Journal of Radioanalytical and Nuclear Chemistry, Vol. 265, No. 2 (2005) 247–256

Incipient archaeometry in Venezuela: Provenance study of pre-Hispanic pottery figurines

L. Sajo Bohus,[1c]* Ma. M. Mackowiak de Antczak,[1a] E. D. Greaves,[1c] A. Antczak,[1a] J. Bermudez,[1c] Zs. Kasztovszky,[2] T. Poirier,[1b] A. Simonits[3]

[1] *Universidad Simón Bolívar,*
[a] *Lab. de Arqueología;*
[b] *Centro de Ing. de Superficies;*
[c] *Lab. de Física Nuclear, Apdo 89000, Caracas 1080A, Venezuela*
[2] *Institute of Isotopes and Surface Chemistry, Chemical Research Centre of the HAS, P.O. Box 77, H-1525 Budapest, Hungary*
[3] *Budapest Neutron Centre, AEKI-KFKI, Budapest, Hungary*

(Received October 12, 2004)

Application of different analytical techniques contributed with new results to the interpretation and the provenance study of Venezuelan figurines dating from the 12th and 15th centuries. Elements in bulk samples, powdered samples of figurines and soil were determined using total reflection X-ray fluorescence (TXRF), instrumental neutron activation analysis (INAA) and prompt gamma activation analysis (PGAA). Results and ceramics macroscopic observations indicate that average elemental composition of the figurines from the mainland significantly differ from those encountered on the Caribbean islands. The multidisciplinary experience de facto formed a group dedicated to archaeometry and provided data for provenance study of pre-Hispanic pottery figurines.

Introduction

In the late sixties, a large research centre was developed to answer the need to improve science in a developing country like Venezuela. A research reactor of 4 MW has been operating since 1964 with remarkable success. Due to different reasons, the scientific productivity decreased slowly and few years ago it was decommissioned. The Universidad Simón Bolivar (USB) group, some time ago was requested to support with nuclear analytical techniques the research effort of Venezuelan archaeologists interested in having chemical and elemental data on ceramic figurines and some other important samples. Since then, we had a timid approach toward this problem lacking a suitable neutron source. Only in recent years, thanks to Professor MOLNÁR, his co-workers, and the International Atomic Energy Agency support we could approach this problem confidently. A group with sufficient technical experience was formed and the data needed was supplied to answer some archaeological questions related to the cultural movement and human migration from the Venezuelan inland toward the Caribbean islands.

During the IRRMA-2002 Bologna meeting, Professor MOLNÁR presented some new results related to PGAA and at the poster session, we had our first meeting that lead to an important collaboration. What most impressed us of this soft speaking scientist was his deep knowledge on the problems encountered in the PGAA technique, its advantages and practical solutions for industrial and health related applications. We could observe his enthusiasm to promote the application in different fields as well. At that time, we had set up a PGAA assembly (IAEA Project) to analyze cryolite and electrolytic bath composition for the Venezuelan aluminum industry. We had a long conversation on problems encountered and several practical solutions were at hand and MOLNÁR suggested applying the most convenient technique. Shortly after the above referred Bologna meeting, we visited this laboratory, at the Institute of Isotopes and Surface Chemistry, Chemical Research Centre of the HAS, Budapest. We brought archaeological samples and almost immediately preliminary data were produced with great enthusiasm. A few months later, results on some Venezuelan pottery were presented in poster form, at the 2nd International Symposium on Radiation Education, organized by Professor MARX in Debrecen, Hungary 21–25, August 2002.[1] Our appreciation was that Prof. MOLNÁR was rather busy during that year, working on several projects and preparing the important book on “Nuclear Chemistry”, however, he had time to help us with our on-going projects, the elaboration of an awarded research contract with the IAEA-Vienna, Austria (IAEA-12283/RO/RBF), and to arrange a visit for Venezuelan scientists and students. Professor MOLNÁR was hosting the IAEA research meeting on New Applications of Prompt Gamma Neutron Activation Analysis in December 2002 and offering once more the opportunity to meet him again so that future projects could be planned. We discussed industrial application and the possibility to further explore cold neutrons in health physics applications. He shared his experience on signal digitalization effect on gamma-spectra and from that point, we explored the possibility to make pulse

* E-mail: sajobohus@yahoo.com

0236–5731/USD 20.00

Akadémiai Kiadó, Budapest
Springer, Dordrecht

digitalization in Virtual Instruments - Lab VIEW environment. We had the opportunity to present him our results of a digital MCA at the Meeting in Trieste (Italy) in May 2003. In our view, Professor MOLNÁR and his collegues played a key role in forming a new research direction in archaeometry using PGAA that in the past was not available for the Venezuelan group. The instrumental neutron activation analysis and the prompt gamma activation analysis methods provided valuable information on figurine technology and manufacturing process including the physical characteristics of fired clay. The Venezuelan group wishes to join the international scientific community with this commemorational issue dedicated to Professor MOLNÁR.

Experimental

In order to gain the maximum possible information from valuable archaeological finds avoiding physical damages to them, different analytical methods are available. The nuclear related methods are often the most convenient since a rather complex picture of the physical and chemical properties of the objects can be discerned. During the past years, we had the opportunity to participate in several projects using these, under the auspices of the IAEA and the FONACIT (National Science Foundation) of Venezuela. These organizations supplied most of the equipment, financed the training courses and short scientific visits. It resulted in the establishment of a well-equipped nuclear analytical laboratory, trained technicians and professionals. Some of the referred equipments are described elsewhere and only a brief review will be given here.

The cultural context of the figurines

In geographical and macro ecological terms, the cultural sphere of influence under scrutiny includes the Lake Valencia region, lake's islands, coastal shores, wetlands, and alluvial/lacustrine valleys (Fig. 1). The Valencioid settlements were concentrated around the lakeshores, clustering in two areas: on the north-western shore (El Roble, La Culebra, El Charral and Los Guayos sites), and on the north-eastern and eastern shores (La Cabrera [Tamarindos], La Mata and Tocorón sites (Fig. 1b).[2] In the coastal bays of the Caribbean, north of the Valencia Basin, the Valencioids entered into interaction with Ocumaroid fishermen and peasants that inhabited this coast since pre-Valencioid times. The nature and intensity of the relationships between the occupants of different sites within the mainland portion of the sphere of influence is largely unknown.[3] No data exists on village layouts, house structures, location of cultivation fields, and micro-regional settlement patterns, or any precise chronological information so that this study is a contribution to the knowledge of Venezuelan heritage.

Fig. 1. Geographic area of interest with the indication of the Los Roques Archipelago (a), Ocumaroid and Valencioid core areas (b)

A group of pottery figurines and fragments have been selected to gather compositional information and elemental analysis by different advantageous techniques, i.e., TXRF, PGAA and INAA. Namely, 40 of them were measured by PGAA, further 14 by INAA and 8 pieces from broken figurines by TXRF qualitative analysis. In addition, a large set of samples has undergone also macroscopic ceramic study.

Gamma-ray induced X-ray emission (GIXE)

Figurines, whose compositional analysis is the main objective of this study, were analyzed also using a rapid method related to X-ray fluorescence, so that major and trace elements could be compared to samples of different archaeological sites. Elements that are conveniently analyzed, as LABRECQUE[4] demonstrated are: Pb, Rb, Sr, Zr. Recently an innovative method for lead determination in powder has been developed in the Nuclear Physics Laboratory.[5] For this purposes, a radioactive, point-like, excitation source of 390 MBq ^{109}Cd emitting 88.032 keV gamma-rays, excites very efficiently the innermost electronic level of lead with a binding energy of 88.006 keV. Consequently, the lead K fluorescent lines are produced and detected by a large-area high-purity germanium detector (HPGe) in a 180° geometry. This geometry causes the Compton-scatter peak to shift down to 66.5 keV, below the lead fluorescent lines significantly reducing the background. Further reduction in the background is achieved by the construction of a new design for source and sample holder in an axial geometry as to minimize Compton-scatter radiation which originates from the Compton-scaterring process in the germanium crystal. Fluorescent signals produced by direct irradiation of aerosol sample filters were compared with standards of lead solutions of known concentrations. Achieved detection limit for lead was 2.3 $ng \cdot m^{-2}$. This sensitive technique may be used to measure the lead content in samples of small quantities.

Total reflection X-ray fluorescence (TXRF)

TXRF has been proved to be a powerful technique in the analysis of art and archeological samples.[6,7] The main advantage of the TXRF technique is its unique capability for microanalysis using just a few micrograms of sample to perform a multielemental analysis.[8] In the case of valuable samples as paintings, sculptures or archeological samples, it is possible to establish the elements in the matrix, in order to achieve a fingerprint for provenance identification.[9] In recent years, the use of TXRF as a tool was established and allowed us to determine the elemental concentration relative to iron, supposed to be the major element in samples. The procedure allows us to establish a fingerprint of samples and contribute to discern the provenance of the Los Roques figurines. Some detail on the analytical technique is given only to complete this section.

Micrograms of 8 different pieces from Los Roques Island and Valencia Lake in the mainland (Table 1) were analyzed. Broken pieces of ceramic material were ground in an agate mortar. The fine powder was deposited onto a quartz reflector. A drop of deionized water was added to achieve uniform sample adhesion to the reflector. The samples then were vacuum dried and spectral data were collected during 500-second acquisition time. The TXRF spectrometer consisted of a molybdenum anode X-ray tube operating at 45 kV and 20 mA and the usual pulse processing electronic chain. The supporting module was fitted with a multilayer monochromator and the spectrometer consisted of a 30 mm^2 Si(Li) (Canberra) detector of 180 eV energy resolution at the 5.9 keV Mn K_α line and a PC-based multichannel analyzer (Canberra S-100).

Instrumental neutron activation analysis (INAA)

This analytical technique has demonstrated its versatility in a wide variety of different applications; in particular, it offers several advantages when small amounts are to be analyzed. The samples, of around 15 mg each, were positioned in the irradiation cell via a pneumatic transferring system, where a thermal neutron flux of $6 \cdot 10^{13}$ $n \cdot cm^{-2} \cdot s^{-1}$ is available at the Budapest Research Reactor. After two minutes irradiation time, and a following cooling period (5 minutes), gamma-ray spectra were collected with a p-type HPGe detector of 36% efficiency. The data acquisition system is housed in a low background shielding. Spectral data were evaluated by Hypermet-PC, a software developed by FAZEKAS et al.,[10] so that the element identification and concentration calculation could be performed with greater accuracy, taking full advantage of INAA sensitivity. The evaluation software includes the KAYZERO method to identify the major components whenever possible, and at the same time to quantify the concentrations of trace elements such as: B, S, Cl, Sc, V, Cr, Ba, Sm, Eu, and Gd.

Prompt gamma activation analysis

PGAA was selected as a convenient non-destructive method to measure major and trace elements at the Institute of Isotopes and Surface Chemistry, Chemical Research Centre of the HAS, Budapest. The samples were irradiated with a cold (20 K) neutron beam of $5 \cdot 10^7$ $n \cdot cm^{-2} \cdot s^{-1}$ supplied by the 10 MW Budapest Research Reactor and the prompt gamma-spectra were collected with a HPGe-BGO detector system arranged in order to perform Compton-suppression. The beam-size can be reduced to a 1 cm×1 cm or to a smaller spot. However, in this case, samples were irradiated with neutrons in a specific area of 4 cm^2 in a fixed frontal position to the detector. A 16k-multichannel analyzer collected the spectra and the evaluation was carried out also by Hypermet PC.[11] The element identification and concentration calculations were performed based on the PGAA data library, completed at the Institute of Isotopes.[12] We were able to determine the major components of H_2O, Na_2O, MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, Fe_2O_3 and MnO parallel to trace elements of B, S, Cl, Sc, V, Cr, Ba, Sm, Eu, and Gd. The observed concentrations of these elements support to the hypothesis about the origin of the pottery from Los Roques Islands and the Lake Valencia Basin. The analysis was carried out over 40 not dried samples, (21 samples were from Los Roques Archipelago and 19 from Lake Valencia Basin).

Table 1. Excavation places and sample identification

Sample identification	Classification number	Archaeological site
1	VLB0008	Valencia Lake Basin – Los Tamarindos
2	VLB100	Valencia Lake Basin – Los Tamarindos
3	VLB075	Valencia Lake Basin – Los Tamarindos
4	Ma1067	Archipelago de Los Roques – Dos Mosquises
5	Ma467	Archipelago de Los Roques – Dos Mosquises
6	Ma7M	Archipelago de Los Roques – Dos Mosquises
7	Ma407	Archipelago de Los Roques – Dos Mosquises
8	Ma3502	Archipelago de Los Roques – Dos Mosquises

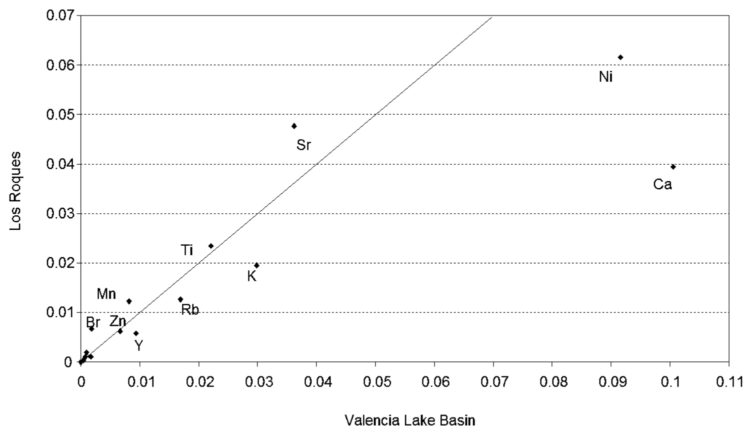

Fig. 2. Comparison of average concentration values for the two groups of samples, measured with TXRF

Table 2. Archaeological figurines INAA identification

BNC No.	Analysis No.	Inventory No.	Locality, archaeological information	Specimen	Stylistic and typological information
513	VL1	VLB-209	Camburito site, eastern shore of Lake Valencia	Figurine bust fragment	Imitative style
514	VL6	VLB-205	Camburito site, eastern shore of Lake Valencia, burial context	Standing figurine	Heterogeneous style
515	VL7	VLB-204	Camburito site, eastern shore of Lake Valencia, burial context	Seated figurine	Heterogeneous style
516	LR9	MA-720	Dos Mosquises Island, Los Roques Archipelago, DM/A/C-3, 20-40 level	Female figurine fragment	Heterogeneous style; standing cylindrical figure
517	LR10	MA-403	Dos Mosquises Island, Los Roques Archipelago, DM/A/B, 20-40 level	Fragment (half of) Female figurine	Standardized style; seated spread legs with canoe-shaped crest
519	LR15	AM-414	Dos Mosquises Island, Los Roques Archipelago, DM/A/B-Y, 20-40 level	Female figurine fragment	Heterogeneous style; standing with crest flat anatomical figure
520	VL21	VLB-01025	Los Tamarindos site, Peninsula la Cabrera, notheastern shore of Lake Valencia	Head fragment	Standardized style
521	LR 23	MA -349	Dos Mosquises Island, Los Roques Archipelago, DM/A/A, 0-20 level	Head with headdress fragment	Imitative style
522	LR28	MA-408	Dos Mosquises Island, Los Roques Archipelago, DM/A/B-12, 20-40 level	Female figurine fragment	Imitative style; standing straight legs rounded head with top
523	LR39	MA-690b	Dos Mosquises Island, Los Roques Archipelago, DM/A/C-6, 0-30 level	Figurine head fragment	Standardized style
508	VL5	VLB-206	La Mata site, eastern shore of Lake Valencia	Figurine headdress fragment	Standardized style
509	VL8	VLB-210	Camburito site, eastern shore of Lake Valencia	Figurine bust fragment	Imitative style
510	LR16	MA-2272	Domusky Norte Island, Los Roques Archipelago, DMN/14, 0-20 level	Female figurine fragment	Heterogeneous style; standing flat anatomical figure

Table 3. Average of the elements present in samples from Mainland and Islands analyzed by INAA

Element	Valencia	Los Roques	Difference, absolute value
Major	wt.%	wt.%	%
K	2.706	1.201	–55.6
Ca	0.922	1.066	+15.6
Ti	0.339	0.210	–38.1
Trace	μg/g	μg/g	%
V	87.43	58.64	–33.0
Mn	497.6	359.8	–27.7
Ga	18.01	16.3	–0.95
Ba	619.4	257.4	–58.4
La	38.99	13.86	–64.4
Sm	6.948	3.837	–44.8
Dy	5.336	3.850	–27.8

Results

Total reflection X-ray fluorescence (TXRF)

Excavation sites and sample identification are listed in Table 1. In Fig. 2 we compare average values of the elemental concentration of the two groups of samples. In this case, the ratio of elements in the bulk material with respect to Fe was employed so that the relationship between the elements in the material could be established without taking into account the absolute mass of the samples. Using a quasi-constant major element in the clay as reference, it is possible to compare only the elemental ratios in samples.[9] These results allow us to know the chemical composition of the figurines' surface. The elements we determined are the following: Cl, K, Ca, Ti, Mn, Ni, Zn, Ga, Br, Rb, Sr, Y and Pb.

Instrumental neutron activation analysis (INAA)

Samples for characterization by INAA are reported in Table 2. The average concentrations of the elements shown in samples by INAA are reported in Fig. 3. The difference in the element contents of Los Roques (LR) and Lake Valencia Basin (LVB) samples, expressed in percentage are listed in Table 3. It is given to establish similarities and differences relative to clay mass analyzed. These values were obtained comparing the average values over all samples from the same groups, i.e., Lake Valencia and Los Roques.

Prompt gamma activation analysis

As from previous investigation of geological samples, also in this case, we determined all the major components, such as H_2O, Na_2O, MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, MnO and Fe_2O_3 with sufficient precision [between 1 and 5% depending on the sensitivities, i.e., on the (n,γ) cross section]. In addition, we identified some geologically important trace elements, like B, S, Cl, Sc, V, Cr, Ba, Sm, Eu, and Gd with extremely high sensitivity for B. In order to classify the objects, characteristic chemical components were sought. Several mass ratios were calculated, and from those which show significant difference between LR and LVB, bivariate diagrams were constructed.

Samples classification was done comparing average values of Na_2O, K_2O, Ti_2O, B, Cl and Cr. The results are discussed more detailed in the paper by KASZTOVSZKY et al.[13]

Associated macroscopic observation: looking for additional ceramic fingerprints

Results from the above mentioned chemical methods must be associated with other investigations, such as petrography and technology studies in order to obtain further data for a complete provenance study (very useful to determine the geographical locus of the materials), since neither the compositional data nor the macroscopic observations alone do not supply overall information about the technological process employed by the craftsman. In particular, ceramologic inspection, i.e., a macroscopic observation based on the knowledge of ceramic processes employed in ceramic artifacts is not provided so far. The possibility of using similar clays and tempers in two different places cannot be totally discarded either even if it is unlikely. In other words, relying only on the ceramologic approach can still generate a local confusion about the real producing site for insular pottery, although the global approach would remain correct.

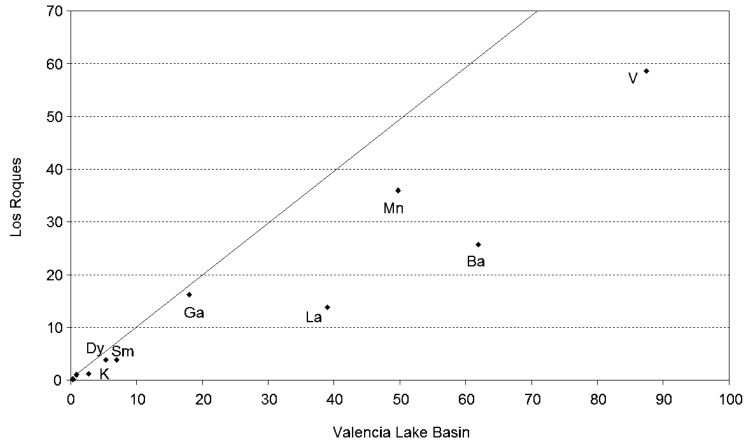

Fig. 3. Comparison of pottery compositions measured with INAA. Expected values should be on the straight line

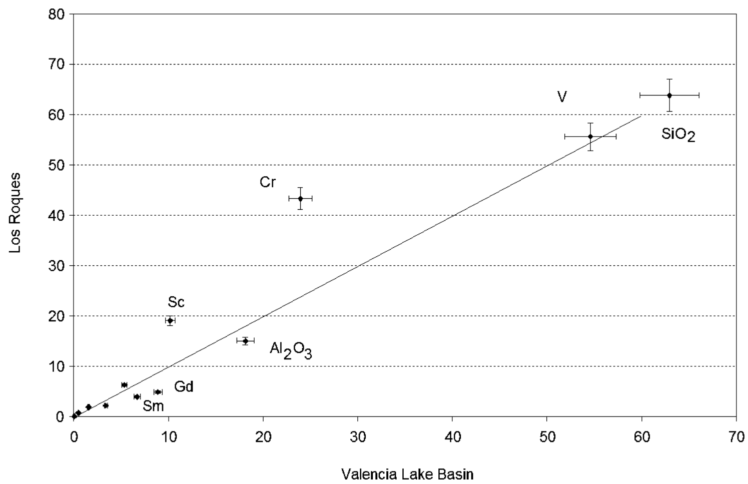

Fig. 4. Major and trace element concentrations for the two groups of samples, measured with PGAA. Deviation from the expected values (continuous line) is shown

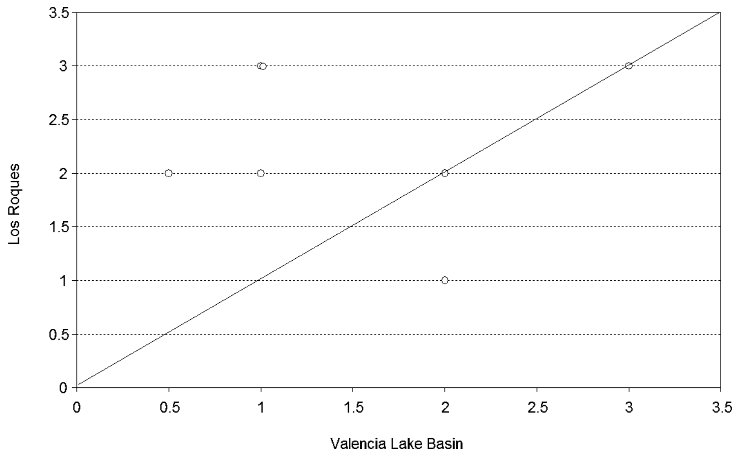

Fig. 5. Dispersion of temper size values (0.5 mm and 3 mm) for the sample groups

Table 4. Comparison of compositional and macroscopic data of some island and continental samples.
Areas with bright grey background are compositionally compatible. Samples in dark grey are not. Samples in white cannot be clearly defined

Reference	in cluster chart 9	out cluster chart 9	in cluster chart 2	out cluster chart 2	in cluster chart 19	out cluster chart 19	Global estimation neutron activation (in/out cluster)	Description	Style (S/I/H)	Excavation site
MA407	X			X	X		in (?)	Figurine	S	Dos Mosquises
MA/1067	X			X	X		in (?)	Head	S	Dos Mosquises
AM/376	?	?	X		X		in	Hermaphrodite fig.	S	Dos Mosquises
AM/418	X		X		X		in	Figurine (part)	S	Dos Mosquises
AM/508	X		X		X		in	Head (part)	?	Los Roques
MA/371		X		X		X	out	Figurine (arm)	H	Dos Mosquises
AM/374		X		X		X	out	Figurine	H	Dos Mosquises
VLB/00100		X	?	?		X	out (?)	Front head	S	Tamarindos
D16	X		X		X		in	Face with eye	S	Tocoron
VLB/58579		X		X		X	out	Head	?	Eastern Shore
VLB/58565	X		X		X		in	Eye and eyebrow	S	Eastern Shore
VLB/58574		X		X		X	out	Head with trunk	S	Eastern Shore
VLB/8843	X		X		X		in	Masculine figurine	S	Caña de Azucar
VLB/20517	X		X		X		in	Leg	S	Caña de Azucar

Table 5. Comparison of ceramological data of island and continental figurines

Reference	Raw material				Firing	Decoration		Shaping						
	Black heart (Yes/No)	Temper size maxi, mm	Temper amount (±20%), grains/cm^2	Temper homogeneity (Yes/No)	Firing stains (Yes/No)	Coating (Yes/No)	Polishing (Yes/No)	Bulk shaping (Yes/No)	Rolls (Yes/No)	Strips (Yes/No)	Pinched clay (Yes/No)	Internal patches (Yes/No)	External patches (Yes/No)	Manufacturing skill 1 to 3
MA407	Yes	3	15	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	1
MA/1067	Yes	1	30	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	1
AM/376	Yes	2	15	No	Yes	Yes	No	No	No	No	No	No	Yes	2
AM/418	No	3	20	No	Yes	Yes	No	No	No	No	No	No	Yes	2
AM/508	Yes	3	15	Yes	No	No	No	Yes	No	No	No	No	Yes	2
MA/371	No	2	15	No	No	Yes	Yes	No	No	No	No	No	Yes	3
AM/374	Yes	2	15	No	Yes	No	No	Yes	No	No	No	No	Yes	3
VLB/00100	No	3	20	No	No	Yes	Yes	No	No	Yes	No	No	Yes	2
D16	No	1	10	Yes	Yes	Yes	No	No	No	No	No	No	Yes	2
VLB/58579	Yes	1	6	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes	2
VLB/58565	No	1	25	No	Yes	No	No	No	No	Yes	No	No	No	2
VLB/58574	No	0.5	30	Yes	No	No	No	Yes	No	No	No	No	Yes	1
VLB/8843	Yes	2	20	No	Yes	Yes	Yes	No	No	No	No	No	Yes	2
VLB/20517	No	1	10	Yes	No	Yes	No	No	No	No	No	No	Yes	2

Discussion

Bulk material and samples from the objects' surface have been analyzed with prior sample preparation, in the case of broken pieces, and without preparation in the case of complete figurines. The analysis of different samples shows rather similar but not identical chemical and trace element composition. The concentrations of major and trace elements indicate that two different groups of the samples exist. From Figs 2 to 5 one can observe that the average elemental compositions for the two suggested groups differ significantly. The straight line represents the theoretical case when samples from the two groups have similar elemental composition. The macroscopic and petrography results give further reinforcement of the data dispersion since they represent the difference in the manufacturing technology of the figurines. Figure 5 shows that the characteristic temper size for the two groups of samples are significantly different.

A revealing trend in the results supports the different provenance of the LVB and LR figurines, which gives a possible new way of the pre-Hispanic environment and society research. However, it would be necessary to analyze a larger number of figurines from the Islands as well as the Mainland. This could be a next step since the total amount of pieces collected in Los Roques Islands is around 800.

BISHOP suggests[14] a number of 15–20 samples for each piece with known provenance for further investigation and to complement the 60 samples from Los Roques Island represented by 3 different styles. A similar number of the mainland samples would be necessary to involve into the study. But in order to compare the specific locations in each area, it is necessary to collect samples from all the archaeological sites. In our particular case this means roughly 370–480 samples from Los Roques and Lake Valencia Basin. Consequently, this indicates that the results presented here have only a preliminary character of information. Comparison between the two groups reveal similarities in the chemical composition of the clay. Main differences were found in Na_2O, K_2O, Ti_2O, B, Cr, and Cl levels.

From the macroscopic ceramic observations, we mention that AM376 insular sample seemed to fit very well with continental VLB008 and VLB8843 samples, respectively, extracted in the Cia and Caña de Azucar sites (Fig. 1b). It is worthwhile to note that only few technological options represent the differences between those samples: polishing, and use of strips. Temper size and amount, evidence of organic matter, fire clouds and hollow shaping are a common pattern in those artifacts. Thus, the AM376 insular sample seems to have been manufactured in the northeastern zone of the Valencia Lake, near the Cia site.

The AM418 insular sample seemed to fit technologically with continental VLB00100 sample, but the compositional data were very different ("out cluster" case), leading to discard a common provenance of both samples. The other insular samples mentioned in Tables 4 and 5 seemed to have no clear relationship with the continental samples, even when fitting well under the compositional point of view ("in cluster"). On the other hand, two artifacts which are included in the same compositional cluster (see INAA and PGAA data) might originate from totally distant excavation sites. Indeed, some chosen samples from such distant sites do present rather similar features. Thus, an association of ceramology with reliable compositional analysis becomes necessary to increase the accuracy of the provenance study, and select or discard some candidates among the probable proceeding sites.

Conclusions

Several techniques have been applied to provide information on different archaeological samples. These techniques were selected to provide complementary data, for example: information on surface composition can be obtained with X-ray fluorescence, elemental concentration in pulverized fragment of pottery sections with INAA and bulk composition with PGAA. Principal component analysis results for 40 PGAA measurements,[12] TRXF and INAA show significant differences between the composition of Los Roques and Lake Valencia figurines well outside of the uncertainty of the measured values. We have to draw attention that also the ceramic temper size comparison supports this observation. This implies that the raw materials of Los Roques figurines are from different locations even if they seem to be related to the mainland due to their stylistic similarity.

The global understanding that some subregions of the Valencia Lake Basin are the root of the majority of insular standardized artefacts does not eliminate completely the doubt whether some of these artefacts comes from Tocoron or Caña de Azucar sites. The results on the provenance presented here seem to be in opposition to the current archaeological hypothesis, according to which the island figurines were produced in the mainland of Venezuela (Lake Valencia Basin). As mentioned, the analysis of a large number of samples from other sites should be necessary to describe more detailed social connection among mainland and island pre-Columbian cultures.

Collaboration with Professor MOLNÁR was a key in the development of all steps of the incipient archaeometry initiative in Venezuela and this study is an important contribution since obtained results suggest the origin and stylistic differentiation of the Los Roques figurines.

*

The International Atomic Energy Agency-Vienna, Austria under the Project IAEA-12283/RO/RBF supported partially this work.

References

1. M. MACKOWIAK DE ANTCZAK, ZS. KASZTOVSZKY, ZS. RÉVAY, A. ANTCZAK, G. L. MOLNÁR, L. SAJÓ-BOHUS, E. D. GREAVES, in: Proc. Intern. Radiation Education Symp., S. UJVARI, L. SAJÓ-BOHUS (Eds), Debrecen, 2002, p. 71.
2. A. ANTCZAK, Late Prehistoric Economy and Society of the Islands off the Coast of Venezuela: A Contextual Interpretation of the Non-Ceramic Evidence, PhD. Dissertation, Institute of Archaeology, University of London, UK, 2000.
3. M. MACKOWIAK DE ANTCZAK, 'Idols' in Exile: Making Sense of Prehistoric Human Pottery Figurines from Dos Mosquises Island, Los Roques Archipelago, Venezuela, PhD. Dissertation, Institute of Archaeology, University of London, UK, 2000.
4. J. J. LABRECQUE, J. E. VAZ, J. M. CRUXENT, X-ray Spectrom., 32 (2003) 25.
5. R. NUÑEZ, T. VILORIA, E. D. GREAVES, L. SAJÓ-BOHUS, Journal of Universidad del Zulia, 2004 (in Spanish).
6. R. KLOCKENKÄMPER, A. VON BOHLEN, L. MOENS, W. DEVOS, Spectrochim. Acta, 48B (1993) 239.
7. R. KLOCKENKÄMPER, A. VON BOHLEN, L. MOENS, X-Ray Spectrom., 29 (2000) 119.
8. R. KLOCKENKÄMPER, Total-Reflection X-Ray Fluorescence, John Wiley and Sons, 1997, p. 127.
9. E. CILIBERTO, G. SPOTO, Modern Analytical Methods in Art and Archaeology, Vol. 155, John Wiley & Sons, 2000, p. 7172.
10. B. FAZEKAS, G. MOLNÁR, T. BELGYA, L. DABOLCZI, A. SIMONITS, J. Radioanal. Nucl. Chem., 215 (1997) 271.
11. ZS. RÉVAY, T. BELGYA, P. P. EMBER, G. L. MOLNÁR, J. Radioanal. Nucl. Chem., 248 (2001) 401.
12. ZS. RÉVAY, G. L. MOLNÁR, T. BELGYA, ZS. KASZTOVSZKY, R. B. FIRESTONE, J. Radioanal. Nucl. Chem., 248 (2001) 395.
13. ZS. KASZTOVSZKY, M. M. ANTCZAK, A. ANTCZAK, B. MILLAN, J. BERMÚDEZ, L. SAJÓ-BOHUS, Nukleonika, 49 (2004).
14. R. L. BISHOP, M. J. BLACKMAN, Acc. Chem. Res., 35 (2002) 603.