

Neutron methods for Amerindian Archaeological Provenance Study and Authentication of Etruscan bronze art objects

Barros H.¹, Sajó-Bohus L.^{1,2}, Kasztovszky Zs.³, H. Postma H.⁴, Vermaercke P.⁵, Schillebeeckx P.⁶, Palacios D.¹, Greaves E.D.¹ and Mackowiak de Antczak M.¹

¹Universidad Simón Bolívar, Apartado 89000, Caracas, Venezuela

²Eötvös Lorand University, Atom Physics Dep. Budapest, Hungary

³Institute of Isotopes, HAS, PO. Box 77, Budapest H-1525, Hungary

⁴Delft University of Technology, Mekelweg 15, 2629 JB Delft, The Netherlands

⁵SCK•CEN, Belgian Nuclear Research Centre, Mol Belgium

⁶EC-JRC-IRMM Geel, Belgium

Corresponding Author: sajobohus@yahoo.com

Abstract.

Elemental compositions of Amerindian pottery figurines and two ancient bronze artefacts are given. Results suggest that the pre-Columbian figurines from Los Roques Archipelago, Venezuela, relate to those from the cultural core area at the Valencia Lake Basin on the mainland. However, their provenance could not be confirmed yet. The two bronze artefacts are not original. The employed analytical techniques (k_0 -NAA, PGAA and NRCA) are briefly discussed.

Keywords: k_0 -NAA, PGAA, NRCA, pottery figurines, bronze artefacts

Introduction

Two, always returning important issues in archaeological and historic art studies concern the provenance and authenticity of artefacts. In this paper neutron-based methods are used to help to solve such problems in the case of Amerindian pottery figurines and ancient bronze objects.

Three neutron-based analytical methods are explored, namely: 1) Instrumental Neutron Activation Analysis (k_0 -NAA), 2) Prompt Gamma Activation Analysis (PGAA), and 3) Neutron Resonance Capture Analysis (NRCA), each with his own advantages and specific features. One example concerns the provenance of pottery figurines within the *Valencioid Sphere of Interaction* (Venezuela), that is, from societies in the core area (Valencia Lake Basin, VLB), and from the peripheral coastal area and Caribbean islands. Therefore some specific areas of production of stylistically diversified pre-Hispanic pottery figurines excavated in the Los Roques (LR) Archipelago could be of interest to be identified. The elemental compositions of these groups of figurines may help to understand the connections between society aspects and meaning of the LR-figurines and to explain the origin of their stylistic differentiation [Sajo Bohus et al. 2005]. Around 130 samples were analysed so far including 31 reported here.

The other study is related to ancient bronze art and museum objects, the possible verification of their authenticity, whether they are genuine or fake artefacts.

Neutron-based analytical techniques

For k_0 -Neutron Activation Analysis (k_0 -NAA) normally small samples are taken from materials or objects for irradiation in a high neutron flux inside a reactor. After a suitable waiting time the gamma radiation of the remaining activity allows to determine the elemental amounts using the k_0 -NAA analytical method [De Corte et al. 1994]. The strength of k_0 -NAA is that nearly all elements can be determined in a non-destructive way without any sample preparation, very often in trace amounts (ppm to ppb level for samples of about 10 mg). We have been using the k_0 -NAA system at the BR1 reactor of SCK-CEN in Mol (Belgium) to analyse ten samples from *Valencioid* pottery figurines. Two channels, S84 and Y4 of this reactor are available for short and long irradiations at neutron fluxes of about $1.0 \times 10^{11} \text{ cm}^{-2}\text{s}^{-1}$. Gamma-ray spectra are acquired with two high purity Ge-detectors (40% detection efficiency relative to the ^{60}Co lines with a 3x3" NaI(Tl) detector). These spectra were analysed with Hyperlab software. Final elemental concentrations of the samples are calculated with the Solcoi/Kazerro program from DSM in Geleen (NL). For the samples synthetic multi-element standards (SMELS) were used as QA/QC samples [Vermaercke P. et al., 2005].

Prompt Gamma Activation Analysis is based on the detection of gamma radiation promptly emitted after the capture of thermal or sub-thermal neutrons by nuclei. Elements are recognized on the basis of energies of the prompt gamma rays. In principle PGAA is capable of identifying all chemical elements simultaneously, although with very different sensitivities [Perry et al., 2002]. The most advantageous feature of PGAA is that it is absolutely non-destructive. One can simply place an object into the neutron beam and after a short period following the irradiation the induced radioactivity is sufficiently decayed. Since materials are fairly transparent to neutrons, an average bulk composition is obtained.

The Budapest PGAA station is installed on a horizontally guided neutron beam from the Budapest Research Reactor (BRR). Since 2000 a beam from a cold neutron source (a liquid hydrogen cell at 16 K) guided over a distance of 36 m to the PGAA measuring station is in use. At this location the thermal equivalent flux of neutrons is $5 \cdot 10^7 \text{ cm}^{-2} \text{ s}^{-1}$. The samples are placed inside a sample holder at a fixed position where the beam size is normally $2 \times 2 \text{ cm}^2$. Gamma radiation is detected with a high purity germanium detector surrounded by scintillation detectors in a Compton-suppression set-up. A detailed description has been given before [Révay Zs. et al., 2004]. When investigating silica-based geological rocks or ceramics, we are able to determine quantitatively all major and some trace elements too. The detectable minor and trace components are those with high neutron absorption cross sections, B, Cl, Sc, V, Cr, Ba, Nd, Sm, Eu, Gd and Dy. The obtained spectra for more than 80 Amerindian samples are evaluated with the HYPERMET-PC gamma-spectrum analysis software. The calculation of concentrations is based on the prompt k_0 -method [Révay Zs. and Molnár G.L., 2003].

The latest development in neutron-based analytical methods is Neutron Resonance Capture Analysis (NRCA). It is based on the peaks, resonances, which occur in neutron-capture cross-sections as a function of neutron energy. These resonances are isotope specific and can therefore be used to distinguish elements in objects in a fully non-destructive manner. Energies of captured neutrons can be determined by the time-of-flight (TOF) technique. With a flight path of length L (m) and time-of-flight t (μsec) the neutron energy E (eV) is given by $E = (72.299 \times L/t)^2$. A capture event can be observed by detecting the prompt capture gamma radiation. The TOF method requires a pulsed neutron source produced by a pulsed accelerator. The TOF of a

capture event is determined with the aid of a start pulse from the pulsed neutron source and a stop pulse derived from the gamma-ray detector. Since it is not necessary to know the gamma-ray energies to generate the stop pulse, a set of large scintillation and low energy resolution detectors can be used for this purpose, and thus large detection efficiency for capture events can be obtained. This efficiency is considerably enlarged by the fact that a cascade of (in the order of 3 to 5) gamma transitions follows each capture event. Many elements have resonances of various strengths. This makes it possible to probe different depths of an object. Since elements use different parts of the neutron spectrum, there is very little mutual influence. The GELINA facility of the EC-JRC-IRMM institute in Geel (Be) has been used in a joint project together with the Delft University of Technology (NL) to develop the NRCA method.

Figurines, samples for analysis and irradiations

Figure 1 gives an impression of the pottery figurines from LR and VLB site. For k_0 -NAA a set of ten crushed samples were prepared from complete or fragmented figurines taken from three different regions: 1) the Los Roques Archipelago located off the central coast of Venezuela, 2) the central coast and 3) the Valencia Lake Basin. Also soil samples were included. From each of the ten samples two subsamples varying between 6 and 100 mg were taken for short irradiations (15 minutes) in channel S84 and for long irradiations (7 hours) in Channel Y4. About 30 elements could clearly be identified in each sample. Bulk powdered crushed samples were also measured in the PGAA system in Budapest Neutron Centre (BNC Hungary).

For the study of complete figurines it is necessary to use one or both of the other neutron-based methods with external beams. Since the PGAA is the best methods for detecting light elements, the pottery figurines were examined with the PGAA-system at the BNC in Hungary.

The other study concerns the evaluation of ancient bronze artefacts. It is known that such artefacts have been copied in later periods, notably during the Renaissance period. It is known that several museum collections (for instance of Etruscan objects) have been infiltrated with fake objects. Recently we have tested two bronze figurines offered by private owners and said to be of Etruscan origin. One of them, the deity *Pan* with flute is shown in figure 10. The other figurine concerns a warrior. Since bronze artefacts are made up mainly from medium and heavy elements the elemental compositions of these objects have been studied with NRCA at the GELINA facility in Geel and compared with an earlier study of Etruscan figurines [Postma et al. 2004].

Results

The results of the k_0 -NAA and PGAA measurements are compiled in tables 1 to 4. The major components determined with PGAA are expressed in oxide form calculated according to oxidation states of these elements (H_2O , Na_2O , MgO , Al_2O_3 , SiO_2 , K_2O , CaO , TiO_2 , MnO and Fe_2O_3). In table 1 typical results of Los Roques figurines and fragment samples obtained with PGAA are quoted. A comparison between compositions of *Valencioïd* pottery material measured with k_0 -NAA and PGAA, and data from an earlier NAA study [Bird et al., 1983] is made (table 2). In table 3 the average values for major and trace elements for the VLB, LR and soil samples as obtained by PGAA are given. Finally elemental ratios derived from the k_0 -NAA measurements, are compared for the two pottery groups (table 4). In figures 2, 3, and 4 the concentrations in crushed samples of the two groups of figurines (LR

and VLB) are plotted for different groups of elements. In the case that the LR and VLB pottery are identical, the data plotted in figures 2, 3 and 4 should lie within errors on the lines bisecting these figures. The same comparison is done in figure 5 for PGAA data of complete pottery figurines. The ratios of element pairs as derived from k_0 -NAA for the two pottery groups are plotted in figure 6. Figures 7 and 8 conclude with the scattering of major elements and concentration differences for two elements (Ba and V) in the LR and VLB pottery with expected averages indicated by dashed lines. In figures and tables where PGAA and k_0 -NAA data are shown, we assumed that elemental concentrations are determined within comparable accuracy and precision.

The compositions of two bronze objects have been determined with the NRCA set-up at the GELINA facility, they are quoted in table 5. One of them, *Pan* with a flute, is shown as an insert in figure 10. A resonance TOF spectrum of this statuette, plotted as a function of neutron energy in figure 9, shows a large number of resonances, which can be attributed to the series of elements given in table 5. The insert of figure 9 shows the separation of the Cu-resonance at 230 eV and the Zn-resonance at 223 eV. Elemental composition of Etruscan bronze artefacts obtained by NRCA is given in figure 10.

Discussion

The average composition of Venezuelan pottery as determined by us is similar to that reported by Bird et al. (1983). However, the provenance of pottery *Valencioid* figurines divided in three groups, *Standardized*, *Imitative* and *Heterogeneous*, on the basis of ceramic elemental composition could not be confirmed. The island figurines have similar compositions as those from the continental samples. This suggests that the majority of island figurines is connected to the culture of the Valencia Lake Basin and likely originated from that area. We expect that most of the trace elements concentrations should have values comparable for the two groups of samples (VLB and LR). However, this is not the case for several elements; they deviate from the symmetry lines in figures 2, 3, 4 and 7. On the other hand there is good correspondence in the log-log representation in figure 5, hiding to some extent dispersion of data. Caesium has a larger concentration for the VLB figurines probably related to sedimentation process taking place near the excavated zone. [Jaffe et al. 1993].

During the smelting of copper in prehistoric and early ancient times several minor elements like As, Sb and Ag can dissolve in copper, sometimes in the amount of several per cent. However, due to its high vapour pressure at the smelting temperature for copper, zinc can only dissolve in copper in very small amounts. Indeed bronze artefacts produced in Europe long before the Christian era, contain fractions of zinc well below one per cent of zinc, which is considered as the upper limit for zinc in genuine prehistoric and early ancient objects [Riederer, 1977]. In the first century BC the Romans invented the so-called cementation process, which made it possible to produce copper-alloys (brass) with several per cent of zinc, finally even up to about 24 %. In figure 10 the zinc and tin concentrations of two groups of bronze objects are plotted: i) Etruscan objects from the 7th to the 2nd c BC from the British Museum in London, all but one has zinc below the 1% limit. ii) A group of Etruscan artefacts taken from a collection bought in 1826 by the Dutch government from Count Corazzi in Italy. Clearly several of them have unexpected per cent zinc and can therefore not be genuine Etruscan objects [Postma et al., 2004]. In addition Zn vs. Sn values of the two recently studied objects from this study are plotted in this

figure. Their Zn-contents are so large that they cannot even be made from Roman material. Likely they are imitations from the Renaissance period.

Conclusion

Pottery figurines excavated on the Los Roques Archipelago have compositions similar to the figurines from the Valencia Lake Basin, and thus the data shown here suggest a close relationship to the core area on the mainland, i.e. they belong to the *Valencioid Sphere of Interaction*, without having a clear data set supporting its provenance. More than those analysed samples reported here would be necessary to trace the provenance of Los Roques figurines.

On the basis of their zinc contents the two bronzes cannot be Roman and are likely late imitations. We suggest that they might have been produced in the Renaissance period.

Acknowledgements

The IAEA financial support is acknowledged under the RC-1228 as well as the USB-DID and FONACIT-Venezuela, participation. The authors want to acknowledge the staffs that operate the GELINA facilities, the reactors in Mol (Be) and Budapest (Hu).

References

- Bird J.R., Duerden P. and D.J. Wilson, (1983). Ion beam techniques in archaeology and the arts Nuclear Science Application B, 1, 1-357
- De Corte F. and Simonits A., (1994). Vademecum for k₀-users, DSM Research
- Jaffe R., Benitez F., Sajo Bohus L., (1993). Assessment of eutrophication chronology via sediment core analysis, case of Lake Valencia, Venezuela. Fresenius Envir. Bull. 2, 602-607
- Perry D.L., Firestone R.B., Molnár G.L. et al. (2002) Neutron-induced prompt gamma activation analysis (PGAA) of metals and non-metals in ocean floor vent-generated samples. J. Anal. Atom Spectrom 17: 32-37.
- Postma H., Schillebeeckx P., Halbertsma R.B., (2004). Neutron resonance capture analysis of some genuine and fake Etruscan copper alloy statuettes, Archaeometry 46 635-646.
- Révay Zs., Belgya T., Kasztovszky Zs., Weil J.L., Molnár G.L. (2004). Cold neutron PGAA facility at Budapest. Nucl Instrum Meth B 213: 385-388.
- Révay Zs., Molnár G.L. (2003) Standardisation of the prompt gamma activation analysis method. Radiochim Acta 91: 361-369.
- Riederer J. (1977). Die Erkennung von Fälschungen mit naturwissenschaftlichen Methoden, in Fälschung und Forschung. 187. Museum Folkwang, Essen, Germany.
- Sajo Bohus L. Mackowiak de Antczak M., Greaves E.D., Antczak A., Bermudez J., Kasztovszky Zs., Poirier T. and Simonts A. (2005). Incipient archaeometry in Venezuela: Provenance study of pre-Hispanic pottery figurines J. Radioanal. Nuc. Chem. 265 (2005) 247-256.
- Vermaercke P., Robouch P., Eguskiza M., De Corte F., Kennedy G., Smodis B., Yonezawa C., Matsue H., Lin X., Blaauw M., Kučera J. (2005), Nuclear Instruments and Methods in Physics Research Section A, to be published as Proceedings of the 4-th International k₀-users Workshop, Madeira, Portugal.

Figures caption

Figure 1 a, b, c *Valencioid Standardised* Seated figurines with Canoe-shaped Crest (a) La Mata, Rodríguez collection, (b) La Mata, Martínez collection, (c) Dos Mosquises Island, Los Roques Archipelago, Antczak collection, Universidad Simón Bolívar, Caracas, Inv. Nr. 372, height 17.5 cm.

Figure 2. Comparison of elemental concentrations for the two groups VLB and LR figurines k_0 -NAA data. Average error is 8 %.

Figure 3. Comparison of average elemental compositions of Valencioid samples. k_0 -NAA data.

Figure 4 Comparison of major elements for figurines given in log-log graphic. k_0 -NAA data.

Figure 5. Trace elements concentration comparison for *Valencioid* pottery. k_0 -NAA data.

Figure 6. Elemental ratios of samples from Los Roques and Valencia Lake Basin. k_0 -NAA data.

Figure 7. Major element scattering for VLB and LR pottery. Expected distribution is given by the dotted line. Data from k_0 -NAA and PGAA

Figure 8. Concentration differences for two elements are further evidenced by the departures from the expected average. k_0 -NAA data.

Figure 9. The resonance spectrum plotted versus neutron energy. The insert shows the two closely lying resonances of copper at 230 eV and zinc at 223 eV.

Figure 10. Elemental compositions of bronze artefacts obtained by NRCA. Dots: Etruscan objects 7th - 2nd c. BC from the British Museum. Squares: Etruscan statuettes from the Corazzi collection of the National Museum of Antiquities in Leiden (NL). Triangles: two artefacts, *Pan* in the insert and warrior from private owners.

Tables caption

Table 1. A typical data set for Los Roques samples analysed with PGAA

Table 2. Comparison of Composition of the Venezuelan pottery measured by k_0 -NAA and PGAA and data from the literature.

Table 3. Major and trace elements average values in archaeological and soil samples with PGAA

Table 4. Comparison of elemental ratios for two pottery groups by k_0 -NAA

Table 5. NRCA bulk metal compositions of *Pan* with flute and a warrior.

Tables and Figures



a b c
 Figure 1. *Valencioid Standardised Seated* figurines with Canoe-shaped Crest (a) La Mata, Rodríguez collection, (b) La Mata, Martínez collection, (c) Dos Mosquises Island, Los Roques Archipelago, Antczak collection, Universidad Simón Bolívar, Caracas, Inv. Nr. 372, height 17.5 cm.

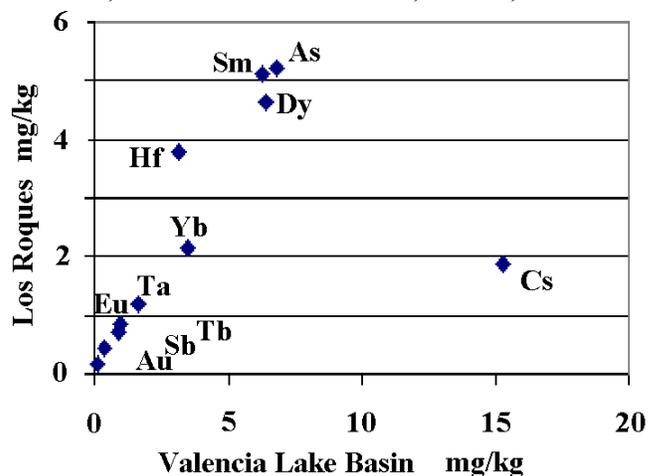


Figure 2. Comparison of elemental concentration for the two groups of figurines from Venezuela. k_0 -NAA data. Average error is around 8 % .

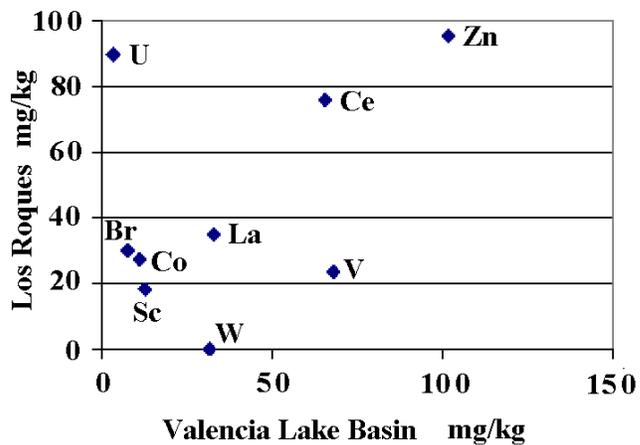


Figure 3. Comparison of average elemental composition for *Valencioid* samples. k_0 -NAA data.

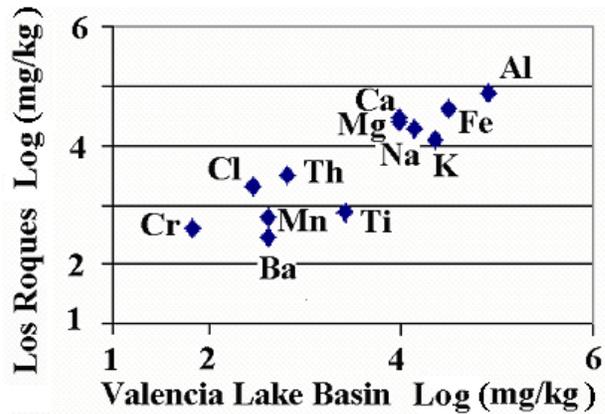


Figure 4 Comparison of major elements for figurines given in log-log graphic. k_0 -NAA data

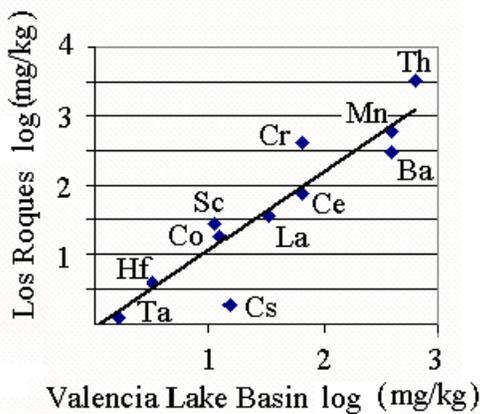


Figure 5. Trace elements concentration comparison for *Valencioid* pottery. k_0 -NAA data.

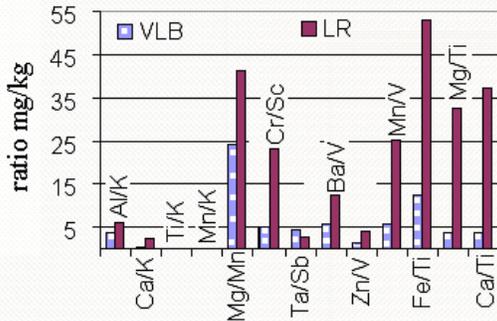


Figure 6. Elements ratio for samples of Los Roques (LR) and Valencia Lake Basin (VLB). k_0 -NAA results.

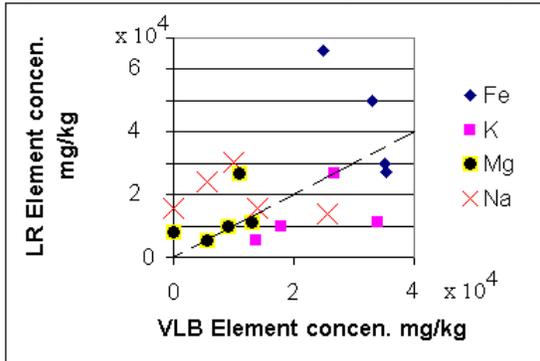


Figure 7. Major element scattering for VLB and LR pottery. Expected distribution is given by the dotted line. Data from k_0 -NAA and PGAA

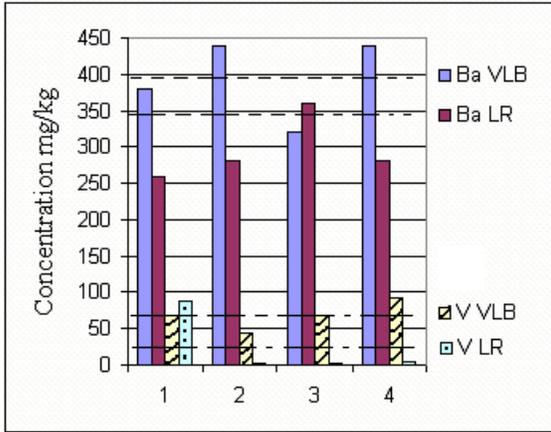


Figure 8. Concentration difference for two elements is further evidenced by the departures from the expected average. k_0 -NAA data.

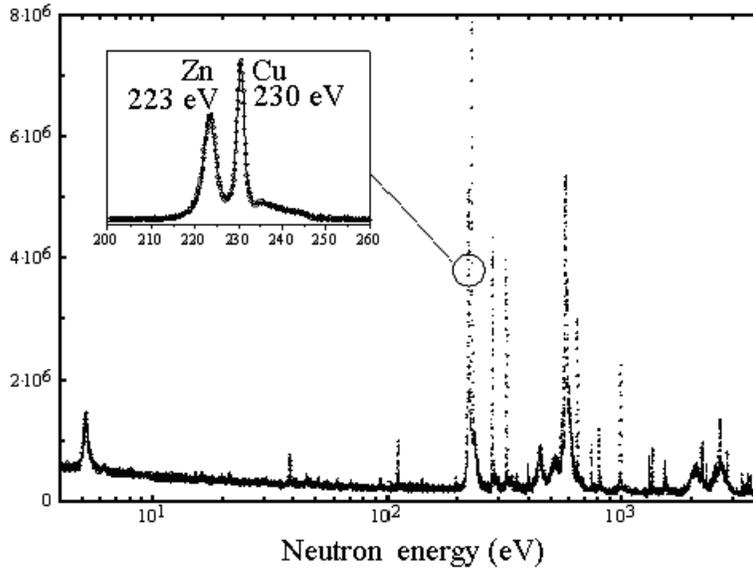


Figure 9. The resonance spectrum plotted versus neutron energy. The insert shows the two closely lying resonances of copper at 230 eV and zinc at 223 eV. NRCA data.

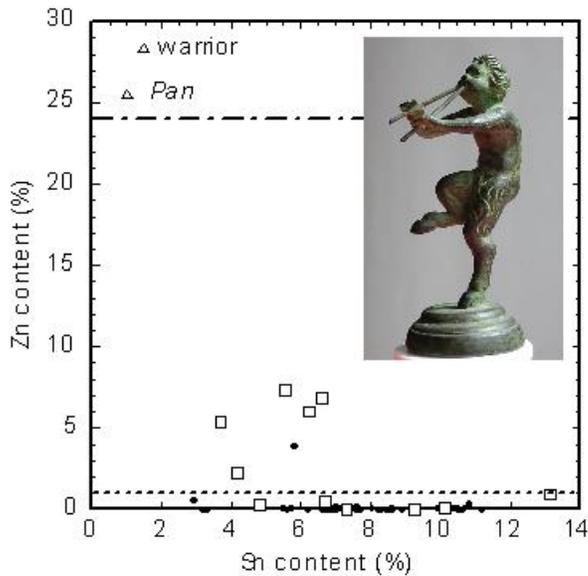


Figure 10. Elemental composition of bronze artefacts obtained by NRCA. Dots: Etruscan objects 7th - 2nd c. BC from the British Museum. Squares: Etruscan statuettes from the Corazzi collection of the National Museum of Antiquities in Leiden (NL). Triangles: two artefacts, Pan in the insert and warrior from private owners.

Table 1. A typical data set for Los Roques samples analysed with PGAA.

Element	AM 464		E82 C17A		A 345		MA 1505		MA 427		MA 880	
	c% mg/kg	unc %										
H2O	1.70	1.6	5.92	1.3	1.82	1.5	1.98	1.4	4.19	1.3	5.81	1.3
Na2O	2.60	2.9	2.25	2.5	3.12	1.7	2.73	2.8	3.26	2.5	1.59	3.2
MgO	1.65	10.9	1.78	12.2	1.34	16.2	1.81	13.3	1.27	13.2	1.97	11.3
Al2O3	15.17	2.9	15.96	2.1	16.25	2.8	15.58	2.1	14.86	2.1	18.22	2.1
SiO2	68.20	2.4	63.54	2.4	68.44	2.4	68.59	2.5	67.84	2.5	61.28	2.4
K2O	3.60	2.0	2.98	2.0	2.66	2.2	2.84	2.1	3.09	2.0	1.71	2.2
CaO	1.61	3.7	1.51	4.0	1.12	4.2	1.49	3.7	1.43	3.7	1.00	4.7
TiO2	0.52	2.0	0.55	2.0	0.52	2.1	0.52	1.9	0.42	2.1	0.87	1.9
MnO	0.07	3.6	0.10	3.1	0.08	3.7	0.04	3.5	0.14	2.4	0.05	4.0
Fe2O3	4.79	2.0	5.39	1.9	4.50	2.3	4.35	2.1	3.44	1.9	7.33	1.9
TRACE /ppm												
B	19.60	1.3	27.40	1.3	13.01	1.3	30.28	1.2	42.21	1.3	87.88	1.3
Cl	344.93	5.0	89.23	7.0	489.33	4.9	414.42	4.5	315.45	4.4	929.00	4.5
Sc	17.82	17.5	0.00		15.63	19.2	14.21	14.6	0.00		33.08	7.4
V	108.71	10.8	0.00		73.64	16.7	94.20	11.9	0.00		259.50	6.5
Cr	0.00		0.00		507.80	11.9	0.00		0.00		0.00	
Nd	0.00		0.00		40.58	12.3	43.53	10.7	30.91	14.8	26.87	16.7
Sm	5.57	2.0	5.31	2.0	5.72	2.1	4.89	1.9	4.06	2.2	2.61	2.3
Gd	7.48	3.9	6.72	4.1	7.68	4.1	5.54	4.1	5.23	3.4	3.15	3.6

Table 2. Comparison of composition of the Venezuelan pottery measured by k₀-NAA and PGAA and data from the literature (NAA).

k ₀ -NAA Pottery Composition			PGAA Pottery composition		NAA - Ref.
Element	our result mg/kg	ref. Bird et al.	Major elements	our result mg/kg	Bird et al. mg/kg
Sc	15.72	(10-35)			
Cr	263.33	(70-400)	SiO2	63.53	63.68
Mn	512.11	75-1500	TiO2	0.64	0.8-1.2
Co	20.36	(10-32)	Al2O3	16.39	16-21
Sb	0.42	0,5-1,5	Fe2O3	5.83	1.5-8.2
Cs	7.85	1,2-10	MgO	1.81	0.06-0.67
Ba	345	180-860	CaO	1.80	0.15-2.8
La	34.26	20-87	Na2O	2.33	0.2-0.6
Ce	71.32	39-55	K2O	2.79	0.5-2
Eu	0.9	(1-4)	MnO	0.08	0.03
Hf	3.53	(2-7)	H2O	4.30	4.6-7.6
Ta	1.42	(1-10)			
Th	1962.2	(5.6-17)			

Table 3 Major and trace elements average values in archaeological and soil samples with PGAA.

PGAA	VLB c%	LR c%	SOIL c%
SiO ₂	63.16	63.90	69.85
TiO ₂	0.51	0.76	0.87
Al ₂ O ₃	17.76	15.02	11.44
Fe ₂ O ₃ +FeO	5.33	6.33	4.74
MgO	1.64	1.97	1.94
CaO	1.69	1.90	1.13
Na ₂ O	1.84	2.82	2.13
K ₂ O	3.34	2.24	1.66
MnO	0.06	0.09	0.07
H ₂ O	4.08	4.53	6.91

PGAA	VLB mg/kg	LR mg/kg	SOIL mg/kg
B	26.65	46.50	19.89
Cl	135.17	1293.57	62.31
Sc	18.55	20.69	18.29
V	136.52	118.47	122.09
Cr	299.43	429.66	348.22
Ba	3565.85	2620.29	2196.34
Sm	6.61	3.96	3.44
Eu	n.o	n.o	n.o
Gd	7.93	4.89	4.02
Dy	n.o	n.o	9.44

n.o. not observable

Table 4. Comparison of elemental ratios for two pottery groups by k₀-NAA.

k ₀ -NAA	VLB	LR
Al/K	3.55	6.03
Ca/K	0.43	2.34
Ti/K	0.11	0.06
Mn/K	0.02	0.05
Mg/Mn	24.32	41.42
Cr/Sc	5.07	23.23
Ta/Sb	4.52	2.60
Ba/V	5.81	12.32
Zn/V	1.49	3.97
Mn/V	5.81	25.30
Fe/Ti	12.49	53.09
Mg/Ti	3.74	32.71
Ca/Ti	3.85	37.27

Table 5. NRCA bulk metal compositions of *Pan* with flute and a warrior.

Element	<i>Pan</i> with flute	Warrior
	Fraction (%)	Fraction (%)
Cu	70.04 ± 0.27	72.62 ± 0.39
Sn	1.47 ± 0.014	1.030 ± 0.015
As	0.0080 ± 0.0007	0.0163 ± 0.0003
Sb	0.0095 ± 0.0014	0.074 ± 0.002
Ag	0.0231 ± 0.0028	0.056 ± 0.001
Zn	28.30 ± 0.28	25.6 ± 0.3
Co	n.o.	0.003 ± 0.001
Fe	*)	0.293 ± 0.002
Pb	n.o.	n.o.

n.o. not observable,

*) some iron observed, is related to the flute.