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Elemental Analysis of Silver Coins during the Umayyads through the PIXE Method

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ABSTRACT

The Umayyads began their rule as the Caliphs of the newly-established Islamic empire in Damascus from 41 to 130 AH (662 to 751 AD). The territory ruled by them had been extended to India to the east and to the Iberian Peninsula in Spain to the west. The Umayyad government reached its peak at the time of Walid ibn Abd al-Malik and Hisham ibn Abd al-Malik. In this study, 42 silver coins belonging to the Umayyad Caliphs (Abd al-Malik ibn Marwan, Walid ibn Abd al-Malik, Sulayman ibn Abd al-Malik, Umar ibn Abd al-Aziz, Yazid bin Abd al-Malik, Hisham ibn Abd al-Malik, Walid ibn Yazid, Yazid ibn Walid, Ibrahim ibn Walid, and Marwan ibn Muhammad) were analyzed through the PIXE method. These coins have been minted at the Wasit, Basra, Damascus, Merv, Darabgerd, and Kerman mints from 82 to 128 AH (703 to 749 AD). The weight of the coins lies between 2.3 and 2.8 grams. The amount of silver in the coins varied from 86.13% to 90.95% with an average of 90.39% silver. In general, except for the year 126 AH (the Umayyad regime's decline), the coins of the Umayyad period are of a great carat, which is because of various factors, such as the political and economic situation, access to silver sources, *etc.* The comparison of coins of the Umayyad era with those of the Sassanid period shows that the technology of extracting and minting silver in the Umayyad period did not differ from that in the Sassanid period. Similarly, the amount of gold in the specimens shows that probably the Umayyads, like the Sassanids, have used Cerussite ore in the minting of their coins. Our table pertaining to the distribution of the elements of gold, silver, and lead in these coins shows that no single ore has been used in minting the Umayyad coins.

1. Introduction

The Umayyads founded the Umayyad dynasty under the leadership of Muawiyah Ibn Abu Sufyan in 41 AH (662 AD) and this government continued until 132 AH (753 AD) (Hawting, 1986, pp.35–39). During Muawiyah's reign, Damascus became the capital of the Islamic State. The territory ruled by them was extended to India in the east and to the Iberian Peninsula in Spain in the west. Abd al-Malik ibn Marwan, the fifth Umayyad caliph (686–707 AD/ 65–86 AH), saved the Umayyad government from chaos when it was on the verge of collapse and, thereby, was able to bring about some reforms in the administrative and financial affairs of the state. Following him, Walid ibn Abd al-Malik (707–717 AD/ 86–96 AH) reached the height of power. The most important issue in the Walid era was the

expansion through conquest, which included the conquest of Transoxania, Sindh, Africa, Andalusia, and conquests on the Roman front. These conquests are of special significance in Walid's political performance. Also, Walid's interest in developmental affairs and, of course, in the treasury that his father had left him, made him have an eye for the Caliphate's development in addition to his own interests (ibid). During the era of Sulayman ibn Abd al-Malik (717–720 AD/ 96–99 AH), the number of conquests fell sharply compared to that of Walid's period. After him, Umar ibn Abd al-Aziz (720–722 AD/99–101 AH) came to rule. His political actions were mostly directed towards the preservation of conquest and supervision of the governors' performance in different regions. Then, Yazid bin Abd al-Malik (722–726 AD/ 101–105 AH) came to rule until the reign of Hisham ibn Abd al-Malik (726–746 AD/ 105–125 AH). Hisham's rule is a brilliant era in the history of the Umayyads and conquests continued during his period (Maqrizi, 1967, p.54).

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After Hisham, there began a decline of Umayyad rule, such that three caliphs, namely Walid ibn Yazid (746 AD/ 125 AH), Yazid ibn Walid (747 AD/126 AH), and Ibrahim bin Walid (747 AD/126 AH) came to power within only one year. Ultimately, the last Umayyad caliph came to rule, *i.e.* Marwan ibn Muhammad (748–753 AD/127–132 AH) and this dynasty came to an end after Marwan was defeated by the Abbasids. The last survivor of the Umayyads went to Andalusia (Spain) and founded the branch known as the Spanish Umayyads, which survived from 759 to 1043 AD/ 138 to 422 AH (Hawting, 1986, p.41).

2. Mint of coins in the Umayyad period

In the Umayyad period, Muslims used Sassanian and Byzantine coins in their exchanges until the reign of Abd al-Malik ibn Marwan (Ibn Khaldun, 1980). Due to the neglect of governments, impure dinars and dirhams with a high degree of impurity became common ((Ibn Khaldun, 1980, 500), which was followed by Abd al-Malik's command for minting coins for the first time in 695 AD/ 74 AH (Ibn al-Athir, 1987, p.167; Baladhuri, 1866, p.651). Today, the oldest coins remaining from Abd al-Malik ibn Marwan's period date back to 699 AD/ 78 AH (Yousef Faraj Allah, 1985, p.37). Abd al-Malik appointed a steady carat for dirham and dinar and, accordingly, he put official currency with its own characteristics into operation and limited the right to mint coins by assigning it only to the state mints (Baladhuri, 1866, p.473).

After Abd al-Malik ibn Marwan, the minting of coins in the periods of Walid ibn Abd al-Malik, Sulayman ibn Abd al-Malik, and Umar ibn Abd al-Aziz continued in the same way (Maqrizi, 1967, p.58). During the reign of Yazid bin Abd al-Malik (722–726 AD/ 101–105 AH), plenty of strict rules were applied to the weight of coins (Baladhuri, 1866, p.652). When Hisham ibn Abd al-Malik came to power (726–746 AD/ 105–125 AH), he closed the mints in all cities except Wasit; and dirham coins were minted only in Wasit (Maqrizi, 1967, p.16). This process continued until the period

of Walid ibn Yazid and, during Marwan ibn Muhammad's period (748–753 AD/ 127–132 AH), he – the last Umayyad caliph – also minted some dirhams in the Harran mint in addition to Wasit (Baladhuri, 1866, p.17).

3. Research background

Several studies have been carried out in connection with coins pertaining to the early years of the Islamic era. In this regard, Ziad conducted his studies, where he collected a series of Umayyad silver coins that had been minted in the Wasit mint between 87 and 120 AH (708–741 AD), through the XRF method. His findings highlight the high quality of the coins minted in this mint, where he reported an average silver content of 94.71% in the coins. His studies showed that there was a clear tendency towards better-quality dirhams over time, which may be due to the high control and constraints on the policies of coin minting by the rulers (Ziad, 1999). Al-Kofahi and Al-Tarawneh analyzed a total of 7 silver dirhams belonging to the Ayoubian era (564–648 AH) and 9 coins belonging to the Mamalik period (648–865 AH) by the XRF method. Their results showed that the amount of silver in the Ayoubian coins was between 8% and 52%, while a content of 12% to 55% silver existed in the coins belonging to the Mamalik era. The amount of copper in the coins belonging to the Ayoubian and Mamalik periods varied from 5% to 79%, and the high levels of copper in these coins has been attributed to the counterfeiting that took place in some mints (Al-Kofahi, Al-Tarawneh, 2000). In other study, Ben Abdelouaheda analyzed a collection of 28 silver coins belonging to the Islamic period (from the 7th to the 15th century) via the PIXE method. His results showed that coins pertaining to the Umayyad and Abbasid periods enjoyed a high carat; however, the coins belonging to the Fatimid and Zirid periods did not enjoy a good carat since their silver content was significantly reduced and their copper content increased. This issue has been attributed to the dominant economic conditions and the surveillance system of these states (Ben Abdelouaheda *et al.*, 2010).

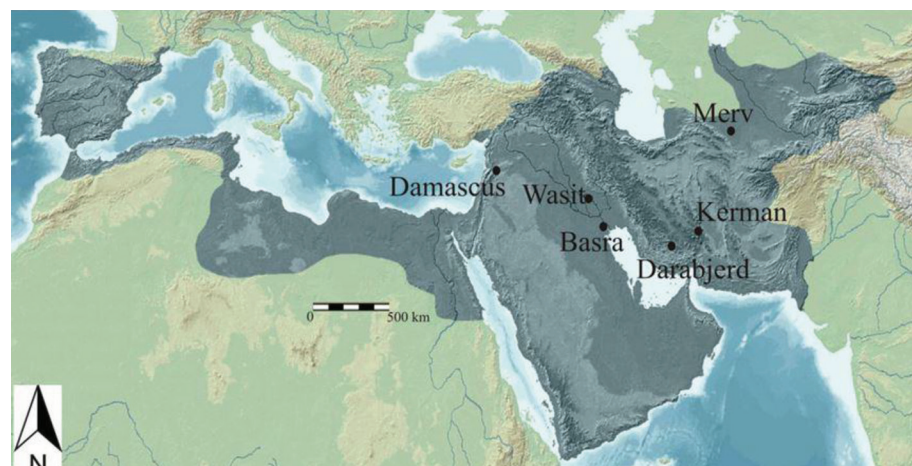


Figure 1. Location of the mints of Umayyad coins in this study.



No. 1: Abd al-Malik ibn Marwan coin minted in Basra in 82 AH with the weight of 2.5 g.



No. 2: Abd al-Malik ibn Marwan coin minted in Wasit in 85 AH with the weight of 2.3 g.



No. 3: Walid bin Abd al-Malik coin minted in Damascus in 88 AH with the weight of 2.8 g.



No. 4: Walid bin Abd al-Malik coin minted in Wasit in 88 AH with the weight of 2.8 g.



No. 5: Walid bin Abd al-Malik coin minted in Wasit in 90 AH with the weight of 2.8 g.



No. 6: Walid bin Abd al-Malik coin minted in Wasit in 90 AH with the weight of 2.7 g.



No. 7: Walid bin Abd al-Malik coin minted in Wasit in 92 AH with the weight of 2.8 g.



No. 8: Walid bin Abd al-Malik coin minted in Wasit in 92 AH with the weight of 2.8 g.



No. 9: Walid bin Abd al-Malik coin minted in Wasit in 92 AH with the weight of 2.8 g.



No. 10: Walid bin Abd al-Malik coin minted in Wasit in 92 AH with the weight of 2.8 g.



No. 11: Walid bin Abd al-Malik coin minted in Darabgerd in 94 AH with the weight of 2.8 g.



No. 12: Walid bin Abd al-Malik coin, minted in Kerman in 94 AH with the weight of 2.7 g.



No. 13: Walid bin Abd al-Malik coin, minted in Merv in 95 AH with the weight of 2.8 g.



No. 14: Walid bin Abd al-Malik coin, minted in Merv in 95 AH with the weight of 2.8 g.

Figure 2. The coins under study pertaining to the Umayyad era.



No. 15: Walid bin Abd al-Malik coin, minted in Wasit in 95 AH with the weight of 2.8 g.



No. 16: Walid bin Abd al-Malik coin, minted in Wasit in 95 AH with the weight of 2.8 g.



No. 17: Walid bin Abd al-Malik coin, minted in Wasit in 95 AH with the weight of 2.8 g.



No. 18: Walid bin Abd al-Malik coin, minted in Wasit in 95 AH with the weight of 2.8 g.



No. 19: Sulayman ibn Abd al-Malik coin, minted in Wasit in 97 AH with the weight of 2.6 g.



No. 20: Sulayman ibn Abd al-Malik coin, minted in Damascus in 98 AH with the weight of 2.8 g.



No. 21: Umar ibn Abd al-Aziz coin, minted in Basra in 100 AH with the weight of 2.8 g.



No. 22: Umar ibn Abd al-Aziz coin, minted in Basra in 101 AH with the weight of 2.8 g.



No. 23: Umar ibn Abd al-Aziz coin, minted in Damascus in 101 AH with the weight of 2.8 g.



No. 24: Yazid bin Abd al-Malik coin, minted in Wasit in 104 AH with the weight of 2.8 g.



No. 25: Hisham ibn Abd al-Malik coin, minted in Wasit in 107 AH with the weight of 2.8 g.



No. 26: Hisham ibn Abd al-Malik coin, minted in Wasit in 108 AH with the weight of 2.8 g.



No. 27: Hisham ibn Abd al-Malik coin, minted in Wasit in 110 AH with the weight of 2.8 g.



No. 28: Hisham ibn Abd al-Malik coin, minted in Wasit in 111 AH with the weight of 2.8 g.

Figure 2. The coins under study pertaining to the Umayyad era. (Continuation)



No. 29: Hisham ibn Abd al-Malik coin, minted in Wasit in 115 AH with the weight of 2.8 g.



No. 30: Hisham ibn Abd al-Malik coin, minted in Wasit in 117 AH with the weight of 2.8 g.



No. 31: Hisham ibn Abd al-Malik coin, minted in Wasit in 117 AH with the weight of 2.8 g.



No. 32: Hisham ibn Abd al-Malik coin, minted in Wasit in 108 AH with the weight of 2.8 g.



No. 33: Hisham ibn Abd al-Malik coin, minted in Wasit in 121 AH with the weight of 2.8 g.



No. 34: Hisham ibn Abd al-Malik coin, minted in Wasit in 121 AH with the weight of 2.8 g.



No. 35: Hisham ibn Abd al-Malik coin, minted in Wasit in 122 AH with the weight of 2.8 g.



No. 36: Hisham ibn Abd al-Malik coin, minted in Wasit in 122 AH with the weight of 2.6 g.



No. 37: Hisham ibn Abd al-Malik coin, minted in Wasit in 123 AH with the weight of 2.8 g.



No. 38: Hisham ibn Abd al-Malik coin, minted in Wasit in 123 AH with the weight of 2.8 g.



No. 39: Hisham ibn Abd al-Malik (105-125 AH) coin, minted in Wasit in 125 AH with the weight of 2.8 g.



No. 40: Walid ibn Yazid, Yazid ibn Walid (126); Ibrahim ibn Walid (126 AH) coin, minted in Wasit in 126 AH with the weight of 2.8 g.



No. 41: Walid ibn Yazid, Yazid ibn Walid (126); Ibrahim ibn Walid (126 AH) coin, minted in Wasit in 126 AH with the weight of 2.8 g.



No. 42: Marwan ibn Muhammad coin, minted in Basra in 82 AH with the weight of 2.5 g.

Figure 2. The coins under study pertaining to the Umayyad era. (Continuation)

4. Umayyad mints

In the various resources and studies, reference is made to more than eighty Umayyad mints where coins had been minted and, except for the Damascus, Afrique (Kairouan), and Andalusia (Córdoba) mints, all the other ones were located in Iran and Iraq, *i.e.* the land belonging to the Sassanid Empire. The first dinar coin of the Umayyad dynasty dates back to 698 AD/ 77 AH without the name of any mint; and the first dirham coin was minted in 699 AD/ 78 AH in Shagh al-Teimareh mint, central Iran (Shams Eshragh, 1990, pp.150–154). In this study, coins that were minted in Damascus (Damascus was the capital of the Umayyad dynasty from 657 to 748 AD/ from 36 to 127 AH), Wasit, Merv, Basra, Darabgerd, and Kerman have been analyzed (Figure 1).

5. Research objectives

Since the territory under the control of Umayyad Caliphs also included areas under the domination of the Sassanids, the aim of this study is to examine whether or not the mineral ores used in the Umayyad coinage were different from those of the Sassanid period. Moreover, with regard to the studied coins belonging to the years 703 to 749 AD (82 to 128 AH), their economic status and the carat of the coins of this time period will be examined.

6. Materials and methods

6.1 Preparation method

In this study, coins pertaining to the Umayyad period, which are kept in the archive of the Museum of Southeast Iran, were examined. To remove contamination from the surface of specimens, the coins were first washed with distilled water, then washed in acetone, and, finally, washed again in distilled water and placed in the room to dry. Thereafter, they were transferred to the Van de Graaff accelerator of the Atomic Energy Organization so that the necessary experiments could be conducted on them through the PIXE method. In total, 42 silver coins were studied, as described below. Two of these coins belonged to the Abd al-Malik ibn Marwan period, and had been minted between 703 and 706 AD (82 to 85 AH) in Basra and Wasit. Another 16 coins were related to the Walid ibn Abd al-Malik period, and had been minted between 709 and 716 AD (88 and 95 AH) in Damascus, Wasit, Merv, Darabgerd, and Kerman. Two coins out of the 42 belonged to the Sulayman ibn Abd al-Malik period, and had been minted between 718 and 719 AD (97 and 98 AH) in Wasit and Damascus. Another three coins belonged to the Umar ibn Abd al-Aziz period, minted between 721 and 722 AD (100 and 101 AH) in Basra and Damascus. One coin belonged to the period of Yazid bin Abd al-Malik, and had been minted in 725 AD (104 AH) in Wasit. Fifteen coins were related to the period of Hisham ibn Abd al-Malik, and minted from 728 to 746 AD (107 to 125 AH) in Wasit, and two coins belonged to

the period of Walid or Yazid or Ibrahim bin Walid, and been minted in 747 AD (126 AH). Lastly, one coin belonged to the Marwan ibn Muhammad era, minted in 749 AD (128 AH) in Wasit (Figure 2).

6.2 Experiment

To measure the elemental concentration of the specimens, a proton beam with an energy of 2 MeV and current of about 2–3 nanoamperes was used. The required proton beam was produced by the 3 MV Van de Graaff accelerator available in the Physics and Accelerator Research Institute. The energy of X-rays was measured by a Si (Li) detector, which was located at 135 degrees to the descending beam; the multichannel system then displayed the obtained spectrum. In addition, GUPIX software was used to quantitatively measure the constituent elements of the specimens (Maxwell *et al.*, 1989). In this study, the standard Merck Art.2700 was used for calibration. Overall uncertainty for the PIXE method was 5% for major elements; 5–10% for minor elements, and 15% for trace elements. The results of this study are shown in Table 1.

7. Results and Discussion

In this study, coins of the Umayyad Caliphs, which had been minted in different mints, were examined. The coins belonging to the Hisham ibn Abd al-Malik and Walid ibn Abd al-Malik periods were the most frequent ones among the studied coins, while Wasit was the most active mint. From among the 42 silver coins under study, 32 were minted between 706 to 749 AD (85 to 128 AH) in Wasit mint. The amount of silver in these coins varies from 86.13% to 90.92% (Table 1). The lowest amount of silver belonged to coin numbered 41, which was minted in 747 AD (126 AH) in the period of one of the three Umayyad caliphs, namely Walid ibn Yazid, Yazid ibn Walid, and Ibrahim bin Walid. The highest amount of silver in these 42 coins belongs to the coins minted during the periods of Walid ibn Abd al-Malik and Hisham ibn Abd al-Malik, when the Umayyad government was at its zenith. The study of these coins shows that various mints, except for a few ones, have minted coins with a clear weight (*i.e.* 2.8 grams), which is indicative of a strong surveillance system over the activity of the mints.

This study shows that a large fluctuation can be observed in the weight of coins pertaining to the Abd al-Malik ibn Marwan period. The coin numbered 1, minted in Basra in 703 AD (82 AH), weighs 2.5 grams, and coin numbered 2, minted in 706 AD (85 AH), weighs 2.3 grams. The amount of silver content in these two coins also ranges from 87.29% to 88.03% (Table 1). The fluctuations in the weight and amount of silver in these two coins can be attributed to the political situation of this period. At that time, the country was in severe chaos: the period when Abd al-Malik reached power and could empower the Umayyad government.

The amount of gold in the studied coins is between 0.28% and 0.91%, and the average gold in these coins is 0.58%.

Table 1. Available elements in coins of the Umayyad era.

No	Ni	Fe	Cu	Ag	Au	Zn	Pb	Ca	Cl	Si	Al	P	S	Ti	Mn	Weight	Mint	Caliph
1	–	0.70	6.19	87.29	0.53	–	0.89	1.35	1.36	1.17	–	–	0.52	–	–	2.5	Basra	Abd al-Malik ibn Marwan
2	–	0.08	0.66	88.03	0.68	–	0.48	0.35	5.20	1.12	0.40	–	–	–	–	2.3	Wasit	Abd al-Malik ibn Marwan
3	–	0.10	4.71	90.95	0.41	–	1.36	0.65	0.53	1.29	–	–	–	–	–	2.8	Damascus	Walid ibn Abd al-Malik
4	0.04	–	5.08	90.54	0.56	–	0.67	0.49	1.03	0.53	–	1.06	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
5	–	0.12	4.09	90.73	0.51	–	0.39	0.48	0.93	0.95	0.56	–	1.24	–	–	2.8	Wasit	Walid ibn Abd al-Malik
6	0.08	0.15	1.72	90.05	0.39	–	0.67	0.64	5.28	1.02	–	–	–	–	–	2.7	Wasit	Walid ibn Abd al-Malik
7	0.08	0.78	5.61	90.58	0.52	–	0.57	0.31	0.02	0.06	0.73	0.34	0.33	0.07	–	2.8	Wasit	Walid ibn Abd al-Malik
8	0.05	0.21	4.54	90.92	0.44	–	0.82	0.96	0.94	0.70	0.42	–	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
9	–	0.08	5.66	90.03	0.68	–	0.48	0.35	1.20	1.22	0.20	–	–	–	–	2.9	Wasit	Walid ibn Abd al-Malik
10	–	0.63	3.19	90.29	0.53	0.07	0.89	1.35	1.30	1.17	–	–	0.52	–	0.06	2.8	Wasit	Walid ibn Abd al-Malik
11	–	–	4.14	93.65	0.52	–	0.65	0.53	0.51	–	–	–	–	–	–	2.8	Darabgerd	Walid ibn Abd al-Malik
12	–	0.13	4.76	91.76	0.76	–	0.78	–	0.73	0.26	–	–	0.92	–	–	2.7	Kerman	Walid ibn Abd al-Malik
13	–	0.09	8.14	86.49	0.44	–	2.10	0.63	0.36	0.62	–	1.11	–	–	–	2.8	Merv	Walid ibn Abd al-Malik
14	0.03	0.19	6.64	86.13	0.72	–	1.49	1.10	1.34	1.90	–	–	0.46	–	–	2.8	Merv	Walid ibn Abd al-Malik
15	–	0.10	4.71	90.35	0.71	–	1.06	0.95	0.83	1.29	–	–	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
16	–	0.15	4.76	90.65	0.91	–	1.46	0.75	0.53	0.79	–	–	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
17	–	0.12	4.79	90.62	0.88	–	1.41	0.78	0.52	0.80	–	–	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
18	–	0.18	4.62	90.71	0.77	–	1.60	0.72	0.61	0.72	–	–	–	–	–	2.8	Wasit	Walid ibn Abd al-Malik
19	–	0.22	4.89	90.52	0.66	–	1.71	0.68	0.62	0.70	–	–	–	–	–	2.6	Wasit	Sulayman ibn Abd al-Malik
20	–	0.20	5.52	90.76	0.61	0.17	0.72	0.70	0.65	0.62	–	–	–	–	0.05	2.8	Damascus	Sulayman ibn Abd al-Malik
21	–	–	7.65	90.14	0.65	–	0.52	0.51	0.53	–	–	–	–	–	–	2.8	Basra	Umar ibn Abd al-Aziz
22	–	–	7.14	90.65	0.55	–	0.62	0.54	0.50	–	–	–	–	–	–	2.8	Basra	Umar ibn Abd al-Aziz
23	–	0.10	4.71	90.95	0.41	–	1.06	0.95	0.29	1.53	–	–	–	–	–	2.8	Damascus	Umar ibn Abd al-Aziz
24	–	0.08	3.66	90.03	0.48	–	0.68	0.35	3.20	0.40	0.12	–	–	–	–	2.8	Wasit	Yazid bin Abd al-Malik
25	0.04	–	5.08	90.51	0.56	–	0.67	0.49	1.03	0.53	–	1.06	–	–	–	2.8	Wasit	Hisham ibn Abd al-Malik
26	0.03	0.10	6.54	90.08	0.57	0.20	0.66	0.53	0.80	0.49	–	–	–	–	–	2.8	Wasit	Hisham ibn Abd al-Malik

Table 1. Available elements in coins of the Umayyad era. (Continuation)

27	0.07	0.11	6.49	90.28	0.53	—	0.70	0.51	0.42	0.89	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
28	0.05	0.14	6.51	90.55	0.28	—	0.68	0.48	0.49	0.82	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
29	0.02	0.09	6.34	90.74	0.32	—	0.64	0.53	0.42	0.90	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
30	0.06	0.12	6.11	90.52	0.52	—	0.82	0.64	0.62	0.59	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
31	0.06	0.14	6.52	90.11	0.62	—	0.72	0.62	0.69	0.52	—	—	—	2.7	Wasit	Hisham ibn Abd al-Malik
32	0.03	0.15	6.54	90.28	0.56	—	0.67	0.48	0.40	0.89	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
33	0.07	0.11	6.28	90.49	0.70	—	0.53	0.51	0.89	0.42	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
34	0.05	0.16	6.55	90.51	0.68	—	0.28	0.46	0.82	0.49	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
35	0.02	0.09	6.74	90.34	0.32	—	0.64	0.53	0.90	0.42	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
36	0.06	0.12	6.52	90.11	0.51	—	0.83	0.59	0.64	0.62	—	—	—	2.6	Wasit	Hisham ibn Abd al-Malik
37	0.06	0.14	6.32	90.31	0.62	—	0.72	0.52	0.62	0.69	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
38	—	0.04	5.04	90.58	0.67	—	0.56	0.49	1.56	1.06	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
39	0.08	0.14	5.02	90.42	0.76	—	0.47	0.99	1.09	1.03	—	—	—	2.8	Wasit	Hisham ibn Abd al-Malik
40	—	0.09	8.49	86.14	0.44	—	2.10	0.36	0.63	0.65	—	1.10	—	2.8	Wasit	Walid ibn Yazid; Yazid ibn Walid; Ibrahim ibn Walid
41	0.03	0.19	6.64	86.13	0.72	—	1.49	1.31	1.10	1.46	—	0.90	—	2.8	Wasit	Walid ibn Yazid; Yazid ibn Walid; Ibrahim ibn Walid
42	—	0.35	7.29	86.19	0.89	—	0.53	1.70	1.17	1.52	—	0.36	—	2.8	Wasit	Marwan ibn Muhammad

Table 2. Distribution of elements in the silver coins of the Sassanid period (Khademi Nadooshan and Khazaie, 2011, p.104)

Cu	Ca	Fe	Au	Pb	Ag	Coin No	King name	Mint House
2.583	0.484	0	0.69	0	93.833	1	Piruz	Istakhr
1.289	0.681	2.13	0.952	0	81.371	2	Piruz	Ardeshirkhoreh
1.326	0.947	7.188	0.714	0	82.531	3	Belash	Ardeshirkhoreh
1.045	1.378	0.3	0.941	0	93.787	4	Kavad	Istakhr
6.455	1.904	3.524	0	0	72.083	5	Kavad	Istakhr
3.375	0.899	0.286	0.874	0	90.527	6	Kavad	Ardeshirkhoreh
9.724	4.133	0.182	0.457	0	85.504	7	Kavad	Darabgird
2.448	1.47	0	0.883	0	92.084	8	Kavad	Istakhr
1.28	5.244	0.278	0.756	0	83.176	9	Kavad	Darabgird
4.337	1.778	0.921	0.275	0	78.865	10	Kavad	Darabgird
3.088	12.829	0.425	0.845	0	77.633	11	Kavad	Ardeshirkhoreh
3.174	6.187	0.591	0.689	0	80.923	12	Xusro I	Ramhormuz
2.652	0	0	0.872	0	95.79	13	Xusro I	Istakhr
9.578	4.321	0	0.686	0	77.688	14	Xusro I	Bishapur
0.579	11.111	1.136	0.595	0.57	73.093	15	Hormuz IV	Bishapur
5.324	2.732	0	0.643	0.709	77.493	16	Xusro II	Istakhr
1.347	0.77	0.223	0	0.88	89.285	17	Xusro II	Istakhr
0.821	1.721	0	0.924	0	83.113	18	Xusro II	Ecbatana
1.98	0	1.112	0.737	0	83.948	19	Xusro II	Ardeshirkhoreh
1.793	2.371	0	0.879	0	86.283	20	Xusro II	Sistan
3.135	2.087	0	1.033	0	89.071	21	Xusro II	Sistan
3.992	0	0	0	0	92.892	22	Kavad II	Ecbatana
2.134	0	0	0.697	0	95.319	23	Kavad II	Iran
1.305	2.438	0.249	0.758	0	90.343	24	Ardeshir III	Istakhr
1.855	0.995	0	0.761	0	87.682	25	Ardeshir III	Bishapur
5.801	0.527	0.326	0.748	0.782	83.154	26	Yazdgird III	Sistan

Since an amount of gold between 0.2% and 1.5% represents the probable use of Cerussite ore in the minting of coins (Meyers, 1979; Sodaei *et al.*, 2013), the amount of gold in the studied coins shows that Cerussite ore had been used in their minting. Study of the silver coins minted in the mints of the Sassanid era shows that Cerussite ores were used to mint these coins (Tables 2 and 3).

On the other hand, a look at the carat of the Sassanid coins shows that these coins, except for those coins of periods when the state had no political and economic stability, enjoyed a high carat and the amount of silver in them sometimes reached above 98% (Hajivaliei *et al.*, 2008; Sodaei *et al.*, 2013; Khademi Nadooshan and Khazaie, 2011; Ben Abdelouaheda *et al.*, 2010). A similar situation is also observed in the Umayyad era in that the Umayyads could mint high-carat coins whose purity sometimes reached 90.95%, while coins with carats below 90% belong to the periods of the Umayyads' decline and of internal conflicts in their government. For example, Abd al-Malik ibn Marwan came to power when the Umayyads' caliphate was on the verge of collapse, and his minted coins at this time were below 90%, but when the situation became better

after his reforms, then the carat of coins increased to more than 90%; another example belongs to the late period of the Umayyads, when three caliphs ("kings") came to power during just one year, and the carat of silver coins dropped again.

In Figure 3, the distribution of gold, silver, and lead elements in Umayyad coins has been illustrated using Dplot software. This chart shows that there was no single ore deposit that was used in the minting of the studied coins, and it is possible to divide the coins into one main group, *i.e.* GA, and seven subgroups, *i.e.* GB, GC, GD, GE, GF, GG, and GH (Figure 3).

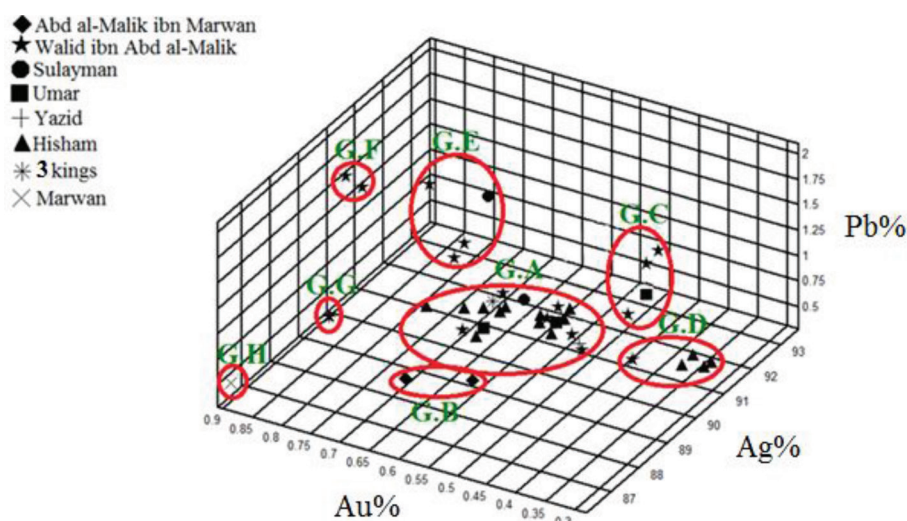
These results show that not only was one single silver source not used in the coins minted at Basra, Wasit, Damascus, Merv, Darabjerd and Kerman mints, but several sources, and that even different bars were used in the minting of coins from one mint in a given period of time.

On the other hand, the best coins were minted in such mints as Damascus and Wasit – due to their political and commercial importance; therefore, the coins of these two mints from 709 to 746 AD (88 to 125 AH) have always held a carat over 90%.

Table 3. Percentage of elements present in Sasanian coins by XRF (Sodaei *et al.*, 2013, p.166). On the other hand, the best coins were minted in such mints as Damascus and Wasit – due to their political and commercial importance; therefore, the coins of these two mints from 709 to 746 AD (88 to 125 AH) have always held a carat over 90%.

Coin No.	King name	Regnal year	Mint house	Unit weight	Weight (gram)	Fe	Cu	Ag	Au	Pb	Au/Ag
1	Piruz	459–84	Istakhr	Drachma	4.1	0	2.7±0.2	96.1±4.8	0.7±0.1	0	0,007
2	Piruz	459–84	Ardeshirkhoreh	Drachma	3.8	2.4±0.2	1.5±0.1	94.1±4.7	1.2±0.1	0	0,013
3	Belash	484–8	Ardeshirkhoreh	Drachma	4.1	0.7	1.4±0.1	89.1±4.4	0.8±0.1	0	0,009
4	Kavad	488–96	Istakhr	Drachma	4	0.3±0.0	1.0±0.1	96.3±4.8	0.9±0.1	0	0,009
5	Kavad	488–96	Ardeshirkhoreh	Drachma	3.6	0.3±0.0	3.5±0.3	94.3±4.7	0.9±0.1	0	0,009
6	Kavad	488–96	Istakhr	Drachma	4	0	2.5±0.2	95.1±4.8	0.9±0.1	0	0,009
7	Kavad	488–96	Darabgird	Drachma	4.1	0.3±0.0	1.4±0.1	91.6±4.6	0.9±0.1	0	0,01
8	Kavad	488–96	Darabgird	Drachma	4	1.0±0.1	5.0±0.5	97.2±4.6	0.3±0.0	0	0,003
9	Kavad	488–96	Ardeshirkhoreh	Drachma	4	0.5±0.0,0	3.8±0.3	94.7±4.7	1.0±0.1	0	0,01
10	Xusro I	531–79	Ramhormuz	Drachma	4	0.7±0.1	3.7±0.3	97.4±4.7	0.8±0.1	0	0,008
11	Xusro I	531–79	Istakhr	Drachma	3.4	0	2.8±0.3	96.3±4.8	0.9±0.1	0	0,009
12	Xusro I	531–79	Bishapur	Drachma	3.5	0	10.9±1.0	88.3±4.4	0.8±0.1	0	0,009
13	Hormuz IV	579–90	Bishapur	Drachma	4.1	1.4±0.1	0.8±0.1	96.2±4.8	0.8±0.1	0.8±0.1	0,008
14	Xusro II	590	Istakhr	Drachma	4.1	0	6.3±0.6	92.1±4.6	0.7±0.1	0.8±0.1	0,008
15	Xusro II	590	Ecbatana	Drachma	4	0	0.9±0.1	98.1±4.9	1.0±0.1	0	0,01
16	Xusro II	590	Ardeshirkhoreh	Drachma	4.1	1.3±0.1	2.3±0.2	95.7±4.8	0.8±0.1	0	0,008
17	Xusro II	590	Sistan	Drachma	4.1	0	2.0±0.2	97.0±4.8	1.0±0.1	0	0,01
18	Xusro II	590	Sistan	Drachma	4	0	3.3±0.3	95.6±4.8	1.1±0.1	0	0,011
19	Kavad II	629	Ecbatana	Drachma	4.1	0	2.1±0.2	97.1±4.8	0.7±0.1	0	0,007
20	Ardeshir III	628–9	Istakhr	Drachma	4.2	0.2±0.0	1.4±0.1	97.5±4.5	0.9±0.1	0	0,009
21	Ardeshir III	628–9	Bishapur	Drachma	4.1	0	2.1±0.2	97.0±4.8	0.9±0.1	0	0,009
22	Yazdgird III	632–51	Sistan	Drachma	4	0.3±0.0	6.4±0.6	91.6±4.6	0.8±0.1	0.9±0.1	0,009

Figure 3. Distribution of the elements gold, silver, and lead in the studied coins of the Umayyad period using Dplot software.



8. Conclusion

Overall, these findings indicate that there is a direct relationship between the political and economic status of the Umayyad caliphate during a given period and the carat of the coins minted at that time; for example, the coins minted during the period of Abd al-Malik ibn Marwan (82 AH) at Basra mint are of a lower carat than the coins minted during the period of Umar ibn Abd al-Aziz in Basra (100 and 101 AH). Furthermore, the coins minted in the late era of the Umayyad caliphate are of lower carat since the government was weakened over this period, such that the three caliphs only ruled over the period of a year (126 AH). The comparison of the amount of gold, silver, and lead in the Sassanid coins with that of the coins minted in the Umayyad period shows that the Sassanid mints, especially those active at the beginning of the Islamic conquests, were still used during the Umayyad period. The comparison of elements used in the Umayyad coins with the elements used in Sasanian coins shows that the technology of extracting and minting of silver in the Umayyad period did not differ from that of the Sasanian period. The economic prosperity of the time, the strong monitoring system over the activities of their mints, the availability of good reserves of silver, and the presence of silver ore of high purity, ensured that the Umayyad coins enjoyed a very good carat. In this regard, Damascus served as the capital, while Wasit enjoyed commercial and military importance; thus, the mints of these two cities managed to mint the coins with the highest carat.

References

- AL-BALADHURI, A.I.Y., 1866. *Futūh al-Buldān*. M.J. de Goeje, ed. Leiden.
- AL-KOFAHI, M.M. and AL-TARAWNEH, K.F., 2000. Analysis of Ayyubid and Mamluk Dirhams Using X-Ray Fluorescence Spectrometry, *Journal of X-Ray Spectrometry*, 29, 39–47.
- AL-MAQRIZI, A.I.A., 1967. *El-Noqud al-eslamieh*. Najaf: Mohammad Bahr-ol Olum. Publication (in Arabic).
- BEN ABDELOUAHED, H., GHARBI, F., ROUMIÉ, M., BACCOUCHE, S., BEN ROMDHANE, K., NSOULI, B., TRABELSI, A., 2010. PIXE analysis of medieval silver coins, *Materials Characterization*, 61, 59–64.
- HAJIVALIEI, M., MOHAMMADIFAR, Y., GHIYASI, K., JALEH, B., LAMEHI-RACHTI, M., OILIAIY, P., 2008. Application of PIXE to study ancient Iranian silver coins, *Nuclear instruments and Methods in Physics Research B*, 266, 1578–1582.
- HAWTING, G., 1986. *The First Dynasty of Islam: The Umayyad Caliphate AD 661–750*. Croom Helm Ltd.
- IBN AL-KHALDŪN, A.A., 1980. *Muqaddimah (An introduction to history)*. Translated to Persian by Mohammad Parvin Gonabadi. Tehran: Bongah Tarjomeh va Nashres Ketab (in Persian).
- IBN AL-ATHIR, A., 1987. *al-Kāmil fī Tārīkh (The Complete History)*, 11. Mohammad Yousef al-Deghaghāt, ed. Beirut: Dar al Kotob al-Ilmiyah (in Arabic).
- KHADEMI NADOOSHAN, F. and KHAZAIE, M., 2011. Probable Sources and Refining Technology of Parthian and Sasanian Silver coins, *Interdisciplinaria Archaeologica, Natural Sciences in Archaeology*, 2011/II/2, 89–95.
- MAXWELL, J.A., CAMPBELL, J.L., TEESDALE, W.J., 1989. The Guelph PIXE software package. *Nuclear Instrument & Methods in Physics Research B: Beam Interactions with materials and atoms*, 43(2), 218–230.
- MEYERS, P., VAN ZELST, L., SAYRE, E.V., 1979. Interpretation of Neutron Activation Analysis Data of Ancient Silver. *Conference of Archaeometry and Archaeological Prospecting*. Edinburgh, UK.
- SHAMS ESHARAGH, A., 1991. *The empire of Islam's first coins*. Isfahan: Istak cultural Services office (in Persian).
- SODAEI, B., HAJIVALIEI, M., KHADEMI NADOOSHAN, F., 2013. Possible Sources for Extraction of Silver by Comparison of Parthian and Sasanian Coins in Mede Satraps. *Mediterranean Archaeology and Archaeometry*, 13(1), 161–170.
- YOUSSEF FARAJ ALLAH, A., 1985. *Al-ayat al-quraniyeh ala al-maskokat al-eslamieh deraseh moqareneh*. Riyadh: Markaz al-Malek Feisal lelbohuth va al-derasat al-eslamieh (in Arabic).
- ZIAD, A., 1999. Chemical Analysis of Some Umayyad Dirhems Minted at Wasit, *Journal of the Economic and Social History of the Orient*, 42(3), 363–351.

