NUMISMATICS

COMPARATIVE ANALYSIS OF SILVER MINING AND PURIFICATION TECHNIQUES IN PARTHIAN AND SELEUCID DYNASTIES BASED ON NUMISMATIC EVIDENCES

Hassan KARIMIAN
University of Tehran, Iran
hkarimi@ut.ac.ir
Hamzeh GHOBADI
University of Tehran, Iran
h.ghobadi@ut.ac.ir

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Abstract: Knowledge of the number and location of mines of the ancient periods has been the subject of common research between archaeologists and archaeo-mineralogists. The scientific significance of the subject becomes apparent when the direct relation between the power of the ancient rulers and number of the mines they owned is perceived. The gold and silver mines, like today, were accounted as the main economic credit and backing of the ancient states. Although mixing silver with other metals was used to produce diverse metal artefacts, silver on its own was most popular for minting coins. Since coin was a symbol of the sovereignty of rulers and an indicator of the economic power of ancient civilizations, silver mining was probably one of the main activities of the ancient craftsmen.
The main aim of this research is to investigate the conditions surrounding, and the techniques used for, extraction of silver from different mines during the reign of Alexander of Macedon, Seleucid rulers (336-129 BC), and Parthian kings (247 BC-224 AD). The kings, whose coins are studied in this research, ruled in Iran from 4th -1st BC. This research is focused on the laboratory results obtained from XRF tests on 24 coins belonging to the mentioned kings. The analysis of the results revealed that despite the advanced technology used for recovering silver from zinc and lead mines in the Seleucid era, the Parthian craftsmen were not highly skilled in this field. In other words, the silver recovery technology was more advanced in the Seleucid era than the Parthian period.
Keywords: *Parthian Numismatics, Seleucid Numismatics, Mineralogy, XRF.*

INTRODUCTION

The time and method of metal mine exploitation are not exactly known. However, since some metals such as gold, silver, and copper can be naturally found, they have been used long before other metals whose ores are hidden in deeper layers of the earth.[1] Gold and silver can perhaps be accounted as the primary metals extracted by ancient Iranians.[2] Melting and purification of silver are among the oldest processes of metalwork.[3] Copper, zinc, and silver resources are mostly found in carbonate rocks which mainly

[1] TOHIDI/GANJI/GANJI/ 2009, 22-27.
[2] MANI/IRAJ/DANESHI/ 2008.
[3] KHADEMI NADOOSHAN/AZIZIPOUR/TAGHI SAFAR/ 2009, 51-58.

belong to the early cretaceous period. In the ancient times, the tools and instruments used for mining and metal extraction were very limited, and so, only open-pit mines with twisted underground networks were extracted up to the surface of underground water.[4] Therefore, a percentage of lead and zinc always remained in the recovered silvers.[5] The first silver artefacts manufactured in relatively similar period in Anatolia, (Bije Sultan, etc.), Mesopotamia (new Uruk culture), Levant (Byblos), and Iran (Arisman and Sialk sites) are examples. As such, evidently, there remained a logical correlation between the richness of the extracted silver and the skill of craftsmen. That is, increased lead and zinc indicate poor craftsmen skills in recovering this precious metal. This is why silver objects of the ancient world encompassed considerable amount of zinc. Indeed such objects were manufactured from silver-containing galena (PBS) using cupellation method; a method which continued for several millenniums almost without any change up to the middle of the past century.[6]

Silver coins are of the most reliable archaeological evidences that can be confidently claimed to belong to a particular era. Thus, recognizing the metals used in coin mint in each era enables one to analyse the metal recovery techniques in that era. As such, in this paper several coins belonging to the eras of Alexander of Macedon and Seleucid rulers (336-129 BC), and also Parthian kings (171-88 BC), have been selected for laboratory tests, in order to answer the question of how much the craftsmen of those eras were acquainted with the silver recovery techniques. Therefore, the main aim of this research is to evaluate the skill of the craftsmen of the mentioned eras in silver mining and purification to be used in coin mints.

THE EXAMINED SAMPLES

The cases adopted in this research include 24 coins selected from the collection of the coins in Iranian National Museum. The selected coins had undergone wavelength spectrometry using X-ray Fluorescence (XRF) spectrometer to measure their silver, copper, lead and gold content. The results of the spectrometry were then processed by the SPSS statistical software to determine the technology of recovering silver from copper and zinc mines, and also to find out the differences between recovery techniques in Seleucid and Parthian eras.

The coins investigated in this research were selected from those with no surface polish[7]. Therefore, after spectrometry, high percentage of chlorine and calcium were found on metal surface, which had caused structural changes in the surfaces. The coins selected from the Seleucid era were generally 1-drachma coins, which were coined in the Hecatompylos mint (the city also known as *Sad-darvazeh*). Since Hecatompylos was also a Parthian capital, the Parthian coins that were minted in this city are also studied. As such, selecting the coins that were minted in a capital common to both dynasties, enabled one to simplify comparison and recognition of the metal elements used in the coins. Table 1

[4] NEZAFATI/PERNICKA 2005, 148.
[5] MOMENZADEH 2005, 11.
[6] MOMENZADEH 2005, 12.
[7] The coin images shown in Table 1 are after being polished.

Table 1. Chronological study of the coins analysed in the present research; samples are dated according to Selwood.

#	King's Name	Reign	Place of mint	Samples
1	Alexander	336-323 BC	Unknown	
2	Alexander	336-323 BC	Unknown	
3	Alexander	336-323 BC	Unknown	
4	Alexander	336-323 BC	Unknown	
5	Seleucus I	305-281 BC	Hecatompylos	
6	Seleucus I	305-281 BC	Hecatompylos	
7	Seleucus I	305-281 BC	Hecatompylos	
8	Antiochus III	223-187 BC	Unknown	
9	Alexander Balas	150-145 BC	Unknown	
10	Alexander Balas	150-145 BC	Unknown	
11	Demetrius	162-150 BC	Unknown	
12	Antiochus VII	139-129 BC	Unknown	
13	Antiochus VII	139-129 BC	Unknown	

[8] SELWOOD 1980.

14	Mithradates I	171-138 BC	Hecatompylos	
15	Mithradates I	171-138 BC	Hecatompylos	
16	Mithradates I	171-138 BC	Hecatompylos	
17	Mithradates I	171-138 BC	Hecatompylos	
18	Mithradates I	171-138 BC	Hecatompylos	
19	Mithradates I	171-138 BC	Hecatompylos	
20	Mithradates I	171-138 BC	Hecatompylos	
21	Mithradates II	123-88 BC	Hecatompylos	
22	Mithradates II	123-88 BC	Ecbatana	
23	Mithradates II	123-88 BC	Rhagae	
24	Mithradates II	123-88 BC	Rhagae	

presents the chronology of the coins under study after being polished.

DATA ANALYSIS

Table 2 summarises the percentage of the share of different elements constituting the selected coins. As shown, silver was used as the main element of all 24 coins. Other elements including copper and gold were used in 21 and 17 coins, respectively. Number of coins containing zinc and lead drops dramatically to only eight and two coins, respectively. Such low percentage has been reflected in columns of *mean* and *median* in Table 3. Also in the table, the *standard deviation*, which addresses the tolerances in the mentioned elements, indicates the highest value of 13.91 for the use of silver. This is an illustration of the difference in silver use during various eras of Parthian kings. However, the changes in the contents of zinc and lead were insignificant, and so, the standard deviations of lead and zinc in mint were reported as 0.18 and 1.75, respectively. This is an indicator of inappropriate use of these elements in the process of coinage.

In Table 2, the "*total*" column shows the total percentage of elements used in the Parthian coins. For instance, in the first row, silver and gold elements constitute 91.24% of the composition of coin one, and the percentage of the remaining elements of this coin are unknown.

The spectrometry results of silver coins of the Seleucid era show that copper, following extraction from other mines, had been added to silver in arbitrary amounts. These results also confirm that addition of copper to silver coins finds route in Seleucid's minting technology, probably to offset the coinage costs. Evidently, the percentage of lead was identical

Table 2. Percentage of share of metal elements based on XRF spectroscopy results.

Coin No.	Silver	Gold	Cop-per	Lead	Bis-muth	Zinc	Iron	Total (%)
1	90.75	0.48	.	.	.	.	.	91.24
2	79.88	0.29	0.17	.	.	.	.	80.35
3	93.07	.	0.23	0.63	0.33	.	.	94.24
4	37.65	1.20	.	.	.	.	.	38.86
5	61.80	.	21.65	.	.	1.51	.	84.98
6	83.93	0.49	0.19	.	.	.	1.19	85.83
7	74.84	1.55	9.64	.	.	.	1.28	87.33
8	96.43	0.84	.	.	.	0.16	.	97.44
9	88.36	0.70	2.04	0.90	.	.	.	92.02
10	92.59	0.66	3.70	.	.	0.27	.	97.24
11	94.43	0.51	1.08	.	.	0.34	.	96.39
12	86.02	0.30	8.48	.	.	.	0.40	95.22
13	93.77	0.9	0.35	.	.	1.68	.	96.72
14	92.83	.	3.24	.	.	.	.	96.08
15	90.86	.	1.60	.	.	.	0.24	92.71
16	95.38	0.303	1.35	.	.	.	.	97.04
17	95.37	17.22	2.31	.	.	0.10	.	98.03
18	96.32	.	2.17	.	.	.	.	98.50
19	91.39	.	1.26	.	.	5.31	.	97.97
20	96.86	0.35	0.46	.	.	.	.	97.68
21	89.22	.	7.54	.	.	0.55	.	97.32
22	87.82	0.72	2.43	.	.	.	.	90.98
23	65.99	0.23	4.94	.	.	.	.	71.17
24	95.67	0.62	2.09	.	.	.	.	98.40
Total	**24.00**	**17.00**	**21.00**	**2.00**	**1.00**	**8.00**	**4.00**	**24**

Table 3. Comparison of metals used based on median and standard deviation.

Parameter	Silver	Copper	Gold	Lead	Bismuth	Zinc	Iron
No. of coins, *N*	24	21	17	2	1	8	4
Mean	86.3057	3.6673	0.6144	0.7665	0.3300	1.2436	0.7828
Median	91.1270	2.0950	0.5190	0.7665	0.3300	0.4495	0.8015
Std. Deviation	13.91939	4.94625	0.36134	0.18880	0	1.75295	0.53257

in Parthian and Seleucid coins. Also, the percentage of gold in Seleucid coins shows similarities between mines used in this era. In contrast, percentage of lead found in Parthian coins confirms inappropriate extraction of silver from mines in this era. Moreover, the absence of sulphur in the Parthian coins indicates that silver was extracted mostly from galena mines, while small amount of silver was extracted from oxidized mines of lead and zinc.

CONCLUSION

The main thrust of this research was to evaluate the extent of the familiarity of Seleucid and Parthian craftsmen with silver mining and purification techniques required for minting. The results of spectrometry of silver coins belonging to the Seleucid era confirm that addition of copper to silver coins was a common practice in this era. Results of data analysis confirmed that although extraction and purification of silver from zinc and lead mines was carried out using advanced techniques in the Seleucid era, this was done quite unprofessionally by Parthian craftsmen. In other words, Parthian craftsmen very much struggled in implementing silver recovery technology compared to the Seleucids.

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