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DATING OF THREE SASANIAN BOWLS FROM THE NATIONAL MUSEUM OF IRAN

AN X-RAY FLUORESCENCE AND SPECTROSCOPIC ANALYSIS

Abstract: Three Sasanian Silver Bowls at the National Museum of Iran, known collectively as the "dancer-musician scenes," have been considered as one of the museum's most iconic works for the past 70 years. Only bowl No. 1 has been examined by numerous Western and Iranian scholars. Based on the catalog of the exhibition "7000 Years of Iranian Art Exhibition" in Vienna (2001-2002), these dishes have been tentatively dated to 8-9th centuries CE. All subsequent exhibitions have followed the same pattern. In addition, the dark heart-shaped decorations on two dishes have been called minā (enameling) in most of the previous publications.

The importance of these three bowls (and also the famous Sasanian silver cup) has been the main reason for their selection for technical analysis, X-Ray fluorescence (XRF), and spectroscopy. However, a well-known Sasanian cup (called also "a silver musician-dancer" piece) was only subjected to a semi-quantitative investigation using XRF analysis. The XRF has been extremely helpful in determining a more exact dating for the three bowls indicated above, but it has also raised serious concerns about the dark heart-

shaped embellishments. Moreover, the dating of the artifacts has been called into doubt by an XRF study of Arabo-Sasanian coins (early Islamic periods) and a comparison of the metal compounds of these objects with those of the three dishes.

Additionally, the authors of the present article have proposed niello for the dark ornamentation on the bowls based on these two technical evaluations. Indeed, spectroscopy was not able to answer the main question about the heart-shaped decorations on bowls No. 1 & No. 2, but it has opened a new venue to challenge the term minā, which was widely used in printed works. However, these two chemical analyses expose the possibility that the items may have been created in a workshop of the same artist (or a group of artists).

Keywords: Sasanian silver bowls; National Museum of Iran; XRF; spectroscopy

Introduction

Considering technical analyses comparatively, this article deals with three of the known Sasanian artifacts at the National Museum of Iran. In the last 70 years, these works, three Sasanian Silver bowls, and a cup, have been repeatedly studied.[1] However, bowl No. 1 has been the most referenced work and has been displayed in most domestic and overseas exhibitions.[2] As A. Sami (1969: 39, 45) reported, these three Sasanian silver works were purchased in Kelardasht.[3]

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[1] These beautiful bowls, no. 1 with registration number 1332, weight 575.07, diameter 23, height 7cm, No. 2, registration number 1332, weight 795.22, diameter 23, height 7.5cm and No. 3, registration number 1337, weight 543.22, diameter 22, height 6.5cm are kept in the Historical Studies Department of the Museum. The Silver Cup, registration number 500, arrived from the Golestan Palace to the Museum (n.d.) by order of the Royal Family (Pahlavi dynasty, Queen Farah) before 1979.

[2] We would like to thank Ms. Zahra Akbari, the Curator of the Department, and we also thank the National Museum of Iran. We would like to thank Ms. Madani for conducting the XRF test, and RCPC of RICHT. We are, also, grateful to Dr. Mushtagh (Germany) for editing the text.

[3] According to the Catalog of Vienna (*7000 Jahre Persische Kunst*, 2001: 327): "obtained from Kelardasht (?) in the eighth century AD"; "This incomplete hemispherical bowl has a meaningful motif on its back. Palm leaf decorations can be seen with four separate figures. In each part of the motif, a female is dancing under a grape tree. A pheasant is seen in the center of the object, with a ring pearl around it. The hair of the females is woven in an artistic style in parallel to the golden decorated forehead and necklaces on the neck. On their arms are long handkerchiefs that hang in front of the body and reflect a kind of movement. Their faces are facing each other in pairs. The flutist looks at his right-hand neighbor who is playing the lute; of the other two girls, one plays the Arghanun and the other has castanets in her hands...". Furthermore, the name of the owner of this silver object and its weight, in Pahlavi, can be clearly seen among the motifs. The Vienna Catalog deals with this in detail with a long explanation attributing this scene to Dionysius scenes and finally to "Goddess Anahita."

In the catalog *7000 Years of Iranian Art* (2001), reference has been made to the most important research background of these great Sasanian works, such as Ghirshman (1957), Vanden Berghe (1959), Henning (1959), Harper (1978, and before 1979) for bowl No. 1. This silver bowl (No. 1), after being displayed in the exhibition along with several other items from the National Museum of Iran and other Iranian museums, was exhibited in many countries around the world such as Germany, Italy, Belgium, Switzerland, Croatia, Spain, France, Turkey, Japan, South Korea, and Brazil. It has been a significant topic in all the printed catalogs of those exhibitions.[4] The catalog (and subsequent exhibitions and catalogs that followed the Vienna event) dated the bowls to 8-9th centuries CE. Therefore, this article aims to answer the following research questions based on XRF and Spectroscopy:

- What are the similarities and differences between these three works?
- Can chemical analyses be effective in approaching a new dating?
- Can compounds of other Sasanian objects and Arab-Sasanian coins be useful for this dating?
- Can these tests discount the hypothesis of using enamel (*minā*) for decorations of the two items (No. 1 and No. 2)?
- Can chemical analysis prove that the Sasanian Cup in the National Museum is really made of silver?

Therefore, to first determine their similarities and dissimilarities, we decided to study the metal compounds of these three bowls in comparison with the silver cup; this will help us to better understand their regular structure and compare it with previous data for reliable dating. Second, based on this and a comparative study with the coins of the early Islamic periods, a reliable new dating has been suggested. Third, we will stress the heart-shaped decoration of the two bowls (No. 1-2) as a new venue of study. Discussions of the composition of these heart-shaped decorations do not appear in previous publications.

We invited Prof. Mohajarani and his assistant from the National University of Iran to visit the museum at another time for spectroscopy. However, the pres-

[4] This valuable archaeological item can also be found in many interior catalogs and exhibitions of the National Museum, including *Exhibition of Iran and the Silk Road* (Catalog 2011, 55), *Glory of Iran* (Catalog 2010, 30), *Golden and Silver Works of Iran* (Catalog 2013, 59), and *Ancient Iran (A Look at Treasures of the National Museum of Iran)* (no date). Numerous international and Iranian scholarly articles can also be referred to, such as Aliei et al. (2019, 51), Mobini and Haghparast (2018, 112), Sami (1969, 29), and Harper (1986, online). Readers will find a long list of research papers on this topic by searching the Internet. However, bowls No. 2 and 3 have never been displayed in exhibitions or published elsewhere.

ence of a covering coat on one of the bowls (No. 1) prevented us from doing this test, so we had to focus on bowl No. 2 instead. Although the spectroscopic analysis of the blue-dark heart shapes was unsuccessful, its only conclusion was that the compounds of these blue-dark heart-shaped decorations could not be fully identified as silver. Furthermore, for more certainty, the authors of the present article invited experts from the Stone Department of RCP to have a look at the heart-shaped decorations, in the museum. They emphasized that this cannot be stone, which was a great help and contribution.

Materials and method

Sasanian bowls

The bowl No. 1 has a significant motif on the back (Pl. 1: 1). A palm leaf decoration with four separate figures can be seen. In each part of the motif, a musician-dancer (three males and one female) is dancing under a grape tree. In the center of the object is a pheasant with a ring pearl around it. The female's hair is artistically braided in parallel with her forehead and a valuable necklace. Each is playing a musical instrument, but the female dancer is holding a very light instrument(cf. Chilek bowl). Their faces are turned to each other in pairs. Their type of dress may reflect a particular season compared with the other two courts.

Despite of the technical and high artistic value, the presence of dark-blue heart-shaped enamels (the so-called *minā*) with excellent manufacturing techniques was the most important reason for us to choose it for the testing. The dark-blue shapes divided the dish into four symmetrical parts; although different, the size of the hearts from the center to the margin is very regular and harmonious.

Bowl No. 2 depicts the same scene as bowl No. 1. However, the cloths of the musicians here differ from their counterparts on No. 1. This bowl (Pl. 1: 2) has not been preserved in good condition; most of the heart-shaped decorations are broken off and a large damage can be seen on the left side of the item.

Furthermore, the photograph shows that there was no space between the outer edge of these decorations and the inner parts of the place where they were located, because most of the heart shapes have fallen off. Scratches under

decorations with sharp points upward could have helped to preserve decorations well (Pl. 2: 1).

The musician-dancers on bowl No. 3 (Pl. 1: 3) are significant. It seems that all of them are wearing thick clothes, which can suggest the cold season. In addition, two of these four people are playing two unknown instruments (the female, who is one of them, is probably playing some kind of a rattle). The absence of the heart-shaped decoration on this work is significant.

Sasanian silver cup:

Another reason for performing XRF on the famous Sasanian Silver Cup (Pl. 1: 4) was the artistic content of the dancer-musician scene of this object in the National Museum. In fact, its artistic elements, such as a female dancer (with the same clothes as in bowl No. 1 or her large breasts, cf. bowls No. 1-3), two male dancers and floral decoration style, etc., led us to this experiment.

Arab-Sasanian Coins

In addition to these four important Sasanian works, we selected a number of coins of the Arab rulers of the early Islamic period for XRF analysis (Table 1). Obviously, Arab-Sasanian coins (post-Sasanian periods) followed Sasanian heritages (i.e., Khosrow II's coins) in terms of technique, design, decorations and some symbols. This individual names on the coins, the mints, the Pahlavi and Arabic legends, make these objects invaluable historical source. However, the use of such silver and gold objects (bowls, cups for eating and drinking, accessories) has been prohibited (*harām*) in Islam (cf. article 227 of Sistani; www.sistani.org). Also, the half-naked female figure on the bowl No. 1 should be added to this category. So, Arabo-Sasanian coins can be the most important documents, in the absence of the silver works of the first Arab rulers, such as the above objects (bowls), to measure the compound comparatively.

Table 1. The list of Rulers whose coins have been tested[5]

row	Ruler/King	Reign	Registry number
1	Khurshīd	740-761	1007/1
2	Khurshīd	740-761	290/1
3	Khālid	761-771	1005/1

[5] The transliteration of the names of the Arab rulers is based on the *Encyclopaedia of Islam* (Second Edition) by Brill (online).

4	Saʿīd	776-778	1006/3
5	ʿumar	771-780	1004/4
6	ʿumar	771-780	302/45
7	Hāni	788-790	2287/1
8	Hāni	788-790	298/3
9	Muḳātil	788-792	2119
10	ʿpzwt	Unknown	302/51
11	ʿpzwt	Unknown	302/42
12	Ibrāhīm	673-683	856
13	ʿUbayd Allāh Ziyād	653-686	1990
14	ʿUbayd Allāh Ziyād	653-686	1303
15	ʿUbayd Allāh Ziyād	653-686	1994
16	ʿUbayd Allāh Ziyād	653-686	313/7
17	ʿUbayd Allāh Ziyād	653-686	312/2
18	Marwān	623-665	1062/2
19	Marwān	684-685	1991
20	ʿAṭiyya bn Aswad	689-697	312/2

Method

The hemispherical form of the three pieces (bowls) was a reason for testing each bowl from three (outer) points; the same method (three points) was also applied to the heart-shaped decorations. For the silver cup, the test was done on six points: three points from the main body and three points on the gilded parts. The method applied for the Arab-Sasanian drachms was based on two points on the obverse and one point on the reverse. The concentrations of the following elements were determined: Si, P, Ti, V, Cr, Fe, Cu, Zn, Ag, Sn, Au, Pb, Bi. The XRF has been evaluated by using Niton XL3t GOLDD+ 950 (Thermo Scientific).

The spectroscopy, also, has been carried out by using optical spectroscopy on two different spots of dishes No. 2 and 3. Conductivity testing and reflectivity testing were done under the Brewster angle together with ultraviolet and visible testing. Conductivity testing was performed using a universal digital multimeter. Brewster reflectance testing was performed using a 635 collimated diode laser and adjustable holder together with a polarizer to select the proper

polarization accurately. UV VIS spectra were taken using the AvaSpec-ULS-2048CL-EVO spectrometer.

However, the heart-shaped decorations were very high after cleaning the covering coat. The following methods were the basis of the work (see Table 2).

Table 2. Spectroscopic report on the bowls

Bowl No. 3 Long way	**Heart-shapes Bowl No. 2**	**Bowl No. 2 Long way**	**Bowl No. 1**	
0/1 Ω	1/2 Ω	0/2 Ω	(OL) High	**Resistivity**

Light Reflection Test under Brewster's Angle

A light reflection test was used for the body and heart-shaped decorations of bowl No. 2 to measure the diminution of light reflection. The reflection was also reduced on the main body parts, but the reflection on the heart-shaped forms was greatly reduced, which shows that they are dielectric (non-conductive).

Ultraviolet-Visible Spectrum Test

This test was also done for No. 2, both the main body and heart-shaped forms. The above-mentioned analysis shows a significant difference between the two parts, with the blue-dark parts described as non-conductive. Sample spectra with different colors are shown below in Pl. 2: 2. Black and red spectra represent the heart-shaped decorations, blue represents scratches (fallen parts of the heart-shaped decorations) and green and violet have been used for the main body of the bowl.

It is difficult to find references to scientific studies involving chemical tests on this type of Sasanian works (musical scenes). One of the problems has undoubtedly been getting access and permission to use the items for tests. In general, chemical tests on Sasanian objects such as plates (Hughes and Hall 1979, 321-344) and coins (Akbarzadeh and Schindel 2021, 40-45) date back to more than 50 years ago. However, most of the previous studies have focused on determining composite materials (cf. Sodaei *et al.* 2013, 2011) and have not provided new dating.

Despite the artistic similarities and manufacturing style of the three items under discussion, there are slight differences between them revealed by chemical tests (Akbarzadeh 2021, 95). XRF indicates that Bowl No. 1 has a silver content of 93 percent on average. Bowl No. 2 has 94 percent. Fallen, broken and damaged parts of the heart-shaped decorations were of great help to review this part. For better adhesion, the artisans deliberately created small sharp indentations (scratches) under these particular decorations to mount them securely.

The third bowl, due to the relative absence of many small details (i.e., heart-shaped decorations) in comparison to the other two bowls, has the highest average silver content, nearly 96%. Moreover, a very small average of gold content sets apart bowls Nos. 1 & 2 and No. 3. This little amount of gold has also been recorded by the device in the same heart-shaped ornaments. Apart from this, copper is another considerable alloy from No. 1 to Nos. 2 & 3. The copper average of these three bowls is comparable to the normal average of Sasanian coins (0.500 to 4.50, excluding exceptional cases) (Akbarzadeh and Schindel 2021, 42-47) but these of Nos. 2 & 3 are also aligned with the cup. Most likely the craftsmen controlled the alloy, copper, with Nos. 2 & 3 or increased it on No.1 (it could have been accidental). Meanwhile, there are no significant differences between these three from in respect of compound metals. This means that the metal compounds of these objects (and the cup) correspond to a regular Sasanian object (cf. Oudbashi *et al.* 2017, 197).

The aim of the XRF on the cup, apart from a comparative study with these three bowls (Table 3), was also to challenge the way it has been called 'silver cup' for the last 70 years. Although its gilded parts can be seen with the naked eye, it is difficult to assume that the average content of gold in it is much higher than other alloys. In fact, however, the average silver content (of the main body) is around 39 percent while in its body, more than 59%, and in its neck, more than 17% of gold was used in the form of a very thin, beautiful strip. This finding is completely at odds with the name of the cup. However, parts of the neck's gold have been lost, which must be due to the poor preservation conditions in the past and the fact that this is where the cup was often held by hand for movement. Its manufacture dates to the Sasanian period. Table 3 shows the results of XF on these four works.

Table 3. XRF metal analysis of the three bowls and the Sasanian cup

Calibration Mode: GeneralMetalAnalysis														
% Sample		Si	Al	V	Cr	Fe	Cu	Zn	Ag	Sn	Sb	Au	Pb	Bi
1007/1	1	14.45	6.87	0.047	0.587	1.21	4.33	0.433	67.43	0.592	0.166	W: 2.45	0.888	0.096
	2	13.75	6.64	0.045	0.570	1.17	4.85	0.409	68.03	0.528	0.145	W: 2.34	0.941	0.100
	3	16.18	7.15	0.052	0.559	1.31	4.45	0.451	65.35	0.561	0.137	W: 2.30	0.932	0.109
	Avg	14.79	6.88	0.048	0.572	1.23	4.55	0.431	66.94	0.560	0.149	W: 2.36	0.920	0.102
290/1	1	0.965	0.550	-	0.595	-	3.09	0.023	92.93	0.218	0.085	0.195	0.971	0.141
	2	1.12	-	0.007	0.586	-	3.14	0.016	93.29	0.224	0.075	0.192	0.989	0.153
	3	1.19	0.420	-	0.594	0.038	3.25	0.012	92.59	0.299	0.078	0.122	1.01	0.156
	Avg	1.09	0.323	0.002	0.592	0.013	3.16	0.017	92.94	0.247	0.080	0.170	0.991	0.150
1005/1	1	2.44	1.78	0.010	0.517	0.154	2.70	0.012	91.38	0.183	0.089	0.414	0.206	0.056
	2	2.70	1.63	0.013	0.529	0.131	2.69	0.011	91.07	0.311	0.064	0.424	0.263	0.048
	3	4.10	2.02	-	0.577	0.213	2.61	-	89.48	0.165	-	0.420	0.161	0.049
	Avg	3.08	1.81	0.008	0.541	0.166	2.67	0.008	90.64	0.219	0.051	0.419	0.210	0.051
1006/3	1	5.46	3.01	0.026	0.429	0.378	6.42	-	82.41	0.257	0.096	0.168	1.02	0.061
	2	5.56	2.67	0.024	0.428	0.355	6.35	-	82.76	0.246	0.129	0.181	1.00	0.061
	3	4.91	2.00	0.012	0.497	0.302	6.65	-	83.80	0.299	0.078	0.176	1.02	0.067
	Avg	5.31	2.56	0.020	0.451	0.345	6.47	-	82.99	0.267	0.101	0.175	1.01	0.063
1004/4	1	4.49	2.61	0.020	0.525	0.268	0.102	-	90.79	0.309	0.116	-	0.450	0.039
	2	3.48	1.99	0.010	0.536	0.181	0.113	-	92.44	0.405	0.090	0.014	0.512	0.047
	3	8.96	4.74	0.011	0.515	0.613	0.148	-	83.71	0.214	0.074	0.014	0.550	0.060
	Avg	5.64	3.12	0.014	0.525	0.354	0.121	-	88.98	0.309	0.094	0.009	0.504	0.048

302/45	1	0.888	0.578	0.021	0.504	-	5.72	0.010	90.47	0.398	0.095	-	1.14	0.087
	2	0.814	0.944	0.018	0.495	-	5.78	0.011	90.23	0.379	0.113	0.012	1.09	0.087
	3	0.769	0.824	-	0.525	0.081	6.59	-	89.49	0.295	0.095	0.014	1.13	0.087
	Avg	0.824	0.782	0.013	0.508	0.027	6.03	0.007	90.06	0.357	0.101	0.009	1.12	0.087

As mentioned earlier, in the absence of some elements, bowl No. 3 contains a little more silver than the other two bowls and, of course, its weight confirms this as well. Spectroscopy also testified to this. Meanwhile, the heart-shaped decorations are non-conductive (i.e., they are in the mega ohm range) whereas other parts of the bowls No. 2 and No. 3 are conductive. Furthermore, No. 3 is more conductive than No. 2.

Although the spectroscopic test did not add any new knowledge about the three bowls, it can be concluded that the heart-shaped decorations are neither silver nor enamel in its special sense. It appears that the spectroscopic test has been more reliable in this case than XRF. We believe that XRF (spot size 8mm, larger than heart-shape size) recorded metal compounds with "slightly raised edges," where the heart-shaped decoration is located. In other words, it misread the intended part of the object. Instead of recording the compounds of the heart-shaped decorations, the device recorded the silver edges around it. It is possible that the device is not able to do this or has recorded silver that has melted with other materials of the heart shapes. The heart-shaped decorations may contain a little silver but it cannot be fully silver as the staff told us; this is why we only doubted the XRF report on the heart-shaped decorations.

These heart-shaped decorations could have been mounted in the bowls Nos. 1 and 2 in two ways. First, the above-molten materials might have been installed and gently sanded and smoothed. Second, these molten metals may have been placed in a few locations as a cold paste (perhaps with a little heat). Scratches and their sharp tips pointing upwards strongly support this suggestion. The makers likely applied these pastes to this scratch gently. However, the lack of a very thin seam between the heart shape's edge and the remaining location edge calls into question the cold paste method.

The heart-shaped forms will remain a questionable subject, however, using a general term such as "enamel" in reference to them is not helpful either, as previously mentioned. Ancient Iran had different types of enamel of varied construction. Researchers know perfectly well how difficult (bordering on impossible) it is to get these three bowls out of the museum for testing in other centers (i.e., SEM recommended) due to the legal regulations, but based on these tests, we suggest

that "niello" (cf. *7000 Jahre Persische Kunst* 2001, no. 159) has been the most likely material of these heart-shaped decorations. It was also used in the manufacturing of the enamel. Niello was not *minā* in its proper sense (cf. Diba 1998, online), however. Combined with copper, lead and especially with gold-silver, niello can reflect blue-dark color. This is probably why the XRF device recorded silver (and gold) only on the heart shapes. Melting these two alloys, silver and copper, not only has a long tradition in Iran but is also a known technique in Sasanian metalwork. Table 1 has confirmed copper and lead in the heart-shaped decorations.

A clear difference is evident between these scratches (Nos. 1&2) and the similar on the plate with a hunting scene of the so-called Peroz in the Metropolitan Museum (online). The noticeable difference in the color of this material in the goats horns and the quiver on the MET plate as well as their thickness, position and damage contrast with color unity, from one side and diameter and different sizes of each of the heart shapes of the bowls Nos. 1&2 from the National Museum of Iran from another side, can be referred as significant differences.

Arab-Sasanian coins metal compounds and the silver bowls dating

Although the similarities and differences of the compounds of these three Sasanian bowls (and the cup) on the one hand, and information on the available data of Sasanian objects on the other (Akbarzadeh and Schindel 2017, 15) leave no doubt in assigning them to the Sasanian period, we decided to do XRF on the Arabo-Sasanian coins. Data of the coins were useful for a comparative approach to the dating of the three Sasanian objects from the Museum.

While the rulers of Tabaristan (in the early Islamic periods) tried to maintain the same Sasanian tradition (compounds), the test showed this was not the case with Arab rulers' coins. This is evidenced, among other things, by the diversity of the compounds of the coins of Arab rulers from the south to the north of Iran. Social and political circumstances are likely a significant factor in the high prevalence of copper in these coins compared to Sasanian coins, especially from the sixth century. Furthermore, the Arab rulers' coins do not show a regular standard structure for the compounds. Did Iranian workers knowingly increase copper in this series of objects or were the objective circumstances the main reason? In fact, the composition of the silver bowls and the cup is not only far from the Sasanian regular structure in using alloys, but it also shows a significant difference with most of the Arab drachms. Isn't the dating of these dishes to the Islamic era (8^{th}-9^{th} cent. AD) questionable? Maybe the XRF test of the coins (Table 4) will clarify the picture.

Table 4. XRF on Arab-Sasanian Drachms

Calibration Mode: GeneralMetalAnalysis														
% Sample		Si	Al	V	Cr	Fe	Cu	Zn	Ag	Sn	Sb	Au	Pb	Bi
1007/1	1	14.45	6.87	0.047	0.587	1.21	4.33	0.433	67.43	0.592	0.166	W: 2.45	0.888	0.096
	2	13.75	6.64	0.045	0.570	1.17	4.85	0.409	68.03	0.528	0.145	W: 2.34	0.941	0.100
	3	16.18	7.15	0.052	0.559	1.31	4.45	0.451	65.35	0.561	0.137	W: 2.30	0.932	0.109
	Avg	14.79	6.88	0.048	0.572	1.23	4.55	0.431	66.94	0.560	0.149	W: 2.36	0.920	0.102
290/1	1	0.965	0.550	-	0.595	-	3.09	0.023	92.93	0.218	0.085	0.195	0.971	0.141
	2	1.12	-	0.007	0.586	-	3.14	0.016	93.29	0.224	0.075	0.192	0.989	0.153
	3	1.19	0.420	-	0.594	0.038	3.25	0.012	92.59	0.299	0.078	0.122	1.01	0.156
	Avg	1.09	0.323	0.002	0.592	0.013	3.16	0.017	92.94	0.247	0.080	0.170	0.991	0.150
1005/1	1	2.44	1.78	0.010	0.517	0.154	2.70	0.012	91.38	0.183	0.089	0.414	0.206	0.056
	2	2.70	1.63	0.013	0.529	0.131	2.69	0.011	91.07	0.311	0.064	0.424	0.263	0.048
	3	4.10	2.02	-	0.577	0.213	2.61	-	89.48	0.165	-	0.420	0.161	0.049
	Avg	3.08	1.81	0.008	0.541	0.166	2.67	0.008	90.64	0.219	0.051	0.419	0.210	0.051
1006/3	1	5.46	3.01	0.026	0.429	0.378	6.42	-	82.41	0.257	0.096	0.168	1.02	0.061
	2	5.56	2.67	0.024	0.428	0.355	6.35	-	82.76	0.246	0.129	0.181	1.00	0.061
	3	4.91	2.00	0.012	0.497	0.302	6.65	-	83.80	0.299	0.078	0.176	1.02	0.067
	Avg	5.31	2.56	0.020	0.451	0.345	6.47	-	82.99	0.267	0.101	0.175	1.01	0.063
1004/4	1	4.49	2.61	0.020	0.525	0.268	0.102	-	90.79	0.309	0.116	-	0.450	0.039
	2	3.48	1.99	0.010	0.536	0.181	0.113	-	92.44	0.405	0.090	0.014	0.512	0.047
	3	8.96	4.74	0.011	0.515	0.613	0.148	-	83.71	0.214	0.074	0.014	0.550	0.060
	Avg	5.64	3.12	0.014	0.525	0.354	0.121	-	88.98	0.309	0.094	0.009	0.504	0.048
302/45	1	0.888	0.578	0.021	0.504	-	5.72	0.010	90.47	0.398	0.095	-	1.14	0.087
	2	0.814	0.944	0.018	0.495	-	5.78	0.011	90.23	0.379	0.113	0.012	1.09	0.087
	3	0.769	0.824	-	0.525	0.081	6.59	-	89.49	0.295	0.095	0.014	1.13	0.087
	Avg	0.824	0.782	0.013	0.508	0.027	6.03	0.007	90.06	0.357	0.101	0.009	1.12	0.087

Calibration Mode: GeneralMetalAnalysis														
% Sample		Si	Al	V	Cr	Fe	Cu	Zn	Ag	Sn	Sb	Au	Pb	Bi
2287/1	1	4.73	2.03	0.060	0.287	0.220	11.32	-	75.18	0.189	0.121	-	4.07	0.298
	2	3.72	1.88	0.051	0.340	0.179	7.12	0.027	80.13	0.325	0.090	0.061	4.31	0.301
	3	4.61	2.22	0.039	0.345	0.261	6.98	0.017	80.10	0.333	0.098	0.043	3.66	0.231
	Avg	4.35	2.04	0.050	0.324	0.220	8.47	0.015	78.47	0.282	0.103	0.035	4.01	0.277
298/3	1	0.837	-	0.022	0.498	0.055	4.14	0.022	92.85	0.432	0.099	0.054	0.796	0.132
	2	0.931	0.710	0.026	0.486	0.082	4.14	0.014	92.01	0.434	0.143	0.035	0.772	0.121
	3	0.617	0.550	-	0.574	0.060	6.01	-	90.31	0.337	0.059	0.033	1.22	0.133
	Avg	0.795	0.420	0.016	0.519	0.066	4.76	0.012	91.72	0.401	0.100	0.041	0.931	0.129
2119	1	1.59	0.625	0.039	0.366	0.107	13.29	-	81.46	0.372	0.090	0.044	1.73	0.127
	2	1.11	-	0.040	0.378	0.035	13.52	-	82.11	0.410	0.110	0.048	1.92	0.174
	3	2.94	1.38	0.031	0.409	0.127	12.54	-	79.87	0.345	0.090	0.046	1.81	0.147
	Avg	1.88	0.667	0.037	0.385	0.090	13.12	-	81.15	0.376	0.097	0.046	1.82	0.149
302/51	1	1.10	0.490	0.021	0.457	0.065	8.27	0.034	87.05	0.431	0.121	0.023	1.76	0.114
	2	1.24	0.936	0.015	0.451	0.046	8.23	0.019	86.59	0.348	0.124	0.024	1.76	0.114
	3	0.844	-	0.009	0.490	0.064	7.67	-	88.29	0.473	0.092	0.016	1.86	0.115
	Avg	1.06	0.476	0.015	0.466	0.058	8.06	0.018	87.31	0.417	0.113	0.021	1.80	0.114
302/42	1	1.34	0.809	0.014	0.514	0.042	2.78	0.011	92.97	0.570	0.144	0.056	0.555	0.100
	2	0.878	-	0.011	0.537	0.049	2.45	0.011	94.74	0.403	0.123	0.063	0.556	0.107
	3	1.08	-	-	0.555	0.040	3.89	0.021	93.01	0.424	0.075	0.054	0.657	0.084
	Avg	1.10	0.270	0.009	0.535	0.043	3.04	0.014	93.57	0.466	0.114	0.058	0.589	0.097
856	1	3.09	0.627	0.023	0.493	0.135	4.27	0.025	88.03	0.456	0.133	0.033	2.40	0.113
	2	2.78	1.19	0.023	0.496	0.100	4.20	0.028	87.65	0.536	0.130	0.033	2.49	0.109
	3	2.76	1.92	0.022	0.485	0.073	4.13	0.020	87.46	0.376	0.141	0.033	2.34	0.103
	Avg	2.88	1.25	0.023	0.492	0.103	4.20	0.024	87.71	0.456	0.135	0.033	2.41	0.108

Calibration Mode: GeneralMetalAnalysis														
% Sample		Si	Al	V	Cr	Fe	Cu	Zn	Ag	Sn	Sb	Au	Pb	Bi
1990	1	8.89	3.45	0.103	0.421	0.602	3.80	0.082	77.74	0.446	0.106	0.864	3.05	0.041
	2	8.08	3.28	0.089	0.428	0.579	3.75	0.065	79.05	0.419	0.117	0.864	2.78	0.035
	3	7.09	2.39	0.061	0.494	0.411	4.20	0.102	81.14	0.452	0.119	0.979	2.36	0.033
	Avg	8.02	3.04	0.084	0.448	0.531	3.91	0.083	79.31	0.439	0.114	0.902	2.73	0.036
1303	1	2.61	1.34	0.018	0.496	0.168	2.34	0.011	90.53	0.479	0.097	0.669	0.924	0.022
	2	3.07	1.27	0.028	0.495	0.188	1.97	0.033	90.67	0.504	0.118	0.683	0.811	0.019
	3	2.46	1.41	0.026	0.497	0.138	2.25	0.021	91.04	0.446	0.124	0.730	0.772	0.024
	Avg	2.71	1.34	0.024	0.496	0.164	2.18	0.022	90.75	0.476	0.113	0.694	0.836	0.022
1994	1	3.49	1.16	0.050	0.529	0.196	3.65	0.098	87.68	0.500	0.133	0.808	1.59	0.037
	2	2.19	1.02	0.030	0.521	0.093	3.79	0.082	89.52	0.441	0.114	0.743	1.30	0.029
	3	3.59	1.42	0.038	0.566	0.182	3.51	0.081	87.71	0.457	0.090	0.748	1.48	0.025
	Avg	3.09	1.20	0.039	0.539	0.157	3.65	0.087	88.30	0.466	0.112	0.766	1.46	0.030
313/7	1	0.650	P: 0.062	0.019	0.512	0.051	2.76	0.283	92.15	0.468	0.118	0.773	2.09	0.027
	2	0.963	P: 0.107	0.022	0.482	0.033	2.85	0.198	91.35	0.460	0.104	0.791	2.07	0.025
	3	0.370	-	-	0.590	-	3.12	0.098	92.53	0.443	0.106	0.714	1.95	0.023
	Avg	0.661	P: 0.056	0.014	0.528	0.028	2.91	0.193	92.01	0.457	0.109	0.759	2.04	0.025
1062/2	1	1.12	P: 0.194	0.021	0.451	0.038	7.64	0.049	88.25	0.447	0.144	0.531	1.01	0.044
	2	1.46	P: 0.177	0.022	0.458	0.073	6.90	0.050	87.58	0.605	0.113	0.525	0.947	0.048
	3	1.28	P: 0.204	-	0.533	0.088	6.16	0.045	89.18	0.380	0.078	0.511	0.760	0.036
	Avg	1.29	P: 0.193	0.014	0.481	0.066	6.90	0.048	88.33	0.477	0.112	0.522	0.907	0.043
1991	1	10.97	4.10	0.058	0.443	0.864	5.54	0.074	74.20	0.408	0.102	W: 1.43	1.49	0.044
	2	10.34	4.09	0.082	0.412	1.05	4.89	0.086	73.63	0.545	0.118	W: 1.34	2.94	0.051
	3	8.09	2.59	0.031	0.501	0.560	5.07	0.030	80.01	0.462	0.081	W: 1.22	1.09	0.032
	Avg	9.80	3.60	0.057	0.452	0.824	5.17	0.063	75.94	0.472	0.100	W: 1.33	1.84	0.042

Calibration Mode: GeneralMetalAnalysis														
% Sample		Si	Al	V	Cr	Fe	Cu	Zn	Ag	Sn	Sb	Au	Pb	Bi
1993	1	6.78	2.16	0.023	0.497	0.337	3.39	0.055	84.52	0.431	0.095	0.616	0.904	0.039
	2	9.58	3.49	0.046	0.430	0.802	3.63	0.050	79.67	0.417	0.076	0.570	0.919	0.037
	3	3.67	1.18	0.008	0.571	0.201	3.89	0.048	88.49	0.353	0.105	0.601	0.773	0.036
	Avg	6.67	2.28	0.026	0.500	0.447	3.64	0.051	84.23	0.400	0.092	0.596	0.866	0.037
312/2	1	0.632	P: 0.192	0.014	0.484	0.047	6.65	Ni: 0.031	88.10	0.524	0.132	0.550	2.12	0.036
	2	1.31	P: 0.206	0.022	0.466	0.121	6.63	Ni: 0.039	87.89	0.426	0.133	0.557	2.13	0.036
	3	0.726	P: 0.195	-	0.549	0.037	6.43	-	88.12	0.496	0.077	0.545	2.16	0.028
	Avg	0.890	P: 0.197	0.012	0.500	0.068	6.57	Ni: 0.023	88.04	0.482	0.114	0.551	2.14	0.033

Conclusion

The dating of archaeological objects has always been one of the crucial topics in cultural heritage studies. In addition to comparative studies, technological advances are also helpful. The artistic value and scholarly background of the three known Sasanian bowls and the cup from the National Museum were some of the reasons why these four items were selected for chemical analyses to verify their dating. Evidently, neither the composition of these three bowls is the same as that of the Arab rulers' coins of the early Islamic period, nor is the composition of the Arab coins present in those Sasanian objects according to comparative metal analysis. Therefore, the view that these three vessels were manufactured in the early Islamic period is questionable.

The metal compositions of these four mentioned items follow a structured pattern which can be observed in many other Sasanian objects. It appears that these four items belong to a brilliant period when art and such techniques were at their highest. A glance at the metal compounds of Sasanian coins from the 6th century CE and the metals used in these four objects from the Museum reminds us of a prosperous period in the combination of these metals and the creation of the items. In contrast, the metal compositions of the drachms of the Arab rulers appears chaotic and irregular. Therefore, it is not surprising that the metal

compounds of an Arab ruler vary from one mint to another. As a result, the four silver items under discussion not only have no signs related to the early Islamic centuries, but according to the results of chemical analyses, they cannot belong to 8th-9th centuries CE as the Vienna catalog stated. Lawergren's opinions (2009: online) should be cited for this claim.

Apart from chemical analyses, the type of needle incision inscription on the bowls casts doubt on their attribution to the Islamic period. What was found on the dishes of the Quri-Qala caves of Kermanshah (Akbarzadeh *et al.* 2001, 71) and previous published scholarly works (Brunner 1974, 109) serves as the proof of this. Furthermore, the figure of the owner or official in the middle of the dish (Fig. 3) is reminiscent of the Sasanian legacy of the 6th century CE. Many features of this portrait can be understood through authentic Sasanian reliefs (Harper 1986, online; Harper and Meyers 1981, passim). The sitting form, the armor on the leg, the ribbon behind the head, the dress, the type of two rings around the portrait, and the headband all reflect late Sasanian art but can hardly belong to early Islamic art. The background of such floral designs (grapes; MET: online), the professional, well-balanced and beautiful separation of each musician from the other by pearl strings, musical instruments, musicians wearing necklaces with specific pearls based on sacred Zoroastrian religious numbers, heart-shaped decorations, etc. all question the dating to the Islamic period.

However, considering the XRF tests and the proximity of the silver average (and other compounds) of these three bowls show that they could have been handmade by the same artist or the same group of professionally experienced artists. These three bowls could not have been made in three different workshops (*7000 Jahre persische Kunst*, 2001: 294).

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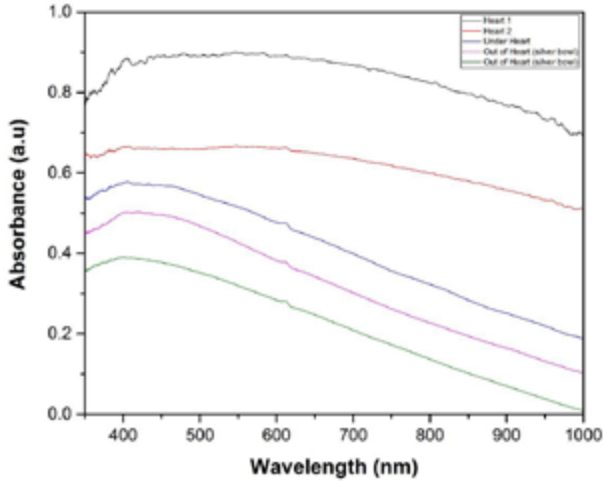
Pl. 1: 1-3 – Silver Sasanian Bowls
Pl. 1: 4 – Silver Sasanian Cup

Pl. 2 – Heart-shaped decorations with sharp tips pointing



Pl. 3 – Sample spectra with different colors