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Study and Analysis of Ancient Sassanid Coins by Using XRF Method

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Abstract: Numismatics always provide researchers with useful and accurate information about the production methods, economic conditions and industrial developments in the field of coinage. The study of the performance of the mints producing these coins is in fact an examination of these characteristics from a different perspectivesSo this study was conducted at Hamadan University in Iran to study the type and amount of metals in coins. variuous chemical and physical aspects of Sassanid coins. For this reason, 40 Sassanid coins from the reign of Qubad 1 were selected from the Museum of the Tomb of Bu Ali Sina. XRF method was used for analysis of different aspects of coins. Physical and chemical laboratory analyses showed that the coins of almost the same sizes were minted during the reign of Qubad 1. The use of the same texts and symbols indicates that the coins were minted according to a specific pattern.

Keywords: *Numismatics, Qubad, Sasanian, XRF.*

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I. INTRODUCTION

The study and examination of ancient coins can provide useful information about economic stability and political conditions, and different states use such technologies in the extraction and production of coins. Golden and silver coins were minted during the Achaemenid period. Ashkan coins were made only of silver or copper, and in their time, money and gold were brought to Iran only through trade [1]. The Sassanids borrowed the material and weight of their coins from their Ashkan ancestors, and like the Ashkans, the face of the coin featured a prominent image of the king and the reverse of the coin was assigned to the kingdom. The influence of Sasanian coinage on their coins in the province of Zabodum, i.e. Persia, is evident. Compared to the coins minted in the previous periods, Sassanid coins underwent many changes in terms of image, double sided coin, use of different alloys, discovery of new elements and use of elements in their inscriptions. Sasanian coins were made of alloy gold, silver, bronze, tin and lead. Unlike the Ashkan period, if gold coins were not multiplied, Ardashir multiplied gold coins. These coins were Roman gold coins and weighed 7.3 grams. Silver coins called dirhams were the most common type of Sasanian coins and were used in trade and exchange. The Sasanian dirham weighs between 3.65 and 3.4 grams [2]. Coins had small and large units, based on the coins in the world's museums, the small units were dirhams, half dirhams, 6 dirhams or dongs, and the large units included four dirhams. A single dinar includes half a dinar, 1.3 dinars, 1.6 dinars, one and a half dinars, and two dinars. Due to the low value of bronze coins, there was no exact weight standard and their approximate weight varied from 15.5 to 1.40 grams. The least valuable of them was Pashzmi [3]. One of the most important features of Sasanian coins is the image of rulers on the coins. Each king had his own crown or forehead band. On the back of the Ardashir coin, the image of a fireplace with three legs can be seen, but from the time of Shapur, the shape of the fireplace has changed and the image of the fireplace is of a single pillar. Or like Yazid, Mehr and Anahita can be seen, but until the mid-late Sassanid period, two images of Yazid were carved on both sides of the shrine. Rarely, there is a separate image of a fireplace on the back of some of the coins of Shapur II, Ardashir II, Bahram IV and Yazdgerd I. [4]. A crown or tiara is a decorative ornament for the head of the king. The officer, that is, Ravi, will be the head, will be the head. The pictures show seals, jewels, famous faces and Sasanian coins. Every Sasanian king had a unique crown. The crown was actually a symbol and decoration of the ruler's relationship with the heavenly forces. Sasanian coins were made from alloys of gold, silver, bronze, tin and lead. Various methods of elemental analysis are used to measure the concentration of elements in ancient samples. Among these

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methods are XRF1, which is non-destructive, which is very useful for ancient samples, given the importance of preserving the originality of the sample, as well as methods such as chemical analysis, which are destructive methods for samples. However, they are used in some cases. Complementary methods such as metallography and XRD5 are also used to check the production methods and physical composition.

In this analysis method, the studied sample is exposed to proton radiation. As a result of the collision of protons with electrons of target atoms, specific X-rays are emitted, which determine the energy of the X-rays, the type of element present in the sample, and the number of X-rays with a specific energy. In the XRF method, the analysis and identification of materials can be carried out at the ppm level. Of course, the limit of this analysis is realistic for the WDS method and for light elements (those with atomic numbers above 9). For such an analysis, 0.1% of the unknown sample is sufficient [11].

According to historical documents, during different periods of the dynasty, central governments and some local rulers minted gold and silver coins. Also, the economic situation of the country varied with the climatic conditions and the political power of the rulers, and the income of each state depended on the political power, so it seems that the value of minted coins depended on the political and economic power of the central and local rulers. By studying the value of coins in different governments, one can broadly understand the financial situation and strength or weakness of the states.

The study of the ancient coins of Iran has always attracted the attention of researchers and archaeologists, both domestic and foreign. Foreign researchers have conducted preliminary research on the construction of Achaemenid, Ashkan and Sassanid schools [4]. In Iran, in the past and recent years, extensive research on Sasanian silver coins has been carried out [5] [6].

In a study conducted by Auliai and his colleagues using the analysis of Ashkan coins, it was determined that the rate of change in the value of silver was proportional to the political and economic conditions of each king [7]. Another study conducted by Haji Wali and his colleagues using Pixi analysis on 30 Sassanid silver coins from the reign of Khusrau Parvez showed that the quality and grade of the coins varied according to the political conditions of the time as well as the geographical location of the coins [8]. Also, using the XRF analytical method, Khademi and his colleagues examined the chemical composition of the silver coins and identified the mines and workshops used to make the coins. Also, this ratio can be used as a factor to identify silver minerals [9]. Sodaei and his colleagues also conducted research on the elemental analysis of Sasanian silver coins using the XRF method [10]. A review and analysis of previous studies shows that almost all of these studies have focused on elemental analysis (XRF) of a specific period.

Therefore, in this study, the amount of metal found in 40 coins from the Qubad period was compared and standardized to determine which metals the coins were made of in this historical period.

II. MATERIALS AND METHODS

- *Qualitative Studies*

The use of the XRF method has become very widespread in recent years due to its unique advantages. At the same time, the accuracy and sensitivity of this method have led to its widespread use for various purposes such as archaeology, paleontology, geoarchaeology, art history, etc. The non-destructive nature of the method has been widely accepted in the study of museum objects. In particular, in the qualitative identification of historical paints, this technique has been widely used. Although difficulties arise in cases such as the identification of paints containing light elements such as lapis lazuli, at the same time this technique has shown its strength in the qualitative identification of paints.

The identification of the colors used in the decoration of pottery is another application of this technique, since it is generally not possible to take a sample of this decoration without damaging the visual effect, this technique is the only non-destructive method of analysis. In another case, this method is used to identify the effects of pesticides on historical tissues. This method has also found widespread use in the field of archaeology, and soil layers have been evaluated for the type and amount of rare elements and salts.

- *Quantitative Studies*

Despite many qualitative works, this technique has been used mainly for quantitative purposes of material identification and classification. The basis of such studies is the accepted principle that the concentration pattern of certain elements in the composition of pottery, metal or stone in a work group is a certain threshold level that can indicate the origin of the raw materials. Based on similar patterns in some elements, archaeological finds can be divided into similar groups. Although such classifications have been made on the basis of mineralogical and physical properties of the artifacts, classification based on geochemical properties has shown strong potential. For example, when the amount of Ti in a sample of the skin of a vessel is systematically higher or lower than in other instances of the same vessel, this feature can be used to differentiate artifacts.

In Iran, such studies using the XRF method have so far been carried out in cooperation with foreign institutions and mainly for the classification of obsidian stones. From the study of new articles, for example, we can mention the evidence of 53 obsidian samples from the Kol Tepe area of Jolfa. In another study, obsidian samples around the Urmia River were analyzed and reported similarities with samples from the Van River in Turkey. It should be noted, however, that unfortunately, not enough information has been provided about the rare elements of Iranian obsidian samples, as a result of the comparative work of the discovered samples, mainly compared with mines in neighboring regions. Despite this shortcoming, which has been keenly felt in the discussion

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of pottery and obsidian dating in Iran, the technique has successfully found its place in studies of the origins of other countries [12].

- *Sample Preparation*

The most important feature of this technique is that it can be easily and directly applied to the sample surface without any special preparation. Also, there are some cases that can be taken into account to improve the quality and accuracy of the work. For instance, heterogeneity of samples may influence accuracy of quatitative results. Alternatively, pottery or stone, used in quantitative studies for homogeneity of samples. Since this technique is considered a surface analysis method, it is necessary toconsider conditions of the surface under study for the validity of the results obtained. For example, oxidized metal surfaces or fragments of the surface of pottery, especially when the target is the pottery body, are not suitable places for sampling. Accordingly, one of the methods in the analysis of the pottery body is the use of freshly broken pottery cores. In cases where the artifacts are not homogeneous, it is necessary to prepare an analysis plan and the best results are obtained for samples larger than 10 mm and thicker than 2-3 mm [13].

- *Data Recording, Processing and Analysis*

During recording stage, signals counted by detector are transmitted to processor and, according to the relevant software, the voltage signals are displayed graphically on the screen as peaks. Here, the information, a typical XRF peak has two axes of energy X and intensity Y. The voltage signals obtained are plotted against the intensity or in other words the number of times a particular signal is counted per unit of time which determines the type and amount of that element [14].

- *XRF Used Equipment*

The S1TITAN model XRF instrument, manufactured by American Broker, is one of the lightest handheld XRF models available in market. High analysis speed and exceptional accuracy are two important quality factors the instrument. Other features include a color touchscreen, a 50 kV X-ray tube, a silicon drift detector (SDD), and a chamber that is completely sealed against ambient moisture and dust. The S1 TITAN series is available in three models: 800, 600 and 500. Other benefits of this instrument include existing calibrations including: alloys, gold and precious metals, bulk materials, soil, mining, restricted and customer-specific materials, higher sensitivity and resolution, faster than previous generations, lower detection limits, easier analysis of light elements such as magnesium, aluminum and silicon, without any vacuum or helium atmosphere mentioned.

- *Preparing Coins for Testing*

Since the XRF technique is a surface technique and the X-ray beam only penetrates a very shallow depth of the sample, the impurities in the sample will certainly affect the final analysis result. Ancient coins dating back to very distant times, about 700 years ago, therefore, over time, due to the phenomenon of surface adsorption, impurities are formed on them wherever they are buried. It can be said that in almost all types of ancient coins of different periods, if we do not clean the coins, the iron element (Fe) will appear, which is formed and hardened by dust on the surface of the [15]. On the other hand, when different metals are mixed, they undergo galvanic corrosion over time [16]. Also, as Bresand [17] explains, the presence of the element bromine can also cause contamination of coins in many cases [18]. Metal oxides (such as copper and silver oxides in copper and silver coins) are also one of the other impurities that are seen on the surfaces of ancient coins [18]. They are divided into two categories, which are:

- Impurities caused by rust, oxidation and hardening of the dust; to remove such impurities, electrochemical reduction methods, NaoH, Zn, bicarbonate solution, and formic acid can be used [8].
- Impurities caused by oils: to remove such impurities, the coins are washed and cleaned with ethanol solutions. For example, to clean antique coins, depending on the amount of dirt, they are placed in a caustic soda solution for 2 to 10 days, and then the damaged layers of the coin are removed with the help of a brush, then the coins are thoroughly cleaned with alcohol and finally rinsed with distilled water.

III. RESULTS AND DISCUSSION

This article attempts to analyze a number of ancient coins of the Sasanian period. For this purpose, we analyzed 40 silver coins from the reign of the first Qubad dynasty in the Bu Ali Sina tomb museum.

- *Initial Tests*

To carry out the analysis process, the XRF device we had in hand was transported to the Bu Ali Sina Tomb Museum, and at this location, the coins that had been cleaned were given to us. The museum officials measured the diameter and thickness of each coin using a caliper and a micrometer, and the weight of each coin using a digital scale. Since the coin did not have a scale, they measured the average of the three horizontal, vertical, and oblique diameters for each coin. The dimensions of the coins are shown in the table below.

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Table 1 Specifications Related to Diameter and Weight of Coins

Back	Face	Museum Number	XRF Number	Diametermm	Weight gr	Number
		2333	38	2.9	4.0	1
 2999		2332	39	2.8	3.9	2
2801 	2800 	2330	40	2.7	4.0	3
 2803	 2802	2329	41	2.8	4.0	4
 2805	 2804	2326	42	2.7	4.0	5
2806 	2807 	2325	43	2.9	4.2	6
2811 	 2809	2323	44-45	2.8	4.1	7
2813 	2812 	2322	46-47	2.8	4.1	8

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9	2.8	48	2320	2.8	2814 	2816 
10	4.1	2.8	49	2318	2817 	2818 

➢ *Analyzing Coins with a Portable XRF Device*

In this analysis, each coin was analyzed separately using a calibrated instrument and the number of analysis for each coin was recorded. Then, information related to the analysis of the coin and the percentage of elements in the coin was retrieved from the machine.

Table 2 The Percentage Concentration of Elements in the Sample.

Coin number	XRF number	Cr	Mn	Fe	Cu	Se	Ag	Cd	Pb	Bi
1	38	0.009	0.005	0.36	4.03	0.03	94.89	< LOD	0.67	< LOD
2	39	0.008	0.005	0.41	1.63	0.03	96.89	< LOD	1.03	< LOD
3	40	0.007	0.006	0.45	2.40	0.03	96.52	< LOD	0.58	< LOD
4	41	< LOD	0.004	0.28	1.83	< LOD	96.52	< LOD	0.19	1.1609
5	42	0.007	0.006	0.42	3.84	0.03	94.61	< LOD	1.05	< LOD
6	43	< LOD	0.006	0.30	4.00	0.03	94.98	< LOD	0.66	< LOD
7	44	0.008	0.005	0.36	1.03	0.03	97.63	< LOD	0.94	< LOD
		0.012	0.006	0.54	1.36	0.02	97.10	< LOD	0.95	< LOD
8	46 47	0.007	0.005	0.27	6.67	0.03	91.31	0.03	1.64	< LOD
		0.009	0.004	0.28	6.63	0.03	91.49	< LOD	1.55	< LOD

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jun1956

9	48	0.009	0.004	0.34	3.90	0.03	94.94	< LOD	0.78	< LOD
10	49	0.010	0.004	0.27	6.49	0.03	92.62	< LOD	0.54	0.03
11	50	0.007	0.005	0.34	4.59	0.02	93.76	< LOD	1.19	0.08
12	51	< LOD	0.004	0.30	5.14	0.04	92.51	0.04	1.95	< LOD
13	52	0.010	0.006	0.69	4.51	0.03	93.67	< LOD	1.06	< LOD
14	53	0.008	0.004	0.52	2.80	0.03	96.25	< LOD	0.38	< LOD
15	54	< LOD	0.003	0.24	1.52	0.04	97.63	< LOD	0.55	0.02
16	56-55	0.008	0.004	0.34	1.38	0.01	97.55	< LOD	0.39	0.31
		0.009	0.006	0.44	3.72	0.03	94.43	< LOD	1.30	0.04
17	57	0.007	0.004	0.43	3.50	0.03	94.68	< LOD	1.31	0.05
18	58	0.007	0.004	0.52	1.52	0.01	96.89	< LOD	0.83	0.22
19	59	0.006	0.005	0.61	1.32	0.03	97.23	< LOD	0.79	< LOD
20	61 62	0.006	0.005	0.33	0.96	0.03	97.72	< LOD	0.95	< LOD
		0.010	0.007	0.43	0.88	0.03	97.76	< LOD	0.88	< LOD
21	63	0.007	< LOD	0.36	5.57	0.02	93.20	< LOD	0.79	0.03
22	64	<LOD	<LOD	0.26	5.46	0.03	92.59	< LOD	1.60	0.06
23	65	0.009	0.007	0.38	1.20	0.04	97.90	0.03	0.43	< LOD
24	67	0.007	0.004	0.34	4.08	0.03	94.56	< LOD	0.94	0.03

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25	68	0.009	0.006	0.61	6.61	0.03	91.77	< LOD	0.95	< LOD
26	69	0.009	0.005	0.32	2.38	0.03	96.16	< LOD	1.09	< LOD
27	70	0.006	0.006	0.69	2.42	0.02	95.99	< LOD	0.85	< LOD
28	71	0.011	0.007	0.50	2.07	0.03	96.45	< LOD	0.90	< LOD
29	72	0.008	<LOD	0.37	3.86	0.03	94.54	< LOD	1.15	0.04
30	73	0.005	0.003	0.40	3.96	0.03	94.34	< LOD	1.21	0.04
31	74	0.007	0.004	0.52	1.03	< LOD	97.56	0.03	0.02	0.77
32	75	0.008	0.005	0.27	1.13	0.02	97.46	< LOD	1.08	0.03
33	76	0.007	0.005	0.24	5.04	0.03	93.59	< LOD	1.05	< LOD
34	77	0.006	0.004	0.45	2.69	0.02	95.62	< LOD	1.18	< LOD
35	78	<LOD	0.005	0.42	3.19	0.03	95.27	< LOD	1.08	< LOD
36	79	0.008	0.003	0.23	6.02	0.02	91.65	< LOD	1.90	0.15
37	80	0.010	0.006	0.50	4.41	0.03	93.78	< LOD	1.24	< LOD
38	81	0.008	0.005	0.33	7.80	0.02	90.48	< LOD	1.35	< LOD
39	82	0.011	0.004	0.31	3.17	0.02	95.81	< LOD	0.65	< LOD
40	83	0.008	0.005	0.30	6.93	0.03	91.75	< LOD	0.96	< LOD

The objective of the analysis of the silver with this method is qualitative analysis and depending on the number of silver, the elements chromium (Cr), manganese (Mn), iron (Fe), copper (Cu), selenium (Se), silver (Ag), lead (Pb), bismuth (Bi) have been found in it, and a high percentage of the element silver has been found in the composition of all the silver.

The percentage of silver obtained clearly shows that the quality and composition of the coins are directly related to the time of coinage, the time of minting, and the political situation of the government at that particular time. The reign of the first Qubad and his wars with internal and foreign invaders had a significant impact on the percentage of silver used in the composition of the coins. The element lead (Pb), which is visible in the spectrum, was probably used to lower

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the melting point of the alloy (Gershman, Roman, 1388). During their period, the Sasanians, faced with the difficulties of transportation, difficult roads, and lack of facilities, avoided transporting raw materials for coinage and extracted and used the required silver from the nearest silver mine. Therefore, the percentage of silver obtained in different goldsmiths varies. Figure 2. Shows the the percentage of silver in different coins.

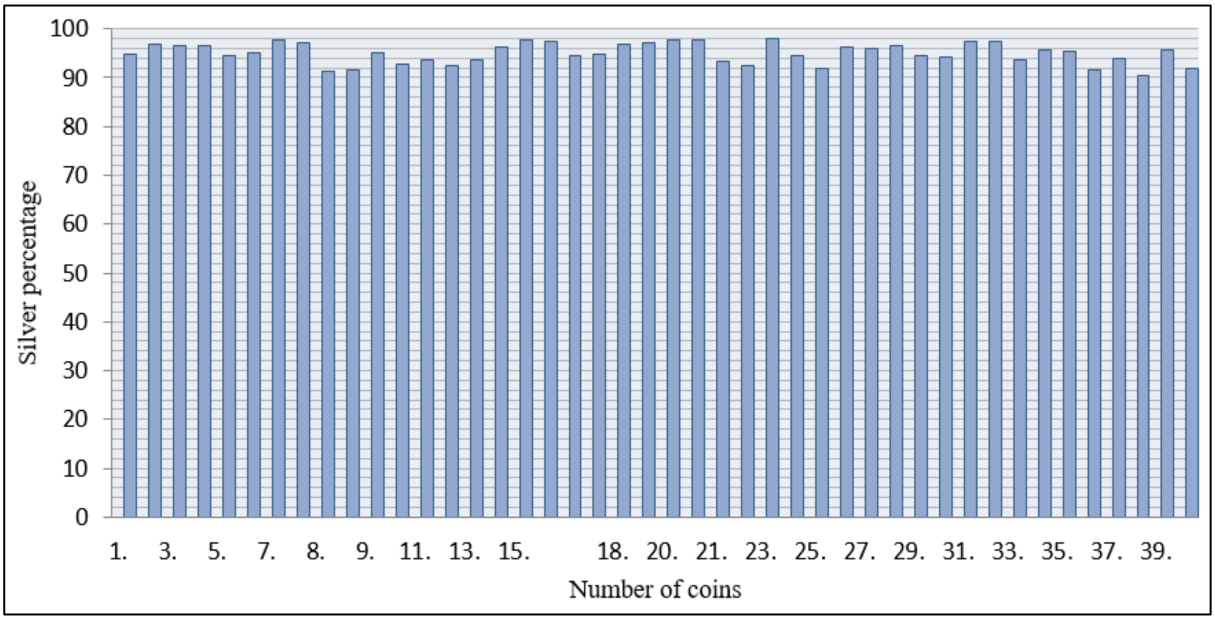

Fig 1 The Percentage of Silver Recovered from the First Qubad Coins

In most cases, the presence of Fe is due to surface contamination (Bayani, Malikzadeh, 1389, Gershman, Roman, 1388). For the production of coins, two techniques are used: goldsmithing and casting. In the casting technique, the desired alloys are first melted and then poured into special molds for the production of coins, which, after cooling and solidification, accurately reflect the design on the coin mold on the coin. Since the boiling point of arsenic is much lower than that of silver and gold, upon melting the corresponding alloy, arsenic evaporates and remains in the alloy. Therefore, arsenic is not found on all silver and gold coins. Archaeological research shows that coins of the first Quba period were minted at that time and the casting technique was not used. However, arsenic has not been found in any of the coin alloys. It can be assumed that during the coin making process, they heated the alloy to make the heads and tails of the coin easier to carve into the alloy, and this heating caused the arsenic element to evaporate from the alloy. It was observed that there is a strong negative correlation between silver (Ag) and copper (Cu) and there is not a very good negative correlation between silver (Ag) and lead (Pb) and manganese (Mn) elements.

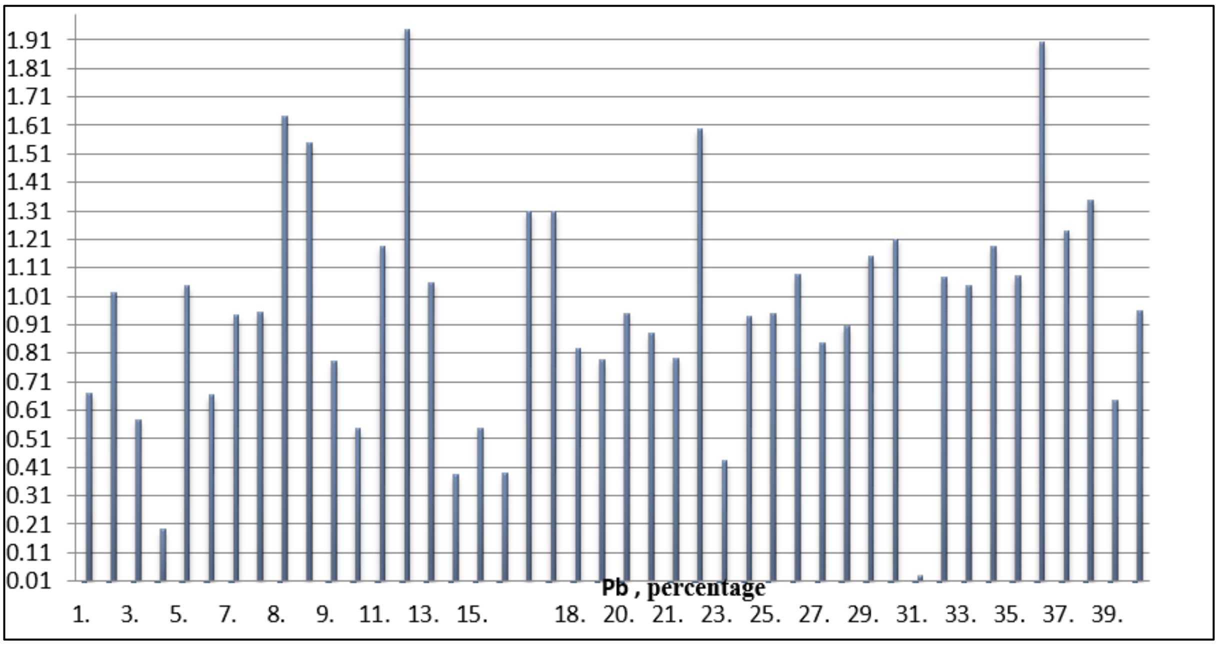

Fig 2 The Percentage of Lead Obtained from the First Qubad Coins

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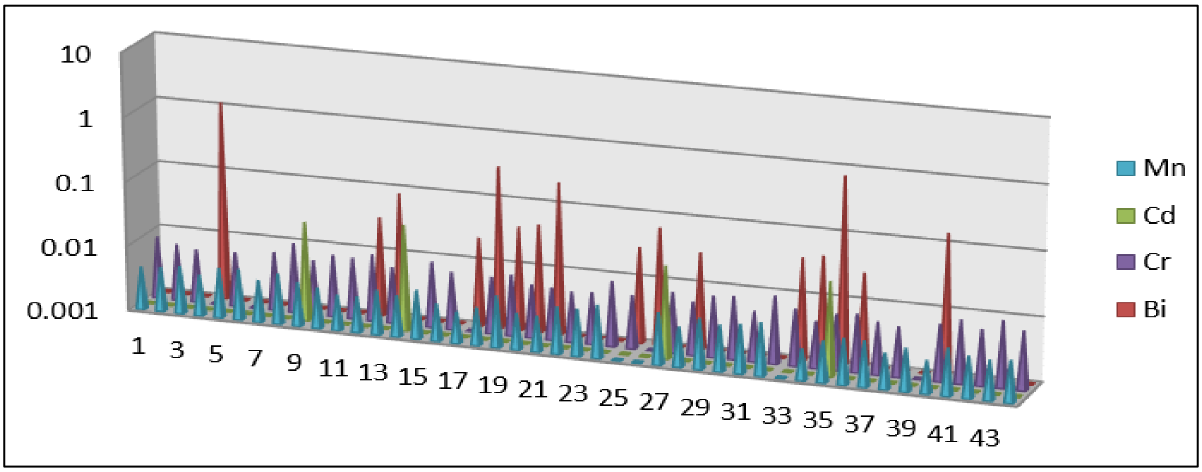

Fig 3 The Percentage of Manganese, Cadmium, Chromium, and Bismuth Recovered from the First Copper Coins

In an analysis that examines the surface of samples, sample preparation, sample homogeneity, cleanliness, and the absence of surface contamination are very important and affect the final result.

To normalize and test the results obtained, we calculated the Cu/Ag ratio and displayed it in a graph. It can be seen that most of the results fall within the specified range. In cases where the results of the coins in the graph are not within the same range, this is due to the different mines used, the different time periods, or the coins being counterfeit.

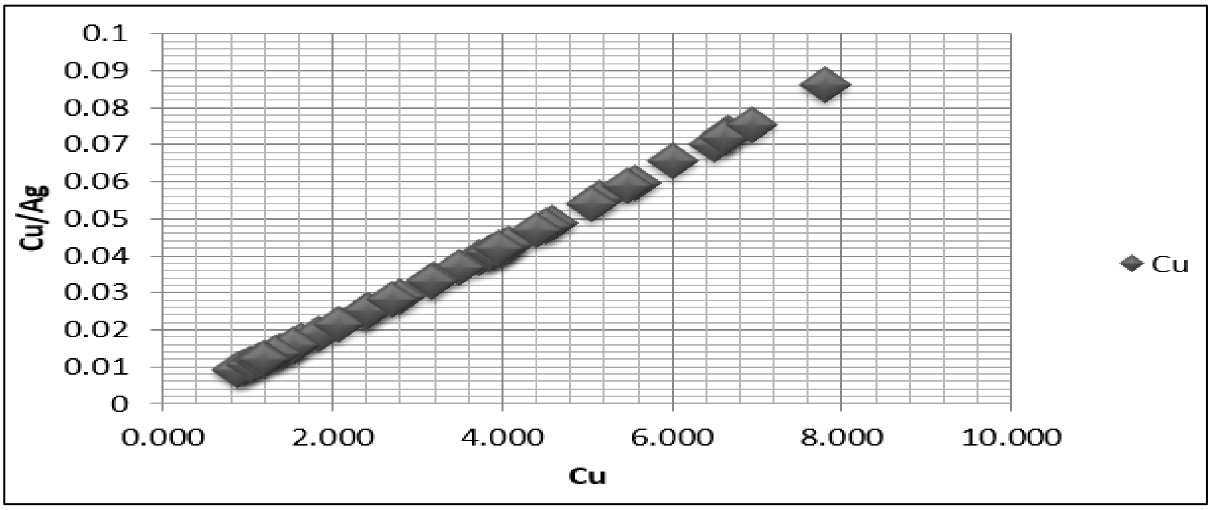

Fig 4 Percentage of Ag in the Ratio of Cu/Ag in Sasanian Coins.

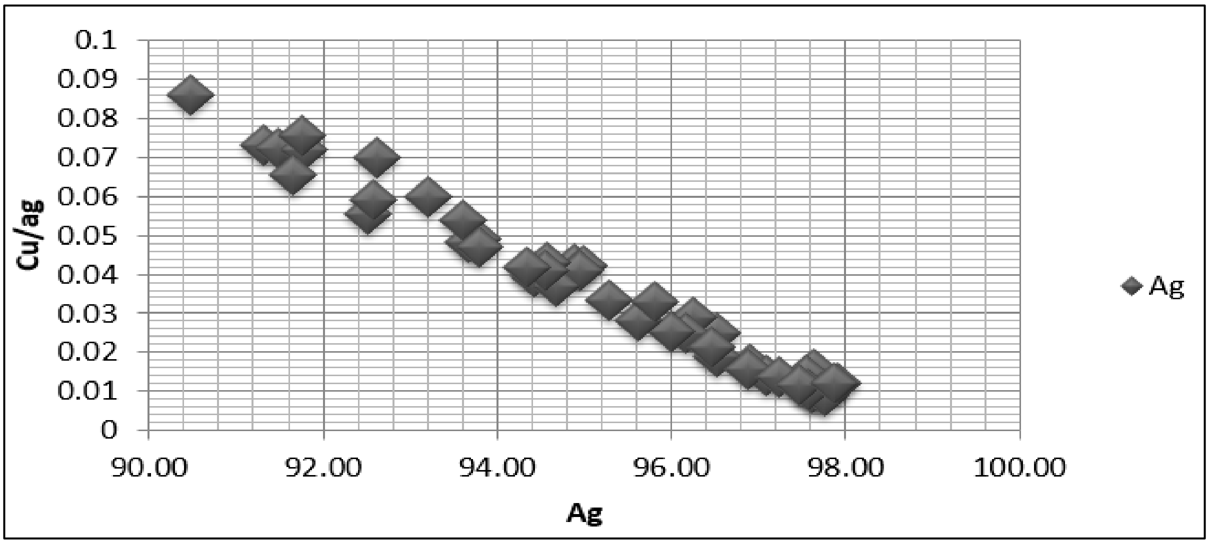

Fig 5 Percentage of Ag in the Sasanian Coins in Terms of Cu/Ag.

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IV. CONCLUSION

In this analysis, using a calibrated instrument, each coin was analyzed separately and the analysis number of each coin was recorded. Then, the analysis of the coins and the information related to the percentage of elements in the coin were obtained from the machine. The relevant information obtained shows that the Sasanian ancient coins are made of chromium (Cr), manganese (Mn), iron (Fe), copper (Cu), selenium (Se), silver (Ag), lead (Pb), bismuth (Bi) and the highest percentage of the element in the composition of all the coins is the element of silver. It was observed that there is a strong negative correlation between silver (Ag) and copper (Cu) and there is no very good negative correlation between the elements of silver (Ag), lead (Pb) and manganese (Mn). The percentage of silver obtained clearly shows that the quality and composition of the coin is directly related to the time of coinage and the political situation of the government at a particular time. The reign of the first Qubad and his wars with internal and foreign invaders have had a significant impact on the percentage of silver used in the coinage.

RECOMMENDATIONS FOR FURTHER RESEARCH

The analysis of metals in the middle of the route in Afghanistan, as well as the determination of metals in various wooden and metal artifacts, and the identification of various materials in border laboratories contribute to this result.

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➢ *Conflicts of Interest*

All authors declare that they have no conflicts of interest to disclose.

REFERENCES

[1]. Wasiq, M, (1387) Dinar Currency in the Monetary History of Iran, Tabriz, Sotoudeh.

[2]. Sahraian, A., (1383) "Quantitative Analysis Measurement by XRD Method Using TEFA System and AXIL Computer Code", Master's Thesis in Physics, Amir Kabir University of Technology

[3]. Averzamani, F, (1369) "A Study of Sassanid Coins". Foruhar Monthly. Tehran: Foruhar Publishing Organization (322).

[4]. Sarfaraz, A, Akbar and Averzamani, F. (1383) "Coins of Iran from the Beginning to the Zand Period", Tehran, Samt Publishing, 3rd edition.

[5]. Caley, E. 1955. Chemical composition of Parthian coins, numismatic notes and monogram. *American Numismatic Society, 129*.

[6]. Gordus, A.A. (1972) The purity of Sasanian silver coins and introduction. *Journal of the American Oriental Society 92, 2: 280-283.*

[7]. Masjedi Khak, P., Khazaei Kouhpar, M., Hagivalie, M., Khademi, F.(2013) Elemental analyses on Ilkhanid Period coins By PIXE: *a case study on King Ghazan silver coins Mediterranean Archaeology and Archaeometry 13(2): 83- 88.*

[8]. Neyestani, J. ,Salehi, A., Mousavi, S.M., Hagivalie, M. , Hejabri Noubari, A.R.(2014) Politico- economic conditions of Ilkhanid coins from different mint houses by PIXE. *Sociology and Anthropology 2(2): 29-34.*

[9]. Oliaiy, P., Shokouhi, F., Lamehi -Rachti M., Rahighi, J., Andami, P., Dilmaghani, J. Etezadi, M. (1999). Application of PIXE to study ancient Iranian silver coins. *International Journal of PIXE 9 (3 & 4): 495-500.*

[10]. Khademi N, F et al.,(1390) “Identification of the metal resources of silver extraction for minting Parthian coins in the province of Greater Media using the PIXE method,” Archaeological Studies, pp. 79-88.

[11]. Sodaei, B., Masjedi Khak, P., Khazaie, M.(2013b). A study of Sasanian silve coins employing the XRF technique. *Interdisciplinaria archaeological Natural Sciences in Archaeology 4 (2): 211-215.*

[12]. Sodaei, B., Hajivaliei, M., Khademi Nadooshan, F. (2013c). Possible sources for extraction of silver by comparison of Parthian and Sasanian coins in Mede Satraps. *Mediterranean Archaeology and Archaeometry 13 (1): 161-170.*

[13]. Golestani Fard, F., Behrevar, M. and Salahi, A., (1383) "Methods of Identification and Analysis of Materials", University of Science and Technology Press

[14]. Bickerman, B., Richard Nelson Fry, David Selwood, David Marshall Long, Nina Garsoyan, Clifford Edmund Bosworth and Gabon, (1983), History of Iran Cambridge (Volume 3): From the Seleucids to the Sasanians Ehsan Yarshater and others, Cambridge.

[15]. Khademi Nadushan, Farhang (1377) "A Review of the Mints of Eastern Iran", Lecturer in Humanities, pp. 187-192.

[16]. Kristiansen, Arthur (1383) "Iran in the Sasanian Period", translated by the late Rashid Yasemi, Tehran, 9th edition.

[17]. Girshman, Roman (1383) "Iran from the Beginning to Islam", translated by Mohammad Moein, Tehran, Scientific and Cultural Publications, 15th edition.

[18]. Bayani, Malekzadeh (1389) "The History of Coins from the Earliest Times to the Sasanian Period", Tehran, Tehran University Press, Volumes 1 and 2,Eighth Edition.