SPECTROCHEMICAL ANALYSIS AND RADIOGRAPHIC INSPECTION OF METAL AND CORE OF THREE OSIRIS STATUETTES FROM THE CITY MUSEUM OF VRŠAC

Branislav Anđelković, Faculty of Philosophy, Belgrade,
Mirjana S. Pavlović and Jelena J. Savović,
Institute of Nuclear Sciences "Vinča", Belgrade

The composition of ancient Egyptian Oziris statuettes was determined by spectrochemical methods. The results obtained prove that metallic parts of the statuettes were made of an alloy of copper, lead, tin and antimony, which contain minor and trace constituents (Zn, As, Fe, Al, Si, Mg...). Core material of the hollow-casted statuettes consisted mostly of SiO_2. The radiographic inspection confirmed a high level of metal corrosion.

Key words: Osiris, bronze-lead alloy, d.c. arc, spectrochemical analysis, radiographic inspection, statuette, Egypt, Late Period.

The City Museum of Vršac, established in 1882, possesses among its treasures a collection of Egyptian antiquities (Anđelković and Panić-Štorh, forthcoming) part of which are three Osiris statuettes. The statuettes were purchased in Egypt and donated to the City Museum by prominent Vršac citizens who traveled to Egypt during the second half of the 19th century. Unfortunately, the exact provenance of the statuettes is unknown.

The first of these statuettes is a standing mummiform *atef*-crowned Osiris, Collection number *Aeg.* 24, in the round (fig. 1) who holds both flail and a peasant's crook with a long stock (i.e. *awet* sceptre). Osiris wears *uraeus* and a closely plaited divine beard. The statuette was hollow-casted by "lost wax" process *(cire perdue)*. An inner siliceous core being, as a rule, left inside the object (cf. Lucas and Harris 1962: 221-222). A blackish core can be viewed through a 6 cm long crack on the back of the statuete. At the base of the statuette is a hole, 0.3 cm in diameter, partially filled, perhaps with the remnants of a thorn-like holder fitted into the hole to fix the statuette to its pedestal. Aside

Гласник Српског археолошког друштва / Journal of the Serbian Archaeological Society
18 (2002) 243-248.

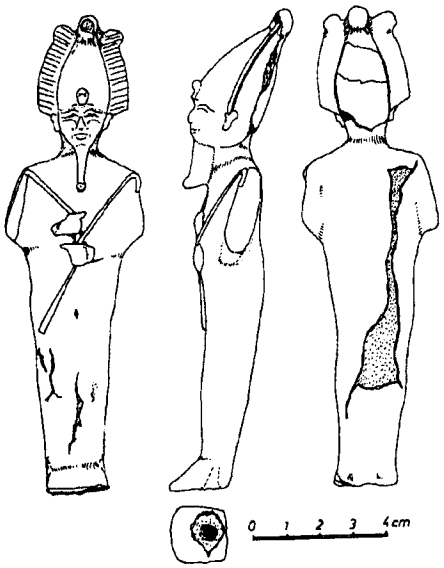


Fig. 1. Osiris, Aeg. 24.

from mechanical damage, the metal it is made of is heavily corroded (pl. Ia).[1] Measurements of the statuette are: height 14.4 cm; maximum width 4.1 cm; and maximum depth 2.3 cm. It can be dated to the Late Period (ca. 747 -332 B.C.).

The second is a standing mummiform hollow-casted statuette of Osiris, Collection number *Aeg.* 25, in the round (fig. 2) crowned with the *atef*, and again holding the flail in his right hand and a peasant's crook with a long stock *(awet* sceptre slightly curved backward) in his left. It has gently modeled features and is wearing *uraeus* and a closely plaited divine beard. It was manufactured by the lost wax process, with an inner siliceous core, gray in color, being left inside. This core can also be viewed through a crack on the back of the figurine There is a vertical hole in the base, approximately 1.2 cm deep, through which the figurine would have been attached to its pedestal. The metal itself is heavily corroded (pl. Ib). Measurements of the statuette are: height 13 cm; maximum width 3.2 cm; and maximum depth 2.1 cm. This piece can also be dated to the Late Period, at approximately the end of 26th Dynasty.

The third piece is a flat-backed Osiris statuette (fig. 3) Collection number *Aeg.* 26, which is solid-cast, holding the flail in it's right hand and a decorated crook in it's left, wearing the *atef*-crown surmounted with sun disc. The god is ornamented with *uraeus* and a closely plaited divine beard. A pointed ending protrudes from the base of the statuette, probably to fit the statuette into a pedestal. Despite a thick coat of secondary corrosion upon the surface, the radiography confirms that the metal is in a good condition (pl. Ic). Measurements of the statuette are: height 12 cm; maximum width 2.7 cm; maximum depth 1.2 cm. It too can be dated to the Late Period, around the second part of 26th Dynasty.

[1] The authors are grateful to the Welding Institute, Belgrade, for the radiograpic inspection of the statuettes (used film was AGFA D7, 100 x 480 mm). We wish to express our appreciation to Professor B. Rothenberg, Institute for Archaeo Metallurgical Studies, University College London, on a few suggestions concerning the Ancient Egyptian metal industry. Thanks are also due to Mr. D. Alcock for English language proofreading.

Fig. 2. Osiris, Aeg. 25.

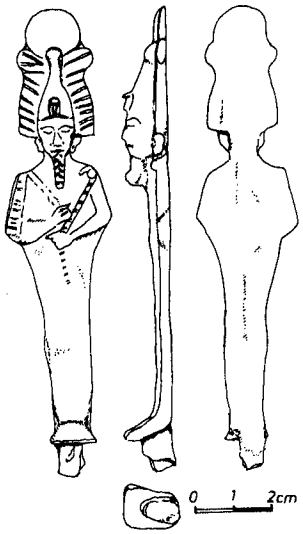


Fig. 3. Osiris, Aeg. 26.

Experimental

Spectrochemical methods were used to determine the composition of the ancient Egyptian statuettes. Metallic samples of all of the three statuettes were examined, as well as the core silicate material of the two which are hollow. Qualitative analyses were made by spectrographic method, and quantitative analyses by using emission spectrometric measurements utilising d.c. plasma.

Sampling

Sample No. 1a is a piece of metal from the back of the statuette Aeg. 24.
Sample No. 1b is a part of the blackish siliceous core of the statuette Aeg. 24.
Sample No. 2a is a piece of metal from the foot of the statuette Aeg. 25.
Sample No. 2b is a part of the grayish siliceous core of the statuette Aeg. 25.
Sample No. 3 is a piece of metal from the pointed ending of the statuette Aeg. 26.

Qualitative spectrographic analyses

The results of the preliminary qualitative spectrographic analyses of the statuettes are given in Table 1.

Sample No.	Major constituents	Minor and trace constituents
1a, 2a, 3	Cu, Pb, Sb, Sn, Ca	Zn, Fe, Al, Si, Ni, Mg, Mn. Cr, Mo, V, Co, Ti, Cd, As, Ba, Sr, Na, Ag, Bi
1b, 2b	Si, Cu, Pb, Ca, Fe, Sb, Mg, Zn	Sn, Al, Ni, Mn, Cr, Mo, V, Co, Ti, Cd, As, Ba, Sr, Na, Ag, Bi

Table 1

Quantitative spectrometric analysis

U-shaped d.c. plasma was used as the excitation source for quantitative spectrometric analysis. U-shaped direct current arc with aerosol supply is a special type of horizontal arc stabilized by gas vortex technique. This arc is primarily characterized by a high stability, realized by the simple experimental set-up and low consumption of the gas used (argon) making its application very economical. The details of this argon-stabilized arc device have been described elsewhere (Marinković and Antonijević 1980; Kuzmanović, Pavlović and Marinković 1996).

Sample preparation

Approximately 50 mg of metallic parts and cores of each sample were weighed and a $HCl+HNO_3$ mixture added. The samples were then heated gently until dissolution was complete. After cooling, sample solutions were made up to a volume of 50 ml. The original sample solutions were diluted tenfold for the major constituents determination.

Calibration standards were prepared in appropriate concentration range from elemental stock solutions. Matrix matched calibration standards were used. All solutions also included a fixed concentration of 0.5% KCl as the spectrochemical buffer.

The method which is based on the fusion of the sample and the method based on the dissolution of the sample in hydrofluoric acid in combination with nitric acid were both used to achieve complete dissolution of the silicate material (Thompson and Walsh 1983).

The results of quantitative analyses are represented in Table 2.

Relatively high Ca and Mg concentrations in the metallic parts of the statuettes could be attributed to the corroded portion of the samples that could not be discarded during the sampling.

Although the word bronze, as used in Egyptology, has a wide meaning (cf. Lucas and Harris 1962: 217) the high lead percentage suggests the three Osiris statuettes, dated to Late Period, should be referred to as bronze-lead or leaded tin-bronze objects. It should be noted that during the later periods the recycling of metal was usual and that, besides local sources, the Egyptians also used a lot of imported metal. The percentage of antimony was relatively high, but was most probably derived accidentally, as an impurity from the copper ore employed, rather than added intentionally, whereas the lead and tin were definitely intentional additions. An inner siliceous core seems to be composed primarily of powdered quartz sand.

Element	Concentration (%)				
	Sample No. 1a	Sample No. 2a	Sample No. 3	Sample No. 1b	Sample No. 2b
Pb	14.2	13.9	15.2	8.66	2.46
Sn	5.14	0.78	4.53	0.30	0.17
Sb	5.44	6.52	5.43	3.57	3.65
Ca	7.35	4.05	2.74	5.08	3.32
Na	0.20	0.11	0.18	1.11	0.46
Zn	0.089	0.031	0.042	3.66	0.68
As	0.62	0.28	0.25	0.21	0.056
Ag	0.26	0.11	0.21	0.30	0.12
Bi	0.26	0.21	0.23	0.067	0.049
Fe	0.10	0.26	0.30	4.66	0.84
Al	0.10	0.25	0.22	0.87	0.90
Mg	0.33	0.19	0.14	1.03	0.15
Ti	0.014	0.025	0.018	0.22	0.069
Ni	0.032	0.011	0.026	0.014	0.016
Mn	0.0059	0.0040	0.0026	0.024	0.0077
Cr	0.0017	0.0030	0.0070	0.0046	0.0022
Mo	0.0035	0.0005	< 0.0005	0.013	0.012
V	0.0025	0.0092	0.0064	0.0075	0.013
Co	0.0072	0.0005	0.0087	0.0065	0.0013
Cd	< 0.0005	0.0005	0.0020	0.54	0.11
Ba	0.0069	0.0024	0.0018	0.027	0.019
Sr	0.024	0.027	0.0054	0.028	0.016
Si	0.10	0.10	0.13	–	–
SiO_2	–	–	–	50 ± 4	70 ± 4
Cu	61 ± 4	49 ± 4	61 ± 4	12.6	13.1

Table 2

REFERENCES

Anđelković, B. and Panić-Štorh, M. forthcoming *The Collection of Egyptian Antiquities in the City Museum of Vršac.*

Kuzmanović, M., Pavlović, M. S. and Marinković, M. 1996 Emission Spectrometric Analysis of Fresh Waters with U-shaped D.C. Arc with Aerosol Supply, *Spectroscopy Letters* 29/2: 205-215.

Lucas, A. and Harris, J.R. 1962 *Ancient Egyptian Materials and Industries*, London.

Marinković, M. and Antonijević, V. G. 1980 Evaluation of the Capability of a U-shaped D.C. Arc for Spectrometric Analysis of Solutions, *Spectrochimica Acta,* Part B, 35: 129-138.

Thompson, M. and Walsh, J. N. 1983 *A Handbook of Inductively Coupled Plasma Spectrometry*, London.

UDK: 73.032.5(497.113):902.65

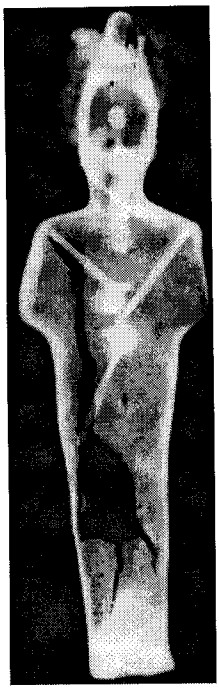
БРАНИСЛАВ АНЂЕЛКОВИЋ, МИРЈАНА С. ПАВЛОВИЋ
И ЈЕЛЕНА Ј. САВОВИЋ

СПЕКТРОХЕМИЈСКА АНАЛИЗА И РАДИОГРАФСКО ИСПИТИВАЊЕ МЕТАЛА И ЈЕЗГРА ТРИ СТАТУЕТЕ ОЗИРИСА ИЗ ГРАДСКОГ МУЗЕЈА У ВРШЦУ

Резиме

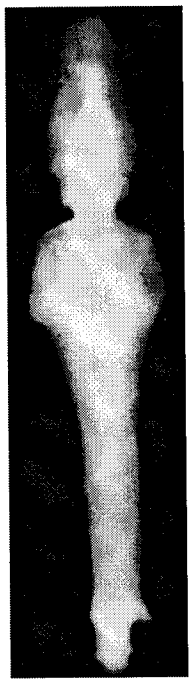
Спектрохемијски су испитани узорци са три статуете Озириса (сл. 1-3) из Градског музеја у Вршцу (инвентарски бројеви *Aeg.* 24-26) купљених у другој половини 19. века у Египту. Прве две, шупље ливене, начињене су у техници тзв. изгубљеног воска и код њих је урађена анализа како металног дела (узорак 1а, 2а) тако и силикатног језгра (узорак 1б, 2б) док је трећа начињена у пуном ливу, те је код ње анализован само метал (узорак 3). Спектрографски је најпре одређен квалитативни састав (табела 1), а затим је урађена квантитативна спектрометријска анализа коришћењем плазме једносмерног стабилизованог лука као ексцитационог извора. Добијени резултати показују да метални део статуета поред главних састојака (бакра, олова, калаја и антимона) садржи и знатан број других елемената (табела 2). Релативно висок садржај калцијума се може приписати слоју патине који није могао бити избегнут при узимању узорка. Радиографско испитивање на индустријском рендгенском уређају у Заводу за заваривање у Београду, показује да је, поред механичких оштећења, знатан део метала прве две статуете прешао у корозионо стање, док је трећа у потпуности сачувана (таб. Iа-ц). Материјал којим су испуњене статуете састоји се претежно од силицијум диоксида (SiO_2) тј. вероватно спрашеног кварцног песка, мада такође садржи и знатан број других елемената. Статуете су израђене од тзв. оловне бронзе. Релативно висок проценат антимона радије се приписује нечистоћи руде бакра него намерном додавању, док су олово и калај свакако додати. Статуете се могу датовати у Позни период (*ca.* 747-332. године пре наше ере).

01. 02. 2002.



a. Radiograph of the statuette Aeg. 24.

b. Radiograph of the statuette Aeg. 25.



c. Radiograph of the statuette Aeg. 26.