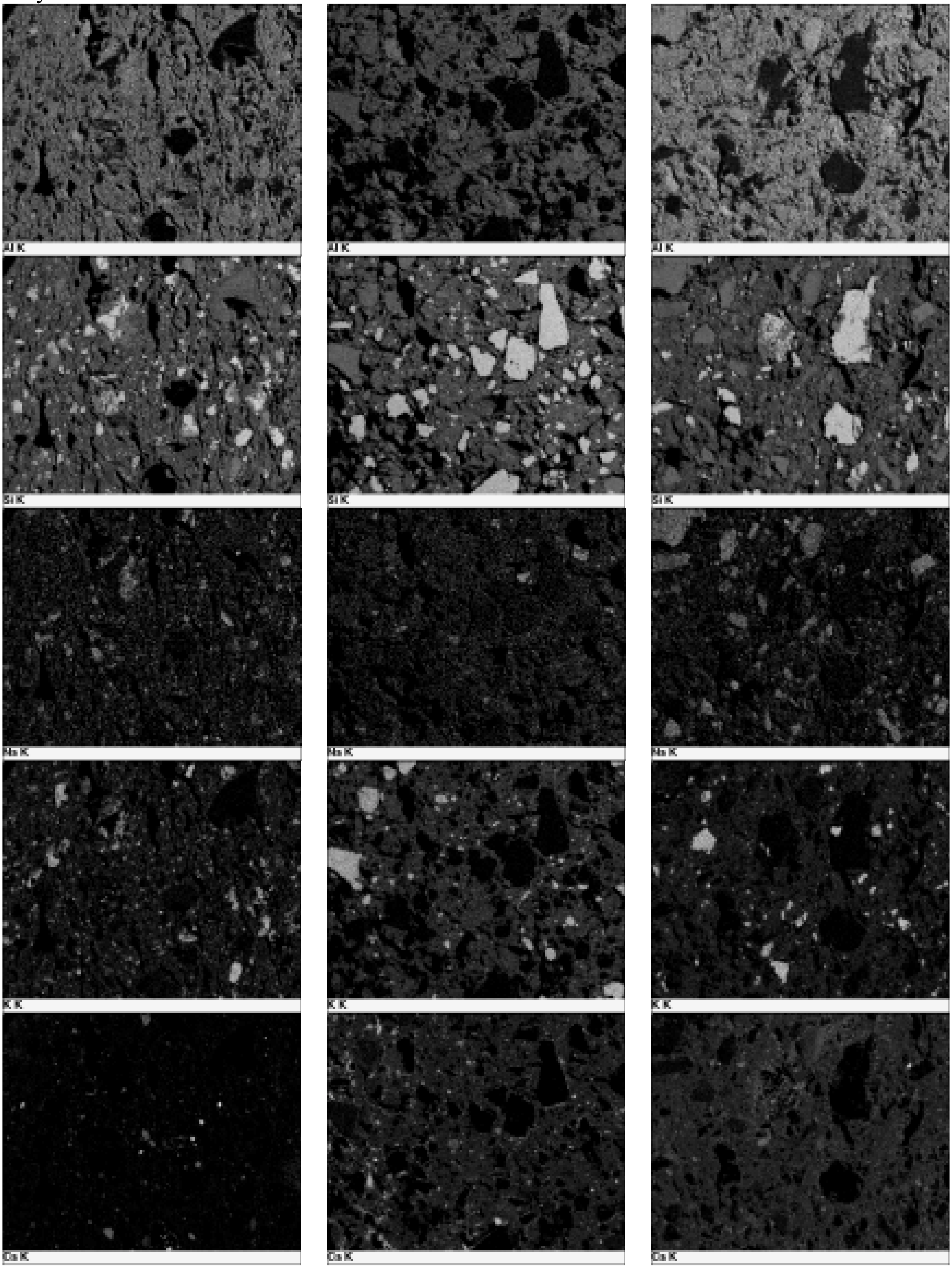
The group represented by the right looking open triangle dots in Figure 10 corresponds to the artefacts with the highest contents of REEs, Cr, Na, Fe and Sc. Plagioclase was found by petrography analysis to be the more abundant mineral, and crystals of potassium feldspar, quartz, biotite, epidota and clinopiroxene were also observed, as well as metallic inclusions. The EPMA X-ray maps also suggest the presence of this mineral as a major constituent (see fig. 11, a). The inclusions were found larger in these samples, suggesting that the exploited clays might result from less erosion and weathering processes, when compared to the ones from the other two groups. It is logic to assume that such clays could be from beds located closer to the origin of the Caunao and Arimao rivers (denomination East_Upstream in figure 10). Indeed, then closer to the massifs of the Arimao, Matagua and Provincial formations, which are rich in lava, basalt, landsite-basalt, andesite-basalt and breach rocks, the concentration of REEs and Cr will be higher, as well as the proportion of plagioclase in the clay composition (see fig. 11, a).

The fragments represented by right looking solid triangle dots have lower concentration of Na, but still high contents of Cr and REEs. The results of the petrography analysis revealed a smaller average grain size, as well as a higher proportion of quartz in the grain inclusions of this group (fig. 11, b). All these observations suggest the use of materials from beds located closer to the mouth of the Arimao and Caunao rivers. Then further to the river mouth, the proportion of plagioclase in the clays shall decrease, the quartz inclusions become more abundant and the grain size shall be smaller due to a larger weathering.

The group of left looking open triangle (North_West) shows the lowest contents of REEs and Cr and the higher contents of Th, Rb and Ba. These artefacts might be elaborated with clays either from Villa Roja or Damuji sources. However, the presence of plagioclase as the major mineral present in the coarse fraction (fig. 11, c) indicates that the materials should be procured from the Damuji beds.

All of the inferences are consistent with the behaviour of Cr and Th during the formation of the igneous rocks [Rankama & Sahama, 1962]. The concentration of Cr is maximal in the ultrabasic rocks, having an average value of several thousands of parts per million (ppm), and it decreases along the differentiation of the magma to only some ppm's in the granites. On the contrary, the average concentration of Th in basic rocks is of only of 3,9 ppm, and rises to 14 ppm in the acid rocks.

The 30 samples analysed from the site El Convento, described as a site of larger occupation or even as major chiefdom (Domínguez, 1991), corresponded to three stratigraphic levels. Samples belonging to all of the three compositional groups were found in this site, but the occurrence of fragments from the group East_Upstream increased toward the more recent layers. One of such fragments consisted of a handle showing the features of a white man face (beard and helmet), and thus evidencing the contact with the Spanish conquerors. These facts might reflect an indication of some displacement of the pottery activities to territories located inland.



a) EAST_UPSTREAM b) EAST_MOUTH c) DAMUJI

Fig. 11 Proportion of quartz and feldspar materials in Jagua samples

Samples from two other sites (Ojo de Agua and Cayo Ocampo) were also collected from three statigraphic levels. In the case of the site Cayo Ocampo, almost all of the fragments corresponded to the East_Upstream compositional group, evidencing a probable major production centre. In the case of the site Ojo de Agua, the further to the west among the analysed sites, samples belonging to both North_West and East_Upstream groups were found, but the proportion of samples from the second group slightly increased toward the more recent layer.

Yayabo and Yaguajay pottery:
Data reduction of the results obtained for the samples of the Yayabo and Yaguajay loci was performed following the same strategy that in the case of Jagua production. A first extraction of the principal components from the concentration values for 11 elements in 35 samples (Table 3) showed the existence of different associations. The first three extracted components accounted for 75 % of the variability in the data set. The high factor loadings of the REEs in the first component indicate that the major variability in the compositional data set is conditioned by the use of clay deposits of different origin. The Sc and Fe are correlated with the REEs, indicating their presence mostly in the clays. The Na and Cr show higher loadings in the second component, and suggest that the second cause of variations is the differences in the composition of the tempering (larger grain size) fraction. However, some of the Cr seems to be associated to the clay composition (see Cr loading in the first component). The different signs for Na and Cr point on to their opposite concentration in the suspected groups. Th and Rb are correlated in the third component, and also seem to be concentrated in the temper fraction. In a way similar to the case of the Jagua region, a second analysis was carried out for the elements present in all of the 66 samples of the region.

Table 3 Factor Loadings after extraction of Principal Components for the Yaguajay-Yayabo pottery.

	Factor loadings					
	35 cases			68 cases		
	PC1	PC2	PC3	PC1	PC2	PC3
LG_SC	**0.898**	-0.057	-0.081	**0.791**	-0.262	0.252
LG_YB	**0.839**	0.148	-0.021	**0.902**	0.139	0.042
LG_FE	**0.836**	0.093	0.022	**0.798**	-0.045	0.276
LG_CE	**0.783**	0.099	0.368	**0.593**	**0.660**	-0.087
LG_EU	**0.761**	-0.076	0.227	**0.846**	0.248	0.066
LG_SM	**0.657**	0.364	0.346	-	-	-
LG_LA	**0.610**	0.299	0.307	-	-	-
LG_NA	0.200	**-0.892**	-0.013	-	-	-
LG_CR	**0.508**	**0.771**	-0.008	0.244	-0.130	**0.958**
LG_RB	-0.025	-0.101	**0.896**	-0.042	**0.613**	-0.282
LG_TH	0.333	0.335	**0.495**	0.015	**0.891**	0.069

The ordination in the PC space (Figure 12) shows several groups. The group showing the largest concentrations for Cr (open circle dots) and lowest values for Na corresponds to most of the fragments from Yayabo. Such large concentration values seem to be conditioned by the weathering of the ultrabasic and basic rocks from the Sierra de Jatibonico. On the opposite, lower values for Cr and higher contents for Na are found for the majority of the fragments from the sites in Yaguajay (open diamond dots).
The inspection of the paste texture of the Yaguajay fragments revealed a proportion of anti-plastic particles of 50 to 80 %, being the most common constituent minerals the plagioclase, quartz, potassium feldspar and biotite, in decreasing order of their abundance. Some times clinopyroxene and hornblende crystals were also observed. The relatively high abundance of plagioclase seems to be conditioned by its weathering from the gabro massifs of the Sierras of Meneses and Bamburanao. The paste of Yayabo samples is not so heavy tempered, and the fraction of particles with sizes from 0.01 to 0,09 mm ranges from 45 to 60 %. The most abundant minerals are quartz, plagioclase, potassium feldspar, and in the case of the samples with larger contents of Cr, fragments of volcanic rocks (four

open circle dots in the upper-left corner of figure 11). The petrography observations confirmed the results observed for the concentration values determined by NAA also for the Yayabo pottery: Lower contents of Na (due to the lower proportion of plagioclase), and the higher contents of metals observed in this work, conditioned by the presence of clinopiroxene and volcanic rocks.

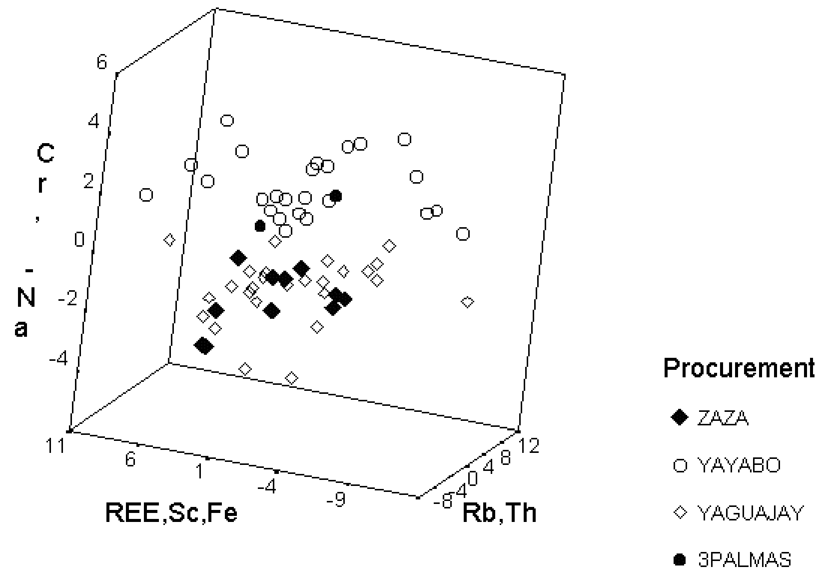


Figure 12 Ordination in the PC space of Yaguajay and Yayabo samples

<u>Archaic sites:</u>
The composition of all of the fragments of the sites of Lagunilla and Caunao matched only to the Jagua North_Upstream group. The absence of fragments corresponding to the other two compositional groups suggests the adoption of pottery manufacture practices by these communities.
The composition of the fragments of the sites Neiva Viejo and Las Damas (solid diamond dots) is closer to the Yaguajay pottery. This fact can be understood as the result of the similarity between the formations surrounding these sites and the one in the northern coast, leading to a similar composition of the resulting from its weathering clays. However, the fragments of the site Tres Palmas (solid circle dots in figure 11) show a composition more similar to the ones from the Yayabo pottery, and it might indicate either the use of clays from farther beds, in the Jatibonico river, or as the result of exchange with the potters of the sites La Nata y Los Ranchos.
The samples from the site La Mata, which is rather distant from all of the agroalfarero influence zones, show a composition far from expected. La Mata is located in a valley surrounded only by formations of ultrabasic rocks (serpentinites, harzburguites, therzolites, wherlites and dunites), and high metal contents would be expected if the pottery would be manufactured with clays from the local beds. However, the ordination of such samples in the PC space lies within the Yaguajay group, and if this community acquired its pottery from that region, it would be an evidence of an exchange corridor along the northern coast for ca 40 km.

CONCLUSIONS
The results obtained after the interpretation of the compositional data lead us to several interesting conclusions:

- The communities living in the keys of the bay, as well as the ones occupying territories in its eastern bank, had a well-consolidated manufacture. The potters from these sites employed clays from the beds located around the mouths of the Caunao and Arimao rivers, not only from their close mouths, but also from deposits located closer to the sources of the rivers. The revealing of a fragment showing the features of a white man face with beard and helmet confirms their establishment until the arrival of the Spanish conquerors. The increase in the proportion of fragments with composition corresponding to the sources located upstream might be an indication of some displacement of their activities to territories located inland.

- The sites Ojo de Agua and Punta de Ladrillos, both located to the West Side of the bay exhibit some ceramic diversity that suggests that either the potters of these sites used raw materials from Damuji and east Jagua bay bank deposits, or they imported ware from the communities of the eastern territories. In any of the ways, the proportion of ceramic fragments of the East_Mouth group increased upon the time.
- The site El Convento exhibits the presence of pottery from the three Jagua variations, corroborating its role as a centre of intense exchange between the communities of the zone.
- The pottery from Yayabo shows the higher concentrations of Cr, Sc and Fe observed in this work, whereas the more abundant mineral presents in the inclusions is the quartz. The ceramic from Yaguajay, although with average concentrations of the metals and REE of the order observed in Jagua East_Mouth pottery, can be distinguished from the later by its higher content of plagioclase. However, the scarce evidence material collected, as well as the scattering in the PC space of the values observed does not allow performing such a clear differentiation of the procurement areas as in the case of the Jagua pottery.
- The fragments found in the archai*c* site Mata evidence the exchange of goods between this archaic community with other agroalfarero settlements.
- The archaic sites Caunao and Lagunillas seem to have developed a local industry, since all of the samples found in these sites are exclusively of the Jagua East_Upstream group.

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REFERENCES

Celaya M., Godo P. P. (1998) Guacanayabo, Jagua, Yucayo: La variación local en la cerámica. (unpublished) Centro de Antropología.

Chirino J. (1992) "Cerámica subtaína de Yaguajay", Vitrales, Suplemento cultural del periódico Escambray, Sancti Spiritus, Año VII.

Colón C. (1867) Códice diplomático americano de Cristóbal Colón. Colección de cartas del gran descubridor del Nuevo Mundo, Almirante Mayor del Mar Océano, Virrey y Gobernador de las Islas y Tierra Firme de las Indias, etc. Habana. Imprenta y Librería "El Iris", 1867.

Davis J. C. (1986) Statistics and Data Analysis in Geology, Second edition, Wiley and Sons, New York.

Domínguez L. (1991) Arqueología de Centro-Sur de Cuba, La Habana, ACC, 102 pp.

Febles J. (1991) Estudio comparativo de las industrias de la piedra tallada de Aguas Verdes y Playitas. Probable relación de estas industrias con otras de Estados Unidos. Arqueología de Cuba y otras áreas antillanas, Ed. Academia, pp. 312-372.

Glascock M. D. (1992) Characterization of archaeological ceramics at MURR by Neutron Activation Analysis and Multivariate Statistics. In Chemical Characterization of ceramic paste in archaeology, Ed. by Hector Neff, Monographs in World Archaeology No. 7, Prehistory Press, pp. 11-26.

Godo P.P., Ramos J., Guadarramas R. (1999) "Arqueología de Jatibonico", Museo Municipal de Jatibonico, Sancti Spiritus, Cuba, (unpublished)
González Alea F. B. (1984) "Localización de Pueblo Viejo: Sitio de fundación de Sancti Spiritus", Museo Provincial de Sancti Spiritus (unpublished)
González Muñoz A., Avello I. (1946) "Asiento Cantabria", Revista de Arqueología y Etnología, Epoca II, Año I, Noviembre, No. 3, La Habana, 11-27.
Guarch J. M. (1978) "El Taíno de Cuba", Academia de Ciencias de Cuba, La Habana, 263 pp.
Herrera Fritot R. (1964) "Estudio de las hachas antillanas", Departamento de Antropología, Comisión Nacional de la Academia de Ciencias de Cuba, 146 pp.
IAEA TECDOC: Introduction of NAA in the archaeological researches in Latin America (under edition)
Kozlowski J. (1975) Las industrias de la piedra tallada de Cuba en el contexto del Caribe, Ed. Academia de Ciencias de Cuba, Serie Arqueología, No. 5, p. 15.
Las Casas, B. (1967) “Apologética Historia Sumaria”, Universidad Nacional Autónoma de México, Instituto de Investigaciones Históricas de México, 2 tomos.
Mapa geológico de la República de Cuba, Academia de Ciencias de Cuba, Instituto de Geología y Paleontología, Escala 1/250 000, Editado por el Instituto de Geología de la academia de Ciencias de la URSS, H-2111, Hojas 13 (F 17-8) y 21 (F 17-12)
Martínez A. M., Falcón A., Chirino J. (1994) "La cerámica del sitio Júcaro II, Municipio Yaguajay, provincia de Sancti Spiritus" (unpublished).
Martínez A. M., Falcón A. (1994) La cerámica del sitio arqueológico Playa Carbó: su forma y decoración (unpublished) Centro de Antropología.
Martínez A. M., Galván A., Chirino J. (1994) La cerámica del sitio arqueológico Júcaro II en Yaguajay, Sancti Spíritus, Centro de Antropología (unpublished).
Morales Patiño O., Herrera Fritot R., Royo F., González Muñoz A., Avello I., Leyva A. (1947) "Cayo Ocampo. Historia de un cayo", Revista de Arqueología y Etnología, Epoca II, Año II, Enero - Diciembre, No. 4 y 5, La Habana, 1947, 55-123.
Pichardo Moya F. (1948) "Los Caneyes del sur de Camaguey", Revista de Arqueología y Etnología, Epoca II, Año III, No. 6-7, Enero - Diciembre, La Habana, pp. 37-54.
Pichardo Moya F. (1960) "Mapa Indoarqueológico de Camaguey", Revista de arqueología y Etnología, Epoca IV, No. I, Junio, La Habana, 7-25.
Rankama K., Sahama Th. G. (1962) Geoquímica, Ed. Aguilar, España, 862 pp.
Report of the First Research Co-Ordination Meeting of the Co-Ordinated Research Programme on Nuclear Analytical techniques in Archaeological Investigations, Smithsonian Institution Conservation Analytical Laboratory, Washington, DC, USA, 23-26 June 1997
Rouse I. (1942) "Arcahaeology of the Maniabon Hills, Cuba", Yale University. Published in Anthropology New Haven, No. 26.
Sayre E. V. (1975) Brookhaven procedures for statistical analyses of multivariate archaeometric data, New York: Brookhaven National Laboratory Report BNL-21693.
Tabío E., Rey E. (1979) "Prehistoria de Cuba", Departamento de Antropología, Academia de Ciencias de Cuba, 1966, Segunda Edición, Ed. Ciencias Sociales, La Habana, 269 pp.